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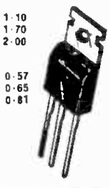

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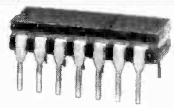

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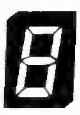

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CD4017	1·15	CD4037	1·10	CD4056	1·50	CD4078	0·25	74LS00	0·24	74LS107	0·44		

74LS

74C MOS

74C00	0·26	74C85	1·90
74C02	0·26	74C86	0·68
74C04	0·26	74C90	0·91
74C08	0·26	74C107	1·30
74C10	0·26	74C151	2·62
74C20	0·26	74C157	2·35
74C30	0·26	74C160	1·18
74C32	0·26	74C161	1·18
74C42	0·92	74C162	1·18
74C48	2·30	74C163	1·18
74C73	0·58	74C164	1·04
74C74	0·59	74C173	0·95
74C76	0·58	74C174	0·95

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46 instruction set
8 bit tristate bus I/O
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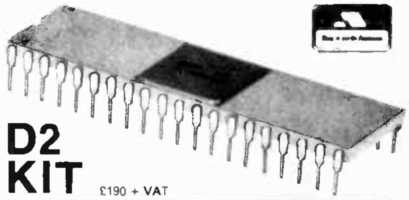


D2 KIT £190 + VAT

PRACTICAL
ELECTRONICS

VOLUME 14 No. 1 SEPTEMBER 1977

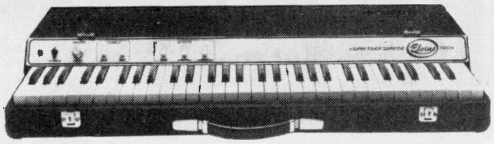
CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

(The CRO Logic Monitor Generator has been unavoidably held over)

Our October issue will be on sale Friday, 9 September, 1977
(for details of contents see page 45)



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Wide range of touch-sensitive response ESU design.
Free from breakthrough noise.
Choice of keyboard C-C or F-F with Transpose Control.
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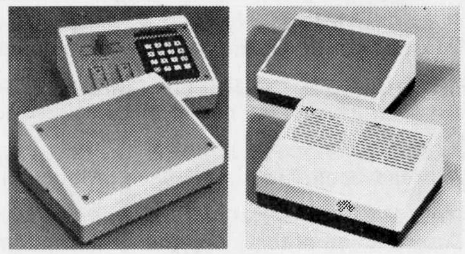

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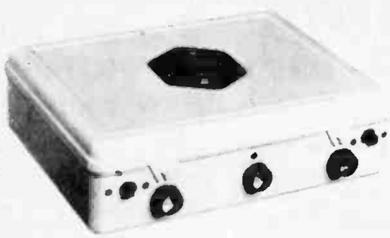
NEW EDU-KIT MAJOR

COMPLETELY SOLDERLESS ELECTRONIC CONSTRUCTION KIT
BUILD THESE PROJECTS WITHOUT SOLDERING IRON OR SOLDER



- 4 Transistor Earpiece Radio
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- Transistor Tester NPN—PNP
- 4 Transistor Push Pull Amplifier
- 5 Transistor Push Pull Amplifier
- 7 Transistor Loud-speaker Radio MW/LW.
- 5 Transistor Short Wave Radio
- Electronic Metronome
- Electronic Noise Generator
- Batteryless Crystal Radio
- One Transistor Radio
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Complete kit of parts including construction plans

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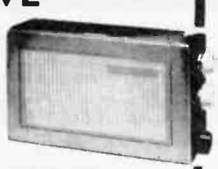
Build this converter kit and receive the aircraft band by placing it by the side of a radio tuned to medium wave or the long wave band and operating as shown in the instructions supplied free with all parts.

Uses a retractable chrome plated telescopic aerial, gain control, V.H.F. tuning capacitor, transistor, etc.

All parts including case and plans

£3·95 P.P. & Ins. 60p

POCKET FIVE

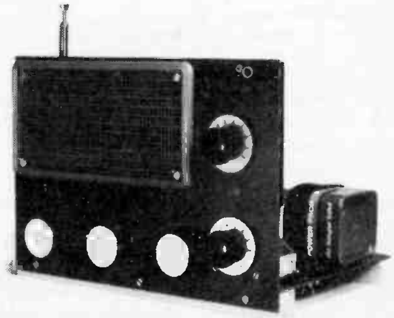


Now with 3in Loudspeaker 3 tuneable wavebands. MW, LW and trawler band. 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, attractive black and gold case. Size 5½in × 1¼in × 3½ in approx.

Complete kit of parts including construction plans.

Total Building Costs: **£3·60** P.P. and Ins. 80p

NEW ROAMER TEN MODEL R.K. 3



MULTIBAND V.H.F. AND A.M. RECEIVER.
13 TRANSISTORS AND FIVE DIODES.
QUALITY 5" × 3" LOUDSPEAKERS.

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Case enclosure kit (if required), £1·90 inc. P. P. and Ins.

NEW Everyday Series

Build this exciting new series of designs.

E.V.5. 5 Transistors and 2 diodes. MW/LW. Powered by 4½V battery. Ferrite rod aerial, tuning condenser, volume control, and now with 3in. loudspeaker. Attractive case with red speaker grille. Size 9in. × 5¼in. × 2¼in. approx. All parts including Case and Plans.

Total Building costs **£4·30** P. & P. + Ins. 80p

E.V.6. Case and looks as above. 6 Transistors 3 diodes. Powered by 9V battery. Ferrite rod aerial. 3in. loudspeaker, etc. MW/LW coverage. Push/Pull output.
All parts including Case and Plans.

Total Building costs **£4·95** P. & P. + Ins. 90p

E.V.7. Case and looks as above, 7 Transistors and 3 diodes. Six wavebands, MW/LW, Trawler Band SW1, SW2, SW3, powered by 9V battery. Push pull output. Telescopic aerial for short waves. 3in. Loudspeaker. All parts including Case and Plans.

Total Building Costs **£6·95** P. & P. + Ins. 90p

ELECTRONIC CONSTRUCTION KITS

E.C.K. 2

Self Contained Multi-Band V.H.F. Receiver Kit.

8 transistors and 3 diodes. Push pull output. 3in loudspeaker, gain control, 7 section chrome plated telescopic aerial, V.H.F. tuning capacitor, resistors, capacitors, transistors, etc. Will receive T.V. sound, public service band, aircraft, V.H.F. local stations, etc. Operates from a 9 volt P.P. 7 battery (not supplied with kit).

Complete kit of parts **£7·95** P.P. and Ins. 90p — including Construction Plans

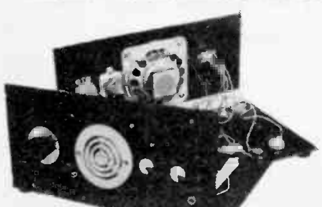
E.C.K. 4

7 Transistors, 6 tuneable wavebands, MW, LW, Trawler Band. 3 Short Wave Bands. Receiver Kit.

With 5in × 3in loudspeaker. Push pull output stage, gain control, and rotary switch. 7 transistors and 4 diodes. 6 section chrome-plated telescopic aerial. 8in sensitive ready wound ferrite rod aerial, tuning capacitor, resistors, capacitors, etc. Operates from a 9 volt P.P. 7 battery (not supplied with kit).

Complete kit of parts **£7·25** P.P. and Ins. 90p — Including Construction Plans

EDU-KIT JUNIOR



Completely Solderless Electronic Construction Kit. Build these projects without Soldering Iron or Solder.

★ Crystal Radio Medium Wave Coverage—No Battery necessary
★ One Transistor Radio
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★ Electronic Noise Generator
★ Electronic Metronome
★ 4 Transistor Push/Pull Amplifier

All parts including loudspeaker, earpiece, MW ferrite rod aerial, capacitors, resistors, transistors, etc.

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WHITE LED (RED EMIT.) RL2-03 .160"	10
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MAG LENS FITS 14 PIN SOCKET
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7400	06
7410	09
7438	12
7453	10
74181	1-35
74123	34
74153	49
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304	56	340K	1-48	565	1-38		
305	60	370	92	566	1-38		
307	44	372	51	567	1-38		
308	69	373	35	709	31		
309K	1-25	376	38	710	24		
310	75	380	93	711	51		
311	67	380-8	1-02	739	75		
319	82	381	1-13	741	29		
320T	1-12	382	1-13	747	53		
320K	1-32	511	2-07	748	31		
322	69	540	1-38	75491	58		
		556A	1-02	75492	63		

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1 x 8K EROM

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256 BIT RAM TRI-STATE

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4000A	16	4016A	40	4049A	42
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4006A	96	4021A	98	4068A	31
4007A	19	4022A	78	4069A	31
4008A	1-27	4023A	18	4071A	19
4009A	41	4024A	63	4072A	25
4010A	38	4025A	18	4073A	28
4011A	19	4027A	42	4075A	28
4012A	18	4028A	70	4078A	28
4013A	32	4030A	32	4081A	19
4014A	1-06	4035A	90	4082A	25
4015A	1-06	4042A	1-05	4528A	1-14
				4585A	1-49

74C00	£0-21	74C74	£0-63	74C162	£1-78
74C02	30	74C76	93	74C163	1-78
74C04	41	74C107	82	74C164	1-92
74C08	41	74C151	1-59	74C173	1-59
74C10	36	74C154	1-92	74C195	1-65
74C20	36	74C157	1-20	80C95	82
74C42	1-18	74C160	1-78	80C97	82
74C73	.85	74C161	1-78		

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4008	99p	4073	26p
4009	57p	4076	118p
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4012	20p	4082	25p
4013	51p	4093	95p
4014	107p	4502	123p
4015	114p	4510	139p
4016	51p	4511	150p
4017	114p	4512	81p
4018	110p	4514	264p
4019	62p	4515	264p
4020	115p	4516	123p
4021	101p	4518	123p
4022	99p	4520	123p
4023	20p	4522	122p
4024	79p	4526	122p
4025	20p	4527	140p
4026	155p	4528	115p
4027	60p	4531	115p
4028	95p	4543	115p
4029	123p	~~4555~~	115p
4030	55p	4556	115p
4033	155p	4581	348p
4034	347p	4582	140p
4035	118p	4584	99p
4040	132p	4585	108p
4041	84p		
4042	89p		
4043	99p		
4044	91p		
4046	137p		
4049	55p		
4050	55p		
4051	140p		
4052	140p		
4053	140p		
4060	140p		

TTL

7400	18p	7410	20p	7492	54p	74172	860p
7401	18p	7411	30p	7493	44p	74173	187p
7402	18p	7412	20p	7494	88p	74174	100p
7403	20p	7413	38p	7495	65p	74175	98p
7404	24p	7414	96p	7496	90p	74176	123p
7405	24p	7416	35p	7497	358p	74177	123p
7406	42p	7417	40p	74100	120p	74178	110p
7407	58p	7420	20p	74104	73p	74179	138p
7408	25p	7421	40p	74105	73p	74180	108p
7409	25p	7422	26p	74107	36p	74181	262p
		7423	32p	74109	75p	74182	83p
		7425	32p	74110	50p	74184	234p
		7426	107p	74111	88p	74185	187p
		7427	89p	74116	251p	74190	134p
		7428	81p	74120	155p	74191	134p
		7430	20p	74121	35p	74192	115p
		7432	29p	74122	53p	74193	115p
		7433	118p	74123	61p	74194	107p
		7437	38p	74125	59p	74195	102p
		7438	38p	74126	59p	74196	134p
		7440	20p	74128	98p	74197	130p
		7442	69p	74132	75p	74198	124p
		7443	130p	74142	302p	74199	199p
		7444	130p	74143	346p	74221	109p
		7445	105p	74144	346p	74246	205p
		7447	90p	74145	90p	74247	195p
		7448	90p	74147	148p	74248	171p
		7450	20p	74148	150p	74249	171p
		7451	20p	74150	150p	74251	170p
		7453	20p	74151	78p	74265	94p
		7454	20p	74153	78p	74278	331p
		7460	20p	74154	138p	74279	75p
		7470	33p	74155	90p	74283	94p
		7472	30p	74156	90p	74284	712p
		7473	33p	74157	82p	74285	712p
		7474	33p	74158	140p	74290	122p
		7475	48p	74159	265p	74293	122p
		7481	125p	74160	102p	74298	173p
		7483	95p	74161	102p	74365	93p
		7484	119p	74162	102p	74366	93p
		7485	128p	74163	102p	74367	93p
		7486	33p	74164	115p	74368	93p
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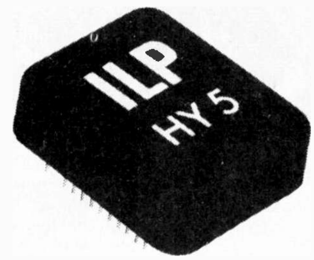
The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropiate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.



FEATURES: complete pre-amplifier in single pack; multi-function equalisation; low noise; low distortion; high overload; two simply combined for stereo.
APPLICATIONS: hi-fi; mixers; disco; guitar and organ; public address.
SPECIFICATION: Inputs—magnetic pick-up 3mV; ceramic pick-up 30mV; tuner 100mV; microphone 10mV; auxiliary 3–100mV; input impedance 47kΩ at 1kHz. Outputs—tape 100mV; main output 500mV R.M.S. Active Tone Controls—treble ±12dB at 10kHz; bass ±12dB at 100Hz. Distortion—0·1% at 1kHz; signal/noise ratio 68dB. Overload—38dB on magnetic pick-up. Supply Voltage—±16–50V.

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HY5 mounting board B.1. **48p** + 6p VAT. P. & P. free

HY30
15W into 8Ω

The HY30 is an exciting New kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of: I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up to date technology available.
FEATURES: complete kit; low distortion; short, open and thermal protection; easy to build.
APPLICATIONS: updating audio equipment; guitar practice amplifier; test amplifier; audio oscillator.
SPECIFICATION: Output Power—15W R.M.S. into 8Ω. Distortion—0·1% at 15W. Input Sensitivity—500mV. Frequency Response—10Hz-16kHz −3dB.

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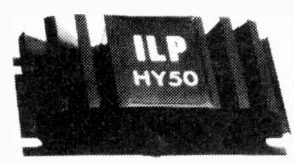
HY50
25W into 8Ω

The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.



FEATURES: low distortion; integral heatsink; only five connections; 7 amp output transistors; no external components.
APPLICATIONS: medium power hi-fi systems; low power disco; guitar amplifier.
SPECIFICATION: Input Sensitivity—500mV. Output Power—25W R.M.S. into 8Ω. Load Impedance—4-16Ω. Distortion—0·04% at 25W at 1kHz. Signal/Noise Ratio—75dB. Frequency Response—10Hz-45kHz −3dB. Supply Voltage—±25V. Size—105 × 50 × 25mm.

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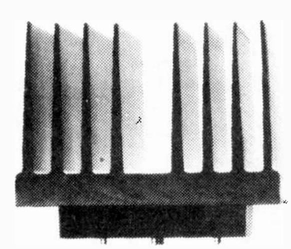
HY120
60W into 8Ω

The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection this amplifier sets a new standard in modular design.
FEATURES: very low distortion; integral heatsink; load line protection; thermal protection; five connections; no external components.
APPLICATIONS: hi-fi; high quality disco; public address; monitor amplifier; guitar and organ.
SPECIFICATION: Input Sensitivity—500mV. Output Power—60W R.M.S. into 8Ω. Load Impedance—4-16Ω. Distortion—0·04% at 60W at 1kHz. Signal/Noise Ratio—90dB. Frequency Response—10Hz-45kHz −3dB. Supply Voltage—±35V. Size—114 × 50 × 85mm.



Price **£15·84** + £1·27 VAT. P. & P. free

HY200
120W into 8Ω

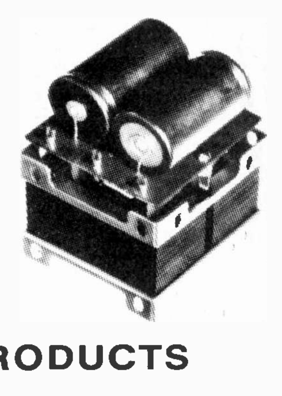
The HY200 (now improved to give an output of 120 watts) has been designed to stand the most rugged conditions such as disco or group while still retaining true hi-fi performance.
FEATURES: thermal shutdown; very low distortion; load line protection; integral heatsink; no external components.
APPLICATIONS: hi-fi; disco; monitor; power slave; industrial; public address.
SPECIFICATION: Input Sensitivity—500mV. Output Power—120W R.M.S. into 8Ω. Load Impedance—4-16Ω. Distortion—0·05% at 100W at 1kHz. Signal/Noise Ratio—96dB. Frequency Response—10Hz-45kHz−3dB. Supply Voltage—±45V. Size—114 × 50 × 85mm.

Price **£23·32** + £1·87 VAT. P. & P. free

HY400
240W into 4Ω

The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.
FEATURES: thermal shutdown; very low distortion; load line protection; no external components.
APPLICATIONS: public address; disco; power slave; industrial.
SPECIFICATION: Output Power—240W R.M.S. into 4Ω. Load Impedance—4-16Ω. Distortion—0·1% at 240W at 1kHz. Signal/Noise Ratio—94dB. Frequency Response—10Hz-45kHz −3dB. Supply Voltage—±45V. Input Sensitivity—500mV. Size—114 × 100 × 85mm.

Price **£32·17** + £2·75 VAT. P. & P. free



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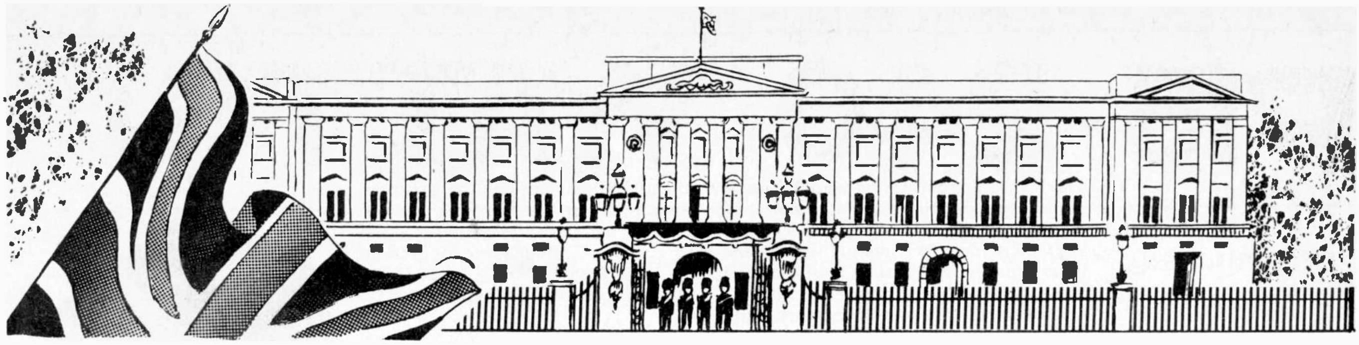

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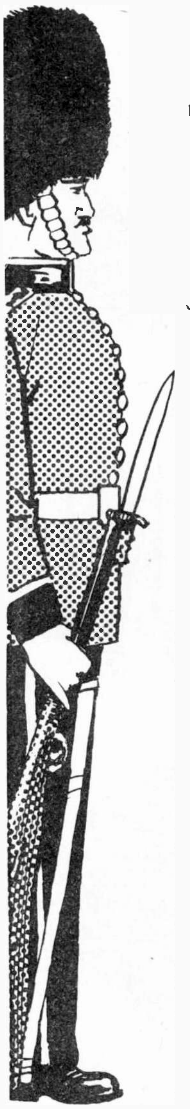

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7403	0·11	0·10	7453	0·12	0·10	74145	0·75	0·72
7404	0·11	0·10	7454	0·12	0·10	74150	1·10	1·05
7405	0·11	0·10	7460	0·12	0·10	74151	0·65	0·60
7406	0·28	0·25	7470	0·24	0·23	74153	0·70	0·68
7407	0·28	0·25	7472	0·20	0·19	74154	1·20	1·10
7408	0·12	0·11	7473	0·26	0·22	74155	0·70	0·68
7409	0·12	0·11	7474	0·24	0·23	74156	0·70	0·68
7410	0·09	0·08	7475	0·44	0·40	74157	0·70	0·68
7411	0·22	0·20	7476	0·26	0·25	74160	0·95	0·85
7412	0·22	0·20	7480	0·45	0·42	74161	0·95	0·85
7413	0·26	0·25	7481	0·90	0·88	74162	0·95	0·85
7416	0·28	0·25	7482	0·75	0·73	74163	0·95	0·85
7417	0·26	0·25	7483	0·88	0·82	74164	1·20	1·10
7420	0·11	0·10	7484	0·85	0·80	74165	1·20	1·10
7422	0·19	0·18	7485	1·10	1·00	74166	1·20	1·10
7423	0·21	0·20	7486	0·28	0·26	74174	1·10	1·00
7425	0·25	0·23	7489	2·70	2·50	74175	0·85	0·82
7426	0·25	0·23	7490	0·38	0·32	74176	1·10	1·00
7427	0·25	0·23	7491	0·65	0·62	74177	1·10	1·00
7428	0·36	0·34	7492	0·43	0·35	74180	1·10	1·00
7430	0·12	0·10	7493	0·38	0·35	74181	1·90	1·80
7432	0·20	0·19	7494	0·70	0·68	74182	0·80	0·78
7433	0·38	0·36	7495	0·60	0·58	74184	1·50	1·40
7437	0·26	0·25	7496	0·70	0·68	74190	1·40	1·30
7438	0·26	0·25	74100	0·95	0·90	74191	1·40	1·30
7440	0·12	0·10	74104	0·40	0·35	74192	1·10	1·00
7441	0·60	0·57	74105	0·30	0·25	74193	1·05	1·00
7442	0·80	0·70	74107	0·30	0·25	74194	1·05	1·00
7443	0·95	0·90	74110	0·48	0·45	74195	0·80	0·75
7444	0·95	0·90	74111	0·75	0·72	74196	0·90	0·85
7445	0·80	0·75	74118	0·85	0·82	74197	0·90	0·85
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J29 3 × 2N3904/06* each

PRICE 60p PER PAK

TESTED DIODE PAKS

J30 12 × OA81
J31 12 × OA91
J32 12 × OA200
J33 12 × OA202
J34 15 × IN4148
J35 20 × IN4001
J36 15 × IN4002
J37 10 × IN4004
J38 8 × IN4007
J39 5 × IN5400
J40 5 × IN5401
J41 4 × IN5404
J42 3 × IN5408

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OPTOELECTRONICS

J43 4 × DL707 + data £2·80
J44 5 × 0·125 red LED £0·50
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J46 5 × 0·2 and 0·125 LEDs mixed colours £0·50
J47 3 × ORP12 equivalent £1·20
J48 5 × OCP71 £1·00

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J50 5 amp SCR, 1 × 50, 2 × 400, 1 × 600 £1·50

UNIJUNCTION/FET PAKS

J51 6 × TIS43/UT46 £1·00
J52 4 × 2N3819 £0·60

PCB PRODUCTS

J53 2 × Etch resistant pens £1·00
J54 2 × Etchant paks £1·00

DIY PRINTED CIRCUIT KIT

CONTAINS 6 pieces copper laminate, box of etchant powder and measure, tweezers, marker pen, high quality pump drill, Stanley knife and blades, 6in metal rule. Full easy-to-follow instructions. **J59 SALE PRICE £5·50**

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J57 54 first quality miniature electrolytics from 0·47μF to 1,000μF £1·20*

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J60 11 × 8 pin DIL Sockets £1·00
J61 10 × 14 pin DIL Sockets £1·00
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J63 20 mixed value 400mW zener diodes 3–10V £1·00
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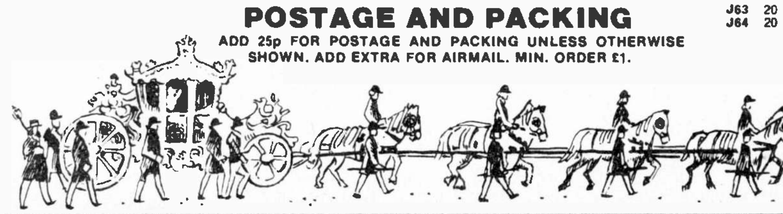

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SHOP AT 18 BALDOCK ST., WARE, HERTS. OPEN 9 to 5.30 Mon/Sat.

PE VOLUME 14 No. 1 SEPTEMBER 1977

AND NOW, HANDS-ON

THE promised technological revolution triggered off by the microprocessor is well under way. The last two years have seen the appearance of a bewildering variety of MPU devices and the choice of device has not been made any easier for the non-expert by the strident claims of rival manufacturers. Now at last the dust is beginning to settle, and a clearer view is obtainable of the microprocessor scene. The several quite different uses of these devices have now become clarified. The best paths for the amateur to pursue have become identified.

Two years ago we published the first account of microprocessors to be written for U.K. constructors. Another 18 months were to pass before *Microprocessors Explained*, our first comprehensive introductory series on this subject, was launched. (This pause for contemplation during the early stages of the "revolution" proved, in the event, very wise.) Last month this series was concluded with an overall perspective of microprocessors and a constructors' guide to the common MPU devices available.

Concurrently with the run of *Microprocessors Explained*, we have published a number of reviews of commercial development systems, several of these being built from the kit of parts by the reviewer before being put through their paces in what the jargon calls "hands-on" experience. This extensive coverage of commercial equipment was deliberate, contrary though it would appear to be to our normal editorial policy. The development systems reviewed ranged from the simplest and least expensive to some representative medium priced equipments—in all embracing the price range likely to be acceptable to most of our readers.

Apart from gratuitous publicity for the makers of these equipments, the reviews provided valuable familiarisation with microprocessor development systems for our readers. They helped to demonstrate the features of various MPU chips and to make clear both the basic philosophy and the techniques involved in this new area of electronics.

So now we have done our "homework" and we trust our readers have also. The time is now right for some "hands-on" experience to be gained.

The development system is likely to be the principal tool of the system designer in the years ahead. This, then, is obviously the first most useful way we can apply the microprocessor in the area of d.i.y. electronics. Hence our very first microprocessor-based project is the *PE Champ Development System*.

Commissioned by PRACTICAL ELECTRONICS for the amateur designer, experimenter and constructor, *Champ* has been realised through the joint enterprise of our regular contributors Messrs. R. W. Coles and B. Cullen. This design has some excellent uncommon features and with its attendant units, the Programmer and the Eraser, offers the individual amateur (and also the small professional designer) overall facilities for developing microprocessor-based systems and for transferring the finalised program into a PROM for incorporation in a dedicated system.

The *PE Champ* is the first electronic design tool of the microprocessor age planned especially for the home designer/constructor. We envisage that with its aid countless electronic projects based on a dedicated pre-programmed microprocessor will in due course be created, and that some of these projects will eventually appear in our pages as straight-forward constructionals.

NEW FORMAT

After a 13-year run without change, the page size of PRACTICAL ELECTRONICS has now been increased, as from this month. We hope readers will welcome this larger format; it does have obvious advantages. We appreciate that the actual timing of this change may seem a little awry. Unfortunately this was dictated by production requirements and had to be synchronised with the re-ordering of bulk paper supplies by our printers.

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Editor.

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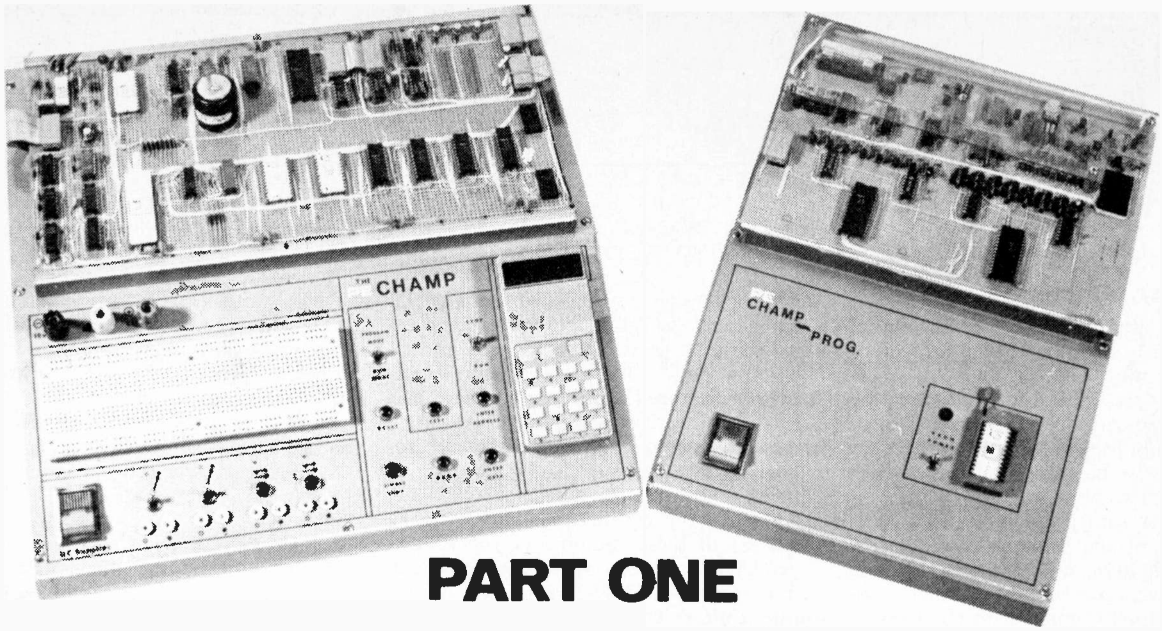
Binders for PE are available from the same address at £2·10 each to UK addresses, £2·70 overseas, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Cheques and postal orders should be made payable to IPC Magazines Limited.

Letters

Queries regarding articles published in PE should be addressed to the Editor, at the Editorial Offices, and a stamped, addressed envelope enclosed. We cannot undertake to answer questions regarding other items, nor to answer technical queries over the telephone.



PART ONE

PE CHAMP

R.W. COLES
B. CULLEN

THE PE CHAMP PHILOSOPHY

THE microprocessor revolution is with us, and before long it will have steamrollered its way through to all but the most rudimentary electronic project areas. Before becoming a revolutionary, however, you have to make a careful choice concerning just what you want from this exciting new technology. A baby computer? A tutorial system? Or perhaps the ability to put together more effective logic and control systems? This choice is necessary because it is a fact that no reasonably priced microprocessor system can give you all of these things in a satisfactory combination.

CHAMP, in keeping with our "practical" image, is about making microprocessors work for a living; it is not a primitive attempt to emulate a full size data processing system which on grounds of cost alone, would fall short of desired performance in most respects. CHAMP is a development system which can be built economically without any requirement for expensive gadgets such as Teletypes, VDUs, or floppy discs; all you need can be built by you, including if you so wish, a PROM programmer and eraser.

WHAT CAN YOU DO WITH IT?

Well, you can't expect to sit down and write BASIC programs which beat you at chess. CHAMP is for examining switches, operating l.e.d.s and relays or playing "God Save the Queen", Stylophone style. It will control your model train layout or your f.m. tuner and Hi Fi system and later help you to put together small, cheap dedicated microprocessor boards to run the firmware programs you have developed to do these jobs. It has a calculator-type organisation which makes it easy for you to build up a collection of programs to crunch decimal numbers, if that is your interest. If you want to learn how to do practical things with microprocessors it will also form an excellent tutorial system to get you started.

HOW DOES IT DO IT?

Well, cheaply for a start. CHAMP uses one of the cheapest microprocessor chips around, but nevertheless has plenty of capability which you would be hard pressed to employ to the full. In our opinion it's no use investing in the fast, all-bells-and-whistles MPU chips unless you can afford the memory and peripheral facilities required to take advantage of their power.

With CHAMP you can write your programs into RAM while you are developing them, but you won't lose them when you hit the mains-off switch. CHAMP program RAM, all 512 eight-bit words of it, is of the CMOS variety which is supported by batteries when the power is off. This advanced feature removes the need for paper-tape readers or cassette interfaces and puts you streets ahead of some of the "noddy" development kits now on the market.

You write your programs into RAM with the aid of a simple hexadecimal keyboard and display, under the supervision of routines in the CHOMP firmware which (to save you buying a lot of expensive PROMs) fits into a single 1702A device.

Interfacing CHAMP is simple because a low cost, program-configured interface chip is provided on the board to allow you to connect up to just about anything from a psychedelic light show to an array of toggle switches. The only addition required is the appropriate buffering, which can be mounted on the integral bread-board socket strip provided for this purpose.

In a nutshell then, the CHAMP philosophy concerns putting microprocessors to work in practical situations as cheaply as possible, using familiar constructional techniques to build a completely self-contained system with simple operating procedures.

SYSTEM FEATURES

★Calculator-based hexadecimal keyboard and display allow rapid program entry and debug

★On-board battery supported CMOS RAM for up to 512 program steps allows retention of carefully entered programs with power off

★Based on well supported Intel 4040 microprocessor. Has 60 easy to learn instructions which include binary and decimal arithmetic and keyboard encoding

★Twenty-four on-chip registers and interrupt facility available

★System monitor program CHOMP allows examination or modification of program memory, and program execution in single-step mode

★Open plan design allows easy access to all parts of circuit; no expensive plug-in cards to buy

★Programmable input/output interface chip makes for versatile interfacing at the breadboard level

★Optional PROM programmer and eraser allows a full development cycle to be undertaken by the home constructor for the very first time

★No need for any expensive peripheral equipment like TTY or VDU

1—MEET THE FAMILY

CHAMP stands for low *C*ost *H*ighly *A*daptable *M*icro *P*rocessor, and we feel that those words really do sum up the main attributes of this versatile and capable system. CHAMP is *not* a toy for you to merely sample the wonders of *real* computers. CHAMP *is* a real computer in its own class, and it will not leave you wishing that you could afford a floppy disc system or another 8K of RAM, because it does not require these things to operate effectively. CHAMP is a development system for both software *and* hardware which will enable you to develop functional programs for their own sake, or for later inclusion in small minimal-hardware systems which could be built for a very small outlay.

CHAMP does not live on a collection of very expensive plug-in cards which have to go into an equally expensive 19in rack case (where you can't get at them anyway without expensive extender cards). Instead it fits on one large "open-plan" 0·1in matrix Veroboard which costs a lot less than a *single* plug in DIP board and allows you to stick your multimeter probes anywhere you like without being a contortionist.

There is ample room on the board for you to add ideas of your own, and all the buses to which you may need access are brought out on the cheap 16-pin DIL sockets so that you can debug or expand your system easily. The CHAMP circuit board slides into guides mounted above an attractive low profile plinth which houses the power supplies and also provides the control panel and a hardware development area.

KEYBOARD

The only peripheral equipment you need to enter and examine your programs is a simple hexadecimal keyboard and display unit which uses 16 keys labelled 0–9 and A–F and can display eight digits in seven-segment format. One of

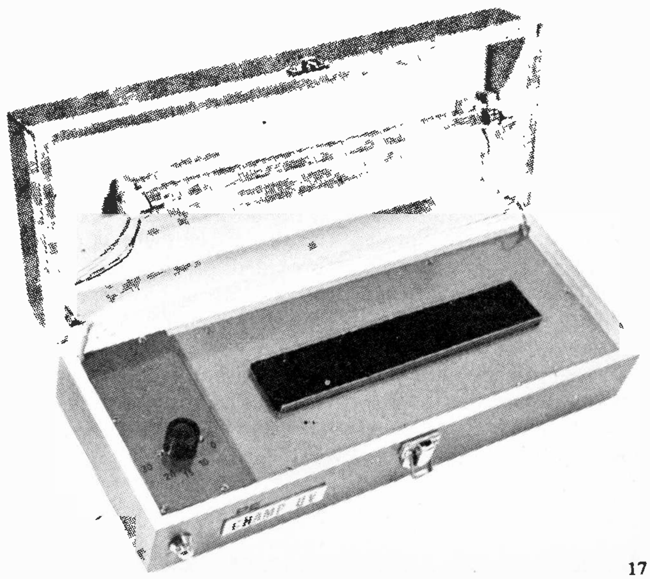
Estimated Component Costs...

CHAMP
with 256 program bytes,
power supply, keyboard
and breadboard socket.......................... £120

CHAMP—PROG plus extra PROM............... £60

CHAMP—UV £12

Full list of i.c.s required will appear next month



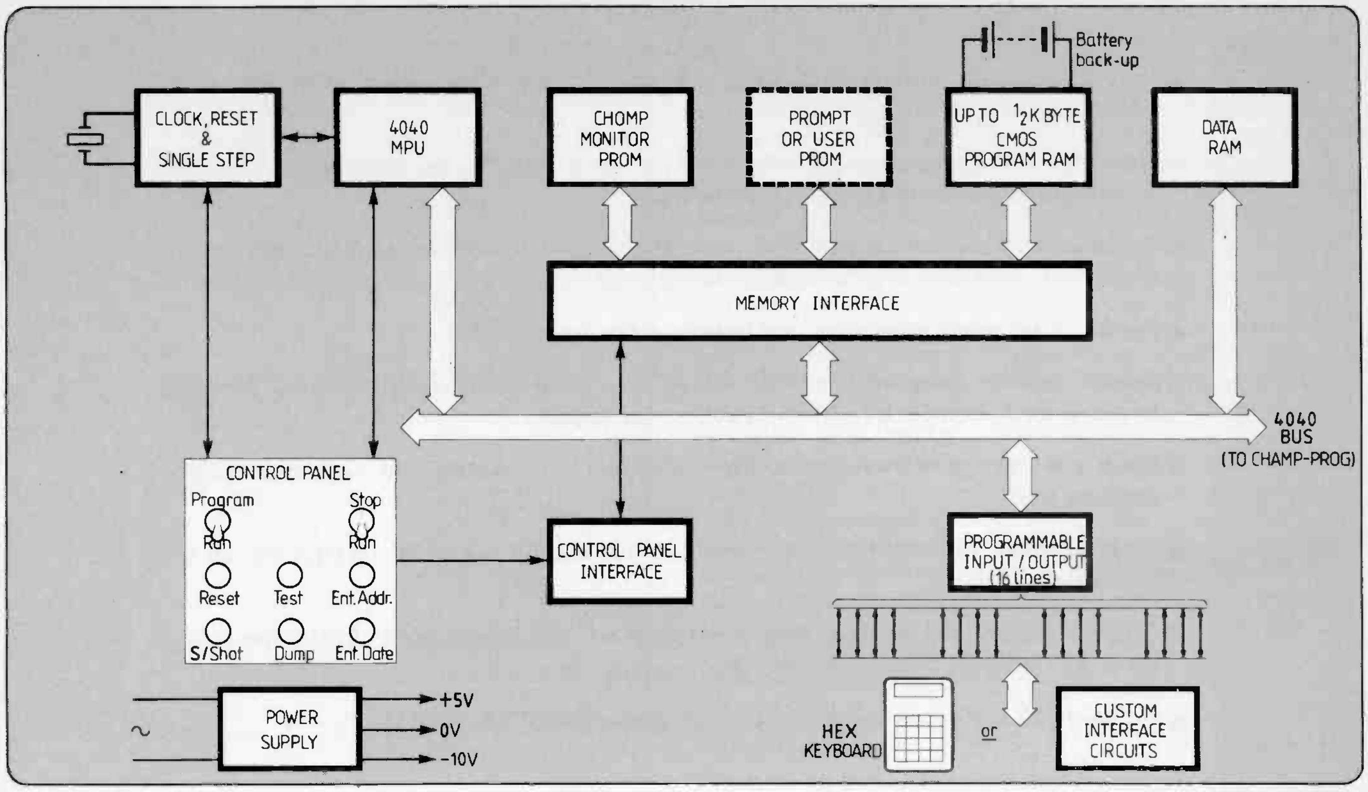


Fig. 1.1. Basic block diagram of the PE CHAMP Development System

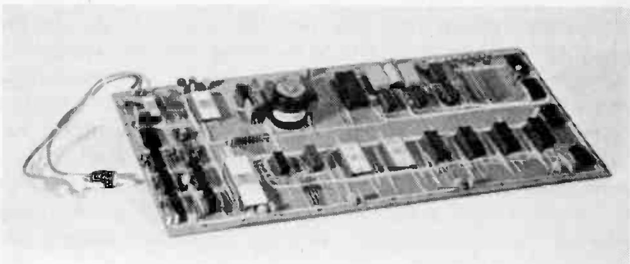
the simplest and cheapest ways to build this keyboard is to modify one of the now commonplace "throw-away" calculators, and constructional details for this and a "build from scratch" version will be provided later.

ENTERING AND RUNNING PROGRAMS

Before you can enter programs of course, you have to write them, and this is done using the evolutionary process of vague flow-chart to detailed flow-chart to list of hexadecimal coded instructions, as developed in Part 3 of *Microprocessors Explained*. Examples of this procedure will be given later, together with some sample programs for you to try out.

When power is applied CHAMP is reset and the display shows the hexadecimal equivalent of the first program RAM address. Pressing keys on the keyboard will enter hexadecimal code up to three digits long and this can be entered either as a new address (by pressing ENTER ADDRESS) or as a program instruction/data value (by pressing ENTER DATA). After the ENTER DATA switch is pressed, the current address is incremented by one to point to the next available location in RAM, ready for further data. If you like, you can examine the existing contents of a RAM location using the DUMP switch whereupon the address will again be incremented to allow you to step through a program and compare it with your paper version. A RESET switch is provided so that any current operation can be aborted, and RUN/STOP and SINGLE SHOT switches allow you to run a program one instruction at a time for debugging purposes.

When you are satisfied with a program you have entered you can throw the MODE switch to the RUN position to allow your program to do its stuff, exiting if necessary with the RESET switch.



CHAMP circuit board

MPU CHIP

CHAMP is built around an INTEL 4040 microprocessor, but provides facilities for the development of programs and hardware for *either* the 4040 itself *or* the simpler 4004. This dual processor versatility is possible because 4004 instructions form a subset of the 4040 instruction set, making it possible to run any program written for the 4004 on a 4040 system. All that you have to remember when writing 4004 programs to try out on CHAMP is that you must not include any "4040 only" instructions in your code.

The 4040 chip on CHAMP itself forms part of a complete microprocessor system which includes a versatile crystal clock circuit and both program and data memory. Two input/output interfaces are provided, one dedicated to the control panel switches and one which can be used either by the hexadecimal keyboard or by any external hardware provided by the user. A single level interrupt is provided which is used by the keyboard but which can also be used externally, when required for any particular application.

MEMORY

With the 4040 system organisation, data RAM is kept separate from program RAM, leading to an easy to understand, calculator-type architecture which is extremely easy to use.

Eight kilobits of program storage are available on a fully stuffed CHAMP board, organised as 1024 eight-bit words. Of these, 512 words are available as two 1702 u.v.-erasable PROM chips, and a further 512 words are available as four 5101 CMOS RAM chips. Only one PROM chip is required for the CHOMP firmware, although both chips will be required if the PROM programmer unit is added later. The CMOS RAM can be added in two 256-word increments if desired, allowing a minimum operational CHAMP configuration of CHOMP (256 words) + 256 words of RAM available for user programs. The CMOS RAMS have a very low current drain when on standby, and because of this they can be made to retain their data without mains power with the aid of a simple power-fail-detect circuit and a 3-cell DEAC battery. This part of the CHAMP circuitry is unique, and gets over that awful problem experienced with most development systems where you have to lose all your laboriously entered hexadecimal code at the end of the day, a problem which usually forces users to buy paper-tape systems or cassette interfaces to allow rapid program re-entry at the start of a new session.

CHOMP

CHOMP stands for ***CH**amp **O**perating system and **M**onitor **P**rogram* and is the name given to the collection of programs required to control all the CHAMP facilities during program entry and debug. CHOMP is entered automatically at power on, and can always be restarted at any time by pressing the RESET button. CHOMP contains routines for refreshing the eight-digit seven-segment display, for accepting and storing keyboard entries, for entering instructions or data into RAM, for examining existing RAM content and for entering a new effective address.

In order to keep costs down, CHOMP has been made small enough to fit into a single 1702A PROM and has been written so as to provide a range of programming examples for those new to the game. Later in this series the complete listing of CHOMP will be provided, together with a full description of how it works. Arrangements have been made for the supply of ready programmed PROMS and also for CHOMP to be loaded into constructors' existing PROMS if required, full details of this service will be provided later.

CHAMP-PROG

CHAMP-PROG is an optional PROM programming accessory for CHAMP which extends the system's usefulness immeasurably. Using this unit, programs developed and debugged in RAM can be transferred to permanent storage in the form of low-cost 1702A PROMS which can be erased and reprogrammed as often as required.

This facility turns CHAMP into a no-compromise development system which enables you to:

(i) Develop and debug programs in CHAMP RAM.
(ii) Develop and debug interface hardware on the CHAMP breadboard, and with CHAMP-PROG.
(iii) Dump your working programs into PROM chips and plug these into "Sons-of-CHAMP" minimal microprocessor circuits which can then be used to carry out dedicated tasks.

This classic use of PROM programming is not the *only* way in which CHAMP-PROG extends CHAMP facilities however; PROMS can now be used simply for the long term storage

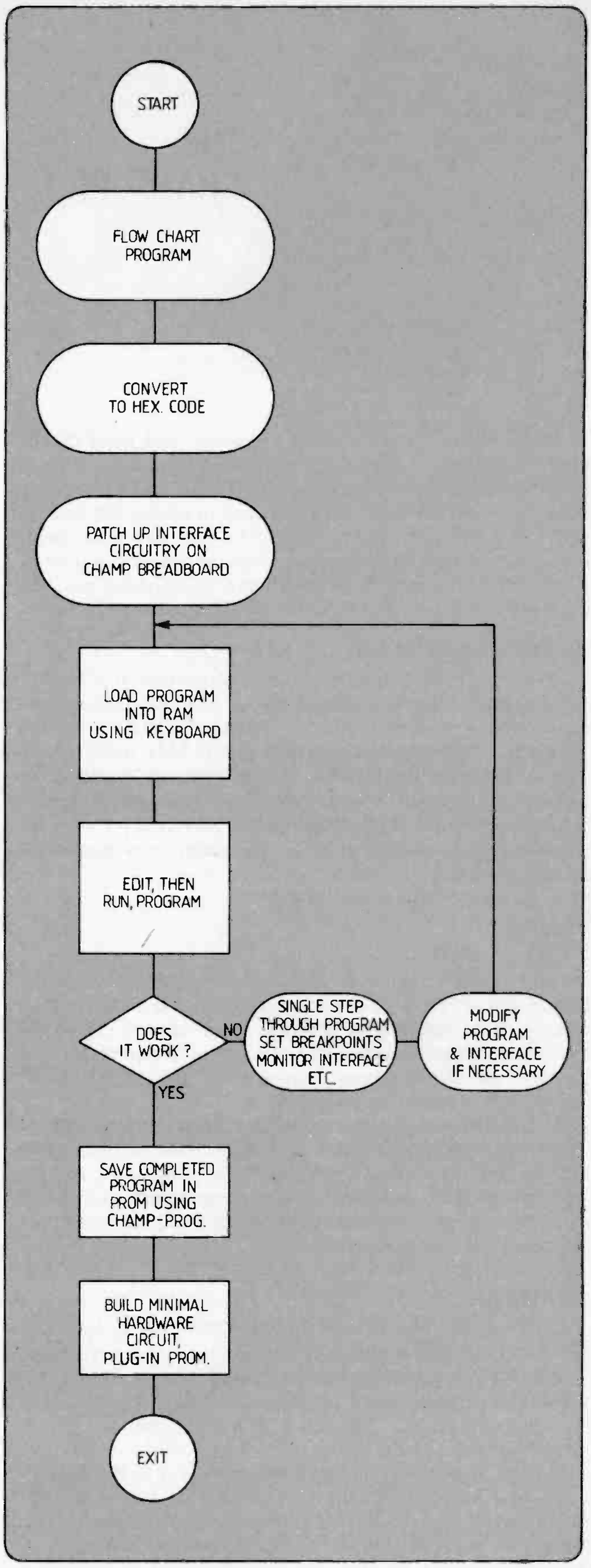
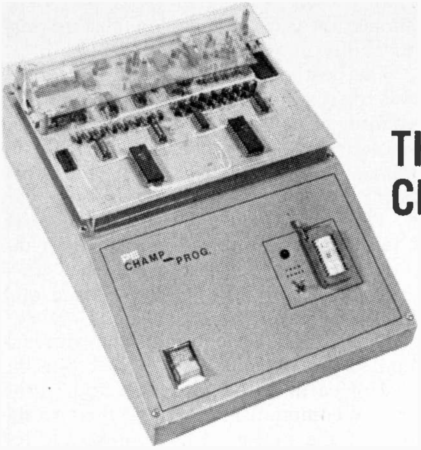


Fig. 1.2. Using CHAMP as a development system



THE CHAMP-PROG

of useful but no longer current programs, and these can be kept in a "box-on-the-shelf" until next required. This is possible because not only does CHAMP-PROG let you dump RAM into PROM, it also allows you to reverse the process and dump PROM back into RAM. In this way a firmware library can be built up, consisting of useful program segments, games programs, etc. all of which can be reloaded into the CHAMP operational RAM area in just a few seconds.

MATCHING PLINTH

CHAMP-PROG is designed to be a companion to CHAMP in every way, including the use of an identical layout technique and a matching plinth. CHAMP-PROG uses the +5V and −10V supplies provided by CHAMP itself, and in addition contains the 80V d.c. supply required for the programming operation. Areas of the "open-plan" circuit board carrying this higher voltage are screened off with the aid of a clear plastic window to prevent any accidental catastrophes with bare wires.

PROMPT

CHAMP-PROG is controlled by a firmware program called PROMPT (PROM *P*rogramming *T*echnique) which fits into a 1702A PROM and is plugged into the second PROM socket on CHAMP. PROMPT uses several CHOMP routines and also uses the CHAMP keyboard and display for the entry of programming requirements and the display of "next entry" prompting messages.

To program a PROM the required address range is entered via the keyboard, the PROM is inserted into the zero insertion force socket, the PROGRAM POWER switch is turned on, and the PROGRAM button depressed. The programming of a full PROM takes about two minutes although dumping PROM data into RAM is of course much faster.

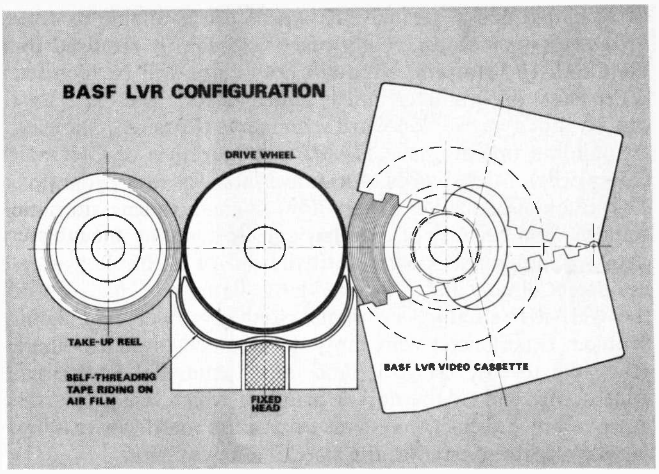
CHAMP-UV

CHAMP-UV, the last of the CHAMP family, is a *safe* but low cost PROM eraser which becomes necessary when CHAMP-PROG is added to the CHAMP system. CHAMP-UV will erase in a matter of minutes any u.v.-erasable PROM including the 1702A, 2704 and 2708 variety, and can handle up to 10 of these at a time.

Erasure is achieved in a light-tight box which houses a short-wave u.v. tube interlocked so that it is always "off" when the lid is open. This interlock is necessary because short-wave u.v. light can be harmful to the eyes and skin. A timer is included so that the over-exposure of expensive chips can be avoided.

NEXT MONTH: The PE Champ Circuitry

NEWS BRIEFS



Low Cost Video Recorder

An agreement recently signed between BASF AG and Bell & Howell Corporation is expected to result in the development for the amateur market of a video cassette recorder based on BASF's Linear Video Recording (LVR) technique. The new recorder is expected to be on the market in time for Christmas 1979.

The LVR cassettes are claimed to occupy only about one quarter of the volume of other video cassettes, yet provide double the playing time. The 6·25mm CrO_2 tape travels backwards and forwards past a stationary head at 3m/sec, and is recorded with 28 tracks.

Economical, high-quality tape duplication is possible in a single pass, using a multiple head.

The small size of the cassette, the low tape consumption, and the use of a simple mechanism and sophisticated electronics mean that the LVR system offers great potential for miniaturisation. For example the tape transport system could be integrated into a video camera.

AVM For Dublin Buses

The Dublin City Bus Service's entire fleet is to have what is claimed to be the world's most advanced automatic vehicle monitoring system (AVM), supplied mainly by Storno Ltd. of Camberley, Surrey.

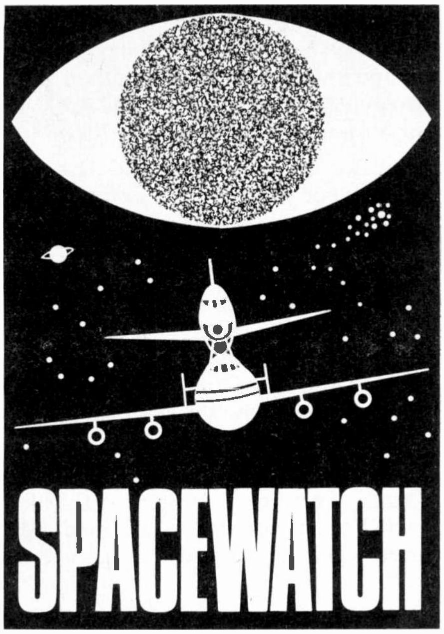
Each bus will be fitted with an odometer, the initial reading of which is fed to a computer at the outset of each journey. Control Inspectors from seven different garages will be able to locate precisely, any bus, using telephone line modems feeding VDU terminals.

A Storno CQF612 v.h.f. Data Transmitter situated on Three Rock Mountain, will be u.h.f. linked to the computer at O'Connell Street. The bus-borne control heads are also capable of speech communication directly to the garage, if requested.

In addition, the Storno bus data unit stores the bus location *and* passenger loading, as well as up to ten mechanical parameters such as engine temperature and oil pressure. The computer system will be interrogating for data at the rate of 900 buses per minute, using a fully duplicated radio system.

Control Inspectors will also be able to watch traffic and passenger queue conditions using remotely controllable CCTV cameras at city centre points.

The system is expected to be in operation by mid 1979.



FRANK W. HYDE

SPACE SHUTTLE: FULCRUM OF THE FUTURE

When history records the first shuttle spaceflight it will mark a new era in man's conquest of the frontiers of the future. In the past there have been great turning points in history but all too often a mere handful of people recognised the implications for the future.

It is to be hoped that at this space turning point, it will be realised that the world has reached a new hilltop. For the first time in all progress the frontiers are limitless in extent. It must be recognised that stagnation in growth will be but the prologue to decline and that utilisation must be the key expanding technology.

The present system of economy is impeded by fiscal considerations. This has become more and more evident by the confinement of incredible technological successes of the space age. Full utilisation is as important in terms of return for any hope of a full and happy future for mankind, as for the future growth of knowledge and understanding.

To set this in perspective low cost utilisation is required. A simple case might be illustrated by the fact that to fly in a round trip from London to the Bahamas and back a payload of 200lb uses about a third of the energy to put the same payload into near Earth orbit. It costs about £300. To put the same payload into near Earth orbit it costs about £50,000.

The answer is not merely re-usability but rather full utilisation. To achieve this situation in a fiscal economy the man-in-the-street has to be alerted to the future benefits to himself and his dependents. These have to be practical and within his grasp.

Therefore, it must mean that the resources can provide him with peace and a good life for himself and every one else. It must be such that want or having less than the next is removed from his experience. This is the vision of the future to be made reality. The shuttle provides the first step.

It is already apparent to those close to the space technology that many practical applications are already in being. Indeed, a whole library of books could be set up to record the benefits already accrued.

Those in the immediately forseeable future cover the low cost communication systems, utilisation of the solar potential, space manufacturing and even space for living in ideal conditions. All these are within the present technology and this is but a start. In all of this mankind can participate.

THE BENEFITS

It is perhaps worth a little look into the potential benefits in the next three decades. The requirements are that the low cost transportation offered by the shuttle provide the way for the high traffic load set up by the utilisation of solar power, the needs of space manufacturing and the welfare runs for the medical care of those in need.

In the beginning the Shuttle Transportation System will be employed in the simplest of its modes. That is, it will operate somewhat as a manned booster.

Permanent space construction systems will be required for the platforms supporting solar energy collectors. Units for *Spacelab* operations will need to be tended and in the early days the duration of the work programmes will mean an exchange of personnel about every 15 to 30 days.

Missions which are being anticipated now will involve flights of longer duration for those such as life science activities. Other missions such as those dealing with material processing will require the transport of raw materials to, and finished products from, the more permanent space plants.

The next phase will be the establishment of permanent stations (automatic and manned) which will need tending. From thence to the third phase which could see permanent geostationary structures of large size. The ability to go into and back from the space involved sets the seal on both utilisation and volume of traffic.

Self-sufficiency will progressively increase where closed ecological environments, will use space generated power and even space produced materials. It will be the era of winning the resources of the Moon and later the other sources of raw materials that will be available for the taking.

NEW TECHNIQUES IN OPERATIONS

During the last two decades the space operations have had a basic pattern. This is that the spacecraft are kept as simple as possible to enable extreme reliability to be achieved.

The cost of the success of this policy was the requirement that the ground based equipment became extremely complicated in order that as many functions as possible remained earthbound. With the easy access to space these considerations can be reversed. The result is that the earth based equipment can be simplified by the introduction of large and complex satellites which can be regularly serviced and multiplied in numbers.

Large antennas of high gain with unlimited power available would reduce the size of earth based terminals and in the case of communications bring them to the size of the present television aerials for any telephone subscriber and indeed perhaps directly to the wrist telephone.

SPACE PROCESSING

High vacuum and the absence of gravity offer certain unique opportunities in manufacturing and processing. Already this has been established in space missions. The growing of crystals and the manufacture of special alloys have attracted the attention of a number of planners.

One example taken from the *Apollo/Soyuz* test mission showed that silicon ribbon could be manufactured in space economically. This has been investigated recently and it was discovered that there is a four to one advantage of the space produced ribbon over present earth based manufacturing methods.

In other fields there are pharmaceutical materials which would benefit from space production. One such is an enzyme, Urokinase, which dissolves blood clots. Its present cost is of the order of £350 per dose. Some 100,000 cases have resulted in death because of this. The cost of production in space would be within reasonable bounds. It was established that in space the zero gravity enabled the raw material for this process, kidney cells, to reach an extremely high yield over the normal method.

In other areas the production of powerful permanent magnets is superior to the process on earth. In the field of optics precision glasses can be raised to a high degree of purity.

PAYLOADS

It might be in order to show the comparisons of payloads for the present system and those possible with the shuttle system. The *Thor-Delta* systems can put a 2,000lb payload into orbit in an 8ft diameter unit. These can be placed in transfer orbits if required. The shuttle will take over from these single unit launches and put into orbit loads of 60,000lb up to 60ft in length and 15ft in diameter.

It is not difficult to extrapolate from there and the prospects for large stations are good. It would seem that the solution of survival may well lie in the control of the Earth from space.

THIS article describes the design and construction of an economical Frequency Counter/Timer unit which operates over the range 1Hz to 25MHz, giving readout on a 5 digit display, and using a crystal controlled oscillator for accurate timing. The instrument is primarily intended for use with digital circuitry, being capable of operating on positive voltage swings from 500mV to 25V. This Counter/Timer may be operated in one of four modes by selection on a single rotary switch:

Position 1 measures frequency from 1kHz to 25MHz.

Position 2 on the mode selector measures frequency from 1Hz to 99·999kHz.

Position 3 simply counts the number of pulses occurring at the input.

Position 4 measures time in increments of 1ms during the enable period signalled at the instrument's input.

When set to read frequency, the instrument will display the result for approximately six seconds before automatically resetting and remeasuring. When set to read time, or count pulses, the instrument will display the result until the manual reset is operated. An input invert switch is provided, which reverses the input state so that the unit can count positive or negative edges when operating in the count mode, or measure the period of either a high or low state when timing.

A d.c. coupled differential input amplifier i.c. is used at the system input, to allow voltage levels to be compared against a voltage offset. A knob is provided for this, which would be adjusted to the mid-point of the input signal voltage swing, so that the amplifier can detect the high and low states with maximum noise immunity.

The semiconductor family chosen for the counters is the standard 7400 series TTL, giving counting speed of typically 25MHz. Since these devices require a single supply of 5 volts, it was decided to use TTL for the control and display logic also, and employ 5V Minitron displays. This eliminated any voltage interface and multiple supply problems.

CIRCUIT DESCRIPTION

The operation of the Frequency Counter/Timer may be divided into three parts; (1) the input and display counter circuitry, (2) the control and reset circuitry, and (3), the 1MHz oscillator and timebase counter. See Figs. 1, 2 and 4.

The timebase counter (IC15–IC20) simply divides the waveform from the oscillator down to 1kHz and 1Hz, the output selected depending upon whether the instrument is required to measure megahertz or kilohertz. If the counter is required to measure on the higher frequency setting, the 1kHz clock is selected by S3a, so that the control circuitry enables the display counter (IC3–IC7) for a period of exactly 1ms. This "enable" command is routed via S3c. The number of pulses entering the input at SK1 during this period is accumulated in the display counter (via S3b), and subsequently displayed for approximately six seconds on the digital readout.

A frequency of say 5MHz, when counted for 1ms, will read 5,000 pulses. Because there are five display digits, and the decimal point is wired to appear after the second digit from the left, this figure will relate directly to megahertz, i.e. 05·000.

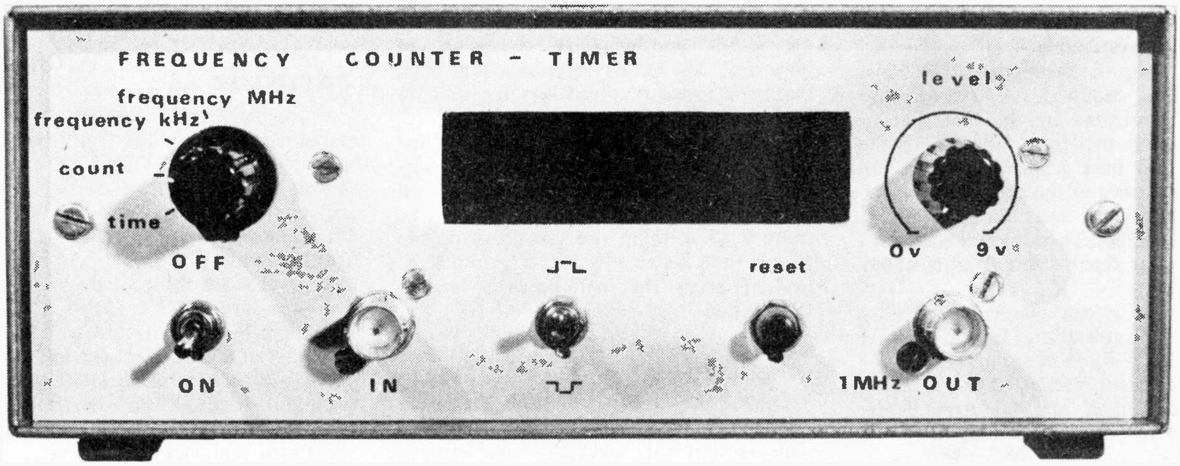
After the six second readout, the control circuitry will reset the display counter, so that the measuring cycle can be repeated.

When the unit is used to measure kilohertz, the 1Hz clock pulse is selected, so that the control circuitry enables the display counter for a period of one second. Hence, the readout will display the number of pulses counted over this period, which will relate directly to kilohertz.

When measuring time, the 1kHz clock waveform from the timebase counter is connected directly to the input of the display counter (S3b, position 4), while the input signal is routed via S3c to the display counter enable. Hence, the display counter will count in increments of 1ms for the period during which it is enabled by the input signal at SK1.

Frequency Counter/Timer

P. LEAH



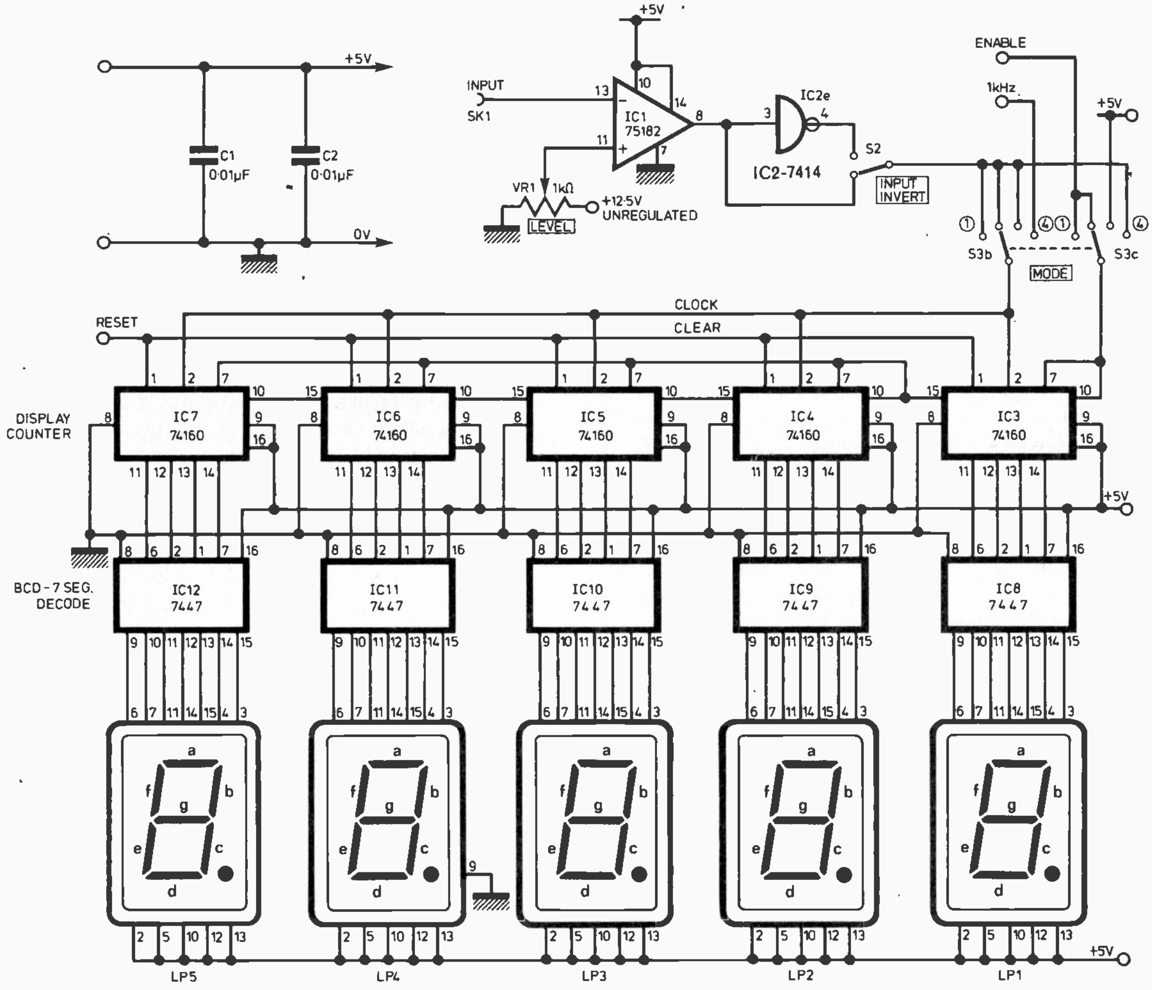


Fig. 1. Input and display circuits. Note that pin 8 of IC1 should go to pin 1 of inverter IC2f. Pin 2 of IC2f then feeds S2 and pin 3 of IC2e

When operating in the count mode, the display counter is connected directly to SK1, and the counter is permanently enabled by S3c (position 3) which is at +5 volts. The display counter will therefore indicate directly the number of pulses entering the instrument's input.

To summarise, the rotary switch positions are:

(1) Frequency in MHz.
(2) Frequency in kHz.
(3) Count pulses.
(4) Time in ms.

INPUT AND DISPLAY CIRCUITS

The input amplifier chosen was the differential input line receiver SN75182 (see Fig. 1), which has a TTL compatible output, and an input resistance of typically 5kΩ at the inverting terminal. The non-inverting input is taken to the wiper of VR1, which is connected between 0V and 12·5V unregulated. Adjustment of this control determines the voltage level about which the input waveform is measured.

The TTL output from this stage (IC1) is connected to inverter IC2e, so that either the inverted or non-inverted signal may be selected via S2.

The display dividers are synchronous decade counter i.c.s which are connected in "carry look-ahead" mode. The "clock" and "clear" lines are each common to all the i.c.s,

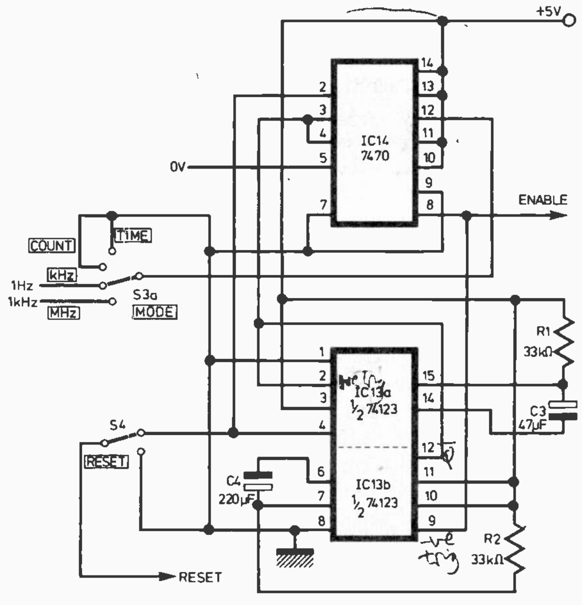


Fig. 2. Control and reset circuit. Pin 16 of IC13 is connected to +5v

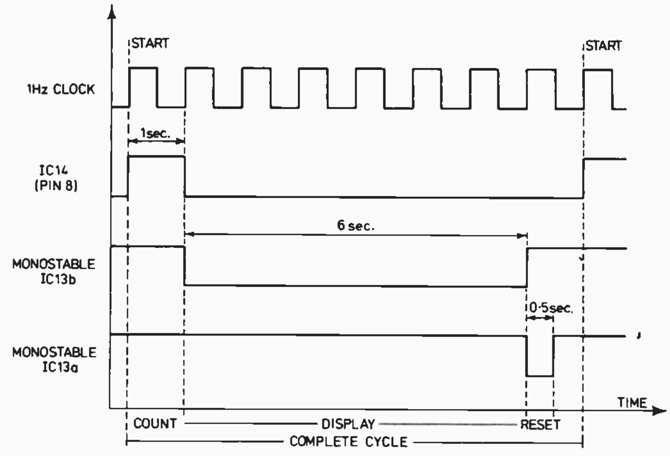


Fig. 3. Waveform timing diagram of control circuit with 1Hz clock selected

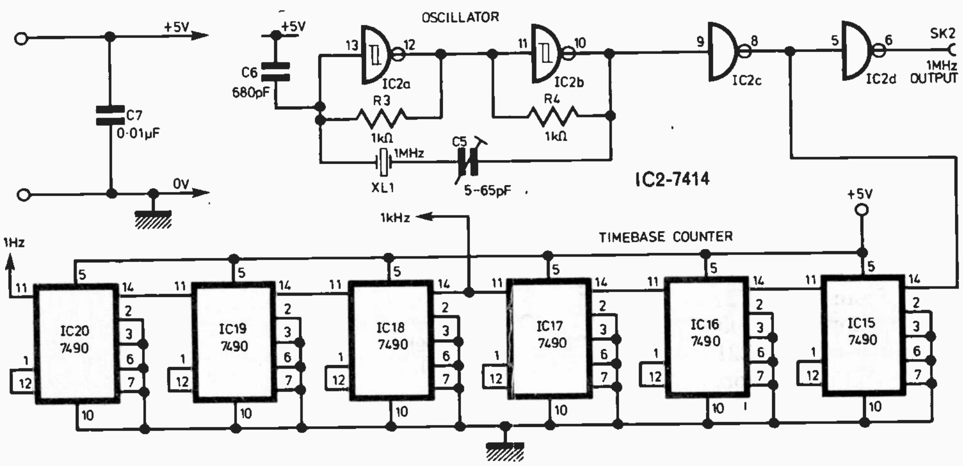


Fig. 4. Oscillator and timebase counter

while the "enable" control from S3c is only connected to the least significant digit in the chain (IC3). The CARRY output from this stage is wired common with the P ENABLE of the other stages, while the T ENABLE pins of the remaining stages are each connected to the RIPPLE-CARRY output of the preceding stage. Hence, each counter i.c. is only enabled for the clock pulse which actually clocks that particular i.c. The BCD outputs are connected directly to the BCD-seven segment decode/display drivers (IC8–IC12), which drive the Minitron displays LP1 to LP5.

CONTROL AND RESET CIRCUIT

The control and reset circuit is shown in Fig. 2, and consists of an edge triggered JK flip-flop (IC14), and the dual monostable IC13. When the system is operating in the frequency mode, either the 1 second or 1ms timing standard will be routed to the clock input of IC14, via switch S3a. Assuming both monostables are in their standby state, the J and K inputs will be at logical 1, which enables the flip-flop to toggle. At the first rising edge of the clock pulse, the Q output will change from logical 0 to logical 1, and hence enable the display counter. At the next rising edge of the clock waveform the flip-flop output will revert to its original state, and disable the display counter.

The falling edge of this "enable" pulse operates the monostable IC13b, which produces a negative going pulse from its $\bar{Q}$ output for a period of approximately 6 seconds. This signal changes the J input of the flip-flop to logical 0 to inhibit further toggling, and ensure that the display counter remains disabled.

The rising edge of this monostable pulse operates the other monostable, IC13a, which sends a reset pulse of approximately 0·5 seconds duration to both the flip-flop, and the display counter.

After the returning edge of this pulse, the display counter and flip-flop are ready for the rising edge of the next clock pulse, so that the complete cycle may be repeated. A timing diagram is shown in Fig. 3.

This particular combination of JK flip-flop and monostable was chosen because it operates on edges rather than levels. This was necessary to eliminate any possibility of premature switching which could occur if the flip-flop was enabled while the clock input was still high. This protection comes from the fact that the i.c.s are activated only during a small voltage window, which is passed through by the clock signal on its positive excursion.

The monostable IC13b dictates the length of time the measured frequency is displayed for. This period of six seconds is determined by resistor R2 (33kΩ) and capacitor C4 (220µF). Should a variable display time be required, the 33kΩ resistor should be replaced by a 10kΩ resistor in series with a 30kΩ potentiometer. This would give a display time variation of 2 to 10 seconds.

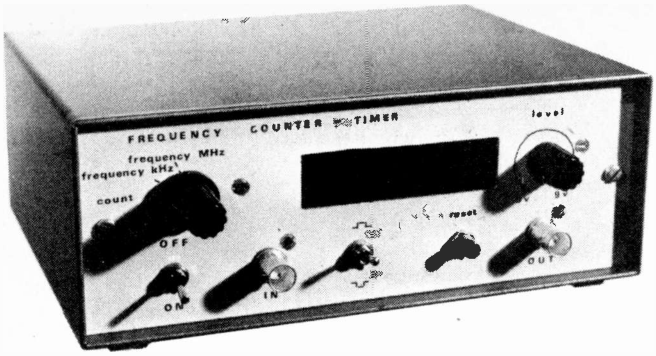
The period of 0·5 seconds produced by the reset monostable, is determined by resistor R1 (33kΩ) and capacitor C3 (47µF).

When operating in the TIME and COUNT modes, a logical 0 state is applied to the CLOCK input of the flip-flop via switch S3a, which ensures that no toggling occurs, as this would fire the monostable and prematurely reset the display counter.

OSCILLATOR AND TIMEBASE CIRCUIT

Figure 4 shows the circuit diagram of the oscillator and timebase counter. The self-start oscillator comprises two cascaded Schmitt trigger NAND gates IC2a and IC2b, each operated in linear mode by connecting a 1kΩ resistor between output and input, with an overall feedback loop via the 1MHz quartz crystal. The 65pF trimmer capacitor (C5) is provided for fine adjustment of the crystal operating frequency, while the 680pF capacitor (C6) acts as a filter to ensure that only the fundamental frequency is generated.

Schmitt input gates were chosen to give a reasonably square waveform, while IC2c is simply used as a buffer for the oscillator output to drive the timebase counter. This



counter utilises a chain of ripple-through devices which divide the clock input by ten at each stage. It is unnecessary to use the more expensive and power consuming synchronous counters in this application, as only the time interval between successive rising edges is critical, and not the execution speed of the counter as a whole. The most significant bit of each decade counter i.c. is connected to the clock input of the following i.c. The PRESET and CLEAR inputs are held in their inoperative states (logical 0). An additional inverter (IC2d) is connected from the 1MHz frequency standard to a BNC socket (SK2) mounted on the front panel.

POWER SUPPLY

The total current taken by the Counter/Timer unit is approximately 800mA, and this can be provided by a mains 9–0–9V, 1A transformer. The output, when fullwave rectified by D1 and D2, and smoothed by C8, produces an unregulated line of just over 12·5 volts. From this, IC21 produces a stable 5 volt power supply. The complete circuit is shown in Fig. 5, and capacitor C9 is connected across IC21 output to prevent oscillation. Disc ceramic 0·01μF capacitors are located between +5V and 0V at various points along the supply line, which, because of their construction, have minimal inductance, and therefore efficiently shunt the fast spikes caused by TTL switching.

Many components used in this instrument may be found going spare in the average constructor's junk box, and indeed the prototype unit shown in the photographs used two parallel 5V ½A regulators instead of a single 1A device, because they were to hand.

CONSTRUCTION

The front and rear panels of the instrument case should be drilled as shown in Fig. 6. The display window can be cut using an Abrafile or nibbler. Once the front panel has been worked, a piece of display filter material can be glued over the display window.

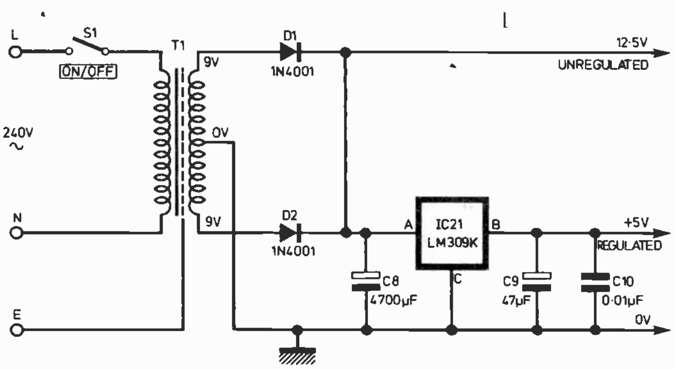


Fig. 5. Power supply circuit diagram. Capacitor C9 is mounted across the leads of IC21 on the back-plate

A different arrangement for SK1 and SK2 might be desired, in which case alternative drillings may be required. In the prototype these were BNC sockets, but since a mains powered instrument housed in a metal case must be earthed, it will follow that with this type of connector, the 0V of the system under test will be linked to mains earth when the test probe common clip is applied. This generally is of no consequence, but if the application envisaged by the constructor should render this undesirable, then pairs of 4mm terminals or sockets would be an alternative for SK1 and SK2.

COMPONENTS . . .

Resistors

R1, R2	33kΩ ¼W carbon (2 off)
R3, R4	1kΩ ¼W carbon (2 off)

Potentiometer

VR1	1kΩ lin.

Capacitors

C1, C2, C7, C10	0·01μF disc ceramic (4 off)
C3	47μF 6·3V tant
C4	220μF 10V elect
C5	5–65pF trimmer (Maplin)
C6	680pF
C8	4,700μF/16V axial lead
C9	47μF 6·3V tant

Semiconductors

IC1	SN75182 or DM8820 (National)
IC2	SN7414
IC3–IC7	SN74160 (5 off)
IC8–IC12	SN7447 (5 off)
IC13	SN74123
IC14	SN7470
IC15–IC20	SN7490 (6 off)
IC21	LM309K
D1, D2	1N4001 (2 off)

Miscellaneous

LP1–LP5	Minitron type 3015F/BM15 (5 off)
S1	Sub-min mains switch (Arrow CTS3 or similar)
S2	Sub-min c/o toggle (Arrow CTS3 or similar)
S3	3P 4W rotary switch (Doram type)
S4	Min push-button c/o (Doram 337 942)
T1	Transformer 9-0-9V 1A
XL1	1MHz crystal
SK1, SK2	Square BNC sockets (50Ω), or 2 pairs of 4mm sockets

Instrument case: 204 × 76 × 152mm.
Ribbon cable
Knobs (2 off)
Grommet for mains lead
Nuts and bolts (6BA and 4BA)
Stick-on feet (4 off)
Three core mains lead, and plug
Wire, plugs, and clips for test probes
Display filter
Main p.c.b.
Display p.c.b.
Letter transfers and spray lacquer

CONSTRUCTOR'S NOTE

The SN75182 differential amplifier (IC1) is not commonly available, but can be obtained from: **Technomatic Ltd, 54 Sandhurst Road, London, NW9 9LR.**

The Minitron 3015F/BM15 displays are also available from **Technomatic**, and **Electrovalue Ltd.**

It is advisable to use a *metal* case for the counter unit, but beyond this the choice is not critical. The prototype utilised the **Doram** box type 3 (code 509-901), with removable front and rear panels only. Another suitable box, perhaps more convenient for wiring, is the **Maplin** model 121 with removable top, but a little less robust. Both cabinets are in the region of £5·00.

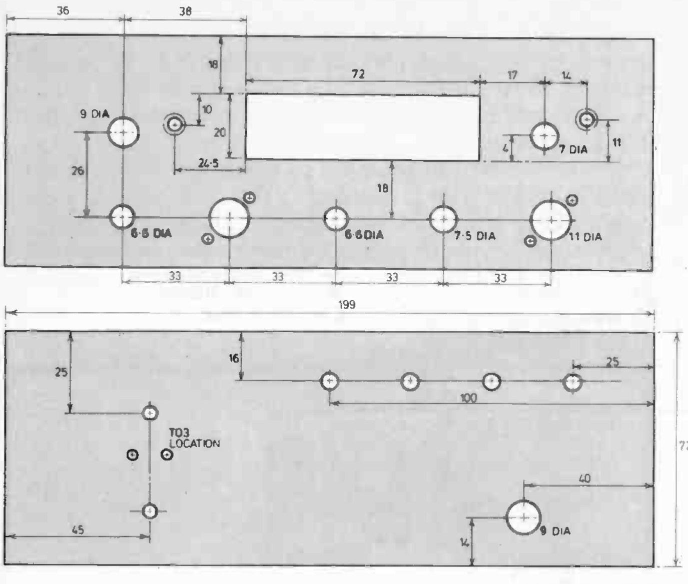
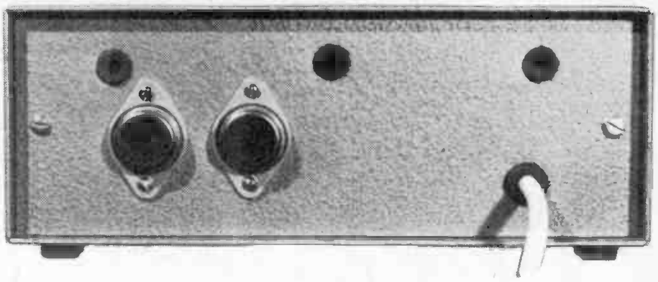


Fig. 6. Cutting details of front and rear panels. Hole sizes are correct only for the particular types of switches and sockets recommended in the components list. Both views are external to the box

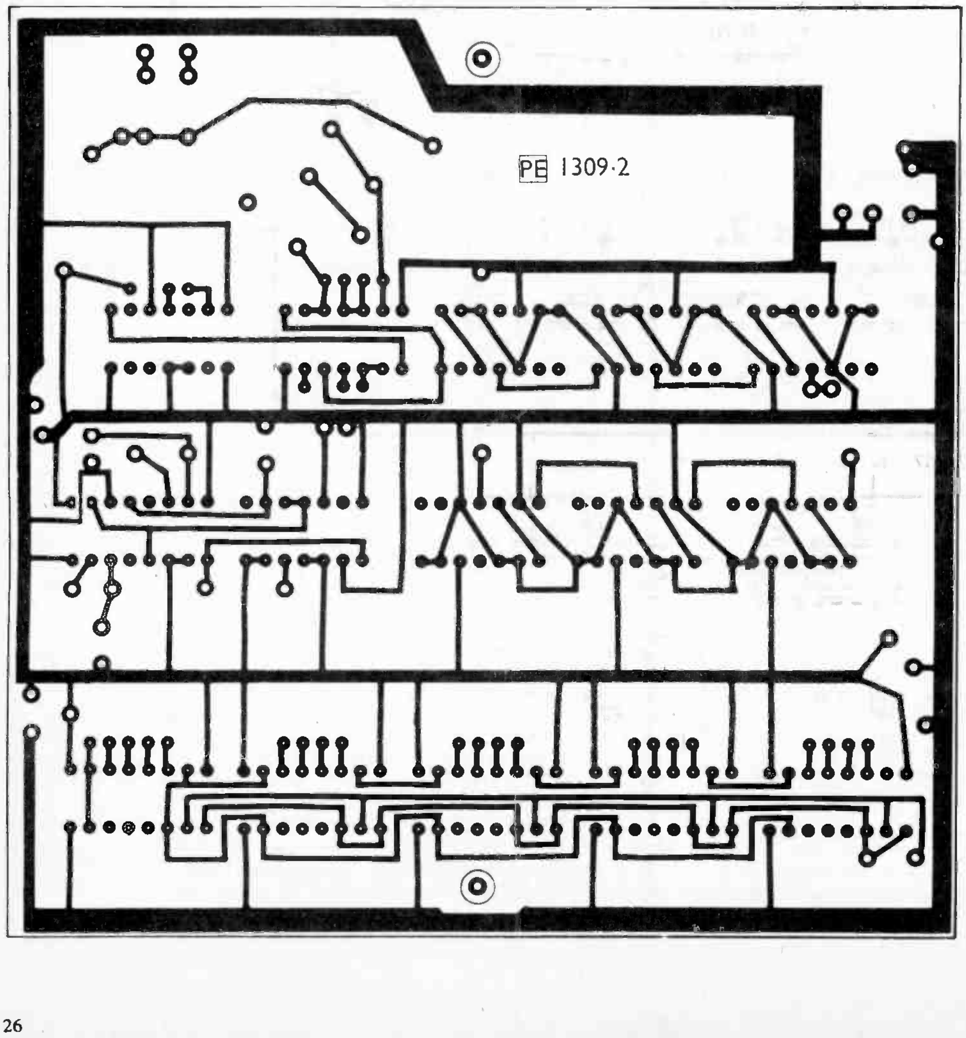
If larger switches are used, or a different box layout, care should be taken to ensure that the front panel mounted components are located clear of the box flanges against which the front panel rests.

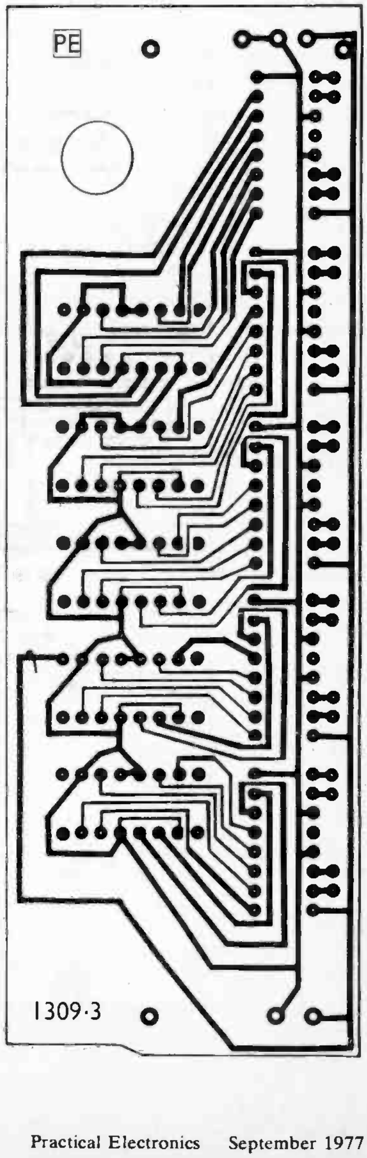


The back-plate diagram of Fig. 6 shows a few ventilation holes, and these will be made more effective if a few more are drilled through the base of the box. An easy method of marking out the holes for the regulator, which utilises the back-plate as a heat sink, is to lay a TO3 mica washer in the correct position and mark through its holes.

The transformer rating is common, and therefore the constructor may find his own source for this component. Differing physical dimensions will result, and so the best way to arrange the inside of the box, is to position the transformer and blank p.c.b. into suitable locations and mark the fixing points through the holes.

Fig. 7. Main p.c.b. and display p.c.b. (full size)





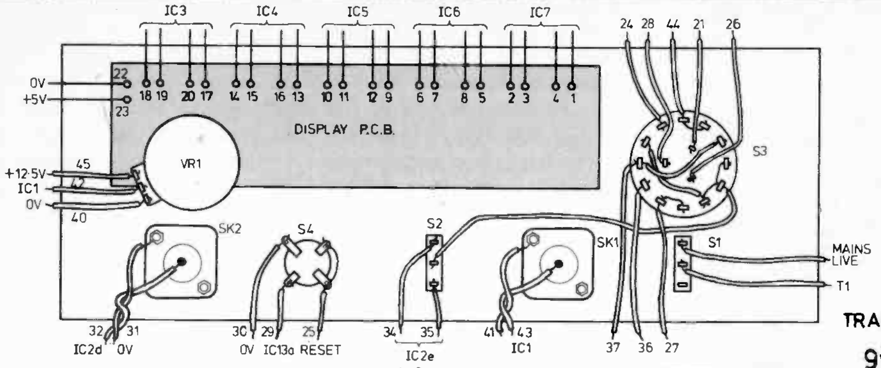


Fig. 9. Front panel rear view giving wiring details for recommended front panel components. The leads are numbered for convenience

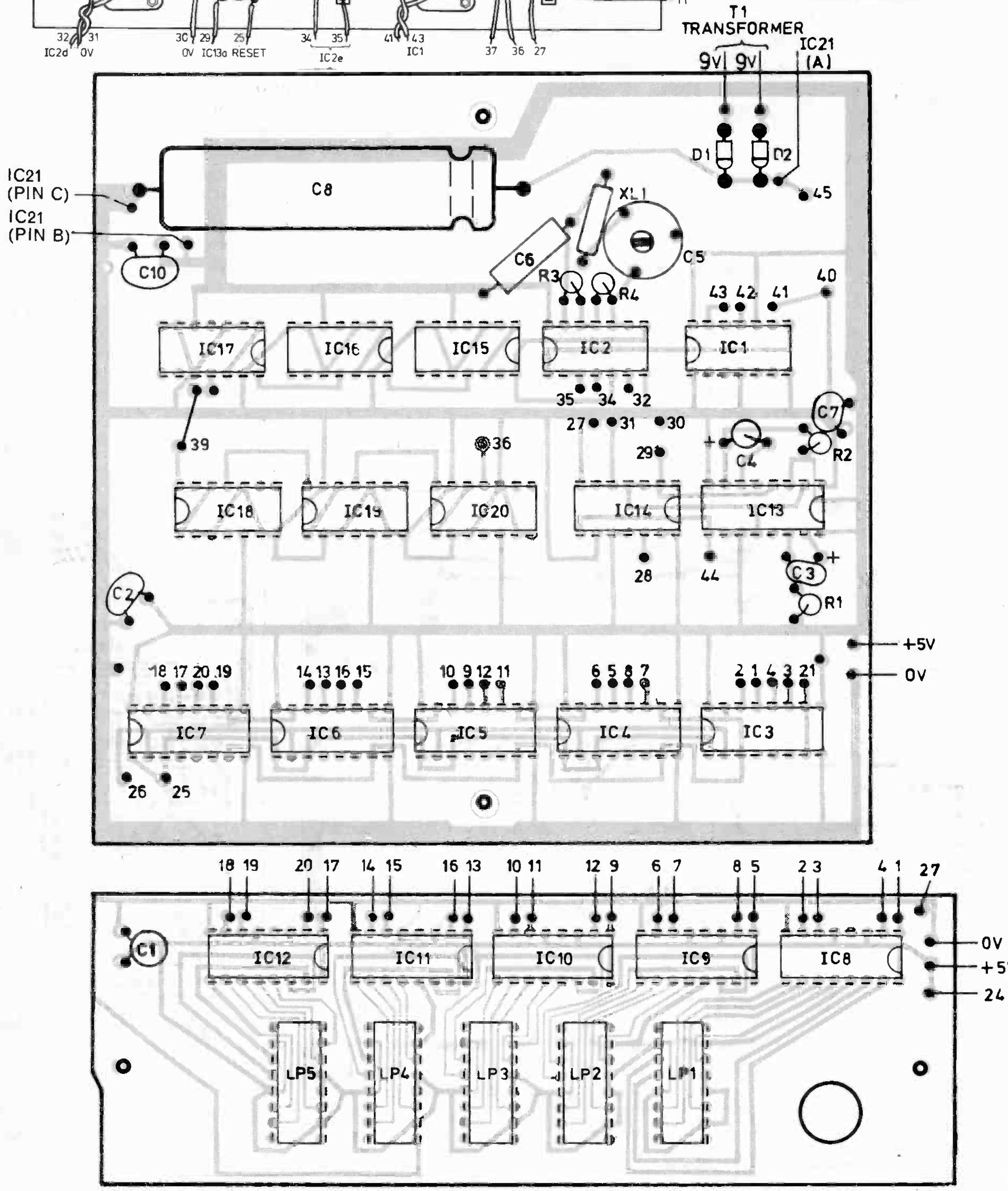
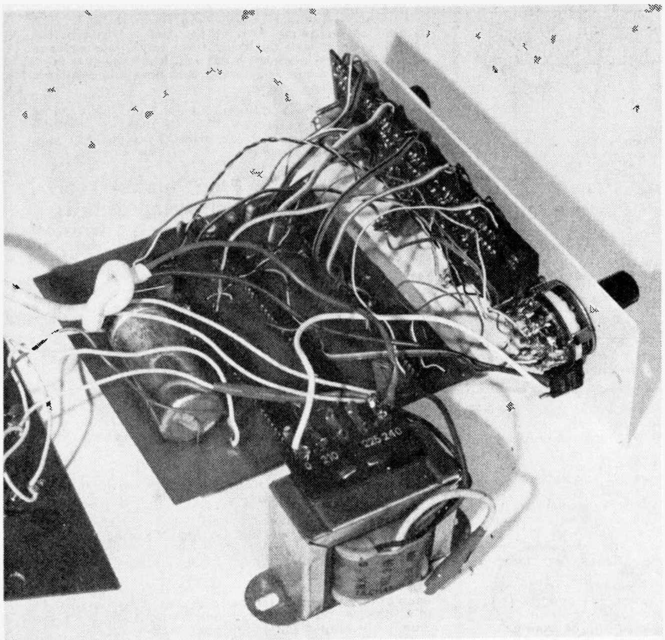


Fig. 8. Layouts for main and display p.c.b.s. Pin 3 of IC3, and other inactive inputs have been used as printed circuit routes, and have no electrical significance. The d.p. is used to orientate the Minitrons



The earth wire of the mains input lead should be connected directly to a solder tag beneath one of the transformer mounting nuts. If the transformer chosen has a screen, then this should also be wired to the solder tag.

Two printed circuit boards are needed, see Fig. 7. The component layouts are shown in Fig. 8.

The display p.c.b. contains the numerical indicators and decode/driver i.c.s, and is mounted on spacers against the front panel. The main p.c.b. contains the remainder of the electronics, and is housed in the base of the cabinet, also on spacers.

Care must be taken when assembling the main p.c.b. to correctly orientate the i.c.s, as some are facing in opposite directions.

A look at Fig. 9 will reveal that the interconnecting wire locations on the front panel are numbered to correspond with those on the p.c.b.s, and for neatness, ribbon cable has been used where possible. A three-conductor ribbon should be used to wire up switch S2 (wires 33, 34 and 35), whereby the centre core (wire 33) is earthed at the p.c.b. end only. Although unconnected at the front panel, this acts as a screen between the outer two conductors. The input and output sockets can be wired with twisted pair cables, irrespective of the type of connector used.

The front panel is labelled using dry letter transfers, which is then spray coated with transparent lacquer for protection. This is probably best done *before* the switches are mounted in position.

CALIBRATION

The only calibration required is the fine adjustment of the trimmer capacitor C5 in the crystal oscillator. This is most easily accomplished by using the Counter/Timer unit to measure a known frequency, whilst adjusting the trimmer to obtain the correct reading.

Most frequency standards use a crystal as their timing source, and the use of these will therefore result in calibration no better than that of the crystal against which the instrument is being compared.

By far the most superior method of calibrating the device is to use the 200kHz carrier frequency of BBC Radio 2, which has an accuracy of 1 in 10^{11}. A simple radio receiver tuned to this station would provide a source, whereby the Counter/Timer unit would be operated in the frequency mode, set to the kHz range. The trimmer capacitor would then be set to give a display of all zeros. It should be noted that this range setting of the instrument is too low to read the full 200kHz. However, since you would not be setting up the basic frequency, but only trimming it, the remaining digits will serve the purpose.

ACCURACY

Once calibrated, the accuracy of the counter will depend on the stability of the crystal, which varies with temperature and age. The oscillator circuit varies with supply voltage also, because the inverters are operated in a linear mode. This supply variation is approximately 10p.p.m./volt. The crystal variation with temperature is approximately 1p.p.m./°C, and hence the overall accuracy of the crystal oscillator over a 0·5V supply variation, accompanying a 20 degree C temperature change would be 25p.p.m., which is 25Hz.

The crystal will further vary by up to 3p.p.m. in the first year of operation, due to ageing; and by an additional 1p.p.m. for each subsequent year.

In any case, the counter will only be accurate to ±1 unit of the least significant digit displayed. This is because the display counter i.c.s are edge triggered, and count the number of rising edges in a given period of time. Depending upon the incidental phase relationship between the timing standard and the input waveform, one edge may or may not be included.

TESTING

As the unit uses TTL almost exclusively, testing only for logical 0 or 1 is necessary. The low state should be typically 0·2V (0·4V max.), and the high state should be typically 3·5V (2·4V min.).

Initially, ensure that a supply of between 4·75V and 5·25V *of correct polarity* is available from the regulator, and applied to the system. The crude input to the regulator i.c. should be in the region of 12·5 volts, but at the very least 7·5 volts if the regulator is to work correctly.

To check that the oscillator and timebase counter is operating, pin 11 of each decade counter i.c. (IC15–IC20) should be monitored with an oscilloscope. This output of each i.c. should reveal an even mark-space ratio, finishing with IC20, where the period will be 1 second exactly, which may be detected with an ordinary multimeter.

If the display counter is suspected of malfunction, it can be checked out by switching S2 to the COUNT position, and applying 1 second pulses to the input at SK1. These pulses are of course available from pin 11 of IC20. The display should begin counting up in seconds, and if this is not so, then the BCD outputs of IC3 to IC7 (pins 11, 12, 13 and 14) should be examined in turn, using a meter. If these outputs are not active, then check that the 1Hz signal reaches the clock line to these i.c.s. Do not forget to adjust VR1 during this test, and if the signal appears at pin 8 of IC1, but not the clock line of the display counter, then there is probably a wiring error.

The control circuit can be tested by operating the instrument in the frequency mode, and monitoring the Q output (pin 8) of IC14 with a 'scope, looking for 1ms or 1s duration pulses occurring at 6 second intervals. Alternatively, monitoring the $\overline{Q}$ output (pin 12) of IC13b with a meter should show a positive going pulse of 1s duration occurring every 6 seconds, when S3 is set to the kHz frequency setting. ★

SWITCH TRIGGER MATS

So thin is undetectable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc. 24in × 18in £2·33. Post and VAT 60p. 13in × 10in £1·85. Post and VAT 50p.

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Electronically changes speed from approximately 10 revs to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. £3·45 including post and VAT. Made up model £1 extra.

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Designed to operate transistor sets and amplifiers. Adjustable output 6V, 9V, 12V for up to 500mA (class D working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only £1·50. VAT and postage 50p.

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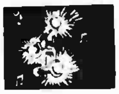

Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450W). Unit in box all ready to work. £7·95 plus 95p VAT and postage.

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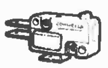

Rated at 5 amps 250V, ideal to make a switch panel for a calculator and for dozens of other applications. Parcel of 10 for £1, VAT and postage paid.

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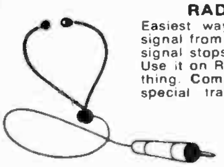

Easiest way to fault find, traces, signal from aerial to speaker, when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything. Complete kit comprises two special transistors and all parts including probe tube and crystal earpiece, £2·95, twin stetho-set instead of earpiece £1 VAT and postage incl.

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Six speeds are available 500, 850 and 1,100 r.p.m. and 7,000, 9,000 and 11,000 r.p.m. Shaft is ¼ in diameter and approximately 1 in long. 230/240V. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor size approx. 2 in dia. × 5 in long. Price £2 including post and VAT.

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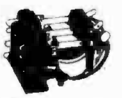

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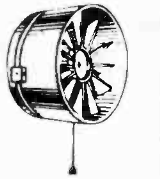


Cleans the air at the rate of 10,000 cubic feet per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc. It's so quiet it can hardly be heard. Compact, 5½in casing comprises motor, fan blades sheet-steel casing, pull switch, mains connector and fixing brackets. £5·25 including post and VAT.

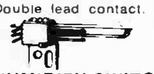
Monthly list available free, send long stamped envelope.

BLACK LIGHT

As used in disco's and stage effects etc.—virtually no white light appears until rays impinge on white collars and cuffs etc.—we offer mains B.L. lamps, 175 watts plugs into any lamp holder requires no choke or control gear price £7 + 95p post aaand VAT or for glamorising rock specimens, looking for watermarks etc. a 9in 6 watt tube with starter, choke lamp holds, etc. all for £4·50 post and VAT paid.

NEED A SPECIAL SWITCH

Double lead contact. Very slight pressure, closes both contacts 12p each.... Plastic push-rod supplied for operating. 10p each. 10 for 68p.



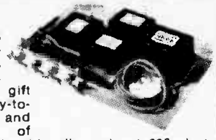
HUMIDITY SWITCH

American made by Ranco, their type No. J11. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch adjustable by a screw, quite sensitive—breathing on it for instance will switch it on. Micro 3 amp at 250V a.c. Overall size of the device approx. 3¼in long 1in wide and 1¼in deep. 65p.

PP3/PP9 REPLACEMENT MAINS UNIT

Japanese made in plastic container with leads size 2in × 1½in × 1½in, this is ideal to power a calculator or radio, iiit has a full wave rectified and smoothed output of 9V suitable for loading of up to 100mA. £2·53.

MULLARD UNILEX



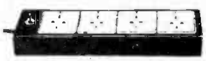
A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one in easy-to-assemble modular form and complete with a pair of Goodmans speakers this should sell at about £30—but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only £14 including VAT and postage.

SHORTWAVE CRYSTAL SET

Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 29, 31 metre bands. Kit contains chassis, front panel and all the parts £1·90—crystal earphone 55p including VAT and postage.

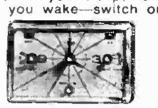
DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of flex cable. Wired up ready to work. £2·75, VAT and postage 85p.

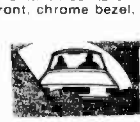


25A ELECTRIC PROGRAMMER

Learn in your sleep: Have radio playing and kettle boiling as you wake—switch on lights to ward off intruders—have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price £2·95. VAT and postage 60p, or with glass front, chrome bezel, £1·50 extra.



WINDSCREEN WIPER CONTROL



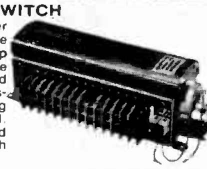
Vary speed of your wiper to suit conditions. All parts and instructions to make. £3·75 post and VAT paid.

THIS MONTH'S SNIP

Breakdown Parcel—four unused, made for computon units containing most useful computors and these computors unlike those from most computor panels, have wire end and of usable length. The transistors for instance have leads over 1in long—the diodes have ½in leads.

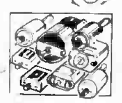
List of the major components is as follows: 17 assorted transistors, 38 assorted diodes, 60 assorted resistors and condensers, 4 gold plated plugs in units which can serve as multipin plugs or as hook up boards for experimental or quickly changed circuits (note we can supply the socket boards which were made to receive these units). The price of this four units parcel is £1 including VAT and post (considerably less than value of the transistor or diodes alone). DON'T MISS THIS SPLENDID OFFER.

MOTORISED DISCO SWITCH



With six 10 amp changeover switches. Multi adjustable switches are rated at 10 amp each so a total of 200W can be controlled and this would provide a magnificent display. For mains operating £4·25 post and VAT paid. Ditto 9 switch £4·95 post and VAT paid. Ditto but 12 switch £5·75 post and VAT paid.

8 POWERFUL BATTERY MOTORS

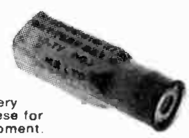


For models, Meccano's, drills, remote control planes, boats, etc. £2.

ROTARY PUMP

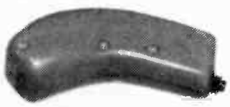
Self priming, portable, fits drill or electric motor, pumps up to 200 gallons per hour depending upon revs. Virtually uncorrodable, use to suck water, oil, petrol, fertilizer, chemicals, anything liquid. Hose connectors each end. £2 post paid.

MERCURY BATTERIES



Bank of 7 Mercury cells type 625 which are approx. ½in diameter by ¼in thick in plastic tube giving a total of 10·7V. Being in a plastic tube it is very easy to break up the battery into separate cells and use these for radio control and similar equipment. Carton of 25 batteries £1·60.

MICRO AMPLIFIER



Ex behind the ear deaf aids, complete with volume control £2·16.

TERMS:
Cash with order—under £6 must add 50p to offset packing etc. BULK ENQUIRIES INVITED. Tel: 01-688 1833.

J. BULL (ELECTRICAL) LTD

(Dept. PE), 103 TAMWORTH RD. CROYDON CR9 1SG

IT'S FREE

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived—often bargains which sell out before our advertisement can appear—it's an interesting list and it's free—just send S.A.E. Below are a few of the Bargains still available from previous lines.

Digital Thumbwheel Switch. Black face flush panel mounting, face size approx. 3¼in × ¾in. White digits 10 positions 0–9. These can be stacked edgewise to any quantity. The right hand and left hand ends have projections for 6BA fixing to the panel. Price left-hand and right-hand end switches £1·50 each + 12p. Intermediate switches £1·25 + 10p.

Mains Transformer upright mounting with top tagboard primary 0–115, 210, 240, two secondaries 115 volts 5mA, and 8·5 volt 1·25A. Note this transformer is ex-new equipment. Price £2 + 18p. ~~Post 30p~~ + 2p.

Mains Transformer, primary 0–110, 127, 150, 180, 220. Secondaries (1) 3, 15–0–3, 15 (2) 2·5V, (3) 0–220V. Fitted primary screen. This is a 30W transformer, ex equipment £2·50 + 20p. Post 40p + 3p.

Ferric Chloride Crystals, for etching copper, making printed circuit boards, etc. Special purchase enables us to offer this in 1lb bags at 50p + 4p. Post 20p + 2p.

Reed Relay with double wound coil 12 volts one coil will close the read switch. 12 volts on the other coil will open the contact or still further close it depending upon whether the current is opposing or assisting. Price £1·50 + 12p. Post 20p + 2p.

Relay, Clare Elliott 670 ohm. Coil sealed in metal can size approx. ¾in by ½in × ½in two pairs of changeover contacts. This type of relay is mounted by its own leads. £1 + 8p.

Desk Instrument Case with sloping front, overall size of sloping front is 4in wide and 5in long. Mounted on a heavy base for stability, base size 4½in × 4in with flex lock. The heavy base is easily removed if not required. The average depth below sloping panel 3in approx. ~~Price £1·50~~ + 12p. Post 50p + 4p. Note the sloping front will be supplied with each of ~~these cases~~ but this already has quite a lot of holes in it, however, it is a simple matter to cut and bend new aluminium front if you use this as a pattern.

Rigonda 6in Mains Battery TV's for spares, these are less tubes and less knobs and will have one or two other parts missing but in the main are complete and worth having if you have one of these televisions or if you do repairs to them. Price £3·50 + 44p. Post £1 + 12½p.

Remember 7029. We are rapidly running out of this and if you have not put any into stock then this could well be your ~~last~~ chance. The price for 100 ~~metre~~ coil £9·50 + 76p. Carriage ~~£2·50 + 20p~~.

Engine Revolution Counter. This is ex-Air Ministry item, beautifully made. As a revolution counter it is driven by a flexible shaft and having a permanent magnet field the voltage output would be dependent upon the speed. Of course it will also run as a low voltage d.c. motor and its speed will be dependent upon the applied voltage. This is dustproof and almost waterproof so it will still run in adverse conditions. One point however, is there are no brushes fitted to these motors, these are special and as yet we have not been able to find a supplier, so you will buy without brushes. The Air Ministry ref. number of the motor is 6A/7A2. We would like to hear from any customer who met this during his service career and who knows of a possible source of brushes. Price £2 + 16p. Post 40p + 4p.

Nicad Battery Charger in neat plastic case size 4¾in × 3¼in × 2¼in approx. with mains input lead and charging output lead terminated with din plug. This is a dual output charger but contains useful mains transformer which makes it easily adaptable for many voltage cells. If not wanted as a charger could very easily be rebuilt as a power unit for receiver or other device. The plastic case has a neon indicator. Price £2·50 + 20p. Post 40p + 4p.

7 Digital Counter. Another special purchase enables us to offer this mains-operated counter for only about a quarter of its proper price. It works off 240V 50Hz mains and requires no step down. There is only one point about this—it counts in even numbers only 2, 4, 6, 8, 10, etc. If you want to count single you must divide the final figure by 2. Price 50p + 4p. Post 10p + 1p.

Garrard 4 Pole Motor, probably made for record player or tape recorder, this is 140V 40–60 cycle. We do not know the Garrard ref. no. but the figure 12 is pressed on the bottom bearing cover. Price £2 + 25p. Post 30p + 4p.

Simmerstat by Sunvic for 2500 watts Sunvic ref. 230707/10776. This is a larger than usual simmerstat dimensions approx. 2½in square by 2½in deep. Price £1·50 + 12p. Post 20p + 2p.

Smiths Time and Set Switch. 15 amp normal mains operated device intended for use with cookers, etc., which could be set to be switched on up to 14 hours in advance and for and up to one period of 4 hours. A very neat glass front instrument with centre control knob size approximately 4½in × 3½in × 2in deep. The Smiths ref. No. CS7400. One obvious use is for switching on your heating an hour or so before you come home so you come home to a warm house. Price £2·50 + 20p. Post 30p + 3p.

Flash Ernie is the name we have given to our latest disco light display because it is a random flasher and is very effective especially with coloured bulbs. Kit consists of motorised stud switch, master control switch, anti spark caps, 9 lamp holders, connecting wire and wiring diagram. Price £5 + 40p. Post 60p + 6p.

Car Cassette Power Kit. This has a stabilised output of 6V, 9V or 12V—this kit consists of transistors—zener, diode and all resistors and condensers, case, and data price is only £2·60 including post and VAT.

Burglar Alarm—The heart of many of these is an infra red beam operated switch—and we offer a bit to make this switch complete with relay from latching and sounding alarm bell—this can also be used for door opening—counting light or dark switching etc., but consists of photo cell—relay, all resistors and condensers and constructional data only £2·25 including post and VAT.

Emergency Light. Works from mains but automatically switches to battery should mains fail—with this your place never will be in darkness—uses PP9 battery (not supplied) otherwise complete kit with data £3·50 including post and VAT. Wall or ceiling mounting case £1·50 extra.

Stereo Gram Cabinets. Long, low, modern teak-veneered cabinet, size approximately 4ft 2in by 15ft 5in. Probable cost to make today over £20. We have a few of these, they are slightly second, at prices ranging from £5 each, depending on condition—sorry but these are for callers only.

Semiconductor UPDATE...

FEATURING : 57109 TMS9940 SCL5421L

R.W. Coles

CRUNCHER

If you own a scientific calculator you will be quite used to carrying out sophisticated arithmetic in floating point or scientific notation, with functions like square roots and sines only a key press away. By comparison, a microprocessor chip is in the abacus league, usually boasting only binary or BCD addition and subtraction as direct operations, with even those restricted in precision to the MPU chip word length.

The magic ingredient required to turn a microprocessor into a calculator is, of course, software. If you write long enough programs you can generate any mathematical function and calculate to any desired precision with even the most humble MPU chip, but those programs will cost you dearly in time, and putting them together can be complicated.

Of course, you may be able to get hold of software that someone else has written, but the chances are it won't suit your system without being rewritten to some extent. Calculator chips are nothing more than MPU chips with the necessary software and interface hardware built in, so wouldn't it be nice if you could use a calculator chip as a peripheral chip in your MPU system to do all the tricky maths as and when required?

Up to now, calculator chips have been very difficult to interface to microprocessors because their inputs and outputs have been geared to keyboard switches and multiplexed displays respectively, but now National have done the obvious and modified a calculator chip to accept direct interface to an MPU. The new chip, coded **57109** but affectionately referred to as the "Number Crunching Unit" handles floating point and scientific notation, trigonometric and logarithmic functions, square roots, coordinate conversion, and memory operations, and is commanded to carry out these operations by means of six-bit binary codes delivered from the microprocessor.

The 57109 doesn't actually need a microprocessor to operate; it can work in isolation with only a few external logic chips and ROM based program, but for my money the possibility of direct MPU interface is its star quality!

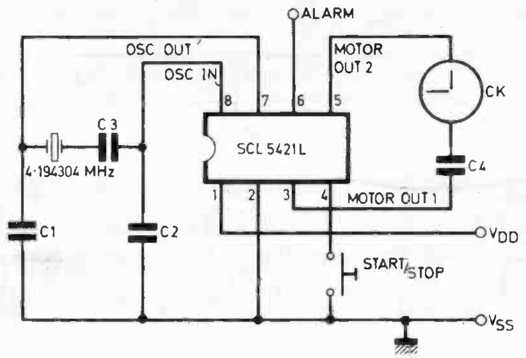


Fig. 1. Simple clock application for the SCL5421L

SHOWDOWN

According to Texas Instruments, the demise of the eight-bit microprocessor is imminent. If that news comes as a bit of a shock, let me hasten to add that most other microprocessor manufacturers would vehemently deny it, and there *does* seem to be an element of line shooting in the announcement.

True to the traditions of the lone-star state, Texas' boast that their *big* **9900** microprocessor family is going to drive all the skinny eight-bit chips right out of town, western style. It's certainly true that they've got a formidable posse together to do the job, take the **TMS 9940** for example . . . The 9940 is a complete 16-bit NMOS microcomputer-on-a-chip, which includes 128 bytes of RAM, 2 kilobytes of ROM, 32 general purpose input output lines, 5MHz clock, hardware multiply and divide, *and* a timer/counter!

If I was you, I would tell *your* pet micro to make sure its interrupt is well oiled, because these Texans will soon ride into town, tall in the socket, and the bytes are going to flow thick and fast.

Don't worry too much though, if you feel that small is beautiful (like me!), the Texas mob are *too* big for many jobs, and that will make them uneconomic for the bulk of eight-bit applications. As far as I am concerned, the magnificent eight rides again!

HANDY CHIP

If you are going a bit boss-eyed peering at those funny square numbers on that "bang-up-to-the-minute", "miracle of modern electronics", digital clock, and even the novelty of accuracy to within a few seconds a month has stopped compensating for the inconvenience of wearing pebble-lens spectacles, what you need is a clock with *hands*. No, no, don't worry, you can still have the accuracy to which you are accustomed and tell your friends about the quartz crystal and 50,000 transistors that make it "tick".

Available from Ritro Electronics, is a neat CMOS chip in an 8 pin mini-DIP which contains an oscillator, a 23 stage binary divider and two push-pull output transistors to drive a stepper motor at 0·5Hz. Coded **SCL 5421L**, the chip requires a 4·194304MHz crystal and has facilities for time setting and a tone output for use with an alarm circuit.

Operation is possible with supplies down to 1·15 volts, making it possible to put together a capable clock with easy-read hands running from a single dry cell!

ACTIVE 'SCOPE PROBE

A versatile accessory for your oscilloscope or frequency counter, presenting minimum loading to the circuit under test

By B. SAVAGE

THE main tool of the serious experimenter and circuit designer, after the multimeter, is the wide-band oscilloscope. In order to use this aid to gain insight into the behaviour of signals in electronic circuits, connection must be made to the circuit under investigation—and made in such a way that no alteration in performance results. This connection is normally made through a length of coaxial cable, the outer sheath being at earth potential to protect the inner conductor, which carries the signal, from the pickup of stray radiation—especially mains hum.

THE CAPACITANCE PROBLEM

The bandwidth of all amplifiers, except the tuned variety, is restricted at both high and low frequencies by the presence of capacitors, whether these are actual components or the phantom capacitances of transistor junctions. Low frequency performance is restricted by the *series* capacitors through which the signal must pass, and the high frequency performance by the *shunt* capacitors which tend to bypass the signal to ground.

A reasonable length of coaxial cable might have a capacitance of 100pF, to which must be added the normal input capacitance of the oscilloscope, typically 25pF across a resistance of 1 megohm. At audio frequencies this capacitance is unimportant, but at radio frequencies most of the signal would be lost in the cable. At 40MHz, 125pF has an impedance of only 32 ohms. It would not be practical to investigate the performance of a tuned circuit, because the resonant frequency would be altered by the extra capacitance added across it. If pulse circuits were the subject of enquiry, the user would have to remember that the pulse rise-time as displayed on the screen of the oscilloscope was lengthened by the time taken by the signal to charge and discharge the cable capacitance.

PASSIVE PROBES

One solution to the problem is the passive probe, which attenuates the signal by means of a series resistance with a small capacitor connected across it (Fig. 1). The probe acts as both a voltage and a capacitance divider—the input capacitance is reduced in the same ratio as the signal is attenuated. In this way, a divide-by-ten probe used with the cable and oscilloscope described above would reduce the 125pF to 12·5pF.

The passive probe reduces the amplitude of the signal, and in achieving a really low input capacitance the consequent attenuation could leave too small a signal to be observed.

There is another difficulty with passive probes. All cables are transmission lines when high frequencies and fast pulses are being considered, and all transmission lines have a characteristic impedance. In the passive probe, each end of the transmission line is connected to what looks like an open

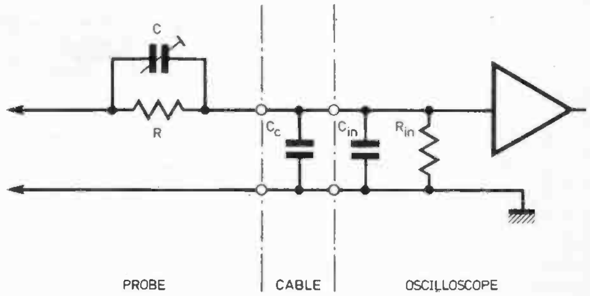


Fig. 1. A simple passive high-impedance probe, providing voltage and capacitance division

EXPANDING OFFER!

To celebrate the increased size of P.E. we are giving you a:—PAPERMATE CHROME PLATED PEN WORTH £3·95 with any watch under £20. PAPERMATE GOLD PLATED PEN WORTH £5·70 if you spend over £20. CHROME PEN & PENCIL SET (or two pens) WORTH £7·90 if you spend over £28. GOLD PLATED SET (or two pens) WORTH £11·40 if you spend over £50. Items may be combined. Offer closes 30th Sept. 1977. Subject to availability.

SPECIAL PURCHASE. CASIO CASIOTRON S15B. Now you can afford probably the best watch in the world! 8 functions LCD with backlight. STOPWATCH, DUAL TIME. ZONES. All stainless steel. Mineral glass Battery hatch. Water resistant to 130 feet. **£49·95** (R.R.P. £89·95) Black or blue face.

R16B (Not illust) **£34·95** Bk or Bl.

ST-1. Hand-held ELECTRONIC STOPWATCH /Calculator. Four stopwatch functions: Standard, Time Out, Two kinds of Lap time. TOTAL Time button. Rollover after 9 hrs, 59 mins, 59·9 secs. Converts Time to Decimal Hours & back again. Full access memory, constants, sq. roots, % etc. **£27·50** (£24·95 without pen).

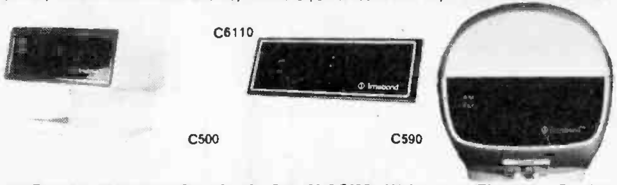
MQ-1. Miniature pocket version of CQ-1. 12 or 24 hour clock, stopwatch and basic calculator **£37·95** (£34·95 without pen & pencil set).

TC410
TC411

TC440
TC441

TC412
TC413

FAIRCHILD TIMEBAND LCD Watches. Latest models with BATTERY HATCH & VOUCHER FOR FREE REPLACEMENT BATTERY. Constant display of Hours & minutes. Push button once for Month & Date, twice for Seconds. Backlight, automatic calendar, AM/PM setting indicator, easily selected alternating time/date display. Beautifully styled Swiss/W. German cases. **TC441** chrome **£19·95**, **TC440** Gold Plated **£21·95**, **TC411** chrome **£24·95**, **TC410** Gold Plated **£27·95**, **TC413** St/St bracelet **£28·95**, **TC412** Gold Pl. **£31·95**.

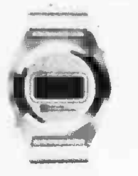


C6110

C500

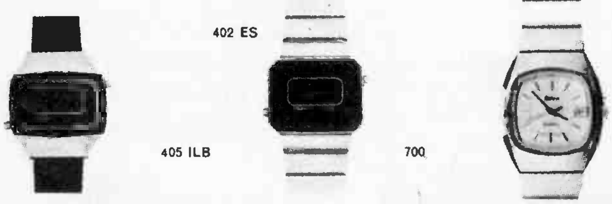
C590

TIMEBAND MAINS DIGITAL ALARM CLOCKS. Wake up to Timeband. Precise timekeeping, can be synchronised to the exact second. Alarm accuracy to the exact minute. Will display last minute digit and seconds. Solid state reliability, silent running. 9 minute snooze, Alarm on, Mains Failure Indicators. **C500** (left) $3\frac{1}{4}$" × $3\frac{3}{4}$" × $3\frac{3}{8}$". Black or white **£14·35**. **C6110** (centre). As C500 but more sophisticated controls **£15·90**. **C590** (right). With built-in High/Low Intensity elevating reading lamp **£23·35**.



From **NATIONAL SEMICONDUCTOR** 5+3 functions. As Timeband but without alternating Time/Date facility. DAC5 series (left).

DAC5 WS Chrome on Strap	£22·90
DAC5 YS Gold Plate Strap	£25·90
DAC5 WB Chrome Bracelet	£24·50
DAC5 YB G.P. Bracelet	£28·50
DAB5 Series (Right)	
DAB5 WB All stainless	£33·50
DAB5 YB Heavy G.P.	£39·50



402 ES

405 ILB

700

IBICO. Traditional Swiss craftsmanship. 5+4 functions LCD. Mineral Glass face. **405 ILB** strap **£33·90**. **405 IS** St/St bracelet **£35·50**. **402 ELB** Stainless steel on strap **£38·90**. **402 ES** All stainless **£39·90**. **700** "1000 day" Quartz Analogue. Stepping Motor. High speed adjustment. Seconds synchronisation. **£33·50**. Not illustrated **450 HS £69·75**. 403 **NS £42·50**. IBICO watches are water resistant to 100 feet or more. (Waterproof straps).

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CALCULATORS. FX-21 £13·95, FX-29 £14·95, FX-105 £16·95, FX-110 £17·95 (Rechargeable batteries £3 pair. AC adaptor/charger £3). **FX-2000 £24·95, FX-201P £44·95, FX-202P £69·95, PRO-FX1 £124·95.**

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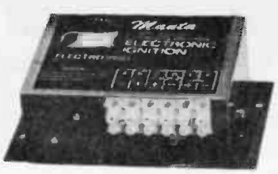

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Construct this invaluable accessory, following our easy step by step instructions (also available separately, price 30p post paid). Send for our free interesting six page brochure—"Electronic Ignition— How it Works" (S.A.E. Please) to:

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Tel.: Wilmslow 29599 for Speakers — Tel.: Wilmslow 26213 for Hi-Fi circuit to the signal. A fast pulse will reflect back and forth in such a line, producing a spurious ringing on the oscilloscope trace.

The ideal solution would be an active input device which could be applied directly to the signal point, presenting low capacitance and high resistance, and conveying the signal to the oscilloscope through a correctly terminated coaxial cable, without any loss of amplitude.

ACTIVE PROBES

Probes which contain a valve or field effect transistor operating in the cathode- or source-follower mode provide less than unity gain, but are sometimes used because of the high input impedance of these devices. An input capacitance of about 6pF can be attained in this way—and the cable to the oscilloscope is properly terminated, avoiding reflections. A slight loss of amplitude results, and this is usually made to equal exactly 50 per cent, for convenience in measurements.

The active probe to be described was constructed for use with a 40MHz oscilloscope. The probe bandwidth extends to over 40MHz at the high frequency end, but gain rolls off below 10kHz. The reduction of low frequency gain is intentional; it would be possible to make a probe which worked down to d.c., but low frequencies can be readily observed without the aid of the probe, and a probe which picked up mains hum would be irritating to use.

It should be stressed that this is not an easy project to build. A certain amount of cut-and-try is needed to ensure linear operation, avoidance of spurious oscillations, and accurate gain setting. However, a well-equipped amateur (who already has a wide-band oscilloscope) should be able to manage it. The difficulty results from the very small capacitances which are being dealt with, which means that the proximity of components to each other and to surrounding metalwork makes a lot of difference to the performance.

CIRCUIT DESCRIPTION

The probe comprises a stepped attenuator feeding a three-stage amplifier with a gain of ten times. The probe input (see Fig. 2) is coupled via an isolating capacitor C1 to an input attenuator controlled by S1, a three-position slide switch.

When S1 is in its forward position (X 10) the incoming signal is applied directly to gate 1 of TR1. The input impedance is 100 kilohms (R3) in parallel with the input capacitance of the MOFSET, about 7pF in the prototype. On this range, the probe has significant gain up to 200MHz, making it an especially useful accessory for a digital frequency meter.

With S1 in the centre position (X 1) the signal passes through R1 and R2 in series (total resistance 900 kilohms) and so is attenuated by a factor of 10 before being applied to TR1. It would seem that a capacitor of about 0·7pF should be connected across R1/R2 to compensate for the 7pF across R3, but in fact the capacitance across the switch contacts is just about right. The effective input capacitance on this range is 3pF.

When S1 is in the rear position (÷10), R4 is connected in parallel with R3, increasing the attenuation to 100 to 1. Here, compensation is needed, and a capacitor of about 68pF (C2) must be connected across R4. The input capacitance is, again, 3pF.

DUAL GATE MOSFET

The amplifying device TR1 is a dual-gate MOSFET, which is like two IGFETS cascode-connected in the same package. The device has two gates, the signal going to gate 1 and a direct voltage of maybe four volts going to gate 2. Because of the cascode connection, there is good isolation between input and output. The stated transconductance is better than 10,000μS, which means that a gain of 10 can be developed into 1,000 ohms. The stated input capacitance of the device is 6pF.

The 1 kilohm load R6 cannot, of course, be shunted by much capacitance if there is to be high frequency gain, so the impedance is lowered to match the cable with two cascaded emitter followers, TR2 and TR3. The r.f. transistor types used have a collector/base capacitance of only about 3pF, which is satisfactory for this application.

Dual emitter followers tend to be unstable near the cut-off frequency unless driven from a high impedance source; the prototype oscillated at 500MHz! This was cured by inserting a resistor, R7, in the base lead of the first emitter follower. Such oscillation cannot be seen on an oscilloscope unless a rectifying probe is used to find it.

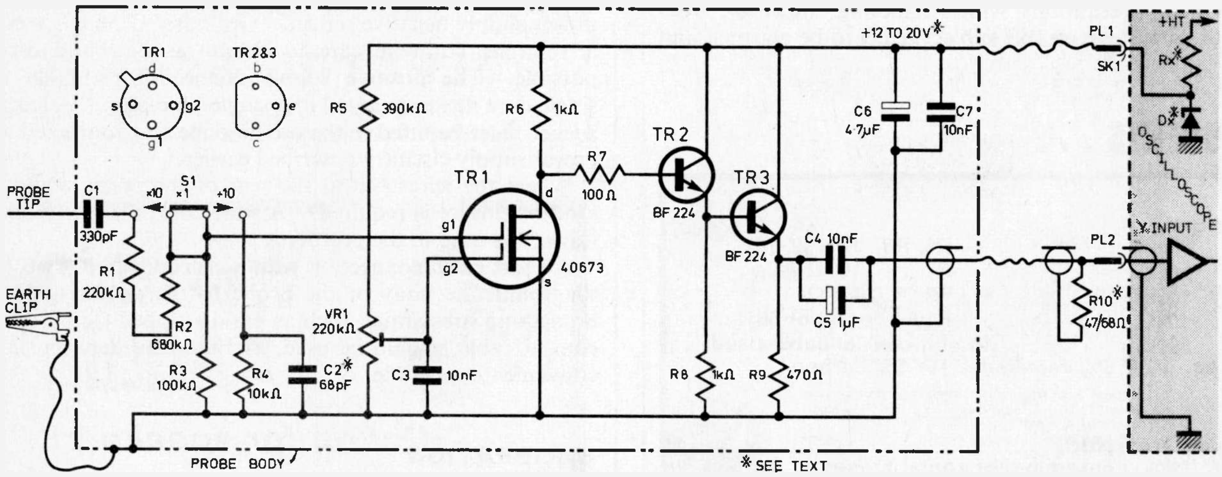


Fig. 2. Circuit diagram of the complete probe, plus suggested power supply arrangement

The coaxial cable which carries the output signal from the probe to the oscilloscope must be terminated with the appropriate value of resistor (R10). With a little ingenuity this can generally be mounted inside the plug.

The power supply for the probe is best drawn from the oscilloscope itself, using a one watt Zener diode D_x with a dropping resistor from a supply line of about 100 to 150 volts. The probe draws in the region of 25 milliamps, and the series resistor R_x should be chosen to allow a total current flow of 35 milliamps. Optimise the voltage for gain (see under "Calibration") before deciding what value of Zener to use.

CONSTRUCTION

The prototype probe was housed in a 105mm length of 22mm (7/8in) diameter copper tube, see Fig. 3. A slot 19mm wide by 25mm long was cut at one end to accept S1. This is a three-hole, three-position slide switch, marketed by Q.A.S. (Quality Audio Supplies, Wollaton Road, Beeston, Notts) and on sale in many audio shops. The switch is secured to the tube by a self-tapping screw through its rear lug.

The printed circuit board is secured by soldering it to the lugs of S1 (all poles are connected in parallel), and must be central in the tube when assembled. The metal case of S1 is connected to the p.c.b. earth rail by a short wire link, in order to ground the probe body.

The 40673 is gate-protected by internal Zener diodes. It pays to take precautions whilst handling, however, even though the literature on this subject tends to be alarmist and makes one wonder how much danger of destruction there really is. A length of metal rod along the front of the bench, connected to ground and upon which one can rest one's forearms will surely be enough. Wrap a thin strand of wire round the pins of the device until it is soldered into place, if you are the belt and braces type.

Type BF224 transistors were used for TR2 and TR3, but many others would do. These are plastics types—if ones with metal cans which are at collector potential are used, make sure that these cannot touch the probe body. A low collector/base capacitance is essential for TR2; the requirements for TR3 are less critical. In any instrument intended for measurement of r.f. voltages, it is important to use components having the minimum self-inductance. For this reason, it is best to use ordinary carbon resistors throughout the probe.

The input prod in the prototype was fashioned from a 6BA bolt with half the head removed. This was soldered to the front of the printed circuit board. A piece cut from a felt marker was used as a front capping, and this was secured by a 6BA nut and a plastics washer, plus a self-tapping screw through the front mounting lug of the switch. A miniature crocodile clip with a 6BA nut soldered into the shaft can be screwed onto the prod for a hands-off connection, or other probes made (Fig. 3).

The signal output from the probe, as already mentioned, is carried via a coaxial cable. The cable outer also provides the power supply negative return. Ordinary 75 ohm TV coaxial is suitable, but take care to choose as flexible a cable as possible. The positive supply connection is made via a single-core flex terminated in a single-pole plug. A matching socket must be fitted to the oscilloscope and connected to the power supply circuitry described earlier.

Where the wires exit at the rear of the probe body, some kind of closure is required. A wine cork, drilled to take the leads, was used in the prototype.

A short earth connection with a crocodile clip is necessary to ground the body of the probe to the circuit under test. Something substantial, such as braid stripped from a piece of coaxial cable, should be used, and the lead kept as short as conveniently possible.

COMPONENTS . . .

Resistors

R1	220kΩ	R6, R8	1kΩ (2 off)
R2	680kΩ	R7	100Ω
R3	100kΩ	R9	470Ω
R4	10kΩ	R10	47Ω or 68Ω
R5	390kΩ		(to suit coaxial cable used)

R1–R4 1/16W 5%, remainder 1/4W 5% carbon

Variable Resistor

VR1 220kΩ sub-min. horizontal preset

Capacitors

C1	330pF polystyrene
C2	68pF polystyrene (see text)
C3, C4, C7	10nF disc ceramic (3 off)
C5	1μF 15V elect. or tant.
C6	4·7μF 25V elect. or tant.

Semiconductors

TR1	40673
TR2, TR3	BF224 etc. (see text) (2 off)

Miscellaneous

S1	3-pole, 3-position slide switch (see text)
PL1/SK1	Single-pole connector
PL2	Coaxial connector to fit oscilloscope Y-input

Printed circuit board. Materials for probe housing, etc.

CALIBRATION

Measurements of radio frequency voltages at high frequencies will always tend to be a little vague, unless you are blessed with lots of patience and some very expensive and sophisticated equipment. This probe is not meant to be a precise measuring device, so do not set an impossible standard of accuracy when calibrating it. Errors of less than 1dB will constitute an excellent standard—and 1dB is about 12 per cent. The probe must be assembled completely whenever a test is being made.

Before attempting to calibrate the attenuator, the gain in the direct (X 10) position must be checked and adjusted for optimum. There are two ways of adjusting gain: changing the supply voltage or changing the voltage on gate 2 of the MOSFET. If the probe is powered from an adjustable bench power supply, varying the voltage by small amounts from a starting point of about 15 volts, at the same time adjusting VR1 for maximum gain, you may well find that a gain of ten can be exceeded. If so, R6 can be reduced to 820 ohms, thus improving the bandwidth. Do not use a supply voltage higher than that required to achieve a tenfold gain.

When it is remembered that one centimetre of twin cable has more than 1pF of capacitance, it will be seen that it is hard to be specific about exact component values in the

'SCOPE PROBE

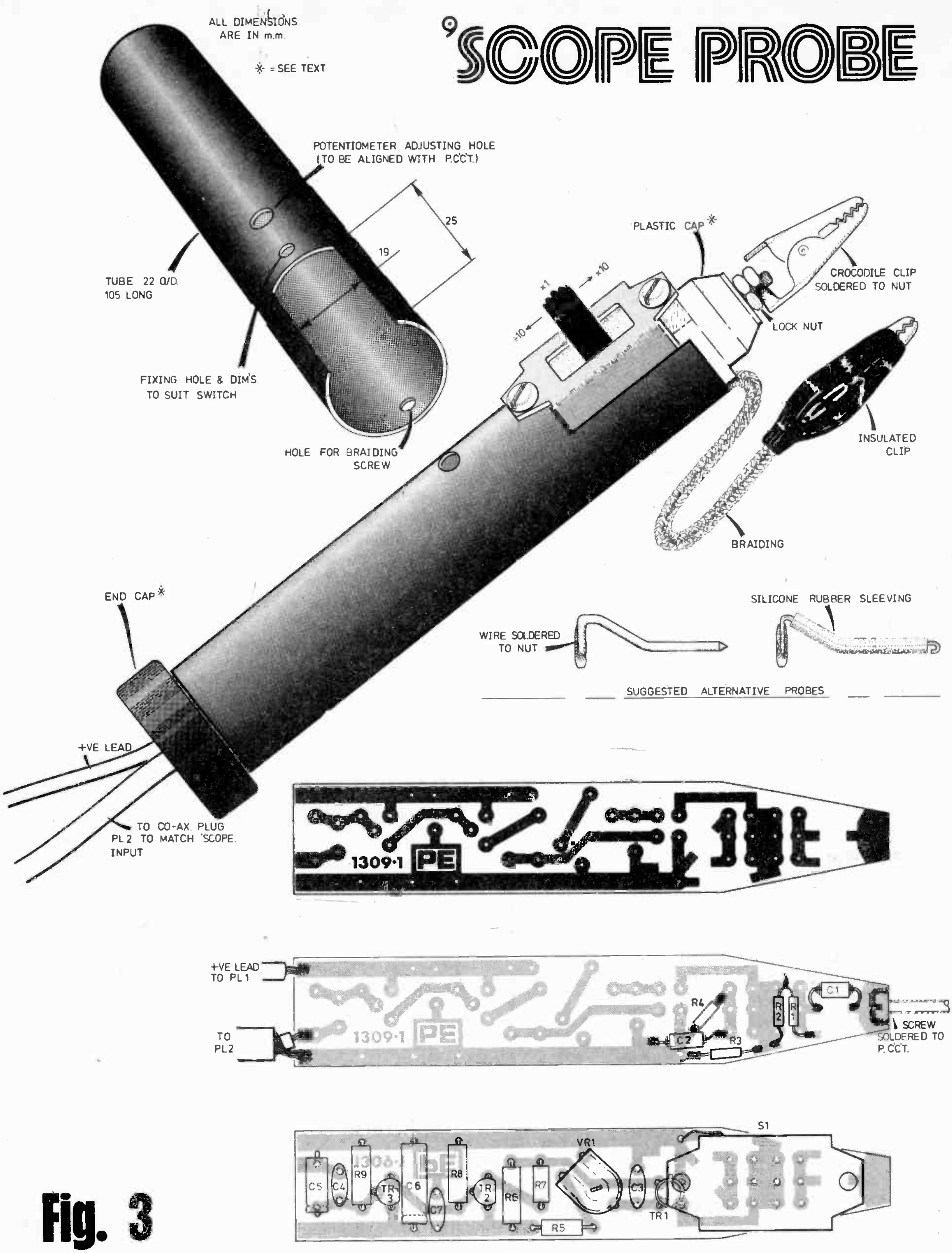
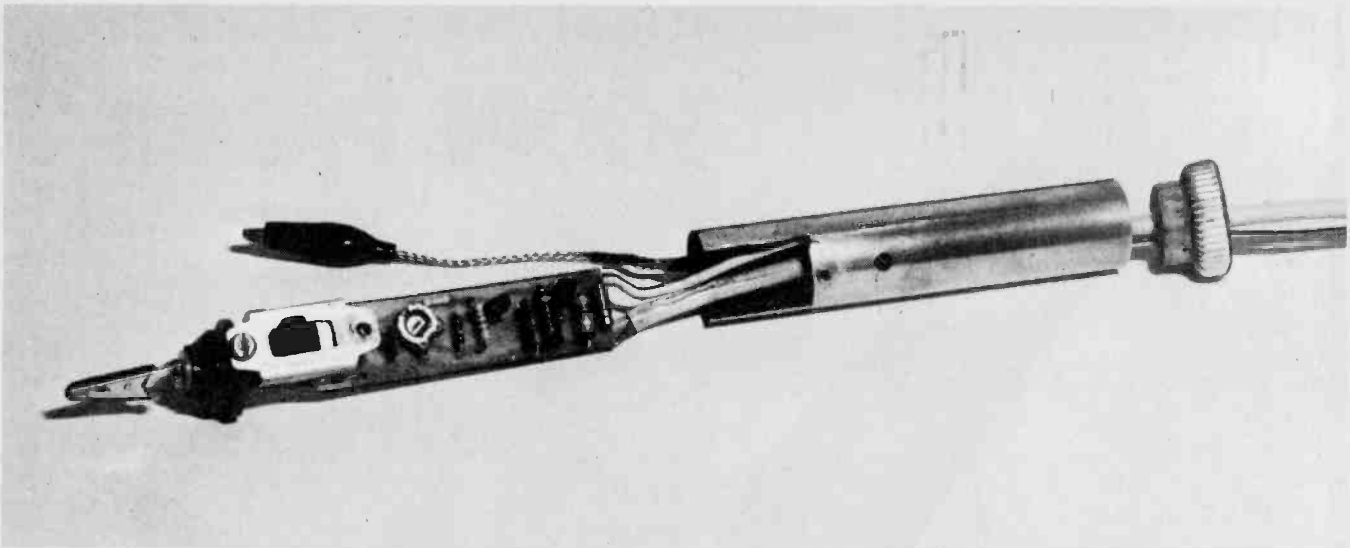


Fig. 3



attenuator. A source of square waves with fast rise times is necessary for setting up the attenuators. All the attenuator components are mounted on the copper side of the printed circuit board, using minimum length leads.

The object of calibration is to get a clean, square leading edge to the displayed test waveform, with minimum overshoot or ringing on the top. With S1 in the X 1 position, it may be necessary to add a very small capacitor, in the form of a short twisted pair of insulated wires, across R1/R2. This can then be trimmed in value by snipping bits off or repositioning. On the ÷ 10 range, some slight change in the value of C2 may be required to produce the best wave-shape.

A simple square wave generator for this purpose may be built using a 7400 quad NAND gate. A frequency of 100kHz would be appropriate. The rise time will be about 9 nanoseconds; if your oscilloscope has wider bandwidth, use a Schottky version which will produce a rise time of some 3 nanoseconds.

FAULT FINDING

Some possible probe faults and suggested cures are as follows:

1. Complete failure

Check voltages—TR1 should be drawing about 10 milliamps, which means that there should be 10 volts across R6. Check that this can be varied by VR1. There is a large tolerance on this figure as these devices vary considerably.

2. Flattening of sine waves

Check that there is a reasonable voltage across R9—not less than about 4 volts as a minimum. You might be using the probe on the wrong range of the oscilloscope—signals at the output of more than one volt peak to peak may be distorted.

When observing non-symmetrical waveforms, do not forget that the probe is inverting the signal.

3. Square wave response lumpy

If this happens even in the direct (X 10) position, supply decoupling is probably at fault—you have a resonant circuit somewhere. Capacitors C6 and C7 should take care of this, if not, try a choke in the supply lead, or even a 10 ohm carbon resistor.

4. High frequency oscillation

If there is inexplicable displacement of the oscilloscope trace or misty effects around pulse waveforms, suspect oscillation first. Use a germanium detector or hot-carrier diode probe to check the output with the input shorted, and then with it open. There should not be more than a few millivolts of noise on the output.

The cure is to increase the value of R7, or if this is ineffective use different transistors for TR2 and TR3.

MEASURING SMALL CAPACITANCES

In the unity gain position, the probe has an input capacitance of about 3pF. It may be used to measure small capacitors, for example the capacitance of an f.e.t. gate or transistor junction, and provide information which is hard to obtain in any other way.

Connect a square wave generator of about 200 millivolts peak to peak output with a frequency of about 200kHz, through the capacitor to be measured to the probe. The resulting square wave displayed on the oscilloscope is related in amplitude to the value of the capacitor. Make a stair-chart using small capacitors of known value, and then use the chart to measure unknown capacitors. Measurements of less than 1pF are quite possible.

Silicon junctions will not be forward biased and will therefore look like capacitors, but it must be remembered that all silicon junctions behave like varactor diodes and change their capacitance with applied voltage. Reverse bias may be applied through a large resistor to simulate this effect. In practice, an f.e.t. gate looks like 5pF, a general purpose transistor collector/base junction like 10pF, and a high-speed diode maybe 2pF.

USING THE PROBE

Remember that the probe is somewhat delicate and would be destroyed by a large r.f. voltage. In the direct connected (X 10) position, a jolt of d.c. will suffice. The manufacturer's literature on the 40673 states that the protective diodes become effective at plus and minus 10 volts. It also states that the diodes will constrain a transient pulse from a source capable of delivering several hundred milliamperes, but this refers to a one microsecond pulse. The input circuit has a time constant of 40 microseconds—it would appear that some caution is needed. ★

Readout—

A SELECTION FROM OUR POSTBAG

Readers requiring a reply to any letter must include a stamped addressed envelope. We regret that we cannot answer any technical queries on the telephone.

Breadboard

Sir—A simple and cheap way of constructing breadboard is to solder d.i.l. i.c. sockets to Veroboard, such that the i.c. fits not into one socket, but into one row of holes in each, situating it between the sockets. This means that if the Veroboard is cut in the right manner, each pin on the i.c. is accessible through the other row of holes. By placing a number of pairs of sockets on the stripboard, a breadboard of any size can be built, whereby the significant cost is that of the sockets.

Figure 1 shows the arrangement of a pair of sockets with the appropriate track cuttings. Here the supply rails run each side of the i.c. holders, and are wire linked to the sockets. Illustrated in Fig. 2 is an end view of the arrangement. Multiple connections may be made through the use of Soldercon pins, as shown in Fig. 3a. A more flexible means of linking the supply rails to the sockets is to use Soldercon pins mounted directly on the Veroboard (Fig. 3b). If 16 pin sockets are used, and a 14 pin i.c. is to be wired, the supply can be jumpered to the correct pin directly, also using Soldercon pins.

W. R. Hinds,
Hammersmith.

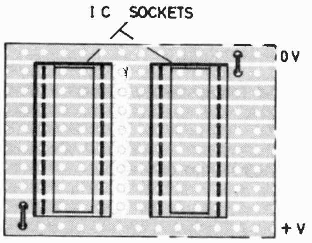


Fig. 1

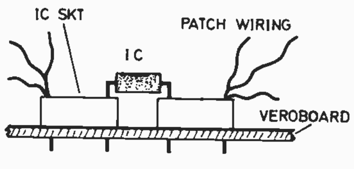


Fig. 2

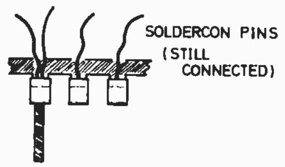


Fig. 3a

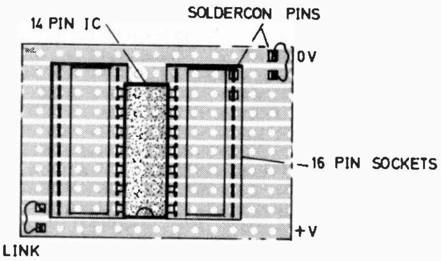


Fig. 3b

A Word of Warning

Sir—Firstly may I say that I welcome an article like the "Earth Leakage Circuit Breaker" which bridges that narrow line between the power and light current engineers.

I am, however, concerned about the implications of current transformer experimentation which are hinted at in your article.

If experiments are carried out using the turns ratios as indicated in Mr. Smith's design (i.e. 300:1), there is a danger that a very high voltage can be induced in the winding which now acts as the secondary of the transformer (75kV on 250V mains). Such voltages are obviously far above the insulation ratings of a normal output transformer and are in addition quite lethal if supplied from the mains

I would, therefore, consider it essential that you issue a word of warning to would be experimenters or constructors with reference to the extremely high voltages available when experimenting with transformers in the current transformer mode.

Further to these comments I would refer to Fig. 4 of the article where various forms of resistive earth leakage faults are illustrated. I would like to see an assessment of the situation should a direct line to earth fault occur, in which case as far as I can interpret the situation, the voltage ratings of both the transformer and the input circuitry would be vastly exceeded during the time required for the breaker or fuse to clear the fault current. This would seem likely to cause severe damage to the input circuitry and I wonder if under such circumstances could a now ineffective breaker be re-closed? If this is so a suitable warning should be published.

Whilst the above comments may appear to be finicky, it has been my experience as an electrical engineer that a person will throw complete trust upon an item of equipment having a title which indicates that it can provide an added safety factor without question or consideration of the duties for which it is rated or has already been called upon to perform.

Since with this equipment and other equipment of a similar nature the safety and protection of the life of the user who may not have any electronic or electrical knowledge is being considered, it is essential that such articles receive the very closest of test and scrutiny prior to their publication and that any shortcomings or risks to the constructor or user are clearly indicated.

P. Bevington,
Birmingham.

In reply to Mr. Bevington's letter, I agree that high voltages are produced by current transformers with open circuit secondaries.

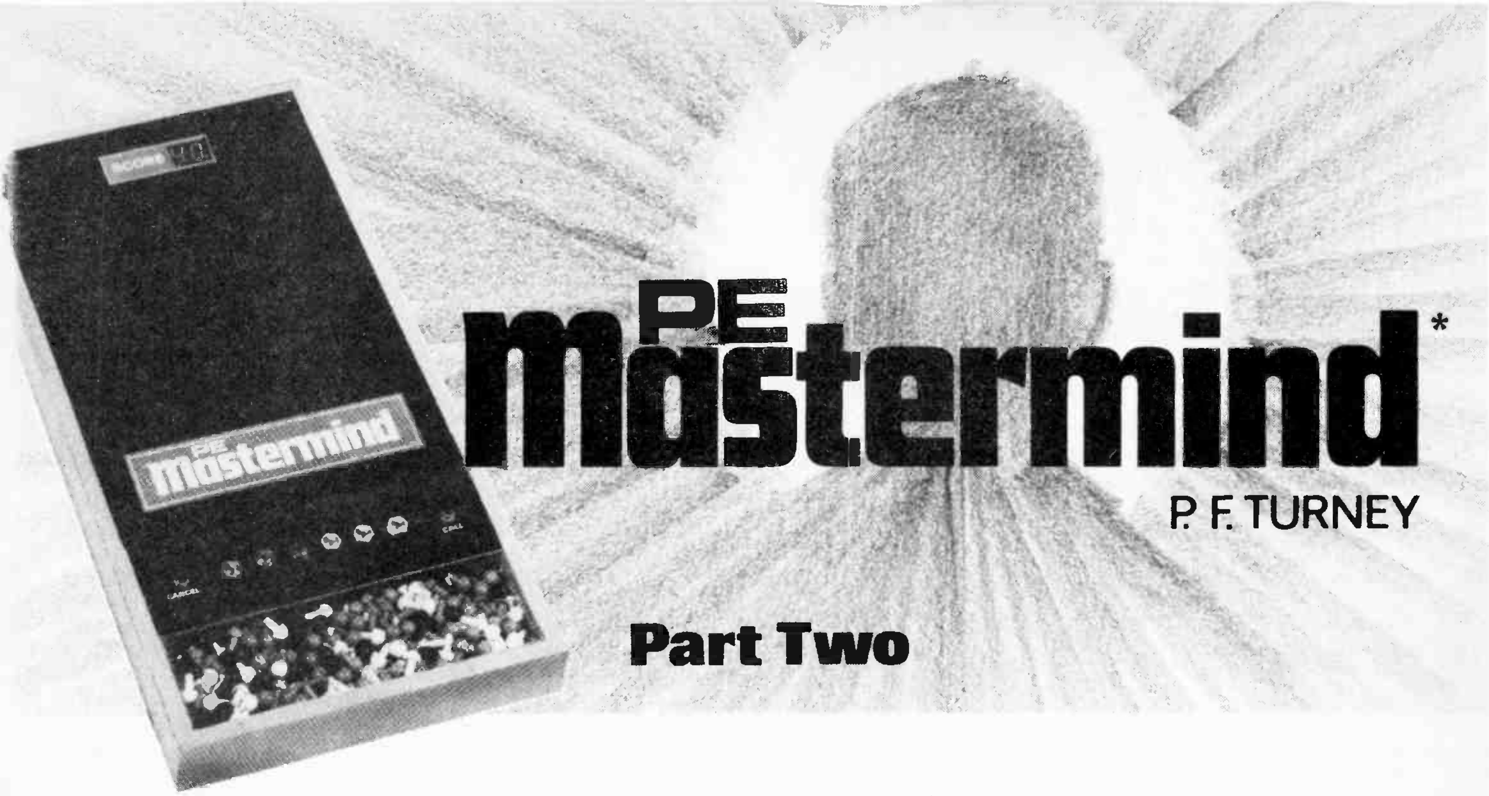
This was not mentioned in the article although the reason for the diodes on the "damp" circuit input of the amplifier was mentioned.

Since the core will saturate, the output at low frequencies will be small but it will of course work as a pulse transformer and give outputs comparable to the spark in a car ignition system.

The low efficiency of the windings means that fast high voltage transients will be produced, but will be caught by the diodes to protect the amplifier.

A warning should be given to avoid direct contact, should a direct line to earth fault happen.

The latter part of the letter reinforces the last paragraph of the article, in that leakage units should be an extra to full formal safety protection.—KAS



PE Mastermind*

P. F. TURNEY

Part Two

THIS month the entry section of the logic is to be described, together with the random number generator, the comparator and the master clock. Modifications for the "4 from 10 colour" facility are indicated where relevant.

THE ENTRY LOGIC

The colours forming a player's deduction are entered into the machine using double pole, changeover, push switches, but any common mechanical switch will generate contact noise that will persist until such time as the contacts settle down after operation. Instead of the output being the desired clean, well defined pulse, it will therefore initially comprise a sequence of noise impulses, called "bounce", which must be removed.

A set-reset latch is used to perform this function and a single TTL package is used for all six latches required for the colour push switches. This is the SN74118N, featuring six individual set inputs and a reset line common to all six latches. If any set ("L") input is taken low the respective "Q" output goes high and if the reset input is taken low all "Q" outputs are made low.

The circuit in Fig. 2.1 shows no button pressed, and the reset line, connected to pin 9, is held at logical zero through the push-to-break contacts of all six switches. All "Q" outputs are therefore in the zero state.

As soon as any button is pressed, the reset connection to earth is broken and a logical one appears on pin 9. This is followed by the application of a logical zero to one of the set inputs via the push-to-make contacts of the switch pressed, which in turn sets the "Q" output high.

ENCODING

Each of the six colours is represented by a three bit binary code. The codes chosen here are those representing the complements of the binary numbers 000, 001, 010, 011, 100 and 101 (0–5). The code for button S1 is therefore the complement of 000, namely 111, and so on.

The encoding is performed by the NOR gates IC12a, IC12b and IC11a of Fig. 2.1. As an example, if S4 is pressed pin 5 of IC10 goes high—sending encoder outputs S and T low to form the code 100.

COMPONENTS . . .

Integrated Circuits

IC1	SN7420N	IC11	SN7402N
IC2	SN7413N	IC12	SN7427N
IC3–6	SN7490N (4 off)	IC13	SN7486N
IC7–9	SN7454 (3 off)	IC14	SN7404N
IC10	SN74118N	IC15	SN7420N

Resistors

R1–R8, R10 1kΩ (9 off) R9 330Ω

Capacitors

C1–C5 0·1μF 10V ceramic
C6 100μF 10V elect

Switches

S1–S6	D.P.C.O. push button switch (6 off)
S7	D.P.C.O. push button switch
S8	Min. push-to-break push button switch

Miscellaneous

0·1in coppered Veroboard, size 95·25 × 431·8mm
12 Veropins. Multi-coloured single core wire.
Sockets for Veropins (see text)

Additions for "4 from 10" game

Integrated Circuits

IC50 SN7407N
IC51 SN7400N IC52 SN7454N

Resistors

R27–R30 1kΩ (4 off)

Switches

S9–S12 D.P.C.O. push button (4 off)
S13 4 pole latching push button (RS)

***MASTERMIND**

We apologise to Invicta Plastics Ltd., of Oadby, Leicester for our unauthorised use of their Registered Trade Mark MASTERMIND in last month's edition of Practical Electronics. It was not our intention to infringe their rights and we acknowledge their exclusive rights in the Mark. We are grateful to Invicta for allowing us to continue using their Trade Mark MASTERMIND for the remainder of the series.

The use of 000 (and its complement) as one of the codes requires special mention, since, as may be seen, the complement of this appears on lines R, S and T even with no button pressed! However, the advantages of using this particular code outweigh this disadvantage, which as we shall shortly see, is easily overcome.

THE INTERRUPT

Whenever a colour is entered, a signal called the "Z" signal (the interrupt) informs the machine that it may commence processing the entered colour. This important signal is generated by IC1 (Fig. 2.1), which functions as follows. When no button is pressed the lines R, S and T from the encoder are all high, but as soon as an entry is made on one of switches S2 to S6 a low will appear on at least one of lines R, S or T, sending pin 6 of IC1a low and thereby setting L6 of IC10. The output of this, pin 14, is the "Z" signal.

The output of switch S1 is taken to pin 9 of IC1b, so that whenever this is pressed the "Z" signal also appears, instructing the machine to read the 111 inherently available on lines R, S or T. This overcomes the disadvantage mentioned earlier.

It is worthwhile to note here that the "Z" signal is high only so long as one of the colour buttons is depressed. The additional circuitry for the "4 from 10 colour" game is shown in Fig. 2.2.

RANDOM NUMBER GENERATOR

A chain of four modulo six counters is used for this generator and the random properties are arranged as follows. The depression of the "Call" button (S7 in Fig. 2.3) connects a 22kHz clock (IC2a) combined with noise from the switch contacts to the counter input. This noise and the variability of switch depression time ensure that the generated codes are random.

The counters used are SN7490 decade types. The required count length of six is arranged by using the occurrence of the state 0110 (binary 6) to reset the counter to state 0000. The resulting count sequence is therefore 000, 001, 010, 011, 100 and 101 corresponding to the codes (in uncomplemented form) for the six colours.

The reset functions are conveniently implemented by connecting the appropriate counter outputs to the two "reset to zero" inputs of each 7490 package. The reset is activated when both of these inputs are taken to logical one (pins 2 and 3 of IC3–IC6), so that the outputs corresponding to the two ones in 110 are connected to these inputs.

The "4 from 10 colour" version requires that the count length of each counter be changed from 6 to 10. This is arranged, as shown in Fig. 2.4(a), by using a four pole change-over switch to disable one of the "reset to zero" inputs to each counter when in the "4 from 10" mode.

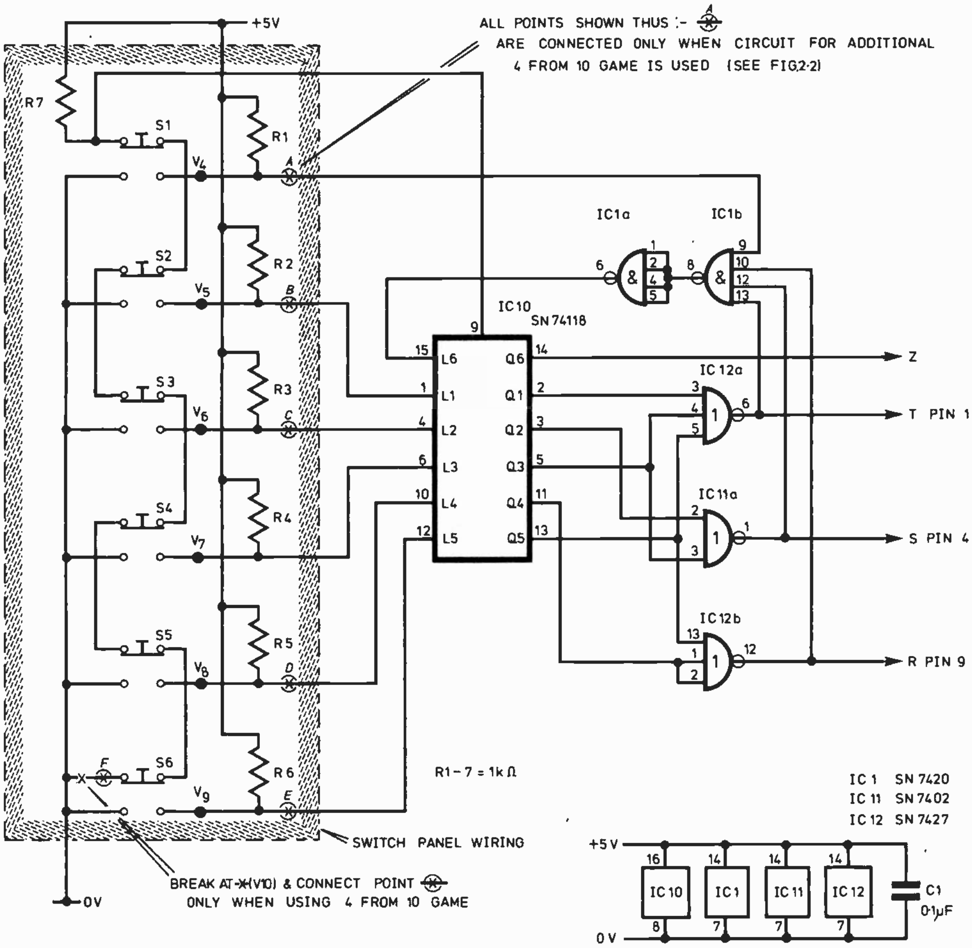


Fig. 2.1 Entry logic for the basic "4 from 6" game. Components within the shaded box are mounted on the switch panel

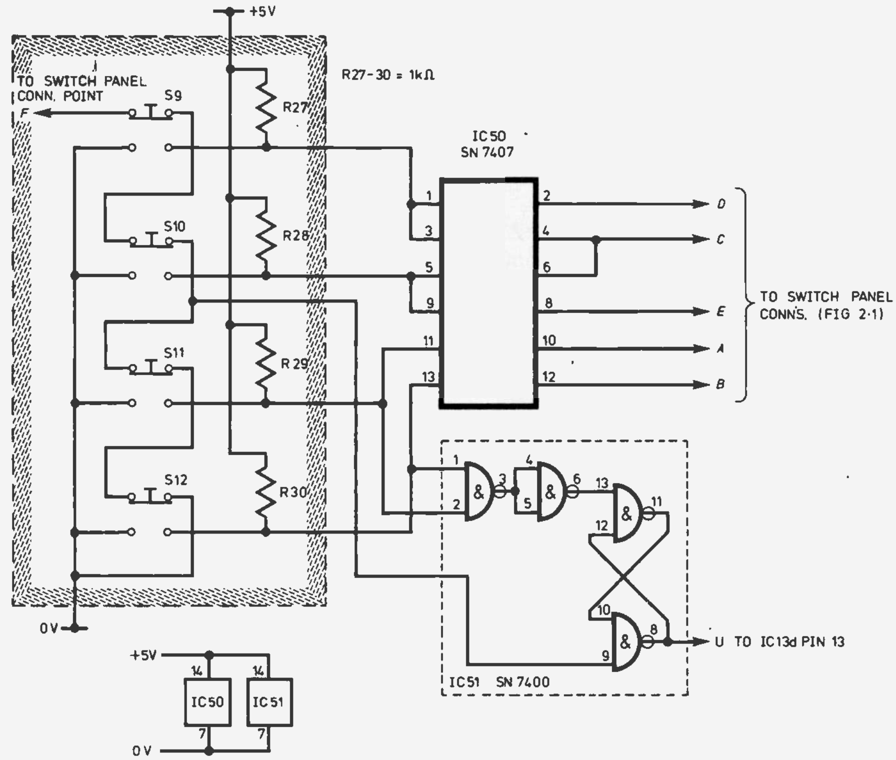


Fig. 2.2. Additional entry logic required for the "4 from 10" game. Switch panel mounted components are within the shaded box

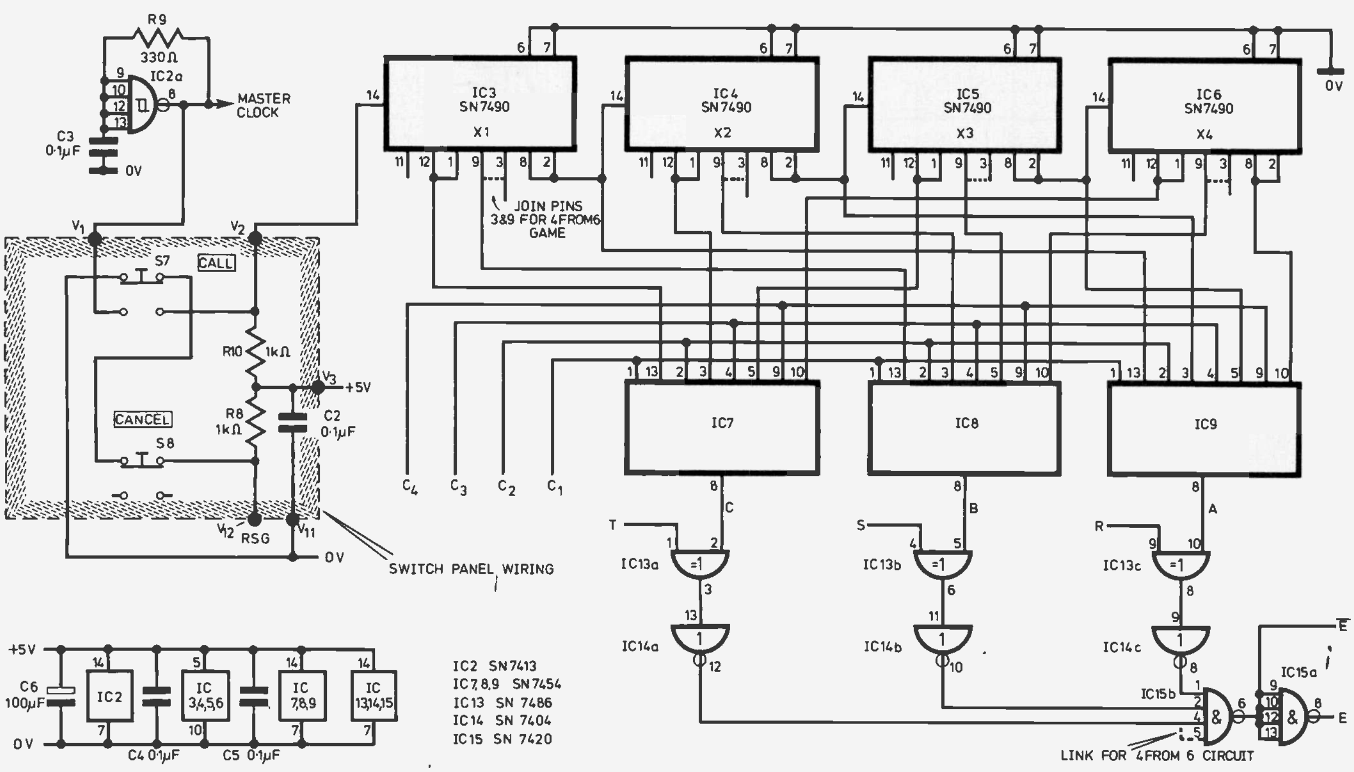


Fig 2.3. The random number generator (RNG) and reset line logic

An essential factor always to be considered with binary counters concerns their behaviour in invalid states (states other than those intended). If one of our counters were for some reason to enter one of these states the machine would be "cheating" the player, since it would, in the "4 from 6 colour" mode have a repertoire of more than six colours—a most undesirable state of affairs! However, here the invalid states are 110 and 111 and the reset function just described will never allow the counter to remain in one of these states and the count sequence will always be valid.

CODE SELECTION

Whenever the player enters a colour, the code produced on data lines R, S and T must undergo a process of comparison with each of the randomly generated codes stored in the generator. If, for convenience, the latter are called the "X codes", then the entered code on the data lines is compared with all four of these in turn, X1, X2, X3 and X4. A data selector is therefore used to select the required X code for comparison with the entry. This is formed by IC7, 8 and 9, which are type SN7454N AND-OR-INVERT packages.

Four timing signals, C_1–C_4 (to be described next month), select the appropriate X code, so that, as an example, when $C_2=1$, X2 will appear complemented on data lines ABC. Note that this complementation now means that the randomly generated codes are of the same form as those on lines RST from the encoder.

THE COMPARATOR

The code on lines ABC is compared with the entry on RST by a logical comparator, comprising IC13, 14 and 15, which produces two outputs, E and its inverse $\overline{E}$, called the equality signals. $E=1$ indicates that the two codes are identical.

IC13 is a type SN7486N quad two input EXCLUSIVE—OR package. These gates are each such that if the two inputs are different the output is high and is low if the two inputs are the same. An EXCLUSIVE-OR gate followed by inversion therefore acts as a two bit comparator. The six bit comparator here is formed from three such two bit sections with the outputs combined with an AND gate, IC15.

Changes to the data selector and the comparator necessary for the "4 from 10 colour" game are shown in Fig. 2.4(b).

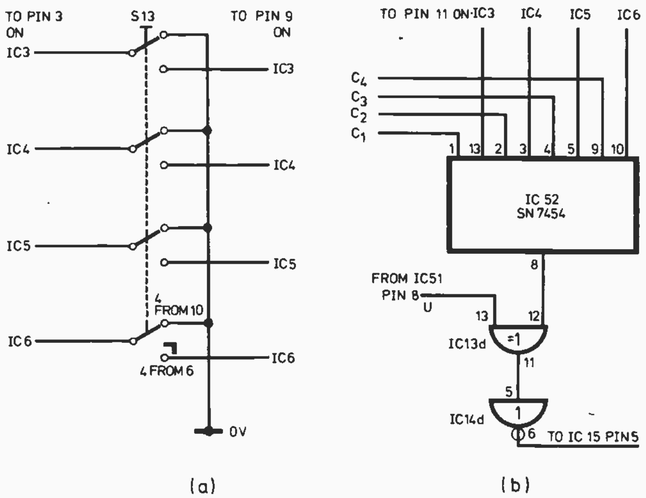
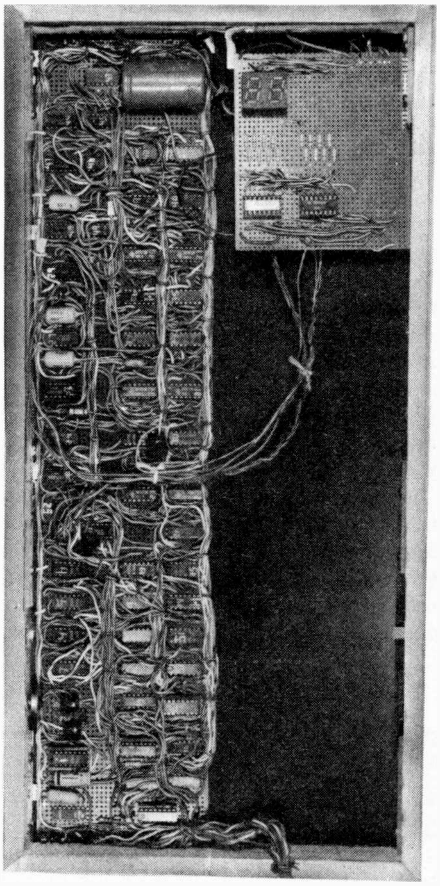


Fig. 2.4(a). A four pole latching changeover push switch wired as shown provides the options for either game (b) the changes necessary to the data selector and comparator for the "4 from 10" game

RESET LINE

In addition to "asking" for the generation of the random codes, the depression of the "Call" button, S7, is arranged to clear all the logic of any records of a previous game, or of "rubbish" when the machine is first switched on. This clear line, called RSG (reset game) is also activated by S8, the "cancel" button. The reset is affected by the appearance of a logical one on this line.



CONSTRUCTION

The wiring diagram of the switch panel is shown in Fig. 2.5 and it should be noted that the chassis is connected to the 5V rail and so must never come into contact with the 0V line. Approximately 20cm of excess wire is allowed for connection to the main logic board. Note that 12 switches are required if you are incorporating the "4 from 10 colour" game.

The colour buttons are painted so as to match the colours of the coloured pegs, which are red, green, black, yellow, blue and white in the standard, commercially available game.

When wiring up it is a good idea to adopt a wiring colour scheme, for example use a red wire for connections to the red entry button, and so on. Maintain a consistent scheme throughout the entire project, as this will considerably ease the tracing of wires in the future.

The logical circuits are divided between two boards, organised as follows:

(a) Board 1—comprising the circuit blocks (except the displays) of Fig. 1.2.

(b) Board 2—comprising the display circuits.

Since it would be impossible to attempt the complete description of board one in this issue a policy of construction has been arranged.

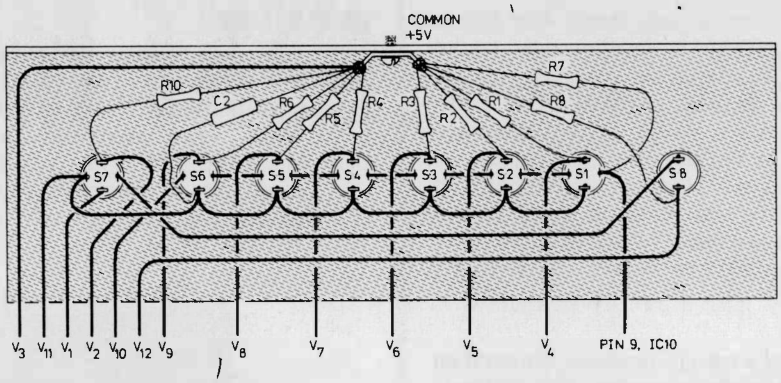


Fig. 2.5. Switch panel wiring for the "4 from 6" game. The V references are Veropins on the main board shown in Fig. 2.6

Each month a diagram illustrating the positions of the relevant i.c.s on the board is to be presented. These will not show the point to point wiring as this is too complex, and must therefore be completed with the aid of the appropriate circuit diagrams. It may be mentioned that each month's construction occupies a reasonably self-contained section of the board.

Fig. 2.6 shows the positions of the i.c.s described in this article and their associated decoupling components. Note carefully the situation of the power rails. Package density on this board is high so do not be tempted to alter their positions, otherwise remaining circuits might not fit on.

In the prototype i.c. sockets were used with the most expensive i.c.s, safeguarding the manufacturers guarantees. Where sockets are not used the most sensible procedure is to firstly position the particular i.c. on the board without soldering it in, complete all connections to it and finally solder in those of its pins to which connections have been made. Making power supply connections is always a good starting point. Number each i.c. as soon as connections to it are completed.

UNCONNECTED LEADS

There are signal connections at the end of this month's construction that cannot be completed until subsequent sections of the logic have been described. It is advisable not to solder in the known end of such leads as this will leave a rather confusing array of loose ends—enough to unsettle the neatest of constructors! The labelling of these connections on all circuit diagrams will allow them to be connected unambiguously when they are required.

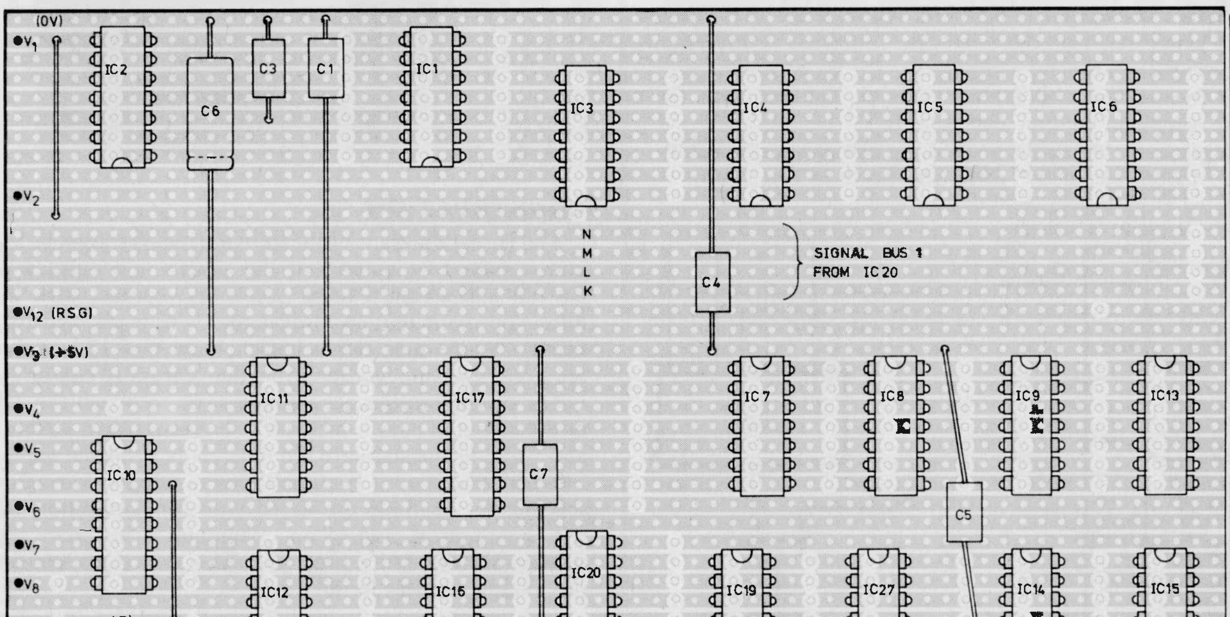


Fig. 2.6. Prototype component layout for one third of the main board (Section 'A' on photograph). Since point to point wiring here is too dense for illustration it is left to constructors to work from the appropriate circuit diagrams

VERO PINS

Connections to and from the boards are made via Veropins, with Fig. 2.6 showing the location of those pins for connections to the switch panel. The wires from this panel are not soldered to these pins yet, as this would make it almost completely impossible to wire up the main board. Instead these connections are made using "flying sockets" which sleeve over the pins and allow easy removal after testing. (If such sockets prove difficult to obtain, Soldercon i.c. sockets may be used instead). When the project is finally completed these sockets can be soldered to the pins to give a permanent and reliable connection.

The three extra i.c.s for the "4 from 10 colour" game can be included as follows. IC50 and 51 can be mounted on a small additional Veroboard located beneath the switch panel, whilst IC52 can be positioned on board 1 between IC17 and 7. The changeover switch may be mounted on the peg-board above board 1.

TESTING

There are two basic ways of checking sequential logic circuits, namely dynamic and static testing. In the former the test procedure is accomplished at the full operating speed of the system, requiring the use of relatively high speed test equipment. In the latter the testing is performed on a slow, step by step basis, so that each operation may be verified using a simple logic probe or the low voltage (approximately 5V) scale of a multimeter. This unit may be tested using the last approach.

When partially completed digital systems are checked, an important point to bear in mind is that unconnected TTL inputs behave as if a logical one is applied to them, and will often need to be grounded before a test may be made. A test schedule follows:

(a) Temporarily connect the switch panel, as described, and check that all six latches of IC10 are in the zero state. Press each of the entry buttons in turn and verify that the corresponding "Q" output goes high for as long as the button is held down, and that the correct complemented code appears on lines RST. When no button or S1 is pressed these lines should read 111. The "Z" signal, IC10 pin 14, should appear whenever any button is pressed, irrespective of which one.

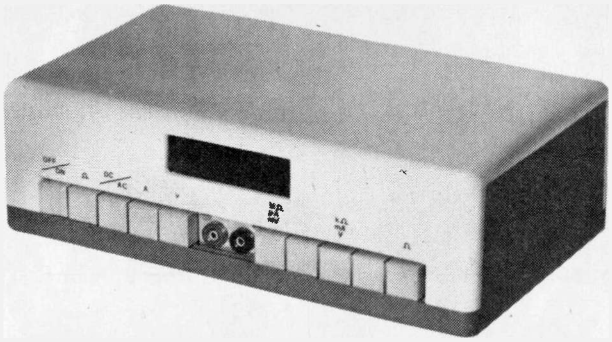
(b) Check that the operation of the "Call" button will summon an unpredictable sequence of four codes in the random generator. The codes 111 and 110 should never occur.

(c) The data selector may be checked by connecting to ground all but one of the enable, or strobe lines (C_1–C_4). The complemented code from the location of the counter corresponding with the ungrounded strobe line should then appear on lines ABC. For example, if C_1, C_2 and C_3 are all connected to 0V, the complemented code X4 from IC6 will be on ABC.

(d) The action of the comparator can be tested by selecting one of the X codes, as described in (c) and then depressing the button corresponding to the colour code within the selected location, for example if X4 is selected and is found to contain the code 001, the depression of S2 will send E high and $\overline{E}$ low. If any other button is pressed E will remain low. Note that the button must be kept depressed throughout the duration of the test.

NEXT MONTH: Scoring logic and control circuits.

NEXT MONTH



DIGITAL MULTIMETER

An excellent project! Construction is made easy using the Siliconix LD130 i.c., when you build this battery powered multimeter.

All ranges are selected on an elegant rank of push-buttons to give, 1V to 1000V, and 1mA to 1A, with both measuring modes capable of a.c. or d.c. Resistance between 1kΩ and 10MΩ can also be measured.

Set to read voltage, the input impedance is 10MΩ. Readout is given on a three-digit (0·3 inch) l.e.d. display with over-range indication

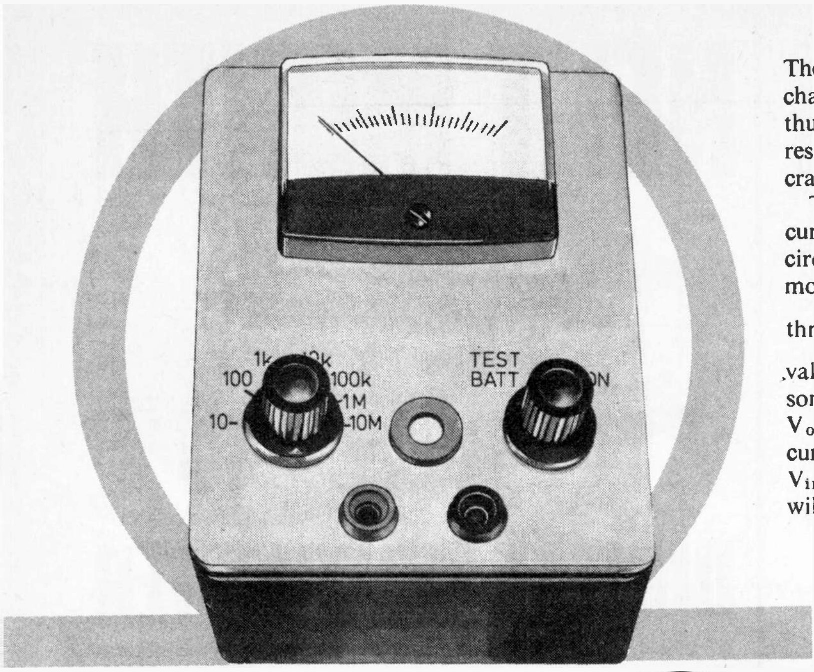
GUITAR SUSTAIN UNIT

To the guitar cognoscenti sustain is simply the artificial extension of a note. However, how this is electronically achieved can be the difference in pounds and performance. Some lower-priced, less elegant designs, can sound harsh and make chord sustain impossible so that you are limited to one or two notes. In contrast, we offer you the sophistication of non-distorting v.c.a. sustain which allows full chords at a price you can afford

Plus PE CHAMP and PE MASTERMIND *continued*

PRACTICAL ELECTRONICS

OUR OCTOBER ISSUE WILL BE ON SALE FRIDAY, SEPTEMBER 9, 1977



Therefore, changing the resistance by a factor of 2 does not change the current through the meter by the same factor, thus the familiar non-linearity is produced, with the high resistance end of the scale becoming progressively more cramped.

The solution to this problem is to maintain a constant current through Rx and to measure the voltage across it. The circuit of Fig. 2 shows an operational amplifier in the inverting mode. The −ve input is the virtual ground point, and current through R_{in} is simply $\frac{V_{in}}{R_{in}}$. Due to op. amp. action, this same value of current must now flow through Rf, V_{out} rising to some value to achieve this. If Rf is half the value of R_{in}, V_{out} will be half V_{in}. Thus the op. amp. acts as a constant current generator, feeding this constant through Rf. If R_{in} and V_{in} are fixed, and Rf is made the resistance under test, V_{out} will be directly proportional to Rf.

LINEAR OHMMETER

R. HARRIS

A LINEAR ohmmeter is an essential piece of equipment for accurate resistance measurement as there is none of the cramping found in the usual log. scaling of the meter. The circuit to be described will measure from 0Ω to 10MΩ in seven ranges. It is straightforward and fairly inexpensive to build, and would suit a newcomer to the hobby, whilst providing him with a very useful piece of test gear. With this fact in mind, a method is described of setting up the ohmmeter which requires no other test gear.

It is also useful for the experienced constructor, to complement the main multimeter, being easier to read and more accurate, and allowing the multimeter to be used just for current and voltage measurements. When one wishes to make a quick resistance check on a component it can be very frustrating if the only multimeter available is connected into a circuit under test.

PRINCIPLE OF OPERATION

The conventional multimeter circuit, good though it is in many respects, suffers from non-linearity of the scale on the resistances ranges. This is because of the nature of the circuit used (Fig. 1). Current through the meter is given by:

$$\frac{V}{Rx + Rv + Rm\ (\text{meter resistance})}$$

Giving the expression some values, for a 100μA meter movement and a 3V battery, Rv + Rm must be

$$\frac{3V}{100\mu A} = 30k\Omega$$

If we now make Rx 20kΩ, the meter will read

$$\frac{3V}{30k\Omega + 20k\Omega} = 60\mu A$$

If we now double the resistance, the meter reads

$$\frac{3V}{30k\Omega + 40k\Omega} = 42{\cdot}8\mu A$$

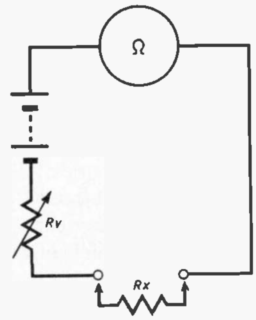


Fig. 1. Conventional ohmmeter circuit

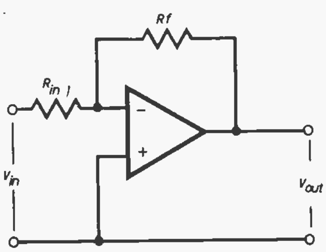


Fig. 2. Op. amp. in the inverting mode

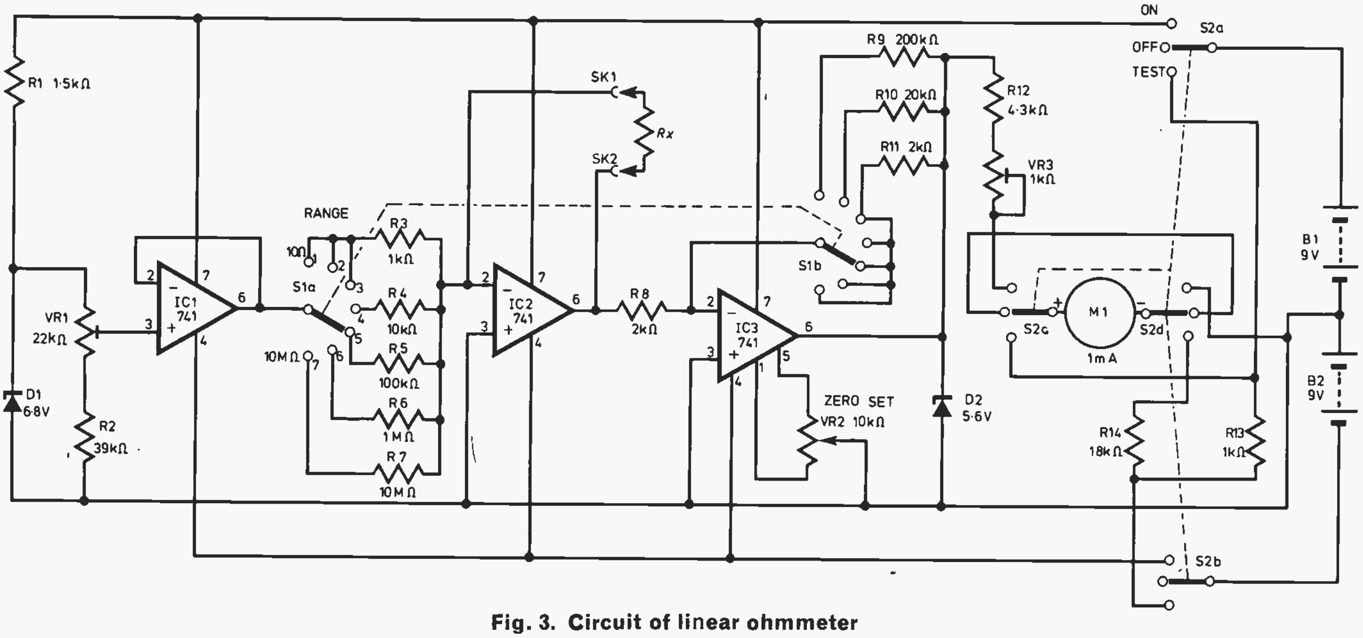


Fig. 3. Circuit of linear ohmmeter

COMPONENTS . . .

Resistors

R1	1·5kΩ 5% ¼W	
R2	39kΩ 5% ¼W	
R3	1kΩ	close tolerance ½W (see text)
R4	10kΩ	
R5	100kΩ	
R6	1MΩ	
R7	10MΩ	
R8	2kΩ	close tolerance ½W (see text)
R9	200kΩ	
R10	20kΩ	
R11	2kΩ	
R12	4·3kΩ 5% ¼W	
R13	1kΩ 5% ¼W	
R14	18kΩ 5% ¼W	

Potentiometers

VR1 22kΩ miniature skeleton preset
VR2 10kΩ linear
VR3 1kΩ miniature skeleton preset

Switches

S1 Miniature "Makaswitch" kit comprising: 1 shafting assembly; 2–12 way single pole wafers (end stop set to give seven ways) (RS Comps)
S2 1–4 pole, 3 way rotary switch

Semiconductors

IC1–IC3 741 (3 off)
D1 BZY88 6·8V
D2 BZY88 5·6V

Miscellaneous

Die-cast box with card slots 121 × 95 × 57mm (4¾in × 3¾in × 2¼in)
2 off 4mm sockets (one red, one black) (SK1, SK2)
2 off 4mm plugs " " " "
2 off croc. clips or clip-on probes
1 off flush mounting spindle lock
2 off PP3 batteries and connectors
Veroboard 0·1in pitch
Veropins if required
2 knobs
M1 1mA meter

THE CIRCUIT

The reference voltage is produced by R1 and D1 across VR1 and R2 (see Fig. 3). The slider of VR1 feeds the non inverting input of IC1, a 741 operating as a unity gain follower. This has an input resistance of several megohms and so does not load the reference voltage components. VR1 is adjusted to give an output of 5V from IC1. Five volts was chosen as a working voltage so that some deterioration of battery voltage could be tolerated before the instrument became inaccurate.

The 5V from IC1 is passed into IC2, the constant current generator, via the input resistor selected by S1a, and in the case of the five upper ranges the output of IC2 is 5V for the maximum value of Rx in that particular range. The two lower ranges share the 1kΩ resistor of the third range, the reason being to prevent drawing too much current from IC1. This means that the maximum output of IC2 on the 10Ω range is 50mV, and on the 100Ω range, 500mV. The output of IC2 is passed into IC3, the function of which is to multiply the output voltage of IC2 by a factor of 100, 10 or 1, depending on the range selected.

ZEROING

IC3 also has an offset potentiometer connected in usual 741 fashion, to zero the meter. Zeroing should be carried out with S1 set to 10 because the gain of IC3 is then at its greatest and any offset is more noticeable.

The output of IC3 is passed to a 1mA meter via R12 and VR3 which are the meter multiplier resistors. VR3 is set to make the meter read full scale with 5 volts across it. D2 is included so that during over-range conditions when the output of IC3 could rise to nearly the +ve supply voltage, the meter movement is not unduly overloaded.

In the "on" position of S2 the meter and multiplier resistors are connected between IC3 output and 0V and the batteries are connected to the circuit. In the "off" position power is removed and the meter movement shorted to prevent too much mechanical movement of the coil assembly.

In the test battery position the meter is connected across the batteries with R14 acting as a multiplier to give approximately f.s.d. with 18 volts applied, and R13 simulating the load of the circuit.

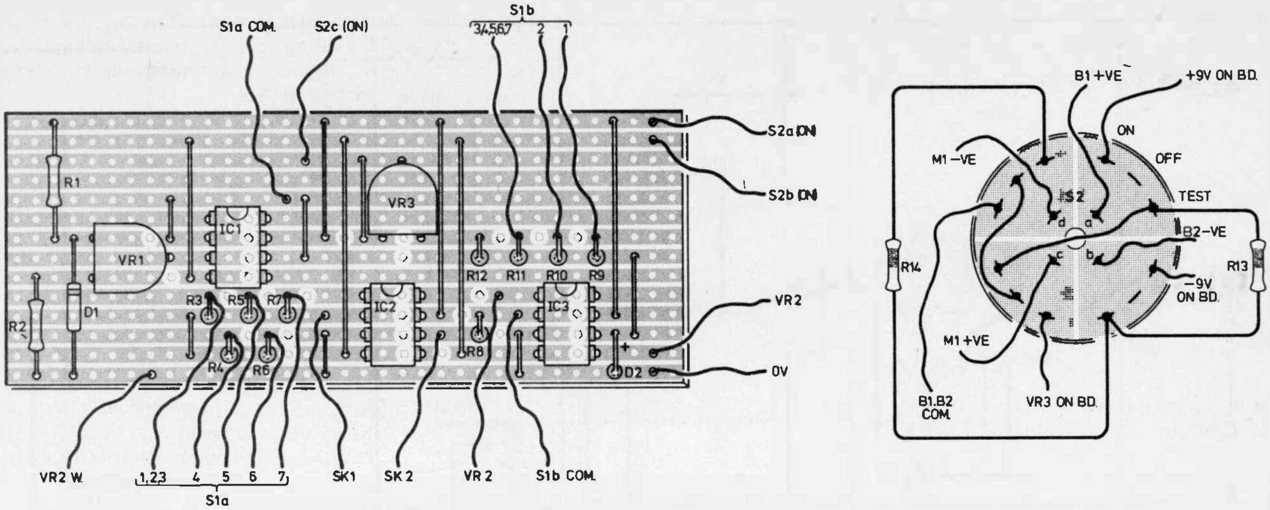


Fig. 4. Board layout and wiring details for switch S2

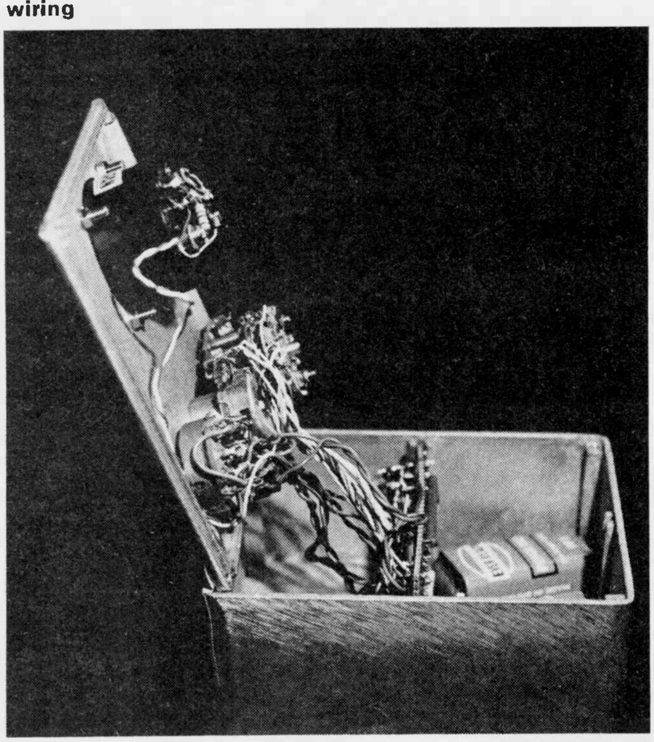
CONSTRUCTION

The instrument was built into a die cast box 121 × 95 × 57mm ($4\frac{3}{4} \times 3\frac{3}{4} \times 2\frac{1}{4}$in) but constructors may well have their own ideas about this.

The circuit itself is built onto a piece of Veroboard 86 × 38mm (3·4 × 1·5in) with a 0·1in hole spacing, and fits into the slots provided in the die cast box. Details are shown in the diagram (Fig. 4).

It is important to remember that in a measuring instrument such as this, final accuracy will only be as good as the components used, and therefore close tolerance resistors are necessary in the measuring section of the circuit. Two per cent resistors were used in the prototype (1 per cent or better could be used if desired, although it will probably be difficult to obtain a 10MΩ resistor for R7 closer than 5 per cent).

The prototype linear ohmmeter showing the range switch wiring



The circuit lends itself to modification, almost any op. amp. could be used, 741s are not imperative although the circuit board details will not necessarily be correct for another type. Because the meter is fed from an active source it too can be almost any sensitivity provided suitable multiplier resistors are used. 1mA was chosen as a compromise between the fragility of a 50 or 100µA movement, and the higher current required for a 5 or 10mA movement.

The front panel of the box was given a brushed finish by clamping it horizontally by the flanges in a vice, and brushing it in one direction with medium grade emery paper wrapped round a wooden block. The lettering was applied with a stencil and pen, although "Letraset" or similar could be used. Finally it was protected with two or three coats of clear lacquer.

SETTING UP

With a voltmeter across the output of IC1, adjust VR1 till the voltmeter reads 5V. Connect the voltmeter across the output of IC3, and with the 10Ω range selected, short the input sockets together. Adjust VR2 till the meter reads 0. With the voltmeter still across IC3 output, switch to the 1kΩ range and place a 1kΩ close tolerance resistor across the input terminals. Check that the voltmeter reads 5V and adjust VR3 to make the instrument meter read full scale.

If the constructor has no test gear available, the following method may be used to set up the ohmmeter. Obtain a mercury cell in known good condition, with an e.m.f. of 5V or less. Temporarily disconnect R12 from IC3 and place the cell across the meter and multiplier chain, observing polarity. Set VR3 for the meter to read in tenths of a milliamp, double the applied e.m.f., that is, for an e.m.f. of 3 volts the meter should read 0·6µA. Now connect R12 to the output of IC1 and adjust VR1 for full scale. Re-connect the meter circuitry and short the input terminals with S1 set to the 10Ω range. Adjust VR2 for zero reading.

Although VR2 has been made a panel mounting control, it will be found that once it has been set it will not be necessary to adjust it very often. For this reason it was flush mounted with a spindle locking device, a slot being cut in the spindle for screwdriver adjustment.

After a final check that the meter is operative on all ranges, and that the battery test position works, the instrument is ready for use. Note that the pointer works the correct way; low resistance on the left, high resistance on the right, unlike a conventional multimeter. ★

Strictly Instrumental

by K. Lenton-Smith

A well-tempered synthesiser keyboard should produce a well-tempered player! However, I suspect that many home constructed instruments suffer from instability and much of the enjoyment that could be derived from the finished product is lost because of the need to knob-twiddle constantly in an attempt to keep the brute in tune. If this is the case, the problem invariably centres round the VCO and voltages from the key contacts.

With most practical projects, nominal voltages will suffice: designed for 9V, it will still work happily on 8V or 10V. Electronic music requires terrifying accuracy for voltage-control of frequency if the instrument is to be acceptable. For example, 0·5V per octave is 42mV for each semitone interval and, as a semitone is divided into 100 cents in terms of tuning and there are those who can hear a 5 cent error, we are looking for accuracy of 2mV or so.

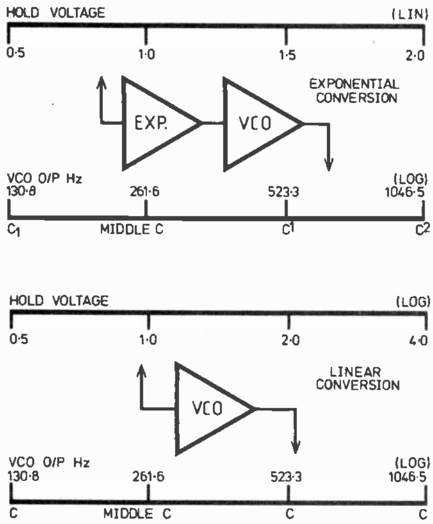
EQUAL VOLTAGE DIVISION

One type of VCO arrangement is to provide a linear series of voltages along the keyboard so that equal voltage increments appear between each semitone. With this system there is no difficulty in providing keyboard voltages. A chain of identical resistors is connected across a constant voltage source, "Span" being arranged by allowing a small adjustment of this voltage. Musical pitch increases on a logarithmic basis, although frequency doubling for each successive octave. Linear voltages thus have to be converted exponentially before being fed to the integrator and comparator.

The critical part of this scheme is the controlled current generator which provides the conversion and, because of the thermal sensitivity of transistors, some sort of "oven" is incorporated in the plan in order to stabilise the convertor as far as possible. Despite all precautions, frequency tends to be erratic and this is evident when playing with other instruments.

GEOMETRIC DIVISION

I recently played a Mini-Korg and decided to test this by tuning it to my Hammond immediately it was switched



Comparing log and linear conversion of control voltages to musical pitches

on. It stayed in perfect tune for several hours of use, measured against the rigid tuning of rotary magnetic generators. I have no circuitry for the Korg, nor was I in a position to look into the "works" at the time, but I guess that a different approach is used in this and other synthesisers.

By arranging that the keyboard control provides a geometric (or log) series of voltages, converted on a linear basis in the VCO, the problems surrounding the current generator can be obviated. Doubling the keyboard voltage results in frequency doubling (or raising pitch by one octave).

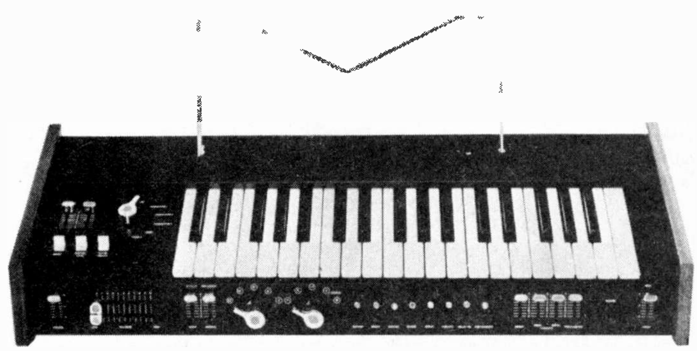
From the reliability aspect, it would seem better to adopt this system in order to dispense with the convertor: the logarithmic keyboard can be arranged with presets and octave switching contacts or CMOS devices. Voltage control from sources other than the keyboard is still available with this method, of course. Provided that thought is given to the possible temperature sensitivity of passive components and that a stabilised power supply is considered to be a *sine qua non*, the instrument will only need to be tuned once—during initial setting up. The only qualification is that rough treatment and slack presets will upset things, but the remedy is fairly obvious!

Exponential convertors cause no problems in other modules, such as transient generators or VCFs: they are only concerned with processing existing frequencies.

UPPER MANUAL

Readers' letters indicate that there is considerable interest in organs. An excellent introductory text for those seeking a broad spectrum understanding of electronic organs and their workings is the revised Musical Instrument Manual, from Pitman, written by Alan Douglas, costs £7·50 and has become a standard work over the years. It is not a constructional book, nor does it contain circuitry of a complete organ, but is a most useful reference manual for those wishing to increase their background knowledge. As a guide to theory and design, it offers chapters that point the way for the self-designed instrument: parts of commercial circuits and experimental methods appear in the book.

The approach by designers over the years to producing instruments capable of serious musical interpretation is probably this book's theme. It can be recommended to anyone contemplating an organ with conventional voices for light entertainment.



The Mini-Korg synthesiser

MARKET PLACE

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned. All quoted prices are those at the time of going to press.

DIGITAL MULTIMETER

A new, low-cost, multi-function digital multimeter intended for both the amateur and professional engineer is the latest product from **Fluke International Co.**, to be marketed by **ITT Instrument Services.**

The Fluke Model 8020A digital multimeter has been designed to withstand the rigours of frequent field use. It incorporates a 3½-digit liquid crystal display of ½in character height, and has the various function and range push-button selectors arranged down one side of the unit to allow one-handed operation.

A custom designed CMOS/LSI circuit provides analogue-to-digital conversion and display decoding and drive. Together, the use of the LSI circuit and LCD help to ensure maximum battery life from the small 9V alkaline cell, which consequently gives up to 200 hours operation.

Standard features of the 8020A include auto-zero and auto-polarity, and the instrument has a total of 26 ranges and six functions. These include ten voltage ranges, from 100μV to 1kV d.c. or 750V a.c. with a basic d.c. accuracy of $\pm$0·25%. There are six resistance ranges, from 100 milliohms to 20 megohms with a basic accuracy of $\pm$0·2%; three ranges for diode test functions, of 2 kilohms, 200 kilohms and 20 megohms; and two conductance ranges.

With the inclusion of the diode test and conductance functions, the 8020A offers, it is claimed, far more comprehensive capabilities than those normally associated with low cost, portable analogue or digital instrumentation.

In the case of the diode test function, for example, sufficient voltage is supplied to turn on a semiconductor junction, so that diodes and transistors can be tested for the correct forward bias voltage in situ. Individual paralleled resistors can also be checked, without the need to disconnect them from circuit.

Two conductance ranges are available. One enables the measurement of resistances as high as 10,000 megohms and thus makes possible the checking of resistance values in high voltage dividers, leakage in capacitors, printed circuits, cables and insulators, etc. The second conductance range measures over the equivalent resistance range from 500 ohms to 1 megohm, and provides the means of directly measuring transistor beta.

Extensive overload protection is a built-in feature and the instrument is protected against accidental or unknown input conditions up to a continuous 300V d.c. or r.m.s. a.c. on all functions and ranges, and against transients up to 6kV. The range of accessories available extends its capabilities into the fields of temperature, r.f., high voltage and current measurement.

Two r.f. probes can be provided. Model 82RF enables the measurement of high frequency r.f. voltages from 100kHz to 500MHz, with an accuracy of 1dB up to 100MHz and 3dB from 200MHz to 500MHz. Model 81RF may be used for frequencies from 100kHz to 100MHz, and has an overall accuracy of 1dB.

The high voltage probe, model 80K-40, is a general purpose accessory for measurements up to 40kV d.c. or 28kV r.m.s. a.c. With a guaranteed probe accuracy of 1% at 25,000V, the 80K-40 is invaluable in TV servicing applications in which the establishment of precise h.t. and e.h.t. values are essential.

To convert the 8020A into an accurate thermometer, the 80T-150 universal temperature probe can be used. The operational temperature range of the probe is -50°C to $+150$°C, and the instantaneous temperature is registered at 1mV d.c./degree.

For high-current measurements, the 801-600 clamp-on current transformer connects directly into the 8020A, as an interface to the circuit being checked. The transformer extends the a.c. current handling capability of the 8020A to 600A, and allows accurate measurements to be made without the need to break the circuit under test.

Other accessories include a battery eliminator and a protective carrying case containing test lead compartments.

The basic price of the Fluke 8020A digital multimeter is £99, the accessories costing extra. Further details, if required, can be obtained from **Fluke International Corp., Dept. P.E., Garnett Close, Watford, WD2 4TT.**

HALL EFFECT MICROSWITCHES

Utilising Hall effect i.c.s to give bounce free switching, **Electronic Engineering Services** have just announced three new ranges of contactless microswitches.

These long life, high reliability microswitches require a maximum operating force of less than 1·2N and, under constant environmental conditions, have a life in excess of 10^8 operations.

The output is derived from two open collector transistors which generate a static uniphase or antiphase signal and, with rise and fall times of less than 0·5μs, switching currents up to 500mA and operating voltages of between 4·5V and 27V, these microswitches will directly interface with all data logic systems.

Designated CM1, 2 and 3, these three sizes of microswitch are interchangeable with standard mechanical versions, have an operating temperature of -25°C to $+70$°C, are available with either push-on or pcb terminations and comply with the application and environmental requirements of classes HSF (DIN 40 040) and IP40 respectively.

Further information on the CM1, 2 and 3 microswitches can be obtained from **Electronic Engineering Services Ltd., 98 Croydon Road, Penge, London SE20 7AB.**

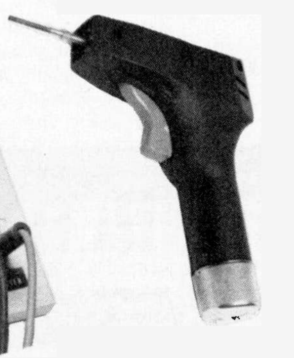
POWER WRAPPER

A budget-priced battery powered wire wrapping gun is the latest product from **Vero Systems (Electronic) Ltd.** This, it is claimed, brings powered wire wrapping within the scope of the development laboratory or serviceman for the first time, since its price is reckoned to be only one-third that of other power tools.

The tool is designed for standard mini-wrap terminals (0·6mm square), and uses 0·25mm wire. A bit and sleeve to give a "modified" wrap are fitted as standard, and there is a built-in backforce device to prevent over-wrapping. Rechargeable nickel cadmium batteries and a battery charger are also available.

The tool is supplied, excluding batteries, at £32·50 and is available from **Vero Systems (Electronic) Ltd., 362a Spring Road, Sholing, Southampton, Hants.**

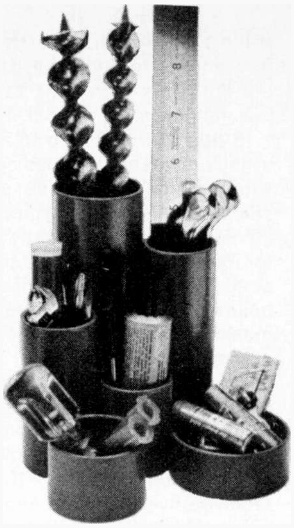
The Fluke 8020A Digital Multimeter



Wire Wrapper from Vero

Hall Effect Switches from Electronic Engineering Services

National Semiconductor combined Digital Watch/Calculator Module



Tidy Tubs from Platignum

CALCULATOR/WATCH MODULE

A set of complementary metal oxide semiconductor LSI devices designed for use in calculator, wristwatch or control applications is now available from **National Semiconductor.**

Using this set of programmable, calculator-oriented processor chips, designated the MM58101 (ROM element) and MM58102 (memory and processor), National have fabricated a combined scientific slide-rule calculator and digital watch module, complete with keyboard and liquid crystal display.

The scientific calculator and watch module is claimed to be the first to use liquid crystal display technology. In addition to presenting a six digit continuous display of hours-minutes-seconds, the unit also has a month/date calendar, AM indicator and dual night viewing lights. In the calculator mode, it employs algebraic logic, has full scientific notation, trig and log functions, store and recall memory, pi, powers of numbers, register exchange and reciprocals.

Hybrid construction is used to mount the chips on a small p.c.b., on which is also mounted a miniature 5 by 4 matrix keyboard and field effect LCD with ⅛inch high digits.

Thirty-six possible switch functions are available on the dual function keyboard. Normally in the numeric entry mode, a function key calls up the upper case functions such as natural logs and sine or cosine. Another key is pushed to place the watch module in the timekeeping mode. The six most significant digits are displayed for calculations, with switches on the side to call up the next six significant digits, as well as the calendar/date functions. Switching to the calculator mode from the timekeeping mode is done by pushing any digit key.

Unlike conventional digital watches there is no complicated procedure for setting time or date, since the calculator keyboard may be used instead. For example, the user can add or subtract seconds by merely pushing the plus or minus key and then the desired number of seconds. Similar procedures can be followed to set hours, minutes and days.

Also, unlike the standard digital watch, the watch-calculator module can be used to store numeric information unrelated to either calculations or time-keeping. For example, if a user wants to remember a telephone number or pricing on an item and has no paper, the number can be punched on the keyboard and entered into the calculator memory. There it will remain as long as there are live batteries in the module, or until the user calls it up and erases the information.

Full technical details of the MM58101 and MM58102 module can be obtained from **National Semiconductor UK Ltd., Dept. P.E., 19 Goldington Road, Bedford, MK40 3LF.**

PROBE

Off-the-shelf availability of the Chinaglia USIJET signal injector, is announced by **Alcon Instruments.** This pen-shaped probe is primarily intended for use in fault-finding and alignment checking in the radio and television areas, but has applications over a wide field including audio and communications markets.

The Usijet incorporates a blocking oscillator as the main signal generator, giving a basic 500kHz signal which is modulated at 1kHz for identification and demodulation check purposes. It is claimed that because of the waveform used the equipment produces harmonics detectable right up to 500MHz, very useful in many servicing applications.

Power consumption is 25mA from an internal 1·5V battery to give a 20V peak-to-peak output at the probe tip.

In use the equipment case is merely connected via a fly-lead to the "earth-line" of the item under test and the probe tip touched on the required point of the circuit under investigation. The Usijet can be used in "live" test conditions and the probe can cope with circuit voltages of up to 500V d.c., somewhat more than would normally be met in most practical circumstances.

The price, complete with earthing lead and instructions, is £11·55 inc. VAT. Further information can be obtained from: **Alcon Instruments Ltd., Dept. P.E., 19 Mulberry Walk, London SW3.**

STORAGE BINS

For many years the name **Platignum** has been associated with writing materials and drawing equipment. Now the Company has come up with a simple and effective idea that should find a home in many varied places.

Called Tidy Tubs, they are ideal for storing components, tools, such as side cutters, long-nose pliers and small screw drivers, in any one of six different size plastic tubs. Each Tub is fixed to its neighbour, forming one compact group.

A word of warning—if you find your Tidy Tubs have disappeared from your workbench or study, they make nice flower trays and are ideal for storing all those special ladies' trinkets that litter the dressing table.

Available in six different colours, the Platignum Tidy Tubs cost £1·50 each and should be obtainable from most good stores and stationers.

CATALOGUES RECEIVED

A new components catalogue and a databook have been received this month which we can recommend to our readers.

The latest Marshall's Catalogue takes on a new format, 32 large size pages, containing many new items including a revamped section on Microprocessors and support devices.

And how's this for progress during the age of spiralling prices, **Marshall's** have actually "Reduced" the cost of their catalogue from 55p (168 small pages) post paid to **35p** post paid. The price to callers is **25p,** the old price was 40p.

Copies of the Marshall's Components Catalogue can be obtained from any of their shops or direct from **A. Marshall (London) Ltd., Dept. P.E., 42 Cricklewood Broadway, London NW2 3ET.**

At the time of going to press, Marshall's are caught up in the Cricklewood postal dispute and readers are advised to order through their Glasgow and Bristol branches.

Now available from Jermyn Distribution is the new 400 page National Semiconductor MOS/LSI Databook. Divided into 14 sections and commencing with Clocks and Counters/Timers it also includes details on Electronic Organ and TV Circuits, A/D converters, Communications/CB Radio Circuits as well as Watches, Calculators and Keyboard Encoders.

Copies of the National Semiconductor MOS/LSI Databook, price £5·95, can be obtained from **Jermyn Distribution, Dept. P.E., Sevenoaks, Kent.**

INDUSTRY NOTEBOOK

By Nexus

BRITAIN LOOKS WEST

Of all the European nations, Britain is the leading investor in the United States according to figures published by the US Department of Commerce. Second place, but a long way behind, is the Netherlands followed by Switzerland, France, Germany and Sweden.

The attractions of the USA are almost self-evident. The richest market in the world, a less onerous tax structure, high levels of productivity and better profits. The push factor, driving investment out of Britain, is high taxation, a squeeze on profits, constant government meddling, low productivity.

Who are the traitors investing overseas? Are they shady speculators? Wide boys? Currency manipulators? The biggest British investor in the United States this decade has been government-controlled BP.

Turning now to electronics, the great Wescon exhibition in San Francisco opening in September was already overbooked with a waiting list of 100 booths by last June. In contrast, the London Electronic Components Show was disappointing in both number of exhibitors and overall attendance.

No, I'm not knocking Britain. Only pointing out the difference between an environment where effort is rewarded and one where it isn't. BP in the USA earns us a lot of dollars. So do the operations of companies like GEC and Plessey and dozens of others overseas. When wealth-creation becomes respectable again in Britain, as it must, there will be plenty of investment here, too.

FREE ENERGY

Alternative energy sources are going to be very good business. Post Office trials on v.h.f. telephone links powered by solar cells have already shown that even in the bleak British winter there is sufficient free energy to keep the batteries topped up. And this with cells of comparatively low efficiency.

IBM is now claiming to have developed a gallium arsenide solar cell with a conversion efficiency of 22 per cent. Early silicon devices were typically 10 per cent efficient and more recently silicon devices for terrestrial use have achieved 18 per cent. These new levels of efficiency (IBM believe they can push up to the theoretical maximum of 27 per cent) could transform present thinking.

At a symposium staged by the Royal Institute of Navigation last December, Colin Mudie, a yacht designer and naval architect, suggested that a 400ft long vessel operating on the edge of the tropics could receive five million kilowatt-hours of energy from the sun per year, sufficient to provide a quarter of the total propulsion power for a ship that length. He didn't think much of this and was proposing sails (wind power) as a better method of helping out on the cost of oil and its conservation. But the big increase in efficiency resulting from the IBM developments would transform his solar energy figures.

Mudie and other workers in the field of naval propulsion are not suggesting doing away with conventional engines. They would remain but be supplemented by other energy inputs. If sails were used they would be in the form of scientifically designed aerofoils controlled positionally by hydraulic actuators, position being determined by electronic computer.

NUMBERS GAME

Gone are the days when I used to brag to acquaintances that my electronic watch (then still a novelty) had the equivalent of 312 transistors in a single chip. And today I'd feel rather foolish in admitting that it cost £80.

Even so, I was knocked back when I was sent advance information on Hewlett-Packard's package which for want of a better name they are calling a wrist instrument because it is more than a wrist watch, having over three dozen different functions including a calculator, a memory, a 200 year calendar, a timer, a stopwatch, an ordinary watch and an alarm. It has 28 keys and a nine-digit display and inside, including the controlling microcomputer, are the equivalent of 38,000 transistors.

The only area where I can still score is on price. The H-P wrist instrument costs 650 dollars. But for that price you could hand it down to your great-great-great grandchild who would still find the calendar accurate. I have to adjust mine every month when there are less than 31 days.

The H-P LSI package may, however, soon be out of date. At a recent IEE meeting, Derek Roberts of Plessey Microsystems was saying that by 1980 we could expect to see the million-device chip!

And while on the numbers game I might mention the increasing complexity of simple (well, they used to be) wiring looms on aircraft. Looking at three generations of aircraft, the Starfighter had 8,000 test points, the Phantom 15,000 and now the MRCA Tornado has 40,000. Cable inspection by computerised automatic testing takes four hours. A good operator with an Avometer and Megger testing for continuity and insulation resistance would spend 10 weeks on the same task.

+7

READY TO GO

It is 10 years since the short-range *Seawolf* self-defence system for the Royal Navy was conceived. Now, after two years of intensive trials in *HMS Penelope*, it is ready for production.

Intruders into naval air space would be wise to keep their distance. A target rocket travelling at over twice the speed of sound was destroyed first shot. Looking for an even more difficult target it was decided to try *Seawolf* against an ordinary 4·5-inch shell. It seems that nobody had thought of doing such a thing before. *Seawolf* attacked at a closing speed of better than Mach 2·5 and engaged successfully.

So *Seawolf* has proved itself as an anti-missile missile. No human operator could hope to exercise control at such speeds of engagement so everything is automatic from threat evaluation to kill recording. Like most big projects *Seawolf* has been a joint development with BAC building the missile, Vickers the launchers and Marconi Radar Systems main contractor on electronics with Ferranti as a major subcontractor.

The first production system is to go in *HMS Broadsword* a Type 22 frigate, now being fitted out in Yarrow's Yard, Glasgow.

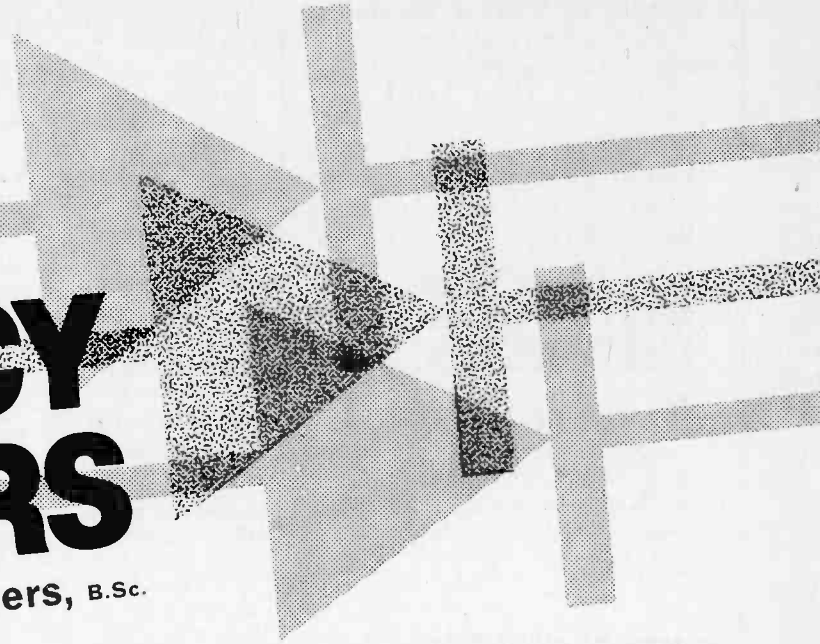
DISTRIBUTORS GAIN GROUND

Forecasts a few years ago that the proliferation of small component distribution companies would cease and just a few big firms would survive have been confounded by events. There are still over 100 in the UK and all seem to be making a living if not a fortune.

What's more, their trade association AFDEC is projecting over 20 per cent growth in the value of component sales through these outlets. In 1978 over £50 million worth of active components will be bought through distributors and over £33 million worth of passive components. The total UK market for components next year is estimated at £254 million for active devices and £244 million for passives.

There will be some price inflation but AFDEC experts say this will be only 5 per cent for active devices, 10 per cent for passive, and thus well below the current general inflation rate. So, relatively, components are still getting cheaper.

HIGH ACCURACY RECTIFIERS



D. F. Bowers, B.Sc.

THE diode has been with us for a very long time, and various types have been used for a multitude of purposes. Still the most common application of diodes is rectification or detection.

Modern diodes of the silicon type are very useful for rectifying medium potentials over a wide range of currents, but at low voltages the forward voltage drop begins to dwarf the applied signal. This voltage drop is in any case dependent on temperature, but at low currents can also vary (logarithmically) with the current through the device.

For a silicon diode the drop is of the order of 0·7V for currents in the milliampere range. Whilst diodes of the germanium or metal oxide type have a lower intrinsic drop, their behaviour is less well defined and their bulk resistance much greater. These diodes also have much higher reverse leakage currents than silicon types.

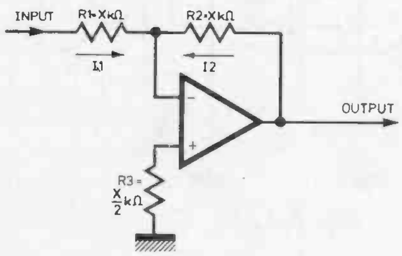


Fig. 1

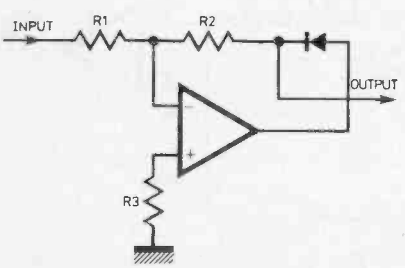


Fig. 2

ACTIVE RECTIFIERS

For low-level audio and control measurements, what is needed is an active rectifier which is free from the aforementioned problems, but is also cheap. This article describes the use of operational amplifiers in this application, showing the numerous possible configurations. The circuits are all designed around the 741 integrated circuit for economy, but faster amplifiers can be used if necessary. All diodes are silicon types, 1N4148 or similar, and should be of good quality to ensure low reverse leakage.

OPERATIONAL AMPLIFIER BASICS

We do not propose to deal with the theory of op. amps. here, but one aspect is particularly useful to us. A unity gain inverting amplifier based on an op. amp. is shown in Fig. 1. The output moves to keep the inverting input at the same potential as the non-inverting input, which is earthed (through a resistor, for reasons of offset). Hence the currents through R1 and R2 must be equal and opposite, and since the resistors are equal in value the voltage drops must also be equal and opposite.

If the circuit is rearranged as shown in Fig. 2, the situation remains the same on negative input excursions, with the op. amp. output settling to one diode voltage-drop (about 0·7V) above the actual output. However, for positive input excursions the diode prevents the amplifier from maintaining the inverting input at earth potential, and feedthrough occurs.

This is overcome by inserting another feedback network as shown in Fig. 3. Output 1 consists of the positive excursions and Output 2 the negative excursions, settling to earth in between.

INTEGRATOR

Either output of Fig. 3 can be fed to an integrator such as that shown in Fig. 4, to produce an output proportional to the mean signal level. The values given are usable down to about 100Hz, but the capacitor value may be increased proportionally for lower frequencies, or decreased to obtain a faster attack (with higher ripple). It should be noted that the tracking performance of this type of circuit is mostly dependent on the quality of the op. amp., and not upon the diode voltage drop.

The feedback resistor, R_{fb} (which should be the same value as R_{in}) is necessary to ensure that the input offset voltage of the op. amp. does not cause the output to saturate. Output offset can be improved by at least an order of magnitude by trimming the 741 in the usual manner by means of the offset null potentiometer.

FULL WAVE RECTIFIER

The circuit of Fig. 4 gives a fair indication of the average value of a complete waveform only if it is symmetrical. If instead we differentially amplify both outputs as in Fig. 5 we have an "ideal" full wave rectifier, shown here producing a triangular waveform from a sawtooth one.

The low values of load resistors on IC1 and high input resistors on IC2 are necessary to prevent the potential on the inverting input of IC2 from interfering with the rectification process. Following this circuit with the integrator will produce an output proportional to the true mean of the input waveform.

THE "PSEUDO-DIFFERENTIAL" CIRCUIT

A simpler circuit providing a positive full-wave rectified output is shown in Fig. 6. For positive input excursions the output of IC1 goes negative and diode D2 conducts. IC1 therefore acts as an inverting amplifier and a current flows out of the inverting input of IC2, which is maintained at virtual earth by R_{fb}. A current flows into this input via R_B, so the net current out of the inverting input of IC2 is $I_{RA} - I_{RB}$. Since IC1 has unity gain, these currents are proportional to the values of R_A and R_B.

For negative input excursions, the output of IC1 goes positive and D1 conducts, so ensuring the maintenance of the virtual earth at the inverting input of IC1. D2 is now reverse biased, therefore no current flows through R_A since it is connected (in series with a 22kΩ resistor) between two virtual earths. The net current from the inverting input of IC2 flows through R_B alone. If $R_A = \frac{1}{2}R_B$, the outputs of IC2 will thus be equal for positive and negative excursions, and the overall gain of the system will be $= R_{fb}/R_B$. For unity gain, R_{fb} in Fig. 6 should be 13·6kΩ.

If a mean value output is required, a capacitor can be added across R_{fb}, transforming IC2 into the integrator circuit of Fig. 4. The effective value of R_{in} is 13·6kΩ.

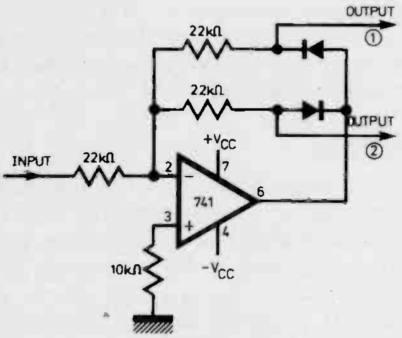


Fig. 3

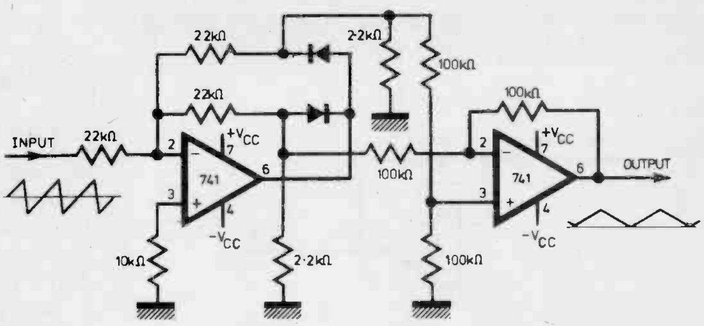


Fig. 5

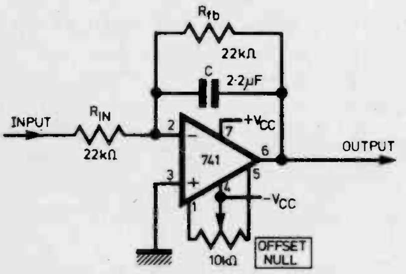


Fig. 4

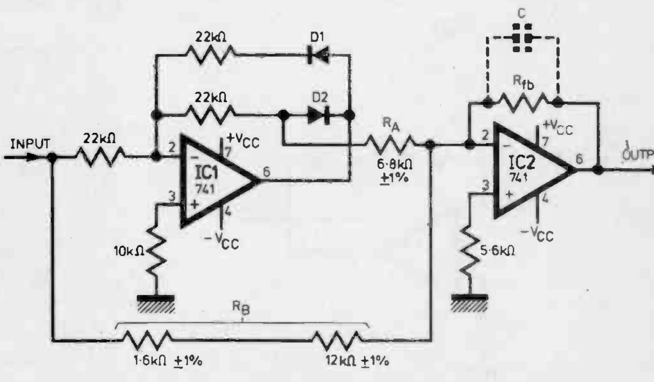


Fig. 6

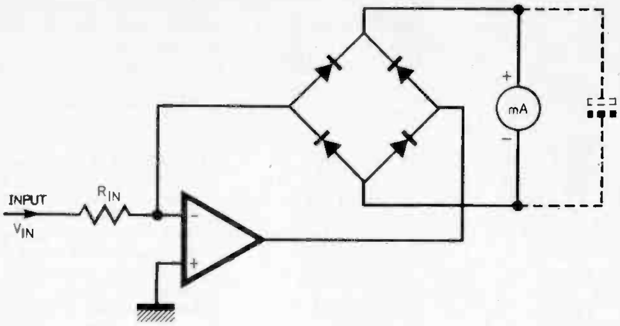


Fig. 7

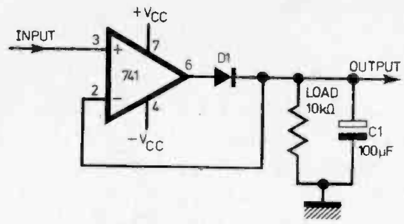


Fig. 8

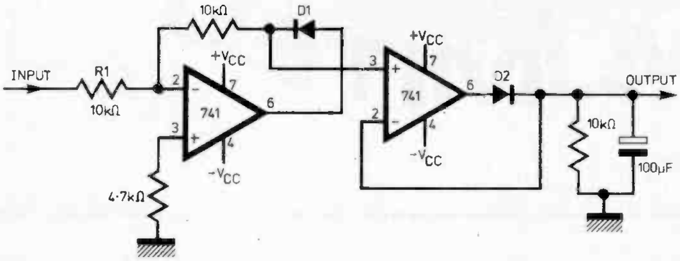


Fig. 9

It should be mentioned that, by reducing the value of the input resistor, all the rectifiers described so far can provide gain as well as rectification.

PEAK LEVEL MONITORING

The rectifier configuration commonly employed in audio millivoltmeters is illustrated in Fig. 7. Essentially it is based upon the same principles as have already been discussed, and relies upon the fact that at any instant, the current in the feedback network equals V_{in}/R_{in}. Neglecting diode leakage, all this current must flow through the meter, and because of the bridge arrangement must always flow in the same direction. Due to the mechanical inertia of the movement, the meter will follow the mean of the input voltage, but connecting a large capacitor across the meter will give the circuit peak reading characteristics.

The major disadvantages of this method are a very slow attack, and the inability of the circuit to provide an output voltage that can be used to control other circuits. The circuit to be described next is capable of overcoming both these disadvantages.

A general circuit for an ideal peak value detector is shown in Fig. 8. For positive input excursions, the inverting input of the op. amp. is made to follow the non-inverting input. If the input signal drops momentarily, the inverting input is held at its previous potential by C1, and the op. amp. output goes hard negative, thus biasing off D1.

The attack of this circuit is limited only by the forward diode resistance and the op. amp. output impedance, and to a limited extent by its slew rate.

This detector can be coupled to the output of the circuit of Fig. 5 to produce an ideal peak value monitor. With the values shown, the decay time will be about one second. This can be changed by altering the value of C1. If the output is used to drive a voltmeter, the impedance of the latter can be used as the load. The decay time will then depend upon the product of this impedance and C1.

ECONOMICAL CIRCUIT

If the peak rectifier can be fed from a low impedance source, or a known impedance (such as a common emitter transistor stage) a neat trick can be used to reduce the number of op. amps. required. The circuit of Fig. 9 is a full-wave peak detector which must either be fed from a source of significantly lower impedance than R1, or must have R1 reduced in value to allow for the source impedance.

On negative input excursions, IC1 feeds inverted signals to IC2, but on positive input excursions D1 isolates IC1 from the circuit, and the input signal is fed directly to the detector. The detector, based on IC2, is the same as that of Fig. 8.

INPUT ISOLATION

While all the circuits shown have d.c. coupled inputs, if any standing d.c. potential is present on the source, a capacitor must be inserted in the input circuit. This capacitor must have a low impedance at the lowest frequency used, in comparison with the input resistor.

For very low level work, signals of less than 10mV, the offset of the operational amplifiers will need to be nulled. This is achieved by connecting a 10kΩ potentiometer across pins 1 and 5 of the 741, with its slider connected to $-V_{cc}$, as shown in Fig. 4. This potentiometer is then adjusted to exactly zero the output with no input signal. ★

A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

TIMER

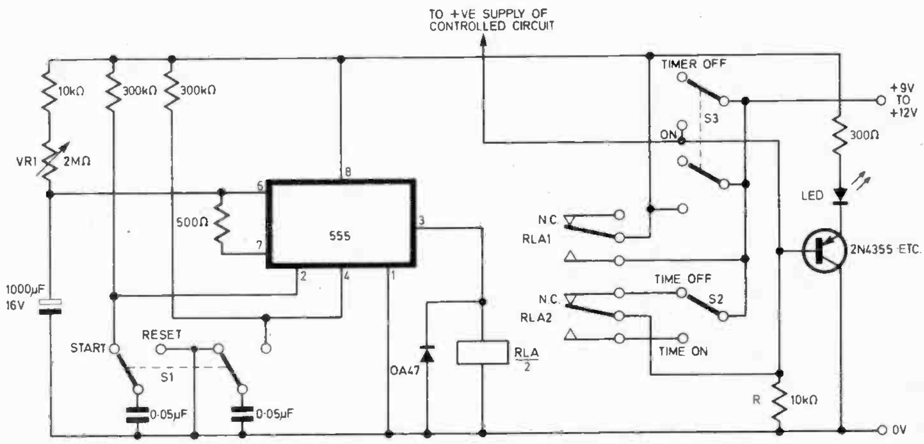


Fig. 1

A TIMER based on a NE555 i.c. is shown in Fig. 1, which can be programmed to switch another circuit on or off after a variable time duration. A manual override switch is included to keep the "controlled" circuit permanently on. If programmed to switch "on" after a time duration, the l.e.d. will illuminate giving warning that time is elapsing to the moment when the controlled circuit will switch on, and remain on indefinitely. If programmed to switch "off" after a duration, the timer will also switch itself off completely.

This circuit was designed primarily for a radio receiver working from a 12 volt supply. Switch S1 is a double pole two-way switch used for the *reset* and *start* function. Switch S2 is for the *time off* or *time on* function, and S3 is the *on/off* and a *timer* switch.

To operate the timer, first switch on S3 and set VR1 for required time interval and S2 for mode of operation. Then switch S1 to *start* position, and switch off S3, otherwise the controlled unit will remain permanently on. The maximum time interval of this circuit is about thirty-five minutes.

Pek Yaw Kee,
Sarawak,
East Malaysia.

WIPER DELAY UNIT

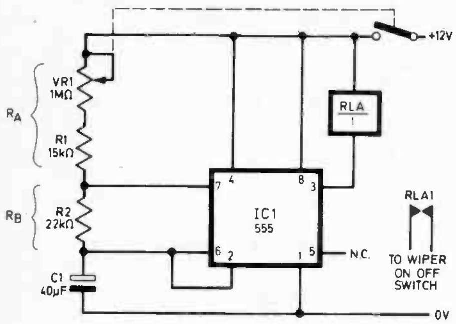


Fig. 1

THE problem with many published designs for windscreen wiper delay units is that they require more than one additional control to be placed somewhere in the car. The requirement to be fulfilled was that only one control be used.

The problem was solved using the circuit of Fig. 1. Operation is simple. IC1 functions as an astable driving the relay whose contacts are wired across the wiper on/off switch.

If continuous wiping is required the wipers are switched on as normal but if intermittent wiping is required the wiper on/off switch is switched off and the unit switched on via the switched pot. The unit switches the wipers on long enough for the "self park" facility to take over and the wipers return to their relaxed position.

The relay contacts must be rated at least 5A, and it must operate at less than 200mA 12V.

With the values given the relay is on for 0·75 seconds and its maximum delay is 38 seconds.

If one wishes to use different values for the timing arm VR1, R1, R2 and C1 the formulae are:

Relay "on" time =
$$0{\cdot}693\ R_A\ C1 \text{ secs.}$$
Relay "off" time =
$$0{\cdot}693\ (R_A + R_B)\ C1$$

K. D. Horton,
Birkenhead,
Merseyside.

TRANSISTORISED DYNATRON

THE circuit for the transistorised dynatron is shown in Fig. 1. Its mode of operation is as follows. If a small voltage *V* is applied to the circuit a current *I* flows, mostly through TR2. As *V* is increased, so does *I* increase (Fig. 2, portion (a)).

At a point determined by the setting of VR1, further increase in *V* results in a decrease in *I* since TR1 begins to conduct, thereby switching TR2 off (Fig. 2, portion (b)). With TR2 cut off, further increase in *V* results in a slower rise in *I* than in portion (a), since most of the current now passes through R2 (Fig. 2, portion (c)).

The negative slope of portion (b) is the familiar dynatron action. In this region the circuit is in effect a two-port network with negative dynamic (i.e. small signal) resistance (Fig. 3).

If such a circuit is connected to a parallel tuned circuit, as shown in Fig. 4, oscillations will be produced, provided the losses in the resonant circuit are not too great to be cancelled out by the negative resistance, and provided the resonant frequency is not too high for the transistors used. This means that almost any tuned circuit can be resonated (within the above limits) without the inconvenience of feedback windings and capacitor.

A further application, a bistable, can be realised by connecting the circuit to a load resistor R_L (Fig. 5), chosen so that the load line cuts the characteristic curve at three points (Fig. 6). The result is a circuit capable of being switched between two stable states by pulses of the correct polarity. The output step can be made almost any required height (within the transistor safety margins) by careful choice of R_L, V_{cc} and the setting of VR1. The input and output are the same point—the junction of the "black Box" and R_L.

These two applications give useful insight into one of the less well understood causes of instability in home-designed equipment. From the point of view of a battery or power supply, any circuit, be it a radio or a burglar alarm, active or passive, is still basically a two-port network, assuming that a split supply is not used. If, around the chosen working point for the circuit, this two-port network exhibits negative dynamic resistance as described above, then the circuit will be inherently unstable.

This would not matter if the power supply and wiring were perfect, but in practice the instability would manifest itself as high frequency oscillation in the wiring, or bistable action. Monostable and astable action are also possible.

D. McClure,
Ayr.

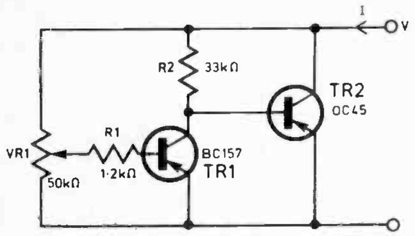


Fig. 1

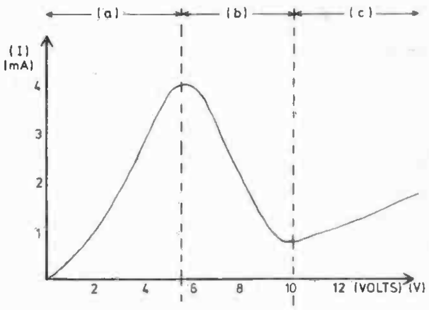


Fig. 2

Fig. 3

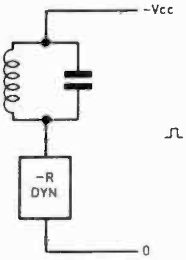


Fig. 4

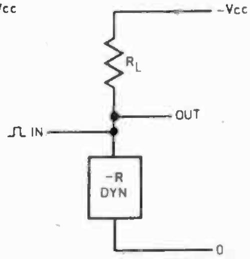


Fig. 5

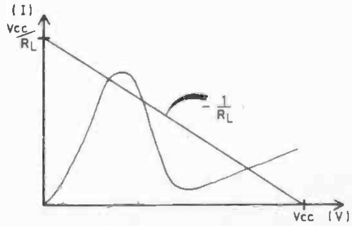


Fig. 6

HIGH IMPEDANCE AUDIO PRE-AMP

THE circuit shown in Fig. 1 was developed to combine the high impedance of a field effect transistor with the high gain and repeatability of an operational amplifier. It will drive an LM380 audio amplifier with about 100mV from almost any type of microphone.

As the f.e.t. has a very high input resistance and is voltage sensitive, R3 need not be varied. Further, most types of microphone can be connected across R3 without isolating capacitors.

The d.c. potentials around the circuit are set by negative feedback from the output of IC1 to the input via TR1 (which acts as a common gate amplifier at d.c.). Transistor TR2 is a current amplifier driving TR1 source, allowing R6, R7, C1 and C2 to have reasonable values. Since common emitter amplifiers have current gain only, while common gate and common source amplifiers have roughly equal voltage gains, the overall gain can be set by feedback to the source rather than the gate of TR1.

The audio frequency gain is set by R6/R7 to approximately 150 (44dB).

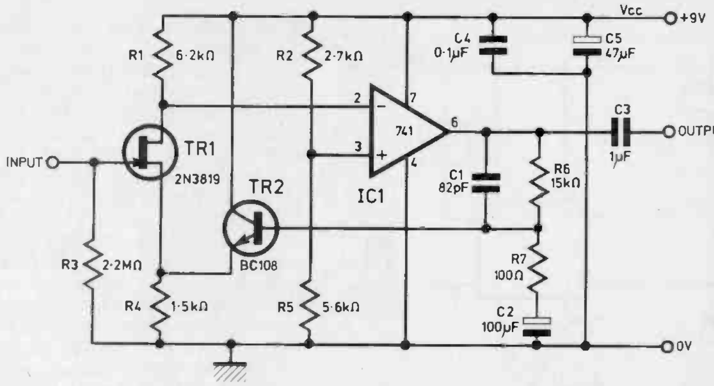


Fig. 1

The upper and lower −3dB points are set to 50kHz and 40Hz by C1 and C2 respectively. Choice of the value of the output coupling capacitor C3 is governed by the input impedance of the following circuit. The value shown would be adequate for driving an LM380. Gain may be reduced by increasing R7, and vice versa, though this will affect the low frequency response. Capacitor C1 prevents h.f. instability.

N. Ing-Simmons,
Henley,
Oxon.

NEWS BRIEFS

Safety Abroad

UNDER the West German Equipment Safety Law, all electrical equipment sold in the Federal Republic must be safe, and certain organisations and standards have been specified by the German Ministry of Labour to indicate how such "safeness" shall be judged. This situation is so complex that it has become difficult even for German manufacturers.

Technical Help to Exporters (THE), the export advisory service of the British Standards Institution, has produced a publication entitled "Electrical Equipment Certification in the Federal Republic of Germany", which will help UK manufacturers to understand the complex procedures for electrical equipment certification in Germany. It will also help them to decide which approval organisations to use.

Copies of this book can be obtained from THE Sales Office, British Standards Institution, Maylands Avenue, Hemel Hempstead, Herts. Price £10 to THE members, £13 to non-members.

Post Office Making History

WHAT should be the world's first commercial millimetric waveguide system, has after a decade of research, been given the go-ahead by the Post Office.

At a cost of £7 million, a waveguide tube of diameter similar to that of a car exhaust pipe, will link Bristol to Reading, with a capacity of 500,000 simultaneous telephone conversations, or 300 television pictures.

The waveguide is a spiral of copper wire around the inside of a glass-reinforced plastics tube, yielding low cost, simple to manufacture and install features, and is a design unique to Britain.

Laying of the 125km waveguide, encased in a steel tube, will begin in 1979, and eventually employ five booster stations to reinforce the digital signals. This venture will involve materials supplied by Marconi, BICC, and the British Steel Corporation, and should be completed by 1983.

POINTS ARISING

***WARNING SYSTEM** (Ingenuity Unlimited, August 1977)*

We understand that organisations representing blind people have recently expressed concern to the Department of the Environment regarding the use of audible warning devices connected to direction indicator systems on motor-cycles.

A number of near-accidents have apparently been caused by blind persons mistaking the sound of such devices for the "Walk" tone at pedestrian-controlled crossings, and so stepping out into the path of traffic.

The DoE is currently considering legislation to control the fitting of these devices to motor-cycles, and we feel that our readers should also be aware of the possible dangers involved.

***BURGLAR ALARM** (May 1977)*

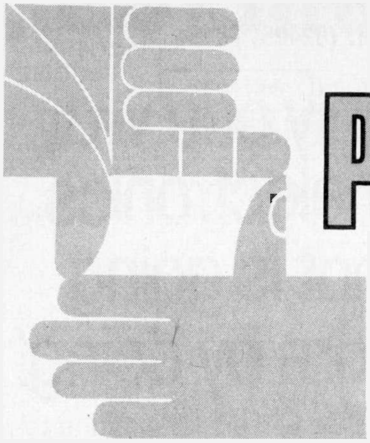
In Fig. 2, page 344, the arrowed connection to S2b (WIPER) should come from the bottom (CHASSIS) track on the p.c.b., not as shown.

The connection labelled S2a (2)(3)(4) should be labelled S2a (WIPER).

***TV SPORTCENTRE** (June 1977)*

The u.h.f. oscillator/modulator incorporated in the Sportcentre was a development from an original design by A. A. Birch, used in the Cross Hatch Generator published in the September 1976 issue.

We apologise for failing, through an oversight, to attribute this part of our TV Sportcentre circuit to Mr. Birch.



PATENTS REVIEW...

Copies of Patents can be obtained from:
the Patent Office Sales, St. Mary Cray, Orpington, Kent   Price 95p each

CINE FADE-IN

In BP 1 468 687, Agfa-Gevaert AG of Germany describe a simple circuit for muting the magnetic recording head of a sound film camera of the Super-8 type now widely sold.

Such muting is desirable for two reasons: firstly, to prevent sound overlap when cutting between scenes (because sound is inevitably recorded one second or so ahead of the picture); secondly, to obviate the "Micky Mouse" effect created by recording speech on a medium as it gathers speed.

As shown in the circuit, Fig. 1, a microphone feeds an audio amplifier, the output signal from which is fed to the coil of the recording head. The output of Amp-1 is, however, connected to the head coil via a further amplifier and this connection will be shunted by the f.e.t. TR1 when in conductive state.

The conductive condition occurs when the gate electrode of TR1 is at negative potential. This is its normal state when switch S1, which is ganged with the motor start/stop switch, is opened.

When S1 is closed, the motor starts and the film runs past the recording head which receives no audio signal, due to the shunting effect of TR1. Over the next second or so, however, capacitor C1 gradually charges, to cause a gradual movement to positive of the f.e.t. gate. The transistor becomes less conductive, so less shunting occurs, and a gradually increasing level of audio signal is fed to the recording head.

The exact time taken for C1 to charge and shunting to cease depends on the values of resistors R1, R2, between which the capacitor and gate are tapped. There is thus a gradual fade-in of the recorded signal, coincident with the film attaining full speed for recording.

BP 1 468 687

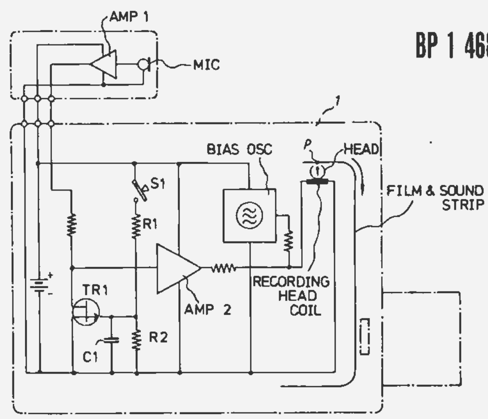


Fig. 1

VALVE SOUND

A timely reminder of the electronic reasons why valved amplifiers and limiters are now making a comeback is given in BP 1 467 649, by Novanex Automation NV of Holland. (In fact some valve equipment has never been away; several recording studios still treasure their fifteen-year-old Fairchild limiters and refuse all cash offers for them.)

Essentially, whereas transistors clip a sinusoidal signal hard and sharp, to produce a trapezium and spiky harmonics, a valve amplifier with transformer coupling smoothes out the sine wave without chopping it. This produces the characteristic "valve sound" of pleasantly smooth limiting on overload.

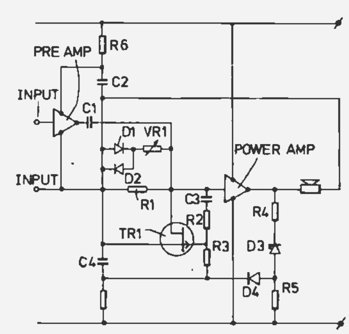
The Novanex patent is for circuitry which creates a valve sound from solid state components. The essential integer is a limiter which is capable of handling a maximum of power without saturation, and this is achieved by designing the limiter so that its performance depends on mains voltage.

Although no component values are given, the basic circuit shown in Fig. 1 uses an f.e.t. as a limiter and a Zener diode to ensure its mains voltage dependency. The preamplifier is capacitor coupled to the power amplifier and resistors R4, R5 and Zener diode D3 are series connected between the power amplifier and the negative terminal of the mains supply.

The gate electrode of the limiter f.e.t. TR1 is connected to the junction of R5 and D3, through diode D4 and R3. The gate is also connected to the input of the power amplifier via R2 and C3. The network of C3, R2 and R3 ensures symmetrical operation of TR1, even at high intensity input levels.

Diodes D1, D2, are oppositely connected in series with VR1 control parallel to R1. This arrangement smoothes out the sinusoidal input for soft limiting and a "valve sound". The Zener arrangement renders the limiting level of the f.e.t. mains voltage dependent so that the limiting level increases with an increase in mains voltage. This, it is claimed, enables basic limiter design to around 20 per cent higher than for a comparable circuit which does not depend on mains voltage.

Fig. 1   BP 1 467 649



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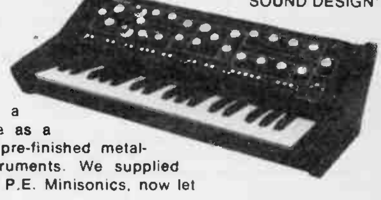

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AC127	0·25	*BD135	0·35	OA10	0·55	1N4007	0·15	7413	0·45
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AC141	0·20	*BD137	0·37	OA70	0·30	1N4148	0·07	7417	0·40
AC141K	0·30	*BD138	0·40	OA79	0·30	1N5400	0·14	7420	0·20
AC142	0·20	*BD139	0·43	OA81	0·30	1N5401	0·16	7422	0·25
AC142K	0·25	*BD140	0·47	OA85	0·30	1S44	0·06	7423	0·35
AC176	0·25	BD144	2·00	OA90	0·08	1S920	0·08	7425	0·35
AC187	0·25	BD181	1·38	OA91	0·08	1S921	0·08	7427	0·35
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ACY18	0·65	BD238	0·85	OA202	0·11	2G306	1·10	7432	0·36
ACY19	0·65	BDX10	0·75	OA210	0·75	2N404	0·60	7433	0·37
ACY20	0·65	BDX32	2·25	OA211	0·75	2N696	0·25	7437	0·42
ACY21	0·65	BDY20	1·42	OAZ200	0·65	2N697	0·16	7438	0·37
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AF117	0·25	BF173	0·39	OC25	0·90	2N1303	0·37	7460	0·20
AF139	0·40	BF177	0·38	OC26	0·90	2N1304	0·45	7470	0·35
AF186	1·50	BF178	0·45	OC28	2·00	2N1305	0·45	7472	0·36
AF239	0·45	BF179	0·48	OC29	2·00	2N1306	0·50	7473	0·36
AFZ11	2·75	BF180	0·45	OC35	1·50	2N1307	0·50	7474	0·40
AFZ12	2·75	BF181	0·45	OC36	1·50	2N1308	0·60	7475	0·59
ASY26	0·45	BF182	0·45	OC41	0·50	2N1309	0·60	7476	0·42
ASY27	0·50	BF183	0·45	OC42	0·50	2N1613	0·33	7480	0·60
ASZ15	1·25	BF184	0·39	OC43	1·50	2N1671	1·50	7482	0·85
ASZ16	1·25	BF185	0·37	OC44	0·50	2N1893	0·33	7483	1·00
ASZ17	1·25	*BF194	0·12	OC45	0·50	2N2147	1·40	7484	1·00
ASZ20	0·75	*BF195	0·11	OC71	0·45	2N2148	1·65	7486	0·40
ASZ21	1·50	*BF196	0·13	OC72	0·45	2N2218	0·33	7490	0·52
AU113	1·70	*BF197	0·14	OC73	1·00	2N2219	0·42	7491AN	0·85
AUY10	1·70	BF200	0·32	OC74	0·50	2N2220	0·35	7492	0·60
BA145	0·15	*BF224	0·20	OC75	0·60	2N2221	0·22	7493	0·70
BA148	0·15	*BF244	0·35	OC76	0·50	2N2222	0·25	7494	0·80
BA154	0·10	BF257	0·37	OC77	1·20	2N2223	2·75	7495	0·80
BA155	0·12	BF258	0·42	OC81	0·75	2N2368	0·17	7496	0·90
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BAX13	0·07	*BF337	0·53	OC83	0·55	2N2646	0·50	74107	0·45
BAX16	0·07	*BF338	0·55	OC84	0·60	2N2904	0·35	74109	0·86
BC107	0·12	BFS21	2·27	OC122	1·50	2N2905	0·35	74110	0·57
BC108	0·12	BFS28	1·38	OC123	1·55	2N2906	0·25	74111	0·86
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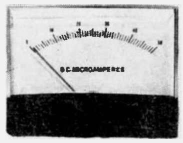

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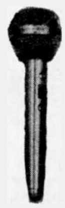

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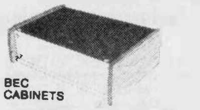

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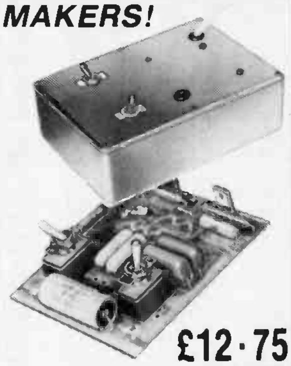

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13	100	9-0-9	2·14	0·38
235	330, 330	0-9, 0-9	1·99	0·38
207	500, 500	0-8-9, 0-8-9	2·59	0·71
208	1A, 1A	0-8-9, 0-8-9	3·53	0·78
236	200, 200	0-15, 0-15	1·99	0·38
214	300, 300	0-20, 0-20	2·56	0·78
221	700 (DC)	20-12-0-12-20	3·41	0·78
206	1A, 1A	0-15-20-0-15-20	3·53	0·96
203	500, 500	0-15-27-0-15-27	3·99	0·96
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S112	500	12-15-20-24-30	2·64	0·78

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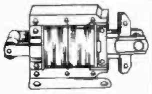

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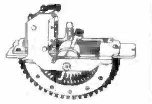

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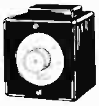

0–60 sec. 230V a.c. operation. Incorporating a lapsed time indicator and repeat facilities. A precision motorised timer ideal for process timing, photography, welding, mixing, etc. Price £6. P. & P. 60p.

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Suitable transformer for 230/240V a.c. £6 + £1 P. & P.

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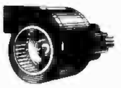

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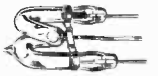

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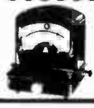

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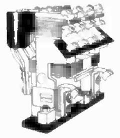

Mfg. by Hendrey Relays type C2839 220/250 a.c. ops. Contact 4C/O at 20 amp at 440V a.c. Price £6. P. & P. 75p.

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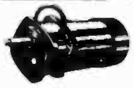

100 r.p.m. 115lb.in. 110V. 50Hz. 2·8A, single phase split capacitor motor. Immense power. Continuously rated. Totally enclosed. Fan cooled in-line gearbox. Length 250mm. Dia. 135mm. Spindle dia. 15·5mm. Length 145mm. Ex-equipment tested £12. Post £1·50. Suitable transformer 230/240V operation £8. Post 75p.

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15 R.P.M.

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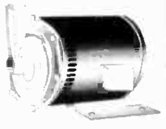

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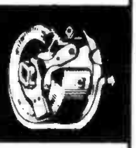

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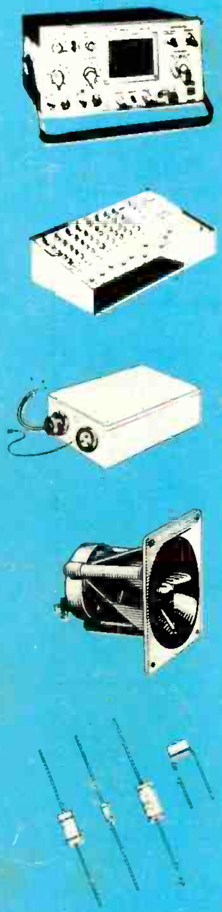

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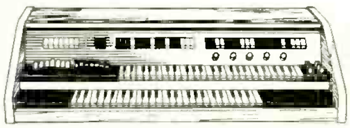
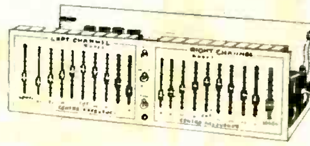


GRAPHIC EQUALISER



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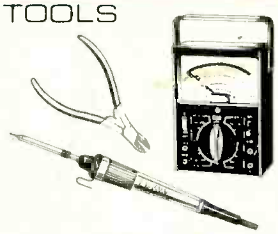

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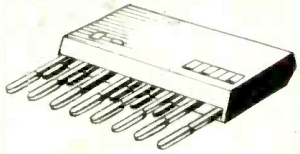

A completely self-contained pedal unit, 13-note, 2-octave range, 4 organ stops. It can be added to any organ! A really unusual extra is the bass guitar stop which uses four envelope shapers to give a real bass guitar sound. A must for the solo guitarist. Full construction details in our catalogue—post the coupon below now!

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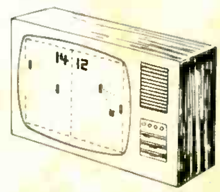

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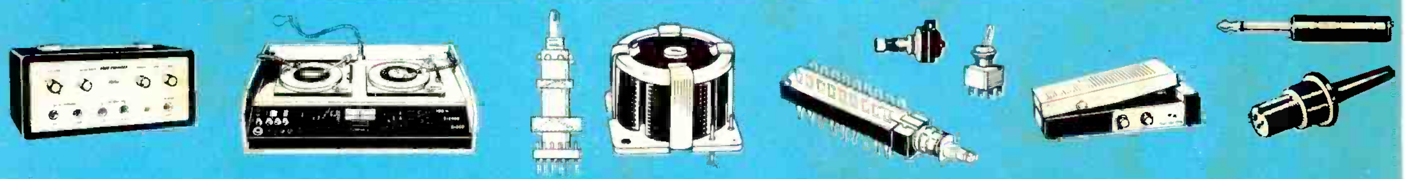

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