Hobby Electronics

APRIL '82
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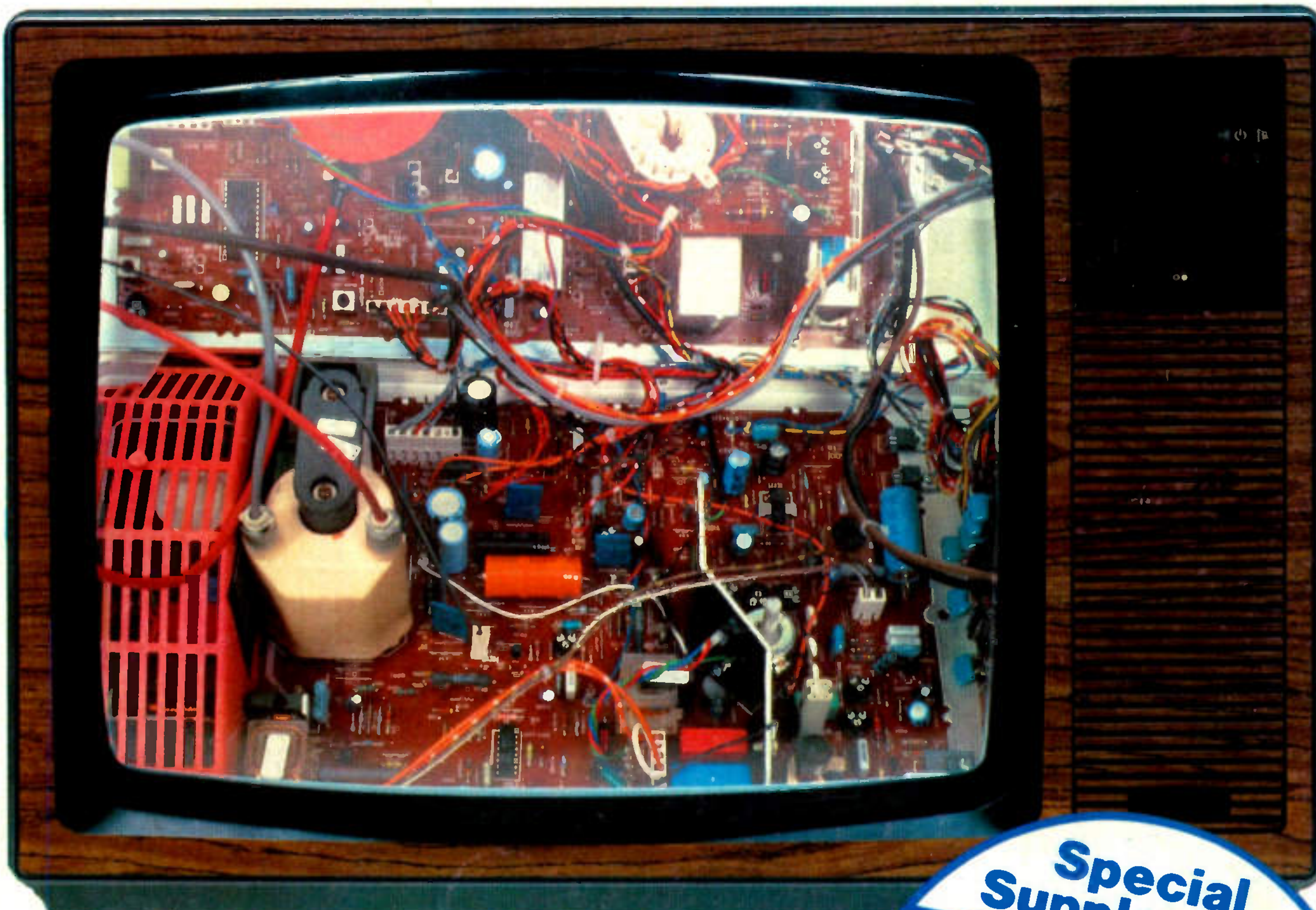
Project Electronics For Everyone

Inside Colour TV

A Non-Technical Guide



Special Supplement
POPULAR COMPUTING No1
A New Monthly Supplement for Budding Computer Experts

Special Features:
Creative Recording • Into Radio

Special Projects:
HE Dual Engine Driver
Digital Capacitance Meter

Hobby Electronics

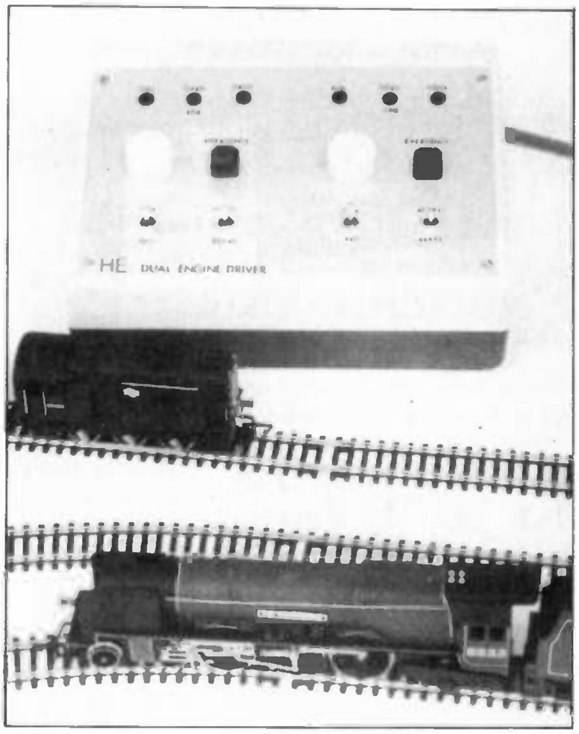
APRIL 1982
Vol 4 No 4

PROJECTS

FEATURES

SPECIALS

REGULARS



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MONITOR

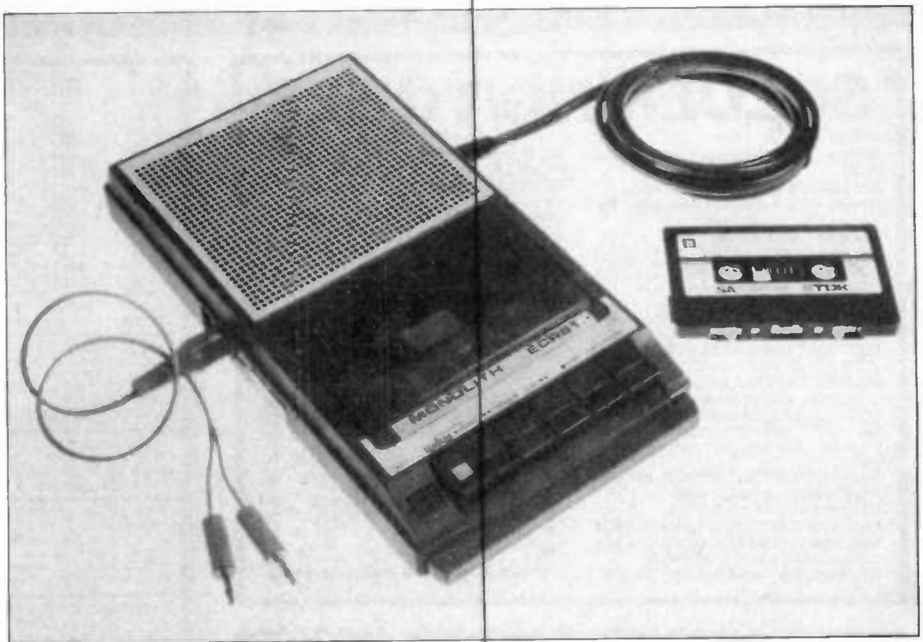
NEW PRODUCTS for home electronics enthusiasts are sometimes thin on the ground. Every month brings a number of announcements concerning the release of new instruments, chips or other components, but many are only of interest to specialists working in industry or institutions.

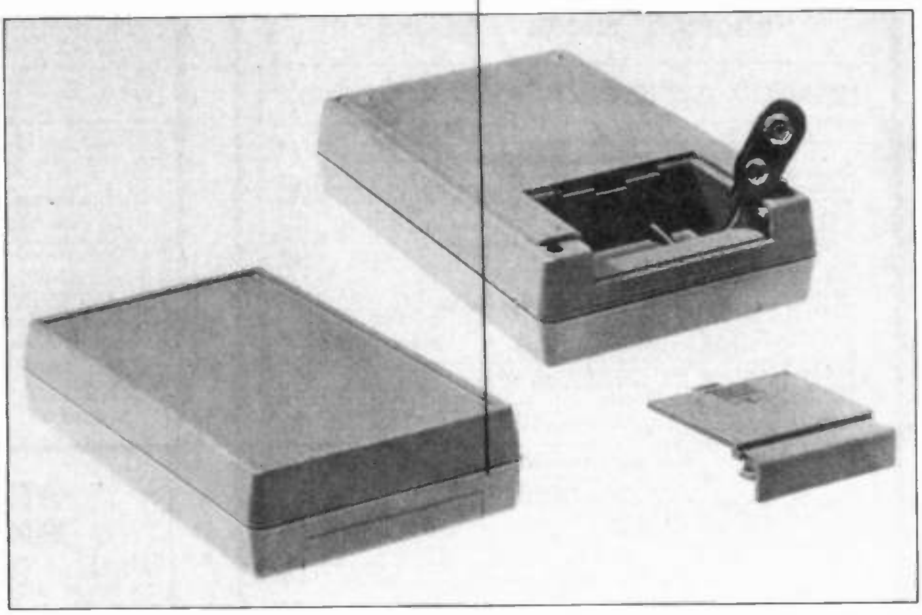
Specialist equipment does have its place, however. The **ECR81 cassette recorder** from **Monolith Electronics** is a good example. It is specially designed as a low-cost data storage medium for home computer systems, such as the Sinclair ZX81.

The problems with using ordinary cassette recorders are well known to home computer operators; the level of the output signal from the computer is often so low that errors are introduced or the data lost altogether. Tape stretching can also cause loss of information, because the computer loses synchronisation with the recorded signal.

The ECR81 (top) has a number of features designed to overcome these commonplace difficulties. It has a high quality cassette mechanism with certified tape tension, torque, speed and head alignment, signal enhancement and shaping circuits for peak performance, and a long-life head matched to TDK's "Super Avilyn" cassette tape. The output level control is preset to eliminate fiddly volume adjustments and a write-protect microswitch is fitted to prevent the accidental erasure of valuable tapes.

The ECR81 is supplied for £47.50, including VAT, and comes fully tested and complete with mains lead, DIN connector and certification tape. All machines have their serial number and performance records (which are checked against the certification tape) kept at the factory. For further information, contact **Monolith Electronics Co. Ltd.**, 5-7 Church Street, Crewkerne, Somerset; Tel. 0460 74321.

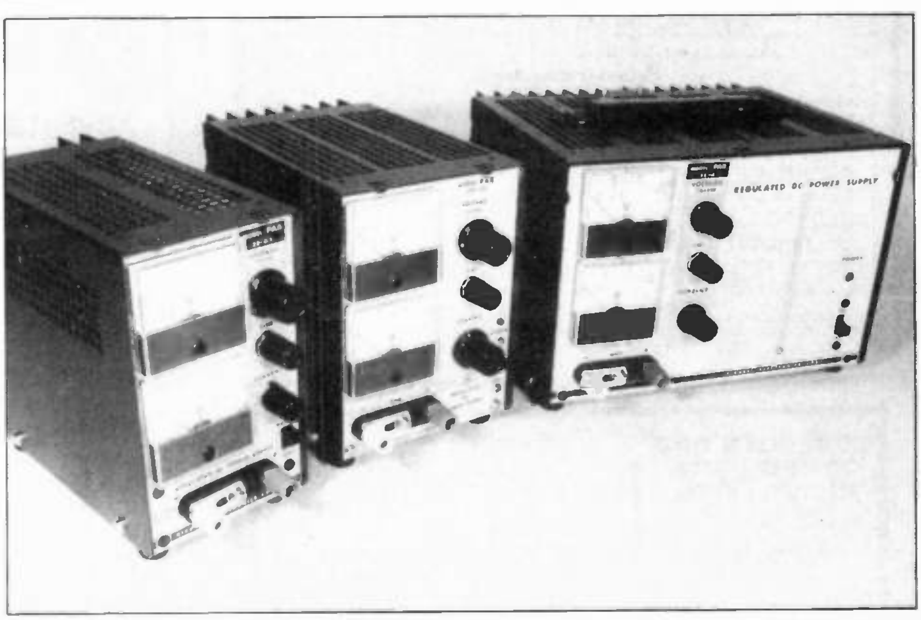




One of the most interesting new releases this month is a new range of **PacTec cases from OK Machine & Tool (UK) Ltd.** The special feature of this series, the HP series, is a battery compartment for standard 9 V batteries. The **HP-BAT-9 V (middle)** is typical; it has a removable battery hatch in the back panel and comes complete with battery clip and lead, as with the other cases in the series.

All are constructed from ABS material for strength and durability and have a textured appearance. They are available in four standard colours (grey, tan, black and blue) and there are a number of useful options, including belt-clips, shoulder straps and wrist straps. Other options provide flame-proof material and electromagnetic/radio frequency shielding.

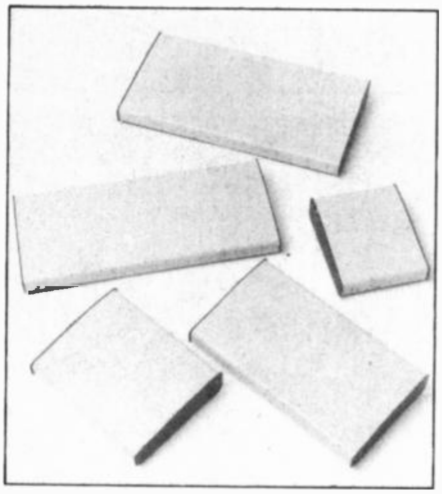
The HP series cases are available from **Watford Electronics** or direct from **OK Machine & Tool (UK) Ltd.**, Dutton Lane, Eastleigh, Hants SO5 4AA, Tel. 0703 610944.



One rather essential piece of equipment for the electronics workshop is a reliable DC power supply. It will soon repay its cost with savings on batteries! **Telonic Berkeley UK Limited's** new range of **Kikusui PAB Series** supplies **(below, left)** offer practical features and a wide range of output options but, best of all, they are attractively priced for the home electronics enthusiast.

There are 17 models in the range, with outputs from 32 V at 0.5 A up to 18 V at 5.5 A. The output voltage may be varied from zero up to the rated output by the use of two variable controls, giving coarse and fine adjustment (some models have a 10-turn potentiometer). Output current is variable from 10% to 100% of the rated value so that a unit may be operated as constant current source, as well as the usual regulated voltage supply. Output voltage and current are displayed on separate meters and overload protection is by constant current transfer.

Prices range from £59 to £138, excluding VAT, and interested readers should contact **Telonic Berkeley UK Limited** at 2, Castle Hill Terrace, Maidenhead, Berks; Tel. 0628 73933.



A new range of boxes, suited for more ambitious projects, have been released by **Boss Industrial Mouldings Ltd.** Their new **BIM 2600** range of small and medium sized desk consoles **(above)** are intended for applications where meters, keyboards or switches are incorporated, with adequate space available on the side and rear panels for mains sockets and connectors.

They range in size from 178 x 210 mm to 483 x 261 mm with an overall height of 51 mm. The sloping front panel is designed to permit comfortable operation of panel-mounted controls and to provide excellent display visibility. Construction is two-piece aluminium in standard colours (brown base and biege top panel) with the whole unit held together by screws running through base rubber feet into hank bushes.

For price and availability contact **Boss Industrial Mouldings Ltd.**, James Carter Road, Mildenhall, Suffolk IP28 7DE; Tel. 0638 716101.

Back in the dim, Dark Ages of Electronics (ie, pre-1956 and the invention of the transistor), all electronic equipment used these funny, tubular-shaped things made of glass and metal; they were called valves (or tubes, as the Americans would have it). There is still considerable interest in much of this obsolete equipment, either as collector's items (on the principle that anything antique will eventually be worth something) or as functioning equipment (an old valve radio makes an excellent 'kitchen set').

One of the main sources of information on the subject is **"The Antique Wireless Newsheet"**, published by **The Vintage Wireless Company** of 64 Broad Street, Staple Hill, Bristol BS16 5NL. The company deals in obsolete electronics of most kinds, including antique wireless, industrial electronics and old components such as valves and speakers.

Their newsheet contains information on all these, plus lists of service data — circuits and manuals — and "complete equipment" for sale. Keen readers of our Famous Names series would also be interested in the occasional feature on some of the less well-known pioneers of radio, such as T. Graham Farish (printed in Newsheet No. 75), who was one of the largest manufacturers of electronic components in the Golden Age of amateur radio, 1920-1933.

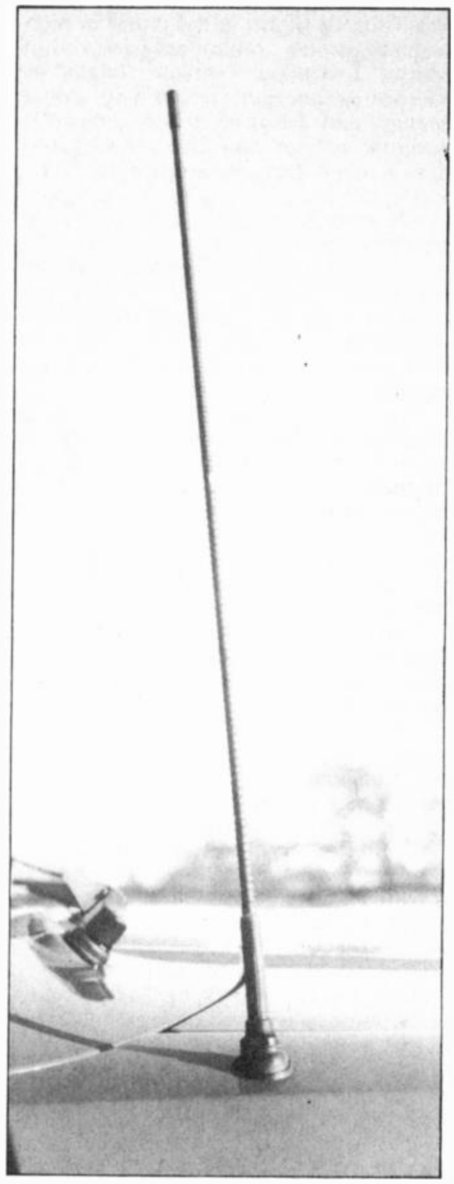
Interested readers should contact the **Vintage Wireless Company** at the above address.

New developments in consumer electronics — the gadgets that we buy for personal use — are sometimes quite rapid. No sooner had last month's article on the **Sinclair** pocket TV been printed, than the **Sony Corp.** of Japan announced their own small-screen TV system. What next? Watch this space!

If Sinclair's past performance is any example, though, they will continue to beat the Japanese manufacturers at their own game — making and selling cheap but efficient products for the mass market (that's us, folks).

Already plans are being made to combine the flat-screen TV with Sinclair's existing computer technology, to develop a low cost integrated terminal/digital phone/work station. This project, which is being undertaken in conjunction with **ICL** (Britain's one-and-only mainframe computer giant) has been dubbed the "One Per Desk IT Work Station"; it is intended to operate as a peripheral to ICL's recently announced digital PABX system and, pending final agreement, production is scheduled to start in 1983.

Sinclair's "existing computer technology" refers, naturally, to the amazing **ZX81**. With monthly production running at 50,000 units (over 60% of which are for export), the ZX81 has achieved worldwide sales of more than 250,000 computers. Sinclair now has ". . . more units installed than any other personal computer manufacturer worldwide . . .", and a good thing that is, too!



Meanwhile, the in-car entertainment industry continues to produce new and more powerful products for us to spend our money on.

The latest from **Blaupunkt** include the **Autoflex** aerial range, the **Toronto** "state of the art technology" radio/cassette combination and the **Blue Magic** line of hi-fi speakers.

The **Autoflex (above)** is described as a "new breed" of car aerial. It is miniaturized (non-telescopic) but provides the highest quality reception on both AM and FM. There are four variations available, for different mounting requirements, but the basic aerial is the same in every case; it is only 45 cm long and consists of a two-direction copper coil wound about a slim glass fibre rod. It is specially designed to reduce wind noise and is virtually indestructible; a highly flexible section at the base ensures that it cannot be snapped off. The non-telescopic construction means that it can never seize-up — and of course it does not need cleaning, greasing or special maintainance. The Autoflex aerials are priced from £21 to £24, including VAT.

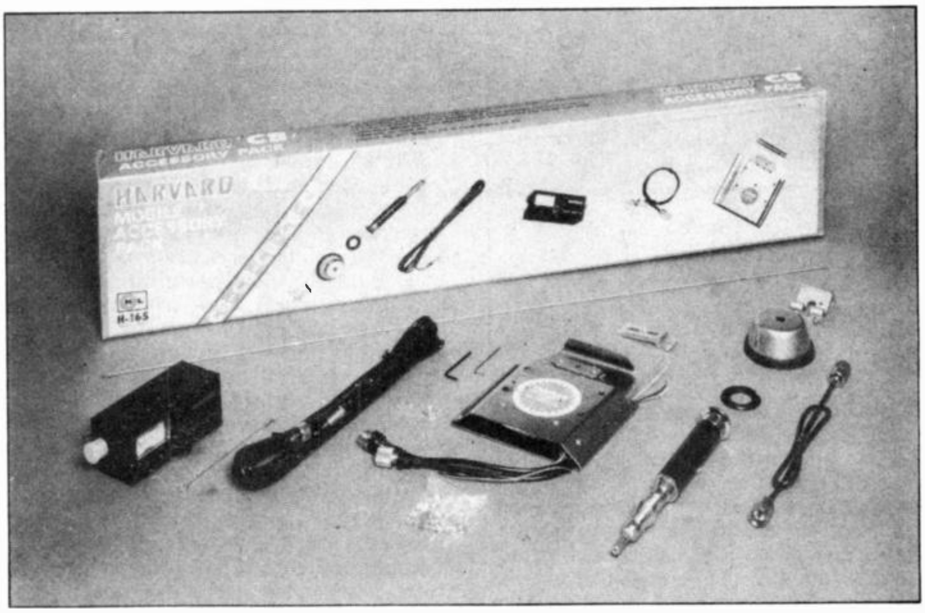
MONITOR

The **Toronto (right)** is the latest in high technology car radio/cassettes, with special operating features (such as microprocessor controlled tuning, digital display and fully electronic controls) designed for optimum performance and ease in use — and, therefore, safety. Unfortunately it is priced accordingly (£275 excluding VAT), but we can all dream.

The **Blue Magic (below)** series speakers, however, are much more accessible. They are designed for flush mounting in door panels or on the rear shelf and can cope with high power outputs up to 40 watts (music power).

The line starts with the SL 1225, a single cone model rated for 25 W music power; there are three dual-cone models, rated from 25 to 30 W and, finally, the top-of-the-line CL 1340 triple cone model. The speakers are supplied in pairs, complete with leads and mounting template, priced from £30.76 to £63.25 per pair, including VAT.

For details, write to **Blaupunkt**, Robert Bosch Ltd., PO Box 166, Rhodes Way, Watford, Herts WD2 4LB; Tel. 01-606 2023.



Now, if there is any room left in the car's dash board, perhaps you are contemplating installing a CB rig? If so, there are several new items which have come to our attention, lately, that may be of interest.

A new entry in the field, which is definitely worth considering if your space is becoming limited, is the **Domico Convoy I**, a slim-line CB transceiver made in Japan and distributed in the UK by **Domicrest Fancy Goods Ltd**. The rig is government approved and carries "all the usual features". The retail price is "something under" £80, including VAT, and Domico also provide a full range of aerials, mikes, SWR meters etc. All items carry a one-year guarantee, with parts and service facilities available at the company's premises, at 31-37 Hoxton Street, London N1 6NJ; Tel. 01-729 4600. Domico products are available from the usual retail outlets but in case of difficulty, contact them at the above address.

Major, (above) manufactured by **Cybernet**, is a more established name among CB operators. Three transceiver models are available — the 2000, 3000 and 5000, plus the Model 4000 base station. Specifications include PLL (Phase Locked Loop) digital synthesiser circuitry, dynamic microphone and built-in circuit protection and they meet all Home Office CB regulations for 27 MHz operation. They are supplied complete with mike, mounting bracket, cable and instruction manual. For more detailed information, contact **Major (UK) Ltd**, Unit 2, Station Yard, Wilbraham Road, Fulbourne, Cambridge CB1 5ET; Tel. 0223 881055.

Finally, you've just bought a rig but have forgotten all the little bits and pieces that (should) go with it, consider the new **H 165 CB accessory kit** from **Harvard (above)**. It contains an MPT 1320 "legal" base loaded 27 MHz FM antenna, a locking slide bracket with key, patch leads, a three-function SWR meter and a gutter-mount for the antenna. The recommended retail price does not appear to have been finalised, but is expected to be around £20. Contact **Harris Overseas Ltd**, Harvard House, 14-16 Thames Road, Barking, Essex IG11 0HX; Tel. 01-594 5533, for up to date price information and availability. **HE**

Rapid Electronics

Tel: 0322 863494
Hillcroft House
Station Road
Eynsford, Kent DA4 0EJ

BARCLAYCARD VISA
Access

LINEAR

		CA3162E	450	LM377	150	LM3900	50	NE566	150	TLO71	45
★709	25	CA3189E	290	★LM380	65	LM3909	70	NE567	100	TLO72	75
★741	14	ICL7106	790	★LM381	100	LM3911	120	NE571	425	TLO84	90
748	35	ICL8038	320	LM382	120	★LM3914	200	RC4136	90	XR2206	300
AY-3-1270	840	ICM7555	80	★LM386	65	★LM3915	200	SN76018	150	ZN414	100
AY-3-8910	700	★LF351	40	LM387	40	LM13600	120	SN76477	150	ZN423	195
★AY-3-8912	625	LF353	85	LM393	100	MC1310	150	TBA800	80	ZN424	135
		LF356	90	★LM709	25	MC3302	150	TBA810	95	ZN425E	390
CA3046	60	LM10	395	LM710	50	MC3340	135	TBA820	80	ZN426E	330
CA3080	65	★LM301A	25	LM725	350	NE515	270	TBA950	290	ZN427E	650
CA3089	215	LM311	70	LM733	75	NE529	225	TCA940	170	ZN428E	480
CA3090AQ	375	LM318	85	★LM741	14	NE531	150	TDA1004	300	ZN1034E	200
CA3130E	90	★LM324	40	LM747	75	NE544	185	TDA1008	320		
CA3140E	45	LM339	50	LM748	35	★NE555	16	TDA1010	225		
CA3160E	100	LM348	50	LM1458	40	★NE556	45	TDA1022	560		
CA3161E	140	LM358	50	LM2917	200	NE565	120	TAD1024	125		

CMOS

		★4017	43	4036	285	4055	115	4082	20	4502	70	4529	150
		4018	60	4039	295	4059	480	4085	65	4503	50	4532	95
4000	14	4019	35	4040	55	4060	85	4086	65	4507	38	4534	495
★4001	12	★4020	55	4041	75	4063	90	4089	140	4508	200	4538	110
4002	14	4021	65	4042	55	4066	35	★4093	33	4510	65	4541	110
4006	65	4022	70	4043	60	4067	395	4094	14	★4511	50	4549	380
4007	17	4023	18	4044	65	★4068	15	4095	90	4512	70	4553	295
4008	58	4024	48	4046	70	4069	18	4097	340	4514	180	4555	45
4009	30	4025	18	4047	70	4070	18	4098	85	4515	180	4556	48
4010	35	★4026	96	4048	55	4071	18	4099	95	4516	75	4559	390
★4011	13	4027	30	★4049	28	4072	18	40106	50	★4518	45	4560	180
4012	17	4028	55	4050	28	4073	20	40109	100	4520	70	4584	45
★4013	22	4029	75	4051	60	4075	20	40163	100	4521	200	4585	99
4014	60	4030	35	4052	70	4076	60	40173	100	4526	80	4724	140
4015	60	4031	170	4053	60	4077	25	40175	100	4527	90		
★4016	22	4034	170	4054	110	4081	18	40193	120	★4528	75		

TTL

		7413	24	7442	40	7480	45	74107	30	74155	60	74177	75
		7414	35	7444	85	7482	70	74109	32	74156	60	74179	65
7400	11	7416	25	7446	60	7483	50	74121	28	74157	43	74180	65
7401	11	7417	25	7447	48	7485	75	74122	45	74160	60	74181	135
7402	12	7420	15	7448	50	7486	25	74123	48	74161	60	74182	75
7403	14	7421	20	7450	16	7489	180	74125	40	74162	60	74190	70
7404	14	7422	20	7451	16	7490	28	74126	40	74163	60	74191	70
7405	17	7427	28	7453	16	7492	45	74132	40	74164	60	74192	70
7406	26	7428	28	7454	16	7492	40	74141	65	74165	60	74193	65
7407	26	7430	15	7460	16	7493	30	74145	65	74167	180	74194	70
7408	15	7432	25	7472	25	7494	35	74147	100	74170	165	74195	63
7409	16	7433	27	7473	28	7495	50	74148	75	74173	60	74196	63
7410	14	7438	27	7474	25	7496	45	74150	75	74174	65	74197	63
7411	20	7437	27	7475	38	7497	120	74153	45	74175	70	74198	95
7412	20	7440	17	7476	30	74100	80	74154	75	74176	55	74199	95

LS TTL

		LS21	15	LS76	20	LS125	30	LS161	42	LS221	60	LS365	38
		LS22	16	LS78	24	LS126	30	LS162	42	LS240	90	LS366	38
LS00	13	LS26	18	LS83	50	LS132	45	LS163	42	LS241	80	LS367	38
LS01	14	LS27	15	LS85	70	LS136	30	LS164	50	LS242	80	LS368	50
LS02	14	LS30	16	LS86	25	LS138	35	LS165	120	LS243	85	LS373	80
LS03	14	LS32	16	LS90	35	LS139	35	LS166	85	LS244	80	LS374	80
LS04	15	LS37	16	LS92	38	LS145	75	LS170	170	LS245	120	LS375	50
LS05	15	LS38	16	LS93	35	LS147	160	LS173	70	LS247	75	LS377	90
LS08	16	LS40	16	LS95	45	LS148	95	LS174	60	LS251	40	LS378	70
LS09	16	LS42	38	LS96	110	LS151	40	LS175	60	LS257	48	LS390	75
LS10	16	LS47	40	LS107	45	LS153	40	LS190	55	LS258	45	LS393	75
LS11	16	LS48	80	LS109	30	LS154	120	LS191	55	LS259	95	LS399	220
LS12	15	LS51	16	LS112	30	LS155	45	LS192	55	LS266	25	LS541	135
LS13	25	LS55	30	LS113	30	LS156	45	LS193	60	LS273	90	LS670	175
LS14	48	LS73	25	LS114	30	LS157	35	LS195	50	LS279	50		
LS15	15	LS74	25	LS122	42	LS158	36	LS196	60	LS283	45		
LS20	15	LS75	27	LS123	55	LS160	42	LS197	68	LS353	100		

TRANSISTORS

		BC157	10	BC558	10	BFX84	25	TIP30	45	★ZTX107	8	2N3054	55
		BC158	10	BCY70	18	BFX85	25	TIP30A	40	★ZTX108	8	2N3055	50
AC125	35	★BC159	8	BCY71	18	BFX86	28	TIP30B	50	ZTX109	12	2N3442	120
AC126	25	BC160	45	BCY72	18	BFX87	25	TIP30C	60	ZTX300	14	★2N3702	6
AC127	25	BC168C	10	BD115	80	BFX88	25	TIP31A	45	ZTX301	16	2N3703	9
★AC128	20	BC169C	10	BD131	35	BFY50	23	TIP31B	45	ZTX302	15	★2N3704	6
AC176	25	BC170	8	BD132	35	BFY51	23	TIP31C	55	ZTX304	17	2N3705	9
AC187	22	BC171	10	BD133	50	BFY52	23	TIP32A	45	ZTX341	30	2N3706	9
AC188	22	BC172	8	BD135	50	BFY53	32	TIP32B	55	ZTX500	15	2N3707	10
AD142	120	BC177	18	BD136	30	BFY55	32	TIP32C	60	ZTX501	15	2N3708	10
AD149	80	BC178	18	BD137	30	BFY56	32	TIP33A	50	ZTX502	15	2N3709	10
AD161	40	BC179	18	BD138	30	BRY39	40	TIP33C	75	ZTX503	18	2N3772	190
AD162	40	BC182	10	BD139	35	BSX20	20	TIP34A	60	ZTX504	25	2N3773	210
AF124	60	★BC182L	8	BD140	35	BSX29	35	TIP34C	85	2N697	20	★2N3819	15
AF126	50	BC183	10	BD204	110	BSY95A	25	TIP35A	160	2N698	40	2N3820	40
AF139	40	BC183L	10	BD206	110	BU205	160	TIP35C	180	2N706A	20	2N3823	65
AF186	70	BC184	10	BD222	85	BU206	200	TIP36A	170	2N708	20	2N3866	90
AF239	75	★BC184L	7	BF180	35	BU208	170	TIP36C	195	2N918	35	2N3903	10
BC107	10	BC212	10	BF182	35	MJ2955	99	TIP41A	60	2N1132	22	2N3904	10
BC107B	10	BC212L	10	BF184	25	MJE340	50	TIP42A	60	2N1613	30	★2N3905	6
★BC108	8	BC213	10	BF185	25	MJE520	65	TIP120	90	2N2218A	45	2N3906	10
BC108B	12	BC213L	10	BF194	12	MJE521	95	TIP121	90	2N2219A	25	2N4037	45
BC108C	12	BC214	10	BF195	12	MJE3055	70	TIP122	90	2N2221A	25	2N4058	10
★BC109	8	★BC214L	8	BF196	12	MPF102	40	TIP141	120	2N2222A	20	2N4060	10
BC109C	12	BC237	8	BF197	12	MPF104	40	TIP142	120	2N2368	25	2N4061	10
BC114	22	BC238	14	BF198	10	MPSA05	22	TIP147	120	2N2369	11	2N4062	10
BC115	22	BC308	15	BF199	18	MPSA06	25	TIP2955	60	2N2484	25	2N5457	36
BC117	22	BC327	14	BF200	30	MPSA12	30	TIP3055	55	2N2646	45	2N5458	36
BC119	35	BC328	14	★BF244B	18	MPSA55	30	TIS43	40	2N2904	20	2N5459	30
BC137	40	BC337	14	BF245	30	MPSA56	30	TIS44	45	2N2904A	20	2N5485	36
BC139	40	BC338	14	BF256B	45	MPSU05	55	TIS45	45	2N2905	22	2N5777	45
BC140	30	BC477	30	BF257	32	MPSU06	55	TIS90	30	2N2905A	22	2N6027	30
BC141	30	BC478	30	BF258	25	MPSU55	60	TIS91	30	2N2906	25	40360	40
BC142	25	BC479	30	BF259	35	MPSU56	60	★VN10KM	45	2N2906A	25	40361	50
BC143	25	BC517	40	BF337	40	TIP29	35			2N2907	25	40362	50
BC147	8	★BC547	7	BFR40	23	TIP29A	40	VN46AF	75	2N2907A	25	40408	70
BC148	8	BC548	10	BFR80	25	TIP29B	55	VN66AF	85	2N2926	9	40594	100
BC149	9	BC549	10	BFX29	25	TIP29C	60	VN88AF	95	2N3053	23		

DIODES

BY127	12	★1N4001	3
OA47	10	1N4002	5
OA90	8	1N4006	7
OA91	7	1N4007	7
OA200	8	1N5401	15
OA202	8	1N5404	16
1N914	4	1N5406	17
★1N4148	2	400mW zen	6p

PANEL METERS

Size 60 × 46 × 35mm

0-50µA	0-500mA
0-100µA	0-1A
0-500µA	0-50V AC
0-1mA	VU
0-10mA	0-300V AC
0-50mA	0-25V
0-100mA	0-30V DC

450p each.

RESISTORS

¼W 5% Carbon film E12 series 4 7Ω 10M **1p each**
½W 5% Carbon film E12 series 4 7Ω -4M7 **2p each**
¼W 1% Metal film E24 series 10Ω -1M **6p each.**

PCB MATERIALS

Alfac PCB transfer sheets — please state type (e g DIL pads etc)	45p
Dalo etch resist pen	100p
Fibre glass board 3.75" × 8"	75p
Ferric Chloride 250ml bottle	100p

BOXES

Dimensions in inches Aluminium

3 × 2 × 1	70p	6 × 4 × 2	120p
4 × 3 × 1½	85p	6 × 4 × 3	150p
4 × 3 × 2	100p	8 × 6 × 2	180p

COMPONENT KITS

An ideal opportunity for the beginner or the experienced constructor to obtain a wide range of components at reduced prices

¼W 5% Resistor Kit Contains 10 of each value from 4 7Ω to 1M (650 resistors) **480p.**

Ceramic Capacitor Kit Contains 5 of each value from 22p to 0 01 (135 caps) **370p.**

Polyester Capacitor Kit Contains 5 of each value from 0 01 to 1uF (65 caps) **575p each.**

Preset Kit Contains 5 of each hor Value from 100Ω to 1M (total 65 presets) **425p each.**

Nut and Bolt Kit Total 300 items **140p.**

25 6BA ¼" bolts	25 4BA ¼" bolts
25 6BA ½" bolts	25 4BA ½" bolts
50 6BA nuts	50 6BA nuts
50 6BA washers	50 6BA washers

CAPACITORS

Polyester Radial Leads 250V 280 type
0 01, 0 015, 0 022, 0 033, **6p**; 0 047, 0 068, 0 1, **7p**; 0 15, 0 22, **9p**; 0 33, 0 47, **13p**; 0 68, **20p**; 1u **23p**.

Electrolytic Radial or Axial leads
0 47/63V, 1/63V, 2 2/63V, 4 7/63V, 10/25V, **7p**; 22/25V, 47/25V, **8p**; 100/25V, **9p**; 220/25V, **14p**; 470/25V, **22p**; 1000/25V, **30p**.

Polyester Siemens PCB
1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, **7p**; 22n, 33n, 47n, 68n, **8p**; 100n, **9p**; 150n, **11p**; 220n, **13p**; 330n, **20p**; 470n, **26p**; 680n, **29p**; 1u, **33p**; 2u2, **50p**.

Tantalum bead
0 1, 0 22, 0 33, 0 47, 1 0 @ 35V **12p**; 2 2, 4 7, 10 @ 25V, **20p**; 15/16V **30p**; 22/16V **27p**; 33/16V, **45p**; 47/6V, **27p**; 47/16V **70p**; 68/6V, **40p**; 100/10V, **90p**.

Ceramic 22p-0-01u 50V **3p each.**
Polystyrene 5% tolerance
10p-1000p **6p**. 1500-4700 **8p**. 6800p-0 012 **10p**.
Trimmers Mullard 808 Series
2-10pF **22p**. 2-22pF **30p**. 5 5-65pF **35p**.

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Miniature mains
606V, 909V, 12012V all @ 100mA **100p each**

High quality, Split bobbin construction

6VA	0-6, 0-6 @ 0 5A, 0-9, 0-9V @ 0 4A 0-12, 0-12V @ 0 3A **220p each.**
12VA	0-6, 0-6 @ 1A, 0-9, 0-9V @ 1 2A, 0-12, 0-12 @ 0 5A, 0-15, 0-15V @ 0 4A **275p each** (plus 40p carriage)
24VA	0-6, 0-6V @ 1 5A, 0-9, 0-9V @ 1 2A, 0-12, 0-12V @ 1A, 0-15, 0-15V @ 0 8A, **330p each** (plus 60p carriage)
50VA	0-12, 0-12V @ 2A, 0-15, 0-15V @ 1 5A, **400p each** (plus 70p carriage)
100VA	0-30, 0-30V @ 1 6A **920p each** (plus 80p carriage)

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OPTO

★3mm red	8	★5mm red	8
★3mm green	12	★5mm green	12
★3mm yellow	12	★5mm yellow	12

Clips to suit 3p each

Rectangular		TIL32	40
★red	12	TIL78	40
green	17	TIL111	60
yellow	17	ORP12	85

Seven Segment Displays

Com cathode		Com anode	
DL704 0 3"	95	DL707 0 3"	95
★FND500 0 5"	65	FND507 0 5"	90
TIL311 0 3"	105	TIL312 0 3"	105
TIL322 0 5"	115	TIL321 0 5"	115

All seven segment displays are supplied with connection details
2N5777 45 Dual Colour LED 60

VERO

Veroblox 350p.
Size 0 1 matrix

2 5 × 1"	22p
2 5 × 3 75"	75p
2 5 × 5"	85p
3 75 × 5"	95p
VQ Board	160p
Veropins per 100	
Single sided	50p
Double sided	60p
Spot face cutter	105p

HARDWARE

PP3 Battery clips	6p
Red or black crocodile clips	6p
Black pointer control knob	15p
Pair Ultrasonics	350p
TO220 twisted vane heatsink	28p
20mm panel fuseholder	25p
4mm terminals (var colours)	33p
TO18 transistor socket	15p
64mm 64 ohm speaker	70p
64mm 8 ohm speaker	70p

REGULATORS

Positive		Negative	
★78L05	25	79L05	65
78L12	30	79L12	65
78L15	30	79L15	65
★7805	45	★7905	45
★7812	45	★7912	45
7815	60	7915	60
LM309K	130	★LM323K	350
★LM317T	120	LM723	40

SOLOERING IRONS

Antex CX 17W Soldering Iron	420p
2 3mm and 4 7mm bits to suit	55p
CX 17W element	190p
Antex X25 25W Soldering Iron	440p
3 3mm and 4 7mm bits to suit	55p
X25 25W element	190p
Solder pump desoldering tool	480p
Spare nozzle for above	70p
10 metres 22 swg solder	100p

CABLES

20 metre pack single core connecting cable, ten different colours	65p
Speaker cable	10p/m
Standard screened	16p/m
Twin screened	24p/m
2 5A 3 core mains	23p/m
10 way ribbon	65p/m
20 way ribbon	120p/m

POTENTIOMETERS

Rotary Carbon track Log on Lin 5K-1M
Single **32p**. Stereo **85p each.**
Slide 60mm travel single
Log or Lin 5K-500K **63p**.
Preset Submin horiz
100Ω-1M 7p.

SOCKETS

★8 pin	7p
★14 pin	9p
★16 pin	10p
18 pin	15p
20 pin	18p
22 pin	20p
24 pin	22p
28 pin	26p
40 pin	32p

Soldercon pins **60p/100**

SWITCHES

Submin Toggle
SPST **55p** SPDT **60p** ★DPDT **50p**
Miniature toggle
SPDT **80p** SPDT centre off **90p**
DPDT **90p** DPDT centre off **100p**
Standard toggle
SPST **35p** DPDT **48p**
★Miniature DPDT slide **12p**
★Push to make **12p** Push to break **22p**
Rotary type adjustable stop
1P12W 2P6W, 3P4W, 4P3W **all 55p each**
DIL switches
4 SPST **80p** 6 SPST **80p** 8 SPST **100p**

CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2 5mm	10p	10p
3 pin	12p	10p	3 5mm	★7p	★7p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	13p	13p	4mm	18p	17p

UHF (CB) Connectors
PL259 Plug **40p** Reducer **14p**
SO239 Square chassis socket **38p**
SO239S Round chassis socket **40p**

IEC 3 pin 250V/6A
Plug chassis mounting **38p**
Socket free hanging **60p**
Socket with 2m lead **120p**

TRIACS + SCRS

SCRs		TRIACs	
★C106D	30	400V 4A	60
400V 8A	70	400V 8A	70
400V 12A	99	400V 16A	105

BRIDGE RECTIFIERS

1A 50V	22	6A 100V	80
1A 400V	35	6A 200V	90
		6A 400V	95

CRYSTALS

				5 0M	240	18 0M	240
				6 0M	200	18 432M	220
100KHz	290	2 4576M	220	6 144M	180	19 968M	300
200KHz	370	3 276M	240	7 00M	250	26 69M	300
1MHz	300	3 579M	120	8 0M	170	27 145M	240
1 008M	370	4 0M	150	10 0M	180	38 6667M	320
1 8432M	300	4 194M	150	12 0M	290	48 0M	220
2 0M	270	4 43M	125	16 0M	240	116M	300

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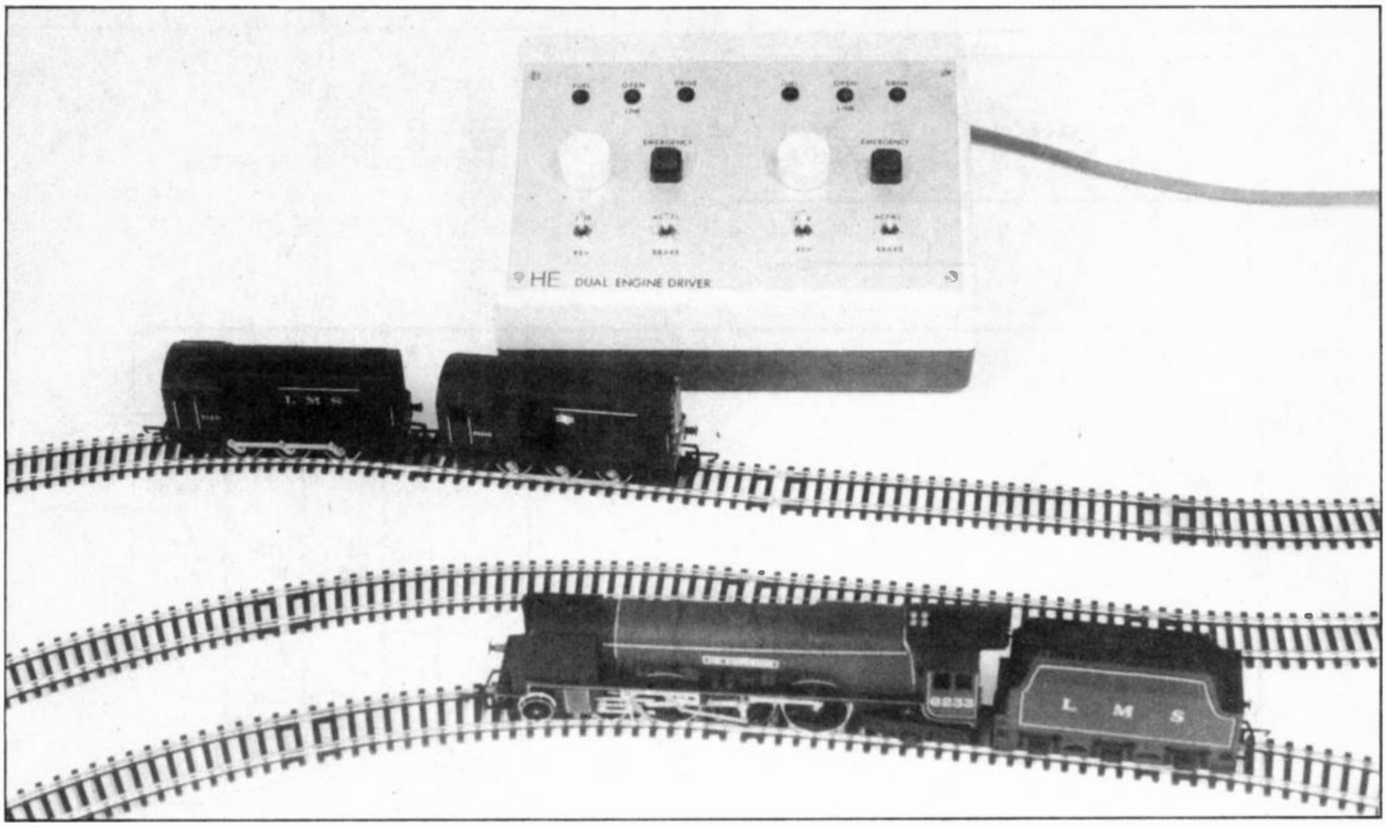


Dual Engine Driver

Jonathon Scott

A double-value model train controller with simulated inertia for scale realism.

MODEL TRAIN CONTROLLERS aren't new; in fact, HE has presented two in the last few years. However, none that we have seen have offered all the features of this one! Our new device offers simulated inertia, twin controllers in one box, real engine-like control layout, realistic pick-up and current drive, which provides automatic compensation for bad contacts. It also has full short/open circuit indication. Whether you are a habitual Hamley's first floor addict or just starting with the beginnings of a railway set-up, this project will give you scale-realism.

Our controller will drive any DC locomotives, up to 15 volt rating at up to 1½ amps per track and has two controllers in the one base (most people have at least two lines in their layout).

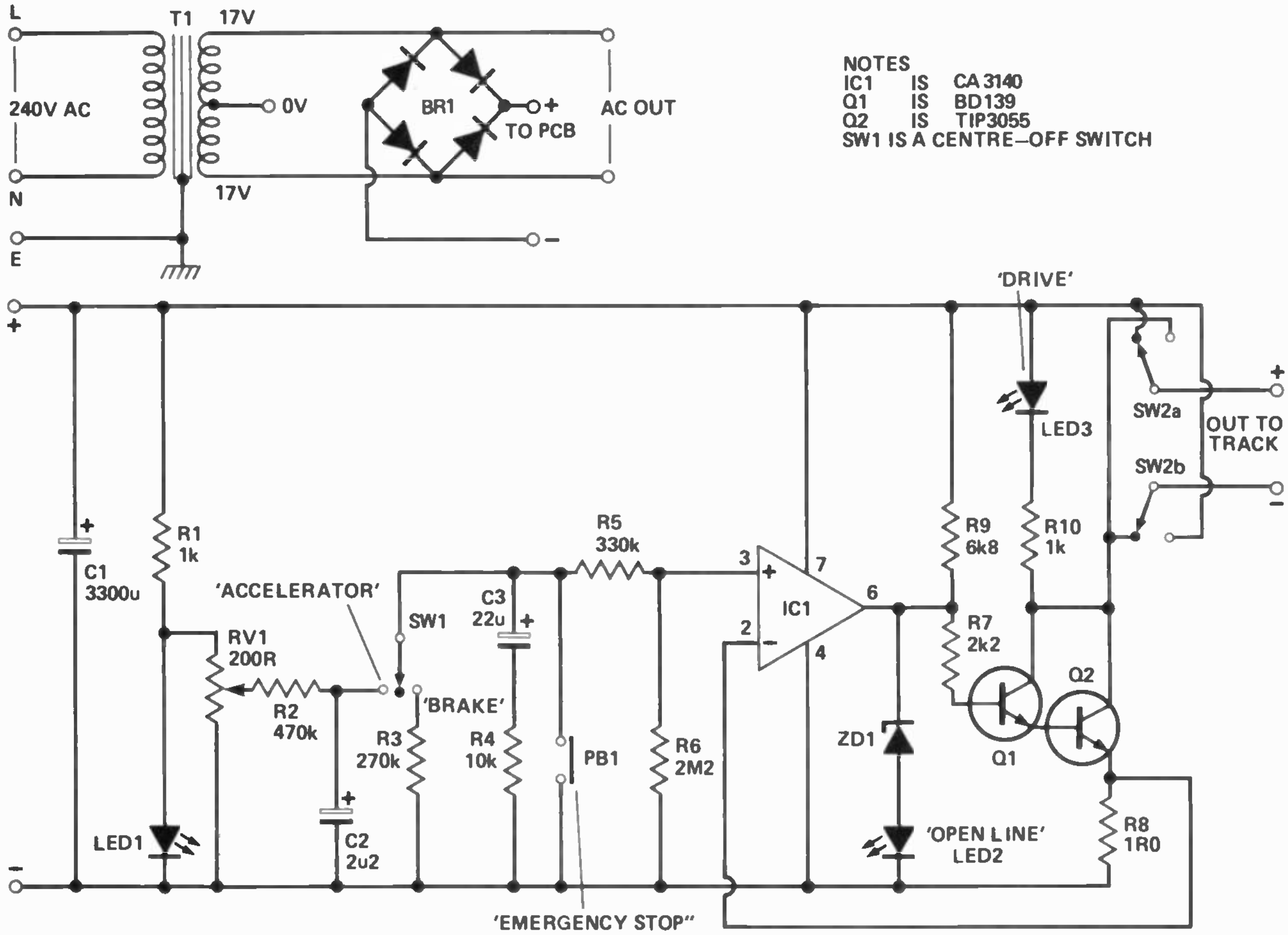
You may also notice that our Dual Engine Driver has rather an unusual control layout. There is a 'throttle', as well as a three-way control switch with positions, labelled 'Accel' and 'Brake' and a centre-off 'Coast' position. When the switch is thrown up to the accelerate position, the controller pulls the train slowly up to the power level set by the throttle and it can be left there for long journeys. Pushed to the centre position, the train will 'coast' and eventually come to a halt. For controlled braking, push the switch to the (momentary) brake position (released, it springs back to 'off'); repeated brake pulses will allow you, with a little practice, to stop neatly at a station. This 'power-coast-brake-coast-brake' sequence may be familiar from travelling on the Tube or on short Main-line runs. In fact a short station-to-station run rarely requires the operator to touch anything but the accel/brake control. For long runs, the throttle needs to be adjusted to set a steady pace — as is the case on an Inter-City run. This controller action is as 'realistic' as we could devise with readily available components. However, real engine-like controls could be made up and fitted to a panel, rather than the base that we used. For example, we could have used a 10-turn potentiometer for the throttle and a 'steam-valve' knob, but we opted for a simpler, less expensive approach. Since these are mechanical, rather than circuit, modifications we leave it up to you!

Construction

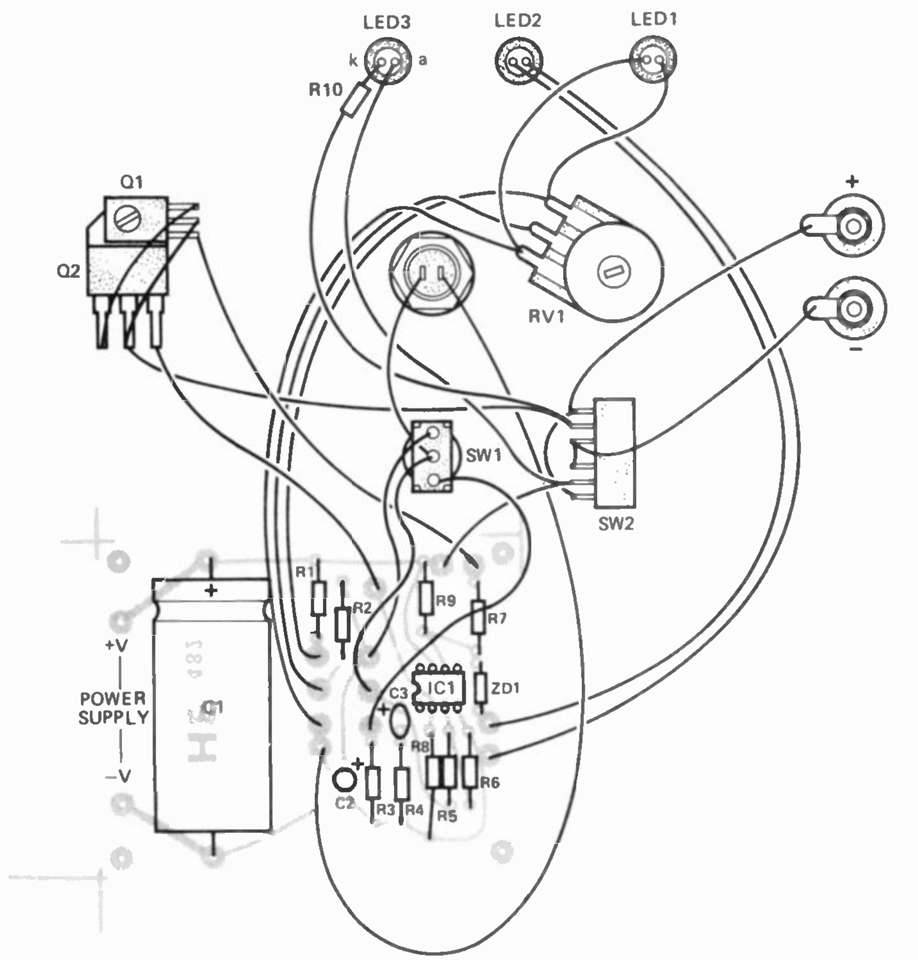
Construction is relatively straightforward — if you follow the steps below and the accompanying layout diagram. Firstly, drill the box and front panel; make the holes for the cable on the rear of the box, and the mountings for heatsinks, PCB, transformer, feet, etc, on the bottom. Once this is done, label the panel with rub-down lettering and spray it with protective lacquer. While this is drying, fit the terminals, transformer, diode bridge, feet and mains cable. The diode bridge should not require a heatsink if it is a 6 Amp type, as specified. We did not use an on-off switch in the AC mains line, as is usual on train controllers, but of course you may if you wish.

Next, fit the components to the PCB, following the overlay (**Figure 2**). Take care to orient the components correctly — only the resistors may be mounted either way around! Finally, fit the transistors to the heatsinks and mount them as shown. If you use a box similar to ours, there is plenty of room for the heatsinks to be individually bracket-mounted on the base and, as they are then isolated, there is no need to insulate the transistors with washers and thermal compound. If, however, you use a metal case as a heatsink, or one heatsink for both channels, you must then insulate Q1, Q2, Q101 and Q201 from the heatsink. Be sure to remove all burs and to use thermal compound; the transistors can develop tens of watts during momentary overloads and this demands several square inches of heatsink and good thermal contact!

When the panel has dried, fit all the knobs, switches etc. Then, all the flying leads should be connected; use



▲ **Figure 1. The circuit for a single controller; the other half is identical.**



◄ **Figure 2. Component overlay for half the board. The full PCB foil pattern is reproduced on page 78**

controls and the LEDs on the front panel, the terminals (6) and the AC 32/0.2 (32 conductors, each 0.2 mm diameter) or heavier gauge wire for the lines which carry 1.5 amps. The remaining connections can be made with ordinary hook-up wire. Now it is time to test the controller. If everything is in order, you should be rolling!

The Dual Engine Driver is capable of controlling any size train, of any gauge, that uses up to 15 V supply. Once it is operational, there are several adjustments that can be made to set up the controller to suit your system. You may, for example, vary the start-up impulse, change the maximum throttle setting or alter the amount of inertia to obtain better performance from your trains. These changes are described below.

The Circuit

The unit consists of two separate, identical controllers, each supplying sufficient power to drive one train, and a common DC supply. The controllers each need 30 VA, maximum, and the specified transformer, rated at 65 VA, will comfortably run both controllers with 'headroom' left for an AC output, as is usual on model train controllers.

Smoothing capacitor C1 lifts the DC supply rail to about 20 V but, as

Parts List

RESISTORS
All ¼W 5% except where stated

R1,10, 101,110	1k
R2,102	470k
R3,103	270k
R4,104	10k
R5,105	330k
R6,106	2M2
R7,107	2k2
R8,108	1R0 2.5 watts
R9,109	6k8

CAPACITORS

C1,101	3300u electrolytic 25 V
C2,102	2u2 radial electrolytic 16 V
C3,103	22u tantalum 16 V

POTENTIOMETERS

RV1,101	200R wirewound

SEMICONDUCTORS

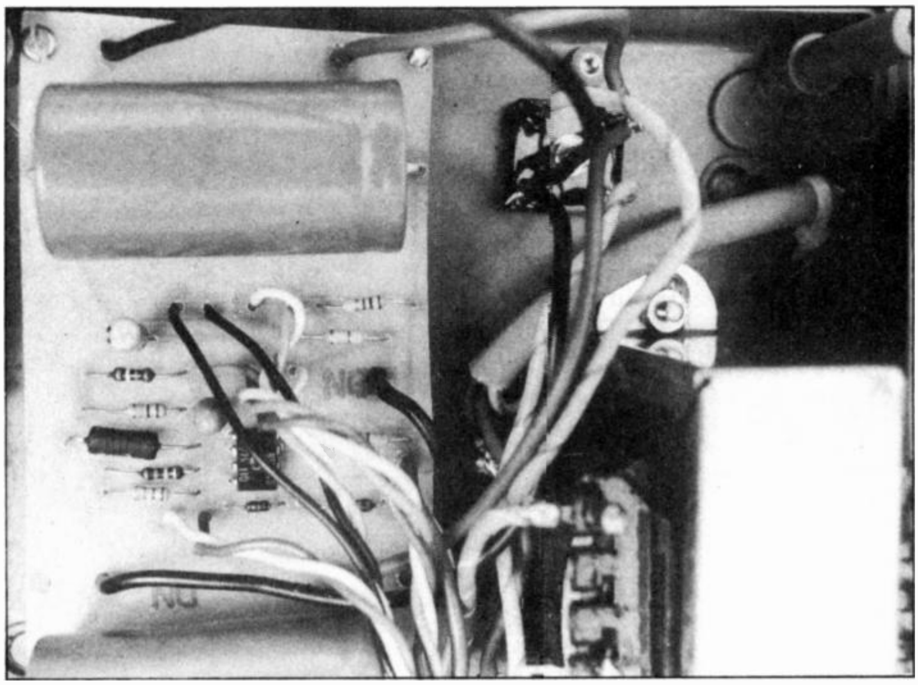
IC1,101	CA3140
ZD1,101	BZX61C 10 V zener diode
LED1,101	0.2" LED red
LED2,102	0.2" LED yellow
LED3,103	0.2" LED green
Q1,101	BD139
Q2,102	TIP3055

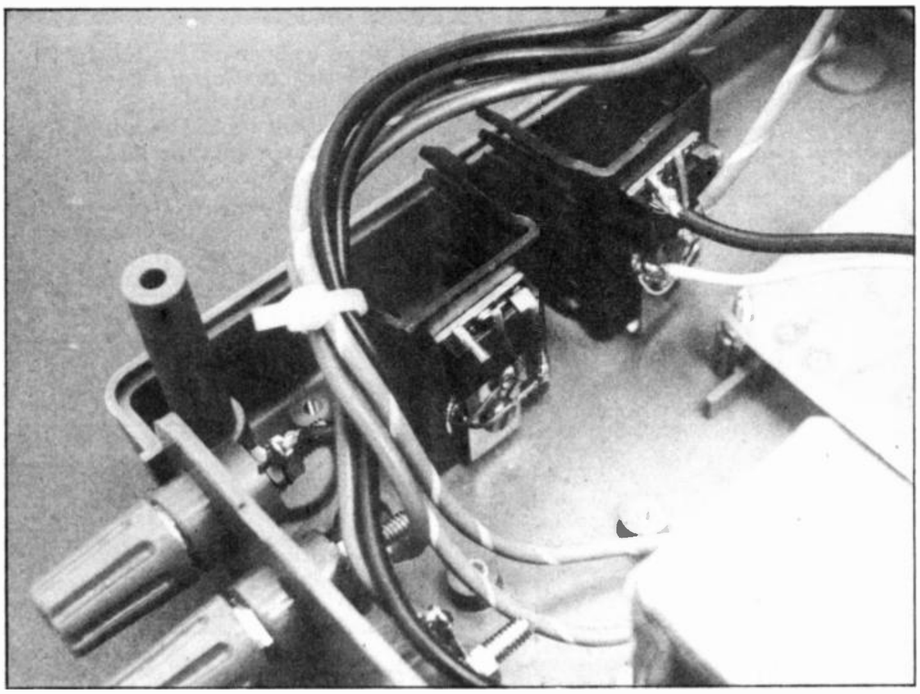
MISCELLANEOUS

T1	Transformer 17-0-17 centre-tapped 4A
BR1	6A 100 V bridge rectifier
SW1	SPDT centre-off toggle switch (momentary action)
SW2	DPDT toggle switch
DP1	push-to-make push button switch

Case, knobs, PCB, grommets, cable, solder etc.

See Buylines, page 21 for cost and availability of these components.





several volts are lost in the controller circuitry, the voltage supplied to the train is about the same as it would be if the supply were unsmoothed. As well as providing 'Power On' indication, R1 and LED1 put a regulated 1V65 across RV1, the throttle control.

Assume, for the moment, that SW1 is in the centre-off position, C3 is discharged and the throttle is set to about ⅓ maximum; C2 will be charged to about 0V5. If SW1 is then switched to the 'Accelerate' position, the voltage on C2 suddenly appears on C3, but rapidly discharges through C3 and R4, the voltage on C3 falling to about 1/10th of its peak value of 0V5. Then, however, C3 begins to charge through R2, ultimately reaching the voltage set by the wiper of RV1. The net effect is a fast voltage pulse on Pin 3 of IC1 which quickly falls, nearly to 0 V, but then gradually rises back up to 0V5. This voltage pulse is translated into a current pulse by IC1 and Q1/Q2, giving that sudden engaged-gear jerk characteristic of certain engines, particularly steam engines, as the slack is taken out of the couplings and the engine begins to build-up full power.

The intensity of the start up pulse can be modified by changing C2 and/or R4; increasing R4 produces a stronger 'jerk' but does not alter the start-up (1/10th of the throttle setting) while decreasing the value of R4 reduces the 'jerk'. Increasing C2 gives both a larger pulse and start-up power while decreasing C2 reduces both. Thus by adjusting the values of both components, you can produce a suitable jolt (one that doesn't lift the engine off the track) and a realistic start-up.

At this point, the voltage on C3 has risen to the value set by the wiper of RV1, the throttle control. Any further adjustments of the throttle will take effect slowly, as the charge on C3 adjusts to the new level, thus simulating the large weight and inertia of an actual train. Increasing C3 increases the inertia while decreasing its value produces a less pronounced effect.

The maximum current drawn by a train, and so its maximum speed, is set by R5/R6. If your engine demands much less than the 1.5 amps which the controller is capable of supplying, it may be necessary to reduce the top speed by increasing the value of R5 and, possibly, reducing the value of R6 — together, they should add up to about 2M5. For example, values of 1M each for R5 and R6 would give a maximum current of approximately 0.8 amps.

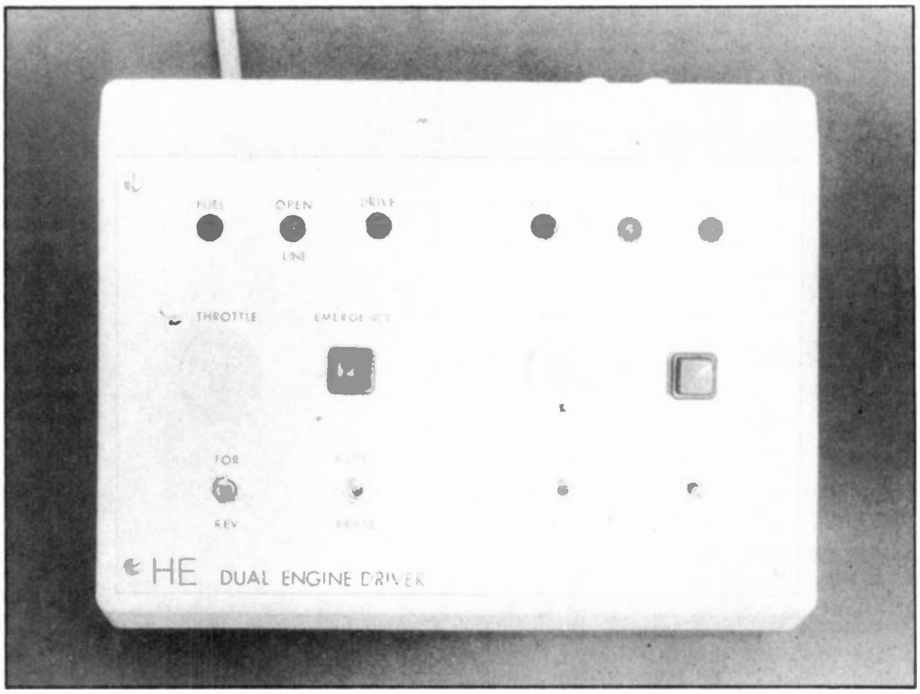
Look again at IC1, Q1 and Q2. The transistors are connected as a Darlington Pair, with the engine as their collector load (via reversing switch SW2a, b) and current-sense resistor R8 as the emitter load. The voltage developed across R8 is in the feedback loop of the op-amp, and IC1 tries to drive the Darlington Pair so that the current through Q1/Q2 develops a voltage across R8 equal to the voltage on the non-inverting input, pin 3. Effectively, this forces the current through the load to be proportional to the voltage at pin 3 (which is, of course, proportional to the voltage on C3!).

Should the impedance of the load be too high — for example, when there is a bad track connection or an open circuit on the output — IC1 output is unable to force more current through Q1/Q2 and so moves towards the positive rail, lighting LED2 and indicating a fault condition.

LED3 is normally on, when a voltage is applied to the output, but is extinguished by a short circuit — thus, all fault conditions are indicated. By its current regulating action, the controller tends to counteract the effects of bad contacts or high resistance paths, but a continuous flicker in LED2 is normal as the engine moves over insulators or particles on the track.

Returning, now, to the control section, if SW1 is moved into the 'Coast' (centre-off) position, C3 discharges slowly through R5 and R6; the current drive also drops, as the voltage on pin 3 decays, and eventually the engine will come to a halt. Of course, if the values of C3, R5 or R6 have been adjusted, the time taken for this to happen will also be effected.

The train can be halted rather more rapidly by switching SW1 into the 'Brake' position (this position is a



'momentary action' ie, the switch springs back into 'Coast' when released). In this position, C3 discharges fairly rapidly through R3, removing the current drive and bringing the engine to a stop. With practice it is possible it is possible to use the brake-coast-brake sequence to bring the train to an exact halt.

Should it be necessary to bring the train to an abrupt stop, the 'Emergency Stop' switch, PB1, shorts C3 to ground through R4, stopping the train in about 1 second.

Our thanks to Hamley's Ltd of Regent Street, who supplied the trains for the picture.

HE

INSIDE COLOUR TV

Interested in how a colour TV works? Want to know what makes it tick? This special feature by guest writer Don Keithley explains all.

MOST of you will have read the article (if not, why not?!), 'How A TV Receiver Works', in the December 1981 issue of Hobby Electronics, so you will know how a black and white TV works. As you'll soon see, colour TV uses all the principles used for black and white TV so you must understand those first.

Briefly, then, you should recall that a black and white TV scene is made up from lots of separate lines (625, in the British TV system) on the face of a phosphor-coated tube. The lines are made by guiding an electron beam from an electron gun across the inside surface of the tube. Controlling voltages applied to the electron gun, and to its deflection coils, tell the beam where to point and how many electrons to send in the beam. As the electrons hit the phosphor, energy is given off in the form of light and the greater the number of electrons, the brighter the light.

Using these very same principles, we can make a colour TV, because the light given off by the phosphor doesn't have to be white (as it is in a black and white TV tube) — it can be red, green, yellow, pink, blue, orange, brown, turquoise, or any colour we want it to be. All we require is a selection of different coloured phosphor spots (say, 10) arranged in groups on the TV screen. All we have to do after *that* is to fire a beam of electrons at the right coloured phosphor spot within each group and *hey presto*, we have a colour TV.

It's Not That Easy

Unfortunately, there are some impossible problems with such a colour TV system. For instance:

- If the picture is to be in sharp focus the groups of phosphor spots will have to be very small — in fact, each group must occupy about the same space as the gap between lines on the screen, ie 1/625th of the screen. This means that each spot will be about 1/10th of this size — but this is too small to be accurately manufactured.
- Not only would it be impossible to manufacture such a tube, it would also be impossible to focus the electron beam on to the correct coloured spot in each group. Blurring of colours would occur, with greens becoming blues, reds becoming browns, etc. etc.
- Even if the gods were on our side and we were able to produce such a tube, and even if we could focus an electron beam to the required accuracy, there would *still* be another impossible bridge to cross — can you imagine just how complex the controlling voltages would have to be? The beam would have to be accurately positioned on one exact spot in one exact group of dots; the number of electrons fired in the beam would have to be specified, the beam would have to be fired, then stopped, then moved on to the next group and the whole process started again — *for every group on the TV screen*. All-in-all, the controlling voltages applied to the electron gun and its deflection coils would be so complex that to transmit them over the air would require far more air-space than there is to spare!
- We must also consider the people who won't have colour TV, because a black and white TV won't be able to produce a picture from such a colour signal (and vice versa) so two completely separate systems would be required, one for black and white and one for colour.

As you'll have guessed by now, this colour TV system is not the one for us. So what do we do? How do we make a better system? One which is technically possible to build, doesn't use any more valuable air-space, and which we can use alongside the existing black and white system without the two interfering. Let's go back to basics and find out just exactly what 'colour' is and perhaps that will give us the answer.

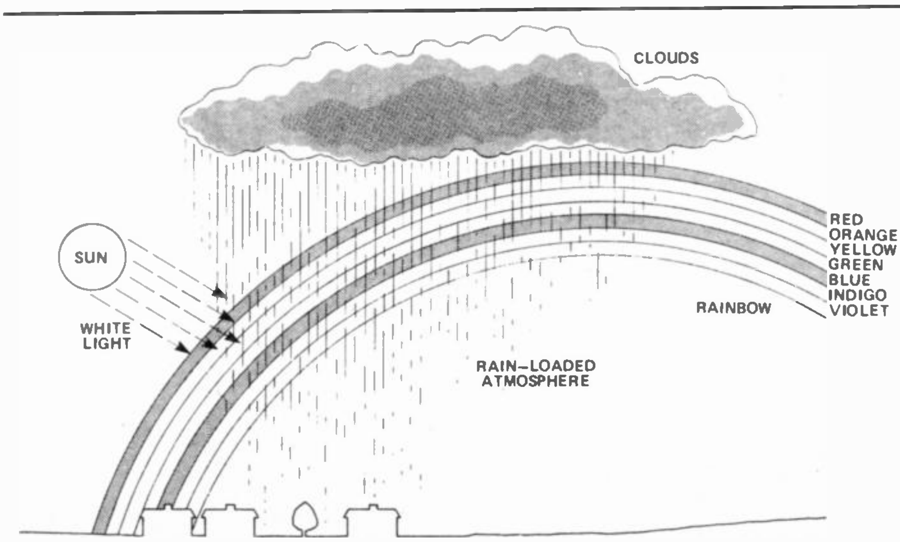
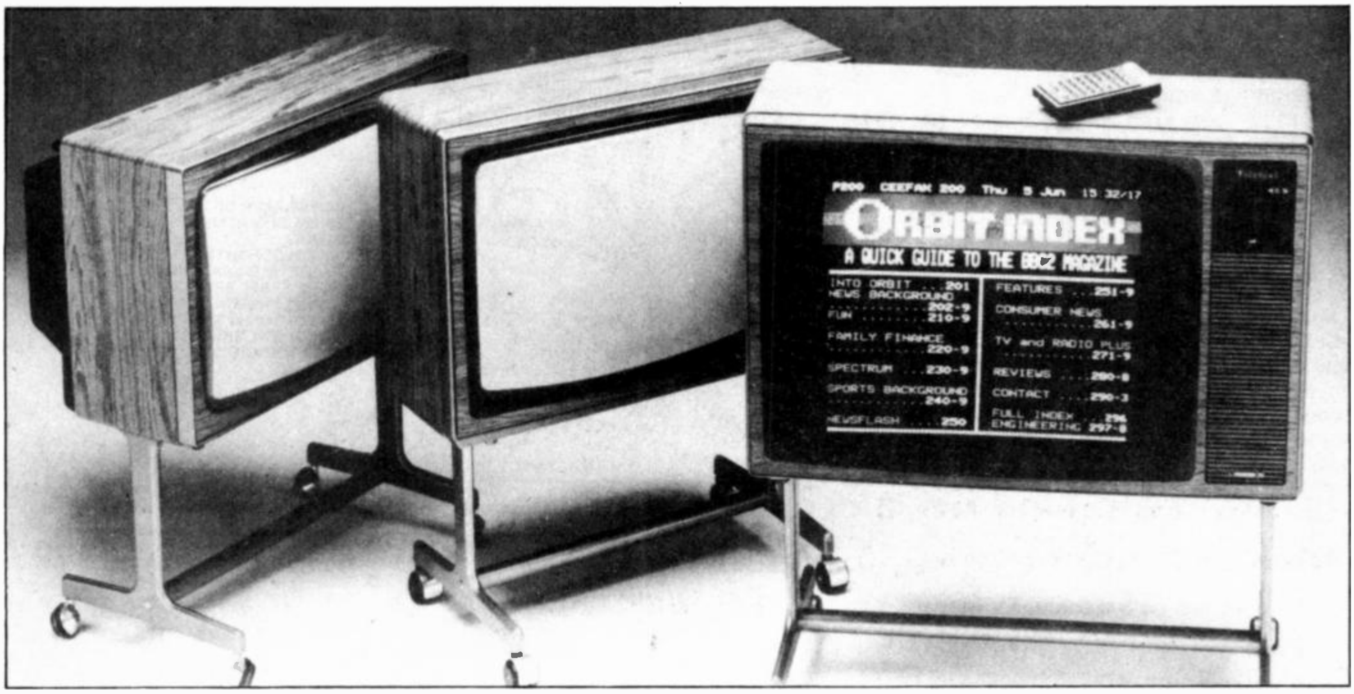


Figure 1. One of the most natural sources of colour is a rainbow. White light from the sun, refracted through a rain-loaded atmosphere, breaks-up into seven colours.



Mother Nature

Colour is a natural phenomenon. You've only to look at the green grass, the blue sky, or the flowering yellow daffodils to see that. Take the example of a rainbow — it's a natural phenomenon, too, but believe it or not a rainbow can be used to show the main principle of colour TV.

A rainbow is formed when light from the sun (white light, that is) shines through an atmosphere loaded with minute rain particles. Rain particles refract the white light (ie bend it) and literally break it up into the seven colours of the rainbow: red; orange; yellow; green; blue; indigo; violet (**Figure 1**).

The rain-loaded atmosphere acts as a prism, similar to the glass prism used in the simple classroom physics experiment. What that experiment proves is that the colour which we call 'white' is simply a combination of other colours. Theoretically, it should be possible to combine the seven colours of a rainbow, or from a prism, back into white light with another prism.

Figure 2 shows how seven colours can be used to create white light but, given the right conditions, we find that we can get white light *from only three colours*, red, green and blue. These three colours are called primary colours. The interesting thing is that white light is created by the three primary colours only when they are in the correct proportion: if the proportions differ, then a non-white colour is created. By controlling the proportion of primary colours, then, a very wide range of non-white colours can be created.

We can show the range of colours obtained with the three primary colours of red, green and blue in what is called a colour triangle (**Figure 3**), where each corner of the triangle corresponds to a pure primary-coloured light. Each point inside the triangle represents a different perceived colour. White light, at the point of equal primary strengths, is at the centre of the triangle.

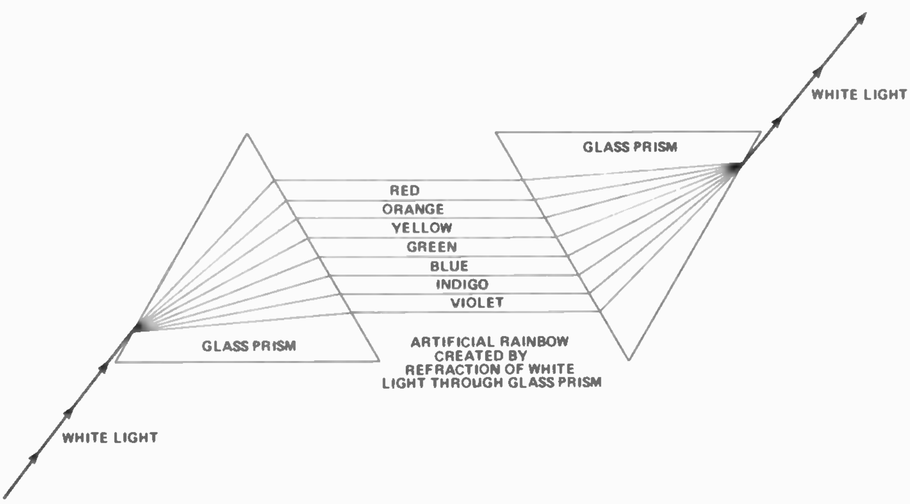


Figure 2. Using a glass prism to create an artificial rainbow from white light and another prism to recreate the white light from the seven colours of the rainbow. It would make a good LP cover!

You can see from this that we can now make a colour TV with a tube which has only three coloured phosphor spots — and not the ten coloured spots of our first example. Manufacturing such a three-colour tube is complex, but not impossible. The coloured spots in the tube are arranged in what are called triads (ie groups of three), so that each spot has one of a different colour next to it. When colour TV tubes were first made, these triads consisted of circular spots, as shown in **Figure 4a**, but later designs have rectangular spots as in **Figure 4b**. There are only a few spots shown in Figures 4a and b but, in reality, a colour TV tube contains many hundreds of thousands.

Implications

The use of only three coloured spots means that, to get any non-primary colour, more than one spot in a group will have to emit light at the same time. To cope with this requirement, more than one electron gun is needed — three, in fact — arranged to fire separate electron beams at each spot in a triad. The electron guns which fire the beams are called red, blue and green guns, not because they fire red, blue and green electrons, but because they are aimed at red, blue and green spots.

Obviously, the red beam in a colour TV tube must hit only the red spot of a triad; similarly, the green beam must hit only the green spot and the blue beam — the blue spot. Any cross-over of electron beams, causing the wrong coloured spot to emit light, would mean that the wrong colour will be emitted and the overall TV scene displayed on the tube will be incorrect: can you imagine blue grass, yellow sky or perhaps pale green people? This is prevented by inserting a metal plate between the tube's screen and the electron guns. In the plate are small holes or slots (one at each triad), which make sure each coloured spot is hit only by the beam from the same colour gun. The plate is accurately positioned so that each beam is cut-off or 'shadowed' from the other two spots of the triad and thus they can never emit their colour when a different beam is fired. Figure 5 shows such a plate (called a shadow mask) and the three electron guns firing beams at the spots of a triad.

Also shown in **Figure** 5 are the convergence coils which allow the individual electron beam to be adjusted so that, at any one time, they all hit the same triad of spots. If the beams hit spots of the wrong triad, the scene displayed by the tube will have a blurred, out-of-focus appearance, especially in areas of sharply contrasting colour changes. By altering the current through the convergence coils, the magnetic fields around them change and hence the deflection of each electron beam can be minutely adjusted until they all hit the same triad. When this is true, the tube is said to be correctly converged.

So — we know how a colour TV tube works: the question now is — how do we actually transmit and receive the controlling voltages which drive the guns in the tube? Remember that our aim is to produce a colour TV system which doesn't interfere with the existing black and white system — the two must be compatible! Well, once again we find the answer is to go back to basics, this time to find out just what the actual differences between 'black and white' and 'colour' are.

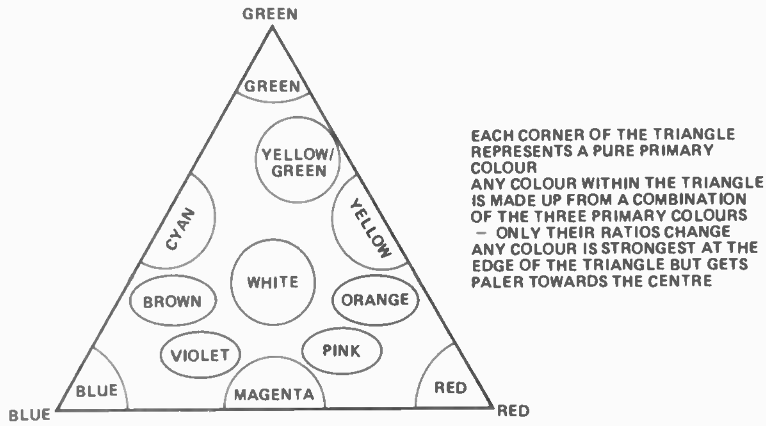


Figure 3. A colour triangle. Every colour that can be shown on a TV screen can be located in a colour triangle.

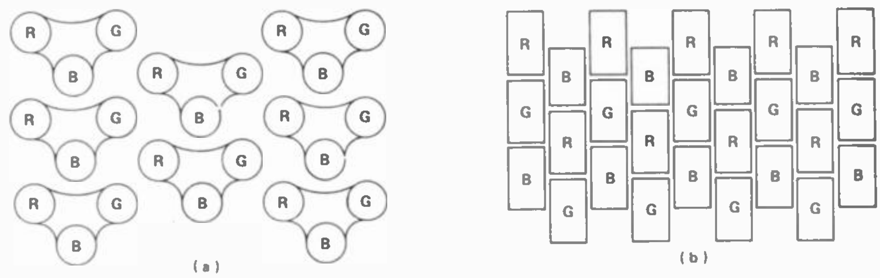


Figure 4. Colour triads of phosphor spots; (a) how triads were originally made; (b) the more usual form in use today.

Mono And Chrome

A black and white (monochrome) scene consists only of brightness information, called luminance. We only see the 'greyness' of any particular part of that scene; if part of the scene is very bright we'll see it on the screen as light grey, or perhaps white; if a part is very dark we'll see it as dark grey or perhaps black.

Colour scenes possess luminance information too — we can always tell how bright a coloured object is — but they also have chrominance. Chrominance is the 'magic' ingredient which defines the actual colour of an object. It's interesting to note that, although human eyes can detect the two different sorts of visual information, some animals' eyes can't. Cattle, for example, can't 'see' chrominance information (their eyes simply do not respond to the frequencies which make up 'colour'). They can only see in black and white! It's the same thing with TV: a black and white TV transmitter doesn't use chrominance information and so the receiver can only display a black and white picture; a colour TV system uses both luminance *and* chrominance information and thus can display the scene in colour.

What we have to ensure, though, is that we can transmit both luminance and chrominance without the chrominance information interfering with the luminance. As long as this is so, black and white TV and colour TV systems will be compatible and both types of TV receiver will display a picture from the same transmitted signal.

A convenient way of studying a system's waveform (such as that in a black and white TV) is to look at its spectrum. Special machines, known as spectrum analysers, can be used to find out the size of the signal present at any frequency and display it (much like an oscilloscope displays a simple waveform) on a cathode ray tube. A typical spectrum, which could be obtained from the screen of a spectrum analyser, of a black and white TV signal is shown in **Figure** 6. Any other black and white TV signal would be similar. In the spectrum, you can see the band of frequencies which holds the luminance information, corresponding to the number of lines per screen, the position of the electron beam on the screen, and the brightness of the beam at any time. You can also see the narrow peak, at a frequency of +6 MHz, which is used to send sound information. The information transmitted for sound is a lot less than that for luminance, hence the sound peak is a lot narrower than the luminance curve.

Darker luminance information, eg dark grey and black, is transmitted on the lower end of the luminance curve while lighter information, eg light grey and white, is transmitted on the upper end. You'll appreciate from the curve that much less 'lighter' information is needed in a black and white TV picture than 'darker' information.

If we were to look at the spectrum of only the chrominance information of a colour scene, we would find it much smaller (about 1/5th) than the scene's luminance information. It is this fact which enables us to transmit the two types of information, together, without interference. The possible spectrum of a colour TV signal is shown in **Figure 7** and the differences between it and the previous spectrum are obvious. The peak holding the chrominance information is at a frequency which, on the previous spectrum, would have been slap bang in the middle of the upper slope of the luminance curve. In the colour spectrum you'll see that the upper luminance slope has been taken back a bit so that the chrominance peak doesn't interfere with it. If you remember, the upper end of the luminance curve contains the information of lighter parts of the TV scene, so all we've done in combining luminance and chrominance into one TV signal is to reduce the overall brightness of the received picture — a colour TV scene is, therefore, *slightly darker than the same scene transmitted in only black and white*. To a large extent, a user can compensate for this by turning up the brightness control: so the lack of brightness information isn't regarded as a serious deficit. Hence, a colour TV system is compatible with a black and white TV system and the two can run side-by-side without interference.

Colour Sums

The way in which chrominance is added to the luminance signal to produce the complete colour signal is interesting. There are three gun signals as well as the original luminance signal, so theoretically there should be four separate signals. However, because of a mathematical relationship between the chrominance and the luminance signals of any colour TV scene, the number of signals actually transmitted is reduced to three. If you remember, the three primary colours — red, blue and green — can be added together in the correct proportions to produce white light. Similarly, by keeping the proportions identical but varying the three guns' controlling voltages, grey light can be made. By turning all three guns off, 'black light' is produced too. By keeping the proportions the same, you see, we have in effect made a black and white TV out of a colour TV. We can state this mathematically:

$$xR + yB + zG = L$$

where: R, B and G are the controlling voltages of the three guns and L is the effective luminance signal voltage which would be applied to a black and white TV gun to produce the same scene; x, y and z are the colour proportions required for the condition to exist. Because the proportions are parts of a whole, then $x + y + z$ must equal 1.

Now, in order that a black and white TV can produce a black and white picture from a colour signal, we know that the luminance signal, L, must be transmitted unaltered. But instead of duplicating the information (which we would be doing if we transmitted the three colour signals as well) we use a clever bit of maths to reduce the number of colour signals: we can send only two *colour difference* signals along with the luminance signal. The three colour difference signals are:

$$R - L;\ B - L;\ G - L.$$

Now, from the luminance signal already sent in a black and white signal, and two of the colour difference signals (say, R — L and B — L), the third colour difference signal (G — L) can be calculated. From the above equation we know that:

$$xR + yB + zB = L$$

And we know that $x + y + z = 1$, so:

$$xR + yB + zG = (x + y + z)L$$

Expanding the bracket:

$$xR + yB + zG = xL + yL + zL$$

So:

$$xR - xL + yB - yL + zG - zL = 0$$

Grouping (you'll see the colour difference signals appear now):

$$x(R - L) + y(B - L) + z(G - L) = 0$$

So, if we know two colour difference signals (R — L and B — L), the third:

$$G - L = -\frac{x}{z}(R - L) - \frac{y}{z}(B - L)$$

This can all be accomplished electronically by a circuit, known as a colour matrix circuit. You can buy them, nowadays, on a single integrated circuit.

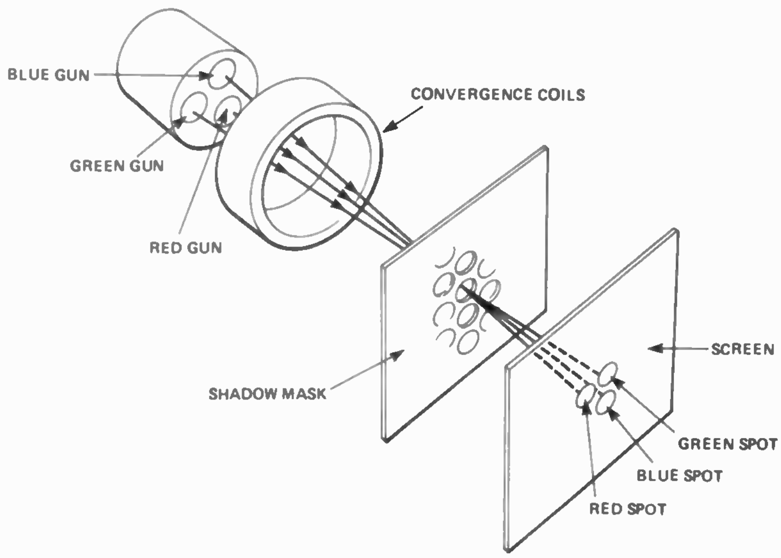


Figure 5. How a shadow mask makes each colour-beam strike a spot of its own colour; you will appreciate the shadow mask needs to be very accurately positioned. Also shown are convergence coils to position all three beams on to the same triad of spots, at any one time.

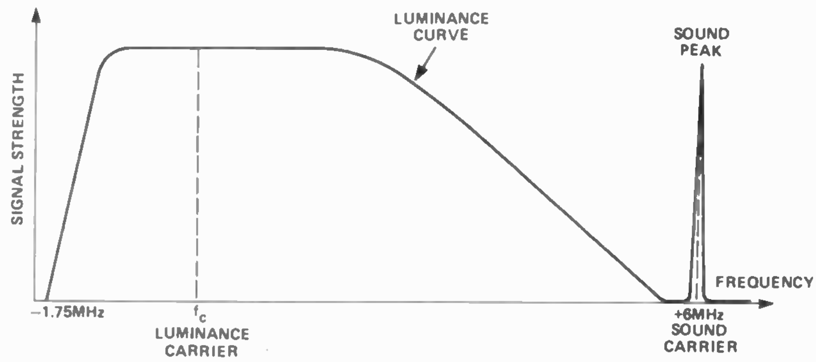


Figure 6. A spectrum of a black and white TV signal showing luminance curve and sound peak.

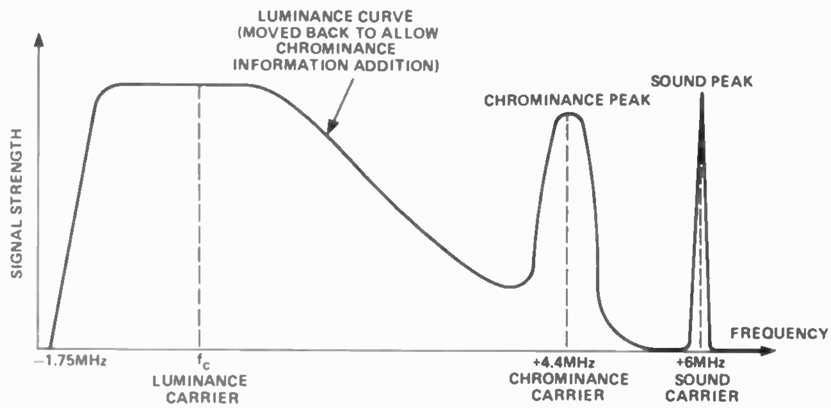


Figure 7. A colour TV signal spectrum. The luminance curve is reduced to allow inclusion of the chrominance peak.

With the aid of a colour matrix IC all the TV has to do is receive the luminance signal along with two colour difference signals and the third colour difference signal is automatically produced. The TV can then display the complete colour picture.

And there you have it; a colour TV system can be made using the same principles which a black and white TV system uses — plus just a few more, of course. We've looked at how the transmitted colour signal differs from a black and white signal, and from this, we've seen how the two TV systems can run together at the same time, without interference. It's all quite simply really, isn't it?

Roll-on 3D TV!

HE

BUYLINE

As a result of our constant search for ways to make life easier for our readers, we have changed the format of the project pages. One of the changes was to remove the ubiquitous Buylines boxes, in favour of a single source-and-supply page — yes, this is it!

Dual Engine Driver

There are only a couple of unusual items in the project, as it was constructed using 'bulk-buy' parts. The 2.5 watt resistor is supplied by Electrovalue (74 EV series), who could be used as a source for the remaining components, thereby saving on postage costs! Otherwise the wirewound pot may be bought from Maplin (250 ohms instead of 200 ohms), and the transformer from Watford (15 volts, centre tapped).

All the LEDs and other semiconductors are available from Technomatic, who specialise in these particular components. The case used for the prototype was from BICC-Vero, who also supply other designs — it's well worth sending off for their catalogue ("Hobby Herald"), which is free on request.

Capacitance Meter

Most of the components used in this project are easily obtained.

The displays must be of the common cathode type, and 0.5 inch size to fit the PCB; they can be bought along with the CMOS ICs from Technomatic.

The normal type of rotary switch comes set for its maximum number of positions; these will have to be reduced to four, via the retaining clip. Also, care must be taken when handling the CMOS ICs, so as to prevent accidental damage. If you are not using sockets, then a low leakage soldering iron is essential — a suitable type is being offered as part of a package by Litesold, who advertise in this magazine.

Signal Tracer

There should be no trouble in obtaining the components for the tracer, especially since there are only around twelve of them! The BC 650 is a special low noise type, but should be fairly easy to buy — Magenta have assured us that they will be getting some in.

Bike Alarm

If you wish to avoid the hassle of shopping around for individual components, then Magenta Electronics are the people to contact. Not only will they send you a complete kit, they can also supply any of those hard-to-find items to supplement your usual sources.

If you wish to buy from separate suppliers, then the capacitors and tilt switches, along with the 7611CMOS op-amp, are contained in the RS catalogue. However, since they only supply to the trade (as so many of you have written to tell us!) you would be advised to contact Crewe Allan & Co. Ltd. at 51, Scrutton Street, London EC2A 4PJ; they can supply any of the components advertised by RS.

The transistors and CMOS timer (7555) are also available from Watford Electronics and the miscellaneous hardware from Maplin. Other items, termed as extras, can be bought from Electrovalue, whose catalogue is well worth getting hold of.

As a guide to the price of this project, take a look at Magenta's advertisement — bearing in mind that this is for a complete kit.

POINTS OF VIEW

Something to say? Let's hear it.

Hobby Electronics' monthly mail is usually a mixed bag of enquiries, requests, suggestions and complaints. Occasionally, too, someone writes in to say how much they like us — or not, as the case may be!

This month's letters are much the usual assortment, but we'd like to hear more about what you want in YOUR electronics monthly magazine. After all, a lot of effort goes into producing HE and we'd certainly like to get it right for you. So why not use this opportunity, every month, to tell us what you like about HE, or what you don't like; what subjects you are interested in and which ones put you to sleep!

In short, we'd like to hear your POINT OF VIEW.

Intruder Confusion

Dear Sir,
While I would agree with most of your readers that your magazine is instructive and comprehensible, I have to say that printing errors would seem to be your downfall.

It has got to the point, now, where one has to wait until the following month for the mistakes to be rectified, before constructing any project.

I have recently spent about £10 on components for your Intruder Confuser (HE January 1982). After constructing two of the devices, neither of which worked, I waited for the following issue for corrections to the circuit.

After turning the IC right way up, I would have thought that this would have solved the problem — but, no. I then had the unit completely checked by an electronics shop; they said they thought it would not work with a 1V5 supply, however, we have not tried putting more voltage onto the device.

Can you please help. The unit is needed because our neighbour's house has just been burgled.
Yours sincerely,
B.M. Haddock,
Wimbledon.

The electronics shop got it wrong too. The LM3909 IC is specifically designed as a low-power LED flasher and is intended to operate from a 1V5 supply, as indicated in the circuit.

As to printing errors, they do arise from time to time but we are making every effort to ensure that the 'times' are fewer. We hope that future excellence will make up for past mistakes, and that we have not fallen too far, in your estimation.

Flushed With Success?

Dear Sirs,
I would be most grateful for any help you can give me.

I started making the 'Diana' Metal Detector but, as I was ill for some time, soon stopped.

I recently bought some more parts for the project, brought out the magazine — and then my youngest daughter put it down the toilet and flushed it!! I now have a half-completed metal detector — and lots of bits.

Please help. I will gladly buy another copy of the magazine, if it is available, or a photocopy of the item concerned, so long as the overlay diagram is clear enough for me to get going again.

I would like to complete the detector before the weather revives.
Sincerely,
J.W. Frith,
Cheshire.

The problems hobbyists encounter are sometimes almost beyond belief! Can any of our readers match this tale of woe? A £10 mixed bag of components, donated by **Magenta Electronics**, will be sent to any reader who can top Mr. Frith's story. Meanwhile, if Mr. Frith would like to turn to our Backnumbers page, he will be able to send in for the article he requires.

Circuit Suggestions

Dear HE,
Do you think your backroom boys are clever enough to design a circuit to solve the following problem?

Time and time again, I walk out of a room and leave the stereo turned on — which can't be that good for the amplifier and other components. What about a circuit which would turn the stereo off after, say, five minutes, if no music had been played for that length of time?

I bet you a binder you can't do it.
Yours,
L. Poltawski,
Manchester.

Although a gadget such as you describe is not, strictly, necessary — an amplifier is unlikely to be damaged merely because the power is on — our 'backroom boys' have been called 'front and centre' and they will look into it.

They won't accept your bet, though — they don't need another binder, thanks all the same.

Radio Research

Dear Sir,
I wonder if you could send me any information you have on the beginnings of radio and electronics in general, and their development up to the present time.

I need this for a sixth Form General Studies project. I am a faithful reader of your magazine and have nearly every copy.

I will be grateful if you can help.
Yours,
M. Ford,
Trowbridge, Wilts.

Much of the information you need can be found by reading through the Famous Names series, but the development of electronics will be covered more extensively in a new series, called The Electronic Revolution, which we are planning to start in the May issue of Hobby Electronics.

Telephone Tricks

Dear Hobby Electronics,
I would like to build an amplifier and speaker for my telephone, and also a digital counter to indicate how many units I am using.

Could you use this as one of your projects? If you already have, could you send me details of how to obtain a copy?
Yours faithfully,
R.W. Almond,
Dagenham, Essex.

Neither of these projects are simple, but we will look into the possibilities.

Danger! UXBattery

Dear Sir,
I have recently constructed a NiCad charger/battery eliminator unit based on a design published in Hobby Electronics. This unit will allow me to use NiCads in most of my battery powered equipment, however, I still need 'dry cells' for my DMM (Digital Multimeter) and electronic flash gun, both of which require the higher voltage obtainable from HP7/MN1500 cells.

Can you publish a circuit or tell me where I can find details of a circuit to re-charge or refresh such batteries? I know that it is possible to purchase commercially manufactured units for this purpose though I would, of course, prefer to build my own.
Yours faithfully,
M.L. Peake,
Bilston, West Midlands.

Charging units for dry cells are commercially available, as you mention, however there are a number of problems in using them. Firstly, the batteries cannot be allowed to become more than half-discharged because, beyond that point, holes have been eaten through the zinc electrode and these cannot be re-plated. Secondly, it is possible that a build-up of gas inside the cell will cause it to swell and go open circuit. Thirdly, there is a danger of explosion, if the charge rate is too high. For these and other reasons, we do not consider the idea suitable for a Hobby Electronics project.

Hobby Indexed

Dear Sir,
I have subscribed to Hobby Electronics for about a year, now, and I find it very useful and interesting. I have two questions which I would be glad if you would answer for me:
1. Do you produce (annual) indexes of all the articles published in HE? If so, what is their cost?
2. Have you ever published an article on the construction of a hand-held device to detect wires, nails or screws in wood? If so, in what issue? If not, could you suggest any source where I might find the details of such a project? It would be very useful to someone, like myself, who sometimes needs to run an electric saw through second-hand timber.
Yours faithfully,
A.H. Jansley,
Tonbridge, Kent.

An annual index is published each January, listing articles which have appeared during the previous year. Indexes for 1979, 1980 and 1981 are available from our Backnumbers Department for the usual cost — see page 64.

This is Mr. Jansley's lucky day (month?); a metal/cable/pipe locator project is being prepared for publication, soon.

'Diana' Speaks

Dear Sir,
I have just purchased my first HE magazine and now I'm hooked.
I am thinking of buying a 'Diana' Metal Detector kit and was wondering if a speaker could be incorporated into it. If so, could you tell me how, and what components would be needed (please explain simply for a beginner).
Many thanks.
Yours sincerely,
T. Fletcher,
Gravesend, Kent.

Adding a 'voice' to the metal detector is a bit more complicated than simply connecting up a speaker. However, we have had a number of requests for this, and a suitable modification will appear shortly.

Fair Comment

Dear Sir,
With regard to Your Letters, HE February 1982, page 23, I feel I should errata your Errata.
In the very last sentence, not only should the notch appear at the top, but should should be spelt should.
Should you find this worth mentioning (I doubt it), I should waste no time in correcting it. Should I? Or should you? Or should we forget it? — I should.
Yours it's a stupid word anyway,
Sincerely,
A. Barnes,
Brentwood, Essex.

I don't think I should comment. Shall I? I shan't.

Astronomical Observations

Dear Sir,
I received your excellent magazine the other day and at once began to read Your Letters. I was absolutely delighted to read the letter from Mr. Robin Cartley, Vice-Chairman of the Crofton Astronomical Society. Myself and a number of friends were just about to write to you regarding a relatively simple radio telescope.
I now write on behalf of my friends, who are hoping that you will feature such a project. We are all students who make the odd kit out of various mags and we believe that this would be an excellent project. We hope that you will give it a shot.
We would also like to take this opportunity to congratulate you on your magazine. It really is marvellous. Please keep up the good work.
Yours sincerely,
M. Carroll,
Wexford, Rep. of Ireland.
PS Any chance of finding out who Clever Dick is?

On our part, we hope that we continue to live up to your good opinion of us, so keep reading HE! Our research on a simple radio telescope is progressing (the theoretical background is quite demanding), but we can't promise anything definite, just yet.

Clever Dick? Never heard of him!

Optical Allusions

Dear Sir,
Having phoned once, to locate this particular item, I was asked to ring back when the person who could help me would be in. Upon phoning again I was told to write in, including an SAE, for all technical enquiries. My enquiry could have been answered in one word; the name of a supplier. However I am writing in, since the lady at the end of the second call put the phone down on me.
Next time I hope I get the first one again!
Issue: November
Article: Flashmeter
Item: BXP25 Photo-diode.
Where is this, or a suitable equivalent, available? No advertisers in your magazine carry one.
Yours waitfully,
B.C. Baldwin,
Hutton Cranswick, East Yorkshire.
PS Give my love to the Switchboard!

Item: BPX25 Photo-diode (note the difference) is stocked by Magenta Electronics (see their advert in any recent issue).
Price: £2.24
Technical Enquiries: In general, 'phone enquiries cannot be answered.
Switchboard: Sorry, they're engaged.

Tug-o-War

Dear Sir,
I have twice built the Tug-o-War project from the October issue of HE. The first time I made my own PCB from a Hobbyprint. I made up the circuit but, when I switched on, it made a continuous buzz. I then found that the enable pin (pin 4) of IC3 was open circuit; when this was corrected the buzz stopped but the project still did not work.
I dismantled it and sent off for a ready-made PCB from the service which now replaces Hobbyprints. Pin 4 of IC3 was open circuit, again, and the same fault was found. When that was corrected, the only part I could not get to work was PB2 — it had no effect, when pushed.
Are there any other faults that you may have published in a later issue of HE? I do hope you can help.
Yours faithfully,
D. Duncan,
Darlington, Co. Durham.

There were two faults in this project. The first, and most serious, was on the PCB foil pattern. Pin 4 of IC3 should be connected to R19; the missing section of copper track should be replaced by a piece of tinned copper wire or a line of conductive paint. Secondly, R20 should be 2k2, not 8k2. We hope the game can now be brought to a successful conclusion. May the best man win.

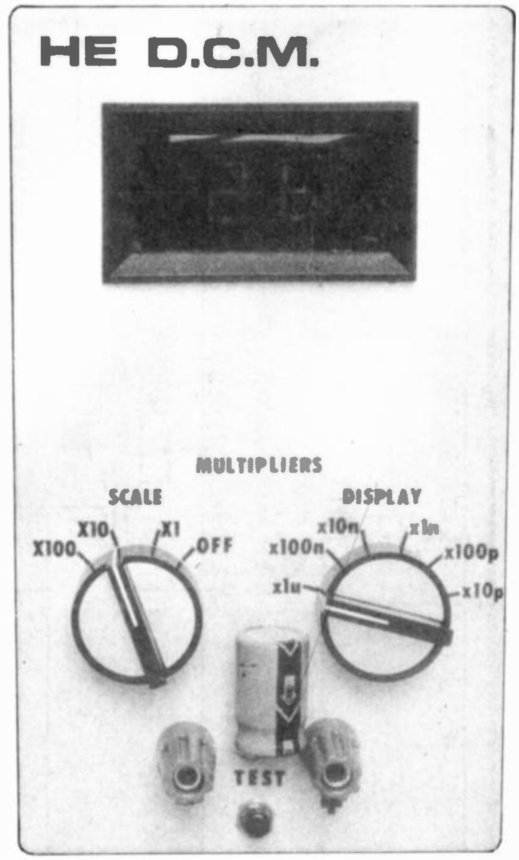
Windscreen Wipe-Out

Dear Sir,
I built the Windscreen Wiper Controller (HE, March '81) but it will not drive the wipers, in any mode. It pulses once, but the relay merely chatters after that.
The wiper switch as three wires and the motor is single-speed, self-parking. I tried the local auto-electrician but, when he saw the unit, his comments were unprintable.
Can you suggest how to connect the unit to the wiper switch?
Yours faithfully,
J. Mapley,
Aberdeen.

The Controller is intended to be 'wired across' ie, in parallel with, the existing wiper switch which can still be used to obtain continuous sweeps, in the usual way. However, given that you have three wires to contend with, this does not appear to be as simple as it sounds (auto electrics do seem to be designed to confuse the non-specialist). We can only suggest that you consult the manual for your car, or carefully trace the wiper circuit to determine which two of the three should be used. Failing that, you should perhaps consult another auto-electrician. Before you do, though, check that the Veroboard tracks between the IC pins have been cut; these track breaks, which were omitted from the bottom view of the layout, should be at D11, E11, F11 and G11. **HE**

Digital Capacitance Meter

Owen Bishop



It's fast, accurate and not too fancy. The HE Digital Capacitance Meter is easy to build and will become one of the most used items in your workshop.

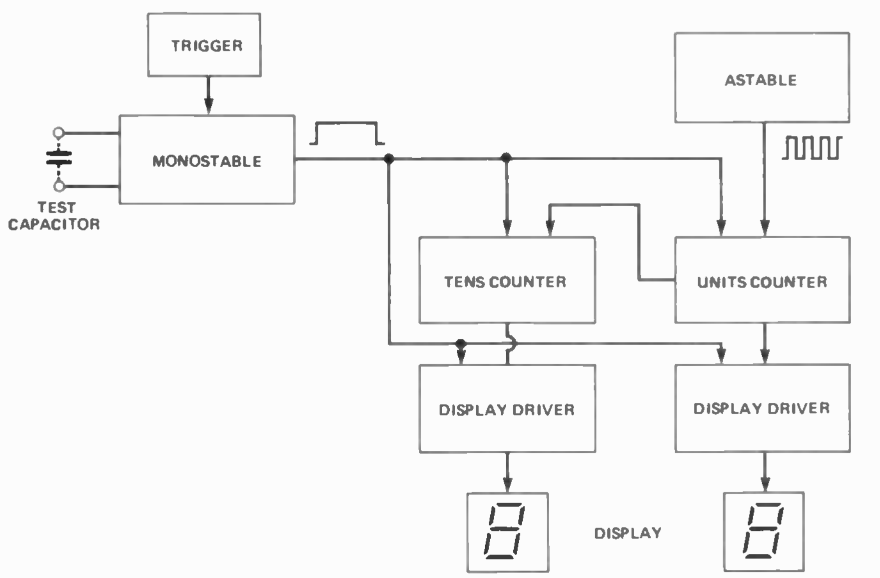
A GLANCE through an electronics catalogue soon shows that most of the cheaper multimeters do not measure capacitance. A few may measure values in the microfarad range, but not many measure in the nanofarad or picofarad ranges. This low-cost meter will, therefore, be very useful; it covers values from 100pF to 9900uF with two digit accuracy, it's cheap and easy to build. It also provides a good indication for values in the 10-100pF range but, in general, the main ranges will satisfy the requirements of most hobbyists.

Many types of capacitor are manufactured to about 10% tolerance yet, for building filters, tuned circuits, timers and the like, it is often important to be able to know the precise value of a capacitor. Electrolytic capacitors, for example, are notorious for having very wide tolerance and for changing capacitance with age and use. Then there are all those look-alike polystyrene capacitors, which are marked in ink that seems specially prone to rub off at the first handling (their physical size is no real guide to their value, by the way). Finally, there are the bargain packs, containing an assortment of imported capacitors whose markings bear no recognisable relationship to any known classification system. When using these, the perplexing question is: "What have we here?". So, a capacitance meter is a distinct asset for these and many other circumstances.

The Circuit

The circuit uses the 556 dual timer IC in two common configurations. One

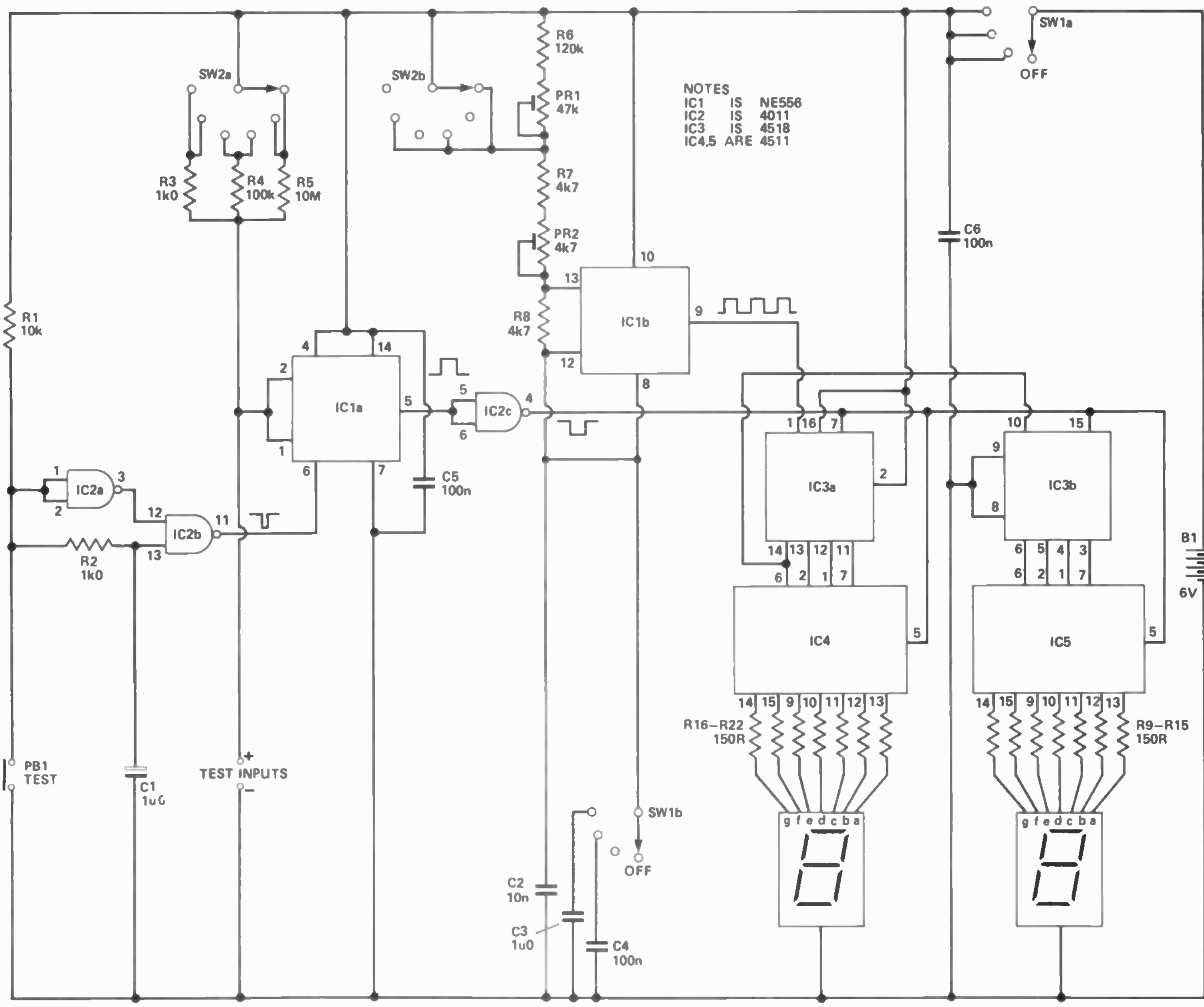
How It Works



The HE DCM measures an unknown capacitor by counting the number of clock pulses which occur during the period of a gating pulse, produced by the monostable. The pulse is triggered by operating a push button switch (the trigger circuit ensures a clean start to the pulse) and its width is proportional to the value of the test capacitor, which is connected into the RC timing network of the monostable.

The gate pulse 'enables' the display drivers and the counters, which then begin to register pulses from the astable multivibrator. At the end of the monostable gate pulse, the display drivers are locked and a two digit number is displayed. The counters are reset to zero, ready to begin a new count.

The DCM has eight ranges, produced by changing the frequency of the astable multivibrator and by controlling the width of the monostable pulse by using different resistors in combination with the test capacitor. This is described more fully in the text.



(NOTE. ON IC4 AND IC5; PIN 8 IS 0V, PINS 3,4 & 16 ARE +6V)

Figure 1. The circuit of the Digital Capacitance Meter.

half, IC1b is an astable multivibrator used to produce a square wave at either of two fixed frequencies. The pulses from the astable are counted by IC3, which contains two complete decimal counters. The first counts units and its output carries over to the second, which counts tens. The display drivers, IC4 and IC5, convert the BCD (Binary Coded Decimal) outputs from the counters to provide the outputs required for driving the 7-segment displays.

The counting action is controlled by the other half of the timer, IC1a, connected as a monostable multivibrator; when triggered, this gives a single positive pulse. As the pulse begins (rises), the counters and display drivers are 'enabled' and pulses from the astable are counted. As the pulse ends (falls), the display drivers are latched to 'hold' and the count is displayed. The counters are reset to zero at this time, ready to restart the count at the next high pulse, but the display 'holds' the count. The display is returned to zero by the enable pulse at the beginning of each run and counting begins immediately.

The length of the pulse from the monostable, IC1a, is proportional to the capacitance of the test capacitor; the greater the capacitance, the longer the pulse and, therefore, more pulses from the astable are counted. The two-figure display is read according to the format indicated by the range-setting knob.

The period of the monostable is set by the test capacitor and whichever resistor, R3, R4 or R5, is selected by SW2a. The frequency of the astable, IC1b, is set by the timing capacitors C2, C3 or C4 and resistors R6, PR1, R7 and PR2. By selecting the appropriate combination of timing components, the meter provides eight decade ranges from 100pF upwards.

Construction

Most of the circuit is accommodated on the printed circuit board. It is best to begin construction with the display circuit. The two 7-segment LED displays are soldered to the board first; make sure the iron is hot and work quickly, so as not to overheat the LEDs. It is better to solder a few pins, then wait a few minutes for the heat to escape before continuing; the decimal point pins (dp) do not need to be soldered. Next, mount R9-22 (or you could use two 14-pin DIL resistor arrays, if you wish).

When you have mounted the displays and resistors, make the battery connections and test the display. Temporarily join the positive line to each of the resistors in turn and check that the correct segments light up on the display. WARNING — the current *must* go through a resistor before it goes to a segment.

The two segment-drivers, IC4 and IC5, are wired in next. The counter, IC3, completes the display section of the meter. To check its operation, connect a pulse generator to pin 1 of IC3; the displays should show a regular count up to 99, returning to 00 and

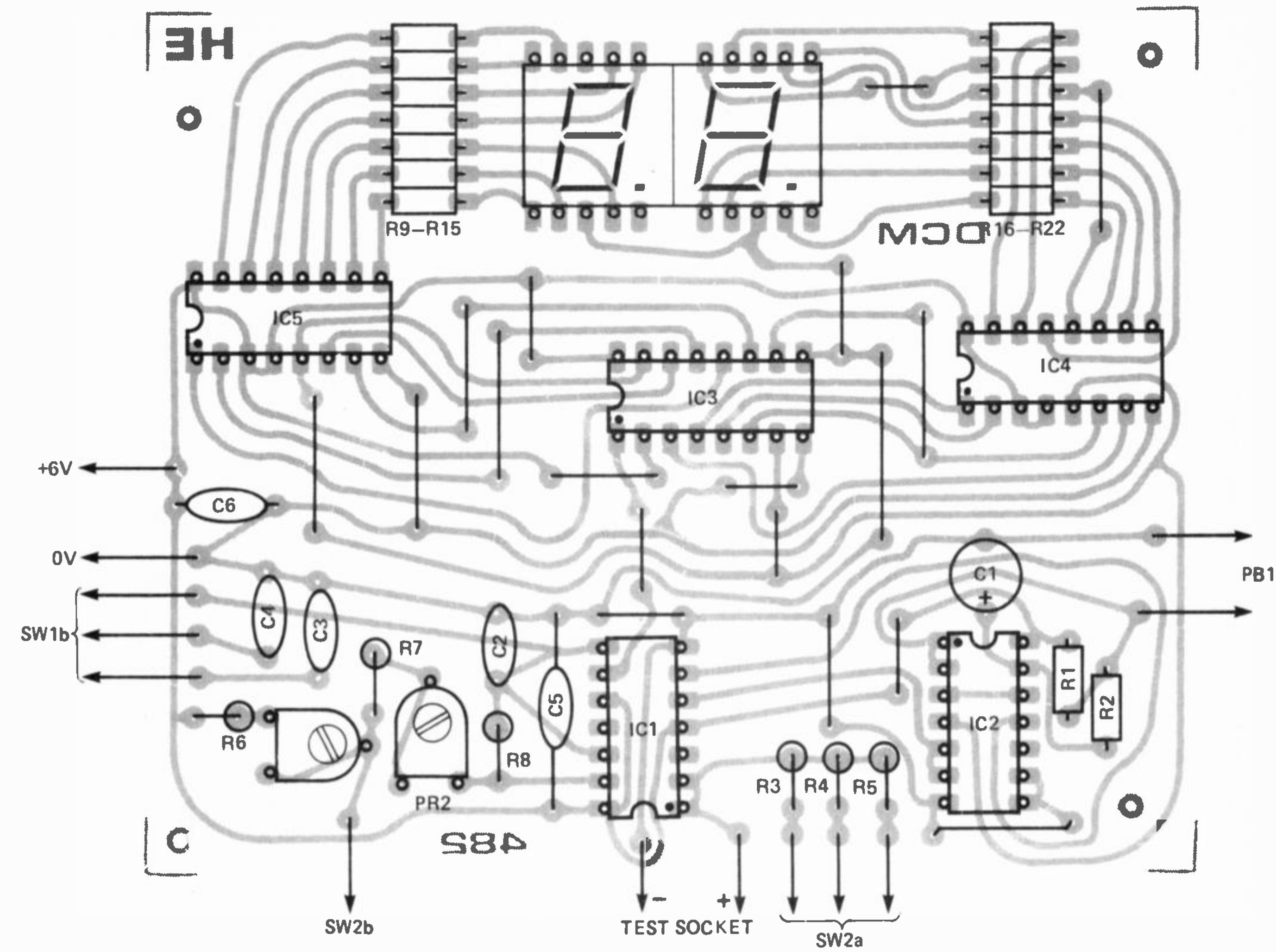


Figure 2. The component layout; note that R9-15 and R16-22 can be either individual resistors (as shown) or 14-pin DIL resistor arrays.

repeating. If you do not have a generator, you can use the output from IC1b which, with its associated components, is the next section of the circuit to be completed.

When the pulse generator (or astable) circuit is complete, connect the power supply. When pin 4 of IC2c is taken low (to 0 V), the display should count rapidly at about 1 kHz. When it is taken high, the count freezes at its current value. The rate of counting is too fast to see properly (the display will appear to show a steady '8'), but you can slow it down by temporarily wiring a large value capacitor (say, 10uF) in parallel with C2. This will let you check that the counters are working properly.

Finally, complete the monostable and trigger circuits, IC1 and IC2, and the remaining components. You will need to make off-board connections to SW2, PB1 and the capacitor test sockets before this part can be tested. It is probably best to mount the panel components and complete all the off-board wiring now. Determine the orientation of SW1 and SW2 and drill the registration holes accordingly. If PB1 and the negative capacitor test socket are correctly positioned, the tag of the socket can be soldered directly to one of the lugs of PB1. The power comes from four HP7 (or similar) cells in a battery holder, which can be held in placed by a 'sticky fixer'. To test the complete circuit, mount a capacitor in the test sockets; it is useful to have a pair of test leads, with 4 mm plugs at one end and crocodile clips at the other, for short-lead and otherwise 'difficult' capacitors. Remember to observe polarity, when testing electrolytic or tantalum capacitors.

You are now ready to switch on and . . . the display should immediately show a value. If nothing happens when you switch on, check that the trigger circuit, which normally has a high output (IC2b, pin 11), goes low for an instant (about 1 mS) when PB1 is pressed. The output of IC1a (pin 5) should normally be low, going high for an instant when PB1 is pressed. If you use a 100 uF test capacitor with SW2 at X1n, the output should stay high for about 10 seconds and, during this time, the display will run from 00 to 99 several times.

Calibration

IC1a is a monostable oscillator that controls the period for which the display counts pulses from IC1b. The period, t, is equal to 1.1RC, where C is the value of the test capacitor and R is the value of whichever resistor (R3 to R5) is switched into circuit. For example, if the test capacitor is 10 nF and we use R4 (100k), $t = 1.1 \times 100 \times 10^3 \times 10 \times 10^{-9} = 1.1$ mS. During this brief period the counter has to count 10 pulses from IC1b so that the display shows '10' at the end of the counting period. Now 10 pulses in 1.1 mS is equivalent to a frequency of 9.09 kHz, and this is the frequency to which IC1b is set when PR1 and R6 are short-circuited out of the timing chain by SW2b. If the test capacitor is 100 nF, the period becomes 11 mS; the display must again count 10 pulses, to show '10', so the frequency of IC2 must be reduced to 0.909 kHz by switching PR1 and R6 into circuit.

To calibrate the instrument we simply have to adjust PR1 and PR2 to give frequencies of 9.09 kHz and 0.909 kHz. The easiest method is to use an oscilloscope. Switch SW2 to position 1, bypassing PR1 and R6; monitor the output from pin 9 of IC1b and adjust PR2 until the period of the signal is 1.1 mS (9.09 kHz). Now switch SW2 to position 2 and adjust PR1 until the period is 11 mS (0.909 kHz) — do not re-adjust PR2 at this stage.

The astable is not calibrated for the two slow frequencies, which are used with test capacitors over 100 uF in

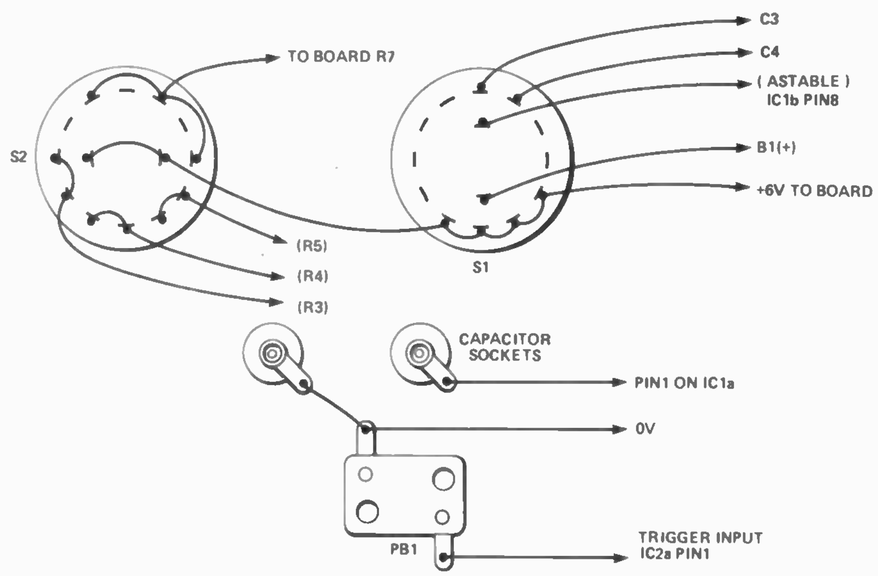


Figure 3. Wiring diagram for the panel-mounted components. Check against the circuit to ensure all the wires go to the right place!

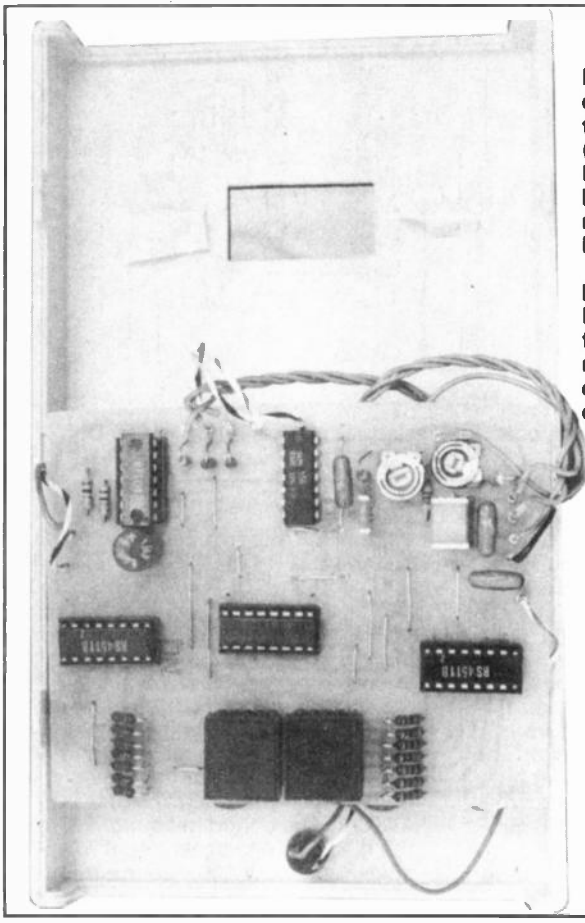


Figure 4. Internal view of the completed DCM, showing the insulated bezel fixings (the display window) and the PCB connecting pin locations. Note that the three resistors at the bottom of the board are mounted vertically.

In our prototype, we used long-legged wire-wrapping DIL socket pins (available from Vero Electronics) to raise the seven-segment displays so that they were closer to the bottom surface of the window, producing a brighter display. It's a trick worth trying.

value. Additional timing capacitors, C3 and C4, are simply added to the timing chain by switching them in via SW1. With C4 in circuit and SW2 in position 6, the frequency becomes 90.9 Hz; with C3 in, it becomes 9.09 Hz.

The accuracy of these two ranges depends on the tolerance of C3 and C4. The polyester capacitors recommended have a tolerance of 10%, which is close enough for this end of the range. You could, of course, purchase several of the same nominal value and test them (using this meter!) to find two closest to the specified values.

If you have no oscilloscope, the only method of calibration is to put a close tolerance capacitor in the test socket and adjust the astable circuit until the correct reading is obtained. It is better not to do this on the lowest range, for stray capacitance may bias the results. Use a 47 nF polyester capacitor on the X1 nF range and adjust PR2 to get a reading of '47' *almost* every time (you may occasionally get '46' or '48', but errors should be no greater than this). Then use a 4n7 polystyrene capacitor on the X100 pF range and adjust PR1 until '47' is obtained. The meter should then be correct for all the other ranges.

Parts List

RESISTORS
All ¼ W, 5% except where specified

R1	10k
R2	1k0
R3	1k0, 2%
R4	100k, 2%
R5	10M, 10%
R6	120k
R7,8	4k7
R9-22	150R (or two 14-pin DIL thick film resistor networks)

POTENTIOMETERS

PR1,2	47k sub-miniature vertical presets

CAPACITORS

C1	1u0 35 V tantalum
C2	10n polyester
C3	1u0 polycarbonate
C4-6	100n polyester

SEMICONDUCTORS

IC1	556 dual timer
IC2	4011B quadruple 2-input NAND
IC3	4518B dual decade counter
IC4,5	4511 7-segment decoder/ drivers

MISCELLANEOUS

PB1	push button switch
SW1,2	2-pole 6-way rotary switches

PCB, two 7-segment LED displays (common cathode 0.5"); ABS case 190 mm x 110 mm x 60 mm; knobs for SW1,2; 2 x 14-pin, 3 x 16-pin DIL sockets; 4 mm terminal sockets (1 red, 1 blue); battery holder for 4 x HP7; 1.0 mm terminal pins; self-adhesive feet; connecting wire; solder, etc.

For sources of components for the HE DCM, see **Buylines**, page 21 A full-sized PCB foil pattern is reproduced on page 78.

Using The Meter

Plug the test capacitor into the socket and select the required range. If in doubt, select a range greater than the one you expect the capacitor to lie in. Switch on, and press PB1. The value will be displayed instantly (though it actually takes a few milliseconds to get there). On all ranges, the displayed figure is multiplied by the display range and the scale factor. For example, if the display switch, SW2, is set to x1u, the scale switch to X10 and the display reads '26', the value of the capacitor is 26 x 10 x 1u = 260 uF.

If the tens digit is zero, switch to the next lower range and press PB1 again. For the two highest ranges; SW2 must be in position 6 (x1u) and SW1 turned to X10 or X100, as necessary.

Switch the meter off when it is not in use, since the display consumes considerable power. In use, however, the meter works so quickly that the reading can be taken in a couple of seconds and the battery will last for many months. **HE**

GUGLIELMO MARCONI

A name that needs no introduction, particularly to residents of Chelmsford, Essex.

Marconi had a decidedly good start to life. Born in Bologna, Italy, of a titled Italian father and an Irish mother, he was brought up on his father's estate and educated in Bologna and in Florence. He then went to technical college in Leghorn, where he specialised in physics (still the best grounding for any engineer) and interested himself, particularly, in the work of Maxell, Hertz and Sir Oliver Lodge.

By 1894, his interest in radio was such that he started a series of experiments at his father's estate. His transmitter used the classic design of Heinrich Hertz — an induction coil with a spark-gap (**Figure 1**); and his receiver used the equally well-established coherer (**Figure 2**). What distinguished Marconi's work from that of the many other pioneers, working with the same equipment at the same time, was his particular interest in aerials, an interest which had sprung from his study of Maxwells beautifully symmetrical equations of electromagnetic radiation.

His own notes on these early experiments show that he was using a vertical aerial with a ground plane, the classic type of aerial still in widespread use today. Very significantly, his notes show that he was obtaining ranges of about 1½ miles and that he had found that, by using a reflector behind an aerial, he could beam the radiation, increasing the range and obtaining better directional characteristics.

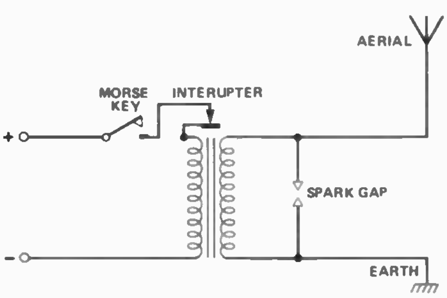


Figure 1. The classic spark-coil transmitter. The spark gap used two spheres, which had enough capacitance between them to tune the secondary of the coil, to some extent.

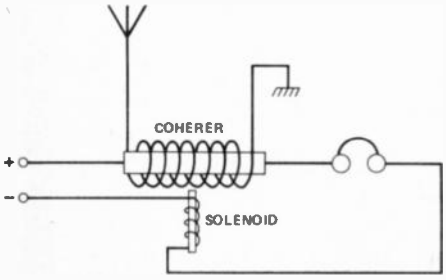


Figure 2. The coherer. The input from the aerial is interrupted continuous waves, and each pulse caused the iron filings in the tube to cling together, carrying current to the earphone and operating the solenoid which loosened the particles again ready for the next burst of RF.

Finding that there was little interest in Italy for his pioneering work, in 1896 he travelled to London to work with Sir William Preece, then Chief Engineer of the Post Office. The Post Office, at that time, was taking a keen interest in the new developments (a change from our usual, contemporary attitude) and Preece encouraged the young Marconi to file patents on his work. Marconi backed up his patents with a series of demonstrations which indicated the increased ranges that were possible by the use of aerials held up by balloons or kites. He achieved a range of four miles on Salisbury Plain, nine miles down the Bristol Channel and, in 1897 at Le Spezia, was able to demonstrate communication between warships at sea and a land station 12 miles away.

The Wireless Telegraph Co.

By this time, Marconi and his co-workers were convinced that radio could be put to serious use so Marconi and his cousin, Jameson Davies, an engineer, financed a number of patent applications and formed the Wireless Telegraph and Signal Company Ltd. In 1900 the company changed its name to Marconi Wireless Telegraph Co., a name which it retained up to the 60s.

During this time, each demonstration by Marconi indicated greater, and therefore more useful, range of communication — 75 miles, between battleships, in 1899, for example. Transmission and reception conditions proved to be better at sea than on land so that, after several demonstrations of this type, the Marconi International Marine Co. (MIMCO) was formed specifically to equip and maintain radio in sea-going vessels. For the first time, it had been possible to communicate between ships which were not visible to each other and, given the importance of sea transport at that time and the length of sea journeys, it was a most sensible approach. Another clutch of patents followed, the most significant of which was one which described the principles of tuning both the transmitter and the receiver, so that it was possible for several transmitters to operate at the same time on different wavelengths without interfering with each other.

Several navies around the world were now installing the 'Marconi Apparatus', as radio was known, and the design of transmitters, receivers and aerials was progressing with every new model that was constructed. Marconi, however, was not satisfied with gradual development and insisted that nothing short of a signal sent across the Atlantic would convince his many sceptical opponents that radio was an invention of real importance. His proposals were scoffed at, because enough was known of radio waves to make it clear that they travelled, like light waves, in almost straight lines and were most unlikely to follow the curvature of the Earth across the Atlantic. Marconi, however, seems to have had different ideas, probably due to the long ranges he had already achieved at sea. Oddly enough, the work of the shy genius Oliver Heaviside, decades earlier, had showed that long-range radio communication would be possible because of the probable existence of an 'ionosphere', a layer of split atoms high above the atmosphere which would reflect long-wave radio signals like a sheet of chicken-wire. Very few engineers, however, had read Heaviside's report and fewer still could follow his arguments, so that it seems likely that Marconi was not familiar with the theoretical basis of his experiment. In December 1901, amid foul weather on each side of the Atlantic, he succeeded in transmitting one signal, the Morse coded letter S (three dots) from St. John's in Newfoundland to Poldhu, Cornwall, establishing for the first time that long-distance radio communication was possible and in the process knocking thousands of pounds off the shares of companies concerned with transatlantic cables!

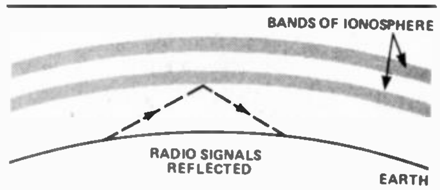


Figure 4. The Ionosphere. The layers of ionised (conducting) gas above the Earth act as reflectors of waves, particularly the longer wavelengths. The reflecting action is more pronounced at night when the remaining ionisation is further away from the surface of the Earth.

This success gave Marconi the impetus to press ahead with the development of long-range radio and he installed equipment of his latest design in the liner 'Philadelphia', which was then able to attain 300 miles by day and a staggering range of 2000 miles by night. It was this difference between day and night ranges, incidentally, which helped to confirm Heaviside's idea of the ionosphere (**Figure 4**), which then gained support from a number of distinguished physicists.

Patents continued to pour out from the Marconi development laboratories, including improved detectors and, significantly, a horizontal directional aerial system. The first spectacular broadcast across the Atlantic was followed by events which captured the imagination of the public; the capture of the mass murderer Crippen on board ship, thanks to a radio message sent out from London, and the use of radio during the sinking of the Titanic in 1912. The Titanic disaster eventually led to the full-scale installation of radio in all ocean-going ships and the establishment of an emergency wavelength which was kept clear at all times and which operators were obliged to monitor for distress calls. The Marconi Marine Co., then as now, not only supplied equipment but trained operators and service engineers and a 'Marconi man', with this enviable background, had a passport to work anywhere in the world. By 1916, Marconi was working with shorter wavelengths (around 15 metres) and was demonstrating beam aerials with very strong directional characteristics. In 1918 the ultimate long-distance signal, England to Australia, was achieved. Marconi had, like Puck in Midsummer Night's Dream, encircled the Earth.

By this time Marconi, awarded the Nobel Prize in 1909, could have retired, assured of fortune and fame in equal proportions and with the inherited Italian title of Marchese. The work of the true pioneer, however, is always concerned with the next step and by the end of the First World War, Marconi was ready with more new ideas. By this time too, his employee David Sarnoff, in the USA, was convinced that radio had an equally bright future as an entertainment medium. Marconi was totally opposed to this, though he took an interest in the first demonstration of public broadcasting from Writtle (near the Marconi works in Chelmsford) when the diva Dame Nellie Melba, using a microphone hastily rigged up with a cigar-box mouthpiece, made what was *almost* the first broadcast using Amplitude Modulation (she had been preceded by one of the office secretaries who had been asked to test the equipment before Melba arrived). Marconi, however, refused to consider involving the Marconi company in the business of public radio reception and defined the firm's role as that of providing transmitting equipment and specialised receivers for communications only. Sarnoff resigned to form his own company, the Radio Corporation of America, but Marconi sold the use of his name for domestic receivers. This was a step that his fellow-directors bitterly opposed and, after Marconi's death, the Company tried to buy back the Marconiphone trademark, but without success.

Moving on with more experiments, Marconi converted his steam yacht, the Elettra, to act as a floating laboratory, for the development of short-wave transmitters and receivers. By 1924, he had obtained a contract from the Post Office to manufacture short-wave transmitters and receivers for the cablegram service and, by 1932, he was working with half-metre wavelengths, getting close to the wavelengths that would soon be used in the early radar experiments. There is little doubt that Marconi himself would have taken the initiative in radar had his health been better. As it was, he died in 1937 surrounded by the tangible evidence of his success and with a worldwide organisation centred on his adopted home town of Chelmsford, Essex; a town so packed with mementos of Marconi that you can hardly move without coming across some evidence of Marconi's long stay there.

As a footnote, the career of the yacht Elettra is worth recording. She was used as a test laboratory by MIMCO after Marconi's death but met her end, like so many others of her age, at Dunkirk. After the Second World War, a converted Motor Torpedo Boat was bought and named Elettra II, to be used for the same purposes. It was a remarkable hulk, so top-heavy with aerials and radar equipment that when it rolled, there was a sickening delay before it righted itself. Then, after a tour of Norway, it was found that all but one of the stringers (the longitudinal beams that were supposed to hold the ship together) was broken! Shortly after that it was scrapped and a new Elettra III commissioned.

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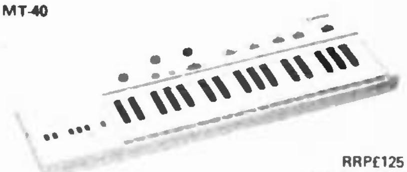

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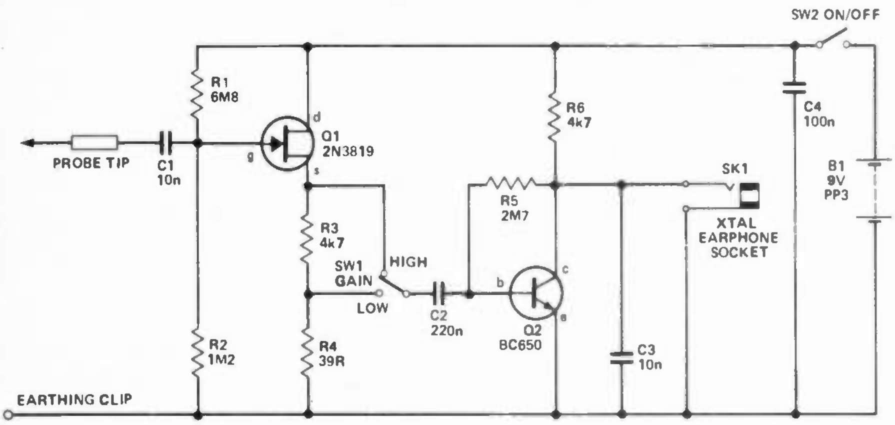
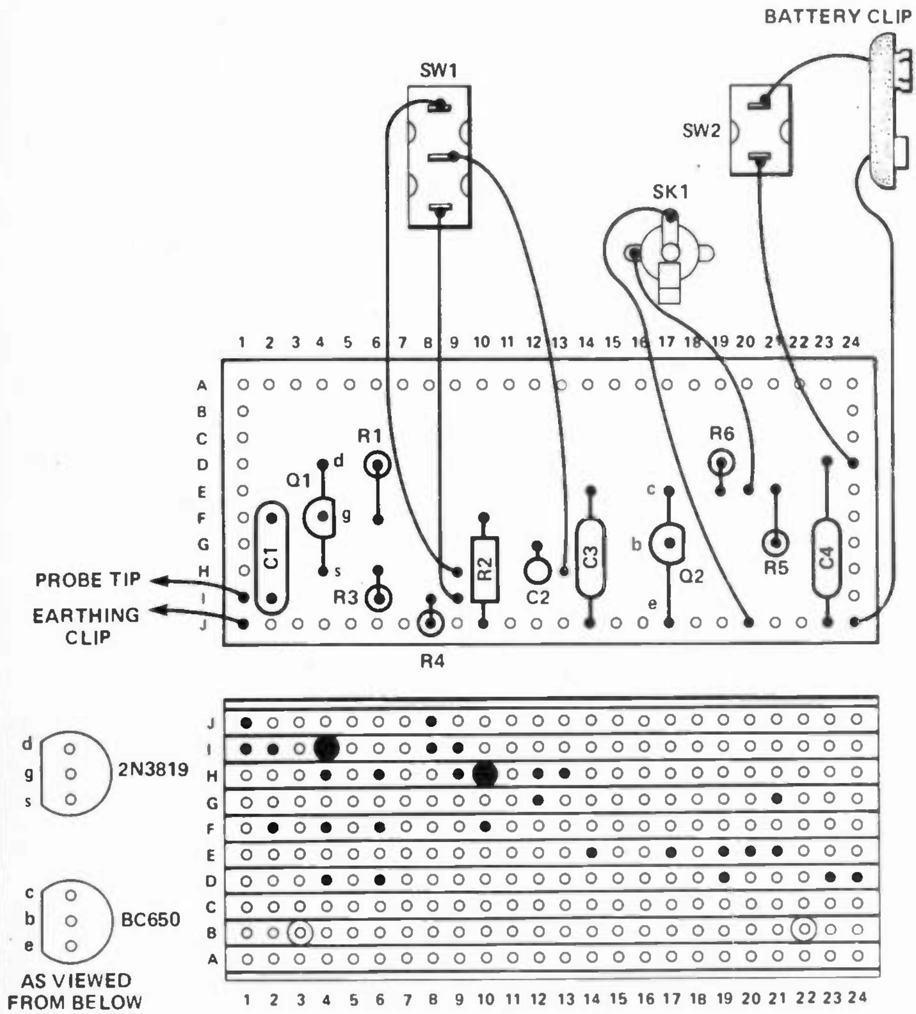




A SIGNAL TRACER for audio work consists of an audio amplifier driving an earphone or loudspeaker, so that small signals can be detected at various points in the circuit. It is a simple refinement, however, to include an AM detector, which will allow signals in the RF (Radio Frequency) and IF (Intermediate Frequency) stages of medium-wave radios to be traced. The circuit shown in **Figure 1** is easy to construct and suitable for audio, RF and IF signal tracing.

The circuit is divided into two stages. The first stage uses Q1 as a source follower, providing no voltage gain but a high input impedance (about 1 Megohm) to prevent loading of the circuit being tested. The second stage supplies all the voltage gain (more than 40 dB) by using Q2 in a common emitter configuration. Q2 is biased near to cut-off by R5 and R6, so that it provides a crude form of rectification, as well as gain. Capacitor C3 acts as an RF filter and, in conjunction with the distortion from Q2, produces AM demodulation.

The input signal to Q2 normally comes directly from Q1 via C2, but when a high level input is present, SW1 can be set to the 'low' position; this avoids overloading by sending the signal through an attenuator network, R3, R4.

Figure 2 shows the component layout on a piece of Veroboard (24 x 10). The device is housed in a small plastic case, so that it can be hand-held, and is connected to the circuit under test via a long M3 bolt (file the tip to a point) with a crocodile clip (on the end of a wire) used for the earth.

The best technique for tracing a signal through a radio is to start at a point, in the signal path, near the first gain stage and work along the signal path towards the output. When you reach a point where the signal 'vanishes' you have roughly located the fault. For example, if there is a signal present at the base of a transistor but not at its collector (or emitter, if it's an emitter follower), then the fault is probably in the transistor or the components around it.

Parts List

RESISTORS

R1	6M8
R2	1M2
R3,R6	4k7
R4	39R
R5	2M7

CAPACITORS

C1,C3	10n polyester
C2	22Cn polyester
C4	100n polyester

SEMICONDUCTORS

Q1	2N3819 FET
Q2	BC650 NPN silicon transistor

POPULAR COMPUTING

The home computer has been around for some time, now. So why are we, at this late stage, introducing a special supplement on the subject? After all, it already has enormous coverage in specialist magazines, in the daily press, on radio and even on nationwide television.

Quite simply, because we believe that there is a side to computing that is NOT adequately covered anywhere else.

For most people, the fun of owning a computer is in being able to write clever programs for games, to keep mailing lists or to do the household accounts. So it's not surprising that most magazines are basically software magazines. The other side of computers — the hardware side — is either ignored, glossed-over or written for experts.

As a magazine for electronics enthusiasts, we think it s about time the balance was adjusted. Hobby Electronics' Popular Computing supplement is intended to do just that. We'll look at the computer from both sides.

We begin with a critical look at computers and computing. What is a microcomputer and just what can you do with it? Do you really need one? To many people, the computer is The Marvel Of The Age and The Answer To All Their Problems. This is a condition that Jonathon Scott calls

Every trade or profession develops a new set of words — or new meanings for old words — that are peculiar to the subject. Our glossary of computer jargon is by no means complete, but it will start to give you a better understanding of

Reading and discussion play a large part in understanding any subject — but there is no substitute for 'hands-on experience'. So, if you are really determined to learn, you'll need a computer — but which one and how much will it cost? You'll have a better idea of the answer to the first question after reading MICRO-MANIA. The second question is answered in our specially prepared guide to

Popular Computing will appear monthly in Hobby Electronics. We're not going to give away our plans, just now, but we've got some really good ideas for you in the months to come. Look out for our special computer projects — you won't see them anywhere else, only in POPULAR COMPUTING

Hobby Electronics' Popular Computing Supplement.

MICRO-MANIA

Jonathan Scott

What's really lurking beneath the keyboard of a PET, TRS-80 or ZX81? What can you do with it?

ALL HOME COMPUTERS are based on the microprocessor integrated circuit. In fact this is physically a rather small part of that thing which comes in the box marked 'home computer'. It is a plain integrated circuit with 40 to 64 pins, and looks just like a lot of other ordinary integrated circuits. You could buy a common one for much less than £10, or for a classy one you might pay £100 or so. Most of the cost of the complete unit is the 'support' equipment — the PCB, memory, keyboards and so on. But more of that later.

How should we briefly characterise this device, upon which books have been written in abundance? Well, for anyone who has a good knowledge of computers two single descriptions are enough, so we'll start there and work back. These are called the 'chip architecture', and the 'instruction set'. Let us draw an analogy to make it clear. We will discuss a microprocessor, and consider a man sitting at a desk as the model.

The architecture of a microprocessor (or CPU, for Central Processing Unit) is usually presented in the form of a small map showing the locations of significant 'places' in the chip. It corresponds to the places in or on the desk where something may reside. In the CPU there will be several spots where a number can be held, just like the memory on a pocket calculator. Our man at the desk has, for example, the top of the desk, which we will suppose can hold only one number of the size the computer deals with at a time. There might be several drawers which can also hold one number apiece. If you want to hang on to a bigger number than will fit in one drawer, you must break it up and put it in several drawers.

One popular CPU is the 6502; it has six locations. Some of these have fixed jobs. To keep a record of where the CPU is up to in its program — this corresponds to two drawers in the desk which hold the page number in a book the man is reading. The book is telling him what to do — it corresponds to the program. Another location is called the 'accumulator' and is the place where the result of a calculation usually goes — this is like the top of the desk. In your pocket calculator it is what you see in the display — the result. A third location is known as 'stack pointer' and also holds a specific piece of information — the place where there is some free memory for holding any numbers you need to keep for a while. It is like a drawer in the desk in which a piece of paper is kept; written on the paper is where to find some blank pages in a pad kept elsewhere (ie outside the CPU).

Temporarily Registered

The other two registers in the 6502 are general purpose registers, typically used for temporary jobs, counting or indexing. The latter need not concern us yet but gives its name to these locations, called 'index registers'. These are like two spare but handy drawers in the desk. If all this has left you confused, then we'll recap using figures. We have chosen the 6502 as it is relatively simple (not a complex architecture) and yet has most of the fundamental bits we need to discuss. It is used in Apple, PET and Acorn computers, among others.

The common CPUs on the market today, like the 6502, 8080 and Z80, are 'eight bit' units. This means that each number is eight bits wide, or is an eight digit binary number. Such numbers span a decimal range of 0-255, of course. Bigger numbers, or fractional ones, must be kept in several locations at once; this need not be a worry yet, as it falls naturally into place later.

So now we know that CPUs have places in them like pocket calculator memories. What can they do with the numbers in these locations? The 'instruction set' is a list of all the possible commands. In a pocket calculator there are a fixed number of keys which either input a number, execute a function such as 'x', or get a result (=). Our man at the desk can do a variety of things, such as "put the number on the next page of the book of instructions into the X-index register", or "go to such-and-such a place if the accumulator is zero". In the 6502 there are about 150 different things which it can do in any one 'move' or instruction. A program understandable by the CPU is composed entirely of these.

The next most fundamental bit in the box is memory. This comes in two kinds — memory that you can put numbers into yourself, rubbing out and replacing the numbers as you will, and memory which contains fixed numbers, which can neither be changed by you nor rubbed out, even by turning off the power. The former is called RAM, (short for Random Access Memory); the latter is ROM, for Read Only Memory. In the computers you buy in the shops, a lot of useful programs which you need frequently are perpetually available within the computer memory because they are in ROM. The size of the ROM (typically 4-16K for BASIC) reflects how comprehensive and convenient are the programs that you buy with the unit. For instance, '4K-BASIC' is relatively small, and consequently a coarse and limited version of BASIC. 8K would be more reasonable. Expensive commercial units might offer 16K or more of language interpreter — quite big, and sporting many clever and useful work-saving pieces of program. The types of 'program' and their merits and uses will be covered in the 'Languages Within Languages' section.

RAM is where the computer holds numbers and where the programs *you* type in are kept. Thus, the more of it you have, the bigger a program you can put in (in any given language) and/or the more numbers you can store at any time. Machines with only 1-4K of RAM must be regarded as small, and will be adequate only if you are programming simple jobs in a very compact form. 16K is typical, and does most 'household' jobs. Machines with 64K or more are now available, but only a tough business job or a large commercial game will demand this.

Peripheral Matters

As well as the CPU and memory, a complete computer will need some way of getting things from you — a keyboard; a way of getting things to you — a screen or printer; and a way of recording your program permanently so you can turn the machine off and not waste all your work — mass storage, usually a disk drive or audio tape facility. The keyboard can be like an electric typewriter, which is nice but adds to the cost, or it can be one of various sorts of economy measures ranging from one with only a few keys to one with those 'solid state' touch sensitive keys, with no moving parts. All will do the job, though if you are at all serious you will find that a full typewriter-style keyboard is the only one which does not eventually get on your nerves.

The cheapest output, and the one used by many manufacturers, is a signal which will put words and numbers on the screen of a home TV set. This is neat and clear. Some computers just put out RF which you tune into with an unused slot in your TV tuner. This is quick, though not so good as the ones that put out video signals which can be fed directly to the video amplifier stages, bypassing the tuner. Video monitors, as they are called, give a clearer picture, although they must be specially purchased — a measure to consider if you are serious. Some units (eg, PET) include a video monitor, so you get one with the purchase price.

Finally, the mass storage. This just means a way of permanently recording your programs in a fashion which allows

PROGRAM | COUNTER

DOUBLE LENGTH NUMBER WHICH ACTS LIKE A BOOKMARK, KEEPING YOUR PLACE IN A PROGRAM.

ACCUMULATOR

THE MOST-USED GENERAL LOCATION. HOLDS A NUMBER WHICH MAY BE INSPECTED, MODIFIED OR MOVED ELSEWHERE AS COMMANDED BY THE PROGRAM.

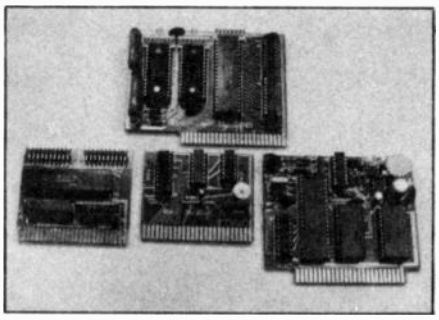
STACKPOINTER

HOLDS A NUMBER WHICH SHOWS WHERE WE CAN 'STACK' UP NUMBERS WE NEED TO HOLD ON TO ELSEWHERE IN THE MACHINE FROM THE CPU

X REGISTER | Y REGISTER

TWO INDEX REGISTERS, CALLED 'X' AND 'Y'. HANDY GENERAL PURPOSE REGISTERS WHICH WE CAN USE FOR ANYTHING WE WANT — USUALLY COUNTING OR POINTING TO THINGS TOO BIG TO HOLD IN THE uP.

Elements of the 6502 CPU.



you to load them back into the computer whenever you want. Most computers allow programs to be put onto an ordinary cassette recorder. This is adequate at first, and it's cheap; but it is also slow, and you have to keep track of where on the tapes you have put various programs. Also, there is the occasional failure and you lose a recording — very painful. Once you are addicted and committed, a disc drive is really necessary. It is fast, reliable and keeps its own catalogue of what you have stored away. By the 40th program, this looks like a godsend!

Languages Within Languages

We have now discussed all the factors which reflect the comprehensiveness and the cost of home computers, and we have abstractly discussed CPU architecture and said that they have a fixed range of instructions which they can execute. Now we will discuss what various 'levels of instructions' are available. These can all be called languages.

The set of instructions which are native to a particular processor — say the 6502 — are said to comprise its 'machine language'. These are fixed and unchangeable with any given CPU. The most fundamental program to a processor is called its 'monitor', and this is a program written in and designed to deal with machine language. Consider what happens when power is first applied to a computer. It must have some starting place, some logical first move. In the Z80, the machine sets the program counter to 0 — which is to say that our man at the desk opens his book of instructions at the first page and puts the book mark there. In the 6502 the 'reset location', as this place is called, is near the very end of the range, rather like the index of the book. When power is first turned on, or when you push the 'reset' button because some catastrophe has scrambled up what you were doing, the bookmark gets back to this place — always the same place for a given brand of CPU.

Living around this place is usually the 'monitor' program. In computer jargon we say that "the monitor takes control", by which we mean that the processor is doing what the monitor program is telling it to do. What does the monitor do? Well, first it prepares the computer for use by getting the keyboard and screen ready for action and generally checking that all is well. Our man at the desk might suddenly wake up, and he will first put his bookmark in the appropriate place, as he does each time he comes to the desk. That page tells him to adjust his chair, close all the filing cabinet drawers, turn on a light if it is dark, and so on. This will all be listed in the book — his 'program'.

Once this has been done, the man will probably sit waiting for some work to come his way. The computer will, when it has finished setting up the job, wait for you to give it something to do by hitting a key or set of keys. The monitor has a few commands which allow you to effectively look at any memory locations you may wish to inspect and to change them, to enter a number representing one of the instructions in the instruction set of the

CPU. It allows you to execute a group of these instructions and also to look, at any time, at the registers in the processor. It may also give you some commands helpful in finding errors in such a program — an act called 'debugging'. (mistakes in a program, of any type, are called 'bugs'.)

Whatever commands a monitor understands will be outlined in some paperwork accompanying the unit, and need only be read up when you want to use the monitor. It is sufficient, at this time, to say that the monitor is a crude mechanism which is very close to the actual machine language of the processor. You need a knowledge of the architecture and the instruction set to use it, and even then it is a slow and tedious process to write and enter programs in machine code.

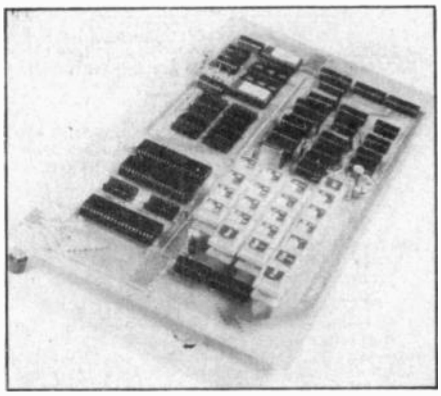
However, suppose we had a dictionary — a dictionary which would allow us to look up nice familiar English words like 'multiply', and get the machine code instructions to do this. And suppose this dictionary lived in the machine already, so that you could type in a phrase like "if E/C = MC then beep" and know that if E/C *does* equal MC the machine will beep. Such a dictionary is often built in, and it is called a 'BASIC interpreter', or just 'BASIC'. Interpreters come in other languages, too, though BASIC is more common today. Some machines have monitors that know if BASIC is in the machine and when they have finished getting the machine in order they hand control over to the BASIC program at once. Others require you to hit some specific key — mentioned in the sheet of instructions that go with the monitor — to cause BASIC to be executed.

BASIC English

With BASIC in control, you can type in a lot of these words, recognised by BASIC, and then have them executed — or 'interpreted', as the jargon goes. There are words to make calculations, words to make decisions, words to collect bits of information from the user via the keyboard, and words to make things happen on the screen. These new words may be regarded as a new 'instruction set', just like the one we mentioned before, except that they are more English-like, and they are also substantially similar from one machine to another. *These are the two major advantages — BASIC is easier to think out, and does not demand a knowledge of the CPU inside the machine*. The price is speed — BASIC is very slow compared to machine language — but the reward is speed of writing and the ability to put the program into your neighbour's machine (although it has perhaps a different CPU in it), because the words of BASIC are standardised. The 'dictionary' inside the machine does the translation for you.

There are better languages than BASIC, each with advantages, which will come soon to home computers. Pascal is even more 'English-like' in its appearance, for instance, and FORTH is much faster to execute — you can take your pick on some machines.

This "language within a language" is



just one more level of flexibility. In fact there is, within the IC itself where you cannot see or change it, another language called 'microcode' and a dictionary to translate this into the particular machine languages of your CPU. The microcode carries out the range of machine language instructions using an even cruder set of instructions which are actually hardware implemented (with, yes, transistors!).

One more point about the languages. We have called them 'interpreters'. An interpreter will take a lot of words in BASIC, say, which are your program, and execute them (in machine code) as it goes. This is slow because it does the 'dictionary-looking-up' as it goes. There is another type of 'dictionary program' which spends some time translating all the words before it even comences the actual running of the program. This process is called 'compilation', and such programs are called 'compilers'. The advantage is that the actual program runs faster than before, but the penalty is that you have to spend some time compiling beforehand, and if you make a change in the original ('source', in the jargon) you have to re-compile the whole thing. In general, the enthusiast's home machine is not geared up for this, and you are better off with an interpreter and a little machine level programming if need be.

What Can You Do With It?

This is of course the £200-plus question. As you take it out of the box, there are really only two valuable uses for a home computer in its basic form: teaching yourself about computers and playing games. Now the skill of writing computer programs has two good points; first it will help you get into the computer industry or make it easier for you to talk to people in it already, and second it is an excellent mental exercise like chess or Mastermind. If these are not of interest to you, perhaps it is time to think again. Playing games is really self-explanatory — if you pour lots of 10p pieces into video games, then you have an idea what this function is worth to you.

But there must be other areas where the home computer can be useful in the home. There *are* other uses, but they fall into two categories — ones that only pay off when you do things on a grander scale than you can at home, and jobs which require some specific 'peripheral' connected to your machine (which costs extra, of course). Now the keeping of mailing lists or stock inventories is one well-known task. Quite honestly, these require expensive printers and only begin to be labour-saving with more than 50 people and two mass-mailings a year. You, the private householder, are very unlikely even to save effort, let alone cost.

The keeping of cross-reference recipes is another potential job, but you have to be a fantastic cook, not to mention a religious bookkeeper and typist to get all the data into the machine and benefit from its being there. The closest you will *ever* get to that as a useful pastime is if someone markets a disk with them all on it, for about £10.

Next come the programs which require some additional peripheral, such as modems, joysticks, plotters, heat sensors, position sensors, movement sensors, switched mains sockets, or a custom peripheral, such as a morse code translator . . .

In future issues, we'll be developing a whole range of simple, but interesting, gadgets you can hang off the end of your computer. We will conclude this article with a few ideas that will give you a hint of what you can get up to with your home computer.

The Morse Maniac

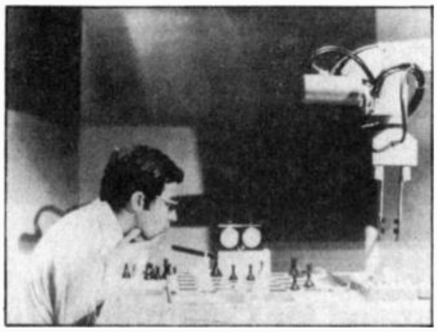
One of the most ingenious purposes to which a computer has been put is the operation of a morse radio station in an amateur DX contest. In these contests, you score points for simply exchanging call signs, often going through a simple ritual of introduction. All the communication is by morse, and what is said is simple, fixed, and repetitive. Once the contact has been made you need only record time, callsign, etc, and maybe post off an acknowledgement later.

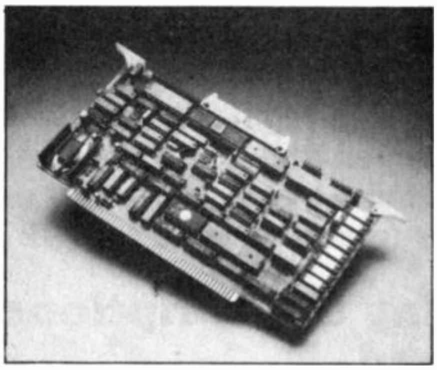
This can be done easily with a computer — it searches regularly through the bands, finds a station, sends the appropriate message (in morse), receives and decodes the morse response, records it all on a printer or a disk, and says goodbye. This it does as fast as possible, night and day, taking not the slightest break. When the contest is over it can print out all the acknowledgements. All that is required is a small box capable of keying the transmitter (allowing the computer to send), and capable of telling the computer when carrier and modulation is being received — a minor electronic feat. This job is specifically for the ardent ham, of course, but then most computer jobs are specific to some pastime.

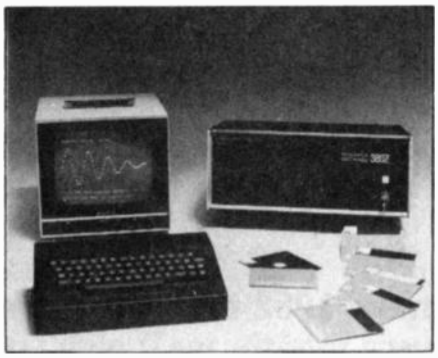
The Clever Watchdog

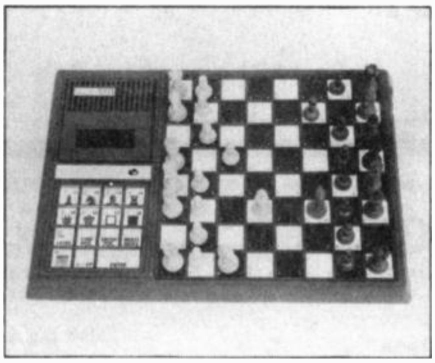
Burglar alarms, particularly the quickly installed area types such as radar units, are prone to false alarms because the unit cannot tell the difference between the odd disturbance of a rattling window, or power surge on the supply, from a man walking across a room. However, a computer can analyse the doppler response and eliminate freak or definitely non-human responses. If you hook an analogue-to-digital converter between the radar and the computer (only a few £'s worth of bits and pieces), the latter will perform quite sophisticated event filtering, giving alarm only when intrusion is fairly definite. It even simplifies the electronics in the radar module, very considerably reducing its cost!

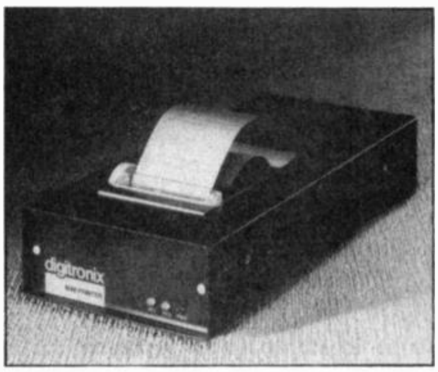
This function ties up your machine, of course, but only when you are out, so it might pay off if you live in a risky area. In addition it can turn lights and aplicances off and on, making the house look inhabited — with the right peripherals, needless to say. If you devise an excellent program to do this, you might even end up selling it to one of the computer houses who buy such things and make them available to others, or to a magazine like this one.











The Formula One Computer

The author of this article has interfaced a common home computer to a slot car track. This required the computer to have control of the current into the car and a set of position reporting sensors dotted around the track. It makes for very interesting programming, working out how to enable the computer to adjust its driving habits to adapt to a car or layout and achieve close to the best possible performance. In the same vein, a computer can make a very realistic and varied model railway organiser, giving interesting hands-off movement and shunting, though this requires quite a lot of interfacing hardware.

The Computer Mail Order

At least one chain of electronic component and hi-fi stores in far-off Australia sell a small peripheral for their line of home computers which allows *your* computer to do your mail ordering direct to *their* computer. You prepare your order; a program that comes with the peripheral does this on your screen. Next you phone up the store's computer. Then you hand the phone over to your computer, tell it to go, and in a couple of hours their computer has despatched the goods and charged your account or credit card. Very neat indeed, and there are no middlemen to lose or confuse your order. This is going to become more common, thought not quickly.

The Wordprocessing Wizard

Wordprocessing may once have been the domain of commercial computers, but it has now really taken off at the domestic level. All you need is a printer with a pleasant typeface. Programs are becoming available which will correct your spelling of up to 10,000 common words, and then set out anything from a party invitation to a business letter. While you might not be able to justify the expense of a home computer, or the printer, just for this purpose, it is worth having the program if you already have the equipment. There is some value to be gained from a precise and correct job application, for example. In addition, if you are in it for the programming experience, it may be worthwhile writing your own program for the job, or a copy of one you have seen used but want to improve.

Conclusion

Well, there are some ideas to start your imagination rolling. If you have a little constructional experience, so much the better, as you may be able to fashion your own interfaces so you can more cheaply hook up the computer to your train or your home appliances. Here at HE it is our intention to publish programs and constructional articles to assist those with home computers. If you are thinking about it, we hope this article has given you some idea of what's possible, and how involved you must get to reap the benefits. For those such as your children, who are growing up in a very computer-involved world, the experience will be invaluable, and for you it may become a very productive hobby, especially if you get involved in the hardware side as well as programming. **HE**

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COMPUTER TALK

If the *Microcomputer Bug* has taken a *Byte,* you'll need an *Interpreter* to *Decode* the jargon of *Computer-Talk.* Keep this *Print Out* handy to *Refresh* your *Dynamic Memory!*

Accumulator
The *register* where arithmetic or logic results are held. Most *CPU instructions* manipulate or test the accumulator contents.

Address
A label or name (usually a *binary* or *hexadecimal* number) specifying a particular *memory* location.

Alphanumeric
Letters and numbers.

ALU
Arithmetic Logic Unit. That portion of the *microprocessor* which performs calculations according to a set of *instructions.*

Array
A group of related *variables* or constants — generally given a name or a label. Arrays are often located in consecutive *memory* locations.

ASCII
American Standard Code for Information Interchange — representing letters, numbers etc by 128 permutations of a 7-bit code.

Assembly Language
Means of representing *program* statements in *mnemonics* and conveniently handling *memory* addressing by use of symbolic terms.

Asynchronous
Operations that initiate a new operation immediately upon completion of current one — not timed by system *clock*.

BASIC
Beginner's All Purpose Symbolic Instruction Code. An easy to learn, widely used *high level language*.

Batch Processing
A method of computer working in which a large number of transactions are grouped together before processing and which are then passed through the various stages of processing as a group or batch. This was the original method of data processing for commercial work and contrasts with *interactive* processing.

Baud
Measure of speed of transmission line. Number of times a line changes state per second. Equal to *bits per second* if each line state represents logic 0 or 1.

Baudot Code
Five-bit code used to *encode alphanumeric data.*

BCD
Binary Coded Decimal. Means of representing *decimal* numbers where each figure is replaced by a *binary* equivalent.

Benchmark:
A standard computing task used to measure the relative speeds of different processors.

Bit
A single *binary* digit, representing either a 'one' or a 'zero'.

Boot
An *instruction* or very short *program* which will initiate a computer's *operating system* (short for bootstrap).

Binary:
Numbering system with the base 2, using the digits 0 and 1 instead of the *decimal* series 0 to 9. All *digital* computers work on *data* and *instructions* presented as *binary* numbers.

bps
Bits Per Second — a rate of *data* transmission between services. Eg 300 bps is a popular rate for some *terminals,* roughly equivalent to 30 characters per second (cps or chps).

Branch
A certain *instruction* included in a *program* which makes the *processor* perform a step out of the usual sequence, usually if a specified condition is satisfied. A branch *instruction* will skip or jump following instructions.

Bubble Memory
A compact, high-capacity random access memory device *(RAM)* which holds *data* as minute magnetic domains or 'bubbles'. The data is not lost when power is removed.

Buffer
(1) An area of *memory* designated to hold *data* being transferred between devices working at different speeds, eg the fast processor and the slower *keyboard, printer* or *disc.*
(2) An electronic device in a signal path designed to allow signals to pass in one direction but to hold back unwanted reverse voltages which might damage the sending apparatus.

Bug
An error in *software*.

Bus
(Sometimes spelt Buss). Basically, the multiple wiring common to several parts of a computer and the number of channels therein — eg a 16-bit bus addressing 64K *memory* locations or a 20-way bus addressing 1 *megabyte.* Bus is now generally identified with the pattern of connections to the plugs and sockets whereby optional units (eg more memory) may be connected to a computer.

Byte
A *binary* number, usually of eight *bits.* It can represent a number from 0 to 255 (8-bit byte) as there are 256 possible combinations of ones and zeros eight bits long.

CAD/I/L
Computer Aided Design/Instruction/Learning.

Chain
A process whereby one computer *program* automatically follows another.

Clock
An oscillator that provides timing signals which synchronise the operations carried out by the *microcomputer*.

COBOL
Common Business Oriented Language. A *high level language*.

Compiler
Software which converts *high level language* statements into either *assembly language* statements, or into *machine code*.

CP/M
Control Program/Microprocessor. A popular *disc*-based *operating system* for *microcomputers* using the 8080 and Z80 *processors.*

CPU
Central Processor Unit. The part of a system which performs calculation and data manipulation functions.

CUTS
Computer Users Tape System. Definition of system for storing *data* on cassette tape as series of tones to represent *binary* 1's and 0's.

Data
Simply, information. The raw material that the computer processes.

Data Base
A system for organising elements of information in a *machine code* file so that a *program* can readily select from this *data* any particular abstraction or combination of information that may be called for. For instance, a customer data base might include full details of all customers (as required for service and distribution departments as well as sales and marketing) and also of every service call and delivery as well as each item invoiced to these customers during a year or longer. A suitable program could access that data base to answer such questions as "identify the customers buying more than £1,000 of item 'A' in less than five deliveries and receiving less than two service calls in the year."

Debug
To correct the errors in a *program*.

Decimal
The familiar counting system, 1 to 10. In computing, however, it is more usual to count from 0 to 9.

Decoder
A device which changes one code to another. For example, a 4-bit *binary* code may be changed to a 1-of-16 code. Certain ICs are made to perform such a function, generally called 4-to-16 line decoders. A 4-bit to 1-of-10 decoder is called a *BCD* to *decimal* decoder — for each 4-bit code in, the decoder will activate the appropriate one of its ten output lines.

Digital
The use of discrete signal levels to represent a value as a coded number or letter.

Disable
The opposite to *enable*. To halt an operation — to turn something off (if only temporarily).

Disc (Disk)
Magnetic storage device allowing fast random access to a large volume of *data*. A full-size hard disc will hold ,say, 5 *megabytes* or more; a smaller *floppy disc* typically holds from 80 to 250 *kilo*bytes but in either case the capacity is being increased all the time.

DMA
Direct Memory Access (or Direct Memory Address). The term refers to the practice of fetching *data* directly from *memory* by an external (or *peripheral*) device without the need for intervention by the *microprocessor*. A good technique for speeding data transfer.

DOS
Disc Operating System — a computer *operating system* held on magnetic *disc* rather than in *ROM*. An *initialisation* process will copy the operating system into *memory* whenever the computer is first turned on. Also an operating system which controls the disc themselves and may supplement, rather than replace, the computer's original operating system.

Duplex
A mode of *data* transmission where each station can send and receive simultaneously.

Dynamic (Memory)
Random Access Memory *(RAM)* requiring constant *refresh* signals but normally using less electrical power than *static* memory.

EAROM
Electrically Alterable Read Only Memory. Typically taking 10 msec to erase and 1 msec to write, this non-volatile storage might be better considered as 'Read Mostly Memory' as the write capability is likely to be limited to say 100,000 cycles.

Edit
Alteration of text in *program* or *data* files. Often necessary, some systems make editing easier than others.

Enable
The opposite to *disable*. To start an operation.

Encoder
The opposite of a *decoder*. A device which accepts uncoded *data* and turns it into the appropriate code.

EPROM
Erasable Programmable Read Only Memory. Writing typically takes one minute and erasing, by ultra-violet light, 10 minutes or longer.

Execute
To perform a sequence of *program* steps.

Execution Time:
The time taken to perform an *instruction* in terms of *clock* cycles.

Firmware
Instructions or *data* permanently stored in *ROM*.

Flag
A linen object that one salutes — but sailors use them to send messages. So do computers. A flag is an indicator signal (usually just one *bit*) that generally signals a condition.

Floppy (disc)
Mass storage which makes use of flexible *discs* made of a material similar to magnetic tape.

FORTRAN
FORmular TRANslation, an early and still popular *high-level programming language*, mainly used for scientific purposes.

Graphics
Literally — drawings; a method of producing graphs or pictorial figures on a suitable output device, usually a video monitor (TV set for most hobby computers) but sometimes a chart recorder or printer.

Hard Copy
A computer printout or listing on paper.

Hardware
All the electronic and mechanical components making up a system.

Hex
Shortened version of Hexadecimal, meaning '6 plus 10', which is a funny way of saying 16. It refers to the number system with a base of 16. This uses 0 to 9 and then A to F of the alphabet to represent its 16 digits. Two hex digits can be conveniently used to represent a byte (eight bits).

High-Level Language
Programming language usually claimed to resemble a natural language and with powerful *instructions*, each generating several *machine language instructions*. *Examples include BASIC, COBOL* and *FORTRAN.*

IEEE
Institute of Electronic and Electrical Engineers (in USA) — a body which has set a number of standards for more orderly interchange of information between various electronic devices, including computers.

Initialisation
The process by which the *processor* is got going after you turn the power on. In some systems you have to do it, in others it's done automatically.

Instruction
A set of *bits* which causes the *CPU* to carry out a particular task. Usually a basic or fundamental command understood by the *microprocessor*.

Instruction Set
That set of fundamental *instructions* which control a *microprocessor's* or computer's basic set of possible operations. In general, the larger the instruction set the more powerful the microprocessor.

Intelligent Terminal
An input/output *(I/O)* device which includes its own logic circuits and *memory* so that, for instance, *data* may be validated or changed in format before transmission to the main computer.

Interactive
A working arrangement under which the computer reacts immediately to respond to any mistakes which may be made by the user or to reply to his enquiries as soon as they are expressed. In some business activities, as also in program writinn, this leads to much faster progress than would otherwise be possible.

Interface
Circuit which connects different parts of system together and performs any processing of signals in order to make transfer possible (ie serial-parallel conversion).

Integer BASIC
Concerned only with whole numbers, cutting off any fractions or decimal parts.

Interpreter
An interpreter is a *software routine* which accepts and *executes* a *high level language program*, but unlike a *compiler*, does not produce intermediate *machine code* but converts each instruction as received.

Interrupt
A signal which suspends processing to allow some other command to be obeyed.

I/O
Input/Output. A computer generally has one or more *ports* through which it communicates with 'the outside world' — *peripheral* devices such as a *keyboard*, video display *(VDU)*, *printer* etc. An I/O port may be just an input or just an output or it can be bidirectional.

Kilo (K)
Normally means 1000, but 1024 (2^{10}) when referring to *memory*.

Kansas (City)
A standard for recording *programs* and *data* on cassette tape, named after the city where a conference was held, at which the standards were agreed.

Keyboard
A device, similar to a typewriter, which is used to *encode alphanumeric* characters in a form that the computer can recognise. The usual method of interacting with a microcomputer, for hobbyists.

Language
A repertory of commands — symbols, expressions etc, used to 'call up' the instructions or procedures a *processor* can execute. Higher-level languages are easily understood by mere humans and computers designed to work with such languages (*BASIC*, for example) use an *interpreter* to change this into the *machine code* under which the processor operates.

Latch
Retains previous input state until overwritten.

Light Pen
A stylus with a light sensor which allows a computer to identify the point at which a Video Display Unit *(VDU)* screen is being touched.

Load
To copy a *program* (eg from tape or *disc*) into *memory*, ready for *execution*.

Location
Physical position; *memory* location is the same as *address*.

Loop
Program technique where one section of program (the loop) is performed many times over.

LSI
Large Scale Integration — the combination of circuit elements in a small silicon chip.

Machine
Short-hand term a for computer or, more usually, a *microprocessor*.

Machine Language (Code)
The lowest (and tediously detailed) level of *program instructions*. All higher level coding must be converted to *machine language* (by *compiler* or *interpreter*) before a *processor* can obey it.

Mainframe
A relatively large computer.The term derives from times before integrated circuits, when *processors* were wired up with large numbers of separate components mounted on circuit cards or boards which were in turn mounted in metal racks or frames enclosed in one or more large metal cabinets.

Mask
Bit pattern used in conjunction with a logic operation to select a particular bit or bits from a machine *word*.

Mega
Prefix for 1 000 000 (10^6).

Memory
Immediate access *data* storage, directly addressable by a central processor *(CPU)* and typically comprising a combination of *RAM* and *ROM*.

Memory Map
Chart showing how *memory* is used by a computer. The arrangement of *data* and *program* within the memory.

Memory Mapped I/O
A technique of implementing *I/O* facilities by addressing I/O *ports* as if they were *memory locations*.

Micro (also u)
Prefix signifying one millionth. Also used descriptively of something very small, though not as small as nano- or pico-.

Microcomputer
A computer system based around a *microprocessor* and generally addressing up to 64K of *memory*.

Micro Cycle
Single *program* step in a *CPU micro program*. The smallest unit of micro program.

Microprocessor
CPU implemented by use of large scale integrated circuits. Frequently implemented in a single chip.

Micro Program
Program inside *CPU* which controls the CPU chip.

Minicomputer
A somewhat vague term for the middle range of computers. Machines addressing up to 64K bytes or words of *memory* tend (at the present time) to be called *microcomputers* and machines able to address more than 64K memory locations tend to be called minicomputers unless they separate into distinct parts, in which case it may be called a *mainframe*.

Mini-Floppy
The smaller size of *floppy disc*, 5¼" in diameter.

Mnemonic
A word or phrase which stands for another (longer) phrase and is easier to remember.

MODEM
Acronym for MOdulator/DEModulator — a device adapting computer *data* for transmission by telephone line and vice versa.

Modulator
A device, included in every good hobby computer, which takes the computer's output and converts it to an RF signal on a suitable TV channel, giving you a cheap, convenient visual display — even if you don't understand what's on the screen.

Monitor
The first level of computer *operating systems:* the *program* which turns *machine code* commands into action, managing input, output etc.

Multiplex
The principle of arranging or communicating information from a number of sources by selecting each source sequentially.

n-sec
Nanosecond, one-thousand-millionth of a second.

Non Volatile
Memory which will retain *data* content after power supply is removed, eg *ROM*.

Object Code
Two-bit patterns that are presented to the *CPU* as *instructions* and *data*.

Octal
Base 8 number system. Character set is decimal 0-8.

Op Code
Operation Code. A bit-pattern which specifies a machine operation in the *CPU*. The basic unit of *machine code*.

Operand
Data used by *machine code instructions*.

Operating System
The computer's resident *program* which determines how *instructions*, input and output *(I/O)* devices etc are managed.

Overlay
A *program* too long for the available *memory* may be entered and processed by instalments, each segment overlaying or replacing the code previously stored while the various values allotted to common *variables* would continue from one program to the next.

Parallel
A method whereby *data,* so many *bits* wide, can be transferred simultaneously over a group of wires — one wire per bit. An 8-bit system requires eight wires. In effect, the bits are transferred 'in parallel'.

Peripheral
Device attached to a computer, eg *printer, plotter, disc* unit, but not necessarily essential to its use.

PIA
A Peripheral Interface Adaptor. A device that does the *interfacing* between the *microprocessor* and/or *memory* and *peripherals,* converting the outgoing *binary* coded signals to the appropriate signals for the periphals and converting any incoming signals to the appropriate code for the computer.

Pointer
In the *microprocessor,* or in *memory* external to it, pointers can be *registers* allocated to listing memory *address* — they 'point' to memory locations.

Port
Terminal which the *CPU* uses to communicate with the outside world.

Printer
A device for producing typed or printed copy *(hard copy).*

Print Out
Same as *hardcopy.*

Processor
See *CPU.*

Program
A set of *instructions,* either in *mnemonics,* in *digital (binary)* form or in a *high-level language,* which tells the computer to perform a sequence of tasks.

Program Counter
Register in the *microprocessor* which keeps track of which part of the program is being *executed.*

PROM
Programmable Read Only Memory. Proms are a special form of *ROM,* which can be individually programmed by the user.

RAM
Random Access Memory. Read write memory. *Data* may be written to or read from any location in this type of memory.

Reset
Simply — go back to the start, do not pass GO, do not collect 200 bytes. A switch whereby computer control is returned to the *monitor* or low-level *operating system* and all internal *variable* values are changed to zero. This may be the only way of getting out of some endless *loop* which has arisen from a programming error.

Refresh
Usually refers to the process required by *dynamic memory* to ensure continued storage of *data* that has been sent to it. Dynamic memory can be thought of as consisting of large numbers of small capacitors. When the *CPU,* for example, wants to store a specific bit of information in memory it charges one of these small capacitors. The capacitor will slowly discharge itself, however, so additional hardware is used to look periodically at all of the capacitors and refresh the charge on each one.

Register
A general-purpose *memory,* or set of memory *locations,* built into the *microprocessor* itself. Sometimes, particular registers may be designated for a specific purpose.

Relative Addressing
Mode of addressing whereby the *address* is formed by combining the current program count with a displacement value which is part of the *instruction.*

Return
The key and corresponding computer instruction which sends the contents of *keyboard buffer* into a computer's *memory* for *execution* (term derives from 'carriage return' on a typewriter).

ROM
Read Only Memory. *Memory* device which has its *data* content established as part of manufacture and cannot be changed.

Routine
A whole *program* or part of a program designed to perform a single function or action.

RS232
A communications *interface* used for *modems* and for serial *printers.*

Run
Instruction to *execute* a *program.*

S-100
Name of a *bus* or connection standard shared by many manufacturers and employing 100 connection positions. Unfortunately, there are some minor variations between different manufacturers' versions of the S-100 bus but the *IEEE* has now defined a universal standard for it.

Serial
Transfer of *data* one *bit* at a time.

Software
The different kinds of *program* required to work a computer.

Source Code
Program written in one of the *high-level languages* and requiring *compilation* into *machine language* before use.

Stack
A last-in-first-out store made up of *registers* or *memory* locations used for temporary storage.

Stack Pointer
Address that specifies the location of the last entry in the *stack.*

Static RAM
Random Access Memory which does not require continuous *refresh* signals. It tends to use more power than *dynamic RAM* and still loses its contents when power is removed.

String
A squence of *alphanumeric* characters.

Subroutine
A part of a *program* which performs a specific task and which is available for use elsewhere in a program, as often as you like.

Syntax
The grammar of a programming *language.*

Terminal
A device, normally remote from the computer, at which *data* can enter or leave a communication network — eg a teletypewriter working over telephone lines.

Time-Sharing
A method of operating a computer whereby two or more users apparently enjoy simultaneous access to, and control of the machine. In practice what is happening is that the computer is attending to the users one at a time, but in a sequence of time intervals so short that none is normally aware of any delay.

Tri State
Description of logic devices whose outputs may be disabled by placing them in a high impedance state.

Two's Complement Arithmetic
System of performing signed arithmetic with *binary* numbers.

TTY
Teletype.

Variable
A specified location in *memory* (usually *RAM*) which is allocated a specific meaning in a *program* or *routine.*

VDU
Visual Display Unit. Usually a TV set in hobby computers, but may be a video monitor which accepts the output directly from the computer.

Vector
Memory address provided to the *processor* to direct it to a new area in memory.

Volatile
Memory devices that will lose *data* content if power supply removed (ie *RAM).*

Word
Parallel collection of *binary* digits much as *byte.*

Word Processor
A computer with *software* for entering, editing, storing, formatting and printing text, rather than processing figures. **HE**

THE AFFORDABLE COMPUTER

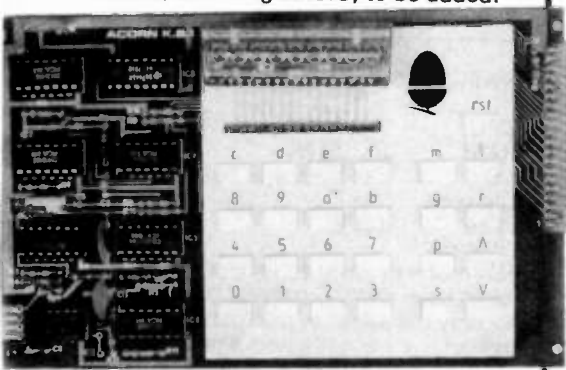
Acorn Computers

Acorn Computers,
4A, Market Hill,
Cambridge.
Tel: 0223-312772

Acorn

CPU	6502
RAM	1K/8K
I/O	Bus Parallel
Cassette	Yes
Price	£65 upwards

The Acorn is a single-board computer with a piggy-back Hex keypad and cassette interface. Although able to be programmed in machine code only, the Acorn micro is designed with rack-based expansion capability allowing extras, including BASIC, to be added.

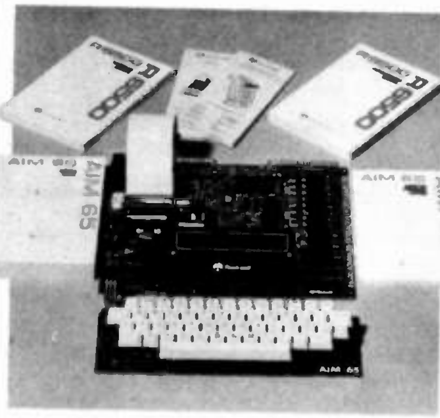


ATOM

CPU	6502
RAM	2K/11K
I/O	Bus Parallel
Cassette	Yes
Price	£125 kit, £150 built

The ATOM is a cased, single-board microcomputer, able to be programmed in either BASIC or assembly code; it also allows nested assembler programs to be written at the same time as BASIC.

Although the ATOM BASIC is an Integer BASIC (it can't handle fractions), an additional ROM chip can be added, providing a full range of mathematical functions, floating point arithmetic and colour graphics commands.



AIM 65

Pelco Electronics,
Enterprise House,
83-85 Wester Road,
Hove, Sussex BN3 1UB.
+ many regional outlets
Tel: 0273-722155

Rockwell AIM 65

CPU	6502
RAM	1K/4K
I/O	Serial Parallel
Cassette	Yes
Price	£265 upwards

The AIM 65 consists of two boards, one holding the 54-key keyboard and the other, the processor, the 20 character, 16-segment LED display and the 20 column printer. When first introduced the AIM 65 had no video interface, however, it now has a video option — so all of you interested in interactive games can breathe again. The machine includes a Text Editor as part of the standard system software and includes 8K of BASIC, an 8K machine code monitor and Assembler options. Other extras include additional RAM, a disc option and a case for the complete system.

ATARI

Ingersoll Electronics,
202, New North Road,
London N1 7BL.
Tel: 01-226 1200

ATARI 400

CPU	6502
RAM	16K
I/O	Serial
Cassette	Yes
Price	£400

The ATARI 400 can be programmed in machine code and BASIC and is supported by a wide range of software packages.

Additional extras include a plug-in board incorporating four RS232 interfaces and a parallel Centronics printer interface port. You will need to buy a special cassette deck as the ATARI 400 supports its own and no other — however, don't worry, the Atari cassette deck comes complete for around £50.

There is also a down-grade model of the ATARI 400, soon to be available in this country for £299.95. Before you rush and order one, though, bear in mind that it is only an ATARI 400 without the essential BASIC pack, which you'll need anyway.

BBC Microcomputers

BBC Microcomputer Systems,
PO Box 7,
London W3 6JX.

BBC Model A

CPU	6502
RAM	16K
I/O	Various
Cassette	Yes
Price	£299

The introduction of the BBC micros caused quite a stir earlier in the year . . . . simply because they were exceptional value for money! Since then, the prices have been increased but they still command a significant share of the home computer market.

The Model A can be programmed in BBC BASIC (probably the most powerful adaptation of BASIC yet) allowing fully structured programming techniques and, in a similar way to the ATOM, can handle nested assembler programs.

A number of additional extras are available, including a floppy disc controller, a speech synthesiser, an Econet interface and a universal expansion interface called the TUBE. This last feature is available on BBC machines alone, providing a direct communications link to the processor. To give an example of the expansion possibilities, plans are under way to develop a 16-bit processor, to connect to the TUBE, that will provide a further 256K of RAM!

The Model A includes sound and bus interfaces and is completely expandable to the Model B.

BBC Model B

CPU	6502
RAM	32K
I/O	Various
Cassette	Yes
Price	£399

Similar in format to the Model A, the Model B machine includes the following extras: a serial interface to RS432 standard; an 8-bit 'Centronics-type' parallel printer port and an I/O port. There is also a 1 MHz buffered extension bus provided for connection to PRESTEL, Teletext or various other expansion units.

HEATHKIT H8

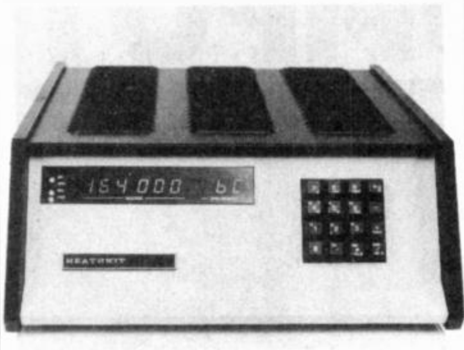
Heath Electronics,
Bristol Road,
Gloucester GL2 6EE.
Tel: 0342-29451

Heathkit H8

CPU	8080
RAM	4K/56K
I/O	Various
Cassette	Yes
Price	£275 upwards

The Heathkit H8 is a bus-based kit system incorporating BASIC and a 4K machine code monitor with full 'front panel' — the front panel (a hangover from the mini-computer days) allows you to inspect and modify the internal workings of the processor.

Extras for the H8 include a disc option, various printers and a VDU. A number of high level languages can be added to the system, loaded from tape or disc.



Nascom Microcomputers

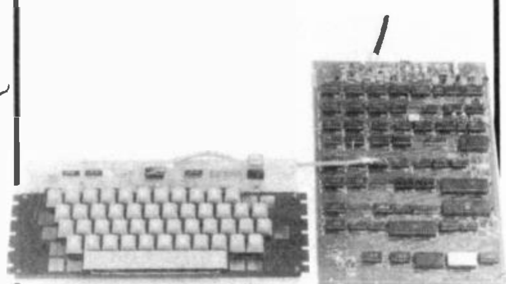
Lucas Logic,
Nascom Microcomputers Division,
Welton Road,
Wedgnock Industrial Estate,
Warwick CV34 5PZ.
Tel: 0926-497733

NASCOM 1

CPU	Z80
RAM	1K/227K
I/O	Serial Parallel Bus
Cassette	Yes
Price	£125

The NASCOM 1, simplest of the NASCOM range, is a full 47-key keyboard machine code system available in kit form or as an assembled, but uncased, system.

Although programmable in machine code only, there is an option for BASIC. Other extras include a motherboard, additional RAM, ROM and discs. A case for the complete system is also available.



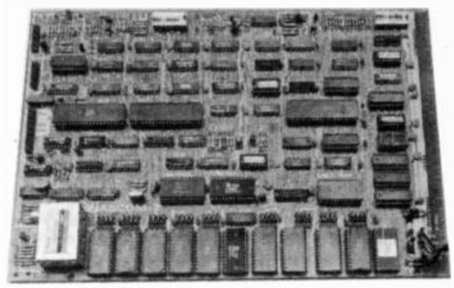
NASCOM 2

CPU	Z80
RAM	1K/227K
I/O	Serial Parallel Bus
Cassette	Yes
Price	£225

Supplied in kit form or as an assembled, but uncased, system, the NASCOM 2 is an upgrade of the NASCOM 1.

The NASCOM 2 comes complete with 8K of Microsoft BASIC, assisted by the NAS SYS operating system with full screen editing. Other optional extras including additional RAM, discs, a high resolution graphics board and a case.

Using a ROMcard for firmware expansion, the NASCOM 2 can also support a wide range of compatible software including enhanced BASIC; MBASIC — a compiled BASIC for fast program execution running under CP/M; NASCOM Pascal; NAS-PEN — NASCOM's word processing package; ZEAP — a Z80 editor-assembler package; NAS-DIS — a companion disassembler for ZEAP; NAS-DEBUG — a debugging aid; NAS-DOS — NASCOM's own disc operating system; and CP/M 2.2 — a full implementation of the CP/M disc operating system.



NASCOM 3

CPU	Z80
RAM	8K/227K
I/O	Serial Parallel Bus
Cassette	Yes
Price	£376

Not much to write about this system — its all been said! The NASCOM 3 is exactly the same as the NASCOM 2 system . . . but it's packaged in a strong case with a high quality QWERTY keyboard.

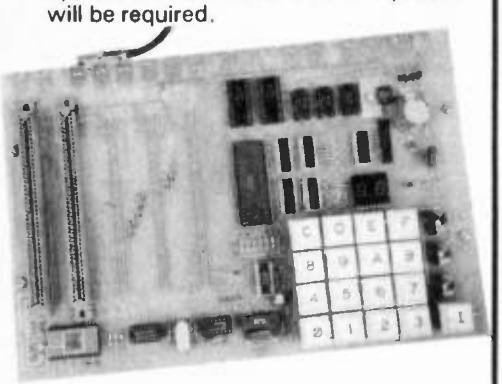
Netronics

Newtronics,
255, Archway Road,
London N6.
Tel: 01-348 3325

ELF II

CPU	1802
RAM	¼K/4K
I/O	Parallel
Cassette	Optional
Price	£60

The ELF II is a fairly basic kit system incorporating CPU and RAM as described above, an 1852 VDU controller, a two digit, seven segment display and a Hex keyboard. The unit can be used for development work or control applications but is particularly suitable for training and education purposes as the system hardware and software is built up in easy stages. Optional extras for the ELF include additional RAM and a motherboard (called the Giant) providing a 1K machine code monitor and an interface for a cassette. Using the cassette interface, various software options are available including ELF-bug — a debugging aid; an Assembler; and BASIC, although to program the system with BASIC an ASCII keyboard will be required.



EXPLORER 85

CPU	8085
RAM	4K
I/O	Parallel Bus
Cassette	Yes
Price	£285

The EXPLORER 85 is an S100-based kit system that when fully expanded can cope with up to six S-100 boards. Complete with a 2K machine code monitor, 8K of Microsoft BASIC can be added via ROM or cassette. No keyboard is supplied with the EXPLORER 85 and neither does it have the ability to directly drive a display, thus you may be glad to hear that an ASCII keyboard and video card are available from Netronics. There is also available a case and a power supply to run the full expansion.

PC 1211

Sharp UK Ltd,
Thorn Road,
Newton Heath,
Manchester M10 9BE.
+ growing network of dealers including Microdigital.
Tel: 061-205 2333

PC 1211

CPU	2 x 4-bit custom processor
RAM	Approx 1.5K
I/O	No
Cassette	Optional
Price	£120 upwards (inclusive of cassette adaptor)

The PC 1211 is a pocket-sized (about the size of a cheque book) 1424 step programmable computer working in the BASIC language. The display consists of a 24 character, 5 x 7 dot matrix LCD strip which rolls to give an 80 character line. A cassette adaptor and a printer interface are available as optional extras. The silver oxide battery cells can be expected to last around 300 hours and the machine thoughtfully turns itself off after seven minutes if you have left it on. A useful little machine!

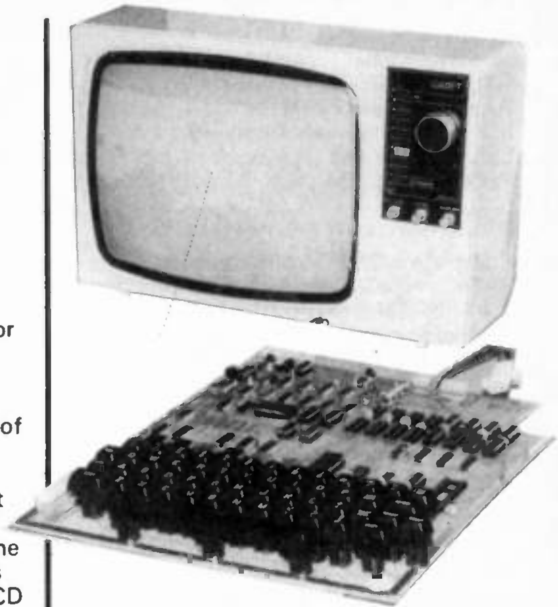
SUPERBOARD II

Mutek,
Quarry Hill,
Box, Wiltshire.
+ many regional dealers
Tel: 0225-743289

SUPERBOARD II

CPU	6502
RAM	4K/32K
I/O	Parallel Bus
Cassette	Yes
Price	£150

The SUPERBOARD II is a ready-built single board computer with a 2K machine code monitor and 8K of Microsoft BASIC in ROM. Options for the SUPERBOARD include room for an additional 4K of plug-in RAM, discs and an RS232 interface. A case for the complete system is also available. A large range of software, on both tape and disc, supports the SUPERBOARD.



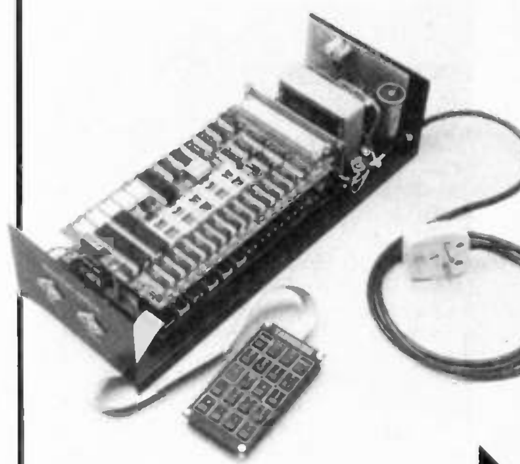
Tangerine Computers

Tangerine Computers,
Forehill,
Ely, Cambs.
Tel: 0353-3633

MICROTAN 65

CPU	6502
RAM	1K/48K
I/O	Bus
Cassette	Optional
Price	£69 upwards

Containing a 1K machine code monitor (Tanbug), the MICROTAN 65 can be expanded with a Tanex board providing a 10K Microsoft BASIC, parallel and serial I/O, an additional 7K of RAM and XBUG (an extension monitor). Tangerine offer Tanram as an expansion system offering a further 40K of user RAM; another system promised a year ago, Tandisc (offering the option to use floppy discs), has still yet to appear on the UK market. With an additional Hex keypad or full ASCII keyboard, this system becomes a very powerful beast indeed.



MICRON

CPU	6502
RAM	8K/227K
I/O	1 serial, 4 parallel
Cassette	Yes
Price	£395

Complete with 10K of Microsoft BASIC and a 3K machine code monitor, the MICRON also provides XBUG, an extension monitor providing Assembler/Disassembler functions, as a standard feature. The unit has a soundboard and is capable of high resolution graphics. Extras offered include additional RAM, an I/O rack system and a disc option.

Tandy Corporation

Tandy Corporation,
12th Floor, Tameway Tower,
Bridge Street, Walsall,
West Midlands WS1 1LA.
+ many regional shops

TRS-80 Model 1

CPU	Z80
RAM	4K/48K
I/O	Optional
Cassette	Yes
Price	£380 upwards

The TRS-80 Model 1 is available with two levels of BASIC: a fairly standard BASIC and one with a few luxury items such as Auto Line Numbering and IF . . . THEN . . . ELSE; and a 48K machine code monitor. A number of options are offered on the Model 1 allowing discs, printers, I/O, high resolution graphics and lower case characters to be used.

TRS-80 Model III

CPU	Z80
RAM	4K/48K
I/O	Parallel
Cassette	Yes
Price	£499 upwards

The Model III is a complete packaged version of the TRS-80 Model I with the added extra of enhanced Level III BASIC. All the options for the Model I are also available for the Model III with the addition of an RS232 interface.

Color Computer

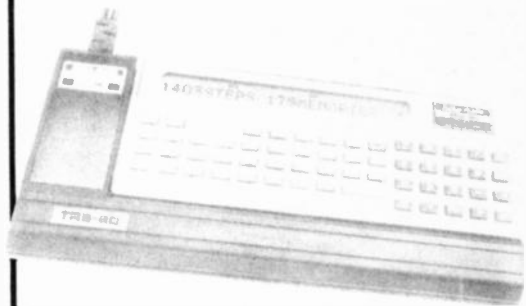
CPU	6809
RAM	16K
I/O	Serial
Cassette	Yes
Price	£449

The new Tandy Color Computer incorporates Color BASIC, different to the BASIC languages used in the Models I and III. Including an option for disc expansion, the Color Computer is also ably supported by a number of Program Paks that actually plug into the machine.

Pocket Computer

CPU	2 x 4-bit custom processor
RAM	Approx 1.5K
I/O	No
Cassette	Optional
Price	£119

The Tandy Pocket Computer is a hand-held BASIC programmable computer almost identical to the Sharp PC 1211 (see description of the Sharp).



TI-99/4A

Texas Instruments,
European Consumer Division,
Manton Lane,
Bedford MK41 7PA.
Tel: 0234-67466

TI-99/4A

CPU	TMC 9900
RAM	16K
I/O	Various
Cassette	Yes
Price	£299

Based on TI BASIC, the TI-99/4A is capable of reproducing 16-colour graphics. Expandable up to 32K, various additional options can support the basic system including a speech synthesiser, a thermal printer, an RS232 peripheral adaptor and a disc memory system. Software options include Pascal and the TMS 9900 Assembler. The TI-99/4A is fully supported by over 400 software packages.

TUSCAN

Transam,
59-61 Theobalds Road,
London WC1.
Tel: 01-405 5240

TUSCAN

CPU	Z80
RAM	1K/8K
I/O	Serial Parallel
Cassette	Yes
Price	£195 upwards

The TUSCAN is an S-100 based development system (kit or ready-built) containing a 2K machine code monitor. Options for both BASIC and Pascal are available. Other extras include casing for the complete system, VDU, a disc option, various firmware and S-100 boards.

UK 101

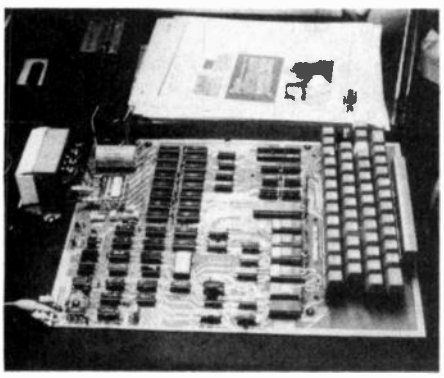
CompShop,
14, Station Road,
New Barnet,
Herts EN5 1QW.
Tel: 01-441 2922

UK 101

CPU	6502
RAM	4K/32K
I/O	Serial Parallel
Cassette	Yes
Price	£149 kit, £199 built

The UK 101, incorporating 8K of BASIC and a 2K machine code monitor (allowing programs to be written in machine code), is basically a UK adaptation of the Superboard II microcomputer.

Allowing expansion of user memory via a RAM pack, extra interfaces and optional disc facilities via an expansion board, the UK 101 can also be upgraded with new machine code monitors.



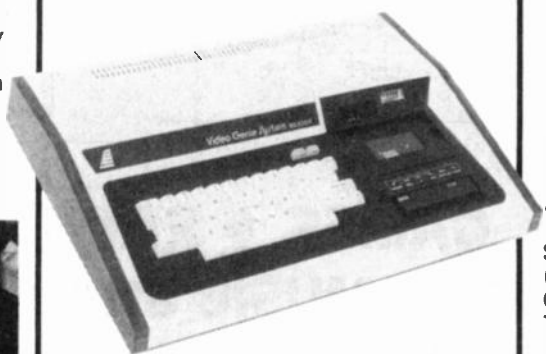
VIC-20

Commodore,
675, Ajax Avenue,
Slough,
Bucks.
+ many regional dealers

VIC-20

CPU	6502
RAM	3K/32K
I/O	IEEE-488 Parallel
Cassette	Yes
Price	£199.99 + VAT

The VIC-20 is a personal computer system incorporating 8K of Microsoft BASIC with colour and sound. However, a word or two about the screen formats. The resolution is not particularly good and very awkward to program in colour. Also, the screen format is not compatible with the PET, so you will find much of the software available on the market will have to be drastically rewritten for the VIC. The system allows for additional memory and an RS232 interface to be added. A special cassette is required for the VIC-20 system costing around £50.



Video Genie

Lowe Electronics,
Bentley Bridge,
Chesterfield Road,
Matlock, Derbyshire DE4 LEF.
+ dealer network
Tel: 0629-2817

Video Genie

CPU	Z80
RAM	16K/48K
I/O	Parallel Bus
Cassette	Yes
Price	£425

The Video Genie is basically a Hong Kong copy of the TRS-80 with Level II BASIC. The machine contains 10K of BASIC and a 2K machine code monitor. Newer versions of the Video Genie contain an upgraded keyboard and no internal cassette; other versions are capable of colour graphics. Extras include a printer and discs via an expansion unit à la Tandy.

ZX81

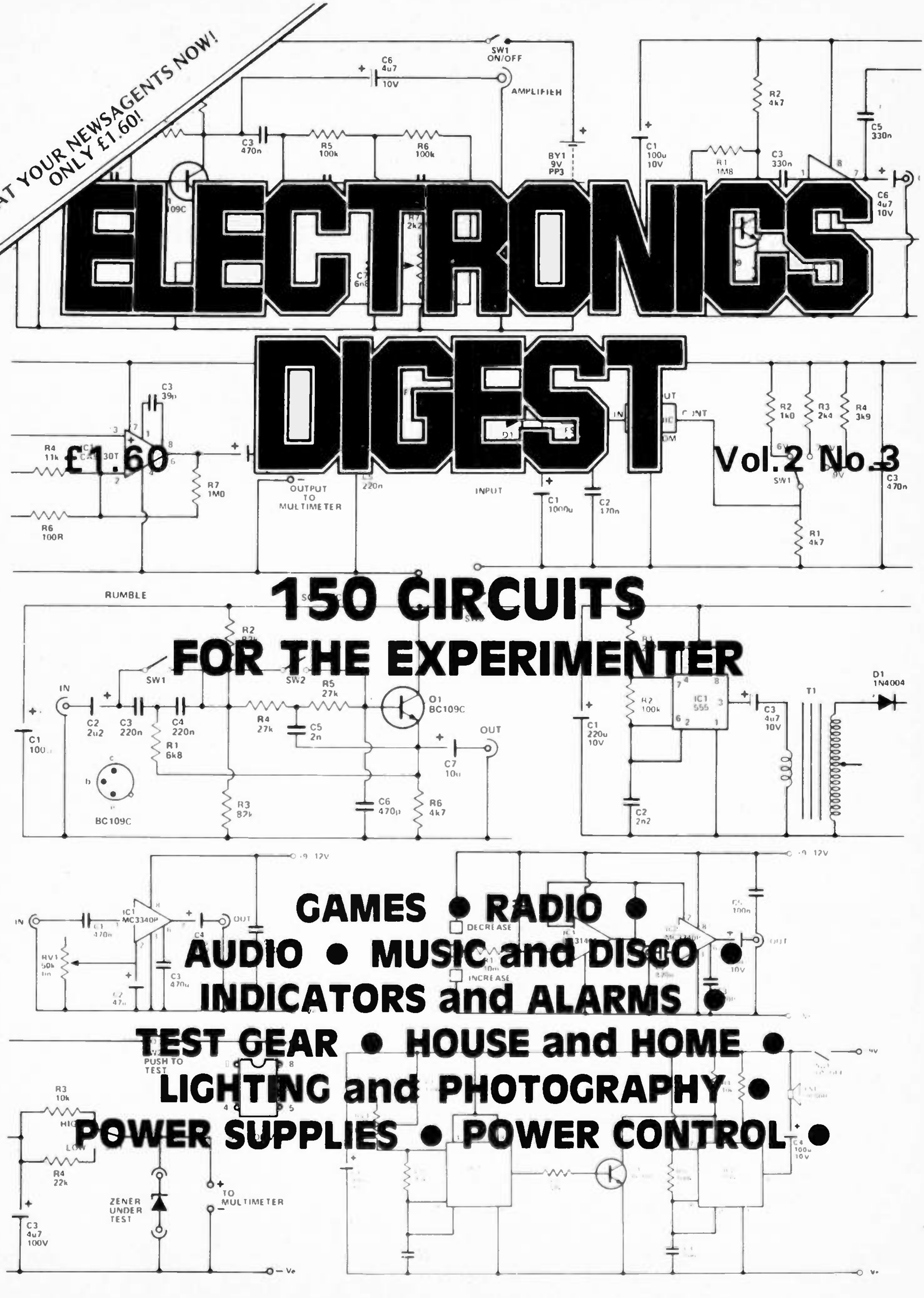
Science of Cambridge,
6, Kings Parade,
Cambridge CB2 1SN.
Tel: 0223-311488

ZX81

CPU	Z80A
RAM	1K/16K
I/O	Bus
Cassette	Yes
Price	£49.95 kit, £69.95 built

You'll all have heard of Clive Sinclair's ZX81 — replacing the successful ZX80; this is the one that has really taken the computer into the home and at less than £50 for the kit you can see why. Complete with 8K of BASIC, the ZX81 can interface to an additional 16K of RAM and a Sinclair printer. There is a wide range of software available for the ZX81. **HE**

AT YOUR NEWSAGENTS NOW! ONLY £1.60!



ELECTRONICS DIGEST

£1.60

Vol.2 No.3

150 CIRCUITS FOR THE EXPERIMENTER

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Clever Dick

In an unusual spirit of helpfulness, I'll start this month's offerings with a piece of useful information. Don't get too excited, though . . .

Dear Clever Dick,
Reference the Audio Millivoltmeter project, HE May 1981.
The transistor specified is a BC 558A but I cannot trace this through the usual suppliers. As I'm keen on constructing this project, perhaps you could suggest where I could obtain the transistor? Alternatively, you might be able to name an equivalent.
Thank You,
D. Summersby,
Canterbury, Kent.

Perhaps? Might? Does this man doubt my wisdom?
Of course I can . . . just let me think a moment.
I'm surprised you haven't been able to find it, though. The BC558 is a fairly common general purpose PNP silicon transistor available from Rapid Electronics and Watford Electronics, among others, and appears in their advertisements in the latest issue of HE. The 'A' designation indicates a different pin configuration; otherwise it is the same as the BC558.

Producing a monthly magazine is like politics — you can please all of the people some of the time, or some of the people all of the time — but you can't please all of the people all of the time (with apologies to A. Lincoln). Sometimes though, we win one . . .

Dear CD,
After buying HE and binders for three years I decided to stop because my money supply was short and it seemed as though most of the circuits you print are just 'mods' of those from Volume 1. But, on the way home one night, I noticed the February '82 issue and thought I'd give you a second chance.
Not bad, I thought, except that you've made a boo-boo in the last paragraph of column one on page 54, in the feature Solder/Soldering.
You state that tin melts at 327°C and lead melts at 232°C; surely this is the other way round? Otherwise it wouldn't tie in with the Eutectic curve on page 54 (I'm an industrial chemist working in the motor industry and just lately I've been investigating solder melting points, as it is used as a car body filler — "lead loading").
Now I've caught you out, don't you think I deserve a binder eh? I've started saving HE again!
Also, was it not Lee De Forest who wrote and worked on photo-resists? Come clean — how about a review of his work on this subject?
Thanks,
A. Mason,
Birmingham.

After a promising start, it appears that we lose, after all. Yes, tin actually melts at 232°C and lead at 327°C, as shown in the diagram at the top of page 54. As for Lee D. Forest, I'm investigating and will let you know when — and if — I find out!

A perceptive reader in Dundee, Scotland, has spotted an error in one of my earlier replies.

Clever Dick,
I read with interest your reply to I. Scholey's request for a supplier of a thyristor (February '82), your answer being R.S. Components.
I have access to the R.S. catalogue where I work and, as I have been searching for some 1% resistors for a digital meter, here was my problem solved! But on the back page, under their "terms of business", R.S. state that they will only accept orders from "bona fide" trade users. Or is it only in your area (south of Watford Gap) that locals can use the trade counter?
Meanwhile I am still searching for the resistors.
Yours sincerely,
T. Bowman,
Dundee.

It seems that I allowed my enthusiasm for R.S. Components well-ordered (and well stocked) catalogue to obscure the fact that they only accept orders from "full time Industrial, Educational and Trade users of electronic and electrical components". Fortunately, there is a solution to your problem: Crewe Allan, 51 Scrutton Street, London EC2A 4PJ, (Tel. 01-739 4846) can supply components from R.S's catalogue.

Many thanks to all those readers who suggested methods for reversing the polarity of a dynamo. Meanwhile, Mr. Lawrence (and, presumably, his car stereo) is still alive and well.

Dear CD,
As a beginner in electronics, I find your magazine very readable and comprehensible. I have now been an avid reader of HE since June '81.
My interest in electronics really takes me to hi-fi and some of its applications and for this reason I am indebted to you for your marvellous new feature, Scaling the Hi-Fi Heights. It really has been very helpful.
I have built your Ladder of Light (January '81) with great success but would like to extend my effects. I would be grateful if you could see your way to publishing a circuit for a strobe light (possibly for use with car tuning, as well) or maybe a circuit for smoothly switching from one pair of speakers to another (for those among us whose amps have only one pair of outputs), or perhaps a series on sequencers and sound lights.
Keep up the good work and thanks for a great mag.
Yours sincerely,
A.M. Lawrence,
Chessington, Surrey.

A couple of interesting suggestions there, which have been passed to the editor for consideration (that's what he calls it).

Some of the subjects we like to talk about — and you like to read — are a little too complex to be covered in just one article. One of the problems with a series, though, is that readers who miss the first few instalments sometimes manage to miss a vital point.

Dear CD,
I am new to HE and have only the last three issues. What do I think about them? Here's what I think: "brilliant, fantastique, super, irresistible, educational — and funny".
I enjoy the feature Into Electronic Components but I have a major problem. I can't build the HE Meter used for the tests 'cause I don't have a circuit or any information about it.
So please, please, please, can you send me those articles?
Yours sincerely,
A. Hunt,
Bath, Avon.

Regular readers of HE can stop chuckling, now. They know that the HE Meter was never a project but a standard multimeter which was on special offer in the August 1981 issue. Although the series was written around this meter, almost any regular multimeter will do the trick — just be careful to switch to an equivalent or higher range than that mentioned in the article.

As the magazine which supported Citizens' Band radio in the days before it became really popular, we have always maintained an interest in the subject, as have at least a few readers.

Dear Clever Dick,
Is the TV/FM Masthead Amplifier suitable for a Citizens' Band radio antenna? Also, the PCB design is not very clear (especially the top foil). Could you please clarify these for me?
While I'm on the subject of CB, I have found that my loft is unsuitable for an antenna. Is it possible to line my bedroom floor with silver foil, with a biscuit tin underneath, and stick a magnetic mount to the biscuit tin?
Yours faithfully,
R. Castley,
Fareham, Hants.

Without knowing in what way your loft is unsuitable, it is difficult to advise how to rig up a suitable antenna — but I would certainly NOT recommend lining the floor with silver foil, or using a biscuit tin as a base for a mag-mount antenna. Try one of the commercially available base station antennas from Telecomms, 189 London Road, North End, Portsmouth (Tel. 0705 662145).

The Masthead Amplifier will operate down to 40 MHz, according to the data sheet, which means that it probably is not useful for the CB band (27 MHz). The component overlay on page 42 shows the bottom PCB foil, viewed from the top ie, through the board. Although it is slightly blurred (due to peculiar production problems that month) it is ACCURATE; the important point is that pin 1, the input, is one on the right of the board, as shown.

I have had many letters suggesting methods for reversing the polarity of a negative earth car electrical system, all of which corresponded to the information I sent on to Mr. Lawrence. Mr. Banks, of Dartford, Kent, also had another interesting suggestion.

Dear CD, ...
Oh, and one more bit of genius (modest, isn't he?) this time regarding your Switch-Tuned Radio project (January 1982). Why not replace one of the presets with a normal potentiometer of the same value, and bring it out to the front panel? This would then give five preset stations and the complete freedom of the dial for those 'on-off' stations you never otherwise listen to.
Yours sincerely,
R. Banks,
Dartford, Kent.

An excellent suggestion which should not prove difficult for HE constructors. If anyone tries it, let me know 'how it works'!

Now for another instalment from the Helpful Hints Department, Ancient History Division.

Dear Clever Dick,
Could you please tell me which relay was used in the Car Alarm project (February 1979) and also, where I can purchase one?
Yours sincerely,
J. Beardswood,
Liverpool.

The relay is listed as a 12 V/280R type with contacts rated at 6 amps; you could try TK Electronics at 11 Boston Road, London W7 3SJ (Tel. 01-579 9794) for a suitable equivalent. Unfortunately, Hobbyprints are no longer produced, so you will have to make your own PCB; take a look at HE's February issue for the easy way.

We always try to make clear where components for HE projects can be obtained, but not always successfully.

Dear Clever Dick,
As a newcomer to your magazine, I would be most grateful if you could help me.
Why is it that nearly every time I try to get components, eg resistors, diodes, capacitors and transistors, I am told to write away to the makers?
As I have decided to build your Noiseless Fuzz Box (HE, February '82), I'm worried that I may not be able to get the components I require. Does the Fuzz Box come in kit form? If not, can you recommend a reliable supplier?
Finally, may I congratulate you on Makin' Tracks; it shows step-by-step, easy-to-follow instructions on how to make PCBs.
Thanks,
G. Logan,
Yorkshire.

Well, I have certainly never advised anyone to "write away to the makers"; they are generally not in the business of supplying parts to small customers (no offence) such as you and I. We try to indicate where parts are commonly available in Buylines and, as of this issue, these have been collected into a single page of information which will make the laws of supply easier to handle. The law of demand is up to you!

That particular project is not available as a kit but all the parts should be available from one of the many mail-order suppliers who advertise in HE.

Occasionally I receive a letter marked "not for publication", which is OK by me (some of them I couldn't print, anyway!), but those who do not include an SAE cannot expect a reply by post, either. Would the lads from Kenmare, Co. Kerry, please take note?

I appear to have quite a few fans in the Emerald Isle.

Dear CD,
I am fourteen and trying to pick up electronics as a hobby, but so far I am only able to make a few simple kits.
I find that HE is the best magazine about. Please, could you send me some information on electronics or old HE magazines?
Yours faithfully,
J. Kilgannon,
Co. Galway, Ireland.
PS Your page is the best in Hobby Electronics.

Well, thanks for the compliment, but I suggest you try reading a few of the other pages, too. Like the Backnumbers and Book Service pages.

Fault-finding by remote control (ie, your letters) is impossible unless the symptoms of the fault are accurately described (it's no use writing in that "it doesn't go!"), so take note of this next letter, when next you have a problem for me to solve!

Dear Clever Dick,
I am operating two televisions from one aerial via a splitter box. One is a 26" colour set with pre-set tuning and the other is a mains-operated portable with a rotary tuning control. If I turn both sets on, leaving the portable un-tuned, I get a perfect picture on the colour set.
However, when I tune the portable, the picture on the colour TV becomes unstable and various interference patterns occur.
It is possible to get a good picture on the colour set by extremely careful adjustment of the tuning of the portable set — but it is difficult. The portable picture is OK at all times.
Can you help?
P.K. Spruce,
Stoke-on-Trent.

Running more than one TV off a single aerial is always a chancy business; you may get two good pictures, but usually you don't. It all depends on the strength of the signal you are picking up from the transmitter. The effect you are describing sounds like insufficient signal strength, so the HE Masthead Amplifier (February 1982) is what you need for a little extra boost down the wire.

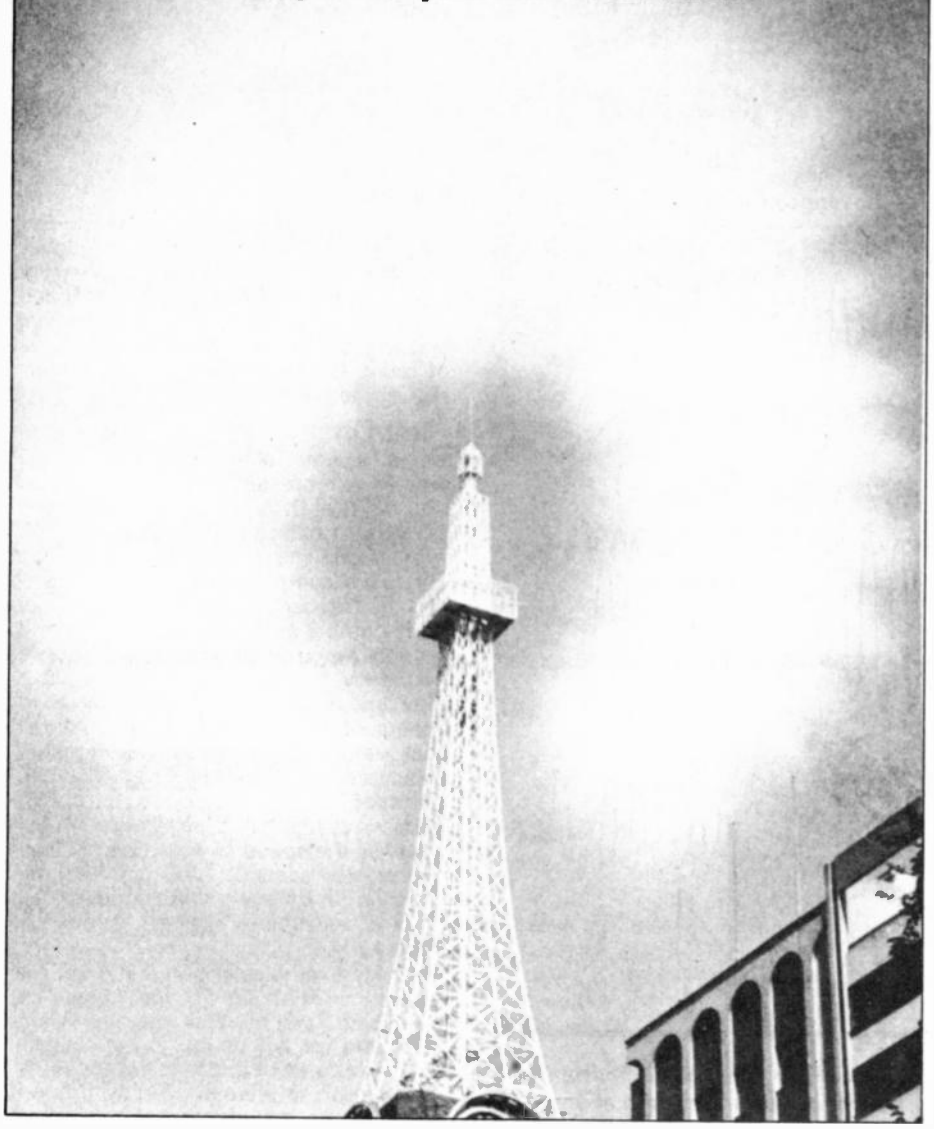
Many HE readers are interested in models, of one kind or another; others have more special interests.

Dear CD,
I was recently asked, by a friend, if I knew a way to take an electronic steam whistle effect for use on a model railway. I could only offer a modern diesel engine horn circuit, which would not suit a steam train.
Please could you help tidy up his problem, and mine.
Yours grovellingly,
A. Donaldson,
Solihull.

This is an easy one; a Steam Loco Whistle project appeared in the March 1981 issue. Your friend might also be interested in the Steam Chuffer (January 1981), not to mention our super Dual Engine Driver in this month's issue.

That's it for this month. Perhaps they'll let me go home, now.

HE



RADIO RULES

A new series, introducing the theory and practice of radio.

ALTHOUGH Hobby Electronics was the first magazine to support Citizens' Band radio in this country, the subject of radio (in general) has never been fully explained in HE. So, now that CB is well-established, we've decided that it's time our readers had a chance to further explore one of the most fascinating aspects of electronics — amateur radio.

Like many electronic hobbies, radio requires some skill, not just in building the equipment, but in operating it. In particular, operating a radio transmitter calls for a very good understanding of the principles of radio, and of operating procedures and practices, propagation (the ways in which radio waves travel through the atmosphere) and interference. An inexperienced — or unqualified — operator can cause untold havoc to essential services such as the Fire Brigade and Ambulance services, who also use radio communications, as well as to other radio amateurs. This is the main reason why anyone wishing to operate an amateur radio station must obtain a licence from the Home Office, establishing that they are competent to use a transmitter without causing interference to other users. Many radio enthusiasts, though, are interested only in short-wave listening, pulling in signals from broadcast or amateur stations in far-off countries, but even this simpler form of amateur radio requires considerable skill and understanding.

This series, then, is intended both to explain the principles of radio and to give an understanding of the skills necessary to become a radio amateur. So whatever your intentions — short-wave listening or operating an amateur radio station — here's your chance to get Into Radio!

ONE of the few ways in which Man differs from the rest of the animal kingdom is in his ability to communicate. All creatures 'talk' to each other, but there are no other animals that can communicate with such flexibility or over such great distances.

Somehow, in the dim distant past, Man evolved past the grunt and snort stage and developed several extremely complex languages. These enabled him to pass on information to other people in his vicinity. If he wanted his message to travel further, he shouted louder. If he wanted to communicate with someone who was out of earshot, he wrote down his message and asked someone to deliver it for him. Several days, weeks or months later, depending on the distance involved, he would receive a reply.

Then the discovery of electricity led to a dramatic change in communication techniques. It became possible to activate electrically operated devices such as buzzers or clicking relays from a considerable distance by simply turning on the current and letting it flow down the cable. In 1838, Samuel Morse invented a code that is based entirely on the relationship between the length of time that the current is turned on and the time that it is turned off. Every letter of the alphabet was allocated a sequence of 'dots' and 'dashes'. A 'dot' is indicated by an audio device, often a buzzer, sounding for a very short period. A 'dash' is indicated by the buzzer sounding for a period three times as long as for a 'dot'. Skilled operators could use this code to send messages at 20 to 30 words per minute and Telegraphy, as this system is called, spread rapidly around the world, especially in America where the cables were nearly always laid alongside the newly built railroads.

The next breakthrough came in 1876 when Alexander Graham Bell invented the telephone. He proved that it was possible to send a *voice* signal along a wire, and the telephone rapidly replaced telegraphy for mass communication. Gradually, a telephone system evolved that uses dozens of cables, running across continents and oceans, so that many hundreds of conversations can be held simultaneously, over vast distances. The system works reasonably well, but it is more suited to short-range communications because of the many thousands of miles of very expensive cable that have to be laid across continents and under oceans.

Fortunately, at the same time as the telephone was establishing itself, a new medium was evolving. In the mid-19th century a physicist, James Maxwell Clark, put forward the theory that electrical waves could be made to travel through the air. He was never able to prove his theory and it was not until some years after his death that Heinrich Hertz managed to generate the very first radio waves. As these waves 'vibrate' many millions of times every second, it was not possible to generate them mechanically and Hertz used a gadget called a Spark Transmitter. This was, simply, a very large capacitor or inductor, fed by an interrupted DC voltage. When the voltage was interrupted, the

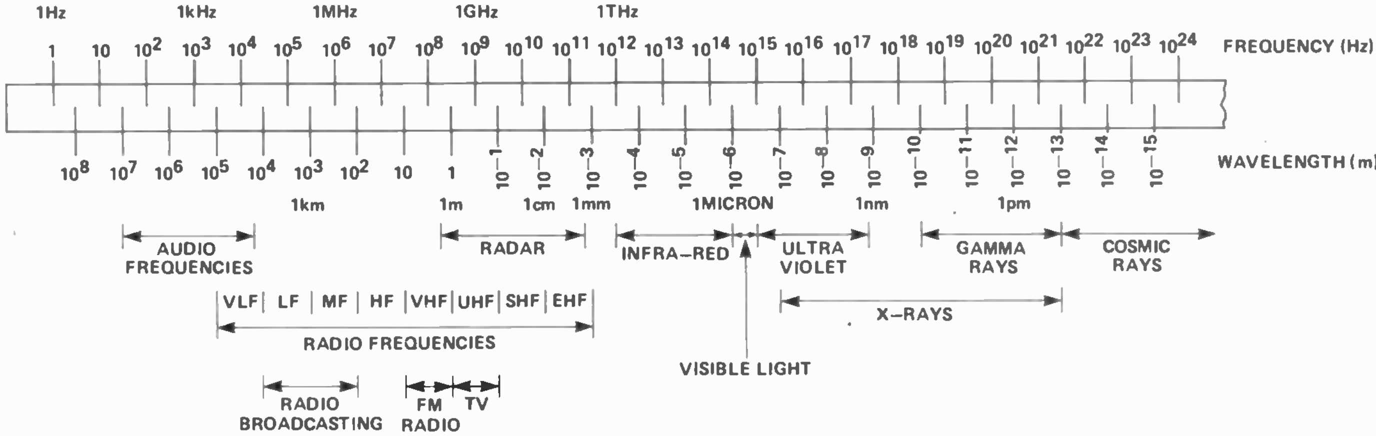
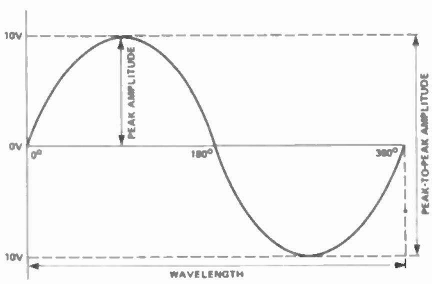


Figure 1. The electromagnetic spectrum covers the range of frequencies from audio up to cosmic rays.



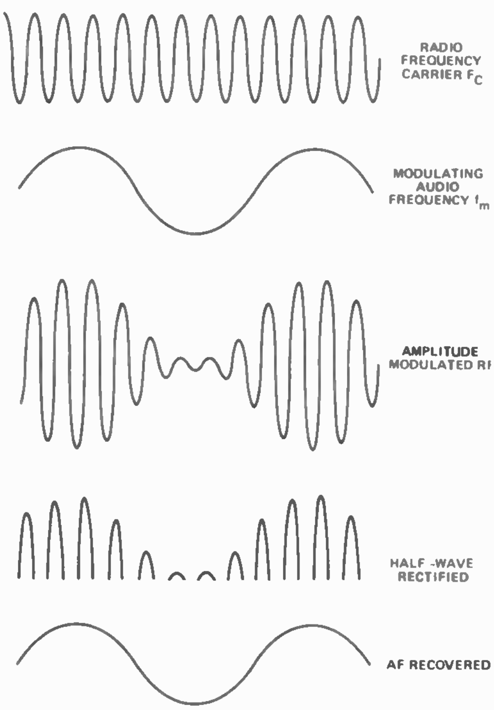


Figure 2 (above). The essential characteristics of a single sinewave. A sinewave may also have a certain *phase*, in relation to another sinewave; this is the angle (between 0° and 180°, measured on the horizontal axis) between the start (0°) of one sinewave and the start of the other. Figure 4 (right). Amplitude modulation and demodulation. The amplitude of the radio frequency carrier is made to vary by the modulating audio signal. The audio is recovered by half-wave rectifying the AM signal and filtering out the radio frequencies.

Figure 3. Electromagnetic waves are sinewaves of energy that result from the acceleration of charged particles. The frequency and wavelength of any electromagnetic wave are related by the speed of light (*c*).

To find the wavelength (λ) of a certain frequency (f), simply divide c by f. That is:

$$\lambda = \frac{c}{f}$$

For example, a 27 MHz radio signal has a wavelength of:

$$\lambda = \frac{300 \times 10^6}{27 \times 10^6} = \frac{300\ 000\ 000}{27\ 000\ 000} = 11 \text{ metres.}$$

The frequency of a station with a known wavelength is found by dividing c by λ. That is:

$$f = \frac{c}{\lambda}$$

So, the frequencies of Radio One are:

$$f = \frac{300 \times 10^6}{275\text{m}} = 1.09 \text{ MHz} \quad \text{or} \quad \frac{300 \times 10^6}{285\text{m}} = 1.05 \text{ MHz}$$

energy stored in the capacitor or inductor was discharged across a narrow 'spark gap', and the spark produced radio waves. These waves are sinusoidal and, in order to understand the principals of radio, it is important to fully understand sine waves.

Sine On

The sine wave shown in **Figure 2** is a graphical representation of a voltage that starts at 0 V, gradually increases to 10 V, falls back to 0 V again, sinks to − 10 V and then rises back up to 0 V. This is one complete cycle of a sine wave and the frequency of a sinusoidal signal is the number of cycles that occur in one second. Some older textbooks still quote frequency in 'cycles per second' but they are now usually called Hertz, in honour of Heinrich Hertz. The peak-to-peak value (amplitude) of the signal is measured from point A1 to A2. The length of one complete cycle. B1 to B2, is the wavelength and, as all radio waves travel at the speed of light (300 million metres per second), we can find the wavelength of any given frequency by dividing the velocity by its frequency (**Figure 3**).

As these examples show, the lower the frequency of a signal, the longer its wavelength will be. This is an important point and we will be looking at it again when we come to examine antennas, as their length is always directly proportional to the wavelength of the signal they are designed to work with.

The spark transmitter that Hertz used is considered to be a 'dirty' transmitter because it radiated radio signals on dozens of different frequencies. During the Second World War, for example, these transmitters were used to jam the enemy's signals because it was not necessary to tune them to a specific frequency — a spark will generate interference across almost the entire radio spectrum.

For practical communications, though, sparks gave way to RF oscillators, electronic circuits that can produce sine waves at radio frequencies; we will explain them in a later issue.

It's not much use being able to send electrical signals through the air if they can't be made to carry information with them. Initially, the process of impressing the information on to the signal used the Morse code and, as cables were no

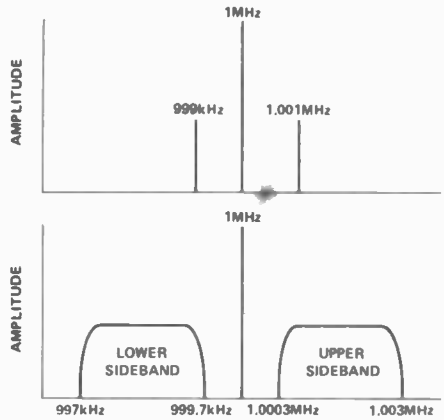


Figure 5. Sidebands, generated by amplitude modulation.

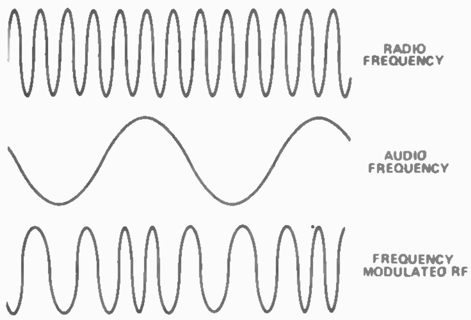


Figure 6. Frequency modulation.

longer used to carry the signal, it was only natural that this system soon became known as 'Wireless Telegraphy'. Unfortunately, 'WT' suffered from the old problem of needing skilled operators, and the search was on for a way of letting people *talk* to each other via radio.

It was soon found to be possible to vary the amplitude of an RF (Radio Frequency) signal in proportion to an AF (Audio Frequency) one, by a process called modulation (**Figure 4**).

However, when one signal is used to modulate another, the result is not really as simple as you might expect. If we were to modulate a radio frequency of 1 MHz with an audio signal of 1 kHz, we would end up with four frequencies — not two (**Figure 5**). The resultant signal always consists of the higher frequency (the 'carrier'), the lower frequency, the higher plus the lower and the higher minus the lower. The 'sum' and 'difference' frequencies, are called the sidebands: the sum signal is the upper one because it is above the carrier and the difference signal is the lower sideband because it is below. When the carrier is being modulated by a constant tone, the sidebands are constant, but when the carrier is modulated by a varying waveform, such as speech, the frequencies of the sidebands will vary within a range of frequencies governed by the modulating frequencies. If the range of the speech frequencies used were to be 300 Hz to 3,000 Hz, then the sidebands would cover the frequencies shown in **Figure 5**.

In fact the bottom half of a modulated carrier wave is a mirror image of the upper half and it carries exactly the same information — using more bandwidth then is actually necessary. To overcome this problem, Single Sideband transmissions are often used. For this sort of transmission, the carrier and one of the sidebands is 'suppressed' at the transmitter and only the other sideband is transmitted. This also means that audio power is not wasted modulating two sidebands. Single sideband transmitters and receivers will be explained in a future article.

Another way to modulate a carrier is to vary its frequency by an amount that is proportional to the amplitude of the modulating signal. This means that the frequency of the carrier is made to vary in frequency either side of its mean frequency, and the greater the amplitude of the modulating frequency, the more the 'deviation' from the mean. As the frequency of the modulating frequency rises, so will the rate of change of the carrier. **Figure 6** shows a typical frequency modulated carrier wave and the modulating sine wave.

FM carriers do not vary in amplitude but, because of the complex nature of the many changing frequencies, they tend to generate a lot of sidebands. This means that an FM signal takes up more room on the RF spectrum, however an FM signal is also relatively immune to noise and interference. In this country, FM is normally used to modulate broadcasts in the VHF (Very High Frequency) band, and the combination of VHF and FM means that the quality of these broadcasts is far better than medium wave AM radio.

NBFM (Narrow Band Frequency Modulation) is a special form of FM. In NBFM signal the total amount of deviation from the carrier frequency is limited to quite a small figure, often 2.5 kHz. This type of FM is usually only used for speech transmissions, as such a narrow band will not carry the quantity of information that is needed for hi-fi quality. The main use for NBFM is in amateur radio and commercial two-way radio, such as the police, taxis, boats and most recently, British CB.

Next month we will be looking at the basic elements of a radio system. We'll be dissecting a transmitter/receiver and getting to grips with some essential ideas of radio circuitry. **HE**

Into Amateur Radio

Before setting up an amateur radio station, it is necessary to obtain a licence from the Home Office. Unfortunately, it is a little more complicated than obtaining a CB licence, but the rewards of amateur radio (the world at your fingertips!) are well worth the effort.

There are actually two classes of licence, A and B, and the basic requirement for either is a pass in the Radio Amateur's Examination (RAE). This is something HE readers should not find too difficult, though, because much of the material will already be familiar!

The other common requirements are (a) British nationality (although Commonwealth or alien residents in the UK may take out a licence under certain conditions) and (b) payment of a fee (£8). To qualify for the full A licence, it is also necessary to pass the Post Office Morse Test not more than 12 months before applying for the licence. The A licence allows operation on any of the amateur bands and permits the use of morse telegraphy; B licence holders are restricted to frequencies below 144 MHz and may not transmit morse.

The RAE consists of two papers; Part 1 contains 23 multiple-choice questions on licencing conditions (the usual beaurocratic stuff), 12 questions on transmitter interference, and takes one hour. Part 2 takes 1¾ hours and consists of 60 multiple-choice questions; five questions are on operating practices and procedures, 11 are on electrical theory, nine on semiconductors, nine on radio receivers, nine on transmitters, 10 questions on propagation and antennas and seven questions on measurements. The RAE is held twice yearly at the City and Guilds of London Institute, Electrical and Telecommunications Branch, 76 Portland Place, London W1N 4AA, but may also be taken at local colleges and examination centres throughout the country.

Morse tests can be taken throughout the year at the Post Office headquarters, in London, at any Post Office Coast Station or at any of the Radio Surveyor's Offices. The Home Office Publication "How to Become a Radio Amateur", which is free of charge from the Radio Regulatory Department, Licencing Branch (Amateur), Waterloo Bridge House, Waterloo Road, London SE1 8UA, contains all the addresses of the Post Office Centres, as well as full details of the requirements for obtaining an amateur licence. The Morse Test is not hard, but does require practice! It involves sending 36 words in three minutes, with up to four corrected errors allowed, and receiving 36 words in the same period. Four corrections may be made in transmission and four errors are allowed in reception. Then, 10 groups of five figures must be sent and received in two periods of 1½ minutes; two receiving errors are allowed and two corrections may be made in sending.

Any reader seriously interested in applying for an amateur licence should contact the authorities at the addresses given, for detailed information on the RAE and the other requirements for a licence. They should also contact the Radio Society of Great Britain. The RSGB, with 29,000 members, is the national society for UK radio amateurs and is their recognised spokesman and representative, both in the UK and internationally. Membership is open to anyone with an interest in amateur radio, whether or not they hold a licence. The RSGB publication "Radio Amateur's Examination Manual", by G.L. Benbow, is an excellent text book for anyone intending to sit the RAE. It is available from the RSGB, 35 Doughty Street, London WC1N 2AE; Tel. 01-837 8688.

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INTO ELECTRONIC COMPONENTS

Part 9 is all about the popular 741 op amp.

ONCE upon a time, engineers used to spend a lot of their time designing transistor voltage amplifiers. The most difficult to design were direct-coupled amplifiers, which used no coupling capacitors. A direct-coupled amplifier will amplify very low frequencies as well as the normal audio range and it will even amplify signals with no frequency at all, that is, DC signals. This means that a small DC voltage at the input of the amplifier will produce a larger DC voltage at the output; the design of these amplifiers is a real headache, because the slightest change in the bias voltage at the input will send the output voltage rocketing up or down.

That all seems a long time ago, because we very seldom need to go through those aspirin-consuming exercises, these days. The reason is that we can be altered by the amount of doping, a single chip of silicon in the form of an integrated circuit. In the previous couple of chapters we've hinted of what can be done. The resistance of a strip of silicon can be altered by the amount of doping so that we can create resistors on a strip of silicon just as easily as we can create junctions. We can also use the silicon to create capacitors, by oxidising the surface and then depositing metal on top of the oxide, just like the gate of a MOSFET. Since silicon can be used to create the four main electronics components (diodes, transistors, resistors, capacitors), there is no reason why complete circuits should not be made from silicon. This fact was first realised, even before the use of silicon in transistors had been established, by W. Dummer, who worked at the Radar Research Establishment in Malvern, in the early 1950s. The idea was much too advanced for British industry (and quite inconceivable to the Civil Service who ran the Radar Establishment and told Dummer to cease work on the idea), but it was enthusiastically taken up in the USA. If the story sounds familiar, you're probably thinking of jet engines, swing wings, or any of the dozens of ideas which had to leave this country to be developed!

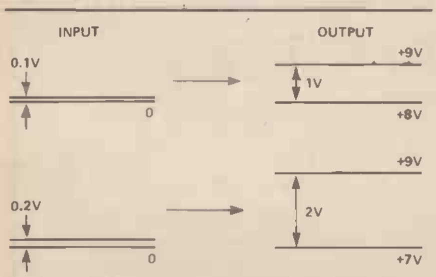


Figure 1. DC amplification illustrated for an inverting amplifier with a voltage gain of 10.

Nowadays, of course, we can buy complete direct-coupled amplifiers in IC form for about the cost of a single transistor. This is because the complete IC amplifier is made in one set of operations — almost the same set of operations as are needed to make that single transistor. One of the best-known direct-coupled amplifiers is the 741; that's the component to which we are devoting the whole of this month's story.

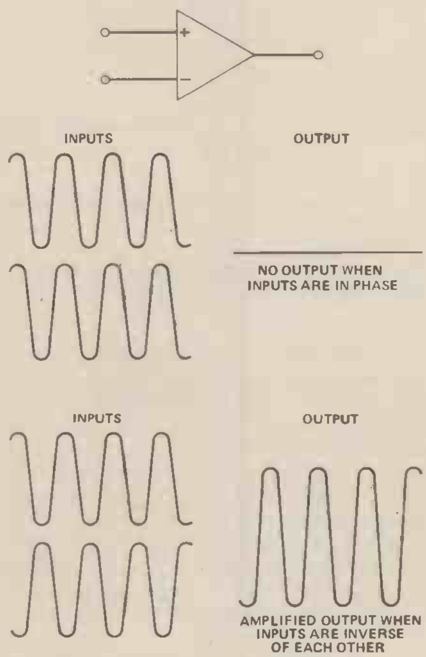


Figure 2. Differential amplification.

It seems odd to think of a complete amplifier as a single electronic component but, as it comes as a single unit, that's what it is. Sometimes we think we would like to know the circuit inside the IC, but we really don't need to know what goes on inside because it doesn't help us to design circuits. What we need to know about the 741 is, in fact, what we need to know about any electronic component — how do we connect it and what does it do? The more we use this approach the better, because the day is rapidly approaching when no-one, apart from the designer, will know exactly what the circuit of an IC is.

What's The Difference?

The 741 is a differential amplifier; unlike the simple voltage amplifier that we are more accustomed to, a differential amplifier has two inputs and the signal which is amplified is the difference between these two inputs. For example, if we put the same sine wave to both inputs, nothing will be amplified because there is no difference. If one of the signals is inverted however (Figure 2), then there is plenty to amplify because the difference between them is a large signal.

What's the point of this arrangement? One reason is that it allows us to use balanced input signals. A balanced signal consists of a pair of identical signals, one the inverse of the other. Now, if any interference is added to these signals, it will be in the same phase on both and won't be amplified by a differential amplifier, whereas the balanced signal will. This allows us to amplify signals which are very weak, weaker than hum or other interference, and to carry them over long cables without risk of interference.

Another reason for using two inputs is that it allows us to use the amplifier in two different ways; when a signal is put in at one input (the 'positive' or non-inverting input), it will result in an output which is in phase with the input, so that connection from the output back to the input will cause positive feedback. The other input ('negative' or inverting input) will, by contrast, result in an output which is phase-inverted compared with the input and, if fed back, this will give negative feedback.

IC It All

The 741 chip can be obtained in various packages, such as a "top-hat" TO-5 transistor casing, but the most useful

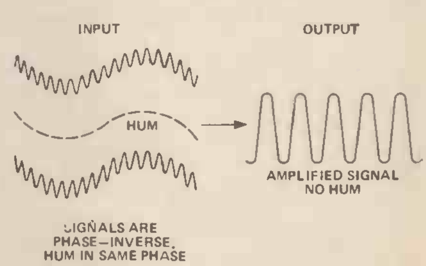


Figure 3. How differential amplification overcomes interference problems.

form for most purposes is the DIL (Dual-In-Line) 8-pin package, shown in **Figure 4**. Not all of the eight pins are used, but identification of pin numbers is easy and the DIL package is used for many other ICs. Notice the two inputs, labelled (+) and (−). The (+) and (−) markings have nothing to do with battery positive and negative; they simply tell you which input is in phase (non-inverting) and which is out of phase (inverting). There is a single output from pin 6, two other terminals which we'll discuss later, and the two supply connections at pins 7 and 4.

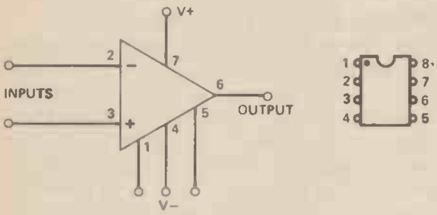


Figure 4. The 8-pin DIL version of the 741.

Many 741 circuits use balanced power supplies, meaning that there are two equal voltages, one positive, the other negative to earth. A popular arangement is +9 V on pin 7 and −9 V on pin 4. This arrangement leads to very simple amplifier circuits, particularly if the 741 is being used for DC or balanced signals, but it is possible to operate the 741 from normal 9 V-and-zero supplies (unbalanced, or single-ended supplies) and we shall look at ways of doing this later.

As it comes, the 741 has a voltage gain for AC or DC of around 100,000 times. This is frighteningly large compared to the transistor voltage amplifiers that we knock up ourselves and it makes nonsense of our usual bias systems. Try this out, using the Eurobreadboard and the circuit of **Figure 5**. The HE meter measures the voltage at the output and the inverting pin (pin 2) is earthed. Now by adjusting the potentiometer RV1, we should be able to adjust the bias on the other input so that the output voltage is exactly zero. Try it — and the chances are you'll find the meter reading either +9 V or, with its needle pressed firmly against the stop, trying to read −9 V. Even if you do manage to get the needle exactly to zero, it's not likely to stay there for long. The reason is not difficult to see. With a voltage gain of 100,000 times at DC, you'll get a shift of 1 V at the output for a change of only 1/100,000 V at the input. That is only 10 uV and you can get 10 uV or so just by exposing a soldered joint to some cold air (as we will see in Part 12 when we look at thermocouples). No ordinary method of biasing is much use when we have gain figures of this magnitude.

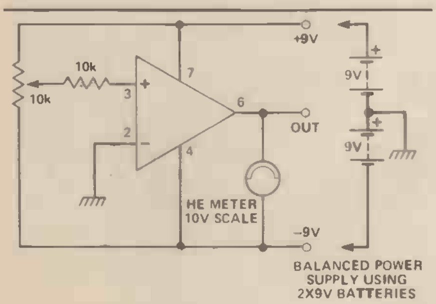


Figure 5. Can you find a bias voltage for the 741?

Getting It Under Control

The simplest way of getting it all under control is to use DC negative feedback. Try the circuit in **Figure 6** — you should find that the output voltage is now exactly zero, with no adjustments to worry about. Why? Well, the non-inverting input has been earthed and the inverting input is connected to the output through a 100k resistor. Now, if the voltage at the inverting input is lower than zero (negative) at some time, then the output will go positive because of the inverting action of the amplifier and this positive voltage, connected to the inverting input through resistor R1, will take the voltage at the inverting input in a positive direction. Suppose, now, that the voltage of the inverting input is positive — more than zero. Because of the inverting action, the output voltage must now be negative and the feedback resistor will make sure that the voltage at the inverting input also goes negative. So, with any voltage change at the output causing the opposite effect at the input, the result is that both input and output settle at zero volts, neither one disturbing the other. This type of bias circuit is used almost universally for 741 circuits, but for a few specialised circuits which need to make use of the full gain of the 741; in these circuits the connections to pins 1 and 5 are used to adjust the bias inside the IC. The circuit used is shown in **Figure 7**. Both inputs are earthed, to set up the circuit, and the potentiometer RV1 is then adjusted until the DC voltage at the output is exactly zero.

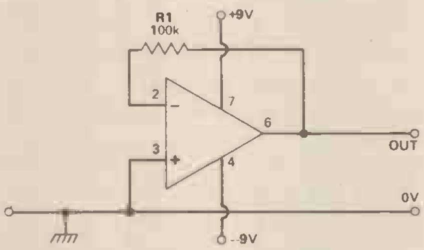


Figure 6. Using negative-feedback bias, with balanced power supplies.

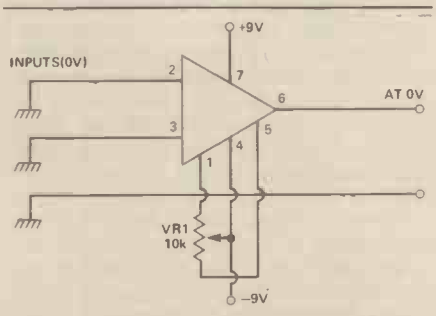


Figure 7. Using the offset adjustment pins of the 741 for a DC amplifier.

Drop It, Drop It

Most uses of the 741 call for much less than its full gain of 100,000 so we're going to look at some of the standard circuits, all of which make use of negative feedback to reduce the gain. The usual method is to use a combination of AC and DC feedback, with all the DC at the output and a fraction of the AC fed back.

One typical circuit, which uses an input to the inverting input terminal of the 741, is shown in **Figure 8**. In this circuit, the resistor shown as R1 can consist entirely of the output resistance of the circuit that is connected to this input, or it can be partly output resistance, partly a resistor wired in place. The feedback is through R2, and the gain of the whole circuit is, quite simply, R2/R1. If, for example, the values are R2 = 100k, R1 = 1k, the gain is 100/1 = 100 times; the DC voltage at the output terminal is zero, because of the DC feedback.

This circuit is that of an inverting amplifier whose input resistance is equal to R1 and whose output resistance is very low. The circuit of **Figure 8** is shown using two power supplies to obtain a balanced +9 V and −9 V, but we can re-design the circuit to use just a single 9 V supply.

The single-ended version is shown in **Figure 9**. The non-inverting input has been biased to a voltage of 4V5 by the two 10k resistors, R3 and R4, and the inverting input will be biased to the same voltage by feedback through R2, as before. We do have to be careful, though, not to connect anything to the input which will alter the DC voltage of the inverting terminal, even by a few millivolts DC. The safest way to ensure this is to couple signals to the input through a capacitor, so that using this circuit means abandoning DC amplification. This is seldom a hardship, because few applications of the 741 call for a DC amplifier used with a single-ended power supply.

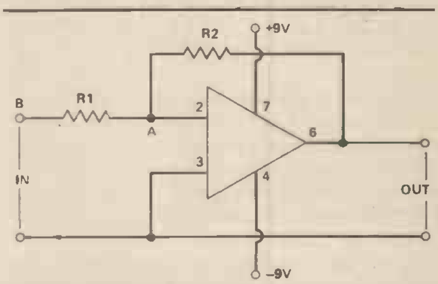


Figure 8. A 741 inverting amplifier circuit using balanced power supplies.

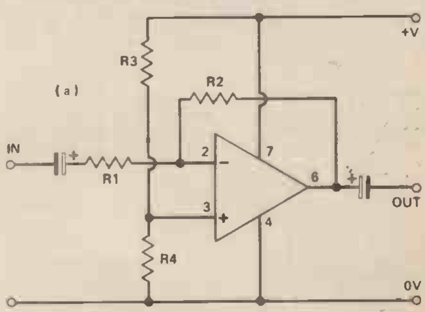


Figure 9. The inverting amplifier circuit rearranged to use a single-ended power supply.

Setting the gain to a fixed value is easy, but varying the gain isn't quite so simple. We could, of course, make either R1 or R2 variable, but it's not really desirable to have potentiometers with none of their terminals at earth voltage, so this method of controlling gain is seldom used. A better method, if we simply want gain control, is shown in **Figure 10**. R2 is the fixed resistor which provides both AC and DC feedback, but additional AC feedback is obtained by using the potentiometer RV1 and capacitor C1 across R2.

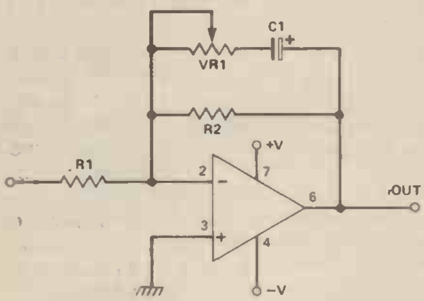


Figure 10. One method of gain control, using variable AC feedback.

The alternative to the inverting amplifier is, reasonably enough, the non-inverting amplifier. A non-inverting amplifier circuit uses feedback to the inverting input, as before, to keep the gain and bias under control but the signal is taken to the non-inverting input, so that the output is in phase with the signal at this input.

A typical circuit, using balanced power supplies, is shown in **Figure 11**. The feedback of both AC and DC to the inverting input is through a potential divider, R1 and R2, and a high-value resistor, R3, is connected between the non-inverting input and earth. The gain is given by (R1 + R2)/R2, which is the inverse of the loss caused by the potential dividing action of R1 and R2. For example, if we used R1 = 100k, R2 = 10k, then the gain would be 110/10 = 11 times.

The input resistance of this circuit can be very high, 1M0 or more, and the output resistance is very low, a fraction of an ohm, so that this is a very useful circuit indeed, particularly since in its balanced form it can be used for DC as well as for AC signals.

Like the inverting amplifier, the non-inverting type can be used with a single

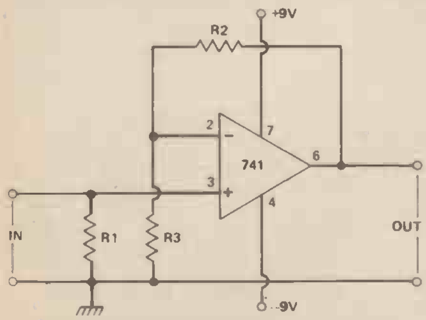


Figure 11. A non-inverting 741 amplifier, using balanced power supplies.

power supply, though at the price of a few complications. The complications arise because the DC level of the inverting input must be the same as the DC level of the output, despite the potential dividing action of the resistors R1 and R2.

A suitable circuit is shown in **Figure 12**. The non-inverting input is biased to half of the supply voltage by means of two equal resistors R1 and R4. The feedback is through the potential divider formed by R2 and R3, but C3 isolates the inverting input from earth for DC, so that the DC voltage of the inverting input is the same as the DC voltage of the output. For AC signals, however, the effect of C3 is so small that R3 behaves as if it were connected to earth. The resistors R2 and R3, therefore, behave as a potential divider for AC signals, but not for DC and the DC bias is therefore unaffected.

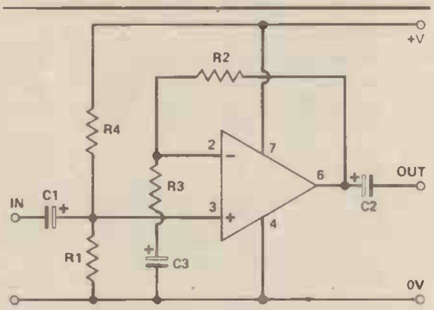


Figure 12. The single-ended power supply version of the non-inverting amplifier.

Since the DC input voltage is half of the supply voltage, the coupling of the signal to the input has to be by a capacitor and if low frequency signals are to be amplified without too much loss, this capacitor must be of a value large enough to pass low frequencies without too much attenuation. The input resistance of the circuit is not as high as that of the circuit which used a balanced power supply, because of the two bias resistors R4 and R1. The input resistance of the circuit is the parallel combination of these two (ignoring the resistance of the 741 itself, because it is very high), so that if each is 100k, then the total input resistance is only 50k. This looks crazy when you glance at the circuit — surely R4 is in series with R1? — but the point is that we are talking about input resistance for AC signals and as far as these are concerned, the positive supply line is as much at earth voltage as the earth line itself because there will be a large-value electrolytic connected somewhere in the power supply between positive and negative supply lines, passing signal frequencies easily. As far as AC is concerned, then, the resistors are in parallel, though they are in series for DC bias currents. The output resistance of the circuit is, as usual, low.

This non-inverting circuit is sometimes called a "follower with gain", because its action is similar to that of an emitter-follower but with voltage gain, which a real emitter follower does not have.

A circuit which actually simulates emitter-follower action is shown in **Figure 13**. The circuit is shown in its double-ended power-supply form, with a single resistor connecting the output to the inverting input. Because there is no division of the signal that is fed back, the gain is unity (one). We often assume that the gain of a transistor emitter-follower is exactly unity, but it seldom is (it's always slightly less than one). Using a 741 in this way is a better way to get true unity gain, with high input resistance and very low output resistance. It is equally possible to achieve unity gain and inversion, but with a lower input resistance, using the circuit of **Figure 14**.

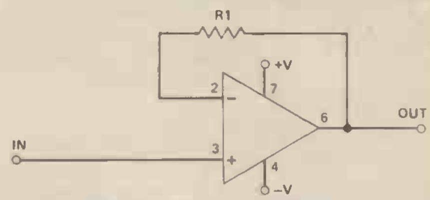


Figure 13. The follower circuit, which has unity gain with very high input resistance and very low output resistance.

There's Always A Drawback . . .

The bias systems of the 741 works perfectly, even if the supply voltage changes, but only so long as it doesn't exceed the maximum working voltage of the chip, which is ± 18 V. The one fly in the ointment is bandwidth.

The 741, you see, was never designed as an audio amplifier chip. It was intended for analogue computers, devices which use very low-frequency signals, so bandwidth was always a minor detail. For a 741 operated at full gain, in fact, the bandwidth is only about 10 Hz, which is hardly hi-fi performance.

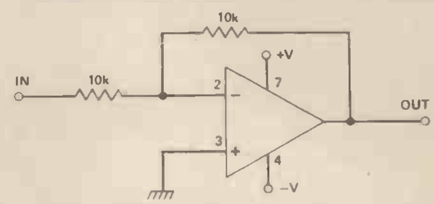


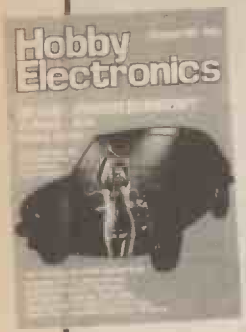
Figure 14. An inverter with unity gain. The actual resistance values are not too important, providing they are equal.

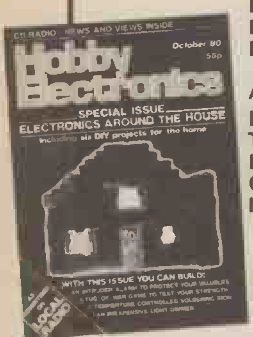
The use of negative feedback obviously helps, but you always have to remember that the bandwidth will be poor if the 741 is used with a high value of gain. At a gain of 100 times, the bandwidth is approximately DC to 10 kHz; this is reasonable, but not as large as a single transistor stage with this much gain, which could easily have a bandwidth of several MHz.

The 741 is a very useful, general purpose op amp but, for special circuits or when high quality is needed, it must be replaced by one of the many ICs which have come after it.

Next month, we'll look at the 'ants' of the electronics world — the vast range of digital ICs. **HE**

BACKNUMBERS





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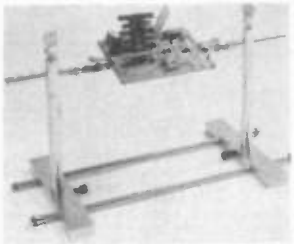

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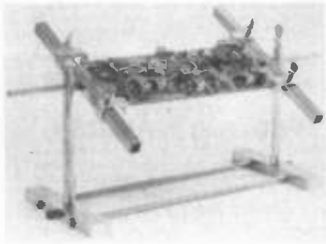

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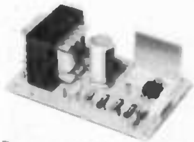

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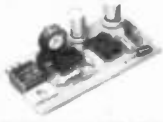

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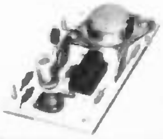

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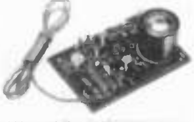

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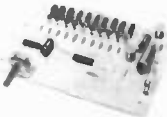

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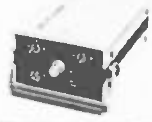

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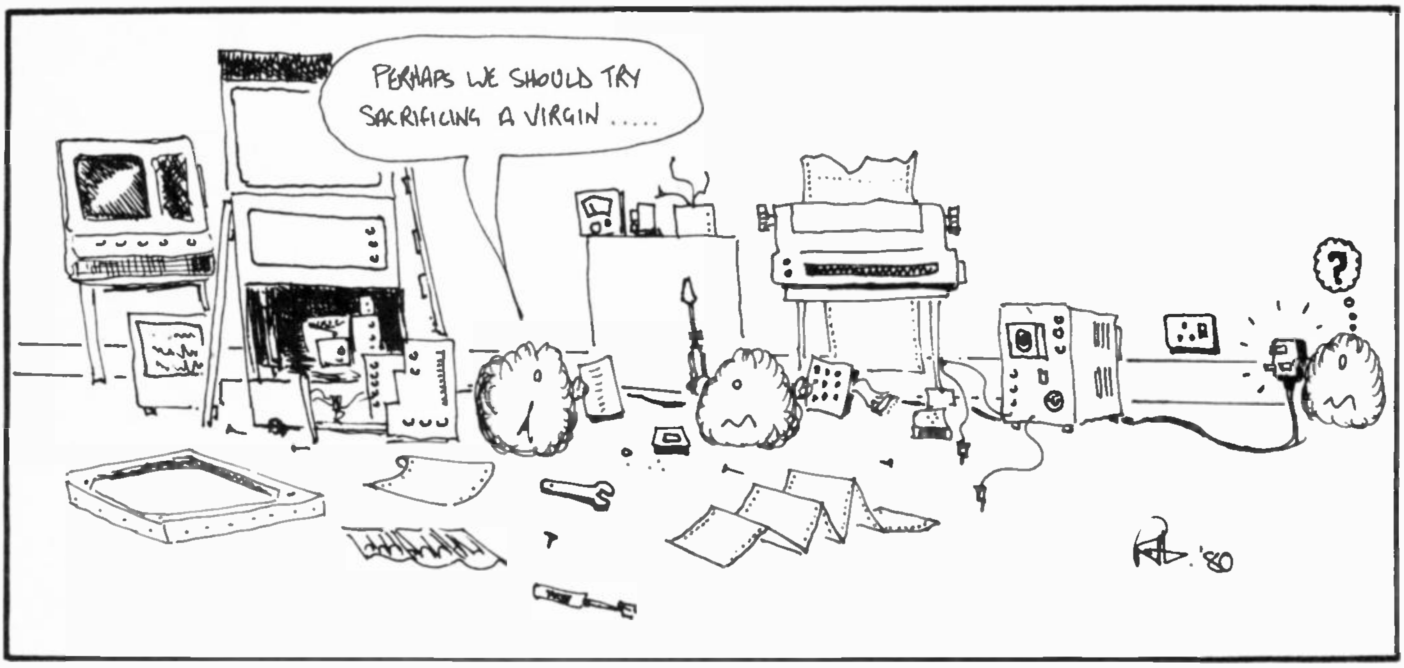

Home from the wars, standing in the centre of the living room, surrounded by large brown boxes and an air of confusion. Thus begins the final act of the 'Quest for Music'.

YOU'VE SURVIVED the demos and the deadly salesman's coffee to return home with the hi-fi of your choice. Only one thing now stands between you and success, the Rite of Installation. Usually rushed, rarely planned, and often botched, this final hurdle can bring to nought many of the gains made earlier, in the buying process.

So put the scissors to one side for a while and let us look at each stage in a logical order, then follow it closely to guarantee the best from those expensive boxes. Read right through and don't do anything until you've got to the end, lest smoking ruin befall you.

Now I've got it — where do I put it?: Earlier on, you decided the size of your proposed loudspeakers on the basis of fitting them into your living room — this is the moment of truth! Has it worked? Take a look at **Figure 1** for some ideas on the siting of seating and speakers. If you can't accommodate one of the schemes shown therein, then take your courage (and couch) in both hands and re-arrange the room! Having spent the time and money to achieve sonic happiness, don't spoil it now for the sake of a few marks on the carpet. Whilst perusing the speaker plans, look around for a possible site for the record deck. Unless the floor is concrete, the deck *has* to go on a separate, wall-mounted shelf. Sorry, but there it is. No coffee table, wall divider and/or cupboard will compensate for a set of floorboards determined to lead your new stylus a merry dance across the vinyl. If you're clever you can hide the shelf brackets behind a wall unit or equipment rack, so that the shelf appears part of the structure. Just make it *solid*. After you've positioned the deck and/or loudspeakers — preferably *not* directly facing each other, the rest of the system will probably site itself. Go for longer speaker leads, rather than extended runs of screened cable from deck to amp.

Now it's there — what do I do with it?: Before setting-up the deck, or switching anything on, consider how to link the units together. The record-deck to amp connection can be accommodated with high-quality screened leads and phono plugs. If you've acquired an SME arm, then use their excellent connectors. An integrated deck might have phono sockets on the rear somewhere. If it does, then invest in a couple of these expensive gold-ended leads; they will repay the cost, over the years. A lot of nonsense has been spouted about speaker leads in recent times — a little sense has come through, too, thank goodness, and the basic requirement for the link seems, at last, undisputed. Simple as it may sound, all that the cable has to do is to join the amplifier to the speaker without offering any resistance (or impedance) of its own to confuse the issue. In this way the amplifier is able to preserve its control over the cones in the speaker, as the damping factor (see Part 1, January '82) is not reduced. Use *at least* thirteen-amp wire, regardless of the power of the amp. Your local electrical retailer will supply the stuff by the yard. If the amp is more than 50 W a channel, then use *two* lengths per speaker, twisting the ends together, at both ends, to form one huge wire for each terminal! This will work out cheaper than the specialised 'Super-wires' and provide a performance comparable to any of them (if you do buy one of these, get "Monster Cable", as it is indisputably the best of the bunch).

I switched it on and nothing happened: Hang on a minute — it wouldn't, would it? No mains connections yet. Let that be a lesson to you. Patience — music comes to him who waits. First we go down to earth literally, while we discuss the avoidance of the dreaded 'hum-loop'. This occurs when there is more than one way for a current to get to earth from the amp or record deck. The symptom is a horri-

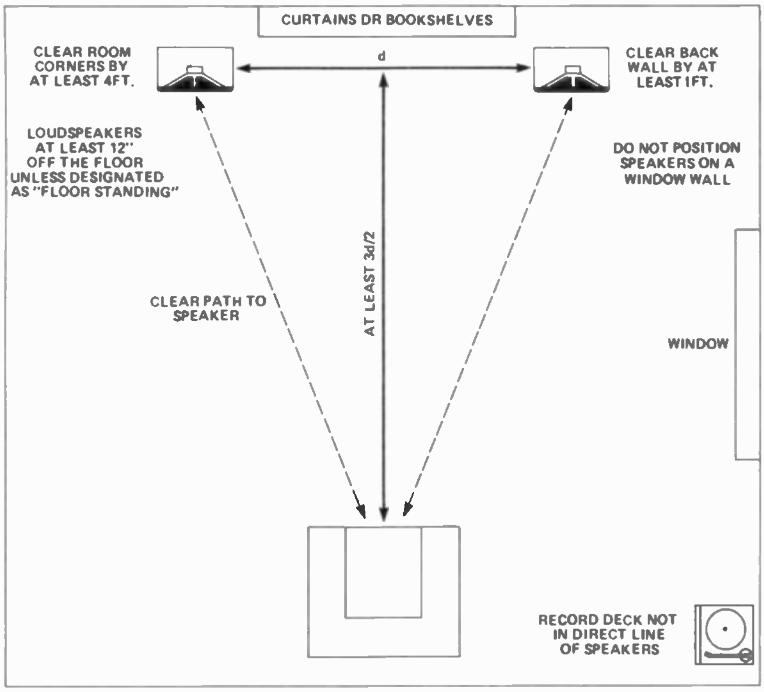

Figure 1. Some pointers of position; keep your listening 'throne' at least 1½ times as far away as the speakers are apart. Don't put the speakers in corners but be prepared to angle them inwards if the sound is at all 'booming'. Record decks should be out of the direct line of the speakers, on a wall-mounted shelf. Putting the speakers on a window wall will greatly impair the stereo image and lead to a dramatic change in sound quality when you pull the curtains at night.

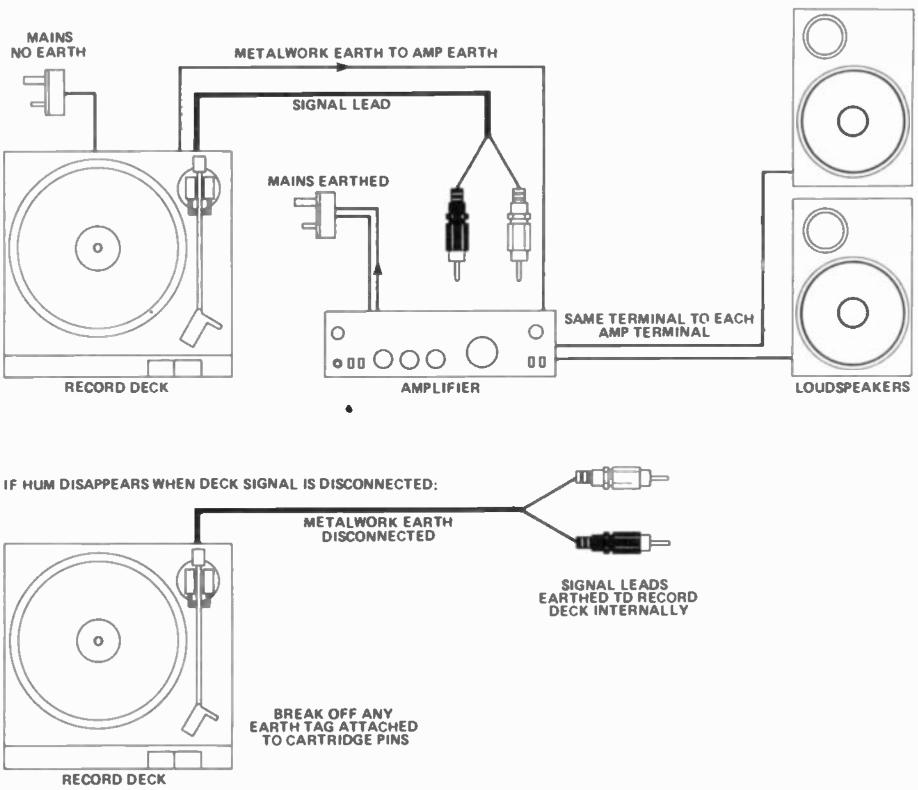

Figure 2. Earthing arrangements. These are the most basic and most successful set-ups, but don't be afraid to experiment to get the best results from your particular system. Make sure only *one* wire goes to mains earth. Some cartridges (eg. Shure) have a small metal tag wrapped around one pin on the back of the body. If you get hum in one channel only, CAREFULLY bend this away from the pin.

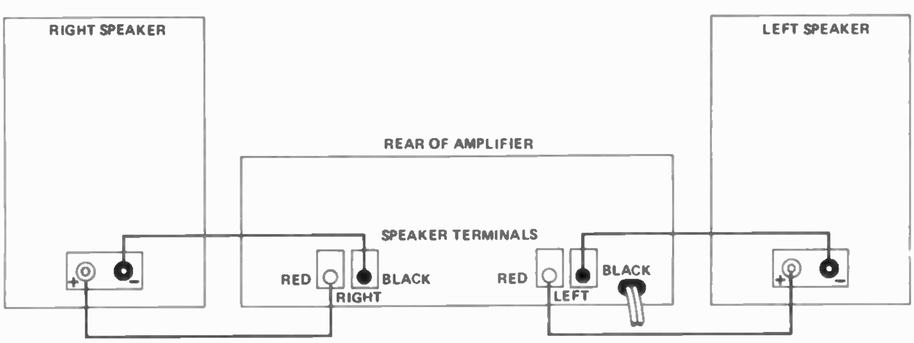

Figure 3. Looks simple doesn't it? Loudspeaker phasing is just a matter of connecting the +ve on the speakers to the same terminal on both channels. Use coloured or 'ribbed' cable and make sure you get it right. If you don't? Very poor bass and no stereo image. Just two small pools of sound around the enclosures.

ble, music-destroying, 50 Hz (or 100 Hz, if the transformer is injecting noise into the circuits) buzz that both saps power from the amp and endangers speakers. Connect the amplifier, only, to the mains earth. There will also be an earth or ground terminal on the back of the amp and a wire from the turntable should be attached here to earth the deck. Some turntables will connect the deck earth to the outer of the phono plugs and thus there will be no external connection. The golden rule is, "so long as it doesn't hum — don't worry about it!" If you intend to expand the system later, it will prove a good idea to get one of those blocks of multiple mains sockets now, rather than later. QED make a nice one, but it's expensive, as are the nice special plugs to fit it — it's up to you whether you feel like splashing out. Bear in mind, though, that a mass of wires all snaking off to one mains socket is neither safe nor condusive to expansion. It's better to "do it right" at the start. One more thing before pushing the button — make sure that the speakers are wired the same way round, ie with the black and red of each enclosure to the corresponding terminal on the amp (use red to +ve). This will ensure the 'phasing' is correct so that the cones move together, rather than against each other. Incorrect speaker wiring would destroy the stereo image as well as the bass response.

Is This a Set-up? If you *have* to set-up the record deck yourself — do try to get the dealer to do it, if possible — then now is the hour! An integrated player is simple. Just set the distance between the rear of the headshell and the stylus to the manufacturer's figure. This is usually 49 mm, but check anyway. Use an alignment protractor to set the cartridge parallel to the headshell sides; again, individual decks vary so much that you'll have to consult the instructions. If you've assembled a record player from separate turntable, arm and cartridge then *have the dealer set it up*. Without wishing to be unkind, this is the only sensible course for a first system. The necessary adjustments are unbelievably precise and involve the use of test records to some degree. If you get it wrong, not only will you remove large amounts of plastic from the LP, like as not you'll re-arrange the anatomy of your beloved cartridge, too. And, before you say it — yes, I *am* trying to frighten you off! It would take a four-page article to explain how to do the job properly and, if demand proves sufficient, you may well see the feature in HE. Until then, let the shop earn its money (you know it makes sense!).

What a Turn-on. . . This is it. You've plugged the deck into 'phono', earthed it properly, set the loudspeakers up in the correct place in the room, fitted all the mains plugs and finally checked everything again. If you haven't, go back two spaces and do it. Do not pass "go" and do not push any mains buttons. Now switch on and advance the volume control to 12 o'clock. All you should be able to hear from your listening position is a faint hiss. If there is any obtrusive humming sound, then check your earthing arrangement against **Figure 2**. If all is well, put a record on, sit back and forget all the hassles.

Now That It's Working . . . What do I Upgrade First? If you're asking this question then you're hooked on hi-fi already and nothing short of a £3000 system will eventually satisfy your evil desires. You have my sympathy. **Table 1** shows a list of recommended units and systems which will assist in choosing a first system and in selecting upgrade-units. It is not complete and will conflict with other magazine's favourite equipment. After all, everyone is entitled to their own opinions — and these are ours. Everything mentioned herein is a model that we have tested and found to represent both good value for money and excellent engineering. The list should be used as a "shopping guide" — not as a Bible. If *you* don't like the sound of any of it, don't buy it!

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Coral MC88E		£20	A
Shure V15 IV/MV30HE		£70/£90	D
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Ortofon FF15		£11	A
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Linn 1TTOK		£250	ALL (except E)
Audio Tech AT1100		£100	D,F
ADC LMF1		£65	A
Mission 774		£150	E,F,D
Syrinx PU2		£170	E,F,D
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Trio L07D		£1100	X
Technics SL10		£300	S
Pioneer PL300		£90	A
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Trio KA 1000	100W	£500	C,D,E,F,S
Monogram 106/109	150W	£440	D,E,F,X,S
Crimson CK1010/1100	120W	£250	B,C,D,F
Quad 44/405	100W	£450	A,B,C,D
Pioneer A9	100W	£450	A,B,C,D
NAD 3020	35W	£90	A,B
Seoum SA4130	35W	£70	A,B
Sansui A9	75W	£130	A,B,C,D
Lentek	70W	£700	E,F,X
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KEF 105II		£900	E,F,X,S
Gale 401		£500	E,F,X,S
KEF 103.2		£250	C,D,E
Celestion 200		£185	A,B,C
Tangent TM3		£120	A,B,C,S
Wharfedale TSR 108		£240	C,D,F
Monitor Audio MA 9		£110	A,B,C,D
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Bike Alarm

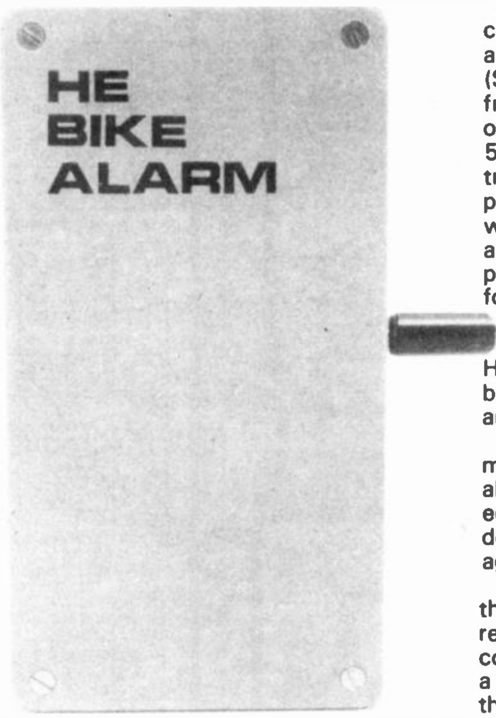
BICYCLE theft is a sad fact of life, but to save you the expense and inconvenience of losing your machine, we have designed a super alarm that safeguards your 'wheels'. In fact this alarm, unlike many others, really will protect the wheels, and other valuable parts from theft, as well as the complete bicycle!

The secret is in the sensing method — the alarm is triggered by movement of the bicycle. This operates one or other of the mercury tilt switches mounted on the printed circuit board inside the alarm. Two mercury switches are used to detect tilt in either direction.

Your bicycle can be left in any position (even upside down!) because the alarm detects *movement* of the bicycle — not its position. Very slight movement or vibration will not accidentally sound the alarm. The circuit is switched on all the time the bicycle is protected, so the use of low current consumption devices is essential.

The alarm is switched on and off by the use of a coded jack plug. When the jack plug is inserted, the alarm is off and the bicycle can be moved freely. If the bicycle is moved when the jack plug is out, however, the loud buzzer will sound for approx 20 seconds. The circuit then resets, so if the bicycle is moved again the alarm is re-activated and the complete cycle is repeated. Limiting the buzzer to 20 seconds is important because, if the alarm is triggered accidentally, or by the bicycle falling over, it avoids annoyance and saves the battery.

Only your personal key can de-activate this movement-sensitive alarm.



The Circuit

The twin 'hearts' of the Bike Alarm are a pair of mercury tilt switches, SW1 and SW2. Inside each is a pair of contact pins and a blob of mercury which is free to move within the glass bulb. Being a metal, mercury is a conductor, so that when the blob is surrounding the contact pins, they are shorted together — the switch is closed (**Figure 1**).

Each time either of the switches closes, a negative pulse is generated by a pulse-forming network, R7, R8, C1 (SW1) or R9, R10, C2 (SW2). Pulses from either switch are coupled, via D1 or D2, to the trigger pin (pin 2) of the 555 CMOS timer, IC3. When it is triggered, the timer output (pin 3) goes positive and turns on Q2, via R15, which drives the alarm buzzer SP1. The alarm will continue to sound for a period set by R14 and C3 (20 seconds for the component values specified), after which IC3 resets — pin 3 goes low — and the 'orrible noise ceases. However, any further movement of the bike will once more disturb the mercury and set off the alarm.

Because the circuit detects movement, the bike can be left in almost any position — it will function equally well when the bike is lying down, standing in a rack or propped against a wall.

Now we come to the cunning bit; the alarm is activated or cancelled by removing or inserting an individually-coded 'key' plug, PL1. Inside the key is a resistor, R1, which must match R2 in the circuit in order to cancel the alarm.

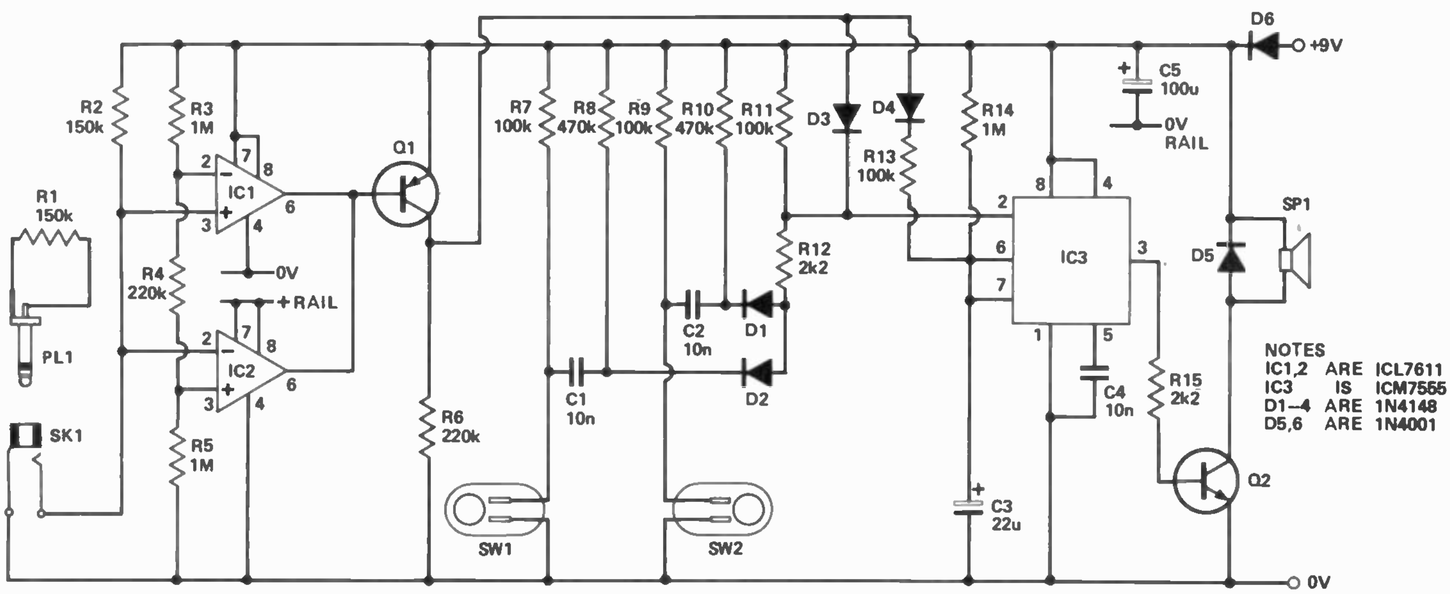


Figure 1. The Bike Alarm circuit.

Thus only the plug made-up to match your chosen value for R2 will de-activate the alarm. Any value of resistance between the limits of 47k and 470k may be used, but they must be equal to within ±5%. A shorted or open circuit plug cannot be used.

The value of R1 is compared with that of R2 in a bridge circuit formed by R1, R2, R3, R4 and R5 (**Figure 2**). If R1 and R2 are equal, the voltage at point 'A' is V/2. If R3 and R5 are equal and R4 is small, the voltage at point 'B' will be slightly above V/2 and the voltage at 'C' slightly below V/2; the values chosen give V_B and V_c a range of 5% above and below V/2.

The next section of the circuit, IC1 and IC2, form a 'Window Comparator' which produces an output only when the input (from the junction of R1, R2) falls between V_B and V_c. If the input is outside this range, one of the IC outputs will be held high, turning Q1 *off* and activating the alarm buzzer.

When the bridge is balanced, by the insertion of the correct resistive 'key', both IC inputs are taken low so that Q1 is turned on.

When Q1 is turned on, two things happen: Pin 2 of IC3 goes positive via D3 to prevent triggering the alarm, and timing capacitor C3 is quickly charged via R13 and D4. Thus when the key is inserted, the alarm is prevented from

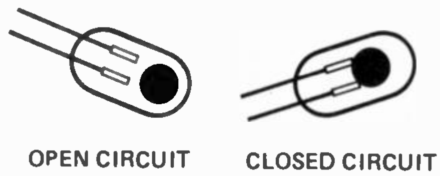


Figure 2. How mercury switches operate.

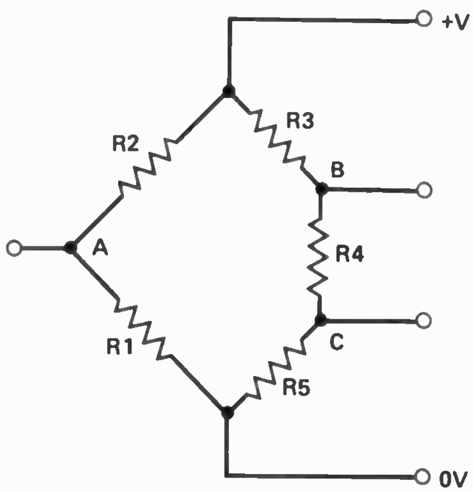


Figure 3. The secrete of the key-code.

triggering and, if the alarm has been sounded, shuts it off in about two seconds.

ICs 1, 2 and 3 are all very low power types, drawing less than 200 uA except when the alarm is sounding, so that a long battery life can be expected. In fact, six AA cells (HP7) should last for up to a year, depending on how often the alarm is triggered.

Construction

This should be straightforward — virtually everything is on the printed circuit board. With the help of the PCB overlay diagram, **Figure 2**, insert the resistors and solder them into place. Next insert and solder the capacitors, being careful to get the electrolytic types the correct way round. Multicoloured polyester capacitors fit either way round.

Now the semiconductors; the diodes must have their cathode (broad band) at the correct end. The transistors must also be oriented correctly, as in the overlay. The IC sockets can be soldered in next — leave the ICs themselves until later. Now solder the wire link, the battery clip, diode D6 and the wire to the buzzer; the second connection to the buzzer is made via its mounting screw.

Finally, the mercury tilt switches are put in; these must be mounted with the

Parts List

RESISTORS

R1,2	See Text
R3,5,14	1M0
R4,6	220k
R7,9,11, 13	100k
R8,10	470k
R12,15	2k2

CAPACITORS

C1,2,4	10n, C280
C3	22u 35 V sub-miniature low-leakage radial electrolytic
C5	100u 10 V radial electrolytic

SEMICONDUCTORS

D1,2,3,4	1N4148
D5,6	1N4001
Q1	BC212 PNP transistor
Q2	BFY51 NPN transistor
IC1,2	1N4001
IC3	7555 CMOS Timer (8-pin DIL)

MISCELLANEOUS

SP1	6 - 9 V mechanical buzzer, 250 mA max. current
PL1,SK1	3.5 mm jack plug and socket
SW1,2	mercury tilt switches

3 x 8-pin DIL IC sockets, PP3 battery clip, double-sided tape, case, solder etc.

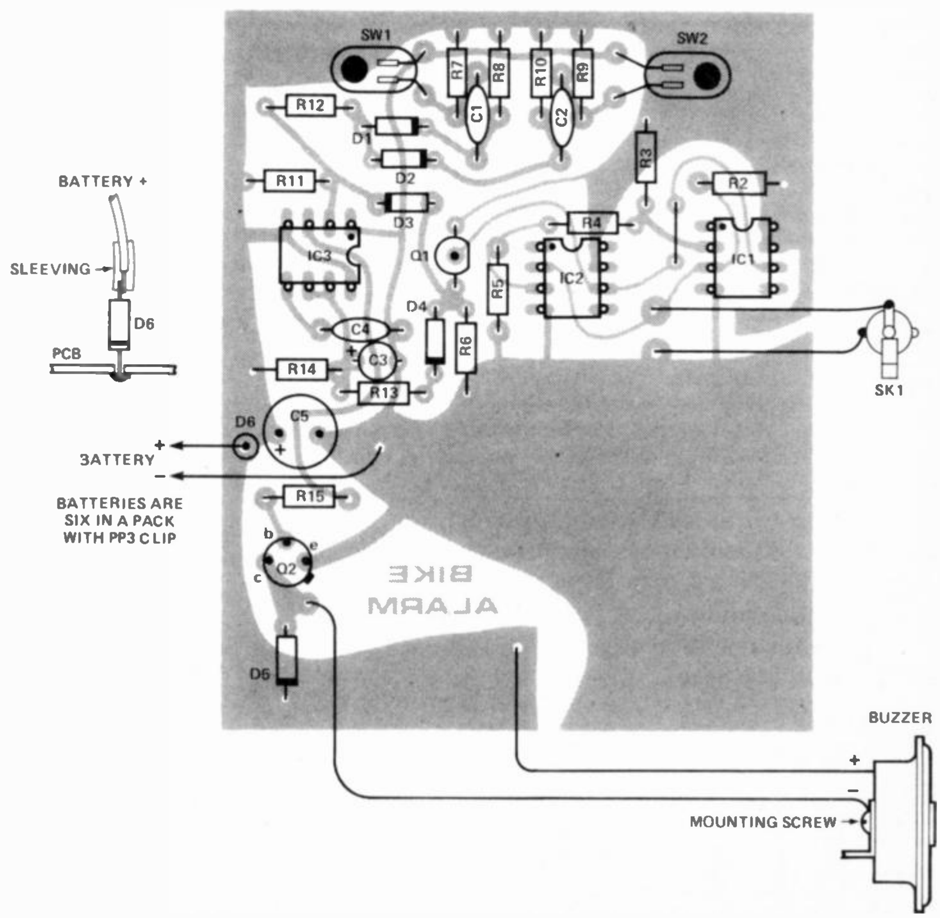


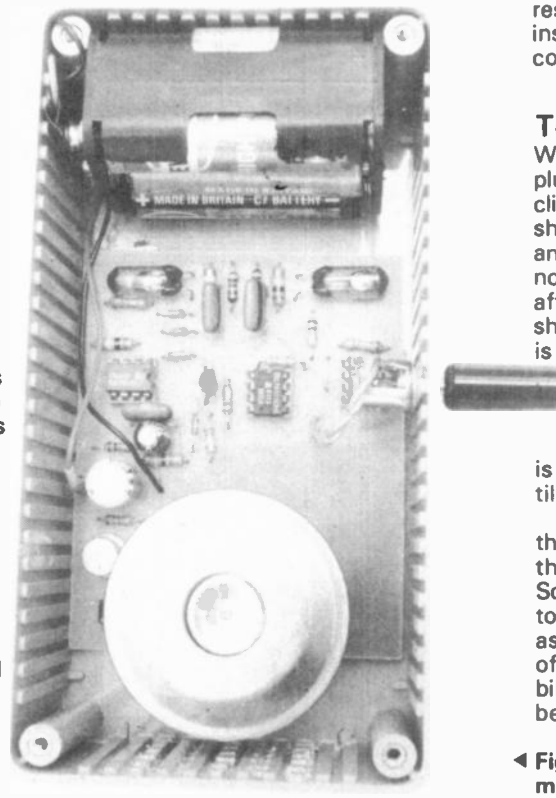
Figure 4. The component overlay. Take care to mount the mercury switches as described in the text.

contacts inside the switch in a horizontal position, otherwise they will not operate correctly. Bend the pins at right angles to the switch and solder them in position. Stick the glass body of the switch to the PCB using a small piece of double-sided tape and be careful not to break the glass — the switches are quite strong but, if there is an accident, remember that MERCURY IS POISONOUS and should not be handled.

Now the case; drill a hole for the jack socket and a set of holes near the buzzer so that it can be well-and-truly heard. The position of these holes depends on where, on the bike, the alarm is to be mounted — drill the holes so that the rain won't beat straight into the works! — so decide how the case is to be mounted, at this stage.

With personal needs and bicycles varying so much, we have left the method of mounting up to the constructor. However, the case must *not* be mounted on its side, as this would place one or the other of the mercury switches in a vertical position and the Alarm would not work.

The jack socket should now be fixed to the case and wired to the appropriate points on the PCB. Then the ICs should be inserted in their sockets; be careful to get them the right way round — and in the correct sockets — so check carefully against the layout diagram.



Next, make up the jack-plug 'key'; this is simply a matter of soldering the resistor between the two terminals inside the plug, but make sure the cover will fit!

Testing

With the PCB flat on a table, insert the plug 'key' and connect the battery clips; wait for about four seconds — all should be quiet. Now remove the plug and tilt the board — makes quite a noise, doesn't it! The buzzer will stop after approximately 20 seconds, and should not sound again unless the case is tilted. To test the 'key', tilt the board, then insert the key plug; the alarm should stop in just a few seconds.

With the 'key' in position, the alarm is inactivated, even when the board is tilted.

Assuming all is well, the PCB and the battery holder can be fixed inside the case using double-sided tape. Screw on the lid and the Alarm is ready to be mounted on your bicycle. Then, as long as you are within hearing range of the buzzer (and it is LOUD), your bike is well protected from any would-be thief!

◀ **Figure 5. Note the position of the mercury switches.**

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CREATIVE RECORDING

IT IS not entirely out of the question, these days, for a group of friends to set up a small semi-professional recording studio. The cost is about the same as that of equipping a five-piece band with instruments, amplification and PA equipment. It's not cheap, but neither is it ridiculously expensive.

However, even this relatively modest investment is impossible for many people — so what options are there, then, for those who would like to experiment with recording, but cannot afford even the cheapest semi-professional gear? Fortunately, lots, because it is not absolutely necessary to have top quality equipment to produce *useful* recordings. The fact is that a recording need only be of *sufficient* quality for the use intended.

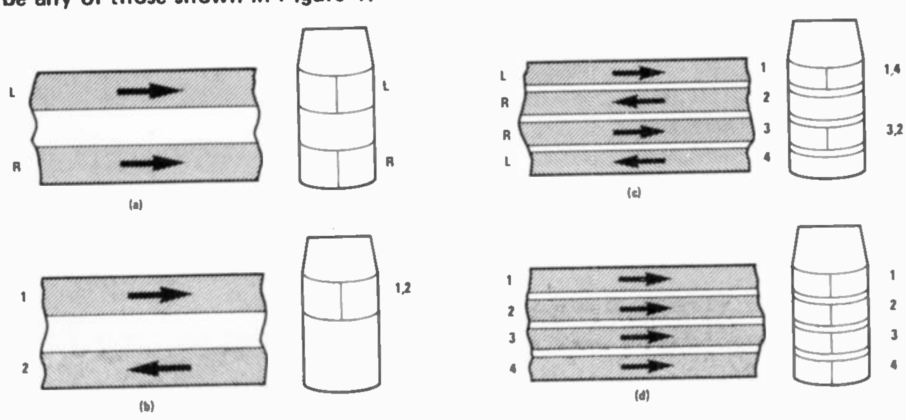
For example, a recording of a band in rehearsal, made for the purpose of perfecting an arrangement, must allow every instrument to be heard clearly, but doesn't need to be 'studio quality'. Similarly, the sound track for an Audio/Visual presentation (a tape/slide show, say, about a local industry), or a sound effects track for an amateur theatrical production, need only match the quality of the equipment on which it is to be played.

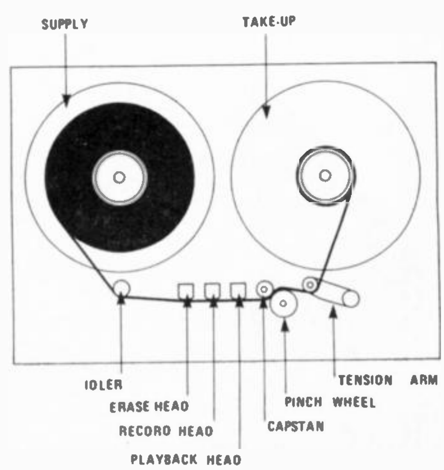
Recording a 'demo' tape of a band is a very common application, but these tapes are made only to persuade a record company representative that a band deserves all the facilities of a top-class studio and that, once this minor technical detail has been attended to, a string of Top Ten albums and singles will result. The record-company man will not be expecting a studio quality demo tape, because a top studio, together with the services of a recognised producer, will always produce a better, and therefore more commercially acceptable, result.

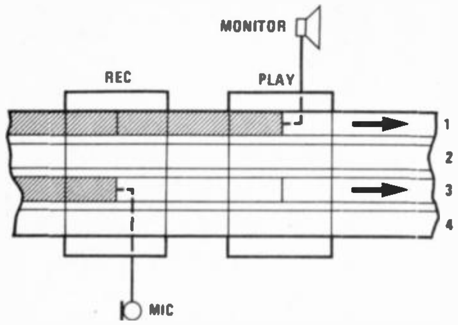
Creative Recording

Of course, there are good recordings — and not so good ones, and the object of any 'session' should always be to produce the best possible result with the funds and equipment available. It's simply not good enough, for example, to just place a microphone in front of a band, plug it in to a cassette recorder and hope it will come out alright. It won't, because this very basic technique will always produce very basic recordings, no matter how good or expensive the equipment. Recording is essentially a creative activity; it's not so much the equipment that determines the result as the way it is used and the important thing, always, is to use whatever tools are available in the most creative way.

Figure 1 (below). Standard recording formats; (a) half-track stereo; (b) half-track mono; (c) quarter-track stereo; (d) four-track recording.
Figure 2 (right). The layout of a three-head open-reel tape deck. The heads could be any of those shown in Figure 1.







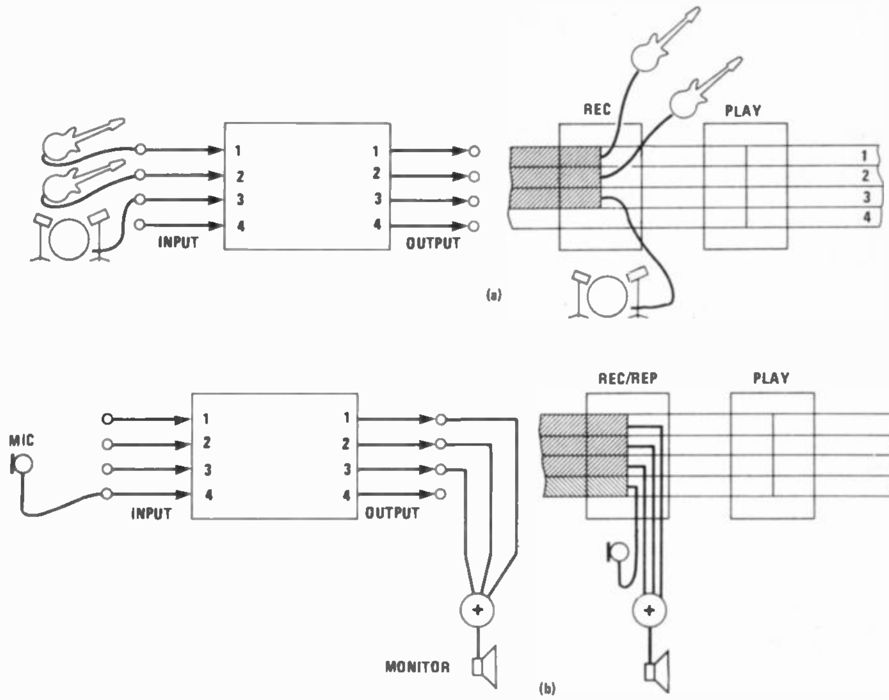


Figure 3 (top). Because of the physical separation between the record and play heads of a quarter-track recorder, it is not possible to record while simultaneously monitoring a pr-recorded track.
Figure 4 (right) The Record/Reproduce heads of a four-track recorded can be independantly switched to either record or reproduce, so that a new recording and the pre-recorded tracks are synchronised. The playback head is used only for quality reproduction when transferring to a stereo master tape.

Accepting that £100,000 worth of complicated equipment is not really necessary to produce useful recordings, what gear *is* necessary? Not very much, really.

It's possible to get by with just one open-reel tape recorder, if you don't mind working in mono, rather than stereo. With care, it is possible to make surprisingly good recordings.

Better still, two tape recorders or cassette recorders (even the portable types are adequate) will, with the same amount of care and attention to detail, produce even better results. Higher up the price scale, one of the new four-track cassette recorders are much easier to use and will give really excellent recordings — again, provided sufficient care is taken.

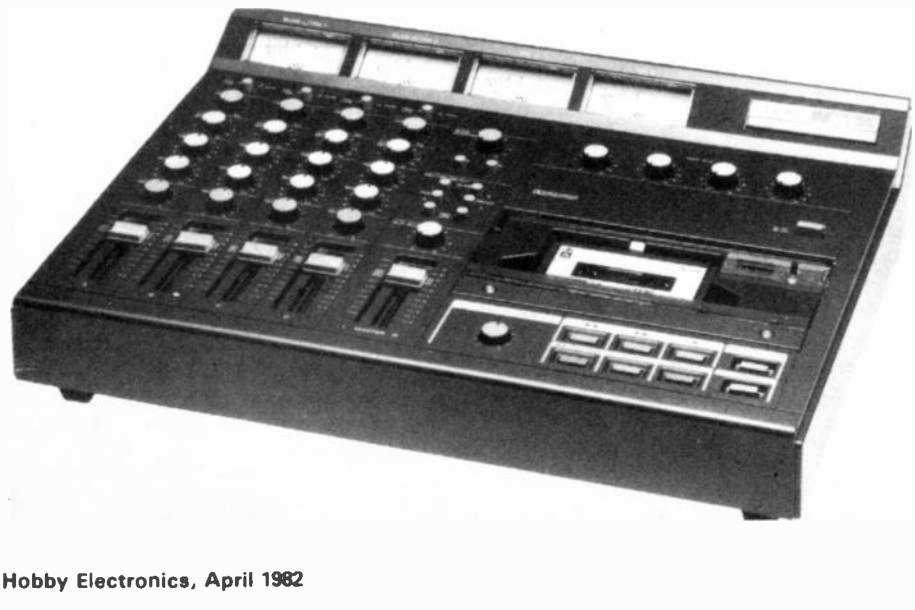
A tape recorder is the 'heart' of a recording set-up, but a certain amount of other gear is also necessary. One or two microphones will certainly be required, as well as a small mixer for blending two or more signals. You'll want to listen to the results of your efforts so some kind of playback system — an amplifier and speakers — will come in handy. A good hi-fi amplifier is quite suitable and, if it has tape monitor facilities, so much the better; one with preamp/main amp connections is even more useful. Then, there are the signal processing units, devices such as compressors and limiters, noise gates and noise reduction units, that can be used to improve the quality of a recording. Finally, there are the various effects — echo, reverb, phasing and so on.

If this list of equipment seems too expensive and formidable, stop and reconsider for a moment; it's not impossible. If you already have a tape recorder or cassette recorder, you need only borrow another — or find a like-minded friend with one! Microphones must be bought, of course, but it's not difficult to get quite good mics at reasonable cost, and these can always be upgraded when funds permit. A mixer? No problem — just keep reading *Hobby Electronics*! As for signal processors and effects units, these have been presented as HE projects since our first issue and more will appear in the months to come. Next month, for example, we have a simple but efficient reverb unit project, together with a full length feature article explaining just what reverb is, and how this electronic effect can be used to enhance a performance or recording.

Are You Creative?

So, given the absolute basics of the setup — one or two tape or cassette recorders and a couple of microphones — the rest is easy! But once you've got everything together, how do you use it? What can you do with it?

The answer to the last question is really down to you, because it depends on your imagination, on your creativity. Remember, all you need is an open reel recorder with "Sound-on-Sound" or (preferably) a pair of tape or cassette recorders, and an ordinary hi-fi system. Think about it!



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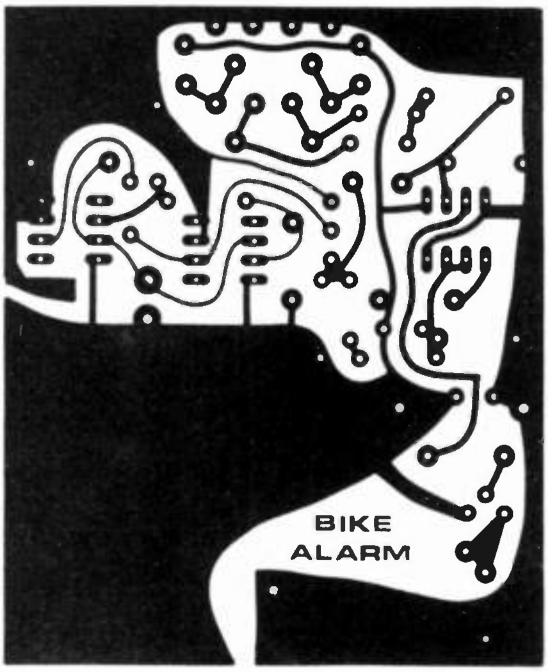
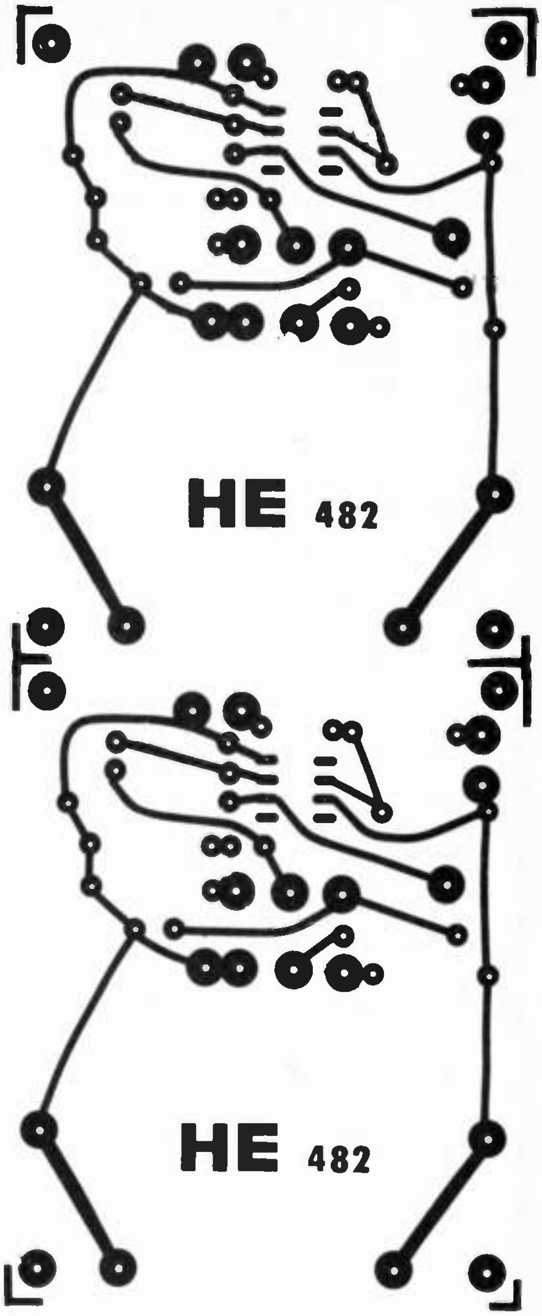
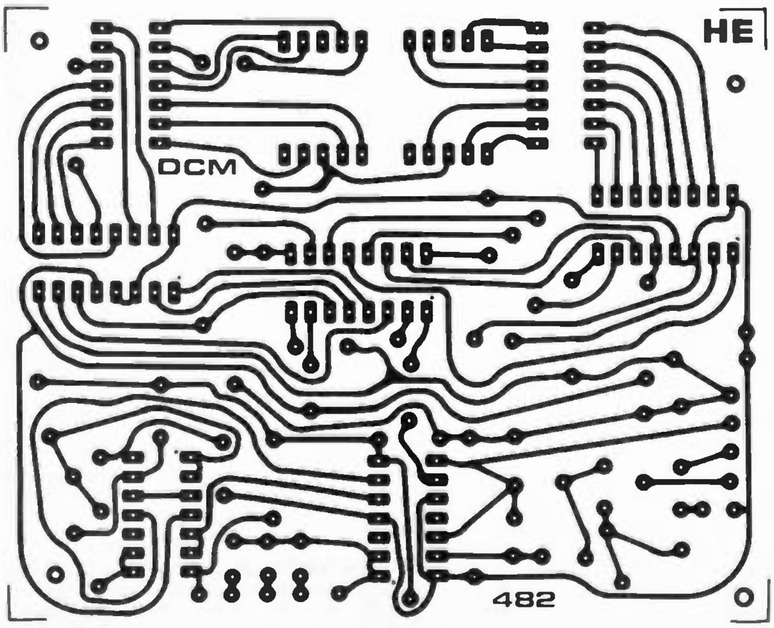


Top: PCB foil pattern for the HE Bike Alarm.

Right: Dual Engine Driver PCB foil pattern. If only one Controller is required, simply cut the pattern in half at the centre key-lines.





Left: The HE Digital Capacitance Meter PCB foil pattern. The many fine lines require considerable care when copying the pattern on to the PCB blank. Take care not to bridge the tracks when soldering in the components. **HE**

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