EVERYDAY ELECTRONICS and computer PROJECTS

Gardner

APRIL 1984 90p

A WIDE SPECTRUM

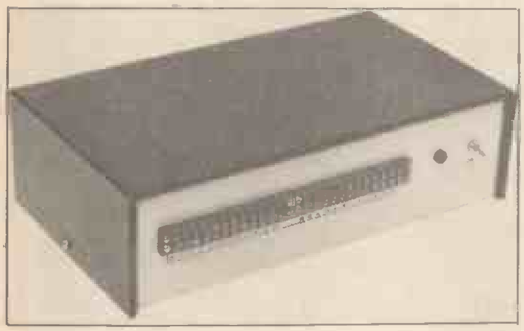
QUASI STEREO
QUIZ MASTER II • FUSE/DIODE CHECKER
MULTIPURPOSE INTERFACE FOR COMPUTERS
plus
DATA ACQUISITION & CONTROL SYSTEM FOR
BBC MICRO, PET, VIC-20 & COMMODORE 64

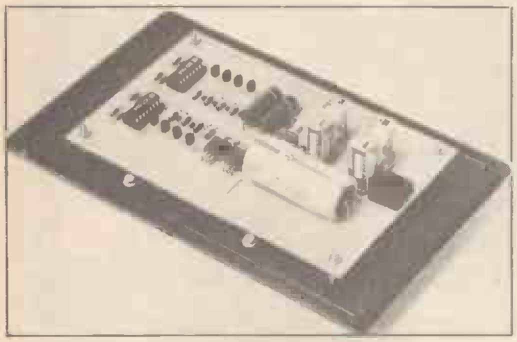
Australia $1.50 New Zealand $1.75 Malaysia $4.95

EVERYDAY ELECTRONICS and computer PROJECTS

VOL. 13 NO. 4 APRIL 1984

PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .





PROJECTS

SERIES

FEATURES

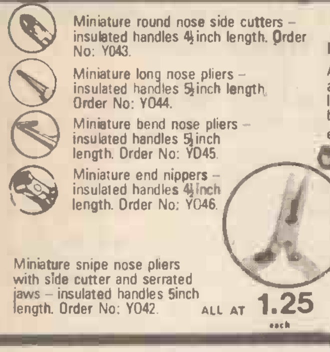
EE MOVES

With effect from April 1, the EE Editorial offices will be located at:
Westover House, West Quay Road, Poole, Dorset.
See page 257 for further details.

Our May 1984 issue will be published on Thursday, April 19. See page 259 for details.

BI-PAK BARGAINS

MINIATURE TOOLS FOR HOBBYISTS



Miniature round nose side cutters – insulated handles 4½ inch length. Order No: Y043.

Miniature long nose pliers – insulated handles 5½ inch length. Order No: Y044.

Miniature bend nose pliers – insulated handles 5½ inch length. Order No: Y045.

Miniature end nippers – insulated handles 4½ inch length. Order No: Y046.

Miniature snipe nose pliers with side cutter and serrated jaws – insulated handles 5inch length. Order No: Y042.

ALL AT **1.25** each

FLEXEY DRIVER
A flexible shaft screwdriver for those awkward to get at screws. Overall length 8½inch. Order No: FS-1 Flat blade 4mm FS-2 Cross point no. 1 £1.75 each.

GRIP-DRIVER
8inch long screwdriver with spring loaded grip on end to hold screws in position while reaching into those difficult places. Order No: SD-1 Flat blade 4mm SD-2 Cross point no.0. £95p each.

MULTITESTERS

1,000 opv Including test leads & Battery
AC volts - 0-15-150-500-1,000
DC volts - 0-15-150-500-1,000
DC currents - 0-1ma-150ma
Resistance - 0-2.5 K ohms 100 K ohms
Dims - 90 × 61 × 30mm.

O/No.1322.OUR PRICE £6.50 ONLY

BRAND NEW LCD DISPLAY MULTITESTER

RE 188m
LCD 10 MEGOHM INPUT IMPEDANCE
*3½ digit *16 ranges plus hFE test facility for PNP and NPN transistors *Auto zero, auto polarity *Single-handed, pushbutton operation *Over range indication *12.5mm (½-inch) large LCD readout *Diode check *Fast circuit protection *Test leads, battery and instructions included.

Max indication	1999 or –1999
Polarity indication	Negative only Positive readings appear without + sign
Input Impedance	10 Megohms
Zero adjust	Automatic
Sampling time	250 milliseconds
Temperature range	–5°C to 50°C
Power Supply	1 x PP3 or equivalent 9V battery
Consumption	20mW
Size	155x88x31mm

RANGES
DC Voltage 0-200mV 0-2-20-200-1000V. Acc. 0.8%
AC Voltage 0-200-1000V Acc. 1.2% DC Current 0-200uA 0-2-20-200mA, 0-10A. Acc. 1.2%
Resistance 0-2-20-200K ohms 0-2 Megohms. Acc. 1%

£35.00 each
BI-PAK VERY LOWEST PRICE

Leather Case for 188m £2.50 EACH

5T21 SCREWDRIVER SET
6 precision screwdrivers in hinged plastic case. Sizes – 0.8, 1.4, 2, 2.4, 2.9 and 3.8mm **£1.75**

5T31 NUT DRIVER SET
5 precision nut drivers in hinged plastic case. With turning rod. Sizes – 3, 3.5, 4, 4.5 and 5mm. **£1.75**

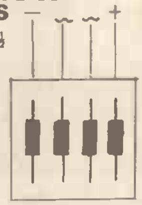
5T41 TOOL SET
5 precision instruments in hinged plastic case. Crosspoint (Philips) screwdrivers – H0 and H1 Hex key wrenches. – 1.5, 2 and 2.5mm **£1.75**

5T51 WRENCH SET
5 precision wrenches in hinged plastic case. Sizes – 4, 4.5, 5, 5.5 and 6mm **£1.75**

VALUE PACKS

Pak No.	Qty	Description	Price
VP1	300	Assorted Resistors Mixed Types	£1.00
VP2	300	Carbon Resistors ½-⅓ Watt Pre-Formed	£1.00
VP3	200		
VP4	150	¼ Watt Resistors 100 ohm-1M Mixed	£1.00
VP5	200	Assorted Capacitors All Types	£1.00
VP6	200	Ceramic Caps Miniature – Mixed	£1.00
VP7	100	Mixed Ceramics Disc. 1pf – 56pf	£1.00
VP8	100	Mixed Ceramic Disc. 68pf – .015pf	£1.00
VP9	100	Assorted Polyester/Polystyrene Caps	£1.00
VP10	60	C280 Type Caps Metal Foil Mixed	£1.00
VP11	100	Electrolytics – All Sorts	£1.00
VP12	60	Bead Type Polystyrene Min Caps	£1.00
VP13	50	Silver Mica Caps Ass. 5.6pf – 150pf	£1.00
VP14	50	Silver Mica Caps Ass. 180pf – 4700pf	£1.00
VP15	50	High Voltage Disc. Ceramic 750v – 8Kv Mixed	£1.00
VP16	50	Wirewound Res. 9W (avg) Ass. 1 ohm – 12K	£1.00
VP17	50	Metres PVC Covered Single Strand Wire Mixed Colours	£1.00
VP18	30	Metres PVC Covered Multi Strand Wire Mixed Colours	£1.00
VP19	40	Metres PVC Single/Multi Strand Hook-Up Wire Mixed	£1.00
VP20	6	Rocker Switches 5 Amp 240v	£1.00
VP21	20	Pcs. 1 – 2 & 4 mm Plugs & Sockets Matching Sizes	£1.00
VP22	200	Sq. Inches Total, Copper Clad Board Mixed Sizes	£1.00
VP23	20	Assorted Slider Pots. Mixed Values	£1.00
VP24	10	Slider Pots. 40 mm 22K 5 × Log. 5 × Lin	£1.00
VP25	10	Slider Pots. 40 mm 47K 5 × Log. 5 × Lin	£1.00
VP26	20	Small .125" Red LED'S	£1.00
VP27	10	Large .2" Red LED'S	£1.00
VP28	10	Rectangular .2" Green LED'S	£1.00
VP29	30	Ass. Zener Diodes 250mW – 2W Mixed Vlts. Coded	£1.00
VP30	10	Ass. 10W Zener Diodes Mixed Vlts. Coded	£1.00
VP31	10	5 Amp SCR's TO-66 50-400v Coded	£1.00
VP32	20	3 Amp SCR's TO-66 Up To 400v Uncoded	£1.00
VP33	200	Sil. Diodes Switching Like IN4148 DO-35	£1.00
VP34	200	Sil. Diodes Gen. Purpose Like OA200/BAX13/16	£1.00
VP35	50	1 Amp IN4000 Series Sil. Diodes Uncoded All Good	£1.00
VP36	8	Bridge Rects. 4 × 1 Amp 4 × 2 Amp Mixed Vlts. Coded	£1.00
VP37	8	Black Instrument Type Knobs With Pointer ¼" Std	£1.00
VP42	10	Black Heatsinks To Fit TO-3, TO-220 Ready Drilled	£1.00
VP43	4	Power-Fin Heatsinks 2 × TO-3 2 × TO-66 Size	£1.00

SILICON BRIDGE RECTIFIERS



Comprising 4 × 1½ amp rectifiers mounted on PCB.
VRM – 150 vlts
IFM – 1.5 Amps
Size: 1 inch square
10 off **£1.00**
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100 off **£7.50**
Order No. As:4RI BRect.

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

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

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National INS8080AN 40 Pin DIL N Channel Silicon GATE MOS TECHNOLOGY As used in Nationals N8080 Micro Computer Family
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TRANSISTOR CLEARANCE
100 All Sorts Transistors. A mixed Bag NPN-PNP Silicon & Germ. Mainly Uncoded You To Sort Pack includes Instructions For Making Simple Transistor Tester. Super Value. Order No. VP60 **£1.00**

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Red plastic case with adjustable fixing bracket. Emits high-pitched wailing note of varying pitch - 100 cycles per minute. Dims - 90mm (dia.) 60mm (depth). Power - 12v DC.
Our Price: £5.50

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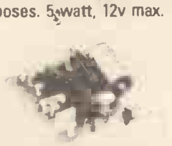
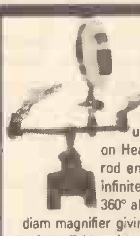


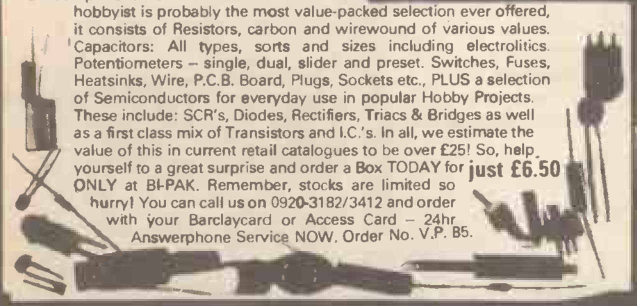
£3.85
Order No. BP124.

The Third and Fourth Hand . . .



. . . you always need but have never got until now. This helpful unit with Rod mounted horizontally on Heavy Base Crocodile clips attached to rod ends. Six ball & socket joints give infinite variation and positions through 360° also available attached to Rod a 2½ diam magnifier giving 25× magnification. Helping hand unit available with or without magnifier. Our price with magnifier as illustrated ORDER NO. T402 **£5.50.** Without magnifier ORDER NO. T400 **£4.75**

TECASBOTY



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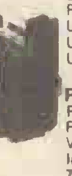
MW398 NI-CAD CHARGER



Universal Ni-Cad battery charger. All plastic case with lift up lid Charge/Test switch. LED indicators at each of the five charging points.

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PP3 (9V)	220-240V AC
U12 (1.5V penlite)	Dims –
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AC127	30p	BC183LB	12p	BF200	35p	TIP30B	50p	2N1307	70p
AC128	30p	BC184	12p	BF224B	20p	TIP30C	45p	2N1308	80p
AC132	90p	BC184B	12p	BF244B	35p	TIP31	38p	2N1613	36p
AC141	30p	BC184L	12p	BF256	35p	TIP31A	40p	2N2222A	30p
AC142	30p	BC186	30p	BF257	35p	TIP31B	40p	2N2369A	28p
AC176	30p	BC187	30p	BF258	35p	TIP31C	45p	2N2646	68p
AC187	30p	BC212A	14p	BF259	35p	TIP32A	40p	2N2904A/5A	30p
AC188	30p	BC212L	12p	BF594	40p	TIP32C	40p	2N2906A	60p
AD149	80p	BC213	12p	BF595	30p	TIP36C	140p	2N2907A	30p
AD161	45p	BC213B	12p	BFR39	20p	TIP41A	50p	2N2926G	12p
AD162	45p	BC213L	12p	BFR79	30p	TIP41B	50p	2N2926R	12p
BC107	12p	BC214	12p	BFR80	30p	TIP42A	60p	2N2926Y	12p
BC107A	14p	BC214B	14p	BFX29	30p	TIP42B	65p	2N3053	30p
BC107B	14p	BC214L	12p	BFX84	30p	TIP120	80p	2N3054	75p
BC108	12p	BC237	18p	BFX85	30p	TIP121	80p	2N3055E	60p
BC108A	14p	BC238B	18p	BFX87	30p	TIP142	120p	2N3442	150p
BC108B	14p	BC307	16p	BFX88	30p	TIP2955	70p	2N3615	200p
BC108C	14p	BC308	16p	BFY50	28p	TIS43	36p	2N3702	12p
BC109	12p	BC327	16p	BFY51	25p	TIS44	40p	2N3703	12p
BC109B	14p	BC328	16p	BFY52	25p	TIS90	30p	2N3704	12p
BC109C	14p	BC337	16p	BFY90	80p	TIS91	30p	2N3705	12p
BC140	35p	BC338	16p	BRY39	40p	VN10KMA	75p	2N3706	12p
BC141	35p	BC441	36p	BSX20	40p	VN66AF	95p	2N3707	12p
BC142	35p	BC461	36p	BSX29	35p	VN88AF	110p	2N3708	12p
BC143	35p	BC477	40p	BU105	170p	ZTX107	12p	2N3710	12p
BC147	12p	BC478	40p	BU205	200p	ZTX108	12p	2N3711	12p
BC148	12p	BC517	45p	BU208A	220p	ZTX109	12p	2N3771	200p
BC157	12p	BC547	15p	MJ2955	90p	ZTX300	15p	2N3772	200p
BC158	12p	BC548	15p	MJE340	50p	ZTX301	18p	2N3773	200p
BC159	12p	BC549	16p	MJE371	90p	ZTX302	20p	2N3819	25p
BC160	50p	BC556	20p	MJE2955	110p	ZTX303	20p	2N3820	45p
BC161	45p	BC557	16p	MJE3055T	80p	ZTX304	20p	2N3823	50p
BC167	15p	BC558	16p	MPSA06	25p	ZTX330	35p	2N3866	100p
BC168	12p	BC559	16p	MPSA56	30p	ZTX500	18p	2N3903	15p
BC169	12p	BCY70	20p	MPSU05	65p	ZTX501	18p	2N3904	15p
BC170	20p	BCY71	20p	MPSU56	60p	ZTX502	18p	2N3905	15p
BC171	13p	BCY72	23p	OC22	150p	ZTX503	18p	2N3906	15p
BC172A	12p	BD131	50p	OC23	150p	ZTX504	30p	2N5172	30p
BC173	13p	BD132	50p	OC26	100p	ZTX531	30p	2N5194	80p
BC177	20p	BD133	60p	OC28	200p	ZTX550	30p	2N5457	42p
BC178	20p	BD135	50p	OC36	220p	2N696	35p	2N5458	48p
BC179	25p	BD136	40p	OC41	75p	2N698	45p	3N128	85p
BC181	23p	BD137	40p	OC42	75p	2N699	40p	3N140	85p
BC182	12p	BD138	40p	OC70	60p	2N706A	26p	3N141	85p
BC182B	14p	BD139	45p	OC76	60p	2N708	30p	3N163	110p
BC182L	12p	BD140	45p	OC81	60p	2N914	36p	3N201	110p
BC183	12p	BF194	14p	OC82	60p	2N918	30p	3N202	125p
BC183B	12p	BF195	14p	OC84	50p	2N930	30p	40406	80p
				TIP29	28p	2N1131	30p	40407	80p
				TIP29A	35p	2N1132	30p		
				TIP29B	50p	2N1303	80p		

TTL

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

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		74LS27	21p	74LS83	51p	74LS138	40p	74LS169	98p	74LS243	81p	74LS293	46p
		74LS28	21p	74LS85	52p	74LS139	39p	74LS170	86p	74LS244	65p	74LS353	71p
74LS00	17p	74LS30	21p	74LS86	23p	74LS147	121p	74LS173	63p	74LS245	86p	74LS362	110p
74LS01	17p	74LS32	21p	74LS90	39p	74LS148	86p	74LS174	58p	74LS247	65p	74LS365	35p
74LS02	17p	74LS33	21p	74LS93	35p	74LS151	46p	74LS175	52p	74LS248	66p	74LS366	35p
74LS04	17p	74LS37	21p	74LS95	46p	74LS153	52p	74LS181	115p	74LS249	66p	74LS367	35p
74LS05	17p	74LS38	21p	74LS96	109p	74LS154	120p	74LS183	201p	74LS251	40p	74LS368	35p
74LS08	18p	74LS40	21p	74LS107	46p	74LS155	46p	74LS190	58p	74LS253	46p	74LS373	70p
74LS09	20p	74LS42	37p	74LS109	35p	74LS156	46p	74LS191	55p	74LS257	40p	74LS374	70p
74LS10	20p	74LS49	63p	74LS112	32p	74LS157	40p	74LS192	55p	74LS258	43p	74LS375	52p
74LS11	20p	74LS51	21p	74LS113		74LS158	40p	74LS193	55p	74LS259	67p	74LS386	130p
74LS12	23p	74LS54	21p	74LS114	32p	74LS160	40p	74LS194	52p	74LS260	30p	74LS390	55p
74LS13	28p	74LS55	21p	74LS122	46p	74LS161	40p	74LS195	52p	74LS266	32p	74LS393	55p
74LS14	32p	74LS63	138p	74LS123	46p	74LS162	40p	74LS196	52p	74LS273	63p	74LS395	98p
74LS15	21p	74LS73	25p	74LS124	166p	74LS163	43p	74LS197	52p	74LS275	145p	74LS398	310p
74LS20	21p	74LS74	25p	74LS125	37p	74LS164	48p	74LS221	63p	74LS279	40p	74LS541	130p
74LS21	21p	74LS75	28p	74LS126	35p	74LS165	60p	74LS240	81p	74LS280	110p	74LS629	200p
74LS22	21p	74LS76	25p	74LS132	41p	74LS166	81p	74LS241	75p	74LS283	46p	74LS669	160p
74LS26	21p	74LS78	25p	74LS136	28p	74LS168	97p	74LS242	80p	74LS290	60p	74LS670	120p

CMOS

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

LINEAR

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

RIBBON CABLE

(Priced per ft)

WAYS	COLOUR
10	26p
20	53p
26	76p
34	100p

DIODES

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

D CONNECTORS

	MALE	FEMALE
9 way	75p	100p
15 way	100p	1140
25 way	140p	195p

D-CONNECTOR COVERS

9 way	110
15 way	110
25 way	125

I.C. SOCKETS

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

ZENER DIODES

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

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

LEDs

5mm:	Red	10p	113:	Red	
	Green	13p		Red	20p
	Yellow	13p		Green	25p
3mm.	Red	10p		Yellow	25p
	Green	13p	323:	Tri.	
	Yellow	13p		Red	20p
CQX21:	Red flashing	65p		Green	25p
				Yellow	25p
251:	Rect/stack.		503:	Square	
	Red	20p		Red	20p
	Green	25p		Green	25p
	Yellow	25p		Yellow	25p

REGULATORS

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

RECHARGEABLE BATTERIES

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

ALUMINIUM BOXES

3⅛" × 1⅞" × ⅞"	
80 × 50 × 25	80p
100 × 65 × 50	1.20
100 × 70 × 40	1.20
100 × 100 × 40	1.20
135 × 70 × 40	1.20
135 × 105 × 40	1.40
180 × 125 × 65	1.95
205 × 155 × 75	2.50

VERO PLASTIC BOXES

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

VERO BOARDS

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

THYRISTORS

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

TRIACS

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

BRIDGE RECTIFIERS

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

Dalo Etch resist
£1.10

SOLDER

20 swg, 3 core
500g 495p

POTENTIOMETERS

Carbon track, ¼ watt log & linear values:

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

SLIDER POTS

60mm track, log & linear values:

Range	Price
5K-500K	80p

PRESETS

Pre-set pots ¼ watt

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

RESISTORS

High stability, ¼ watt, 5%

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

High stability, ½ watt, 5%

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

CAPACITORS

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

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

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

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

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

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

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

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EVERYDAY
ELECTRONICS
and computer PROJECTS

VOL. 13 No. 4 APRIL 1984

HOME ENTERTAINMENT: A WIDER VIEW

Some changes or new developments seem patently obvious after the event and make one wonder why they were not thought of before. The home entertainment scene currently provides a couple of such cases.

For a first example, consider the time it has taken for the combined TV and audio system to appear. Except for rare and expensive up-market versions, the television set has maintained a separate and independent existence; its makers apparently confident that limitations imposed by miniscule speakers were more than adequately compensated for by the alluring colour pictures it could display.

Another example is the coolness shown by set makers towards any wider use of the TV as a monitor or display unit for other forms of signal input.

But things have been changing. First video games, then microcomputers and video recorders, and now just around the corner is cable TV and the direct broadcast satellite. Set manufacturers are at last showing signs of appreciating this changing situation and are introducing facilities for auxiliary inputs to their latest models. And now finally the bringing together of visual and sound systems within a single rack or cabinet assembly has been realised—and by a British company, we are pleased to note. Fidelity launched their AVS1600 hi fi rack system with 16in colour TV last month and are to be congratulated on being the first in this field.

This development serves also to bring attention to the progress made in electronic engineering and manufacture in the consumer products' area, which is no less impressive than in the professional and defence electronics areas. Quite remarkable is the close packing of high technology that is commonly achieved today in electronic products. Moreover, hand in hand with miniaturisation of components goes a high standard of reliability.

To be honest, these two important aspects of contemporary electronics go unheeded by the vast majority of consumers who use and depend upon these products. But to the technically minded, and especially those brought up on valves or familiar at least with the early transistor days, the transformation is remarkable. Sudden breakdowns are no longer commonplace. Even with the most complex products, such as TV receivers, calls upon the service engineer are rare and when they do occur the service engineer's task is relatively simple and speedily performed, usually involving the substitution of a module or circuit board. (Component reliability is in fact discussed by Pat Hawker in this month's *Radio World*.)

The home constructor cannot expect to match the degree of close-packing now routine in factory produced equipments. But he does enjoy the benefits of greater reliability that is inherent in modern components, and this must make his hobby all the more satisfying and worthwhile. And, however comprehensive the electronic conglomerations that appear on the domestic market may become, it is fair to assume there will always remain needs and opportunities for extending further their usefulness by peripheral and auxiliary units designed and built at home.

Fred Bennett

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AUDIO SINEWAVE SWEEP GENERATOR

BY R. E. LIDDIARD

THE requirement for low distortion sine waves for use in audio equipment is well-known. Testing the performance of an amplifier, for example, demands that the signals used be of particularly good quality. In some applications sweep generators are required—audio frequency spectrum analysers being one example, and freedom from harmonics is often very important. Designing low distortion sine-wave sweep generators using conventional components is both cumbersome and expensive, frequently involving several voltage controlled filter stages.

This article introduces a new device—an opto-coupled resistor—and describes an inexpensive, but excellent performance, audio frequency sinewave sweep generator/oscillator.

WIEN BRIDGE OSCILLATORS

A basic Wein Bridge Oscillator is shown in Fig. 1. Oscillations are produced in this circuit when the gain in the amplifier exactly compensates for the losses in the RC feedback circuit and the input is in-phase with the output. (Phase is the amount that a.c. current and a.c. voltage are "out of step" with each other.) In Fig. 1 this occurs when the phase change from C2 R2 is the same as the phase change from C1 R1. If C2 = C1 and R2 = R1 these phase changes are only equal when the frequency

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

and the gain of the amplifier is exactly 3.

If the gain is greater than 3, the output will increase until it reaches the supply voltage, when "clipping" will occur. If the gain is less than 3, the output will simply die away, so we use a thermistor circuit to control the gain automatically. If the output from the amplifier rises, the average current through the thermistor RTH rises and so does its temperature. This reduces its resistance and lowers the gain of the amplifier again, giving just the control we need.

LOW DISTORTION CIRCUIT

Distortion in this type of circuit is about 0·02 per cent and this is mostly due to non-linearities in the amplifier as the voltage on both its inputs swing up and down over a range one-third of the output. By using two amplifier stages, with one input on each stage connected to earth, this "common-mode" non-linearity can be eliminated and distortion reduced to around 0·001 per cent. Such a circuit is shown in Fig. 2.

In this case, sinusoidal oscillations are maintained when the output of op-amp A1 is just greater or equal to twice the output of op-amp A2, and the outputs are exactly out-of-phase. Automatic gain control is still achieved by means of a thermistor circuit, though its operation has been reversed.

Frequency can be altered either by changing the values of *R* or by changing the values of *C*. Traditionally double-ganged potentiometers have been used to change *R*.

DESIGNING A SWEEP GENERATOR

Modifying the circuit of Fig. 2 to produce a sweep generator presents two problems:

Firstly, whatever components are used to replace the resistances *R*, they must respond equally and simultaneously to external control. Any tracking error between the two resistive elements will result in "bounce"—fluctuations in output amplitude as the frequency is changed.

Secondly, the resistances of the devices must be strictly linear, that means the same both forward and reverse biased,

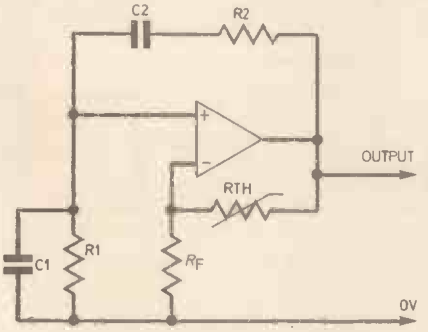


Fig. 1. Basic Wein Bridge Oscillator.

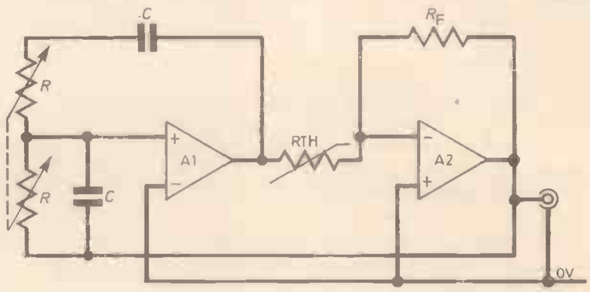
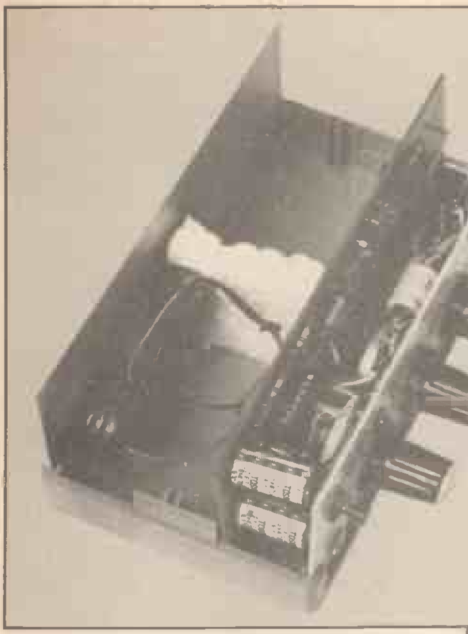


Fig. 2. Low distortion a.f. sinewave oscillator.



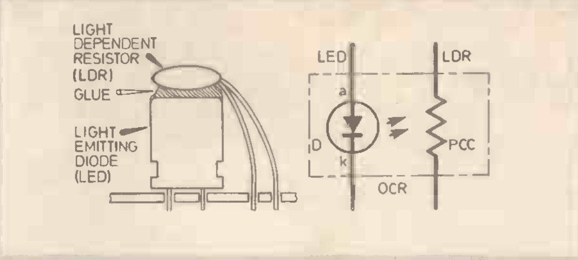


Fig. 3. Opto-coupled resistor (OCR): (a) physical arrangement of light dependent resistor (l.d.r.) and light emitting diode (l.e.d.); (b) circuit symbol.

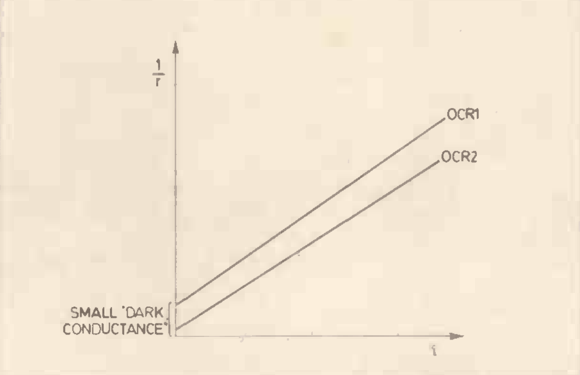


Fig. 4. Opto-coupled resistor characteristics.

otherwise distortion will occur. This latter problem tends to eliminate all directional components such as diodes and transistors, but leaves one device which has good resistive properties at suitable signal levels—the light dependent resistor (l.d.r.).

OPTO-COUPLED RESISTORS

By physically connecting a light dependent resistor (l.d.r.) to a light emitting diode (l.e.d.), as in Fig. 3, a truly bidirectional "opto-coupled resistor" is formed, whose resistance is inversely proportional to control current (or conversely, whose conductance is proportional to control current) as shown in Fig. 4.

Different combinations of l.e.d. and l.d.r. will produce different "slopes" because of physical differences in construction and variations in internal performance, but the characteristics remain essentially linear. These can be matched by means of external components as illustrated in Fig. 5.

*R*x is a high value resistance applied across the output of one of the l.d.r.s to compensate for differences in resistance at low control currents. *VR*y is used to overcome the variation of light outputs of different l.e.d.s and different transfer characteristics of l.e.d./l.d.r. combinations. Good matching can be achieved in this way over a 1000:1 range of resistance. In the Sweep Generator described below, *R*x was found to be unnecessary.

Such opto-coupled resistors are suitable for use in any application where an external control of resistance is required, provided the current through the l.d.r. is not too small, when noise levels may become prohibitive. Multiple devices can be constructed and matched by "cascading" opto-coupled resistors as shown in Fig. 6. Note that the control circuit is completely isolated from the resistance circuits, which are also isolated from each other.

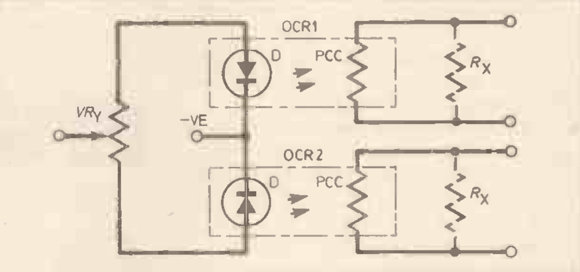


Fig. 5. Matching circuit for two opto-coupled resistors.

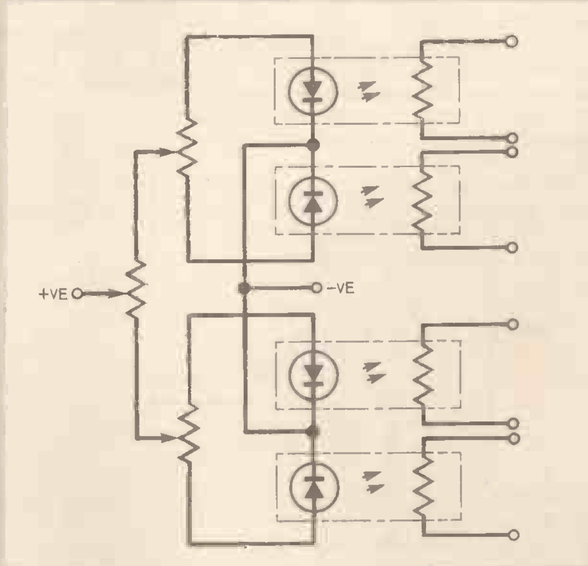


Fig. 6. Multiple opto-coupled resistors in cascade.

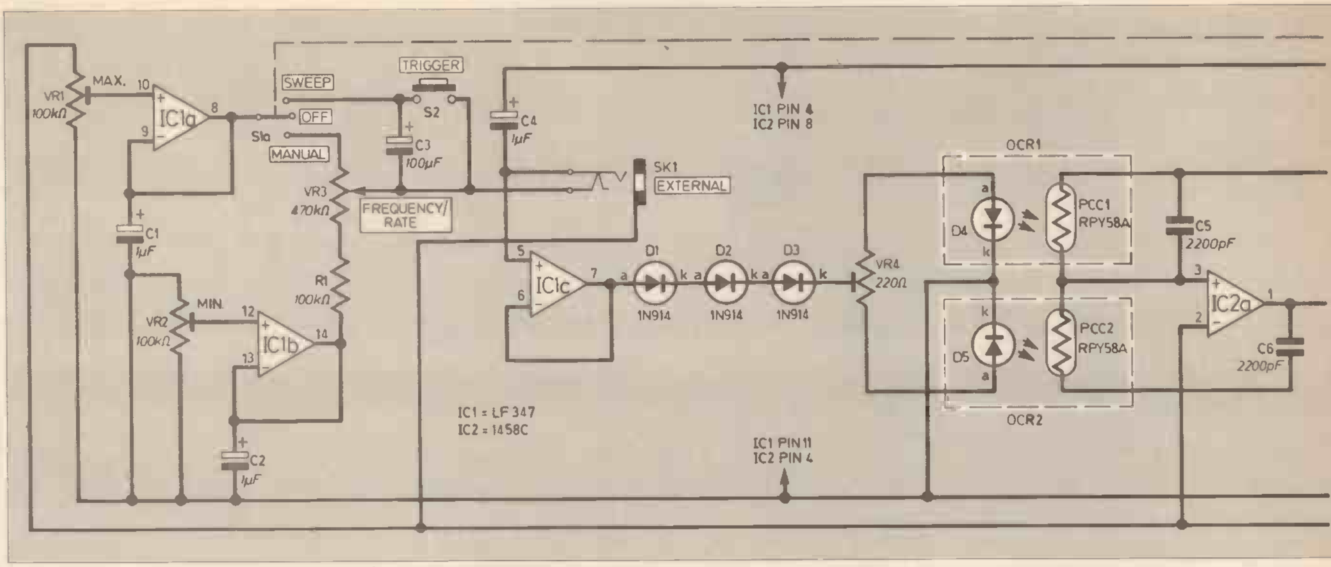


Fig. 7. The full circuit diagram for the Audio Sinewave Sweep Generator.

AUDIO SINEWAVE SWEEP GENERATOR CIRCUIT

The full circuit for the Audio Sinewave Sweep Generator is shown in Fig. 7. The Wien Bridge oscillator as described above, is formed by IC2, OCR1, OCR2, VR4, C5, C6, R2 and RTH1.

IC1a and IC1b set the maximum and minimum voltages applied to the buffer IC1c which supplies the OCRs through D1 to D3 and VR4, so effectively VR1 and VR2 set the maximum and minimum frequencies respectively.

The FREQUENCY/RATE control, VR3, permits the selection of any frequency between these limits in MANUAL mode and determines the sweep rate in SWEEP mode—the sweep rate being set by the rate at which C3 is charged. C3 can be increased or decreased if slower or faster ranges of sweep rate are required, and for this reason C3 has been mounted on the back of the facia panel, not the printed circuit board.

The circuit is designed to sweep from high frequency to low (the delay at the start of a sweep as RTH1 takes effect is much reduced at higher frequency) but by re-adjusting VR1 and VR2 and reversing the polarity of C3, a sweep from low to high frequency can be produced.

S1 provides MANUAL/SWEEP selection and S2 is the sweep TRIGGER. A socket is provided at the input of IC1c for EXTERNAL frequency control and lends itself to phase-locked loop techniques if required.

At the output of the oscillator a buffer is provided in IC1d with VR5 as a LEVEL control, but loads less than 1kΩ should be avoided.

A 9V plus 9V power supply is provided by two PP9 batteries, B1, B2.

SPECIFICATION

Operating Modes: Manual or Sweep
Distortion: <0·002% at 1kHz
Frequency Range: 20Hz to 20kHz (but see text)
Output Amplitude: 0V to 5V r.m.s. (0V to 14V peak-to-peak)
Buffered Output Stage. Suits loads of greater than 1kΩ impedance
External Frequency Control is also provided

COMPONENTS

Resistors

R1	100kΩ
R2	1kΩ
R3	100kΩ
R4	1MΩ
R5	2·2kΩ

All ¼W carbon ±5%

See Shop Talk page 231

Potentiometers

VR1,2	100kΩ miniature horizontal skeleton preset (2 off)
VR3	470kΩ linear, standard spindle
VR4	220Ω miniature horizontal skeleton preset
VR5	10kΩ linear, standard spindle

Capacitors

C1	1µF 100V elect.
C2	1µF 100V elect.
C3	100µF 25V elect.
C4	1µF 100V elect.
C5	2200pF polystyrene
C6	2200pF polystyrene
C7	470µF 16V elect.
C8	470µF 16V elect.

Semiconductors

D1,2,3	1N914 diode (3 off)
D4,5	light emitting diode, square (overall 6·4mm x 3·8mm), yellow (2 off)
D6	light emitting diode 5mm dia., red, with clip
IC1	LF347 quad op-amp, 14-pin d.i.l.
IC2	1458C dual op-amp, 8-pin d.i.l.

Switches

S1	4-pole, 3-way rotary
S2	single-pole, on/off push button

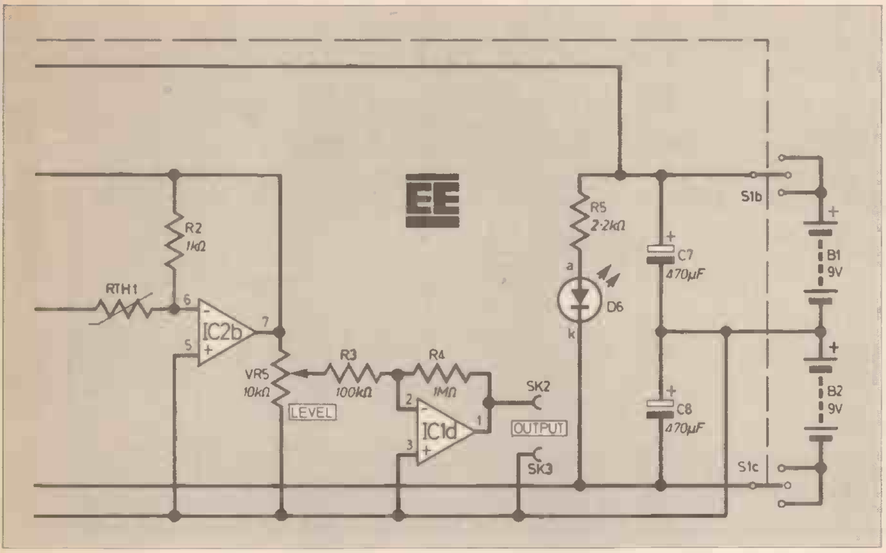
Sockets

SK1	jack socket 3·5mm,
SK2	terminal post, red, with 4mm top socket
SK3	terminal post, black, with 4mm top socket

Miscellaneous

B1,2	9V battery, PP9 (2 off)
PCC1,2	light dependent resistor, RPY58A (2 off)
RTH1	thermistor, R53

Battery clips for PP9 (2); collet knob black, 15mm collet cap grey, 15mm collet nut cover; d.i.l. socket, 8-pin; d.i.l. socket 14-pin; p.c.b.; Veropins 1mm; Verobox 212 or similar plastics case, size 153mm wide, 84mm deep, 59mm high.



CONSTRUCTION

PRINTED CIRCUIT BOARD

A diagram of the printed circuit board is shown in Fig. 8. The layout has been designed to accommodate the close proximity of S1 when using a Verobox type 212.

COMPONENTS approximate cost £25

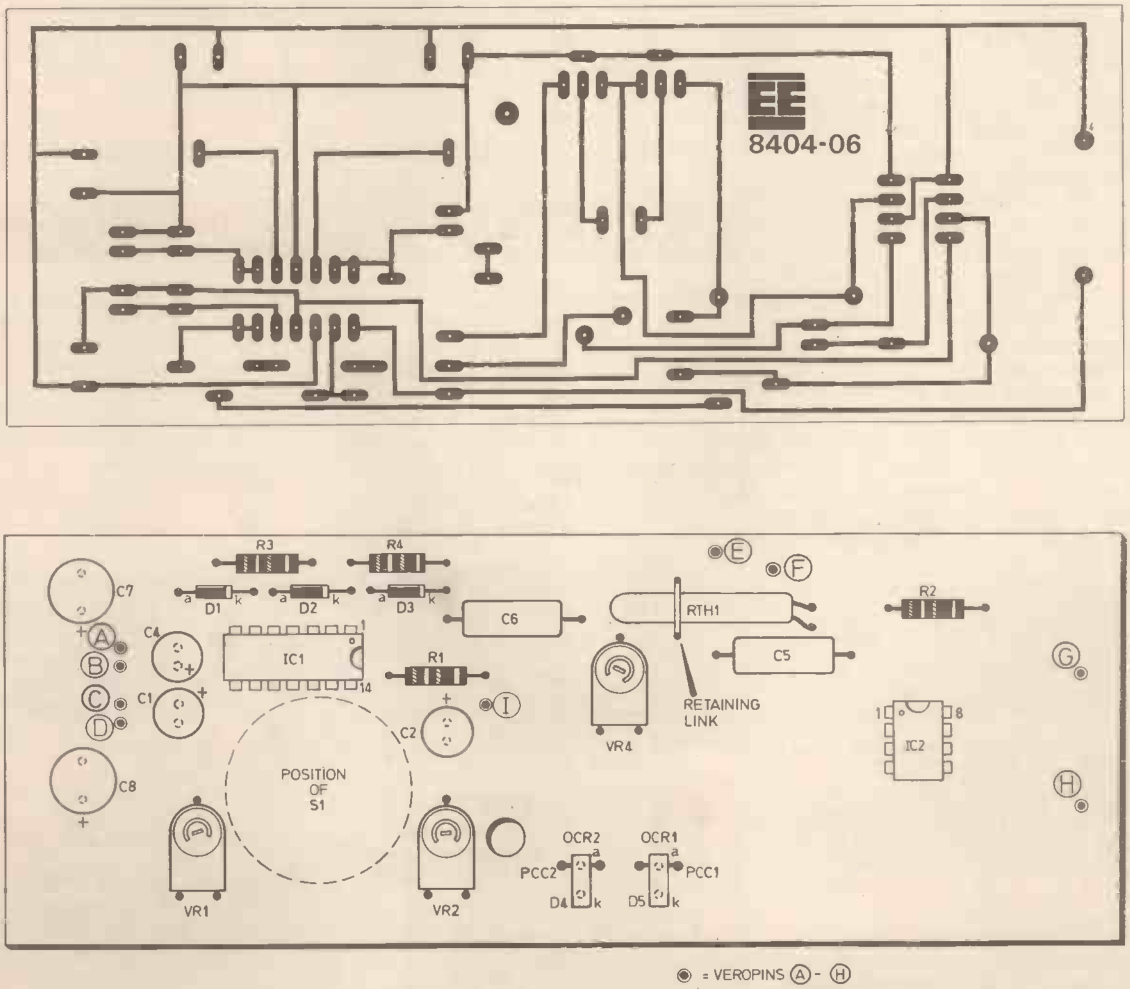


Fig. 8. Printed circuit board for the Audio Sinewave Sweep Generator.

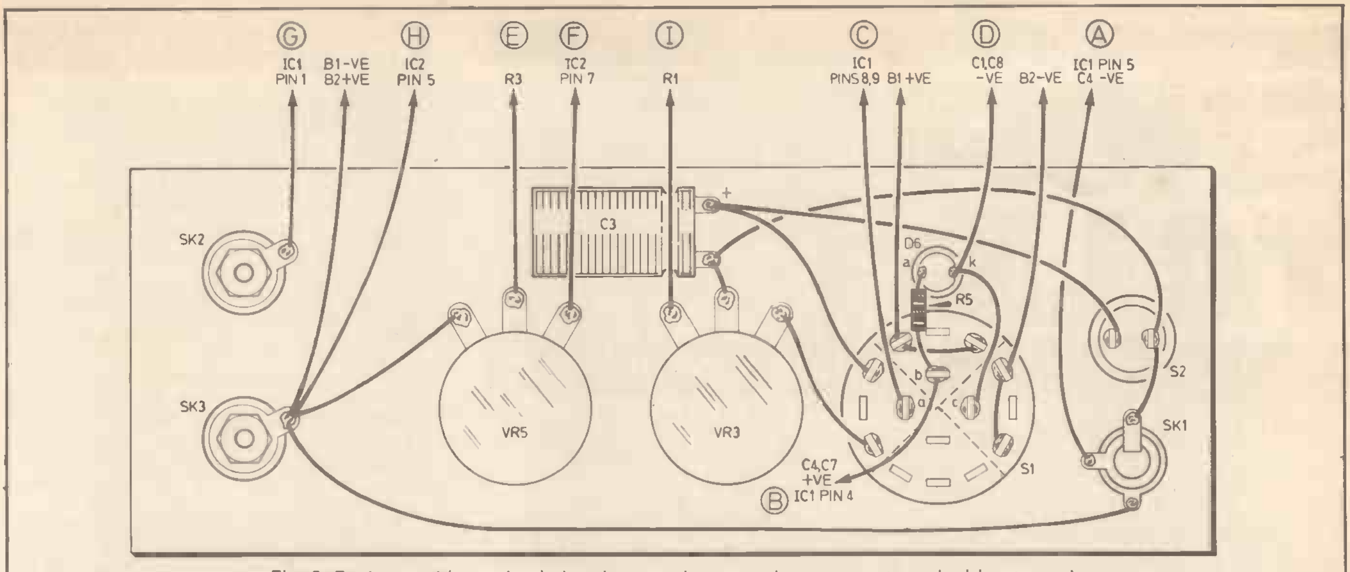


Fig. 9. Facia panel (rear view) showing panel mounted components and wiring to p.c.b.

Drill a $\frac{3}{16}$in hole in the p.c.b., as shown, to accommodate leads from the battery to S1 and the earth terminal SK3. Fit Veropins—where indicated. These will facilitate the interwiring to the off-board components.

Solder the l.e.d.s in position first, taking care to ensure the correct polarity.

Glue the l.d.r.s to the l.e.d.s using a clear adhesive and solder the l.d.r. leads in position. When the glue has set, paint the l.e.d./l.d.r. combinations with several coats of black paint. It is vital that all external light is excluded from these devices.

Solder the remaining components as shown and solder the retaining link in position over the thermistor using insulated wire. NOTE: this link also forms part of the circuit. Finally check that the p.c.b. is free from short circuits between the tracks, and insert the i.c.s.

Mount components onto the facia panel and wire up in accordance with Fig. 9.

SETTING UP

Starting with all presets and potentiometers in the mid-position, and S1 set to MANUAL, adjust VR1 and VR2 until oscillations are produced. If the oscillations are fluctuating, adjust VR4 until a constant amplitude sine wave is heard. With VR3 set alternately to maximum and minimum, adjust VR1 and VR2 respectively to set the desired range of frequencies.

At this stage it is useful to check that the output is not affected by the presence of a bright light. If any change is detected, apply another coat of paint to the opto-coupled resistors and repeat the setting-up procedure.

OPERATION

In MANUAL mode, the Audio Sinewave Sweep Generator provides low distortion sine waves between 20Hz and 20kHz. In SWEEP mode the entire audio spectrum can be swept in 20 seconds with no detectable "bounce". Faster sweep rates can be readily achieved by reducing the value of C3.

Amplitudes up to 16V peak-to-peak are produced without clipping.

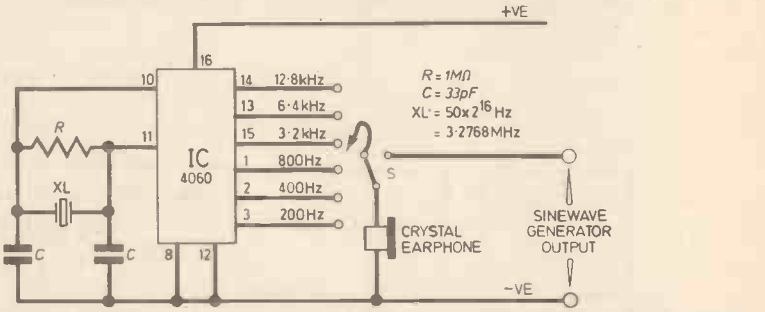


Fig. 10. Circuit of a crystal oscillator and frequency divider suitable for calibration purposes.

CALIBRATION

A simple, yet accurate method of calibrating the sine-wave generator can be performed using the circuit in Fig. 10. This consists of a crystal oscillator and frequency divider using a single chip—a CMOS 4060. A range of accurate frequencies are provided as shown in the diagram. Any supply voltage between 5V and 15V can be used.

To calibrate the sine-wave generator switch S1 to MANUAL and adjust the FREQUENCY/RATE until the same tone is heard when compared with the crystal oscillator. Although the crystal oscillator produces square waves, it is quite easy to match the tones using this circuit.

If required, a calibration scale can be added to the FREQUENCY/RATE control. □

BY DAVE BARRINGTON

Catalogue Received

The latest edition of the excellent **Greenweld** 1984/5 Components Catalogue has been increased to 84 pages and includes many new lines.

The biggest increase appears to be in the "Connector" section, where the increasing demands of the computer interfacing requirements has resulted in a new family of special edge connectors and multi-cable "artery" leads. These include RS232 and Centronics connectors.

Other additions include an expanded range of audio modules and semiconductors.

All prices are quoted on the page and include VAT. Also, there are five 20p "Big G" discount vouchers on the inside back cover. These are redeemable with purchases on the basis of: one voucher accepted with any order over £4; thereafter one voucher for every £3 worth of goods ordered up to a maximum of five vouchers.

Copies of the Greenweld 1984/5 Components Catalogue cost £1 (70p plus postage), or 70p to callers to their shop. Mail orders for copies should be sent to **Greenweld Electronics Ltd., Dept. EE, 443 Millbrook Road, Southampton, SO1 0HX.**

Mothercard

Talking of the increasing demands from readers for "inter-active" modules to make the home computer more versatile and practical, **Velleman (UK)** have developed a range of plug-in boards for the Sinclair ZX machines.

Resulting from customers' enquiries wanting to expand the features of their systems, they have introduced an interface system consisting of a specific motherboard for each type of computer, and interface cards that can be plugged onto the motherboards.

It is possible, using the various cards, to add to each system the following features: Eight open collector outputs (25V/50mA); code K2609. Analogue-to-Digital conversion, 8-bit precision, 5·1V full-scale; code K2610. Eight opto coupler inputs; code K2611. A Centronics parallel printer interface; code K2614. Digital-to-Analogue conversion, 8-bit precision, 1·02V full-scale.

The motherboards for the ZX81 and the ZX Spectrum are available now, offering space for four interface cards. They are provided with a 23-pole edge connector at the back, giving the facility to connect the ZX printer or to stack more motherboards one after the other.

Power is taken from the computer's 9V d.c. supply or from an external unregulated 9V to 12V d.c. power source, depending on the consumption and the number of interface cards used.

For details and prices write to: **Velleman (UK) Ltd., Dept. EE, PO Box 30, St. Leonards-on-Sea, East Sussex TN37 7NL.**

ZX Expansion boards from Velleman

CONSTRUCTIONAL PROJECTS

Multipurpose Interface for Computers

The mains transformer used in the *Multipurpose Interface for Computers* project was purchased from RS Components. This is from their 20VA range and carries the stock number: 207-582.

The two 9V 1·1A secondary windings are wired in parallel to give the required 9V 2·2A rating.

The 2A circuit breaker CB1 is also listed by RS Components under the "subminiature" range and should be ordered as stock number: 335-996.

If this project is to be built on the EE p.c.b., the relay used should be of the type specified: RS 349-658. This is to agree with the allocation of mounting holes and solder pads on the board. If other relays are used then suitable leads can be taken from the board to the relay mounting tags.

It must be pointed out that RS Components will not supply to the general public and the above components will have to be ordered through your local recognised component supplier.

The 16-pin quad opto-isolator is stocked by Bi-Pak and is designated ILQ74 and should be ordered as: Code 1517. It is also available from Rapid and TK Electronics.

Microcomputer Interfacing Techniques

The ADC 0817 40-pin 16-channel 8-bit analogue-to-digital i.c. used in the *Data Acquisition and Control Data Board* appears to be only available from Cricklewood Electronics Ltd.

Timer Module for Central Heating Systems

The choice of relay for the *Timer Module for Central Heating Systems* is not critical and is dependent on the power requirements of the appliance being controlled. A relay with a coil resistance of between 180 to 500 ohms, with mains rated contacts should be suitable.

For a wider choice of relay, it is possible to wire two sets of contacts on a double-pole changeover type in parallel to enable it to handle higher currents. The relay can be mounted to the side of the board and leads taken from the board to the relay contact tags.

Audio Sinewave Sweep Generator

The bead thermistor type RA53 used in the *Audio Sinewave Sweep Generator* is stocked (No. 151-114) by RS Components. It is also listed by Greenweld and Maplin as type R53. This thermistor is rated 5kΩ at 20°C and has a minimum resistance of 80Ω.

The "square" l.e.d.s are now stocked by most advertisers. However, the light dependent resistor, type RPY58A, is currently only listed by Maplin (code: HB09K (LDR RPY58A) and Cricklewood Electronics.

Quasi-Stereo

The dual operational amplifier i.c., type 1458C, used in the *Quasi-Stereo* project appears to be only listed by Enfield Electronics, Greenweld and Maplin.

An alternative device, with identical technical specification, is the μA747C. However, this is a 14-pin device and would necessitate changing the printed circuit board layout to cater for the different pinning of this i.c.

We cannot foresee any component buying problems for the *Quizmaster II* and the *Fuse and Diode Checker*—the second in our "Black Box" projects.

A Black Box Project

FUSE/DIODE CHEC

THIS simple circuit is for quick testing of fuses that are not visably checkable such as those found in 13A plugtops. Because of its oscillating action, it will also test diodes and give an indication as to which end is the cathode.

CIRCUIT DESCRIPTION

The circuit diagram of the Diode/Fuse Checker is shown in Fig. 1. The design is based around the CMOS 4011 input NAND gate. Two NAND gates (IC1a and IC1b) are used to form a bistable multivibrator (as in last month's Black Box circuit) using R1, R2 and C1. This in turn feeds two more NAND gates, one of which inverts the signal of the other.

The output of IC1c goes to a touch plate, the output of the other gate (IC1d) goes to the two l.e.d.s connected inversely back to back and then on to the other touch plate. Because of the oscillating function of the circuit, the polarity across the two plates alternate, so that if a short connects the two plates together (such as a fuse), then current will first flow as shown in Fig. 2a illuminating D1, current will then flow in the opposite direction as in Fig. 2b, illuminating D2.

This will continue while there is a connection across the plates. If the fuse has blown, then no current can flow either way and neither l.e.d. will light.

DIODE CHECKER

If a diode is connected across the plates, then current will flow only in one direction, illuminating the appropriate l.e.d. (as in Fig. 2c) and if the l.e.d. is positioned accordingly, it will show the cathode end (k) of the diode under test, if that diode is functioning.

If the diode has gone short circuit, both l.e.d.s will light (as for the fuse) and if it is open circuit, neither will come on.

ALL DESIGNS FEATURED IN THE BLACK BOX SERIES WILL USE THE SAME BLACK PLASTICS CASE AND SAME SIZE PIECE OF STRIPBOARD

CONSTRUCTION

The circuit is built on a piece of stripboard 24 holes by 10 strips and the layout is shown in Fig. 3. The case is the same black plastic case, 80 × 61 × 41mm, as used in all Black Box projects.

Mount the i.c. socket first, followed by the links, resistors and capacitors. A small piece of copper was used as the two touch plates (see photo), as it was easy to solder to the back of them. Alternatively, brass could be used or even another piece of stripboard.

Drill the four holes in the lid of the box, solder the wires to the plate and glue the plates to the lid after passing the cables through the appropriate holes, using epoxy resin or something similar. While this is setting, prepare the cutout for the switch and then fix this in the box.

Connect up all the cables to the board and switch, and also to the l.e.d.s and touch plates. Fit the i.c. into the holder, taking usual precautions for CMOS. The board was held in the box with double-sided tape, and foam was used to stop the battery shaking about.

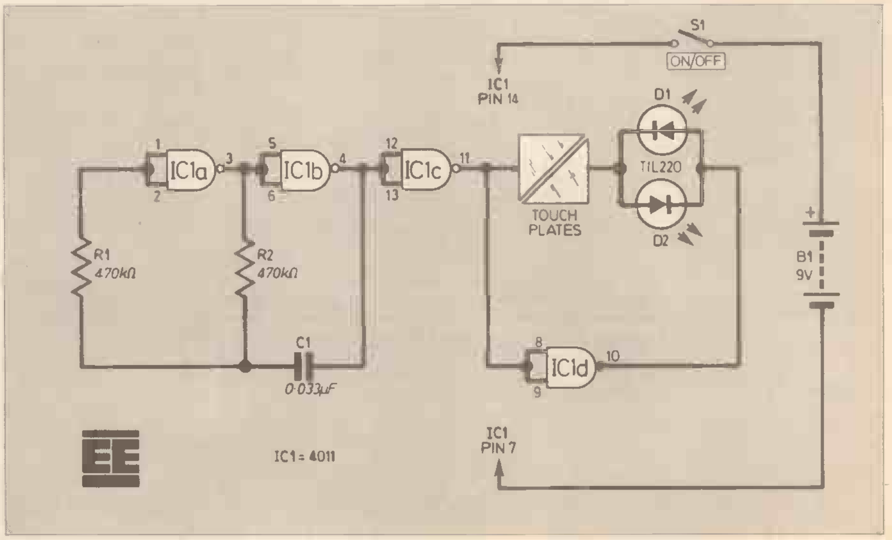
TESTING

Switch the unit on, short out the two touch plates with a piece of wire and both l.e.d.s should light up (you should just be able to see them oscillating). Place a known, good diode across the plates (such as a 1N4001) after taking away the piece of wire and one l.e.d. will light up corresponding to the cathode end (k) of

the diode. If the other end is illuminated then swap the connections to each l.e.d. around. If, however both l.e.d.s light up or not at all, then the diode is either short circuited or open circuited.

Please note: due to the simplicity of this circuit, diodes with an average forward current of less than 10mA (such as AA144) or diodes with less than a peak reverse voltage of 7V (such as a BA104 or BA117) should not be used with the Diode/Fuse Checker, as damage to the diode may result. □

Fig. 1. Circuit diagram of the Fuse/Diode Checker.



KER

BY L. A. PRIVETT

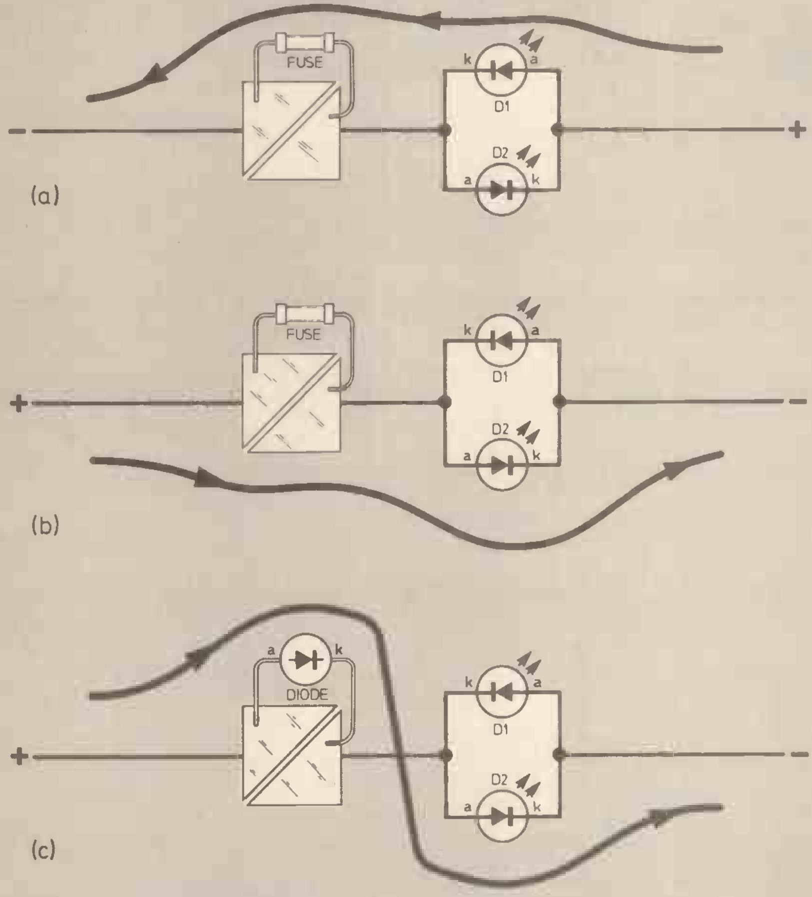
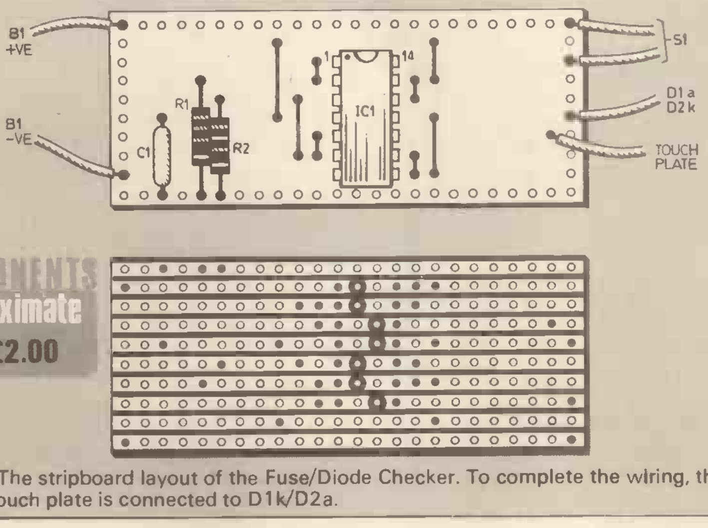
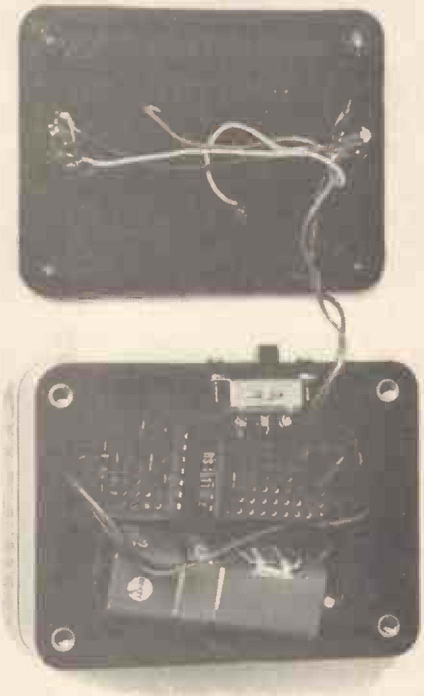


Fig. 2. (a) and (b) show the current path when testing a good fuse. Note that both l.e.d.s light alternately. (c) shows the current flow when a good diode is placed across the touch plates lighting only one l.e.d.



COMPONENTS approximate cost £2.00

Fig. 3. The stripboard layout of the Fuse/Diode Checker. To complete the wiring, the other touch plate is connected to D1k/D2a.



View inside the finished model. A piece of foam holds the board and battery in place when closed.

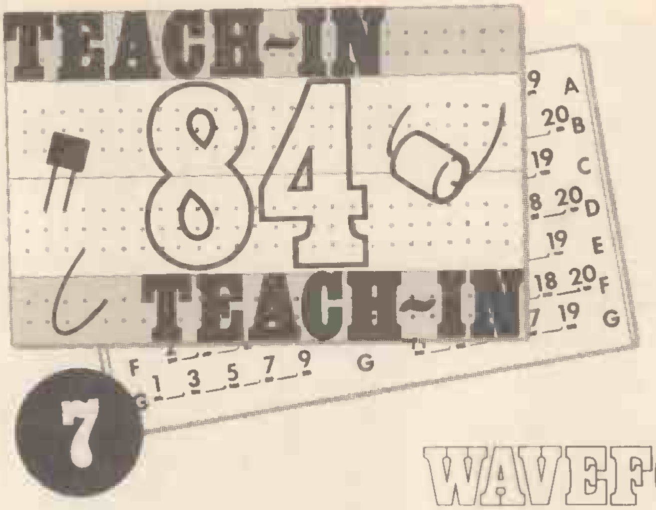
COMPONENTS

Resistors
R1,2 470kΩ (2 off)

Capacitor
C1 0·033µF polyester

Semiconductors
D1,2 TIL220 5mm red l.e.d. (2 off)
IC1 4011 CMOS quad 2-input NAND gate

Miscellaneous
S1 d.p.d.t. miniature slide switch
B1 9V PP3 battery
Black plastic case, 80 x 61 x 41mm; 0·1in matrix stripboard, 10 strips by 24 holes; battery clip; 14-pin i.c. socket; wire; piece of copper sheet, 40 x 40mm (for touch plates); double-sided tape; small piece of foam rubber.



A TWELVE-PART HOME STUDY COURSE IN THE PRINCIPLES AND PRACTICE OF ELECTRONIC CIRCUITS. ESSENTIALLY PRACTICAL, EACH PART INCLUDES EXPERIMENTS TO DEMONSTRATE AND PROVE THE THEORY.
USE OF A PROPRIETARY BREADBOARD ELIMINATES NEED FOR SOLDERING AND MAKES ASSEMBLY OF CIRCUITS SIMPLE.
THE IDEAL INTRODUCTION TO THE SUBJECT FOR NEWCOMERS. ALSO A USEFUL REFRESHER COURSE FOR OTHERS.

By GEORGE HYLTON

WAVEFORMS & DISTORTION

THE oscillators we've made so far have been of a type that generates something approximating to square waves (Fig. 7.1). Any repeating waveform which is not a sine wave contains harmonics (multiples of the basic frequency). These affect the tonal quality of the sound heard when the wave is used to energise a loudspeaker or earphone. Square waves have a timbre reminiscent of organs or reed instruments.

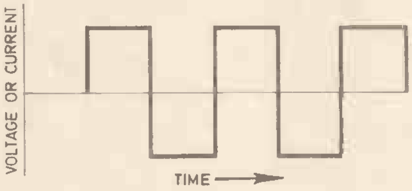


Fig. 7.1. Square wave.

EXPERIMENT 7.1

PHASE SHIFT OSCILLATOR

A pure sine wave makes a rather smooth-sounding note. To demonstrate this, build the oscillator shown in Fig. 7.2. This is a phase-shift oscillator. You'll remember that when talking about op-amps I explained how what is meant to be negative feedback can become positive and cause oscillation. The phase-shift oscillator exploits this.

Normally, if the collector output of a single-stage transistor amplifier is fed back to the base, feedback is negative and the circuit is stable. (This is the basis of the auto-bias technique.) In a phase-shift oscillator, CR "time constant" components are inserted in the negative feedback path to provide enough time delay to provoke oscillation at one particular frequency.

With the values of R and C shown, oscillation is at an audio frequency. At low settings of VR1, oscillation stops, because the fed-back signals are too attenuated.

Set VR1 so that the circuit just oscillates. You'll find that the sound has the pure quality I mentioned.

If you set VR1 very carefully to a point where the circuit just fails to oscillate you'll find that any sudden upset, like disconnecting then re-connecting the battery, produces a bell-like "ting".

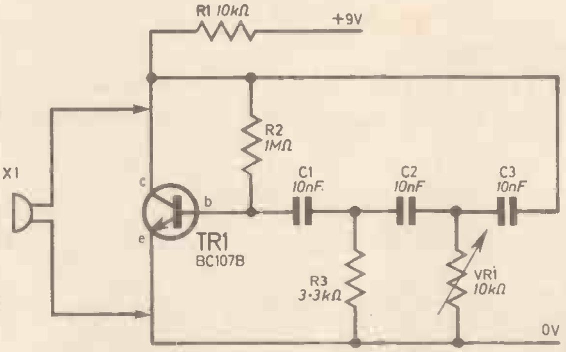


Fig. 7.2 (left). Phase shift oscillator circuit.

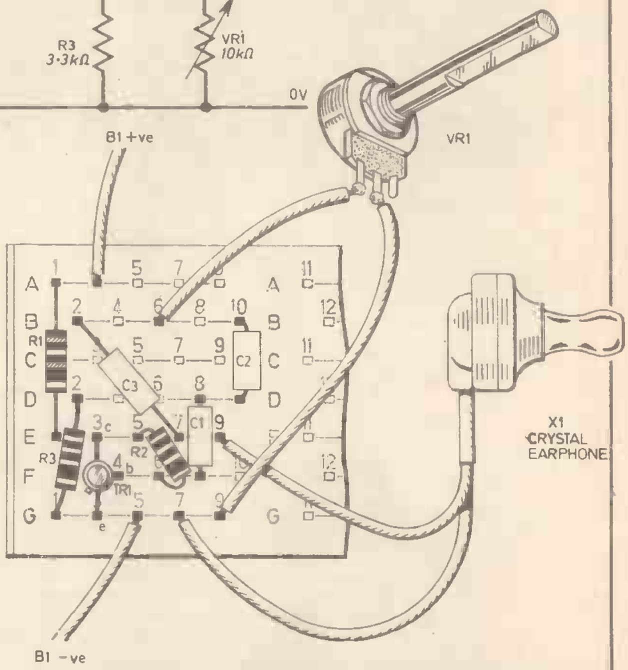


Fig. 7.3 (right). EBBO component layout for Fig. 7.2.

The explanation is that the sharp change of voltage caused by suddenly connecting the battery generates frequencies, some of which are close to the oscillation frequency. The circuit tries to keep these circulating. It can't, but they die away slowly, turning what would normally be a click into a "ting". This process, called ringing, can occur in badly-designed negative feedback amplifiers and in filters with sharp cut-offs.

At high settings of VR1 the tone sounds harsher. Some other noise seems to creep in. The pure sine wave of the just-oscillating circuit is now distorted.

OVERLOAD

What causes the distortion? Well, there is a limit to the size of sine wave which your circuit can generate. Suppose TR1 collector voltage (V_{CE}) is 4V. If the oscillation makes the collector current increase, this voltage falls (because R1 drops more volts).

At some low collector voltage TR1 ceases to function as an amplifier. Let's say this is 0·1V. Then driving the base harder has no effect: the collector voltage just stays at 0·1V. The result is that, at the collector, what should have been a sine wave gets its negative voltage peaks flattened (Fig. 7.4).

When the collector current is driven too far the other way, a similar overloading effect happens. A negative drive to the base reduces I_C. But I_C can't be reduced below zero. Once the zero point ($I_C = 0$) is reached, further negative base drive has no effect. The collector current is cut off and that's that. Under these conditions there is no voltage drop in R1 and V_{CE} is the same as V_{CC}.

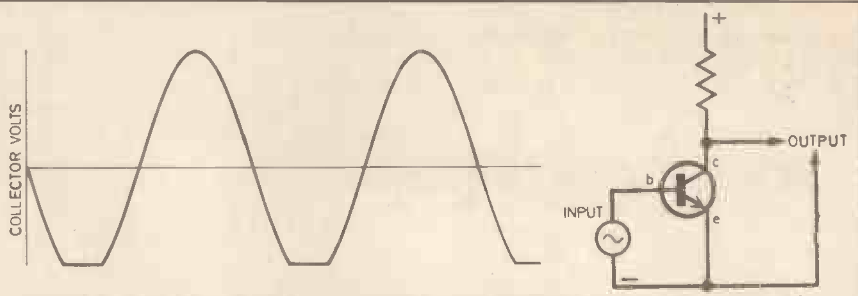


Fig. 7.4. Peak clipping: collector voltage waveform when the positive peaks of the input signal are too large.

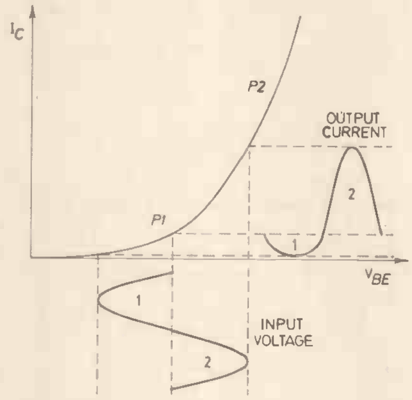


Fig. 7.5. How the non-linear characteristic of a transistor produces distortion.

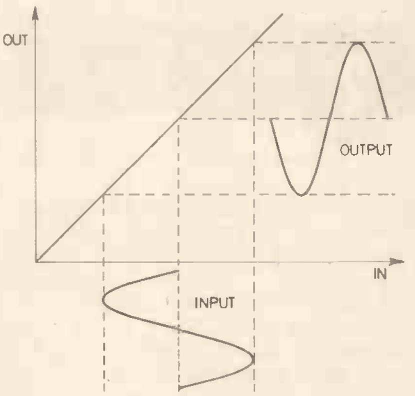


Fig. 7.6. A linear transfer characteristic gives distortionless amplification.

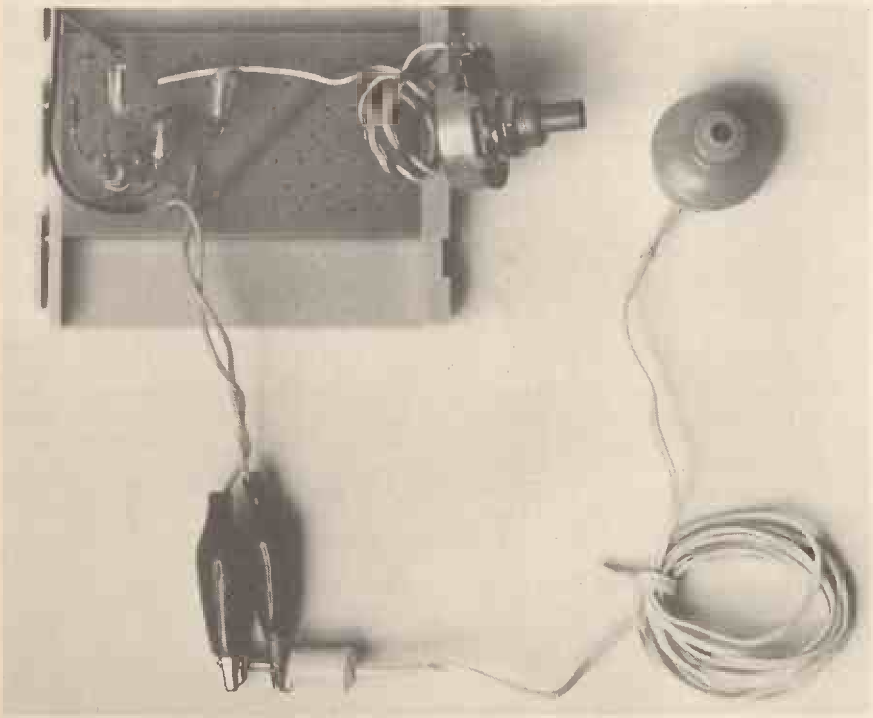
NON-LINEAR TRANSFER

This form of peak clipping or limiting is a common sort of distortion. It is easily cured by reducing the signal level. There is another common kind of distortion which is harder to deal with. It occurs when a transistor is voltage-driven.

Changing the base voltage (V_{BE}) of a bipolar transistor makes the collector current vary as shown in Fig. 7.5. The important point about this graph is that it is curved. (In the case of field-effect transistors, the shape of the curve is rather different but it is still a curve rather than a straight line.)

This is unfortunate. In audio amplifiers we want the output waveform to be a faithful enlargement of the input. With a curved input-versus-output graph (often called a transfer characteristic) this kind of fidelity is impossible. If we bias the transistor to a working point such as *P1* and apply a sine-wave input voltage as shown, the output current wave is distorted. The negative-going parts of the input wave have less effect on I_C than the positive-going parts.

What can be done about it? One possibility is to operate at point *P2* where the characteristic is less bent. This means biasing the transistor to a greater d.c. collector current.



CURRENT DRIVE

What is needed is a straight-line transfer characteristic, like Fig. 7.6. Such a linear characteristic gives zero distortion. It so happens that the relationship between base current and collector current is linear. So if a bipolar transistor can be current-driven rather than voltage-driven, distortion is minimised.

Current drive means that the signal must come from a source whose impedance is very much greater than the input impedance of the transistor. Unfortunately, the input stage of an amplifier usually can't be current-driven because, for lowest noise, a bipolar transistor has to be voltage-driven. The only useful distortion-reducing trick left is negative feedback. Distortion is reduced as the feedback reduces the gain.

EXPERIMENT 7.2

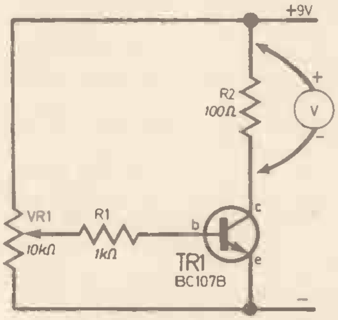


Fig. 7.7. Experiment to show heat effects.

TEMPERATURE EFFECTS

Set up the circuit of Fig. 7.7. (Work out your own EBBO layout.) R2 drops 1V for every 10mA of collector current. Set the collector current to 30mA (3V). Switch off the battery for five minutes. Switch on again and observe the voltage reading. It increases slowly, indicating an increase in collector current.

This is the result of the transistor warming up internally. Let's confirm that transistors are affected by heat by warming this one externally. Switch off. Leave for five minutes to cool. Remove R2 but leave the meter in place.

Switch on. Set VR1 to give any convenient meter reading. Squeeze the case of TR1 between finger and thumb, taking care not to touch the leadout wires. After squeezing for a while the meter reading increases, as your body heat travels to the active semiconductor material inside the case.

ENERGY CONVERSION

Where did the heat come from in the first experiment, when we weren't holding the transistor? It was generated inside the transistor. When current flows through a resistor, the resistor warms up. The electrical energy is turned into thermal energy.

A transistor is not a resistor, but to the battery it looks rather like one. When 9V drives 1mA through any circuit, to the 9V source the circuit looks like 9kΩ. If the circuit is a transistor then the warming effect is just the same.

In our first experiment (R2 in place) the current was set high to increase the heating effect. The amount of heat released in a resistor depends on the current, naturally. But the current depends on the voltage. Take 1Ω and apply 1V: 1A flows. Apply 2V and 2A flows. The amount of heat released depends on both voltage and current.

To be precise, it depends on voltage times current. So if 1V and 1A gives one unit of heating, 2V and 2A give, not two but four units. The units are in fact watts, and watts (W) are the measure of the rate at which energy is being expended. So 2V × 2A = 4W.

THERMAL RUNAWAY

Internal heating can be dangerous. Make a transistor too hot and it dies.

The danger is great in "power amplifiers", that is, amplifiers which have to deliver considerable power (to loudspeakers, for example).

Your finger-and-thumb experiment shows that a warm bipolar transistor passes more current. It therefore consumes more power. But this in turn raises the internal temperature, and this makes the transistor pass more current . . . and consume more power . . . and get hotter . . . and hotter . . . and hotter. The circuit "runs away".

So why haven't all our transistors destroyed themselves by thermal runaway? Two reasons. First, there has always been enough resistance in the way to limit the current to something safe. Take Fig. 7.7. Here there is 100Ω. Even if the full 9V were applied to 100Ω the current would only be 90mA. In fact, the transistor can't get hot enough to pass 90mA, because the more volts lost in R2 the less volts across the transistor. At 90mA, the voltage across TR1 would be zero; so, no heating. The most heating occurs when the current is 45mA and the voltage across TR1 and R2 is the same (4·5V).

The power being expended in each of them is then 4·5V × 45mA. Volts times milliamps gives the power in milliwatts (mW); 1000mW = 1W.

COOLING

The other reason why our transistors haven't destroyed themselves is that they are cooled by the air around them and by radiating heat. These cooling processes get more efficient as the transistor gets hotter. For once, nature is on our side.

But only up to a point. There is a limit to the rate at which heat can be removed. The only practicable way of increasing the cooling rate is to clamp the transistor to a metal plate. The plate provides a larger escape area for the heat.

Small transistors can't be helped much by such a heatsink because the internal heat has to get to the outside case of the device from the hidden semiconductor material inside. It can't do this instantaneously; the heat has to cross the thermal barrier between semiconductor and case.

But our transistors are designed only for low-power operation. High-power transistors are mounted on metal plates or studs which can be bolted to heatsinks.

Heatsinks are often made of aluminium, with fins to increase the surface area, as on a radiator, and blackened. A heatsink is described in terms of the amount by which its temperature rises when 1W is being dissipated. Thus a heatsink may be described as "3°C/W". In this case, if it were clamped to a transistor dissipating 3W its temperature would rise by 9°C.

POWER IN A.C. CIRCUITS

Power is volts times current. The meaning of voltage and current in a d.c. circuit is quite clear. But in a.c. circuits voltage and current are constantly changing. How do you measure power in this case?

The principle is to measure the a.c. quantities in a way that makes them directly comparable with d.c. An a.c. meter "reads" an a.c. current whose heating effect, when it flows through a resistor, is the same as d.c. of equal strength.

To make a.c. and d.c. equivalent in this way, the quantities have to be what are called r.m.s. currents and voltages. R.m.s. ("root mean square") refers to the mathematical basis for the equivalence.

Multimeters with a.c. scales are marked in r.m.s. voltage or current. Unfortunately, meters are liars. They really measure another kind of a.c., average-value a.c., which is much easier to measure than r.m.s. So your meter measures average-value a.c. but its scales are marked in r.m.s.

The meter reads correctly only if the a.c. currents and voltages have waveforms which are sine waves. With other wave shapes the meter reading is wrong. True r.m.s. meters do exist, but they are expensive.

AUDIO POWER

Fortunately, the errors are usually not too enormous. All the same, they exist. To make life easier when talking about audio power, equipment makers usually quote values for sine-wave signals. (Real speech and music are not of sine wave form.)

Amplifier specifications often don't quote r.m.s. power but peak power, which is greater and makes the figures look good. Peak power is also more relevant to distortion. As we've seen, an "overload" type of distortion happens when an amplifier can't handle the peak signal. So an amplifier's peak power rating says how much it can deliver round about the point where peak clipping begins. *See page 238*

CHECK YOUR PROGRESS

Questions on *Teach-In 84 Part 7*
Answers next month

Q7.1 A transistor has a collector load resistor of 100Ω. The supply voltage (Vcc) is 10V.

(a) What is the maximum current that can flow in the load?

(b) What is then the load power dissipation?

(c) What is the transistor power dissipation? (*i.e.*, collector volts times collector current).

(d) What are the conditions in this type of circuit for maximum power dissipation in the transistor?

(e) What are then the collector voltage (V_{CE}) and current?

(f) If the transistor has h_{FE} = 100 what base current is required in condition (e)?

Q7.2 In transistor data, the temperature rise due to internal heating is described in terms of a "thermal resistance" R_{TH} between the collector-base junction and the case or mounting stud of the transistor; for example, if R_{TH} (junction to case) = 10°C/W and the transistor is dissipating 2W, the junction temperature is 20°C higher than the case temperature.

(a) If the maximum safe junction temperature is 150°C and the transistor is on a heatsink which holds its case at 50°C, what is the maximum power which can safely be dissipated in the transistor?

(b) If the ambient temperature around the heatsink is 25°C, what must be the thermal resistance between heatsink and air?

Q7.3 In audio power stages like Fig. 7.10, the peak load current is half Vcc divided by RL. (This occurs when one transistor is "cut off" and the other is "hard on" with its V_{CE} = 0.) The peak load power is then (Vcc/2) times the load current, which in turn is (Vcc/2)/RL.

(a) If Vcc = 20V and RL = 4Ω what is the peak power?

(b) What is the peak power if Vcc is raised to 40V?

(c) If the r.m.s. (sine wave) power is half the peak power, how can it be calculated in terms of Vcc and RL?

ANSWERS TO PART 6

Q6.1 *(a)* pnp.

(b) The circuit is similar to Fig. 6.9 except that TR1 is pnp. *The input voltage is fixed at 4·5V by R1 and R2. The meter is replaced by R3. Negative feedback forces Vx to be equal to Vy. This makes the voltage across R3 be 4·5V, so the emitter current is 4·5mA.*

(c) 4·5mA approx., since Ic is nearly the same as IE.

(d) If R4 were 1kΩ it would drop 4·5V. But there is a drop of 4·5V in R3. Together these would use up all the supply voltage, leaving nothing to operate TR1.

(e) None. Vy is still Vcc/2.

(f) 3mA. (Vy and Vx become 3V.)

LETTERS

Teach-In Buzz

Sir—I have a problem; In your *Experiment 4.4* (see *Teach In '84*—January issue) I constructed the circuit according to the schematic (Fig. 4.10) using Veroboard and it didn't work. No buzz. I then noticed that the EBBO layout was different, so I rewired accordingly. Still no buzz.

By experimenting I found that if I left the VR1 as shown on the EBBO layout, but connected the earpiece to the TR1 input instead of to earth, I did get a buzz, which varied (in volume) with the setting of the VR1, but there was no change in frequency. The system worked equally well if either the (a) or (b) connections of the potentiometer (VR1) were totally disconnected. And in all cases the system worked better (louder) if the 10kΩV was replaced by 100kΩ potentiometer.

Evidently I am doing something wrong, and as I am conscienciently (!) working through all the experiments and progress checks, I would be very glad if you would please tell me where I am going wrong.

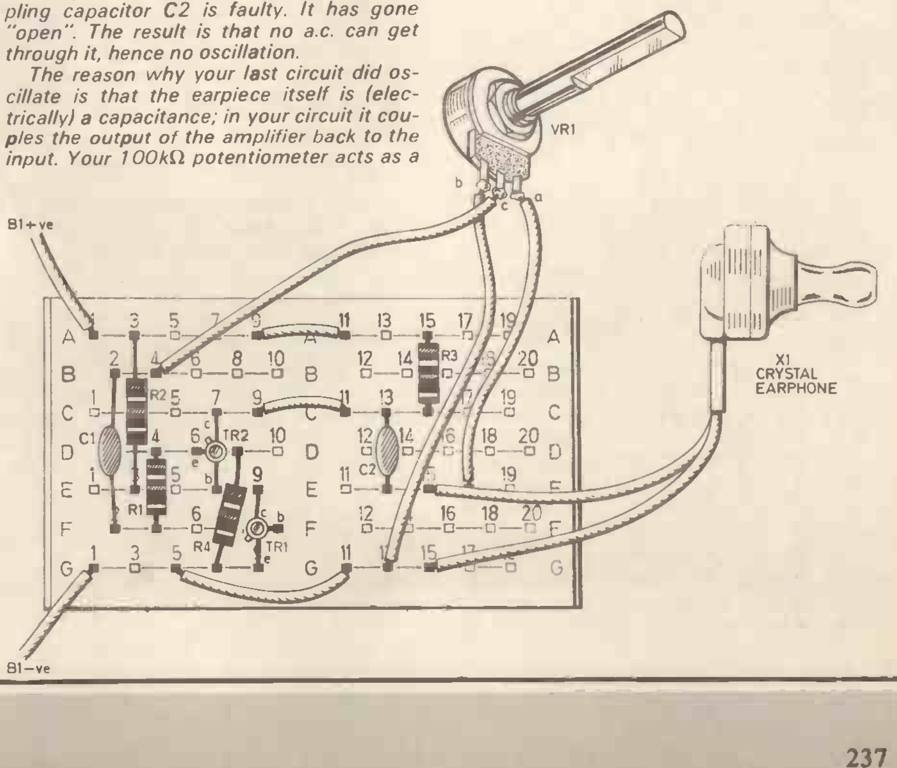
R. W. Seymour-Lee
Newbury,
Berks.

Sorry about the error in Fig. 4.11. The end of VR1 marked "a" should be connected to C2 and the earphone X1, as shown in the corrected version of Fig. 4.11 given here.

However, this is not the only problem in your case. I deduce from the symptoms which you describe that your output coupling capacitor C2 is faulty. It has gone "open". The result is that no a.c. can get through it, hence no oscillation.

The reason why your last circuit did oscillate is that the earpiece itself is (electrically) a capacitance; in your circuit it couples the output of the amplifier back to the input. Your 100kΩ potentiometer acts as a "volume control" by bypassing some of the output current to "earth." As the slider approaches "a" the volume then falls (and eventually oscillation ceases).

Thank you for drawing the problem of the drawings to my attention.—George Hylton.



DISTORTION VERSUS DISSIPATION

We've seen (Fig. 7.5) that for low distortion a transistor should operate with a fairly large standing collector current. That's fine for a pre-amplifier or the low-signal-level parts of a power amplifier. But for the output stage, where signal voltages and currents are highest, high standing current is bad from the power dissipation point of view.

Suppose, for example, that the transistor in Fig. 7.8 has to deliver maximum power to a 10Ω load. The condition for this is that Vcc is shared equally between load and transistor. In this example, the 10Ω load drops 10V so the current is 1A. The transistor also runs at 10V, 1A so its "collector dissipation" is 10W. The transistor dissipates 10W whether or not there is any signal present.

This is a warm and wasteful mode of operation. For economy, it would be preferable if the transistor were switched off when there is no signal. Then, when a signal arrives, it should be switched on just enough to handle this particular strength of signal without overloading.

PUSH-PULL

Such an amplifier can be built. It is called a "sliding bias" amplifier. But you are unlikely to come across one. There is another way of achieving the same objective which works better. It's called push-pull working.

The principle is illustrated in Fig. 7.9. Here RL is the load to which power must be delivered. There are two batteries. V1 is twice the voltage of V2.

Suppose VR1 is a linear-law "pot". With the slider at the half-way point, half of V1 is tapped off: 10V. No current flows in RL because the "tapped off" 10V is opposed and cancelled by V2.

If the slider is now moved up, towards (*a*), more of V1 is tapped off. This overcomes V2 and current flows downwards through RL. When the slider reaches (*a*), the net voltage applied to RL is V1 – V2. This is 10V in our case (20V – 10V) so 1A flows in RL and the power is 10W.

Now move the slider back to the midpoint of VR1, then on downwards. Below the midpoint, the tapped-off portion of V1 is less than 10V. So V2 overcomes it. Current flows from V2 into the slider and upwards through RL. With the slider at (*b*), the full 10V of V2 is applied to RL. Current is now 1A and power 10W.

By moving the slider up and down past the midpoint, current can be made to flow first one way then the other through RL. In other words, the arrangement generates a.c. If RL were a loudspeaker, and the slider were waggled up and down at an audio frequency, sound would be emitted. The peak power would be 10W.

This mode of operation is called push-pull working. To make it practical, we first replace V2 with a capacitance C1 (Fig. 7.9b). With the slider at the mid-

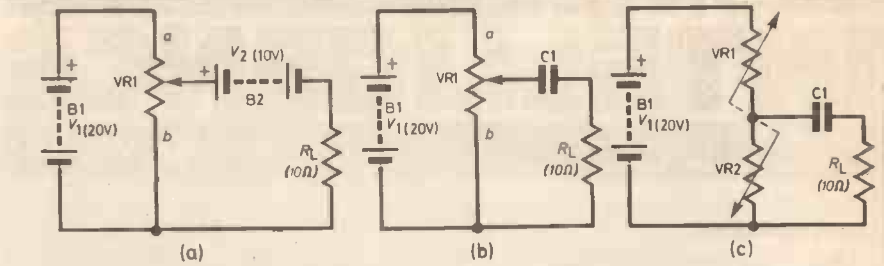


Fig. 7.9. "Thought experiments" to illustrate push-pull operation. (a) Two-battery circuit. (b) How a capacitor can replace one battery. (c) Two-resistance version of (b) which is easier to transistorise.

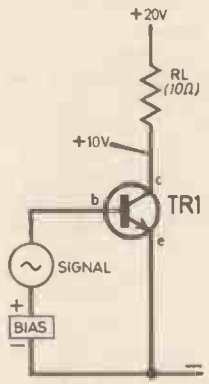


Fig. 7.8. Rudimentary power amplifier.

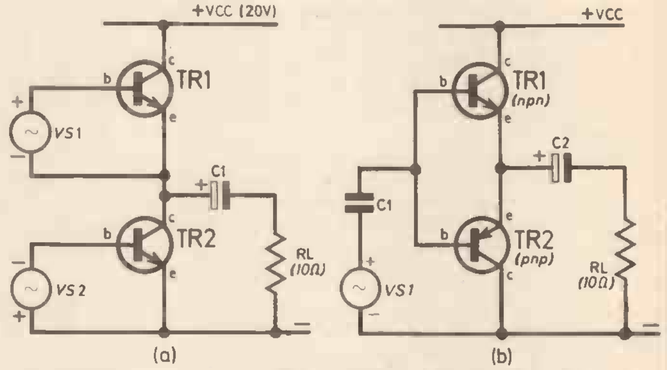


Fig. 7.10. Two versions of a push-pull power stage. (a) Single polarity transistors with two signals in anti-phase. (b) Complementary transistors with single signal.

point C1 charges to 10V. Move it up, and more current flows into C1. Move it down towards (*b*) and C1 discharges, current flowing out. RL receives to-and-fro currents as before.

The next step is taken purely because a potentiometer like VR1 can't be imitated directly by transistors. But an equivalent can (Fig. 7.9c). Here VR1 increases as VR2 decreases and vice-versa. The voltage at their junction moves up and down exactly as before.

By substituting transistors for VR1 and VR2, and controlling their effective resistances by applying signals to their bases, the circuit becomes an audio power amplifier. Peak power to RL is 10W.

TRANSISTOR PUSH-PULL

One possible scheme is shown in Fig. 7.10a. Here, the signal voltage is duplicated. One copy, Vs1, drives TR1. The other copy, Vs2, drives TR2, but with the reverse polarity.

When the voltages are as shown, TR1 is turned on. Current flows from Vcc+ via TR1 into C1, so RL gets a downward current. The actual amount depends on how hard TR1 is turned on, and this depends on the signal amplitude. Meanwhile, TR2 is held off. No collector current can flow as base is negative.

When the next audio half-cycle occurs, the signal polarity reverses. TR1 is now held off but TR2 turned on. C1 discharges through TR2, giving an upward current through RL. If there is no signal, TR1 and TR2 are both off.

BIAS

The arrangement has one drawback. Since a transistor passes no collector current until VBE reaches around 0·6V, audio signals less than 0·6V are ignored. The result is bad distortion.

To avoid this, TR1 and TR2 must be given enough bias to turn them on slightly in the absence of a signal. Even a small positive signal can then turn a transistor on further.

COMPLEMENTARY OUTPUT STAGE

The Fig. 7.10a arrangement is often used in high-power amplifiers. But for low and medium power circuit (*b*), Fig. 7.10b, is commoner. Its advantage is that only one signal (Vs1) is needed. The arrangement makes use of the fact that a positive signal turns an *npn* transistor on, but a *pnp* transistor off.

When Vs1 polarity is as shown, TR1 is turned on and delivers a current to C2 and RL. When the polarity reverses, the negative signal turns TR1 off but TR2 on, and RL gets a reverse current as before.

In the no-signal condition, both transistors are off. But in practical circuits they are given enough bias to turn them on slightly in the absence of a signal.

With both circuits, when the signal is large, TR1 handles the positive half cycles and TR2 the negative ones. For small signals the standing bias makes both transistors operative.

Next month: Power In General

COUNTER INTELLIGENCE

BY PAUL YOUNG

Unsurpassed

The introduction of the home microcomputer has produced a curious dichotomy and in the short term view, the electronics hobby has suffered. Those who started constructing them, soon found they were more fascinating to play with, worse still, many teenagers who were almost certain candidates for the electronics hobby were being wooed on to the home computer by advertising and television coverage.

The other day, I happened to visit a large stationer's in London and the first thing that met my eyes was several shelves full of home computers. I think they might have had more success, assuming they were trying to attract the casual buyer, if they had avoided such arcane language. The large notice saying "128 Kilobytes of RAM" would be meaningless to the tyro, whereas, "Produces 130,000 characters or 20,000 words" might give him some idea what it was all about.

Well, they are here to stay and I suppose I shall be told, "If you can't beat 'em, join em", though it goes against the grain for some of us more mature chaps. It was therefore, with great interest, that I read what the Right Honorable Tony Benn had to say on the subject, in one of the "nationals".

"This technology represents as great an advance in the communications arts as did the printing press, the television, radio—or telephone and tape recorders". He goes on to say, "It is for typing—simple typing—that the machine has proved itself to be unsurpassed, offering to my shaky two-fingered typing an undreamed of capacity to produce perfect copy without, as before, consuming more bottles of Tippex than mugs of tea."

Positive Charge

I was interested to see in the February issue of EVERYDAY ELECTRONICS a constructional article on a *Negative Ion Generator*. I have been exchanging letters on the subject of the benefit of negative Ions with a knowledgeable reader.

We were discussing when the air was more likely to be charged with an excess of positive Ions. During thunderstorms, of course, but he said there was also a theory that people living under high voltage electric pylons suffer in this way although no satisfactory conclusion has been arrived at.

It made me wonder if the average colour television produces positive Ions. As a corollary, has anyone produced a meter that would show the amount of positive or negative Ions in a room.

I suppose an Electroscope might be the answer. Readers' views on this would be most welcome.

Finally, here is a way of testing your Ioniser that I can personally vouch for. View the end of the pin in total darkness and a tiny blue corona will be visible round the tip. It is very small, and a magnifying glass would be helpful.

I don't know whether it will work with five pins and it might be better to make the test after the first pin is placed in position.

EVERYDAY ELECTRONICS SOFTWARE SERVICE

The EE Software Service provides an easy and reliable means of program entry for our computer-based projects. All programs have been tested by us and consist of two good quality copies of the working program on cassette tape. Certain program listings are also available.

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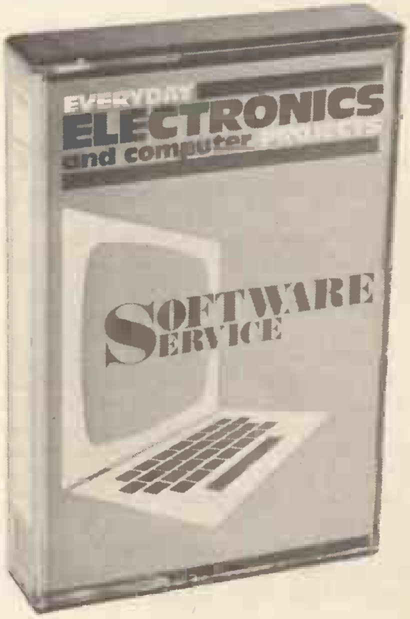

PROJECT TITLE	CASSETTE CODE	CASSETTE COST	LISTING CODE	LISTING COST
ZX81 SPEED COMPUTING SYSTEM (Feb 83)	T001	£2.95	L001	£2.95
REAL-TIME CLOCK (*Apple II*) (May 83)	T002	£2.95	L002	£2.95
REAL-TIME CLOCK (*BBC Micro*) (May 83)	T003	£2.95	L003	£2.95
EPROM PROGRAMMER (*TRS-80 & GENIE*) (June 83)*	T004	£3.95	N/A	—
STORAGE 'SCOPE INTERFACE (*BBC Micro*) (Aug 83)	T005	£2.95	—	
ELECTRO-CARDIOGRAPH (*BBC Micro*) (Jan 84)	T006	£2·95	—	—
EPROM PROGRAMMER/ROM CARD (*ZX81*)** (Feb 84)	T007	£3.95	—	—

*Includes Command List with examples.
**Includes Keyboard Overlay.

MICROCOMPUTER INTERFACING TECHNIQUES

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PART TEN: DATA ACQUISITION AND CONTROL

BY J. ADAMS B.Sc., M.Sc. & G.M. FEATHER B.Sc.

In the previous articles the techniques of I/O control and the monitoring of analogue quantities from the real world have been treated separately.

In many actual applications it is necessary to take corrective action on the basis of comparisons made between readings of physical parameters and their prescribed values. For example, analogue voltages developed from separate temperature probes, could be converted into digital values monitored by the microcomputer and compared with pre-determined values allotted for the particular application.

If this comparison shows that correction is desirable then appropriate signals could be sent to individual output devices controlled by the microcomputer so that the necessary correction could be achieved.

Such a system allows the repetitious monitoring of analogue quantities over long periods of time and this allied with a precise control in response to these measurements will obviate human error.

In addition, if transient events are monitored using the system, the speed of the microcomputer allows an almost instantaneous response. It should be apparent that the considerable flexibility and undoubted accuracy of such systems offer many advantages over manual systems.

CLOSED-LOOP SYSTEM

This month's project in the series is a closed-loop feedback control system. Information obtained from a 16-channel analogue-to-digital converter is fed back to the microcomputer so that it can control seven separate output devices to compensate for the effect of external changes.

This method is, of course, more crude than a closed-loop system including full proportional control (employing perhaps a DAC) but it is cheaper and easier to implement.

In practice a degree of pseudo-proportional control can often be achieved by the subsequent on-and-off switching of appropriate devices and this can be further improved by anticipatory on-off control. In such control systems the devices are actuated before the measured physical parameters reach their threshold values. This approach reduces oscillations of the monitored quantities of "hunting" as it is generally termed.

It is a relatively straightforward matter to write the requisite software with appropriate anticipation values included to prevent this occurring.

APPLICATIONS

There are many applications for such regulatory control systems. Two obvious and useful applications—in the house and in the greenhouse—are outlined below.

HOUSE ENERGY MANAGEMENT SYSTEM

The main shortcoming of conventional central heating control systems is the inherent lack of flexibility. This is exemplified by the continuous reprogramming

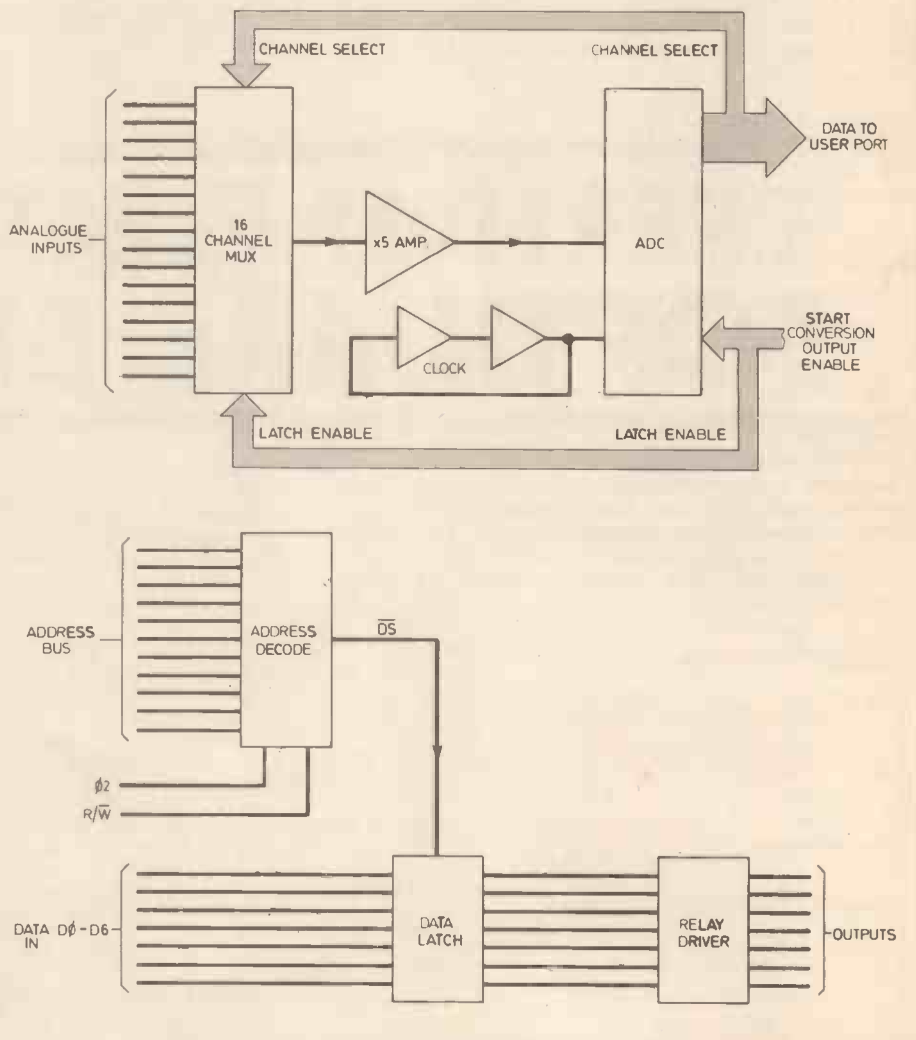


Fig. 10.1. Block diagram giving system overview.

of the clock needed, for example, every weekend. If measurements of individual room temperatures are collated periodically together with the temperature of the water and perhaps the external air temperature, then the appropriate output responses can be triggered to provide a closed-looped feedback control system.

GREENHOUSE MANAGEMENT SYSTEM

A similar closed-looped procedure may be adopted in a greenhouse management system. "Dry" temperature probes can be used to send information to the microcomputer so that air and soil temperatures can be monitored efficiently.

If "wet" temperature probes are also used, then the relative humidity can also be computed. The ambient light conditions may also be measured and assessed.

Suitable software controlled responses to complete the feedback loop include using output signals to switch a heater on or off, controlling a ventilator fan or perhaps opening or closing blinds.

SYSTEM OVERVIEW

The reader should by now be fully versant with the techniques of analogue data acquisition using an ADC and the control of external devices, as these have been fully dealt with earlier in this series.

Fig. 10.1 shows the individual input and output sections of a closed-loop micrcomputer control system.

INPUT SECTION

The input section can handle simultaneously up to sixteen channels of analogue data from appropriate transducers. All channels have a full range sensitivity of 1V and are unipolar. The input impedance of each is approximately 10kΩ.

Digital data from this section is transferred to the microcomputer via its user port, the ADC and channel multiplexing operation being also fashioned from this port. Simple transducers, for temperature and light intensity, are described briefly at the end of the article.

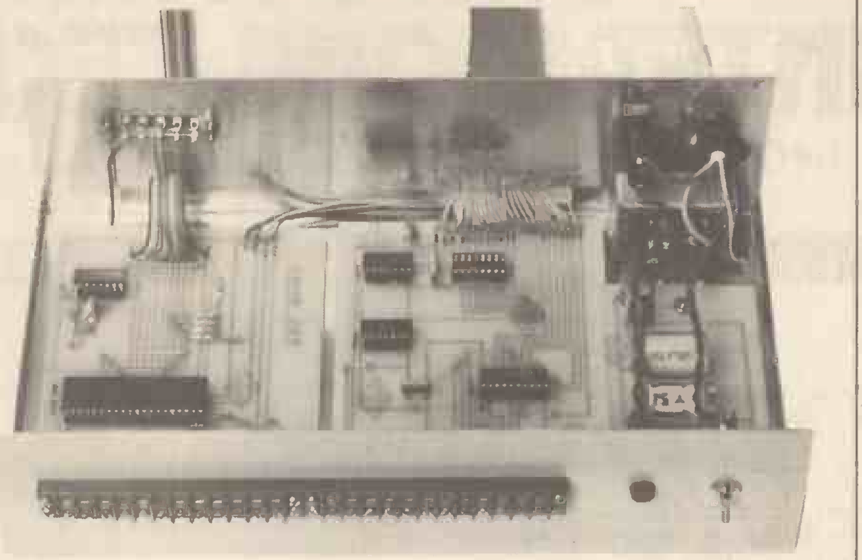
OUTPUT SECTION

Seven individually controllable outputs are provided which can operate a 5V relay situated at the device to be controlled. The output board is driven from the extension bus, suitable address bus decoding and data bus latching circuitry being included.

POWER SUPPLY

The power supply included is quite conventional circuitry to develop the ±7·5V supplies for the analogue signal amplifier on the input board and +5V for all the TTL supplies and the output relay drivers.

COMPONENTS



Resistors

R1–8, R9–16	10kΩ x 8 commoned s.i.l. (2 off)
R17	30kΩ
R18	7·5kΩ
R19–26	100kΩ (8 off)
R27	1kΩ
R28,29	220Ω (2 off)

All ¼W carbon ±5% unless specified otherwise

COMPONENTS approximate cost £50

Capacitors

C1	1000pF ceramic plate
C2,3	0·1µF polyester type C280
C4,5	1000µF 25V elect. axial (2 off)
C6	0·1µF polyester type C280

Semiconductors

D1	BZX61 5·6V Zener 1·3W
D2–5	W005 1A 50V bridge rectifier
D6,7	BZX61C7V5 7·5V 1·3W Zener (2 off)
IC1	741 op-amp
IC2	ADC 0817 16-channel multiplexed A-to-D converter i.c.
IC3	74LS04 low power Schottky TTL hex inverter
IC4	74LS133 low power Schottky TTL 13-input NAND
IC5	74LS27 low power Schottky TTL triple 3-input NOR
IC6	74LS04 low power Schottky TTL hex inverter
IC7	74LS273 low power Schottky TTL octal latch
IC8	ULN2001 7-stage Darlington driver i.c.
IC9	7805 +5V 1A voltage regulator

See Shop Talk page 231

Miscellaneous

S1	miniature on-off toggle
FS1	1·25A anti-surge 20mm fuse
LP1	panel mounting mains neon
T1	mains primary/two 0–9V 330mA secondaries
TB1,2	12-way barrier strips (2 off)
TB3	5-way barrier strips
VR1	10kΩ miniature horizontal carbon skeleton preset

Printed circuit boards: Input board, single-sided size 135 x 100mm, *EE PCB Service*, Order code 8404–02; Output board, single-sided size 135 x 100mm, *EE PCB Service*, Order code 8404-03; Power supply board, single-sided size 100 x 57mm, *EE PCB Service*, Order code 8404–04; 20mm panel mounting fuse holder; aluminium case, vinyl covered top size 275 x 153 x 75mm approx.; 6BA fixings, soldertag and board spacers; p.v.c. covered stranded connecting wire; 11-way ribbon cable; 23-way ribbon cable; single-sided Veropins (73 off); 22 s.w.g. tinned copper wire; d.i.l. i.c. sockets: 40-pin (1 off), 20-pin (1 off), 16-pin (2 off), 14-pin (3 off), 8-pin (1 off); 3-core mains cable; cable clamp and grommet for mains cable.

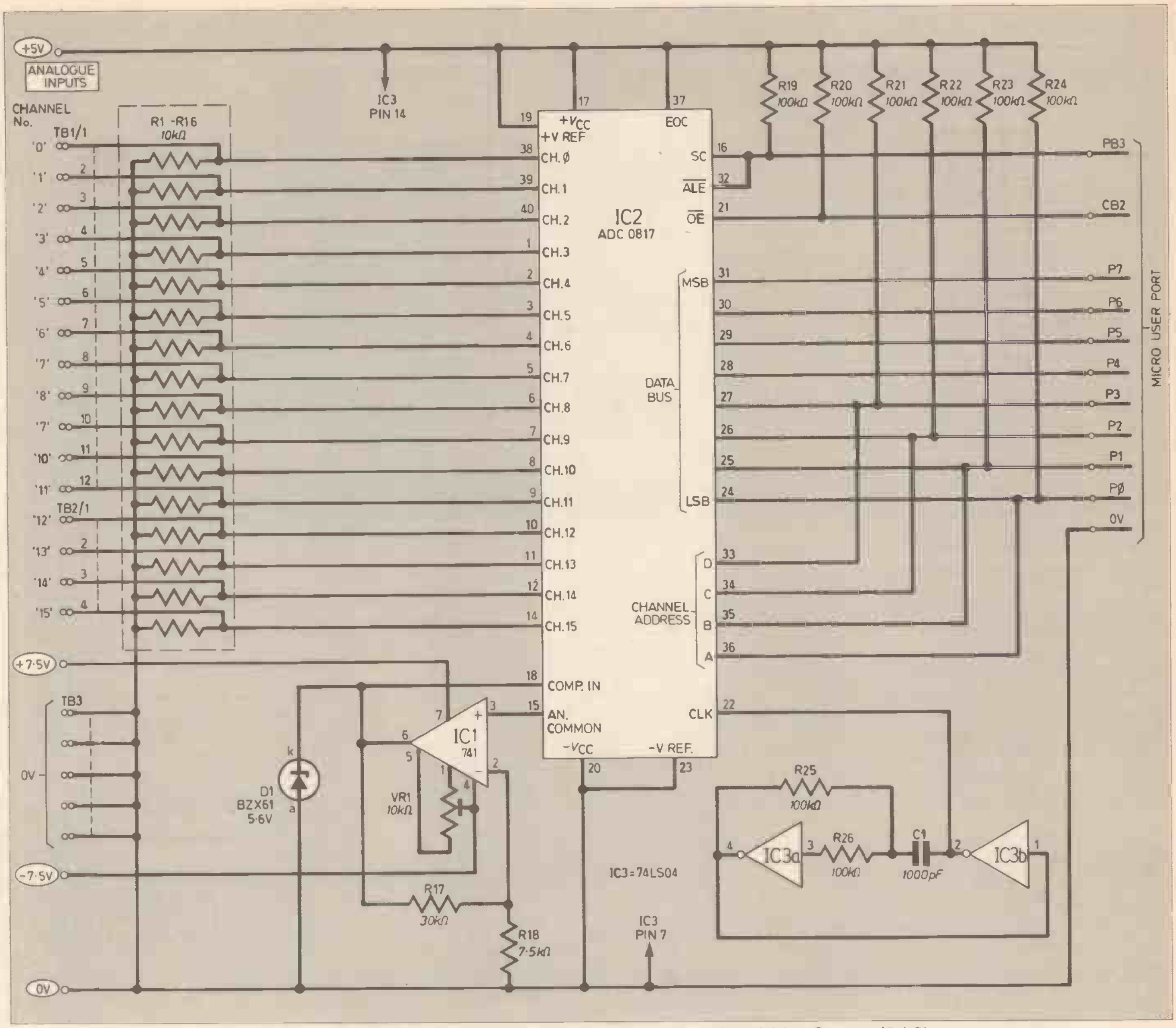


Fig. 10.2. Circuit diagram of the input section of the Data Acquisition System (DAS).

THE INPUT SECTION CIRCUITRY

Fig. 10.2 shows the complete circuit of the input board section of the system.

The ADC 0817 (IC2) is a 16-channel 8-bit successive approximation type analogue-to-digital (ADC) and is provided with tri-state output lines. The maximum input range for each analogue channel is dependent upon the reference voltage used and is, in this case, +5V.

This is rather higher than the usual range of transducer output circuitry and an operational amplifier, IC1, is included between the output of the multiplexer (channel selector) and the input to the ADC section of the device.

No on-chip clock is provided with the ADC 0817. The necessary clock signals are generated by IC3 which is wired as a simple astable circuit.

The maximum clock frequency for the ADC 0817 is quoted by the manufacturers as being 640kHz, but in this application a much lower clock is permissible and a frequency of approximately 30kHz is employed.

The 16-channel multiplexer section of the ADC 0817 requires a 4-bit address code and this is routed from the user port via the four least significant lines of the 8-bit port configured for output. This operation precedes the start conversion signal and the address is latched into the multiplexer hence holding the selected channel whilst conversion takes place. This procedure is explained in more detail in the software section.

THE OUTPUT SECTION CIRCUITRY

As previously mentioned, the output section of the circuitry interfaces directly with the extension bus. Readers of last month's article will realise that address bus decoding is necessary to provide the device select signal for the data bus latch.

Fig. 10.3 shows the complete circuit of the output section circuitry. IC4, IC5 and IC6 provide decoding for up to twelve address bus lines along with the ø2 clock signal, I/$\overline{\text{O}}$ and R/$\overline{\text{W}}$ lines. The number of lines actually used depends upon the microcomputer as detailed last month. Note that any unused inputs to the 74LS133 thirteen input NAND gate should be pulled up to logic 1 by direct connection to +5V.

The arrangement of this decoding circuitry and the number of lines used depends upon the microcomputer used and is identical to that featured in the output port design feature detailed in last month's article. In order to avoid unnecessary repetition, readers are referred to that article for further details.

When a valid address is detected by the circuit and the I/$\overline{\text{O}}$ and R/$\overline{\text{W}}$ control bus lines are low, data present on DØ to D6 is latched into IC7, the 74LS273 octal latch.

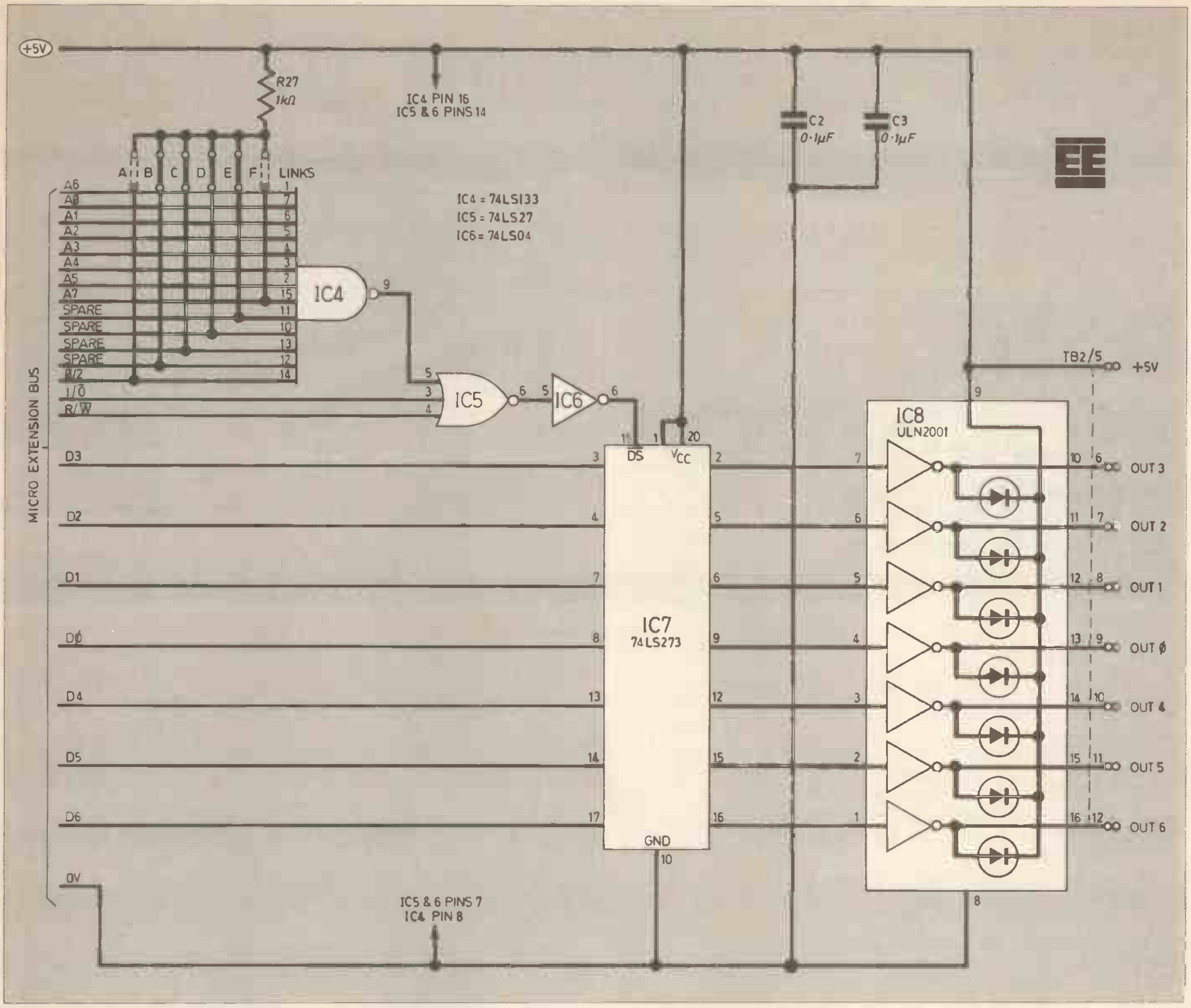


Fig. 10.3. Circuit diagram of the output section of the DAS.

The Q outputs of this drive the seven stage Darlington transistor array, IC8. Each output of this is capable of switching up to 500mA and can be used to actuate a switch located at the particular device to be controlled.

It should be noted, however, that the use of relays can induce spurious signals on the buses. One practical solution to this problem is to use optically isolated zero-crossing solid-state switches. These allow the switching of perhaps a heater when the mains voltage is at the zero-point of its cycle.

POWER SUPPLY CIRCUITRY

The power supply for the system is relatively conventional and Fig. 10.4 should be consulted.

The 240V a.c. mains is placed across the primary of T1 via S1 the on-off switch. Power on is indicated by mains neon, LP1.

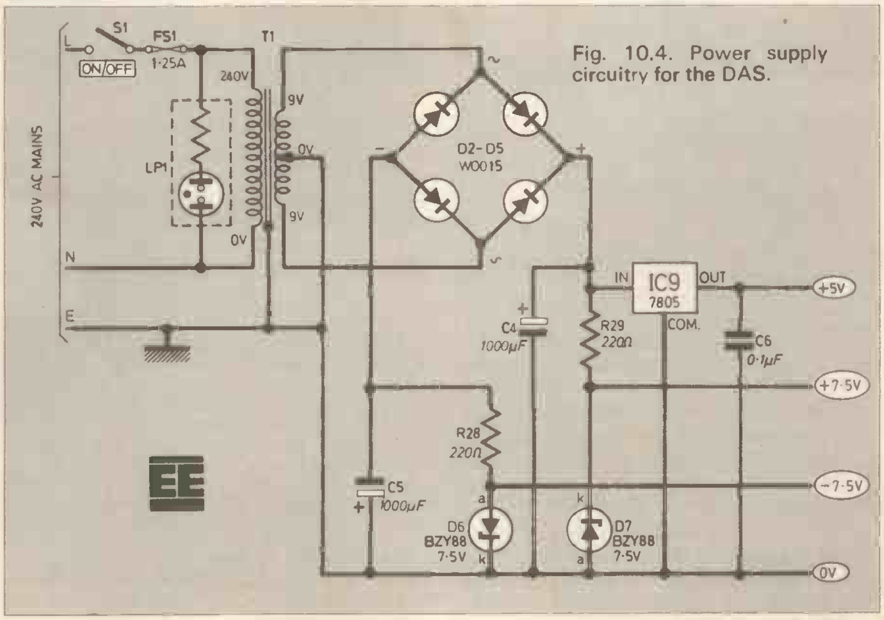
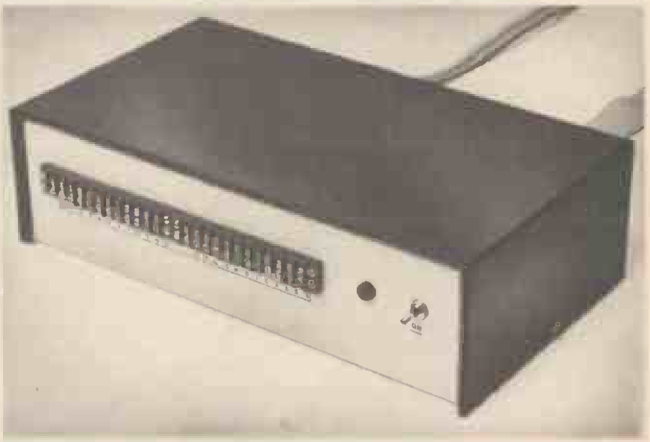


Fig. 10.4. Power supply circuitry for the DAS.

18V appears across the centre tapped secondary of T1. The bridge rectifier (D1 to D4) provides full-wave rectification to give pulsating d.c. of peak value, about ±13V. C3 smooths the +ve peaks to feed IC9. Negative peaks are smoothed by C4.

The ADC and other digital sections of the circuity require the usual +5V supply, which is provided for by the 7805 voltage regulator, IC9. The 741 operational amplifier is operated at ±7·5V. The current requirement is very small and these supplies are derived from the Zener diodes, D6 and D7, and associated dropper resistors R28 and R29.

DATA ACQUISITION SYSTEM



INPUT BOARD

The three sections of the system are each constructed on separate printed circuit boards.

The actual-size master p.c.b. pattern for the ADC input board is shown in Fig. 10.5. This board is available from the *EE PCB Service,* Order code 8404–02. The layout of the components on the board topside is given in Fig. 10.6.

Assemble the components as shown paying attention to the polarity of D1. Resistors R11 to R27 are a little unusual in appearance to those normally found in EE. These are s.i.l. packaged (single-in-line) and contain eight equal value resistors all "commoned" at one end. This gives nine s.i.l. pins. These packages must be assembled the correct way round. There is a small white dot above the "common" pin.

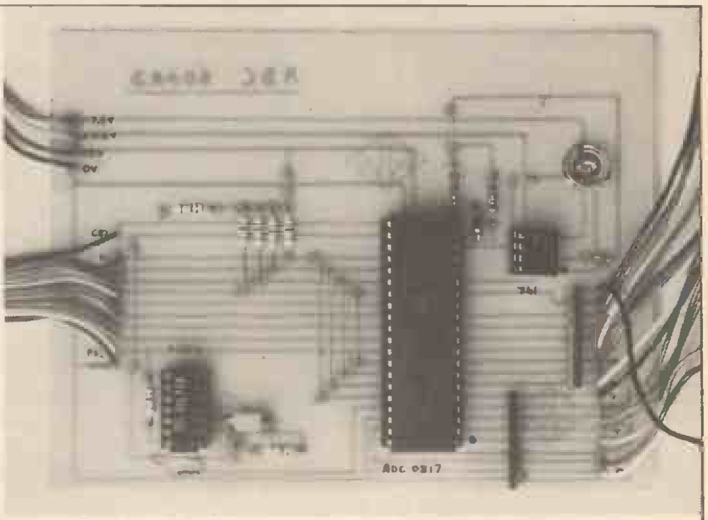
In the prototype the leads to the board were soldered directly to the board. It may be better to use Veropins for each of these connections, as then the boards may be positioned in the case, and interwired, and to the case mounted components in situ.

Sockets were used to hold all i.c.s (except IC9), and we recommend that constructors do likewise. Do not reset the i.c.s in their sockets until the system has been fully wired up.

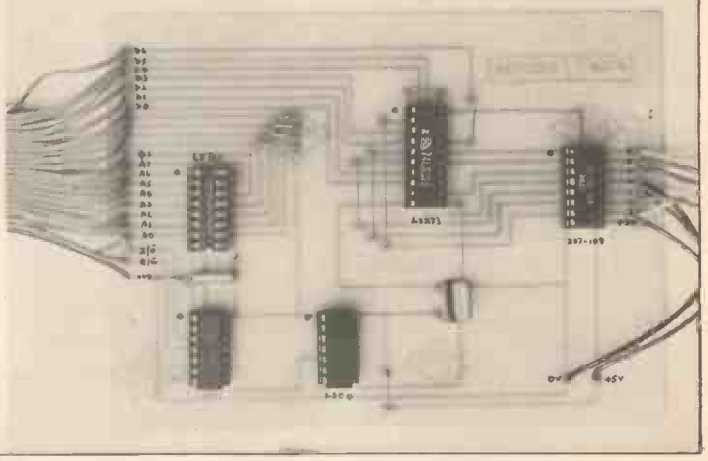
OUTPUT BOARD

The printed circuit board master pattern actual-size, for the Output board is shown in Fig. 10.7, with the component layout on the p.c.b. topside given in Fig. 10.8.

The p.c.b. is available from the *EE PCB Service,* Order code 8404–03. Assemble the board as indicated. Use Veropins for all cable connection points.



The completed DAS "Input" board.



The fully assembled DAS "Output" board.

INPUT BOARD

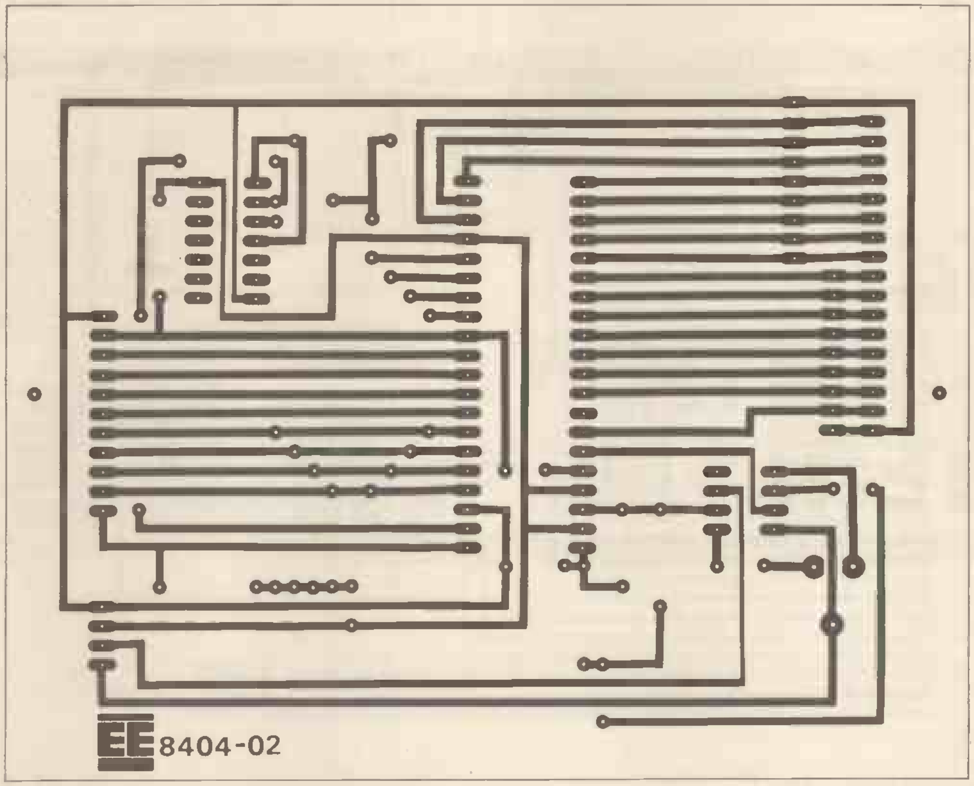


Fig. 10.5. Actual-size master pattern for the DAS input section. This board is available from the *EE PCB Service*, Order code 8404–02.

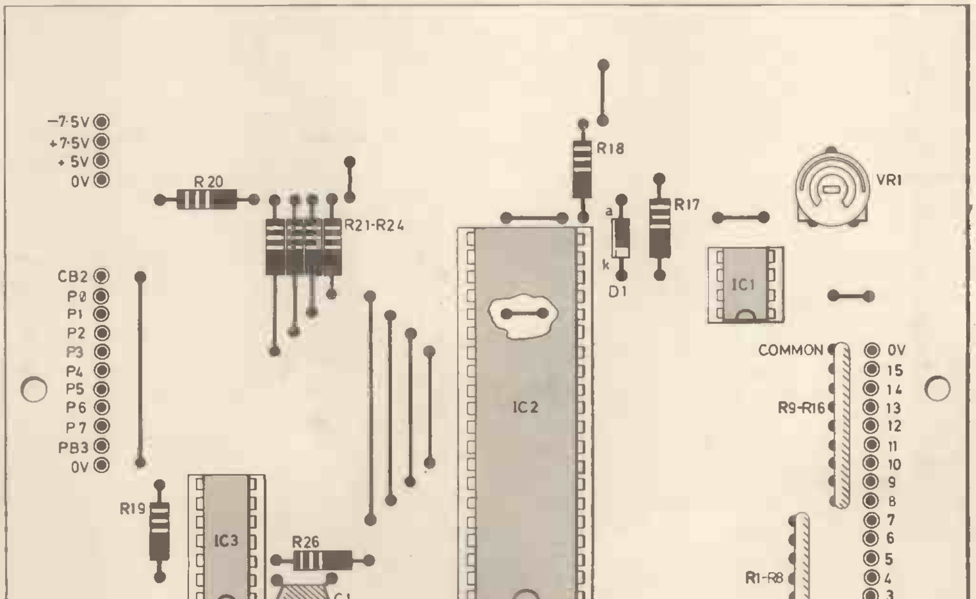


Fig. 10.6. Layout of the components on the topside of the "Input" board.

OUTPUT BOARD

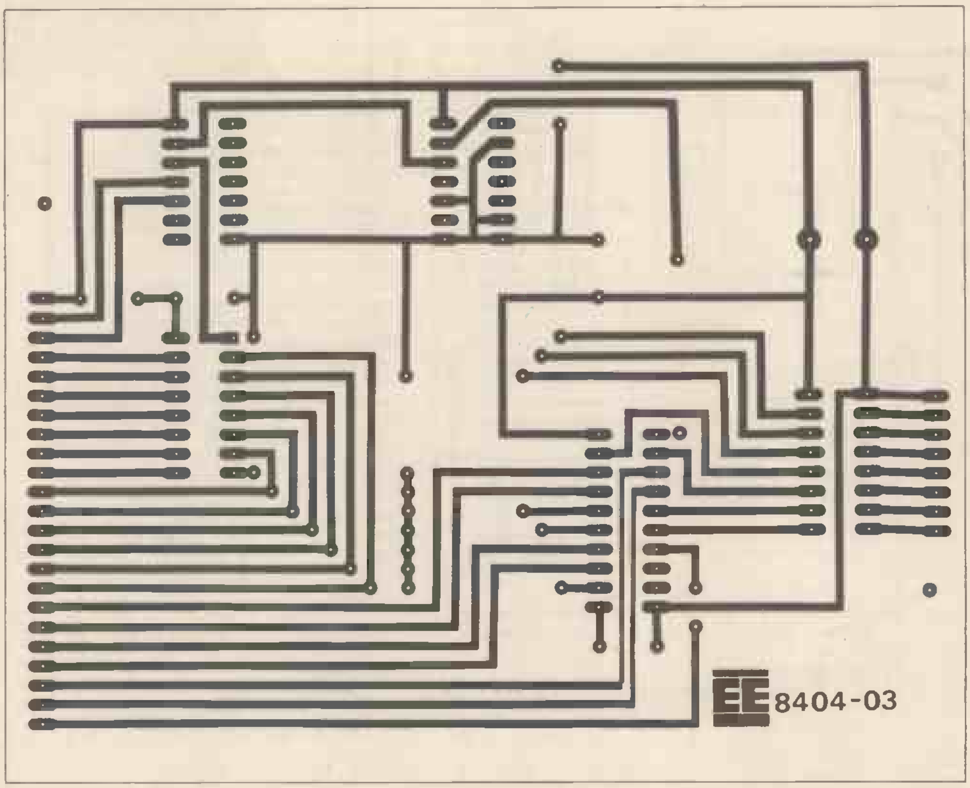


Fig. 10.7. Actual-size master pattern for the DAS "Output". This board is available from the *EE PCB Service*, Order code 8404–03.

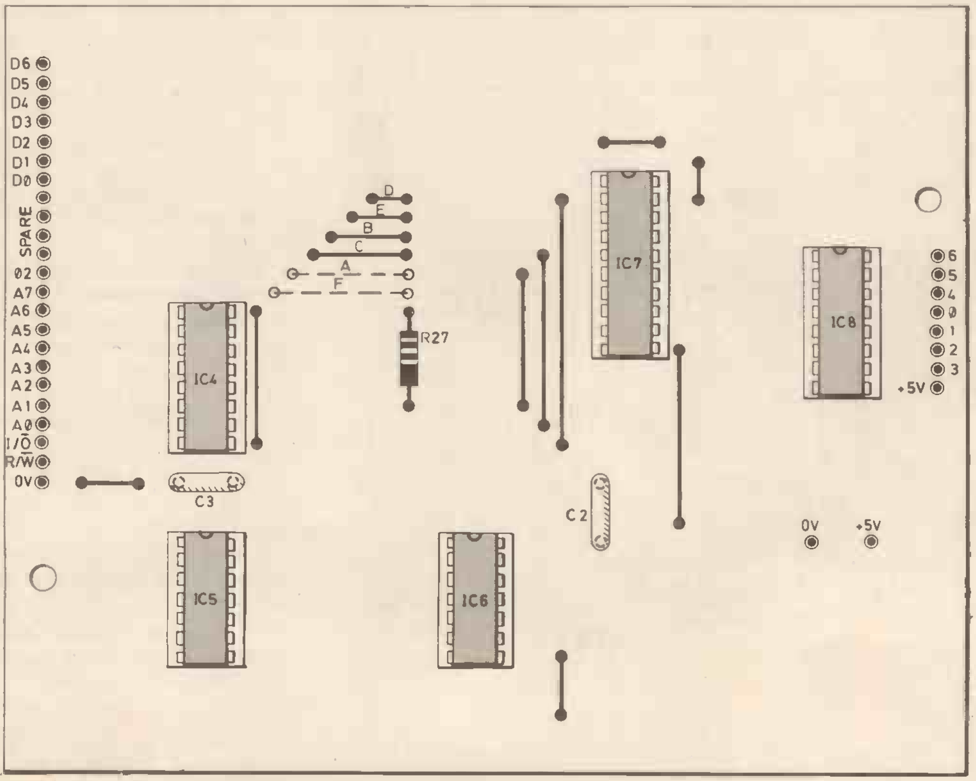


Fig. 10.8. Layout of the components on the topside of the "Output" board.

POWER SUPPLY

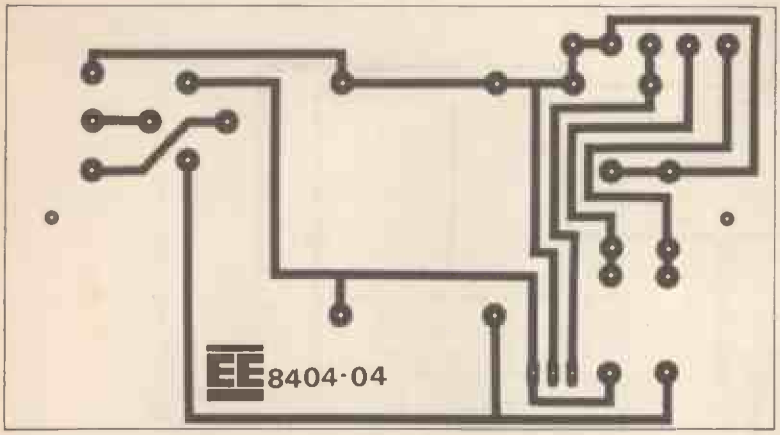


Fig. 10.9. The actual-size master p.c.b. pattern for the power supply board for the DAS. This board is available from the *EE PCB Service*, Order code 8404–04.

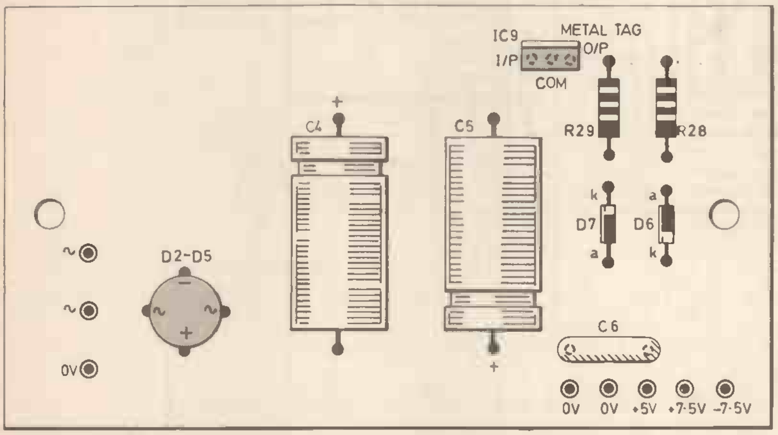
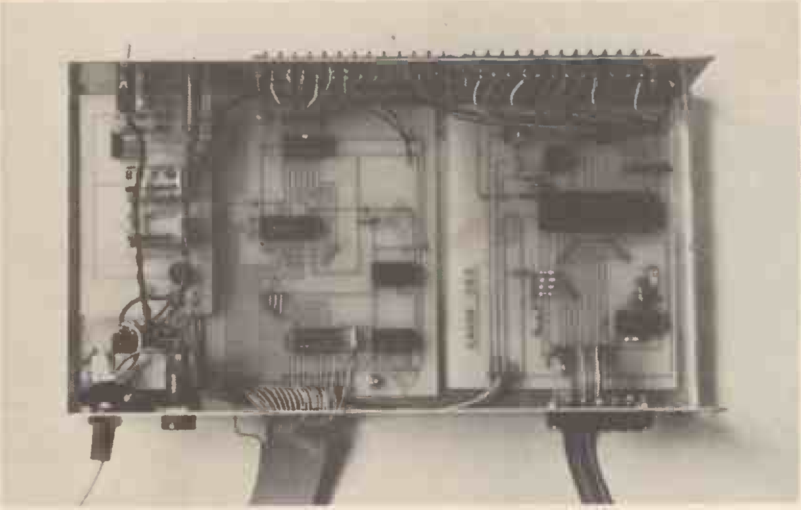
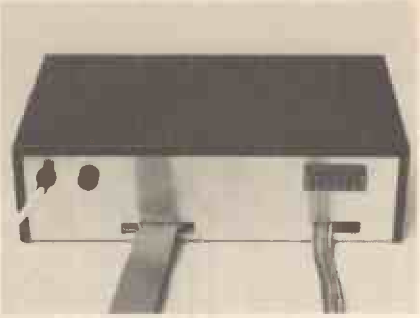


Fig. 10.10. The layout of the components on the topside of the DAS power supply board.



Plan view of the prototype DAS with lid removed from case.



Rear panel of the prototype DAS.

SOFTWARE

The techniques involved for the software Microcomputer Data Acquisition and Control System have been covered in earlier articles. A possible sequence of operations is outlined below:

1. Disable tri-state by taking the appropriate output line from the microcomputer (to pin 21 of the ADC) to logic zero.
2. Disable address-latch by taking the appropriate output signal line from the microcomputer (to pin 32 of the ADC) to logic zero.
3. Configure the user port for output by setting all bits in the appropriate data direction register for the port.
4. Select ADC channel required (0-15).
5. Route channel selected (to pins 36, 35, 34, 33 of the ADC) using the four least significant lines of user port previously configured for output.
6. Enable address-latch by sending logic one output signal to pin 32 of the ADC.
7. Initiate conversion by sending the address-latch line to logic zero thus allowing a negative going pulse to reach the start conversion pin (16) of the ADC.
8. Wait for the conversion to be completed (not necessary if using BASIC).
9. Configure user port for input by clearing all bits in the appropriate data direction register.
10. Enable the tri-state by taking the appropriate output signal line to logic one.
11. Read the value presented to the user port via lines 31 to 24 from the ADC.
12. Disable the tri-state by taking the appropriate output signal line to logic zero.
13. Configure the user port again for output by setting the requisite bits in the data direction register.
14. Compare digital result obtained from ADC with allotted value.
15. Turn on or off appropriate output control device on extension bus.
16. GOTO step 4.

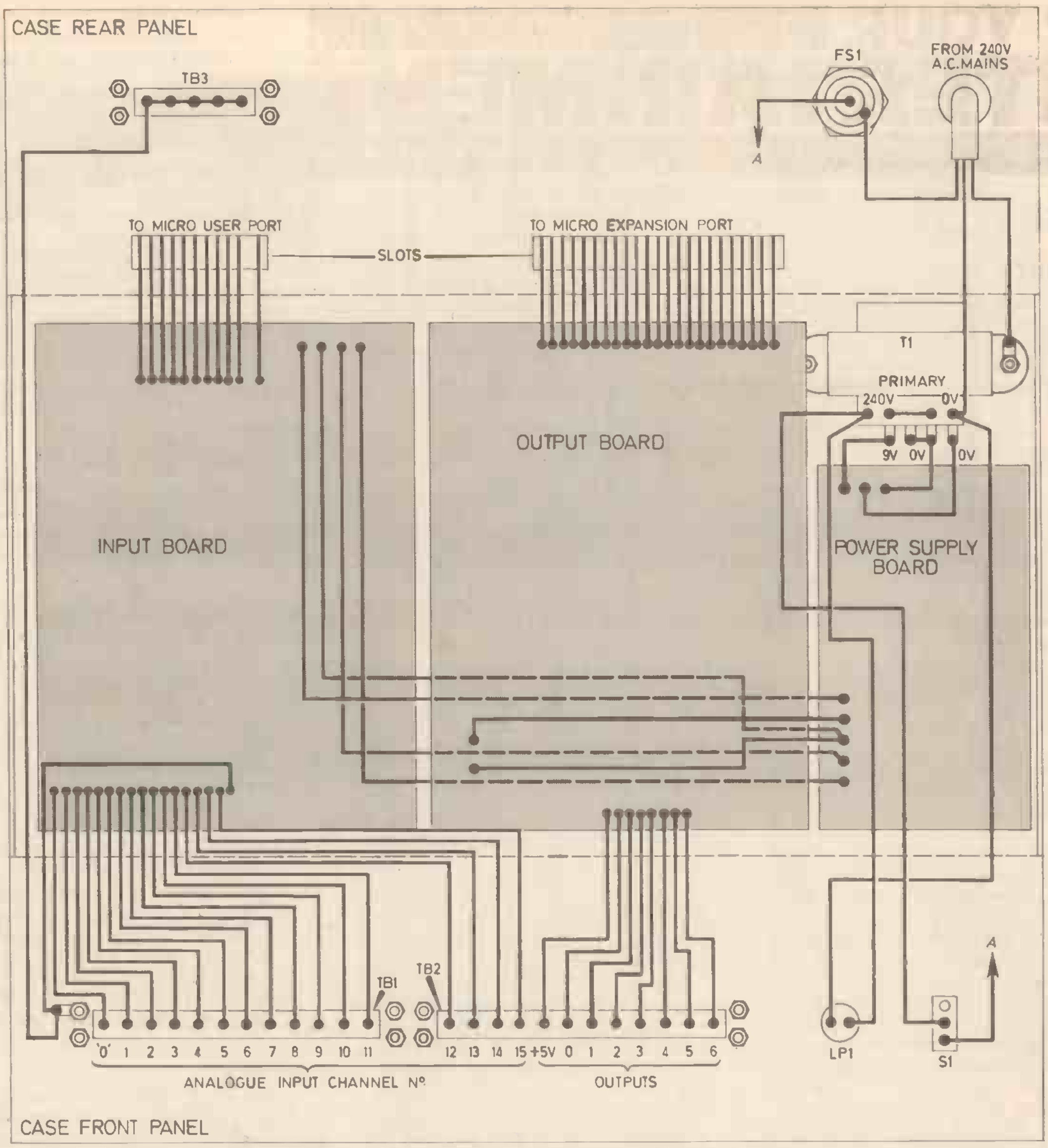
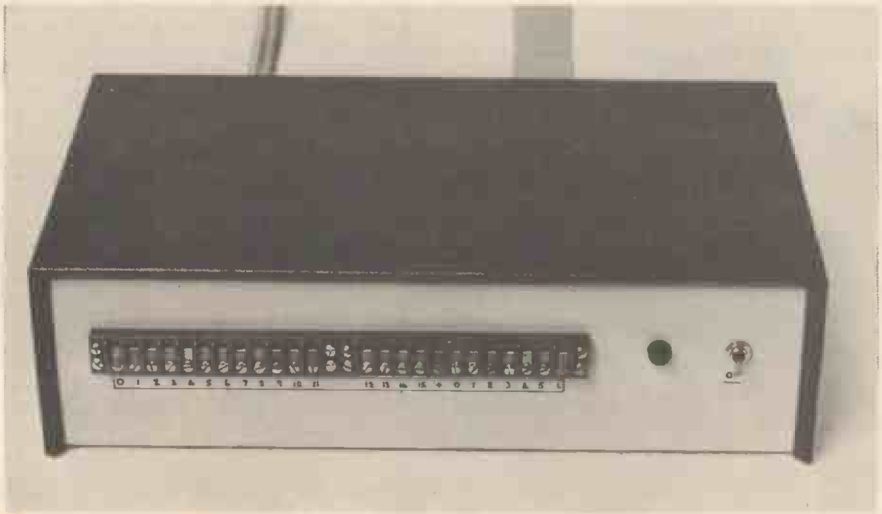


Fig. 10.11. Position of components and circuit boards for the complete DAS with full interwiring details.



Shows the front panel of the prototype DAS.

POWER SUPPLY

Most of the power supply components are mounted on a p.c.b. The actual-size master p.c.b. pattern is given in Fig. 10.9. This board is available from the ***EE PCB Service***, Order code 8404–04.

Assemble the components on the top-side of the board according to Fig. 10.10 paying attention to the orientation of the diodes, electrolytic capacitors and IC9.

INTERWIRING

Prepare the case and fit all the components. Mount the three p.c.b.s on suitable height spacers above the base of the case and interwire and connect to the case mounted components as shown in Fig. 10.11.

The ends of the ribbon cables should be suitably terminated to mate with the micro in use. Insert all i.c.s paying attention to polarity. Label the case as shown in the photographs.

Next month:
Vehicle Control with the Micro

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Mole Proof

Earlier this year there was considerable cufuffle about the leakage of secret Government documents. Leaking of course, has been much, much easier since the ready availability of Xerox copy machines in the 60s.

Before the advent of copying machines it was very hard to copy a document quickly and unobtrusively. Although spy films still show the hero or villain snapping away with a miniature camera, this is stretching credibility.

As anyone who has ever tried to take close-up shots with a camera will know, there are any number of pitfalls. Focussing is critical, especially if the light level is low and the camera aperture wide open. You need a very steady hand, or a tripod, to avoid camera shake. It is all too easy to get highlights, with the light source reflected from the surface of the paper.

"Wet" photo copy machines made things easier. But they were slow to use and there was the added problem of how to get rid of the throw away wet negative sheet that came out of the machine along with the positive copy. It's no joke, if you are a mole copying a hundred-page document, to try to get rid of a hundred sheets of paper sodden with chemical developer!

Although the original Xerography invention, made by Chester Carlson, dates back to before the war, it was not until the 60s that Rank Xerox made plain paper copying a part of office routine. It wasn't long before people with secret documents, started worrying about unauthorised copying. So Rank-Xerox invented and patented, a system of making documents uncopyable.

There is a high intensity light in a Xerocopy machine and if the paper being copied contains a coloured fluorescent material this light is absorbed at one wavelength and re-emitted at another. This dazzles the copier by swamping the image contrast.

Secret Message

On early Xerox copying machines, the 813 and 3600, it was possible to make a message secure simply by writing it on paper with red or orange fluorescent colouring. The original message is perfectly legible, but completely uncopyable.

The Xerox anti-copy patent specified the best type of dyes to use in aerosol sprays. But in the 70s, Rank-Xerox came out with a new generation of machine, for instance, the 4000, which could produce superbly clear copies of dye-masked messages that baffled the older machines.

All modern Xerox machines contain dazzle proof optics. So they can make clear copies of virtually any messages that can be read by the human eye. Paradoxically, if Government departments were to use older machines, they would be able to make a document secure by dye masking.

Some of the early machines are in fact available, for outright purchase. They are reconditioned models taken out of rental service. So if anyone wants to make their office mole proof, they need only buy an old machine and some sprays of fluorescent dye.

Radio Mole

The hunt for Government moles reminded me of something that happened when I was in the Air Force, during the last few months of National Service. We were learning to service high power radio transmitters. The only way to check the transmitter was to tune it to the transmission frequency and run the valves up to full power. But the output stages would blow up if there was no aerial.

Obviously stray radio transmissions from a workshop on an RAF base could have interfered with important communications. So the workshop transmitter could be either connected to a real aerial, or a string of light bulbs that served as a dummy aerial.

One day, one conscript unplugged the dummy aerial and plugged in the real one. He then broadcast a *"Mayday"* emergency signal. All across England air-sea rescue was mobilised and they soon pin-pointed the Wiltshire air base.

The military police on the airbase swiftly pin-pointed the workshop most likely to house the guilty man. All but two people denied knowledge of the incident. The remaining two pleaded innocence but blamed each other. The military police, fearing questions in Parliament about unfair collective punishment, couldn't lock up both airmen. The police tried for days to extract an admission of guilt. But they failed and both suspects walked free.

We never did know which one of the two had done the deed.

Cashless Society

The cashless society is coming. Some cash and credit cards carry a magnetically coded identity strip. The next generation of cards are quite literally miniature computers.

It is not generally known that the Cardphone public telephone boxes, which are being installed by British Telecom around Britain, use a holographic technique. You buy a card, that looks like a credit card, which lets you make a limited number of "free" phone-calls when you push it into a slot in the telephone box. As you make the calls, an l.c.d. shows how the units are being used up.

It would be possible to base the phonecard system on magnetic technology, erasing areas of magnetism, one at a time, a holographic card is much more secure. However, the phonecard system, which comes from the Swiss company Landis and Gyr, relies on the optical phenomenon whereby light shone on an ultra-fine pattern will create interference effects, like fringing round a grating or colours from oil on water.

Phonecard

The Phonecard, which is made of plastic and looks like a credit card, has a track in the surface which contains a series of individual holograms.

Each one produces a characteristic pattern of light and shade when illuminated by a strong lamp.

This light and shade pattern is sensed by photo cells which switch the telephone on. As each unit of telephone time is used up, the holograms are destroyed, one by one, by a sharply focussed heat beam. If you look carefully at a Phonecard you can see the track along the top surface, with tiny bumps where units have been burned out.

On the continent, especially France, they are experimenting with an even more exotic kind of card, appropriately christened the "Smart Card". Again, this looks like a plastic credit card, but it contains an astonishing array of electronics.

Buried inside the plastic there is a microprocessor, and several levels of memory. Some levels are readily accessible to give a readout of the card serial number. Some are accessible only when the microprocessor is interrogated by another computer.

For instance, the card can be used instead of cheques, with each cash withdrawal or payment subtracted from a credit balance programmed into the card's memory. The Smart Card is in effect an electronic wallet.

Current cards have a memory of 8K bits, which is sufficient capacity for 200 separate banking transactions. Several French cities, including Lyon, have shops and telephones equipped with computer units which can interrogate Smart Cards so that they function instead of cash.

Paper Security

In theory the cashless society makes life safer and easier for everyone. But in practice this isn't necessarily so.

A friend of mine has been trying for over a month to subscribe to one of the new video systems that lets you do banking and shopping by a telephone line hooked up to a home computer. The delays have all been caused by office bureaucrats fumbling the paper work.

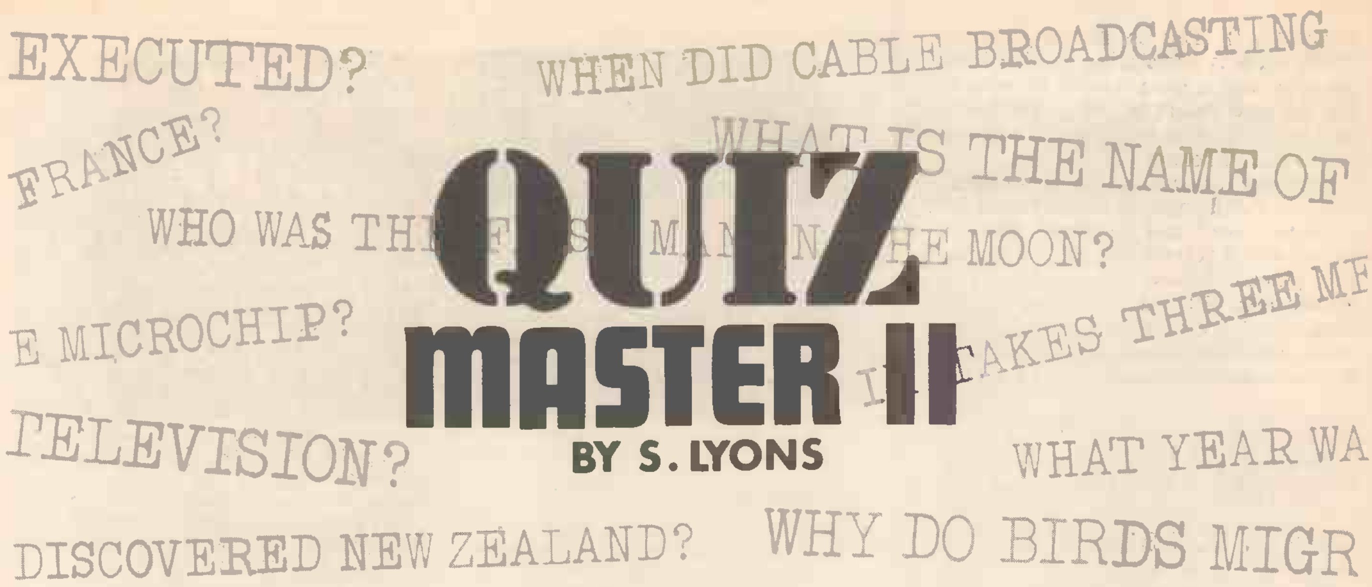
Exotic cash cards can only be secure if they rely on the user keying in a secret password or code number. But all too many people write their secret word or number on their card, or on a piece of paper which they keep in the same wallet as the card. So security is gone!

Thanks to the cashless society, it's possible to order goods, services and theatre tickets by telephone or video screen, using the number of your credit card. But often people who use credit cards throw away the copy receipt which they are given when they have used the card in a shop or restaurant. These receipts give the card number, the owner's name and signature. So once again security is jeopardised.

Your cash will never be 100 per cent safe, even in a cashless society. We shall always need paper, if only to keep a record of electronic transactions. And, of course, pen and paper is the only system that works when there's a power cut!

QUIZ MASTER II

BY S. LYONS



DETERMINE who is first on the button in panel games with the Quiz-Master II. For up to eight players, each with a hand-held response control, the unit gives both audible and visual indication of the fastest to press, upon which, all other response units are disabled.

The design has provision for up to eight response units to be used, each connected to the main control unit by 5-pin DIN plugs on leads to 5-pin DIN sockets.

The circuit of the Quiz-Master II is in two parts, the response units, and the main control unit. It is the function of the latter to determine who pressed first, and isolate all other response units. The response unit consists of a switch, resistor, and an l.e.d.

RESPONSE UNIT CIRCUIT

The response unit circuit is shown in Fig. 1. L.e.d. D1 is not physically connected to switch S1 (except by the zero volts line) and is driven by the main control unit, and will only light up if its switch closure has been accepted as a valid response (that is, if it was pushed first).

Switch S1 is a non-latching push-to-make type, and is used to generate a TTL logic 1 when open and logic 0 when closed. The required voltage level is set by resistor R1.

All this is housed in a small, plastic box. To link it to the main control unit, individual twin screened cable is used, terminated with a 5-pin DIN plug.

MAIN CONTROL UNIT

Fig. 3 shows the circuit diagram of the main control unit. The heart of the circuit is IC1, a 74LS373 octal transparent latch. The inputs of this device are fed from the switches of the response units, and the outputs are fed to three logic gates. Two of these gates are used to produce the signals for the indicators, the other is an 8-input NAND gate.

This gate produces the necessary latch signal for IC1, and also the signal to control the piezo-electric buzzer. Note that there is an inverter gate immediately after the NAND gate output; this is to produce the correct logic level for IC6.

The RESET signal is produced by S2 and R2. S2 is a non-latching push-to-break switch. The logic levels generated by these components are logic 1 when the switch is pressed, and logic 0 when not pressed. The signal is ORed with the inverted output of IC5 to produce the latch enable signal fed to pin 11, IC1.

When a response unit has been pressed, it sends a logic 0 to an input of IC1. If no other unit has been pressed before it, the output associated with this input will also be at logic 0, all other outputs at logic 1. This will cause the output of IC5 to go to logic 1.

Inverter IC4e inverts this to logic 0 to drive the buzzer, and to change the output of IC6 from logic 1 to logic 0. This will latch the outputs of IC1, in effect, freezing the state of it, preventing any other response unit operating. To reset the unit, a logic 1 is required on the other input of IC6, produced by S2.

RESPONSE DISPLAY

A visual indication of which response unit initiated the above effect is displayed on both the master control unit's front panel, and on the appropriate response unit. The signal to drive the l.e.d.s comes from the outputs of IC1, via an inverter. The inverter is used as an inverting buffer, one for each l.e.d., two per output line. The l.e.d. is extinguished when the unit is reset.

POWER SUPPLY

The power supply unit is quite simple (see Fig. 2), using a standard 5V monolithic voltage regulator integrated

Fig. 1. Response unit circuit diagram.

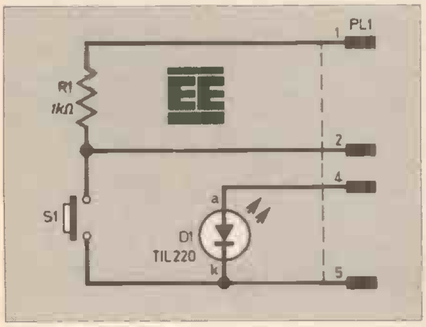
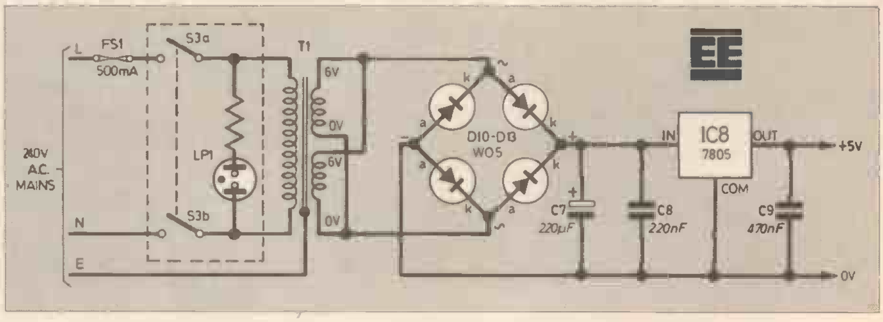


Fig. 2. Circuit diagram of the power supply section.



circuit (IC7). This is the only device which requires heatsinking, bolting it to the case with a mica washer between it and the case should be fine. A few holes or slots to allow air to circulate inside the case would be helpful.

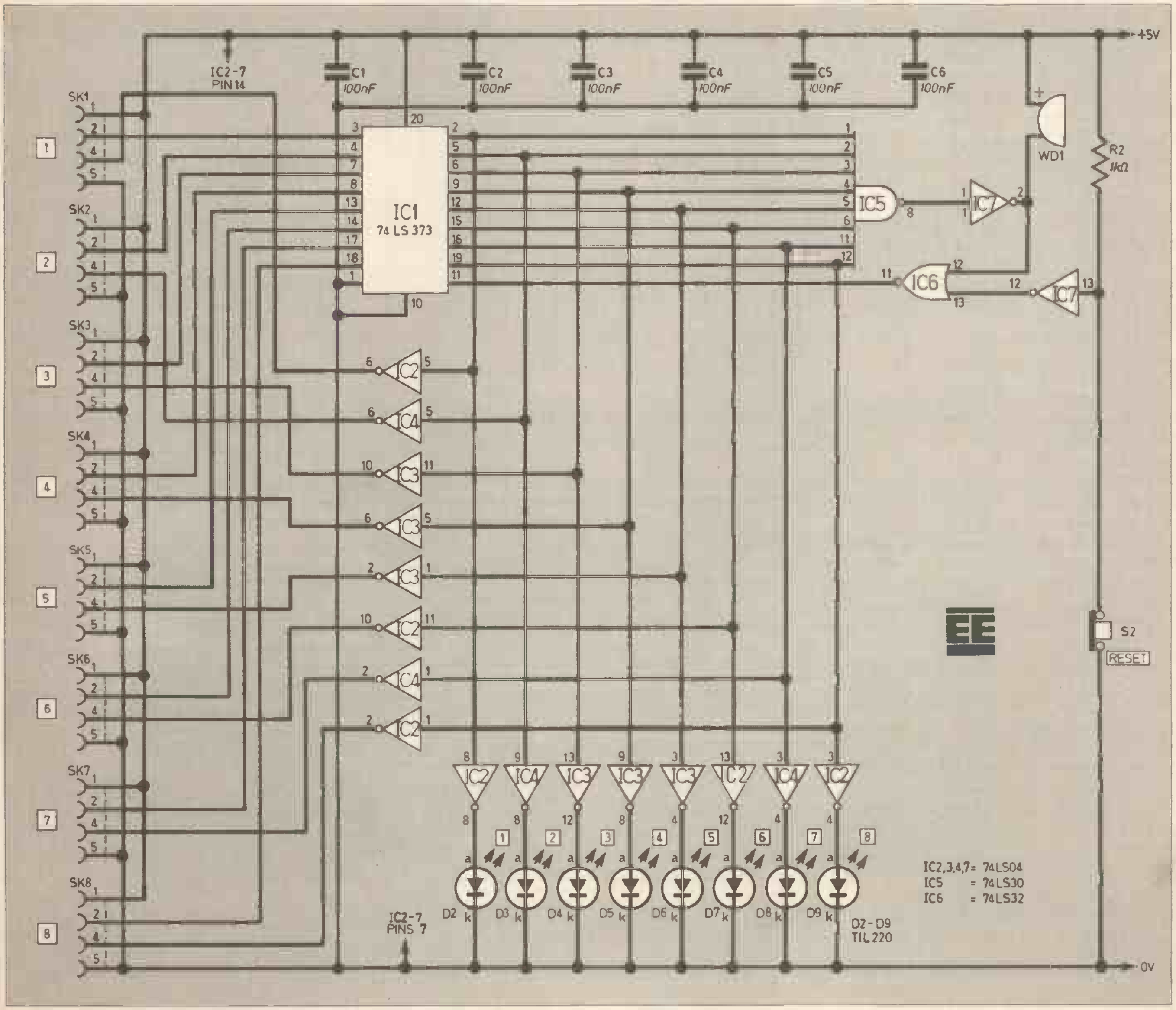
The rest of the circuit is straightforward, the illuminated mains switch S3 on both "live" and "neutral" lines of mains, with a 500mA fuse FS1 in the live line placed before the switch. The transformer T1 has two secondary windings of 0V to 6V each at 250mA, wired in parallel. The bridge rectifier is a standard readily available 50V, 1A type.

CONSTRUCTION

MAIN CIRCUIT BOARD

With the exception of the l.e.d.s and the buzzer, all the components are mounted on the circuit board. The circuit takes

Fig. 3. Complete circuit diagram of the Quiz-Master II main control unit.



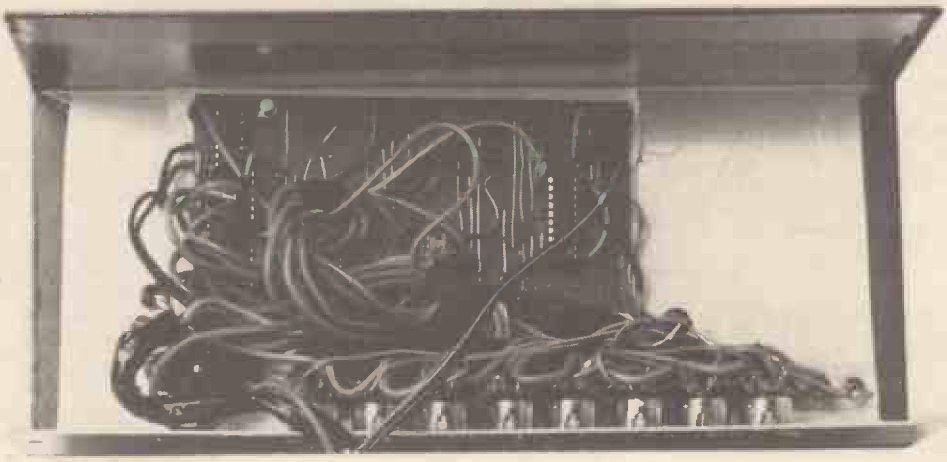


TABLE 1

A	+12V
B	SK8/2
C	SK7/2
D	SK6/2
E	SK5/2
F	SK1/2
G	SK2/2
H	SK3/2
J	SK4/2
K	D5a
L	D8a
M	SK2/4
N	D3a
O	WD1
P	SK7/4
Q	SK8/4
R	D9a
S	SK1/4
T	D7a
U	SK6/4
V	D2a
W	SK5/4
X	D6a
Y	SK4/4
Z	D4a
AA	SK3/4
BB	0V
CC	WD1

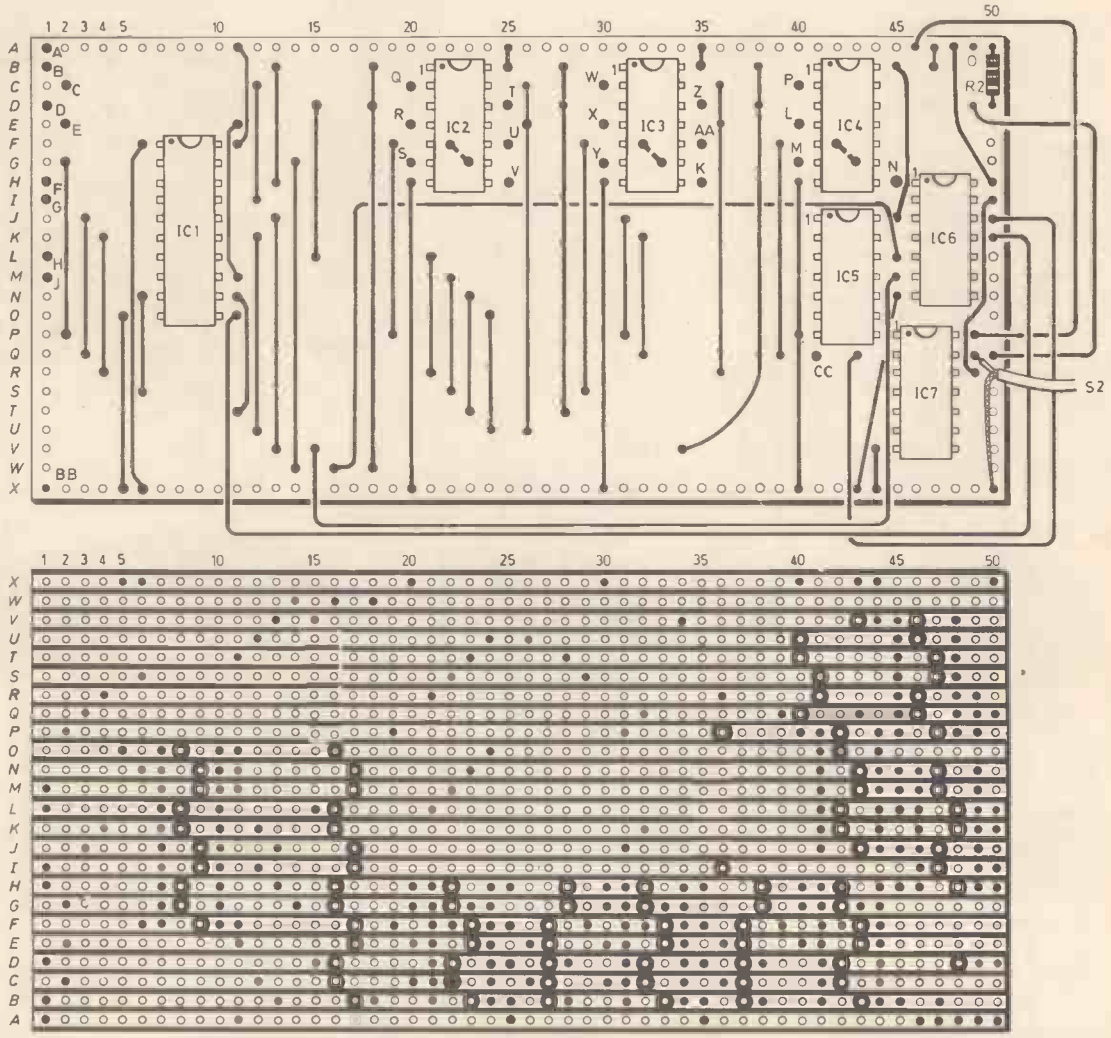


Fig. 4. The component layout and trackside view of the main control unit stripboard assembly. Note that the wires to case-mounted components are lettered (A, B, C and so on) and the destinations of these wires are given in Table 1 (above left). For clarity, the decoupling capacitors, C1 to C6, have been omitted from this view, but should be soldered across the power supply pins of the i.c.s (on the trackside, if necessary). Note also the links under IC2,3 and 4 and that some links use the same holes in the board.

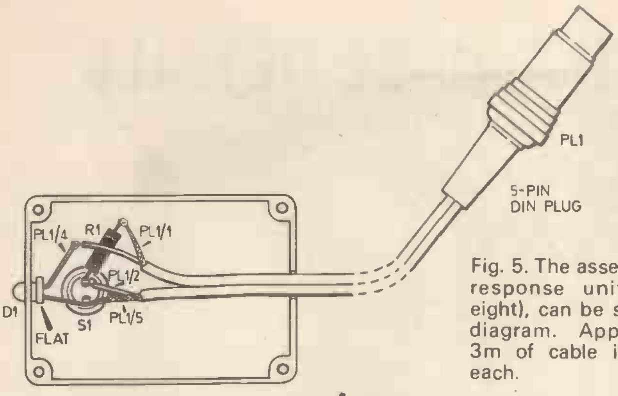


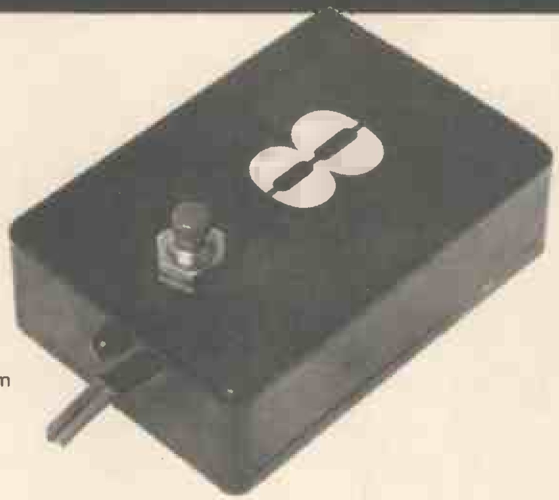
Fig. 5. The assembly of the response unit (one of eight), can be seen in this diagram. Approximately 3m of cable is used for each.

the form of a stripboard. The component layout and trackside view are shown in Fig. 4.

Although TTL i.c.s are used, sockets are used in the construction to allow easy replacement of faulty chips. As TTL is used, decoupling capacitors are required to be mounted close to the i.c.s. It is advised that the sockets are soldered in first, followed by the capacitors, so as not to forget them. The rest of the components are then fitted in as normal.

The connectors for the response units can be fitted into the aluminium case, along with the other case-mounted items, such as mains switch, reset switch, fuse holder and l.e.d.s. Once fitted, they can be wired up to the circuit board.

COMPONENTS



RESPONSE UNIT (8 off)

Resistors

R1	1kΩ (8 off)

Semiconductors

D1	TIL220 5mm red l.e.d. (8 off)

Miscellaneous

S1	non-latching push-to-make switch (8 off)
PL1	5-pin 240° DIN plug (8 off)

Twin screened cable (approximately 24m); plastic case, 70 x 50 x 25mm (8 off)

MAIN CONTROL UNIT

Resistor

R2	1kΩ

Capacitors

C1–6	0·1μF ceramic (6 off)
C7	220μF 16V elect.
C8	220nF polyester C280
C9	470nF polyester C280

Semiconductors

IC1	74LS373 TTL octal latch
IC2–4,7	74LS04 TTL hex inverter (4 off)
IC5	74LS30 TTL 8-input NAND gate
IC6	74LS32 TTL quad 2-input OR gate
IC8	7805 5V, 1A regulator
D2–9	TIL220 5mm red l.e.d. (8 off)
D10–13	WO05, 1A, 50V bridge rectifier

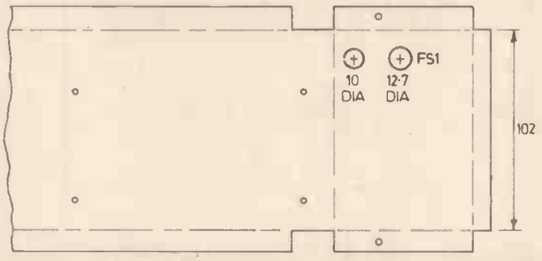
Miscellaneous

S2	non-latching push-to-make switch
S3/LP1	mains switch with integral neon indicator
SK1–8	5-pin 240° DIN socket (8 off)
WD1	piezo-electric buzzer
FS1	500mA 20mm quick blow fuse
T1	0V–6V, 0V–6V 250mA mains transformer

Aluminium case, 250 x 110 x 80mm; 20-pin d.i.l. holder; 14-pin d.i.l. holder (6 off); wire; mica insulating mounting kit (for IC8); chassis fuse holder for 20mm fuse; 0·1in matrix stripboard, 24 strips by 50 holes.

COMPONENTS approximate cost £34

QUIZ-MASTER II—CASE DETAILS



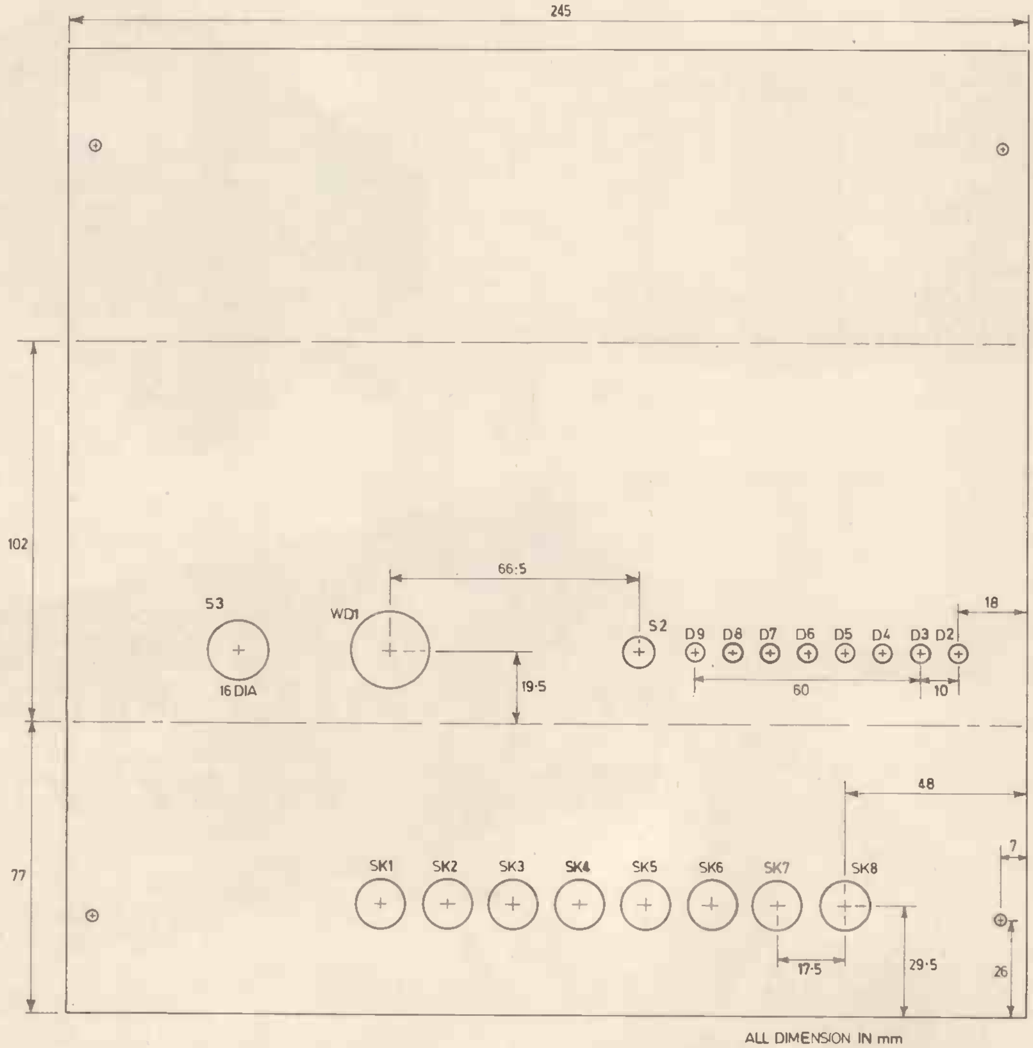
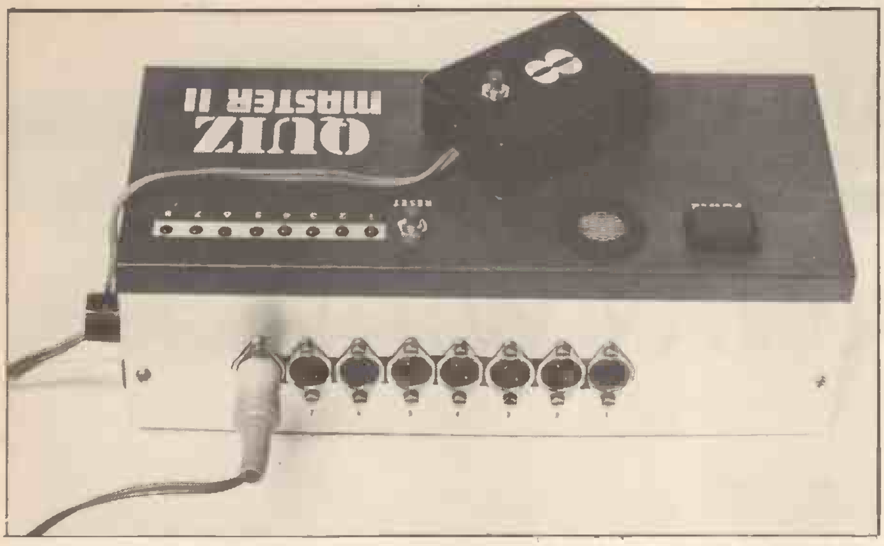
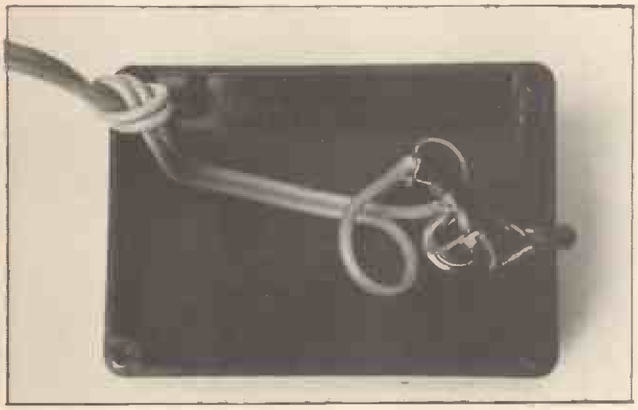


Fig. 6. Drilling details and case-mounted component positions for the Quiz-Master II case. This case is a two-part chassis type and can either be fabricated or a box of similar dimensions can be purchased. The top diagram shows the end panel of the bottom half with holes for the mains cable and fuse holder. Note all hole sizes must be checked with components to be used.

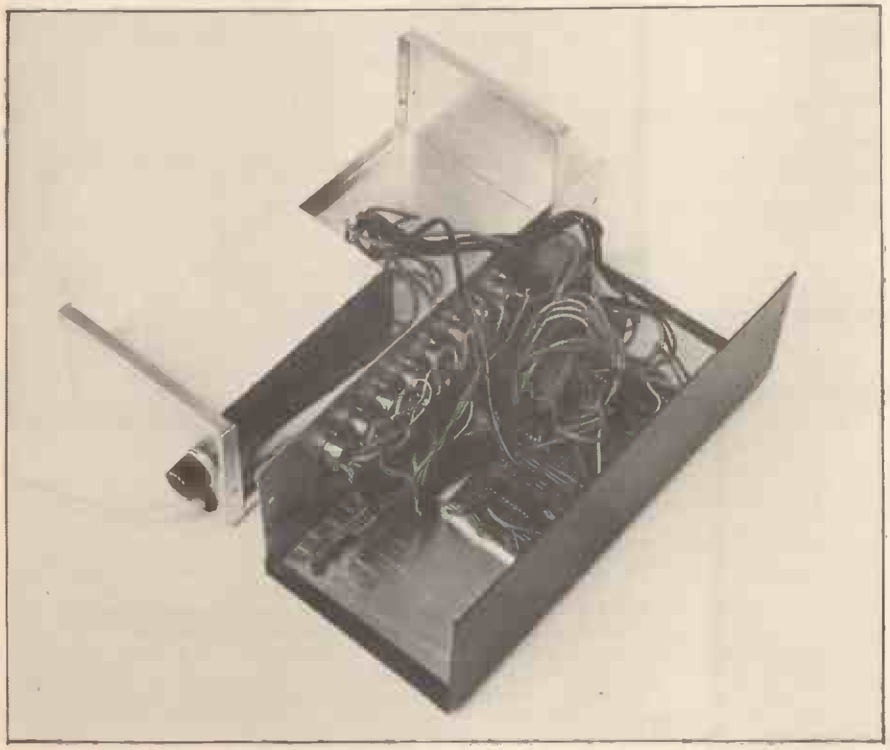




(Above). The rear view of the Quiz-Master II showing the DIN sockets with one response unit plugged in.

(Left). The internal wiring of one of the response units.

(Below). The two halves of the chassis case separated to show the internal wiring of the main control unit. Note the prototype unit uses a proprietary power supply unit rather than the unit described in the text.



The power supply is constructed on a separate board, and is straightforward to build. The only thing to remember is to make sure the voltage regulator is facing the right way, to allow it to be bolted to the case. Two wires for both the 5V rail and 0V rail emerge from the p.s.u. This is to provide five volts to both the circuit, and the response units via SK1 to SK8.

As the prototype unit uses a proprietary power supply module, no construction drawing has been given. However, it can be seen from the circuit diagram (Fig. 2) that it is a fairly simple assembly made on a piece of stripboard.

The transformer and IC8 (via a mica washer and insulating bush) should be screwed to the case and the bridge rectifier and capacitors soldered to the small piece of board. Wires are then taken to the main board, sockets and l.e.d.s.

The response units are easy to construct, as no circuit board is needed. All components are mounted on the switch. Three holes are required in the box housing the components, one for the switch, one for the l.e.d., and the other for the cable to leave the box. See Fig. 5.

TESTING

Before any i.c.s are inserted on the main board, it is advisable to check that the power supply is in order. Although TTL are quite hardy little bugs, they do not like their power rails swapped over. This can be done with a multimeter on the 10V range. The correct voltage should be 5V.

Next, the inputs to IC1 should be checked. The voltage on these inputs should be 5V when the switch is open, dropping to 0V on pressing the switch. With no i.c.s installed, no l.e.d.s should light. If any light, there is a solder bridge somewhere on the board.

Once all i.c. sockets have been checked for power, switch the unit off and insert the i.c.s, making sure they are the correct way round. Now switch on. If the buzzer sounds, press RESET. Assuming that no i.c. is faulty, and no solder bridges remain undetected, the buzzer should stop, and no l.e.d. will light. Press a response unit's button. The buzzer should sound, and two l.e.d.s will light up; one on the response unit pressed, and the other on the main control board. Now press another response unit. It should have no effect.

OPERATION

To operate the unit in a quiz, each contestant should be given a response unit, plugged into the back of the main control unit. Any number of units up to eight may be plugged in, unused response units need not be plugged in. Switch on, and press RESET. This may not be necessary, but is a good habit. Now proceed with the questions. After a response unit has been activated, it can be reset, whilst the answer is given ready for the next question. At the end of a session, switch off and remove the response units. □

EVERYDAY news ... from the world o

HOME and AWAY WINS for UK

UNDERSEA LINKS

A £7.25 million contract for the world's first international optical fibre undersea cable was signed recently by Sir George Jefferson, Chairman of British Telecom.

It was for a 122km cable, linking the UK and Belgium, to be made in Britain by the submarine systems division of Standard Telephones and Cables. Sir Kenneth Corfield, STC's Chairman, signed the contract for the company.

The contract award means that, in two year's time, phone calls, computer data and messages will travel between Britain and continental Europe as pulses of laser light along tiny strands of ultra pure glass as thin as a human hair.

The investment is shared between four countries. Half will be held by British Telecom International, and the balance by three European telecommunications administrations—the Deutsche Bundespost of West Germany, the Belgian RTT and the Netherlands PTT.

The cable, capable of carrying nearly 12,000 phone calls simultaneously, will be laid by British Telecom's cableship *HMS Alert* in the spring of 1985. It will be buried to protect it against damage by shipping, in particular by trawling activities.

The new optical fibre cable will operate in digital form, at speeds of up to 280 million bits (binary digits) a second (Mbit/s). Digital operation uses on-off impulses to carry a variety of information technology services, as well as speech, along the same path more efficiently than present-day analogue transmission.

It offers considerable savings in transmission costs by using the advanced form of optical fibre operation known as singlemode transmission. This enables a single ray of laser light to travel great distances along the fibre before regeneration at a repeater.

Technical Note

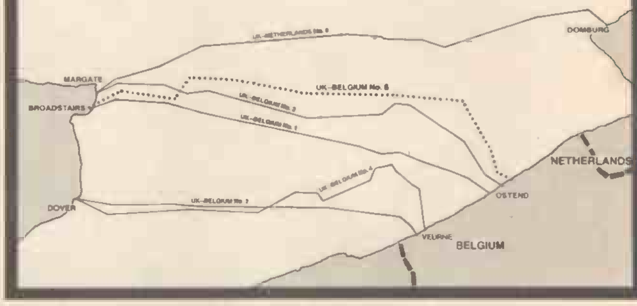
The new UK-Belgium cable, the fifth system between the two countries, will contain three pairs of fibres. Each pair will work at 280Mbit/s—a capacity of 3,840 64kbit/s circuits, giving a total cable capacity of 11,520 circuits.

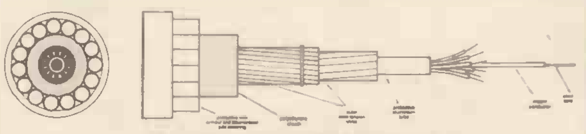
The system will use long-wavelength (1,300nm) singlemode transmission. It will contain three submerged repeaters, each containing three both-way optical regenerators. They will be installed at approximately 30km intervals, to give a total system length between terminal stations of 122km.

British Telecom notched up another major world first in optical fibre communications.

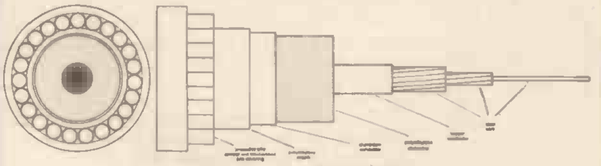
In this latest achievement, they successfully brought into service the world's first 140Mbit/s commercial optical fibre link, using singlemode transmission, between Luton and Milton Keynes.

WORLD'S FIRST INTERNATIONAL UNDERSEA
OPTICAL FIBRE CABLE





FUTURE OPTICAL FIBRE SUBMARINE CABLE
4,000 telephone circuits per fibre pair 12,000 circuits per cable



MODERN COAXIAL SUBMARINE CABLE
4,000 telephone circuits

ROYAL PET

The microcomputer manufacturer, Commodore Business Machines (UK) Ltd, has become the first manufacturing company to be granted the Royal Warrant of Appointment by Her Majesty The Queen for computer business systems.

General Manager of Commodore UK, Mr Howard Stanworth, said: "As a high technology company with a growing manufacturing and ancillary supplier base in the UK, we are delighted and honoured to receive the Royal Warrant of Appointment to Her Majesty The Queen."

ALL-ROUND HOME ENTERTAINMENT CENTRE

–FIDELITY SCORES A FIRST

VISUAL and audio home entertainment from one integrated system. It had to happen of course, and to London-based Fidelity go the honours for being first in this field.

The Audio Visual System 1600 announced in February incorporates a 16-in colour TV, a 3-waveband tuner, a belt driven record player, a stereo cassette deck, a 24 watt amplifier (12 watt per channel) and comes with matching loudspeakers and a remote control.

The television has an optional spatial sound which electronically separates the sound to create a stereo effect through the floor standing speakers. The television can function as a video monitor for use with home computers and video equipment. Either can be plugged directly into the 21-pin Euro connector monitor socket at the rear of the system to give crisper computer graphics and sharper reproductions on video recordings. Fidelity is looking ahead, for this monitor socket will additionally suit cable and satellite systems of the future.

The expected inclusive retail price is around £400.

Stereo (from tape, record or radio) and TV can be operated at the same time, with video sound being available via headphones. Thus all the family needs seem to be catered for by this stylish rack equipment with hinged glass door. The floor standing speakers are finished in a dark rosewood effect.

Whether as a second set for the larger household, a natural for the teenager's room or a perfectly adequate main entertainment centre for the smaller home — the AVS1600 seems sure of a warm welcome by the British public.

The London-based editorial team. (Left to right) Derek Gooding, Brian Terrell, Dick Hooper, Fred Bennett, Jackie Doidge, Peter Loates, Roy Palmer, Graham Hodgson and Dave Barrington.

From the dizzy heights of the 21st floor, King's Reach Tower, with panoramic views of Westminster and the meandering Thames in old London Town, Everyday Electronics moves to the 2nd Floor offices by the quayside at Poole Harbour in Dorset, with an elevation a mere masthead above sea level.

As from next month Everyday Electronics editorial department will be based at Poole, Dorset. The editorial team currently producing our companion magazine Practical Electronics in Poole, will then be responsible also for Everyday Electronics.

Mike Kenward, Editor of Practical Electronics will be editor of both magazines. As many readers will know, Mike was assistant editor of Everyday Electronics from its launch in 1971 until 1977. He took over as editor of Practical Electronics from Fred Bennett when PE moved from London.

The existing PE editorial team will be augmented to meet this new situation. Dave Barrington will move from London to take up the post of Assistant Editor/Production. Fred Bennett, present editor of Everyday Electronics, will be Consultant Editor and will remain based in London.

All other members of the present EE team are seeking pastures new.

ADVERTISEMENT DEPARTMENT

Earlier this year Advertisement Manager Roy Smith handed over to David Tilleard who now has overall responsibility for both titles. He is assisted by Richard Willett who continues as Advertisement Representative for Everyday Electronics.

EDITORIAL TEAM

Of the present EE editorial team Brian Terrell and Peter Loates are "founder members", working on this publication continuously since issue number one. In 1977 the following transferred to EE: David Barrington and Derek Gooding (ex-Practical Electronics); and Roy Palmer (ex-Practical Householder). More recent recruits are: Jackie Doidge, Graham Hodgson and Richard Hooper.

The disbanding of this team has been a considerable wrench to all concerned and particularly so for the longer serving members. The old team now bid farewell to their readers and hand over to their colleagues at Poole confident that readers' needs and interests will be in safe hands.

RADIO WORLD

BY PAT HAWKER G3VA

Reliability

Over the years we have come to expect a great improvement in the reliability of consumer electronics of all types. Perhaps the most dramatic has been in colour television receivers; with an improvement of from an average of about four faults per year, with the early dual-standard sets, to an average of only about one fault in three years in current models.

Murphy's Law unfortunately seems to mean that there are still a few "rogue" models that keep service engineers busy. A recent *Which?* report, however, suggests that the differences between brands are unlikely to be big enough to worry about—regardless of whether manufactured in Europe, or Japan the country that a decade ago did so much to improve the reliability of mass-produced equipment.

Today, relatively few faults are due to basic electronic circuit design, while semiconductor devices do not have the inherent failure mechanism of the diminishing cathode emission of thermionic devices. Though it should not be forgotten that for such specialised applications as submerged cable repeaters, the Post Office at their research centre at Dollis Hill in the 1960s developed valves designed to provide continuous operation for at least 20 years.

Although semiconductor devices do not wear out, this does not mean they are immortal. Their working lives can be brought to a sudden end by over-voltage transients, although good circuit design can provide protection against these events. Protection circuits may not themselves always prove satisfactory and for some professional equipment it may be necessary to ask "do we need a protection circuit for the protection circuit?"

Dust-free manufacture of materials is one of the major reasons for improved reliability. But semiconductors can still fail or change characteristics from such mechanisms as electro-migration; that is, the movement of aluminium atoms along a conductor caused by collisions with the conducting electrons to the extent where eventually this results in an open-circuit.

Also there is dielectric breakdown; for example, due to defects in the very thin gate insulator regions of metal oxide semiconductors, and that old enemy corrosion, due to absorbed moisture on the chip surfaces. Contamination of materials during manufacture; for example, oil contamination from machines may not show up for months or years.

Q–Fax

For over a decade electronic device manufacturers have aimed at what they call "zero defects" and published life-test data, though these figures may be averaged over different factories in different parts of the world, and have to be viewed with caution.

The UK's largest manufacturer of electronic components, Mullard Ltd., has recently introduced in its factories a Q-Fax ("quality facts") system to keep the workforce informed on results, defects and targets. A 380-page teletext-type Q-Fax system has been installed at Simonstone, Lancashire where component parts for colour picture tubes are made. A rotating sequence of six-pages is displayed automatically, but staff are encouraged to call-up any of the pages.

After three months' operation, Mullard claim the system, by improving communication between management and the shopfloor, is resulting in a steady decrease in component defects. The idea raises the age-old question, does this type of information technology have lasting effects once the novelty has worn off?

I recall one major Japanese manufacturer has another approach. Workers are encouraged regularly to beat-up with sticks dummies representing the management!

In the end it all comes down to finding ways in which people can be encouraged to exercise continuous care and skill over long periods—and to ensure that dust-free really means dust free.

Radio Callsigns

It is now some 50 years since every radio broadcasting station on the medium- or long-wave bands had its own callsign. For instance, 2MT for the Writtle experimental station; 2LO for London; 6ZY for Manchester and 5XX for the Daventry long-wave station.

This practice was dropped in Europe in the early 1930s, but continues, even today, in the USA, with many thousands of three- or four-letter callsigns (each beginning W or K) and with suffixes AM for amplitude-modulated medium-wave stations; FM for the VHF frequency-modulated stations; and TV for television stations.

With so many stations on the air it is not surprising that the owners value greatly callsigns that are easy to remember. Particularly those that identify with city or network such as WNBC and WNYC.

Callsigns are issued by the Federal Communications Commission (FCC) though the call-letters are often suggested by the applicants. As part of the current "de-regulation" process FCC has made it clear that it no longer expects to be involved in the call-letter disputes that arise.

The FCC will no longer officially insist that all call-letters should be in "good taste", although FCC's Mass Media Bureau staff have warned the commissioners that it would not be proper for an agency of the federal government to issue "clearly obscene or indecent" callsigns. The commissioners however believe that if a community objects to a callsign it can "make its displeasure known to the station or the advertiser".

In the days when the Post Office used to issue amateur radio callsigns there were a number of three-letter combinations listed as "not to be issued". Even so, I can think of one or two people who were saddled with embarrassingly explicit callsigns!

Legal Transceivers

The Department of Trade and Industry have recently confirmed to the R.S.G.B. that the installation and use by short-wave listeners of two-way transceivers is not in contravention of the existing Wireless Telegraphy Acts. This is provided, of course, that the equipment is used only to receive sound radio broadcasts from authorised broadcasting stations or to receive transmissions from licensed amateur radio stations.

This ruling shows how difficult it is to bring prosecutions for "pirate" operation of unlicensed transmitting equipment under the existing law since it is necessary always to prove use of the equipment. Whether this will remain true when the current Telecommunications Bill (including the Part VI amendments to the Wireless Telegraphy Acts), is enacted, is an interesting question since this would seem to make possible prosecution of persons in control of or in possession of specified equipment.

There is also, of course, the point that many people buy equipment while they are h.f. listeners with the genuine intention of using the transmitting facilities only when they obtain a licence. But for some the temptation proves too great!

CB Changes

The new conditions attached to British CB licences since 1 February seem unlikely to have any major effect on this service, particularly since there does not seem to be much effort devoted to enforcing the regulations or to checking on whether only the 280,000 licence holders are using 27MHz transmitters, though there have been a lot of prosecutions.

No new licences will be issued to anyone under 14 years, but there is no restriction on younger people using transmitters under supervision. It will be possible to use home-constructed aerials with loading coils in the more effective position two-thirds of the way up the element.

The ban on the playing of music and re-broadcasting radio programmes has always existed but is now made more explicit. The licence now highlights the recommendation that *Channel 9* should be used only for calls requesting assitance and other emergencies.

What may produce greater changes not only in "pirate" CB but also "pirate" broadcasting and pirating on h.f. and on amateur bands is the Telecommunications Bill when (or if) it finally reaches the Statute Book, following the delay caused by the General Election and the political controversy about privatisation of British Telecom.

MAY FEATURES...

EXPERIMENTERS PSU...

All serious constructors require a reliable power supply. This unit fits the bill admirably with a switchable output ranging from 2–12V in steps of 1V. A novel feature is the use of a power op/amp which provides the output current up to a maximum of 325mA. The output is short-circuit protected and is accurate to within 0·1V.

VARICAP AM RADIO

In this a.m. receiver the principle of the variable capacitance diode is employed as the tuning medium. The full medium-wave band is covered, the output is designed for a crystal earphone.

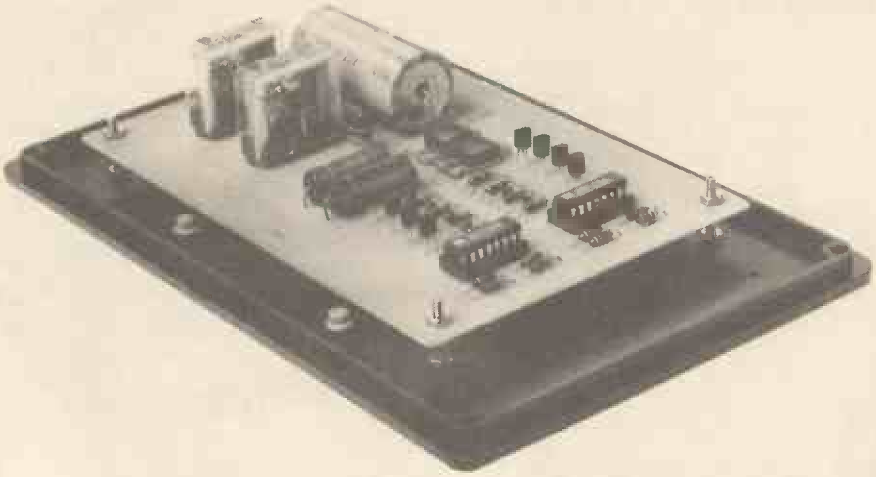
SIMPLE LOOP/ BURGLAR ALARM

This battery operated alarm system has been designed around the wire loop principle often seen in shops to protect easily stolen articles such as radios. The design does, however, have many other uses since the alarm sounds for a preset period once the loop is broken.

EVERYDAY ELECTRONICS and computer PROJECTS

MAY 1984 ISSUE ON SALE FRIDAY, APRIL 19

MULTIPURPOSE INTERFACE FOR COMPUTERS



M. P. HORSEY

SOFTWARE APPLICATIONS FOR MODEL RAILWAY CONTROL USING THE RM380Z AND VIC-20

THE unit described here is designed to interface to the user port or parallel printer port of a micro. Details of its use with the Research Machines 380Z computer—popular in schools—and the VIC-20 are given. The circuit is expected to work with most other machines, since it uses the standard data outputs as required by a parallel interface printer.

The unit has eight separate channels to control eight devices. It was built with a model railway in mind, and channels one to four will sink 100mA—suitable for l.e.d.s, or small bleepers, and so on.

Channels five and six will sink 500mA to 1A, depending on the heatsink used on the power transistors. These outputs will drive small motors in train-sets, robots, and the like. Channels seven and eight have relay outputs, and provide a variety of uses, including controlling the polarity of the motor outputs, to enable the motor to reverse.

The unit will therefore power two trains, forward and reverse, and provide four more low current outputs for signals and other accessories.

Considerable economies may be made if fewer outputs are required. For example, for just one train, only the components associated with channels five and seven will be needed. The simple programs included, will enable the speed and direction of a train to be computer controlled, via channels five and seven.

OPTICAL ISOLATION

The interface power supply is totally isolated from the computer data and power outputs by means of an optical isolator chip. This ensures that should a disaster occur to the interface, the computer cannot be damaged. Each l.e.d. in the interface chip requires a sink current into the computer of about 7mA. Thus with all computer data outputs low, a maximum current of 56mA is required from the 5-volt supply from the computer.

COMPUTER DATA OUTPUTS

The eight data outputs are normally numbered Ø to 7. This may cause some confusion since channel 1 will be driven from data Ø, channel 2 from data 1, and so on to channel 8 from data 7.

Each computer data output is normally low (that is, nearly 0V). When a suitable number is POKEd to the appropriate address, the required data output will go high (nearly 5V), and this in turn switches on the chosen output from the interface.

SOFTWARE CONTROL

The combination of data outputs required, is controlled by POKEing a suitable number, determined in the following way:

The number POKEd must be converted into an 8-bit binary number. If the right-hand bit is a zero, then DØ will be low. If the right-hand bit is a one, then DØ will be high. If the next bit is a zero, then D1 will be low. The examples in Table 1 should clarify the situation.

In a computer program, the command POKE A,B is used to POKE the number B (as described above), into address A. Different computers will require different addresses for A, and some computers may employ an alternative to the command POKE (for example, the BBC computer).

CIRCUIT DIAGRAM

The complete circuit diagram is given in Fig. 1.

Each of the eight channels work in a similar way. Consider channel 1. When DØ is low (nearly 0V), current from the computer 5-volt supply will flow via current limiting resistor R1, through the internal l.e.d. in the quad opto isolator chip IC1, and into DØ. Channel 1 internal photo-transistor will turn on, and the voltage at the base of transistor TR1 will

Table 1. POKEing data into the port.

POKEd number (decimal)	Equivalent binary number	Data outputs							
		D7	D6	D5	D4	D3	D2	D1	DØ
Ø	ØØØØØØØØ	low	low	low	low	low	low	low	low
1	ØØØØØØØ1	low	low	low	low	low	low	low	hi
2	ØØØØØØ1Ø	low	low	low	low	low	low	hi	low
3	ØØØØØØ11	low	low	low	low	low	low	hi	hi
16	ØØØ1ØØØØ	low	low	low	hi	low	low	low	low
64	Ø1ØØØØØØ	low	hi	low	low	low	low	low	low
8Ø	Ø1Ø1ØØØØ	low	hi	low	hi	low	low	low	low

be near zero. Thus TR1 will be turned off and no current will flow into its collector.

If the decimal number 1 (binary 00000001) is POKEd to the computer port, then D0 will go high (nearly 5V), and no current will flow through the l.e.d. The internal photo-transistor will turn off, and the voltage at the base of TR1 will rise—due to the current flowing through resistor R9. Transistor TR1 will therefore turn on, and current will flow from the 12-volt supply, through the load connected to OUTPUT 1.

Channels 1 to 4 work in an identical way. Channels 5 and 6 are similar, except that the emitter of the BC184L transistor is connected to the base of the power transistor type TIP41A. Thus a much larger current can be controlled.

Channels 7 and 8 drive relays, which can in turn control a variety of options—even mains circuits if suitable precautions are taken.

Diodes D1 to D8 protect their respective transistors against any back-e.m.f. voltage spikes caused by inductive loads such as motors and relays.

SHORT CIRCUITS

It should be noted that a 2-amp thermal circuit breaker, CB1, is included in the design. This is rather large for model railways, and in this application, a lower current circuit breaker may be considered desirable. Alternatively, the circuit could be powered from a train-set controller, in which case the cut-out switch on the controller will provide the necessary protection.

POWER SUPPLY

A fairly conventional power supply circuit is included, and a transformer can be selected to suit the current requirements

COMPONENTS

Resistors

R1–8	470Ω (8 off)
R9–16	10kΩ (8 off)
R17,18	120Ω 2W (2 off)

All ¼W carbon ±5% except where stated otherwise

Capacitors

C1	0·1μF polyester type C280
C2	4700μF 25V elect. axial

See Shop Talk page 231

Semiconductors

IC1,2	ILQ74 quad opto-isolator (16-pin d.i.l.) (2 off)
TR1–5,7, 9,10	BC184L *npn* silicon (8 off)
TR6,8	TIP41A *npn* silicon (2 off)
D1–8	1N4148 or 1N4001 (8 off)
D9–12	WO 05 1A 50V diode bridge

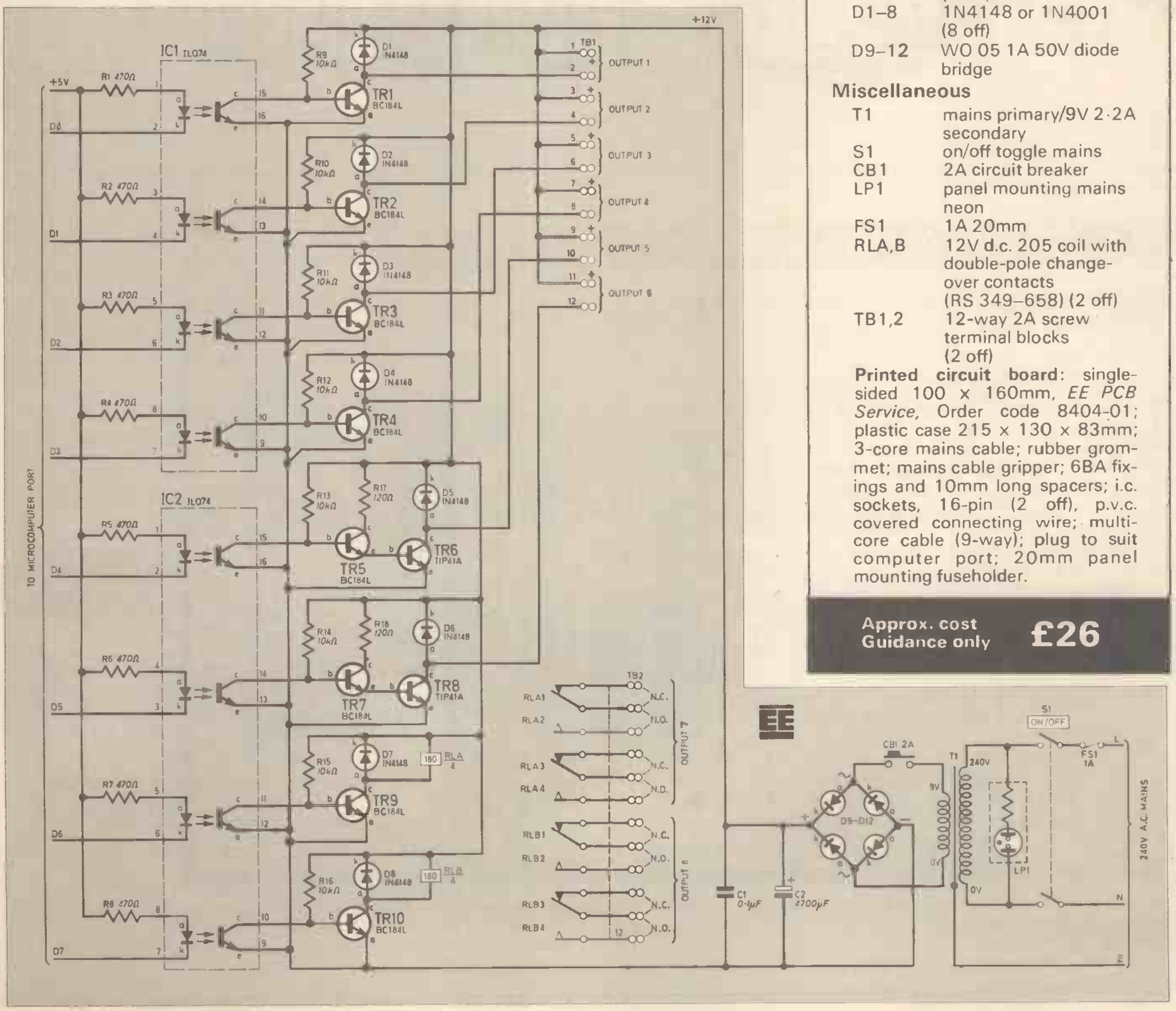
Miscellaneous

T1	mains primary/9V 2·2A secondary
S1	on/off toggle mains
CB1	2A circuit breaker
LP1	panel mounting mains neon
FS1	1A 20mm
RLA,B	12V d.c. 205 coil with double-pole change-over contacts (RS 349–658) (2 off)
TB1,2	12-way 2A screw terminal blocks (2 off)

Printed circuit board: single-sided 100 x 160mm, *EE PCB Service*, Order code 8404-01; plastic case 215 x 130 x 83mm; 3-core mains cable; rubber grommet; mains cable gripper; 6BA fixings and 10mm long spacers; i.c. sockets, 16-pin (2 off), p.v.c. covered connecting wire; multi-core cable (9-way); plug to suit computer port; 20mm panel mounting fuseholder.

Approx. cost Guidance only £26

Fig. 1. Complete circuit diagram of the Microcomputer Interface.



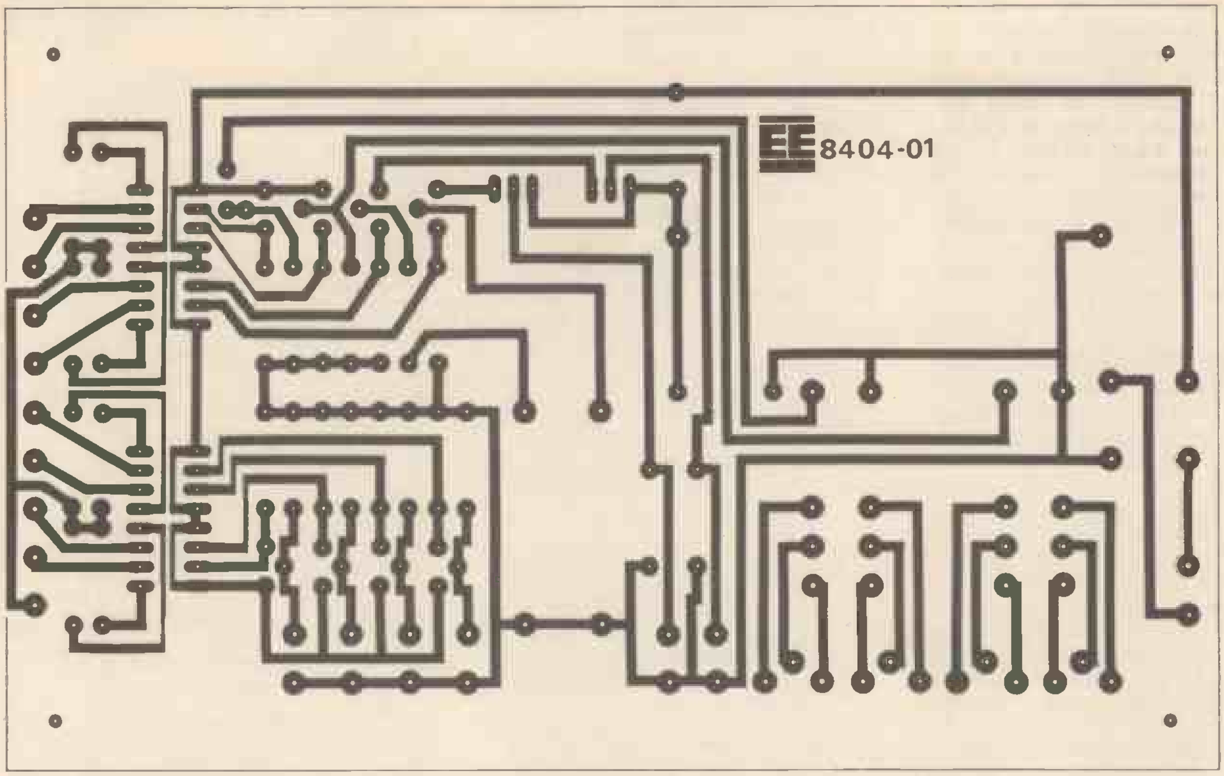


Fig. 2. The actual-size master pattern for the Multipurpose Interface p.c.b. This board is available from the *EE PCB Service*, Order code 8404-01.

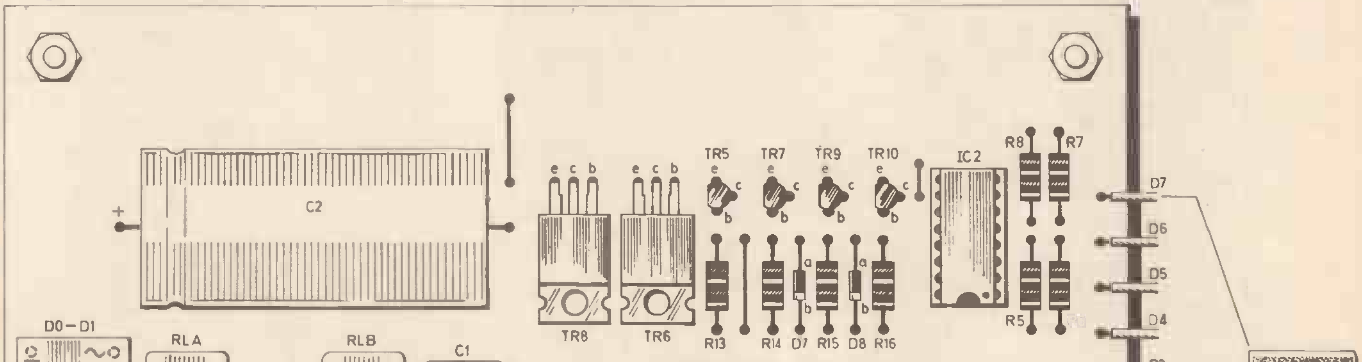


Fig. 3. The layout of the components on the topside of the p.c.b. with full interwiring details to case mounted components and computer output port.

envisaged. Note that the 9-volts a.c. transformer output is raised to nearly 13-volts d.c. when connected to a bridge rectifier (D9 to D12) and smoothing capacitor C2, but the maximum a.c. current is reduced by a factor of × 0·62. Thus if the two 9-volt windings of the transformer listed are connected in parallel the maximum a.c. current is 2·2A. This is reduced to a maximum of 2A using the thermal cut-out switch indicated, but the maximum d.c. current available is 2A × 0·62 = 1·24A.

CONSTRUCTION

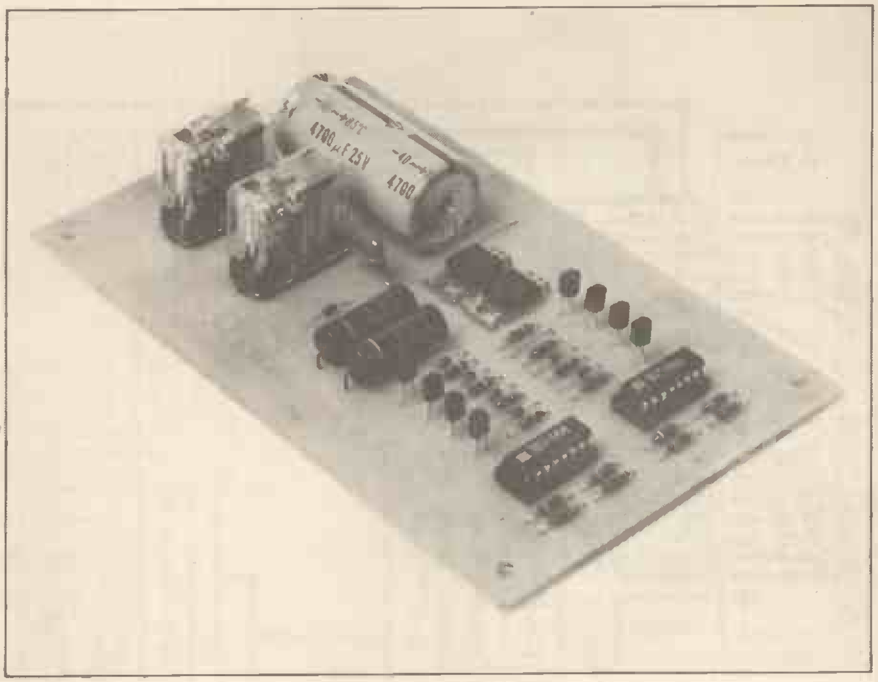
CONSTRUCTION

The prototype was constructed using a printed circuit board measuring 160 × 100mm. The actual-size master p.c.b. pattern is shown in Fig. 2. Provision has been made for all eight channels. If less are required omit the relevant components. This board is available from the *EE PCB Service*, Order code 8404-01. Begin by drilling the holes required to anchor the p.c.b. to the case.

Next, assemble the p.c.b. according to Fig. 3.

Solder in the i.c. holders, wire links and resistors, noting that resistors R17 and R18 are 2 watt types.

The diodes must be fitted with the correct polarity (that is, the right way round), and care must be taken with the BC184L transistors, to ensure that the leads are correctly orientated. If BC184 (without the L) transistors are used, note that the leads will be in a different order.



The fully assembled p.c.b. ready for wiring up.

The power transistors may be fitted to the circuit board as shown, and no heatsink is necessary if small model railway motors are driven. For larger currents, heatsinks should be secured to the metal plates of the transistors.

Alternatively, the power transistors may be fastened to a sheet of metal (or the case—if made of metal), and flexible wires used to connect them to the p.c.b. If both transistors share one heatsink, use mica washers and insulating bushes.

The relays specified will fit directly to the p.c.b. Other relays may be used with different pin-outs. These would be mounted off-board and connected to the board using flexible wires.

CASE

A sturdy plastic box measuring 215 × 130 × 83mm was used to house the interface and power supply. Drill the necessary holes for the mains lead, fuse, mains switch, cut-out switch, neon and transformer. Drill holes in the lid of the case for mounting the stripboard, and

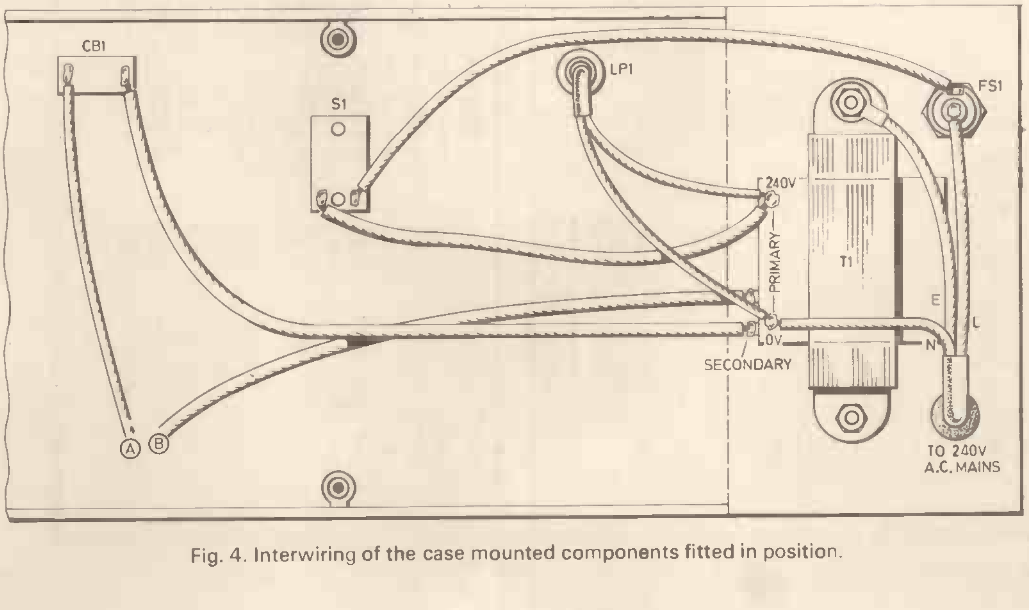


Fig. 4. Interwiring of the case mounted components fitted in position.

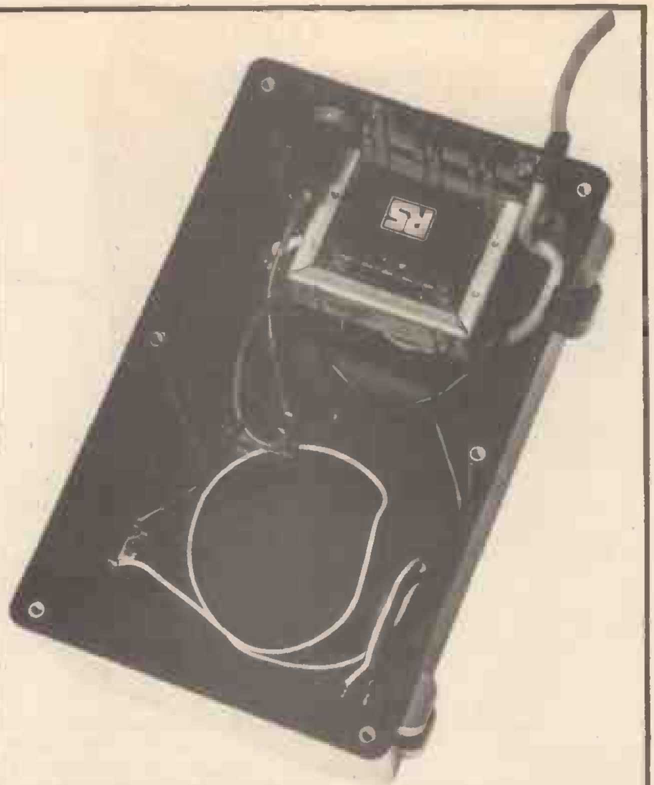

Shows the case mounted components fitted and interwired.

Table 2. User port pin assignments

RM 380Z

Pin no.	Function
5	DOØ
6	DO2
7	DO4
8	DO6
9	+5V
18	DO1
19	DO3
20	DO5
21	DO7

VIC-20

Pin no.	Function
2	+5V
C	DØ
D	D1
E	D2
F	D3
H	D4
J	D5
K	D6
L	D7

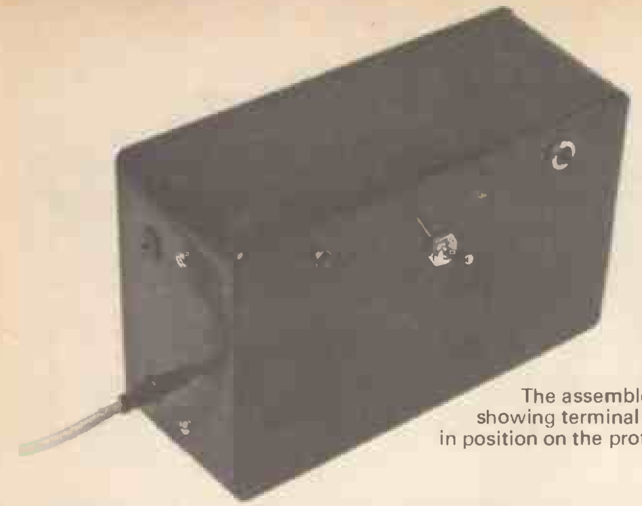
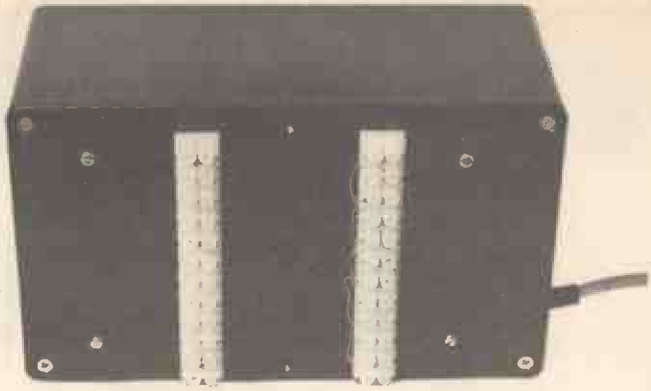
MODEL RAILWAY CONTROL SOFTWARE FOR RM380Z

```
10 REM"TRAIN5"RML380Z
20 LET P=&FBFF:Q=0
30 PUT12:GRAPH
40 PLOT 30,55,"T R A I N"
50 PLOT 30,52,"*********"
60 PLOT 0,40,"You may select the following:"
70 PLOT 10,34,"F:forward   R:reverse   S:stop"
80 PLOT 22,28,"Speed:type 1 to 9"
90 PLOT 0,22,"______________________________________"
100 PLOT 0,16,"Present Conditions:"
110 PLOT 5,10,"Direction:"
120 PLOT 50,10,"Speed:"
130 PLOT 0,2,"______________________________________"
140 IF B$=""THEN LET B$="STOPPED"
150 IF Q=0 THEN A=0
160 LET C$=STR$(A)
170 PLOT 27,10,B$
180 PLOT 62,10,C$
190 REM TRAIN RUNNING LOOP
200 LET A$=GET$(0)
210 IF A$<>""THEN GOTO 310
220 IF A>8 THEN 270
230 FOR X=1 TO 10-A
240 IF B$="REVERSE" THEN POKE P,64 ELSE POKE P,0
250 NEXT X
260 IF A<1 THEN 200
270 FOR X=1 TO A
280 POKE P,Q
290 NEXT X
300 GOTO 200
310 REM SELECT DIRECTION & SPEED
320 IF A$="F"OR A$="f"THEN B$="FORWARD":LET Q=16
330 IF A$="R"OR A$="r"THEN B$="REVERSE":LET Q=80
340 IF A$="S"OR A$="s"THEN B$="STOPPED":LET Q=0
350 LET A=VAL(A$)
360 GOTO 150
```

MODEL RAILWAY CONTROL SOFTWARE FOR VIC–20

```
0 REM ***************
1 REM ***         ***
2 REM *** ADAPTED ***
3 REM ***         ***
4 REM *** FOR THE ***
5 REM ***         ***
6 REM ***  VIC20  ***
7 REM **           **
8 REM ** BY J.HALL **
9 REM **           **
10 REM***************
15 POKE37138,255
20 LETP=37136:Q=0
30 PRINT"■":POKE36879,157
40 PRINT"■■        TRAIN"
50 PRINT"■         *****"
60 PRINT"■■ YOU MAY SELECT THE          ■ FOLLOWING.■"
70 PRINT"■■■  ■   F = ■FORWARD"
72 PRINT"■  ■   R = ■REVERSE"
75 PRINT"■  ■   S = ■STOPPED"
80 PRINT"■■    ■ SPEED = ■1-9"
85 FORY=0TO8000:NEXT
90 FORT=38TO160:POKE36881,T:NEXT
95 POKE36879,29
100 PRINT"■■■■PRESENT CONDITIONS  "
105 PRINT"■■■■■■******** **********"
110 PRINT"■■■■DIRECTION:"
120 PRINT"■■■■   SPEED:"
130 FORT=160TO38STEP-1:POKE36881,T:NEXT
140 IFB$=""THENLETB$="■STOPPED"
150 IFQ=0THENA=0
160 LETC$=STR$(A)
170 PRINT"■■■■■■■■■■■■■■■■■■";B$
180 PRINT"■■■■■■■■■■■■■■■■■■■■■■";C$
190 REM **TRAIN LOOP**
200 GETA$
210 IFA$<>""THENGOTO310
220 IFA>8THEN270
230 FORX=1TO10-A
240 POKEP,V
250 NEXT
260 IFA<1THEN200
270 FORX=1TOA
280 POKEP,Q
290 NEXTX
300 GOTO200
310 REM ***SELECT***
320 IFA$="F"THENB$="■FORWARD":Q=16:V=0
330 IFA$="R"THENB$="■REVERSE":Q=80:V=64
340 IFA$="S"THENB$="■STOPPED":LETQ=0:V=0
350 LETA=VAL(A$)
360 GOTO150

READY.
```

The assembled unit showing terminal blocks in position on the prototype.

terminal blocks, and holes for the computer lead, and output connections. Connect the data input cable to a suitable connector to mate with the socket on the computer. Fig. 5 in conjunction with Table 2 gives details.

Care must be taken with the clearance between the p.c.b. components and the transformer. For added safety, the transformer was mounted with its mains connections the opposite side from the p.c.b.

OUTPUT TERMINAL BLOCKS

Take care to use wire capable of carrying the required current to the output terminal blocks. The connections to channel 7 (relay 1) are shown to permit forward/reverse motion of a motor driven from channel 5. This enables the interface to be used with the programs listed below.

MOTOR CONTROL

The speed of the motor may be controlled by rapid switching on and off of the appropriate power transistor, and providing the program loop which controls this is quite short, the results achieved can be very good. The direction is controlled by a relay, such that if the relay is switched off, the motor direction is forward, but if the relay is turned on, the motor direction is reversed.

COMPUTER PROGRAM FOR MODEL RAILWAY

The variable P is used to select the appropriate output address, and Q is the number to be POKEd to that address. The program plots some instructions on the TV monitor, and indicates the present conditions (that is, what the train should be doing).

Care has been taken to keep the speed control loop short, to ensure smooth running.

Another precaution is, that if the direction is changed from FORWARD to REVERSE (or vice versa) the speed drops to zero and has to be typed again. This ensures that the motor is not unduly strained.

SETTING UP AND TESTING

Double check construction and interwiring. Do not connect the interface to the computer at this stage.

To test the interface, begin by switching on the power supply. Connect a voltmeter to the +12V line (+ve terminal of C2), and connect its negative lead to output 1. The voltmeter should read about 12 volts. Repeat this procedure for outputs 2 to 6. Observe the relays; they should be on, that is, the n.o. contacts should be closed.

If further testing is desired—before connecting to the computer, a 5 or 6 volt supply may be connected to the +5V supply line, and the negative of the supply connected in turn to each data input. A voltmeter connected as before should indicate a zero reading when the appropriate data input is negative.

Finally, switch off the interface unit, and connect it to the computer. Switch on the computer and interface. The initial data output will be zero (binary ØØØØØØØØ). Thus each output should be "off". This may be checked with a voltmeter connected as before.

With the Research Machines 380Z computer, typing the BASIC command: POKE&FBFF,1 should produce the binary number ØØØØØØØ1 to be output, and hence DØ will go high, causing the voltmeter on output 1 to read 12 volts. POKE&FBFF,2 will cause the next output to switch on, POKE&FBFF,4 the next, then 8,16,32,64,128 will cause outputs 3 to 8 to switch on respectively.

Finally, try out the program listed with a small motor or model train. Designing more complex programs to use with the interface is where the fun really begins.

CONNECTING TO THE VIC-20

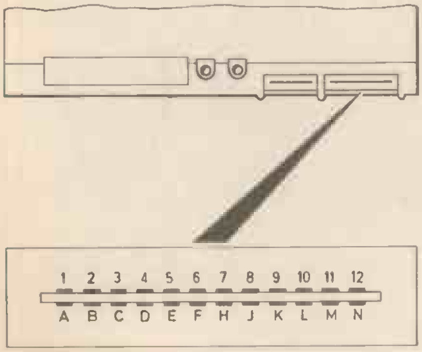
Like the Research Machines 380Z, the VIC-20 computer also provides the required data outputs, but at address 37136. The VIC-20 also requires the number 255 to be POKEd at address 37138, in order to set the lines as outputs.

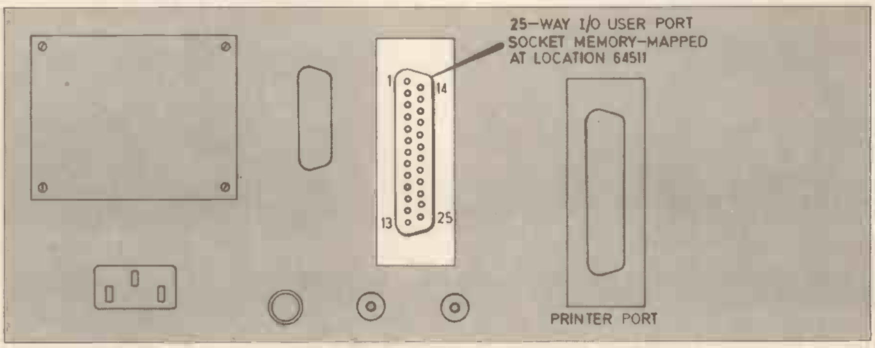
Bearing this in mind, the VIC-20 may be connected to the interface unit using a 2 × 12-way 0·156in p.c. edge connector, the connector should be wired to suit the socket shown in Fig. 5 and Table 2.

Converting the train program for use with the VIC-20, required numerous modifications, as this computer has no PLOT or PRINT@ command. The large display characters also required program modification to display the required information.

The finished program does perform exactly the same task as the one designed for the Research Machines 380Z computer. □

Fig. 5. Location and pin numbering of suitable outlet sockets on the RM380Z and VIC-20 micros.





WHY NARROW BAND F.M. ?
Part 1

BY E.A. RULE

DURING the past few years prior to the establishment of a Citizen's Band radio service in the UK, there was much debate concerning the best modulation system for such a service. Many arguments were put forward either in favour or against single sideband (s.s.b.), frequency modulation (f.m.), or amplitude modulation (a.m.), depending on personal viewpoints. The system that was finally chosen for CB radio was narrow band frequency modulation (n.b.f.m.).

In this article we shall now take a closer look at this mode of transmission and compare it with a.m. in the context of amateur radio, CB radio and point-to-point communications. Broadcasting has certain special requirements and features, and does not come into the present discussion.

First we must consider the major difference between the two systems and that is in regard to the actual method of modulation of the carrier wave. Fig. 1 shows an a.m. signal which consists of the modulating audio signal and r.f. carrier being added together in a way that causes the *amplitude* of the carrier to change. As the audio and carrier frequencies are different there will be phase differences between them and when the two signals are in-phase their amplitudes will add, and when they are out-of-phase their amplitudes will subtract, thus producing the amplitude modulated carrier wave in Fig. 1(c). Note that the actual *frequency* of the carrier wave is constant.

With the f.m. system, the modulating audio is added to the carrier in such a way that its *frequency* varies but its amplitude remains constant. Fig. 2 shows how this occurs. This change in frequency is called the deviation of the carrier and is the equal to the modulation of the a.m. carrier wave.

OVER MODULATION

Now with the a.m. system it is possible to over-modulate the carrier, Fig. 3 shows what happens. If the amplitude of the audio modulating signal is greater than the amplitude of the carrier it will still increase the overall amplitude when they are in-phase but as it cannot reduce the carrier to less than zero when they are out-of-phase the carrier is "cut off" for the duration of the time that the audio is trying to take the carrier below zero. This results in severe distortion of the carrier and "splatter" into nearby channels adjacent to the transmitter frequency.

In theory it is not possible to over-modulate an f.m. carrier as when the audio modulating signal is increased in amplitude it simply causes a larger shift in the frequency of the carrier. This would at first seem to be the answer to many problems, but, in practice there are other factors which set the limit to how much deviation can be applied.

First the actual tuned circuits of the transmitter will limit the amount of deviation. These have to have a response that is even, over the total amount of frequency shift, otherwise as the signal shifts towards the edge of the selectivity of the tuned circuits there will be a reduction in the output, Fig. 4. This would mean that amplitude modulation was being introduced. Therefore the total deviation must be kept to within the capabilities of the transmitter tuned circuits (and aerial) bandwidths.

RECEIVER BANDWIDTH

Also there is the question of receiver bandwidth. If the deviation of the transmitter is greater than the receiver bandwidth then the signal would pass outside the receiver passband and be lost, or at the very least again have amplitude variations added to it (Fig. 4). For normal amateur and CB equipment this maximum deviation is limited to around 5kHz and this is equal to the 100 per cent modulation of the a.m. system. Without going into the technical reasons, this also means that a similar number of stations can be spaced into a given frequency band. A wider deviation would reduce the number of f.m. stations in a given band.

DETECTION SYSTEMS

The next major difference between the two signals is in the detection system used in the receivers. The a.m. detector has to respond to amplitude changes in the incoming signal and this means that it will

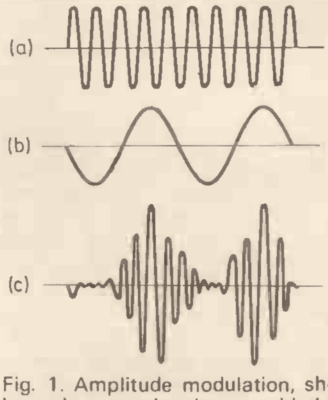


Fig. 1. Amplitude modulation, showing how the two signals are added in- or out-of-phase to produce the final modulated carrier.

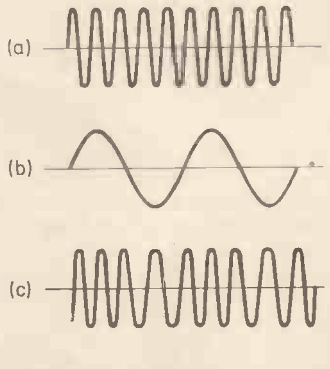


Fig. 2. Frequency modulation. Note that the final carrier is constant in AMPLITUDE.

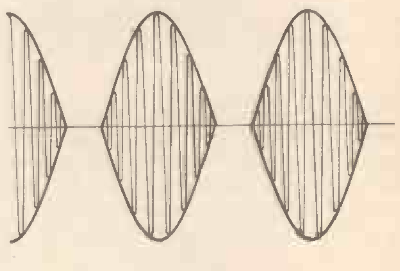


Fig. 3. Over-modulated carrier wave. Note the gaps in the carrier where the modulating signal has tried to reduce the amplitude below zero.

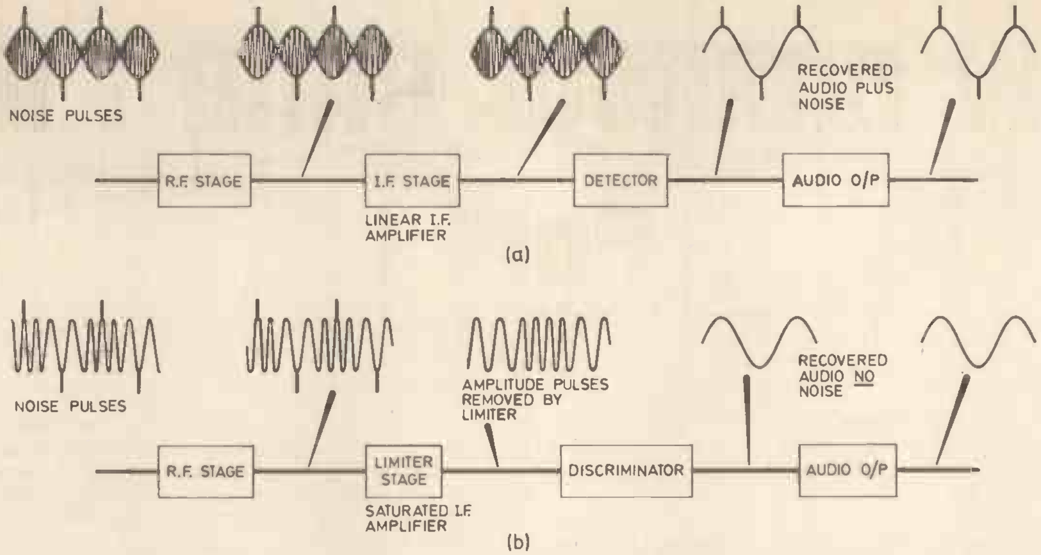


Fig. 5 (above). Showing how noise pulses are removed by the f.m. limiter stage and prevented from being passed on to the output. On a.m. the detector responds to noise pulses as if it were a normal amplitude modulated signal and passes them on to the output.

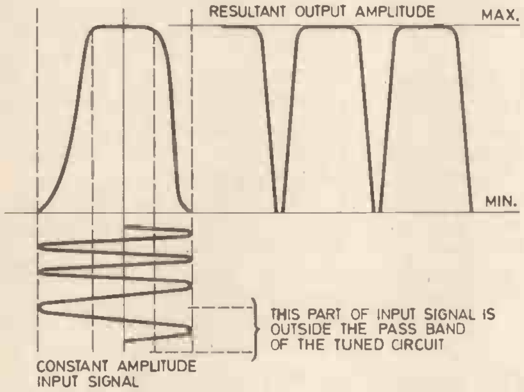


Fig. 4 (left). Showing how a signal of constant amplitude, but frequency shifted due to modulation, can be moved outside the tuned circuit's passband and cause resulting amplitude modulation of the signal.

also respond to amplitude interference such as, car ignition systems, switching, motor commutators, and so on.

The f.m. detector is designed to respond to changes in frequency of the incoming carrier and can be made insensitive to amplitude changes. Therefore it is far less likely to respond to amplitude sources of interference like car ignition. This at once makes it a better system for use in mobile installations, as it is automatically immune to impulse noises, and is many hundreds of times better than the a.m. system.

Fig. 5 shows a carrier with impulse noise on it and how it passes through the two types of receiver.

SIGNAL AMPLIFICATION

The next main difference between the two types of receiver is the way the stages amplify the signal. With the a.m. system, the changes in amplitude must be preserved and this means that any amplifying stage must not distort the signal. In order for this to happen arrangements must be made to reduce the amplification on strong signals so that the stages are not overloaded. This automatic gain control (a.g.c.) is an important design feature of all a.m. receivers.

On f.m. we are not concerned with amplitude variations but only the changes in frequency, and in fact the stages can be allowed to saturate and this will prevent amplitude changes from reaching the f.m. detector, further improving the immunity to impulse noises and the like. It also simplifies the design of the amplifying stages. A further advantage is that once saturation (limiting) has been reached the audio output from the receiver is constant.

On a.m., if you are listening to a weak station with the volume control turned up and a strong local comes on, you will get deafened! On f.m. both signals would be the same volume—although in practice only the stronger one would be heard, due to the *capture effect* (more about this later).

Fig. 6 shows a typical input output curve of an f.m. receiver. Note the rapid reduction in noise as the signal strength increases. Compare with the a.m. curve Fig. 7.

A good f.m. receiver will be designed so that even very weak signals fully saturate (limit) the i.f. amplifier stages, which in practice means that all signals will be at the same output volume irrespective of their actual strength. This is why changing the transmitter power has no effect whatever on the received signal once it is strong enough to reach the limiting level, unlike a.m. where increasing the transmitter power will produce a change in output at the receiver.

CAPTURE EFFECT

With a f.m. receiver the detector or, to give it its proper name, the discriminator will "capture" a signal which is on the same frequency but stronger. The better the receiver, the less difference there will be between the two signals in strength before the receiver captures the stronger.

For example, if you are listening to say a fixed station of a given strength and a mobile station is on the same frequency, at first you will only hear the fixed station. Then quite suddenly as the mobile station comes into range its signal will become slightly stronger than the fixed stations and the receiver will "capture it". The result is a sudden switch from one station to the other. The better the receiver the more abrupt the change-over will be. There is no warning, it just happens. This is unlike a.m. where you can hear the weaker signal building up underneath the stronger until it is strong

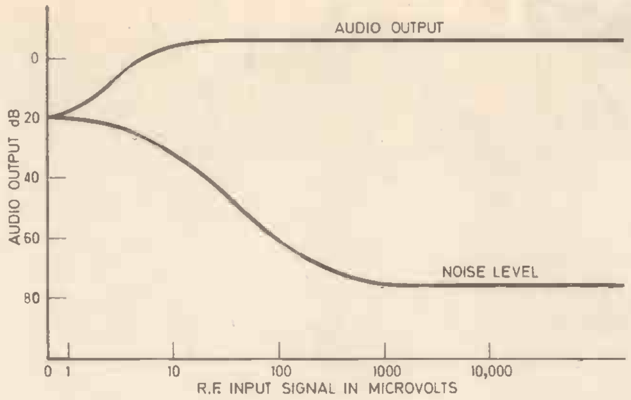


Fig. 6. Typical f.m. receiver input/output response.

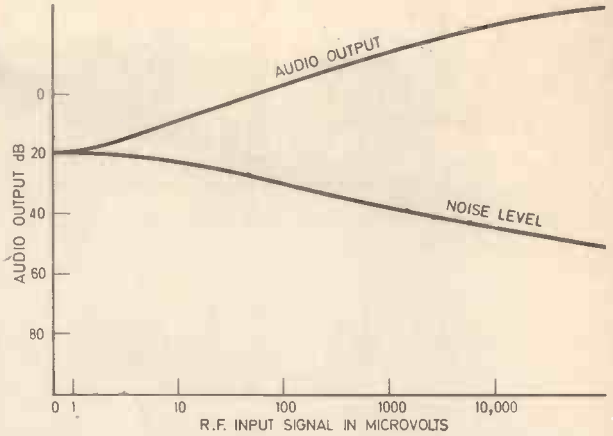


Fig. 7. Typical a.m. receiver output/input response. Responses will vary from design to design with the better receivers having a more constant output and quicker reduction in noise. However, on a.m. there is *not* an equivalent effect to the "capture" effect of f.m.

enough to cause severe interference before taking over.

This is one of the reasons why it is possible to "break in" on an a.m. contact but not an f.m. one. If you tried to break in on an f.m. contact you would just not be heard unless your signal was strong enough to be captured by the receiver.

RESIDUAL NOISE

Now this capture effect also applies to noise. When the signal you are trying to receive drops below the residual noise level the receiver will capture the noise in the same way as it would a stronger signal. The result is that f.m. signals which are getting weaker will suddenly disappear into the noise, whereas on a.m. you can often "copy" them right down into and sometimes even below the residual noise level. At this threshold point an increase in f.m. transmitter power can make an improvement in reception which is quite dramatic due to the receiver again capturing the stronger signal.

On the a.m. system an increase in signal of 3dB (double power) will not make much practical difference to the received signal although of course it will improve it to some extent. On f.m. the same change in power at the capture point can make all the difference between a signal being 100 per cent copy and not being heard at all, assuming of course that the receiver has a good capture ratio.

CAPTURE RATIO

This is normally quoted in dBs and the smaller the figure the better. The figure quoted is the difference in power required between two signals on the same frequency before the receiver will capture the stronger.

For example, if the receiver is quoted as having a 3dB capture ratio then one signal would have to be twice the power of the other. If the receiver was quoted as 0·5dB (modern hi-fi stereo receivers achieve this) then the power change is only 1·12 times. Note here that we are referring to *received* power and not transmitter power.

The effect of this "capturing" of the stronger signal is why it is possible for f.m. stations that are in different localities to have "nets" on the same frequency without mutual interference. On a.m. there would be a hetrodyne whistle in the background all the time.

Next month we shall consider some of the actual circuits used and their differences, as between the f.m. and a.m. systems.

PLEASE TAKE NOTE

Games Scoreboard
(January 1984)

The first paragraph on page 44 should read:

"If for example, S4 was set to position '2' and S3 set to position '5', on the 25th pulse from the low frequency oscillator, the inputs . . ."

The original text had inadvertently transposed the references to switches S3 and S4.

The last sentence in the first paragraph of page 45 states incorrectly that 4066 quad bilateral switches (IC9 to IC12) are *opened* by taking the control pins to logic high when in fact the opposite is true, that is, a logic high on the control pin *closes* the switch.

Teach-In 84
(January 1984)

Experiment 4.4, diagram Fig. 4.11. The end of potentiometer VR1 marked "a" should be connected to capacitor C2 and the earphone X1 at point E17. See page 237.

Microcomputer Interfacing Techniques Part 8
(February 1984)

Oric Port Board. There is an error in the circuit diagram, Fig. 8.6, and the component layout Fig. 8.9. In both diagrams the signal line labelled "I/O pin 5" should be labelled "I/O Control Pin 6".

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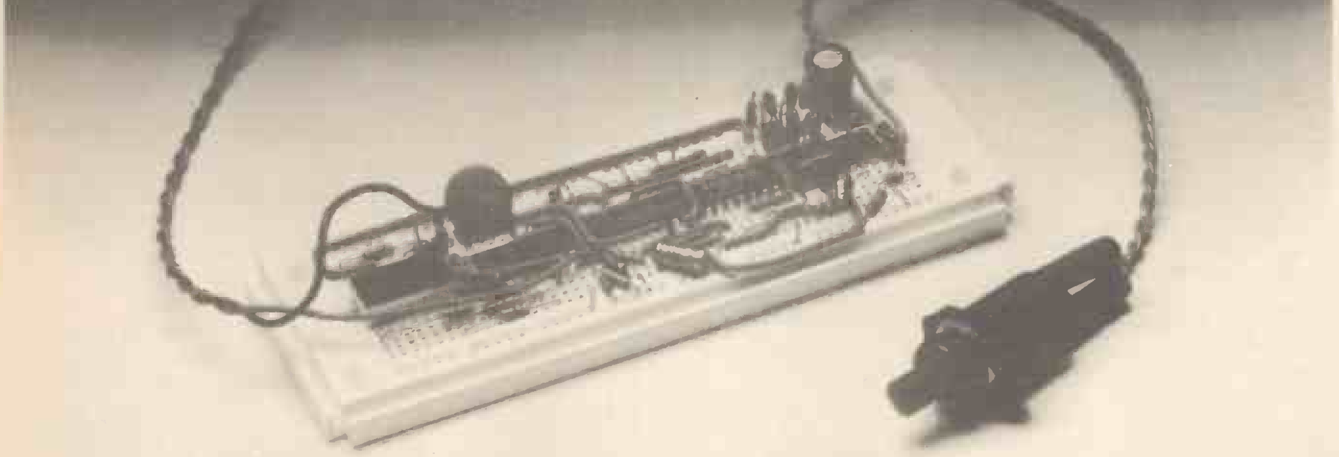

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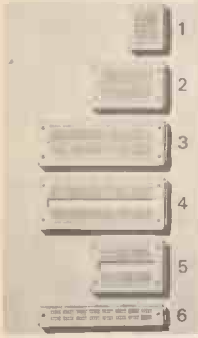

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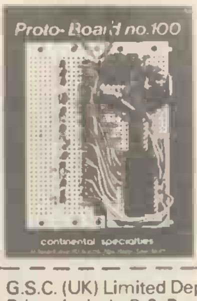

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QUASI-STEREO ADAPTOR

BY R.A. PENFOLD

TELEVISION sound is often criticised as being of a rather poor technical quality, but this is not strictly true as the f.m. sound channel used in the UK television system is capable of providing quite a high level of fidelity with good bandwidth, signal-to-noise ratio, and low distortion.

Television sets generally have a comparatively poor sound quality due to the rather simple output stages and small loudspeakers which do not equal those of even low cost hi-fi systems.

These days many television sets have an earphone or tape socket which can be coupled to a hi-fi amplifier and speakers to give a considerable improvement in the audio quality. However, the television sound channel provides only a monophonic signal (with no immediate prospect of stereo being introduced), and this can lead to disappointing results.

QUASI-STEREO EFFECT

With a monophonic signal coupled to both channels of a stereo system the sound produced seems to emanate from mid-way between the two loudspeakers and a stereo image is obviously not obtained. This can sound rather as if the sound is being fed to the listener along a tunnel and results may actually be preferable if only one stereo channel is fed with the input signal.

There is no way of producing a true stereo signal from a mono one, but there are various ways of producing a *quasi-stereo effect*. Rather than producing a proper stereo image processors of this type, spread out the sound between the two loudspeakers so that more spacious and realistic results are obtained.

FILTERING SYSTEM

The most common method of synthesising a pseudo-stereo signal from a mono input is to use a simple system of filtering, where the lower middle and bass frequencies are fed into one channel with the upper middle and treble frequencies being fed into the other channel.

The two filters used to split the signal are designed to give no overall change in the frequency response of the system. High frequency sounds are on one side of the sound stage, low frequency sounds are on the opposite side and middle frequencies are in the central image area.

This system can sometimes work well, but a major drawback is the inbalance in the signal-to-noise ratio of the two channels that is produced. One channel is fed with the high frequency sounds and therefore has most of the background "hiss" and a poor signal-to-noise ratio, while the other channel has most of this hiss filtered out and therefore has a very good signal-to-noise ratio.

This problem can be overcome using more complex filtering with two complementary filters having several peaks and troughs in their frequency response being used, but quite complex circuits are needed to completely eliminate the problem using this method.

PHASE CHANGES

A less well-known method of producing a quasi-stereo signal is to use phase changes to spread out the pseudo-stereo image. As this method does not alter the frequency response of either channel there is no problem at all with an inbalance of the signal-to-noise ratios of the two channels and quite a good quasi-stereo effect can be obtained using this method.

In order to produce a good stereo image it is essential for the signals fed to the loudspeakers to be in-phase, like the two signals in the oscillograph shown in Fig. 1a. In other words the two signals must rise and fall in amplitude together, and must be of the same polarity. Furthermore, the two loudspeakers must be connected with the same phase so that a signal in both channels causes the speaker diaphragms to move backwards and forwards together, and not one diaphragm to move forwards while the other travels backwards.

Signals in both stereo channels then produce a central image, or one slightly offset from the centre of the sound stage, depending on the relative strength of the signal in each channel.

The most simple method of producing a quasi-stereo effect using a phasing

Fig. 1a. In-phase signals.

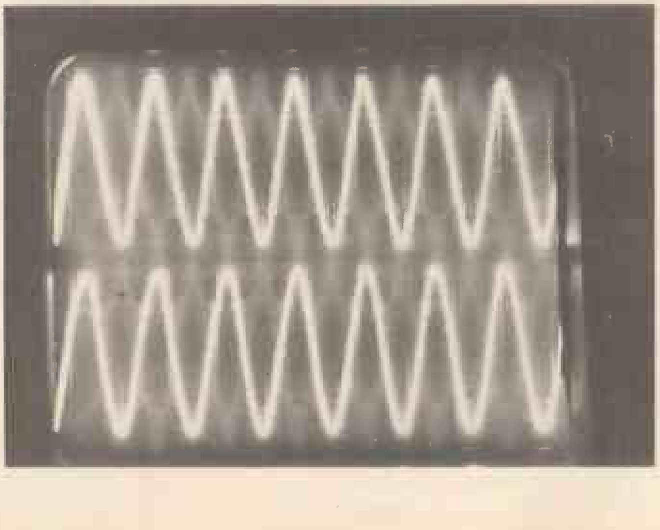
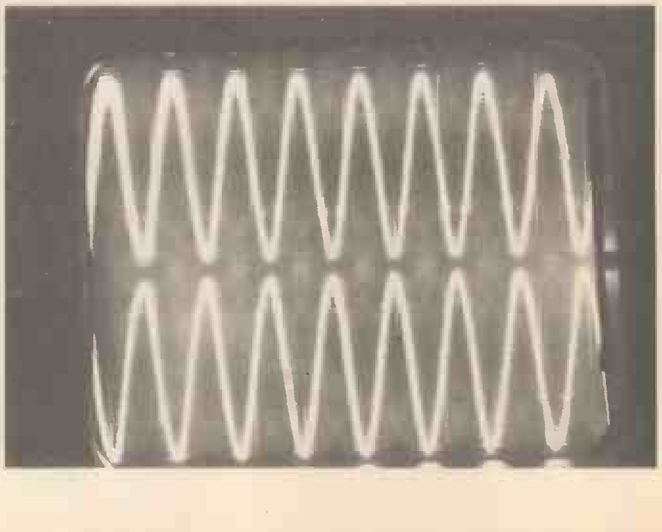


Fig. 1b. Out-of-phase signals.



technique is to simply reverse the connections to one loudspeaker so that the in-phase relationship of the two channels (and thus the central image as well) are destroyed. The sounds then seem to come, as they actually do, from the two loudspeakers. An obvious limitation of this system is that no central image at all is obtained and a less obvious one is that bass frequencies tend to be phased-out and there is consequently a noticeable loss of bass performance.

Much better results are obtained using a phase shift circuit in one channel so that the two channels are in-phase at some frequencies, out-of-phase at certain frequencies (as in Fig. 1b) and somewhere between these two extremes at other frequencies (as in Fig 1c). This produces a central image at frequencies where an in-phase relationship is produced and the sides of the quasi-stereo image at frequencies where the phase difference between the two channels is substantial.

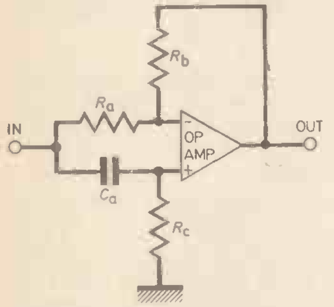


Fig. 2. Basic phase-shift network.

PHASE SHIFTER

Phase shifting without introducing any changes in frequency response can be obtained using a simple circuit based on an operational amplifier and Fig. 2 shows the standard configuration.

At low frequencies C_a has a very high impedance in relation to the resistance of R_c, and C_a therefore has no significant effect on the circuit. The operational amplifier then acts as a simple inverting amplifier with R_c biasing the non-inverting input to the central 0V supply rail, and R_a plus R_b normally having the same value, so that unity voltage gain is obtained.

At high frequencies C_a has a low impedance and effectively couples the input signal direct to the non-inverting input of the operational amplifier. Although at first sight it might seem that the coupling to the non-inverting input would cancel out the basic unity gain inverting amplifier function of the circuit and produce no output, this is not the case. R_a and R_b set the voltage gain from the non-inverting input to the output at two times, but this is reduced to unity by the coupling of the inverting input.

Thus the circuit acts as an inverter at low frequencies, gives no phase change at high frequencies and produces intermediate degrees of phase change between these two extremes. Unity voltage gain is obtained at all frequencies.

CIRCUIT DESCRIPTION

The full circuit diagram of the Quasi-Stereo Adaptor is shown in Fig. 3. IC1 is used as a simple buffer amplifier and this ensures that the first phase-shift circuit is fed from a suitably low source impedance. R1, R2 and C1 are used to produce a centre-tapping on the supply which is used to bias the non-inverting input of IC1 (and the other operational amplifiers used in the circuit).

One output is taken from the output of the buffer amplifier, and this signal undergoes no phase change.

The output of the buffer amplifier is also fed to a series of four phase-shift circuits of the type described above. At low frequencies there is no overall phase shift through these four circuits since the inversion through the first phase shifter is cancelled out by the inversion through the second stage and the inversions through stages three and four also cancel out each other.

COMPONENTS

Resistors

R1,2	4·7kΩ (2 off)
R3	56kΩ
R4,5,7,8, 10,11, 13, 14	18kΩ (8 off)
R6,9,12, 15	100kΩ (4 off)

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Capacitors

C1	4·7μF 63V axial elect.
C2	1μF 63V radial elect.
C3,8	10μF 16V radial elect. (2 off)
C4–7	1nF polycarbonate (4 off)
C9	100μF 10V radial elect.
C10	100nF polyester

Semiconductors

IC1	741C op-amp
IC2,3	1458C dual op-amp (2 off)

See Shop Talk page 231

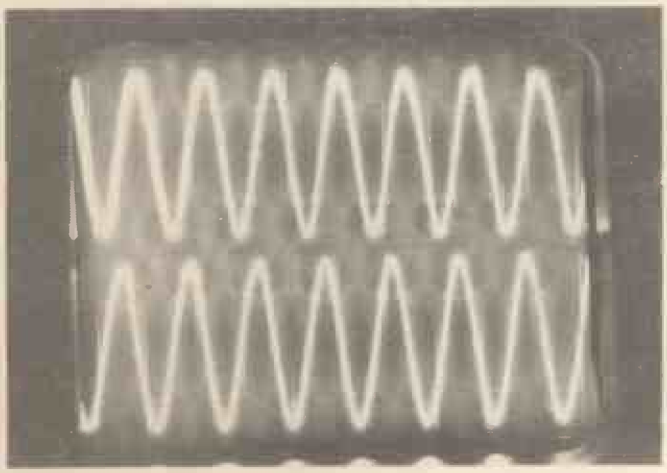
Miscellaneous

S1	rotary on/off switch
B1	9V PP6 battery
SK1,2,3	phono sockets (3 off)

Printed circuit board: single-sided, size 105 x 48mm, *EE PCB Service,* Order code 8404-01; case, 133 x 102 x 38mm (AB10); Veropins; battery connector; connecting wire.

Approx. cost Guidance only **£8**

Fig. 1c. Randomly-phased signals.



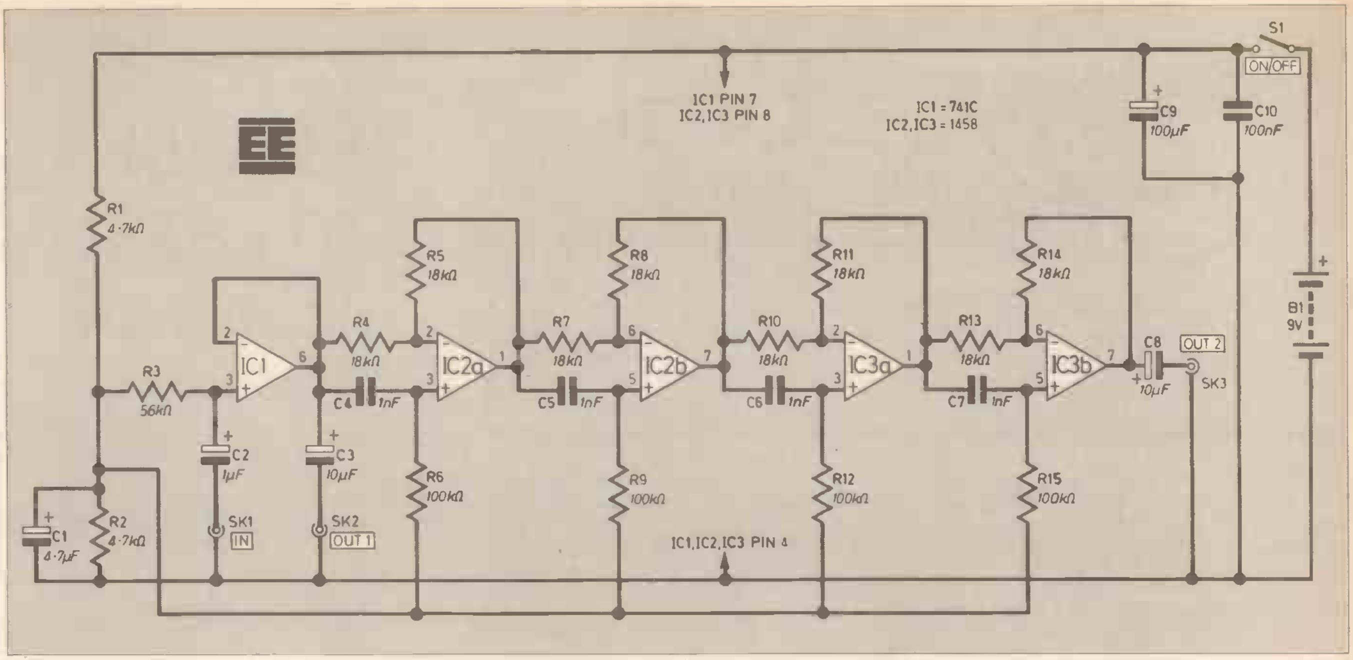


Fig. 3. Complete circuit diagram for the Quasi-Stereo Adaptor.

This is an important factor as it gives in-phase signals at bass frequencies and avoids the cancelling effect mentioned earlier and its attendant loss of bass response.

FREQUENCY INCREASE

As the input frequency is gradually increased the degree of phase shift through the circuit increases as well, until the signals become out-of-phase at frequencies around 700Hz. Increasing the input frequency further gives a greater phase shift so that the signals gradually move back into phase again, and then back into antiphase at about 4kHz.

At still higher frequencies the signals move back into phase again, but at this point the maximum phase shift of the circuit is achieved and a further increase in frequency does not produce a further change in phase shift.

The circuit, thus, gives outputs that are in-phase at high frequencies, low frequencies and a narrow band of frequencies, at a little over 1kHz, with antiphase outputs being produced at frequencies at around 700Hz and 4kHz. In practice this seems to give good results without either the sides or centre of the sound stage being excessively strong and dominant and certainly seems to give a much more spacious sound than straightforward monophonic reproduction.

POWER SUPPLY

A 9-volt supply at a current drain of only about 4mA is required, and this is obtained from a PP6 size battery. The unit only has one control, and this is merely on/off switch S1. The maximum input level that can be handled without clipping and severe distortion occurring is around 2V r.m.s. which is more than adequate. Although the processed signal passes through five operational amplifiers, these are all used with only unity voltages gain and the noise and distortion levels of the unit are therefore negligible.

CONSTRUCTION

CASE

An aluminium box measuring about 133 × 102 × 38mm makes a neat housing for this project, but there are a number of cases of a similar size that are readily available and any of these should suffice. A metal case is a better choice than a plastic one for this application though, since a metal case will provide screening and should eliminate any slight pick-up of mains hum or similar interference.

The overall layout of the unit is quite simple and straightforward. Phono sockets are used for SK1 to SK3 on the prototype, but these can be changed for any type of audio connector that will be more convenient in use.

The copper track pattern and component layout of the printed circuit board (105 × 48mm) are reproduced actual-size in Fig. 4. Construction of the board should be perfectly straightforward provided the appropriate types of capacitor specified in the components list (or a physically similar alternative) are used. Veropins are used on the board at points where connections to B1, S1, or the sockets will be made.

The finished printed circuit board is mounted on the base panel of the case using 12·5mm 6BA bolts, and 6·35mm spacers to keep the underside of the board clear of the metal case. The final wiring is then completed and it is not essential to use screened cable to make the connections from the component panel to the sockets.

Note, the printed circuit board is available from the *EE PCB Service*, Order code 8404-01.

IN USE

An important point to note is that the unit should only be used with a television set that has an output socket of some kind, which should come from the audio stages of the set via an isolation circuit so that there is no risk of obtaining an electric shock. Simply taking an audio output from across the loudspeaker of a television receiver is not satisfactory since one of the output leads would almost certainly connect direct to one side of the mains and this would be extremely dangerous indeed.

The input signal is coupled to SK1 and the outputs from SK2 and SK3 are coupled to the inputs of the amplifier. The prototype is used with the phase-shift circuits in the left-hand channel, but it does not really matter which channel is the ordinary mono signal and which is the phase shifted one. The effect is much the same either way.

It is possible to use the unit with sources other than a television receiver and it can be used with a video cassette recorder, for example, or if f.m. stereo reception is very noisy it may be advantageous to switch to mono in order to obtain a much lower noise level and then use the adaptor to give a quasi-stereo effect.

The effect of the adaptor is most noticeable when a signal having a large number of frequency components spread across the whole audio spectrum is processed, such as a piece of orchestral music or applause from a large audience. The sound stage should then clearly extend from one loudspeaker to the other with a reasonably strong central image and not just the sound seeming to emanate from the two loudspeakers. □

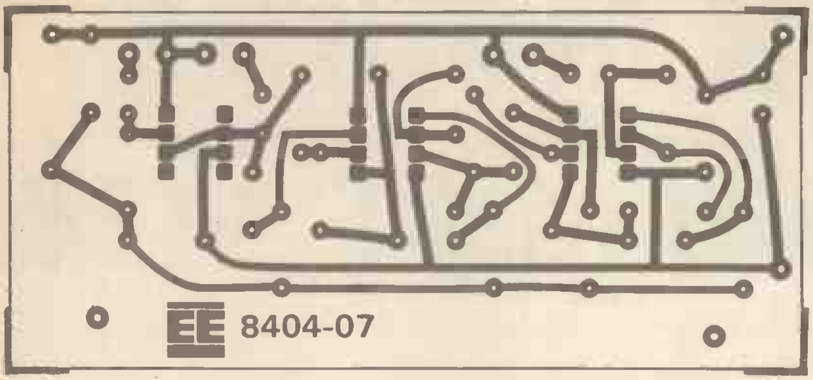


Fig. 4. The master p.c.b. (full-size) for the Quasi-Stereo Adaptor.

QUASI-STEREO ADAPTOR

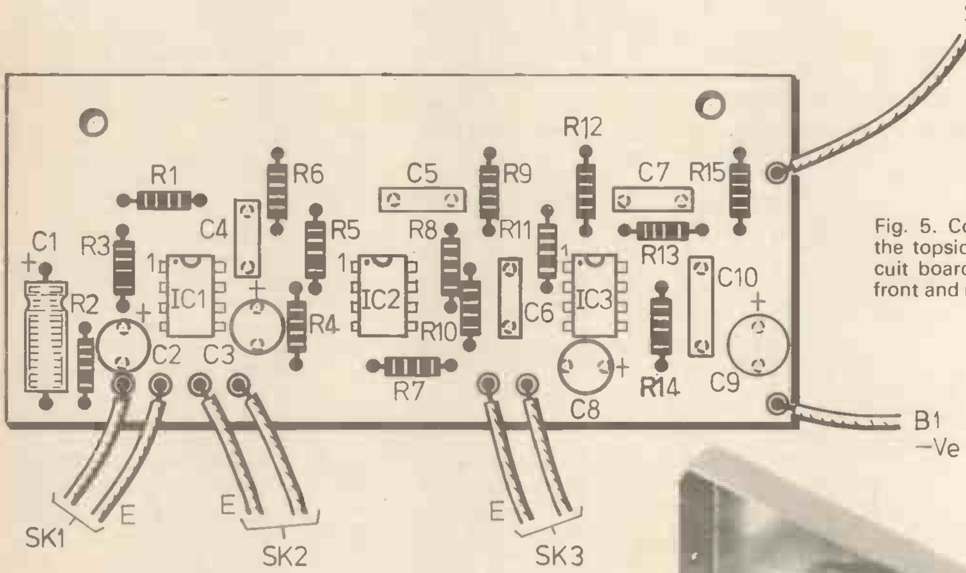
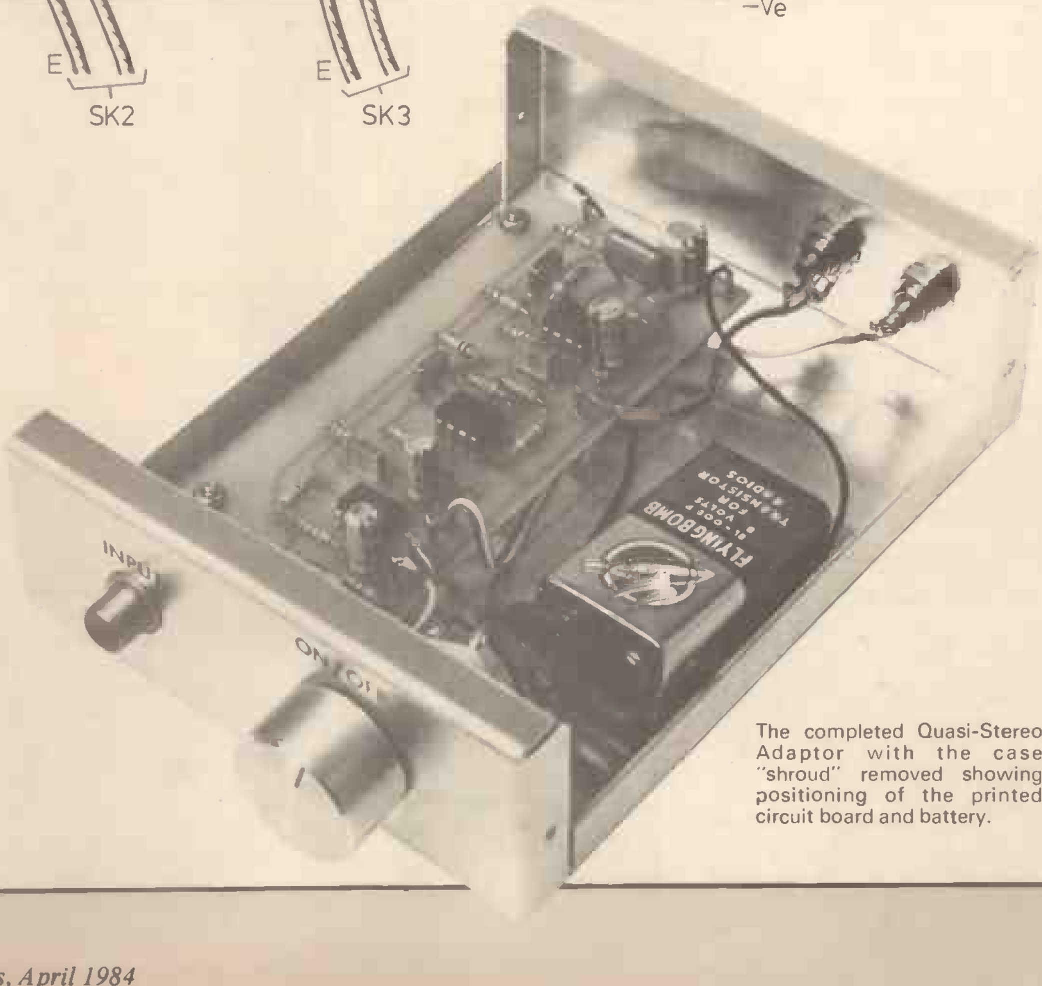


Fig. 5. Component layout on the topside of the printed circuit board with wiring to the front and rear panels.



The completed Quasi-Stereo Adaptor with the case "shroud" removed showing positioning of the printed circuit board and battery.

TIMER MODULE FOR CENTRAL HEATING SYSTEMS

BY S.IBBS

THERE are many occasions when an accurate interval-timer is extremely useful in the home and elsewhere. This simple-to-build module was originally designed to control a central-heating system, but details are given to show how its use can be extended far beyond this.

Most central heating systems have a manual/auto switch, the normal arrangement being a switch in the live line to either bypass or go via the clock mechanism (see Fig. 1). It is all too easy to switch it to manual, for example, to heat up the water, and then forget to turn it back, so that money is wasted with the system being on too long.

Thus an easy way of providing control would be to insert a timing module between points *A* and *B* in the diagram,

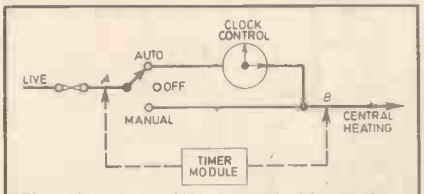


Fig. 1. Manual/Auto switching of a typical system with positioning of Timer Module indicated.

which would automatically bypass the switch and clock for a predetermined length of time. Such a circuit would not affect the normal Auto/Manual operation of the heating. The project described here has a push to start button, and a push-button to abort the timing sequence at any time. It also contains a range switch, the prototype being set to 40 minutes (low) and 80 minutes (high), to cater for hot water or radiators, respectively.

CIRCUIT DESCRIPTION

The first design used a 555 in a simple monostable circuit, but experiments showed that the large electrolytic capacitors needed for long timing periods could not be depended upon to give the required repeatable accuracy. The solution was to use an oscillator clocking a binary ripple counter, the 4020, the frequency of the oscillator being adjustable.

The oscillator is formed around two gates of a CMOS 4011 quad 2-input NAND gate, and the output is fed into the input pin 10 of the 4020. See circuit diagram, Fig. 2. At switch-on, a brief reset pulse is fed by C2 and R2 to the 4020 reset (pin 11) to ensure that all the outputs are low. This is achieved because at the instant of switch-on, C2 acts like a short circuit, but very quickly charges up, and then R2 pulls the pin down to 0V to enable counting to commence.

The low output at either pin 1 or 2 (selected via S1) is inverted by another gate of the 4011 (IC1c) to provide a high level at the base of the transistor TR1, which turns on and energises the relay placed as a collector load. One set of contacts short out the push-to-make switch, so that the supply line is established and retained when the start button is released, whilst the other set of contacts is connected between points *A* and *B* (Fig. 1) to provide the live line to the central heating.

The pins of the 4020 go high and low in a very specific sequence after a predetermined number of input pulses; pin 1 after 4096 pulses and pin 2 after 8192, and so on until eventually the selected pin goes high, causing the base of the transistor to go low, turning off the relay. This opens both sets of contacts, thus disconnecting the supply to the circuit and the live to the central heating. S2 is included so that the timing sequence can be cancelled at any time. It is a push-to-break, and disconnects the relay coil from the supply line, turning the whole unit off.

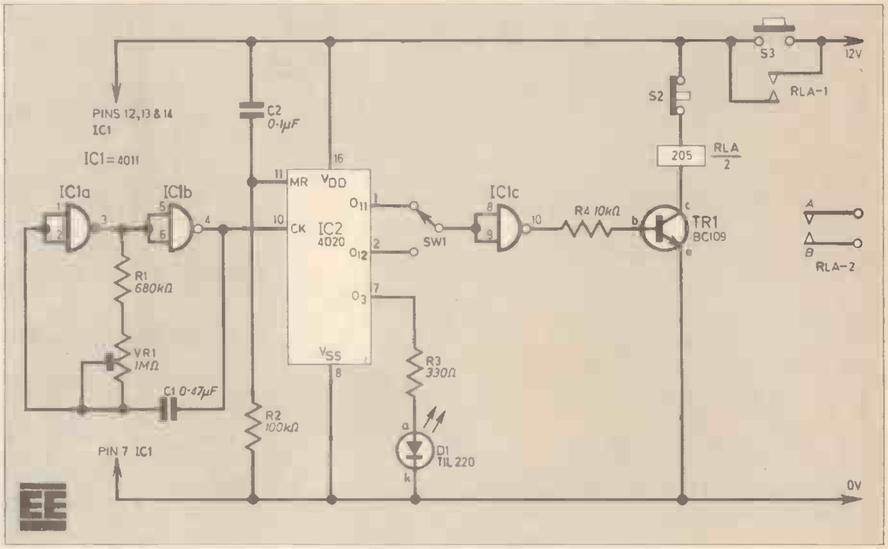
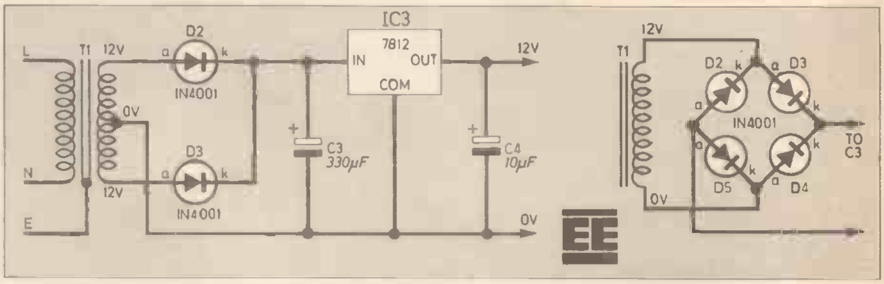


Fig. 2 (above). The oscillator circuit diagram and (below) suggested power supply circuits for the Timer Module. S3 is the start button and S2 aborts the timing cycle.



SUPPLY

The power lead is taken from the supply to the central heating, **after the fuse** for safety reasons, and is transformed by T1, rectified by the diodes and smoothed by C3 before being regulated by the 7812 (IC3). An l.e.d. and a current limiting resistor is connected to another of the 4020 outputs to provide a flashing indication that the circuit is operating, but this is purely optional and may be omitted if desired.

CONSTRUCTION

CIRCUIT BOARD

There should be no problems associated with construction; however, readers are reminded that parts of the circuit are at **mains potential**, so great care is obviously essential. It is advisable to use a p.c.b. and a suggested design for one is given in Fig. 3. Mount the components, taking care to observe the polarity of the diodes and capacitor, and the orientation of the i.c.s, transistor and regulator. See Fig. 4.

The transformer can be either a 12V–0–12V centre-tapped type, in which case the diodes D2 and D5 are omitted, and the centre tapping is connected to 0V, or a 0–12V transformer, which will need all four diodes as a bridge rectifier.

The relay was soldered to the board as shown, and small lengths of wire used to make the necessary connections. Ensure that the relay contacts are capable of carrying the required current, if necessary by connecting more than one set of contacts in parallel.

S3 has a pair of normally open (N/O) contacts wired across it, and the other set of N/O contacts will eventually be connected between points *A* and *B*, but it is best to calibrate the unit first. Monitor pin 4 of IC2 and adjust VR1. The time taken for pin 2 to go high will be time taken for pin 4 of IC1 to change from one state to the other, times 128. For example, if it changes state every 37·5 seconds, pin 2 will go high after 80 minutes (pin 1 after 40 minutes). The other contacts can now be wired in.

The module can be mounted in any convenient sized box (earthed if metal is used), with two leads running from it via grommets or strain relief bushes. One lead provides the mains supply to the module, the other runs from the relay to *A* and *B*. The transformer is bolted inside the case, with the mains earth lead connected to a soldertag.

CONCLUSION

Spare pads have been provided on the p.c.b., and looking at the waveform diagram it can be seen that if, for example, pin 2 of IC2 goes high after 60 minutes, pin 3 does not change state until two hours have passed, whilst pin 15 changes state every 15 minutes. For those constructors who would like to, S1 can be

COMPONENTS

See Shop Talk page 231

Resistors

R1	680kΩ
R2	100kΩ
R3	330Ω
R4	10kΩ

Capacitors

C1	0·47μF polyester
C2	0·1μF polyester
C3	330μF 25V elect.
C4	10μF 16V single elect.

Semiconductors

D1–4	1N4001 (4 off—see text)
D5	TIL220 5mm red l.e.d.
TR1	BC109 *npn* silicon
IC1	4011 CMOS quad 2-input NAND gate
IC2	4020 CMOS 14-stage binary ripple counter
IC3	7812 12V, 1A regulator

Miscellaneous

VR1	1MΩ miniature horizontal preset
T1	12V (or 12V–0–12V see text) 100mA mains transformer
RLA–2	miniature 12V relay, 205Ω coil with d.p.d.t. mains rated contacts
S1	s.p.d.t. miniature toggle
S2	push-to-break momentary action
S3	push-to-make momentary action

Printed circuit board: single-sided size 90 × 65mm, *EE PCB Service*, Order code 8404–05; case to suit; mains lead; soldertag; equipment wire; mounting hardware.

Approx. cost Guidance only £14

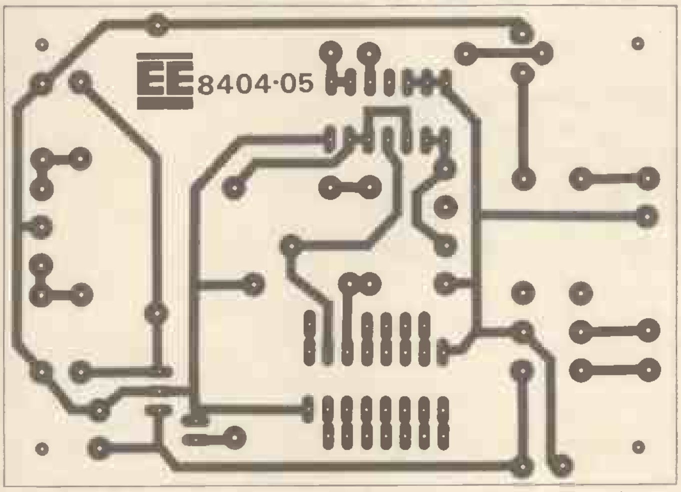


Fig. 3. Full-size printed circuit master pattern for the Timer Module.

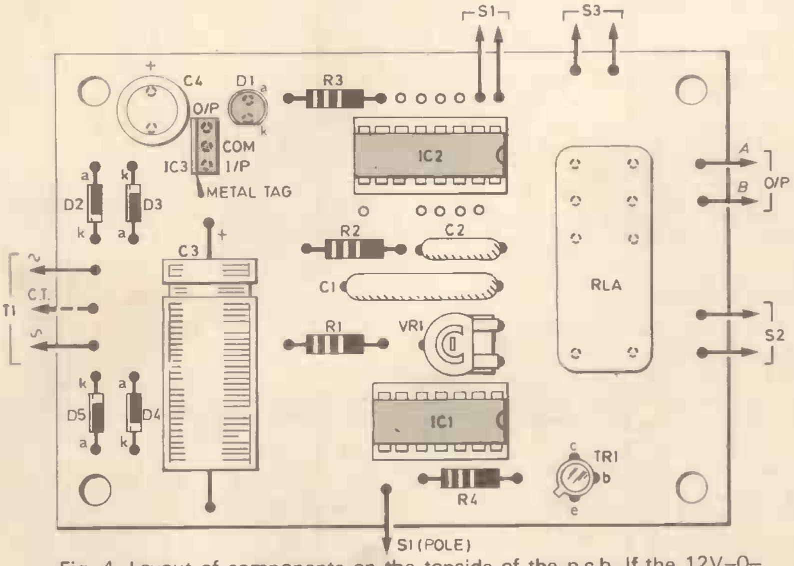


Fig. 4. Layout of components on the topside of the p.c.b. If the 12V–0–12V transformer is used, D2 and D5 are omitted and the C.T. terminal is used.

Table 1

pin no.	pulses needed to switch output on
9	2^1 (2)
7	2^4 (16)
5	2^5 (32)
4	2^6 (64)
6	2^7 (128)
13	2^8 (256)
12	2^9 (512)
14	2^{10} (1024)
15	2^{11} (2048)
1	2^{12} (4096)
2	2^{13} (8192)
3	2^{14} (16384)

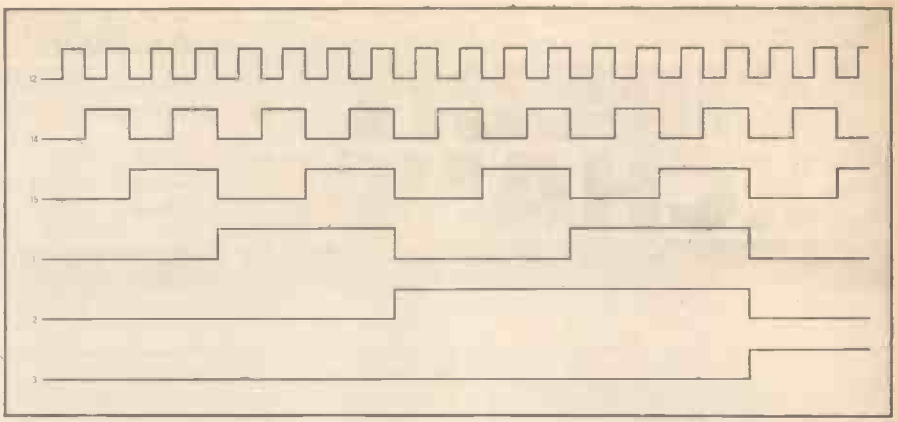


Fig. 5. Waveform diagram for some of the pins of the 4020 binary counter i.c.

changed for a 4-way rotary switch to select any of these outputs, and indeed if R1 were removed and two leads run to a two megohm linear pot, a four range variable timer (very useful in the kitchen) would be provided, with VR1 acting as a minimum time adjustment control.

The table shown gives the sequence of pins on IC2, each one going high after twice the period of its predecessor, pin 3 taking the longest time, so if two pins, for example, 12 and 14 were chosen, again with a pot replacing the fixed resistor R1, a two range darkroom timer could be constructed.

With a little imagination, the module can form the basis of several very useful projects, and it is hoped that the above suggestions have provided food for thought. If used for the central heating, there is no reason why the pushbuttons should not be mounted remotely in the kitchen, making the unit even more convenient to use. □

CIRCUIT EXCHANGE

HEADS AND TAILS

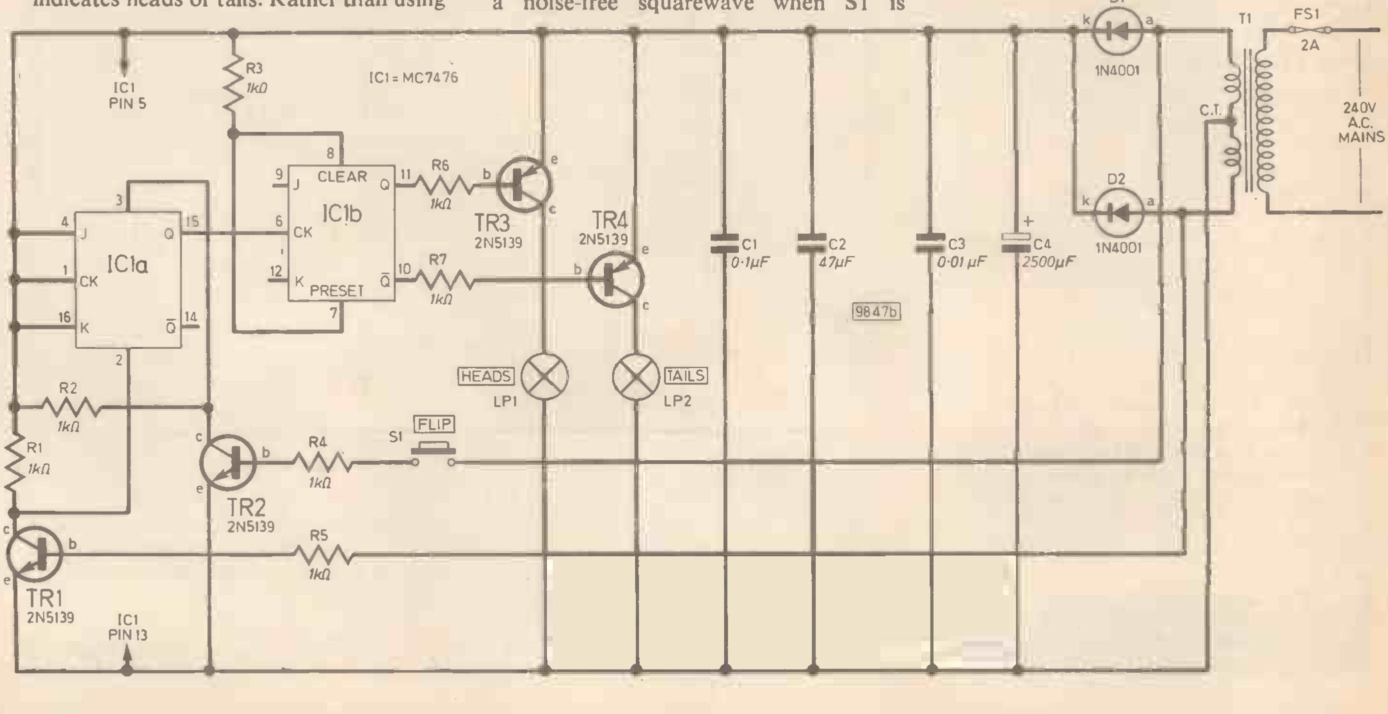
THIS project is ideal for school laboratories as a probability demonstrator or study aid.

The simple circuit diagram shown uses a TTL i.c. and four low-cost transistors. The visual readout of the second flip-flop indicates heads or tails. Rather than using an astable, or some other potentially unsymmetrical "odds determinator", heads and tails counts the power line frequency so that both the length of time the push button is held down and the phase of the power at the instant the push button is depressed combine to provide a truly random 50–50 long term result.

In the first J.K. flip-flop only the direct inputs (CLEAR and PRESET) are used so that the circuit squares up and follows the power line frequency as long as S1 is closed. Transistors R1 and R2 alternately set and reset the flip-flop immediately after each sequential power line zero crossing. The Q output of the first J.K. is a noise-free squarewave when S1 is closed, and either a logic 1 or 0 when the switch is open.

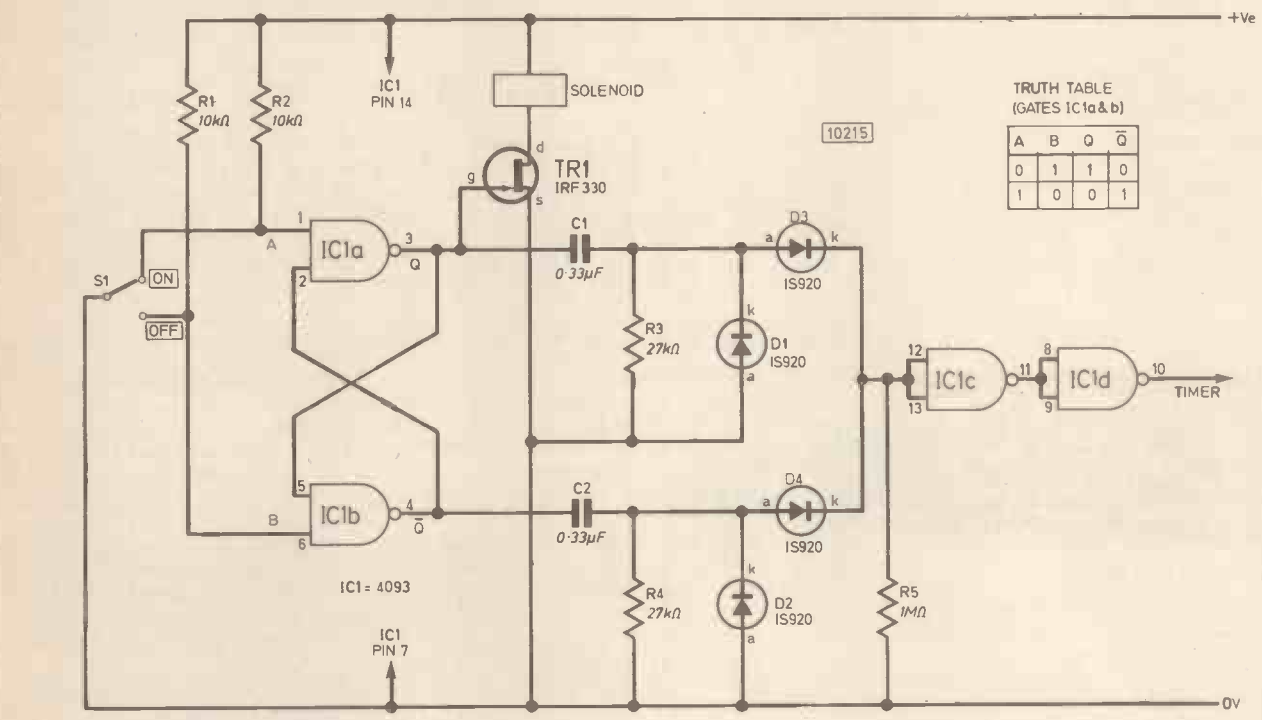
The output of the first J.K. flip-flop is used to cycle the second J.K. which is connected as a binary divider. One of its outputs drives the HEADS indicator and the other drives the TAILS lamp. Transistors TR3 and TR4 provide sufficient power for the flip-flop outputs to drive the lamps. When S1 is closed both lamps cycle on and off 30 times a second, a speed much faster than the eye can follow to discourage cheating.

Hamid Reza Nameri,
Tehran,
Iran.

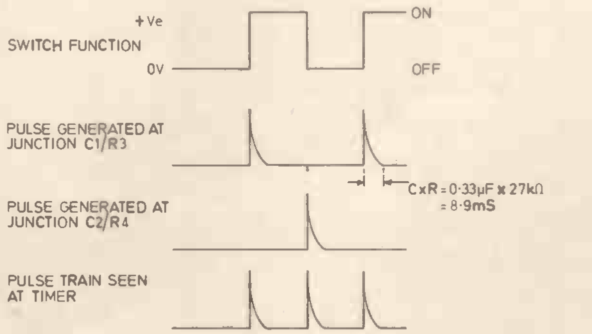


CIRCUIT EXCHANGE

This is the spot where readers pass on to fellow enthusiasts useful and interesting circuits they have themselves devised. Payment is made for all circuits published in this feature. Contributions should be accompanied by a letter stating that the circuit idea offered is wholly or in significant part the original work of the sender and that it has not been offered for publication elsewhere.



PULSE GENERATOR



THE purpose of this circuit is to measure the time period for which the solenoid is energised. This is done by generating a positive pulse for every operation of the on/off switch. These pulses are fed to a timer counter set to single line count. With the on pulse the timer starts to count and on the off pulse the timer stops and displays the period.

When the on/off switch is switched to the on position the output from gate 1 becomes positive, the f.e.t. TR1 is gated and the solenoid becomes energised. Capacitor C1 and resistor R3 differentiate this voltage and produce a pulse whose length is C1 × R3 = time. Diode D3 conducts this pulse to gate 4 via gate 3 which gives a double inversion so that the pulse maintains the same polarity but is buffered from the circuit. This pulse is used to gate (start) the timer.

As the output from gate 1 becomes positive the output from gate 2 decays in a negative direction. This negative pulse is fed to the common rail via C2 and D2.

When the on/off switch is switched to the off position the output states of gates 1 and 2 will reverse (R1, R2 and gates 1, 2 are a simple debounce circuit). Gate 2 will generate a positive-going pulse whose duration is C2 × R4 which will be fed to the timer via D4 and gates 3 and 4 which will stop the counter.

The negative pulse generated at gate 1 will be fed to the common rail via C1 and D1. The time displayed on the timer will be the duration for which the solenoid has been energised.

D. R. Fownes,
Wolverhampton.

NEW · NEW · NEW · NEW PRODUCTS NEW · NEW · NEW · NEW

TRANSISTOR TESTER

THE latest addition to the **Osborne Electronics** 4000 series of hand-held test units is the model 4500 Transistor Tester.

Completely self-contained, the unit is claimed to simplify and speed the task of checking the *pn* junctions of discrete semiconductors whether in or out of circuit.

The checking of *pnp* or *npn* transistors, diodes and open or short circuit junctions are instantly identified by a series of l.e.d.s which indicate the junction status. This is carried out by connecting two test probes across the junction to be checked.

Further information is available direct from:

Osborne Electronics,
Dept EE, Binstead Road,
Ryde, Isle of Wight.

SUPER SAVER

HOW often do you turn on the immersion heater for a quick boost, then forget to turn it off again? To prevent this wastage, and to help older people who may not feel comfortable using a programmable timer, **Superswitch** have introduced a simple run-back timer control.

Operating on the same principle as many kitchen timers, but designed so that it is capable of switching the immersion heater load, Superswitch's 1512 controller is claimed to be easy to use and understand.

With the two-position switch at "timed", the dial is set to the time required; anything from a few minutes to two hours. The controller then counts down to zero. At any time, you are able to see how much time is left to run, or turn the dial forward or back, to adjust the length of time the immersion heater will remain on.

The Superswitch 1512 Immersion Heater Controller is expected to sell for around £20. Further information and local stockists addresses may be obtained from:

Superswitch Electric Appliances Ltd., Dept EE,
7 Station Trading Estate,
Camberley, Surrey GU17 9AH.

CLEAN SWEEP

THE introduction of their new VHS VCR head cleaner, which may be used wet or dry, is announced by **Bib Audio/Video Products.** Bib claim that this cleaner is the safest and easiest to use cleaner yet devised.

Developed in the Bib Laboratories, they claim many special features for the cleaner. The most significant being the type of non-abrasive cleaning tape, which is a special spun bonded polyester made to their own specification.

Another feature is the automatic way in which the correct amount of fluid is applied to the cleaning tape. The fluid is released by pressing a button for one second on the side of the cassette housing, which feeds the fluid into a chamber through which the cleaning tape passes, eliminating the chance of applying too much or too little.

This ensures that the whole tape travel path, including tape heads, drum, guides, audio heads and capstan are cleaned in one simple operation. The cleaning time takes only 10 seconds.

It is recommended that the cleaning tape is never re-wound as each cleaning operation presents a new portion of cleaning tape to the heads and avoids the "re-playing" of accumulated contaminants. The cleaner will last for 35 cleanings, or four years' average use.

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

Attractively packed in a descriptive carton, this new cleaner has a recommended retail price of £9.98 including VAT.

Bib Audio/Video Products Ltd,
Dept EE, Kelsey House,
Wood Lane End,
Hemel Hempstead HP2 4RQ.

SQUARE one FOR BEGINNERS

CAPACITORS come in a bewildering range of types and sizes mainly because, unlike resistors, it is impossible to devise a single method of construction that will yield a sufficiently wide range of values and working voltages.

A capacitor consists of two plates of conductive material separated by an insulator or dielectric. It is the combination of materials for these two elements that causes the confusion. Besides its value, a capacitor also has a working voltage and tolerance. If either of these are important, they are specified in the components list.

Another major division is polarised and non-polarised capacitors. Generally the polarised types are large in value and must be connected up correctly. Within the above parameters, a capacitor is often chosen because of its size and stability.

This being the case, it means that virtually any capacitor with the same value and the same, or higher, voltage rating will work in a given circuit and this should be borne in mind when experimenting with spare or surplus components.

NON-POLARISED CAPACITORS

Polyester capacitors are widely used and cover the middle range of capacitances and the typical range is from 0·01µF to 2·0µF. Polyester capacitors are available in tubular, tablet and block forms and have a tolerance of 10 and 20 per cent. The normal working voltage is up to 400V d.c.

A miniature dipped case type often referred to as a C280 is shown in Table 1. This type of capacitor is wax treated and covered with a hard lacquer. The various coloured bands represent the value of the capacitor, using a similar code to the resistor one. The two top bands give the first two digits and the third the multiplier. A fourth band gives tolerance and the fifth the working voltage.

The smallest capacitors are the ceramic type and range from 1·8pF to 0·1µF (see Fig. 1). These capacitors have close tolerance, low loss and high stability.

A wide range of polystyrene capacitors are available in the range 10pF to 0·1µF. Thus they cover very nearly the same range as ceramics. They have a better electrical performance than the ceramics and are available with close tolerances such as 5, 2½ and 1 per cent.

However, polystyrene capacitors are rather more expensive and are only used where there special characteristics are essential. Polystyrene capacitors are tubular in shape and rather more bulky than ceramics. They can be used as a general purpose low value type where tolerance is not so important.

ELECTROLYTICS

Electrolytic or polarised capacitors are a special case. They provide quite a large value of capacitance, but must be connected the right way round in the circuit. They are made with specific working voltages, which must not be exceeded in practice.

It is however, permissible to use them at a lower voltage than the stated working voltage. Electrolytics are available as "double-ended" types with the connecting leads emerging from either end; also as "single-ended" types with both leads at the same end of the component. Double-ended types, as shown in Fig. 1, are recommended for general purpose use.

CAPACITOR COLOUR CODE

	TANTALUM microfarads (µF)				SERIES C280 picofarads (pF)				
Band (ring) Colour	1st band	2nd band	Spot (Multiplier)	3rd band	1st band	2nd band	3rd band (Multiplier)	4th band	5th band
BLACK	–	0	1	10V	–	0	1	20%	–
BROWN	1	1	10	–	1	1	10	–	100V
RED	2	2	100	–	2	2	100	–	250V
ORANGE	3	3	–	–	3	3	1000	–	–
YELLOW	4	4	–	6·3V	4	4	10000	–	400V
GREEN	5	5	–	16V	5	5	100000	5%	–
BLUE	6	6	–	20V	6	6	1000000	–	–
VIOLET	7	7	–	–	7	7	0·01	–	–
GREY	8	8	0·01	25V	8	8	0·001	–	–
WHITE	9	9	0·001	3V	9	9	–	10%	–
PINK	–	–	–	35V	–	–	–	–	–

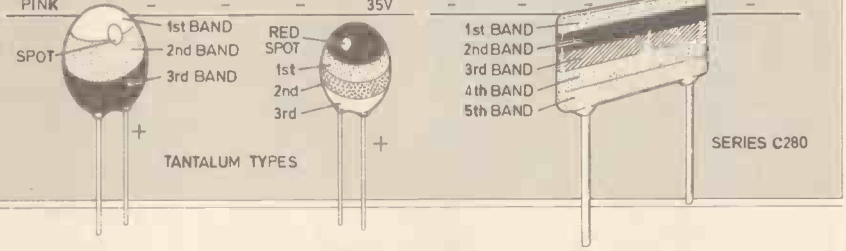


Table 1: The capacitor colour coding for tantalum and series C280 capacitors.

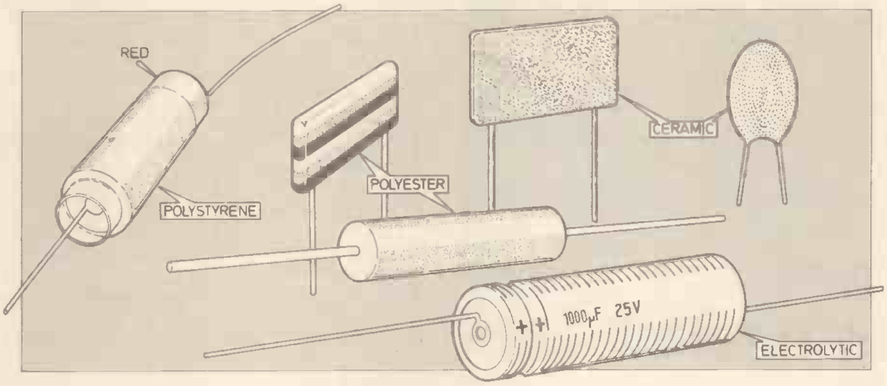
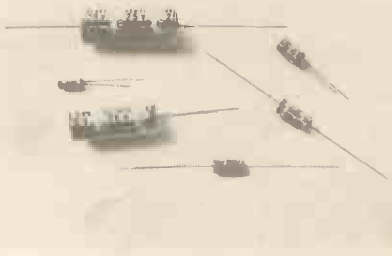
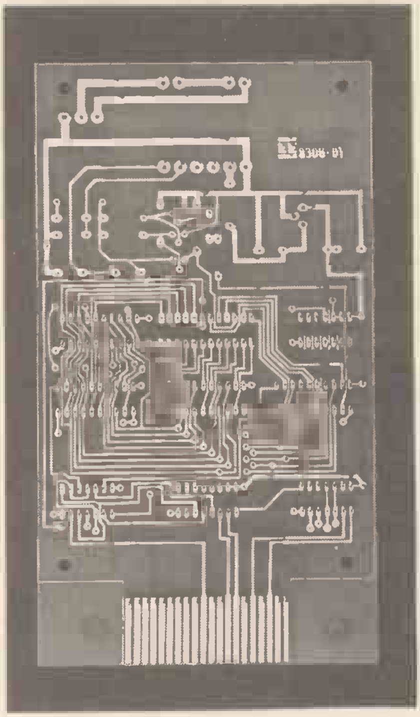


Fig. 1. A diagram showing the various shapes of commonly used capacitors.



Aluminium electrolytic capacitors.

EVERYDAY ELECTRONICS PRINTED CIRCUIT BOARD SERVICE



Printed circuit boards for certain EE constructional projects are now available from the EE PCB Service, see list. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Remittances should be sent to: EE PCB Service, Everyday Electronics Editorial Offices, Westover House, West Quay Road, Poole, Dorset BH15 1JG. Cheques should be crossed and made payable to IPC Magazines Ltd.

We regret that the ordering codes for the August projects have been incorrectly quoted in the Sept-Oct issues. Correct codes are given here.

Please note that when ordering it is important to give project title as well as order code. Please print name and address in Block Caps.

Readers ordering both p.c.b.s *and* software cassettes may send a single cheque/PO for the combined amounts listed.

Readers are advised to check with prices appearing in current issue before ordering.

PROJECT TITLE	Order Code	Cost
Eprom Programmer, TRS-80 (June 83)	8306-01	£9.31
Eprom Programmer, Genie (June 83)	8306-02	£9.31
Eprom Programmer, TRS-80 & Genie (June 83)	8306-03	£1.98
User Port Input/Output *M.I.T. Part 1* (July 83)	8307-01	£4.82
User Port Control *M.I.T. Part 1* (July 83)	8307-02	£5.17
Storage 'Scope Interface, BBC Micro (Aug 83)	8308-01	£3.20
Car Intruder Alarm (Aug 83)	8308-02	£5.15
High Power Interface *M.I.T. Part 2* (Aug 83)	8308-03	£5.08
Pedestrian Crossing Simulation *M.I.T. Part 2* (Aug 83)	8308-04	£3.56
Electronic Die (Aug 83)	8308-05	£4.56
High Speed A-to-D Converter *M.I.T. Part 3* (Sept 83)	8309-01	£4.53
Signal Conditioning Amplifier *M.I.T. Part 3* (Sept 83)	8309-02	£4.48
Stylus Organ (Sept 83)	8309-03	£6.84
Distress Beacon (Sept 83)	*8309-04	£5.36
Distress Beacon Pocket Version (Sept 83)	8309-05	£3.98
D-to-A Converter *M.I.T. Part 4* (Oct 83)	8310-01	£5.77
High Power DAC Driver *M.I.T. Part 4* (Oct 83)	8310-02	£5.13
Electronic Pendulum (Oct 83)	8310-03	£5.43
TTL/Power Interface for Stepper Motor *M.I.T. Part 5* (Nov 83)	8311-01	£5.46
Stepper Motor Manual Controller *M.I.T. Part 5* (Nov 83)	8311-02	£5.70
Digital Gauss Meter (Nov 83)	8311-03	£4.45
Speech Synthesiser for BBC Micro (Nov 83)	8311-04	£3.93
Car On/Off Touch Switch (Nov 83)	8311-05	£3.11
4-Channel High Speed ADC (Analogue) *M.I.T. Part 6* (Dec 83)	8312-01	£5.72
4-Channel High Speed ADC (Digital) *M.I.T. Part 6* (Dec 83)	8312-02	£5.29
TRS-80 Twin Cassette Interface (Dec 83)	8312-03/09	£7.43
Environmental Data Recorder (Dec 83)	8312-04	£7.24
Touch Operated Die (Dot matrix) (Dec 83)	8312-05/06	£4.34
Touch Operated Die (7-segment) (Dec 83)	8312-05/07	£4.34
Continuity Tester (Dec 83)	8312-08	£3.41
Central Heating Pump Delay (Jan 84)	8401-01	£3.33
Biological Amplifier *M.I.T. Part 7* (Jan 84)	8401-02	£6.27
Temp. Measurement and Control System for ZX Computers (Jan 84)		
Analogue Thermometer Unit	8401-03	£2.35
Analogue-to-Digital Unit	8401-04	£2.56
Games Scoreboard (Jan 84)	8401-06/07	£9.60
Eprom Programmer/ROM Card for ZX81 (Feb 84)	**8402-01	£7.84
Oric Port Board *M.I.T. Part 8* (Feb 84)	8402-02	£9.56
Negative Ion Generator (Feb 84)	*8402-03	£8.95
Temp. Measurement and Control System for ZX Computers (Feb 84)		
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Commodore 64 Extension Port Connector *M.I.T. Part 9* (Mar 84)	8403-04	£4.71
Digital Multimeter Add-On for BBC Micro (Mar 84)	8403-05	£4.63
Multipurpose Interface for Computers	8404-01	£5.72
Data Acquisition "Input" *M.I.T. Part 10* (Apr 84)	8404-02	£5.20
Data Acquisition "Output" *M.I.T. Part 10* (Apr 84)	8404-03	£5.20
Data Acquisition "PSU" *M.I.T. Part 10* (Apr 84)	8404-04	£3.09
Timer Module (Apr 84)	8404-05	£3.58
A.F. Sweep Generator (Apr 84)	8404-06	£3.55
Quasi Stereo Adaptor (Apr 84)	8404-07	£3.56

*Set of four boards. **Calibrated with C1, VR1 and IC3 fitted.
M.I.T.—Microcomputer Interfacing Techniques, 12-Part Series.

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Install your own system and save using built and tested modules

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Requires no installation. Easily assembled using our professionally built and tested modules.

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- Key operated switch - Off, Test and Operate
- Provision for an extension speaker
- Fully self-contained
- Uses US 5063, PSL 1865, Key Switch 3901, 3" Speaker 3515

only £37.00 + V.A.T.

Now you can assemble a really effective intruder alarm at this low price using tried and tested Riscomp modules. Supplied with full instructions, the kit contains everything necessary to provide an effective warning system for your house or flat. With a built-in LED indicator and test position the unit is easily set-up requiring no installation. It may simply be placed on a cupboard or desk. Movement within its range will then cause the built-in siren to produce a penetrating 90dbs of sound, or even 110db's with an additional speaker. All parts included and supplied with full instructions for ease of assembly. Size 200 x 180 x 70mm. Order as CK 5063

DIGITAL ULTRASONIC DETECTOR US 5063

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NEW

- 3 levels of discrimination against false alarms
- Crystal control for greater stability
- Adjustable range up to 25ft.
- Built-in delays
- 12V operation

This advanced new module uses digital signal processing to provide the highest level of sensitivity whilst discriminating against potential false alarm conditions. The module has a built-in exit delay and timed alarm period, together with a selectable entrance delay, plus many more outstanding features.

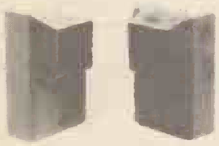
ULTRASONIC MODULE US 4012

£10.95 +V.A.T.

- Adjustable range from 5-25ft.

This popular low cost ultrasonic detector is already used in a wider range of applications from intruder detectors to automatic light switches and door opening equipment, featuring 2 LED indicators for ease of setting up.

INFRA-RED SYSTEM IR 1470 only £25.61 +V.A.T.



Consisting of separate transmitter and receiver both of which are housed in attractive moulded cases, the system provides an invisible modulated beam over distances of up to 50ft. operating a relay when the beam is broken. Intended for use in security systems, but also ideal for photographic and measurement applications. Size 80 by 50 by 35mm.

POWER SUPPLY & RELAY UNIT PS 4012

Provides stabilised 12V output at 85mA and contains a relay with 3 amp contacts. The unit is designed to operate with up to 2 ultrasonic units or 1 infra-red unit IR 1470. **Price £4.25 + V.A.T.**

SIREN MODULE SL 157

Produces a loud penetrating sliding tone which, when coupled to a suitable horn speaker, produces S.P.L.s of 110dbs at 2 metres. Operating from 9-15V. **Price £2.95 + V.A.T.**

5½" HORN SPEAKER HS 588

This weather-proof horn speaker provides extremely high sound pressure levels (110dbs at 2 metres) when used with the CA 1250, PS 1865 or SL 157. **Price £4.95 + V.A.T.**

3-POS. KEY SWITCH 3901

Single pole, 3-pos. key switch intended for use with the CA 1250. **Price £3.43 + V.A.T.**

ALARM CONTROL UNIT CA 1250

Price £19.95 + V.A.T.

The heart of any alarm system is the control unit. The CA 1250 offers every possible feature that is likely to be required when constructing a system whether a highly sophisticated installation or simply controlling a single magnetic switch on the front door.

- Built-in electronic siren drives 2 loud speakers
- Provides exit and entrance delays together with fixed alarm time
- Battery back-up with trickle charging facility
- Operates with magnetic switches, pressure pads, ultrasonic or I.R. units
- Anti-tamper and panic facility
- Stabilised output voltage
- 2 operating modes - full alarm/anti-tamper and panic facility
- Screw connections for ease of installation
- Separate relay contacts for external loads
- Test loop facility

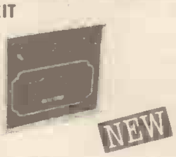
SIREN & POWER SUPPLY MODULE PSL 1865

only £9.95 + V.A.T.

NEW

A complete siren and power supply module which is capable of providing sound levels of 110dbs at 2 metres when used with a horn speaker. In addition, the unit provides a stabilised 12V output up to 100mA. A switching relay is also included so that the unit may be used in conjunction with the US 5063 to form a complete alarm.

HARDWARE KIT HW 1250

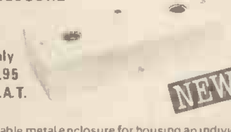


only £9.50 + V.A.T.

NEW

This attractive case is designed to house the control unit CA 1250, together with the appropriate LED indicators and key switch. Supplied with the necessary mounting pillars and punched front panel, the unit is given a professional appearance by an adhesive silk screened label. Size 200 by 180 by 70mm

ULTRASONIC MODULE ENCLOSURE



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Suitable metal enclosure for housing an individual ultrasonic module type US 5063 or US 4012. Supplied with the necessary mounting pillars and screws etc. For US 5063 order SC 5063; for US 4012 order SC 4012.

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Originally for sale at £8.95, these well made units 70×50×25mm provide both audible and visual alarms. Uses 2 IC's, PB2720 transducer, etc. Available ready built, with circuit and instructions for just **£3.95**. Also available as a kit, PCB + all components, box, wire, etc, together with instructions. Only **£2.95**.

RIBBON CABLE

Special purchase of multicoloured 14 way ribbon cable – **40p/metre**; 50m **£18**; 100m **£32.00**; 250m **£65.00**.

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Panels with assorted TTL inc LS types. Big variety. 20 chips **£1.00**; 100 chips **£4.00**; 1000 chips **£30.00**.

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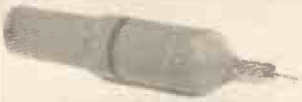
Z901 Can you follow the flashing light/pulsating tone sequence of this famous game? Supplied as a fully working PCB with speaker (no case) plus full instructions. Only **£4.95**

Z902 Probably the most popular electronic game on the market – based on the old fashioned pencil and paper battleship game, this computerized version has brought it bang up to date! We supply a ready built PCB containing 76477 sound effect chip, TMS1000 micro-processor chip, R's, C's etc. Offered for its component value only (board may be cracked or chipped, it's only **£1.95**. Instructions and circuit, **30p**.

STORE CLEARANCE!!

We've bought so much surplus recently our stores are bulging at the seams! In order to clear some space, we're once again offering "Bargain Parcels" which have proved very popular in the past. They contain resistors, capacitors, switches, panels with transistors and IC's, screws and various hardware + all the odd bits and pieces which have accumulated over the years. Each parcel weighs 10lbs and costs just **£8.00**.



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Model A124. Unit plugs directly into 13A socket, and will charge up to 4 AA cells at a time. Only **£4.80**.

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AA size **99p** each; C size **199p**; D size **220p**; PP3 size **395p**.

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A199. A versatile stabilized power supply with both voltage (2-30V) and current (20mA-2A) fully variable. Many uses inc bench PSU, Nicad charger, gen. purpose testing. Panel ready built, tested and calibrated. **£7.75**. Suitable transformer and pots **£6.00**. Full data supplied.

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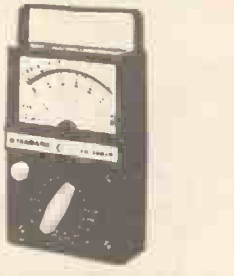

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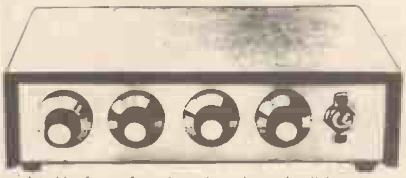

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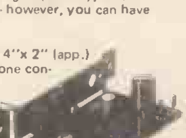

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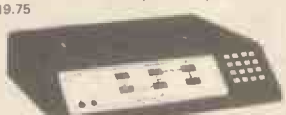

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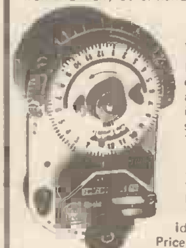

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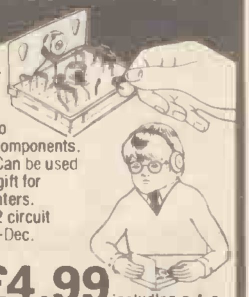

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