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Technical Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. We regret that queries cannot be answered over the telephone, they must be submitted in writing and accompanied by a stamped addressed envelope for reply.

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THE JUNE ISSUE WILL BE PUBLISHED ON 4th MAY

BUILD A PROJECT ON CSC

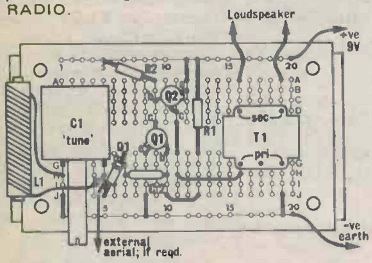
FREE

FILL IN COUPON & RECEIVE FREE COPY OF

ELECTRONICS BY NUMBERS PROJECT No 1 'TWO TRANSISTOR RADIO'

ELECTRONICS BY NUMBERS. TWO-TRANSISTOR RADIO.

Now using Experimentor Breadboards and following the instructions in "Electronics by Numbers" ANYBODY can build electronic projects.
Simply look at the diagram – this has exactly the same type of layout of all EXPERIMENTOR boards. Look at the component list and select the component Q1, this is an NPN transistor type 2N3904, this plugs into holes C10, D11, and B12. Easy isn't it?
Now take C2, which is a .1 uf capacitor, this plugs into holes H7 and H10.
Do the same with all the components, connect a 9 volt battery and you have a perfect working TWO-TRANSISTOR RADIO.



YOU WILL NEED

B1–9 VDC battery
C1–365–pF variable capacitor
C2–.1–uF capacitor
D1–Diode, 1N914 or 4148 or equiv.
L1–Standard broadcast loopstick antenna
Q1–NPN transistor, 2N3904 or equiv.
Q2–PNP transistor, 2N3906 or equiv.
R1–100,000–ohm resistor, ¼ watt
R2–4700–ohm resistor, ¼ watt
S1–SPST switch
T1–500:8–ohm matching transformer
SPKR–8–ohm speaker

Building radios is lots of fun. Here's a loud-speaking crystal set. L1 and C1 form the circuit that tunes the radio. For better performance substitute a germanium diode such as IN34 or IN60.
These projects use components which are readily available from all suppliers and we've made a special effort to design the projects so that in many cases substituting close but wrong component values of different transistors will still result in a working circuit.
FILL IN THE COUPON AND WE WILL SEND YOU FREE OF CHARGE A COPY OF THE FULL PROJECT "TWO-TRANSISTOR RADIO".

PROTO-CLIP TEST CLIPS.

Brings IC leads up from crowded PC boards. Available plain or with cable with clips at one or both ends.

PC – 16 pin. £2.75.
PC – 16 pin with cable. £6.00.
PC – 16 with cable and 16 pin clips at both ends. £10.25.

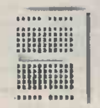
CONTINENTAL SPECIALTIES CORPORATION
CSC

Europe, Africa, Mid-East: CSC UK LTD.
Unit 1, Shire Hill Industrial Estate,
Saffron Walden, Essex CB11 3AQ.
Telephone: SAFFRON WALDEN 21682.
Telex: 817477.

EXPERIMENTOR BREADBOARDS.

No soldering modular breadboards, simply plug components in and out of letter number identified nickel-silver contact holes. Start small and simply snap-lock boards together to build breadboard of any size.
All EXP Breadboards have two bus-bars as an integral part of the board, if you need more than 2 buses simply snap on 4 more bus-bars with the aid of an EXP.4B.

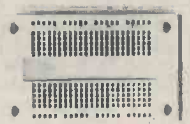
EXP.325. The ideal breadboard for 1 chip circuits.
Accepts 8,14,16 and up to 22 pin IC's.
ONLY £1.60.



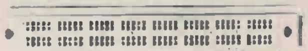
EXP.350. £3.15.
270 contact points with two 20-point bus-bars.

EXP. 300. £5.75.

EXP. 650 for Micro-processors. **£3.60.**



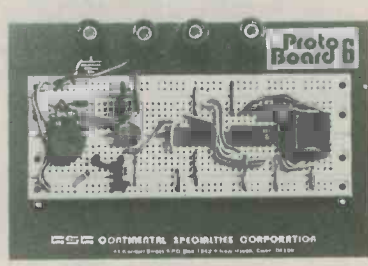
EXP 4B.
More bus-bars.
£2.30.



ALL EXP.300 Breadboards mix and match with 600 series.

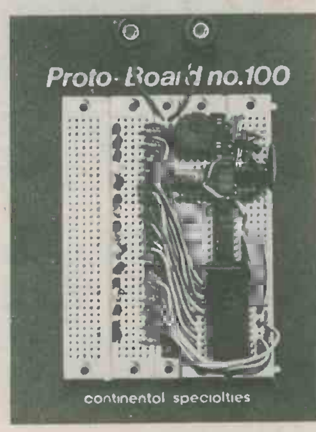
PROTO-BOARDS.

THE ULTIMATE IN BREADBOARDS FOR THE MINIMUM COST.
TWO EASILY ASSEMBLED KITS.



PB.6 Kit, 630 contacts, four 5-way binding posts accepts up to six 14-pin Dips.

PROTO-BOARD 6 KIT. £9.20.



PB.100 Kit complete with 760 contacts accepts up to ten 14-pin Dips, with two binding posts and sturdy base. Large capacity with Kit economy.

PROTO-BOARD 100 KIT £11.80.

HOW TO ORDER AND RECEIVE FREE COPY OF TWO-TRANSISTOR RADIO PROJECT.

It's easy. Give us your name and full postal address, in block capitals. Enclose cheque, postal order or credit card number and expiry date. OR telephone 0799 21682 and give us your Access, American Express or Barclaycard number and your order will be in the post that night.

EXPERIMENTOR. BREADBOARDS.	CONTACT HOLES.	IC CAPACITY 14 PIN.DIP.	UNIT PRICE INCLUDING POSTAGE AND V.A.T.
EXP. 325	130	1	£ 2.53
EXP. 350	270	3	£ 4.21
EXP. 300	550	6	£ 7.29
EXP. 650	270	use with 0.6 pitch Dip's	£ 4.69
EXP. 4B.	Four 40 Point Bus-Bars	Bus-Bar Strip	£ 3.29
TEST CLIPS			
PC. 16.			£ 3.78
PC.16-18.			£ 7.56
PC. 16-18 Dual Clip.			£12.15
PROTO-BOARDS.			
PB. 6.	630	6	£11.01
PB. 100.	760	10	£13.82

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SEMICONDUCTORS-COMPONENTS

CERAMIC PAK

Containing a range of first quality miniature ceramic capacitors.

16160 – 24 – 3 of each value:– 22pf. 27pf. 33pf. 39pf, 47pf, 68pf, 82pf 60p*
16161 – 24 – 3 of each value:– 100pf. 120pf. 150pf. 180pf. 220pf. 270pf. 330pf, 390pf 60p*
16162 – 24 – 3 of each value:– 470pf. 560pf. 680pf. 820pf. 1000pf. 15000pf. 2200pf. 2200pf. 3300pf 60p*
16163 – 21 – 3 of each value:– 4700pf. 6800pf. ·01uf. ·015uf, ·022uf. ·033uf, ·047uf 60p*

ELECTROLYTIC PAKS

A range of paks each containing 18 first quality, mixed value miniature electrolytics.

16201 – values from 47mFD – 10mFD 60p*
16202 – values from 10mFD – 100mFD 60p*
16203 · values from 100mFD – 680mFD 60p*

CARBON RESISTOR PAKS

These paks contain a range of Carbon Resistors assorted into the following groups.

16213 · 60 mixed ¼w 100ohms – 820 ohms 60p*
16214 · 60 mixed ¼w ·1K ohms – 8·2K ohms 60p*
16215 – 60 mixed ¼w 10K ohms – 83K ohms 60p*
16216 – 60 mixed ¼w 100K ohms – 820K ohms 60p*
16217 · 40 mixed ½w 100 ohms – 820 ohms 60p*
16218 – 40 mixed ½w 1K ohms – 8·2K ohms 60p*
16219 – 40 mixed ½w 10K ohms – 82K ohms 60p*
16220 · 40 mixed ½w 100K ohms – 820K ohms 60p*
16230 60 mixed ¼w 1 Meg – 10 Meg ohms 60p*
16231 40 mixed ½w 1 Meg 10 Meg ohms 60p*

COMPONENT PAKS

16164 – 200 Resistor mixed value approx (Count by weight) 60p*
16165 150 Capacitors mixed value approx (Count by weight) 60p*
16166 50 Precision resistors Mixed values 60p
16167 · ¼w resistors mixed values 80 60p*
16168 5 pieces assorted ferrite rods 60p*
16169 2 Tuning gangs MW/LW VHF 60p*
16170 – 1 Pack wire 50 meters assorted colours single strand 60p
16171 – 10 Reed switches 60p*
16172 3 Micro switches 60p*
16173 – 15 Assorted pots 60p*
16174 – 5 Metal jack sockets 3 x 3·5 mm 2 x standard switch types 60p*
16175 30 Paper condensers – mixed values 60p*
16176 · 20 Electrolytics trans. types 60p*
16177 1 Pack assorted hardware – Nuts/bolts, gromets etc 60p
16178 – 5 Mains slide switches assorted 60p*
16179 – 20 Assorted tag strips and panels 60p
16180 – 15 Assorted control knobs 60p*
16181 3 Rotary wave change switches 60p*
16182 2 Relays 6-24v operating 60p*
16183 · 1 Pak. copper laminate approx 200 sq inches 60p
16184 15 Assorted fuses 100mA-5 amp 60p
16185 50 metres PVC sleeving assorted size and colours 60p

METAL FOIL CAPACITOR PAK

Containing 50 metal foil Capacitor like Mullard C280 series. Mixed values ranging from ·01uf – 2·2uf. Complete with identification sheet. O/N:16204 £1·20*

SLIDER PAKS

16190 6 Slider potentiometers mixed values 60p*
16191 · 6 Slider potentiometers all 470 ohm 60p*
16192 – 6 Slider potentiometers all 10k 1in 60p*
16193 – 6, Slider potentiometers all 22K 1in 60p*
16194 – 6 Slider potentiometers all 47K 1in 60p*
16195 – 6 Slider potentiometers all 47K log 60p*

TRANSISTORS

BRAND NEW — FULLY GUARANTEED

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC126	£0.18	BC109A	£0.08	BC548	*£0.10	BFY51	£0.16	TIP2955	£0.60	2N3708	*£0.07
AC127	£0.18	BC109B	£0.09	BC549	*£0.10	BFY52	£0.26	TIP3055	£0.50	2N3708A	*£0.07
AC128	£0.16	BC109C	£0.10	BC550	*£0.14	BIP29	£0.38	TIS43	£0.22	2N3709	*£0.07
AC128K	£0.28	BC147	*£0.07	BC556	*£0.14	BIP20	£0.38	TIS90	*£0.18	2N3710	*£0.07
AC132	£0.20	BC148	*£0.07	BC557	*£0.13	BIP19/		UT46	£0.20	2N3711	*£0.07
AC134	£0.20	BC149	*£0.07	BC558	*£0.12	20MP	£0.80	ZTX107	*£0.10	2N3819	£0.18
AC137	£0.20	BC157	*£0.10	BC559	*£0.14	BRY39	£0.45	ZTX108	*£0.10	2N3820	£0.35
AC141	£0.22	BC158	*£0.10	BD115	£0.50	BU105	£1.40	ZTX109	*£0.10	2N3821	£0.60
AC141K	£0.30	BC159	*£0.10	BD116	£0.80	BU105/		ZTX300	*£0.12	2N3823	£0.60
AC142	£0.20	BC167	*£0.12	BD121	£0.85	02	£1.95	ZTX500	*£0.13	2N4058	*£0.12
AC176	£0.18	BC168	*£0.12	BD124	£0.70	BU204	£1.40	2N1613	£0.20	2N4059	*£0.14
AC176K	£0.28	BC169	*£0.09	BD131	£0.35	BU205	£1.40	2N1711	£0.20	2N4060	*£0.14
AC178	£0.25	BC169C	*£0.10	BD132	£0.35	BU208/		2N1889	£0.46	2N4061	*£0.12
AC179	£0.25	BC170	*£0.09	BD131/		02	£2.25	2N1890	£0.45	2N4062	*£0.12
AC180	£0.20	BC171	*£0.09	132MP	£0.80	E1222	£0.38	2N1893	£0.30	2N4284	*£0.18
AC180K	£0.28	BC172	*£0.09	BD133	£0.40	MJE2955	£0.90	2N2147	£0.75	2N4285	*£0.18
AC181	£0.20	BC173	*£0.09	BD135	£0.38	MJE3055	£0.60	2N2148	£0.70	2N4286	*£0.18
AC181K	£0.28	BC177	£0.16	BD136	£0.35	MJE3440	£0.62	2N2160	£1.00	2N4287	*£0.18
AC187	£0.18	BC178	£0.16	BD137	£0.35	MPF102	£0.28	2N2192	£0.38	2N4288	*£0.18
AC187K	£0.28	BC179	£0.16	BD138	£0.36	MPF104	£0.36	2N2193	£0.38	2N4289	*£0.18
AC188	£0.18	BC180	£0.25	BD139	£0.36	MPF105	£0.35	2N2194	£0.38	2N4290	*£0.18
AC188K	£0.28	BC181	*£0.25	BD140	£0.36	MPSA05	*£0.20	2N2217	£0.22	2N4291	*£0.18
AD140	£0.60	BC182L	*£0.09	BD139/		MPSA06	*£0.20	2N2218	£0.22	2N4292	*£0.18
AD142	£0.85	BC183	*£0.09	140MP	£0.80	MPSA55	*£0.20	2N2218A	£0.20	2N4293	*£0.18
AD143	£0.75	BC183L	*£0.09	BD155	£0.80	MPSA56	*£0.20	2N2219	£0.20	2N4921	*£0.55
AD149	£0.80	BC184	*£0.09	BD175	£0.60	OC22	£1.50	2N2219A	£0.24	2N4923	*£0.65
AD161	£0.36	BC207	*£0.11	BD176	£0.60	OC23	£1.50	2N2904	£0.18	2N5135	*£0.10
AD162	£0.35	BC208	*£0.11	BD177	£0.68	OC24	£1.35	2N2904A	£0.21	2N5136	*£0.10
AD162/		BC209	*£0.12	BD178	£0.68	OC25	£1.00	2N2905	£0.18	2N5138	*£0.10
162MP	£0.70	BC212	*£0.09	BD179	£0.75	OC26	£1.00	2N2905A	£0.20	2N5194	£0.66
AF114	£0.25	BC212L	*£0.09	BD201/		OC28	£0.80	2N2906	£0.16	2N5245	*£0.40
AF115	£0.25	BC213	*£0.09	202MP	£1.70	OC29	£0.95	2N2906A	£0.19	2N5294	£0.34
AF116	£0.25	BC213L	*£0.09	BD203	£0.80	OC35	£0.90	2N2907	£0.20	2N5296	£0.36
AF117	£0.25	BC214	*£0.09	BD204	£0.80	OC36	£0.90	2N2907A	£0.22	2N5457	£0.32
AF118	£0.40	BC214L	*£0.09	BD203/		OC70	£0.24	2N2926G	*£20.09	2N5458	£0.32
AF124	£0.30	BC227	*£0.16	204	£1.70	OC71	£0.15	2N2926Y	*£0.08	2N5459	£0.35
AF125	£0.30	BC238	*£0.16	BDY20	£0.80	TIC44	*£0.29	2N2926O	*£0.08	2N5551	*£0.36
AF126	£0.30	BC251	*£0.15	BDX77	£0.90	TIC45	*£0.35	2N2926R	*£0.08	2N6027	£0.34
AF127	£0.32	BC251A	*£0.16	BF457	£0.37	TIP29A	£0.40	2N2926B	*£0.08	2N6121	£0.70
AF139	£0.35	BC301	£0.28	BF458	£0.37	TIP29B	£0.42	2N3052	£0.16	2N6122	£0.70
AF180	£0.60	BC302	£0.29	BF459	£0.38	TIP29C	£0.44	2N3054	£0.40	40311	£0.38
AF181	£0.58	BC303	£0.28	BF594	*£0.30	TIP30A	£0.40	2N3055	£0.40	40313	£0.95
AF186	£0.50	BC304	£0.38	BF596	*£0.28	TIP30B	£0.42	2N3414	*£0.16	40316	£0.95
AF239	£0.38	BC327	*£0.16	BFR39	£0.24	TIP30C	£0.44	2N3415	*£0.16	40317	£0.40
AL102	£1.20	BC328	*£0.15	BFR40	*£0.25	TIP31A	£0.40	2N3416	*£0.29	40326	£0.40
AL103	£1.18	BC337	*£0.15	BFR79	*£0.28	TIP31B	£0.42	2N3417	*£0.29	40327	£0.45
AU104	£1.40	BC338	*£0.15	BFR80	*£0.28	TIP31C	£0.44	2N3614	£1.00	40346	£0.45
AU110	£1.40	BC440	£0.30	BFX29	£0.22	TIP32A	£0.40	2N3615	£1.05	40347	£0.65
AU113	£1.40	BC441	£0.30	BFX30	£0.30	TIP32B	£0.42	2N3616	£1.05	40348	£0.80
BC107A	£0.08	BC460	£0.38	BFX84	£0.22	TIP32C	£0.44	2N3646	*£0.09	40360	£0.36
BC107B	£0.09	BC461	£0.38	BFX85	£0.24	TIP41A	£0.44	2N3702	*£0.08	40361	£0.36
BC107C	£0.10	BC477	£0.20	BFX86	£0.25	TIP41B	£0.46	2N3703	*£0.08	40362	£0.38
BC108A	£0.08	BC478	£0.20	BFX87	£0.22	TIP41C	£0.48	2N3704	*£0.07	40406	£0.45
BC108B	£0.09	BC479	£0.20	BFX88	£0.22	TIP42A	£0.44	2N3705	*£0.07	40407	£0.35
BC108C	£0.10	BC547	*£0.10	BFX90	*£0.55	TIP42B	£0.46	2N3706	*£0.08	40408	£0.52
				BFY50	£0.16	TIP42C	£0.48	2N3707	*£0.08	40409	£0.75

74 SERIES TTL IC'S

BI-PAK STILL LOWEST IN PRICE; FULL SPECIFICATION GUARANTEED.

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
7400	£0.13	7409	£0.13	7441	£0.50	7481	£0.85	7492	£0.35	74122	£0.39
7401	£0.11	7410	£0.11	7442	£0.40	7482	£0.68	7493	£0.30	74123	£0.40
7402	£0.11	7411	£0.17	7445	£0.65	7483	£0.58	7494	£0.75	74141	£0.55
7403	£0.11	7412	£0.15	7446	£0.60	7484	£0.88	7495	£0.50	74154	£0.82
7404	£0.11	7413	£0.24	7447	£0.48	7485	£0.68	7496	£0.50	74180	£1.50
7405	£0.11	7414	£0.50	7448	£0.56	7486	£0.22	74100	£0.85	74181	£0.58
7406	£0.22	7416	£0.23	7475	£0.29	7489	£1.70	74110	£0.36	74190	£0.68
7407	£0.22	7417	£0.23	7480	£0.44	7490	£0.32	74118	£0.80	74198	£1.85
7408	£0.13	7440	£0.12	7481	£0.85	7491	£0.64	74119	£1.18	74199	£1.85
								74121	£0.24		

CMOS IC'S

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CD4000	£0.14	CD4011	£0.15	CD4020	£0.90	CD4028	£0.68	CD4043	£0.88	CD4071	£0.17
CD4001	£0.15	CD4012	£0.16	CD4021	£0.82	CD4029	£0.85	CD4044	£0.82	CD4072	£0.17
CD4002	£0.16	CD4013	£0.42	CD4022	£0.82	CD4030	£0.46	CD4047	£0.87	CD4081	£0.17
CD4006	£0.92	CD4015	£0.76	CD4023	£0.15	CD4031	£2.00	CD4049	£0.42	CD4082	£0.18
CD4007	£0.17	CD4016	£0.42	CD4024	£0.65	CD4035	£1.00	CD4050	£0.42	CD4510	£0.99
CD4008	£0.92	CD4017	£0.75	CD4025	£0.15	CD4040	£0.88	CD4055	£1.00	CD4511	£0.95
CD4009	£0.45	CD4018	£0.85	CD4026	£1.20	CD4041	£0.76	CD4069	£0.17	CD4516	£1.00
CD4010	£0.48	CD4019	£0.42	CD4027	£0.50	CD4042	£0.72	CD4070	£0.17	CD4518	£1.00
										CD4520	£1.00

LINEAR IC'S

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CA3011	*£0.80	LM301	*£0.29	MC1350	*£1.20	UA710C	*£0.40	SL414A	*£1.95	TBA540	*£2.10
CA3014	*£1.35	LM304	£1.60	MC1352	*£1.40	UA711C	*£0.32	TAA550B	£0.35	TBA810S	*£0.75
CA3018	*£0.65	LM308	*£1.00	MC1352	*£1.40	72711	*£0.32	TAA621A	*£2.00	TBA810	*£0.98
CA3020	*£1.70	LM309	£1.50	MC1469	£2.95	UA723C	£0.45	TAA621B	*£2.50	TBA820	*£0.70
CA3028	*£0.80	LM320		MC1496	*£0.90	72723	£0.45	TAA661	*£1.50	TBA9200	*£2.50
CA3035	*£1.40	-5V	£1.50	NE536	*£2.66	UA741C	*£0.24	TAD100	*£1.30	TCA270S	*£2.00
CA3036	*£1.00	LM320		NE550	£0.95	72741	£0.24				
CA3042	*£1.50	-12V	£1.50	NE555	£0.24	741P	*£0.20				
CA3043	*£1.85	LM320		NE556	£0.60	UA747C	*£0.60				
CA3046	*£0.70	-15V	£1.50	NE565	*£1.20	72747	*£0.60				
CA3052	*£1.60	LM320		NE566	*£1.50	UA748	*£0.35				
CA3054	*£1.10	-24V	£1.50	NE567	*£1.70	72748	*£0.35				
CA3075	*£1.50	LM380	*£0.85	UA702C	*£0.46	748P	*£0.35				
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OUTPUT VOLTAGE RANGE	12,6 V dc
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RIPPLE	<5mV 2,2 Amp
DIMENSIONS (mm)	W140 × H90 × D140
WEIGHT	1,490 Kg.

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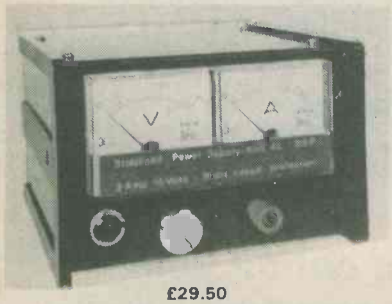

£29.50

INPUT VOLTAGE	220 V ac ± 10% 50-60 Hz
OUTPUT VOLTAGE RANGE	1,7÷15 V. dc
LOAD REGULATION	< 0,2% 0÷2,8 Amp
DIMENSIONS (mm)	W140 × H90 × D155
RIPPLE	3mV 2,8 Amp
WEIGHT	2,330 Kg.

AL.330 P

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INPUT VOLTAGE	220 V ac ± 10% 50-60 Hz
OUTPUT VOLTAGE RANGE	3,4÷30 V. dc
OUTPUT CURRENT RANGE MAX	3 Amp
LOAD REGULATION	< 5% 0-2,8 Amp
RIPPLE	10mV 2,8 Amp
DIMENSIONS (mm)	W270 × H90 × D155
WEIGHT	4,250 Kg.

STOCKISTS

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Anson Electronics,
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Amateur Radio Shop,
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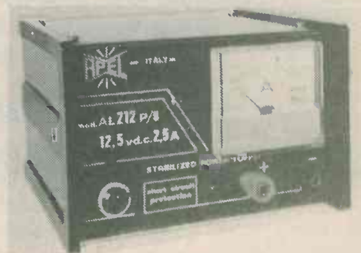
OUTPUT VOLTAGE RANGE	± 15 V. dc
OUTPUT CURRENT MAX	5 Amp
LOAD REGULATION	< 0,1% 0-45 Amp
RIPPLE	< 2mV 4,5 Amp
DIMENSIONS (mm)	W210 × H155 × D250
WEIGHT	5,100 Kg.

AL.212 PS



£18.00

INPUT VOLTAGE	220 V ac ± 10% 50-60 Hz
OUTPUT VOLTAGE RANGE	12,6 V dc
OUTPUT CURRENT MAX	2,5 Amp
LOAD REGULATION	<0,3% 0÷2,2 Amp
RIPPLE	<5mV 2,2 Amp
DIMENSIONS (mm)	W140 × H90 × D140
WEIGHT	1,490 Kg.
AMPEROMETER	

AL.315 P2

£54.00

INPUT VOLTAGE	220 V ac ± 10% 50-60 Hz
OUTPUT VOLTAGE RANGE	± 1,7 ± 15 V dc
OUTPUT CURRENT RANGE MAX	3 Amp
LOAD REGULATION	< 0,2% 0-2,8 Amp
RIPPLE	< 3mV 2,8 Amp
DIMENSIONS (mm)	W270 × H90 × D155
WEIGHT	4,140 Kg.

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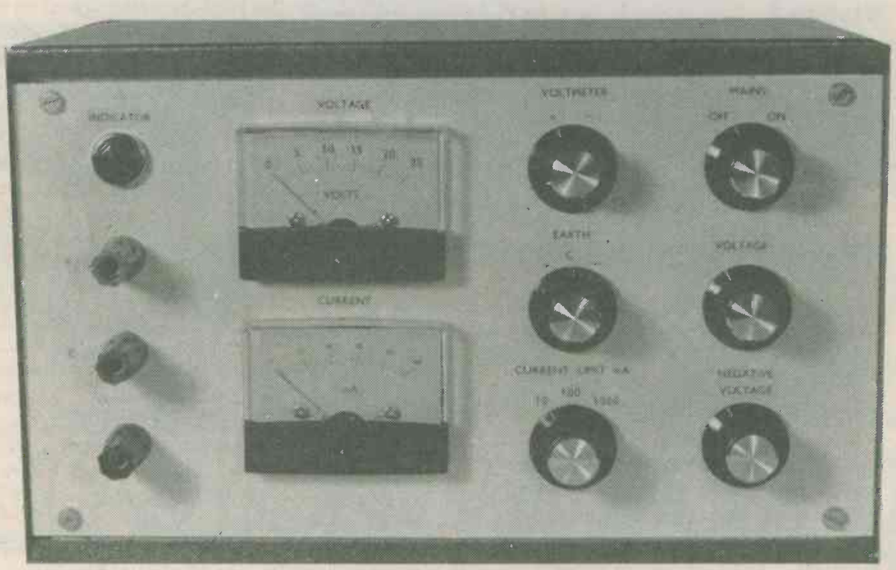
WORKSHOP POWER SUPPLY — Part 1

By R. A. Penfold

A VERSATILE INSTRUMENT

- ***Continuously variable output from 7.5 to 42 volts***
- ***Current limiting at 1 amp, 100mA or 10mA***
- ***Dual supply rail option with independent positive and negative control***



An impressive front panel display. Outputs are available at the three terminals to the left of the meters. Immediately to the right of the meters are the voltmeter switch, the earth selector and the current limit switch. At the far right are the mains on-off switch, the positive output voltage control and the negative output voltage control

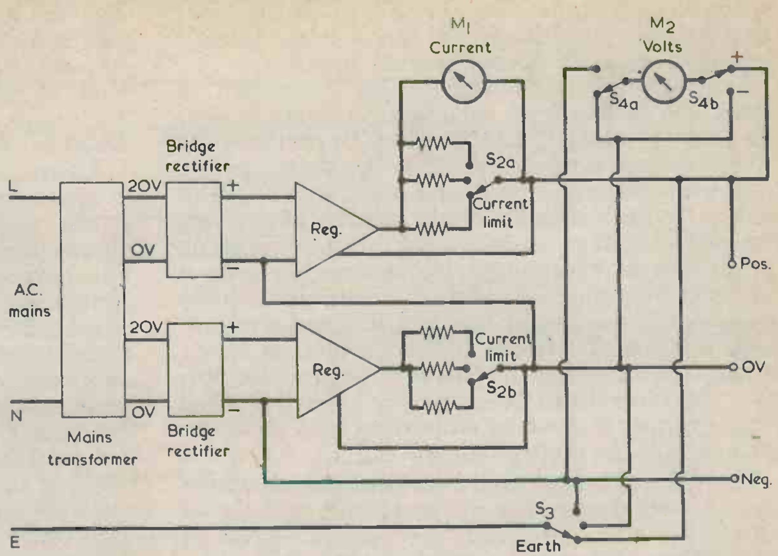


Fig 1. Simplified diagram illustrating the basic design of the power supply. There are two outputs, which can be employed on their own or in series. Alternatively, the unit may be used as a dual rail supply with a centre zero voltage rail

When building and servicing electronic equipment the need for some form of power supply frequently arises. Often it is possible to use batteries to power the equipment, but this is not always practical. How, for example, can a 25 watt audio amplifier be fully tested using ordinary dry batteries as a power source? It is mainly for supplying fairly high voltage and current requirements that a workshop supply is needed, and it is largely for applications of this type that the versatile instrument described in this article was developed.

CURRENT LIMITING

This unit can provide a single voltage rail which is continuously variable between about 7.5 volts and 42 volts at a maximum current of about 1 amp. A current limit of 1 amp is incorporated in the design in order to protect the instrument from accidental short-circuits and overloads at its output. This ensures that the power supply will not be damaged by excessive current, but it is also desirable that an output current limit be provided to protect the equipment being supplied as well. Since 1 amp may be too high a limit for some supplied equipment, two alternative current limits of 100mA and 10mA are provided. The three current limits of 1 amp, 100mA and 10mA are selected by a 3-way switch, this being set to suit the particular item which is supplied. A meter which monitors the output current is fitted in the supply, and its full-scale deflection sensitivity is equal to the selected current limit.

The supply can also be used to provide dual supply rails which are positive and negative of a common rail, the voltages being continuously variable from about 7.5 volts plus 7.5 volts to 21 volts plus 21 volts. The two supply rail voltages are independently variable, allowing the positive and negative rail voltages to be equal or unequal as desired. The unit can therefore supply nearly all operational amplifier circuits as well as power amplifiers having a direct coupled output. An output voltage meter is fitted.

The output is very well smoothed, with a noise level of approximately 1mV at any output voltage and current combination. Output voltage regulation is excellent, and there is a drop of only about 40mV when the output current is changed from zero to full load. Of course, if the output current exceeds the selected limit level the output voltage falls, maintaining the output current at the limiting value.

BASIC OPERATION

As the design is a little unusual it would perhaps be advisable to consider the basic operation of the supply before proceeding to the circuit details. The general arrangement of the instrument is illustrated in Fig. 1.

The mains transformer has two secondary windings, each of which feeds a separate bridge rectifier and smoothing capacitor network. The two resultant d.c. outputs are then fed to conventional adjustable voltage regulator circuits. Each regulator has a current limit circuit which is actuated by the voltage dropped across a resistor in series with the output. The voltage across this resistor is applied to the base and emitter of an internal transistor in the integrated circuit regulator. The transistor has no effect on output voltage until its base-emitter voltage rises to a level which causes it to conduct, whereupon it then causes the output voltage to be reduced. The value of the series resistor in the power supply is such that about 0.66 volt is developed across it when the output current is at the chosen current limit level. Since the transistor in the regulator i.c. is, obviously, a silicon device, this voltage is approximately that needed to make it conductive. The difference between the base-emitter voltage needed to just make the transistor conduct and that which causes full saturation is extremely small, whereupon the regulator output voltage falls very rapidly to a safe level when any attempt is made to draw excessive current. This gives a very well defined current limit threshold.

A voltmeter with a full-scale deflection sensitivity of 0.66 volt is connected across the current limit resistor of one of the regulator circuits. Since each regulator actually has three switched series resistors to provide the three current limits, the voltmeter will indicate f.s.d. at the current limit irrespective of which resistor is selected. Thus, the f.s.d. sensitivity of the meter is automatically switched to 1 amp, 100mA or 10mA at the same time as the output current limit is set and it thereby acts as an output current monitor.

The two regulator outputs are connected in series, the output from each being adjustable over the range of about 7.5 to 21 volts. In practice, the output voltage range provided by the prototype is a little wider than this, with the result that any unit built up to the design should be capable of covering the quoted voltage range, taking into consideration the effects of component tolerances. For output voltages between 7.5 and 21 volts it is only necessary to use one or other of the regulator outputs. Voltages of between 21 and 42 volts can be obtained by employing the two series-connected outputs, the central rail being simply ignored. A dual output supply is given by employing both regulator outputs and the central supply rail.

The current meter could be switched so that it can connect across the current limit resistor of either regulator, permitting the output current of the negative rail to be monitored when the unit is used in the dual rail mode. However, the author felt that the circuit complication involved was not worth-while, and this facility has not been incorporated into the prototype. (An indication of overload in the negative rail may, in any case, be provided by switching the internal voltmeter to that rail.)

A voltmeter with an f.s.d. of 25 volts can be switched to monitor the output voltage from either regulator circuit. It is not possible to monitor the output voltage of the two regulators when these are used in series, but it is an easy matter to individually adjust the two output voltages to produce the required sum voltage.

A further 3-way switch enables the mains earth to be connected to the central rail, the negative rail or the positive rail, as appropriate for the conditions under which the power supply is being used. This may seem to be a minor point, but in fact it is an important one. Obviously, when the unit is used in the dual supply mode the central rail should be earthed, and in many instances it does not matter whether the positive or negative rail is earthed in the single supply mode, although it should not be the unused central rail which is earthed when the two outputs are employed in series. The importance of having the correct output earthed arises when the equipment being supplied is connected to some other item of mains powered equipment having an earthed input or output. For example, the equipment being supplied could be an amplifier which has a positive earth. If, say, a millivoltmeter having an earthed input terminal is connected to the amplifier no problems will arise if the power supply has its positive output earthed. On the other hand, a short-circuit through the the earth wiring will be given if the power supply is incorrectly switched for a negative earth.

COMPONENTS

Resistors
(All fixed values ½ watt 5% unless otherwise stated)
R1 3.3kΩ
R2 4.7kΩ pre-set potentiometer, 0.1 watt, horizontal
R3 0.68 Ω 1 watt (see text)
R4 6.8 Ω
R5 68 Ω
R6 12k
R7 2.2kΩ
R8 0.68 Ω 1 watt (see text)
R9 6.8Ω
R10 68Ω
R11 12kΩ
R12 2.2k Ω
R13 220kΩ
R14 47kΩ pre-set potentiometer, 0.1 watt, horizontal
VR1 22kΩ potentiometer, linear
VR2 22kΩ potentiometer, linear

Capacitors
C1 4,700 μF electrolytic, 40V Wkg., single-ended with mounting clip
C2 100pF ceramic plate
C3 0.1 μF type C280
C4 100 μF electrolytic, 25V Wkg.
C5 4,700 μF electrolytic, 40V Wkg., single-ended with mounting clip
C6 100pF ceramic plate
C7 0.1 μF type C280
C8 100 μF electrolytic, 25V Wkg.

Transformer
T1 mains transformer, secondaries 0-20V 1.2A, 0-20V 1.2A (see text)

Semiconductors
IC1 723C in 14 pin d.i.l.
IC2 723C in 14 pin d.i.l.
TR1 2N3055
TR2 2N3055
D1-D8 1N4002

Switches
S1 d.p.s.t., rotary toggle
S2(a)(b) 2-pole 3-way rotary (see text)
S3 1-pole 3-way rotary, break-before-make (see text)
S4 (a) (b) 2-pole 2-way rotary, break-before-make (see text)

Meters
M1 0-100 μA moving coil (see text)
M2 0-100 μA moving-coil (see text)

Indicator
PL1 neon indicator with integral series resistor, 240V A.C.

Terminals
SK1, 2, 3 insulated terminals (see text)

Fuses
FS1 1 amp cartridge fuse, 20mm.
FS2 1 amp cartridge fuse, 20mm.

Miscellaneous
Metal instrument case (see text)
6 control knobs
2 fuseholders, 20mm., chassis-mounting
Finned aluminium heatsink (see text)
2 sets mica washers and insulating bushes (for TR1 and TR2)
Materials for printed circuit board
3-core mains lead
Nuts, bolts, wire, etc.

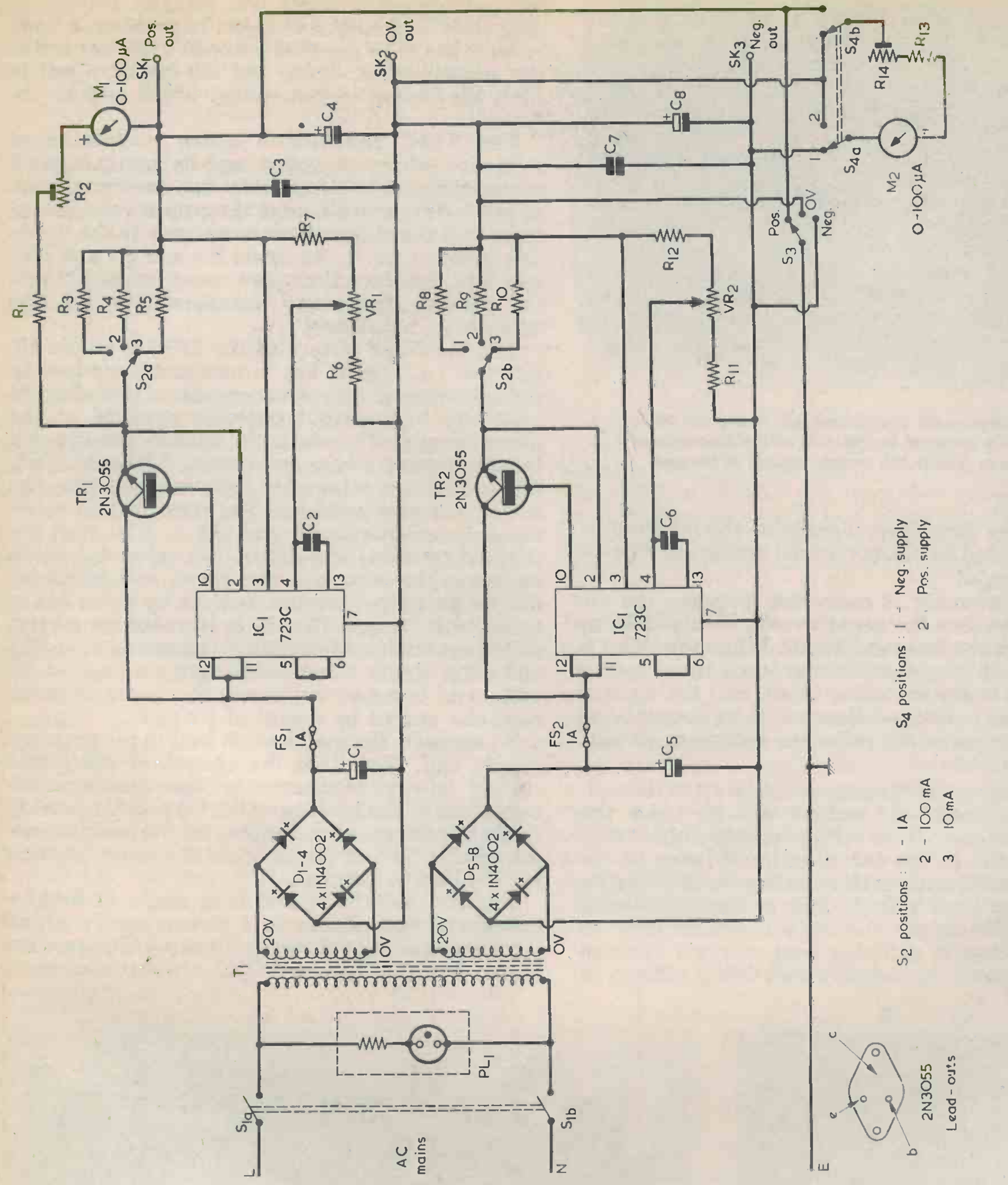


Fig 2. Complete circuit of the workshop power supply. Output current limiting can be set for 1 amp, 100mA and 10mA. Output voltages for each rail are continuously variable from 7.5 to 21 volts, and the two outputs can be used in series to provide a maximum of 42 volts. Any output terminal may be connected to the mains earth

COMPLETE CIRCUIT

The complete circuit of the power supply is shown in Fig. 2. The a.c. mains input is applied to the primary of T1 via on-off switch S1(a)(b). PL1 is the mains indicator, this being a panel-mounting neon with integral series resistor intended for mains operation. The secondaries feed two bridge rectifiers, D1 to D4 and D5 to D8, and the rectified voltages are then smoothed by the large value electrolytic capacitors, C1 and C5.

A 723C integrated circuit voltage regulator appears in each voltage stabilizing circuit. As is shown in Fig. 3, the 723C consists basically of an operational amplifier having a reference voltage

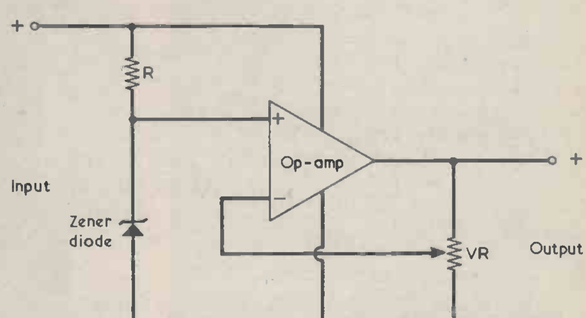
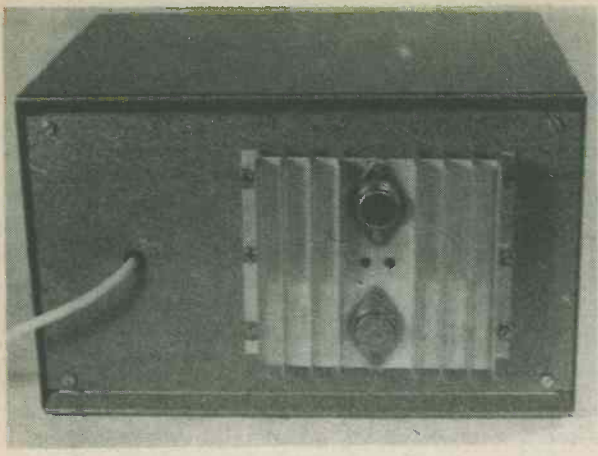


Fig 3. A continuously variable stabilized output voltage can be obtained with the basic circuit shown here



Two large pass transistors are mounted on a heatsink secured to the rear of the instrument case in which the power supply is housed

(depicted in simplified manner in the diagram as being provided by a zener diode) applied to its non-inverting input.

A potentiometer is connected between the op-amp output and the negative rail, its slider being returned to the inverting input. When the slider is at the top of the potentiometer track the output is connected to the inverting input, and the op-amp functions as a voltage follower with its output being virtually equal to the reference voltage at its non-inverting input.

Should the potenticmeter slider be set to the centre of the track, the output will be twice the reference voltage. This voltage relationship is that which results in the inverting input being at the same potential as the non-inverting input. Because of the very high voltage gain of the operational amplifier the output voltage will remain fixed at this level despite differing load currents between the output and the negative rail. Other settings of the potentiometer slider will produce corresponding stabilized output voltages. In practice, a fixed resistor has to be inserted between the lower end of the potentiometer track and the negative rail to limit the highest output voltage which may be obtained.

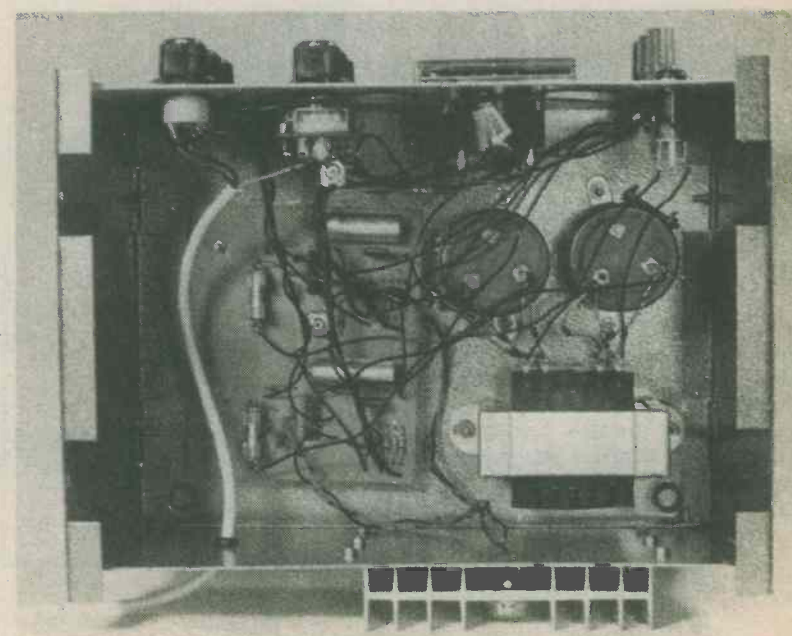
The 723C contains a quite sophisticated reference voltage generator, and its output at pin 6 connects direct to the op-amp non-inverting input at pin 5. VR1 and VR2 are the output voltage controls, and the slider of each connects to the inverting input at pin 4. Resistors R6 and R7 and R11 and R12, set the adjustment range limits. C2 and C6 provide frequency compensation for the operational amplifiers.

The stabilized output of the 723C is at pin 10, but the i.c., which has a maximum dissipation rating of 800mW only, is not capable of providing the relatively high output currents required of the power supply. Therefore, the outputs are coupled to two discrete power transistors, TR1 and TR2, which function as emitter followers and pass the output currents provided. The current limit series resistors are R3 to R5 and R8 to R10, and are selected by S2(a) and S2(b). The voltmeter which measures the voltage across them, and hence indicates the output current, is given by meter M1 in series with R1 and R2. R2 is adjusted for correct meter sensitivity. Meter M2, in company with R13 and R14, forms a voltmeter with an f.s.d. of 25 volts, and is connected across the upper or lower regulator output by means of S4(a)(b).

S3 connects the mains earth lead to the required supply rail. Note that the chassis of the power supply always connects to the mains earth regardless of the position of S3. C3 and C4 provide final smoothing and decoupling for the positive output, whilst C7 and C8 carry out the same function for the negative output.

The two fuses, FS1 and FS2, might at first be considered superfluous in a power supply which has automatic output current limiting. They are included because TR1 and TR2 are mounted on a

Layout of component parts inside the case. Note the two large electrolytic capacitors, C1 and C5, which are mounted between the mains transformer and the front panel



Another view of the workshop power supply with its comprehensive control options. The legends on the front panel are taken from "Panel-Signs" Set No. 4.

heatsink which is at chassis potential, with the result that their bodies have to be insulated from the heatsink by mica washers and insulated bushes. If, for any reason, this insulation should fail, the unregulated section of the power supply could be short-circuited. The fuses thus protect this part of the supply. For optimum heat dissipation the transistors and the heatsink are positioned at the rear of the case, whereupon a short-circuit could also be given if a piece of wire or metal accidentally connected together one of the transistor bodies and the heatsink or if one of the transistor bodies came into contact with a conductor at earth potential.

COMPONENTS

The mains transformer employed for T1 is an R.S. Components part having two 20 volt 1.2 amp secondaries, and is described as a "50VA Transformer" with the type number 207-273. This is available through retailers who handle R.S. Components items. The two meters are both 0-100μA types, and are available from several suppliers, including Maplin Electronic Supplies and Home Radio. They have rectangular faces measuring 60 by 45mm. and an internal resistance of 580Ω. S3 and S4 must be break-before-make rotary switches, and these can be obtained from Maplin Electronic Supplies. Break-before-make switches are essential here as otherwise the power supply outputs could be temporarily short-circuited when they are changed from one setting to the next. S2 may be a 4-pole 3-way rotary switch with only 2 poles used. S3 can be 4-pole 3-way with only 1 pole used. S4 can be, say, 2 poles of a 4-pole 3-way switch with adjustable end stop set for 2-way operation, or any other combination which gives 2-pole 2-way working.

The heatsink for the two transistors is a standard drilled type having dimensions of 124mm. wide and 102mm. high and can be seen in the photograph of the case rear. Two of the fixed resistors, R3 and R8, are specified in the Components List as 0.68Ω. In practice, each consists of a 1.2Ω $\frac{1}{2}$ watt 5% and a 1.5Ω $\frac{1}{2}$ watt 5% resistor in parallel. The printed circuit board on which they are wired has provision for two resistors at both the R3 and R8 positions. The calculated value given by 1.2Ω and 1.5Ω in parallel is 0.667Ω, which is sufficiently accurate for the present application.

The metal instrument case in which the power supply is built has dimensions of 254mm. wide by 159mm. high by 197mm. deep. This is a "Centurion" case model 222F, obtainable from Maplin Electronic Supplies. Finally, the three terminals, SK1, SK2 and SK3 are insulated types with a 4mm. top socket in addition to the usual terminal screw connection. They are available in various colours from which the constructor may make his own choice.

CONSTRUCTION

The layout and drilling dimensions for the front panel are shown in Fig. 4. The three terminals require a 7mm. hole, after which a small notch is made at the hole top to accommodate a locating pip in the insulated section of the terminal. The two large circular cut-outs for the meters may be made with a fretsaw. Once these cut-outs have been made, the meters themselves can be used to mark out the positions of the four small mounting holes around each. The remainder of the front panel drilling requires no comment apart from the hole for PL1. Some neon indicators may require a hole with a different size to that shown in Fig. 4.

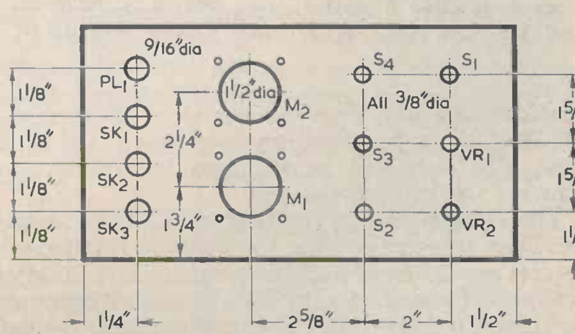


Fig 4. Drilling details for the front panel of the case

The mains transformer is mounted on the base of the cabinet at the left rear, with the primary and secondary tags facing towards the front. C1 and C5 are positioned side by side in front of the transformer, using suitable capacitor mounting clamps.

NEXT MONTH

In next month's concluding article we shall continue with constructional details and then carry on to the testing and setting up of this power supply.

(To be concluded)

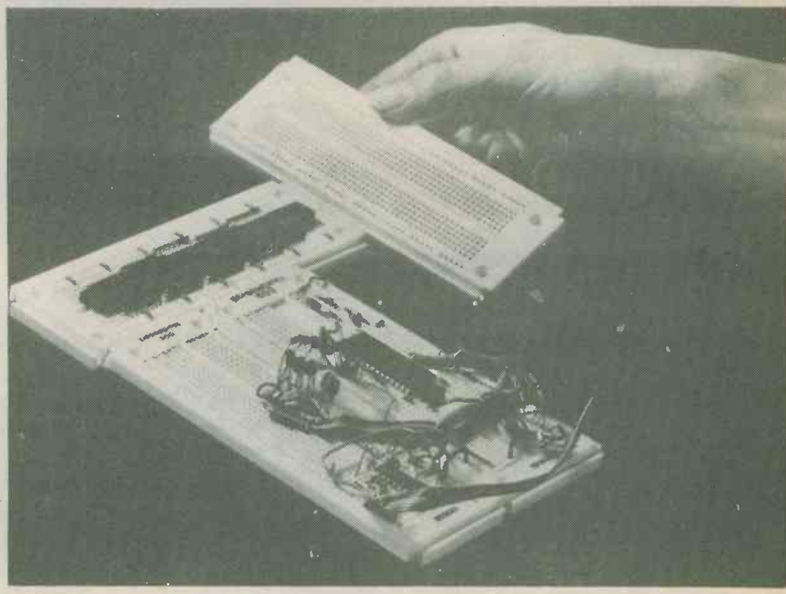
NEWS . . . AND

CSC's EXPERIMENTOR BREADBOARDS

Continental Specialties Corporation, CSC, have announced three new advances in Breadboard design in their new Experimentor Breadboards.

Firstly, price — for as little as £1.60, CSC's Experimentor sockets let you design, assemble and modify circuits as fast as you can push-in — or pull-out — component leads. All Experimentor Breadboards have 0.1in. pitch which accepts all components, have letter/number system which identifies every hole and have built in bus-bars. They are precision-moulded out of durable, abrasion, temperature resistant material and pre-stressed nickel-silver contacts for positive connections and longer life.

Secondly, compatibility, Experimentor 600 Series 0.6in. centre is ideal for Microprocessors, clock chips, RAM's, ROM's, PROM's, etc. Whilst Experimentor 300 Series accept all DIP's on 0.3in. centres. Both units of course accept transistors, LED's, resistors, capacitors, pots, indeed almost any component and use ordinary solid core wire for jumper leads.



CSC Experimentor Breadboards are manufactured for development engineers, either professional or amateur

Finally, you can arrange your Breadboard to suit your circuit. Simply snap-lock together any size Experimentor Breadboard to any other vertically or horizontally.

THE VITAL VIDEO RACE RECORD

After a year's highly successful operation with two Fujinon semi-broadcast lenses. Racecourse Technical Services Ltd. — the firm that supplies officials with the vital video race-record which provides essential data for stewards' enquiries — has decided to purchase another lens of the same type. The lens will be supplied by Survey and General Instrument Co. Ltd.

The camera used is the Ikegami CTC 3X, and it has been adapted to take the Fujinon lens using a special mounting plate. The resulting combination is a powerful system with near broadcast standard but much lighter than the conventional broadcast camera with zoom lens.

This f 1.8 lens zooms from 29.5mm at wide angle to 413mm telephoto, and is particularly suitable for recording evening sporting events where the ambient light level is of low intensity. Every effort has been made to give this high power lens excellent light gathering properties: lens surfaces are all electron-beam coated to give especially good transmission ratios, and the iris is set electronically.

A Fujinon semi-broadcast lens in action on an RTS colour camera at Sandown Park

. . . COMMENT

BRITAIN'S FIRST AMATEUR SPACECRAFT

The International Amateur Satellite Corporation (AMSAT) has to date, launched eight amateur satellites in the OSCAR series (Orbiting Satellites Carrying Amateur Radio). These have been built internationally by radio amateurs in the USA, Germany, Canada, Japan and Australia.

The University of Surrey's Telecommunications Research Group is to build Britain's first amateur spacecraft. It is working in conjunction with AMSAT and with the active support of Britain's electronics, telecommunications and aerospace industries.

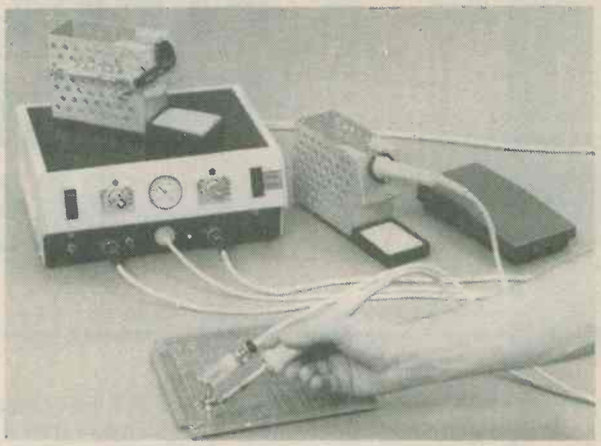
The new satellite, to be built at Surrey University, will be Britain's first contribution in flight hardware to the Amateur Space Programme. The details of the special features and experiments that it will carry are still under discussion, but it is hoped to include a facility to enable radio amateurs all over the world to study the effects of the ionosphere on radio propagation.

The construction and testing of the satellite will take about two years and the cost is expected to be around £150,000 — a possible launch opportunity exists early in 1981. Support for the project is being provided by the Amateur Satellite Corporation (AMSAT) USA; the Amateur Satellite Organisation of the UK (AMSAT-UK); The Radio Society of Great Britain and a number of government agencies and commercial firms.

The University of Surrey's Telecommunications Research Group are certainly to be congratulated on their initiative and we are sure our readers will join with us in wishing the project every success.

Although we pride ourselves on being a practical magazine it is also part of our policy to stimulate interest in the scientific outreaches of our hobby and we shall continue, from time to time, to give news of this ambitious venture.

DESOLDERING STATION FOR INDUSTRY



The Weller DS100 PEC Soldering/Desoldering Station with variable temperature control, from The Cooper Group

Cooper Tools Ltd., of Wear District 6, Washington, Tyne and Wear, has further developed its range of soldering and desoldering tools with the introduction of the soldering/desoldering station DS 100 PEC.

This new soldering/desoldering station has been specifically designed to meet the requirements of the electronic industry where highly sensitive components such as MOS and FETS are used.

The new DS 100 PEC can be operated either from factory compressed air systems or from a built-in vacuum pump. Both tools soldering and desoldering are operated at the safe low voltage of 24V, without earth connection. The vacuum for the desoldering action is controlled by a two-stage foot switch.

COMING CLUB EVENTS

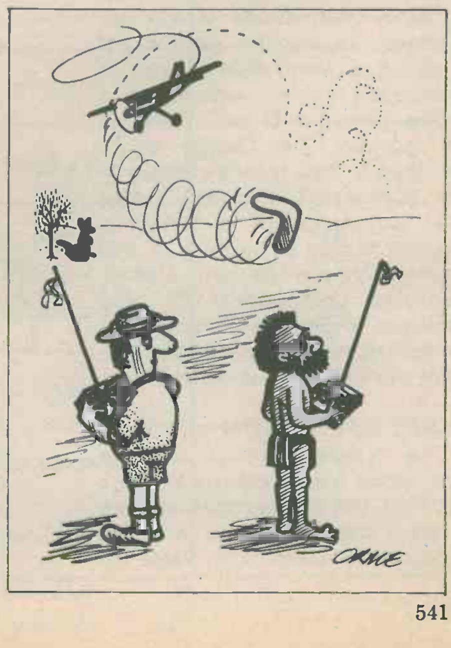
●Royal Naval Amateur Radio Society Activity Period 0800 GNT 13th April 1979 to 1700 GMT 22nd April 1979. Location: HMS Belfast, Pool of London.

It is hoped to have at least three stations operational for twenty four hours per day during the above period using the call sign GB2RN. QSL's will be acknowledged on receipt only. The ship is open to the public from 1100 to 1800 daily and visitors are welcome.

Trio Corporation of Japan have kindly donated a complete HF installation to the special amateur demonstration station aboard the ship.

●The Northern Radio Societies' annual Radio & Electronics Exhibition NRSA 79 will be held at Belle Vue, Manchester on Sunday 22nd April 1979.

The exhibition opens at 11.00 am, entrance fee is 20p which includes one raffle ticket, and the entrance is at the rear of Belle Vue opposite the main car park.



SUGGESTED CIRCUIT

ELECTROLYTIC CAPACITANCE METER

By G. A. French

Many modern electrolytic capacitors have rather faint markings of value, and it quite often happens that these become partly or wholly erased particularly if the capacitors have been employed in a number of experimental circuits. Also, it is sometimes desirable to check electrolytic capacitors to ensure that they are offering their full nominal capacitance after having been held in stock for a considerable time.

Both these factors indicate that a useful item of test equipment can be a device which measures the capacitance of the capacitors concerned. However, the measuring device would not be employed very frequently and it would be uneconomic to make up permanantly a unit which required a great deal of components or even, these days, a meter movement.

Fortunately, electrolytic capacitors are notoriously wide tolerance components which are employed in circuits capable of accepting a very wide spread in capacitance values, whereupon a precise indication of capacitance is not required. The design to be described in this month's article in the "Suggested Circuits" series takes advantage of a fortuitous operating feature of the 555 i.c. and requires only a small number of inexpensive components. It also employs a measuring instrument for the evaluation of capacitance, this being the user's wrist watch!

BASIC OPERATION

The basic circuit of the capacitance meter appears in Fig. 1 and, here, the 555 is connected in a standard circuit giving a one-shot monostable action. The value of resistor R is known, whilst the value of the capacitor C is to be determined. A simple monitor circuit, which may be an arrangement of l.e.d.'s, can be connected to the output of the 555 to indicate whether this is in the high or low voltage state.

When the switch is closed the capacitor is discharged and the inputs at pins 2 and 6 of the 555 are low. The output at pin 3 of the 555 is then high. As soon as the switch is opened the capacitor commences to charge. When the voltage on the upper plate of the capacitor reaches two-thirds of the supply potential the internal comparator in the 555 becomes triggered and the 555 output goes abruptly low. The output remains low as C continues to charge until it reaches the full supply potential, and will only go high again when the switch is closed and the capacitor once more discharged.

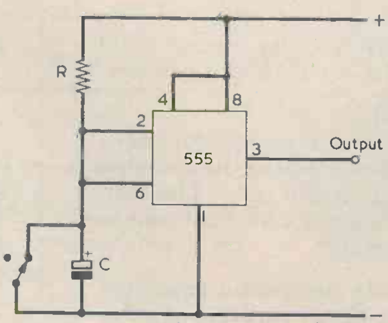


Fig. 1. The time taken for the capacitor to charge sufficiently to trigger the 555 is very nearly equal to the time constant of R and C. This enables the capacitance of C to be readily evaluated

In the circuit, the time taken for the capacitor to charge up to 63.2% of the supply voltage is known as the time constant of the capacitor and resistor. The time constant, in seconds, is equal to C times R, where C is in farads and R is in ohms or, more conveniently, where C is in microfarads and R is in megohms. The 555 triggers when the voltage across the capacitor is two-thirds, or 66.7% of the supply voltage. If we make the assumption that the 555 triggers after a time equal to the time constant of the capacitor and the resistor we shall be introducing only a relatively small error (acceptable with wide tolerance electrolytic capacitors) and shall have an extremely simple capacitance measuring device as a result. All we need to do is to find the time, in seconds, between the opening of the switch and the change in 555 output, and we can then use this time to calculate the value of C.

Before proceeding further, we have to consider the relationship between the capacitance, the resistance and the measured time constant. The time constant is equal to C multiplied by R. It follows from this that C is equal to the time constant divided by R.

FULL CIRCUIT

The full circuit of the electrolytic capacitance meter appears in Fig. 2. One addition here to the basic circuit of Fig. 1 is the 555 output monitor given by the two l.e.d.'s and their series resistors, R9 and R10. These indicate the output state of the 555: when the output is high LED1 is extinguished and LED2 is lit, and when the output is low LED1 is alight and LED2 is turned off. The short-circuiting switch of Fig. 1 appears as S1, with current limiting resistor R8 in series. R8 merely reduces possible sparking at the switch contacts if these close to short-circuit a charged test capacitor, and has no other effect in the circuit.

The single resistor of Fig. 1 is replaced by the seven resistors R1 to R7, these being selected by the range switch S2. When position 1 is selected the serious resistance is 1M Ω whereupon the value of the test capacitance in microfarads is its time constant multiplied by 1. Position 2 of S2 switches in a 330k Ω resistor and since this is (approximately) one-third of 1M Ω the capacitance value is equal to the time constant multiplied by 3. If a 10 μF capacitor is connected to the test terminals the time constant with the 330k Ω resistor will be 3.3 seconds, giving a calculated capacitance value after multiplication by 3 of 9.9 μF. In practice, the timing will be to the nearest whole second, but this numerical example illustrates how the use of a 330k Ω resistor causes the multiplying figure to be 3.

R3 has a value of 100k Ω, giving a multiplying figure of 10. The resistor values proceed in a similar manner up to R7, which has a value of 1k Ω and gives a multiplying figure of 1,000. The accompanying Table lists the ranges and also shows nominal range limits, corresponding to time constants of 2 to 10 seconds. In use, it is almost certain that periods somewhat in excess of 10 seconds will be employed for measurement. Although such periods take up a little more time, they can yield a surprisingly high accuracy in results.

To take an example of how the meter may be used, let us imagine that we have an unknown electrolytic capacitor whose value we judge to be about 100 μF. Accordingly, we set S2 to range 4 and connect the capacitor to the test terminals. We then measure the time between the opening of switch S1 and the changeover of illumination in the two l.e.d.'s. We find this to be approximately 2 seconds, giving a calculated value of 30 times 2, or 60 μF. If we want a greater accuracy we can repeat the operation with S2 set to range 3. Should we find that the time constant then measures at 5 seconds we can say with more accuracy that the value of the capacitor is 10 times 5, or 50 μF. We could get an even higher level of accuracy by measuring the time constant with S2 switched to range 2, where the multiplier is 3, although the measurement will take longer than 10 seconds to carry out.

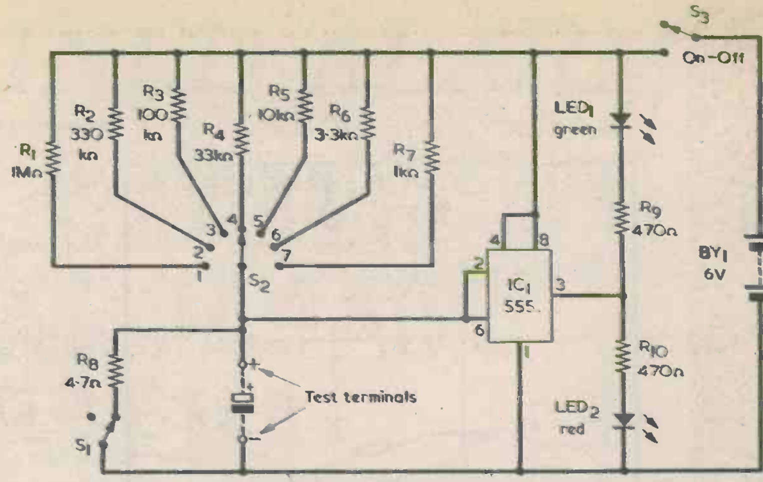


Fig. 2. The full circuit of the electrolytic capacitance meter. The ranges provided by S2 are listed in the table

TIMING PROCEDURE

It might be considered that the measurement of the time constant could be rather difficult to carry out but the process is, in fact, quite easy. A front panel layout similar to that shown in Fig. 3 is helpful, the two l.e.d.'s being mounted fairly close together. Switch S1 should be a toggle type, which will have a quick snap action. When the meter is switched on with S1 closed the red l.e.d. lights up. The test capacitor may then be connected to the test terminals.

If the wrist watch has a sweep second hand the switch may be put to the open position as the hand passes a 5-second division. With a digital watch the switch may be operated when the seconds figure reaches a multiple of 10. When the watch is held close to the panel of the meter it will be found possible to observe it whilst keeping the l.e.d.'s within the field of vision. The sudden change from the red l.e.d. to the green l.e.d. is very noticeable.

It will be seen that the positions of S2 in Fig. 3 are marked with the multiplier to which they correspond. All that then has to be remembered

TABLE

S2 Setting	Nominal Range	Multiply seconds by:
1	2-10 μF	1
2	6-30 μF	3
3	20-100 μF	10
4	60-300 μF	30
5	200-1,000 μF	100
6	600-3,000 μF	300
7	2,000-10,000 μF	1,000

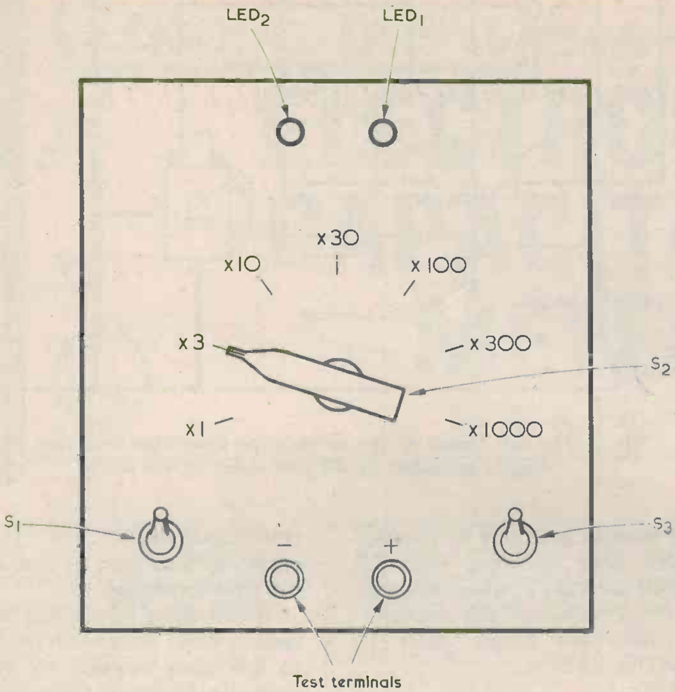


Fig. 3. A suitable panel layout. Mounting the two l.e.d.'s close together makes the changeover from LED2 to LED1 very noticeable visually

is that the test capacitance in microfarads is equal to seconds multiplied by the multiplier. A range of 2 μF to greater than 10,000 μF is available with the meter.

The current drawn from the 6 volt supply is of the order of 7mA plus charging current in the test capacitor. The latter will be initially 9mA when large value capacitors are being checked on range 7, and becomes progressively smaller on the lower ranges. A supply of 6 volts is employed since this will cater for nearly all electrolytic capacitors having low working voltages.

Apart from R8, all the resistors may be $\frac{1}{4}$ watt. R8 can pass some high momentary currents and it would be preferable to make this resistor $\frac{1}{2}$ watt. R1 to R7 can be 5% types and the remainder 10%. Switch S2 may be a 1-pole 12-way type with adjustable end-stop set for 7-way operation.

As a final point, if the capacitor being measured has been out of use for a considerable time it is advisable to allow it to charge by way of the meter for a short period before measuring its value. The initial charge will allow the capacitor electrolyte to "form" so that the capacitor then exhibits its true value. ■

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SUSTAINED ALARM UNIT By Vincent S. Evans

A neat circuit which allows a single 555 to do the job of two.

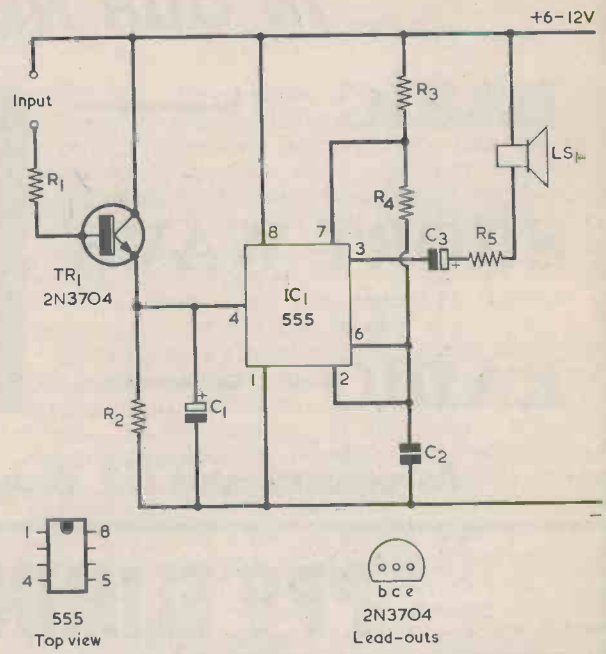
The 555 integrated circuit employed in this alarm project is a multivibrator designed to be used either in the astable mode or as a monostable. In the present application, however, the device has been made to offer both functions simultaneously. Published circuits which have come to the writer's notice use two 555's to achieve the same result, i.e. one to act as a timer and the other as an audio oscillator.

ACTIVE PERIOD

The astable mode is triggered by a momentary short-circuit at the input and continues for about 60 seconds. This period can be shortened, or extended to over ten minutes, by altering the value of the capacitor C1, according to the purpose for which the alarm is going to be used. R2 also influences the length of the period but is best kept within the limits of 33kΩ to 100kΩ.

In the circuit the resistor — capacitor chain R3, R4, C2 is the usual astable configuration for free running oscillation, producing a continuous audible frequency via the loudspeaker. The oscillation can only happen, however, if pin 4 of the i.c. is disconnected or held more than some 0.8 volt positive of the negative rail. (Pin 4 is the reset pin and is usually connected direct to the positive rail.) If pin 4 is held below 0.8 volt the astable function is cut off.

TR1 is normally turned off, with no voltage at its base. It passes negligible collector current and C1 is held discharged by R2, whereupon the voltage at pin 4 is below the critical 0.8 volt level. The astable multivibrator cannot then operate. If a positive pulse is applied to TR1 base by a temporary short-circuit of the input terminals the transistor turns on and causes C1 to charge to nearly the full supply voltage. The astable multivibrator will then start and will continue running until C1 has discharged sufficiently through R2. The period during which the multivibrator operates is much longer than the time constant of C1 and R2, because it ends when the voltage across C1 is a relatively small fraction of that it initially held when charged.



The circuit of the sustained alarm unit. In this, the 555 i.c. functions both as an astable multivibrator and as a controlling timer

It is worth mentioning that if the input short-circuit is maintained the timing period cannot start and the alarm sounds continuously. This can be put to good effect in some applications. If the input is connected to a trigger mat the alarm will sound continuously if an intruder stands on the mat. What is more, it will continue to sound for the timing period after the intruder has left the mat, thereby adding to his confusion. Other means of operating and triggering the alarm circuit can be readily devised.

The output of the 555 is connected to the speaker via capacitor C3 and output current limiting resistor R5. The speaker may have any impedance between 3Ω and 15Ω. R5 could be omitted with an 80Ω speaker, and this should give the loudest sound. Due to the inductive effect of the speaker voice coil it may still be necessary in some cases to insert a resistor of some 10Ω in series with an 80Ω speaker for best results. The musical pitch of the audio note can be changed by varying the value of C2. ■

COMPONENTS

Resistors
(All ¼ watt 10% unless otherwise stated)
R1 10kΩ
R2 100kΩ — R4 33kΩ
R3 10kΩ — R5 82Ω ½ watt

Capacitors
C1 220μF electrolytic, 16V. Wkg.
C2 0.1μF polyester
C3 220μF electrolytic, 16V. Wkg.

Semiconductors
IC1 555 — TR1 2N3704

Speaker
LS1 see text

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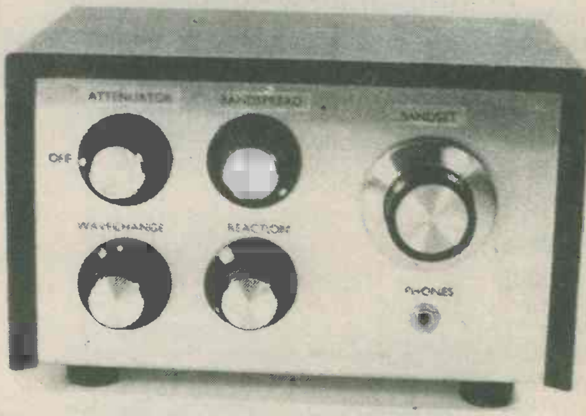

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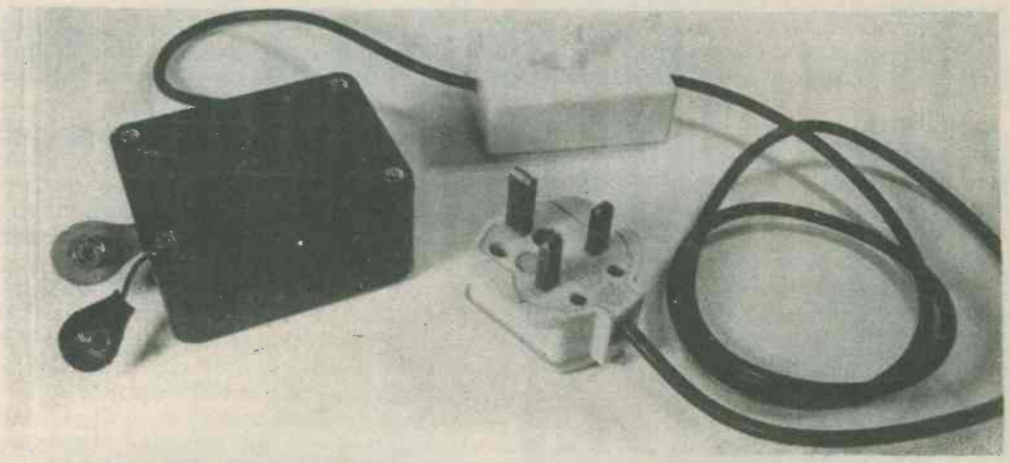

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DESIGNING REFLEX CIRCUITS — Part 1

By Sir Douglas Hall, Bt., K.C.M.C.

Salient features in the design of reflex radio receivers

For anyone to be able to design his own circuits — perhaps the most exciting aspect of our hobby — he must have a basic knowledge of fundamental theory. That is to say, he must not only be able to recognise that a certain symbol represents, say, an audio frequency choke, he must also understand the total effects that this component will have on the circuit. With this yardstick in mind, readers will be able to judge whether the present article is likely to be helpful to them.

REFLEX RECEIVERS

A modern reflex receiver is one in which one or more active semiconductor devices is made to amplify more than once. Usually, one mode of amplification is at radio frequencies and the other is at audio frequencies, but in superhet designs the amplifications may be at intermediate frequencies and at audio frequencies. In the case of short wave superhets, the amplification can be at radio and intermediate frequencies or, even, at all three frequencies.

Reflex receivers were very popular in the early days of broadcasting since they allowed a single valve to amplify at the two separate frequencies, and the valves of the time were expensive and delicate. In addition, each valve drew 1 amp from a 4 volt accumulator as well as h.t. current from a high tension battery of 60 volts or more. There was obviously an advantage to be gained if one valve could effectively do the job of two. The popularity of the circuit fell away when dull emitter valves having lower filament current requirements were introduced. The reflex circuit came back into favour when the first transistors capable of working at radio frequencies appeared as, like the early valves, these devices were expensive and rather fragile. There may seem less reason for using the reflex circuit today now that cheap transistors are available, but components generally are still expensive and a reflex receiver circuit uses far fewer of these than does the superhet. Design experiments are much less costly.

Fig. 1 shows a circuit in common use in the early 20's. John Scott-Taggart employed a similar arrangement, followed by a single amplifying triode, in his famous ST100 design which he described in *Modern Wireless* dated 9th January, 1923. It is known that at least 100,000 of these receivers were made, including one by the author some five years after the article appeared!

It will be seen that the valve amplifies as a tuned anode r.f. amplifier, the cat's whisker type crystal detects (after *very* careful adjustment!), the step-up transformer gives a voltage gain of about 5 times, after which the valve amplifies again, this time at audio frequency. The circuit was surprisingly efficient, and loudspeaker results were possible from the local station with one valve only. Reaction was obtained by inductively coupling the anode and grid coils together by means of a moving coil holder specially made for the purpose.

MODERN CONDITIONS

In designing reflex receivers for modern conditions, various points should be borne in mind.

Fig. 1. Reflex circuits were very popular in the early days of valves as they enabled one valve to carry out the functions of two. In this circuit, dating from the 1920's, the diode is a crystal detector with cat's whisker

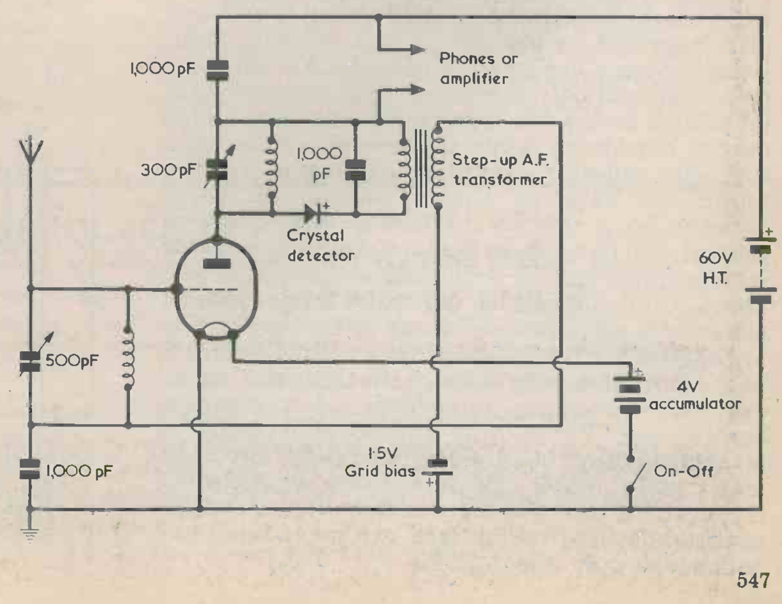
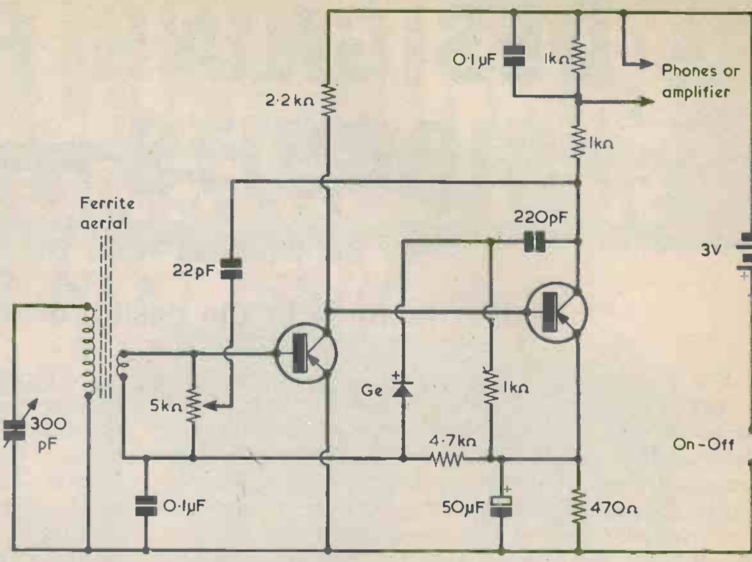


Fig. 2. A popular circuit from the days of low gain germanium transistors. Phasing problems preclude its use with modern transistors.



First, for maximum efficiency and economy the use of two reflexed transistors instead of one is suggested. Next, selectivity is nowadays more important than sensitivity which is, in any case, much easier to obtain. If the receiver is to employ only one tuned circuit, good selectivity requires careful design of circuitry. Should two or more tuned circuits be used, the only advantage of the reflex circuit over the more efficient superhet begins to fall away because of the consequent increased complication and expense. Thirdly, with modern high amplification transistors steps must be taken to avoid low frequency instability due to positive feedback. Precautions here are quite simple if the golden rule is observed that with medium and long wave designs any audio frequency at the output of the second transistor must be out of phase with any signal at the input of the first. In order that this state of affairs can be arranged, it should be remembered that the output of a common emitter amplifier is out of phase with its input, whereas in the cases of both common base and common collector amplifiers the output is in phase with the input.

It is also important to arrange that the output impedance of one transistor and the input impedance of the next should be similar. Much gain can be lost by damping the high output impedance of a transistor by coupling it to a following transistor having a low input impedance. For this purpose it should be remembered that common base amplifiers have a low input impedance and a high output impedance while the reverse applies with common collector amplifiers. Common emitter amplifiers have an output impedance which depends on a number of factors but which, in general, can be taken as medium. Input impedance with common emitter amplifiers also depends on a number of factors and in particular it rises with an increase in amplification factor or the application of negative feedback, and it falls with an increase in the current passing through the transistor. As an example, the input impedance of a common emitter amplifier with an amplification factor of 500 and passing 100μA might in a typical circuit be about 125kΩ, while a device with an amplification factor of 100 and passing a current of 1mA could, in the same circuit conditions, exhibit an input impedance of only about 2.5kΩ.

EARLY DESIGN

Fig. 2 shows a medium wave circuit which was very popular in the late 50's and early 60's. Applying the considerations which have just been dis-

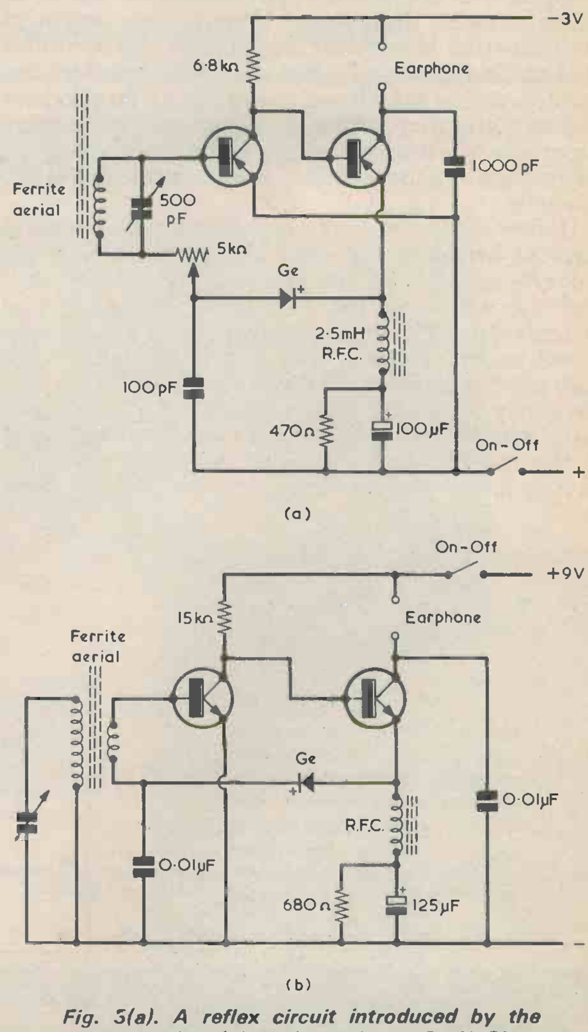


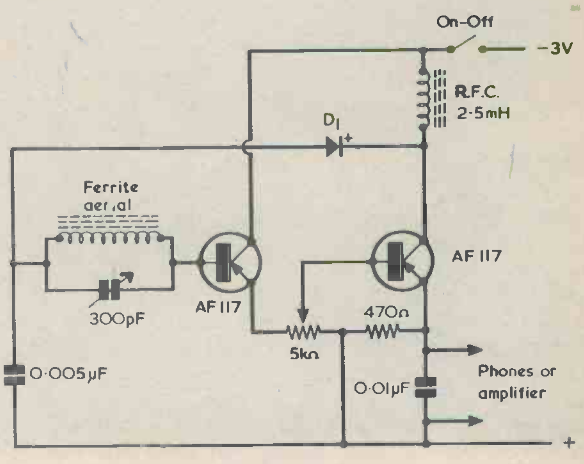
Fig. 5(a). A reflex circuit introduced by the author in 1964 (b). A circuit due to G. W. Short which was published in the January 1968 issue of this magazine cussed it will be seen that TR2 output is in phase with TR1 input. With modern transistors there would be uncontrollable audio frequency instability. But the design used to be fitted with low amplification surface barrier germanium transistors so that stability was usually maintained. Selectivity was poor. In some versions employing more efficient transistors heavy negative feedback was applied to preserve stability.

In the April 1964 issue of this magazine the author introduced the circuit shown in Fig. 3(a). Here, in the reflex loop, a common emitter transistor is followed by a common collector amplifier, so that the output of the pair is out of phase with the input and no low frequency instability problem arises. Also, because the impedance at the emitter of the first transistor is low there is good matching to the diode which does not damp the tuned circuit. The original circuit employed micro-alloy germanium transistors, but an article by the author in the November 1965 copy of this magazine described a modified circuit incorporating silicon transistors. In the January 1968 issue G. W. Short published an article showing his version of the circuit, which appears in Fig. 3(b). It will be seen that basically the two circuits are the same, although the one produced by G. W. Short has conventional coupling to the tuned circuit. Reaction with the circuit of Fig. 3(b) was pre-set by physically orienting the r.f. choke in relation to the tuned coil or by a small twisted wire capacitor from the collector of TR1 back to the tuned coil; whereas the author's circuit offers variable reaction by means of the 5kΩ potentiometer together with appropriate orientation of the r.f. choke. Either circuit will still give good results today, though selectivity will be a problem in areas where there is a powerful local transmitter. Indeed, these circuits give very similar results to those obtained with a ZN414 integrated circuit.

"MINIFLEX"

The circuit shown in Fig. 4 was introduced by the author in the issue of this magazine for June 1968 and has appeared in various forms since, the latest version being called the "M5" and appearing in the copies for April and May 1977. The name "Miniflex" was given to the circuit. All recent versions have employed silicon transistors, and in the "M5" the selenium diode has been replaced by a silicon diode shunted by a 47pF capacitor.

Fig. 4. The author's "Miniflex" circuit, which originally appeared in June 1968



D_1 Selenium diode type M3

In this circuit the first transistor is connected in the common collector mode and the second as a common emitter amplifier. Hence, as in the circuits shown in Fig. 3, the reflex output of the second transistor is out of phase with the input of the first transistor, and complete stability results. Here again, reaction is variably controlled by a potentiometer. The r.f. choke is oriented for proper reaction at the long wavelength end of the waveband. The circuit is sensitive and reasonably selective, and the author prefers it to that shown in Fig. 3(a).

(To be concluded)

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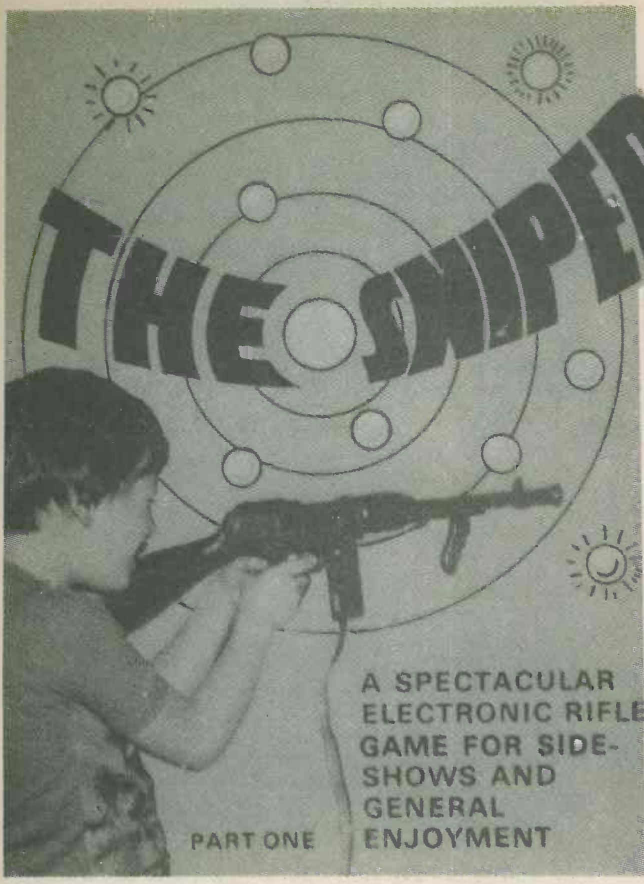

By E. A. Parr

• • •

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ENORMOUS FUN TO PLAY

This project was originally constructed as a fund raising side show for a Cheese and Wine party, but it is also great fun to play at home. The game consists of a machine gun and a target of ten lights, connected by an electronic control box. The lights come on one at a time, the machine gun "sees" the lights via a lens and photo-electric cell and the marksman tries to shoot the lights. The machine gun "fires" ten bullets per second, and hits and bullets are recorded on seven segment displays. The game ends after 80 hits or 800 bullets. In its original use, a prize of a bottle of whisky was given for the least number of bullets for 80 hits, and it provoked quite a needle match to the benefit of our playgroup funds!

There is no age limit in this electronic rifle game. It is ideal for amusing the young

The gun is equipped with suitable sound and visual effects for added realism.

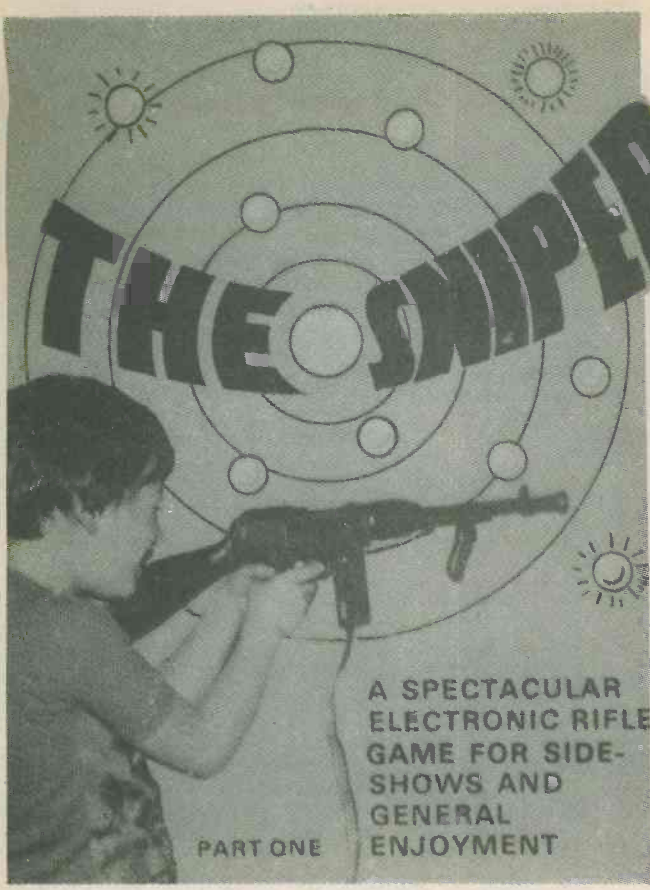
TARGET DESCRIPTION

As just mentioned, the target consists of ten light bulbs. These are 12 volt 2.2 watt m.e.s. types in batten lamp holders mounted in a random pattern on a board measuring about 4ft. by 3ft. Although the lights come on in a fixed sequence it is hard to memorise the pattern, and to the average marksman the display seems random.

The circuit to drive the lights is shown in Fig. 1. IC1 is the ubiquitous 555 connected as an oscillator with a period of about 4 seconds. The 555 output simply steps on a 7490 decade counter, IC3, via IC2 (a). The output of IC3 is decoded by IC4 and used to turn on one of the ten target lights via an open collector inverter and a simple output stage.

With a machine gun firing ten bullets per second, it would be a little bit too easy if the marksman were allowed to saturate the target. When a hit is given, the control logic sends a pulse to IC2 (a) pins 9 and 10 to step the counter. As we shall see, the control logic also inhibits the gun for 0.5 second which covers the slight possibility that the 555 was also pulsing the counter at the same time.

Switch S1 inhibits the stepping of the counter. This is used when the game is being set up in a new location. The stationary target simplifies the setting of the sensitivity of the gun photo-electric cell.



By E. A. Parr

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VERY SUCCESSFUL FUND RAISER

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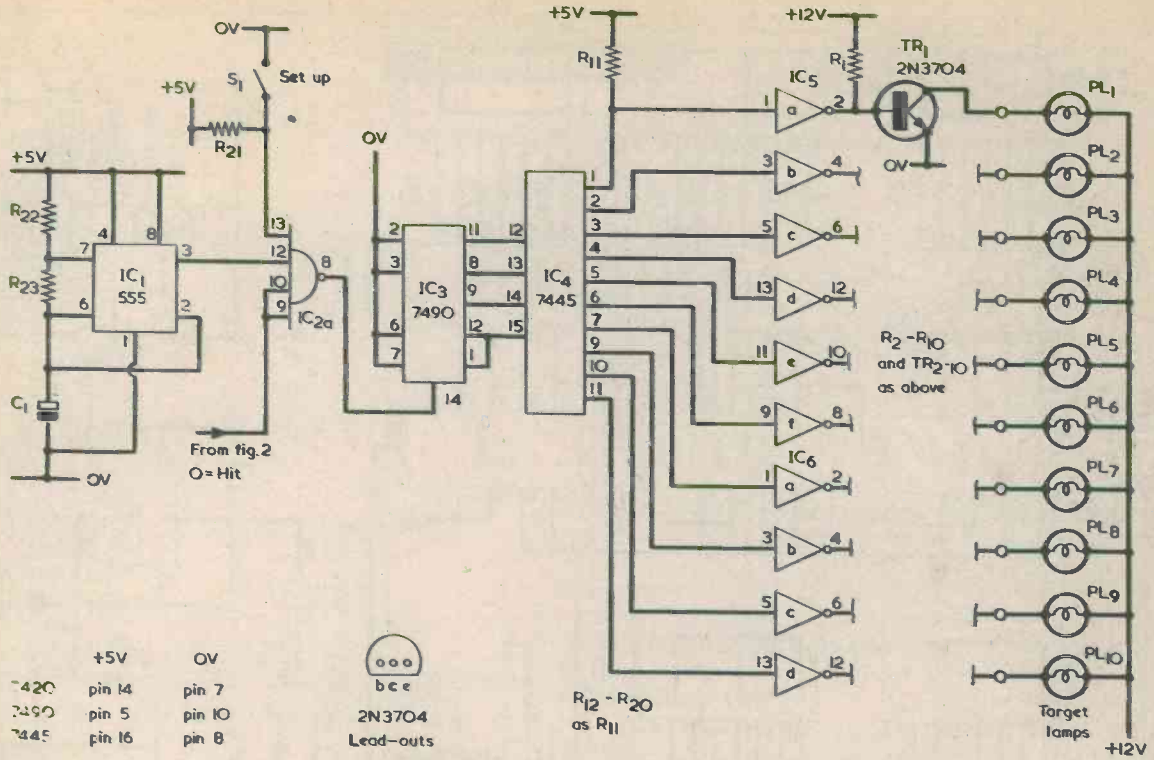


Fig. 1. The target logic

MAIN CONTROL LOGIC

The main logic is shown in Fig.2. Although the target logic and control logic are drawn separately they were, in fact constructed on one board.

The heart of the logic is the hits counter and display (IC12, IC13, IC17, IC18) and the shots counter and display (IC14 to IC16 and IC19 to IC21). These are text book circuits using 7490 counters, 7447 decoders and common anode seven-segment displays.

The machine gun rate is determined by IC1(a), arranged to be a 10Hz oscillator of approximately equal mark-space. The "bullets" produced are gated at IC2(b). IC2 pin 5 input comes from the bounce removing flip-flop IC9(a)(b), and is at a "1" when the trigger is pulled. IC2 pin 2 input inhibits the bullets for 0.5 second when there is a "hit" and IC2 pin 1 input inhibits the bullets when the game is over. These latter two signals will be described later.

The bullet pulses go straight to IC16 pin 14 to increment the shots counter.

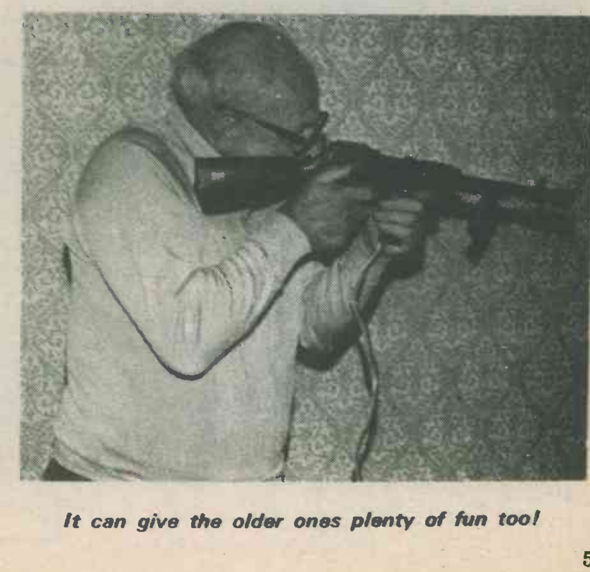
The p.e.c. signal from the gun is nominally at 12 volts positive when the p.e.c. is on target. This is changed to a t.t.l. signal by TR11 and IC7(a). It is then gated with the bullets by IC9(c) to give a "0" pulse for a hit, which steps the hit counter IC13. The same signal also goes to IC2(a) pins 9 and 10 in Fig.1 to step on the lights after a hit.

At the same time the monostable IC10(b) is triggered. This has a period of 0.5 second and serves two purposes. The first is to sound the front panel hit buzzer via TR12. The second is to inhibit the bullets so the target can step on as described previously. The inhibit is done by IC7(d) onto pin 1 of IC2(b). The buzzer is any audible alarm which can be operated by TR12, such as the RS Components audible warning device No. 248-808.

When the circuit was first built, it was found that a race could develop between IC2(b) and IC10(b). This had the effect of counting several hits for one bullet. The race was cured by the addition of C4.

When IC12 pin 11 goes to a "1" (for 80 hits) or IC14 pin 11 goes to a "1" (800 bullets) the output of IC8(a) goes to a "0", inhibiting further bullets, and TR13 lights the "game over" lamp.

The gun effects are produced by IC11. IC11(a) is a simple buffer, and drives a gun l.e.d. This is a large red l.e.d. in the gun body to simulate the gun flashes. IC11(b) is a 400Hz oscillator, swept up and



It can give the older ones plenty of fun too!

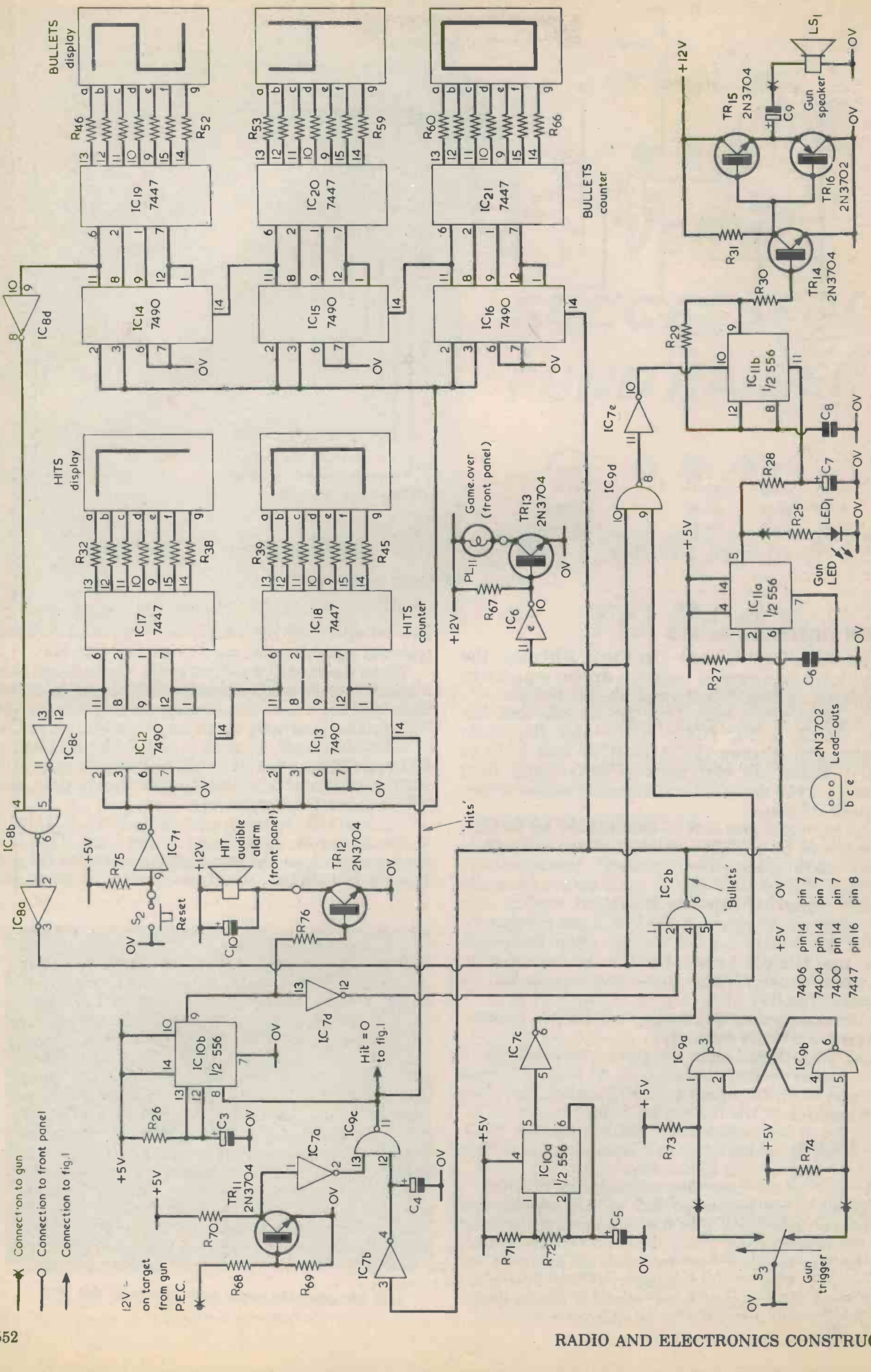


Fig. 2. The main logic. Pin connections to the five 7-segment displays depend on the particular displays employed

COMPONENTS

Resistors
(All fixed values ½ watt 5%)
R1-R10 2.2kΩ
R11-R21 4.7kΩ
R22 100kΩ
R23 1kΩ
R24 10kΩ
R25 120Ω
R26 100kΩ
R27, R28 1kΩ
R29 22k
R30 10kΩ
R31 1kΩ
R32-R66 270Ω
R67 2.2kΩ
R68, R69 47kΩ
R70 4.7kΩ
R71 1kΩ
R72 100kΩ
R73-R75 4.7kΩ
R76 270Ω
R77 2.2kΩ
VR1 500kΩ or 470kΩ pre-set potentiometer, 0.1 watt.

Capacitors
C1 47μF electrolytic, 10V. Wkg.
C2 0.022μF polyester
C3 4.7μF electrolytic, 10V Wkg.
C4, C5 1μF tantalum, 16V. Wkg.
C6 0.01μF polyester
C7 100μF tantalum, 5V. Wkg.
C8 0.1μF polyester
C9 1,000μF electrolytic, 25V. Wkg.
C10 22μF tantalum, 16V. Wkg.
C11 5,000μF electrolytic, 25V. Wkg.
C12 0.1μF polyester
10-off 0.01μF polyester (see text)

Transformers
T1 Mains transformer, secondary 9V at 1A
T2 Mains transformer, secondary 6V at 1A

Displays
5-off 7-segment common anode displays

Semiconductors
TR1-TR15 2N3704
TR16 2N3702
IC1 555
IC2 7420
IC3 7490
IC4 7445
IC5, IC6 7406
IC7 7404
IC8, IC9 7400
IC10, IC11 556
IC12-IC16 7490
IC17-IC21 7447
IC22 15V LAS
IC23 7805
REC1, REC2 silicon bridge rectifier, 1 amp.
LED1, LED2 general purpose l.e.d. red

Switches
S1 s.p.s.t. toggle
S2 push-button, press to make
S3 s.p.d.t. microswitch
S4 d.p.s.t. toggle

Speaker
LS1 miniature speaker, 75Ω

Alarm
Audible warning device (see text)

Fuses
FS1 Cartridge fuse, 500mA
FS2, FS3 Cartridge fuse, 2A

Lights
PL1-PL11 12v 2.2W m.e.s.

Miscellaneous
Gun (see text)
12-core cable
Lens
Stripboard (see text)
11-off m.e.s. batten bulbholders
3-off fuse holders
Interconnection plugs and sockets (see text)

down by the ramp generated by IC11(a), R28 and C7. The ramp is applied to the control voltage pin of IC11(b). The resulting warble is applied to a speaker in the gun by TR15 and 16. Having just seen "Star Wars", the author had a preference for a laser gun! The effects make the gun very satisfying to use.

The "reset" push button sets the bullet and hit counters to zero.

NEXT MONTH

Next month's concluding article will deal with the gun circuit and the gun construction, together with other relevant information.

The full Components List appears with the present article. It will be noted that ten 0.01uF capacitors are listed without C-numbers. These are distributed throughout the circuit as supply bypass capacitors at one per two 74 series i.c.'s. The 15V LAS photo-electric cell is available from RS Components. The prototype logic was assembled on an i.c. stripboard, RS Components No. 433-911. Alternative means of mounting and wiring the components can of course be used. IC23 is a 7805 5-volt regulator, also available from RS Components. It is rated at 1 amp and has an input voltage range of 7 to 25 volts. Switch S3 is a microswitch, such as the RS Components 337-879. (RS Components do not deal directly with individual constructors, and readers will need to order the appropriate parts through a retailer such as Ace Mailtronix Limited, Tootal Street, Wakefield, West Yorkshire, WF1 5JR.)

Details of the gun and lens, etc., will be given next month. Some of the parts in the Components List will also appear in circuits to be published next month.

(To be concluded)

EXCLUSIVE NEW SERIES

TUNE-IN TO PROGRAMS

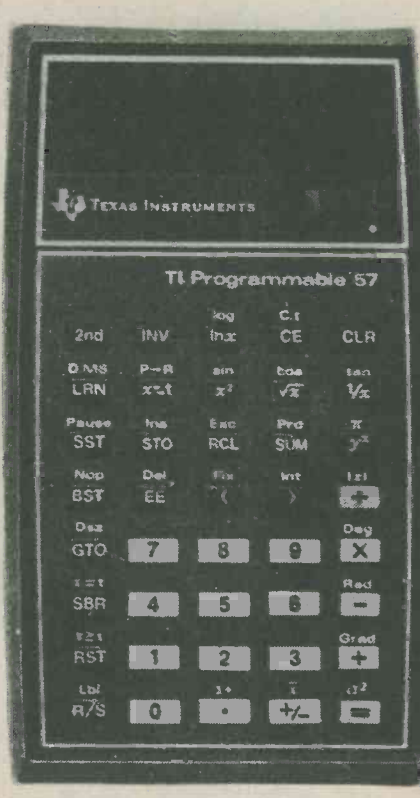
Part 4

by

Ian Sinclair

Take a running jump

Normally, a program progresses smoothly from step 00 through steps 01, 02, 03, and so on to the last step, which is usually the [R/S] instruction. A jump is a step, backwards or forwards, which is out of sequence for some reason. The key on the Texas Instruments TI-57 marked [GTO] ([GOTO] on the PR-100) causes a program to jump in this way, and can also (see later) be used to locate a part of a program.



The keyboard of the Texas Instruments TI-57 programmable calculator. Most keys have a second function, whereupon facilities are nearly double the number of keys provided

LABELLING KEY

When the [GTO] key is used in a program, it must be followed by a number, 0 to 9 on the TI-57, to indicate where the next step is. How does the number tie in with the program? The answer, as far as the TI-57 is concerned, is the labelling key, marked [Lb1], and activated by pressing [2nd] [R/S]. Suppose, for example, we want to find values of the reactance of a capacitor C at various frequencies. Just for the sake of an example, say we want to find the reactance of a 0.01μF capacitor at 1kHz and then at each 1kHz upwards. The formula for reactance of a capacitor is:

$$X_C = \frac{1}{2\pi fC}$$

which is $1/f \times 1/2\pi C$, with only the value of f changing from one calculation to the next.

The program of Fig. 1 does this. The first 7 steps are used to calculate the value of $1/2\pi C$, with the value of the capacitance C stored in memory 1. The value of $1/2\pi C$ is then stored in memory 1 ready for use, replacing the value of C in that memory. The

Program

LRN 2 X π X RCL 1
= 1/x STO 1 Lbl 0
(RCL 2 X 1 EE 3)
1/x X RCL1 =
Pause Pause Pause
1 SUM 2 GTO 0 LRN

Procedure

Enter value of C in μ F,
followed by EE 6 +/-
STO 1 1 STO 2
Fix 2 CLR RST
R/S Read answer on display at each pause.
Test Data: C = 0.01μ F gives first answer 1.59 X 10^4 which is displayed as 1.59 04.

Fig. 1

next step in the program is [Lbl] [0] which doesn't cause anything to happen. As the name suggests, it's just a label, a way of marking a part of the program. The PR-100 uses the step number as a label rather than inserting a label into the program.

The program now goes on to [RCL] [2], taking out of memory 2 the value of frequency which, at the start, is 1kHz. The value of frequency is inverted (giving 1/f), the value of $1/2\pi C$ recalled using [RCL] [1] and the two multiplied to give the value of X, the reactance. This is displayed, with three pauses to give you time to note it down, then 1 is added to the memory store by programming the instruction [1] [SUM] [2]. To calculate the reactance of the capacitor for the new frequency, we do not need to go over the whole program again, we only need the bit concerned with frequency. The next instruction is therefore [GTO] [0], meaning "go to the program step following label 0", which is the calculation of 1/f. The complete program therefore starts by calculating $1/2\pi C$, then 1/f, then multiplies and displays, but does not repeat the calculation of $1/2\pi C$, only the calculation of 1/f and the multiplication, display and increase of f value. Note that the steps [X] [1] [EE] [3] are used following the recall of the f value, so that the value in kHz is converted into values of frequency in Hz, as is needed in the formula. This, of course, could be tidied up by expressing the formula in kHz.

We can, of course, press [R/S] while the answer is being displayed (during the pause) and find out what frequency we've got to by pressing [RCL] [2]. Another press of [R/S] will start the program running again.

A jump made by using [GTO] and [Lb l] is very useful when part of a program has to be repeated. This type of jump is called an unconditional jump, because there's no choice about it: when the program gets to [GTO] [0] it just has to go to label 0. The [GTO] key followed by a two-digit number (such as 01, 07, 14, 26) can be used after the machine has been programmed (and after the[LRN] key has been pressed for the second time) to go to any part of a program, so that a program can be started at any point. More of this sort of thing later.

Even more useful than the unconditional [GTO] jump is the ***conditional*** jump, which enables decisions to be made. Suppose, in the program we've just illustrated, we want to stop the calaculations when f=20kHz. We can program so that the value of f is compared with 20, and when the two are equal, the action stops. The key which does this is [x=t], activated by pressing [2nd] [SBR].

MEMORY 7

To be able to use the [x=t] instruction in a program, we need to have a number stored in the "t" register, which is memory No. 7 of the TI-57. When the step [x=t] occurs in a program, the number in the display is compared with the number stored in memory 7. If the two numbers are equal, so that x=t (x is always taken as the number on the display) then the program goes on to the next step as if nothing had happened. If the two are not equal then the following step of the program is skipped, and it is the step ***after that one*** which is actually used. Suppose, for example, we had the sequence, a very common one, in our program:

[x=t] [R/S] [GTO] [0]

If the number in the display equals the number in memory 7, then the program stops, displaying that number. If the number in the display is not equal to the number in memory 7, then the [R/S] step is skipped, and the next instruction is [GTO] [0], so that the program goes to label 0 and runs on from that point.

This step lets us program the calculator so that it will stop after it has done a pre-arranged amount of work. Let's go back to that program which calculated the reactance of a capacitor for values of frequency in 1kHz steps from 1kHz to 20kHz. A program is shown in Fig. 2, making use of the [x=t] key. The early steps are pretty much the same as we used before, but we are now using a modified formula so that we don't need to change the units of frequency from kHz to Hz. On each run through, we check the value of frequency against the number stored in memory 7. We will enter 20 into memory 7 before we run the program, so that when the number in store 2 is less than 20, the next instruction will be to add 1 to the number in store 2 and then to go to label 0 to start another calculation. When the 20kHz value has been displayed, then the [x=t] instruction ensures that there is no skip this time, and the [R/S] step stops the action of the

Program

LRN 1 STO 2 159 ÷
RCL 1
= STO 1 Lbl 0 RCL 1÷
RCL 2 = Pause Pause
Pause
RCL 2 x=t R/S 1 SUM
2 GTO 0 LRN

Procedure

Enter value of C in μ F
STO 1 Fix 2 20 STO 7
CLR RST
R/S
When the run has finished, the figure 20 will be displayed indicating that 20 calculations have been completed.

Fig. 2

program. We can place the [x=t] step anywhere we like in the program — within limits. The limits are that we must be sure that it does what we want. If, for example, in the program of Fig. 2 we used [x=t] before the value of reactance had been calculated, then we would find that the program stopped before the last calculation.

A slight modification of Fig. 2 is given in the program of Fig. 3.

One of the very useful features of the TI-57 is that a total of four "questions" can be put for a decision. In each case, if the answer is NO, the program skips the next step; if the answer is YES, the program continues normally. The first of these conditional jumps, as they are called, is the [x=t] step which we've just met. We can also use the key sequence [INV] [2nd] [SBR], which is [INV] [x=t], asking the question "is x NOT equal to t?". Two more skips are available from the key [x≥t]. Used by itself (pressing [2nd] [RST]) the question is "is x greater than or equal to t?". When the [INV] key is used (before or after [2nd]) the question is then "is x less than t?"

The ability to test the number in the display in these four ways makes some quite interesting programming possible. PR-100 owners should note that their corresponding key is [SKIP] which will cause the program to skip a step (or two, depending on what the next step is) if the number in the display is negative. This avoids the use of a memory as a test register, but needs some thought in the programming stage. In our example, the frequency value in use would have to be subtracted from 20 before the [SKIP] step operated.

CALCULATING POWER

By now, you should be getting a flavour of the calculating power which the TI-57 and the PR-100 can deliver, so let's look at a program which makes a lot of use of conditional jumps.

Let's suppose that we are working on the resonant frequencies of coils and capacitors. What we want to find are the ranges of capacitors that we can use with given coils to resonate in the range 1MHz to 30MHz — we can, of course, alter the program to accommodate different frequency ranges. We want to be able to enter the coil inductance value, in μH, onto the display, to press [R/S], then see the display give the nearest preferred value of capacitor which will resonate around the upper limit (in this case around 30MHz). Pressing [R/S] again will result in a display of the preferred capacitor value which gives a resonant frequency closest to the lower limit, 1MHz in this case. A real bit of computing magic, this one, and quite a tall order. How do we go about it?

In fact, it would be quite easy if we knew right now what we shall soon know about sub-routines; it's not so easy at our present state of learning. The program (Fig. 4) starts by calculating what value of capacitance is needed to resonate with the amount of inductance at 30MHz. The formula here is $C = 28/L$, with C in pF. This quantity of capacitance is stored in memory 1, and a 1 is stored in memory 0. The division of [RCL] [1] by [RCL] [0] at this stage leaves the value of C unchanged, and the result is stored in memory 7, which is the test register.

The next steps are comparisons of the preferred values 1, 1.5, 2.2, 3.3, 4.7 and 6.8pF with the value of C which is stored in memory 7. Memories 2 to 6 inclusive are used for storing preferred values, the first value of 1 is used directly. If any one of these values in pF exceeds the value in memory 7, the [GTO] [2] instruction causes the value to be displayed. If the final value of 6.8pF is too small, the instruction [10] [Prd] [0] which follows the last [x≥t] step divides the capacitance value in memory 1 by 10, using [RCL] [1] [÷] [RCL] [0] when the program repeats. If the next run through produces a preferred value (now in the range of 10 to 68pF) greater than the value of capacitance stored in memory 7, the

This is a slight modification of Fig. 2. Instead of 20 being displayed at the end of the program, the display flashes to draw attention to the fact that this is the end of the program. This is done by using an impossible instruction; in this case GTO 1 should be GTO 1 with nothing entered under Lbl 1.

Program

```
LRN 1 STO 2 159 ÷
RCL 1
= STO 1 Lbl 0 RCL 1
÷ RCL 2
= Pause Pause Pause
RCL 2 x=t GTO 1
1 SUM 2 GTO 0 LRN
```

Procedure

As for Fig. 2.

Fig. 3

The program aims to find what range of capacitor preferred values will tune a given inductor (value in μ H) between 1MHz and 30MHz.

Program	**Procedure**
LRN 1/x X 28 =	Enter as follows:
STO 1 1 STO 0	1.5 STO 2
Lbl 1 RCL 1 ÷ RCL 0	2.2 STO 3
= STO 7	3.3 STO 4
1 x ≥ t GTO 2	4.7 STO 5
RCL 2 x ≥ t GTO 2	6.8 STO 6
RCL 3 x ≥ t GTO 2	CLR
RCL 4 x ≥ t GTO 2	Enter inductance in μ H
RCL 5 x ≥ t GTO 2	RST
RCL 6 x ≥ t GTO 2	R/S
10 Prd 0 GTO 1	Display shows C in pF for closest to 30MHz
Lbl 2 X RCL 0	R/S
= R/S 889 Prd 1	Display shows C in pF for closest to 1MHz.
1 STO 0 GTO 1 LRN	All C values are nearest preferred values.

Fig. 4

preferred value is displayed by recalling the figure from memory and multiplying by the power of 10 stored in memory 0.

If the values are still too low, the number in store 0 is multiplied by 10 again (equivalent to using capacitors in the range 100 to 680pF) and so on. The final result will be the preferred value of capacitance which is the nearest (on the low side) to that needed for tuning to 30MHz. At the next press of the [R/S] key, the capacitance value in store 1 is multiplied by 889, since this gives the amount of capacitance needed to tune to 1MHz. Memory 0 is returned to 1 again, and the loop of operations starting at label 1 is started again. The same procedure is used, ending with the display showing the preferred values nearest (on the low side) to that needed to tune to 1MHz. The answer is, once again, in pF.

Take your time over this one, it's a much more elaborate program than anything we have done before. The idea is too show just what can be done with these remarkable machines. Next month we'll have a different type of jump operation which is already built into the machine in the form of the [Dsz] key.

Double Deccer Series

We regret that No. 7 in this series, also written by Ian Sinclair, has been held over to next month due to pressure on space.

The article will be ***Sound-Operated Light Switch.***

ENLARGER METER

By M. V. Hastings

Low cost indicator monitors light intensity

This simple enlarger exposure-meter can be built at comparatively low cost and, after initial checks for a particular box of paper, enables the correct exposure to be given without the need for test strips. The unit is actually a light level meter which, for the sake of cheapness, does not incorporate a meter movement. Instead, measurements are taken by adjusting a potentiometer for changeover of illumination in two light-emitting diodes and then reading the relative light intensity from a scale fitted to the potentiometer. The potentiometer is calibrated in arbitrary units from 0 to 100.

The instrument has a range of at least 5 stops. Power is obtained from an internal 9 volt PP3 battery, which should have an adequate life as current consumption is only of the order of 5 to 10mA (depending on the battery voltage itself). A facility for checking battery voltage is provided in the meter.

BASIC PRINCIPLE

The circuit is based on the comparator arrangement shown in Fig. 1. The non-inverting input of an operational amplifier couples to the potential divider consisting of the calibrated potentiometer, VR, and the photocell. The resistance of the photocell reduces as the light falling on it increases in intensity. The inverting input of the op-amp connects to the slider of the pre-set potentiometer, RA.

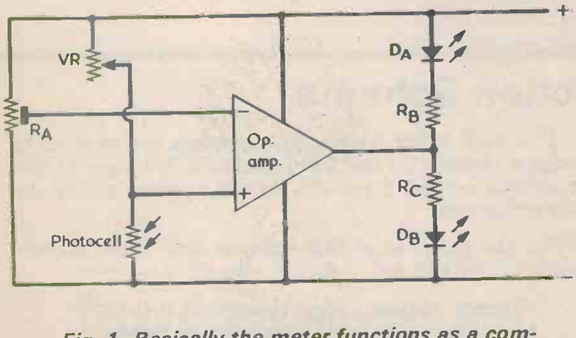


Fig. 1. Basically the meter functions as a comparator, VR being adjusted for equal input voltages to the operational amplifier. Light intensity in the photocell is then indicated by a scale fitted to VR

The output of the operational amplifier couples via RB to the l.e.d. DA and via RC to the second l.e.d., DB. If the voltage at the non-inverting input is negative of that at the inverting input, the op-amp output goes fully negative and diode DA lights up. When the non-inverting input is positive of the inverting input the output goes fully positive and diode DB becomes lit up.

When the photocell is illuminated at the maximum light level which will need to be measured, and with VR set to insert almost minimum resistance into circuit, RA can be adjusted so that the voltages at the two inputs of the operational amplifier are equal, as shown by the l.e.d.'s. If the light intensity falling on the photocell reduces the photocell resistance increases and it is necessary for VR to insert a higher resistance in order to bring the two op-amp inputs to the same voltage. The lower the light level on the photocell, the higher is the resistance which has to be inserted by VR to balance the circuit. As a result, measurements of light intensity can be obtained by first adjusting VR for equal voltages at the op-amp inputs and then reading off the intensity from the scale fitted to the potentiometer.

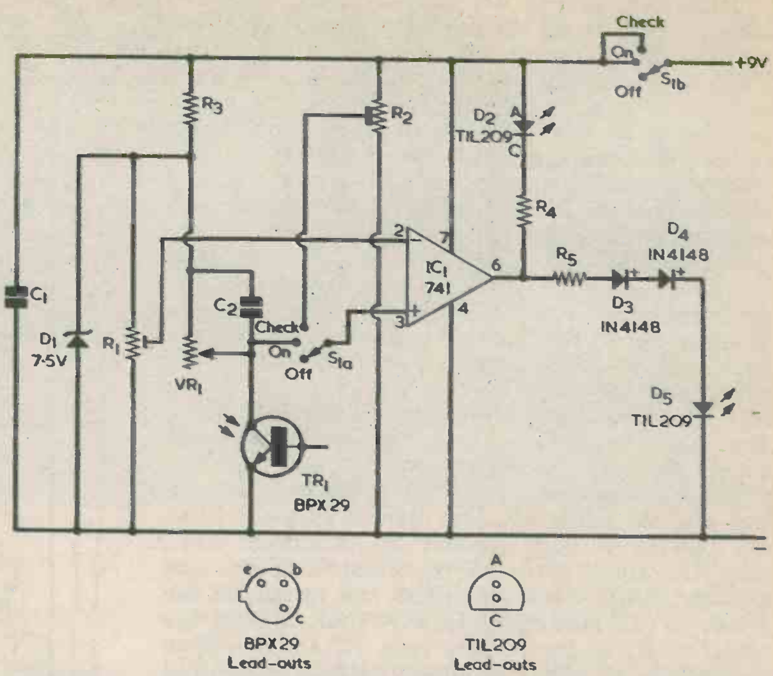
If the operational amplifier had a lower voltage gain it would be possible to adjust the potentiometer so that the output was at a voltage central between the positive and negative rails, with both l.e.d.'s alight at equal brightness. In practice, however, the op-amp has an extremely high gain level and it will be very difficult to adjust the potentiometer to give the precise resistance which results in an output at half-supply voltage level. As the potentiometer slider is adjusted to the balance setting it will reach a point where one l.e.d. abruptly extinguishes and the other lights up. The required balance setting is then that at which the l.e.d. changeover effect takes place.

WORKING CIRCUIT

The complete circuit appears in Fig. 2. This has some additional components, when compared with Fig. 1, to meet practical working requirements.

The main addition is a simple zener voltage stabilizing circuit, employing R3 and D1, which provides a regulated supply to the input networks for the op-amp. This is necessary because the photosensitive device which reacts to light intensity is a phototransistor, and this does not provide a true resistance as does, say, a cadmium sulphide cell because the current it passes does not vary greatly with changes in the applied voltage. However, its response to changes in light level is virtually instantaneous, whereas the decay time of a cadmium sulphide cell to reductions in light level can be as long as a few seconds, a factor which

Fig. 2. The full circuit of the enlarger meter. The balance setting of VR1 is indicated by changeover of illumination in the two l.e.d.'s



COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
- R1 47kΩ pre-set potentiometer, 0.1 watt, horizontal
- R2 47kΩ pre-set potentiometer, 0.1 watt, horizontal
- R3 330Ω
- R4 4.7kΩ
- R5 4.7kΩ
- VR1 2MΩ or 2.2MΩ potentiometer, log.

Capacitors
- C1 0.1μF type C280
- C2 0.1μF type C280

Switch
- S1(a)(b) 4-pole 3-way rotary (see text)

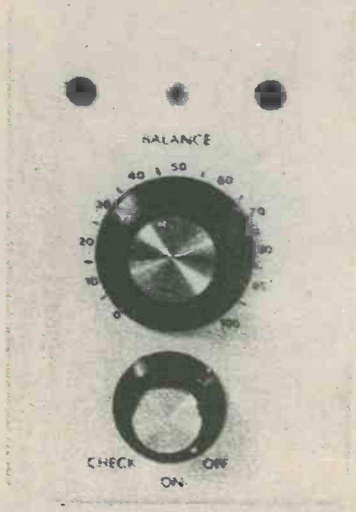
Semiconductors
- IC1 741 in 8-pin d.i.l.
- TR1 BPX29
- D1 BZY88C7V5
- D2 TIL209
- D3 1N4148
- D4 1N4148
- D5 TIL 209

Miscellaneous
- Plastic case (see text)
- 9-volt battery type PP3
- Battery connector
- 2 control knobs
- 2 l.e.d. panel-mounting bushes
- Wire, solder, etc.

would make an enlarger meter employing such a cell rather awkward to use.

No connection is made to the base of the phototransistor which functions purely by controlling the current which flows through its collector and emitter terminals.

If VR1 is adjusted to insert a fairly high resistance when the phototransistor has only a low level of illumination, the resulting high impedance at the non-inverting input of the op-amp could cause this input to be rather prone to stray pick-up of mains hum and similar electrical interference unless suitable precautions were taken. The noise, when amplified by the op-amp could cause both l.e.d.'s to be apparently switched on simultaneously, thereby masking the balance setting of the potentiometer. This trouble is overcome by adding the filter capacitor C2. The capacitor slows down the speed at which the circuit responds to changes in light intensity, but the delay is slight and is not significant.



Front panel layout. The phototransistor is immediately above the balance control, with D2 to its left and D5 to its right

Two silicon diodes, D3 and D4, are connected in series with D5 and they are conductive when the output of the operational amplifier is positive. They are needed because the op-amp output voltage, when fully negative, is still about 2.5 volts positive of the negative rail. Approximately 1 volt is needed across the two diodes before they commence to pass forward current, and their presence ensures that D5 is fully extinguished when the op-amp output is negative.

Putting S1(a) to the "Check" position disconnects the non-inverting input from the phototransistor and VR1, and connects it instead to the slider of R2. This potentiometer is adjusted such that, when the battery voltage is at its lowest acceptable level, the voltages at the inverting and non-inverting inputs are equal and the circuit is at the l.e.d. changeover point. For battery voltages higher than the minimum level the non-inverting input of the op-amp is positive of the inverting input and D5 lights up. The reverse happens when the battery voltage is below the minimum level, and D2 then becomes illuminated. Since the voltage across R1 is stabilized, the voltage at the slider of R2 falls more rapidly than that at the slider of R1 as the battery ages. R2 slider will be negative of R1 slider if battery voltage should fall to the 7.5 volt stabilizing level provided by D1, and will continue to be negative for still lower battery voltages. R2 is, of course, set up after R1 has been adjusted to its final setting.

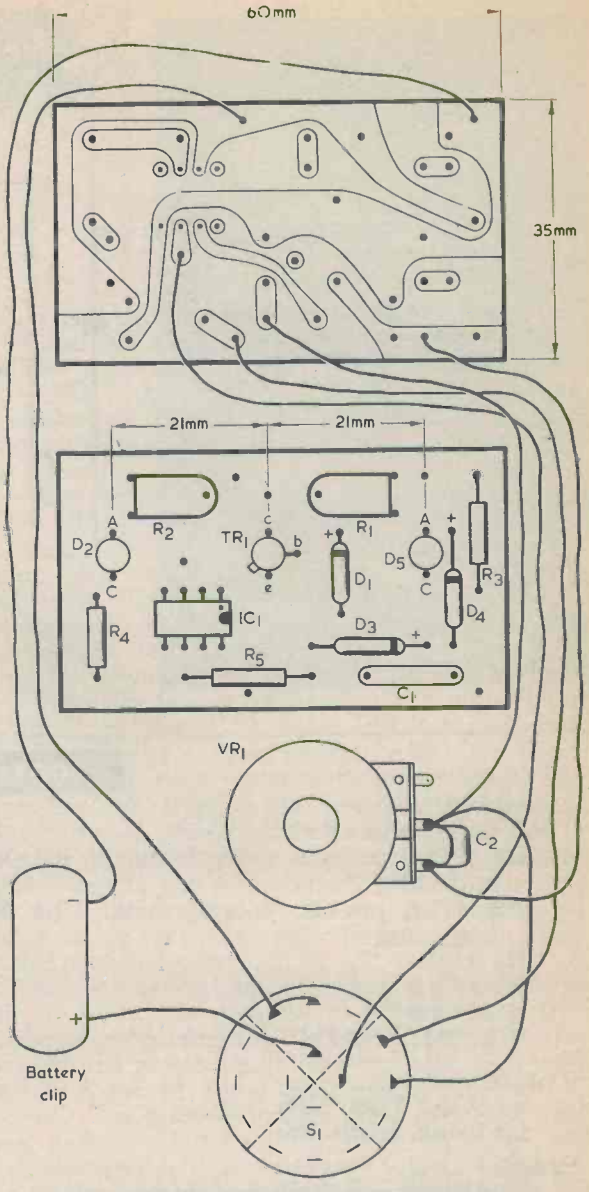
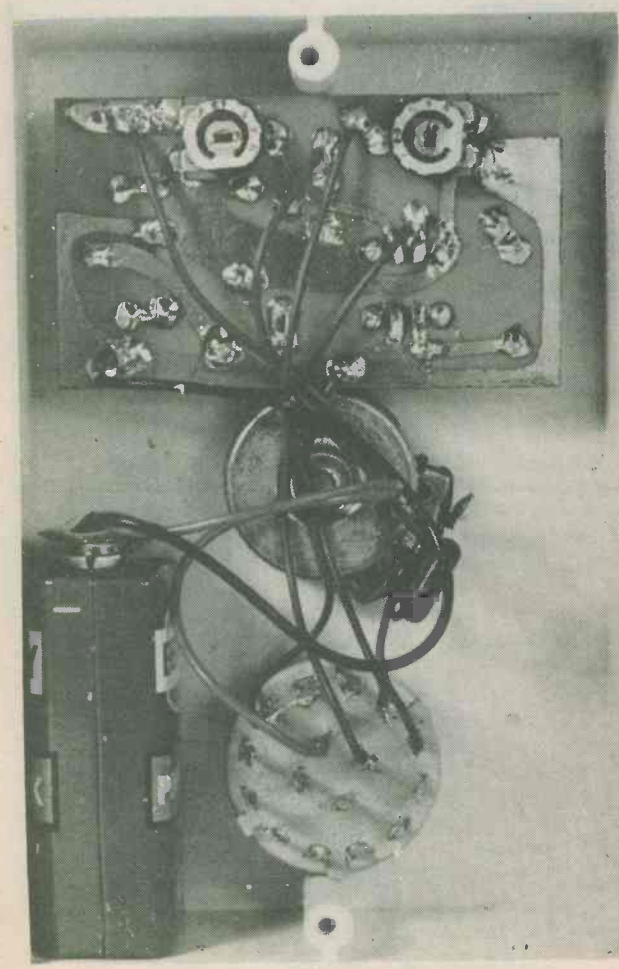


Fig. 3. The enlarger meter wiring. The printed board is reproduced full size for tracing. Note that R1 and R2 are mounted, in practice, on the copper side of the board. For reasons of clarity they are shown here on the component side

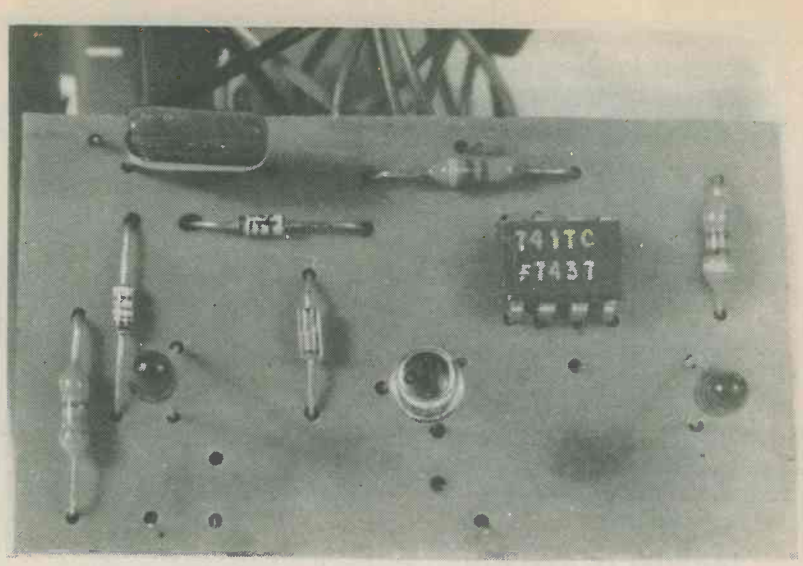


Assembly inside the enlarger meter case. R1 and R2 are mounted on the copper side of the printed board

On-off switching is provided by S1(b), and C1 is the supply bypass capacitor. The BPX29 phototransistor is available from Brian J. Reed.

CONSTRUCTION

An inexpensive plastic box having approximate outside dimensions of 114 by 76 by 38mm. is used for the prototype, this being a box type PB1, as retailed by Maplin Electronic Supplies. Any similar plastic case capable of housing the components would also be suitable. As can be seen from the photograph of the front panel, VR1 is mounted centrally with S1(a) (b) below it. D2 and



The component side of the printed circuit board

D5 appear at the upper end of the panel, with TR1 between them.

TR1 has a standard TO18 encapsulation except for the transparent top which allows light to reach the internal semiconductor material. It requires a 5mm. (0.2in.) diameter hole in the panel. The holes for the two l.e.d.'s should have a diameter which accepts the l.e.d. panel-mounting bushes.

The printed circuit board is reproduced full size in Fig. 3, which also shows the other wiring in the meter. It is important to note that, for clarity, R1 and R2 are shown as being on the component side of the board. In practice, they are mounted on the *copper* side of the board as, otherwise, it would be impossible to adjust them after the board has been fitted in the case. External connections are also made to the copper side of the board.

After the board has been assembled, the l.e.d. centres should be 21mm. on either side of the centre of the phototransistor. The l.e.d.'s and the phototransistor then pass through appropriately positioned holes in the front panel of the case, the board being positioned right at the top of the case with R1 and R2 uppermost. It will probably be found easiest to assemble the board and then mark off the front panel holes with its aid before drilling these holes. The board is light and is quite securely held in place by the panel-mounting bushes of the l.e.d.'s The holes for VR1 and S1(a) (b) should be drilled *after* the mounting arrangements for the printed board have been settled. The hole for VR1 should be positioned so that the potentiometer body is just slightly clear of the lower edge of the printed board when the latter is mounted in position. There is plenty of room below the potentiometer for S1(a) (b), and this should preferably be positioned with its body fairly close to the bottom of the case. Note, incidentally, that this component is a 4-pole 3-way switch with no connections made to two of its poles. Before wiring up to the switch, confirm with a continuity tester the outer tags which correspond to the inner tags. With some switches the tag positioning may differ from that shown in Fig. 3.

VR1 must be a potentiometer with a log and not a linear track and the positive stabilized voltage must be connected to the correct end of the track, as illustrated in Fig. 3. Otherwise only a very restricted part of the scale will be available, making the meter difficult to use satisfactorily. C2 is mounted on the tags of VR1 and not on the printed board.

When the printed board assembly has been completed and finally fitted in the case, VR1 and S1(a)(b) may be mounted and the wiring from these components and the negative battery clip to the board completed. As already mentioned, the associated wires are soldered to the copper side of the board. The PP3 battery is placed to one side of S1(a)(b) and may be held in position by a homemade aluminium clamp. Alternatively, it can be secured by simply placing a piece of plastic foam between its rear edge and the inside surface of the case lid.

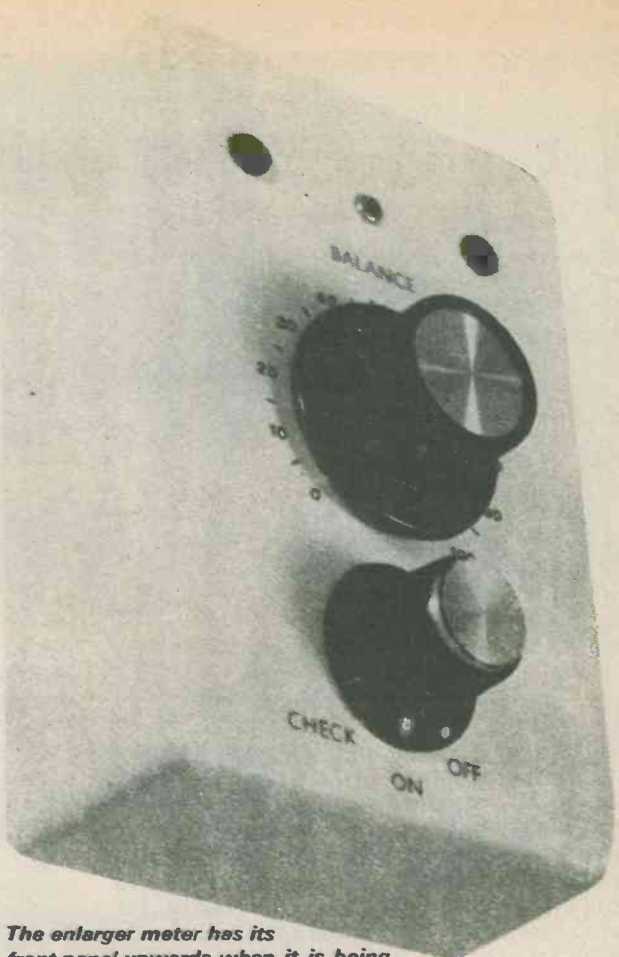
CALIBRATION AND USE

In use the meter monitors the light intensity of the enlarger by being placed on the enlarger baseboard with the phototransistor directed towards the enlarger lens.

It is first necessary to adjust R1 so that VR1 covers the required sensitivity range. Put a negative of average density in the enlarger and adjust it for a medium size print (8 to 10in. long). Place a diffuser, which should have a degree of translucency similar to greaseproof paper, under the enlarger lens and set the lens to minimum aperture. Find a setting for R1 which enables VR1 to balance the meter (i.e. reach the l.e.d. changeover point) when it is close to the anticlockwise end of its range.

Open up the lens one stop at a time and note the new balance settings of VR1. These should be well spread out, although they will not form a linear scale. If cramping of the balance points occurs at one end of the scale, by experimentally setting R1 to either side of its present setting it should be possible to obtain a more equal spacing.

This exercise is merely to ensure that the potentiometer has the required range for measuring the light intensity of the enlarger. Its scale is not marked up with the balance points just found, but is given instead a purely arbitrary linear numbered scale. With the prototype this was from 0 to 100, using numbers taken from "Panel-Signs" Set No. 4 (available from the publishers of this magazine).



The enlarger meter has its front panel upwards when it is being used to assess enlarger light intensity

To find the scale setting for a particular box of paper, first find by test strips the exposure time and aperture required to give a good print from an average negative. With the negative and diffuser in place and the enlarger set to this aperture, place the meter on the baseboard and find the balance setting. Write the corresponding scale number and exposure time on the box for future reference.

In order to find the exposure required for new negatives the meter is put to this setting with the negative and diffuser in position, and the enlarger lens aperture is adjusted to balance the enlarger meter. The exposure time is not altered.

It is possible to use the meter as a spot meter, reading either a highlight or shadow tone as preferred, or as an integrating meter employing a diffuser under the enlarging lens whilst metering. These different methods of use will require different scale settings for any one box of paper. Therefore the scale setting must be determined using the method of metering to be employed to determine the exposure for new negatives.

The final adjustment is to set R2 so that l.e.d. changeover occurs with a supply potential just slightly below 8 volts. Ideally, a variable voltage power supply should be used to provide this voltage, but alternatively it may be given by a partly exhausted battery monitored by a testmeter set to an appropriate volts range. R2 is then adjusted to the l.e.d. changeover point. At battery voltages above the minimum level D5 will then turn on, whilst at lower voltages D2 will be lit up. ■

In your work-shop

VALVE HI-FI AMPLIFIERS

Class A Output, Stages

With a sigh of relief Smithy switched off the music centre on his bench and closed its transparent lid. It had suffered from that most aggravating of all faults: an intermittent. Unexpectedly, the right hand channel would suddenly disappear on occasion, to reappear just as mysteriously several minutes later. It had taken the combined efforts of Smithy and his assistant Dick to finally run the fault, almost literally, down to earth. After determining that no voltage changes occurred anywhere when the fault was present they had embarked on a tiresome and time-consuming procedure of gently flexing the printed boards and tapping possible components until the trouble was finally located. It consisted of an occasional short-circuit between the centre conductor and the braiding of a screened lead connecting to the volume control.

"That," remarked Dick, as he commenced to carry the two speakers over to the "Repaired" rack, "represents at least two hours gone up the chute. And all for a lousy short!"

"I know," repeated Smithy dolefully, "but at least we did replace *something,* even if it was only a bit of screened wire. Sometimes you can spend ages on an intermittent, and you cure it in the end simply by resoldering a dry joint. It's a good thing that nearly everything we handle these days is solid-state. We used to get a lot more intermittents in the old valve days."

VALVE AMPLIFIERS

"Why was that?" asked Dick, as he returned for the music centre itself.

"Simply because valve equipment ran much warmer than semiconductor equipment does. The result was that all the components and wiring used to get good and hot when the equipment was switched on and would then cool down again after it was turned off. The resulting expansions and contractions all over the place meant that any connection which was liable to go intermittent was firmly encouraged to do so. I shudder to think what would have happened if they'd tried to make music centres like the one we've just fixed with valves!"

"I don't know about music centres," said Dick, returning to his stool and perching himself on it, "but the keener hi-fi buffs seem to be getting all het up these days about valves. I picked up a couple of audio mags recently and they both had articles about amplifiers with valve output stages."

Smithy pricked up his ears.

"I've noticed that preoccupation with valves, too," he remarked. "Whats more, I've seen ads for power output valves which are directed entirely at the hi-fi market. I find it an extremely interesting trend."

"What advantages," asked Dick, "do valves have over transistors?"

Smithy stroked his chin ruminatively.

"Well," he said slowly, "there are two obvious advantages which are given by valves when they are used in the output stage of an audio amplifier. The first of these is that if a transistor output stage overloads it produces quite unpleasant distortion. This is simply the effect of clipping and it causes a sine wave to become partly changed to a square wave. When, on the other hand, a valve output stage is overloaded you don't go into an abrupt clipping process. You still get distortion, of course, but it comes on more gently and it doesn't sound so harsh. The second possible advantage with a valve output stage is a matter of fundamental design. A hi-fi valve output stage is run in Class A or Class AB whilst the semiconductor output stage is kept close to Class B. It's impossible to get crossover distortion with the valve output stage, but it's quite feasible, with a poorish design, to get it in the transistor output stage."

"But surely," protested Dick, "the better hi-fi designers would have got rid of transistor crossover distortion effects years ago."

"You're probably right there," admitted Smithy carelessly. "Anyway, another thing in favour of valve output stages is that they're fundamentally very simple in operation. What seems to be happening at the moment on the hi-fi scene is that there's a growing body of opinion which says that the performance of an audio amplifier cannot be judged entirely by laboratory tests, and that it should also be judged by subjective listening tests. You may then find that some hi-fi listeners will state that they prefer a valve amplifier to a transistor amplifier having an identical laboratory specification just because the sound from the valve amplifier is 'rounder' or has a higher level of 'musicality'."

VALVE BIASING

"Blimey," snorted Dick, "that's pretty vague, isn't it? What do *you* think about it?"

"To be quite honest," replied Smithy, cautiously, "I haven't got a very firm opinion either for or against the value of subjective amplifier tests. I think that the best way to look upon a hi-fi installation is to say that it is a musical instrument in its own right. It is obviously impossible for a hi-fi system to exactly reproduce, say, a symphony orchestra spread over a large stage because all the hi-fi loudspeakers can do is reproduce composite signals made up from the sound-creating instruments in the orchestra. This doesn't, of course, prevent a hi-fi outfit from producing quite superb music. As there are no end of electronic, electrical and often mechanical links between the original orchestra and its loudspeaker reproduction, it would seem reasonable to judge the loudspeaker copy of the original sound by subjective checks as well as by electronic measurements. The argument is that since the hi-fi amplifier is one of the links in the chain then it should be given subjective listening tests."

"It's funny," said Dick, "why there's such a lot of controversy at present amongst hi-fi people."

Smithy chuckled.

"My dear Dick," he grinned, "there has *always* been controversy amongst hi-fi people! Even in the old days before the word 'hi-fi' started to be used there were still arguments raging about audio reproducing equipment."

Dick absorbed this information.

"Let's go back to valve output stages," he said after a moment. "I have to admit that I'm not entirely clear about this Class A and Class B business."

"All right," said Smithy equably. "Since there is an increasing interest at present in hi-fi output stages, it will do no harm at all to go into the old basics under which these stages operate."

He reached over and pulled his note-pad across the bench towards him. Picking up a pencil he quickly traced out a valve curve. (Fig.1(a).)

"Now here," he continued, "is a curve showing valve anode current plotted against grid voltage. To use

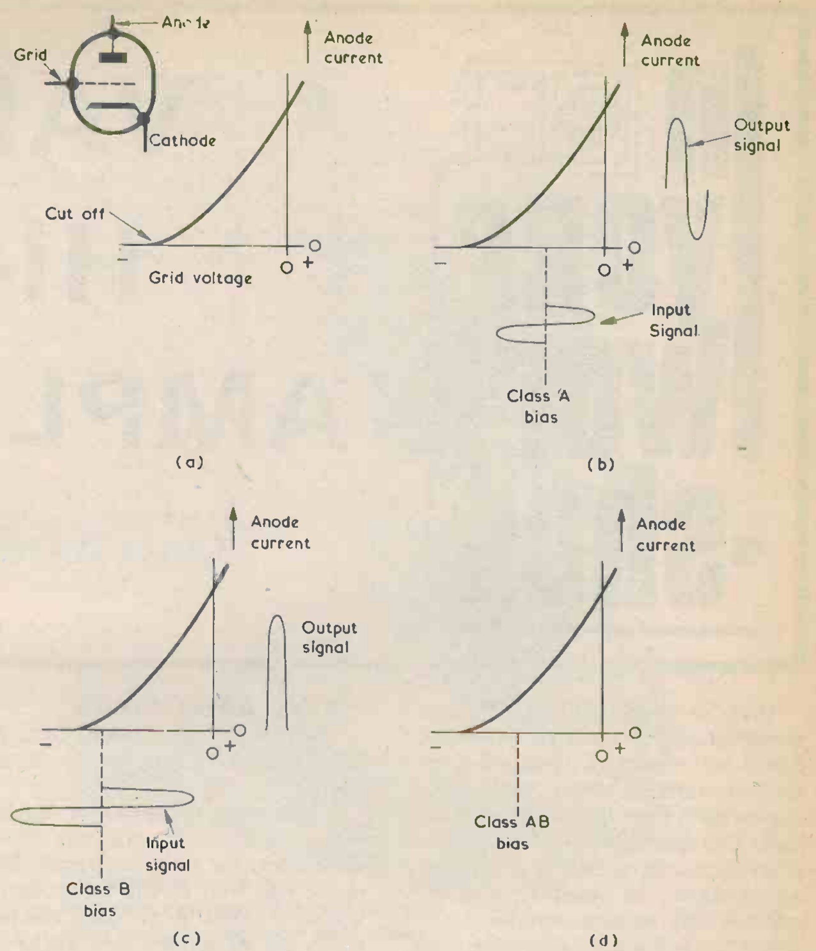


Fig. 1(a). An anode current-grid voltage curve for a valve
(b). With Class A operation the grid bias is approximately at the centre of the linear section of the curve
(c). The Class B bias point is at or very close to the cut-off point
(d). Class AB bias is roughly mid-way between Class A and Class B

the proper terms we say that it is an Ia-Vg curve. The grid voltage is relative to cathode potential and I hardly need to tell you that anode current decreases as the grid goes more negative. The grid normally has a fixed bias which keeps it negative of the cathode and things are usually arranged such that the positive signal input half-cycle peaks do not take it positive of the cathode, although in some circuit designs this can happen. When the grid goes positive of the cathode it acts like the anode of a diode and a current flows just as it would in a diode. Now, here's the bias condition for Class A."

Smithy added a broken line, together with an input and output waveform. (Fig.1(b).)

"That bias," remarked Dick, "is just about mid-way between zero grid volts and the cut-off point."

"That's right," concurred Smithy. "The input voltage waveform will normally not extend beyond the zero grid voltage or the cut-off voltage points, whereupon the resulting anode current waveform is a fairly undistorted version of the grid voltage waveform. I'll do Class B next."

Smithy rubbed out the waveforms on his sketch and added new ones. (Fig.1(c).)

"This time," he remarked, "the bias point is very near to cut-off. Nearly all the anode current waveform is then that which results from positive half-cycles at the grid."

"Gosh," remarked Dick. "That anode waveform is really distorted. What's this Class AB business you mentioned just now?"

"That's a bias setting which is roughly mid-way between Class A and Class B," stated Smithy. "Like this."

He busied himself again with his eraser and pencil. (Fig.1(d).)

"How," queried Dick, "does the valve work when it's in Class AB?"

"It gives Class A amplification for small signals," replied Smithy, "and a mixture of Class A and Class B amplification for strong signals. Just for the sake of completeness I should add that, with valves, Class AB operation can be subdivided into Class AB1 and Class AB2. Class AB1 is Class AB working in which grid current doesn't flow on positive half-cycle input peaks. Class AB2 is given when grid current *is* allowed to flow. A high power valve amplifier could use Class AB2, but it wouldn't be used in a high fidelity amplifier. Fair enough?"

PUSH-PULL OUTPUT

"I think so," said Dick doubtfully, "but nothing you've told me up to now has convinced me that valves can be better than transistors in an audio amplifier output stage."

"That's because you haven't got the complete picture yet," said Smithy. "Now, one disadvantage with valves of the type which are used in audio amplifier output stages is that they can only work with anode load impedances of the order of 2 to 8k Ω, depending upon the particular valve used. So they've got to have a step-down iron-cored transformer to match the anode to the speaker. Transistor output stages don't have this snag because they can work directly into the low impedance of the speaker. Also, for true high fidelity output, the valve output transformer has to be carefully designed to give a very tight coupling between its primary and secondary at all audio frequencies and, preferably, for a fairly wide range of frequencies above the audio spectrum as well. Because of all this, a good hi-fi valve output transformer is a pretty heavy and hefty bit of work, and is correspondingly expensive."

"What you're saying," complained Dick, "seems to be aimed *against* valve output stages rather than towards them."

Smithy held up a finger.

"Ah," he remarked brightly, "but, having accepted the necessity for a valve output transformer we can next make a virtue out of that necessity by using it in a delightfully simple push-pull output stage. Like this."

Once again, Smithy's pencil moved busily across his note-pad, as he traced out the push-pull circuit. (Fig.2.)

"What's the first valve in this circuit of yours?" asked Dick, pointing to the triode at the left of Smithy's sketch.

"It's a phase-splitter," explained Smithy. "The input signal is applied to its grid and when this goes positive the triode passes increased anode and cathode current. The result is that its anode goes negative and its cathode goes positive. The opposite happens when the signal at its grid goes negative, and the overall effect is that the signals passed to the grids of the two output valves are in anti-

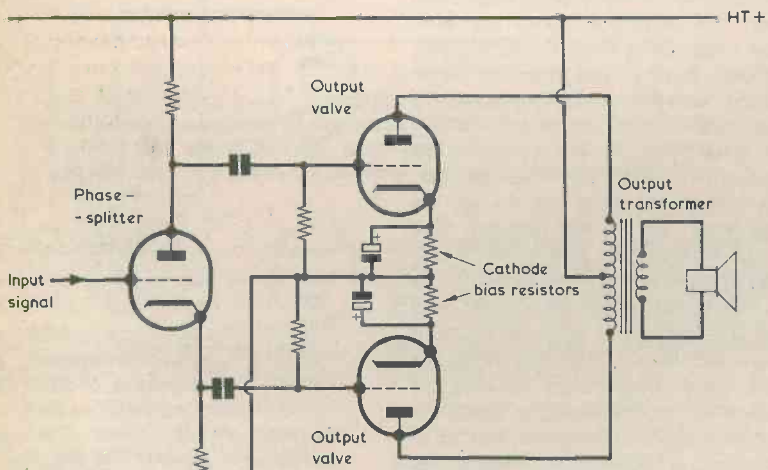


Fig. 2. A standard Class A or Class AB valve output stage. The valves are shown as triodes for simplicity, but in practice they would usually be tetrodes or pentodes

phase. There are, incidentally, quite a few alternative phase-splitter circuits employing valves, but the one I've shown here is the easiest to understand. The anode and cathode load resistors for the phase-splitter have equal values, so that the out of phase signals passed to the output valve grids are equal in amplitude."

"The two output anode signals will also be out of phase, won't they?"

"They will," confirmed Smithy, "and the anodes are applied to the opposite ends of the centre-tapped primary of the output transformer. The output valves are biased by way of the resistors between their cathodes and chassis. These resistors drop a small voltage which makes each cathode positive of the grid, which is the same, of course, as biasing the grid negative of the cathode. This form of biasing is all right for Class A or Class AB operation, but it couldn't be used for Class B operation. With Class B operation the cathodes would connect direct to chassis and the grids would be biased negative by a specially produced fixed voltage."

"Could you use Class B with that push-pull circuit?"

"Oh yes," said Smithy. "One of the output valves then handles the positive-going signal half-cycles going to the phase-splitter grid and the other handles the negative half-cycles going to that grid. The two lots of anode half-cycles recombine in the output transformer and the complete signal then appears in the secondary for application to the speaker. The effect will be similar to a transistor output stage having an input driver transformer and an output speaker transformer, the only difference being that the driver transformer replaces the valve phase-splitter." (Fig.3.)

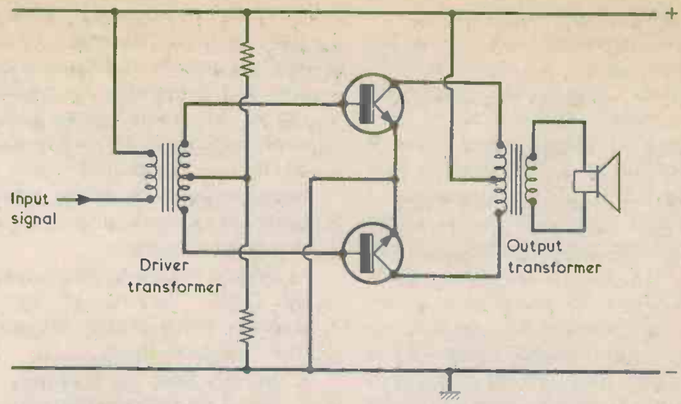


Fig. 3. A familiar Class B transistor output stage using transformers. The two resistors bias the transistors so that they pass a small quiescent current

"Stap me," exclaimed Dick, "why, of course, the two circuits are the same! I should have seen it at once — I've handled enough transistor output stages in my time! what's the advantage of a valve Class B output stage, Smithy?"

"The same as it is with a transistor Class B output stage. You get maximum efficiency in terms of audio power output compared with the power supplied to the output stage. Also, there is minimum heat dissipation in the output valves. Even at maximum output power, each valve is only passing anode current for about half the time."

HI-FI OPERATION

"Would a Class B valve output stage be all right for a hi-fi amplifier?"

Smithy seemed almost shocked at the idea.

"Oh no", he replied. "Class B would be okay for a public address amplifier handling speech, but it would never do for a hi-fi valve amplifier. One reason is that you're liable to get crossover distortion, just as with a Class B transistor output stage, but the main reason is that Class A and Class AB valve operation offers specially good working conditions which are not given with Class B working. For a kick-off, let's suppose that the two output valves are nearly identical in characteristics and that they are biased in Class A. They will both draw a standing current from the positive h.t. supply, even in the absence of a signal. The combined anode current flows first from the h.t. positive rail to the output transformer primary centre-tap, and then the separate anode currents flow in opposite direction to the two anodes. Both valves draw the same anode current and the standing magnetic field produced by one half of the primary is exactly cancelled out by the standing magnetic field produced by the other half of the primary. The result is that the iron core of the transformer is not magnetised at all by the standing anode current, and the transformer is able to function more efficiently. The only time the core gets magnetised is when a signal comes along, and then the two anodes feed the outside ends of the primary with signals of opposite polarity." (Fig.4).

"I don't see how that gives any advantage over Class B operation," stated Dick, critically. "With Class B operation the standing anode current is quite small and the transformer is still called upon to handle signal currents only."

Smithy threw a sharp glance at his assistant.

"That's a very good point," he remarked. "And you're quite right in what you say. With Class B working, though, you don't get the symmetry of operation that you get with Class A, where both output valves are handling the signal all the time. With Class A operation, too, non-linearity in one valve tends to be cancelled out by the similar non-linearity in the other, giving much less distortion than would be given if one valve were used in a single-ended output stage on its own. Indeed, when the valves are identical any even harmonics produced by them cancel out in the

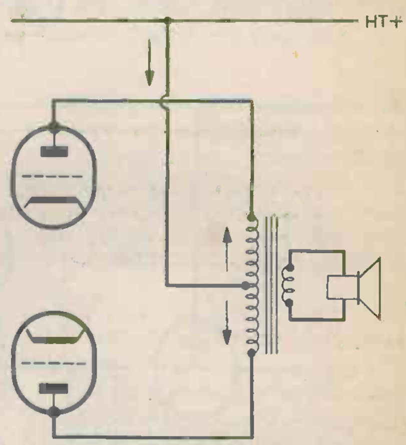


Fig. 4. In a class A or Class AB valve push-pull output stage, anode current flows from the h.t. positive rail to the output transformer primary centre-tap, after which it flows in opposite directions in the two halves of the primary. ("Conventional" current, flowing from positive to negative, is assumed here)

transformer primary. Unfortunately, the same cancellation effect is not given with odd harmonics."

"Are there any other cancellation effects?"

"There are two more. If there is any power supply ripple on the h.t. positive rail the ripple current flows through the two halves of the transformer primary in opposite directions, whereupon it cancels out in the primary. In the reverse direction there is a cancelling effect to the h.t. positive rail with the anode signal currents because the anode currents of the two output valves add up to what approaches a constant value even when they are handling a signal. This reduces power supply decoupling requirements."

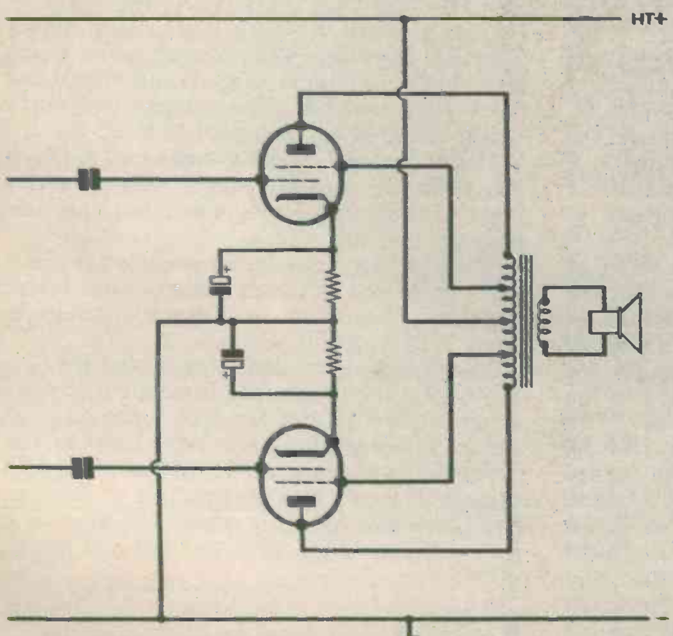


Fig. 5. The "ultra linear" output stage uses two tetrodes with their screen-grids connected to additional taps in the output transformer primary. The circuit has also been used with pentodes, the screen-grids of which are similarly connected to the transformer primary taps

ULTRA-LINEAR

"I'm beginning to see why these valve output stages are becoming more and more popular with hi-fi addicts," pronounced Dick. "They certainly have some features that you don't find with transistor output stages. You've shown triodes in your circuits up to now. Are these the only types of output valve which could be used?"

"I showed triodes purely for reasons of simplicity," replied Smithy. "In practice, the output circuits would use tetrodes or pentodes, which offer much higher output powers than triodes do. Unfortunately, they tend to give more distortion. And this is where a special circuit, which first saw the light of day in the early 1950's, comes into play. It's known as the 'ultra-linear' output circuit. Here it is."

Smithy picked up his pencil and drew a further circuit on his note-pad. (Fig.5.)

"And that," he stated cheerfully, "is the last output stage circuit I'll draw for you today. The ultra-linear output stage uses tetrodes, and their screen-grids are connected to taps in the transformer primary which are roughly mid-way between the centre-tap and the outside ends, being slightly closer to the centre-tap than the ends. This very simple circuit alteration results in an output audio power which is very nearly as high as would be given by the tetrodes in a normal circuit, whilst the distortion level is of the order of that given by triodes. Beautiful, isn't it?"

"I'll say," agreed Dick, looking at the circuit enthusiastically. "How about negative feedback?"

"That depends upon the amplifier design," said Smithy. "The standard approach here is to take feedback from the secondary of the output transformer and apply it to the cathode circuit of an early valve in the amplifier. But there can be many variations on this theme." (Fig.6.)

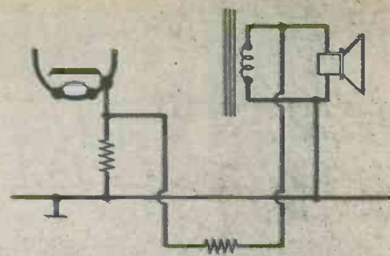


Fig. 6. A common method of obtaining negative feedback is to couple the output transformer secondary back to the cathode circuit of an early valve in the amplifier chain

"If valve hi-fi amplifiers are potentially so good," remarked Dick, "why did they become replaced by transistor hi-fi amplifiers?"

SNAGS WITH VALVES

"Because of the snags," said Smithy. "To start off with, there's that expensive output transformer which I've already mentioned. Then the output circuits are all in Class A, or in Class AB1 if a little more output power is required, which makes them very inefficient. For example, a 20 watt mono amplifier could require an h.t. supply of around 400 volts at 150mA, which means that there's 60 watts of h.t. power going in for 20 watts of audio coming out. The power consumed by the valve heaters could well add another 20 watts or so to the power input. So the mains transformer needed to power the amplifier will be pretty bulky and expensive, too. And we're only talking about a mono amplifier. The power supply requirements would be doubled if we wanted two amplifiers for a stereo system. Again, valves aren't like transistors because their characteristics vary with age. Add to all these points the fact that the valve amplifier is heavier and larger than its transistor equivalent and you can see why commercial production of hi-fi equipment had to change over to semiconductors. But it's nice to see that some of the true high fidelity enthusiasts are prepared to put up with all these difficulties with valves if they consider that the end result is a better sound. One thing is certain and that is that it will be well worthwhile keeping an eye on the future development of high fidelity valve amplifiers."

"They're certainly in a class of their own," agreed Dick. "Class A, in fact!" ■

SHORT WAVE NEWS
FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

● LAOTIAN QUEST

Signals from the Far East have been coming through quite well on the odd occasions over the past couple of months. Some of them — received at the tail end of the 'season' — are listed in this article, but the real search has been that for Laos on the LF bands. An account of that follows.

When deciding to 'listen out' for local or regional stations in any particular country, one must first collate the facts concerning such transmitters, secondly choose the most favourable time for reception here in the U.K., and then listen on a regular basis. The collated facts are listed below with the results achieved — or not achieved — mostly the latter!

Two stations in the Domestic Service open at 2230 (around the best time for reception of Laos here in the U.K. during the period October to February inclusive), these being Vientiane on **6130** and Udomsai on **6910**. Both channels are hopeless, the former is in a broadcast band and the latter is covered by commercial QRM. The remainder open at 2300, these being Xieng Khouang on **4757** and **6675** (nothing but utility QRM although the former channel showed promise at times — but no Laos); Savannakhet on **7385** (surrounding QRM — no Laos); Pakse on **6600** (thought to be promising but military music and announcements in English, with time-check, at 2300 proved it was Moscow with the all-English programmed World Service — presumably an internal relay — it was using Russian some nights later); Luang Prabang on **4703** (no results after many attempts). Lastly there is Houa Phan on **4657** and **6198**, the latter channel would be hopeless and was ignored but the former did produce very weak signals on two occasions in December when conditions were very good for reception of the area. At 2300 there were announcements, at 2305 YL with an Asian-type song, local-type music, the signal (such as it was) being lost under QRM at 2315. Was it Laos? I don't know, I didn't get any positive identification, so must list it as a tentative reception and try again.

● MEXICO

Radio Mexico on **15385** at 2315, OM with love song in Spanish, YL with announcements.

● SAUDI ARABIA

Riyadh on **11685** at 1855, OM with the Holy Qur'an Service (religious chants), scheduled here from 1800 to 2100 (at the time of writing!).

● NORTH KOREA

Radio Pyongyang on a measured **6401** at 1958, tuning signal repeated, identification in Korean and the National Anthem in the opening of the Korean Service to South Korea and Japan (in the External Service). This transmission is scheduled both here and on a logged and measured **6251** from 2000 to 1800. The former frequency is the better channel for listeners here in the U.K.

Radio Pyongyang on a measured **6338** at 1713, YL with the Arabic programme for Africa, the Near and Middle East, scheduled here from 1700 through to 1900.

Radio Pyongyang on a measured **6576** at 1720, OM with the French programme directed to Europe (discussion in French), scheduled here from 1700 to 1850.

Radio Pyongyang on a measured **9977** at 1536, YL with announcements in English in the English programme intended for Africa, the Near and Middle East, scheduled here from 1500 to 1650.

Radio Pyongyang on **11350** at 1532, OM with a song in Korean in a programme of local music in the Domestic Service, scheduled on this channel from 0400 to 0900, 1500 to 1800 and from 2000 to 0300.

● CHINA

Radio Peking on **11040** at 1410, YL with the Kazakh programme in the Domestic Minority Language Service, scheduled here from 1400 to 1455.

Radio Peking on **11455** at 1734, Chinese orchestral music in the Cantonese programme directed to S.E. Africa and S.E. Asia, scheduled here from 1700 to 1800.

Radio Peking on **9860** at 2310, OM with the Spanish programme to South America, scheduled from 2300 to 2400.

Radio Peking on **11980** at 2337, YL with the programme for Laos, scheduled here from 2330 to 2400.

Radio Peking on **7050** at 2232, YL and OM in Portuguese to Brazil, scheduled from 2200 to 2300.

Radio Peking on **17650** at 1143, YL in Thai to Thailand, the programme being scheduled here from 1130 to 1200.

PLA Fukien Front on **4380** at 1727, OM in Chinese with the programme for Taiwan in the Network 2 service, scheduled here from 0230 through to 1900.

CPBS Peking on **4460** at 2140, OM with a talk in Chinese in the Domestic Service 1 programme, scheduled here from 1103 to 1735 and from 2000 to 0020.

CPBS Peking on **7935** at 1423, Chinese opera in the Domestic Service 1 programme, scheduled from 1323 to 1735 and from 2000 to 2330.

CPBS Peking on **11000** at 2342, YL with programme for Tibet in the Domestic Minority Language Service, scheduled here from 2330 to 0025.

CPBS Peking on a measured **8007** at 2226, YL in Chinese in the Domestic Service 2 scheduled here from 0700 to 1600 and from 2100 to 2400.

● CHINA — REGIONALS

CPBS Lanzhou, Gansu, on **4865** at 1510, Chinese music, YL with a song, OM and YL announcers. The schedule is from 0320 to 0600, 1000 to 1600 and from 2120 to 0100 (Sunday to 0600).

CPBS Nanning, Kwangsi, on **4905** at 1517, OM in Chinese in a relay of Peking Domestic Service 1. The schedule is from 2000 to 2200 (from May to October from 2000 to 2300 and from 1100 to 1735).

CPBS Wuhan, Hupeh, on **3940** at 1534, YL and OM in a Chinese drama. The schedule is from 0850 to 1605, 2100 to 0100 and from 0300 to 0740.

S. KOREA

Seoul on **9870** at 1333, OM with a newscast in English followed by "News Highlights of the Past Week" in the English programme for Europe, scheduled from 1330 to 1400 on this channel.

● THAILAND

Radio Bangkok on a measured **4830.5** at 1549, OM's with a discussion in Thai. The schedule is from 2200 to 1600 and the power is 10kW but frequency can vary to **4833.**

● MONGOLIA

Ulan Bator on a measured **4763** at 2200, opening with the Mongolian National Anthem, OM and YL announcers in the Domestic Service 1st Progamme, scheduled here from 1054 to 1500 and from 2200 to 0100. Also logged in parallel on **5055.**

● SAUDI ARABIA

Riyadh on **21505** at 1320, Arabic music in the Domestic Service scheduled here from 0730 to 1700.

● MADAGASCAR

Radio Nederland Relay on **21480** at 1402, OM with the Dutch programme to S.E. Asia, scheduled from 1330 to 1425.

● NEPAL

Radio Nepal, Khumaltar, on **3425** at 1518, local music (flute-like instrument and drum), YL with announcements at the end of the English programme "Thanks for listening and good night" followed by a trumpet fanfare. The schedule is from 0020 to 0350 (Sundays until 0450) and from 1150 to 1720. English programmes are radiated from 0220 to 0230 and from 1435 to 1520. The power is 100kW. Also logged in parallel on **5005.**

● INDIA

Radio Kashmir, Srinigar, on a measured **3277** at 1526, OM's with a discussion in vernacular in the Domestic B Programme, scheduled from 0130 to 0200 and from 1130 to 1705. The power is 7.5kW.

AIR Lucknow on **3205** at 1528, YL with announcements in Hindi followed by the news in English at 1530. The schedule is from 0025 to 0215 and from 1140 to 1830, the power is 10kW.

AIR Bombay on **4840** at 1735, OM with local songs, Indian music in the Domestic B Programme, scheduled here from 0230 to 0400 and from 1230 to 1830, the power being 10kW.

AIR (All India Radio) Hyderabad on **4800** at 1740, OM with songs, local music in the Domestic A Programme, scheduled here from 1200 to 1830 with a power of 10kW.

AIR Delhi on **4860** at 1740, local songs and music in the Home Service, scheduled here from 0245 to 0400, 1030 to 1215, (Forces programme from 1235 to 1315), 1445 to 1830 with English newscasts at 1430 (Sunday), 1530, 1730 and at 1800.

AIR Hyderabad on **4800** at 1545, YL with a newscast in English followed by OM with a current affairs talk in English. The schedule is from 1200 to 1830 ('A' Programme Service) and the power is 10kW.

AIR Delhi on **3365** at 1550, OM with the news in English in the 'A' Programme, scheduled from 0025 to 0230 with a power of 10kW.

● VIETNAM

Hanoi on a measured **4944** at 1521, local music, OM with songs in Vietnamese in the Home Service 1, scheduled here from 2055 to 1630 (English programme from 2130 to 2145) but the frequency can vary up to **4950.**

Hanoi on **10040** at 1823, YL with the English programme to Europe, scheduled from 1800 to 1900.

● INDONESIA

RRI (Radio Republik Indonesia) Medan on a measured **4764** at 1502, OM in Indonesian (presumably a newscast). The schedule (a relay of Medan 1) is from 2300 to 2330 and from 0900 to 1700, the power being 50kW. The frequency of this one can vary from that shown to **4769.**

RRI Sorong on **4875** at 2120, Indonesian music, YL with songs, YL announcer. The schedule is from 2100 to 2330 and from 0800 to 1400 and the power is 10kW.

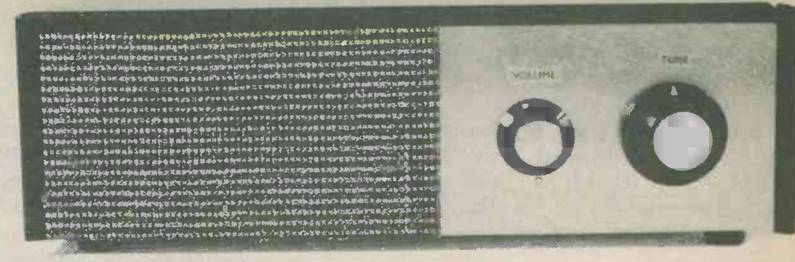
Yogyakarta on a measured **5046** at 1524, OM with a local newscast in Indonesian mentioning several place names "Vientiane" etc. The schedule is from 0100 to 0300, 0455 to 0800 and from 0955 to 1700. The power is 20kW.

● SARAWAK

Radio Malaysia, Kuching, on **4835** at 1550 typical local-style music, YL with songs. The schedule is from 2200 to 0130 and from 0830 to 1600, the power being 10kW.

● NOW HEAR THIS

RRI Tanjungkarang, Indonesia, on a measured **4002.5** at 1538, OM with announcements in Indonesian after a newscast (I presume) followed by a male chorus. Signal faded out by 1545. The schedule is from 2200 to 0130, 0455 to 0710 and from 0855 to 1600 and the power is 2.5kW.



VHF MAINS TABLE RADIO

Part 2 By R. A. Penfold

This concluding article completes constructional details and describes alignment.

In last month's article we discussed the circuit and components of this receiver, then dealt with initial constructional steps. We now continue with the remaining constructional details, concluding with the alignment of the trimmers, the i.f. transformer and the quadrature coil.

COMPONENT PANEL

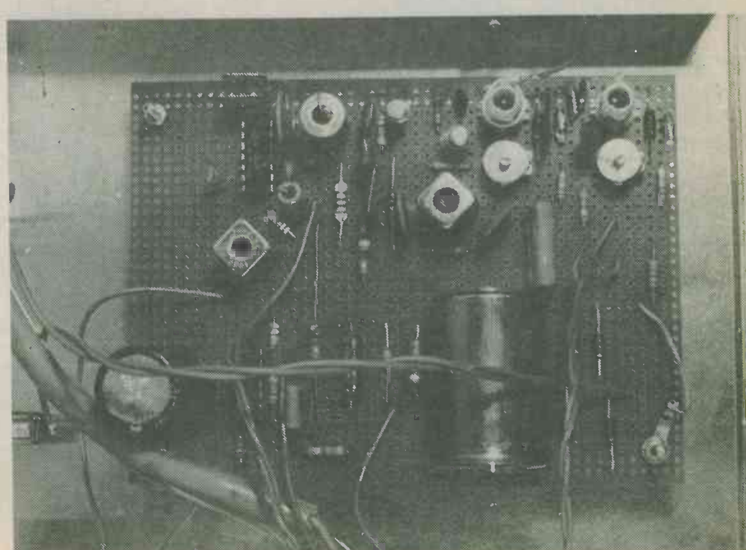
Virtually all the components are mounted and wired up on the plain 0.1 in. matrix perforated board, which has 50 by 36 holes. Details are given in Fig. 4. The three mounting holes are drilled out 6BA clear. It is also necessary to slightly enlarge the holes which take the mounting lugs of IFT1 and L4, and these need to be about $\frac{1}{16}$th in. in diameter. IFT1 and L4 have pin spacing on a matrix of approximately 0.15 in., but they will fit into the 0.1in. matrix board if they are mounted diagonally as shown in the diagram.

With this type of construction the components are fitted to the appropriate points on the board, and their lead-out wires or mounting lugs are bent flat against the board underside, being directly connected to each other as shown by the broken lines in Fig. 4. In the majority of cases the lead-out wires will be long enough for the connections to be made, but where necessary tinned copper wire of about 22 s.w.g. can be used to bridge any gaps. Tinned copper wire is also employed for the long wiring run which is at chassis potential. Note that connection is made to both mounting lugs of IFT1 and to one of the mounting lugs of L4.

The centre tags of the ceramic filters are the common terminals and, since these devices are symmetrical, it does not matter which of the other tags is regarded as the input and which is regarded as the output. L1 and L3 are supplied with ferrite cores which are not required here and are removed. L2 consists of a short length of single strand insulated wire of around 22 s.w.g. One end of the wire is passed through the board and soldered at hole 18j in the board. It is then looped around the middle of L3 to form a single turn coupling coil and its free end, shortened as necessary, will be soldered to SK1 after the component board has been mounted in the case.

The completed board is secured to the base of the case with L1 and L3 to the rear, spacing washers about $\frac{3}{8}$in. long being used to keep the underside wiring well clear of the metal case. Before the board is finally mounted, however, it must be connected, using multi-strand insulated hook-up wire, to the front panel components. T1, the mains lead, S1 and FS1 should also be connected into circuit at this stage. Fig. 5 shows the point-to-point wiring to VR1, S1 and VR2. Before connecting to S1 confirm with an ohmmeter the appropriate tags of this switch, as these may differ in positioning

A close look at the component board. Note the connection to the metal case which is made by way of the solder tag under one of the securing nuts



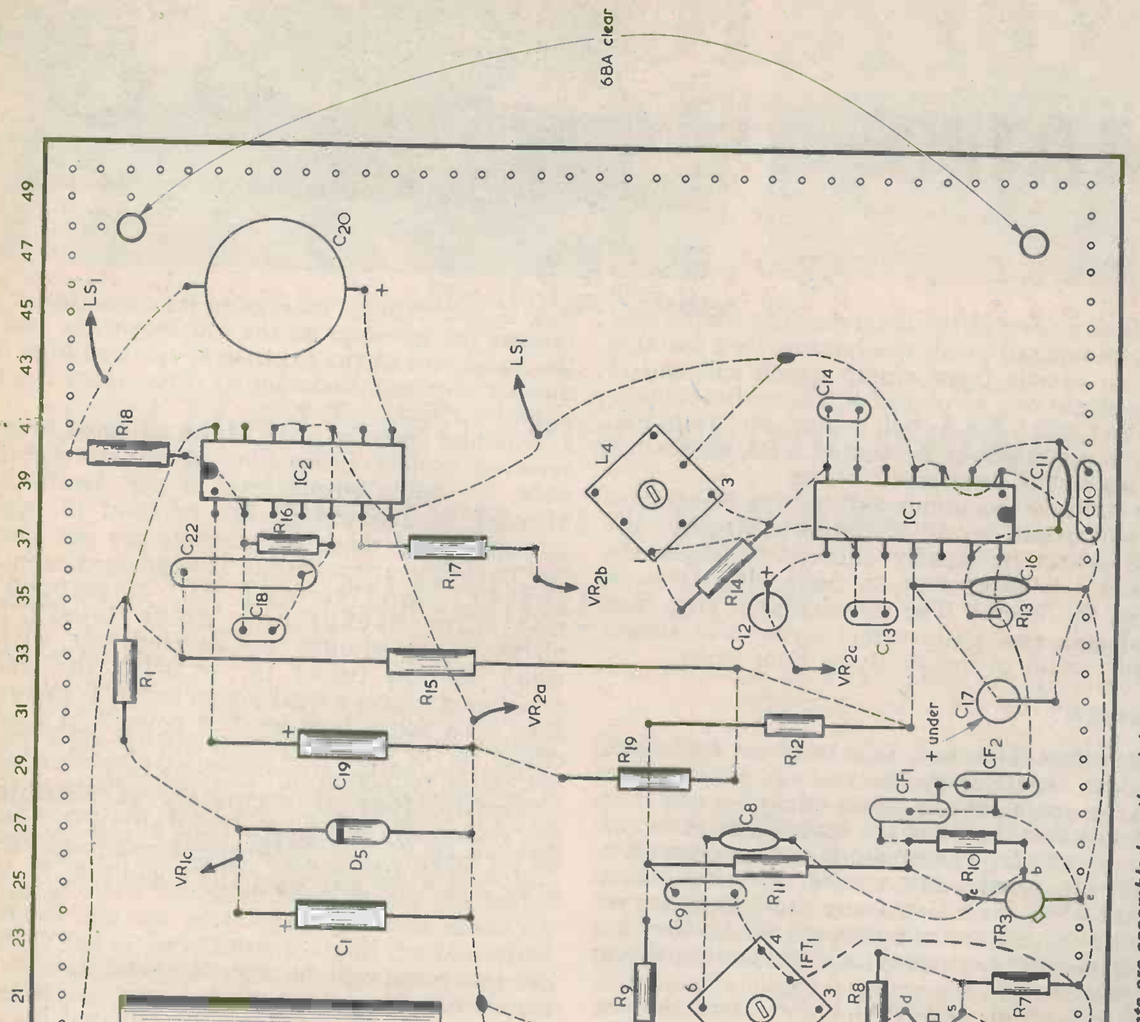
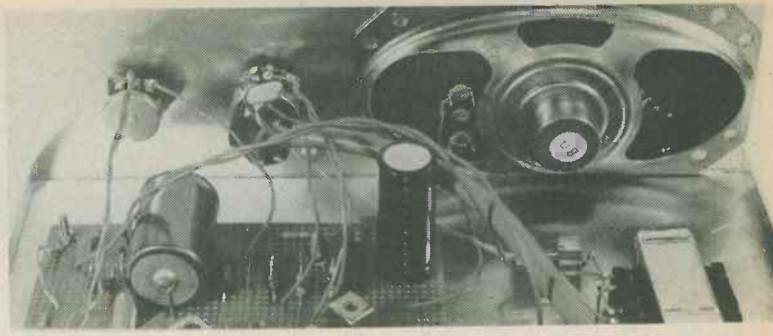


Fig. 4. Very nearly all the components are assembled on the plain perforated board shown here. Connections under the board are indicated by the broken lines

A view from the rear. Capacitor C15 is not mounted on the component board and is soldered across the tags of the volume control



from those shown in the diagram. The mains lead should be secured inside the housing by a suitable plastic or plastic faced clamp which will ensure that no strain can be placed on the mains connections at S1 and VR2. As will be apparent from Fig. 5, C15 is mounted on the tags of VR2, and is not wired up on the component board.

It is strongly recommended that the component panel wiring and layout, the other wiring and the general layout be strictly adhered to unless the constructor is competent to make alterations or redesign the layout. The circuit has a very high level of gain and an incorrect layout will almost certainly result in instability or hum loops.

ALIGNMENT

First adjust TC1 and TC2 to about half their maximum capacitance. As yet, no adjustments should be made to the cores of IFT1 and L4. Remember that the lid of the case will be removed during alignment, whereupon it becomes possible to accidentally come into contact with the mains wiring at S1 and T1. Great care must be observed to ensure that the mains points are not touched by the fingers or by any metal tool, as a serious shock could then result.

With an aerial connected to SK1 and the set switched on it should be possible to receive a few stations but probably not very well. The prototype works well using just a couple of metres of ordinary hook-up wire as an aerial, and this type of aerial works best when it is positioned horizontally since very nearly all v.h.f. broadcast stations use horizontal polarisation. It may be necessary to experiment a little with the position and orientation of the aerial to obtain a really good aerial signal. In poor reception areas a more sophisticated aerial might be needed to provide good results.

TC1 is given any setting which enables all the desired stations to be received, and the precise setting is not critical. Increasing its capacitance increases the coverage at the low frequency end of the band, but at the expense of reduced high frequency coverage. Reducing its capacitance has the opposite effect.

TC2 and the core of IFT1 are adjusted to peak received signals. Since f.m. signals are involved here, the audio output level is not significantly affected by changes in the r.f. and i.f. signal strengths, and these adjustments are not simply for maximum audio output. Instead, maximum r.f. and i.f. signal strength will correspond to minimum background noise level. The adjustments should be carried out with a weak station tuned in, or with the aerial positioned to give a weak signal input, as there will then be a fairly high level of noise, and any increase in the signal strength will produce a very noticeable reduction in this noise level.

Finally, tune as accurately as possible to any reasonably strong signal and adjust the core of L4 for maximum audio output. Use a proper trimming tool when adjusting IFT1 and L4.

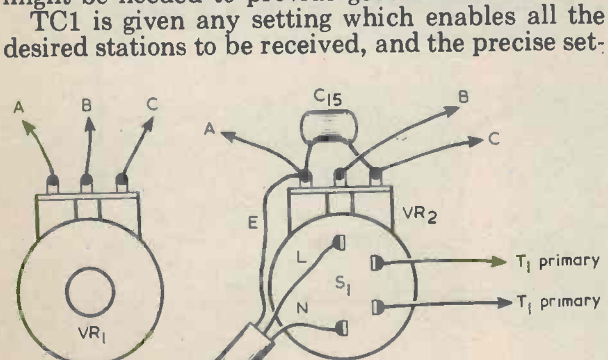


Fig. 5. The wiring behind the front panel to VR1, VR2 and S1

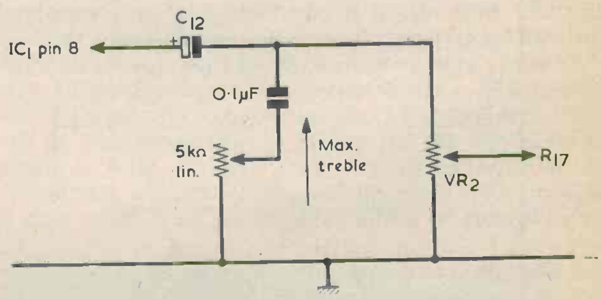


Fig. 6. If desired, a tone control may be added, employing the circuitry shown here

TONE CONTROL

Simple top-cut tone controls are often fitted to f.m. radios and it is an easy matter to add one to the present design, if this should be desired. It is merely necessary to decrease the value of C15 to 0.15μF, and to add a 5kΩ linear potentiometer and a 0.1μF polyester capacitor in series across the track of the volume control. The added circuitry is shown in Fig. 6. Of course, if the tone control is added it will be necessary to modify the front panel layout somewhat in order to accommodate the additional potentiometer.

(Concluded)

OPTO-ISOLATOR A.C. SWITCH

By John Baker

TIL111 provides control voltage isolation in a.c. mains switching circuit

When an electronic circuit is used to control mains powered equipment it is normal to employ either a relay or a triac as the switching device. A triac has certain advantages over a relay, such as ruggedness, high speed operation and no moving parts to wear out, with consequent almost unlimited life. On the other hand, it has the major drawback that one of its terminals (designated A1 or MT1) has to be common to both the controlled and the controlling circuit, which means that the controlling circuit has to be connected to the mains.

In some applications such a connection is at least undesirable and in others it can be quite definitely not permissible. As an example, thermostats for controlling the temperature of liquids used by photographers may have electronic temperature sensors and, to avoid the risk of dangerous shock, such sensors must be reliably earthed. They could not then be coupled directly to a triac controlling the heating element for the liquid concerned.

One possible method of isolating electronic control and triac circuits is to couple the two together by way of an isolating transformer. However, if the control signal were of a d.c. nature the drive circuit providing the a.c. input to the isolating transformer would be unnecessarily complicated.

OPTO-ISOLATOR

An alternative approach is to use some form of opto-isolator. An opto-isolator is a simple unit consisting of a light-emitting device positioned close to a photosensitive component in a light-proof box. A home-made opto-isolator was, for instance, described in the article "L.E.D.-L.D.R. Isolator" which appeared in the April 1975 issue of this magazine, and this employed a TIL209 light-emitting diode in conjunction with an ORP12 photoconductive cell. When the l.e.d. was extinguished the ORP12 exhibited a high resistance, this falling to a low value when the l.e.d. was alight. There was no electrical connection between the l.e.d. and the photoconductive cell, and the latter, in its low resistance mode, could turn on a triac by way of an amplifier.

Nowadays, ready made opto-isolators are available on the home constructor market. These are completely self-contained, and have the advantages of small physical size, very high speed of operation and the ability to drive a triac directly without the need for any subsequent stages of amplification.

The unit described in this article is a slightly simplified version of the circuit featured in the earlier article and it employs the opto-isolator type TIL111.

THE CIRCUIT

The circuit diagram of the opto-isolator a.c. switch appears in Fig. 1. Here, the triac is connected in series with the neutral mains lead to the load to be switched, and the load will not be switched on until a current of some 20mA is passed through the gate and A1 terminals of the triac. The load will then be supplied with the full mains voltage less an insignificant voltage of the order of 1 volt dropped across the triac. Once it has been triggered to the conducting state, the triac stays conducting until the current flowing between its A2 and A1 terminals falls to a low level. Since the triac is in an a.c. circuit the current flowing through it falls to zero at the end of each half-cycle, so that it becomes re-triggered by the gate current at the start of the next half-cycle. If the gate current is removed the triac turns off at the end of the appropriate half-cycle and the load is then fully switched off.

A low voltage power supply, from which the gate current for the triac can be derived, is provided by step-down transformer T1, the bridge rectifier incorporating D1 to D4, and the smoothing com-

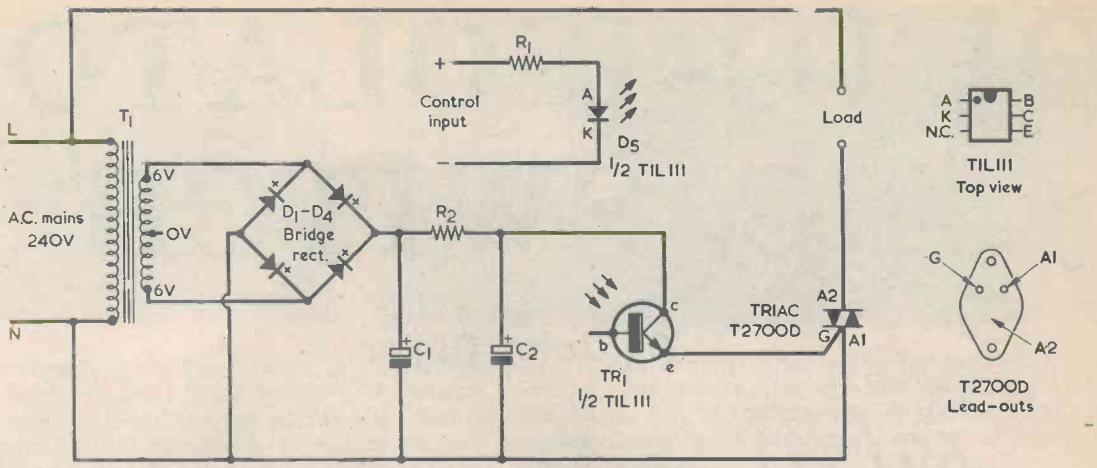


Fig. 1. The circuit of the opto-isolator a.c. switch. D5 and TR1 are combined in the single TIL111 package

COMPONENTS

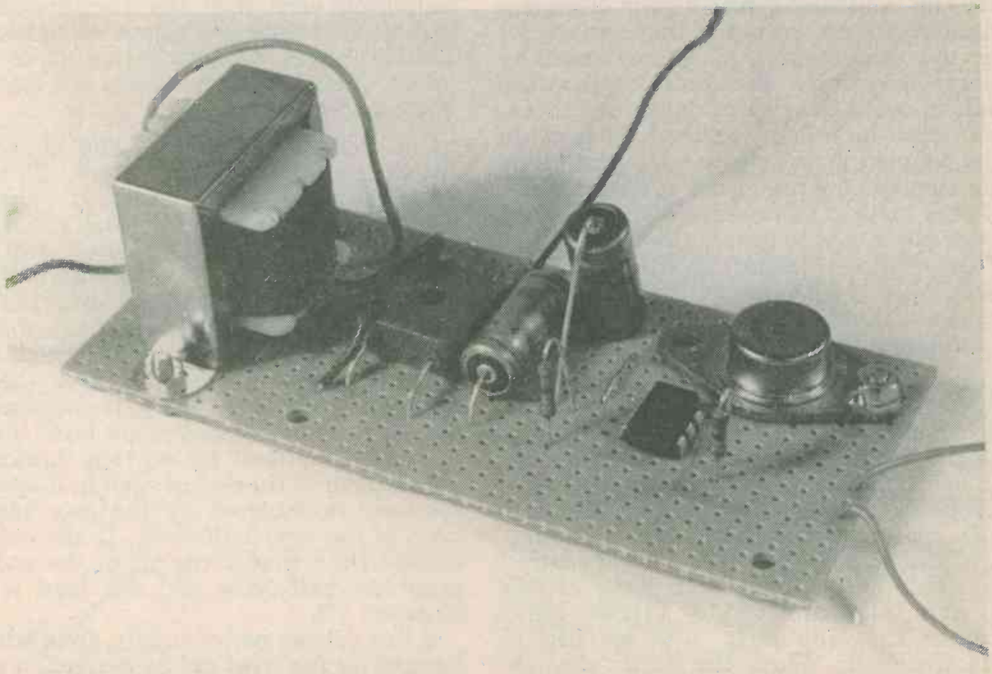
Resistors
R1 180 Ω ½ watt 5% (see text)
R2 330 Ω ½ watt 5%

Capacitors
C1 100μF electrolytic, 25V. Wkg.
C2 100μF electrolytic, 25V. Wkg.

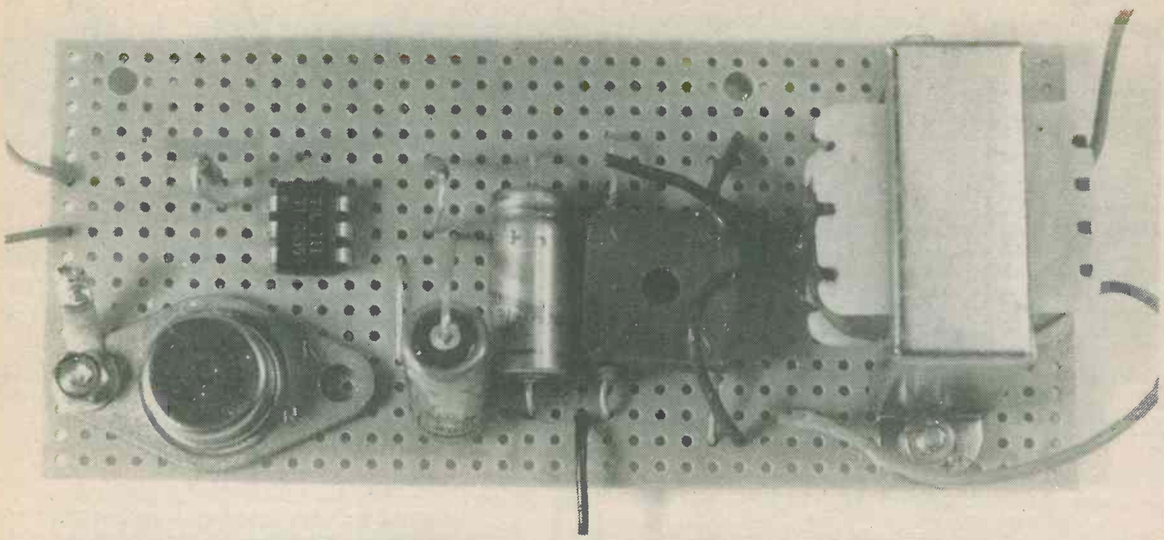
Transformer
T1 Sub-miniature mains transformer, secondary 6-0-6V at 100mA (see text)

Semiconductors
Triac T2700D (see text)
D1-D4 Silicon bridge rectifier, 50V 1A or 2A
TR1/D5 TIL111 (see text)

Miscellaneous
Veroboard, 0.1in. matrix
Veropins
6BA mounting bolts, nuts, wire etc.



A small Veroboard panel accommodates the opto-isolator components, including the mains transformer



The connection to the case of the triac, which provides the A2 terminal, is made by way of a solder tag and a 6BA nut and bolt, the bolt passing through the Veroboard

ponents C1, R2 and C2.

The TIL111 opto-isolator consists of an l.e.d. and an n.p.n. phototransistor. These are shown separately in the diagram as D5 and TR1, but in practice they are enclosed together in a small 6-pin d.i.l. package. In this circuit the phototransistor is used in the normal configuration with no connection made to the base of the transistor, and only minute leakage currents flow between the collector and the emitter when the l.e.d. is extinguished. Turning on the l.e.d. causes the collector-emitter current to be considerably increased and, provided sufficient current is fed to the l.e.d., the current through TR1 will be great enough to turn on the triac.

The input control voltage applied to R1 and D5 should be 6 volts with the polarity indicated, and R1 will then cause the l.e.d. current to be approximately 25mA. With the prototype circuit, an l.e.d. current of 20mA was sufficient to turn on the triac. However, due to component tolerances it may be found necessary to increase the l.e.d. current to turn the triac on fully, and this may be achieved by reducing the value of R1 and/or increasing the control voltage above 6 volts. With different control voltages and values of R1, the l.e.d. current in mA is equal to the voltage across R1 (i.e. the control voltage minus 1.4 volts dropped across the l.e.d.) multiplied by 1,000 and divided by the value of R1 in ohms. The l.e.d. current must not exceed the maximum rated value for the TIL111 of 60mA, and it should be possible to obtain satisfactory operation at currents comfortably below this level.

The loads controlled by the triac may have a current consumption of up to 1 amp, which corresponds to a maximum wattage of 240 watts with the U.K. 240 volt a.c. mains supply. It will be noted that, with the triac connected in the neutral line to the load, all the load wiring is at live potential when the triac is turned off. If correct wiring procedures are carried out this should not represent a hazard, and the alternative approach of inserting the triac in the live line would mean that T1 secondary circuit would be at live instead of neutral potential. Even with the method of switching employed, it is still essential that the switch unit to be housed in a robust insulated case which allows no access to any of the circuit points, and that either the negative or the positive side of the control voltage to the l.e.d. be reliably earthed. All other pertinent precautions against accidental shock must be fully observed.

CONSTRUCTION

The components can be assembled on a Veroboard of 0.1 in. matrix using the wiring layout illustrated in Fig. 2. This is perfectly straightforward, but make quite sure that none of the 14 breaks in the copper strips are omitted and that they are all effective. Two 6BA clear holes are drilled out at holes Q34 and B34 for mounting the mains transformer, and it is advisable to ensure that those two holes are correctly positioned by checking with the particular transformer to be employed before drilling them out. The mounting bolts for T1 must be isolated from the remainder of the circuit, and with the mounting bolt positions shown in Fig. 2 this isolation is achieved by the 6 breaks in the copper strips along vertical line 31.

When the gate and A1 lead-outs of the triac are passed through the holes indicated in Fig. 2, the left-hand hole in the metal case should appear over hole D2. This hole is also drilled out 6BA clear. A 6BA bolt is then passed through the hole, through a 6BA spacer to hold the body of the triac slightly clear of the board, and then through the hole in the triac case. A solder tag and 6BA nut are passed over the bolt and the nut is tightened up. The solder tag provides the connection to the triac A2, and the gate and A1 lead-outs are soldered to the copper strips at the holes through which they pass.

The remaining components are soldered to the board in normal fashion and care must be taken to ensure that no two adjacent strips are bridges together by blobs of solder. The "0V" secondary centre-tap lead of T1 does not connect into the circuit. The end of this lead should be covered with insulating tape and positioned well clear of com-

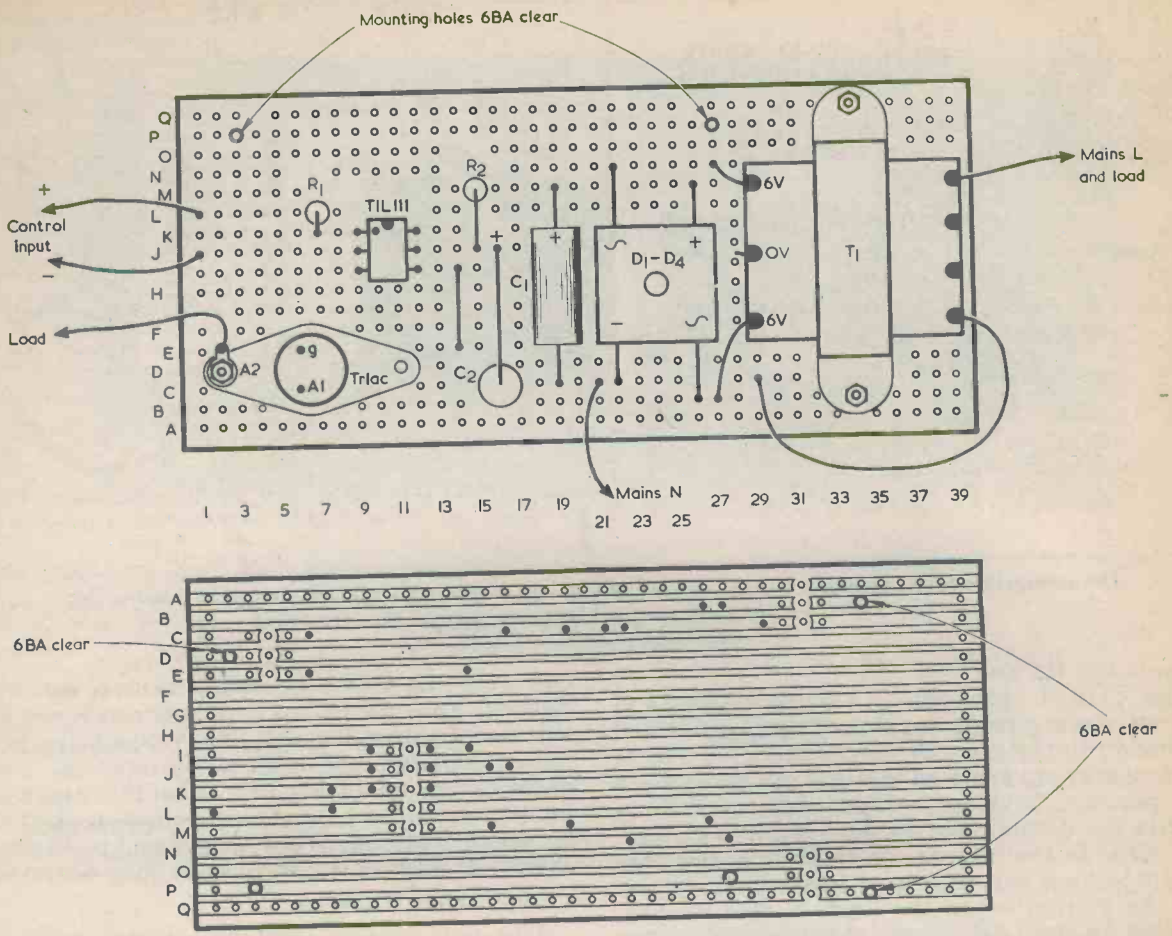


Fig. 2. The components of the opto-isolator switch may be assembled on a Veroboard panel. This has two mounting holes to enable it to be secured to a suitable surface

ponents and connections. For greatest reliability, Veropins suitable for 0.1 in. Veroboard should be soldered in place at the positions where external connections are made to the board, these being at the points where the control voltage and the neutral mains lead connect to the board. Since the mains transformer has flying leads an external terminal block suitable for mains voltages should be used for the connections to the mains supply and the load.

Before bringing the unit into use, thoroughly check all wiring for correctness. A continuity tester should be used to make certain that the input l.e.d. circuit is, in fact, isolated from the remaining circuitry. Also, make sure that the l.e.d. driving circuit is properly earthed.

COMPONENTS

A few of the components used in this switch unit are a little out of the ordinary and require some comment. The T2700D triac used in the prototype can be obtained from Electrovalue, and this has a voltage rating of 400 volts at a maximum current of 6 amps. The TIL111 opto-isolator is available from Greenbank Electronics, 94 New Chester Road, New Ferry, Wirral, Merseyside L62 5AG. A suitable component for transformer T1 is available from Maplin Electronic Supplies. ■

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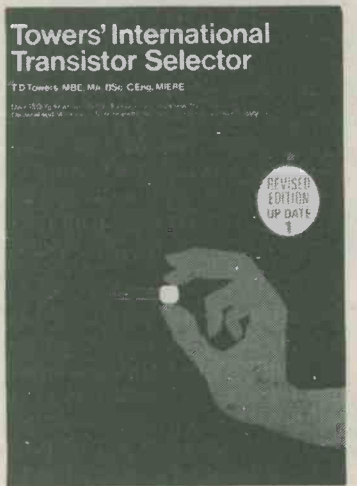

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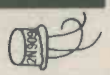

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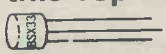

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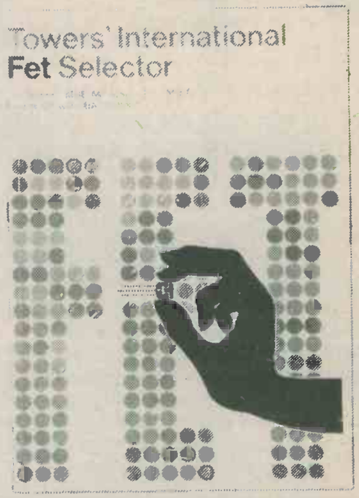

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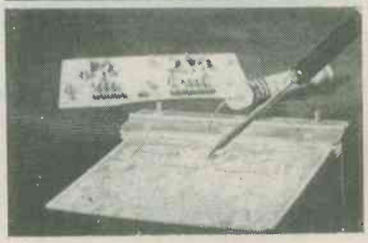

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(Continued on page 583)

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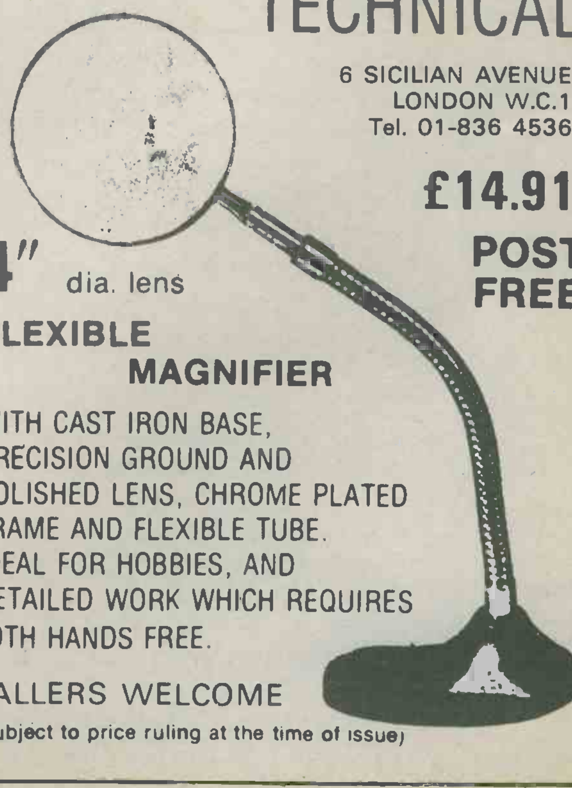

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