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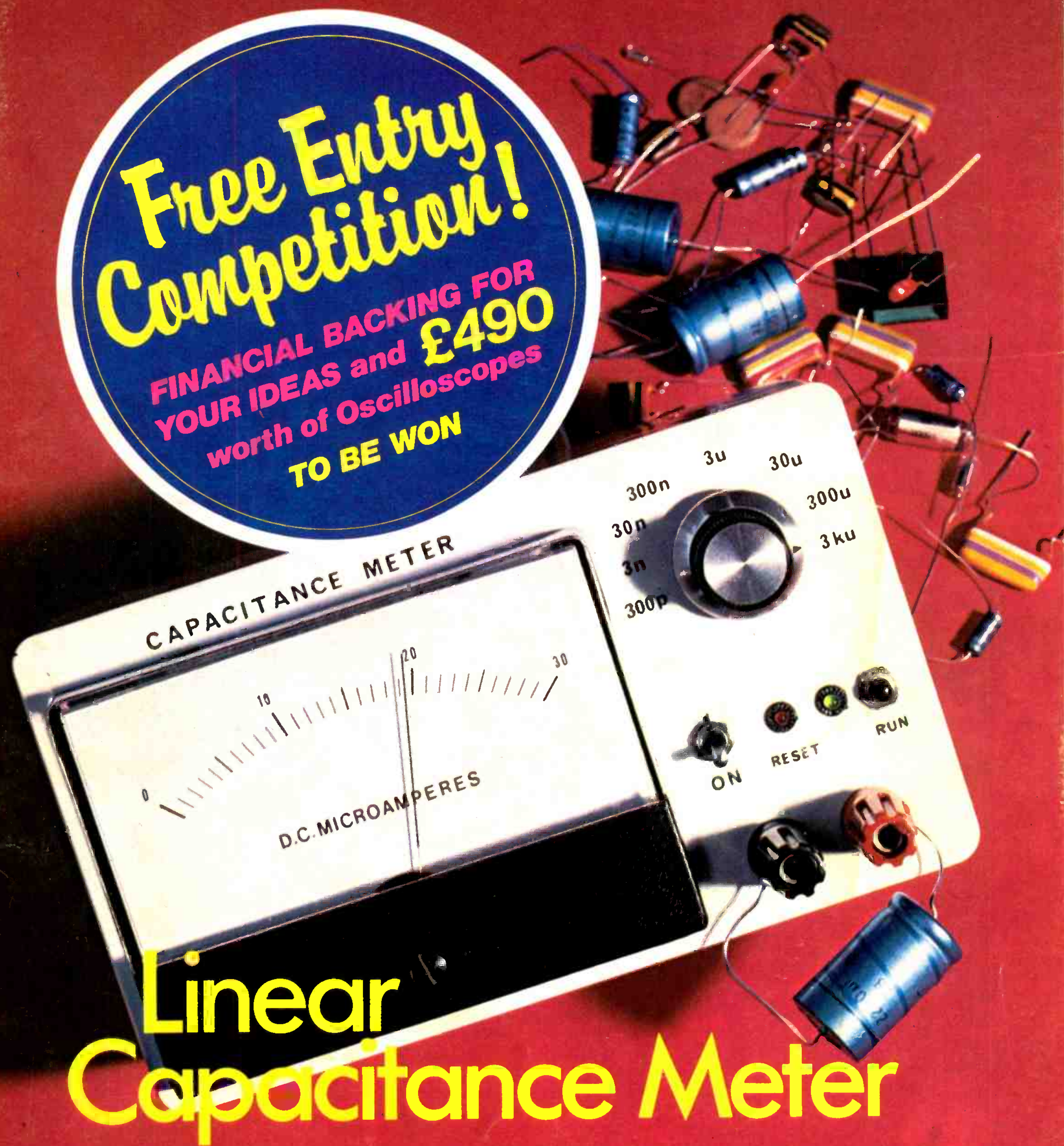

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PRACTICAL
ELECTRONICS

VOLUME 14 No. 10 JUNE 1978

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our July issue will be on sale Friday, 9 June 1978
(for details of contents see page 765)

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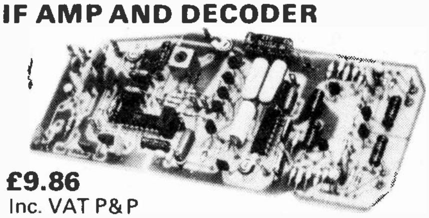
TECHNOLOGY:
Double sided epoxy printed circuit board with plated through holes. Dual gate effect transistors; Silvered coils.

FI 2846 IF AMP AND DECODER



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CIRCUIT TECHNOLOGY
Epoxy printed circuit board; Monolithic integrated circuits; ceramic filter.

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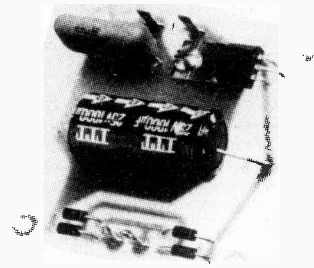

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TECHNOLOGY:
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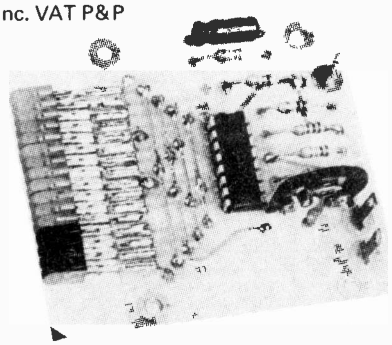
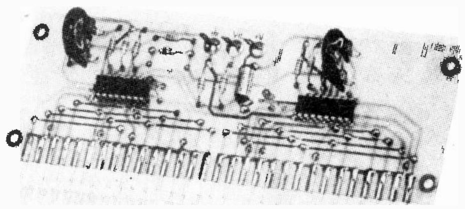


LED VU-METER
Station strength indicator



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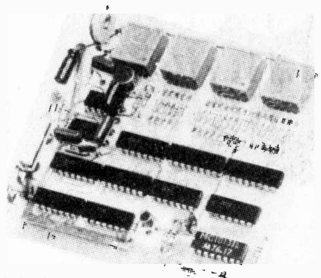

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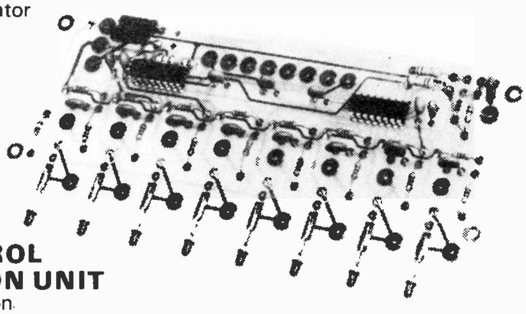

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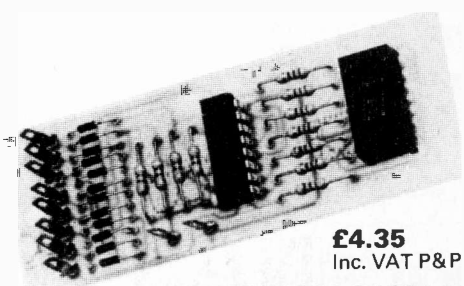

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AC187	0·25
AC188	0·25
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BC108	0·12
BC109	0·13
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*BC118	0·16
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*BC126	0·25
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BC177	0·19
BC178	0·16
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BC301	0·45
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BF178	0·45
BF179	0·48
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BF185	0·37
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BF200	0·32
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BF259	0·45
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BFX85	0·41
BFX87	0·35
BFX88	0·32
BFY50	0·28
BFY51	0·26
BFY52	0·26
BFY64	0·30
BFY90	1·32
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7437	0·42
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4010	62p	4020	1.32	4030	51p	4070	50p	4520	1.26
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Silicon npn and pnp from **8p** ea: LEDs, red **19p**: yellow or green **23p** (3 or 5mm): Photo transistors from **76p**.

KEEN PRICES ★ GOOD SERVICE ★ WIDE RANGES

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5% if list value of order over £10
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Goods sent post free on C.W.O. orders in U.K. over £5 list value. If under, add 27p per order.

MONTHLY BARGAIN LISTS
S.A.E. brings monthly list of bargains. Also current quick reference price list of all ranges.

Cash with order (P.O. or cheque payable to Electrovalue Ltd) or your Access or Barclaycard number.
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ELECTROVALUE LTD

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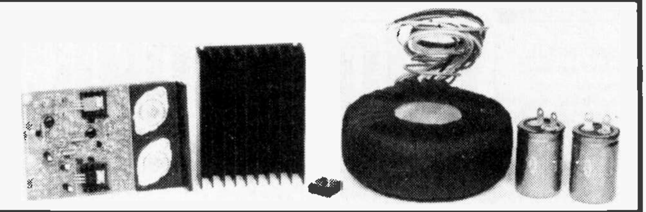
Northern Branch (Personal shoppers only) 680 Burnage Lane, Burnage, Manchester M19 1NA. Phone (061) 432 4945.

TWO NEW SUPERMODULES: 170W INTO 4 OR 8 OHMS



By popular demand we have designed higher powered versions of our well known modules. The CE 1704 which gives 170W into 4 ohms and the CE 1708 which gives 170W into 8 ohms are physically similar to the original types and have the same combination of compatible performance features which makes CRIMSON amplification audibly superior to the competition and the only choice if you have an ear for music. We have also produced suitable power supplies which again use our superb TOROIDAL TRANSFORMERS, only 50mm high, with a 120-240 primary and single bolt fixing.

Write or phone for more information and biased opinions.

POWER AMPLIFIER MODULES	Home	Europe
CE 608 60W/8 ohms 35-0-35V	£16.30	£16.60
CE 1004 100W/4 ohms 35-0-35V	£19.22	£19.30
CE 1008 100W/8 ohms 45-0-45V	£23.22	£23.00
CE 1704 170W/4 ohms 45-0-45V	£29.12	£28.46
CE 1708 170W/8 ohms 60-0-60V	£31.90	£31.04
TOROIDAL POWER SUPPLIES		
CPS 1 for 2 x CE 608 or 1 x CE 1004	£14.47	£18.40
CPS 2 for 2 x CE 1004 or 2/4 x CE 608	£16.82	£20.57
CPS 3 for 2 x CE 1008 or 1 x CE 1704	£17.66	£21.35
CPS 4 for 1 x CE 1008	£15.31	£19.18
CPS 5 for 1 x CE 1708	£22.68	£26.50
CPS 6 for 2 x CE 1704 or 2 x CE 1708	£23.98	£27.70
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Recommended for improved reliability		
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T.H.D.	: TYPICALLY <·02% ANY POWER, 1kHz, 8 OHMS
T.I.D.	: INSIGNIFICANT
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S/N RATIO	: 110dB
FREQ. RESPONSE	: 10Hz – 35kHz, –3dB
STABILITY	: UNCONDITIONAL
PROTECTION	: DRIVES ANY LOAD SAFELY
SENSITIVITY	: 775mV (250mV or 100mV ON REQUEST)
SIZE	: 120 x 80 x 25mm

CRIMSON ELEKTRIK

Please note our new address and telephone number:

1A STAMFORD STREET, LEICESTER LE1 6NL

Telephone: (0533) 537722

Home prices include V.A.T. and postage. C.O.D. 90p extra, £100 limit. Export no problem. European prices include carriage, insurance and handling, payment in **Sterling** by bank draft, P.O., International Giro or Money Order. Outside Europe, please write for specific quote by return. Send SAE or two International Reply Coupons for full literature. Favourable trade quantity price list on request. High quality pre-amp circuit 20p.

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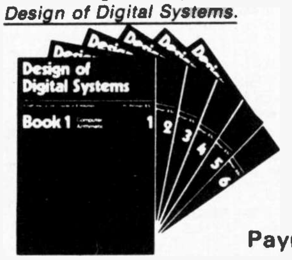

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AND OTHER PROJECTS

PHOTOGRAPHS in this advertisement show two of our units containing some of the P.E. projects built from our kits and PCBs. The cases were built by ourselves and are not for sale, though a small selection of other cases is available.

LIST—Send stamped addressed envelope with all U.K. requests for free list giving fuller details of PCBs, kits and other components.

OVERSEAS enquiries for list Europe—send 20p: other countries—send 50p.

KIMBER-ALLEN KEYBOARDS AND CONTACTS

Kimber-Allen Keyboards as required for many published circuits. The manufacturers claim that these are the finest moulded plastic keyboards available. All octaves are C to C, the keys are plastic, spring-loaded, fitted with actuators, and mounted on a robust aluminium frame.

3 Octave (37 notes)	£25·50
4 Octave (49 notes)	£32·25
5 Octave (61 notes)	£39·75

Contact Assemblies (gold-clad wire) for use with the above keyboards (1 required for each note):

Type GJ: Single-pole change-over	each 24p
Type GB: 2 pairs of contacts, each pair normally open	each 27p
Type GC: 3 pairs of contacts, each pair normally open	each 36p
Type GE: 4 pairs of contacts, each pair normally open	each 45p
Type GH: 5 pairs of contacts, each pair normally open	each 57p
Type 4PS: 3 pairs of contacts plus single-pole changeover	each 53p

Printed Circuit Boards for use with GJ, GB and 4PS contacts (thus eliminating much interwiring) are available. Details in our lists.

RHYTHM GENERATOR

15-Rhythm Tempo, Timing and Logic control unit (excl. sw's but incl. PCB)	£12·90
10-Instrument Effects circuits	£13·56
PCB for Effects circuits	£4·25
Power Supply incl. PCB	£12·00

128-NOTE TUNE-PROGRAMMABLE SEQUENCER (P.E. Nov/Dec 77)

Enables a voltage controlled synthesiser to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are keyboard initiated and note length and rhythmic pattern are externally variable. (Please use order codes quoted in brackets.)

Main Circuit (Nov) excl. sw's (KIT 76-1)	£20·60
Power Supply (KIT 76-3)	£6·05
Trigger Inverter and Alt. Output (KIT 76-2)	£1·35
LED Counter (KIT 76-4)	£2·45
PCB (as published) for KITS 76-1 & 3 (PCB 76A)	£2·61
PCB for KITS 76-2 & 4 (PCB 76B)	£2·54

P.E. STRING-ENSEMBLE (P.E. commencing Mar 78)

The new keyboard string-instrument synthesiser.

Power Supply Basic component set	£9·22
Tone Generators (incl. Test components)	£14·93
PCB for PSU and Tone Generator	£3·40

Details of further kits and PCBs in our list.

FORMANT SYNTHESISER (Elektor 1977/78)

Very sophisticated music synthesiser for the advanced constructor who puts performance before price. Details in our lists.

3-CHANNEL SOUND-TO-LIGHT (P.E. Apr. 76)

A simple but effective sound-to-light controller capable of operating 3 lamps each of approximately 700 watts. Includes power supply, thyristors, and by-pass switches.

Component set (incl. PCB)	£11·95

DISCOSTROBE (P.E. Nov. 76)

4-channel light-show controller giving a choice of sequential, random, or full strobe mode of operation.

Basic component set	£18·19
Printed circuit board	£3·45

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)

Multi-function circuits that, with the use of other external equipment, can serve as lie-detector, alphaphone, cardiophone etc.

Pre-Amp Module Components set (incl. PCB)	£4·22
Basic Output Circuits—combined component set with PCBs, for alphaphone, cardiophone, frequency meter and visual feed-back lampdriver circuits.	£6·59
Audio Amplifier Module Type PC7	£7·75

10% DISCOUNT VOUCHER (PE66)

TERMS: Correctly costed, C.W.O., U.K. orders over £40 goods value. Valid until end of month on cover of P.E. This voucher must accompany order.

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AC128	26p
AC176	26p
BC107	14p
BC108	14p
BC109	14p
BC109C	15p
BC177	14p
BC184	12p
BC187	25p
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BC209C	14p
BC213	15p
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BC262	25p
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BC478	29p
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2N3054	66p
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2N3704	12p
2N3819	35p
2N3820	64p
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INTEGRATED CIRCUITS

301 8-pin DIL	48p
318 8-pin DIL	230p
320-15	58p
324 14-pin DIL	87p
341-15	195p
709 8-pin DIL	48p
723 TO5	105p
723 14-pin DIL	56p
726 TO5	930p
741 8-pin DIL	32p
748 8-pin DIL	63p
4024 14-pin DIL	46½p
4069 14-pin DIL	18p
4136 14-pin DIL	126p
7805 TO220	205p
7806 TO220	205p
7808 TO220	205p
7812 TO220	205p
7815 TO220	205p
7818 TO220	205p
AY10212 16-pin DIL	650p
AY16721/6	195p
CA3046 14-pin DIL	90p
CA3080 8-pin DIL	82p
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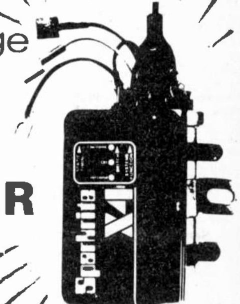

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X4 KIT ~~£14.95~~ £12.95	
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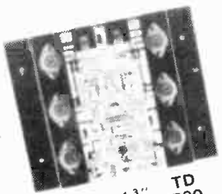
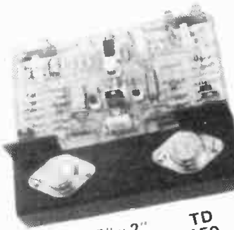


7" x 9" x 1¾" TD 500

Featuring
Electronic Short Open & Thermal Overload Protection.

Brief Spec.
Input Sensitivity 0.775.v. R.M.S. (O.D.B.) at 25 K Ohms
Frequency Response 20 Hz-20 KHz
Hum & Noise – 100 dB Relative full output



5" x 5" x 2" TD 150

T.H.D. at full powr 0.1%
T.D. 500 300W into 2 Ohms
220W into 4 Ohms

Size 7" x 9" x 1¾" 140W into 8 Ohms	£45.00
Power supply P.S. 300	£28.50
T.D. 150 150W into 4 Ohms	
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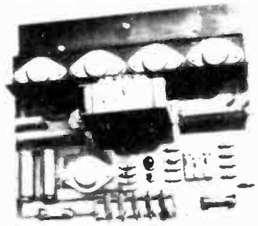
Note P.S. 300 will drive 2 T.D. 150 amplifiers

All output ratings are R.M.S. continuous sine wave output.

AMPLIFIER MODULES



SPEC. INPUT SENSITIVITY 60 mV for full output
Frequency response 20 Hz-20 KHz
HUM & NOISE – 70 dB

TL60 5 × 5 × 3in
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• 2 R.C.A. 110 watt 15 amp transistors
£18.25

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4 CHANNEL SOUND TO LIGHT SEQUENCE CHASER – 4LSMI

- Full wave control
- RCA 8A Triacs
- 1000W per channel
- Fully supressed and fused
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Model 501 500W per channel as above without sound triggering
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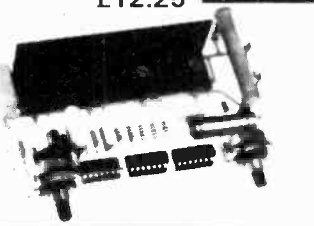

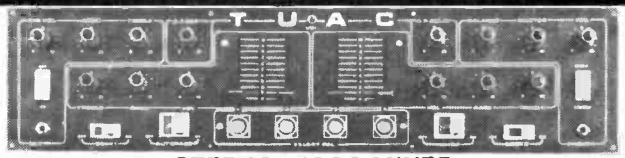

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With touch sensitive switching and auto fade

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OUTPUT: Up to 3 volts (+ 12dB) available. Attenuated output for TUAC Power Modules. Rotary master and balance controls. Band width 15Hz – 25kHz ± dB.
P.F.L.: Output 250mV into 8 ohms. Rotary volume control. Monitoring facility for all 4 channels. Selection via touch sensitive illuminated switches. Switched visual cue indicator.
Miscellaneous Facilities: Two illuminated deck on/off switches. Mains illuminated on/off switches. Auto fade illuminated on/off switch. Mains powered with integral screen and back cover. Complete with full instructions.
Size: 25in long × 6in high × 3in deep.

£129.00

Mono Disco Mixer with autofade **£45.00**

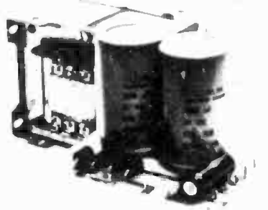
3 CHANNEL LIGHT MODULATOR SILMB

- RCA 8A Triacs
- 1000W per channel
- Each channel fully suppressed and fused
- Master control to operate from 1W to 125W
- Full wave control

£20.25

Single Channel Version 1500 Watts
£9.75

POWER SUPPLIES



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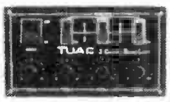
PIEZO SUPER HORN ONLY £8.50

FRONT PANEL FOR LIGHTING EFFECT MODULES

(complete with switches, neons and knobs) as illustrated



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• Full logic integrated circuitry
• Dimmer control to each channel

3SDMI **£14.50**

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16216 – 60 mixed $\frac{1}{8}$w 100K ohms – 820K ohms **60p***
16217 – 40 mixed $\frac{1}{4}$w 100 ohms – 820 ohms **60p***
16218 – 40 mixed $\frac{1}{4}$w 1K ohms – 8·2K ohms **60p***
16219 – 40 mixed $\frac{1}{2}$w 10K ohms – 82K ohms **60p***
16220 – 40 mixed $\frac{1}{2}$w 100K ohms – 820K ohms **60p***
16230 – 60 mixed $\frac{1}{8}$w 1 Meg – 10 Meg ohms **60p***
16231 – 40 mixed $\frac{1}{2}$w 1 Meg – 10 Meg ohms **60p***

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AC128	£0·18	BC148	*£0·08	BC557	*£0·13	BIP20	£0·38	TIS90	*£0·22	2N3710	*£0·07
AC128K	£0·26	BC149	*£0·08	BC558	*£0·12	BIP19/20MP	£0·80	UT46	*£0·22	2N3711	*£0·07
AC132	£0·20	BC157	*£0·10	BC559	*£0·14	BRY39	£0·45	ZTX107	*£0·10	2N3819	£0·20
AC134	£0·20	BC158	*£0·10	BD115	£0·50	BU105	£1·70	ZTX108	£0·10	2N3B20	£0·35
AC137	£0·20	8C159	*£0·10	BD116	£0·80	BU105/02	£1·95	ZTX109	*£0·10	2N3821	£0·60
AC141	£0·22	BC167	*£0·12	BD121	£0·65	BU204	£1·70	ZTX300	*£0·12	2N3823	£0·60
AC141K	£0·30	8C168	*£0·12	BD124	£0·70	BU205	£1·40	ZTX500	*£0·14	2N4058	*£0·12
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AC176K	£0·26	BC170	*£0·10	BD131/132MP	£0·85	MJE2955	£0·98	2N1889	£0·45	2N4061	*£0·12
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BC107C	£0·08	BC478	£0·20	BFY51	£0·16	TIP42A	£0·53	2N3703	*£0·08	40362	£0·38
BC108A	£0·08	BC479	£0·20			TIP42B	£0·55	2N3704	*0·07	40406	£0·45
BC108B	£0·08	BC547	*£0·12			TIP42C	£0·57	2N3705	*£0·07	40407	£0·35
BC109C	£0·08	BC548	*£0·12			TIP2955	£0·65	2N3706	*£0·08	40408	£0·52
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7402	0·15	7411	0·23	7445	0·90	7484	0·98	7495	0·70	74141	0·75
7403	0·15	7412	0·23	7446	0·90	7485	1·00	7496	0·80	74154	1·20
7404	0·15	7413	0·27	7447	0·78	7486	0·30	74100	1·00	74180	1·00
7405	0·15	7414	0·58	7448	0·80	7489	2·50	74110	0·50	74181	2·00
7406	0·30	7416	0·28	7475	0·48	7490	0·42	74118	0·90	74190	1·40
7407	0·30	7417	0·28	7480	0·50	7491	0·75	74119	1·85	74198	1·85
7408	0·15	7440	0·15	7481	0·95	7492	0·45	74121	0·30	74199	1·85

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Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CD4000	0·15	CD4012	0·20	CD4022	0·90	CD4031	2·20	CD4046	1·30	CD4071	0·23
CD4001	0·18	CD4013	0·52	CD4023	0·20	CD4035	1·30	CD4047	1·10	CD4072	0·23
CD4002	0·18	CD4015	0·98	CD4024	0·80	CD4037	0·95	CD4049	0·55	CD4081	0·20
CD4006	0·98	CD4016	0·50	CD4025	0·20	CD4040	0·95	CD4050	0·55	CD4082	0·23
CD4007	0·18	CD4017	0·98	CD4026	1·70	CD4041	0·82	CD4054	1·10	CD4510	1·30
CD4008	0·98	CD4018	1·00	CD4027	0·60	CD4042	0·82	CD4055	1·40	CD4511	1·60
CD4009	0·58	CD4019	0·55	CD4028	0·98	CD4043	0·98	CD4056	1·35	CD4516	1·40
CD4010	0·58	CD4020	1·10	CD4029	1·15	CD4044	0·94	CD4069	0·40	CD4518	1·25
CD4011	0·20	CD4021	0·98	CD4030	0·55	CD4045	1·40	CD4070	0·40	CD4520	1·25

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CA3014*	£1·70	MC1466L	£4·50	LM320-24v	£1·50	72710*	£0·30	SN76023N*	£1·75	TAD100*	£1·30
CA2018*	£0·75	MC1469R	£2·95	LM380-14P	£0·85	uA711C*	£0·32	SN76110*	£1·50	TBA540Q*	£2·20
CA3020*	£1·70	MC1496G*	£0·98	LM381*	£1·55	72711*	£0·32	SN76115*	£1·90	TBA641B*	£2·25
CA3028*	£1·02	NE536*	£3·50	LM3900N*	£0·65	uA723C	£0·45	SN76660*	£0·75	TBA800*	£0·80
CA3035*	£1·70	NE515A*	£3·50	MC724P	£1·50	72723	£0·45	SL414A*	£1·95	T8A810S*	£1·05
CA3036*	£1·35	NE540*	£1·50	MC1303L*	£1·48	uA741C*	£0·24	TAA5508	£0·35	T8A820*	£0·80
CA3042*	£1·50	NE550*	£0·95	MC1304P*	£1·90	72741*	£0·24	TAA621A*	£2·00	TBA920Q*	£3·40
CA3043*	£1·85	NE550D*	NLA	MC1310P*	£0·95	741P*	£0·20			TCA2705*	£2·20
CA3046*	£0·80	NE555	£0·32	MC1312PQ*	£1·90	uA747C*	£0·70				
CA3052*	£1·60	NE556	£0·82	MC1330P*	£1·20	72747*	£0·79				
CA3054*	£1·35	NE561*	£3·95	MC1350*	£1·20	uA748*	£0·35				
CA3075*	£1·50	NE5628*	£3·95	MC1351P*	£1·20	72748*	£0·35				
CA3081*	£1·50	NE565A*	£1·75	MC1352P*	£1·40	748P	£0·35				
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CA3090*	£4·25	NE567*	£1·80								
CA3123*	£1·90	uA702C*	£0·46								
LM301*	£0·39	72702*	£0·46								
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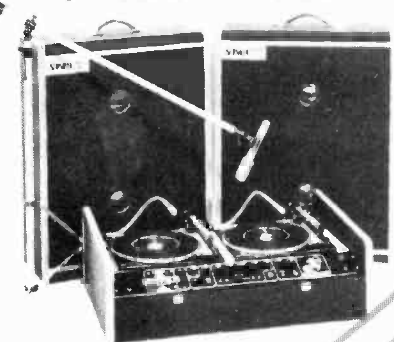

illustration shows GXL Centaur System

These systems feature full mixing for two decks tape & mic with monitoring facilities – override and are supplied complete with sound to light - sequencer, display, speaker leads etc.

JUST PLUG IN AND GO!

BSR Decks – 17,000 Line Loudspeakers – Rugged Aluminium Trimmed Cabinets – Cue Light And Phones Output – Slave Output – Deck Lights/Motor Starts (GXL)

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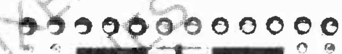

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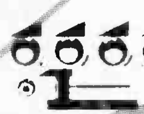

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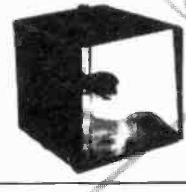

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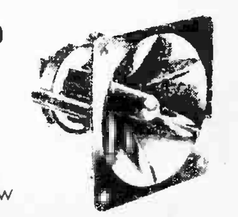

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PE VOLUME 14 No. 10 JUNE 1978

MONEY

PROBABLY one thing that is of universal interest is cash. As electronics enthusiasts we have particular interests in money. Will the chancellor reduce the tax rate? Surely that interests all earners? Will he change the V.A.T. rates? More about that later. Will the government impose further wage restraints?

We now know the answers to most of these points—this is being written a few days after the budget. Although we doubt if many M.P.s are constructors or, even if they have the interest, have time to read this, however a couple of points are worth making . . .

CAREERS

At the time of writing it is still not obvious if we will be returning to "free collective bargaining". For the last two years many in the electronics industry have found that their qualifications and experience no longer give them any monetary advantage. For some time we have seen the "electronics workers" on the move; more applicants for jobs than ever before simply because it is one way to get ahead financially.

It may be argued that this movement is healthy for the industry although we doubt it. What it does mean is that people are finding a way of beating the system and that they are finding it necessary to do this.

It has now been suggested that four year degree courses should be introduced. Great, we are in favour. The rate technology is moving we are going to need some of the best, most highly educated people we can find, and make no mistake the British educational system can produce the best. It may mean fewer degrees but we will need the elite; there is already a danger of too many chiefs and too few indians. But will we find these people, can we continue to encourage them to take a degree course, and a longer one than at present—perhaps not if the rewards are not there at the end of the rainbow!

V.A.T.

No doubt many readers, in particular those in the component supply business, will remember all the fuss a while back over the introduction of two rates of V.A.T. to electronic components. It may be necessary to remind some that this system is still in force.

It means that one component—say a loudspeaker—can be subject to different rates if sold for different applications. It would probably be interesting to carry out a survey now that manufacturers, distributors and retailers have been living with this system for some time. For instance, it may be that proportionately fewer speakers are now made and sold for radio applications—an application that is subject to the higher tax rate—although just as many will find their way into radios. This is no doubt more prevalant in the amateur world than anywhere else.

We can only hope that at some stage someone will be able to make enough fuss about the component situation to get the whole thing reviewed and then maybe, just maybe, we could get back to the lower rate for all components. This would reduce the workload of all concerned in their supply and, most important, reduce the price of some of them to us.

One point that we are thankful for is that this product (P.E.) is not subject to V.A.T. We are sure that all readers will stand behind us on that one, even if their views do not concur with those expressed above.

Mike Kenward

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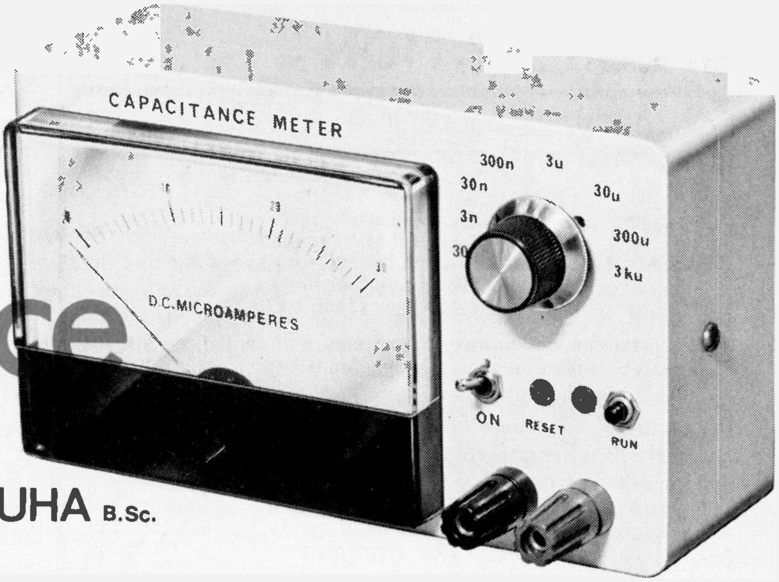
Linear Capacitance Meter

A.A. LUHA B.Sc.



★ **MEASURES UNKNOWN CAPACITANCE**
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THIS PIECE OF EQUIPMENT IS JUST WHAT YOU NEED!

THE need to measure capacitance accurately and quickly arises fairly often in electronics. The construction of Wien bridge oscillators, precision timers, active filters and tuned circuits all demand component selection if best results are to be obtained. In the past the most common methods of measurement have been the use of a capacitance bridge or the measurement of reactance using a multimeter and a.c. source. Both methods are cumbersome and lead to instruments with non linear scales, and in the form usually constructed by amateurs have limited accuracy and range. The instrument described here overcomes most of these problems offering direct measurement of capacitance over a range of eight decades on a linear scale.

PRINCIPLE OF OPERATION

The operation is based on the integrator shown in Fig. 1a. The behaviour of this circuit is described by the mathematical expression:

$$V_{OUT} = -\frac{1}{RC}\int V_{IN}\,dt \qquad (1)$$

Solving this equation gives

$$V_{OUT} = -\frac{V_{IN}}{RC}\Delta t \qquad (2)$$

By making $V_{OUT} = -V_{IN}$ and rearranging equation 2 as an expression for C, we have:

$$C = \frac{\Delta t}{R} \qquad (3)$$

It follows that we can measure the capacitor in the feedback loop of the integrator by measuring the time taken for the output voltage to fall to $-V_{IN}$. The measurement of time interval is the most accurate measurement available and it follows that this need not limit the accuracy and precision of the measurement. In the meter to be described the limitations of accuracy are imposed by the meter movement, range resistors, and timer capacitor, but the accuracy could be greatly improved if required, by measuring time digitally.

CIRCUIT DESCRIPTION AND OPERATION

The operation of the instrument is indicated in the block diagram Fig. 1b. The integrator is fed from a reference voltage generator and the integrator output is compared with this voltage in an inverting comparator. An analogue timer, based on a second integrator, measures the time taken for the output of the integrator to fall to $-V_{REF}$, and the output is shown on a panel meter. In use the unknown capacitor is connected across the input terminals and the RESET/START button depressed. At the end of the measurement period a green l.e.d. indicates that measurement is complete. A second push of the RESET/START button discharges the unknown capacitor and resets the circuit for a further measurement. The reset state is indicated by a red l.e.d. and is automatically entered on initial application of power.

The complete circuit is given in Fig. 2 and its operation is best understood with the aid of the timing diagrams in Fig. 3. The instrument consumes little power and may be battery operated. In Fig. 2, can be seen the supply arrangement and the V_{REF} generator, which is a simple zener diode source buffered by an operational amplifier connected as a voltage follower. The temperature stability of this circuit is not particularly good but is maximised by ensuring a constant Zener current of about 1mA. This is insignificant compared to the performance limitations of the analogue meter movement. If a digital version was constructed it would be worthwhile using a more expensive reference diode here. The reference voltage is adjusted to 1V by VR1. It should be noted that this adjustment is only needed in an analogue instrument because V_{REF} is also used in the time measurement circuit.

The reference voltage is supplied to the first integrator IC2 via the transmission gate IC7a and one of the range resistors. The unknown capacitor is connected as the feedback element of this integrator in parallel with the transmission gate IC7b. The negative going integrator output is compared with V_{REF} at the summing junction of IC3 which operates open loop as a comparator. The output voltage of the comparator is

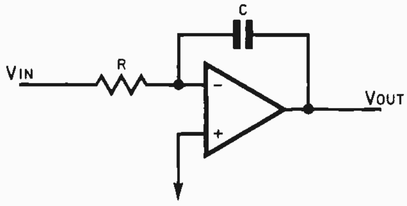
SPECIFICATION

Ranges	8 ranges: 300pF–3000μF in decade steps
Accuracy*	Typically 2·5% on all ranges (dependent upon meter movement, range resistors and capacitor)
Precision	1% on range 1 (300pF) 0·25% all other ranges
Measurement time	3 seconds max from 3μF–3000μF 300ms all other ranges
Power consumption	25mA max (each battery)

*Precision is defined as the relative standard deviation for repeated measurements on the same capacitor, calculated from the equation:

$$\text{Percentage Precision} = \frac{\sqrt{\frac{\Sigma (x-\bar{x})^2}{n}}}{x} \times 100$$

where x is the mean of n measurements, and x is an individual measurement. The precision is a guide to the accuracy which can be obtained if measurements are referred to a known value capacitor.



(a)

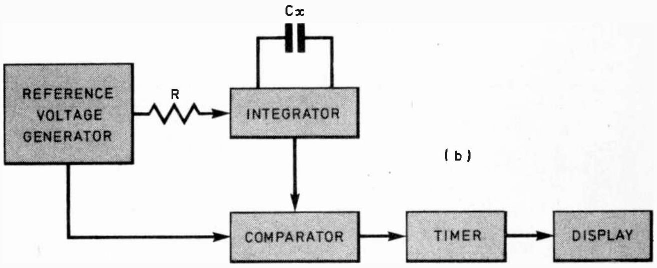


Fig. 1 (b) Block diagram of Linear Capacitance Meter

monitored by the indicator circuit comprising R15, R16, TR1 and D3, and is also fed into the NOR gate IC4a. The comparator output is gated with the output of the RESET/START generator, and the resultant output of IC4a is the actual time taken for Cx to charge to the reference voltage (which relates to the value of Cx). In a digital instrument this time would be measured directly with a clock generator.

In the analogue instrument described here, time is measured by the second integrator comprising IC5, C3 and one of the range resistors R10–R14. The way this circuit measures time is apparent from equation 2. We see that in Fig. 1a the output voltage of the integrator is proportional to the time for which the input voltage V_{IN} is connected, for constant R and C. In the meter unit the input voltage to the second integrator is V_{REF} and it is connected through the transmission gate IC7c which is open only during the integration period of the unknown capacitor Cx. This time measuring integrator is reset by the transmission gate IC7d. It is this second integrator which requires V_{REF} to be set accurately to 1V in order to measure time accurately. It is further important that the time measuring integrator capacitor is a precision component. Although 1% precision capacitors are expensive it is worth pointing out that this design requires only one such component in order to cover an eight decade range. This is because the input resistors of the two integrators can both be varied.

In the RESET AND RUN circuitry of Fig. 2 half of a dual JK FLIP FLOP is used, connected as a simple toggle circuit. The initial condition of reset is established by holding the SET input of the CD4027 high during the period when power is first applied. As C5 charges through R22 the output of IC4d eventually goes low which then enables the CLOCK input. The CLOCK input is driven from the output of the monostable comprising IC4b, c, R21, C4 and S3. The input of IC4b at pin 1 is normally held low by R20, C4 is uncharged, and the input applied to IC4c is high. The output of IC4c is therefore low and this is applied to the second input of IC4b. As soon as pin 1 of IC4b receives a positive pulse from S3 via R19, the output goes low (being a NOR gate). This is transmitted via C4, which can only charge slowly via R21, to the input of IC4c whose output therefore goes high. This high is applied to the input of IC4b which therefore remains low even if the other input has now gone high. This condition remains until C4 has charged through R21 when the circuit reverts to its initial state. The long time constant of C4, R21, was chosen by experience to prevent false output pulses. It is surprising how long human fingers dwell over pushbuttons!

INITIAL RESET

Fig. 3 shows the initial conditions as produced by the "power-up reset" function. The first integrator output V_{INT} is held at zero because IC7b is open and IC7a is closed. The second integrator output is similarly zero. As soon as the push button is pressed the first and second integrators ramp negatively until the first integrator crosses $-V_{REF}$. At this point the comparator IC3 changes state and disenables the transmission gate IC7c via the NOR gate IC4a. The timing capacitor C3 remains charged because the off resistance of the transmission gates IC7c and IC7d is extremely high and the input bias current of the CA3140 is extremely low. The output of IC2 continues to ramp negatively until the amplifier saturates. This is close to the negative rail. The circuit is now in a stable state with the meter displaying the measured capacitance. Capacitor C3 will of course be discharging slowly, but the rate is measured in only fractions of a millivolt per second. In the author's instrument no discernable movement of the pointer takes place in a one minute period after completion of a measurement. A second press of the push button initiates a reset and returns the circuit to its initial state ready for the next measurement.

CONSTRUCTION

The circuit was built on a piece of stripboard measuring 36 conductors by 43 holes (see Fig. 4.) and then mounted against the back of the meter, using the meter screws for fixing. The case size or shape is not too important, but the prototype used a plastics box of dimensions 172 × 100 × 55mm, and was fairly compact at this size. The battery holders were clamped under a stiff cardboard plate, and fastened by two 6BA nuts and screws.

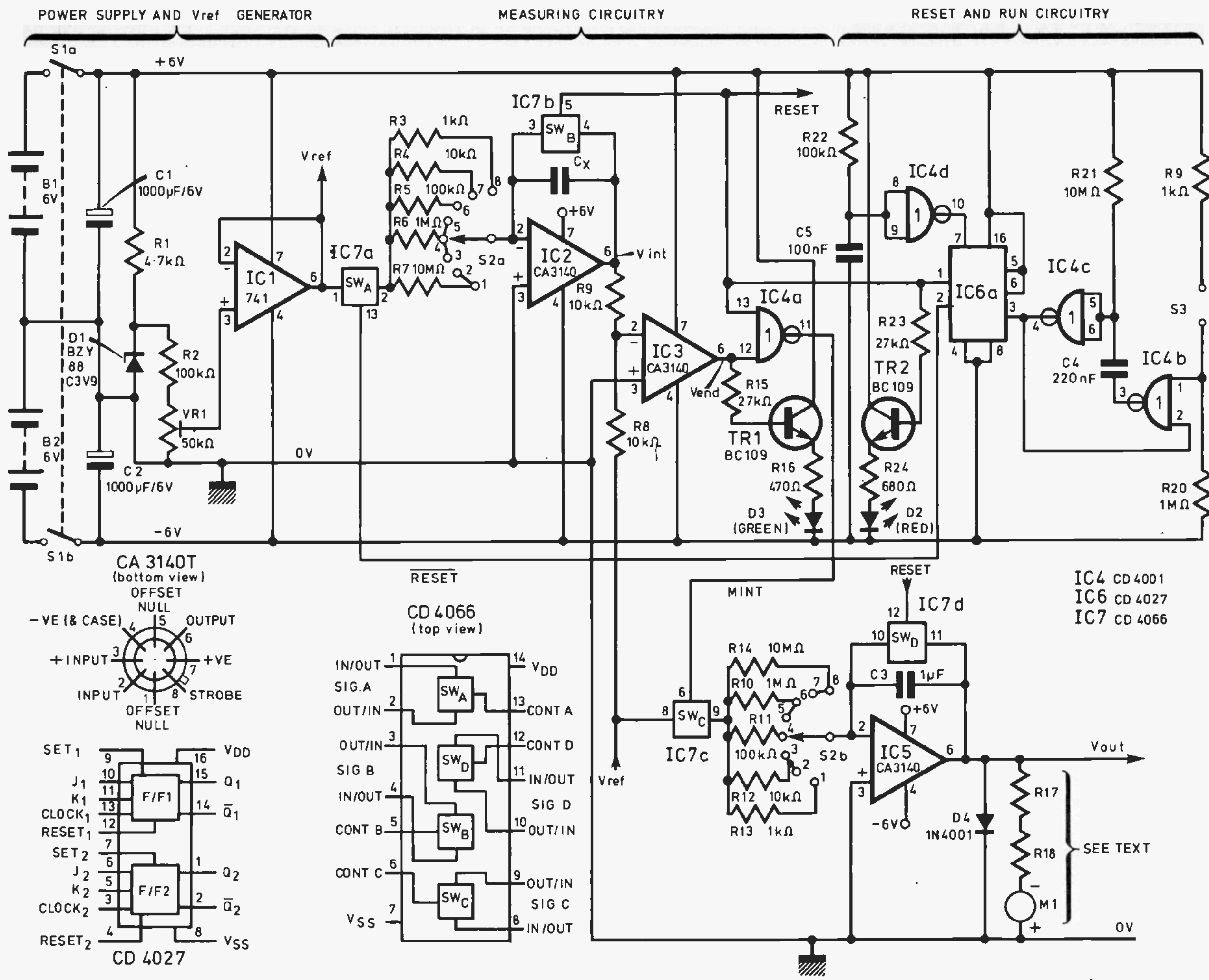
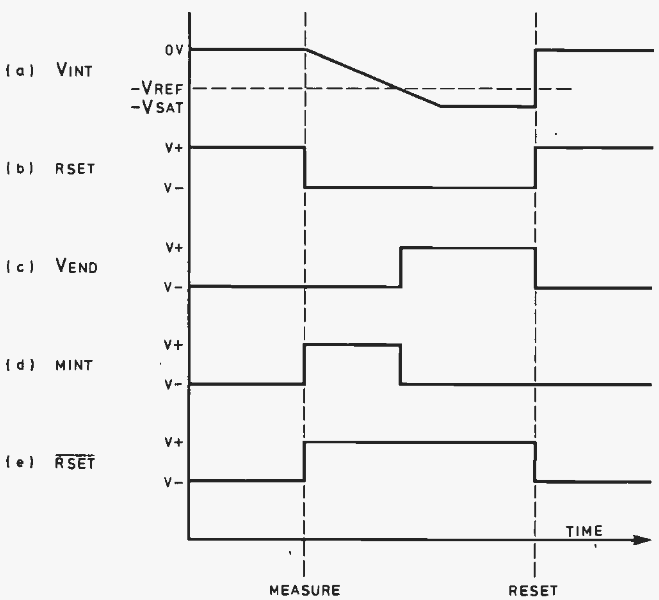


Fig. 2. Circuit diagram. Cx is the capacitor under test. The MINT line is the measurement period integration signal

Fig. 3. Timing diagram



COMPONENT SELECTION

A number of components call for some comment, and a few are best selected during setting up of the meter. The use of the relatively new CA3140 operational amplifier is of prime importance in the design. This device is one of a new family of BIMOS amplifiers which incorporate the advantages of MOS and BIPOLAR technologies on a single chip. They seem destined to take over from the 741 in many areas because they can offer greatly improved performance, albeit currently at somewhat increased cost. Both integrators in the present circuit use the CA3140 to minimise errors caused by the integrator capacitor charging (or discharging) via the input bias current of the amplifier. The maximum input bias current for the device is 50pA (typical 10pA) at 25°C compared with 1μA for the standard 741. This current is small compared with the smallest charging current used in the circuit, which is 100nA, and therefore is not a significant source of error. The CA3140 also has a very creditable slew rate of 9V/μS making it some 15–18 times faster than the 741, and therefore quite useful as a comparator. In this circuit the positive and negative extremes of the comparator output are directly compatible with the CMOS logic circuits. The CA3140 does contain MOS transistors in its input stage and is susceptible to the same problems of static as any CMOS logic i.c.

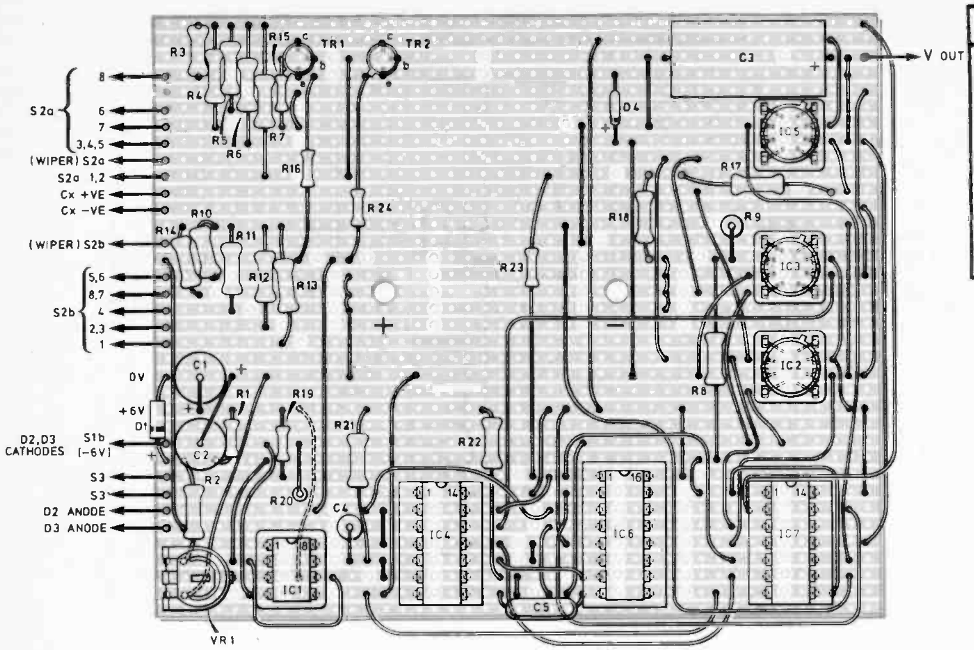


Fig. 4. **Component layout (actual size). Ensure that the fixing holes are spaced correctly for the meter being used**

TABLE 1. METER RANGES		
switch positions	**output voltage**	**f.s.d. with 30μA meter (see text)**
1	1V/100pF	300pF
2	1V/1nF	3nF
3	1V/10nF	30nF
4	1V/100nF	300nF
5	1V/1μF	3μF
6	1V/10μF	30μF
7	1V/100μF	300μF
8	1V/1000μF	3000μF

C=P

Electrolytic capacitors may have tolerances as wide as −25 + 100%. In multiple time constant systems the meter can be used to ensure that, for example, "period A" ***really does*** **outlive "period B" when near-value capacitors are used**

In general the accuracy of the instrument is dependent on the range resistors, the timer capacitor C3, and the reference voltage V_{REF}. The latter can be set accurately if the constructor has access to a digital voltmeter, otherwise it can be set up with a multimeter to $\pm 2\frac{1}{2}\%$. The range resistors should be high stability 2% metal oxide types and could be selected with a digital multimeter to advantage. Note, however, that the range resistors are in series with the transmission gates IC7a and IC7c. They therefore define the charging currents only when they are large compared with the "on" resistance of the gates. The typical resistance of a CD4066 at room temperature can be as much as 550Ω. Ideally this device should be selected for low "on" resistance but if this is impracticable the most serious error occurs on range 1 and this can easily be circumvented.

When range 1 is selected the input resistor of the second integrator is nominally 1kΩ. Thus with a typical CD4066 the actual input resistance defining the charging current would be about 1·12kΩ with a worst case of 1·55kΩ. This would obviously give rise to errors of 12% and 55% respectively, with the indicated capacitance being too small. The simplest solution is to select this resistor by direct calibration with a known capacitor. This is quite simple on this particular range because silver mica capacitors of 100pF–200pF of 1% tolerance are cheaply and easily available.

The procedure for calibrating the instrument on this range is therefore as follows. Using 1kΩ as the range resistor, press the RUN button and record the reading. Now reset the meter by pressing the button again and place a known 100pF (or similar value) capacitor across the input terminals and press the button. The difference between the second and first readings should be the value of the capacitor. If the reading is too low reduce the value of the range resistor and *vice versa*. Alternatively a 1kΩ skeleton preset could be fitted. Note that the reason for making two measurements is that the circuit does not contain provision for eliminating stray wiring capacitance which will be of the order of 5–10pF. This only affects the lowest range and can be otherwise neglected.

The meter multiplier resistances R17, R18, have not been defined because the actual values will depend on the meter movement used. This is not critical since the output of the second integrator is of low impedance and can swing close to the negative rail. Thus any voltmeter with a sensitivity of 5V f.s.d. or better could be used directly without R17/R18, because the output is defined in terms of volts/μF according to Table 1. Alternatively if a current meter is available the multiplier resistors R17/R18 must be used. Two resistors have been specified because in general it is not possible to select a single resistor from the preferred values available to make a meter multiplier. Note that it is essential to know or to measure the internal resistance of a current meter in order to calculate the multiplier resistance. This should be borne in mind if a purchase is made since many of the cheapest meters available through retail outlets do not have this information supplied. The method of calculating R17/R18 is best illustrated by example. The author had available a 30μA movement of internal resistance 1400Ω. This is converted to a 3V f.s.d. meter by a multiplier resistor fulfilling the equation:

$$E_{f.s.d.} = I_{f.s.d.} \times (R_{meter} + R_{multiplier})$$

where $E_{f.s.d.}$ is the required full scale deflection voltage, and $I_{f.s.d.}$ is the meter sensitivity for full scale deflection. Thus in the present example

$$3\cdot0 = 3\cdot0 \times 10^{-5}\,(1400 + R_{multiplier})$$

$$\therefore R_{multiplier} = 10^{5} - 1400 = 98600\Omega$$

COMPONENTS . . .

Resistors

R1	4·7kΩ
R2	100kΩ
R4, R8, R9, R12	10kΩ 2% m.o. (4 off)
R5, R11	100kΩ 2% m.o. (3 off)
R6, R10	1MΩ 2% m.o. (2 off)
R7, R14	10MΩ 2% m.o. (2 off)
R3, R13	1kΩ 2% m.o.
R15, R23	27kΩ (2 off)
R16	470Ω
R17, R18	see text
R19	1kΩ
R20	1MΩ
R21	10MΩ
R22	100kΩ
R24	680Ω

All resistors ¼W 5% unless otherwise stated. R7 and R14 may be difficult to obtain and so selection from 5% tolerance resistors may be necessary

Potentiometer

VR1 50kΩ min preset

Capacitors

C1, C2	1,000μF/12V elect (2 off)
C3	1μF 1% polycarbonate (Electrovalue)
C4	220nF polyester
C5	100nF polyester

Transistors and diodes

D1	BZY88 C3V9
D2	l.e.d. red
D3	l.e.d. green
D4	1N4001
TR1, TR2	BC109

Integrated circuits

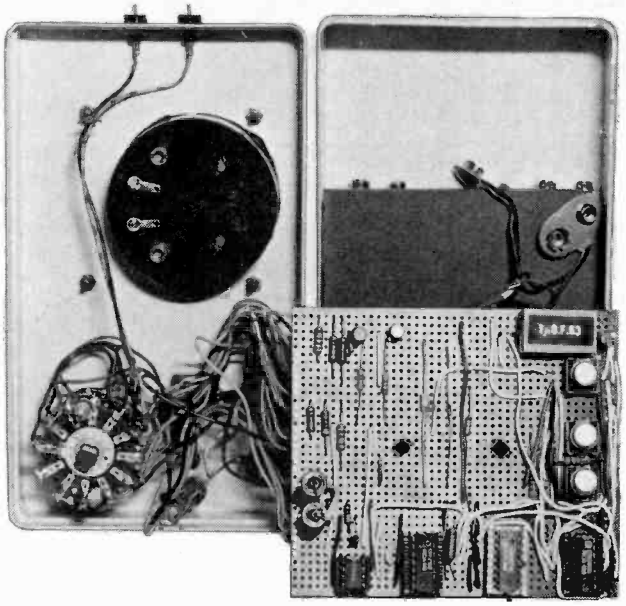
IC1	741
IC2, IC3, IC5	CA3140 (3 off)
IC4	CD4001
IC6	CD4027
IC7	CD4066

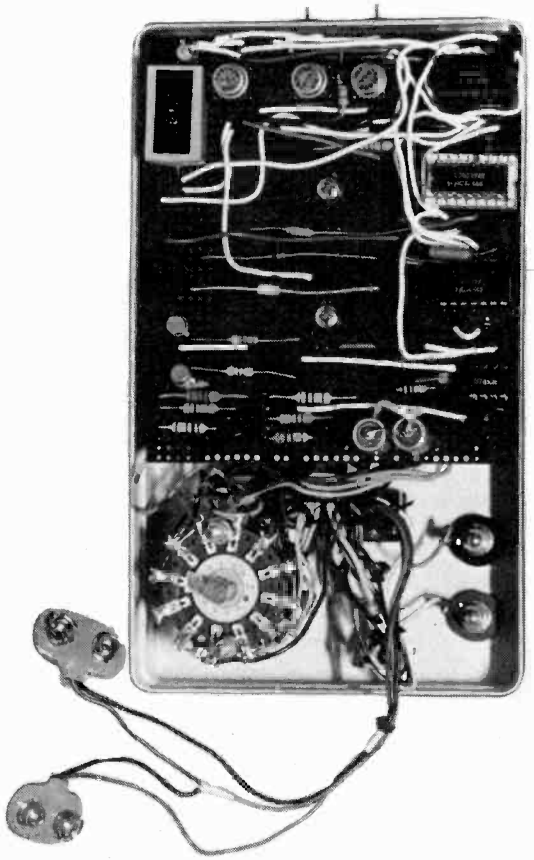
Switches

S1 d.p.s.t. switch
S2 2-pole 8-way (make before break)
S3 push to make (momentary contact) switch

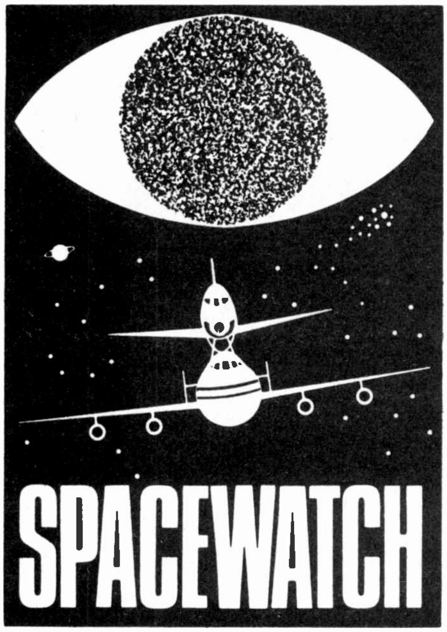
Miscellaneous

B1, B2 4 off HP7 each. Battery holder to suit
4mm terminals red, black
1mm sockets red, black
Pointer knob
Meter (see text)
Clips for l.e.d.s
Plastics box (prototype used 172 × 100 × 55mm)
Stripboard 0·1in matrix





This can be made up from 91kΩ and 7·5kΩ to an acceptable accuracy from E24 resistors. It is worthwhile making the output voltage of the final integrator available externally if a digital voltmeter is available, because although the accuracy of the instrument is limited, the precision or reproducibility is very high indeed. This makes it possible to measure capacitors to better than ±0·2% providing a known standard capacitor is available to correct the readings. ★



FRANK W. HYDE

SKYLAB

In March this year space engineers of the USA successfully re-established contact with Skylab. The space station has been dormant for four years. It was necessary to do this as a first step towards the boosting of the vehicle to a higher Earth orbit.

In April a further manoeuvre was made. Another will be needed in or about October 1979. These actions are required because Skylab is losing height faster than was predicted when it was launched in May 1973.

At that time it was expected that Skylab would remain in stable orbit until the 1980s when the Shuttle would be available to assist.

The fear that made these decisions necessary was that Skylab might make an unscheduled and perhaps disastrous re-entry and not burn up without mishap. The effect of the early demise of Cosmos 954 no doubt has had some effect on the decision about Skylab. It is perhaps relevant to point out that large units may not completely burn up and that some 5 to 10 per cent may fall to Earth. Should the second action on Skylab, in April, subsequently prove ineffective then the vehicle can be targeted to remote regions of the oceans.

The first corrective move commenced in March. A series of commands were sent to Skylab to activate the receivers and speaker systems. It was expected that the telemetry system would operate even after the interval of four years. The condition of the temperatures and pressures, the orientation of the vehicle in space and the gas that was still available for its thruster motors. The first command did in fact bring a response but this was lost after two minutes.

As the space station passed over the Bermuda tracking station some 92 minutes later a second command was sent. There was a "hum" response but no data. The flight control then resorted to the back-up system for communication. This was entirely successful. Further commands were then sent to charge the station's batteries from the solar panels. Finally the computer was checked out on March 13th.

If the plans work out successfully then Skylab may have a second lease of life. Studies are already being undertaken as to how the station could be used in conjunction with the European Spacelab brought up in the Shuttle.

If the problems are solved then Skylab might well become the first space platform for the construction of large space structures to collect energy from the Sun or as a launch pad for other missions.

COSMOS 954

The post mortem on Cosmos 954 has so far yielded a few scraps and a little information. The parts that have been found have been radio active at about 20 roentgens/hour. One large piece found in a crater two metres in diameter showed a level of 100 roentgens/hour and was removed in a safety package for examination. New equipment was sent out to search for parts which might have been buried in the ice.

From the information available it has been estimated that the satellite was of 6,000 kilogrammes. Specialists have estimated that a satellite of such mass would have a residue of 5 to 10 per cent which was not vaporised. It would seem therefore that it was as the USSR said, the satellite was intended and indeed did burn up almost completely on re-entry.

The nuclear reactor on board was thought to be about 50 kilogrammes of enriched uranium. It is worth noting that a killer satellite could be used in emergencies of the Cosmos 954 type. It is perhaps a significant point that a few days after the scare the Soviet Union launched Cosmos 967, and in a circular orbit at 66 degrees from the equator. Eight days later Cosmos 970 was launched into a highly elliptical orbit inclined at 65 degrees to the equator. Before one whole revolution had been completed Cosmos 970 had been moved to a more circular orbit and at the same inclination as Cosmos 967, so that it passed close to Cosmos 967. On command from control on the ground Cosmos 970 blew up. It was considered that this was a satisfactory indication that Cosmos 967 would have been destroyed had control so wished when they were close together.

It should be noted that both the USSR and the USA are examining the use of high energy laser beams for use against spacecraft. Already a level of generation has reached hundreds of joules per pulse.

The USA has been attempting to close the gap in defence against satellite vulnerability. One of the most sensitive areas is that of solar "sails". Although they are transparent to most forms of radiation they are susceptible in the region of the wavelengths which absorb power. The positive step is to remove the solar arrays and use radio isotope generators. Already two US satellites have been fitted with such generators and a range of new applications were planned with generators from 10 to 100 kilowatts. However, President Carter has proposed a ban on reactors in orbit. This is ironic because the USSR has already adopted the thermal isotope generator. At least ten of the recent launchings have had them.

SHUTTLE BOOKINGS IN ADVANCE

The US Space Agency is now taking reservations for the years 1982 and 1983. This information comes from the manager of flight cargo schedules, Chester M. Lee.

Iran and West Germany have made partial payments for 1982/83 launches. Japan is considering a spaceflight in 1983. Canada, India and the European Space Agency (ESA) have also reserved Shuttle flights.

Mr Lee said: "We have all the cargo we can handle for 1980 and a few spaces left in 1981."

The Goddard Memorial Symposium on the international uses of the space shuttle and space laboratory drew 400 participants from the United Kingdom, Italy, Canada, Germany, France, India, Japan and the United States. The prime topic at the symposium was the European Spacelab, built by ESA to fly in the Shuttle's cargo bay. This multi-purpose facility will be used for experiments in Earth observations, astronomy, physics, solar and atmospheric chemistry, biology and space manufacturing.

NASA and ESA will equally share the first Spacelab flight, now scheduled for December 1980. Spacelab 1 will be truly of an international content. Spacelab 2, scheduled for April 1981 will carry the experiments of 47 USA scientists and 12 United Kingdom scientists. Among the principal investigators are Allen Gabriel of the Appleton Laboratory and Peter Willmore of the University of Birmingham. Spacelab 1 will be carried by Shuttle Orbiter 102. It is being built in California. The first of its six test flights will take place in June 1979.

JUPITER: PLANET OR STAR

A Soviet scientist has produced some evidence to add to the theory that Jupiter is a star rather than a planet. The suggestion is that Jupiter is either a star in formation or a dying one.

Professor N. Kozyrev of the Leningrad Pulkovo Observatory told a scientific meeting that the nucleus of Jupiter has a temperature of 196,000 degrees Centigrade. The professor constructed a mathematical model of Jupiter's nucleus and the results of using this model seem to agree with those obtained from astrophysical observations and also from details of the Jupiter heat stream recorded by Pioneer 10 and Pioneer 11 probes.

FREE ENTRY COMPETITION!

AN OPPORTUNITY FOR INVENTORS FINANCIAL BACKING and £490 worth of SCOPEX 'SCOPES TO BE WON

1st Prize A Scopex 4D10A dual beam oscilloscope worth over £200.

Runner up Prizes Two Scopex 4S6 single beam oscilloscopes each worth over £140.

Can you invent or design a novel project that could form a commercial product? We give you the chance to win the financial backing your ideas might deserve. Successful designs may be backed commercially by a Venture Capitalist to develop saleable products and you—as the designer—would receive financial benefit.

Even if your design is not deemed suitable for development you could still win yourself a piece of test gear worth over £200. Some designs may also be published in P.E. as constructional projects and payment will be made at the time of publication—so you could gain in any or all of three ways!

If you do come up with a winning design, who knows, you could soon be a partner in a going concern.

HOW TO ENTER

The contest is for practical items incorporating electronics as a major part of the overall system. There is no restriction on the application, e.g. it could be a video tape recorder or a door bell. It may be for domestic use or for industry.

Entries must be written/drawn clearly on one side of plain paper with the entrant's full name and address at the top of every sheet. Each entry to comprise:

(a) a brief summary of the design (about 50 words);

(b) any such further descriptions, drawings, sketches, photographs and circuit diagrams, etc., you consider the judges may need to form the best appraisal of your design. **DO NOT SEND ACTUAL MODELS.**

Each entry must have a properly completed entry coupon cut from P.E. firmly affixed to the back of the summary. Entrants may be requested to supply prototypes for evaluation at later stages of the judging. All entries must be in English.

Readers may be assured by P.E. that ideas submitted will not be misused or transmitted to other parties by anyone concerned with the competition.

SEND YOUR ENTRY TO
Practical Electronics Inventors Competition
55 Ewer Street, London, SE99 6YP

FREE ENTRY COUPON

PRACTICAL ELECTRONICS INVENTORS' COMPETITION
(Block letters please)

NAME (Mr/Mrs/Miss)......................................

....

ADDRESS..

....

....

....

TELEPHONE NUMBER if any..........................

I certify that

*delete clause NOT applicable

*(a) This entry is my own original idea and has not been copied from any other source;

*(b) This entry has been made on behalf of the company/group members listed and is our own original idea not copied from any other source;

(c) This idea has not been published or offered for publication elsewhere.

I/We agree to abide by the rules and conditions.

SIGNED...

SECOND CHANCE

Another free entry coupon will appear next month.

The closing date is August 31st 1978.

RULES AND CONDITIONS

There is no entry fee nor limit to the number of entries a reader may submit but each entry must be accompanied by a proper printed entry coupon, cut from PRACTICAL ELECTRONICS, and must bear the entrant's own full name and address. Entries will also be accepted from groups or companies, in which case the entry must be submitted and represented by an individual and the other involvements declared on a separate sheet of paper attached to the back of the summary with the coupon.

All accepted entries will be examined by a panel of expert judges including the Editor of Practical Electronics, and assessed on (a) originality of the idea, (b) technical merit, (c) practicability, (d) economic viability, (e) market potential, (not necessarily in that order). The prizes will be awarded for the best entries in order of merit. In the event of the same idea being submitted by two or more entrants, presentation of the entry (clarity, best expression, etc.) will decide such winner(s) or winning order.

In the event that the judges consider there are not enough entries of a sufficiently high standard, the Editor reserves the right not to award any prize(s) at his discretion.

Entries arriving after closing date will not be considered, nor will any received that are illegible, not wholly understandable, are not accompanied by a properly completed entry coupon or in any other way do not comply exactly with the instructions and rules.

No responsibility can be accepted for entries lost or delayed in the post or otherwise; proof of posting will not be accepted as proof of receipt. No entries can be returned.

The competition sponsors reserve the right to adapt or amend any entry—after judging has been completed—for purposes of publication and/or commercial development. They also reserve the right to consider any other entries for commercial production. Where any idea is adapted or developed for commercial production payment and/or royalties and/or direct involvement in the company concerned will automatically be negotiated with the designer or person named on the entry coupon.

Winning entries will not necessarily be developed commercially, but Practical Electronics will pay the usual reproduction fee for any entries published.

Ideas already covered by a patent owned by the representer, but not already in or on offer for commercial production, may be submitted but this fact must be clearly stated together with the relevant patent nnmber.

Decisions of the judges, and of the Editor in all other matters affecting the competition, will be final and legally binding. No correspondence will be entered into nor interviews granted.

Winners will be notified by post and brief details of winning entries published later in Practical Electronics.

The contest is open to all readers, but those outside the U.K. may be requested to provide a British address to which any prize may be sent. Development of any idea must take place within the U.K.

Employees and the families of employees of IPC Magazines Ltd., and the printers of Practical Electronics and anyone directly connected with the competition are not eligible to enter.

Kit Review...

LEADER 103 P.S.U.

THE LPU103 power supply unit reviewed here is one of a new range of kits available from Arrow Electronics. The company claim the kits are of "bug proof" design and because they are only supplied in kit form the minimum of components have been used whilst still retaining a high standard in both performance and reliability.

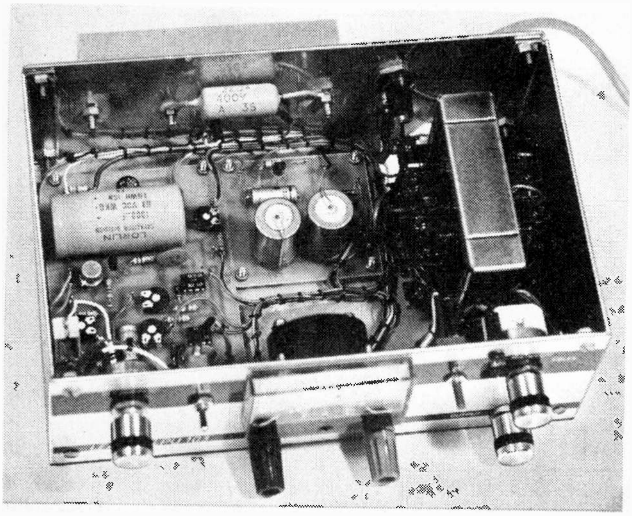
Nickel cadmium batteries can also be recharged using the p.s.u. with the charging voltages and currents being displayed on the meter of the instrument.

SPECIFICATION

The output voltage of the LPU103 is variable from 0 to 30V with current limiting available in two ranges: 0 to 100mA and 0 to 1A.

The unit can sustain short circuits at full current for considerable lengths of time but because of heat dissipation, when the short is removed the meter calibration will alter by 3–5 per cent until the case temperature is reduced.

Therefore sufficient space must be left around the unit to allow adequate air circulation.



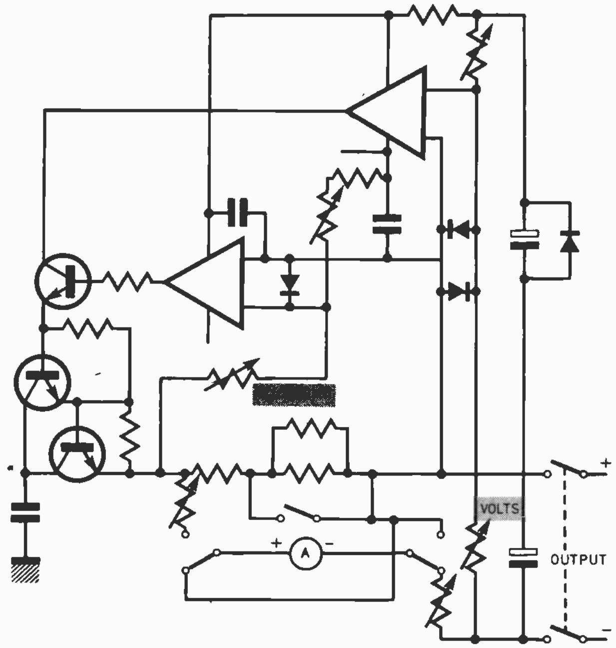
CIRCUIT DETAILS

The circuit of the LPU103 is designed around two 741 operational amplifiers connected as differential voltage comparators, one to control the current and the other the voltage. The outputs of these two i.c.s are fed to a triple Darlington of which one transistor, a 2N3055, is used as the series pass transistor and is mounted on a heatsink.

The problem of output transients when switching the unit on is eliminated by the inclusion of an output switch. This switch allows the unit to be on continuously with the output terminals only showing a voltage when it is on.

TOOLS

The only tools required to build the unit are, small wire cutters, a suitable earthed soldering iron with a 3/32 inch bit, fine nosed pliers, screwdriver, 4BA spanner and, to avoid



Circuit diagram of the LPU103

damaging the front panel when fitting the switches and potentiometers, the correct sized spanners.

The kit includes solder, plenty of wire and also rubber sleeving for the soldered joints.

ASSEMBLY INSTRUCTIONS

If any type of kit is to be constructed successfully clear instructions are of paramount importance. Therefore before starting to build the unit the instructions were read through carefully and using the component list provided each part was checked and identified. The p.c.b.s were also checked for any short or open circuit.

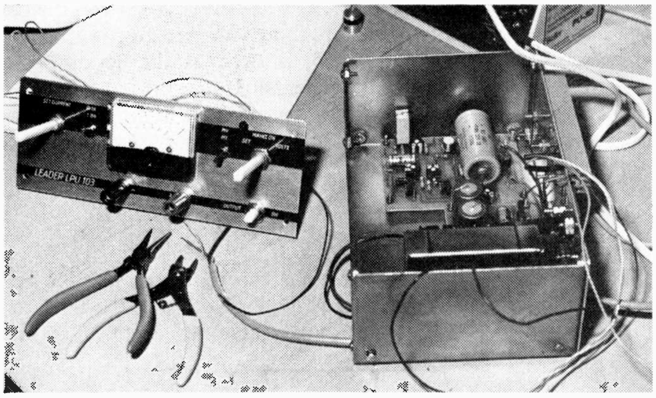
The instructions advised that all the components should be placed so that their values or type printed on the body can be read from above the board to enable them to be easily checked in case of incorrect positioning; with this noted the first of the two p.c.b.s could be soldered.

The assembly instructions are very comprehensive and any constructor who reads them carefully should have no difficulty in successfully building the kit.

CONSTRUCTION

Vero pins were supplied for connecting wires to and from the p.c.b.s and these were inserted using a layout drawing to ensure correct positioning and then soldered to give a good connection to the track.

The instructions gave a point by point soldering guide with a p.c.b. component layout for visual checking.



The only criticism of the p.c.b. assembly was the fitting of a 1000μF 63V capacitor which according to the instructions should be soldered second. As this is such a large component it was felt that this would hamper the assembly of the rest of the board and so noting its position the board was soldered leaving this capacitor to be fitted last.

After both p.c.b.s had been soldered they were cleaned and checked for any shorts and then placed to one side and the front panel assembly started.

As the front panel of the unit is anodised, care was taken to avoid handling it with dirty hands or marking it when fitting the switches, potentiometers and sockets.

The heatsink and transformer were already mounted onto the chassis so only the power transistor and p.c.b.s had to be fitted. The main p.c.b. had to be filed on one corner to enable it to fit correctly. With this completed the unit was ready for wiring.

To reduce the noise to a minimum in the finished unit the position and length of the interconnecting wires is of prime importance and for this reason the length of every wire used is given.

With the wires soldered into position and sleeved where appropriate the unit was then ready for testing.

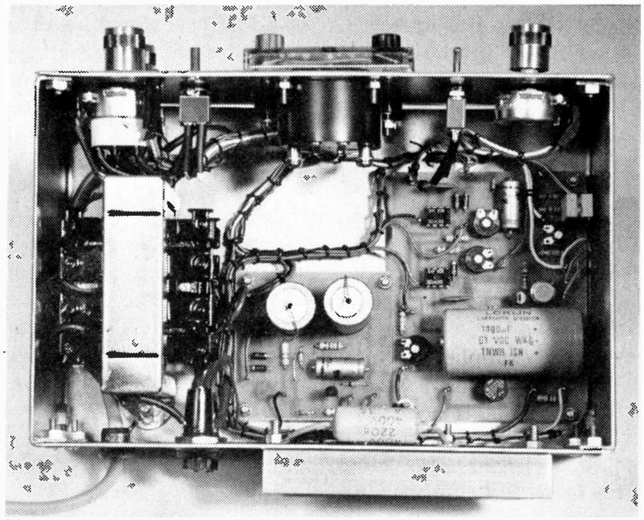
TESTING AND CALIBRATION

All the supply connections were rechecked and using a multimeter both phases of the mains lead and earth were tested for shorts. The interconnecting wires were also checked to ensure they were soldered correctly.

With the testing completed without problems the unit was connected to the supply and as the unit worked first time the voltage and current outputs were calibrated.

The final test to be carried out on the p.s.u. was to check the output noise level.

The reading obtained for the output noise was outside the manufacturer's stated limit. The instructions advised that this figure could be improved by adjusting the front panel wiring and after several attempts the best reading obtained was 0·15mV which was inside the stated limits.



FINISHED UNIT

The LPU103 is a rugged reasonably priced instrument capable of meeting the needs of most constructors. The specification matches many of the more expensive ready built units available. As each kit is housed in an attractive hammer finished case with a distinctive red stripe across its front panel, constructors can if they wish build up a complete range of matching test equipment.

The LPU103 kit can be obtained from Arrow Electronics Limited, Leader House, Coptfold Road, Brentwood, Essex. Price £29·99 (including VAT and Post and Packing).

FOOTNOTE

Peter Clarke of Arrow tells us that he had so many problems trying to get instructions for his kits printed that eventually, being faced with a further three weeks delay, he went out and bought himself a printing machine and the equipment to make the plates. He then taught himself how to print and printed the instructions, all within a week.

It's good to hear of a company that is prepared to take such steps to supply the goods.

★

POTTERY has become a very popular hobby with many amateur potters now possessing their own small electric kilns. Many such kilns are only supplied with an indicating pyrometer and have no automatic temperature control. The sight of a kiln which has been forgotten and gone above its firing temperature is heart-breaking because the clay melts (vitrifies) at high temperatures and can cause many pounds worth of damage to the inside of the kiln.

The unit described here does two things. Firstly, it enables a control temperature to be set, and holds the kiln at this temperature; secondly, it enables the potter to "soak" his glazes, thus improving the glaze quality. The controller can also be used with enamelling kilns.

THE PYROMETER

It is assumed that a thermocouple and indicator (indicating pyrometer) are already fitted to the kiln. Fig. 1 shows how the voltage across the indicating meter varies with temperature. This particular pyrometer is for a stoneware kiln capable of reaching 1300°C, so the thermocouple will be of the platinum-rhodium type.

CIRCUIT DESCRIPTION

The complete circuit diagram of the controller is shown in Fig. 2. The unit is connected directly across the pyrometer meter at points A and B using nickel-plated terminals and a short length of single-core screened cable. With the high input impedance of IC1 (when used as a voltage follower) the connection of the controller across the meter will not affect the meter reading. No cold-junction temperature compensation has been included since it is assumed that the controller will always be working above 1000°C, therefore compensation will have little effect.

The output of IC1 is amplified 100 times by IC2. The voltage variation at the output of IC2 is therefore 0–1·3 volts

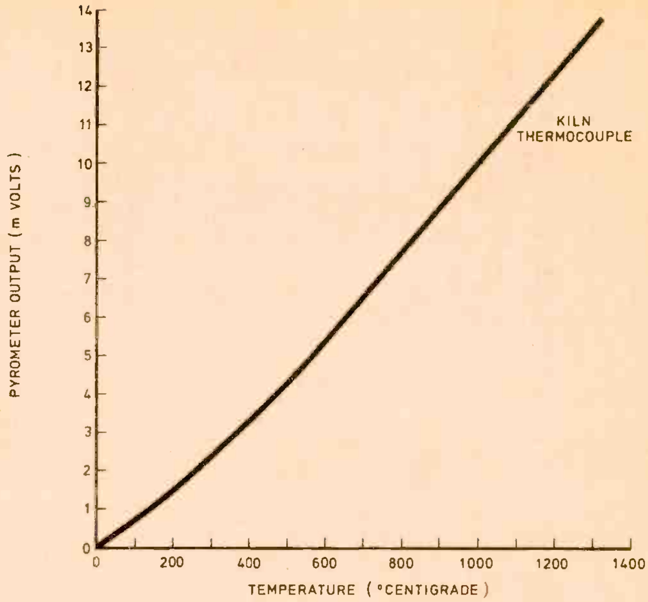


Fig. 1. Graph showing the millivolt/temperature curve of the platinum-rhodium thermocouple

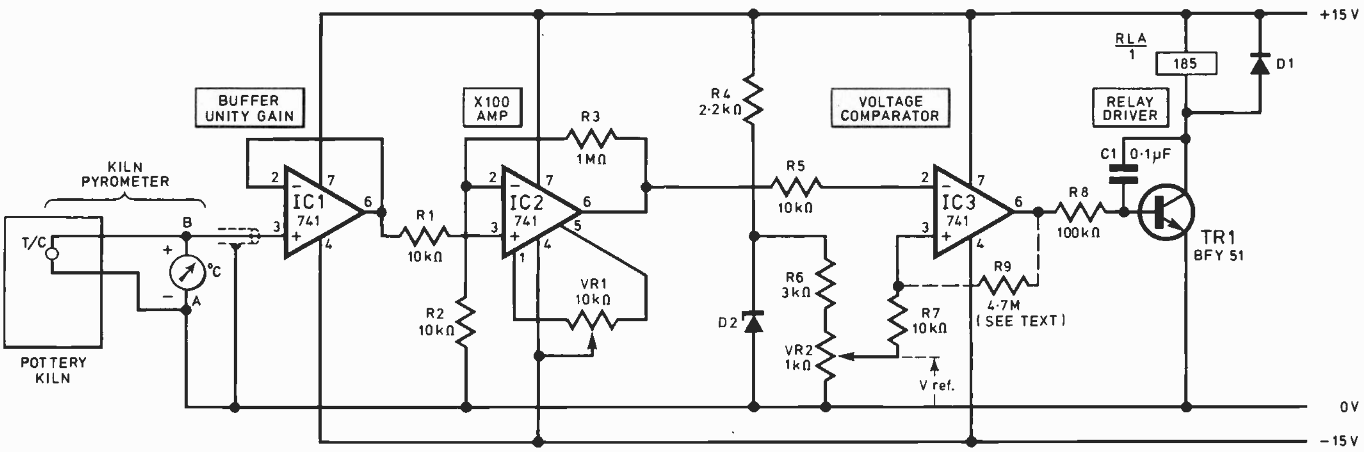


Fig. 2. Circuit diagram of the controller

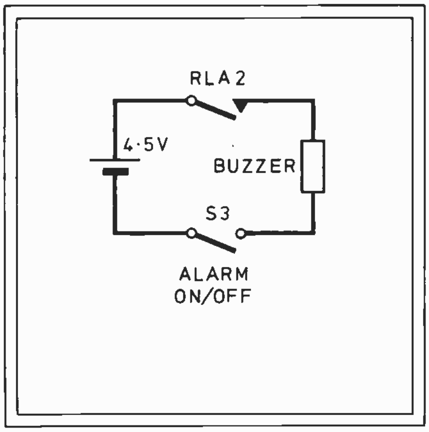


Fig. 3. Kiln up to temperature alarm (optional)

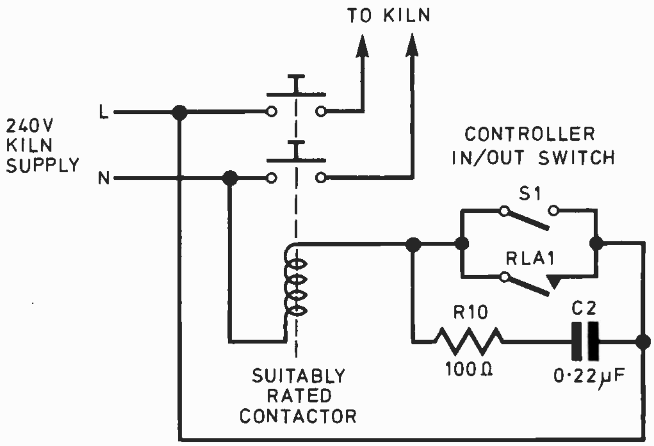


Fig. 4. Wiring diagram of the kiln contactor

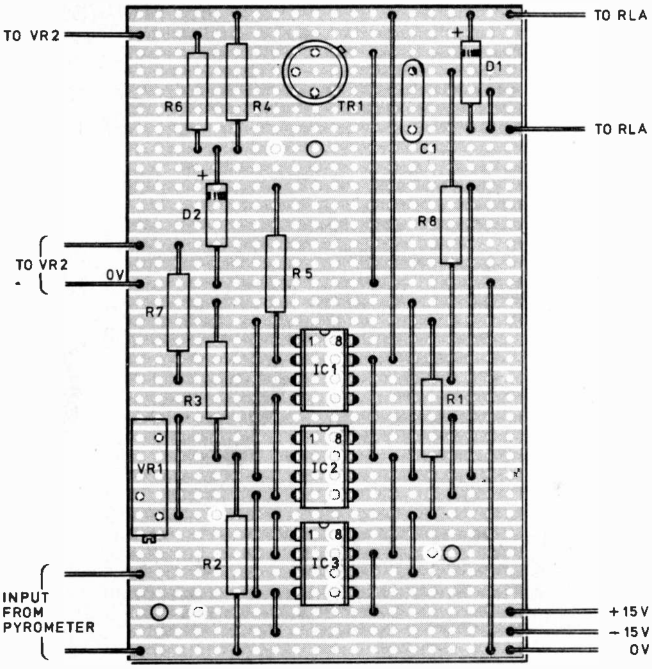


Fig. 5. Main circuit board

for the thermocouple response shown in Fig. 1. IC3 acts as a voltage comparator with its reference voltage derived from a temperature-compensated, 6·2 volt, zener diode.

When the voltage of pin 2 of IC3 goes positive with respect to pin 3 (reference) then the output of IC3 will go negative, turning off TR1, de-energising RLA and switching off the kiln. On the author's controller no hysteresis was included as the relatively long thermal time constant of the thermocouple and kiln prevented erratic operation. However, hysteresis may be added by the inclusion of R9 if erratic operation occurs. VR2 should be a ten-turn wirewound potentiometer fitted with a turns counting dial.

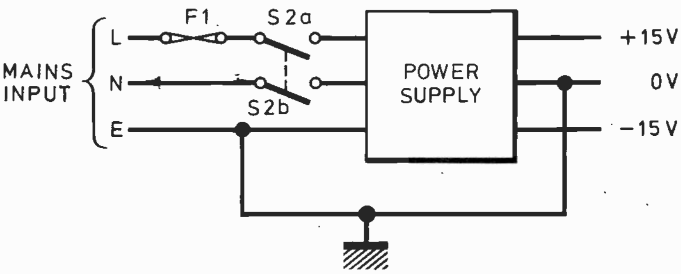
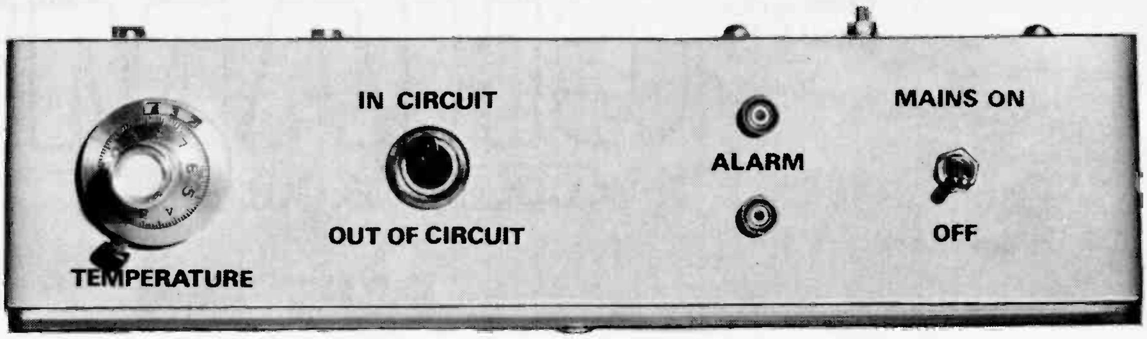


Fig. 6. Wiring diagram of power supply unit



COMPONENTS . . .

Resistors

R1, R2, R5, R7, R8	10kΩ (5 off)
R3	1MΩ
R4	2·2kΩ
R6	3kΩ (see text)
R9	4·7MΩ (see text)
R10	100Ω

All 5% ¼W carbon

Potentiometers

VR1 10kΩ 20-turn cermet trimmer ¾in
VR2 1kΩ 10-turn wirewound

Capacitors

C1 0·1µF ceramic
C2 0·22µF 45V polycarbonate

Semiconductors

D1 1N4148
D2 1N821 (6·2V Zener)
TR1 BFY51

Integrated Circuits

IC1, IC2, IC3 741 op amp (3 off)

Switches

S1 5A toggle
S2 1A toggle D.P.S.T.
S3 Single pole on/off toggle

Miscellaneous

Heavy duty relay RS type 348-920 with mounting plate and socket
Chassis mounted fuse holder (2 off)
100mA fuse (2 off)
Turns counting dial for VR2
Thermocouple
Outlet plug and socket
Diecast box 180 × 120 × 60mm
Contactor (if req.)

Constructor's Note

A suitable *outlet plug and socket* can be obtained from **Harrison Mayer,** Craft and Education Division, Uttoxeter, Meir, Stoke-on-Trent.
The catalogue number is 365741.

CONSTRUCTION

In the prototype the components were soldered on to 0·1in. matrix stripboard using the layout shown in Fig. 5.

After soldering, the board was mounted into a 180 × 120 × 60mm diecast box and secured in position using 6BA countersunk screws and spacers. The heavy duty relay was fitted into the case on a mounting plate and socket.

The mains power supply used in the prototype was a fully encapsulated commercial unit, but any regulated dual supply with an output current of 100mA could be used. The mains input to the power supply was protected with two 100mA fuses fitted into chassis mounted fuse holders.

If the kiln to be used is fitted with safety switches on the doors a mains contactor is normally fitted in the back compartment. If it is not, a suitably rated contactor should be fitted into the back compartment and can either be permanently wired to the controller using high temperature cable or by using an outlet plug and socket. If a plug and socket is to be used care should be taken to ensure that it is capable of handling the high temperatures involved. For this reason it is recommended that constructors use the type given in the component list.

A "kiln up to temperature" alarm circuit is shown in Fig. 3. This unit can be incorporated into the controller if required using the relay contact RLA2. The 4·5V battery, switch 3 and the buzzer were all enclosed in a separate case outside the unit.

SETTING UP

Those constructors with access to a high impedance d.c. millivoltmeter or a d.v.m. can produce a millivolt/temperature curve for their own thermocouple.

If a chrome-alumel thermocouple is used its output will be approximately four times that shown in Fig. 1 and the resistor R6 should be lowered so the reference voltage V can be varied from zero to Vt:

Where Vt = mV × 100.

At the highest working temperature needed.

With R6 selected the input leads should be shorted together and VR1 adjusted to give zero volts at the output of IC3. The unit can either be calibrated by applying known millivolt levels to the input of the IC1 and adjusting VR2 until the relay de-energises or it can be directly calibrated in use from the pyrometer reading.

When in use the controller should be placed a short distance away from the kiln, otherwise the components will become overheated.

Finally a table (or graph) showing the setting of VR2 against temperature cut-out should be produced. ★

PE CHAMP

R.W. COLES B. CULLEN

PART TEN

CHAMP—U.V.

THE combination of CHAMP and CHAMP-PROG produces a microprocessor development system which can be used not only to experiment with software techniques, but also to produce other working microprocessor systems with dedicated PROM based programs and hardware interface circuitry which has been fully tested in advance on the CHAMP breadboard.

This month we conclude the CHAMP series with a deeper examination of the uses to which CHAMP-PROG can be put, and with the constructional details of the CHAMP-U.V. PROM erasing system.

USING CHAMP-PROG

You may remember that in part one of the CHAMP series we stated that CHAMP-PROG extended the CHAMP system not only in its role as a PROM programmer but also as a system for copying data *already* stored in a PROM *back* into the CHAMP program RAM. A facility for copying data into RAM makes the whole system even more flexible and allows the following:

(i) Programs can be "dumped" into a PROM to release the valuable CHAMP CMOS RAM area for more pressing jobs with the knowledge that the original programs can be easily reloaded into RAM when necessary.

(ii) PROMS can be modified by loading their contents into CHAMP RAM, making the necessary changes, and then reloading the erased PROM with the updated contents.

(iii) PROMS can be "insert/delete" edited using the relocating ability of the PROMPT program.

(iv) PROMS can be duplicated by first copying them into RAM and then using CHAMP-PROG in the usual way.

The PROMPT software published last month does not have the ability at present to load data back into RAM, because there simply was not room in the single 4702A chip to do this. The PROMPT program is, however, laid out in such a way that it is very easy to produce a new version, say PROMPT II, which *will* perform this useful function. Before you start to groan at the prospect of *another* financial outlay for software, remember that if you already have a CHAMP-PROG and PROMPT, then PROMPT II will only cost you the price of an additional PROM because of course you can now do all the programming yourself! In addition, the generation of PROMPT II makes an excellent introduction to the use of the CHAMP-PROG system, and so we have treated the production of this new firmware as a worked example accordingly.

WUNBYTE II

If you examine the flowchart and listing of PROMPT published last month you will notice that the only part of the program directly involved with the programming hardware is the subroutine WUNBYTE which addresses the source and destination, and generates with software the accurately timed program-enable pulse. To generate the new PROMPT II firmware all that is required is the replacement of this subroutine by a new one which transfers data in the other direction. The new subroutine can be called WUNBYTE II and does not need to be as lengthy or as complex as the original because there is no longer a need for the program-enable timing counter. A listing of the new subroutine is shown in Fig. 10.1. and as you can see WUNBYTE II starts at the same address as WUNBYTE so that the JMS WUNBYTE call is still effective. The new subroutine is shorter than the original, but this is of no consequence because the BBL instruction will pop the stack as usual, and operations will recommence at the line immediately following the JMS.

Apart from the new subroutine and an area of blank space following it, the rest of PROMPT II is identical to the original PROMPT, and of course the new PROM is destined for the same socket on the CHAMP main board, where it can be used alternately with the original when required.

PROGRAMMING SEQUENCE

To create PROMPT II the following sequence must be followed.

(i) Connect up CHAMP-PROG to CHAMP and connect the mains supplies. Ensure that CHOMP and PROMPT are in their respective sockets on the CHAMP main board, and place an erased PROM in the CHAMP-PROG programming socket.

(ii) Switch on CHAMP and enter the 56 lines of WUNBYTE II into CHAMP program RAM starting at, say, address 200H (you could of course start *anywhere* in the CHAMP RAM space).

(iii) Press RESET then TEST to enter PROMPT, turn on the CHAMP-PROG mains, and then enter Adr1, Adr2 and Adr3 as follows to copy WUNBYTE II into the new PROM at location 15AH.

Adr1 = 200H (for example)
Adr2 = 237H (200H + 56 decimal)
Adr3 = 05AH (destination in PROM)

(Remember to turn the PROM POWER switch to the ON position immediately before pressing the ENTER DATA button after Adr3 has been keyed in).

MCS 40 PROGRAM SHEET

TITLE	WUNBYTE II (ALTERNATIVE TO WUNBYTE FOR PROMPT)	DATE 09 01 78 PAGE NO. 1 OF 3

PAGE	LINE	ROM	CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	4 0						* THIS SUBROUTINE
	1						CAN BE USED IN
	2						PROMPT INSTEAD OF
	3						WUNBYTE & HAS
	4						THE EFFECT OF
	5						LOADING SOURCE
	6						DATA IN P.ROM. BACK
	7						INTO CHAMP
	8						PROGRAM RAM *
	9						
	A						Adr 1 = Start of source
	B						in P.ROM.
	C						Adr 2 = End of source.
	D						
	E						Adr 3 = Start of destination
	F						in RAM.
1	5 0						
	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
1	5 9						
1	5 A	D1		WUNBYTE	LDM	1	PROM → RAM S.ROUTINE
	B	FD			DCL		ADDRESS 4265 No 1
	C	28			FIM	8	
	D	80			8	0	
	E	29			SRC	9	LOAD PORTS W & X
	F	A3			LD	3	WITH SOURCE ADDRESS

ORIGINAL PROMPT

MCS 40 PROGRAM SHEET

TITLE	WUNBYTE II	DATE 09 01 78 PAGE NO. 2 OF 3

PAGE	LINE	ROM	CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	6 0	E4			WR0		IN P.R.O.M.
	1	A2			LD	2	
	2	E5			WR1		
	3	D2			LDM	2	ADDRESS 4265 No 2
	4	FD			DCL		
	5	29			SRC	9	
	6	0B			SB1		SELECT REG. BANK 1
	7	EC			RD0		READ PROM (1st NIBBLE)
	8	F4			CMA		COMPLEMENT IT.
	9	B1			XCH	1	PUT IN REG 1
	A	ED			RD1		READ PROM (2nd NIBBLE)
	B	F4			CMA		COMPLEMENT IT
	C	B0			XCH	0	PUT IN REG 0.
	D	D0			LDM	0	
	E	FD			DCL		
	F	28			FIM	8	SELECT DATA RAM
1	7 0	10			1	0	CHIP 0 REG 1, CHAR 0
	1	29			SRC	9	
	2	A1			LD	1	
	3	E0			WRM		STORE 1st NIBBLE FOR MATCH.
	4	69			INC	9	NEXT RAM CHAR.
	5	29			SRC	9	
	6	A0			LD	0	STORE 2ND NIBBLE FOR MATCH.
	7	E0			WRM		
	8	28			FIM	8	
	9	00			0	0	ADDRESS CORRECT
	A	29			SRC	9	PROGRAM RAM
	B	AE			LD	E	DESTINATION CHIP.
	C	E1			WMP		
	D	2D			SRC	D	SELECT PROGRAM RAM
	E	A1			LD	1	BYTE
	F	E3			WPM		WRITE 1st NIBBLE

(iv) When the "done" message is displayed, turn the PROM POWER switch to the OFF position and then press RESET and TEST to re-enter PROMPT. Enter the following addresses to copy the part of PROMPT *before* WUNBYTE into the new PROM, and then initiate programming in the usual way.

Adr1 = 100H (start of PROMPT)
Adr2 = 159H
Adr3 = 000H (start of PROMPT II)

(v) When "done" is displayed once more, turn the PROM POWER switch to the OFF position, and then press RESET and TEST to re-enter PROMPT. The following addresses are then entered to program the remaining part of PROMPT into the new PROM in the usual way.

Adr1 = 1A6H (start of MATCH)
Adr2 = 1FFH (end of PROMPT)
Adr3 = 0A6H

(vi) When "done is again displayed turn off the PROM power and remove the newly programmed PROM. PROMPT II now lives!

USING PROMPT II

Apart from the subroutine WUNBYTE, the new PROMPT II is identical to the old one, and addresses are entered exactly as before with the same meanings:

Adr1 = start of source data
Adr2 = end of source data
Adr3 = start of destination area

The important difference is of course that the *source* addresses now refer to a PROM in the programming socket, and the *destination* address refers to a location in CHAMP program RAM. This also means that the most significant digit of addresses 1 and 2 is redundant and can be set to anything (usually zero to avoid confusion), and that the most significant digit of Adr3 now becomes important and is used to select the destination chip in CHAMP program RAM. Provided you think in terms of source and destination rather than RAM and PROM no confusion should arise when swopping

MCS 40 PROGRAM SHEET

TITLE	WUNBYTE II	DATE 09 01 78 PAGE NO. 3 OF 3

PAGE	LINE	ROM	CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	8 0	A0			LD	0	
	1	E3			WPM		WRITE 2ND NIBBLE
	2	00			NOP		
	3	00			NOP		
	4	0E			RPM		READ DATA BACK
	5	B5			XCH	5	FOR MATCH CHECK
	6	0E			RPM		
	7	B4			XCH	4	
	8	28			FIM	8	
	9	20			2	0	
	A	29			SRC	9	STORE MATCH DATA
	B	A5			LD	5	IN DATA RAM
	C	E0			WRM		
	D	69			INC	9	
	E	29			SRC	9	
	F	A4			LD	4	
1	9 0	E0			WRM		
1	9 1	C0			BBL	0	END OF WUNBYTE II
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	A						
	B						
	C						
	D						
	E						
	F						

NOPS TO LAST THEN PROMPT CONTINUES WITH MATCH

Fig. 10.1. WUNBYTE II program listing

from one PROMPT version to the other! Data transfer is initiated as usual by the depression of ENTER DATA after keying in Adr3, although now the "done" message is displayed almost immediately because the transfer to RAM is very much faster. When using WUNBYTE II, there is no need to turn the PROGRAM POWER switch to ON of course, since all the necessary power is supplied by CHAMP itself.

OTHER POSSIBILITIES

No doubt many readers have spotted the fact that with extra PROM space available on CHAMP, the two versions of PROMPT could both be available simultaneously, and of course there would be no need to duplicate all of the original PROMPT, only the WUNBYTE II would be needed, with some means of selecting *which* subroutine is used by PROMPT when it is run. (This would require a reference to switches, and the ENTER DATA and ENTER ADDRESS buttons could easily be redefined for this purpose.)

Of course the addition of an extra PROM or PROMS is a major modification to CHAMP, but this could nevertheless be done without too much trouble.

If you *did* add this extra PROM it would of course be mostly empty, and then your thoughts could turn to what *other* goodies you could add to the system. How about a WUNBYTE III which would not *transfer* data but simply check one area against another, thus providing a new VERIFY facility in fact. Or how about a WUNBYTE IV which would be used to move data around in CHAMP RAM and would not need the benefit of CHAMP-PROG at all. Insert/delete editing would be possible with WUNBYTE IV providing some spare locations were left at the start of a program (think about it). Flow charts for these other WUNBYTE variants are shown in Fig. 10.2 and these could be the source of a lot of fun for CHAMP users, with many other possibilities no doubt suggesting themselves as experience is gained.

PROM ERASER

An essential companion to a PROM programmer like CHAMP-PROG is of course a PROM eraser, and fortunately these units are not difficult to build. All that's really required is a lightproof box with a short wave ultraviolet (U.V.) lamp mounted inside it and a resting place for the PROMS being erased. We decided against the minimal "lash up" approach to the design of an eraser at a very early stage for two very important reasons:

(i) Short wave U.V. light at the correct wavelength of 2537 Angstroms can be harmful to living organisms, and this of course includes CHAMP programmers!

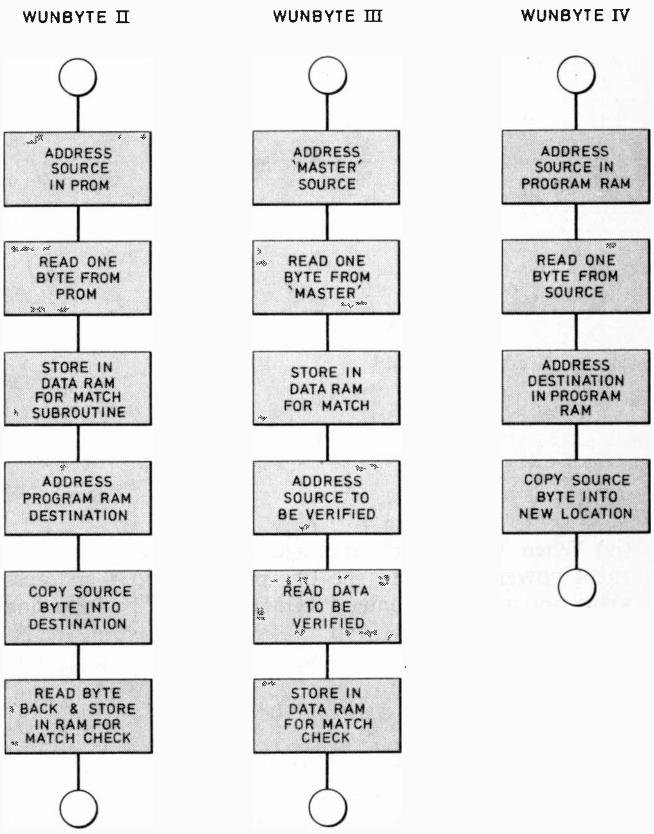
(ii) Over exposure of 4702A PROMS to the erase light can shorten their life.

In order to avoid the implications of both (i) and (ii), a good deal of thought was put in to make CHAMP-U.V. safe for both the programmer *and* PROM. Technically, there is no real problem to building a PROM eraser, short wave lamps are available from specialist companies such as Anderman who seemingly stock them primarily for medical purposes. The lamps resemble normal 8 watt fluorescent strip lights, and use exactly the same miniature 2-pin base, and the same ballast choke and starter. Lamp power is provided by the usual 240V a.c. mains supply. The required integrated light dose, which is defined as intensity × exposure time, is stated by Intel to be six Watt-Seconds per square centimetre, and this can be provided quite quickly by the small 8W tubes when they are placed within 1in of the PROM.

CHAMP U.V.

CHAMP-U.V. is built in a plywood case measuring 380 × 140 × 100mm and is completely self contained. Eye safety is ensured by the use of a microswitch which will not allow the lamp to light until the lid is closed and secured. PROM safety is ensured by the incorporation of a clockwork timeswitch which allows "set-and-forget" erasing to be undertaken.

Fig. 10.2. Flowcharts for WUNBYTEs II, III & IV. Note: WUNBYTE IV makes a RAM block-move possible. Source and destination blocks can overlay each other, but with an incrementing address counter data can only be moved *down* in RAM, if over-writing unused source data is to be avoided. Modifying PROMPT to permit address decrementing would be possible, and would allow data to be moved *up* (i.e. to a higher start address). WUNBYTE IV allows program blocks to be moved aside to make room for single extra instructions when required

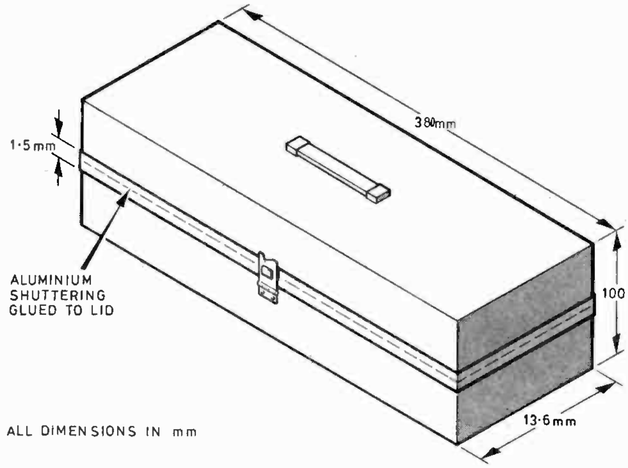


The circuit of CHAMP-U.V. is shown in Fig. 10.4, and as you can see, after the complexities of CHAMP and CHAMP-PROG, CHAMP-U.V. should come as a spot of light relief! The microswitch, which is operated by the box lid, is in series with the mains input, as is the clockwork timer. The neon mains indicator is wired to show that mains is applied correctly when the lid is closed, and not to show that the timeswitch is still on. The timeswitch itself makes a distinct sound rather like the ticking of a time-bomb when active, and so there seemed little need for additional facilities to announce the end of an erase cycle. The timeswitch can be set by means of a knob inside the case to provide erase cycles ranging from zero to thirty minutes, with periods of about twenty minutes being the norm for 4702A devices.

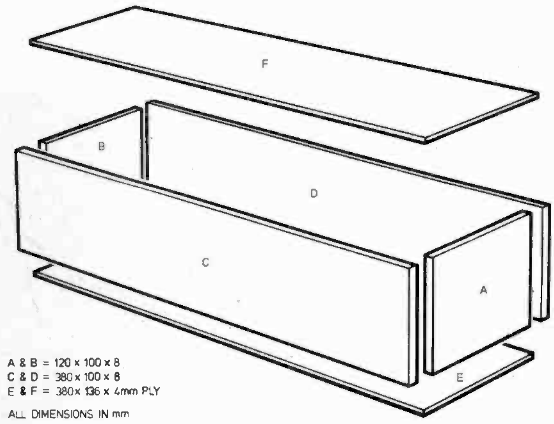
The lamp is mounted lengthways in the lid of the case and provides a full 200mm of active length for the erasure of PROMS. A total of twelve PROMS can be erased simultaneously when required, and these are mounted on a strip of conductive plastics foam which is located immediately under the tube when the lid is in the closed position.

CONSTRUCTION

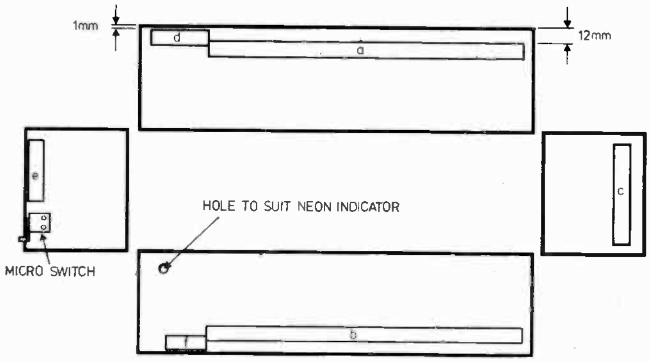
The CHAMP-U.V. case is made from 8mm plywood and is pinned and glued together using simple butt joints. The best way to build the case is to start by assembling the body and the lid as one piece and then to saw the resulting box completely through to separate the lid. Plywood runners are



(a) Basic case dimensions

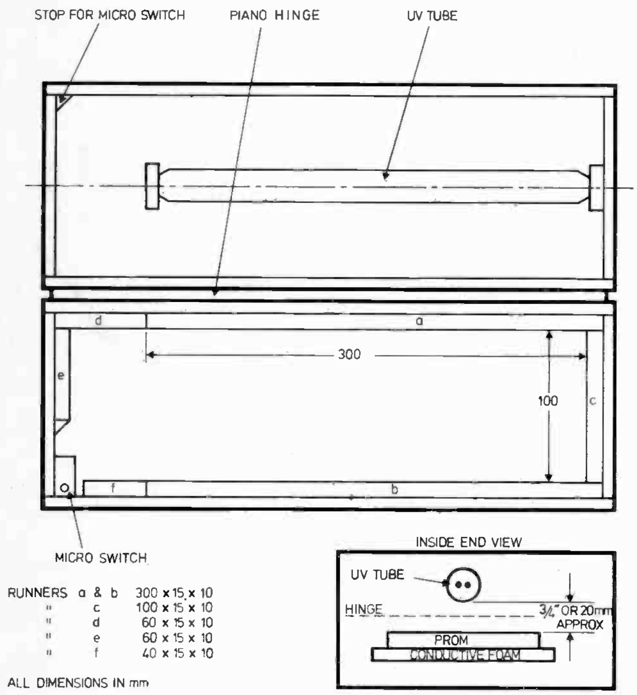


(b) Plywood parts

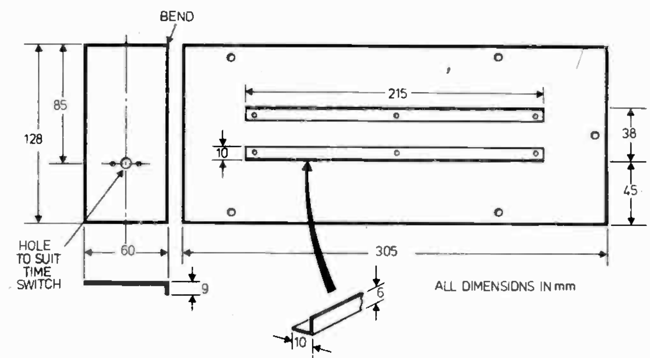


(c) Runner positions

Fig. 10.3. Constructional details of CHAMP-U.V.



(d) Internal layout of case



(e) Aluminium parts

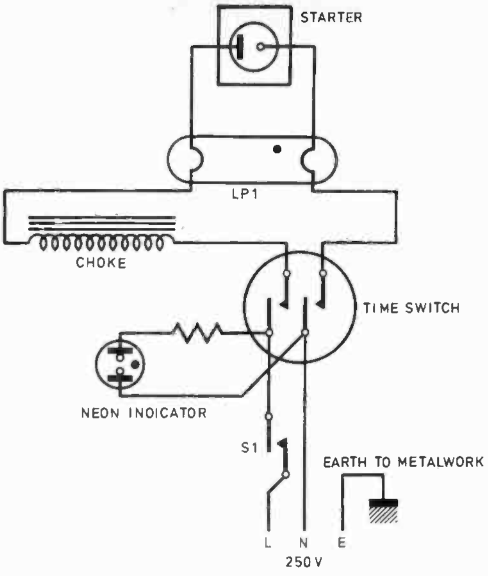


Fig. 10.4. Circuit diagram of CHAMP-U.V.

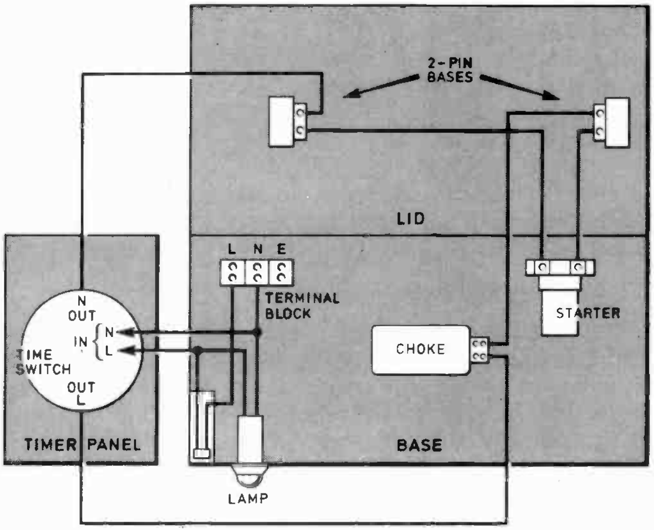


Fig. 10.5. Wiring layout of U.V. unit

It is most important that the lid operated microswitch feature of this design is incorporated, to immediately switch off the U.V. tube when the top is lifted. The optimum position for the microswitch is *near the front* of the box as shown in this photograph

COMPONENTS...

Ultraviolet tube. 12 inch, 8 watt, 2537 Angstrom

Choke. Smart & Brown 69386, 8 watt, 0·16A (or similar).

Starter. GEC 155/100 (or similar).

Timeswitch. 30 minute clockwork timer unit. Contacts *closed* during timing period, and of mains rating. (Available from many surplus suppliers).

Microswitch. 240V a.c., 2A, with leaf spring and actuating plunger.

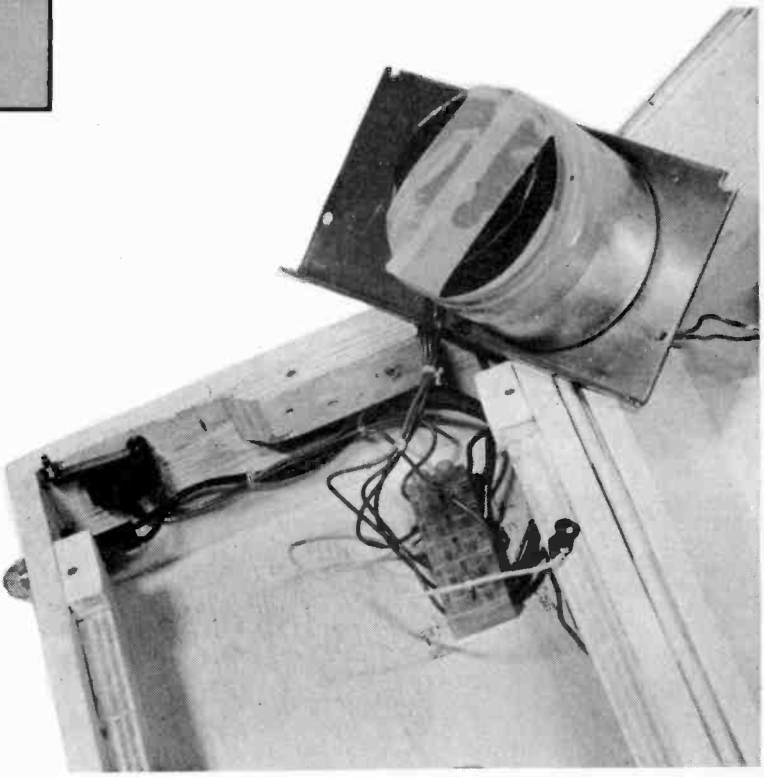
Neon indicator lamp. 240V type.

Miscellaneous. 2-pin tube sockets. 3-way terminal block, 4 mm and 8 mm plywood, aluminium sheets, etc.

The U.V. tube is available from Anderman & Co. Ltd., Central Avenue, East Molesey, Surrey KT8 0QZ.

WARNING

It is *essential* that these U.V. lamps are used correctly if health damage through U.V. exposure is to be avoided. Observe the manufacturers caution fully.



then pinned and glued inside the box to locate the timer panel and the PROM panel, which are both cut from aluminium sheet. Two aluminium brackets are also cut out and bent to form a PROM carrier which can be lined with conductive plastics foam when the rest of the case is completed (Fig. 10.3).

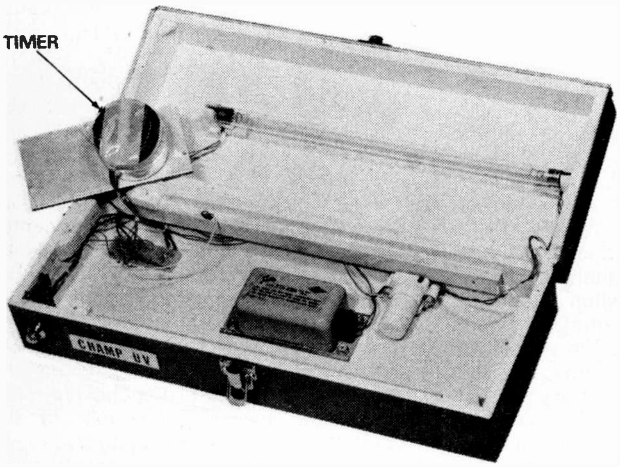
The lid is attached to the body of the case by means of a plastics piano hinge secured externally with small woodscrews, and this hinge, together with aluminium shuttering glued along the other three edges of the lid, ensures a light-tight seal for complete safety.

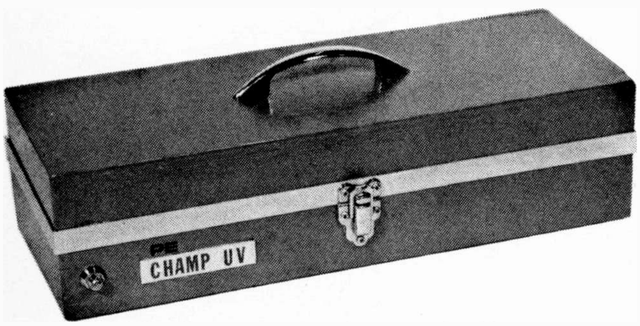
The U.V. lamp bases are fitted to the inside of the lid with the aid of small plywood blocks, and the starter, ballast and a terminal block are secured to the bottom of the case using small woodscrews and nuts and bolts. The microswitch is secured to the inside of the case with small woodscrews, and must of course be carefully positioned to ensure correct operation when the lid is closed. A small plywood fillet is mounted in the case lid to actuate the microswitch.

Wiring up should be carried out with mains quality flexible wire in accordance with Fig. 10.5. Notice that the aluminium panels *must* be connected to the mains earth for safety reasons.

When wiring up is completed, the unit can be connected to the mains and tested for correct operation. A conventional fluorescent tube could be substituted for the U.V. version during the testing phase if it becomes necessary to operate the lamp with the lid open.

The prototype case was finished with aerosol paints and polyurethane varnish using the same techniques as before on CHAMP and CHAMP-PROG. Finally, a carrying handle should be screwed to the lid of the case, and an attache case latch screwed to the front to hold the lid closed for transportation purposes.





FREE OFFER NOTICE

No further Intel Programming manuals are available, but many MCS Users Manuals remain. These will continue to be sent free of charge on receipt of an 8 x 10 inch envelope with 25p stamp (32p 1st class).

USING CHAMP-U.V.

Complete erasure of PROMS prior to reprogramming is absolutely essential for reliable operation. The erasure process is a linear one and does not occur suddenly, and so even when a cell location appears to be erased, further exposure may be required to reach a satisfactory level of gate discharge.

A CHAMP-U.V. system built as described will probably erase all 4702A type PROMS satisfactorily if they are given a 20 minute exposure, but for greater accuracy, system calibration can be an advantage. This is achieved by programming a PROM with all "ones" (FFH in every location) and then giving it short erase increments of say, 2 minutes; checking after each increment for proper erasure. When the chip appears to be completely erased, note the time required and in normal practice always use a cycle of *five times* that duration.

This calibration need only be carried out once, since PROMS are very consistent in their requirements, and a factor allowing for ageing in the lamp tubes has been incorporated.

PROM PREPARATION

Before erasure, always check the quartz window on the PROM for any dirt particles which may cause shadows on the chip, and also wipe them over with a swab soaked in methylated spirit to remove any films which may be opaque to U.V. light. This latter precaution is particularly necessary if gummed labels have been used to cover the PROM when in use.

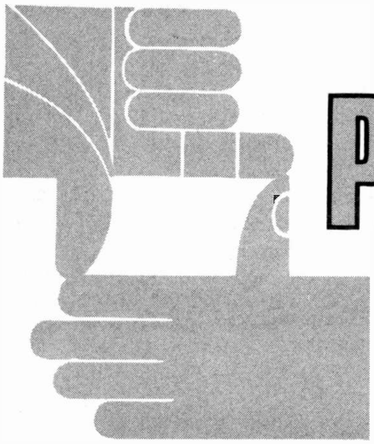
CHAMP-U.V. is quite capable of erasing any U.V. sensitive PROM including the larger capacity 2704 and 2708 types. The 2704/2708 chips do, however, use a different technology and generally require exposure periods of up to one hour for correct erasure. If CHAMP-U.V. is to be used to erase these devices exclusively, a clockwork timer with a one hour endurance could easily be substituted instead of the thirty minute unit specified earlier.

CONCLUSION

This brings us to the end of the CHAMP series, and we feel sure that everyone who has successfully built all, or part, of the CHAMP system will share our enthusiasm in the results obtained. Our CHAMP is in constant use and has been used to develop several dedicated systems and some "just for fun" software. There are of course many possibilities for additions to the basic system, and we will be glad to hear from anyone who has specific needs which may be catered for in subsequent articles, and from those who wish to pass on programs or hardware designs to their fellow CHAMP enthusiasts.

Meanwhile, the CHAMP programming service for CHOMP, PROMPT, and user programs will continue to be available as long as it is required.

Good luck, and successful programming! ★



PATENTS REVIEW...

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

SOLO VOICING   BP 1 477 217

Several circuits for enabling a would-be singer to perform along with a solo voice on a pre-recorded disc or tape, the pre-recorded voice being routed to one loudspeaker of a stereo pair and the amateur voice to the other have recently been patented by Sony. Now, in BP 1 477 217, Sony patent what is the logical conclusion of this train of patenting activity—a circuit for eliminating a featured solo voice and enabling would-be singers to replace that voice with their own.

The circuit, Fig. 1, shows a right channel amplifier TR1 operating as an emitter-follower. The left channel amplifier TR2 is operable, under switch control (S1), either in similar manner as an emitter-follower or as an inverting amplifier, e.g. common-emitter configuration.

The adders 1, 2 and 3 together combine the signals from the left and right amplifiers with that from a microphone X1 into which the would-be vocalist sings. The adder outputs are then fed to tape recorder amplifiers with playback through the loudspeakers.

A stereo source from conventional disc or tape, is applied to the inputs of the left and right amplifiers and the right stereo signal is applied to adders 1, 3. The left stereo signal is, in one position of the phase switch S1, inverted in phase. In the alternative switch position, the phase is non-inverted.

It is here important to note that the featured solo sound on a conventional recording (which solo sound the Sony circuit is required to eliminate and replace with an amateur sound) is recorded in phase and in equal amplitude in both channels. In the inverting state of the left channel amplifier, the adder 2 is supplied with amplified right stereo signal, including the original common solo signal components, along with the phase-inverted left stereo signal, which now includes the same solo signal components as the right but in opposite phase. Adder 2 thus subtracts right from left and in so doing cancels the common solo components.

Fresh solo sounds, produced by microphone X1, can now be added at 1, 2 to the remaining signal, which corresponds to instrumental accompaniments. The reproduced sound thus corresponds to the original accompaniment, plus fresh solo. For the purposes of comparison, a mono mix of the original solo and accompaniment can be reproduced by the left channel loudspeaker either simultaneously or alternatively with the replacement mix.

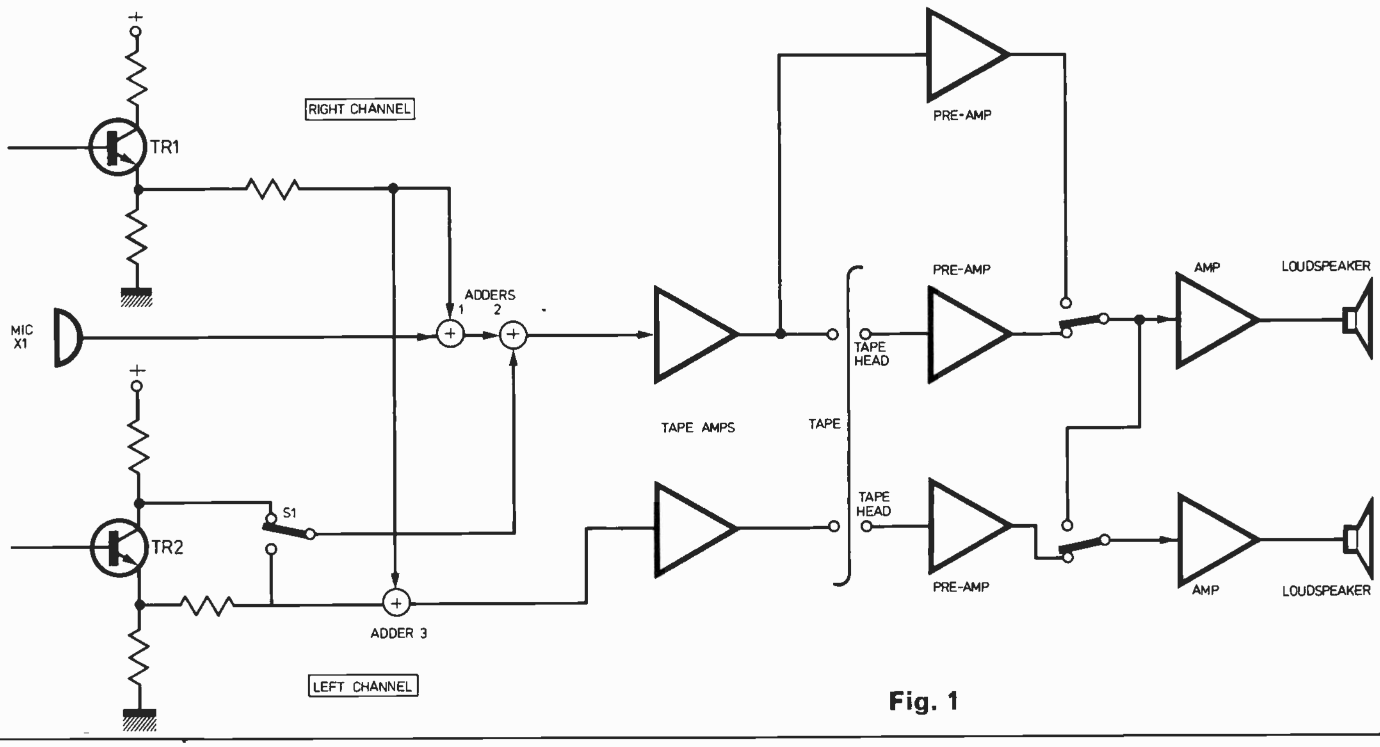


Fig. 1

Market Place

Items mentioned 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.

13 AMP SOCKET TESTER

Here is a tester which could have started out as an idea in Ingenuity Unlimited. It is a very compact 13 amp plug with two indicator lights to show up live, neutral or earth faults.

A positive must for any "sparks" tool box, contractors, installation engineers.

The retail price is £3·95 and quantity discounts are available from **Galatrek Engineering, Scotland Street, Llanrwst, North Wales. (0492 640311).**

Inventive minds that would relish the opportunity of materialising an electronic idea into a commercial product with financial backing should turn to page 728.

ACE CARD

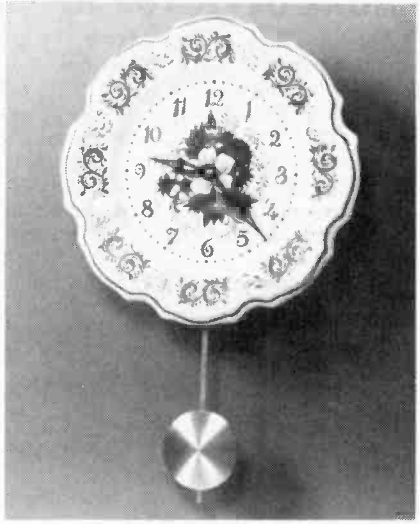
The Casio Mini Card calculator is the same length and width as a playing card. It is as thin as two ice cream wafers. Being so thin it is fragile and in fact will flex without much force. Nevertheless, for the careful user it is an extremely compact shirt pocket masterpiece of miniaturisation.

The LCD display will show up the respective sign when any of the four basic mathematical functions are performed. There are memory plus and minus keys, memory recall, a per cent function and clear and all clear keys.

If an overflow of the eight digit display occurs during calculation, in an answer or in the memory, an E appears and further operations are halted until the all clear key is pressed.

A couple of G-10 silver oxide batteries give approximately 1,000 hours of continuous operation.

Designated the LC-78, it is available at £16·95 from **Tempus, 19–21 Fitzroy Street, Cambridge, CB1 1EH.**

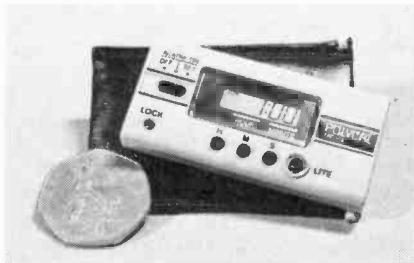


KITCHEN QUARTZ

Smiths Industries have introduced a range of domestic quartz clocks under the brand name "Astral".

The model shown is the "Melanie Pendulum", with blue or brown pattern and battery powered decorative pendulum, at £18·95.

For those not wishing to be pendulous the price is £11·50.



NON TIC TAC

This LCD alarm clock is the size of a packet of razor blades and has a quiet but effective waking tone, a pleasurable change from the old analogue fire bells.

Some digital alarms require a considerable amount of button pushing if an earlier alarm time is needed. This little fellow cleverly uses simultaneous button pressing to advance in 10 minute jumps or straight from a.m. to p.m. etc. Inadvertent resetting is prevented by the incorporation of a hold down setting lock.

Its logic element is MOS–LSI and for insomniacs there is a backlite(sic). The operating instruction booklet does read a little funny at times—"The reminder alarm will ring when the local time four minutes before it automatically cuts off."

Clock accuracy is the familiar ± 30 seconds per month.

The model, TAC–1, which gets its name from the abbreviation of Travel Alarm Clock, is available at £22·50 from **Tempus, 19-21 Fitzroy Street, Cambridge.**

Tempus also offer a battery change kit—watch case opening tool, battery specifications chart, replacement instructions and non-metallic tweezers—all for 35p. Watch batteries 65p each

SMOKE DETECTOR IC

A single chip smoke detector i.c. is announced by Siliconix of Swansea. The SM110 operates from a standard 9 volt alkaline battery with a current drain of less than 10 microamps in the standby mode. Its input impedance is very high making it suited to photoelectric sensors; the output needs only a simple drive circuit to power either a piezoelectric or electromechanical horn.

Other features include a very low input leakage current, adjustable sensitivity, noise input suppression, adjustable sourcing current and trouble signal timing as well as latching and non-latching operation.

The price of the SM110 is £2. A 12·6 volt version, the SM120 is also available, price soon to be announced.

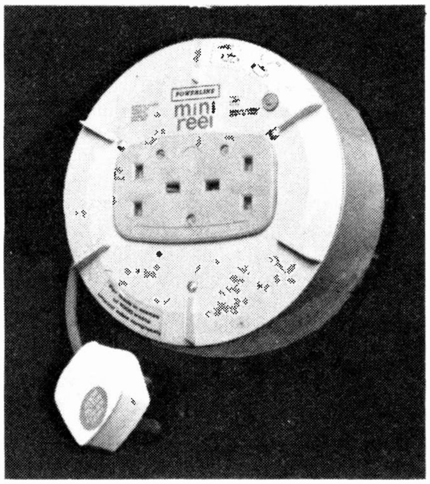
Full data from **Siliconix Ltd., Llanllienwen Close, Morriston, Swansea, SA6 6NE.**

SEMINAR ON CASSETTE

Late last year Intel held a very successful two-day Memory Designers Seminar at Wembley, London. The proceedings of this seminar were recorded and are now available on C-120 cassettes complete with slide book and explanatory manual.

AVP811	CCD Memory Devices and Systems	£4
AVP812	Static and Dynamic RAMS	£4
AVP813	EPROMS and 22-pin 4K RAMS	£4
AVP814	Memory Design with 4K and 16K RAMS	£6
AVP816	Debugging a Memory System	£4
AVP817	The complete set	£15

Intel Corporation (UK) Ltd, 4 Between Towns Road, Cowley, Oxford OX4 3NB.



MINI-REEL

The Burgess mini-reel extension cable is fitted with a twin 13 amp outlet and eight metres (26 feet) of three core cable.

A thermal and current overload cut-out permits normal usage of up to six amps.

Weighing less than a metric bag of sugar the mini-reel has a recommended price of £8·35 plus VAT.

PRICE REDUCTION

Ampex has announced a price reduction, effective immediately, on the Ampex 220 demagnetizer and headcleaner.

The demagnetizer and headcleaner is a special cassette patented by Ampex in which a rotating ceramic magnet is used to degauss the head of a cassette recorder or player. Simultaneously, a strip of non-abrasive fabric is transported by the machine to clean the head and tape path. This enables the recorder/player to deliver its best performance.

The Ampex demagnetizer cassette works automatically without batteries or mains power and can be used hundreds of times without reduction of its effectiveness.

From its former recommended retail price of £3·32p, the Ampex 220 demagnetizer is now reduced to a recommended price of £2·89.

Ampex magnetic tape products are available throughout the United Kingdom, from leading hi-fi and record shops. **Ampex International, 72 Berkeley Avenue, Reading, Berks.**

BIG LED

A large (20mm) l.e.d. display has been placed on the market by Hewlett-Packard. The new HDSP-3400 series numeric device is the largest display in Hewlett-Packard's seven segment product line which starts at 2·6mm.

Readable in bright light at distances of up to ten metres the big l.e.d. is designed for use in electronic instruments, point-of-sale terminals, television sets, weighing scales, digital clocks and other applications requiring low power consumption in a large, easy to read display.

Packaging is standard 15mm d.i.l. Price £1·80.

Data, **Hewlett-Packard Limited, King Street Lane, Winnersh, Wokingham, Berkshire, RG1 5AR.**

IC MOTOR CONTROL

A range of hybrid i.c.s in TO3 8 pin packages for the control of motors up to 0·1 horsepower from low level inputs, has been announced by **Rapid Recall.**

The devices comprise of a 741 operational amplifier, a special driver chip and a complementary pair of power transistors together with a frequency compensating capacitor all enclosed in a TO3 package. The internal circuitry is electrically isolated from the outer casing thus allowing easy heat sinking.

There are three basic models which differ in output current capability. They are 8510 (1 amp), 8520 (2 amp) and 8530 (2·7 amp), all of which will provide maximum output current at output voltages up to 24 volts. Multiple devices can be connected in parallel to provide even higher currents or voltages. Each device is available in two temperature ranges: −55 to 125°C (suffix M) and −25 to 85°C (suffix I).

The chip has short circuit protection, the maximum current of which is set by a pair of external resistors chosen to suit the application.

The 741 is powered by an internal regulator and will provide a gain of >100dB if required. Quiescent current of the unit is only 50mA max.

An interesting application of the device is in programmable power supplies. The input can be coupled to a digital-to-analogue converter which can, in turn, be controlled by thumbwheel switches. This arrangement allows the output voltage to be set to within ±0·1V d.c.

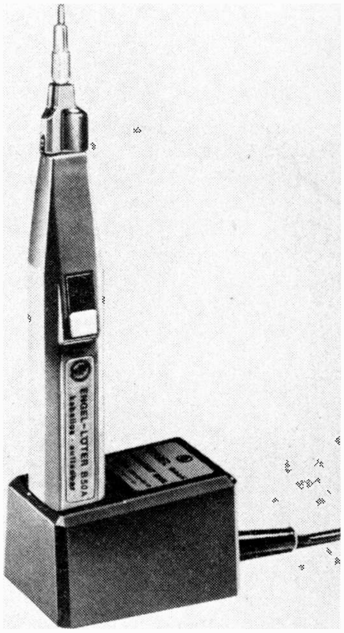
Further details obtainable from **Rapid Recall Limited, 9 Betherton Street, Drury Lane, London WC2H 9BS.**

RECHARGEABLE IRON WITH SPOTLIGHT

A new version of the Engel B50 rechargeable soldering iron is available.

The iron now incorporates a built-in spotlight to illuminate the working area and has long life rechargeable nickel-cadmium batteries. Of compact design, the B50 will give up to 100 intermittent operations (350 continuous). Recharging can be performed overnight in about eight hours (overcharging is impossible).

The trigger switch is fitted with a safety catch to prevent accidental operation. The bit, for work up to 2·5 sq. mm, heats up to an operating temperature in the region of 350 degrees centigrade in about seven seconds. Other bits are available.



Designed for recharging from normal AC mains, the B50 comes complete with cleaning pad, protective cover, two lighting fittings and screwdriver. A particular advantage is that no stray eddy currents which might damage a sensitive i.c. are generated when the iron is being used.

Priced at £16·50 including carriage, packing and VAT it is available only from the UK agents, **Kelgray Products Ltd., Kelgray House, Sandy Lane, Crawley Down, Sussex RH10 4HS.**

STEREO HEADPHONE AMPLIFIER

J.P. MACAULAY

HIGH quality stereo headphones have been available for many years now but they are usually considered as merely an adjunct to a full scale stereo system. This is a pity since even a relatively cheap pair are capable of the kind of reproduction usually associated with expensive speakers. There are also many situations which preclude the use of a speaker system at orchestral levels whereas a pair of headphones will deliver the same sound levels with an input of a few milliwatts, without disturbing the neighbours!

It was these thoughts that prompted the design described in this article. The main requirements of such an amplifier are the same as those for any hi-fi unit with the main problem being the minimisation of noise, especially hum.

The amplifier must also possess a fairly high input impedance in order to match most signal sources. In the development stage many different circuits were considered but most were found not to measure up to the requirements already outlined.

Consideration was given to the inclusion of Baxendall tone controls but this was rejected on the assumption that the amplifier would be used mainly as a monitor of high quality sources, many of which would already provide such control.

Sensitivity is 20mV for maximum output, and as this is very high it is recommended that a potential divider, or a log. volume control is used in front of the amplifier. This should have a value of at least 220kΩ in order to avoid shunting the input impedance of the circuit.

CIRCUIT DESCRIPTION

The circuit diagram of one channel of the headphone amplifier is shown in Fig. 1. The transistor TR1 which is connected in the common emitter mode provides all the voltage amplification for the circuit.

IC1 is a 741 op. amp. which is used with 100 per cent negative feedback and operates as a voltage follower with unity gain. In this mode the bandwidth extends from d.c. to over

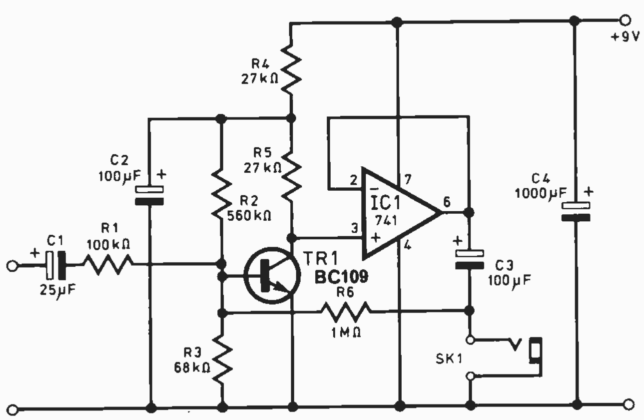


Fig. 1. Circuit diagram of one channel of the Headphone Amplifier

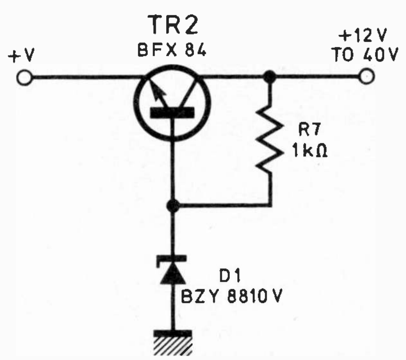


Fig. 2. Series regulator circuit which can be used if the unit is to be fitted into an existing piece of equipment.

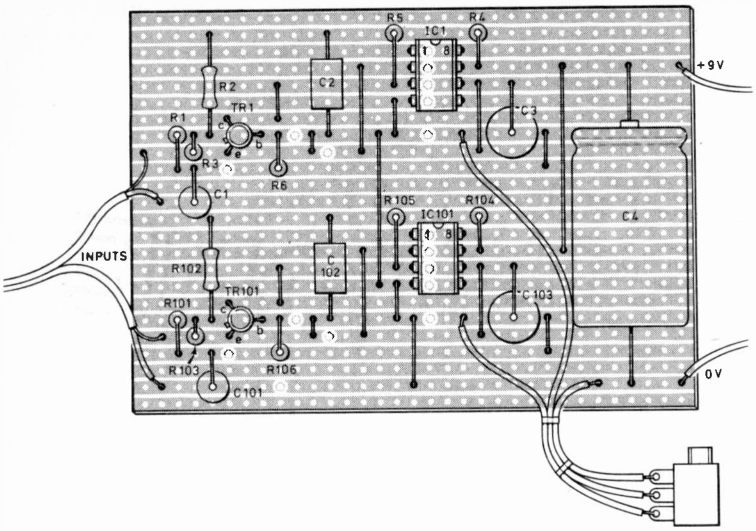


Fig. 3. Circuit board layout for Headphone Amplifier

100kHz.

The non-inverting input of IC1 is taken from the collector of TR1 and the i.c. used as a non-inverting amplifier with signal feedback applied via R6 to the base of TR1.

The complete circuit acts as a virtual earth amplifier, the gain of which is determined by the ratio of R5 to R6. The output power available from this arrangement is limited to about 25mW, which proved sufficient to deafen most listeners!

The current consumption of the circuit is about 6mA and it can be operated either from a 9V battery or the series regulator circuit shown in Fig. 2.

COMPONENTS . . .

Resistors

R1	R101	100kΩ (2 off)
R2	R102	560kΩ (2 off)
R3	R103	68kΩ (2 off)
R4, R5	R104, R105	27kΩ (4 off)
R6	R106	1MΩ (2 off)
*R7		1kΩ

Capacitors

C1	C101	25μF (2 off)
C2	C102	100μF (2 off)
C3	C103	100μF (2 off)
C4		1,000μF

All 25V electrolytics

Semiconductors

*D1		BZY 88 10V
TR1	TR101	BC109 (2 off)
*TR2		BFX 84
IC1	IC101	741 op. amp. (2 off)

Miscellaneous

1 off 0·1 in matrix stripboard
2 off stereo jack plug and socket (see text)
1 off PP3 battery (see text)
1 off battery clip (if req.)
2 off holder for i.c. (if req.)
1 off S.P.S.T. toggle switch (see text)

* See Fig. 2 and text

CONSTRUCTION

In the prototype both channels of the amplifier were mounted on 0·1in Veroboard using the layout shown in Fig. 3.

Care should be taken to ensure that the appropriate breaks are made to the copper tracks and that all the electrolytic capacitors are correctly orientated before soldering them to the board. The two i.c.s can either be mounted in holders or soldered directly onto the Veroboard.

After soldering, the board was checked for any solder shorting the copper tracks and the excess flux was also removed.

The output connections from the circuit board to the headphones were made via a stereo jack socket and the two input leads to the amplifier were made using screened cable. The screened lead of each cable should be connected to the 0V line.

HOUSING THE UNIT

The amplifier can either be housed in an existing piece of equipment or in a separate case.

If the unit is to be installed in an existing piece of equipment the series regulator circuit shown in Fig. 2 could be used with the inputs of both channels connected internally and the jack socket fitted to the control panel.

The prototype is used as a piece of test equipment fitted into a separate case and powered by a PP3 battery.

The two screened input leads were terminated using another stereo jack socket and an on/off switch was fitted to the positive lead of the battery.

USES

The headphone amplifier has many applications, the prototype being used mainly for checking f.m. tuners on the author's bench. ★

BOOK REVIEWS

Radio Circuits Explained
By Gordon J King
Published by Butterworth Co Ltd
145 pages, 160mm × 240mm. Price £5·50

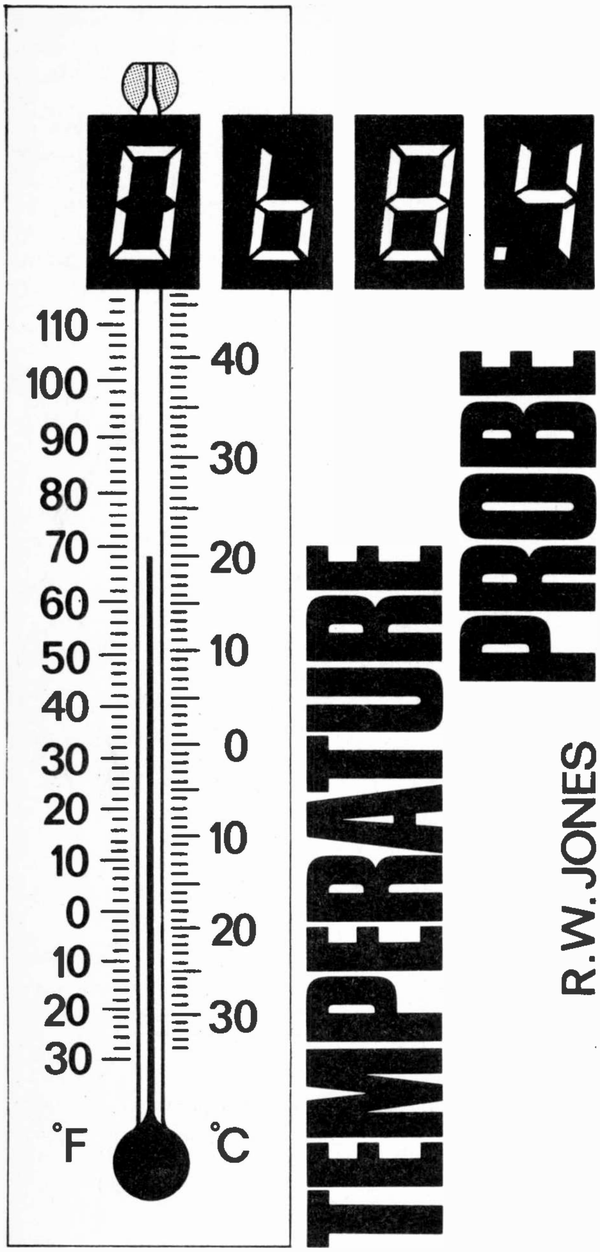
THERE have been many advances made in the field of radio circuits and with the introduction of new devices many different design ideas are being incorporated into modern receivers. The problem for both the technician and hobbyist is keeping abreast of these advances.

This book examines the developments made and explains the principles involved in each section of the receiver with the aid of clear diagrams and graphs.

The opening chapters cover block flow and FIMS diagrams and progress through mixers, RF amplifiers and oscillators to detector circuits. Basic audio and power amplifiers are discussed and with the use of manufacturers' diagrams it is shown how they are employed in practical circuits. Also included are power supplies and regulators with the final chapter dealing with stereo coding and decoding.

Many people should find this book very helpful in developing a clearer understanding of the techniques used in modern radio circuits.

D.J.S.



TEMPERATURE PROBE

R.W. JONES

COMPONENTS . . .

Resistors

R1	2·2kΩ 2% ¼W
R2	680Ω 2% ¼W
R3	3·3kΩ 2% ¼W
R4, R5, R6, R7	100kΩ 1% ¼W (4 off)
R8	1·2kΩ 5% ¼W carbon

All metal oxide types except where stated

Potentiometers

VR1 1kΩ 10 turn cermet
VR2 10kΩ single turn cermet

Switches

S1 D.P.S.T. pushbutton (latch type)

Semiconductors

D1	1N4148
D2	Miniature l.e.d. (red) T.I.L. 209
TR1, TR2	2N3819 *n* channel f.e.t. (2 off)
IC1	741 op. amp.

Miscellaneous

1 off Polystyrene case 100 × 50 × 40mm
2 off PP3 batteries
2 off Battery clips
1 off Tube of Araldite
Length of copper tube ⅜in inside diameter
High temperature wire R.S. type (357–110)
0·25in 2-pole jack plug and socket

This probe was designed to enable temperature measurements from −10 to 100°C to be made using the 0–100mV range of a digital multimeter. It is possible for an analogue meter with the same full scale deflection (0–100mV) to be used, but for readings below 0°C the meter connections would have to be reversed.

CIRCUIT DESCRIPTION

The circuit diagram of the probe is shown in Fig. 1. Its operation is dependent on the linear relationship between the changes in resistance and temperature of a p.n. junction.

The two f.e.t.s are used as constant current generators with the 741 amplifying the difference in voltage between the temperature probe (a) and the 0°C reference level (b) which are connected to pins 2 and 3 of the op. amp. The meter is connected across VR2 and measures the amplified output of the 741. This output is directly read as degrees Centigrade.

If the probe senses a temperature of 0°C, the difference between the two 741 inputs should be zero and the meter should indicate 0°C.

When the probe is exposed to a positive temperature change its resistance is reduced and the voltage applied to pin 2 of the 741 falls. The voltage on pin 3 remains constant and the 741 amplifies the voltage difference between these two pins. The amplifier output is then measured by the meter across VR2.

The l.e.d. is used as an on/off indicator with its current controlled by R8.

CONSTRUCTION

The prototype was housed in an R.S. polystyrene case with the on/off switch, l.e.d. and jack plug fitted into the side of the case and the two 4mm sockets mounted on the top.

The components are soldered onto a printed circuit board, the design of which is shown in Fig. 2 with the component overlay shown in Fig. 3. The two board contacts which are used for the output terminals should be drilled out to 4mm diameter and after the p.c.b. has been soldered and checked it can be mounted into the case (Fig. 4) using the two 4mm sockets to hold it in position.

PROBE

A cross section of the probe is shown in Fig. 5; it can be constructed using ⅜in inside diameter copper tubing and is connected to the unit via high temperature wires and a jack socket.

The diode must be well insulated to ensure that it does not short out to the case of the probe and after the high tempera-

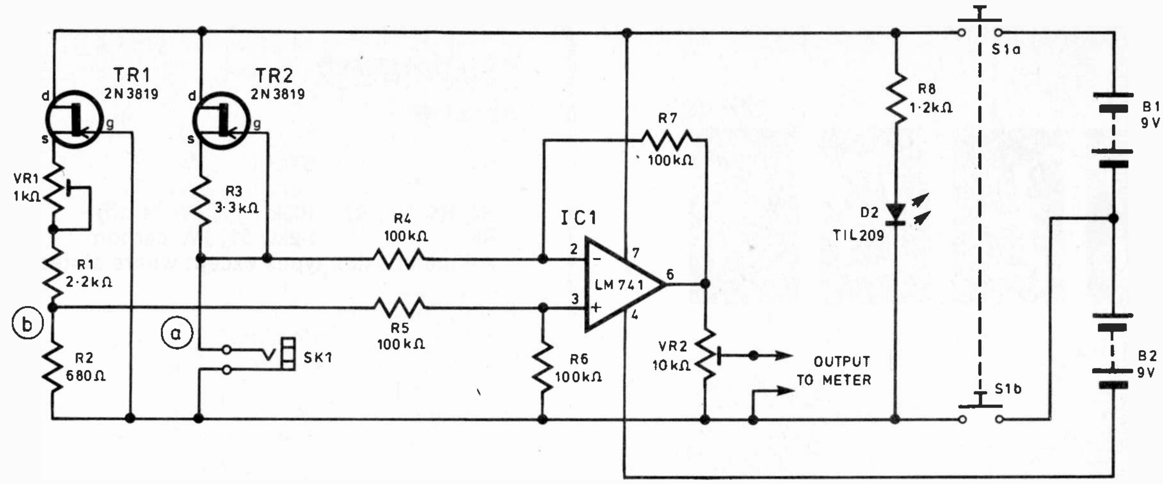


Fig. 1. Circuit diagram of the Temperature Probe

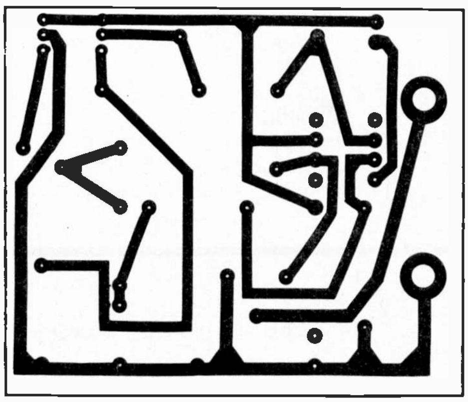


Fig. 2. Printed circuit board design

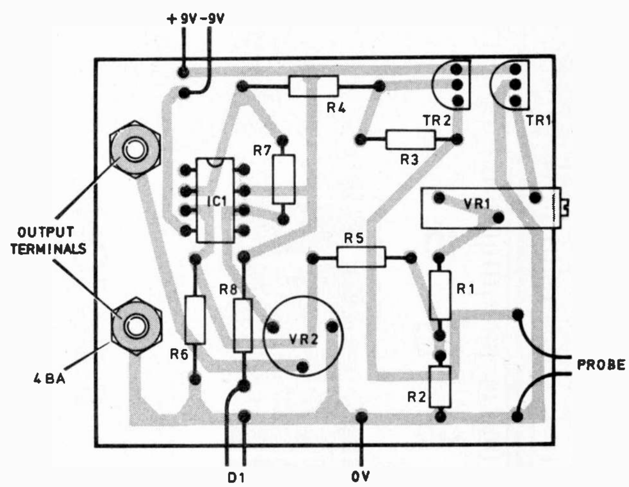


Fig. 3. Component layout for p.c.b.

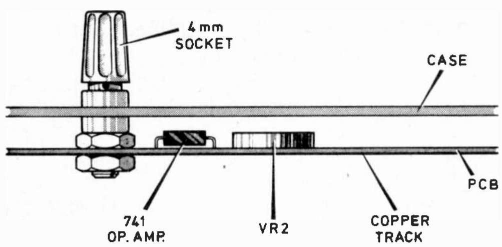


Fig. 4. Mounting details for p.c.b.

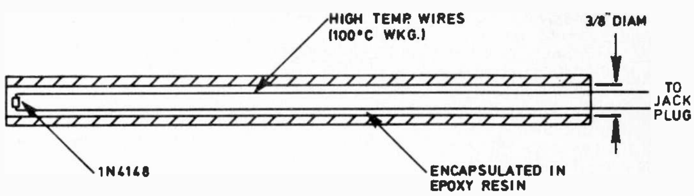


Fig. 5. Probe assembly

ture wires have been connected, the diode should be placed in the tube as close as possible to one end. The entire probe can then be encapsulated with Araldite.

BATTERIES

The unit is powered by two batteries which are fitted to the bottom of the case and then covered with a piece of foam to protect the back of the p.c.b. from any damage.

CALIBRATION

After the unit has been assembled and tested it is then ready for calibration. As the characteristics of diodes vary from device to device the instrument should be recalibrated whenever the sensing diode/probe is replaced.

For calibration, boiling water is used as the 100°C standard and melting ice as the zero 0°C standard. The probe should first be immersed in a bowl of melting ice and water and the multiturn pot VR1 adjusted until the meter connected across the output terminals indicates zero. The probe should then be placed in simmering water and VR2 adjusted to obtain full scale deflection on the meter.

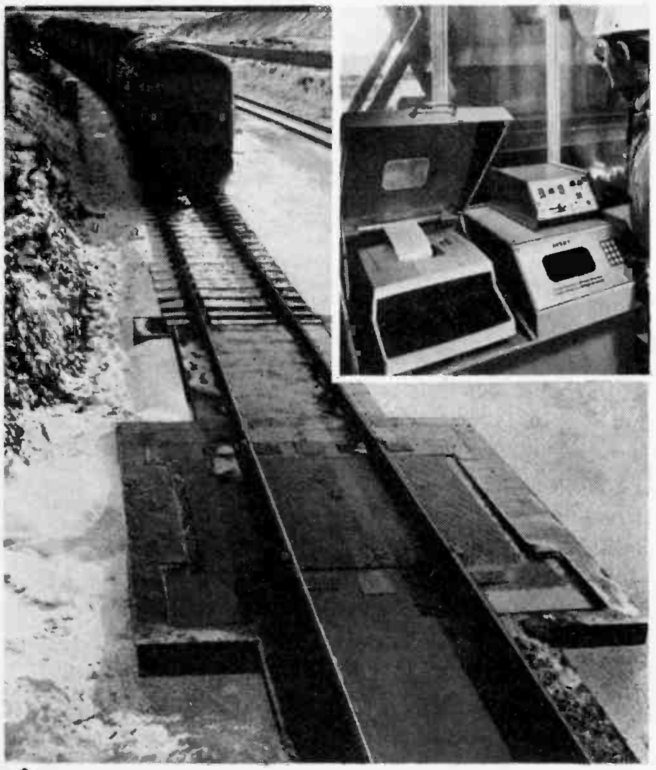
With the calibration completed the unit is now ready for use. ★

IEA·ELECTREX

A look at some of the more interesting items at the Birmingham Exhibition Centre (13-17 March)

An entirely new type of test instrument for the analysis and synthesis of digital waveforms has been introduced by Gould Instruments Division. Designated the Gould Advance DSA600, it consists of a memory which stores digital waveforms plus peripheral circuitry which permits the capture of signals from a circuit under test, the programming or modification of signals by the operator, the generation of the stored signals and the display of the memory contents.

Analyser applications include logic testing and simulation on both asynchronous and synchronous systems, such as avionics, radar, communications, data processing and industrial control, for research and development, test, service and production purposes. It can also be used to turn a basic oscilloscope into a form of storage oscilloscope and can be used in conjunction with the Gould Advance PG52 pulse generator to provide a programmable high-power data output.



W & T Avery Limited are pioneering the use of microprocessors in the weighing machine industry. A number of successful applications have already been made, one of which is at the National Coal Board's Grimethorpe Colliery in Yorkshire, where a weighing-in-motion system has been installed as part of a new bulk loading scheme.

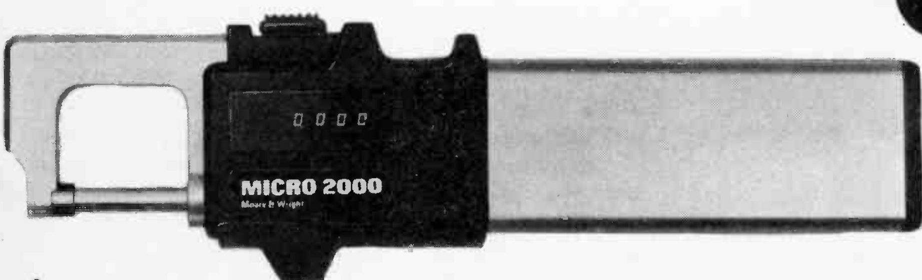
In the picture above a locomotive has shunted filled wagons through the loading bay and over the weighing system seen in the foreground.

The system is designed to weigh two-axle wagons whilst travelling at speeds of up to 8 km/h.

The inset shows the instrumentation used. The printer produces individual axle weights for each wagon and the total weight for the entire train excluding the locomotive.

Above is a 2-3 seater open sports car developed by Electraction Ltd., of Maldon, Essex. The glass fibre body is mounted on a galvanised steel tubular chassis arranged to absorb energy in the event of an accident through a safety bumper at the front and an energy absorption compartment at the rear. The batteries are mounted on sliding trays.

Range: Up to 90km (56 miles)
Speed: Up to 58km/h (36 m.p.h.)
Control: Thyristor controller made by Cableform (Pulsomatic Mark 10).

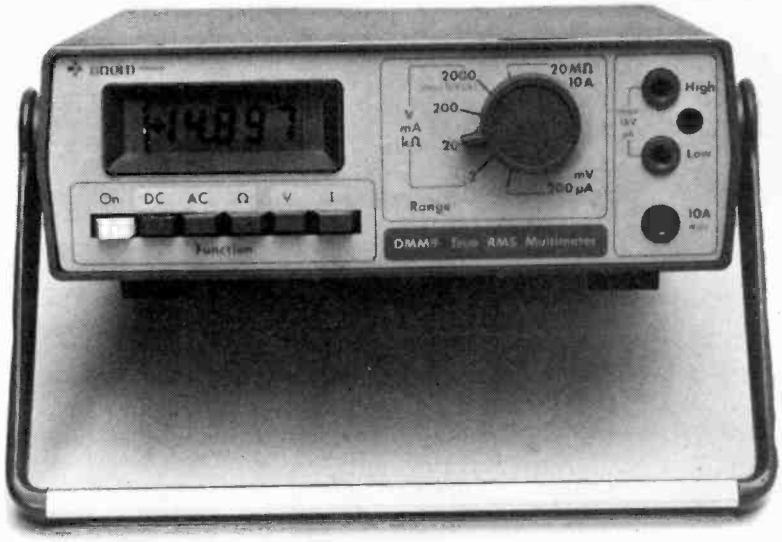


The Moore & Wright "Micro 2000" electronic hand micrometer. The Micro 2000 uses a unique combination of specially developed solid state electronics and precision optical systems to measure to an accuracy of ±2 microns and show the reading on a brightly lit integral digital display.

At the F.W.O. Bauch stand, visitors could enter realms of Startrek when trying out the new IE-10A Audio Spectrum Analyser from Ivie Electronics Inc. A slick hand held unit weighing only 15oz (430gms) can be aimed at a sound source to get an immediate breakdown of its frequency components. Powered by rechargeable Ni-Cad cells, the analyser/sound level meter will display graphically on a matrix of l.e.d.s sound pressure levels over a 45dB range.

The 160 l.e.d. display matrix gives ten octave channels on the x axis (32Hz-16KHz), and the y axis is selectable for 1, 2, or 3dB resolution, calibrated from 45dB to 140dB S.P.L. (−116 to +9dBm) on A or C weighting.

A range of inexpensive accessories enable the analyser to measure amplifier power, voltage and harmonic distortion.



Also from Gould is the DMM9 a new 4½ digit multimeter with a 0·05 per cent measurement accuracy and true r.m.s. measuring facilities.

It features 28 a.c. and d.c. voltage, current and resistance measurement ranges, including a separate 10A current range, and is also available with optional probes for temperature, radio-frequency and high-voltage measurements.

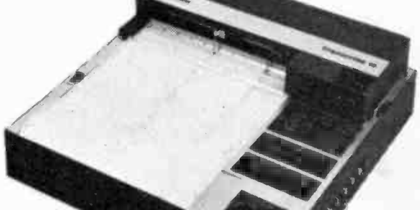
The DMM9 has a maximum reading 19999, and maximum resolutions on the current, voltage and resistance ranges of 10μV, 10nA and 100mΩ, respectively.

A combined a.c./d.c. facility is also available to measure a.c. waveforms with a d.c. content.

Because true r.m.s. voltage measurement is the only accurate way of assessing the energy content of an a.c. waveform, the DMM9 is ideal for applications where power is the main parameter of interest, e.g. in the electricity supply industry or in applications involving thyristor control.

A railway of the future, controlled by micro computers, was the centrepiece of the CAF MicroSoft Ltd. stand. With 13 points, 25 yards of HO gauge track, an eight stage speed controller, and two Fleischmann diesel-outline locomotives, the layout represents a versatile, flexible, low-cost peripheral to a microcomputer-based industrial control system.

The new digital clamp meter KEW 777 from Eagle International is designed for safety and ease of operation. It has large, clear definition liquid crystal display and measures to 1,000 amps a.c. as well as 1,999 ohms and 1,000 volts a.c.



Latest product news from Bryans Southern is of a compact "combination" instrument that they believe to be unique throughout the world. It introduces entirely new transient store electronics developed by Bryans, and fitted within the mainframe of their well-proven 28000 series chart recorder. The resulting instrument offers a facility for processing transient signals and producing precision hard copy plots of them.

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.

"Camm's Comic"

Sir—Whilst in no way disagreeing with M. Hughes' tribute to Mr Fred Bennett I must object to the disparaging reference to "Camm's Comic". In the immediate post-war years through to the dawn of the transistor age the so-called "comic" provided a fund of information for many embryo radio/electronic engineers where contemporary publications featured circuitry and components beyond the capabilities and finances of most students.

Personally I feel my introduction to the magic of this hobby (and latterly, my profession) owes much to the writings of the late F. J. Camm and I am surprised that no attempt has ever been made to commemorate him—perhaps by an annual competition for the best article from a newcomer?

As for the amateur forsaking the "junk-box", junk box does not equate with junk components nor apparatus. Rather the term junk may be applied to many of the modern gadgets seemingly devised to use as many components as possible instead of offering useful function.

L. G. Rix, BSc,
Melton Mowbray.

Electronics Club

Sir—I wish to inform you that our Club was set up in September 1977 at Shakespear House, Clapcot Way, Wallingford, Oxon.

The Club is a non-profit-making club for the pursuance of electronics as a hobby. The Club exists to provide mutual exchange of knowledge and experience in the fields of radio, electronics, electrical engineering and related sciences and technology. The club also provides education and encouragement to younger members who wish to make electronics their hobby and/or their career.

J. Gilpin,
Wallingford Electronics Club.

Future

Sir—I was prompted by your editorial in the March issue of P.E. to consider the future of the electronics hobbyist. At the present time, nearly all electronics publications are fairly brimming with articles and courses to introduce the hobbyist to the latest arrival on the scene—microprocessors. It seems that any amateur so inclined, providing his pocket will stand it, can learn all about these devices. Fine!

But what of the future? In a few years, when the enthusiasm has died down, will you continue to deliver elementary articles on such matters? Will it be possible for beginners to work their way up from Ohm's law to micros as has now been the case? Or will you only publish articles which presume the reader to have a working knowledge of the interior of a microprocessor chip, program writing etc.? If that is the case, then the "amateur" electronics field will surely be limited to those already into electronics by virtue of their profession.

Let us hope that this will not be so, and that you will run a series of "Teach-In" articles every few years as *Everyday Electronics* does in an elementary way.

C. Nelms,
Elstead, Surrey.

You are certainly looking ahead, but the point is very valid, and one that is well taken. No doubt many people from all walks of life will ultimately want, or need, to know more about microcomputers and we are sure you will not find this need overlooked.—Ed.

POINTS ARISING

DIGITAL MULTIMETER *(October 1977)*

The Siliconix LD130 i.c. used in this project is apparently prone to "lock-up" when the power is first switched on. This condition manifests itself by a constant display reading of 007, and it is necessary to re-cycle the power supplies to clear it.

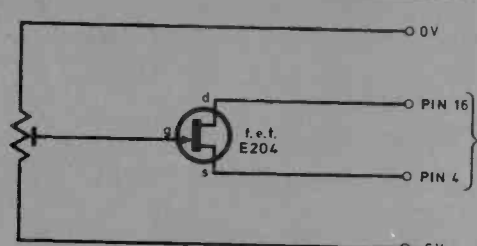
A modification is illustrated (right) which will rectify the fault and not affect the accuracy of the instrument. Adjustment of the instrument is best carried out with the meter set to DC CURRENT, no input applied, and well-used rather than new batteries. With the preset wiper towards 0V the display will flash as if on over-range. As the wiper is revolved towards the negative rail the display will cease flashing, and indicate a number which decreases as the control is further rotated. Correct setting of the preset is just beyond the point where zero is displayed.

Modification kits comprising the preset potentiometer, E204 f.e.t., and necessary stripboard and fixings (with instructions) are available from Sparks Developments, Dept. P.E., 53 North Street, Melbourne, Derby, DE7 1FZ.

AUTO-RANGING D.C. VOLTMETER *(February 1978)*

A few corrections are necessary in Fig. 5, the component layout (specifically the power supply). Zener diodes D5 and D6 should be transposed, and also R1 with R2, so that they conform to Fig. 3. These are drawing errors which will not affect operation, but a correction which *must* be made is to transpose the labelling of +6V OUT and −6V OUT.

Also, note that in Fig. 2, VR2 is connected between pins 1 and 5 of IC2, and the output of IC3a is pin 3.



Semiconductor UPDATE...

FEATURING : SN75416/17/18/19 BC650/BC651 1435 ADC0816/ADC0817

R.W. Coles

THE HEAVY MOB

Want to make a solenoid an offer it can't refuse? Then call in the heavy mob from Texas. Working under the **"SN75416** series" alias, and not using their real names like "Crusher Hargreaves" and "Hammer Hoskins", these new arrivals are guaranteed to beef up any logic team. Each member comes in a smart black fourteen pin package and carries two drivers which can each sink 500mA and hold off over 70 volts. The four members currently in town cater for all four varieties of logic gating, NAND, AND, NOR and OR and have low current p.n.p. input stages so that they can make-out with TTL or MOS families when required. Any loads which try any funny business with inductive spikes get clamped with a 500mA diode, and remember these boys are fast, 100 nanoseconds fast.

THE QUIET ONES

Any advance in the art of hi-fi is sure to be popular, even though most advances these days are pretty marginal! For those who strive to eliminate all sources of noise from their system, so that they are better able to hear the noise generated by their records or tapes, Motorola have something new to offer. The **BC650/651** transistors are claimed to be the lowest noise input transistors available today, generating noise voltages of only 4, 3 and 2·5 nanovolts at 10, 120 and 1,000 hertz respectively when run at collector currents of 200mA. The two new transistors are n.p.n. devices and are rated at 30 volts (BC650) and 45 volts (BC651) with a minimum h_{fe} of 380 at 2mA and an f_t of 300MHz. They come in low cost TO92 plastic packages and should be ideal for use in the "front ends" of domestic hi-fi amplifiers and high power disco' music systems.

THE FAST ONE

I am including my next offering, not because I expect anyone to rush out and buy one (they are a little expensive), but because it is an interesting new device which has pushed out the frontiers of performance in the analogue amplifier field quite dramatically.

I am talking about the Teledyne Philbrick **1435** which is described as an "Ultrafast differential input operational amplifier" in the data sheet. Ultrafast it *certainly* is because it sports a gain-bandwidth product approaching *one gigahertz*, and can be used in standard operational amplifier configurations to provide a 20db to 40db gain from d.c. to beyond 10MHz! Despite its high speed performance the 1435 is a precision device, offering 0·01% gain accuracies and rapid recovery from input voltage steps, making it ideal for the amplification of complex waveforms in video and other signal processing applications.

When I first read the data sheet I immediately saw in this device the makings of a very simple, but capable, Y amplifier for an oscilloscope, and there seems to be no reason why it should not be used for this purpose when provided with an f.e.t. source follower input stage and a switched attenuator. In this role its 75 nanosecond settling time and less than 1% overshoot on square pulses would be a great advantage.

The 1435 is made using hybrid technoogy and lives in a small 14-pin hermetic d.i.p. package.

BRIDGING THE GAP

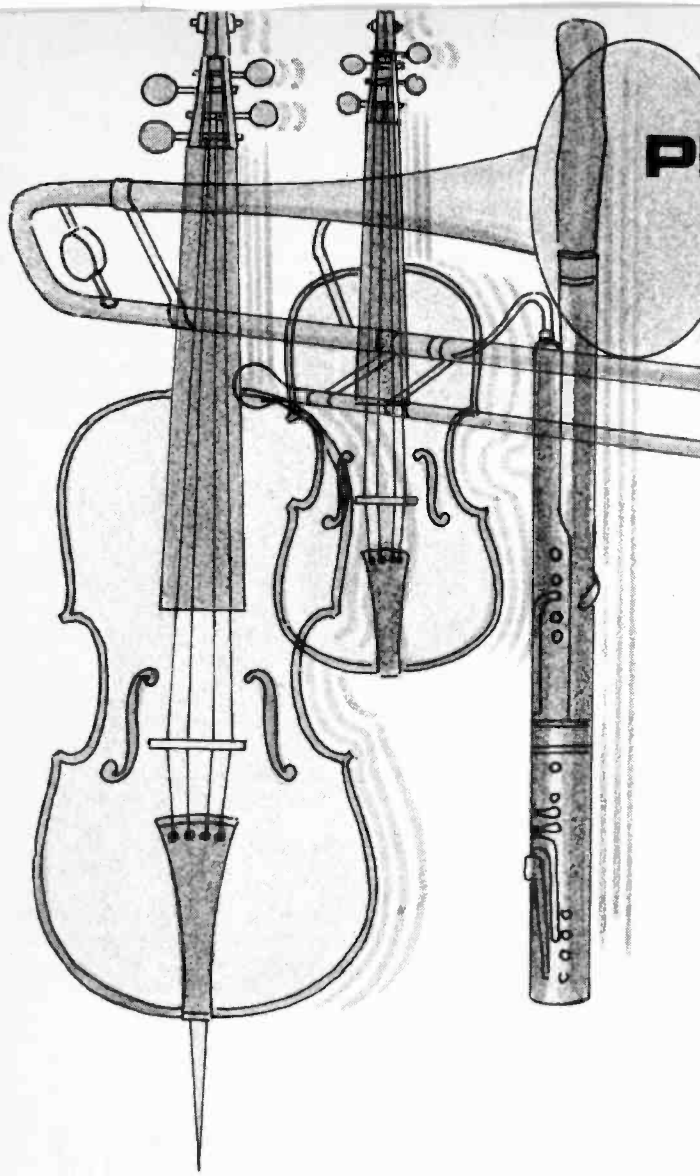
It has been said that any signal conditioning that can be carried out with analogue circuitry, can (in theory anyway), be carried out just as well with digital circuitry. Of course, microprocessors have not yet reached the point at which we can connect an aerial to an input port and a speaker to an output port and then expect to write some software which will tune in "Desert Island Discs". Given a micro' that worked sufficiently fast however, this sort of high speed signal processing would become perfectly feasible because the processes involved in converting a modulated r.f. signal into a signal suitable for driving a loudspeaker can be described mathematically, and we all know just how nifty micro's can be at doing sums! Speed is not the only limiting factor though; the conversion of analogue signals to digital form has been an expensive business which precluded its use except for the most demanding applications, even when only low frequencies were involved.

There *have* been major advances recently which have made the digital processing of analogue signals more practical; modules or circuit boards are now available which contain an analogue-to-digital converter paired with analogue signal multiplexers which permit the converter to be shared by a number of analogue inputs. These modules and circuit boards have been made fully compatible with the popular microprocessor fuses, but costing several hundred pounds apiece they are still not the stuff of which revolutions are made. To take the analogue world by storm we need a low cost monolithic converter and multiplexer, and the first example of such a system-on-a-chip has just been announced by National. Termed "Single Chip Data Acquisition Systems", the **National ADC0816** and **ADC0817** devices really do represent an attempt to bridge the gap between the microprocessor and the essentially analogue world that it lives in. The chips accept up to sixteen separate analogue signal inputs and then select one by means of a multiplexer for conversion to an eight bit digital word. Signal selection is controlled by means of a four bit binary address word which can be latched in directly from a microprocessor bus, or fed via an existing output port.

The eight bit data outputs are tri-state and can also be connected directly to a data bus.

The multiplexer output is brought out to a package pin and must be linked externally to the converter input, allowing signal conditioning and/or multiplexer expansion to be achieved easily. The converter itself is a rather unusual 256R type (256 resistors of value R and a switch tree selection system) instead of the more usual R2R type. Conversion is achieved by means of a successive-approximation sequence, and takes only 100µs per channel which means that a.c. signals of up to 300Hz per channel can be coped with (proportionately higher if less channels used), as well as d.c. inputs.

The ADC0816 is specified over a wide temperature range whereas the ADC0817 is specified at 25°C only and has reduced performance, albeit at a lower cost. Both chips are CMOS and draw only about 1mA from a 5V supply.



PE STRING ENSEMBLE

A.J. BOOTHMAN B.Sc.

Part 4

THE Voice circuitry of the String Ensemble is primarily designed to produce a basic tone which when processed through the Chorus Generator gives the simulated sound of an orchestral string section. Two other voices are also provided to add variety to the overall effect and have the basic characteristics of Woodwind and Brass instruments. The circuitry includes the facility to vary the degree of mixing of the voices, and the switching which enables changes of register to be made in both upper and lower sections of the keyboard.

THE VOICING SYSTEM

The outline of the voicing system is shown in Fig. 4.1, and consists of two sections covering upper and lower parts of the keyboard separately. Outputs from the threshold diodes, following the diode gates, for the upper section of the keyboard are taken to staircase networks in the voicing system

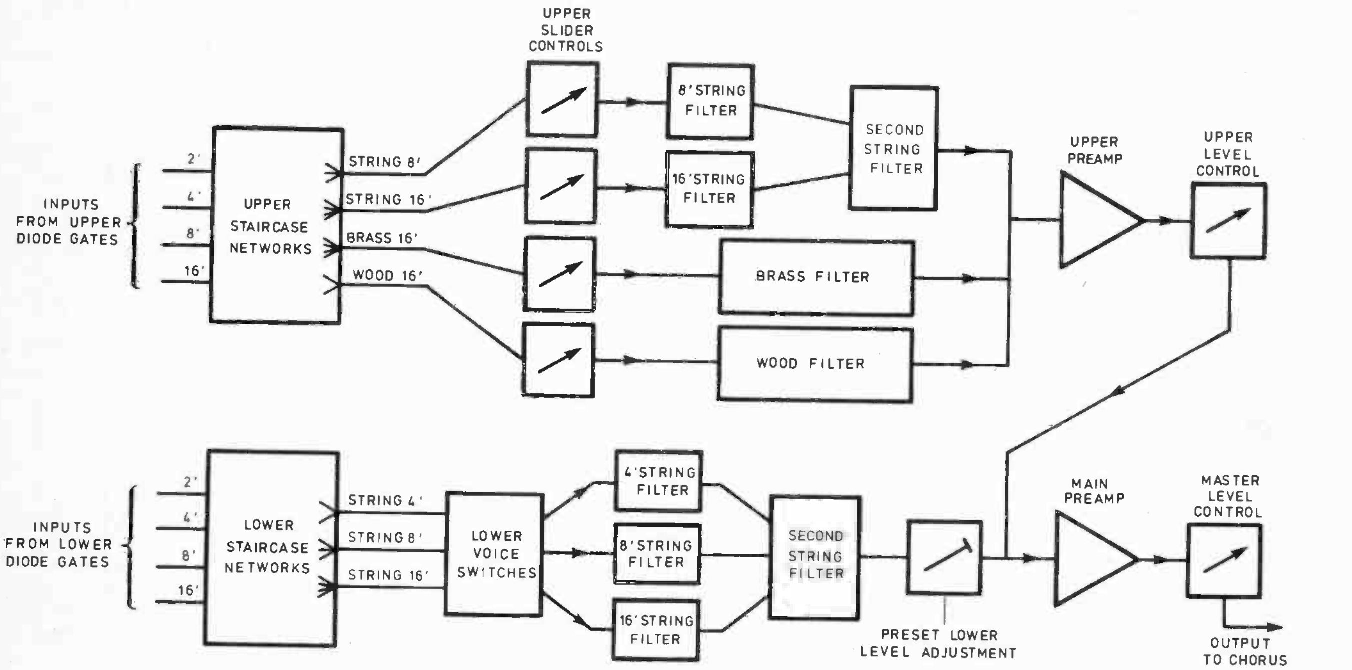


Fig. 4.1. Schematic of the voicing system

which produce stepped waveforms suitable for the four instruments, three at 16ft pitch and one at 8ft pitch. Each instrument is controlled by a slider potentiometer and has its own filter. The string voicing consists of a combination of both high and low pass filters which in conjunction with the second filter, which processes both registers, are in active form. Brass and Woodwind voices are produced by ringing band pass active filters and following a common preamplifier all upper voices are adjusted by a level control on the front panel.

A similar staircase network section produces stepped waveforms for strings in the lower section of the keyboard at 16ft, 8ft, and 4ft, which are then controlled by the lower voice switches and followed by similar string filters to the upper section with a preset level control on the Voice Board.

The combined voices from the full keyboard are amplified together and set by the master level control on the front panel. This signal is passed to the Chorus Generator for processing and returned to the Voice Board for distribution to the Swell Pedal and output sockets.

STAIRCASE NETWORKS

The effect of the Staircase networks is shown in Fig. 4.2 where waveforms (a) to (d) are square waves at 2ft, 4ft, 8ft, and 16ft each coming from the respective diode gate busbar. The square waves contain odd harmonics only which have limited use in the generation of musical instrument tones. Since the square waves on each busbar are octave related even harmonics are available by mixing outputs from each busbar. Generally an amplitude relationship is used where the level of each successively higher even harmonic content is half that of the harmonic below.

Waveform (e) in Fig. 4.2 is produced by mixing an input at 16ft (d) with half the level at 8ft (c), and is used as the base waveform for the woodwind. The description "staircase" can be understood from the shape obtained. Waveform (f) is produced by mixing an input at 16ft with half the level at 8ft, a quarter the level at 4ft, and one eighth the level at 2ft. This waveform is used for all 16ft strings and brass, giving the addition of higher even harmonics.

Waveform (g) is obtained by mixing a fundamental at 8ft with half the level at 4ft and a quarter the level at 2ft for the 8ft strings, whilst waveform (h) has a fundamental at 4ft with half the level at 2ft and is used for the 4ft strings in the lower section.

VOICE CIRCUITRY

Full circuit details are given in Fig. 4.3. Resistors R69 to R76 terminate the output busbars from the diode gate circuits and are essential in any tests of the diode gate system if the Voice Board is removed. R77 to R98 perform the staircasing function prior to slider or switch controllers. The upper string filters are associated with IC32, the brass with IC33, woodwind with IC34 and lower strings with IC35. VR16 and VR17 control the resonant frequencies of the brass and woodwind filters respectively and require setting to avoid the violent peak occurring within the keyboard range. IC36 amplifies all the upper voices and is followed by the upper level control VR18.

LOWER STRING CONTROLS

Switches S3 to S6 are interlinked. With S3 depressed the 16ft and 8ft waveforms from the lower section of the keyboard are linked to String I and II slider controls respectively, and

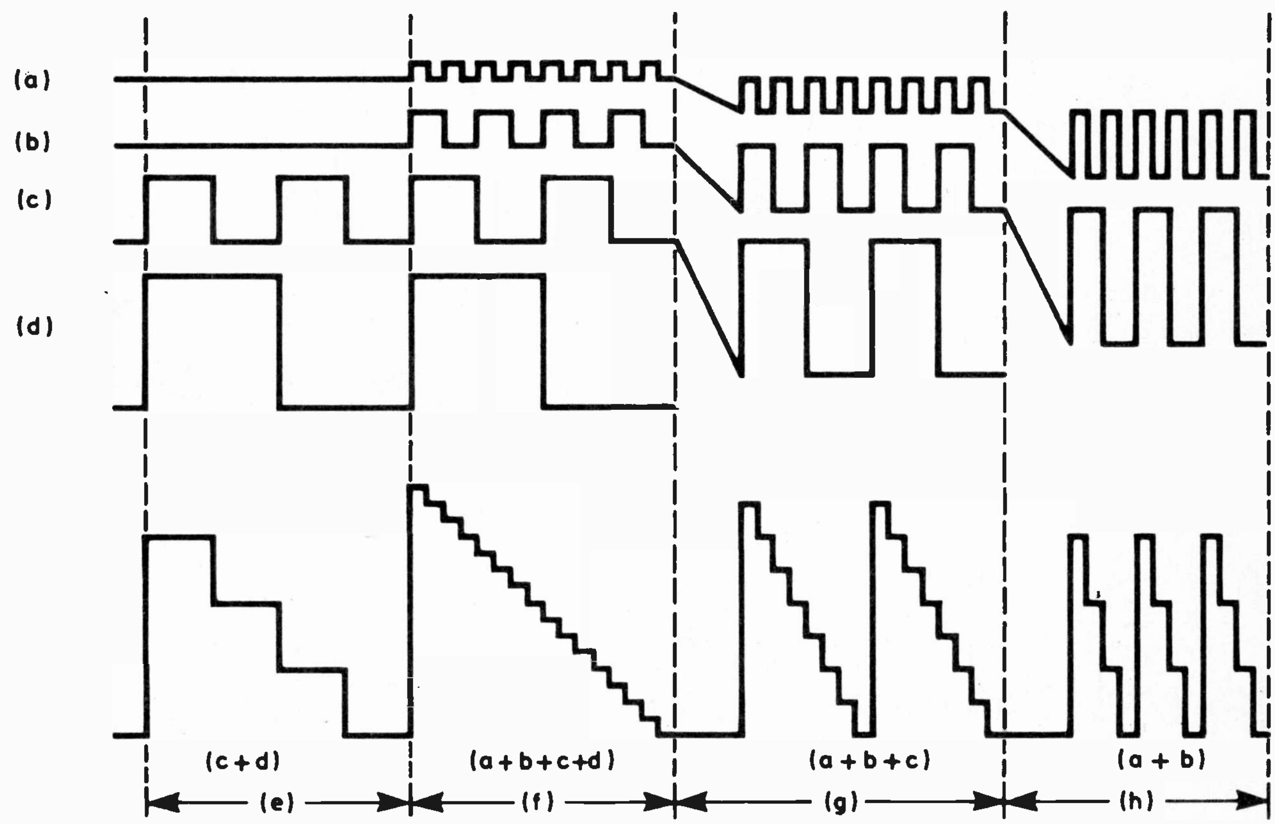


Fig. 4.2. Formation of staircase waveforms from octave related squarewaves

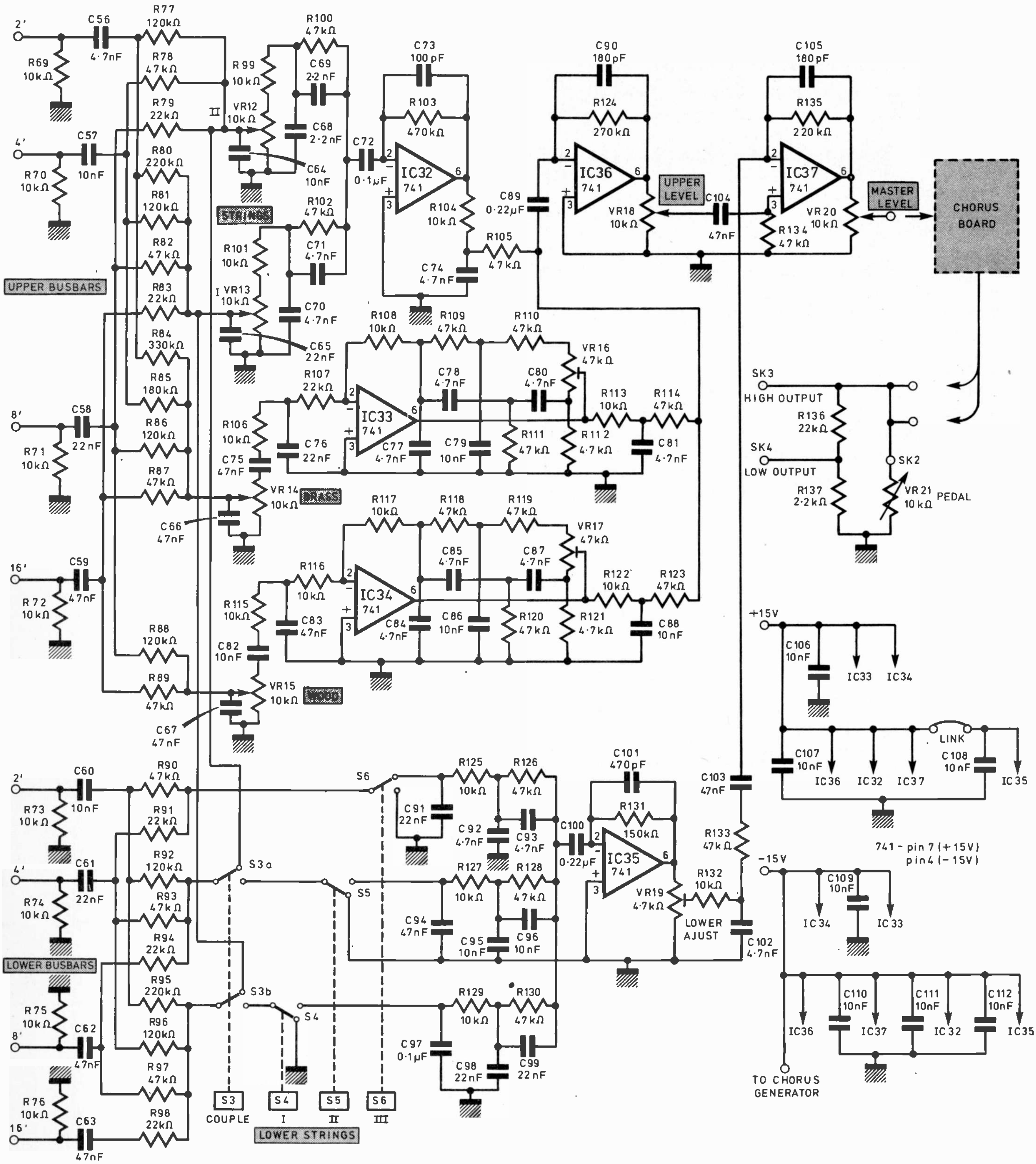


Fig. 4.3. The complete voice circuitry

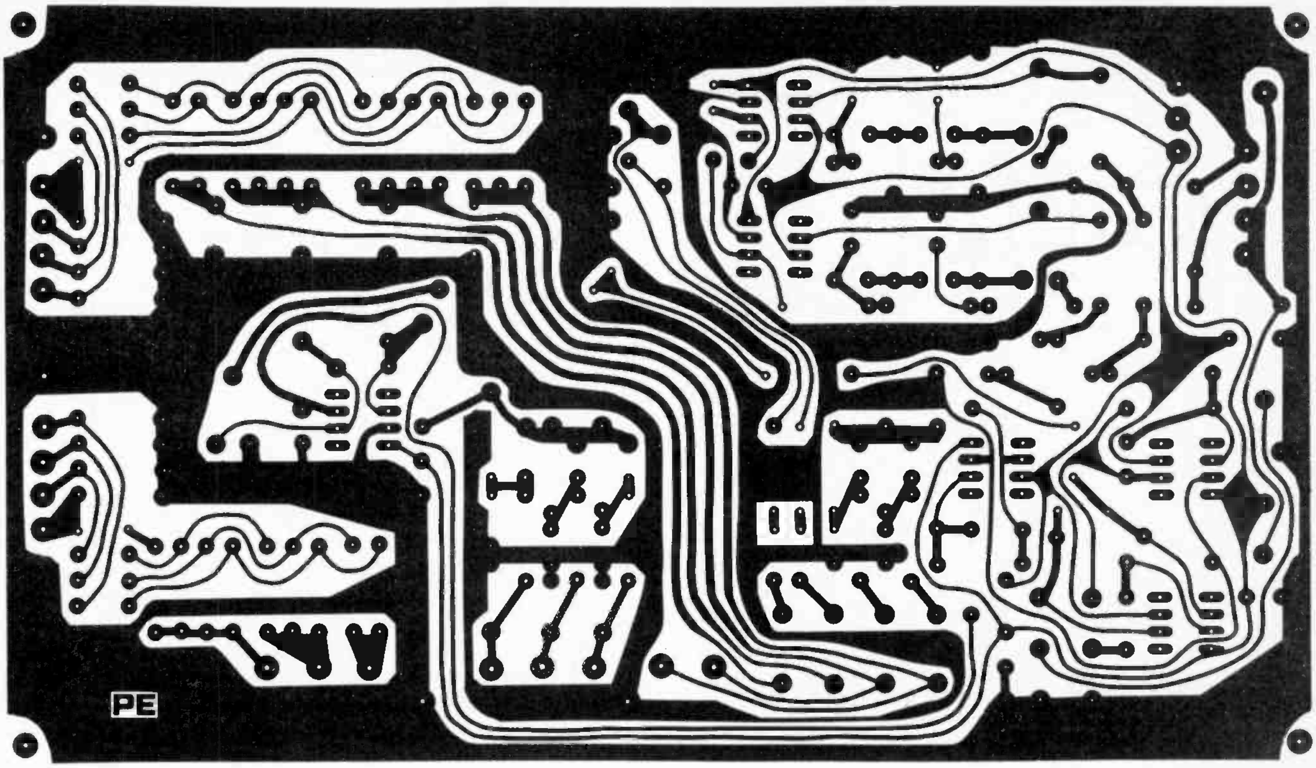


Fig. 4.4. Etching detail for the voice p.c.b.

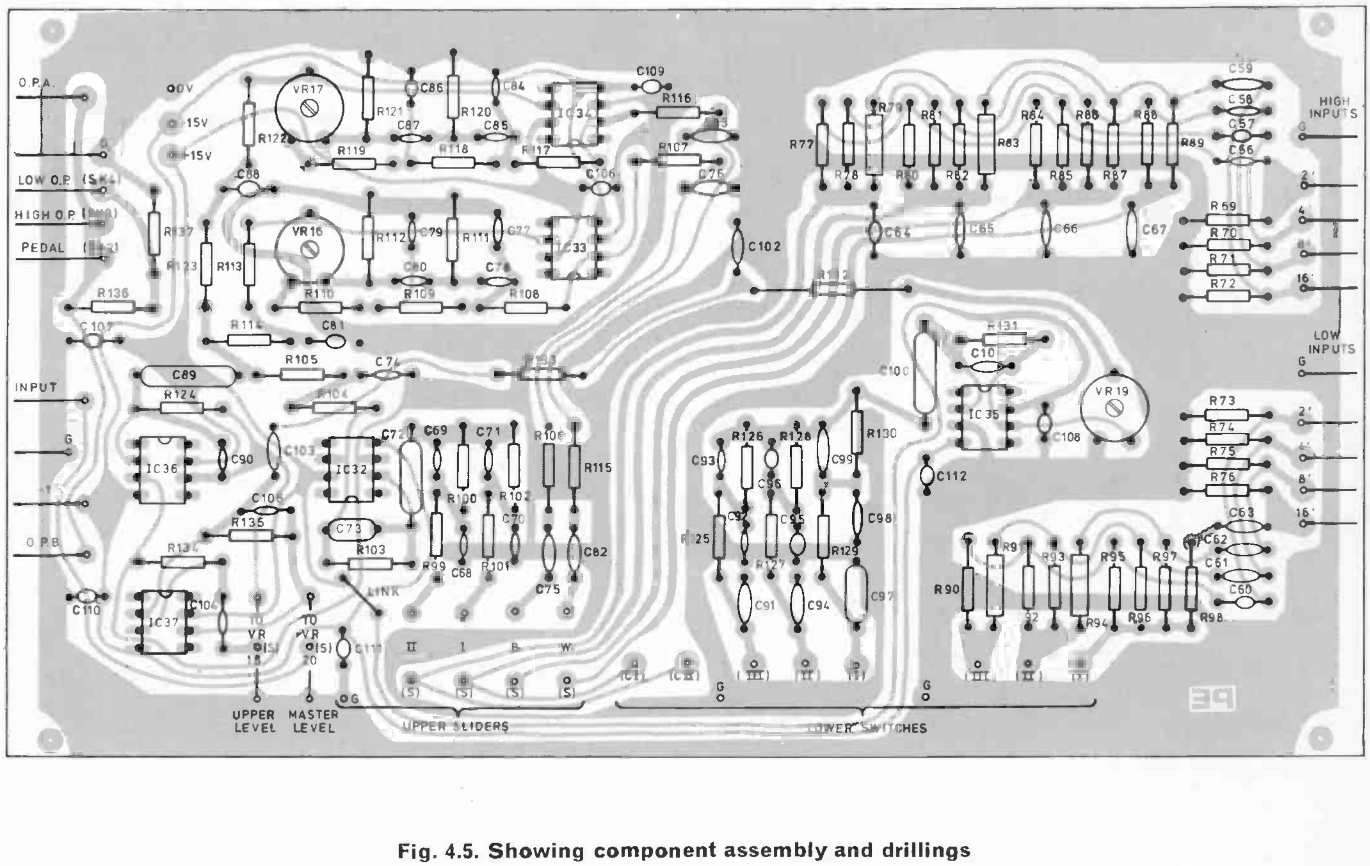


Fig. 4.5. Showing component assembly and drillings

COMPONENTS . . .

VOICING SYSTEM

Resistors

R69–76	10kΩ	R105	47kΩ
R77	120kΩ	R106	10kΩ
R78	47kΩ	R107	22kΩ
R79	22kΩ	R108	10kΩ
R80	220kΩ	R109–111	47kΩ
R81	120kΩ	R112	4.7kΩ
R82	47kΩ	R113	10kΩ
R83	22kΩ	R114	47kΩ
R84	330kΩ	R115–116	10kΩ
R85	180kΩ	R117	10kΩ
R86	120kΩ	R118–120	47kΩ
R87	47kΩ	R121	4·7kΩ
R88	120kΩ	R122	10kΩ
R89–90	47kΩ	R123	47kΩ
R91	22kΩ	R124	270kΩ
R92	120kΩ	R125	10kΩ
R93	47kΩ	R126	47kΩ
R94	22kΩ	R127	10kΩ
R95	220kΩ	R128	47kΩ
R96	120kΩ	R129	10kΩ
R97	47kΩ	R130	47kΩ
R98	22kΩ	R131	150kΩ
R99	10kΩ	R132	10kΩ
R100	47kΩ	R133	47kΩ
R101	10kΩ	R134	47kΩ
R102	47kΩ	R135	220kΩ
R103	470kΩ	R136	22kΩ
R104	10kΩ	R137	2·2kΩ

¼ watt 5% carbon film

Capacitors

C56	4·7nF ceramic	C82	47nF ceramic
C57	10nF ceramic	C83	47nF ceramic
C58	22nF ceramic	C84–85	4·7nF ceramic
C59	47nF ceramic	C86	10nF ceramic
C60	10nF ceramic	C87	4·7nF ceramic
C61	22nF ceramic	C88	10nF ceramic
C62–63	47nF ceramic	C89	0·22μF polyester
C64	10nF ceramic	C90	180pF
C65	22nF ceramic	C91	22nF ceramic
C66–67	47nF ceramic	C92–93	4·7nF ceramic
C68–69	2·2nF ceramic	C94	47nF ceramic
C70–71	4·7nF ceramic	C95–96	10nF ceramic
C72	0·1μF polyester	C97	0·1μF polyester
C73	100pF	C98–99	22nF ceramic
C74	4·7nF ceramic	C100	0·22μF polyester
C75	47nF ceramic	C101	470pF ceramic
C76	22nF ceramic	C102	4·7nF ceramic
C77–78	4·7nF ceramic	C103	47nF ceramic
C79	10nF ceramic	C104	47nF ceramic
C80	4·7nF ceramic	C105	180pF
C81	10nF ceramic	C106–112	10nF ceramic

Potentiometers

VR12–15 10kΩ lin Sliders, VR16–17 47kΩ Presets 100mW submin. VR18 10kΩ lin, VR19 4·7kΩ Preset, VR20 10kΩ lin, VR21 10kΩ Pedal

Integrated Circuits

IC32–37 741

Miscellaneous

SK2–4 Mono standard jack. S3–6 bank of two-pole two-way switches interlocked. 47 terminal pins 1 printed circuit board.

the 4ft signal is inoperative. S4, 5 and 6 convert the lower section to 16ft, 8ft and 4ft strings only, but more than one control button may be depressed at the same time. Except when in the couple condition the Lower Voices have a fixed amplitude preset by VR19, and balancing of the two parts of the keyboard is achieved with the Upper Level Control.

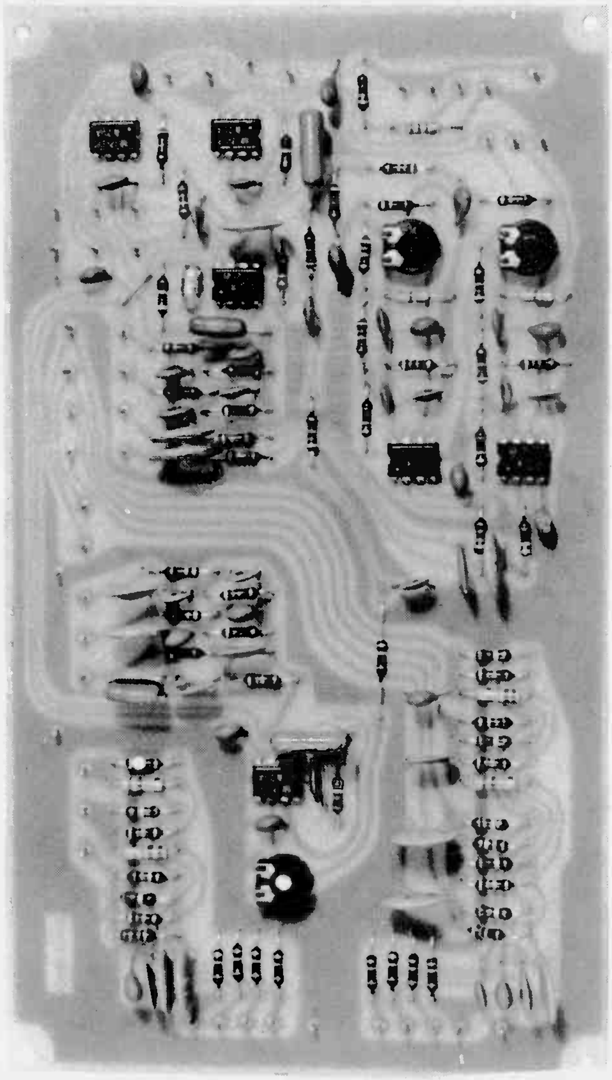
PREAMPLIFIER

Upper and Lower Voices are fed to the complementary (anti-phase) inputs of preamplifier IC37 to compensate for the additional inverting amplifier, IC36, in the upper voice channel. The main purpose of the Master Level Control VR20 is to compensate for the many modes and styles in which the instrument may be played, either melodic or chordal, single or multi-voiced, and it may be used to prevent overloading of the Chorus Generator input under extreme conditions.

OUTPUT AND SUPPLIES

After processing by the Chorus Generator the signal is returned to the Voice Board on which it is controlled by the Expression Pedal via socket SK2. Divider resistors R136 and R137 give high and low level outputs at SK3 and SK4.

The Voice Board is powered by +15 volt and −15 volt supplies obtained from the regulators on the PSU/Tone Generator Board, and capacitors C106 to C112 are incorporated to ensure stable operation to the 741 Operational Amplifiers.



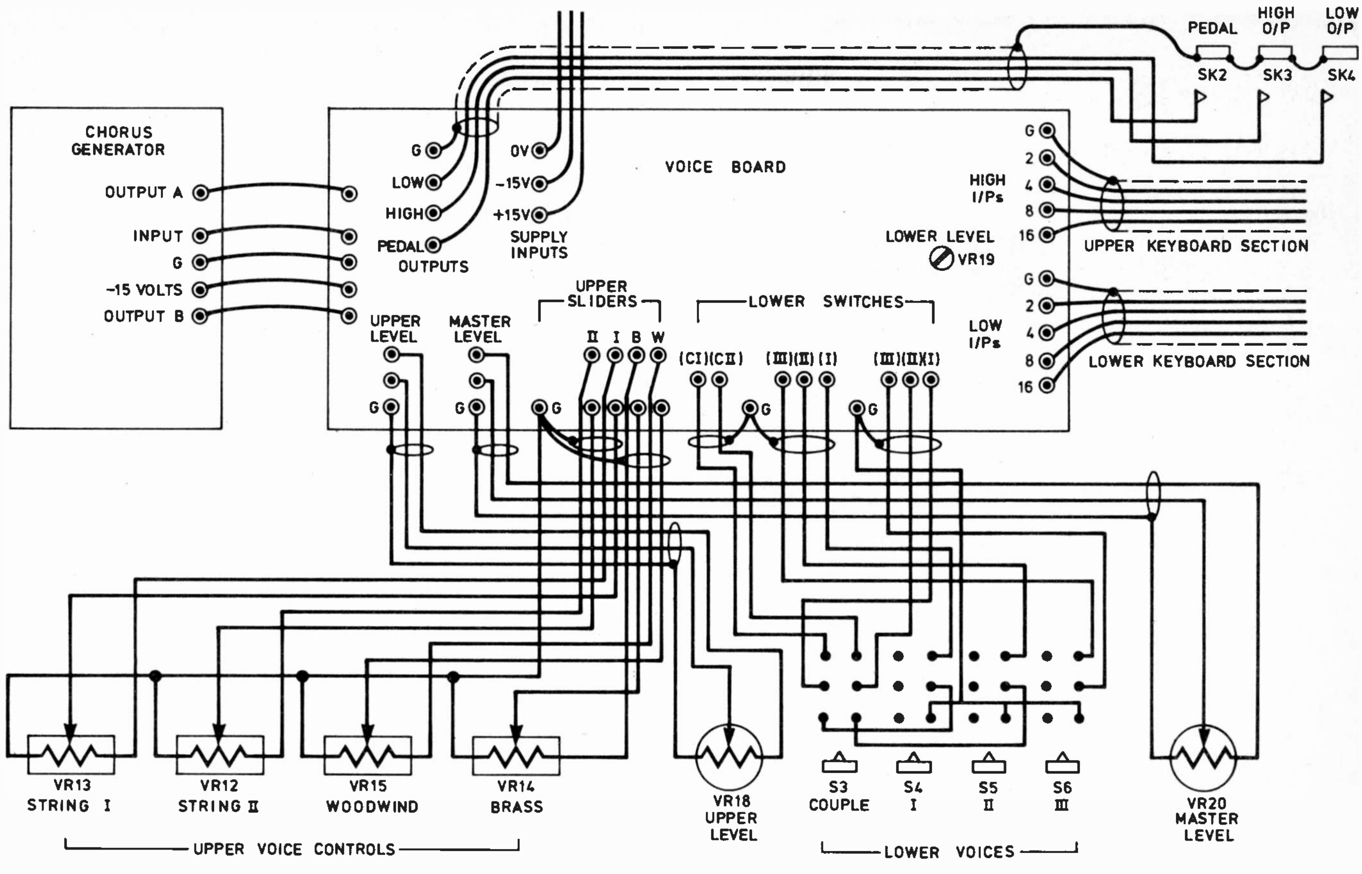


Fig. 4.6. Voice and Chorus interwiring

VOICE BOARD CONSTRUCTION

The Voice circuits described are mounted on a printed circuit board, the etching and drilling details of which are given in Fig. 4.4, with the component assembly details in Fig. 4.5. To assemble the board the terminal pins should first be inserted followed by resistors, i.c.s, preset potentiometers, small capacitors, large capacitors and the wire link next to R103.

INTERWIRING OF THE VOICE AND CHORUS CIRCUITRY

The Chorus Generator interfaces with the Voice Board only, as shown in Fig. 4.6, whilst the Voice Board provides connections to all controls and output sockets. The wiring details given in Fig. 4.6 should be followed carefully, and it should be particularly noted that in some cases screen connections are made at one end of a cable only whilst in others both ends of the screen are connected.

Supply inputs to the Voice Board are taken direct from the PSU/Tone Generator at +15 volts, −15 volts, and 0 volts. Pedal and output signals are taken through a single 3-core screened cable to sockets SK2–SK4 with both ends of the screen connected.

High and low inputs are each taken from the diode gate busbars through a four-core screened cable with the screen connected at each end. The Upper and Master Level Controls are connected by two-core screened cables with the screen soldered at both ends.

UPPER VOICE CONTROLS

A ground lead is taken from the Voice Board and connected to one of the slider controls. A lead is then taken from this point to each voice potentiometer. The remaining terminals on VR12 and VR13 are connected via a four-core screened cable with the screen soldered at the Voice Board end, but not to the potentiometers. Similarly VR14 and VR15 are connected via a four-core screened cable.

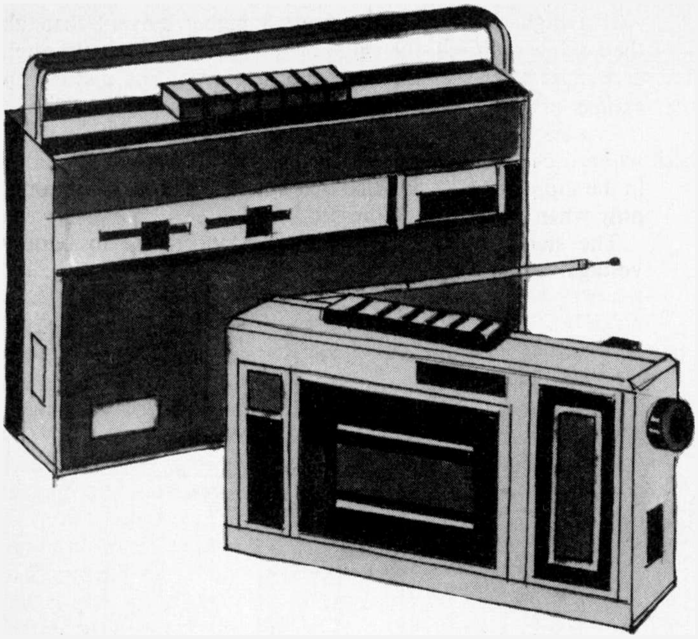
LOWER VOICE SWITCHES

A ground lead is taken to the tags (or pins) shown on S4, S5 and S6, which are strapped together. Three multi-screened leads are then used to complete interconnection to the switches and in each case the screen is only soldered to the Voice Board end whilst the other end is cropped and cleaned up to prevent shorting to other switch connections.

The first lead is two-core and interconnects the relevant pins on the Voice Board to S3. The second lead is three-core and interconnects the Voice Board to S3. The second lead is also three-core and interconnects to the two tags shown on S3 and one tag on S6. Ordinary wire connections are then made as shown between S3 and S4, and between S3 and S5.

Note: Omissions from Part One Components List are C6, C7, C9, C12–10nF ceramic, C8–68pF.
In Fig. 2.5 diodes D23–30 should be reversed. Fig. 2.2 shows them correctly polarised.
In Fig. 3.6 IC28 should be a 14 pin device. The two extreme left pin connections should be ignored.

NEXT MONTH—Cabinet construction



Battery Voltage Monitor

S.V. ESSEX

Utilising one inexpensive CMOS integrated circuit, the device described in this article gives a positive indication, by means of a light emitting diode, whenever battery voltage falls below a certain preset level.

BATTERY LEAKAGE

Whenever a battery is allowed to discharge too far it usually leaks—as many people have found to their cost at one time or another. Not only is the leakage unsightly and messy, but it is also extremely hard to remove.

Occasionally batteries will leak even when the equipment being supplied gives no indication of falling battery voltage.

Battery voltage is also of paramount importance in connection with test instruments—although these may be stabilised by means of a Zener diode, once the battery voltage falls past a certain level the diode can no longer exercise control and inaccuracies result.

Both leakage and inaccuracy can be prevented by employing a battery voltage monitor, which gives a positive indication of when batteries should be changed well before these problems are encountered.

CIRCUIT OPERATION

The circuit is shown in Fig. 1. Each of the four 2-input NOR gates in the CD4001 CMOS i.c. is used as an inverter by connecting the two inputs together.

The negative supply connection to the four gates is taken to the battery negative line via the light-emitting diode D1, across which an almost constant voltage is developed; even when the circuit is in its quiescent state (i.e. the battery voltage is relatively high), a small leakage current flows through the i.c., which is sufficient to bias the l.e.d. on, although it is not enough to illuminate it beyond a faint glow.

Two of the four gates are connected in cascade, the output from the second gate being connected to the inputs of the two remaining gates, which are connected in parallel. The four gates form one high gain amplifier, such that the output switches very rapidly from high to low when the input voltage to the first gate exceeds a certain proportion—usually 45–50 per cent—of the voltage supplied to the i.c. In figures this is the battery voltage minus about 1·6V developed across the l.e.d.

When the output from the last two gates begins to change state the threshold voltage is thus about 5·3V at a battery voltage of 9V, dropping to about 4·3V when the battery voltage has fallen to 7V.

POTENTIAL DIVIDER

R1, VR1 and R2 form a potential divider across the supply lines; if VR1 is adjusted so that its slider is at a potential of 5·4V (relative to the battery negative line) when the battery voltage is 9V, it will be found that at 7V the slider voltage is 4·2V. Thus, although the slider voltage is higher than the threshold voltage when the battery voltage is high, as battery voltage falls a point is reached where the slider voltage is lower than the threshold voltage and the output of the gates goes from low to high.

Since R3 is connected between the output and the i.c. negative supply pin, it thus draws current which increases the current flowing through D1. This slightly increases the voltage developed across the l.e.d., which, in turn, increases the threshold voltage: a regenerative process is initiated and the i.c. output gates saturate, causing an appreciable current to flow through D1, which then becomes illuminated.

Because the circuit operation is regenerative, there is a certain amount of hysteresis present (about a fifth of a volt), so that if the l.e.d. lights up when the battery voltage drops to 7V, it will remain on until the battery voltage exceeds 7·2V. This characteristic could be useful where a load is drawing high current peaks from a partially discharged battery. Although the battery voltage in between current

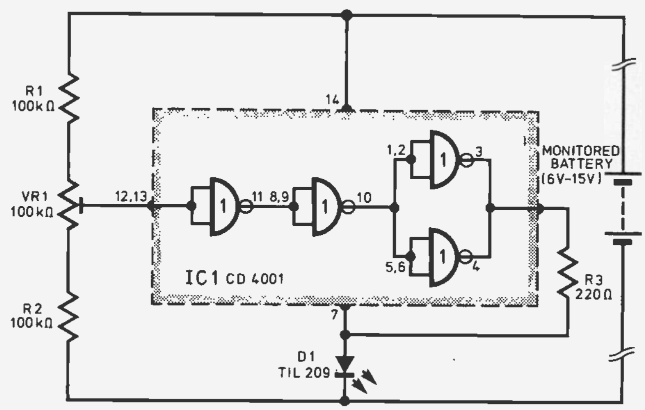


Fig. 1. Circuit of Voltage Monitor

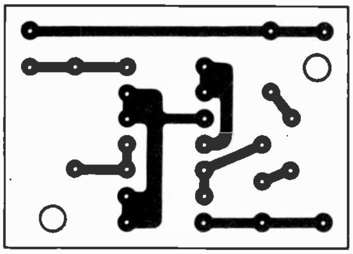


Fig. 2. Suggested printed circuit layout

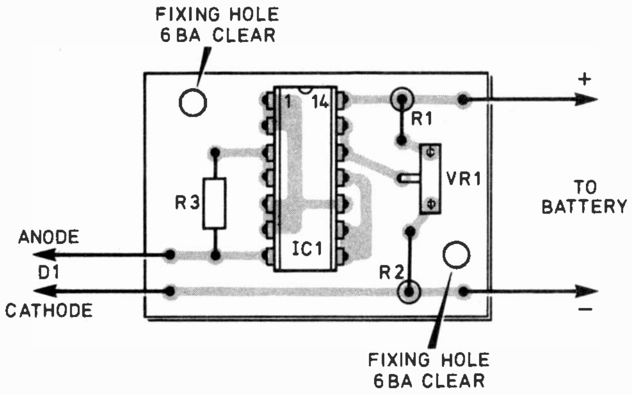


Fig. 3. Showing component assembly and wiring

peaks may be above the safe limit, any excessive rise in the internal resistance of the battery—which in this case could be the deciding factor as to whether or not the battery requires changing—would still mean that the l.e.d. would light up, since the battery voltage would momentarily drop below the preset limit; the hysteresis in the circuit would hold the diode on.

If the hysteresis provided by the basic circuit is insufficient, it can be increased by including a low value resistor (less than 10 ohms) in series with the l.e.d.

WORKING RANGE

The prototype was set to switch on when a nominal 9V battery voltage dropped to 7·2V, although the circuit will work on any voltage in the range 6–15V. With the value of R4 given, the current through D1 is about 10mA just before the l.e.d. cuts out.

COMPONENTS . . .

Resistors

R1, R2	100kΩ
R3	220Ω
All ¼W 10% carbon	

Potentiometer

VR1	100kΩ miniature preset

Semiconductors

D1	TIL 209
IC1	CD4001

If a higher voltage is used, or a higher current through the l.e.d. is required, the value of R4 can be altered, although care must be taken not to exceed the current and dissipation ratings of the i.c.

The standby current is about 0·4mA at 10V, if this is felt to be excessive a small pushbutton switch can be included in the supply to the circuit, so that battery voltage is monitored only when the button is pressed.

The standby current is roughly proportional to battery voltage.

CONSTRUCTION

The circuit, being small, can easily be constructed on a scrap of printed circuit board or Veroboard left over from a larger project: the layout is entirely non-critical although a suggested p.c. board layout is shown (Fig. 2).

When assembling the circuit, small components should be soldered in first and the CMOS i.c. left to last to prevent damage due to overheating. An i.c. socket can be used if desired.

The i.c. should not be handled excessively; although static discharge protection circuits are built into the inputs to the gates, there is no point in taking unnecessary risks. Care should also be taken to connect the i.c. into the circuit the right way round; incorrect connection could lead to an excessively high current flowing through it and the l.e.d.

SETTING UP

The easiest way to set VR1 correctly is to connect the circuit up to a variable voltage power supply, and adjust VR1 so that D1 lights up at the required battery end voltage. The battery voltage monitor can then be connected into the piece of equipment which is to be protected. ★

MICRO-BUS

Compiled by DJD.

Appearing every two months, Micro-Bus will present ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data books. The most original ideas will probably come from readers working on their own microcomputer systems, and payment will be made for any contribution featured here. This is also the place to air your views, in general, on this new technology, so let's be hearing from you!

THIS month's Micro-Bus describes a system which was developed to enable a microprocessor to play waltzes *as it composes them*. The main part of the program, which will play polyphonic tunes containing up to three notes sounded simultaneously, is described in full, together with the codes to enable it to play the first eight bars of a waltz. With the addition of a random-number generator and some extra control routines the micro can be made to compose as it plays.

MOZART'S DICE WALTZES

The idea of composing music mechanically has its origins in the 18th century when a number of pieces were published which used the throws of dice to randomly select between possibilities at different points in the music. Perhaps the best known of these is the "Musikalisches Würfelspiel" or "Musical Dice Game" attributed to Mozart and published two years after his death in 1793. This pamphlet enables anyone without the least musical ability to compose an almost unlimited number of different waltzes with the aid of a pair of dice. There is some doubt as to whether Mozart actually designed the game, although he was undoubtedly interested in such subjects, and the manuscript for his Adagio KV516 shows the bars arranged by letters in a similar way to the Musical Dice Game.

The Musical Dice Game consists of a set of bars numbered from 1 to 176, and a pair of tables. To compose the first eight bars of a waltz a pair of dice is thrown eight times, and the first table gives the number of the bar to be used at each stage for each throw. The other table is used with a second set of eight dice throws to give the second half of the waltz. The bars are so contrived that, no matter what combination of them is put together, the result will be a pleasant waltz. Since the choices for the eighth bar in each part are the same there are a total of 11^{14} possible waltzes; a number so large that playing a different one every minute it would take 700 million years to hear them all!

MUSIC FROM A MICRO

Although it is simple enough to write a program which uses software timing to play monophonic tunes (only one note sounded at a time), most of the interest of music lies in the simultaneous sounding of several notes to produce harmony and counterpoint, and this dictates the use of some extra hardware to produce the notes independently of the micro. Originally a design was contemplated using a top-octave note generating chip, three 1-of-12 selectors for the note selection, three 6-stage binary dividers and three 1-of-6 selectors for the octave selection, together with latches and addressing logic for interfacing this with the micro. The scheme was soon abandoned when it was realised that the same capability is provided in one Motorola part: the MC6840 Programmable Timer Module. In the mode of operation used here it effectively acts as three independent programmable dividers, so that an organ based on one chip can sound up to three notes at once.

MC6840 PROGRAMMABLE TIMER MODULE

The Programmable Timer Module, or PTM, is a recent addition to the M6800 family, and is Motorola's answer to the Intel 8253 Counter/Timer which it resembles in many ways. It contains three 16-bit counters whose contents can be read at any time, and three 16-bit buffer registers which can be written to by the micro. The contents of these buffers can be transferred to the counters either immediately they are written, or else only under the control of an external gate input $\overline{G1}$, $\overline{G2}$, or $\overline{G3}$. The counters are decremented on each clock pulse derived either from the microprocessor clock $Ø_2$, or from an external signal of lower frequency presented at the respective clock input $\overline{C1}$, $\overline{C2}$, or $\overline{C3}$. When a counter reaches the count of zero, a time-out occurs and a bit is set in the status register. What happens next depends on the mode of operation programmed for that counter by its control register. There are four basic modes of operation, and any of the three counters can operate in any mode. In single shot mode the counter's output goes low at time-out and remains low until the counter is re-initialized. In continuous mode the content of the buffer register is loaded into the counter at each time-out so that a continuous square-wave is produced at the output. Additionally the timers can be programmed to generate an interrupt when a time-out occurs. In frequency comparison mode an interrupt is generated if the input period is less than (or alternatively, greater than) the counter time-out, and finally, in pulsewidth comparison mode an interrupt is generated if the input "down time" is less than (or greater than) the counter time-out.

The PTM is addressed as eight consecutive memory locations, the first two of which provide access to the three control registers and the status register, and the last three pairs of which are used to write to the buffer registers or read the current values of the counters. The MC6840 is available from Cramer Components Ltd., 16 Uxbridge Road, Ealing, London, W5 2BP, for £12·73 plus 80p postage (VAT extra).

MUSIC INTERFACE

The complete circuit for the music interface is shown in Fig. 1. The three counters of the PTM are used in continuous mode, and the gate inputs are grounded to enable the counters. The clocks are derived from the microprocessor clock, so the inputs $\overline{C1}$, $\overline{C2}$, and $\overline{C3}$ are left unconnected. The three outputs are taken to an adder circuit at the input of an LM386 1 watt audio amplifier chip which drives a loudspeaker. The two MT8T26 quad bidirectional buffer packages and the TTL gates are needed to interface the PTM to the D2 kit's bus. In a small system the PTM could be connected directly to the microprocessor's address and data lines in which case these parts could be dispensed with. As shown, the PTM is addressed as locations \$2010 to \$2017.

The music produced by the circuit sounds "organlike" since the amplifier is fed with the unmodified squarewave outputs of the PTM, but with extra circuitry it would be possible to add filtering or envelope shaping, possibly under control of the micro, to simulate other instruments or sounds. Once configured, the three counter outputs will produce frequencies equal to half the clock frequency divided by N+1, where N is the 16-bit number loaded into the respective buffer register. To obtain silence from any output, zero can be loaded into the buffer to give an inaudibly high frequency. To play tunes a program is needed to read the music stored in some notation in memory, and from this, load the correct divisors chosen to give the musical scale of notes, into the three counters at the correct times.

MUSIC NOTATION

The notation used for encoding tunes to be played by the micro uses one byte for each note, and one byte for each change in duration. The codes are shown in Fig. 2. The note codes use the lower four bits to determine the note, and bits 4 to 6 to determine the octave of the note (7 for the highest octave and 1 for the lowest), giving a total range of 7 octaves. For silence, a code of $60 is used. The top bit specifies whether the notes will be sounded. If the top bit is zero, the next note code is fetched immediately; if one, the program waits for a certain duration while the notes sound. This duration is set up by specifying a duration code with $D in the lower four bits. The upper four bits then give a duration of 1 to 16 units. Fig. 3 shows the note codes for a section of the keyboard (the values in brackets give the codes with the top bit set).

The notation is best explained by an example. Fig. 4 shows the music for the first eight bars of a dice waltz, together with the hex codes which, when supplied to the program to be described, will play the tune at the loudspeaker of the music interface.

MUSIC PROGRAM

The main part of the music program is subroutine PLAY, shown in Fig. 5, which converts the note codes into the correct divisors and loads them into the PTM to generate the music. Its operation is shown by the flowchart of Fig. 6. A duration code, when encountered at any time, sets the duration parameter DURN to the value of the top four bits. Note codes cause the divisors for the notes specified to be loaded into successive buffer registers of the PTM until a note code with the top bit set has been encountered; at this point the program delays for the currently standing duration, and the register pointer is reset. The table SCALE gives the divisors for a well-tempered top octave; these are doubled for each successive lower octave.

The main program to call subroutine PLAY and play a tune, such as the one given in Fig. 4, is shown in Fig. 7. This is

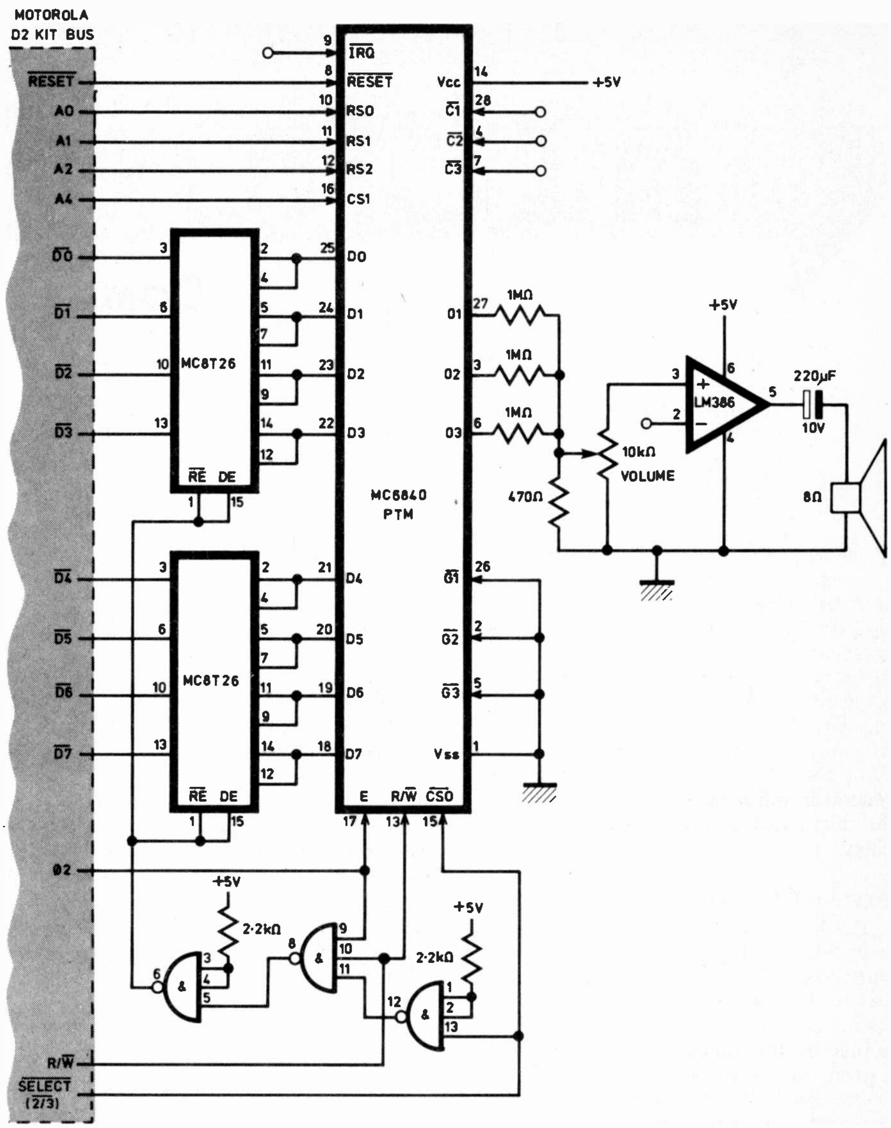


Fig. 1. Circuit for the music interface described in the text, based on the MC6840 PTM

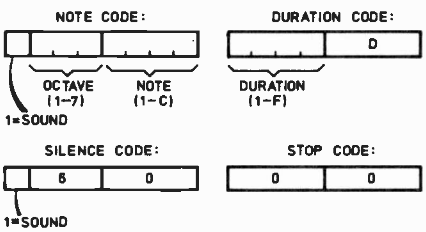
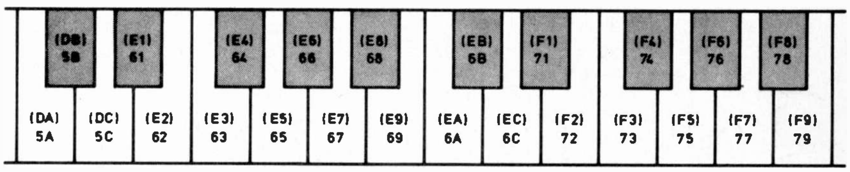
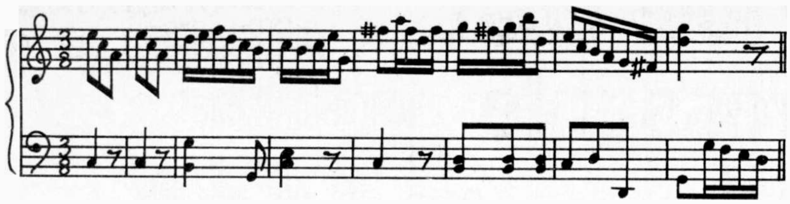


Fig. 2. The four types of 8-bit code used to encode tunes for the music program described

Fig. 3. Note codes corresponding to the notes of a section of the keyboard. The same values with the top bit set are shown in brackets





```
WALTZ FCB $2D,$72,$4A,$E0,$EA,$65,$E0
 FCB $72,$4A,$E0,$EA,$65,$E0
 FCB $1D,$6C,$55,$C9,$F2,$F3,$EC,$6A,$C5,$E9
 FCB $6A,$52,$CA,$E9,$EA,$F2,$2D,$65,$60,$E0
 FCB $74,$CA,$1D,$F7,$F4,$6C,$E0,$F4
 FCB $75,$4C,$CC,$F4,$75,$4C,$CC,$F9,$2D,$6C,$4C,$CC
 FCB $1D,$72,$4A,$E0,$EA,$69,$CC,$E7,$65,$BC,$E4
 FCB $2D,$45,$75,$E9,$1D,$D5,$D3,$52,$60,$E0,$CC,0
```

Fig. 4. The music for the first eight bars of one possible Mozart dice waltz, together with the hex codes for playing this on the system described in the article. Each line of codes corresponds to one bar of the music

```
                 NAM    PLAY
               * SUBROUTINE TO PLAY LIST OF NOTES
               *     POINTED TO BY X.
               *
0000 0002      NOTE   RMB    2
0002 0002      PNOTE  RMB    2
0004 0002      PTIMER RMB    2
0006 0001      DURN   RMB    1
0007 0001      TOP    RMB    1
               *
     0240      TEMPO  EQU    $240
     2010      TIMER  EQU    $2010      MC6840 PTM
               *
               * WELL TEMPERED SCALE *
               *
0008 0000      SCALE  FDB    0,451,426,402,379
000A 01C3
000C 01AA
000E 0192
0010 017B
0012 0166             FDB    358,338,319,301
0014 0152
0016 013F
0018 012D
001A 011C             FDB    284,268,253,239
001C 010C
001E 00FD
0020 00EF
               *
0022 DF 00     PLAY   STX    NOTE
0024 CE 2012   NEWSET LDX    #TIMER+2
0027 DF 04     STIMER STX    PTIMER
0029 DE 00     MORE   LDX    NOTE
002B A6 00            LDA A  0,X
002D 26 01            BNE    NSTOP
002F 39               RTS              RETURN
0030 08        NSTOP  INX
0031 DF 00            STX    NOTE
0033 16               TAB
0034 C0 0D            SUB B  #$0D
0036 C5 0F            BIT B  #$0F      2ND DIGIT D?
0038 26 04            BNE    SET
               * D = DURATION CODE *
003A D7 06            STA B  DURN
003C 20 EB            BRA    MORE
003E 36        SET    PSH A
003F 16               TAB
0040 84 0F            AND A  #$0F      NOTE PART
0042 48               ASL A
0043 8B 08            ADD A  #SCALE
0045 97 03            STA A  PNOTE+1
0047 4F               CLR A
0048 89 00            ADC A  #SCALE/256
004A 97 02            STA A  PNOTE
004C DE 02            LDX    PNOTE     POINT TO DIVISOR
004E A6 00            LDA A  0,X
0050 97 07            STA A  TOP
0052 A6 01            LDA A  1,X
0054 58               ASL B
               * DOUBLE DIVISOR FOR EACH LOWER OCTAVE *
0055 C0 E0     SHIFT  SUB B  #$E0
0057 24 06            BCC    NSHIFT
0059 49               ROL A            WITH CARRY SET
005A 79 0007          ROL    TOP
005D 20 F6            BRA    SHIFT
005F 4A        NSHIFT DEC A            AS DIVIDES BY N+1
0060 DE 04            LDX    PTIMER
0062 D6 07            LDA B  TOP
0064 E7 00            STA B  0,X
0066 A7 01            STA A  1,X
0068 08               INX
0069 08               INX
006A 32               PUL A
006B 4D               TST A
006C 2A B9            BPL    STIMER
               * TOP BIT SET = SOUND NOTES *
006E 96 06     SOUND  LDA A  DURN
0070 CE 0240   LONGER LDX    #TEMPO
0073 09        WAIT   DEX
0074 26 FD            BNE    WAIT
0076 4A               DEC A
0077 26 F7            BNE    LONGER
0079 20 A9            BRA    NEWSET
               *
                      END
```

Fig. 5. Subroutine for the MC6800 micro which plays music stored in memory in coded form

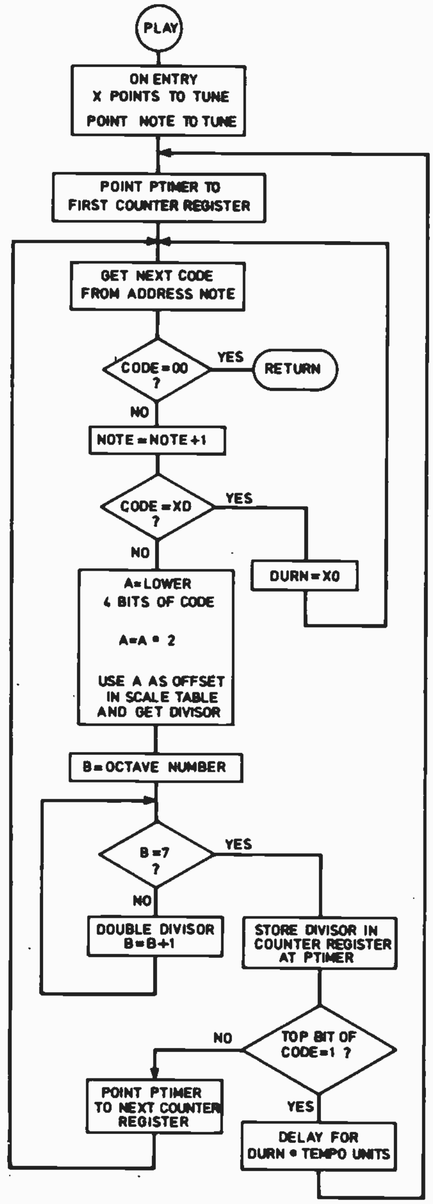


Fig. 6. Flowchart for subroutine PLAY shown in Fig. 5

Fig. 7. Main program for the MC6800 micro which configures the three counters of the PTM for continuous mode, and then calls subroutine PLAY

```
0080                  ORG    $80
0080 CE 8283   BEGIN  LDX    #$8283    CONFIGURE PTM
0083 FF 2010          STX    TIMER
0086 86 82            LDA A  #$82
0088 B7 2010          STA A  TIMER
008B CE 0092          LDX    #WALTZ    POINT TO MUSIC
008E BD 0022          JSR    PLAY
0091 3F               SWI
               *
```

entered at BEGIN. These programs were developed and run on a Motorola D2 kit, which is based on the MC6800 micro, although it should be a simple matter to modify them to run on any other. To implement the composing of dice waltzes a random number generator is used to choose between several alternatives for each bar. One approach would be to use the random number as an offset to a table of pointers to the alternative bars. The composition of music by computer is certainly not exhausted by the techniques described, and it is hoped that those interested will be stimulated to experiment further. It seems as unlikely that music generated in this linear way will be memorable any more than a line of random numbers will form a pleasing overall pattern.

A more enlightened approach might be to compose from the top down; for example, starting with a simple theme which is developed and embellished. Perhaps the most amusing suggestion was to use the Musical Dice Game to generate continuous "musak" which would never repeat itself! When by chance an especially pleasing waltz cropped up, the sequence of bars could be noted down for posterity.

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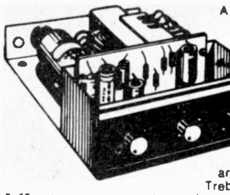

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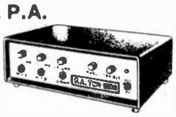

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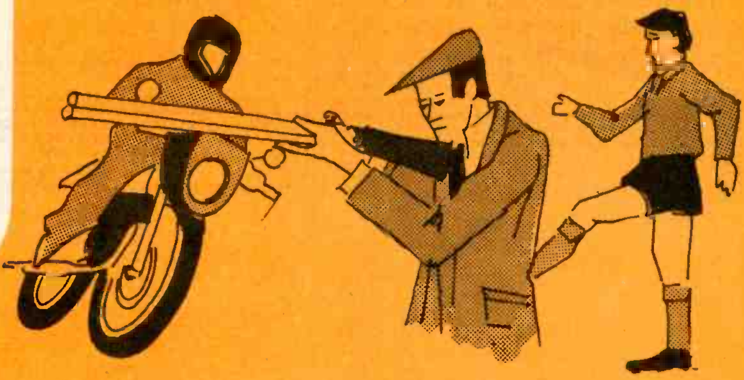

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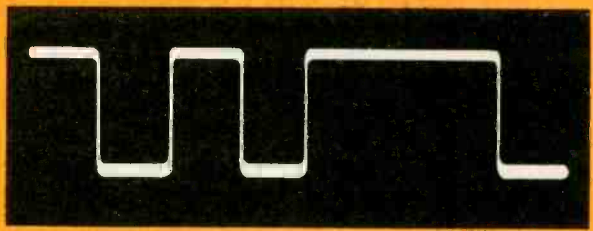

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See page 728

PRACTICAL

ELECTRONICS

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INDUSTRY NOTEBOOK

By Nexus

The Common Good

International political and economic quarrels are constantly in the news. The USA and Britain are at odds with the Japanese in matters of trade, for example. And Britain is frequently in dispute with EEC partners, individually or collectively. Such squabbles tend to obscure some fine international co-operative ventures.

One such is Meteosat, 22,000 miles up, quietly doing its job of providing world weather maps and met. data for the common good of mankind. It was built for the European Space Agency by the COSMOS consortium of aerospace companies and launched by the Americans from Cape Canaveral. In all there will be five satellites to give complete global coverage. The Americans are supplying two and the Japanese and the Russians one each.

Japanese Imports

But having recorded with pleasure something that unites us all through science, we still cannot avoid considering what divides us internationally in trade and industry. In the UK, Japanese car imports have displaced colour TV as the main talking point. Not that the Japanese threat to British electronics goods manufacturers has disappeared although there is some easement in the TV sector where the agreement on restricting sales is reported to be working reasonably well.

The knock-out blow which closed Thorn's Skelmersdale picture-tube plant has left Mullard in a more favourable position as Britain's sole producer. Even so, Mullard have had to adopt an aggressive attitude (i.e. reduce prices and profits margins) to sell 650,000 tubes out of 1·8 million used in the UK last year. The Japanese, however, still managed to sell 583,000 with the rest coming mainly from Canada and the USA. Mullard also got some help from the rise in value of the Japanese yen. Mullard report having "turned the corner" with the Japanese market share in the UK dropping sharply in recent months.

The British Radio Equipment Manufacturers Federation (BREMA) has been negotiating an agreement on music centres where the Japanese have over half the UK market. Trade in this sector is said to be sluggish and with large stocks of Japanese products already in the UK it seems likely that even if agreement is reached there will be little effect in the short term.

Brain-power Exports

The Post Office Viewdata service, becoming operational in the UK a year earlier than expected, looks like being an export success. Already adopted by Germany, it is now being examined in the United States following its public showing at Atlanta, Georgia, last October. The system is being sold through Insac Data Systems Ltd, a company set up by the NEB to market British computer software overseas.

Another software company, Compeda Ltd, owned by the National Research Development Corporation, specialises in selling systems based on university and government-sponsored research. Exports of systems packages are expected to account for at least 60 per cent of turnover according to Keith Trickett, managing director of Compeda. One of the systems offered is called the Pipework Design Management System expected to appeal to the petrochemical, gas and process industries. Another is Gaelic, a design system for i.c.s and p.c.b.s.

Setting Up the Arabs

Closely allied to pure brain-power exports such as selling software and supplying consultancy services is technology exporting, a controversial subject because as well as transferring technology it can also transfer jobs, not politically attractive at periods of high domesic unemployment.

Egypt, for example, is anxious to move into high-technology industries such as electronics and aerospace and some British electronics technology has already been transferred to the Cairo area and is in production. Recently announced is a big helicopter deal in which the Anglo-French Lynx will be built in Egypt, both airframe and engines, initially from kits of parts but progressively building up an indigenous aerospace industry which eventually could conceivably compete in the world market and with lower labour costs pose a threat to the companies now supplying all the know-how.

The process of educating those nations aspiring to industrial expansion is something we have to learn to live with. It is not new. I remember being startled to discover an American multinational, well known for antagonism to the Communist political system, cheerfully selling technology, and production machinery to match, to some Eastern Bloc countries. The Americans involved were confident that by the time the Eastern Bloc manufacturers had mastered the technology, they themselves would already be well ahead on the next generation of products, always a step ahead. A supporting argument was that if they didn't supply the know-how and equipment, then somebody else would, so you might as well get the business while it is going.

IEA/Electrex

People are slowly becoming accustomed to the National Exhibition Centre near Birmingham. The IEA/Electrex show attracted a substantially greater attendance than formerly. Facilities for visitors are far greater than at the old London venue but it wasn't just this that brought the crowds along but a more optimistic trade outlook and the stands were certainly busy with good enquiries for products and services. The electrical part of the exhibition was more dominant and busier but I heard no complaints from exhibitors in the electronics section.

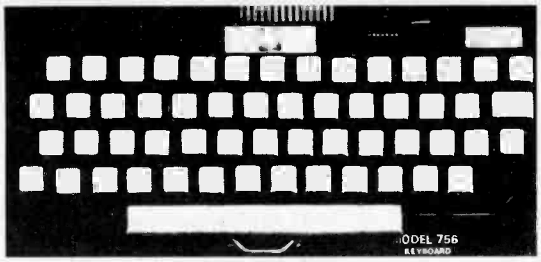
An interesting feature was the number of new towns and industrial development areas which took exhibition space, some with very large stands, in an effort to encourage industrial investment. Their full-colour brochures are fully on a par with those from travel agents, and it seems hard to resist the advertised attractions. "When you're in Wakefield you are in the heart of Rugby League country—and among people who work as hard as they play."

Overstretch

Videomaster, who built a £4 million turnover company from scratch in four years has been unable to finance expansion and, although still trading, is in the hands of the Official Receiver. Fresh capital is being sought. Eighty per cent of the business was in the volatile TV games sector where promotional costs are high and price-cutting nothing short of savage.

Engineers' Pay

The IEE Salary Survey shows that the hypothetical average professional electrical/electronics engineer had a salary increase of 5 per cent since the last annual survey, well below the rate of inflation. But the gap between those employed in the public and private sectors narrowed. In the public sector the average Fellow or Member engineer was ahead by £1,180 p.a. and this has now fallen to £840. In the case of Associate Members the respective figures are £890 and £630 p.a.



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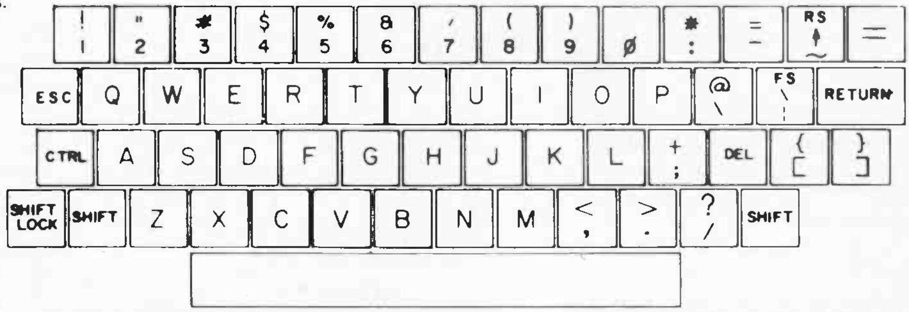

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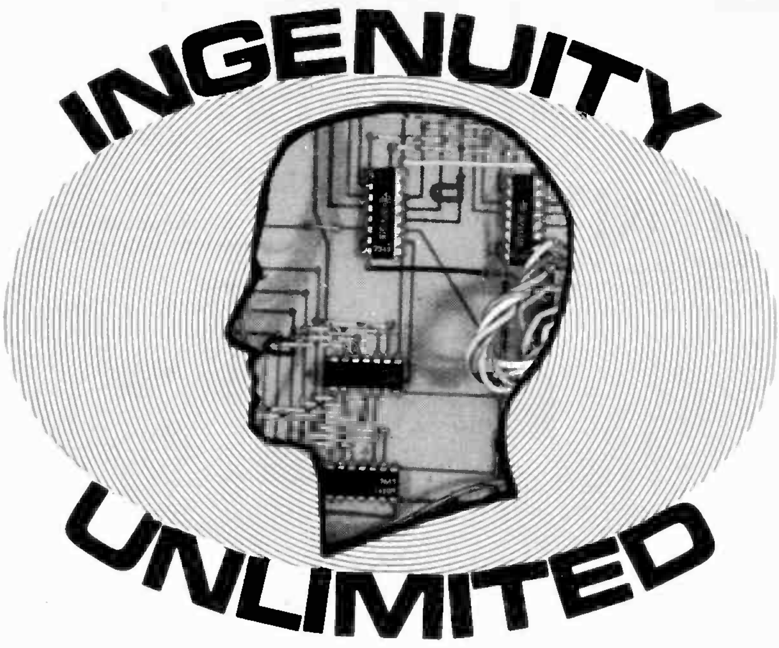

A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

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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.

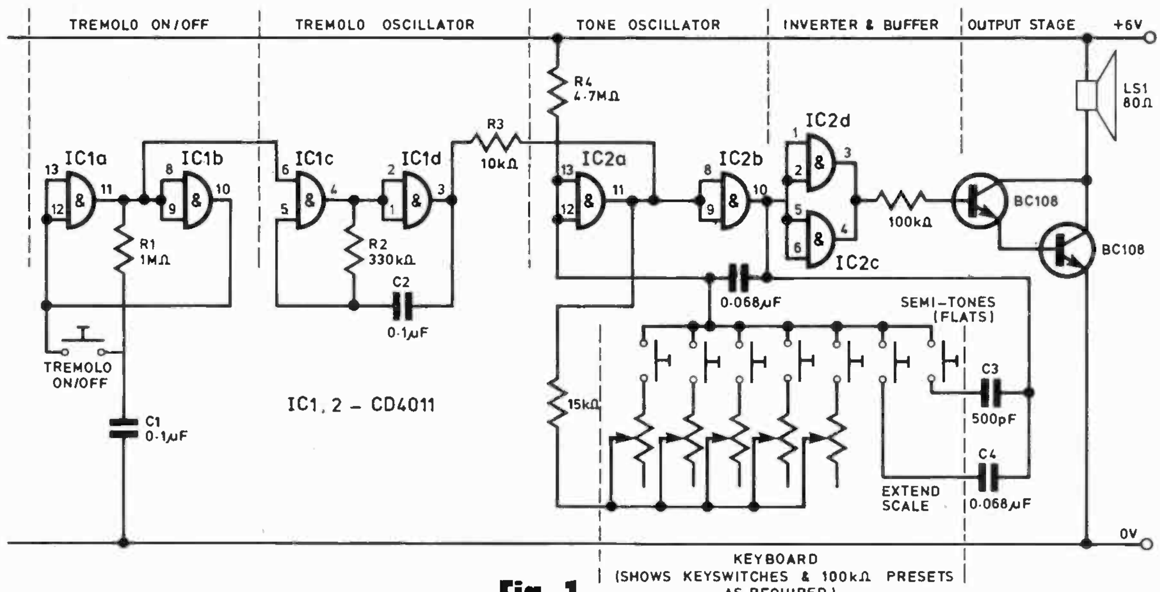


Fig. 1

MUSICAL CALCULATOR

THE rapid advances in pocket calculator technology has resulted in many cheap keyboards being available on the surplus market, several of which are suitable to form the basis of a small electronic organ.

Using the two CD4011 i.c.s as shown in Fig. 1 at least two octaves may be covered, each key selecting an individually adjusted miniature skeleton preset thus producing the required note. The oscillator drives a simple amplifying stage consisting of a Darlington pair and a balanced armature insert producing a more than adequate sound level.

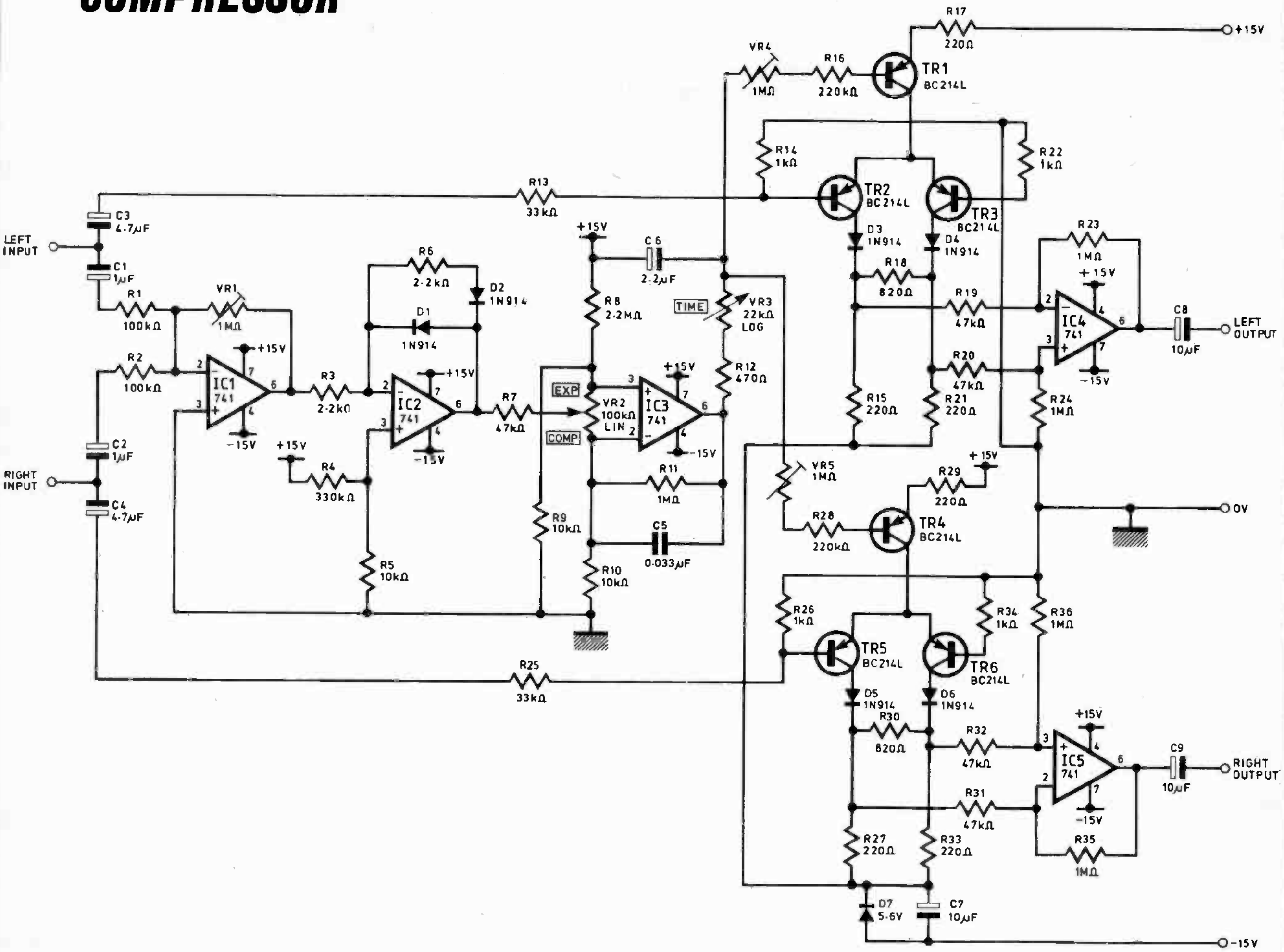
IC2 provides a switchable tremolo effect needing only one key to turn it either on or off; a further key being used to parallel C4 with C3 to produce the flats to any note pressed. The range covered by the keyboard can be extended by using another "control" key to double the value of the capacitor in the oscillator.

Of especial benefit when used by the forgetful child is the fact that no on/off switch is necessary. With a 6 volt supply, and high gain, low leakage transistors, the quiescent current is unmeasurable on a 50µA meter, although the tremolo should be left in the off condition as it consumes nearly 0·5mA.

Only the simplest keyboards have an independent connection available to each key but the printed circuit of most is easily modified after a little patient examination. The circuit is, of course, monophonic, i.e. depression of two keys produces a third, unrelated note, nevertheless an amusing musical toy can be constructed at very little cost, its accuracy dependant only on careful tuning of each note.

D. Ian,
Hampton Court,
Surrey.

STEREO EXPANDER/ COMPRESSOR



THIS circuit will help in making low noise, high quality recordings on a good stereo tape recorder. It could also enhance the reproduction from an f.m. tuner or from discs. The input signals are mixed and buffered by IC1, which has a variable gain to enable inputs within the range 10mV to 1V r.m.s. to be accepted. The signal is then half-wave rectified by IC2, and further amplified by IC3, which can work in the inverting or non-inverting mode depending on the setting of VR2, which also dictates the gain of this stage. A control voltage then appears across C6. The attack and decay time of this voltage is controlled by VR3 within the range 20ms to 200ms.

The control voltage is fed to two voltage controlled amplifiers (v.c.a.s), one for each channel. These utilise the forward conducting resistance of silicon diodes, which can be varied according to the current being passed through them.

Looking at the left channel v.c.a., the current through diodes D3 and D4 is controlled by TR1, and hence by the control voltage. The audio signal is injected into TR2 which along with TR3 forms a long tailed pair. Anti-phase signals appear at the inputs of IC4, which amplifies the difference as the output signal. R18 tends to minimise this difference, and hence the gain of the v.c.a. As more current is passed through the diodes, the gain increases.

VR4 and VR5 are adjusted so that 550mV is dropped across each of the resistors R17 and R29. VR1 is adjusted so that when a signal of normal listening level is fed into the inputs, adjustment of VR2 makes little difference to the overall output level.

P. R. Williams,
Stevenage,
Herts.

FADE UP/DOWN IN THYRISTOR CIRCUITS

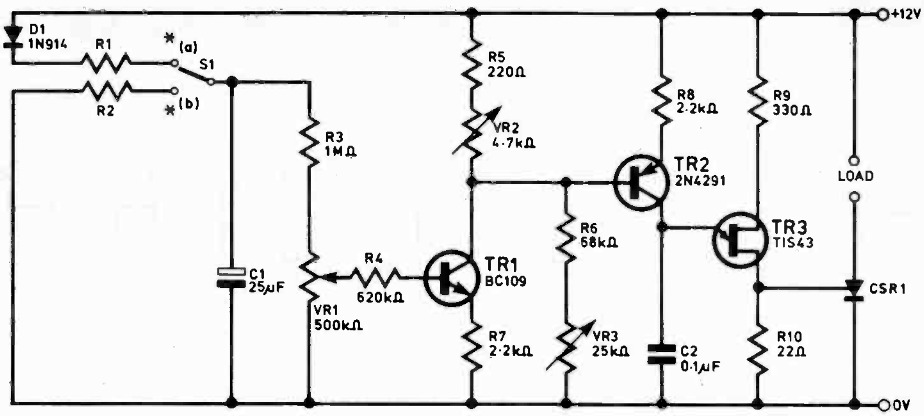


Fig. 1

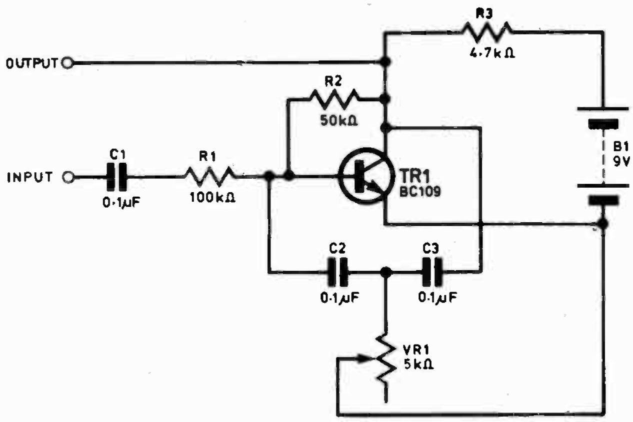
Among the many published thyristor circuits for power control, I do not recall seeing one with a "fade-up/fade-down" feature. The circuit depicted in Fig. 1 will do this; as shown it is applicable to a load requiring 12V, but it could probably be adapted to higher power requirements.

The main controls are VR1 for thyristor firing control, and switch S1 for fade-up/down control. The setting of VR1 determines maximum load current, via two stages of amplification TR1 and TR2, then through a conventional u.j.t. firing circuit based on TR3. Fade-up/down is provided by the charging and discharging of C1, as regulated by S1, R1 and R2. With S1 switched to position (a), CSR1 output will gradually rise to the maximum governed by VR1, whilst with S1 switched to position (b), C2 will discharge and fade-down will occur.

Fade times of about 30 seconds were obtained with R1 or R2 equal to 5mΩ, whilst at 68kΩ fade times were nil. R1 and R2 could be made variable if required.

VR2 and VR3 are included for setting the bias on TR2; they should be adjusted when setting up so that zero output and full output from the s.c.r. are obtained from the extreme settings of VR1 (do this with C1 disconnected and S1 connected to the positive rail).

J. Duffill,
Cheltenham,
Glos.



SIMPLE WAA-WAA

This system is very cheap but very effective, and comparable with many commercial circuits now on the market. It was designed chiefly for use with an electric guitar, though it is also very effective on other instruments.

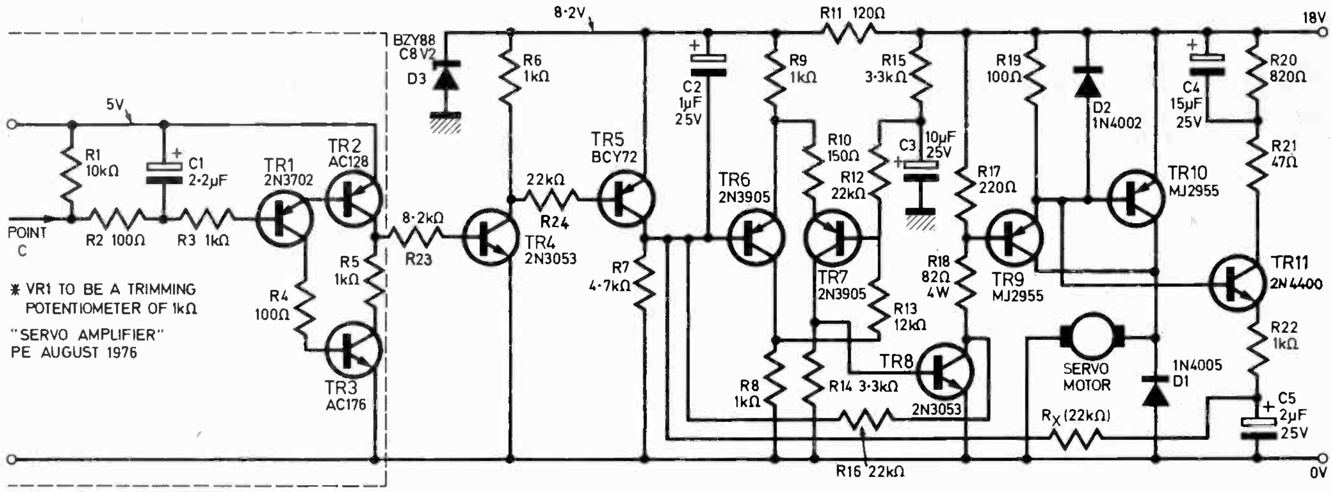
It consists of a basic "T"-filter network in the feedback bias of a transistor amplifier. According to the component values, a small range of frequencies are boosted while others around are attenuated. As VR1 is rotated, the range is shifted and a different band of frequencies are boosted.

In the circuit shown, the component values have been selected so that with potentiometer rotation the narrow frequency-selective band sweeps over the entire range of the guitar, so giving the desired "Waa-Waa" effect.

The value of VR1 should not be more than 5kΩ as the degree of rotation would then be too small for the musician to be able to control the effect confidently. If the guitar used with the unit has a particularly weak output signal then RI can be reduced. The circuit will run on a PP3 9V battery.

S. D. Le Maistre,
St. Laurence,
Jersey.

SPEED CONTROLLER



THIS system was designed to control the speed of a radio controlled car capable of speeds of up to 35 m.p.h. The circuitry is intended for use in conjunction with the "Proportional Radio Control System" published in P.E.

One of the main disadvantages of using a variable resistor between the supply and the motor to provide speed control is that any control action which varies the speed of the car, also varies the current available to the motor and consequently the torque or pulling power. The speed controller shown in Fig. 1 uses pulse width modulation techniques which not only overcome these problems, but also provide reduced current consumption from the supply of nickel cadmium batteries used in the car.

Since the racing car is to be driven in one direction, i.e. for forward control, only one half of the servo amplifier circuit is required for use. This is shown for convenience in Fig. 1 and comprises transistors TR1, TR2 and TR3. A 1kΩ resistor acts as a dummy load in place of the servo motor. The servo feedback potentiometer on the servo drive board is replaced by a trimming potentiometer of the same value in order to trim the completed system with respect to the transmitter.

A variable d.c. output of 0 to 4V is available between points C and 0V rail when the corresponding joystick movement in the transmitter is 0 to 5kΩ. This available voltage is used to switch transistors TR4 and TR5 to provide a maximum d.c. output of 8V which is necessary to provide the variable speed control of the car as follows:

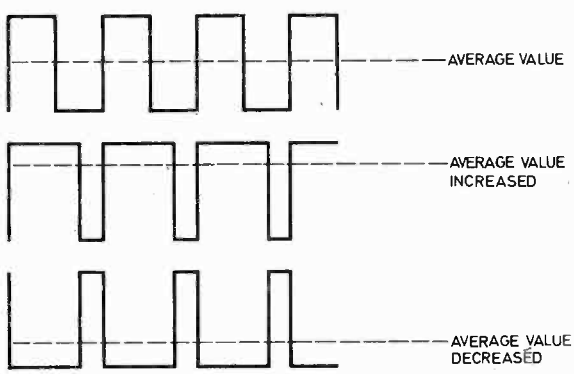


Fig. 2

TR6 and TR7 form a Schmitt trigger and TR8 provides the phase inversion for oscillations to occur. The output at TR8C is a square wave whose mark/space ratio depends on the d.c. voltage present at point C. When mark/space ratio is 50 per cent, the time that the voltage is on is the same as the time that the voltage is off, giving an average value of the voltage as shown in Fig. 2. If the mark/space ratio is altered so that the on time is increased the average value of the voltage will rise and hence the car will speed up. Consequently when the mark/space ratio is decreased the car will slow down.

The output of the Schmitt circuit feeds a Darlington connected driver and output stage TR9 and TR10 that drives the motor. The motor used in the car is the popular "Bullett" motor supplied by most radio control shops. This motor was found to have a "start" current of 10A at 18V and a "run" current of approximately 6A which varies at different motor speeds. Diode D1 suppresses inductive kick-back of the motor while D2 protects TR10 from voltage transients of the motor.

Transistor TR11 serves as a current sense amplifier in order to compensate via the feedback resistor Rx for variations in the frequency of the Schmitt trigger output.

A stack of 2 ampere-hour nickel cadmium batteries have been used to provide the 18V supply. The circuit can also be used with a 12V supply by decreasing R11 to approximately 100Ω.

Transistors TR9 and TR10 must be mounted on a heatsink.

L. Sadarangani,
W. Ealing.

WAVEFORM GENERATOR

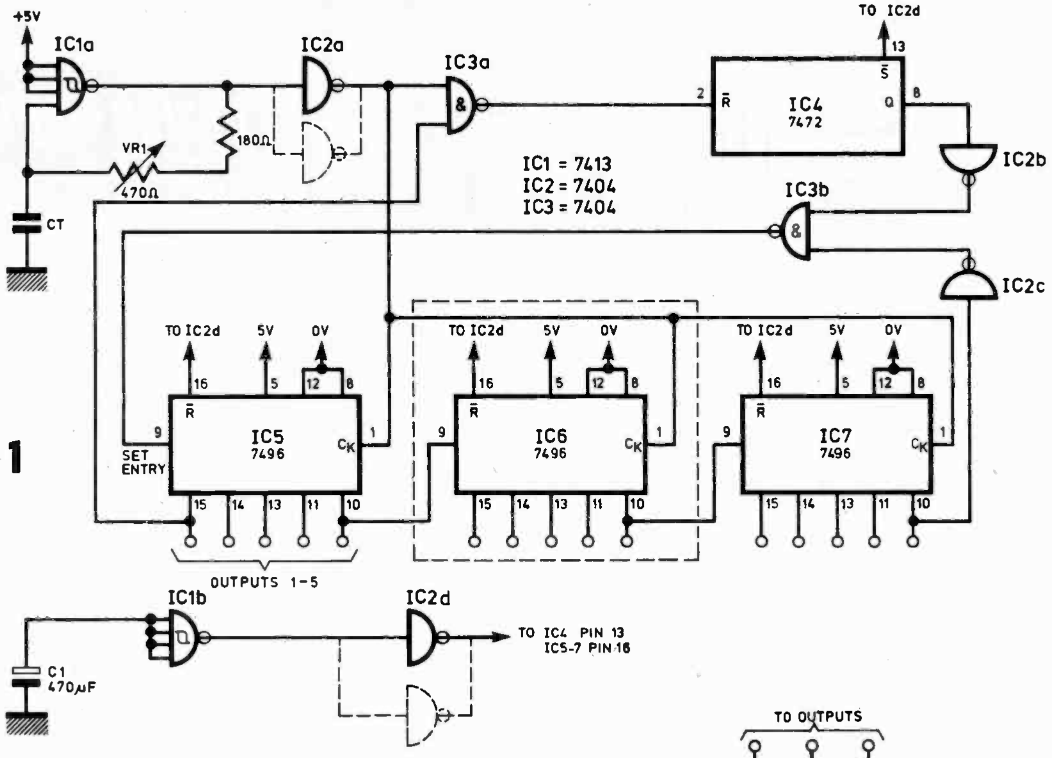


Fig. 1

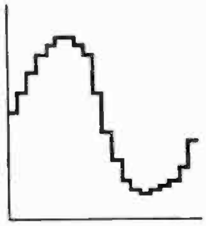


Fig. 2

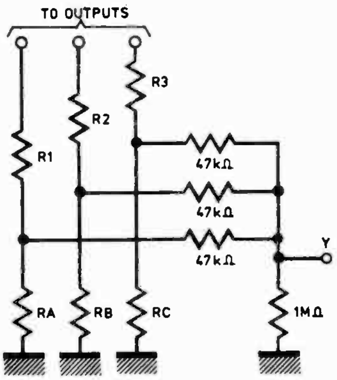


Fig. 3

WHEN the circuit shown in Fig. 1 is switched on, the input of IClb is held "low" by C1, setting all the outputs of the 7496 shift registers to the "low" state, and setting the Q output of flip-flop IC4 "high". The "Set Entry" of IC5 (pin 9) is, therefore, also "high". When C1 charges to the threshold value, IClb changes state, thus removing the reset instruction to the shift registers.

ICla forms a clock whose frequency is determined by CT its output passes via IC2a to the C_K input of the registers and to IC3a. On the first negative going clock pulse, the "high" on pin 9 of IC5 is transferred to output number 1 (pin 15). This "high" is fed to IC3a, and when the clock output next goes "high" the output of IC3a goes "low" resetting IC4 and presenting a "low" to the set entry of IC5. On subsequent clock pulses the "high" on output 1 is shifted through the registers (ICs 5–7), each of the outputs switching "high" in turn.

When pin 10 of IC7 switches "high", IC2c and IC3b apply a "high" to the SET ENTRY of IC5, thus starting the sequence once more.

IC6 may be duplicated to provide more outputs (circuitry within dotted lines). If this is required, IC2a and IC2d should have one or more inverters connected in parallel with them to facilitate the extra load.

A waveform may be divided into X portions, each portion having a specific amplitude (Fig. 2). By connecting each output of Fig. 1 to a potential divider (Fig. 3), the amplitude of each output pulse may be pre-set, thus enabling the desired waveform to be taken off at point Y. The more outputs used, the more accurate will be the resulting waveform.

R1, R2, R3 . . . can be around 2·2kΩ and RA, RB, RC . . . may be varied to provide the required amplitude.

A unit was built in which the variable resistors were built onto a piece of Veroboard which plugged into an edge connector mounted on the case. Each waveform needed could then have its own program card.

The circuit of Fig. 1 could also be used to "scan" a solid state display etc.

A. Damper,
Carshalton,
Surrey.

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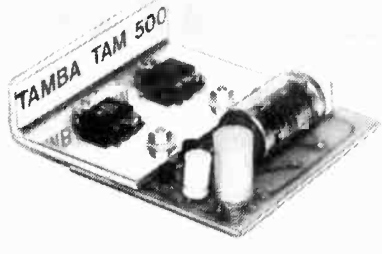

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7403	0.12	7495	0.54	74185A	1.20	74LS83	0.78	74LS353	1.05	4055	1.00
7404	0.13	7496	0.60	74186	7.20	74LS85	0.90	74LS365	0.50	4060	0.98
7405	0.13	7497	2.38	74188	2.70	74LS86	0.35	74LS366	0.50	4066	0.48
7406	0.28	74100	0.94	74190	1.05	74LS93	0.95	74LS367	0.50	4067	3.50
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7408	0.14	74105	0.40	74192	0.99	74LS107	0.36	74LS386	0.37	4069	0.17
7409	0.14	74107	0.28	74193	1.05	74LS109	0.36	74LS670	2.00	4070	0.17
7410	0.13	74109	0.45	74194	0.90	74LS112	0.38			4071	0.17
7411	0.18	74110	0.46	74195	0.84	74LS113	0.36			4072	0.17
7412	0.21	74111	0.70	74196	0.90	74LS114	0.36	4000	0.14	4073	0.17
7413	0.25	74116	1.60	74197	0.90	74LS123	0.82	4001	0.15	4075	0.17
7414	0.54	74118	0.82	74198	1.48	74LS124	2.45	4002	0.16	4076	1.05
7416	0.27	74119	1.30	74199	1.48	74LS125	0.44	4006	0.92	4077	0.46
7417	0.27	74120	0.82	74221	1.50	74LS126	0.44	4007	0.16	4078	0.22
7420	0.13	74121	0.25	74273	2.15	74LS132	0.69	4008	0.92	4081	0.17
7421	0.28	74122	0.40	74279	1.25	74LS136	0.40	4009	0.45	4082	0.20
7422	0.17	74123	0.53	74283	1.70	74LS138	0.53	4010	0.48	4085	0.72
7423	0.25	74125	0.44	74284	6.85	74LS139	0.53	4011	0.15	4086	0.76
7425	0.20	74126	0.45	74293	1.35	74LS151	1.05	4012	0.16	4089	1.55
7426	0.25	74128	0.62	74298	1.92	74LS153	0.50	4013	0.42	4093	0.65
7427	0.25	74132	0.68	74390	1.92	74LS154	1.20	4014	0.80	4094	1.80
7428	0.34	74135	0.68	74393	2.12	74LS155	0.86	4015	0.77	4095	1.10
7430	0.13	74136	0.75			74LS156	0.86	4016	0.42	4096	1.10
7432	0.24	74137	0.94			74LS157	0.47	4017	0.77	4097	3.50
7433	0.32	74141	0.58	74LS00	0.19	74LS158	0.53	4018	0.87	4098	1.12
7437	0.24	74142	2.00	74LS01	0.19	74LS160	1.22	4019	0.42	4099	1.90
7438	0.24	74143	2.00	74LS02	0.19	74LS161	0.69	4020	0.92	4404	1.00
7440	0.13	74144	2.00	74LS03	0.19	74LS162	1.22	4021	0.82	4412	0.30
7441	0.52	74145	0.64	74LS04	0.20	74LS163	0.69	4022	0.82	4428	0.80
7442	0.55	74147	1.30	74LS05	0.20	74LS164	1.20	4023	0.15	4445	1.50
7443	0.90	74148	1.18	74LS08	0.19	74LS168	2.00	4024	0.66	4449	0.30
7444	0.90	74150	0.99	74LS09	0.19	74LS169	2.00	4025	0.15	4501	0.17
7445	0.70	74151	0.60	74LS10	0.19	74LS170	1.76	4026	1.28	4502	0.88
7446	0.70	74153	0.60	74LS11	0.19	74LS173	1.05	4027	0.50	4507	0.50
7447A	0.64	74154	1.05	74LS12	0.19	74LS174	1.12	4028	0.67	4508	2.25
7448	0.60	74155	0.63	74LS13	0.46	74LS175	1.05	4029	0.86	4510	1.05
7450	0.13	74156	0.63	74LS14	1.10	74LS189	2.85	4030	0.48	4511	0.98
7451	0.13	74157	0.63	74LS15	0.19	74LS190	0.81	4031	2.34	4512	0.92
7453	0.13	74159	1.70	74LS20	0.19	74LS191	0.81	4033	1.25	4514	2.85
7454	0.13	74160	0.80	74LS21	0.19	74LS192	1.80	4034	2.00	4515	2.80
7460	0.13	74161	0.80	74LS22	0.19	74LS193	1.80	4035	1.00	4516	1.02
7470	0.28	74162	0.80	74LS26	0.24	74LS195	1.12	4036	2.40	4518	0.99
7472	0.22	74163	0.80	74LS27	0.40	74LS196	1.20	4037	0.99	4519	0.50
7473	0.26	74164	0.89	74LS30	0.19	74LS197	1.20	4038	1.00	4520	1.05
7474	0.26	74165	0.89	74LS32	0.25	74LS221	1.12	4039	2.80	4521	2.00
7475	0.30	75166	0.99	74LS37	0.27	74LS247	0.97	4040	0.88	4522	1.35
7476	0.26	74167	2.70	74LS38	0.27	74LS248	0.97	4041	0.77	4527	1.60
7480	0.45	74170	1.68	74LS40	0.19	74LS249	0.97	4042	0.72	4528	0.92
7481	0.90	74172	4.00	74LS42	0.53	74LS251	1.00	4043	0.82	4529	1.10
7482	0.80	74173	1.18	74LS47	0.97	74LS253	1.05	4044	0.82	4536	3.56
7483	0.72	74174	0.89	74LS48	0.97	74LS257	1.05	4045	1.40	4553	4.20
7484	0.90	74175	0.68	74LS49	0.97	74LS258	1.05	4046	1.32	4555	0.85
7485	0.88	74176	0.88	74LS51	0.19	74LS266	0.39	4047	0.96	4556	0.85
7486	0.26	74177	0.88	74LS54	0.19	74LS273	2.50	4048	0.60	4558	1.25
7489	2.00	74178	1.20	74LS55	0.20	74LS279	0.50	4049	0.42	4566	1.40
7490	0.35	74179	1.10	74LS73	0.30	74LS283	1.00	4050	0.42	4583	0.75
7491	0.65	74180	0.90	74LS74	0.34	74LS289	2.85	4051	0.84	4585	1.03

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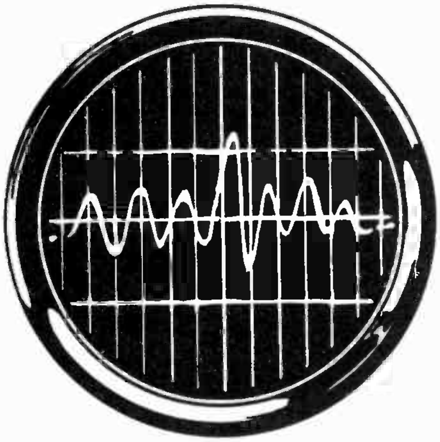

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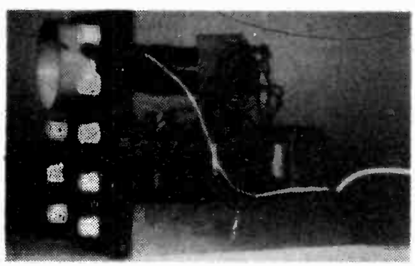

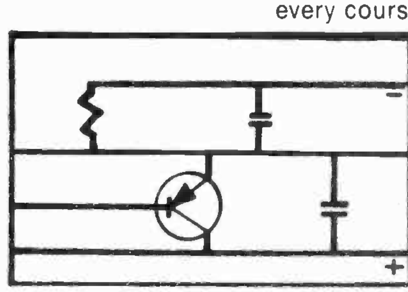

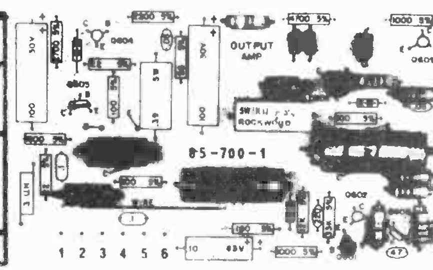

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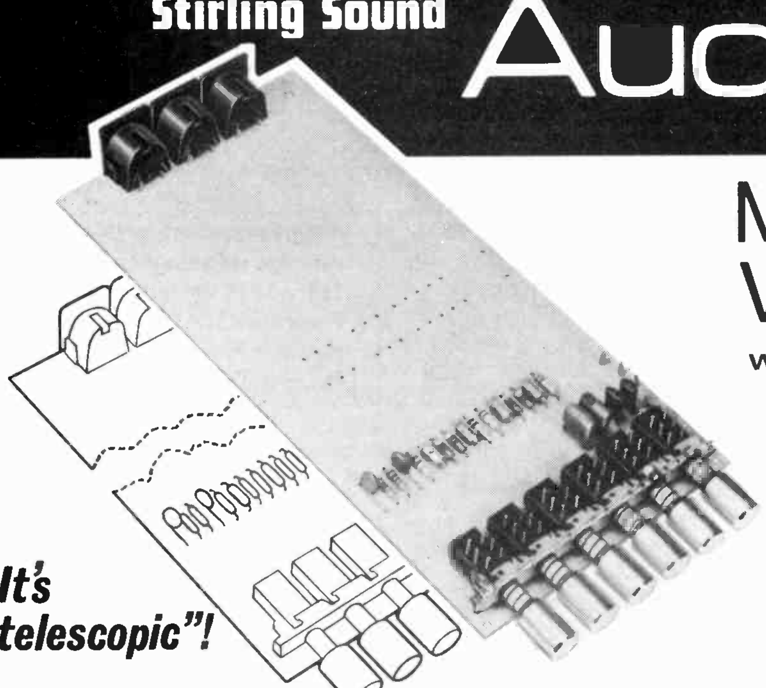
Stirling Sound Audio Plan®



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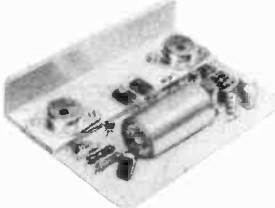
It's "telescopic"!

Audio Plan Unit Three stereo six push-button selector/filter unit with front panel fascia Size 240 × 105mm

£6.75 POST FREE & INC. VAT.



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Outputs quoted in watts R.M.S. into 4 ohms ± 1 dB. Figures in brackets indicate the appropriate Stirling Sound power supply. For full range, see our new catalogue.

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Power Units have low volt D.C. take off point

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Assembly	Power Amps.	Control	Selector	Power Supply	Price Post Free & Inc. VAT
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Sawicki Mk.2-5 Channel Microphone Mixer

Easy to construct D.I.Y. kit includes:-
All Metalwork screened and plated. All specially selected components, including IC sockets. Ready drilled and legended PCBs. Teak finished end pieces. Simple assembly instructions with all diagrams and colour codings. Can be built in a couple of evenings; no previous experience necessary. Fully guaranteed against defective materials and components.

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Accurate VU Meter (–20:0:+3) VU
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THD – Better than 0.1%
S/N ratio Better than 65dB
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Lo Frequency EQ better than 35dB swing @ 20Hz
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Foldback – 100mV @ 1.0KHz available
I/P Clipping level – 600mV @ 1.0 KHz
VU Meter calibration – OVu = 4dBM (1.228VRMS)
Power requirements – less than 3VA. Ref. 220–240v AC

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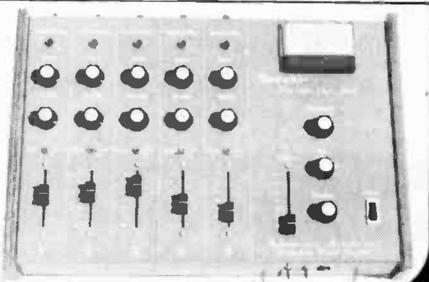
Front View


Rear Panel View



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TRANSISTORS

2N696	0.39	2N2219	0.38	2N3397	0.19	2N4062	0.20	2N5247	0.44	40410	0.82
2N697	0.31	2N2219A	0.39	2N3438	0.85	2N4064	1.35	2N5248	0.44	40411	3.10
2N698	0.49	2N2220	0.39	2N3440	0.75	2N4074	2.65	2N5294	0.44	40594	0.87
2N699	0.58	2N2221	0.25	2N3441	0.92	2N4121	0.27	2N5295	0.44	40595	0.98
2N706	0.30	2N2221A	0.25	2N3442	1.45	2N4122	0.27	2N5296	0.44	40673	0.80
2N706A	0.30	2N2222	0.25	2N3638	0.17	2N4123	0.19	2N5298	0.44	40669	1.30
2N708	0.30	2N2222A	0.25	2N3638A	0.17	2N4124	0.19	2N5447	0.16	AC126	0.48
2N718	0.30	2N2369	0.27	2N3702	0.14	2N4125	0.19	2N5448	0.16	AC127	0.48
2N718A	0.54	2N2369A	0.27	2N3703	0.14	2N4126	0.19	2N5449	0.20	AC128	0.48
2N720A	0.85	2N2646	0.80	2N3704	0.14	2N4284	0.38	2N5457	0.38	AC151	0.43
2N722	0.45	2N2647	1.55	2N3705	0.14	2N4286	0.22	2N5458	0.35	AC152	0.54
2N727	0.50	2N2903	1.60	2N3706	0.14	2N4287	0.22	2N5459	0.32	AC153	0.59
2N914	0.38	2N2904	0.31	2N3707	0.14	2N4288	0.22	2N5460	0.65	AC153K	0.59
2N916	0.33	2N2904A	0.31	2N3708	0.12	2N4289	0.22	2N5484	0.37	AC176K	0.70
2N917	0.38	2N2905	0.31	2N3709	0.12	2N4347	2.20	2N5485	0.40	AC176	0.54
2N918	0.45	2N2905A	0.31	2N3771	2.16	2N4348	2.65	2N5486	0.40	AC187	0.59
2N929	0.37	2N2906	0.25	2N3772	2.20	2N4918	0.65	2N5490	0.64	AC187K	0.65
2N929A	0.37	2N2906A	0.25	2N3773	3.15	2N4919	0.70	2N5492	0.64	AC188	0.54
2N930	0.37	2N2907	0.25	2N3819	0.36	2N4920	0.83	2N5494	0.65	AC188K	0.65
2N930A	0.85	2N2907A	0.25	2N3820	0.39	2N4921	0.54	2N5496	0.67	AD161	1.00
2N1711	0.30	2N2923	0.17	2N3821	0.96	2N4922	0.60	2N6027	0.64	AD162	1.00
2N1889	0.30	2N2924	0.17	2N3900	0.28	2N4923	0.75	2N6107	0.45	AF106	0.60
2N1890	0.30	2N2925	0.19	2N3901	0.30	2N4924	1.15	2N6108	0.55	AF109	0.52
2N1893	0.30	2N2926	0.17	2N3903	0.20	2N5086	0.30	2N6109	0.55	BC107	0.16
2N2102	0.50	2N3053	0.25	2N3904	0.18	2N5087	0.30	2N6111	0.49	BC107A	0.16
2N2192	0.58	2N3054	0.72	2N3905	0.18	2N5088	0.30	2N6121	0.41	BC107B	0.16
2N2193	0.50	2N3055	0.75	2N3906	0.18	2N5089	0.30	2N6122	0.44	BC108	0.16
2N2193A	0.52	2N3390	0.50	2N4031	0.55	2N5190	0.65	2N6123	0.48	BC108A	0.16
2N2194	0.42	2N3391	0.40	2N4032	0.65	2N5191	0.75	2N6124	0.45	BC108B	0.16
2N2194A	0.45	2N3391A	0.45	2N4036	0.72	2N5192	0.80	2N6125	0.47	BC108C	0.17
2N2195	0.40	2N3392	0.17	2N4037	0.60	2N5193	0.75	40361	0.55	BC109	0.16
2N2195A	0.40	2N3393	0.17	2N4058	0.22	2N5194	0.80	40362	0.55	BC109B	0.17
2N2217	0.55	2N3394	0.17	2N4059	0.17	2N5195	0.97	40363	1.45	BC109C	0.18
2N2218	0.35	2N3395	0.19	2N4060	0.22	2N5245	0.37	40408	0.82	BC140	0.30
2N2218A	0.38	2N3396	0.19	2N4061	0.19	2N5246	0.38	40409	0.82	BC141	0.32

				BC214B	0.17	BC549B	0.14	BD244A	0.70	BF182	0.37	BFX89	1.37	MJE520	0.50
				BC214C	0.17	BC549C	0.15	BD244C	0.87	BF183	0.44	BFY50	0.27	MJE521	0.70
BC147	0.13	BC182B	0.13	BC214L	0.18	BC557	0.14	BD245A	0.69	BF184	0.41	BFY51	0.27	MJE2955	1.65
BC147B	0.13	BC182L	0.15	BC214LB	0.18	BC558	0.13	BD245C	0.72	BF185	0.37	BFY52	0.27	MPF3055	1.05
BC148	0.13	BC182LA	0.15	BC214LC	0.18	BC559	0.15	BD246A	0.72	BF194	0.16	BFY90	1.35	MPF102	0.33
BC148B	0.13	BC182LB	0.15	BC237B	0.13	BCY70	0.21	BD246C	0.93	BF195	0.16	BR101	0.55	MPF103	0.44
BC148C	0.13	BC183	0.12	BC238A	0.13	BCY71	0.26	BD433	0.44	BF196	0.16	BRY39	0.55	MPF104	0.44
BC149	0.15	BC183A	0.12	BC238B	0.13	BCY72	0.18	BD434	0.46	BF197	0.18	BSX19	0.35	MPS105	0.44
BC149C	0.15	BC183B	0.13	BC238C	0.13	BD115	0.88	BD435	0.46	BF198	0.19	BSX20	0.35	MPSA05	0.27
BC157A	0.15	BC183C	0.13	BC239B	0.16	BD131	0.55	BD436	0.46	BF199	0.19	BSX21	0.35	MPSA06	0.27
BC158A	0.15	BC183L	0.15	BC239C	0.17	BD132	0.75	BD437	0.55	BF224J	0.22	BU104	1.80	MPSA12	0.44
BC158B	0.15	BC183LA	0.15	BC257A	0.18	BD135	0.40	BD438	0.55	BF225J	0.27	BU105	1.55	MPSA14	0.33
BC159A	0.17	BC183LB	0.15	BC258B	0.19	BD136	0.40	BD529	0.49	BF244A	0.38	BU126	1.08	MPSA55	0.27
BC159B	0.17	BC183LC	0.15	BC259B	0.19	BD137	0.41	BD530	0.55	BF244B	0.33	BU204	2.20	MPSA56	0.27
BC160	0.38	BC184	0.12	BC300	0.43	BD138	0.41	BD535	0.70	BF245A	0.44	BU205	2.40	R2008B	2.45
BC161	0.38	BC184B	0.13	BC301	0.43	BD139	0.43	BD536	0.70	BF245B	0.44	BU206	2.70	R2010B	2.15
BC167	0.13	BC184C	0.13	BC302	0.37	BD140	0.43	BD537	0.74	BF257	0.35	BU208	2.70	TIP29A	0.49
BC167B	0.13	BC184L	0.13	BC303	0.54	BD181	1.90	BD538	0.77	BF258	0.35	ME0401	0.22	TIP29C	0.65
BC168A	0.13	BC184LB	0.15	BC307	0.16	BD182	2.20	BD539	0.60	BF259	0.35	ME0402	0.22	TIP30A	0.54
BC168B	0.13	BC184LC	0.15	BC307A	0.16	BD183	2.35	BD540	0.60	BF336	0.42	ME0404	0.17	TIP30C	0.70
BC168C	0.13	BC212	0.15	BC307B	0.16	BD187	0.95	BDX14	1.32	BF337	0.49	ME0412	0.22	TIP31A	0.54
BC169B	0.13	BC212A	0.15	BC308	0.16	BD235	0.46	BDX18	1.90	BF338	0.52	ME0414	0.22	TIP31C	0.72
BC169C	0.13	BC212B	0.15	BC308B	0.16	BD236	0.44	BDY20	1.90	BFR39	0.30	ME4001	0.16	TIP32A	0.59
BC177	0.22	BC212L	0.18	BC309A	0.16	BD237	0.44	BDY55	1.90	BFR40	0.29	ME4002	0.16	TIP32C	0.82
BC177A	0.22	BC212LA	0.18	BC309B	0.16	BD238	0.44	BDY56	2.10	BFR41	0.30	ME4003	0.16	TIP41A	0.76
BC177B	0.25	BC212LB	0.18	BC309C	0.16	BD239A	0.44	BF115	0.39	BFR79	0.30	ME4101	0.11	TIP41C	0.97
BC178	0.22	BC213	0.15	BC327	0.22	BD239C	0.59	BF160	0.33	BFR80	0.30	ME4102	0.11	TIP42A	0.86
BC178A	0.25	BC213A	0.15	BC328	0.20	BD240A	0.49	BF161	0.65	BFR81	0.30	ME4103	0.11	TIP42C	1.08
BC178B	0.35	BC213B	0.15	BC337	0.20	BD240C	0.59	BF167	0.37	BFX29	0.34	ME4104	0.11	TIP2955	0.70
BC179	0.25	BC213C	0.15	BC338	0.23	BD241A	0.49	BF173	0.37	BFX30	0.34	ME6101	0.22	TIP3055	0.59
BC179A	0.25	BC213L	0.17	BC547	0.13	BD241C	0.65	BF177	0.27	BFX84	0.30	ME6102	0.22	TIS34	1.05
BC179B	0.25	BC213LA	0.17	BC547A	0.13	BD242A	0.55	BF178	0.27	BFX85	0.38	MJ2955	1.35	TIS42	0.50
BC179C	0.26	BC213LB	0.17	BC547B	0.13	BD242C	0.62	BF179	0.33	BFX86	0.30	MJE340	0.62	TIS43	0.47
BC182	0.12	BC213LC	0.17	BC548	0.13	BD243A	0.65	BF180	0.37	BFX87	0.35	MJE370	0.62	TIS90	0.22
BC182A	0.12	BC214	0.17	BC549	0.14	BD243C	0.87	BF181	0.37	BFX88	0.30	MJE371	0.86	TIS91	0.27

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CA3018	0.75	LM379S	4.25	LM324	0.75	TAA930B	1.45
CA3018A	1.10	LM380N8	0.96	LM7815K	1.75	TAD100	2.00
CA3020	2.20	LM380N14		LM7824K	1.75	TBA120	0.80
CA3020A	2.50		1.08	LM78L05CZ		TBA500	2.24
CA3028A	0.90	LM381AN	2.70		0.30	TBA5000	2.34
CA3028B	1.25	LM381N	1.69	LM78L12CZ		TBA510	2.35
CA3030	1.50	LM382N	1.32		0.30	TBA5100	2.48
CA3030A	2.20	LM384N	1.55	LM78L15CZ		TBA520	2.60
CA3038	2.90	LM386N	0.88		0.30	TBA5200	2.70
CA3038A	4.10	LM387N	1.10	MM5314	4.60	TBA530	2.35
CA3045	1.55	LM388N	1.00	MM5316	4.60	TBA5300	2.45
CA3046	0.77	LM389N	1.00	NE555	0.33	TBA540	2.60
CA3048	2.45	LM702C	0.81	NE556	0.85	TBA5400	2.70
CA3052	1.78	LM709	0.70	NE558N	1.98	TBA550	3.60
CA3080	0.85	LM7098	0.50	NE560	4.50	TBA5500	3.80
CA3080A	2.10	LM70914	0.49	NE561	4.50	TBA56000	3.00
CA3086	0.50	LM710	0.67	NE562	4.50	TBA570	2.10
CA3088B	1.87	LM71014	0.64	NE565	1.39	TBA5700	2.20
CA3089B	2.90	LM711CN	0.72	NE566	1.75	TBA7000	2.20
CA30900	4.40	LM723C	0.75	NE567	1.90	TBA720A0	2.06
CA3130	1.06	LM723C14	0.45	NE571N	4.95	TBA750	2.36
CA3140	1.04	LM726	5.80	SAS560	2.70	TBA7500	2.45
LM301	0.30	LM741C	0.70	SAS570	2.70	TBA800	1.30
LM307N	0.50	LM741C8	0.30	SAJ11D	2.10	TBA810S	1.30
LM308N	0.95	LM741C14	0.30	S041P	1.35	TBA820	0.80
LM309KC	1.95	LM747CN	0.99	S042P	1.35	TBA920	2.99
LM317K	3.35	LM7488	0.50	SN76001N		TCA160C	2.36
LM318N	2.45	LM74814	0.90		1.30	TCA1608	2.55
LM320TS	2.15	LM1303N	1.15	SN76003N		TCA270	2.99
LM320T12	2.15	LM1304N	1.52		2.38	TCA730	4.50
LM320T15	2.15	LM1305N	1.52	SN76013N		TCA740	4.50
LM320T24	2.15	LM1307N	1.22		1.50	TCA750	3.00
LM320P5	1.15	LM1310N	2.10	SN76023N		TCA760	2.00
LM320P12	1.15	LM1351N	1.30		1.50	TCA105	1.49
LM320P15	1.15	LM1458N	0.45	SN76033N		TCA440	1.65
LM320P24	1.15	LM1496N	0.97		2.35	TDA1022	7.50
LM323K	6.95	LM1808N	2.10	TAA263	1.35	TDA1024	1.24
LM339N	0.60	LM1812N	6.20	TAA300	3.70	TDA1034	4.75
LM340T5	0.88	LM1820N	1.16	TAA320A	1.15	TDA2020AD	
LM340T15	0.88	LM1828N	1.90	TAA350A	3.00		4.50
LM340T24	0.88	LM1830N	1.90	TAA521	1.10	UAA170	2.15
LM341P5	0.80	LM1841N	1.90	TAA522	2.10	UAA180	2.15
LM341P12	0.80	LM1845N	1.50	TAA550	0.48	TL080CP	1.25
LM341P15	0.80	LM1848N	1.98	TAA560	2.10	TL081CP	0.90
LM341P24	0.80	LM1850N	1.90	TAA570	2.20	TL082CP	1.10
LM348N	0.95	LM1889N	4.90	TAA370A	5.45	TL083CN	1.40
LM358N	0.60	LM3301N	0.60	TAA630	2.40	TL084CN	1.45
LM360N	3.00	LM3302N	0.55	TAA960	3.90	LF355N	0.80
LM370N	3.30	LM3401N	0.55	TAA970	4.20	LF356N	0.80
LM371H	2.35	LM3900N	0.68	TAA611B	2.50	LF357N	0.80
LM350K	6.45	LM3905N	1.15	TAA621	2.50	LF13201N	3.00
LM373N	3.35	LM3909N	0.78	TAA661A	1.65	LF13331N	3.00
LM374N	3.36	LM3911N	1.10	TAA661B	1.45	LF13741H	0.80
LM377N	1.80	LM7805K	1.75	TAA700	4.50	LF13741N	0.55
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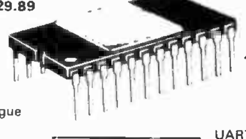

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74LS02N	0.26	74LS156N	1.20	74C175N	0.90	7489N	2.45
74LS03N	0.26	74LS157N	0.60	74C192N	1.11	7490AN	0.45
74LS04N	0.29	74LS158N	0.85	74C193N	1.11	7491AN	0.85
74LS08N	0.26	74LS160N	1.43	74C195N	1.04	7492N	0.45
74LS10N	0.26	74LS161N	0.85	7400N	0.17	7493N	0.45
74LS12N	0.26	74LS162N	1.43	7401N	0.17	7494N	0.90
74LS13N	0.58	74LS163N	0.85	7402N	0.17	7495N	0.76
74LS14N	1.43	74LS164N	1.43	7403N	0.17	7496N	0.70
74LS20N	0.26	74LS168N	2.43	7404N	0.17	7497N	1.95
74LS26N	0.39	74LS169N	2.43	7405N	0.22	74100N	1.40
74LS27N	0.50	74LS174N	1.33	7406N	0.56	74107N	0.35
74LS28N	0.42	74LS175N	1.26	7407N	0.55	74118N	0.95
74LS30N	0.26	74LS181N	3.95	7408N	0.22	74119N	1.40
74LS32N	0.27	74LS189N	3.74	7409N	0.22	74121N	0.28
74LS37N	0.32	74LS190N	1.00	7410N	0.20	74122N	0.55
74LS38N	0.32	74LS191N	1.00	7411N	0.26	74123N	0.55
74LS40N	0.29	74LS192N	1.98	7412N	0.20	74125N	0.45
74LS42N	1.07	74LS193N	1.98	7413N	0.36	74141N	0.86
74LS47N	1.09	74LS196N	1.28	7414N	0.80	74148N	1.35
74LS48N	1.09	74C00N	0.24	7416N	0.36	74145N	0.86
74LS49N	1.09	74C02N	0.24	7417N	0.36	74150N	1.20
74LS51N	0.26	74C04N	0.24	7420N	0.22	74151N	0.76
74LS54N	0.26	74C08N	0.24	7423N	0.32	74153N	0.76
74LS73N	0.42	74C10N	0.24	7425N	0.32	74154N	1.20
74LS74N	0.42	74C14N	1.41	7427N	0.32	74155N	0.70
74LS75N	0.58	74C20N	0.24	7430N	0.22	74157N	0.78
74LS76N	0.42	74C30N	0.24	7432N	0.30	74160AN	1.10
74LS78N	0.42	74C32N	0.24	7437N	0.35	74161AN	1.10
74LS83AN	1.20	74C42N	0.92	7438N	0.32	74162AN	1.10
74LS85N	1.10	74C48N	1.38	7440N	0.20	74163AN	1.10
74LS86N	0.44	74C73N	0.54	7441AN	0.84	74164N	1.36
74LS90N	1.10	74C74N	0.56	7442N	0.76	74165N	1.36
74LS91N	1.20	74C76N	0.54	7445N	1.40	74167N	2.50
74LS92N	0.86	74C83N	1.30	7446AN	0.90	74174N	1.60
74LS93N	1.10	74C85N	1.30	7447AN	0.80	74175N	1.00
74LS95AN	1.10	74C86N	0.64	7448N	0.80	74176N	0.90
74LS96N	1.35	74C89N	4.39	7450N	0.22	74177N	0.90
74LS107N	0.42	74C90N	0.85	7451N	0.22	74180N	1.00
74LS109N	0.42	74C93N	0.85	7453N	0.22	74181N	2.00
74LS122N	0.80	74C95N	1.04	7454N	0.22	74182N	0.80
74LS123N	0.83	74C107N	1.22	7460N	0.22	74184N	1.50
74LS124N	2.70	74C150N	4.14	7470N	0.46	74185AN	1.50
74LS125N	0.50	74C151N	2.47	7472N	0.30	74188AN	3.25
74LS126N	0.50	74C154N	3.68	7473N	0.44	74189N	2.60
74LS132N	0.85	74C157N	2.21	7474N	0.32	74190N	1.40
74LS136N	0.44	74C160N	1.11	7475N	0.80	74191N	1.20
74LS138N	0.65	74C161N	1.11	7476N	0.45	74192N	1.20
74LS139N	0.65	74C162N	1.11	7480N	0.60	74193N	1.20
74LS145N	1.30	74C163N	1.11	7481N	1.00	74196N	1.20
74LS151N	1.07	74C164N	1.04	7482N	0.90	74197N	1.00
74LS153N	0.58	74C165N	1.04	7483N	1.05	74198N	2.00
				7484N	1.20	74199N	2.00

CMOS

4000	0.22	4016	0.52					4068	0.27	4086	0.89
4001B	0.22	4017B	1.05	4030	0.84	4050B	0.85	4069B	0.24	4089B	2.10
4002	0.22	4018B	1.05	4031B	2.25	4051B	0.85	4070B	0.85	4093B	1.00
4006	1.25	4019B	0.52	4035B	1.30	4052B	0.86	4071B	0.24	4094	2.30
4007	0.22	4020B	1.15	4037	1.20	4053B	0.98	4072	0.27	4095	1.30
4008B	0.99	4021	1.05	4041B	0.85	4054	1.48	4073B	0.24	4096	1.30
4009	0.58	4022B	1.00	4042B	0.86	4055	1.65	4075B	0.24	4097	4.65
4010	0.58	4023B	0.22	4043	1.05	4056	1.65	4076B	0.99	4098	1.00
4011B	0.22	4024B	0.76	4044	1.00	4059	6.00	4077	0.70	4510B	1.20
4012	0.22	4025B	0.22	4045	1.76	4060B	1.15	4078	0.27	4511	1.75
4013B	0.52	4027B	0.55	4046B	1.50	4063	1.35	4081B	0.24	4516	2.10
4014	1.00	4028B	0.92	4047B	0.96	4066B	0.75	4082	0.27	4518B	1.20
4015	1.05	4029B	1.10	4049	0.96	4067	4.85	4085	0.89		

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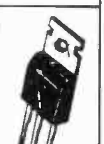

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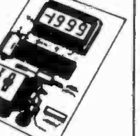

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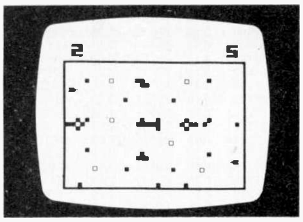

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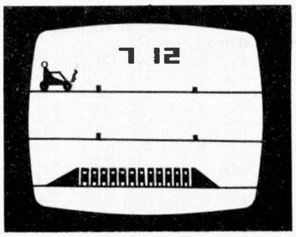

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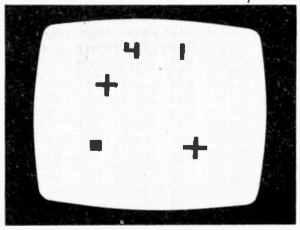

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AD161	40p	BD132	40p	TIS43	35p
AD162	40p	BD133	48p	2N2646	60p
AF279	75p	BD137	40p	2N2905	21p
BC107	12p	BD138	40p	2N2926	12p
BC108	10p	BD139	42p	2N3053	28p
BC108C	12p	BD140	44p	2N3054	52p
BC109	12p	BF173	20p	2N3055	50p
BC109C	15p	BF181	30p	2N3442	130p
BC147	10p	BF194	10p	2N3702	10p
BC148	10p	BF195	10p	2N3703	10p
BC149	10p	BF196	10p	2N3704	10p
BC157	10p	BF197	12p	2N3705	10p
BC158	10p	BF200	28p	2N3706	10p
BC159	10p	BFR39	24p	2N3708	10p
BC182	12p	BFR79	26p	2N3710	10p
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BC184	12p	BFX48	32p	2N3904	15p
BC212	14p	BFX84	22p	2N3906	15p
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7410	14p	7473	29p	74151	79p
7413	28p	7474	29p	74154	144p
7414	62p	7475	51p	74155	73p
7420	14p	7476	29p	74157	66p
7427	36p	7483	91p	74159	200p
7430	14p	7485	132p	74164	126p
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7437	36p	7490	46p	74179	120p
7438	36p	7491	75p	74180	120p
7440	15p	7492	52p	74190	188p
7442	65p	7493	52p	74191	158p
7445	88p	7495	73p	74192	120p
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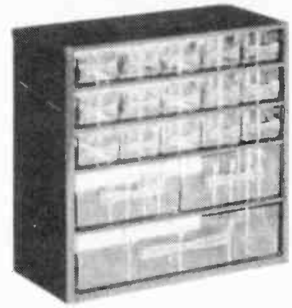

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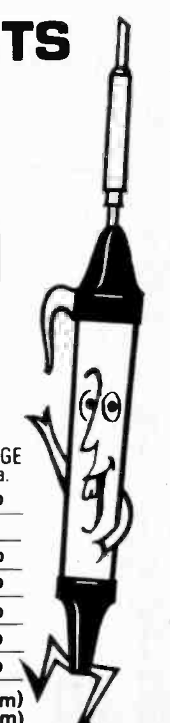

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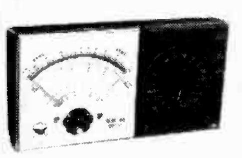

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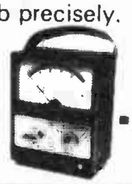

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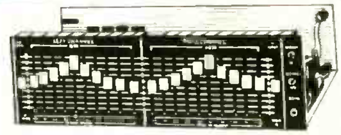

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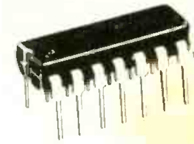

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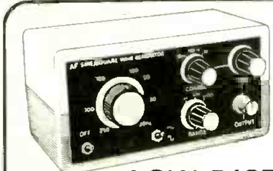

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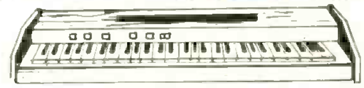

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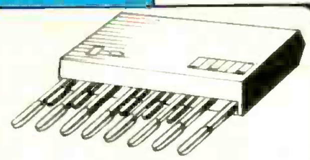

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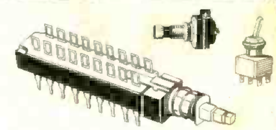

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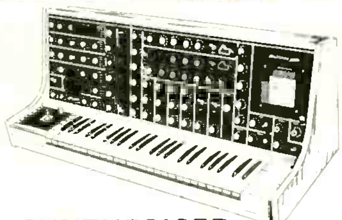

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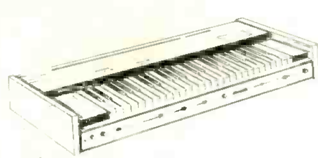

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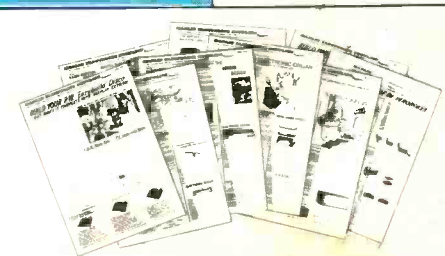

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