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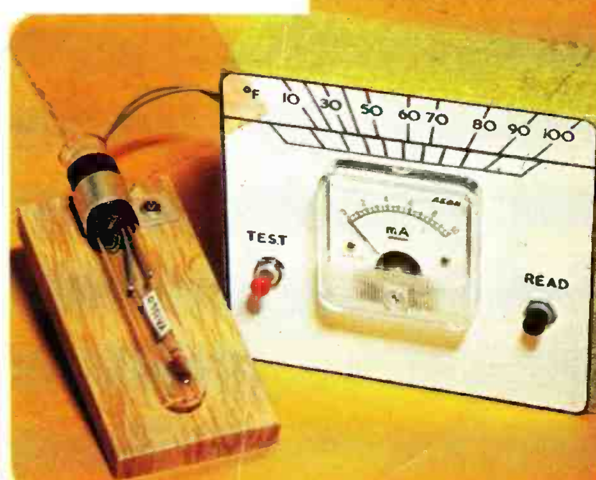

METRONOME

THE 'NUTS & BOLTS' OF THOSE PROJECTS

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MINIATURE MAINS Pri 240v
with two independent secondary windings

No.	Type	Price
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MINIATURE MAINS Pri 240v

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2022	9v-0-9v 100mA	85*
2023	12v-0-12v 100mA	£1·30*

1 amp MAINS Pri 240v

No.	Secondary	Price
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2027	9v-0-9v 1amp	£2·20* p&p 30p
2028	12v-0-12v 1amp	£2·60* p&p 30p
2029	15v-0-15v 1amp	£2·90* p&p 30p
2030	30v-0-30v 1amp	£3·80* p&p 30p

STANDARD MAINS Pri 240v
Multi-tapped secondary mains transformers available In ½amp, 1amp, & 2amp current rating. Secondary taps are 0-19-25-33-40-50v

Voltages available by use of taps:
4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 50, 25-0-25volts

No.	Rating	Price
2031	½amp	£3·42* p&p 30p
2032	1amp	£4·40* p&p 50p
2033	2amp	£5·45* p&p 85p

AUDIO OUTPUT Pri 1·2k Secondary 5ohms
200mW Dimensions 20×16×15
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Pri 20k Secondary 1k Ratio 5:1
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Pri 100k Secondary 1k 15×13×13mm
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Pri 10k Secondary 2K-C.T. 15×13×13mm
Order no. 2040 £0·35*

LT712 MIN OUTPUT
Pri 500ohm Secondary 8ohms 100mW 15×13×13mm
Order no. 2041 £0·28*

LT717 MIN INPUT
Pri 150k Secondary 1k 20×15×15mm
Order no. 2042 £0·52*

LT719 MIN INPUT
Pri 20k Secondary 1k 20×15×15mm
Order no. 2043 £0·32*

LT722 MIN DRIVER
Pri 10k Secondary 2k—C.T. 20×15×15mm
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Pri 1·2—C.T. Secondary 3·2 & 8ohm 200mW Dimensions 20×15×15mm
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Pri 500ohm Secondary 3·2 & 8ohm 200mW Dimensions 20×15×15mm
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Pri 1k C.T. Secondary 500ohm C.T. Dimensions 25×20×20mm
Order no. 2047 £0·43*

LT729 MIN OUTPUT
Pri 200ohm C.T. Secondary 3·2 & 8ohms 400mW Dimensions 25×20×20mm
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LT730 MIN OUTPUT
Pri 500ohms C.T. Secondary 3·2 & 8ohms 500mW Dimensions 25×20×20mm
Order no. 2049 £0·42*

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Type	Size	Order No	Colour	Price
TIL209	·125"	1501	RED	12p
TIL211	·125"	1502	GREEN	25p
TIL213	·125"	1503	YELLOW	25p
FLV115	·2"	1504	RED	12p
FLV310	·2"	1505	GREEN	25p
FLV410	·2"	1506	YELLOW	25p

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Pack of 5	·2"	1508/·2	30p

NUTS & BOLTS

BA BOLTS—packs of B.A. Threaded cadmium Plated screws, slotted cheese head. Supplied in multiples of 100

Type	No	Price	Type	No	Price
1" 0BA	839	£1·12	1" 4BA	845	£0·51
½" 0BA	840	£0·83	½" 4BA	846	£0·38
1" 2BA	842	£0·69	¼" 4BA	847	£0·33
½" 2BA	843	£0·54	1" 6BA	848	£0·50
¼" 2BA	844	£0·63	½" 6BA	849	£0·30
			¼"6BA	850	£0·33

BA NUTS—packs of cadmium plated full nuts in multiples of 100

Type	No	Price	Type	No	Price
0BA	855	£0·90	4BA	857	£0·42
2BA	856	£0·60	6BA	858	£0·36

BA WASHERS—flat cadmium plated plain stamped washers supplied in multiples of 100

Type	No	Price	Type	No	Price
0BA	859	£0·19	4BA	861	£0·15
2BA	860	£0·15	6BA	862	£0·12

SOLDER TAGS—hot tinned supplied in multiples of 100

Type	No	Price	Type	No	Price
0BA	851	£0·42	4BA	853	£0·30
2BA	852	£0·36	6BA	854	£0·30

INSTRUMENT CASES. In two sections Vinyl Covered Top and Sides, Aluminimum bottom, front and back.

No.	Length	Width	Height	Price
155	8"	5¼"	2"	£1·40*
156	11"	6"	3"	£1·80*
157	6"	4¾"	1½"	£1·25*
158	9"	5¼"	2½"	£1·60*

ALUMINIUM BOXES. Made from Bright Ali., Folded Construction. Each Box Complete with half inch deep lid and screws.

No.	Length	Width	Height	Price
159	5¼"	2¼"	1½"	62p*
160	4"	4"	1½"	62p*
161	4"	2¼"	1½"	62p*
162	5¼"	4"	1½"	74p*
163	4"	2½"	2"	64p*
164	3"	2"	1"	44p*
165	7"	5"	2½"	£1·04*
166	8"	6"	3"	£1·32*
167	6"	4"	2"	86p*

BRIDGE RECTIFIERS

SILICON 1AMP

Type	Order No	Price
50vRMS	BR1/50	£0·25
100vRMS	BR1/100	£0·28
200vRMS	BR1/200	£0·30
400vRMS	BR1/400	£0·35

SILICON 2AMP

Type	Order No	Price
50v	BR2/50	£0·40
100v	BR2/100	£0·45
200v	BR2/200	£0·50
400v	BR2/400	£0·55
1000v	BR2/1000	£0·65

FUSE HOLDERS & FUSES

Description	Order No	Price
20mm×5mm chassis mounting	506	£0·07*
1¼"×¼" chassis mounting	507	£0·10*
1¼" car inline type	508	£0·20*
Panel mounting 20mm	509	£0·22
Panel mounting 1¼"	510	£0·24

QUICK BLOW 20mm

Type	No	Type	No	Type	No
150mA	611	1A	615	3A	619
250mA	612	1·5A	616	4A	620
500mA	613	2A	617	5A	621
800mA	614	2·5A	618		

ALL 5p EACH

ANTI-SURGE 20mm

Type	No	Type	No	Type	No
100mA	622	1A	625	2·5A	628
250mA	623	2A	626	3·15A	629
500mA	624	1·6A	627	5A	630

ALL 7p EACH

QUICK BLOW 1¼in

Type	No.	Type	No.	Type	No.
250mA	631	500mA	632	800mA	634

ALL 7p EACH

Type	No.	Type	No.	Type	No.
1A	635	2·5A	638	4A	641
1·6A	636	3A	639	5A	642
2A	637				

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D.P.D.T. standard slide	1974	£0·12*
Toggle switch S.P.S.T. 1½amp 250v AC	1975	£0·33*
Toggle switch D.P.D.T. 1amp 250v AC	1976	£0·36*
Rotary ON-OFF mains switch	1977	£0·42*
Push switch—Push to make	1978	£0·13*
Push switch—Push to break	1977	£0·18*

ROCKER SWITCH
A range of rocker switches SPST—moulded in high insulation. Material available in a choice of colours ideal for small apparatus

Colour	No	Price
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BLACK	1981	£0·22*
WHITE	1982	£0·22*
BLUE	1983	£0·22*
YELLOW	1984	£0·22*
LUMINOUS	1985	£0·22*

DESCRIPTION	No	Price
Miniature S.P.S.T. toggle 2amp 250v AC	1958	£0·50*
Miniature S.P.S.T. toggle 2amp 250v AC	1959	£0·55*
Miniature D.P.D.T. toggle 2amp 250v AC	1960	£0·65*
Miniature D.P.D.T. toggle centre off—2amp 250v AC	1961	£0·85*
Push button S.P.S.T. 2amp 250v AC	1962	£0·65*
Push button S.P.S.T. 2amp 250v AC	1963	£0·68*
Push button D.P.D.T. 2amp 250v AC	1964	£0·80*

MIDGET WAFER SWITCHES
Single-bank wafer type—suitable for switching at 250v AC 100mA or 150v DC in non-reactiver loads make-before-break contacts. These switches have a spindle 0·25" DIA and 30° indexing.

DESCRIPTION	Order No	Price
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3 pole 4 way	1967	£0·48*
4 pole 3 way	1968	£0·48*

MICRO SWITCHES

	Order No	Price
Plastic button gives simple on-off action Rating 10 amp 250v AC	1969	£0·20
Button gives 1 pole change over action Rating 10amp 250v AC	1970	£0·25

DISPLAYS

LED TYPE	Order No	Price
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BDL747 ·6" single	1511	£1·50
BDL727 ·5" double	1512	£1·80

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MVR7912 12v	£2·00	MVR7924 24v	£2·00

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But a wrist-calculator is only worth having if it offers a genuinely comprehensive range of functions, with a full-size 8-digit display.

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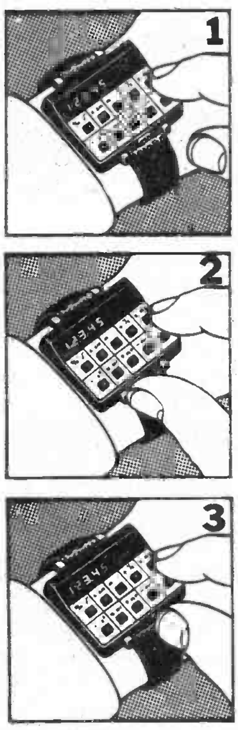
How to make 10 keys do the work of 27
The Sinclair Instrument wrist calculator offers the full range of arithmetic functions. It uses normal algebraic logic ('enter it as you write it'). But in addition, it offers a % key; plus the convenience functions $\sqrt{x}$, 1/x, x^2; plus a full *5-function memory*.

All this, from just 10 keys! The secret? An ingenious, simple three-position switch. It works like this.



1. The switch in its normal, central position. With the switch centred, numbers – which make up the vast majority of key-strokes – are tapped in the normal way

2. Hold the switch to the left to use the functions to the left above the keys...

3. and hold it to the right to use the functions to the right above the keys.

The display uses 8 full-size red LED digits, and the calculator runs on readily-available hearing-aid batteries to give weeks of normal use.

Dimensions:
1 13/16" (46 mm) wide,
1 7/16" (37 mm) deep.
Weight:
less than 1 oz (28 g).

Assembling the Sinclair Instrument wrist calculator
The wrist calculator kit comes to you complete and ready for assembly. All you need is a reasonable degree of skill with a fine-point soldering iron. It takes about three hours to assemble. If anything goes wrong, Sinclair Instrument will replace any damaged components *free:* we want you to enjoy assembling the kit, and to end up with a valuable and useful calculator.

Contents
Case and display window.
Strap.
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Switches.
Special direct-drive chip (no interface chip needed).
Display.
Batteries.

Everything is packaged in a neat plastic box, and is accompanied by full instructions. The only thing you need is a fine-point soldering iron.

All components are fully guaranteed, and any which are damaged during assembly will be replaced free.

The wrist-calculator kit is available only direct from Sinclair Instrument. Take advantage of this 10-day money-back undertaking.

Send the coupon today.

KIT ONLY £9.95 PLUS VAT, P&P

To: Sinclair Instrument Ltd,
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* Please send me . . . (qty) Sinclair Instrument wrist-calculator kits at £9.95 plus 80p VAT plus 25p P&P (Total £11).

* I enclose cheque/PO/money order for £..................

* Complete as applicable.

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(Please print)
I understand that you will refund my money in full if I return the kit undamaged within 10 days of receipt.

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2·2/63	10p*		
2·5/64	10p*		
4·7/16	8p*		
4·7/63	10p*		
5/10	10p*		
6·8/25	10p*		
6·8/40	10p*		
8/70	10p*		
10/25	9p*		
10/35	10p*		
10/64	10p*		
15/40	10p*		
16/10	10p*		
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20/70	10p*		
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22/16	10p*		
25/25	11p*		
33/50	12p*		
47/6V3	10p*		
47/16	10p*	330/16	15p*
47/25	10p*	470/6V3	10p*
50/10	10p*	470/10	12p*
50/15	10p*	470/16	15p*
100/18	6p*	470/25	19p*
100/25	10p*	680/25	25p*
100/50	15p*	1000/16	25p*
150/35	15p*	1000/50	40p*
220/16	15p*	1500/25	35p*
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	1·24	184L	11p*	ORP12	65p	3705	14p*
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BC107	11p	212A	13p*	30A	58p*	3819E	25p*
107A	12p	212L	15p*	31A	57p		
108	10p	213B	12p*	41A	67p		
CIL108	6p	214	15p*	42A	80p		
BC108B	11p	214L	17p*	TIS43	35p		
108C	12p	262A	19p	ZTX300	13p*		
109	12p	287	28p	302	18p*		
109B	13p	300	35p	500	15p*		
109C	13p	301	34p	502	18p*		
117	18p*	303	35p	1N914	5p		
142	24p	338	16p*	1N4001	5p		
143	24p	557	15p*	4002	6p		
147A	9p*	BCY71	18p	4005	9p		
147B	10p*	72	14p	4006	10p		
148	9p*	BFY50	25p	4148	5p		
148B	10p*	51	25p	2N2219	30p		
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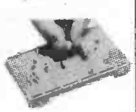

This Board allows 2 TO5 or 1 DIL IC Station to be used and so is primarily intended for discrete work or for linear IC application where considerable numbers of discrete components may be required.
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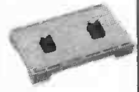
µ-DEC 'B' (Model PB41)



The µ-DEC 'B' is for similar uses as µ-DEC 'A', but has two 16 lead IC sockets as part of the Board.
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THE KIT COMPRISES EVERYTHING NEEDED
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Gives instant changeover from "Sparkrite" ignition to conventional ignition for performance comparisons, static timing etc., and will also switch the ignition off completely as a security device. Includes switch connectors, mounting bracket and instructions. Cables excluded.
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2N708	0·21
2N709	0·50
2N718	0·27
2N718A	0·50
2N720A	0·80
2N914	0·35
2N916	0·30
2N918	0·38
2N929	0·25
2N930	0·26
2N1131	0·60
2N1132	0·60
2N1613	0·35
2N1711	0·37
2N1893	0·38
2N2102	0·60
2N2218	0·33
2N2218A	0·37
2N2219	0·30
2N2219A	0·32
2N2220	0·35
2N2221	0·25
2N2221A	0·26
2N2222	0·25
2N2222A	0·25
2N2368	0·25
2N2369	0·25
2N2369A	0·25
2N2646	0·75
2N2647	1·40
2N2904	0·36
2N2904A	0·37
2N2905	0·37
2N2905A	0·38
2N2906	0·28
2N2906A	0·25
2N1907	0·21
2N2907A	0·22
2N2924	0·15
2N2926	0·13
2N3019	0·55
2N3053	0·30
2N3054	0·60
2N3055	0·70
2N3390	0·25
2N3391	0·25
2N3319A	0·25
2N3392	0·16
2N3393	0·15
2N3394	0·15
2N3439	0·88
2N3440	0·64
2N3441	0·85
2N3442	1·35
2N3638	0·16
2N3638A	0·16

2N3639	0·30
2N3641	0·20
2N3702	0·17
2N3703	0·15
2N3704	0·15
2N3705	0·15
2N3706	0·16
2N3707	0·18
2N3708	0·16
2N3709	0·18
2N3710	0·16
2N3711	0·18
2N3712	1·20
2N3713	2·30
2N3714	2·45
2N3715	2·55
2N3716	2·80
2N3771	1·85
2N3772	2·00
2N3773	2·90
2N3789	2·90
2N3790	3·10
2N3791	3·10
2N3792	3·50
2N3794	0·20
2N3819	0·36
2N3820	0·38
2N3823	0·75
2N3904	0·21
2N3906	0·22
2N4036	0·67
2N4037	0·55
2N4058	0·20
2N4059	0·20
2N4060	0·20
2N4061	0·17
2N4062	0·18
2N4126	0·17
2N4289	0·20
2N4919	0·65
2N4920	0·70
2N4921	0·50
2N4922	0·55
2N4923	0·70
2N5190	0·60
2N5191	0·70
2N5192	0·75
2N5195	0·90
2N5245	0·35
2N5294	0·40
2N5295	0·40
2N5296	0·40
2N5298	0·40
2N5447	0·15
2N5448	0·15
2N5449	0·19
2N5457	0·32
2N5458	0·33
2N5459	0·29
2N5484	0·34
2N5486	0·38
2N6027	0·53

2N6101	0·65
2N6107	0·42
2N6109	0·42
2N6121	0·38
2N6122	0·41
2N6123	0·43
2N6126	0·45
40361	0·45
40362	0·48
40363	1·20
40406	0·58
40407	0·45
40408	0·65
40409	0·65
40410	0·65
40411	2·85
40594	0·75
40595	0·85
40673	0·75
AC126	0·37
AC127	0·44
AC128	0·37
AC151V	0·35
AC152V	0·50
AC153	0·49
AC153K	0·55
AC176	0·40
AC176K	0·60
AC187K	0·55
AC188K	0·55
AD161	0·85
AD162	0·85
AF105	0·55
AF109	0·75
AF124	0·65
AF125	0·65
AF126	0·65
AF127	0·65
AF139	0·69
AF186	0·50
AF200	0·70
AF239	0·74
AF240	0·98
AF279	0·80
AF280	0·85
BC107	0·15
BC108	0·15
BC109	0·15
BC113	0·17
BC115	0·19
BC116	0·19
BC116A	0·20
BC117	0·22
BC118	0·16
BC119	0·30
BC121	0·45
BC132	0·30
BC134	0·15
BC135	0·15
BC136	0·19
BC137	0·14
BC140	0·40
BC141	0·45

BC142	0·30
BC143	0·30
BC147	0·12
BC148	0·12
BC149	0·13
BC153	0·27
BC154	0·27
BC157	0·12
BC158	0·11
BC159	0·14
BC160	0·50
BC161	0·50
BC167	0·12
BC168	0·12
BC169	0·12
BC170	0·16
BC171	0·14
BC172	0·12
BC177	0·20
BC178	0·20
BC179	0·23
BC182	0·11
BC182L	0·14
BC183	0·11
BC183L	0·14
BC184	0·12
BC184L	0·14
BC207	0·12
BC208	0·11
BC212	0·14
BC212L	0·17
BC213	0·14
BC218L	0·16
BC214	0·16
BC214L	0·17
BC237	0·14
BC238	0·12
BC239	0·15
BC251	0·15
BC253	0·22
BC257A	0·17
BC258A	0·17
BC259B	0·18
BC261A	0·21
BC262B	0·19
BC263C	0·24
BC300	0·45
BC301	0·45
BC303	0·60
BC307	0·20
BC308	0·18
BC309C	0·25
BC317	0·14
BC318	0·12
BC327	0·20
BC328	0·19
BC337	0·19
BC338	0·21
BC547	0·12
BC548	0·12
BC549	0·13
BCY30	1·03
BCY31	1·06

BCY32	1·70
BCY33	1·00
BCY34	1·20
BCY38	2·00
BCY42	0·60
BCY58	0·25
BCY59	0·25
BCY70	0·25
BCY71	0·26
BCY72	0·24
BD115	1·20
BD116	1·20
BD131	0·51
BD132	0·54
BD135	0·37
BD136	0·37
BD137	0·38
BD138	0·38
BD139	0·40
BD140	0·40
BD239	0·40
BD240	0·45
BD241	0·45
BD242	0·47
BD243	0·60
BD244	0·62
BD245	0·65
BD246	0·66
BD529	0·42
BD530	0·47
BDY20	1·13
BF115	0·38
BF117	0·70
BF121	0·55
BF123	0·55
BF152	0·25
BF153	0·25
BF154	0·25
BF159	0·35
BF160	0·30
BF161	0·60
BF166	0·40
BF167	0·38
BF173	0·38
BF177	0·30
BF178	0·35
BF179	0·35
BF180	0·40
BF181	0·40
BF182	0·45
BF183	0·45
BF184	0·38
BF185	0·35
BF194	0·14
BF195	0·13
BF196	0·14
BF197	0·17
BF198	0·18
BF200	0·35
BF225J	0·25
BF244	0·35

BF245	0·34
BF246	0·75
BF254	0·24
BF255	0·24
BF257	0·37
BF258	0·45
BF259	0·49
BF459	0·45
BFR39	0·28
BFS21A	2·60
BFS28	1·04
BFS61	0·30
BFS98	0·27
BFX29	0·38
BFX30	0·40
BFX84	0·40
BFX85	0·41
BFX87	0·40
BFX88	0·40
BFX89	1·25
BFY50	0·34
BFY51	0·38
BFY52	0·36
BFY53	0·34
BFY90	1·37
BRY39	0·50
BSX20	0·31
BSX21	0·32
BU105	1·50
BU205	2·20
ME0402	0·20
ME0404	0·15
ME0412	0·20
ME4102	0·10
ME4104	0·10
MJ480	1·35
MJ481	1·55
MJ490	1·35
MJ491	1·85
MJ2955	1·25
MJE340	0·58
MJE370	0·58
MJE371	0·60
MJE520	0·45
MJE521	0·65
MJE2955	1·40
MJE3055	0·85
MP8111	0·35
MP8112	0·40
MP8113	0·45
MPF102	0·30
MPSA05	0·23
MPSA06	0·24
MPSA12	0·35
MPSA55	0·24
MPSA56	0·24
MPSU05	0·50
MPSU06	0·56
MPSU55	0·55
MPSU56	0·60
TIP29A	0·45
TIP30A	0·49
TIP31A	0·50

TIP32A	0·50
TIP33A	0·80
TIP34A	0·90
TIP35A	2·50
TIP36A	3·35
TIP41A	0·70
TIP42A	0·80
TIP29c	0·60
TIP30c	0·65
TIP31c	0·66
TIP32c	0·75
TIP33c	1·10
TIP34c	1·20
TIP41c	0·85
TIP42c	0·95
TIP2955	0·65
TIP3055	0·55
TIS43	0·30
CA3020	1·78
CA3020A	2·29
CA3028A	1·01
CA3028B	1·29
CA3030	1·24
CA3030A	1·89
CA3045	1·40
CA3046	0·89
CA3048	2·23
CA3049	1·66
CA3052	1·62
CA3053	0·60
CA3080	0·68
CA3080A	1·88
CA3086	0·51
CA3088	1·59
CA3089	2·52
CA3090	3·80
CA3130	0·94
LM301A	0·65
LM301N	0·44
LM307N	0·65
LM308C	1·82
LM308N	1·17
LM309K	2·10
LM317K	3·00
LM318N	2·25
LM323K	6·40
LM339N	1·75
LM379N	3·95
LM380-8	0·90
LM380N	0·98
LM381A	2·45
LM381N	1·60
LM382N	1·25
LM389N	1·00
LM702C	0·75
LM709C	0·65
LM709N	0·45
LM710C	0·60

LM710N	0·60
LM723C	0·85
LM723N	0·75
LM741C	0·65
LM741N	0·50
LM741-8	0·40
LM747N	0·90
LM748-8	0·50
LM748N	0·50
LM3301N	0·85
LM3302N	1·40
LM3401	0·70
LM3900	0·75
LM3905	1·60
LM3909	0·68
MC1035	1·75
MC1303	1·47
MC1304	1·85
MC1305	1·85
MC1306	1·00
MC1310	1·91
MC1312	1·98
MC1327	1·54
MC1330	0·92
MC1350	0·75
MC1351	1·20
MC1352	0·97
MC1357	1·45
MC1458	0·91
NE555	0·53
NE556	1·05
NE565	1·20
NE566	1·65
NE567	1·80
SAS560	2·50
SAS570	2·50
76003N	2·55
76013N	1·70
76013ND	1·57
76023ND	1·57
76033N	2·55
TAA301A	1·50
TAA320A	1·15
TAA350A	2·48
TAA521	1·00
TAA522	1·90
TAA550	0·60
TAA560	1·60
TAA570	2·30
TAA611B	1·85
TAA621	2·15
TAA661A	1·32
TAA661B	1·32
TAA700	3·91
TAA930A	1·00
TAA930B	1·05

TAD100	1·95
TBA120	0·65
TBA400	1·50
TBA500	2·21
TBA500Q	2·30
TBA510	2·21
TBA510Q	2·30
TBA520	2·21
TBA520Q	2·30
TBA530	1·98
TBA530Q	2·07
TBA540	2·21
TBA540Q	2·30
TBA550	3·13
TBA550Q	3·22
TBA560Q	3·22
TBA570	1·29
TBA570Q	1·38
TBA641B	2·50
TBA651	1·80
TBA700	1·52
TBA700Q	1·61
TBA720Q	2·30
TBA750	1·98
TBA750Q	2·07
TBA800	1·20
TBA810	1·16
TBA820	1·03
TBA920	1·79
TBA920Q	2·99
TBA940	1·62
TCA160C	1·85
TCA160B	1·61
TCA270	2·25
TCA280A	1·30
TCA290A	3·13
TCA420A	1·84
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TCA740	2·76
TCA750	2·30
TCA760	1·38
TCA800	3·13
UAA170	2·00
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SN7400	0·21	SN7413	0·51	SN7440	0·21	SN7470	0·46	SN7485	1·85	SN74118	0·99	SN74157	0·98	SN74180	1·77
SN7401	0·21	SN7416	0·61	SN7441	1·03	SN7472	0·38	SN7486	0·41	SN74119	1·80	SN74160	1·41	SN74181	3·70
SN7402	0·21	SN7417	0·61	SN7442	0·78	SN7473	0·43	SN7490	0·61	SN74121	0·49	SN74161	1·41	SN74190	1·91
SN7403	0·21	SN7420	0·21	SN7446	1·23	SN7474	0·43	SN7491	0·98	SN74122	0·45	SN74162	1·41	SN74191	1·91
SN7404	0·26	SN7423	0·39	SN7447	1·17	SN7475	0·58	SN7492	0·61	SN74123	0·58	SN74163	1·41	SN74192	1·62
SN7405	0·26	SN7425	0·39	SN7448	1·17	SN7476	0·51	SN7493	0·61	SN74141	1·03	SN74164	1·23	SN74193	1·62
SN7406	0·74	SN7427	0·39	SN7450	0·27	SN7480	0·45	SN7494	0·74	SN74145	1·06	SN74165	1·23	SN74196	1·17
SN7407	0·74	SN7430	0·21	SN7451	0·21	SN7481	1·10	SN7495	0·78	SN74150	1·66	SN74167	3·70	SN74197	1·17
SN7408	0·29	SN7432	0·39	SN7453	0·21	SN7482	0·67	SN7496	1·03	SN74151	1·11	SN74174	1·52	SN74198	2·93
SN7409	0·29	SN7437	0·55	SN7454	0·21	SN7483	1·33	SN74100	1·15	SN74153	1·11	SN74175	1·35	SN74199	2·93
SN7410	0·21	SN7438	0·55	SN7450	0·21	SN7484	0·85	SN74107	0·43	SN74154	1·85	SN74176	1·23		
SN7412	0·21														

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DL707	2·00	3·00	3" Red
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CD4001	0·20	CD4019	1·10	CD4043	1·00
CD4002	0·20	CD4020	1·12	CD4044	0·94
CD4006	1·16	CD4021	1·01	CD4045	1·43
CD4007	0·20	CD4022	0·97	CD4046	1·32
CD4008	0·97	CD4023	0·20	CD4047	1·15
CD4009	0·57	CD4024	0·79	CD4049	0·56
CD4010	0·57	CD4025	0·20	CD4050	0·56
CD4011	0·20	CD4027	0·56	CD4510	1·54
CD4012	0·20	CD4028	0·91	CD4511	1·54
CD4013	0·57	CD4029	1·17	CD4516	1·40
CD4014	1·01	CD4030	0·57	CD4518	1·25
CD4015	1·01	CD4031	2·26	CD4520	1·25
CD4016	0·56	CD4037	0·97	CD4553	4·07
CD4017	1·01	CD4041	0·83		

Please enquire about CMOS not listed

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3, 4, 5, 6, 7 pin	15p	12p	15p
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JACK ¼" mono plastic	16p	20p	20p
¼" mono screened	25p	—	30p
¼" stereo plastic	25p	25p	25p
¼" stereo screened	35p	—	45p
3·5m standard	10p	12p	10p
2·55m standard	10p	10p	—
MAINS USA 2 pin flat	15p	15p	15p

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DPDT 70p
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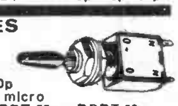

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Sliders	45p	75p
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Data Sheet 5p + SAE

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PROJECTS..
THEORY.....

MATRIX MARKER

With this copy of Everyday Electronics comes another exclusive tool designed specially for our readers. A handy instrument for the constructor when assembling components upon a piece of circuit board, this Matrix Marker also has additional uses, as explained in this issue (see page 215).

ON THE RIGHT TRACK

This month's gift will help simplify construction work. As every seasoned constructor knows, after the actual building has been completed comes the moment of truth. With some trepidation the final connection is made and then the power switched on. Some output or activity signifies that the circuit is functioning and we can breathe again freely. Ah, but supposing the results are negative and nothing, just nothing at all, appears to be happening? Disappointing of course, but not the end of the world.

But just how does one go about checking the circuit? This is a problem all novices in the field of electronics have to face—once at any rate. Much is learnt through trial and error checking and testing, far better though if this is not entirely haphazard, but follows a logical sequence in relation to the particular circuit undergoing fault diagnosis. Quite often new constructors write admitting their frustrations and sense of helplessness when a circuit constructed exactly according to plan fails to work. Frequently the remedy is easy, if you know how. Our new series *Fault Finding* will help resolve such problems in the future.

DON'T MISS OUT

Every day brings letters from enthusiasts who have just become aware of Everyday Electronics. As they read through our pages, they see references to past projects and past series like *Teach In*. This prompts them to write enquiring about the availability of back issues. Sadly we have to tell them that back numbers cannot be supplied.

So far as *Teach In* is concerned, this popular biennial feature reappears this autumn in our October issue. *Mark carefully*!

In the meanwhile, newcomers to Everyday Electronics will find an exciting variety of projects and other entertaining and informative articles every month. To avoid missing an issue, we strongly advise placing a firm order with your newsagent.

STAFF NOTE

Mike Kenward takes his leave of us after over five years as assistant editor on this magazine. Mike was involved in the initial planning of EE and has throughout been a dedicated leading member of our team. Through *Shop Talk* he has been adviser and guide to countless readers. We wish him well in the future.

Fred Bennett

Our June issue will be published on Friday, May 20.
See page 227 for details.

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VOL. 6 NO. 5 MAY 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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By F. G. RAYER

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS * excluding V.A.T.

£17.50 excluding case

THE tuning arrangements in this unit are designed to split up coverage into several relatively small bands, and at the same time avoid the ganging or alignment difficulties which can arise with a multi-range tuner. This allows maximum efficiency, and also greatly facilitates tuning on short wave bands.

The receiver is intended for general long, medium and short wave reception of ordinary a.m. (amplitude modulated) transmissions. However, a carrier and beat frequency oscillator is easily added, as explained, and this allows reception of s.s.b. (single-sideband) and c.w. (Morse) amateur signals over the 80 metre band. Even a short or indoor aerial will bring in many amateur signals on these frequencies.

Reference to the mixer and oscillator circuit in Fig. 1 will help clarify the tuning arrangements which are adopted.

AERIAL TUNING

Switches S1, S2, S3 and S4 are sections of a 4-pole 3-way switch. With S1 at *S*, the short wave coil L2 is in use, with L1 allowing coupling of an external aerial. With S1 at *M*, L3 is in use, and L4 is shorted by S2. Coil L3 is the medium wave winding of the ferrite rod aerial. When S1/2 is at *L*, L3 and L4 are in series for long wave reception.

Capacitor VC1 is a separate variable tuning capacitor, and is used to peak up wanted signals in all cases. As VC1 is not ganged with the oscillator tuning circuit, no trimming, ganging or alignment difficulties will arise.

OSCILLATOR TUNING

Coils L5 and L6 are the oscillator coils, selected by S3 and S4 respectively; L5 is for short wave reception, and L6 is for both m.w. and l.w. reception.

Oscillator tuning is by the small value capacitor VC2, operated by a cord drive. Switch S5 is a single pole range selection switch. When this is at position *1*, only VC2 is in use, but at position 2 C7 (50pF) is added in parallel with VC2, while position *3* adds C8, position *4* adds C9, and so on. As the value of VC2 (75pF) is greater than the progressive 50pF added at each switch position, the action of S5 is to break up the oscillator tuning coverage into nine smaller bands, with some overlap at the maximum and minimum settings of VC2. If VC2 were also 50pF, its minimum capacitance, and other stray capacitances would result in small gaps between bands provided by the multiband switch S5.

Coils L5 and L6 are fixed-inductance coils. As 1 or 2 per cent capacitors are used for C7 to C14, the positions of S5 can thus be given "ready calibrated" frequency bands.

For example, position *6* (250pF plus VC2) provides reception from 4030kHz, and thus includes most of the 80 metre amateur band

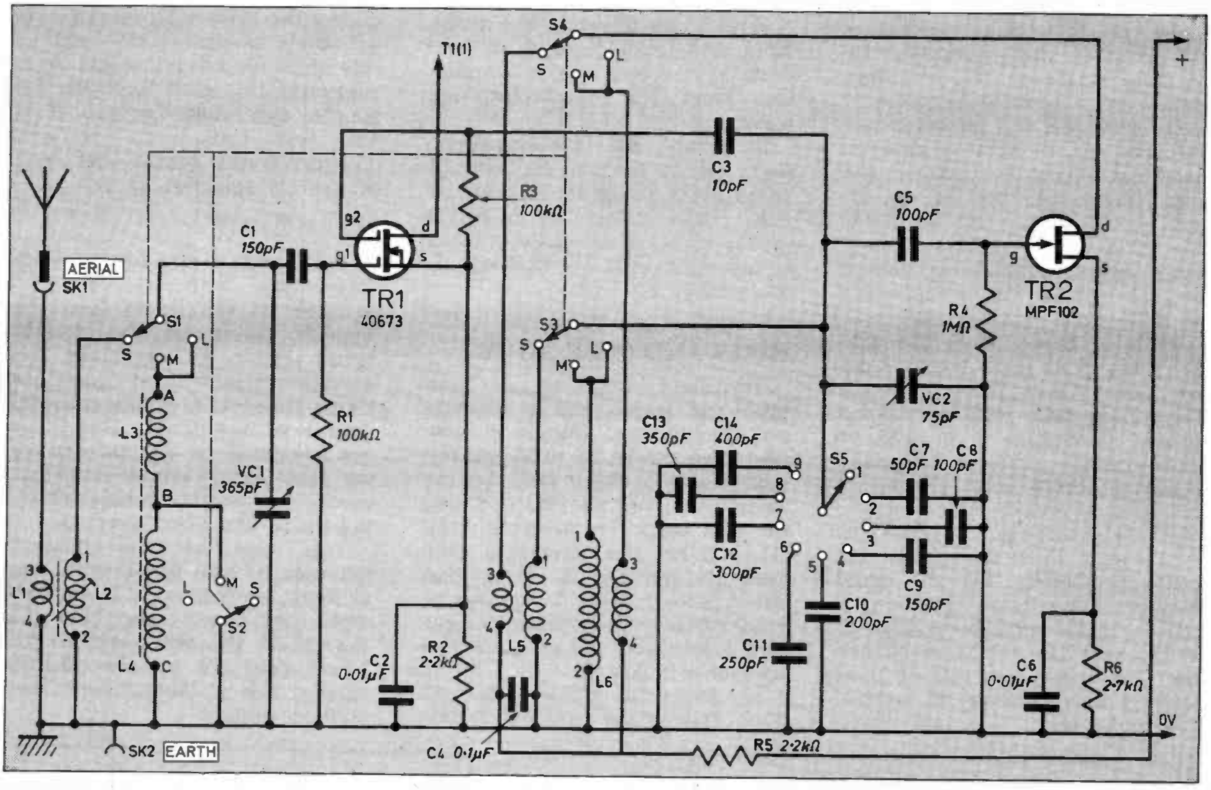
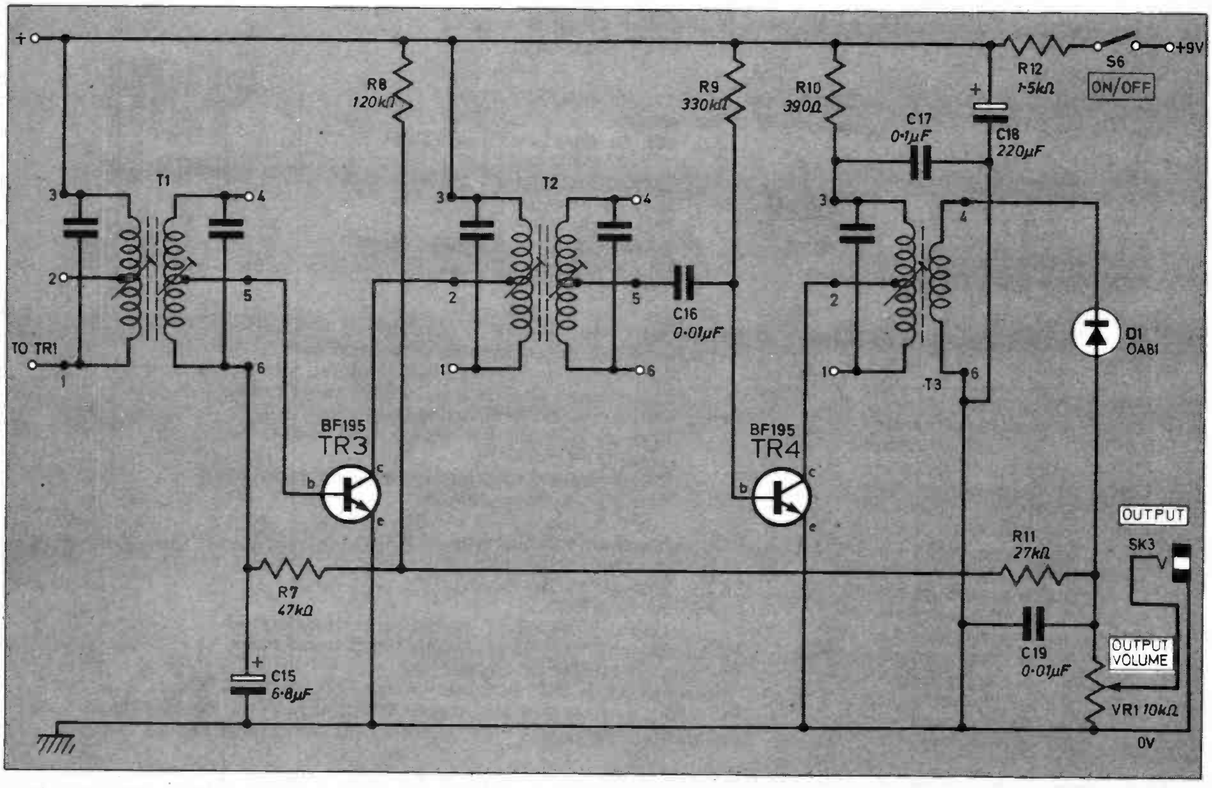


Fig. 1. The mixer and oscillator circuit of the Multi-band Tuner.

Fig. 2. Circuit for the i.f. amplifier used in the Multi-band Tuner.



(3800 to 3500kHz). Position 7 (300pF plus VC2) gives the remaining coverage of this particular band down to 3500kHz.

Although L5 and L6 are manufactured to a high degree of accuracy, slight changes in the *exact* coverages are to be expected, but despite this the bands should be found to be very near those given, so that a wanted frequency falls within the swing of VC2.

With S1 to S4 at *S*, the nine positions of S5 allow tuning from approximately 10MHz to 2985kHz. Tuning capacitor VC2 will need a simple calibrated 0 to 100 or similar scale, and S5 will need marking according to the bands obtained as shown later.

When S1 to S4 is at *M*, positions *1*, *2* and *3* allow reception from 1685 to 500kHz, for the usual medium wave band. Positions *4* and *5* are not used, because these would take the oscillator outside the low frequency end of m.w. band where nothing of interest can be heard.

With S1 to S4 at *L*, the multiband switch S5 is used at positions *6*, *7*, *8* and *9*, giving reception from 309 to 125kHz long wave.

In actual use, tuning operations will be obvious. Selector S1 to S4 is set to *Short*, *Medium* or *Long* as required. Then S5 is turned to the band wanted, which is tuned by VC2. Wanted signals are peaked by VC1.

MIXER AND OSCILLATOR

Transistor TR1 is a gate-protected device, and so requires no special care. Should a non-protected device be used, various equivalents perform well, but on no account must the shorting loop or wire on it be removed until R1, R2, R3 and associated components are wired. Note that drain, gate 1, gate 2 and source lead-outs are not in the same relative positions on the actual device as shown in Fig. 1.

No particular points arise with TR2. It may be felt worthwhile coding the leads with short pieces of small diameter sleeving, as this helps identification. Yellow is suggested for gate 1, brown for source, and white for gate 2 of TR1, with drain leads left bare; TR1 drain runs to pin 1 of IFT1 of the i.f. amplifier.

I.F. AMPLIFIER

The circuit of the intermediate frequency amplifier which operates at 465kHz is shown in Fig. 2. There are two double-tuned i.f.t.'s (intermediate frequency transformers) and one single tuned i.f.t. giving a useful degree of selectivity. The i.f.t.'s are pre-tuned by the maker, and the cores should not be disturbed, except for possible careful touching up as described later.

This part of the receiver occupies its own board, with pins or flying leads from IFT1 for TR1 drain, and positive supply to R5, Fig. 1. At the other end of the board, pins are for the positive supply, and a connection to the volume control.

Components

Resistors

R1	100kΩ
R2	2·2kΩ
R3	100kΩ
R4	1MΩ
R5	2·2kΩ
R6	2·7kΩ
R7	47kΩ
R8	120kΩ
R9	330kΩ
R10	390kΩ
R11	27kΩ
R12	1·5kΩ
R13	330kΩ
R14	6·8kΩ

All resistors ±5% ¼W carbon

Capacitors

VC1	Jackson 00 single-gang 365pF
VC2	Jackson C804 75pF
C1	150pF plastic or ceramic
C2	0·01μF plastic or ceramic
C3	10pF plastic or ceramic
C4	0·1μF plastic or ceramic
C5	100pF plastic or ceramic
C6	0·01μF plastic or ceramic
C7	50pF silver mica 1 or 2%
C8	100pF silver mica 1 or 2%
C9	150pF silver mica 1 or 2%
C10	200pF silver mica 1 or 2%
C11	250pF silver mica 1 or 2%
C12	300pF silver mica 1 or 2%
C13	350pF silver mica 1 or 2%
C14	400pF silver mica 1 or 2%
C15	6·8μF elect. 6V
C16	0·01μF plastic or ceramic
C17	0·1μF plastic or ceramic
C18	220μF elect. 10V
C19	0·01μF plastic or ceramic
C20	47pF or 50pF plastic or ceramic
C21	800pF silver mica 2%
C22	0·05μF plastic or ceramic
C23	100μF elect. 10V

See **Shop Talk** page 231

Semiconductors

TR1	40673 *n*-channel dual gate f.e.t.
TR2	MPF102 *n*-channel f.e.t.
TR3	BF195 silicon *npn*
TR4	BF195 silicon *npn*
TR5	2N3704 silicon *npn*
D1	OA81 or similar germanium diode

Miscellaneous

VR1/S6	10kΩ log. potentiometer with on/off switch
L1	8 turns coil on 11mm (7/16-inch) cored former (see text)
L2	31 turns coil on 11mm (7/16-inch) cored former (see text)
L3/4	Denco MW/LW 5FR ferrite rod aerial
L5	Wearite PO5 coil } or Denco replacements (see text)
L6	Wearite PO7 coil }
L7	Denco Range 2 RED miniature dual purpose coil
S1/4	4-pole 3-way rotary switch
S5	1-pole 12-way rotary switch
S7	on/off switch slide type
SK1	Wander socket (red)
SK2	Wander socket (black)
B1	9V type PP9
T1	Denco IFT18/465 i.f. double tuned transformer
T2	Denco IFT18/465 i.f. double tuned transformer
T3	Denco IFT14 i.f. transformer

Perforated board 0·15 inch matrix size 12 x 12 holes, and 11 x 21 holes; 70 mm (2¾ inches) diameter tuning drum; 4555 drive; small pulleys, cord and spring; PP9 battery clips; materials for case; control knobs (5 off).

Difficulty with this amplifier is unlikely. One possible source of trouble depends on the spreads in gain of TR3 and TR4. If instability arises, usually shown as continuous whistles (which may cease on tuning in a strong signal) then a resistor may be placed between the junction of R9/C16 and TR4 base; or between TR3 or TR4 collector and pin 2 of the i.f.t. A usual value will be about 220 ohms to 1 kilohm. An unnecessarily high value will reduce gain.

Diode D1 provides detection and the usual automatic volume control voltage for TR3, as strong signals move TR3 base negative; D1 is also able to act as a demodulator for s.s.b. and c.w. when the c.o. and b.f.o. mentioned is added.

AUDIO AMPLIFIER

No provision has been made for a.f. amplification in this unit, it being designed simply as a "front end". The output of the i.f. section can be fed into any external general purpose amplifier (of which a number of designs have appeared in previous issues of Everyday Electronics). It may be considered convenient to build a small amplifier on a board for mounting inside the case of the tuner and operating from the same 9 volt battery—sufficient space has been made available to accommodate such an addition.

MIXER/OSCILLATOR BOARD

If 0·15inch matrix perforated board is used, components can be placed exactly as in Fig. 3. The board measures approximately 50×50mm. Drill it to take two 6BA bolts, used to mount it on the 255×100mm metal chassis; fitting is later simplified by drilling the chassis at the same time. Place soldering tags under the nuts, and use extra nuts so that the board can be locked firmly, with about 5 to 10mm in clearance.

It is probably advisable to insert a few components at a time, turn the board over, and solder the joints, then snip off any excess wire. The MC connections are to the metal chassis.

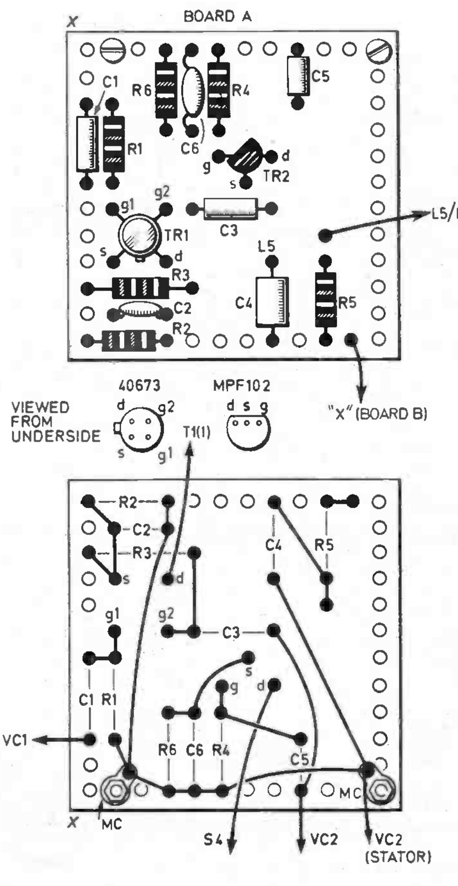
Leads will be needed for external connections and they can be red for positive, green for TR2 drain, yellow for T1 pin 1, and black from C5. The board fits with the 6BA bolts near the front and VC2, and a tag is put under one, in contact with the chassis, for VC2 moving plates connection.

I.F. AMPLIFIER

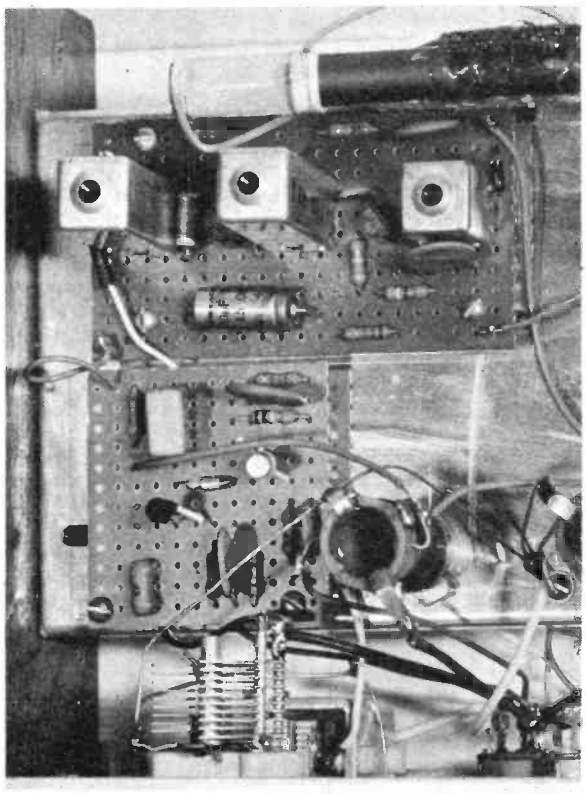
The i.f. amplifier shown in Fig. 4 is prepared in a similar way to the mixer/oscillator board and measures 45×80mm. Holes are drilled for the i.f.t. pins and metal can tags, and a hole is required under T1 and T2, to reach the lower cores. The board is mounted with 6BA bolts, as described earlier.

Pins are convenient here, for

Fig. 3. Layout and wiring of the mixer/oscillator board.



Photograph showing the mixer/oscillator board and the i.f. amplifier board mounted in the chassis and wired up.



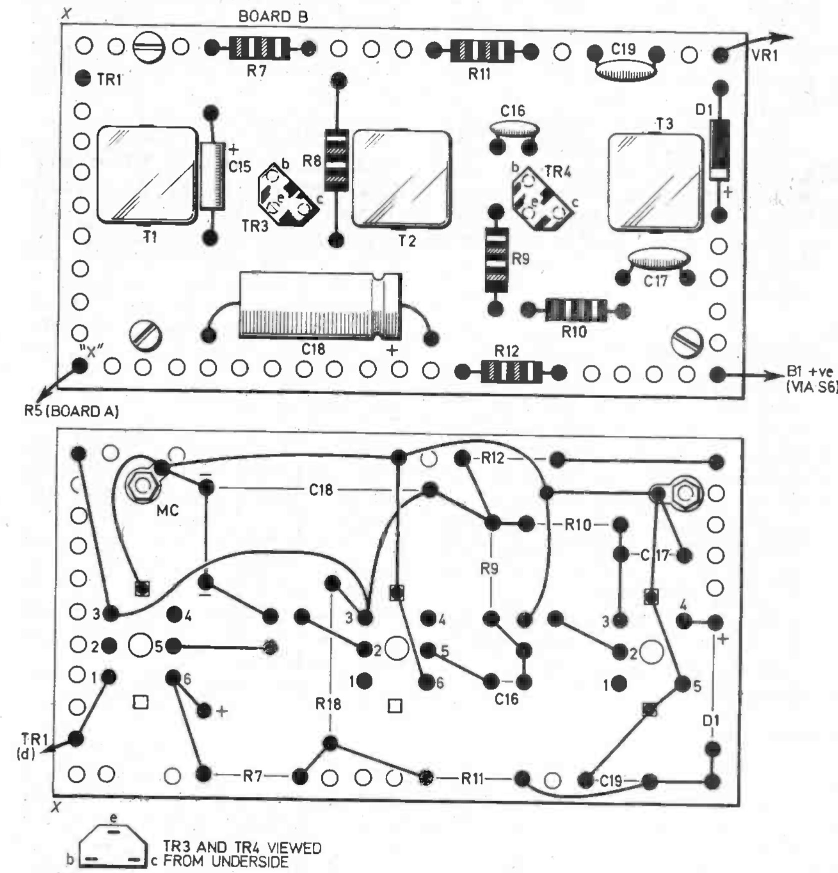


Fig. 4. Layout and wiring of the i.f. amplifier.

connections to TR1, positive, and volume control when the interconnecting leads are wired (see later).

The amplifier may be tested at this stage, if desired, but the volume control must be connected to complete the base circuit to TR3, and the output connected to an audio amplifier and loudspeaker.

Once it is known that the i.f. amplifier is working, either by using a 465kHz signal from a generator or by tuning in signals with the completed tuner, adjustment of the cores can be checked. A properly shaped trimming tool is essential, otherwise the cores may become cracked and jam in the former. The Denco TT5 tool is suitable.

Final adjustment can be made by ear, in which case a signal which is quite weak can be used (with the volume control of the tuner turned up); the use of strong signals will operate the a.g.c. circuit and give misleading results.

Alternatively, a test meter may be inserted in series with the positive supply to the i.f. amplifier and the cores adjusted, using a strong input signal, for minimum battery current (maximum a.g.c. voltage).

Another method is to clip a high resistance voltmeter on a 2·5V or similar low range, from D1 negative to chassis and adjust the cores for maximum voltage reading.

ALTERNATIVE COILS

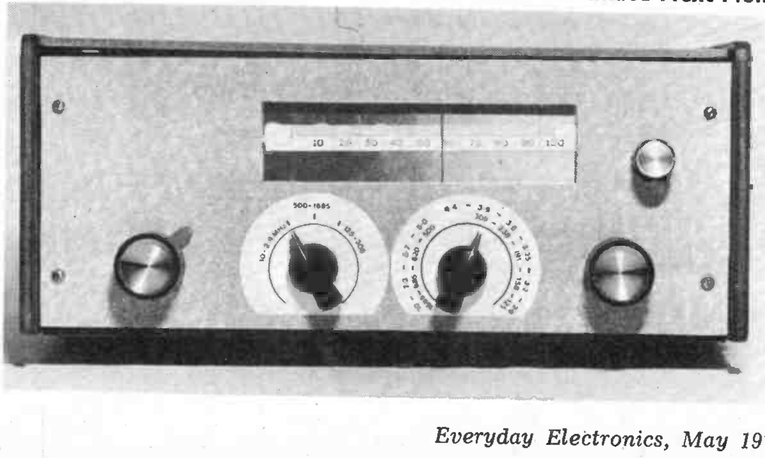
The PO5 and PO7 oscillator coils are in limited supply (see *Shop Talk*) but other coils may be used here. The original coils are 4·8μH and 144·2μH inductance, and the easiest substitute is to fit Denco (Clacton) Ltd. coils of the nearest higher inductance values, so that turns can be removed to secure the same band coverage as provided by the PO5 and PO7.

To replace the PO5 in this way the Denco "White" Range 3, 1·6MHz oscillator coil, *valve type*, is used. Remove 15 turns from the tuned winding. This is readily carried out by temporarily unsoldering leads to pins 8 and 9 (which overlap the tuned winding) and then unsoldering the lead to pin 1. Unwind 15 turns as mentioned, and re-solder the wire to pin 1, cutting off the excess wire. Resolder the leads to 8 and 9, as before. Connections are as follows: 1 to chassis, 3 to switch and variable capacitor circuit, 9 to drain via switch, and 8 to positive circuit. Set the core with about 20 threads of the 6BA rod projecting, and afterwards adjust as necessary to secure band coverage required.

For the PO7, the Denco "White" Range 1, 1·6MHz oscillator coil, *valve type*, is suitable, also with 15 turns removed. Again temporarily unsolder 8 and 9 to permit easy unwinding. Unsolder pin 7, unwind turns as mentioned, and re-solder. Connections for this coil are: 5 to chassis, 7 to switch and variable capacitor, 8 to drain via switch, and 9 to positive circuit. About 25 threads of the 6BA rod should project.

These coils will occupy the positions shown for the PO5 and PO7.

Continued Next Month



Using your MATRIX MARKER

THIS page is designed to illustrate the uses of the Matrix Marker given free with this issue. To see how to use each section, lay the Marker over the photograph below and check each section's use against the relevant captions.

The reverse side of the Marker carries a reference for 0·15 inch matrix boards, this can be used in the same way as that for 0·1 inch matrix. The reverse also provides two rulers, one calibrated in cm. and sub-divided into mm., and one calibrated in inches and sub-divided into sixteenths.

The basic tool and rules can be used as a drawing instrument and for marking out cabinets etc. If a pencil with narrow lead is used—such as the Pentel clutch pencil with 0·7mm lead—the holes can be used for marking out basic paper designs and boards.

TO18 AND TO5 HOLES

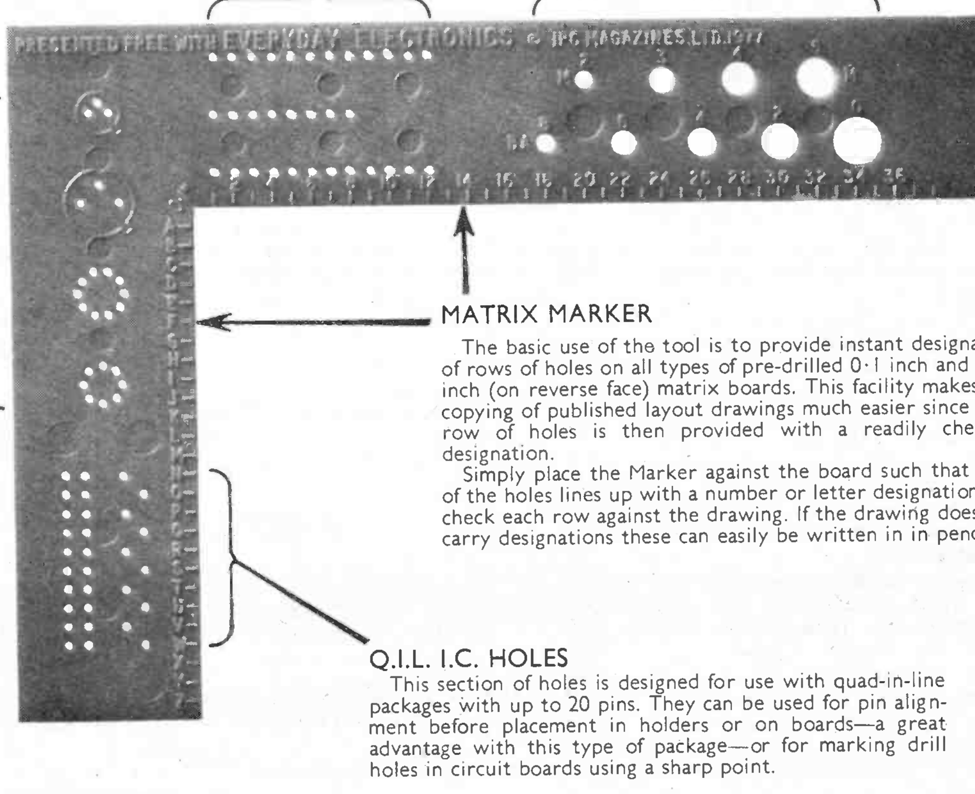
Holes to suit TO18, TO5 transistor and 8 and 10 pin TO5 i.c. packages. These holes can be used to align pins prior to placement in holders, or on pre-drilled boards or to mark boards for drilling using a sharp point.

D.I.L. I.C. HOLES

This section of holes are for use on 8, 14, 16 and 24 pin dual-in-line i.c.s. They are useful for correcting pin spacing before inserting the i.c.s. in holders or pre-drilled board. They can also be used with a sharp point to mark out drilling holes on a circuit board.

SCREW SIZES

Two rows of holes showing screw sizes in metric and BA. Place screws in these holes to see which size they are. Can also be used to check drill sizes when drilling various holes.



MATRIX MARKER

The basic use of the tool is to provide instant designation of rows of holes on all types of pre-drilled 0·1 inch and 0·15 inch (on reverse face) matrix boards. This facility makes the copying of published layout drawings much easier since each row of holes is then provided with a readily checked designation.

Simply place the Marker against the board such that each of the holes lines up with a number or letter designation and check each row against the drawing. If the drawing does not carry designations these can easily be written in in pencil.

Q.I.L. I.C. HOLES

This section of holes is designed for use with quad-in-line packages with up to 20 pins. They can be used for pin alignment before placement in holders or on boards—a great advantage with this type of package—or for marking drill holes in circuit boards using a sharp point.

Remote Reading Thermometer

By F. G. RAYER

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS excluding V.A.T.

£4.50 excluding bell-wire

The temperature-sensing element of this thermometer is intended to be placed out-of-doors, with twin bell-wire or a similar lead running to the reading instrument. As well as showing temperatures outside, clear of the house, it could be fitted in a heated greenhouse or elsewhere, allowing a check to be kept on temperatures from indoors.

The resistance of a thermistor changes with temperature, and Fig. 1 shows a graph which was made by the author, using a VA 1040 thermistor. Its resistance was found to change from 1200 ohms at 10 degrees Fahrenheit to just under 85 ohms at 100 degrees Fahrenheit. As this is a very useful temperature range, the reading or indicating part of the circuit is designed to suit.

It is possible to use bridge and other circuits, with very low currents and amplification, but these in turn can introduce the need for temperature compensation, and more complication.

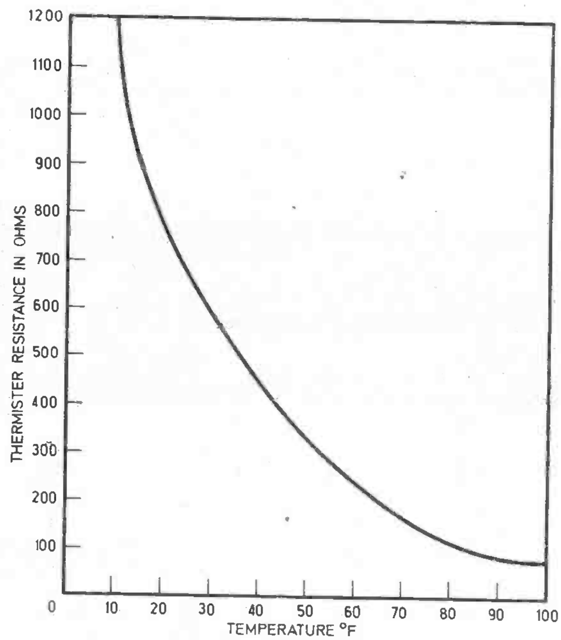
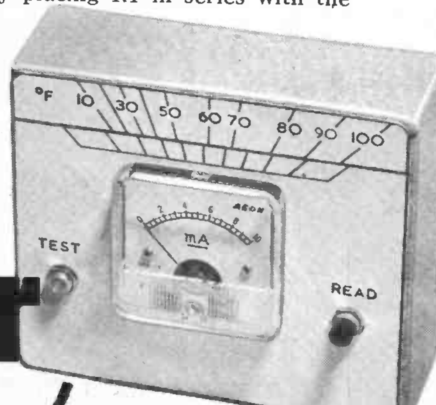


Fig. 1. Graph showing how the resistance of the thermistor varies with temperature.

CIRCUIT DESCRIPTION

The complete circuit diagram of the system is shown in Fig. 2. By placing R1 in series with the



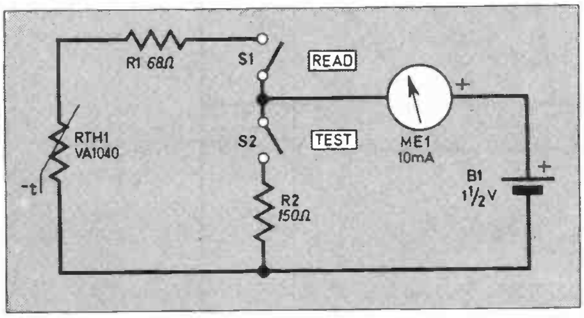


Fig. 2. Circuit diagram of the Remote Reading Thermometer.

Components

Resistors
R1 68Ω
R2 150Ω
Both ¼W carbon ± 5%

Thermistor
RTH1 VA1040 disc type

Miscellaneous
ME1 10mA d.c. moving coil meter
S1, 2 push-to-make, release-to- break (2 off)
B1 1·5 volt type U7
Tagstrip, 2-way insulated; bell wire; test tube; materials for case.

See Shop Talk page 231

thermistor, the combined resistance of R1, thermistor, and meter, at the lowest temperature reading, does not allow current to exceed 10mA, so that a readily available meter is suitable. This also allows the use of a single cell battery, the e.m.f. of which is approximately 1·5 volts.

As a constant current of this magnitude is not feasible, the push switch S1 is incorporated, and is simply pressed when it is required to see the temperature.

The TEST switch S2, with R2, allows the meter to operate as a 0 to 1·5 volt voltmeter, drawing nearly 10mA, so when the test reading falls short of f.s.d. by a selected amount the battery should be renewed.

CONSTRUCTION

A small wooden case, about 110×95×30mm will easily accommodate the components, as shown in Fig. 3 and photograph. A plastic box or other case could be used if available. Two strips from an old cycle lamp battery are bent and bolted to form clips for the dry cell. The cap is anode (+ve). A tag strip provides anchor points for the leads running to the thermistor.

The completed case can be painted or covered with self-adhesive material (as in the prototype), and fitted with a back, which has a hole or loop so that it can be hung on a wall in a convenient position.

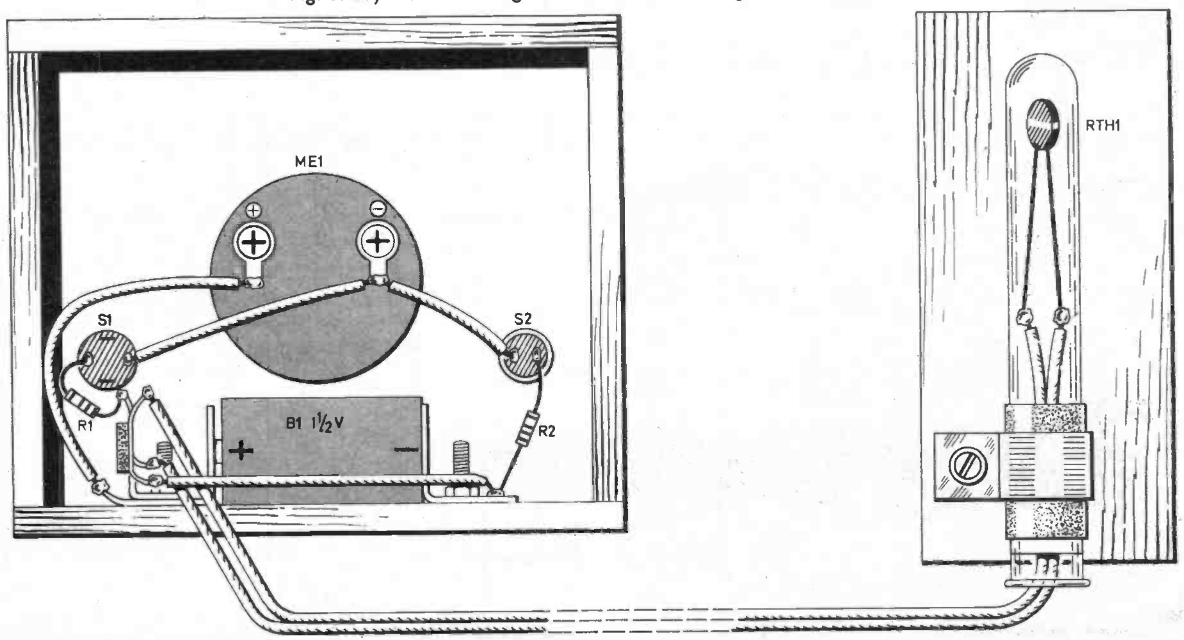
The thermistor must be protected from rain or moisture. It can be soldered to twin leads, and sealed in a 12mm test tube, as shown in Fig. 3, using a cork and melted wax. This item can be free-standing, by fitting it in a hole in a block of wood, or it can be held by a clip which goes round the tube and is screwed to wherever readings are required. A piece of rubber between clip and tube will help secure the tube and reduce the possibility of the tube breaking when the clip is fitted.

SCALE

A full-size front panel template is shown in Fig. 4. This can be copied and glued to the front of the box. The markings under the line agree with the 0 to 10mA points of the meter scale, acting as an extension of them. Temperatures are read off from the upper scale.

With a new battery in place, press the TEST button, and put a mark level with the meter reading on the lower scale. When a

Fig. 3. Layout and wiring of the Remote Reading Thermometer.



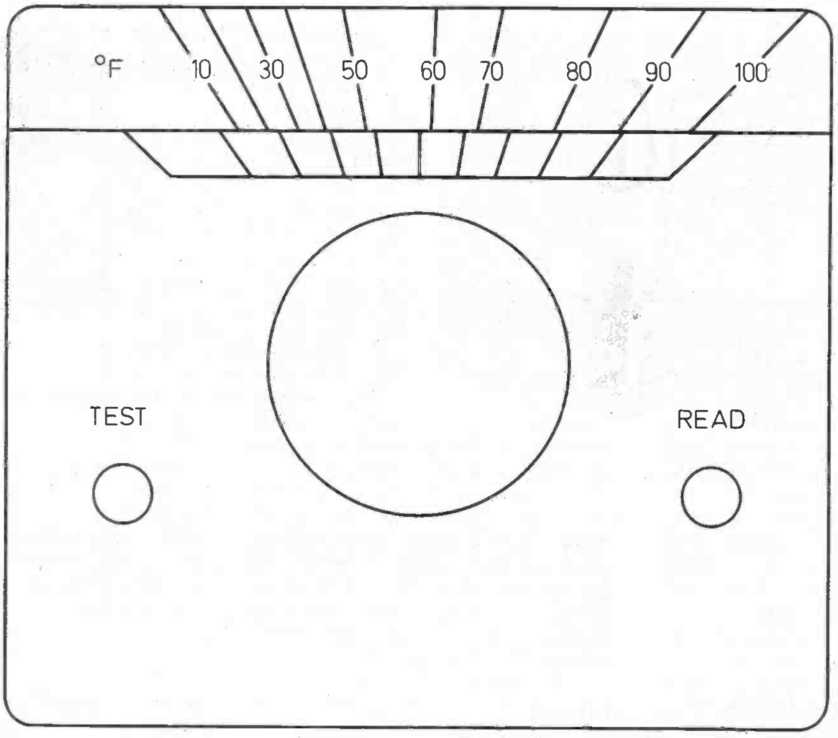


Fig. 4. Front panel showing scale calibrations.

test shows a significantly lower reading, replace the battery.

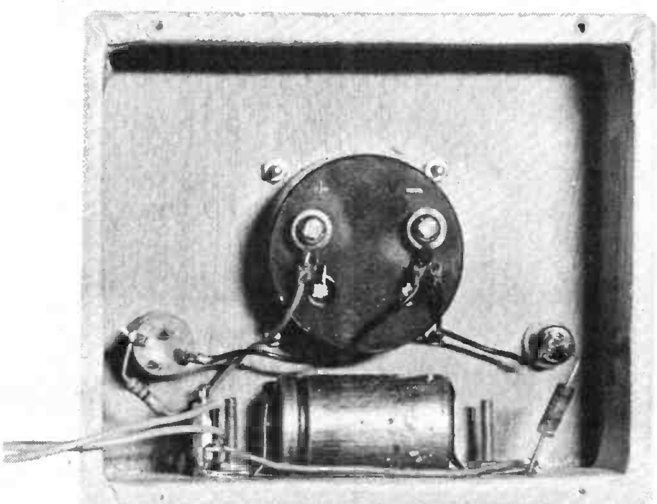
CALIBRATING A SCALE

If an individually calibrated scale is preferred, omit the temperature readings from the template of Fig. 4. Place the thermistor and a mercury or other thermometer together, leaving them some time so that a reliable reading is obtained, and then mark the correct temperature on the scale, as shown when the READ button is pressed. The thermistor can be out of its tube for this, provided it is not placed in water.

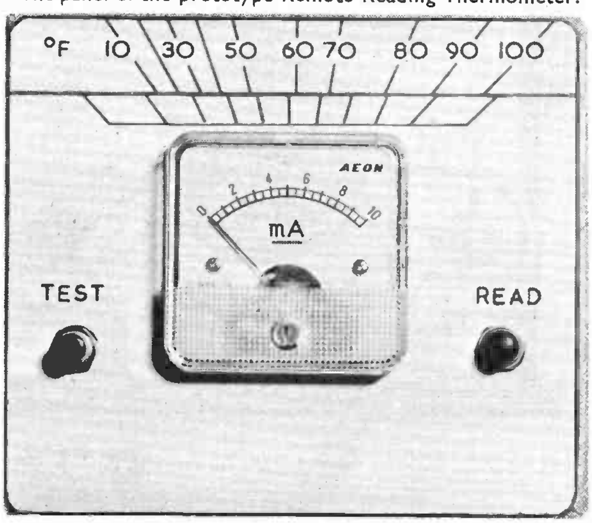
A refrigerator will provide a range of low temperatures in various sections and the freezer box. A closed cardboard box containing the thermometer and thermistor (connected to its indicator unit) appears to provide satisfactory higher temperatures, when left for some time in a warm position.

Either Celsius or Fahrenheit calibration (or both) may be adopted. It should be stressed that if individual calibration is used instead of the scale in Fig. 4, then the thermistor and thermometer bulb should be in close proximity, and be left for some time under the same conditions of heat. Radiant heating of them should not be used. ⌑

Internal view of the Remote Reading Thermometer.

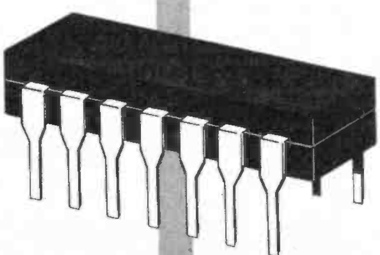


Front panel of the prototype Remote Reading Thermometer.



Doing it Digitally... Part 8

By O. N. Bishop



THIS MONTH'S article is primarily concerned with the applications of counting circuits but we begin with two brief ideas that will be of use to anyone building and using digital circuits.

LOGIC PROBE

A logic probe is a device which gives a visual indication of the logic condition of the point to which it is applied. In this simple probe, an l.e.d. is used to show when a high state is detected.

The probe is built around an old ball-point pen. First remove the plug from the top of the pen and the brass tip and plastic ink tube from the bottom. Pull the plastic ink tube off the brass writing tip using pliers. Discard the plastic ink tube and clean the ink from the tip using a solvent such as methylated spirit.

Next take a piece of thin flexible wire which is about a centimetre longer than the pen. Strip both ends and solder one end into the brass tip. It is easier if the end of the wire is folded several times to fit tightly in the tip.

Bore a small hole (large enough for the wire to pass through freely) about three centimetres from the upper end of the tube. Now thread the wire through the tube and glue the tip back in its original position. Next thread a long piece of the same wire through the hole in the side of the tube and out through the end. Strip the end and solder a resistor to it. The resistor must be small enough to fit inside the tube (use $\frac{1}{8}$W type). Solder the resistor to the cathode of the l.e.d. so that the l.e.d. will light when its other lead is taken to positive.

The pen is shown at this stage of construction in Fig. 8.1. Pull the wire through the side of the tube until the free lead of the l.e.d. meets the free end of the wire soldered to the tip. Solder the two together and, gently pulling the wire through the side of the tube, push the resistor into the tube until the l.e.d. is flush with the end of the tube. Glue it in place. Connect a crocodile clip to the end of the long piece of wire emerging from the side of the tube and the logic probe is ready for use.

The crocodile clip should be connected to a convenient 0V point near the place to be examined.

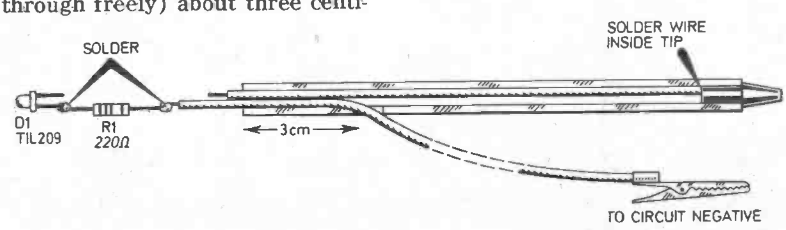


Fig. 8.1. The logic probe just before completion. The wire with the crocodile clip must be pulled to bring the resistor inside the tube and the free end of the l.e.d. must be soldered to the end of the wire.

BATTERY SANDWICH

It may happen that the constructor wishes to arrange for a tape recorder or radio to be controlled by one of his logic circuits. The battery sandwich is a device which fits among the batteries and enables the set to be switched on and off from outside (assuming that the set's on/off switch is left permanently on).

The sandwich is made from a thin piece of plastic or card which has a piece of copper foil or brass strip glued on either side (Fig. 8.2a). A wire is taken to each piece of metal and these wires run out through any convenient hole in the case.

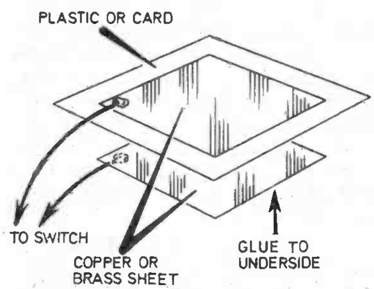


Fig. 8.2a Construction of the battery sandwich. In use the sandwich is placed between two batteries.

The battery sandwich is placed between two of the batteries or between a battery and one of the terminals of the set (Fig. 8.2b). The set will not work now unless the two wires are touching.

The set can be switched on and off by a power switch (see Part 5) medium or high power, if it is wired as shown in Fig. 8.3.

The power switch and radio are powered by the radio batteries.

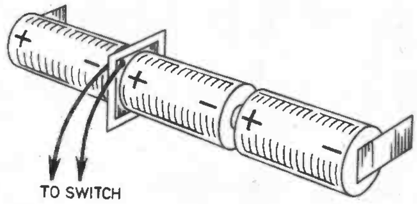


Fig. 8.2b. The battery sandwich of Fig. 8.2a in position.

The other circuits which control the power switch are powered by their own 6V battery.

Current from the positive side of a radio battery flows out of one side of the sandwich to the load terminals of the power

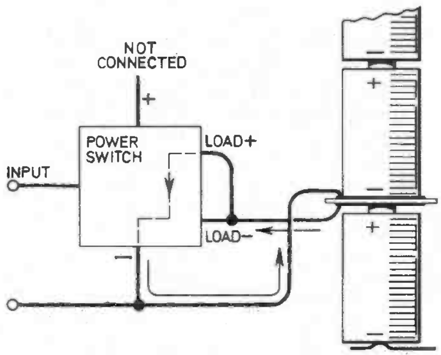


Fig. 8.3. To switch a radio or cassette recorder on and off the battery sandwich is placed between two batteries and connected to a power switch.

switch. The current then flows through the power transistor to the negative line and then back to the radio.

The current flowing in through the positive load terminal powers the 2N2926 transistor if this is a "low on" switch. Note that the negative line of the power switch is connected to the negative line of the other circuits but the positive line is not connected, since the power comes from the radio batteries.

LAP COUNTER

Though presented here as a lap counter for use with a model car racing set, the circuit to be described can be used for counting any objects passing between a lamp and photocell.

A fast response is essential for the light detector and so the phototransistor light operated switch must be used (see Part 5). With this type of detector even the shadow of a single finger moving as fast as possible between the light and phototransistor will trigger the counter.

The output from the phototransistor light operated switch can be fed directly to the input of the 7493 counter i.c. as shown in Fig. 8.4. For the 7493 to count up to 15 the *A* output and *B* input must be connected (pin 12 to pin 1). The two reset pins 2 and 3 will set the counter output to zero if taken high—to count they must be held low.

If more than 15 laps are to be counted, a second 7493 can be added wired identically to the first except that its pin 14 is connected to the *D* output (pin 11) of the first 7493.

It will probably be necessary to count the laps of two cars and for this two lap counters will be required. The lamp can be placed between the two tracks and a photodetector (Fig. 8.5a) on either side of the tracks feeding the appropriate lap counter.

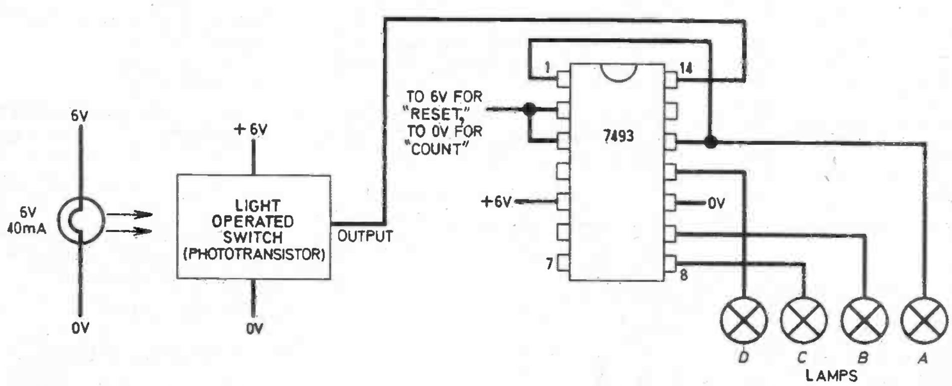


Fig. 8.4. Circuit diagram of the lap counter. The lamp is placed on one side of the track and the light operated switch on the other so that a passing car interrupts the light beam.

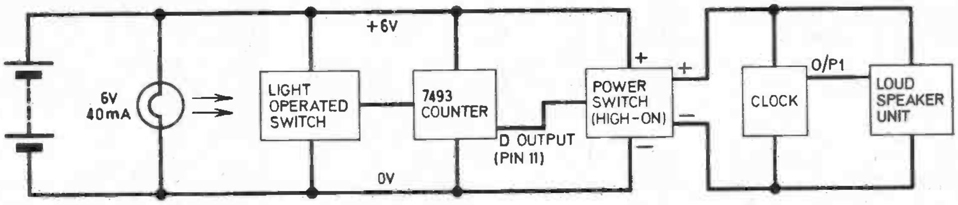


Fig. 8.5. To switch on the alarm after eight laps wire up the system as shown.

LAP ALARM

It is easy to arrange for some sort of alarm to sound when a fixed number of laps have been completed. The easiest numbers of laps to count are one, two, four and eight as these have only a single logic one in their binary representation, 0001, 0010, 0100, 1000 respectively. This means that only one output of the counter is high for these counts so the power switch has only to be wired to the appropriate output.

If a circuit to sound an alarm after eight laps is required, then use the circuit of Fig. 8.5. Here a "high on" power switch is used to supply power to a clock and loudspeaker unit as in Fig. 5.10 (Feb. '77).

At the start of each race reset the counter to zero. At each lap the count will register and at the eighth lap the *D* output will go high for the first time and the alarm will sound. End of race!

For counting one, two or four laps, the power switch is connected to the *A*, *B* or *C* output respectively.

It is also fairly easy to count numbers which have two logic ones in their binary representations. These are three (0011 in binary), five (0101), six (0110), nine (1001), ten (1010) and twelve (1100).

The two appropriate outputs are connected to a two-input NAND gate from a 7400 i.c. When the two outputs go high, the NAND output will go low. This output is connected to a "low on" power switch and the alarm will sound as before (see Fig. 8.6).

To get the longest possible race on one 7493 a four-input NAND gate with each of its inputs connected to the outputs of the 7493 must be used. The 7440 i.c. contains two such gates and its pin connections are shown in Fig. 8.7. The alarm will now sound at binary 1111 i.e. after 15 laps.

If two 7493's have been used as suggested above and the longest possible race is desired then an eight-input NAND gate will be required to detect when the outputs of both counters are all high. The 7430 i.c. contains one such gate and its pin connections are also shown in Fig. 8.7. The alarm will now sound after 511 laps.

As well as sounding an alarm, this technique can be used to do other things. It could be used for switching off the power supply to the track so that the car automatically stops after a given number of laps.

The power to the track is fed through a power switch but the switch must be a high power version.

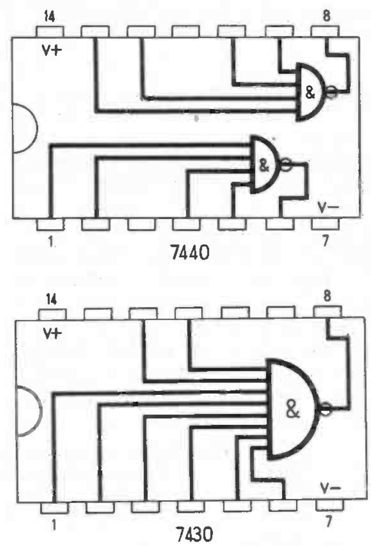


Fig. 8.7. Pin connection details of the 7440 and 7430 integrated circuits.

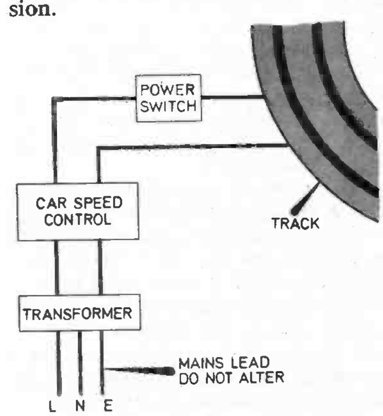


Fig. 8.8. The power switch must be connected between the car speed control and the track. **DO NOT** touch the mains connections.

> **IMPORTANT**
>
> **If a mains transformer is used to power the track, wire the power switch between the transformer and the track as shown in Fig. 8.8 and never interfere with the connections between mains and transformer.**

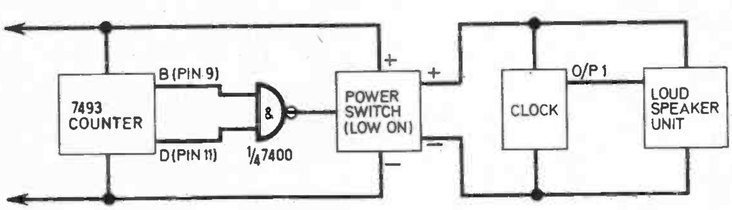


Fig. 8.6. For an alarm after ten laps one gate of a 7400 must be used to detect when the *B* and *D* outputs of the counter go high.

REACTION TIMER

This reaction timer uses the 7493 to count the number of pulses that a clock circuit produces during the time it takes for

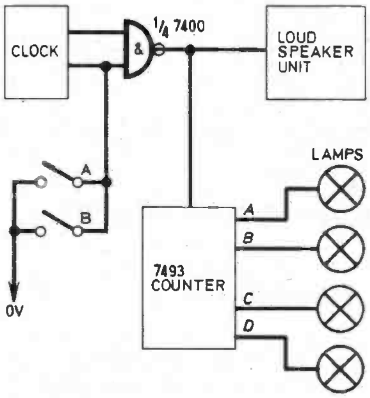


Fig. 8.9. Circuit diagram of the reaction timer.

a person to press a switch after hearing a cue. If the speed of the clock is known then the time of reaction can be calculated.

Something to start and stop the counter is required. This design uses two switches which could be part of the keyboard described earlier. One person operates one switch and as soon as this happens an alarm note is sounded. As soon as the second person hears the alarm he must operate the other switch to turn off the alarm. The time between the on and off is the reaction time of the second person.

The circuit of the reaction timer is shown in Fig. 8.9. The output of the clock is fed through a NAND gate to the loudspeaker unit and also to the counter.

The other input of the NAND gate is fed to two switches. Pressing either of these connects the input to low thus stopping any pulses through the NAND gate.

The first person keeps his finger on switch *A* pressing it down thus inhibiting the operation of the alarm. As soon as he releases his finger the note will be heard and the second person must press switch *B* as quickly as possible to stop the alarm again. With his finger still on the switch the output of the counter is read to see how many pulses have been counted.

With a single 7493 only 15 pulses can be counted. If the clock is running at 150 pulses per second the maximum reaction time will be 0·1 second. This would be just fast enough for a quick reaction so for average reaction times the clock needs to be slowed down to this frequency or below if it is found to be too high. The E below middle C on the piano is 160Hz so tune the clock to just below this.

If the frequency of the clock is too high and suitable timing capacitors cannot be found then the output of the clock could be passed through a flip-flop or two to divide it down to a suitable rate.

The alternative to setting the clock frequency to a low value is to use two 7493's which enable a count of 511 to be made.

To round off this section why not try putting together the last two circuits to form a lap timer?

INTERRUPTED TONE SIREN

In previous circuits an alarm system has been used which has been made from a clock circuit feeding into a loudspeaker unit. It will probably have been found that unless the tone is very loud it does not attract attention easily. A noise that is interrupted —like the pips on a telephone, or the ringing of the telephone bell —is noticed much more readily.

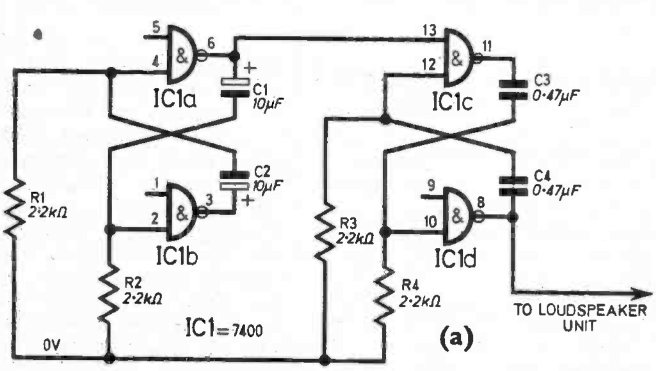
On ambulances, fire engines and police cars two-tone alarms are used so that people quickly hear them coming even above the other noises in the street. The way to generate an interrupted note is to use two clocks. One clock is used to generate the noise and the other to switch the first on and off at regular intervals. The first operates at around 400Hz and the second at about 1Hz. The circuit is shown in Fig. 8.10a and the connections on the experimental deck are in Fig. 8.10b.

Gates IC1c and IC1d form the fast clock but it will only oscillate if pin 13 of IC1c is high. This signal is derived from the output of the slow clock formed from IC1a and IC1b so it will be high for about 0·5 seconds and low for about the same time. The loudspeaker unit thus produces 0·5 seconds pips—a much more effective sound than a continuous tone.

To speed up the pip rate decrease the value of capacitors C1 and C2. To change the pitch of the pips change C3 and C4. The two capacitors in each of the clocks do not have to be of equal value: having C1 and C2 different will vary the on to off times.

TWO TONE SIREN

The interrupted tone siren needs only one 7400 i.c. so is an economical project. A much more interesting noise can be made with two 7400's. With these, three clocks can be built—one slow and two fast but at different frequencies. The slow clock switches each of the faster ones on alternately, the outputs being fed through two diodes to the speaker



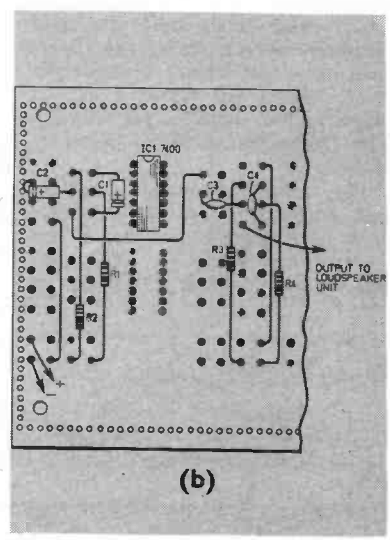
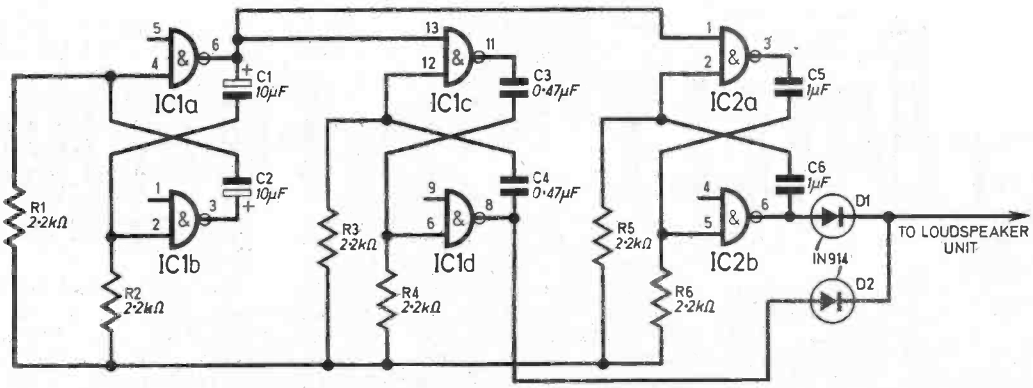


Fig. 8.10. Interrupted tone alarm. The circuit diagram is shown at (a) and the layout on the experimental deck at (b).



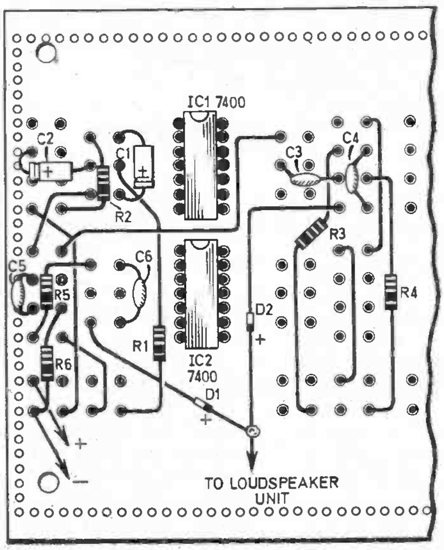


Fig. 8.11. Two-tone alarm. Circuit diagram above and layout on the experimental deck left.

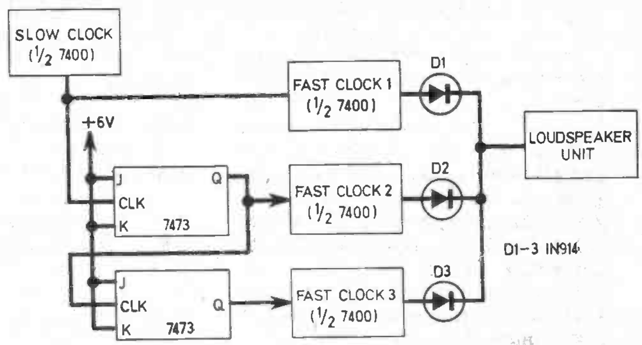


Fig. 8.12. An automatic tone generator. The circuit shown could be used as a door chime.

Components

Logic Probe
R1 220 Ω $\frac{1}{8}$W carbon
D1 TIL209 l.e.d.
Exhausted ball-point pen; thin flexible wire; crocodile clip

Reaction Timer
IC1 7493
IC2 7400
Clock unit; Loudspeaker unit; Keyboard; l.e.d.s. (4 off).

Lap Counter
LP1 6V 40mA
D1 to D4 TIL209 l.e.d.s. (4 off)
IC1 7493 IC3 7440
IC2 7400 IC4 7430
Light operated switch (phototransistor type); Power switches (low on and high on types) (2 off); Clock and Loudspeaker units.

Battery Sandwich
Thin piece of plastic or card; copper foil or brass strip

Interrupted Tone Alarm
R1-R4 2·2k Ω (4 off)
C1, 2 10µF 10V elect. (2 off)
C3, 4 0·47µF plastic or ceramic (2 off)
IC1 7400
Loudspeaker unit.

Two Tone Alarm
All components of the Interrupted Tone Alarm *plus*
R5, 6 2·2k Ω (2 off)
C5, 6 1µF 10V elect. (2 off)
D1, 2 IN914 (2 off)

unit (see Fig. 8.11a and b). With a little experimenting with capacitor values a good imitation of a police siren can be obtained.

ELECTRONIC MUSIC

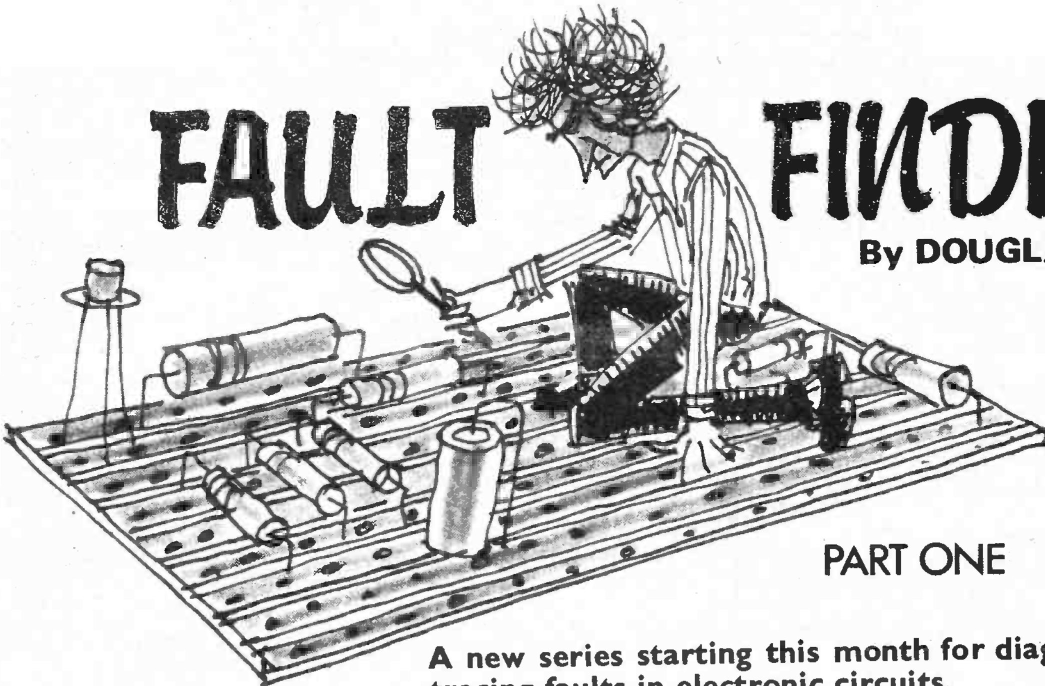
The last circuit was very nearly an electronic organ. It is not too difficult to make up three or four clocks each running at different speeds i.e. tuned to different notes. Each of these can be turned on and off using the unused pin of one of the NAND gates just as pin 13 was used in Fig. 8.10. If each of these pins is taken to the keyboard whose construction was described earlier, then the organ can be played though "in reverse", for the notes will sound when the keys are released rather than when they are pressed. To alter this state of affairs inverters could be placed between the keyboard and the clocks.

If automatic operation is desired try making four clocks one slow and three fast (tuned to different notes). The circuit is shown in block form in Fig. 8.12. The output of the slow clock goes to two flip-flops. The clock and the two flip-flops form a counter whose output goes from binary 000 to 111 (zero to seven). If the three outputs are made to operate the fast clocks the output will be a repeated eight note tune consisting of single notes and chords. If the notes are chosen well it could make a pleasant door-chime.

To be continued

FAULT FINDING

By DOUGLAS VERE



PART ONE

A new series starting this month for diagnosing and tracing faults in electronic circuits.

Some years ago a research psychologist, working for the Army, announced that he could train cooks to trace faults in radio sets. What's more, he said, he could train them to do it faster than radio mechanics.

To prove his claim, he produced the "radio set" shown in Fig. 1.1. The circuit blocks were cardboard flaps which could be lifted up to reveal a sign that a block was working or faulty. You don't have to be a radio mechanic to see that the greater part of the receiver is in the form of a long chain of circuits, with the aerial at the input end and the loudspeaker at the output.

The standard way of testing such a receiver is to feed in a signal at the aerial end and see what happens. If the receiver is faulty, nothing happens, because the signal gets lost somewhere along the chain.

FOLLOW THE SIGNAL

One way of finding out what has gone wrong is to follow the signal along the chain, making tests at each stage. When the signal disappears, the faulty stage is identified, and the mechanic then makes local tests to identify the fault.

That, as I said, is *one* way to find the fault. But is it the best way? The psychologist knew, on strictly logical grounds, that it isn't. In tracing the progress of the signal along the chain, step by step, the mechanic is asking a series of questions. Is the aerial circuit faulty? No. Then is the frequency changer/local oscillator faulty? No. Then is the i.f. amplifier faulty? . . . and so on, right to the loudspeaker

If the fault is near the beginning of the chain, this procedure is fine. A few questions identify faulty elements. But if the fault lies near the *end* of the chain, to the right of the dotted line, then at least three questions are wasted. The most efficient strategy is to start in the *middle*. If you test the input of the i.f. amplifier and there is no signal then you know it must be the frequency changer part or aerial circuit which is faulty, and two further tests at most will tell you which.

So, if the measure of a good mechanic is his ability to find the faulty stage, using the smallest number of tests, then, on average, the start-in-the-middle strategy pays off.

This, of course, was precisely what the psychologist taught the cooks. The radio mechanics, who used the begin-at-the-beginning-and-go - on - to - the - end strategy, were beaten. Naturally, the radio mechanics pointed out that real radio sets are not cardboard "block diagrams", and that to mend them you need to master all sorts of skills which cooks don't have—soldering, operating test gear, and so on. True, but the fact remained that in dealing with circuits in long chains the cooks' strategy is the best one. No doubt the mechanics, being intelligent fellows, went on to use it on real receivers.

SIMPLE TESTS FIRST

The moral of the story is that, in fault tracing as in life, a little thought can avoid a great deal of trouble.

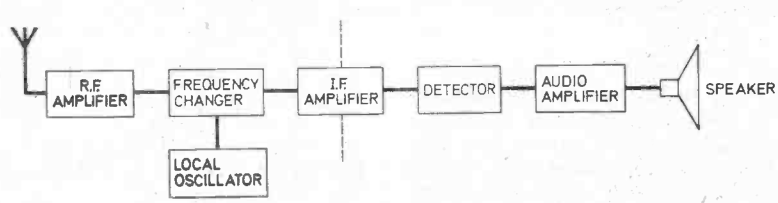


Fig. 1.1. Block diagram of a typical radio receiver.

Most of the circuits which appear in E.E. are a lot less complex than a radio receiver. But, in a simple circuit, with six components, would you clear a fault by unsoldering and replacing each component in turn, until at last the fault disappeared? Or would you first make some simple tests which will at least give an indication of what the fault might be, and also clear some of the components of suspicion?

Army radio mechanics have at their disposal a fair amount of test equipment. The average electronics enthusiast doesn't. In these articles the only bit of special test equipment called for will be the ubiquitous multimeter, which I'll refer to for short by its American name, the VOM, which stands for volt-ohm-meter. (Many of these instruments measure current as well, but volts and ohms are more useful.)

However, it is often possible to make quite useful tests without a meter. To illustrate this we'll work our way through the procedure of fault-finding in a simple audio amplifier. The fault is the usual one—no audio output!

Such an amplifier is made up of a chain of circuits, so in theory there's a best strategy for isolating the faulty area. However, it often happens that the amplifier is divided naturally into two parts, see Fig. 1.2.

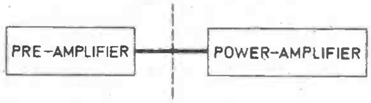


Fig. 1.2. A convenient point to "split" an amplifier.

There's the pre-amplifier part, which generally contains all the controls (equalisation, volume, tone, etc.) and the power amplifier which contains everything else (including, in mains-operated equipment, the power supply unit). Even though these two "halves" of the amplifier may not be strictly equal, it's usually very convenient to start by checking that signals are getting from one to the other.

Even if you don't have an audio oscillator, audio signals are usually available in the home in some form or other: from a gramophone pick-up or a radio receiver, for example. They can be connected temporarily to the faulty amplifier to provide a signal to trace through the circuit.

WARNING

Readers are warned against using TV sound. The circuitry of the usual mains TV set is not isolated from the mains. If you connect up to, say, its loudspeaker you may get a lethal 240V, 50Hz, as well as a volt or so of audio.

TEST PROBE

To detect the signals you need some sort of listening device. It's important that the device shouldn't upset the part of the circuit to which it is connected (e.g. by drawing too much current). To avoid this, a very high impedance listening device should be used. The most easily obtained is a crystal earpiece, but big old-fashioned metal diaphragm high-impedance magnetic headphones can be used (not miniature "transistor" earpieces, which are usually very insensitive) provided that a 100 kilohm resistor is wired in series.

It's also advisable to include a d.c. blocking capacitor of around 100nF (0·1μF). This should be a non-electrolytic type, since it will have to block d.c. of either polarity.

For transistor work, a 100nF, 250V working is fine, but valve amplifiers use h.t. supplies of up to 500 volts, so a higher voltage rating is needed for them. (However, beginners should avoid valve equipment: the voltages are too high for safety.)

It is very convenient to make a test probe with a 100 kilohm resistor built in (see Fig. 1.3 for details). To do this you need an old ball-point pen.

Remove the ink tube. File off the tip of the conical end, so as to remove the ball and expose the hole through which the ink runs. Give the bronze tip a thorough clean to remove the traces of ink. Pulling a bit of thread through the hole helps to clean the inside.

Now for soldering. The probe tip can be a pin. Cut off the head, and run solder over the end of the shank. Fill the inside of the hole in the bronze insert with solder. Finally, insert the pin while keeping the bronze hot with the soldering iron, and then allow to cool. Obtain a 100 kilohm resistor small enough to fit into the plastic barrel of the ball-point pen, solder as shown, attach a flexible insulated lead and slide the barrel of the pen along the lead and back into place.

To complete the probe you need an "earth" lead—another flexible insulated conductor, this time terminated in a crocodile clip. And, of course, the d.c. blocking capacitor. It's a good idea to mount the capacitor and the ends of the leads on a screw terminal block, as shown in Fig. 1.3. The block provides an anchorage point for the earphone leads. As an alternative to earphones you can connect up to an audio amplifier such as the audio part of a pocket radio receiver.

USING THE PROBE

To use the probe, first clip the "earthy" lead to the earthy or common side of the battery or amplifier. The probe point is now applied to various parts of the circuit where the audio signal should be audible. It may be very weak in the earlier stages of the amplifier but fortunately the human ear is immensely sensitive and in a quiet room even low-level signals can be heard.

As mentioned earlier, the most convenient "half way point" for the first test is the output of the pre-amp or the input to the power amplifier. These are, electrically, the same point but may in prac-

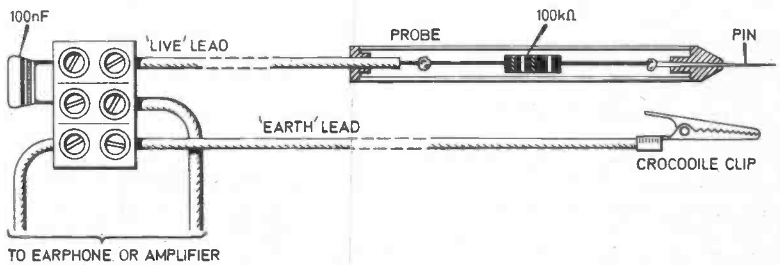


Fig. 1.3. Construction details for a handy test-probe for feeding to an earpiece or amplifier.

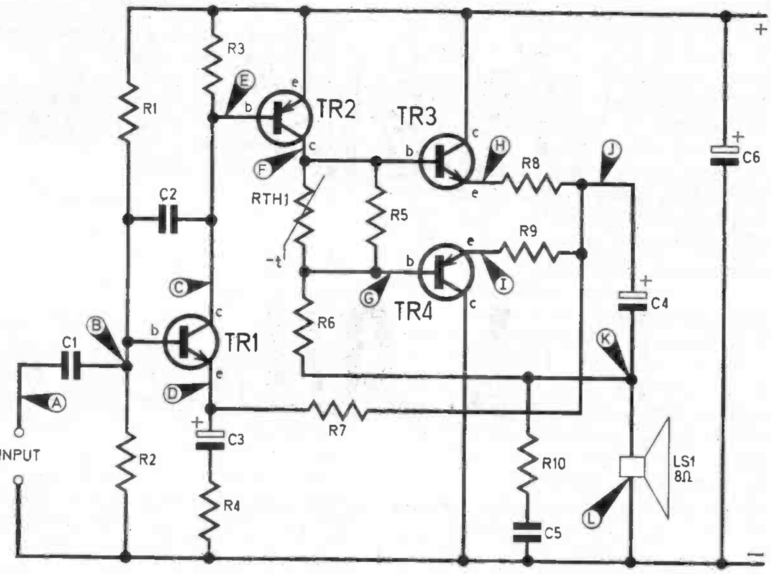


Fig. 1.4. The circuit diagram of a typical audio amplifier with test probe points indicated by *A* to *L*.

tice be at opposite ends of a connecting cable.

In testing, do always bear in mind the sad fact that a great many faults are caused by faulty connecting cables, plugs and sockets. The fact that a signal goes into one end of a cable is no guarantee that it will come out at the other end!

Well, let's suppose that the audio signal which you've applied to the amplifier from your gramophone, radio, test oscillator, or whatever source you can conveniently lay hands on, does in fact appear at the output of the pre-amp and the input of the power amp. This proves that the fault is in the power amp, and you must now try to find out what part of the circuit it's in.

TYPICAL AMPLIFIER CIRCUIT

So let's look at the circuit of Fig. 1.4. I've chosen a fairly typical circuit, such as might be found in medium-fi audio gear with a power output of 3 to 10 watts.

To the beginner, unfamiliar with audio circuitry, this may seem very complicated. At this stage, however, you don't need to know more than is required to trace the signal from input to output.

One elementary fact helps you to do this. In a working transistor, handling audio signals, the signals are present at two electrodes at least. They are always present at the base (the input) and should also be present at either the collector or the emitter, or both. So the transistor lead-outs are obvious test points. They are easily identified even in an "unknown" piece of equipment whose circuit diagram you don't possess.

Again, even in unknown equipment, it's usually possible to guess which transistor is in the first stage, which is in the second and so on. The power transistors in the output stage are identifiable because they are big, and fitted with heat sinks or coolers.

Logically, the first test should be made on the middle stage of Fig. 1.4, that is TR2. But since you can probably test all the stages in a few seconds it's not obligatory to sit down and rack your brains to find the right sequence.

Since there is a fault which has caused lack of output, the signals must disappear at some point along the chain. Once you've identified that point you can start searching, by other tests, for the cause of the trouble.

That will be the subject of later articles in this series. Before leaving simple signal-tracing tests, however, I'd like to make a few further points. First, nothing which has been said so far proves that there's anything wrong with the amplifier itself. The fact that when an input is applied there's no sound in the loudspeaker could be explained quite simply by a fault in the loudspeaker itself, or a break in the connections to it.

One fairly common fault—an open-circuit voice coil—can be identified by testing at the connecting tags on the speaker itself. If there is audio at *K* but not at *L* (with the earthy side of LSI disconnected) the voice coil is broken or jammed.

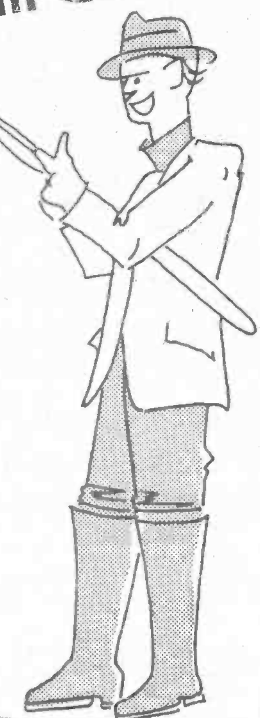
Usually, faults cannot be pinpointed with such accuracy by signal-tracing tests. This is because a fault in one stage can easily put the preceding stage out of action. Thus a base-emitter short in TR2 will cause the signal to disappear from the collector of TR1, making it appear that TR1 may be faulty.

Signal-tracing with the ears is not a very good way of finding faults such as low sensitivity or high distortion. The earphone is a poor indicator of these: one really needs some sort of instrument. Fortunately, these faults are often accompanied by abnormal d.c. voltages in the circuit, and these can be found by means of simple voltmeter tests which we"ll look at next time.

To be continued

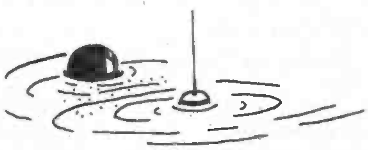
. . . . On average the start-in-the-middle strategy pays off

...Next Month

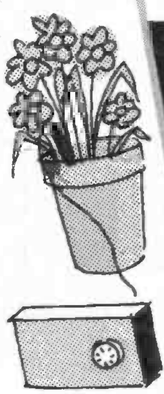


Fish Attractor...

An ingenious device to be submerged in your fishing territory. When operating it arouses the curiosity of any nearby fish resulting in them taking a closer look . . . and hook?



SOIL MOISTURE MONITOR



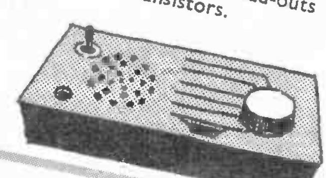
Emits a low-frequency audible tone whose pitch depends on the moisture content between the probes.

DOOR CHIME INHIBITOR

Just the job to quieten the impatient caller.

TRANSISTOR LEAD OUT INDICATOR...

Useful for identifying the lead-outs from unmarked transistors.



everyday electronics

JUNE ISSUE
ON SALE
FRIDAY
MAY 20

metronome

By A. J. Flind

Helps you to keep a constant tempo

THE traditional metronome is a clockwork device widely used by musicians. It gives a loud regular ticking sound at an adjustable rate, which sets the "beat" (tempo) for the piece of music being practised.

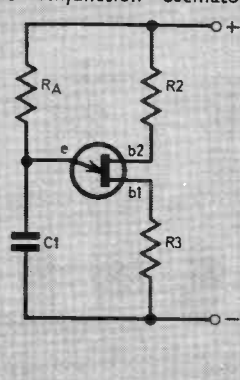
Many designs for electronic metronomes have appeared in print, some with additional features such as flashing lights, but most use either the two-transistor astable flip-flop for pulse generation or a "blocking oscillator" using a transformer. Both these designs are inherently more complex, use more components, and draw a higher operating current than the circuit to be described here, which uses a unijunction transistor. The unijunction needs only the simplest of circuits for it's operation, and it's short pulse output makes it ideal for use in a metronome.

THE UNIJUNCTION TRANSISTOR

At this point, some discussion of the operation of the unijunction is called for. Physically, it looks like an ordinary transistor, but here the resemblance ends; internally it is a very different animal. Without going too deeply into theory, it's operation as an oscillator is explained as follows.

Looking at Fig. 1, the unijunction has three terminations, referred to as emitter, base 1, and base 2. The two bases are taken to the supply lines via resistors R2 and R3 which are of low value and used for current limiting and stability. The emitter is coupled to the junction of R1 and C1. When the supply is switched on, the device appears as a high resistance between bases b2 and b1, and only a small current (about 1mA) flows through it. The emitter does not conduct at all. Capacitor C1 commences to charge through R1, and this continues until the voltage across it, i.e. the potential at the emitter, has reached a certain threshold value (usually about 5 to 7 volts) at which point the emitter suddenly becomes conductive and rapidly discharges C1 through e/b1 and R3. At the same time the whole device becomes more conductive and a far greater current flows through the device b2 to b1. With C1 discharged, however, the device reverts to it's former high resistance state and the whole cycle recommences.

Fig. 1. Basic unijunction oscillator circuit.



The outputs thus consist of short pulses, positive-going at b1, negative-going at b2, plus an approximate sawtooth at the emitter, though it should be noted that the latter is at high impedance and for most applications some kind of buffer stage (usually a simple emitter follower) is required.

The repetition frequency is entirely dependent upon the values of R1 and C1, and the circuit will operate reliably from sub-audio frequencies to above 100kHz.

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ESTIMATED COST OF COMPONENTS *
excluding V.A.T.

£3.20
excluding case

CIRCUIT ACTION

The complete circuit diagram of the unit is shown in Fig. 2. The basic pulse generator works exactly as described above. Potentiometer VR1 and R1 takes the place of R_A, giving a variable repetition rate to the output pulses with R1 setting the maximum speed. The fixed amplitude output is taken from b1 and is available through VR2, the volume control. The required amount of signal is then passed across to the base of transistor TR2, operated in a switching mode, normally biased off and passing no current but being turned no briefly by the positive pulses from originating at b1.

This arrangement results in considerable savings in terms of components used and in current drawn from the supply. Resistor R4 sets the minimum volume level; if the device cannot be turned right down it is less likely to be inadvertantly left running. Capacitor C2 is a decoupler—a small battery such as PP3 as used here cannot supply the heavy current required during the brief periods when TR2 is conducting at high volume, but this capacitor can store sufficient charge to meet the demand easily. With the value given the circuit will in fact give a few ticks after being switched off.

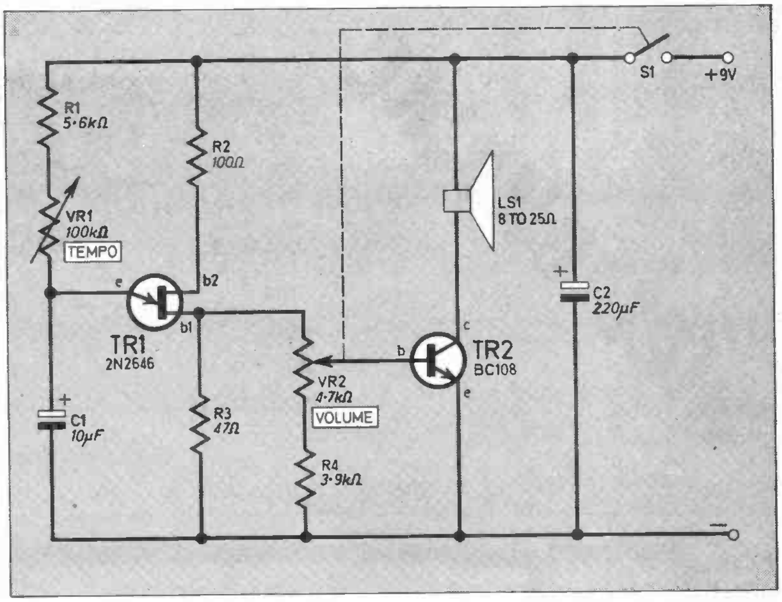
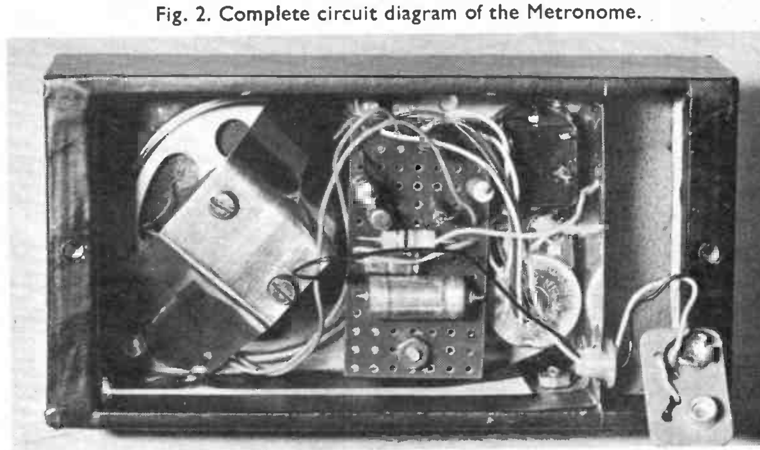


Fig. 2. Complete circuit diagram of the Metronome.



CONSTRUCTION

The layout of the components is not critical and may be changed to suit requirements. The components in the prototype were set out on a piece of 0·15 inch matrix stripboard size 7 strips by 14 holes as shown in Fig. 3 which also shows the layout of the components within the case and complete wiring up details.

The speaker used was salvaged from an old tape recorder but any small speaker with an impedance of greater than 8 ohms will be suitable.

The case for the original had Fablon covered plywood sides and aluminium front and rear panels, though many constructors may prefer to use one of the many commercial cases available. The prototype case measured 135 x 70 x 40mm.

A piece of U-shaped tinplate or aluminium fitted as shown produces a battery holder/compartment. It is always wise to build

Components

Resistors
R1 5·6kΩ
R2 100Ω
R3 47Ω
R4 3·9kΩ
All ¼W carbon ± 10%

Potentiometers
VR1 100kΩ lin. carbon
VR2/S1 4·7kΩ log. with switch

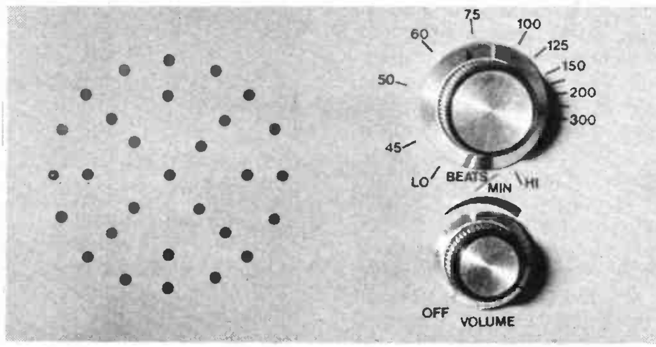
Capacitors
C1 10μF elect. 10V
C2 220μF elect. 10V

Semiconductors
TR1 TIS43 *n*-type unijunction
TR2 BC108 silicon *npn*

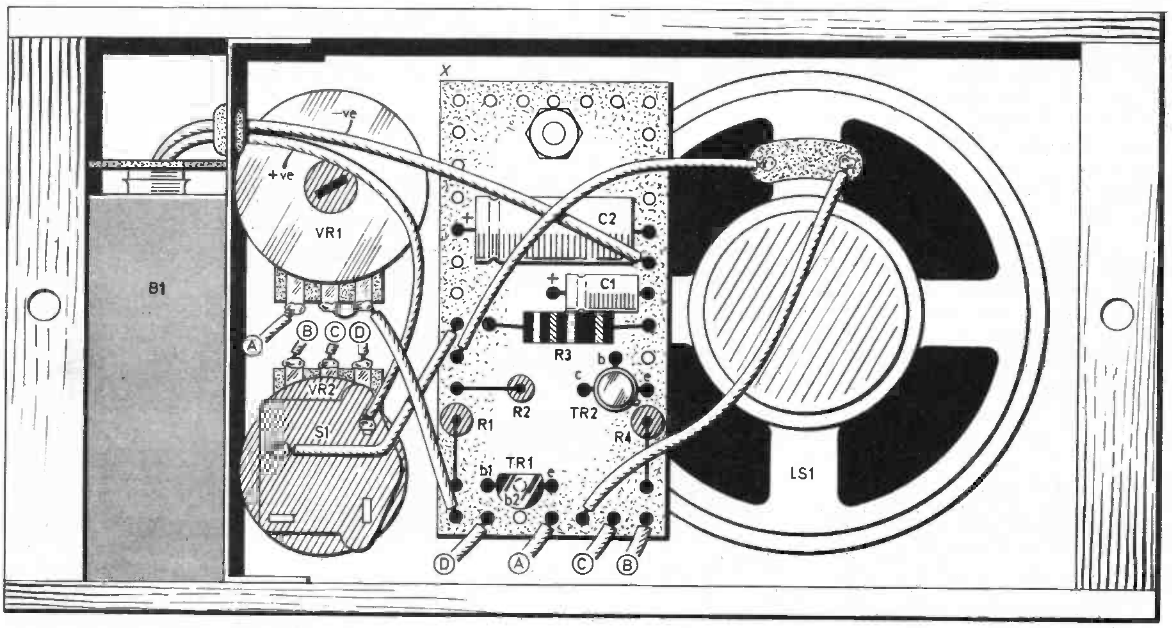
Miscellaneous
LS1 miniature loudspeaker, coil resistance 8 to 25 ohms
B1 9 volt type PP3
0·15 inch matrix stripboard size 7 strips by 14 holes; battery connectors; knobs (2 off); connecting wire; case materials.

See **Shop Talk** page 231

metronome



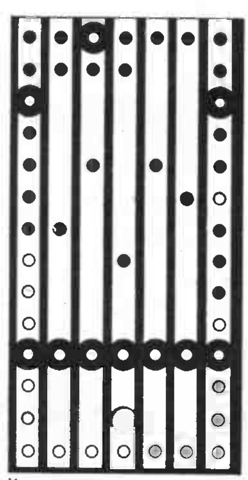
Photograph showing front panel markings.



the housing round the unit after it has been constructed.

Calibration is simply carried out using a watch with sweep second hand and counting and then marking the front panel accordingly. A neat and professional finish can be obtained using coloured Fablon front panel and Letraset.

The volume was found to be more than adequate on the prototype and with an average current drain of 4mA the battery type specified will provide many hours of use before replacement is necessary. ☐



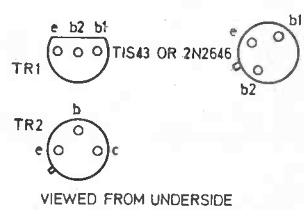
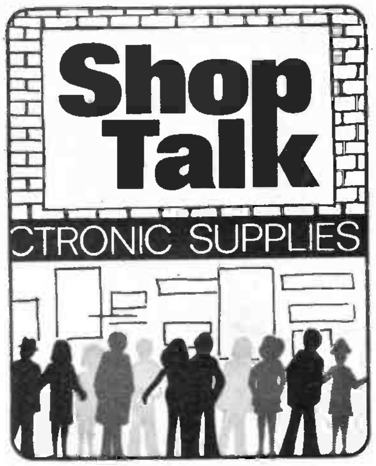


Fig. 3. Layout and wiring of the complete Metronome.



By Mike Kenward

New products and component buying for constructional projects.

IT is with some feelings of sorrow that I sit down to write this, my last Shop Talk. Having been with EVERYDAY ELECTRONICS since it started some 5½ years ago, the time has come for me to move on. I hope that over the years I have been able to be of assistance to more than a few readers and I can assure you that Brian Terrell—who will be taking on the task of keeping you informed about component buying—will continue the tradition.

We on EVERYDAY ELECTRONICS have always tried to operate on a personal level with you the reader and we hope you feel at home in our pages and know that you can contact us if any of our projects give you problems.

Having said my piece I had better make sure it's true and provide you with enough information to go out and get the parts for our projects this month.

Multi-Band Tuner

The coils used in the Multi-Band Tuner are now very limited in supply. Home Radio have a few in stock but once they are gone constructors will have to use the alternative Denco coils and modify them as described in the text. Denco advertise in our issues and you will find their address in later pages.

The only other problem which may occur is the supply and fitting of the dual gate MOSFET. For supply we suggest you contact one of the larger firms specialising in semiconductor sales—there are a couple that advertise only semiconductors in our pages.

As far as fitting the device is concerned if an alternative with no gate protection is used we suggest you wind some thin wire around all the connecting wires to short them out and only solder the device with an earthed or low leakage iron, without power applied to the circuit. Some of these devices can be damaged by static so its best to be careful.

With such a large list of components a few pence extra on each one will greatly increase the overall cost so watch this when buying the bulk of the parts.

Metronome

No buying problems with parts for the Metronome although the speaker may be fairly costly in comparison to other parts. You could of course use one from old equipment provided it is not too large to fit inside a suitable cabinet and that its impedance is greater than eight ohms.

Remote Thermometer

Most stockists should be able to supply all the electronic parts for the Remote Thermometer, the only item which could provide any problem is the test tube—however we are informed that a number of larger stores sell small items of chemistry equipment including suitable test tubes. In any case almost any suitable small tube with a stopper will do and most chemists will be able to supply small pill tubes. The cost of the meter will determine the overall cost of the project so look around before buying.

Resistance Meter

No problem with buying components for the Resistance Meter although you may have to go to one of the larger suppliers for the f.e.t. The size of the meter will determine the accuracy of the readout and, as above, the overall cost of the unit.

New Products

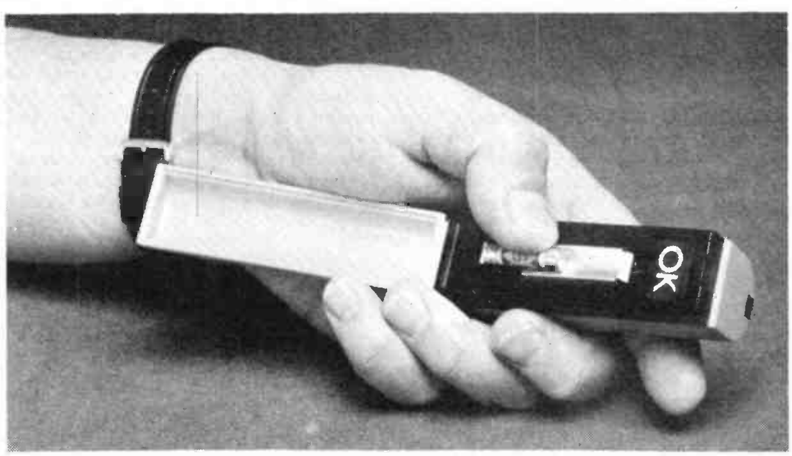
A fuse checker has recently been introduced by Moulds For Plastics Ltd., Watchmead, Welwyn Garden City, Hertfordshire, AL7 1AP. This simple item will provide a quick check on fuses from 1A upwards. It should prove useful to anyone doing a fair amount of electrical wiring. The unit costs £1·25 including VAT and packing, is supplied ready for use and can be obtained direct from the manufacturers at the above address.

News of 27 new watch styles from Texas instruments included a piece on improved circuit designs. These improvements enable the ladies watch styles to be made smaller—and the i.c.s. now incorporate a special driver circuit which compensates for battery voltage variations.

The new range includes four styles aimed at the youth sports market which feature a do-it-yourself decal design kit—the watches in this range carry a suggested retail price of £13·95 including VAT.

Another new catalogue has come our way, this one from Bi-Pak, it has 127 pages well packed with components, information, equipment, etc. The company supply a good range of books in addition to their large stock of general components and semiconductor devices.

Bi-Pak state that all orders are despatched by return, except when out of stock, and that they can supply overseas readers provided extra is included for air mail, which is charged at cost. Catalogue cost is 50p plus 15p post and packing.



Physics is FUN!

By DERRICK DAINES

Sound Wave Transmission

When sound travels through the air, what exactly is it that travels? The answer is illustrated quite beautifully by means of a "Slinky" spring, a toy that is designed to utilise kinetic energy in walking downstairs by itself.

For the wave transmission demonstration two people may stretch the spring some 5 to 6 metres quite easily without distortion. One then gives a push at the end he holds, when a wave is seen quite clearly traversing the length of the spring and returning backwards and forwards several times before it decays.

So what has travelled? The spring ends up in exactly the same position and condition that it was before, but *something* goes down the spring—you can see it. Clearly, the answer is that energy has travelled and the people holding the spring will feel the difference each time the wave reaches them; they will feel the arrival of the energy, see Fig. 1.

The spring is also useful in the study of *how* the energy travels and one may observe the compression and expansion of the rings of the spring. The front of the energy wave has compressed rings, whilst immediately behind it the rings are expanded, subsequently quickly settling down to their normal condition, see Fig. 2.

Fig. 2. Shows compression pattern for wave travelling along a spring.

By analogy we may compare the travelling wave to that of a single sharp sound such as a hand clap, and although the demonstration is quickly accepted, it is my general experience that folks like to play around with the spring for some time before the concept of the transmission of pure energy is really assimilated.

Of course, the spring transmits energy in only one dimension. Moreover, if a continuous stream of pulses or waves is transmitted, the reflected waves interfere with the arriving ones and the result is a hopeless jumble.

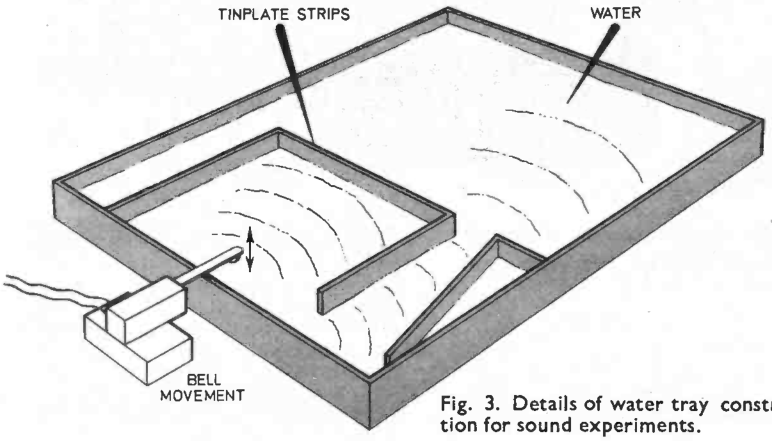


Fig. 3. Details of water tray construction for sound experiments.

Water Tray

Now when this old greybeard was trying to grow his first whiskers, he saw in a school laboratory a simple piece of apparatus that seems to have gone out of fashion. It was a water tray. By its aid one could study the transmission of waves in two dimensions and what is more send a continuous stream of waves. I see no reason why anyone should not have enormous fun with one and at the same time learn an awful lot about acoustics.

Take a large waterproof tray of enamel or tinplate, the bigger the better, place it on a level surface and pour enough water into it to fill it about 25mm deep. The "sound source" is the movement from an electric bell or buzzer arranged so that the clapper repeatedly touches the surface of the water, thus sending a continuous stream of waves radiating outwards. Adjust the voltage and vigour of the movement so that the waves are so small as to be almost decayed by the time they reach the far end of the tray.

Now cut lots of strips of tinplate about 35mm wide and bend them in a variety of shapes. Any shape may be placed vertically in the path of the waves and the resultant reflection of of the waves studied.

Application

This is not just a toy. For example, one may bend the strips into a scale cross-section of a hi-fi speaker reflex cabinet to study the efficiency of the design. Again, one might wish to make a scale cross-section of a particular hall or theatre to study dead spots or standing waves. It is not suggested that a water tray will give the answers in every case, but it will certainly provide a starting point for more careful analysis.

For greater ease of observation or for showing to a larger audience such as a group of students, a spotlight may be arranged inclining at an angle onto the surface of the water and so reflected up onto a suitably-placed and inclined screen.

The transmission of sound through an aperture distant from the sound source is particularly interesting and readers are invited to place two strips at right angles to the flow of waves. Start with a wide gap between the ends of the strips and gradually close it. Some surprises are in store!

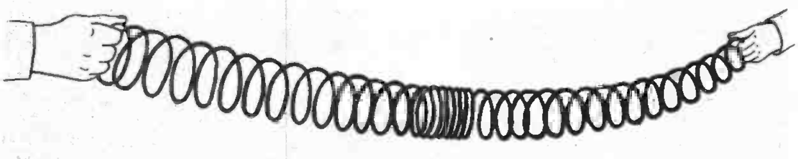
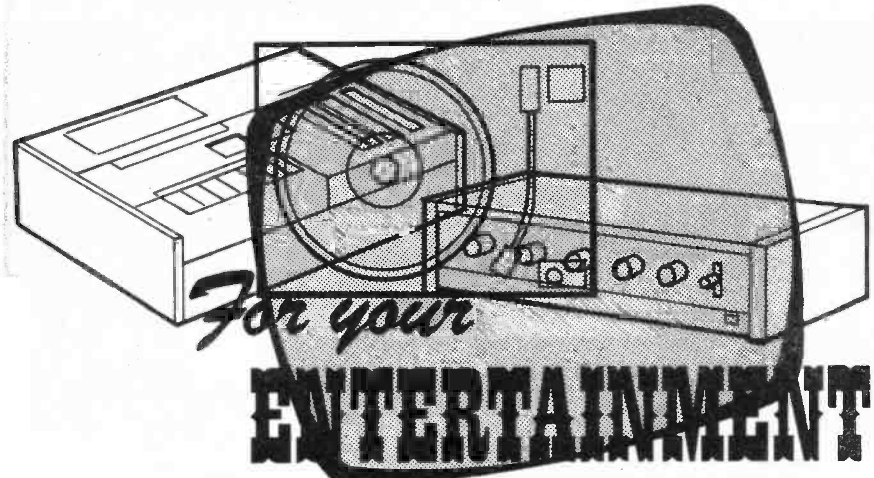


Fig. 1. An "energy packet" travelling along a Slinky spring.



By ADRIAN HOPE

IT'S BECOMING an increasingly expensive business to use battery-powered equipment. A full set of batteries for a portable cassette recorder or even a calculator can now cost you up to £1 and, with careless use, can need replacement in a very short while. Some tips and spin-off thoughts may thus be of interest.

Calculating Costs

Before buying a calculator, (or, for that matter a digital watch) do give thought to the different types of read-out displays that are now available. These fall into two broad groups. Light emitters, such as light-emitting diodes, or l.e.d.s, and electroluminescent displays, actually produce light themselves, and thus show in the dark. But they also consume a considerable amount of battery power. Light controlling displays, such as liquid crystals, do not produce light, and thus cannot be read in the dark; but they are far more economical to run.

Portable radios drain their batteries far more slowly than cassette recorders, because whenever a recorder is used the motors as well as the amplifier must be running and consuming extra power. But a useful economy can be made by rewinding tapes either by hand, using, for instance, the little manual mechanical rewinder marketed by Bib, or on a mains-powered recorder if you have one. It also makes sense to consider the possibility of investing in rechargeable rather than expendable cells, as advertised for instance in the pages of EVERYDAY ELECTRONICS

Expensive Metals

Rechargeable (sometimes called secondary) cells use the expensive metals nickel and cadmium as their electrodes, whereas ordinary, expendable (sometimes called primary) cells use the much cheaper materials zinc and carbon or zinc and steel for their electrodes. So rechargeable cells cost several times more than their expendable equivalents. You also need the correct charger for the cell in question, to deliver the correct voltage and the correct current for the correct period of time. Great care must be taken not to over-charge, that is push into the cell too much current for too many hours, as this can damage it irreparably. Used sensibly, rechargeable cells can be a valuable investment, and they have the added advantage of being virtually leak-proof. But ignorant mis-use of nicad cells, for instance by crossing your fingers and trying to recharge them with a car battery charger, can be an expensive folly. And by the way, bear in mind that expendable and rechargeable batteries which are supposedly exact equivalents are often of slightly different physical size. This may make it necessary to pack them into a battery compartment with a wedge of conductive foil, to avoid intermittent contacts.

Sleep On It

If you feel, (quite understandably) deterred from investing in rechargeable cells, don't forget the valuable trick that is as old as the hills but still works surprisingly well. This is that if you keep a torch under pillow at night it will last far longer than one kept on the shelf or in the cupboard. It works but why?

One of the odd things about battery technology is that anyone who really knows the subject admits that the more they learn the less they really understand about what actually happens at the chemical interface of the electrodes. It is an immensely complicated business, but the "pillow" effect is almost certainly due to the fact that a warm, rather than cold or hot, environment helps the depolarisers incorporated in a battery function. These prevent the congregation of gas bubbles at the electrodes which bubbles would otherwise increase internal resistance and decrease battery efficiency.

Corrosion

An interesting point often overlooked is that battery technology is a sister to corrosion technology. When you put two pieces of metal in a conductive fluid or electrolyte, they corrode away and this is what produces electrical power.

Although more is being understood about corrosion every day, many of its subtleties are still a mystery. For instance, although it makes sense to expect rust or corrosion on a car where two different metals, for instance steel chassis and aluminium trim, join and produce a corrosion cell when it rains, it makes far less sense that steel on its own rusts in water. The short answer is that different electric potentials arise, dependent on the slightly different amounts of oxygen dissolved in the water which is in contact with the steel. If you can get rid of all the oxygen dissolved in the water, the steel won't rust.

Monster Batteries

All this makes an interesting lead-up to a question that few people can answer. What's the biggest battery in the world? The answer is that it's an oil rig in the North Sea. These metal monsters, resembling several Eiffel Towers standing on the sea bed and and supporting a platform, are effectively giant steel electrodes in salt water which is a highly corrosive electrolyte. All kinds of attempts are being made to prevent the North Sea rigs from functioning as batteries and rusting in the process!

One possibility is to coat the steel with special epoxy resin paint; but just as a pinprick hole in the underseal of a car will enable a rust patch to start and flourish under the seal, so it is impractical to rely on 100 per cent perfect rig leg coating. Another idea is to form the legs of concrete, but inevitably the concrete piles contain a massive amount of reinforcing steel, which is also rust-prone.

Most successful so far are the electrical methods adopted. In one case the rig is treated like a cell on trickle charge! Sufficient current is pushed down the rig legs or "electrodes" to prevent them from rusting away, and producing their own discharge current.

On the other hand, BP use a sacrificial system. The structure itself is regarded as the cathode and zinc anodes are dangled in the sea. These are eaten away, just as the electrodes of a battery in your portable recorder or pocket calculator are eaten away every time you switch it on. BP, like everyone concerned with the North Sea operation, is decidely but understandably reticent about discussing the corrosion countermeasures adopted on their rigs. So it is sadly impossible to take this train of thought further and work out the amount of electric power available from those monster corrosion batteries that are now starting to supply this country with North Sea oil.

RESISTANCE METER

By R. A. PENFOLD

Capable of reading 100 ohms to 1 megohm on a linear scale in four switched ranges.

As one of the first pieces of equipment to be purchased by most electronics enthusiasts is a multimeter, most readers will have some type of resistance measuring gear. However, the resistance ranges of an ordinary analogue multimeter leave something to be desired in two main respects.

Firstly, the scale reads "in reverse", the zero being on the right hand side rather than on the left. Secondly, and perhaps more importantly, the scale is not linear. While it is very broad towards the zero end, the scale is extremely cramped at the other end.

This non-linearity tends to make resistance measurement somewhat awkward and, moreover accuracy suffers badly at the high resistance end of the scale where only a small pointer error will produce a very inaccurate result. On the basic resistance range of the author's multimeter, for example, the distance between the 2 kilohm and 10 kilohm markings is less than 2mm.

Obviously, a forward-reading linear scale resistance meter would be more satisfactory, and it is such an instrument that forms the subject of this article. The unit covers four ranges: 1, 10 and 100 kilohms and 1 megohm f.s.d. (full scale deflection). Power is obtained from two 9 volt PP3 type batteries and, as the current consumption is less than a couple of milliamps, these have virtually their shelf life with normal usage of the meter.

PRINCIPLE OF OPERATION

With a knowledge of Ohm's law, the basic operating principle of the resistance meter is easy to understand, and Fig. 1 helps to illustrate this. As will be seen from the diagram, the resistor under test is fed from a constant current source, and a high impedance voltmeter is used to measure the voltage produced across the test resistance.

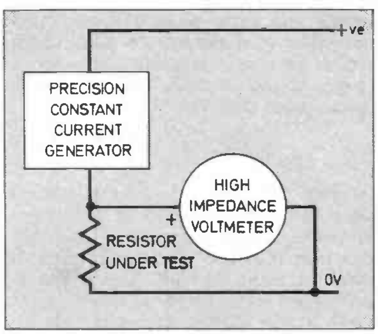


Fig. 1. Method of operation of the Resistance Meter.

From Ohm's law, we know that $V = I \times R$, and so the voltage across the resistance is proportional to its value. If we take a simple example and assume that the voltmeter reads 0 to 1 volt and that the constant current feed is 1mA, then a 220 ohm resistor would produce a reading of 0·22V (0·001 × 220 = 0·22). An 820 ohm resistor would produce a reading of 0·82V (0·001 × 820 = 0·82). By simply calibrating the meter 0 to 1 kilohm instead of 0 to 1V, a forward reading linear scale resistance meter is produced.

OTHER RANGES

Further ranges can be obtained by using a different feed current. By reducing this current to 100 microamps, for example, a test resistance of 10 kilohm is needed to produce full scale deflection of the meter (0·0001 × 10,000 = 1).

The exact current and voltmeter sensitivity used is not important, provided that they match up. If the voltmeter has a sensitivity of 1·2V f.s.d., for instance, then using a feed current of 1·2mA will provide a 0 to 1 kilohm range.

It is essential for the voltmeter to have an extremely high input impedance, otherwise a significant amount of current would be diverted through the voltmeter circuit and the level of this current would increase in proportion to the meter reading. This would

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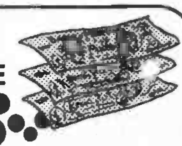


ESTIMATED COST OF COMPONENTS excluding V.A.T.

£6.00

excluding case and probes

prevent a constant current from being fed to the test resistance and would seriously degrade linearity.

On the 0 to 1 megohm range. the constant current feed is only a little over 1 microamp, which is far too small to operate a conventional voltmeter circuit anyway.

PRACTICAL CIRCUIT

Using modern semiconductor devices, it is possible to produce a very simple practical circuit, as can be seen from the circuit diagram of the unit in Fig. 2. A field effect transistor (f.e.t.) forms the basis of the constant current generator. This type of device is very different from an ordinary bipolar transistor, one of the main differences being that a f.e.t. will conduct quite heavily unless it is reverse biased. An ordinary bipolar transistor will not conduct significantly unless its base is forward biased.

Here, TR1 is reverse biased by having its gate terminal connected to the negative supply and a resistor connected in its source circuit. Current flowing through the d-s terminals of the f.e.t. and through the source resistor thus produces a positive potential across the source resistance. This makes the gate negative with respect to the source.

The f.e.t. will tend to stabilise the current flow when connected in this manner because, if the drain potential were altered and an increase in current occurred, the voltage across the source resistor would increase. This causes an increase in the reverse bias which counters the original current increase.

Connected to TR1 are four source bias resistors (VR1 to VR4), any one of which can be selected by switch S1. This gives four different selectable currents, one for each range covered.

A type 741C operational amplifier i.c. is the active component of the high impedance voltmeter. This has a 100 per cent negative feedback loop, the inverting (−) input being connected direct to the output. The circuit thus has unity voltage gain between the non-inverting (+) input and the output, but only an extremely small input current is required as the device has an input impedance of hundreds of megohms when used in this configuration.

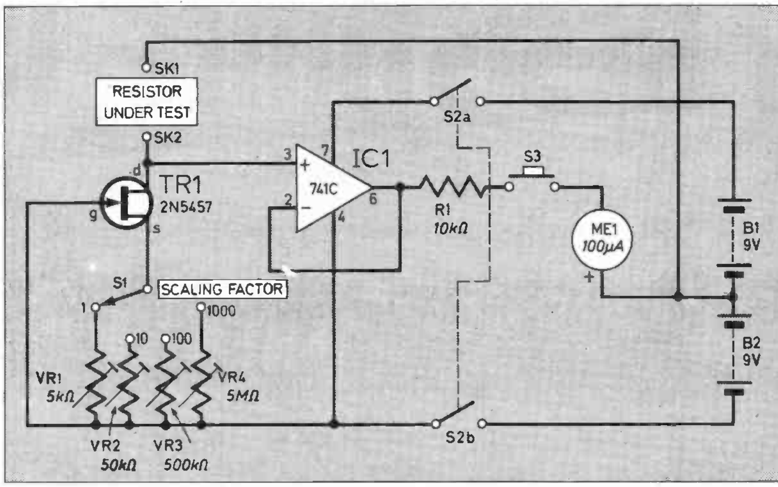


Fig. 2. The complete circuit diagram of the linear scale Resistance Meter.

The output of the i.c. is connected via R1 and S3 to the 100 microamp meter ME1.

ACTION OF VOLTMETER

With the two test prods (connected to SK1 and SK2) shorted together, the non-inverting input and the output of the i.c. will be at the central zero potential, as is the positive terminal of the meter. The meter will therefore read zero. However, with a resistor connected across the test prods (i.e. between SK1 and SK2), the non-inverting input and the output of the i.c. go below the 0V supply line and a positive deflection of the meter takes place. Presets VR1, VR2, VR3 and VR4 are adjusted to produce the correct full scale deflection resistance for each range.

It is necessary to connect the meter circuit to the i.c. output by way of S3 because, with no resistor connected across the test terminals, a current greater than the f.s.d. of the meter would be passed. This would be insufficient to harm the meter in the short term, but could be damaging if

Components

See **Shop Talk** page 231

Resistor
R1 10kΩ ¼W ± 10%

Potentiometers
VR1 5kΩ standard horizontal preset
VR2 50kΩ standard horizontal preset
VR3 500kΩ standard horizontal preset
VR4 5MΩ standard horizontal preset

Semiconductors
TR1 2N5457 n-channel field effect transistor
IC1 741 operational amplifier (8 pin d.i.l.)

Switches
S1 1-pole 12-way rotary with adjustable end-stop
S2 2-pole on/off rotary
S3 miniature push-to-make, release-to-break push button

Miscellaneous
ME1 100μA d.c. moving coil meter
SK1, 2 wander sockets (2 off)
B1, 2 9V battery type PP3 (2 off)
Stripboard 0.1in matrix 31 holes by 12 strips; plastics case size 47 × 75 × 113mm or larger—(see text); two test probes with leads and plugs; control knobs (2 off); battery clips (2 pairs); wire; solder.

RESISTANCE METER

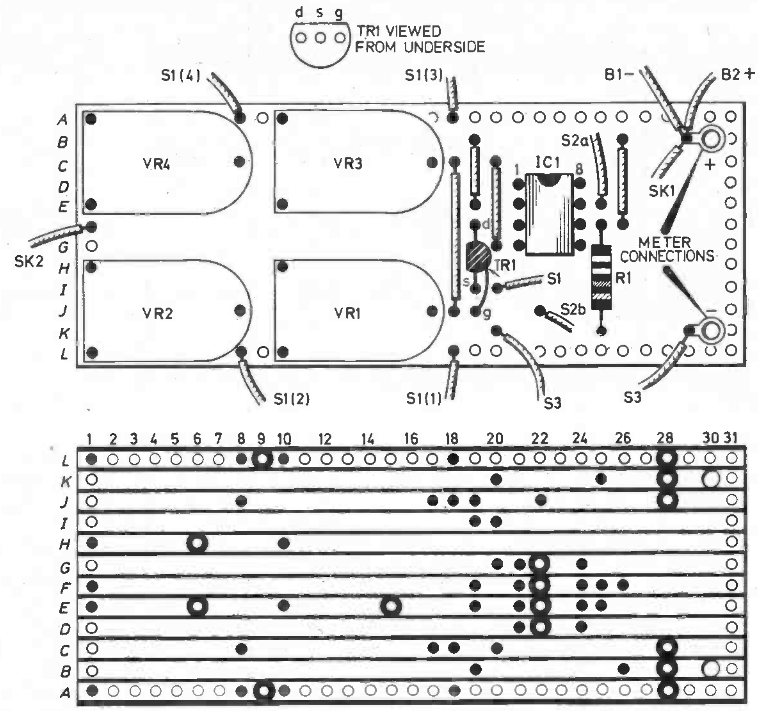
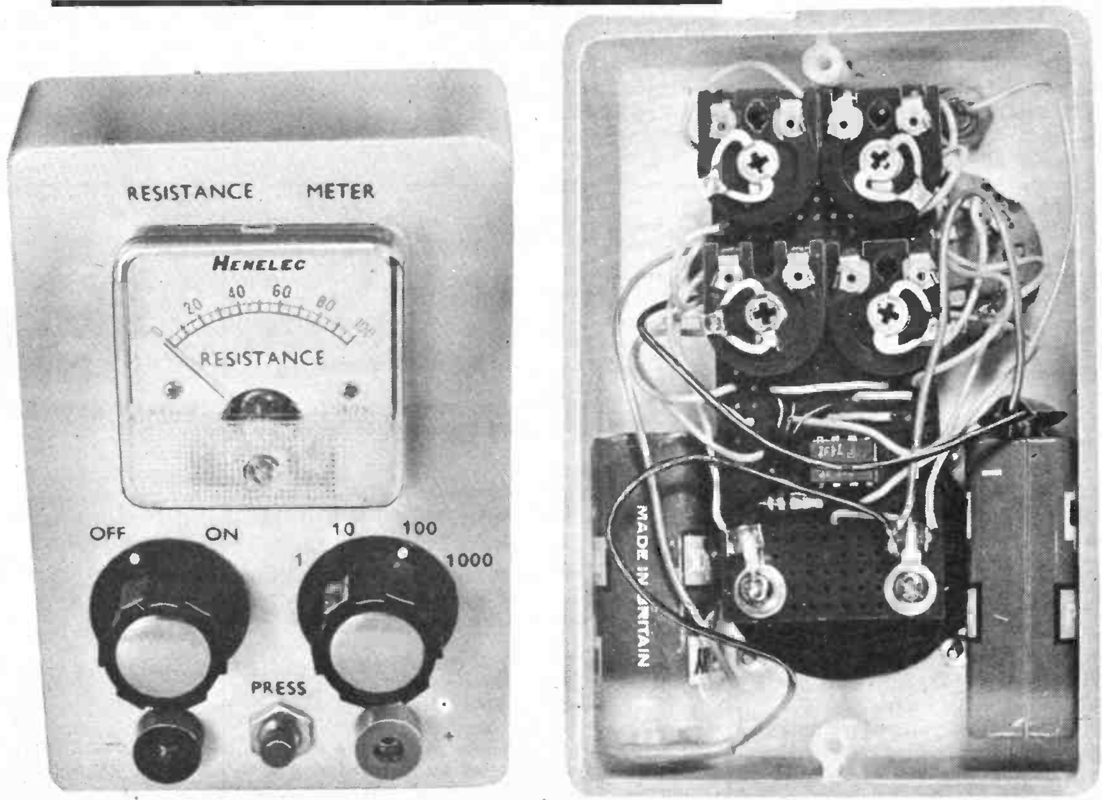


Fig. 3. The layout of the components on the stripboard and the breaks to be made along the tracks on the underside of the board.



Photograph of the front panel (below, left) and inside (below, right) of the completed prototype Resistance Meter.

it were maintained for long periods. The meter is therefore not connected until S3 is depressed.

Power is obtained from the equal positive and negative supplies usual with op-amps, with S2 functioning as the on/off switch.

COMPONENT PANEL

All the small components are mounted on a 0·1 inch pitch stripboard, which measures 79 × 30mm (12 strips × 31 holes); Fig. 3 shows the full wiring details of this panel.

Construction should be started by cutting out a panel of circuit board, of the size described, using a hacksaw. Then make the 15 breaks in the copper strips (see diagram) and drill the two meter mounting holes using a No. 31 drill. The panel is mounted on the meter terminals when it has been completed, and if a type of meter other than that employed in the prototype (HeneDec 38 series) is used, the positions of the mounting holes and the relevant breaks in the copper strips may need to be altered accordingly.

The components and link wires should then be soldered in, leaving the f.e.t. and i.c. until last. Take care not to bridge any adjacent copper strips with blobs of excess solder, especially when connecting the i.c.

THE CASE

A 47 × 75 × 113mm plastics case was used as the housing for the prototype. This makes an inexpensive and compact enclosure for the unit, but as it is only just big enough to take all the parts, very inexperienced constructors would be well advised to use a slightly larger case.

The general layout of the prototype can be seen from the photographs, but the exact layout is not critical. Any layout can be used that enables all the components to fit reasonably neatly.

WIRING

The external wiring, to components mounted on the case, required to complete the unit is shown in Fig. 4. All connecting leads are insulated with sleeving and the whole of the wiring is perfectly straightforward. When the wiring has been completed, the unit is finished by mounting the component panel on the meter and connecting the two batteries.

SETTING UP

Four close-tolerance resistors are required for calibration, and these should preferably have a tolerance of 2 per cent or better (5 per cent should be regarded as an absolute maximum tolerance). The values needed are 1 kilohm, 10 kilohm, 100 kilohm and 1 megohm.

With S1 switched to position 1 (fully anticlockwise), S2 in the "on" position and the four preset resistors set at about their midway rotation, connect the 1 kilohm resistor across the test prods and depress S3. Then adjust VR1 to produce exactly full scale deflection of the meter.

The other three ranges can then be calibrated in the same way, using the 10 kilohm, 100 kilohm and 1 megohm resistors respectively to provide the calibration points. The meter is then ready for use.

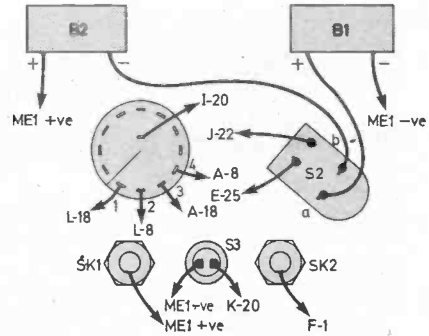


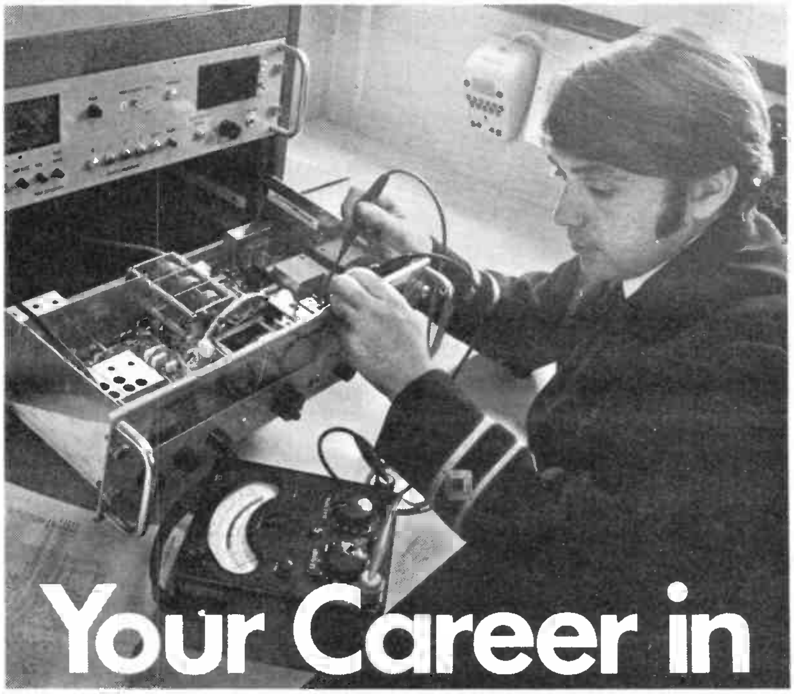
Fig. 4. Wiring up details from panel mounted components to component board locations.

Resistors of other values can be used for calibration if they are available and can provide calibration points at more than about half f.s.d. The nearer the calibration point is to f.s.d., the better the calibration accuracy is likely to be.

Accuracy is extremely good on the prototype, and the constant current generator is highly efficient. When monitoring the current fed to the test resistor using a digital multimeter, no change in current could be detected between zero and f.s.d. of the meter. The accuracy of the finished unit is thus mainly dependent upon the accuracy of the calibration resistors and the meter linearity.

It is recommended that the type of test prods used should be those that can be clipped to the leadouts of the test resistor. This will leave the operator's hands free to operate S3. Crocodile clips are an inexpensive alternative. ⌑

JACK PLUG & FAMILY...



A KH electronics officer checking out a receiver in the radio room of "Esso Mercury".

Your Career in Electronics

by Peter Verwig

MARINE ELECTRONICS

THE earliest form of electronics, wireless communication, found its first application in ships. One recalls that Marconi established his first coastal wireless telegraphy station at the Needles Hotel, Alum Bay, Isle of Wight as early as 1897, and that in the following year he was getting Lloyds, the marine insurance people, interested and also that the Italian navy signified its intention of adopting the Marconi system of wireless telegraphy, the first navy to do so.

The next big breakthrough was the use of wireless as a navigational tool. The directional properties of aerials had been noticed from the beginning and by 1907 Bellini and Tosi had produced a successful method of wireless direction finding and the Bellini-Tosi patents were bought by the Marconi Company in 1912. By receiving signals and measuring their direction from two known points such as coastal stations it was now possible for a ship to fix its approximate location at any time and in any weather state, including fog.

The ships radio station and its radio direction finder are still with us in greatly refined form. But although they are still the fundamental equipment required by law, they form only a modest part of the total electronics fit of the larger merchant vessels which will also have at least one radar, one or more echo sounders and one or more of a whole selection of electronic navigational aids now available.

In addition, there might be electronic control and monitoring of engine room machinery, Doppler speed measuring equipment for docking purposes, closed circuit and multi-channel television for entertainment, and a public address system.

If we address our attention to naval vessels we find that a modern warship is packed tight with electronics. A guided missile cruiser may have 150 transmitters and receivers of various types if one includes all the radars, beacons and sonars.

An aircraft carrier may have 100 or more items of radiating equipment not counting all the electronic communication and navigation equipment carried on each of the embarked aircraft. And in the naval environment all major fighting ships have a computer complex which analyses the threat position at all times, makes decisions on the best countermeasures and may even fire the ship's weapons. And submarines, operating in their underwater environment, have a different set of problems demanding yet another range of equipment.

SEA DRILLING RIGS

In recent years off-shore oil and gas exploration and the big oil platforms have developed an entirely new electronics business which includes high-precision navigation for exact placement of rigs and data-transmission from platform to shore as well as ordinary communications. And the old manned lightships are slowly being replaced by unmanned automated structures which do the same job but can be controlled remotely from the shore.

Yet another area of activity is playing a major role in the exploration and study of the ocean depths.

All this activity can be grouped under the general heading of Marine Electronics. The subject has cropped up from time to time in previous articles in this series. For example, we devoted a whole article to a career as a ship's electronics officer. And on the manufacturing side marine electronics has received mention as part of a company's total activities, as, for example, in the February 1977 issue when we discussed briefly the marine electronics capability of Redifon as part of their business.

Practically all the large electronic companies have a marine division. EMI, Plessey, Marconi, Redifon, MEL (part of Philips), Decca, all have their maritime connections, some mainly in the naval field including weapons control, others serving both naval and merchant marine requirements.

This month we shall look at marine electronics a little more closely through the eyes of Kelvin Hughes, a company which operates exclusively in the marine sphere.

The company is now a division of Smiths Industries Ltd. but operates independently from its own offices, showrooms and factories, as befits a specialist company serving the needs of a specialist clientele.

KELVIN HUGHES—HISTORY

The Hughes part of Kelvin Hughes was established in 1752 and was thus in existence long before electronics was thought of. The company made precision instruments and perhaps the best remembered today of their early customers was Captain Bligh of H.M.S. Bounty who bought a chronometer from Hughes. The story of the mutiny on the "Bounty" and Bligh's extraordinary voyage of 4,000 miles in an open boat in 1789 is well documented in literature and on film.

The Kelvin part of the name comes from Kelvin, Bottomley and Baird another great company with historic connections in marine navigation, especially compasses.

The German Luftwaffe brought the two companies together following the "blitz" in World War II and they reformed as a single unit with common interests as Kelvin Hughes.

Kelvin was the influential scientist, Lord Kelvin after whom a scale of temperature was named. He was intensely interested in wireless in the early days and was one of the first visitors in 1898 to Marconi's Alum Bay coast station.

Few companies can claim such a distinguished history or such illustrious forebears as Kelvin Hughes and some of the aura of the old days still clings. Not that the present company is old-fashioned, far from it, but when you visit the company or look at its products there is a deep feeling that everybody is conscious of a distinguished tradition that is worth preserving in this helter-skelter age and, above all, that craftsmanship is not yet dead.

PARENT GROUP

The parent group, Smiths Industries, is strong in automobile components and is a world leader in aerospace with Smiths equipment flying in 450 airlines and air forces round the world, the last tally showing 170 different types of aircraft flying in 138 countries. The last Smiths balance sheet showed a turnover of £180·8 million with a pre-tax profit of £16 million. The total number of employees is 20,000.

Within the group Kelvin Hughes has a workforce of 1,400 people and a turnover of £14 million and thus may be regarded as a well-established operation of medium size within a successful British-based group selling to international markets. In fact the group's last year's total sales of £180 million, 44 per cent was sold overseas and Kelvin Hughes' export performance is considerably higher than the group average.

PRODUCTION PLANTS/ DEPOTS

Kelvin Hughes production units are at Hainault in Essex, and Ystradgynlais in South Wales. There are eight depots in ports in the U.K. and subsidiary companies in Singapore, Malaysia, Norway and Sweden. A world-wide chain of agents provide back-up sales and service on all Kelvin Hughes products.

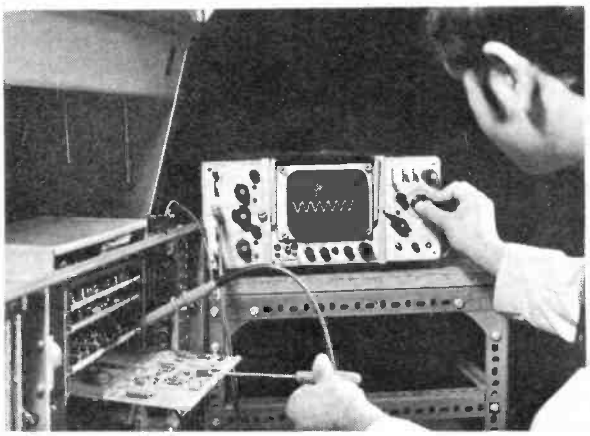
As well as supplying specialist hardware for marine use, the company is the world's largest agent for Admiralty charts. A complete set, covering the world, consists of some 3,000 charts all of which need constant updating. As well as standard navigational charts Kelvin Hughes supplies radio navigation charts for the Loran, Decca and Consul radio navigation systems.

SURVEYS

For marine surveys Kelvin Hughes is in partnership with the French Compagnie Générale de Géophysique in a company called Anglo French Offshore Surveys Ltd. AFOS has its own geophysical survey ships for data collection, and on-shore computer centres for analysing the data.

One of the AFOS specialities is precise underwater positioning as required by the off-shore oil industry. Oil platform positioning, well-head recovery and pipe laying all need extreme accuracy and a system devised by Kelvin Hughes engineers can determine position in good conditions to within 2 metres.

Sea bed data is obtained by a number of methods including seismic techniques for exploring the underlying bed rock and underwater television for close inspection. This branch of marine electronics is of increasing im-



Type 21 marine radar console under test.

Smiles all round by students on a course on Situation Display at the KH training centre.

together with interswitching of duplicated radar sets in which field the company did pioneering work, and a high export level, all contributed to the Queen's Award to Industry won by Kelvin Hughes in 1967. The following year KH won a Queen's Award for technological innovation with the Humber fish detection equipment. In 1975 Kelvin Hughes had a third win for technological innovation with the successor to the Photoplot radar known as the Situation Display.

Study in concentration in the radio room of "Baltic Enterprise".

portance as under-water prospecting expands beyond oil and gas to other mineral riches beneath the seas and oceans.

UNDERWATER ACTIVITY

No company has a higher reputation in echo-sounding than Kelvin Hughes. The three main applications of the technology are in depth measurement for navigational purposes in which the traditional term of echo-sounders is still used, in fish-finders, and in sonar which is the underwater equivalent of radar and generally associated with defence against submarines, torpedoes and the detection of underwater mines.

All in fact operate on the same principle of emitting an underwater impulse and measuring the time interval of its reflection from an underwater object whether it be the sea bed, a shoal of fishes, or a submarine.

There is however a great difference in sophistication between the systems, depending upon their application. A hydrographic echo-sounder like the MS 48 which has been approved by the Hydrographer of the Navy for marine survey is of far higher sophistication than those bought, for example, by amateur yachtsmen. Similarly, for fish-finding Kelvin Hughes offer several new systems including a long-range all-round fish finder and a precision equipment which can, for example detect single fish at considerable depths as well as shoals. The efficiency of modern fish-finding equipment is so high that the element of luck has all but disappeared.

With the W.G. Fishsounder you can not only look down below and detect fish but also, with the aid of a net monitor, see fish above and below the trawl head-line and the echoes from the sea bed and the surface. Today's professional fisherman no longer works in the dark and this is one reason for the decimation of fish stocks and the need for conservation if future supplies are to be maintained.

Kelvin Hughes does not manufacture ship's radio stations but buys in individual transmitters and receivers, some designed to KH requirements, and engineers them into systems. The company is thus able to offer complete radio packages and, through Sea Staff Services, the radio and electronics officers to operate and service the equipment at sea.

ACHIEVEMENTS

It is perhaps in radar that Kelvin Hughes has shown the greatest originality. It was KH who invented the Photoplot radar which used a rapid photographic process to give a bright-screen display of remarkable versatility. The Photoplot,

SITUATION DISPLAY

In the Situation Display many of the special features of the Photoplot have been retained but instead of a photographic projection of the radar plot the Situation Display uses television techniques.

One of the problems of radar is the difficulty of interpretation of the data displayed on the conventional radar screen. There are many classic cases of the "radar-assisted collision" where faulty interpretation of radar information and subsequent avoiding action has actually resulted in collision rather than avoiding it.

The Situation Display considerably simplifies interpretation by presenting all situations in a real-world manner as if the observer was high overhead and looking down on all the shipping movements within radar range. A unique feature is that with the long "tails" rapidly built up on the display it is possible to estimate the speed as well as the track of all other vessels in comparison to one's own speed which is, of course, known. But there are also many other features which puts Situation Display ahead of other types and, although expensive, it has found considerable favour in the market place.

Originally designed for use with radars of Kelvin Hughes manufacture it can now be supplied with interfacing to radars of many other manufacturers and it seems likely that Situation Display will be selling strongly right through the 1980s. The Situation Display can also be used effectively in harbour radar application such as that of the Forth Ports Authority providing a shore-based navigation service for the busy Firth of Forth.

The Under Secretary of State for the Royal Navy, Mr. P. Duffy, M.P., examines microwave components during a visit to Kelvin Hughes engineering department.

Assembly of Type 1006 navigation radars developed for the Royal Navy.

EQUIPMENT

Kelvin Hughes is one of Britain's major suppliers of conventional marine radars with combinations of scanners, transmitters/receivers and displays in all the most popular powers and sizes complete with interswitching on dual installations of X-band (3cm) and S-band (10cm) systems.

As a generalisation rain and sea-clutter are less bothersome on S-band while X-band provides much better resolution on small targets. With an S-band radar with high-mounted scanner and an X-band equipment with a low scanner there are few radar navigational problems which cannot be successfully resolved.

In naval radar Kelvin Hughes produces equipment developed in association with the Admiralty Surface Weapons Establishment approved for use on both fighting and support surface ships and in submarines.

In general, marine electronics has followed the general trend in electronic engineering with extensive use of modern semiconductor circuit technology. In addition marine equipment has to satisfy rigid international standards and the quality of the engineering has to withstand the marine environment. This is not just a question of whether equipment will survive exposure to salt spray and other forms of corrosive environment but also of standing up to the peculiar vibration characteristics of ships. Many an equipment found quite suitable for use on land has come to grief after a few hundred hours at sea, sometimes only a few hours.

OPPORTUNITIES

If marine electronics with its special engineering requirements and exciting operational possibilities appeals to you, there are many career opportunities open to you.

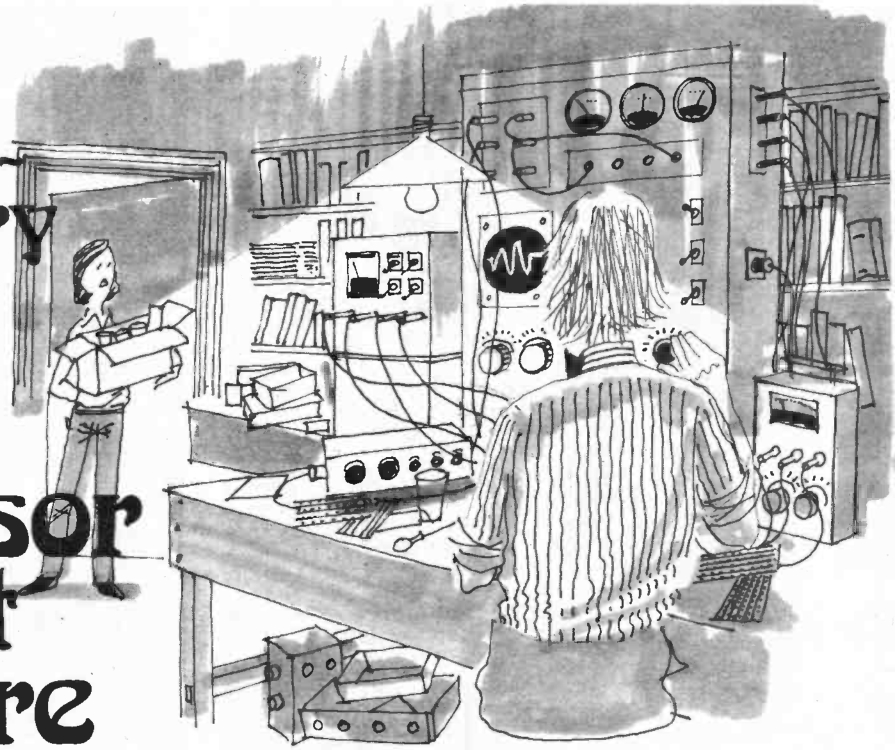
We have described Kelvin Hughes but similar work is done by other companies so there is plenty of choice. There is variety, too, in the type of work from designing in the laboratory, through manufacture, testing, field installation and servicing. There is also opportunity for the globe trotter as a marine electronics officer on board ship or as a technician supporting survey teams.

Like other branches of electronics there is naturally a preference on the part of employers towards those holding a recognised qualification but for youngsters there is always the chance of joining as an apprentice.

Don't despise the Royal Navy as a first-class training ground where you can earn as you learn. There are few organisations where you can get so much experience and it is a fact that civilian employers look kindly on Navy-trained men, not only because of the high level of technical training and experience of ex-ratings and officers but because they value the responsible attitude which is a natural result of Navy life. After all, when, as a service engineer at a port, you are called out at two o'clock in the morning to service a radar on a tanker with a fast turnround you need self-discipline and an appreciation of sea-faring and seafarers.

Marine electronics is a specialist activity looking for people who really want to become specialists. In many ways it is more demanding than other branches of electronics but it has the great virtue of being an expanding activity and despite the present recession in the shipping industry it has good growth prospects and job opportunities.

The Extraordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

THE PROF. was engaged in making an experimental contact microphone using a thin slice which had been carefully cut from a crystal of Rochelle salt.

Although the materials which he was using were more expensive than the aluminium foil which Bob had used to make his experimental pick-ups (described last month), the amount required to construct each contact-microphone was very small.

CONDUCTIVE PAINT

To make sure of good contact to each face of the crystal slice, the Prof. was using electrically conductive silver paint which consists of finely divided silver powder suspended in a liquid.

"That smells rather unusual, Prof.", remarked Bob, "what is it?"

"What you can smell, Bob, is the vapour of a substance called toluene, which is the chief liquid constituent of this electrically-conducting paint.

The paint consists of a suspension of very fine flakes of pure silver metal in the liquid toluene, and I am applying it to the opposite faces of this crystal slice of Rochelle salt. As the toluene evaporates, the microscopic flakes of silver metal adhere together to produce a continuous film of metal which is in close contact with the surface of the Rochelle salt.

This will pick up any minute changes in the electrical condition of the surface of the Rochelle salt, caused by vibration, and convey the corresponding electrical signals to any electrical conductor which is in contact with the metallic film."

"Can ordinary silver paint be used, Prof.," Bob asked, "or is it only possible to use this special paint with real silver, which seems rather expensive to me?"

"Other materials can be used, Bob, such as electrically conducting paint containing finely-divided copper or graphite, as the conducting medium instead of the more expensive silver, but ordinary 'silver paint' does not usually contain any silver at all, and will not conduct electrically. This is because the silver colour is produced by fine flakes of powdered aluminium, and although aluminium does conduct electricity, each flake is insulated by a fine, transparent coating of aluminium oxide, so that electrical current does not pass from one flake to the next. With electrically conductive silver paint, copper paint or graphite paint, there is no insulative coating of this nature, so the paint conducts quite well."

"As you will know from our earlier experiments, graphite paint is used quite a lot, and is available from T.V. repair specialists, and engineering supply houses, but does not conduct as well as copper or silver.

Conductive copper paint can be prepared by suspending finely divided copper in a liquid such as toluene, but is more difficult to prepare and store than conductive silver paint. A big problem is corrosion, and because copper corrodes much more rapidly than silver, the copper paint will not last as long as silver, unless it is protected from air and moisture by a layer of plastic film or lacquer. Copper conductive paint is used commercially in circumstances where it is protected from corrosion, and where the lower electrical conductivity of copper is acceptable."

"But Prof., I thought that the electrical conductivity of copper is high—surely that is why it is used for wiring?"

"Yes, Bob, but silver is an even better conductor of electricity than copper, which is another reason why professional people and many manufacturers of high quality electronic equipment, feel that the extra expense is very well justified, especially where the quantity needed is very small.

Now I think that the small

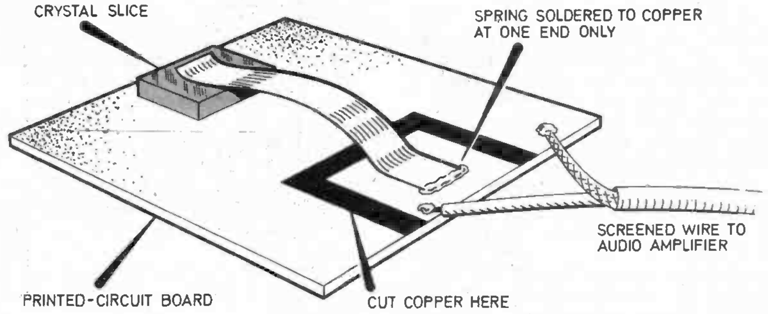


Fig. 1. The simple mounting the Prof. made for the crystal.

quantity of silver conductive paint on my Rochelle crystal slice is nearly dry, so I'll prepare the remaining parts necessary to complete the contact-microphone."

MAKING THE MICROPHONE

The Prof. cut a piece of thin fibre-glass copper laminated printed-circuit board about 3cm square and used a craft knife to remove a few thin strips of copper to give the pattern shown in Fig. 1.

From a piece of very thin springy sheet metal he cut a small spring, and carefully bent the ends up slightly as shown.

Next he soldered the spring in place on the printed board at the point shown in Fig. 1, and connected a screened audio cable from the board to the input of an audio amplifier. By carefully slipping the crystal slice into place underneath the spring, the Prof. made sure that the metal spring contacted one of the silvered faces, and the circuit-board contacted the opposite face. He also made sure that the spring pressure was sufficient to hold the crystal firmly in place, but not so tightly as to break it.

By turning up the volume control of the amplifier, the Prof. found that the vibration of anything in contact with the board was amplified and heard as sound from the loudspeaker, so that the ticking sound made by an old-fashioned mechanical wristwatch, which he held in contact with the board, could be heard clearly through the loudspeaker.

ACOUSTIC GUITAR PICK-UP

"Could this be used with acoustic musical instruments, such as guitars, banjos and so on?" Bob asked.

"Yes," the Prof. replied, "and crystal contact-microphones are produced commercially by a number of companies for use as musical pickups. To obtain maximum efficiency, the crystal slices are carefully cut at angles which are specially selected for the purpose. The slices are then laminated together with alternate layers of silver foil, which gives a further increase in output.

Although the simple contact microphone which I have just made is not as sophisticated as some of the commercial products, I can suggest a very interesting use for it. You could test a number of other materials very easily, for piezo-electric activity, by cutting slices from materials such as copper sulphate, quartz and other crystalline materials, and also non-crystalline substances such as wood, bone, amber, plastics. Each slice of material can then be tested very easily by slipping it underneath the spring, and checking for an audible output from the amplifier when the slice is subjected to vibration."

to be continued

"It's a self-winding clock. I simply rotate this handle, depress these buttons, set the dials to zero, put these switches on, elevate these bars, turn those shafts and the clock winds itself" up.

GEORGE HYLTON brings it down to earth

SOME of the readers' questions I am sent by the editor crop up so frequently that I've come to regard them as hardy annuals. (A hardy annual in gardening terms, is a plant which grows from seed, flowers, and dies, all within a year leaving behind a crop of seeds for the next generation.)

Just such a question is the one which says something like: "My audio amplifier, with the volume turned right up, plays Radio 1. Why?"

The latest example comes from a Sheffield reader, P. Sherman, who has been experimenting with his tape recorder. He finds that if he plugs a loudspeaker into the microphone socket and an earphone into the monitor socket he can hear foreign radio stations. How, he asks, can *more* stations be received?

Sensitivity

A tape recorder contains a sensitive amplifier. The output of a microphone may be only a millivolt. To monitor this, it must be increased to perhaps 1 volt for earphone listening. A voltage gain of around 1000 is required. If an a.m. radio signal gets into the amplifier and is somehow rectified in the first stage the resulting audio is then amplified and made audible.

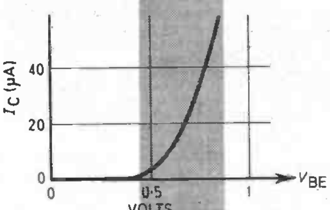


Fig. 1. Graph showing collector current against base/emitter voltage.

To see how an ordinary audio preamplifier can rectify a.c. signals you must look at the transistor characteristic curves. If the base-emitter voltage is less than about 0·5 volts (for a silicon transistor) very little collector current flows (Fig. 1.). At higher voltages the current increases rapidly.

Now, in audio preamplifiers the first transistor is commonly operated at a very low collector current (30 microamps) to reduce noise. So the base-emitter voltage is near 0·5 volts. If a *large* a.c. signal is applied, negative voltage swings reduce the collector current a little but positive ones increase it a lot. The result is a net increase in collector current.

If the a.c. signal is an a.m. radio wave, the net increase varies with the modulation, which means that an audio frequency (the programme) is produced.

Aerial

To get the radio signal into the amplifier some sort of aerial has to be provided. In the present case the aerial was the loudspeaker leads. The fact that there was a speaker at the end probably made very little difference.

Our Sheffield reader wonders if the effect can be put to use to turn the tape recorder into a proper radio receiver tunable to many stations. I rather doubt it, but if anybody who experiences accidental reception wants to try, an arrangement with a tuned circuit aerial and earth and a separate coupling coil (Fig. 2) might be worth a try. But it is unlikely to provide much selectivity.

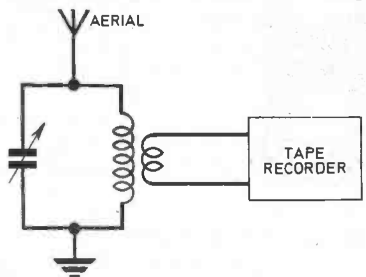


Fig. 2. Tuned circuit arrangement for experimentation.

Lowpass filter

To *prevent* r.f. breakthrough (which can put unwanted noises into an audio system) some sort of low-pass filter at the amplifier input is needed. A capacitance of about 1 nanofarad (1nF = 1000pF) connected between base and emitter leads of the input transistor (Fig. 3.) often helps to by-pass r.f. A series resistor of about 1 kilohm as shown increases its effectiveness.

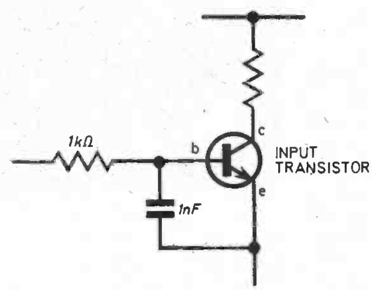


Fig. 3. Low pass filter to reduce unwanted r.f. signals.

PLEASE TAKE NOTE

We apologise to our readers and Ferranti Ltd. for an error on the *Instant Info.* chart given free with the March issue of E.E. Regarding transistors ZTX300 and ZTX301, *Ic* max should be 500mA and not 200mA as printed.

In the *Guitar Practice Amplifier*, Feb. '77 issue, there is an omission on Fig. 2. There should be a link wire connecting IC1 (pin 5) to C4 +ve.

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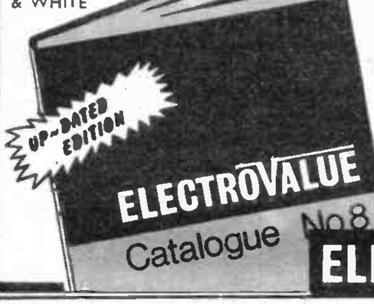

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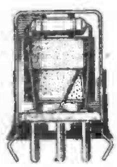

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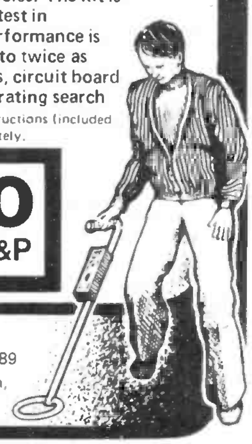

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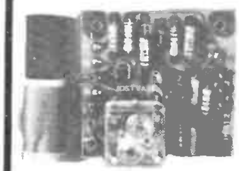

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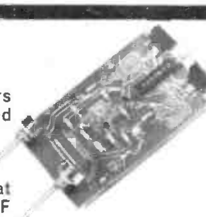

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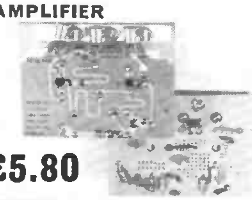

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