

PRACTICAL

ELECTRONICS

SEPTEMBER 1971

209

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POWER CONTROLLER



Also inside...

TIMER
with **DIGITAL READOUT**

ADCOLA Soldering Instruments add to your efficiency

THE NEW 'INVADER'

ADCOLA L.646

for Factory Bench Line Assembly

A precision instrument—supplied with standard 3/16" (4.75 mm) diameter, detachable copper chisel-face bit*.

Standard temp. 360°C at 23 watts.

Special temps. from 250°C—410°C.

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B 38 $\frac{1}{8}$ " — 3.2 mm CHISEL FACE

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B 14 LL $\frac{1}{4}$ " — 2.4 mm CHISEL FACE

B 44 LL $\frac{1}{8}$ " — 4.75 mm SCREWDRIVER FACE

PRICE
£1.85



Don't take chances. We don't. All our ADCOLA Soldering Instruments are of impeccable quality. You can depend on ADCOLA day after day. That's why they're so popular. You get consistent good service... reliability... from our famous thermally controlled ADCOLA Element and the tough steel construction of this ideal production tool.

* Write for price list and catalogue

ADCOLA

Regd. Trade Mark

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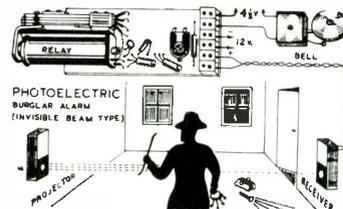
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Everything needed (except plywood) for building: 1 Invisible-Beam Projector and 1 Photocell Receiver (as illustrated). Suitable for all Photoelectric Burglar Alarms, Counters, Door Openers, etc.

CONTENTS: 2 lenses, 2 mirrors, 2 45-degree wooden blocks. Infra-red filter, projector lamp holder, building plans, etc. Price £1.00 Postage and Pack. 5p (U.K.). Commonwealth: Surface Mail 10p, Air Mail 30p.

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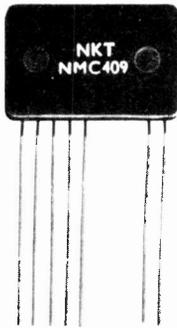
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"guid gear in sma' buik" from NKT

With a range of thick film hybrid microcircuits off the shelf, Newmarket brings alive for you the old Scottish proverb quoted above—
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NMC409 Slow Speed Eccles-Jordan "Divide-by-two"

This RST flip-flop is designed specifically for slow speed switching in industrial controls where standard monolithic TTL/DTL finds it difficult to cope with the large voltage transients arising and where the precise stabilised 5-1V d.c. supply needed for TTL/DTL is difficult to provide (and costly). The NMC409 can work on any unregulated supply of 6-24V, and is immune to fast voltage spikes because it is designed not to switch faster than 10 kHz. Size: 1.1in × 0.7in × 0.23in. One-off price £2.50

NMC396 Precision 6V Regulator d.c. Supply

This self-contained d.c. voltage regulator provides a precise 6V, 150mA d.c. output from a 7-15V d.c. input. The hybrid assembly technique allows the output voltage to be set during manufacture

typically to within 25mV of 6V (in contrast to the wider absolute tolerances unavoidable in monolithics). The NMC396 has all the electrical robustness and stability of a discrete-component assembly and incorporates overload protection. Ideal for deriving a precise 6V from a 9 or 12V battery, it can also be fed from a standard d.c. power pack such as the NKT PC101.

Size: 0.60in × 0.60in × 0.25in. One-off price £2.50



NMC426 Optoelectronic Solid State Logic Indicator

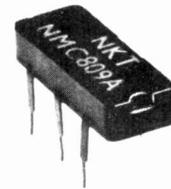
This microcircuit is designed primarily to indicate visually the state of a binary logic circuit but can be used in any circuit calling for a visual indication of the existence or absence of a d.c. voltage at a test point. Completely self-contained it only requires three connections to a nominal 5V d.c. supply, to earth and to the test point. The light display is a gallium arsenide phosphide solid state diode lamp with virtually unlimited life. The NMC426 incorporates an internal d.c. amplifier enabling the light to switch on with an input drive of only 1µA or 2V, and it takes a current of only a few µA from standard TTL/DTL logic gates. Size: 0.42in × 0.31in × 0.13in. One-off price £2.83



NMC809A Wide Band Amplifier

This wide band amplifier is a self-contained d.c. feedback pair (with output buffer stage) with access to the internal feedback loop for response tailoring. The hybrid assembly technique enables the low frequency gain to be set in manufacture to precisely 22dB and gives a narrow gain spread difficult to achieve by monolithic techniques. Usable for bandwidths up to 50MHz, the NMC809A employs the easily handled standard dual-in-line package. Its thick film hybrid assembly eliminates the parasitic stray capacitances to earth unavoidable with monolithics and gives it the electrical stability and robustness of discrete component designs.

Size: 0.71in × 0.28in × 0.15in. One-off price £3.34



distributors

For further details contact one of the distributors listed below. (In the case of large scale requirements you can save time by referring direct to Newmarket.)

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Coronet House,
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Telex 81146

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Tel.: 0715/65311
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Eastern Aero Electrical Services Ltd.,
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The Fabulous BRAND NEW 1971

WORLD WIDE RECEPTION
THOUSANDS OF TRANSMISSIONS AND STATIONS THE WORLD OVER!

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THIS OFFER ONLY FROM US!

VEF 204 8 WAVEBAND

10 TRANSISTOR PLUS 2 DIODES PORTABLE RADIO

AND NOW WITH 'SHIP-TO-SHORE' MARINE BAND

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WE COULDN'T EVEN MAKE THEM FOR OUR FANTASTIC PRICE!

***COMPARE IT'S PERFORMANCE with £42 RADIOS!**



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Spot Face Cutter 38p. Pin Insert Tool 48p. Terminal Pins (0.1 or 0.15) 36 for 18p. Special Offer Pack consisting of 5 2 1/2in x 1in boards and a Spot Face Cutter—50p.

RECORD PLAYER CARTRIDGES. Well below normal prices!
G90 Magnetic Stereo Cartridges, Diamond Needle, 6mV output, £4. ACOS GP 67/2 (Mono, Crystal) 75p. ACOS GP 91/3 (Compatible, Crystal) £1. ACOS GP 93/1 (Stereo, Crystal, Sapphire) £1.25. ACOS GP 93/1D (Stereo, Crystal, Diamond) £1.63. ACOS GP 94/1 (Stereo, Ceramic, Sapphire) £1.50. ACOS GP 94/1D (Stereo, Ceramic, Diamond) £1.88. ACOS GP 95/1 (Stereo, Crystal with two L.P./Stereo needles) £1.25.

TRANSISTORISED FLUORESCENT LIGHTS, 12 volt. All with reversed polarity protection. 8 watt type with reflector suitable for tents, etc. £3. Postage/Packing 25p. 15 watt type, batten fitting for caravans £4. Postage/Packing 25p. 13 watt type, batten with switch. 22in x 2in. x 1in £5. Postage/Packing 25p. THESE CAN BE SENT ON APPROVAL AGAINST FULL PAYMENT.

MULLARD POLYESTER CONDENSERS
1,000pF, 1,200pF, 1,500pF, 1,800pF, 2,200pF, 15p per dozen (all 400V working). 0.15µF, 0.22µF, 0.27µF, 30p per dozen (all 160V working). 25% discount for lots of 100 of any one type.

RESISTORS
1/2 and 1 watt. Most values in stock. 50p per 100. 10p per dozen of any one value. **WIRE WOUND MAINS DROPPERS.** Hundreds of values from 0.7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered "assorted" at 50p per dozen.

SILVER MICA/CERAMIC/POLYSTYRENE CONDENSERS
Large range in stock, 75p per 100 of any one value. 15p per dozen.
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We have huge numbers of components in quantities too small to advertise individually. In order to "clear the decks" we have made up parcels containing a mixture of carbon and wire-wound resistors, electrolytic and paper condensers, controls, transistors, diodes etc., for a tiny fraction of normal price. It is emphasised that these are mixed parcels only—contents cannot be stipulated! Sold only by weight.
Gross weight 2 lb. £1 (postage 20p)
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NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.

Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray £1.00
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SPECIAL 50p PACKS. ORDER 10 PACKS AND WE WILL INCLUDE AN EXTRA ONE FREE ! ! !

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50 50p		(6 cells will power a Micromatic radio)	
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SPECIAL OFFER

Garrard SP25 Mk.III
Goldring G800H
Teak plinth and tinted cover. Ready wired for immediate use.

£19.50

Please add £1.15 for post and packing

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Please add 50p for post and packing

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Thorens IS0A B11	£42.50
Goldring GL69/2	£21.50
Goldring GL69P2	£29.50

* Items marked can be mounted in plinth and cover, ready wired for £4.50 extra plus 25p for post and packing

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Please add 50p for post and packing

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Please add 35p for post and packing

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Teleton F2300 (new product)	£39.75
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Teleton TSP50	£53.00
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Wharfedale 100-1	£114.00

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Please add £1.25 for post and packing

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Celestion Ditton 15	£49.50
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Goldring G800E	£10.95
Goldring G800SE	£15.95
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Shure M3DM	£4.95
Shure M445/7/C	£7.20
Shure M55	£9.20
Shure M75E	£14.50
Shure V15 Type 2	£29.00
Shure M44E	£8.25
Shure M31E	£8.75
Shure M32E	£8.15
Audio-Technica AT66	£4.95
Audio-Technica AT35	£14.95
SMC 101	£3.15
MC15	£5.75

TAPE DECKS & RECORDERS

Please add 75p for post and packing

Teleton FXB 5100	£46.50
Teleton TCR130	£28.75

PERSONAL CALLERS VERY WELCOME!

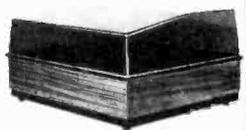
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PLINTHS & COVERS

(as illustrated)

£3.25



plus 35p post and packing

Finished in real teak veneer with tinted dustcover. Ready to use (fully assembled). Suitable for Garrard SP25, 2025TC, 3000, AT60, 2000, 2500, 3500, 5100, 1025, SL65B.

Also for B.S.R. McDONALD MP60 and others

Plinths and Covers for AP76, AP75, SL72B, SL75B, SL95B. £4.25 plus 35p post and packing.

Also finished in walnut to match Japanese equipment—no extra charge.

GLOBAL TRANSEUROPEAN COMBO

Made by world famous European manufacturer

COMPLETE HI-FI STEREO SYSTEM

VHF/MEDIUM/LONG WAVE Tuner Amplifier 4 watt per channel, separate tone and balance controls. Two neat speakers with wooden slatted front. Single play deck in plinth and cover. Finished in teak. Fully guaranteed 12 months. On constant demonstration.

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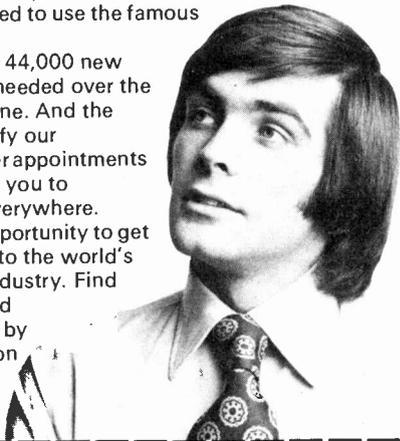
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	1-11	12-24	1-11	12-24
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SN7401	0-20	0-18	SN7475	0-45
SN7402	0-20	0-18	SN7476	0-45
SN7403	0-20	0-18	SN7480	0-70
SN7404	0-20	0-18	SN7481	1-40
SN7405	0-20	0-18	SN7482	0-87
SN7406	0-80	0-75	SN7483	0-87
SN7407	0-20	0-18	SN7484	2-00
SN7408	0-20	0-18	SN7485	3-62
SN7409	0-20	0-18	SN7486	0-33
SN7410	0-20	0-18	SN7489	0-87
SN7411	0-23	0-21	SN7491A	1-21
SN7412	0-48	0-48	SN7492	0-87
SN7413	0-40	0-38	SN7493	0-87
SN7416	0-84	0-78	SN7494	0-87
SN7417	0-84	0-78	SN7495	0-87
SN7420	0-20	0-18	SN7496	0-87
SN7423	0-51	0-47	SN7497	6-40
SN7425	0-48	0-45	SN74100	1-65
SN7427	0-48	0-45	SN74104	1-52
SN7428	0-80	0-75	SN74105	1-52
SN7430	0-23	0-21	SN74107	0-52
SN7432	0-48	0-45	SN74110	0-80
SN7433	0-80	0-75	SN74111	1-57
SN7437	0-84	0-80	SN74118	1-30
SN7438	0-84	0-80	SN74119	1-92
SN7440	0-23	0-21	SN74121	2-00
SN7442	0-85	0-81	SN74123	2-85
SN7443	2-88	2-70	SN74145	1-80
SN7444	2-88	2-70	SN74150	3-52
SN7445	2-80	2-40	SN74151	1-40
SN7446	1-00	0-95	SN74153	1-40
SN7447	1-00	0-95	SN74154	2-20
SN7448	1-00	0-95	SN74155	1-68
SN7449	1-00	0-95	SN74156	1-68
SN7450	0-20	0-18	SN74157	1-92
SN7451	0-20	0-18	SN74160	1-80
SN7453	0-20	0-18	SN74161	2-60
SN7454	0-20	0-18	SN74162	4-26
SN7456	0-20	0-18	SN74163	4-26
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SN7472	0-32	0-30	SN74165	2-25
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Type	1-24	25-99	Type	1-24	25-99
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CA3000V1	1-80	1-60	CA3035	1-28	1-10
CA3001	2-68	2-40	CA3035V1	1-23	1-10
CA3001V1	2-68	2-40	CA3036	0-78	0-65
CA3002	1-80	1-60	CA3037	1-85	1-47
CA3002V1	1-80	1-60	CA3037A	2-53	2-25
CA3004	1-80	1-60	CA3038	2-53	2-25
CA3005	1-17	1-05	CA3038A	3-40	3-03
CA3006	2-80	2-50	CA3039	0-84	0-75
CA3007	2-63	2-34	CA3040	2-40	2-14
CA3008	1-80	1-60	CA3041	1-37	1-27
CA3008A	2-96	2-64	CA3042	0-99	0-97
CA3010	1-37	1-23	CA3043	1-37	1-23
CA3010A	2-53	2-25	CA3044	1-20	1-07
CA3011	0-74	0-65	CA3044V1	1-20	1-07
CA3011PRP			CA3045	1-23	1-09
CA3012	0-74	0-65	CA3046	0-69	0-60
CA3012V1	0-89	0-79	CA3047	1-37	1-25
CA3013	1-05	0-94	CA3047A	2-53	2-25
CA3014	1-24	1-10	CA3048	2-04	1-81
CA3014V1	1-24	1-10	CA3050	1-84	1-64
CA3015	2-09	1-86	CA3051	1-34	1-20
CA3015A	3-40	3-03	CA3052	0-68	0-47
CA3016	2-48	2-19	CA3053	0-60	0-41
CA3016A	3-73	3-33	CA3054	1-09	0-97
CA3018	0-84	0-75	CA3055	1-69	1-51
CA3018A	1-10	0-99	CA3056	1-20	1-07
CA3019	0-84	0-75	CA3056A	3-19	2-85
CA3020	1-28	1-13	CA3059	1-65	1-46
CA3020A	1-60	1-43	CA3060	1-71	1-37
CA3021	1-56	1-39	CA3062	2-55	2-27
CA3021V1	1-56	1-39	CA3064	1-20	1-07
CA3022	1-30	1-18	CA3065	1-20	1-07
CA3023	1-28	1-13	CA3066	2-11	1-84
CA3026	1-00	0-90	CA3067	2-18	1-94
CA3026PRP			CA3068	2-43	2-16
CA3028A	1-00	0-90	CA3070	1-71	1-37
CA3028B	1-05	0-94	CA3072	1-66	1-48
CA3029	0-87	0-77	CA3075	1-13	1-00
CA3029A	1-65	1-47	CA3076	1-30	1-18
CA3030	1-37	1-23	CA3078	3-19	2-85
CA3030A	2-53	2-25	CA3080	0-75	0-70
CA3033	2-53	2-25	CA3080A	3-19	2-85

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2N696	20p	2N3754	12p	40348	57p	BCY34	30p	BSX77	27p	NKT271	20p
2N697	20p	2N3763	12p	40360	42p	BCY39	80p	BSX78	27p	NKT274	20p
2N698	25p	2N3704	17p	40361	47p	BCY40	50p	BSX79	27p	NKT275	20p
2N706	12p	2N3705	15p	40362	57p	BCY42	15p	BSY10	27p	NKT281	27p
2N708	15p	2N3707	15p	40370	57p	BCY43	15p	BSY11	27p	NKT401	87p
2N709	62p	2N3708	9p	40407	40p	BCY54	32p	BSY25	15p	NKT402	90p
2N718	25p	2N3709	10p	40408	52p	BCY58	22p	BSY26	17p	NKT403	75p
2N726	30p	2N3710	12p	40410	57p	BCY60	97p	BSY27	17p	NKT404	62p
2N727	30p	2N3711	12p	40410	57p	BCY70	20p	BSY28	17p	NKT405	62p
2N914	17p	2N3715	22-20	40467A	35p	BCY71	42p	BSY29	17p	NKT451	62p
2N916	17p	2N3716	22-20	40468A	35p	BCY72	17p	BSY32	25p	NKT452	62p
2N918	30p	2N3791	22-75	40600	57p	BCZ10	27p	BSY36	25p	NKT459	47p
2N929	22p	2N3819	37p	40673	11-25	BCZ11	27p	BSY37	25p	NKT460	47p
2N930	27p	2N3823	37p	AC107	30p	BCZ12	27p	BSY38	25p	NKT613F	32p
2N1090	20p	2N3824	12p	AC126	20p	BCY39	22p	BSY40	32p	NKT674F	30p
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2N1303	17p	2N3856A	30p	AC187	82p	BD132	85p	BSY45	37p	NKT10439	37p
2N1304	22p	2N3858	35p	AC188	37p	BDY10	21-37p	BSY54	40p	NKT10519	32p
2N1305	22p	2N3858A	35p	AC188	37p	BDY11	21-37p	BSY56	90p	NKT20329	47p
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2N1308	30p	2N3860	30p	ACY20	25p	BDY19	1-97p	BSY90	12p	NKT80113	12p
2N1309	30p	2N3866	11-50	ACY21	25p	BDY20	1-12p	BSY95A	12p	C111	75p
2N1507	17p	2N3877	40p	ACY22	20p	BDY38	97p	C1424	27p	C425	25p
2N1613	25p	2N3877A	40p	ACY28	20p	BDY60	82p	C426	40p	C428	37p
2N1621	32p	2N3881	40p	ACY31	25p	BDY61	82p	C441	30p	C442	30p
2N1632	30p	2N3900A	40p	ACY40	20p	BDY62	21-25	C425	25p	C428	37p
2N1637	30p	2N3901	47p	ACY41	25p	BF115	25p	C426	40p	C441	30p
2N1638	27p	2N3903	35p	ACY44	40p	BF117	47p	C428	37p	C442	30p
2N1671B	11	2N3904	35p	AD140	52p	BF163	37p	C744	30p	D16P1	37p
2N1711	25p	2N3905	37p	AD143	57p	BF167	32p	D16P2	40p	D16P3	40p
2N1889	32p	2N3906	37p	AD150	62p	BF173	32p	D16P4	40p	D16P5	40p
2N1893	27p	2N3907	37p	AD161	37p	BF177	30p	D16P6	40p	D16P7	40p
2N2147	27p	2N4059	11p	AD162	37p	BF178	30p	D16P8	40p	D16P9	40p
2N2148	57p	2N4060	12p	AF106	42p	BF179	30p	D16P10	40p	D16P11	40p
2N2160	57p	2N4061	12p	AF114	25p	BF180	35p	D16P12	40p	D16P13	40p
2N2193	40p	2N4062	12p	AF115	25p	BF181	32p	D16P14	40p	D16P15	40p
2N2193A	42p	2N4244	47p	AF116	25p	BF184	25p	D16P16	40p	D16P17	40p
2N2194A	30p	2N4282	17p	AF117	25p	BF187	25p	D16P18	40p	D16P19	40p
2N2211	27p	2N4303	47p	AF118	82p	BF188	17p	D16P20	40p	D16P21	40p
2N2218	32p	2N4287	17p	AF119	20p	BF195	20p	D16P22	40p	D16P23	40p
2N2219	32p	2N4288	17p	AF124	20p	BF196	42p	D16P24	40p	D16P25	40p
2N2220	25p	2N4289	17p	AF125	20p	BF197	42p	D16P26	40p	D16P27	40p
2N2221	25p	2N4290	17p	AF126	20p	BF198	42p	D16P28	40p	D16P29	40p
2N2222	30p	2N4291	17p	AF127	17p	BF200	52p	D16P30	40p	D16P31	40p
2N2287	11-07	2N4292	17p	AF139	37p	BF224	20p	D16P32	40p	D16P33	40p
2N2297	30p	2N4303	47p	AF178	42p	BF225	20p	D16P34	40p	D16P35	40p
2N2368	17p	2N5027	62p	AF179	72p	BF237	22p	D16P36	40p	D16P37	40p
2N2369	17p	2N5028	57p	AF179	72p	BF238	22p	D16P38	40p	D16P39	40p
2N2369A	17p	2N5029	47p	AF180	32p	BF244	32p	D16P40	40p	D16P41	40p
2N2410	42p	2N5030	42p	AF239	27p	BFW58	27p	D16P42	40p	D16P43	40p
2N2484	27p	2N5172	12p	AF279	47p	BFW59	25p	D16P44	40p	D16P45	40p
2N2484A	32p	2N5174	62p	AF280	47p	BFW60	25p	D16P46	40p	D16P47	40p
2N2539	22p	2N5175	52p	AF280	62p	BFW61	47p	D16P48	40p	D16P49	40p
2N2540	22p	2N5176	40p	AFZ11	32p	BFX12	22p	D16P50	40p	D16P51	40p
2N2613	35p	2N5232A	30p	ASY26	25p	BFX13	22p	D16P52	40p	D16P53	40p
2N2614	30p	2N5245	45p	ASY27	37p	BFX29	30p	D16P54	40p	D16P55	40p
2N2646	52p	2N5246	42p	ASY28	27p	BFX30	30p	D16P56	40p	D16P57	40p
2N2696	32p	2N5249	67p	ASY30	27p	BFX33	37p	D16P58	40p	D16P59	40p
2N2711	25p	2N5265	25-25	ASY36	25p	BFX44	37p	D16P60	40p	D16P61	40p
2N2712	25p	2N5266	22-75	ASY50	25p	BFX68	67p	D16P62	40p	D16P63	40p
2N2713	27p	2N5267	62-62	ASY51	32p	BFX84	25p	D16P64	40p	D16P65	40p
2N2714	30p	2N5305	37p	ASY54	32p	BFX85	25p	D16P66	40p	D16P67	40p
2N2865	62p	2N5306	40p	ASY76	25p	BFX86	25p	D16P68	40p	D16P69	40p
2N2904	30p	2N5307	37p	ASZ21	42p	BFX87	27p	D16P70	40p	D16P71	40p
2N2904A	32p	2N5308	37p	ASZ21	42p	BFX88	27p	D16P72	40p	D16P73	40p
2N2905	37p	2N5309	62p	AI103	11-25	BFX89	62p	D16P74	40p	D16P75	40p
2N2905A	40p	2N5310	42p	BC107	12p	BFX93A	62p	D16P76	40p	D16P77	40p
2N2906	25p	2N5354	27p	BC107	12p	BFY10	32p	D16P78	40p	D16P79	40p
2N2906A	27p	2N5355	27p	BC108	12p	BFY11	42p	D16P80	40p	D16P81	40p
2N2907	30p	2N5356	32p	BC109	12p	BFY17	22p	D16P82	40p	D16P83	40p
2N2929	15p	2N5363	47p	BC119	30p	BFY18	32p	D16P84	40p	D16P85	40p
2N2924	15p	2N5366	32p	BC115	27p	BFY19	32p	D16P86	40p	D16P87	40p
2N2925	15p	2N5367	57p	BC116A	27p	BFY20	11-60	D16P88	40p	D16P89	40p
2N2926	15p	2N5457	37p	BC118	32p	BFY21	42p	D16P90	40p	D16P91	40p
Green	14p	28005	75p	BC121	20p	BFY24	45p	D16P92	40p	D16P93	40p
Yellow	12p	28020	82	BC122	20p	BFY25	45p	D16P94	40p	D16P95	40p
Orange	12p	28102	82	BC123	25p	BFY26	45p	D16P96	40p	D16P97	40p
2N3013	32p	28103	25p	BC126	35p	BFY29	50p	D16P98	40p	D16P99	40p
2N3014	32p	28104	25p	BC140	30p	BFY30	50p	D16P100	40p	D16P101	40p
2N3053	25p	28501	32p	BC147	17p	BFY41	47p	D16P102	40p	D16P103	40p
2N3054	50p	28502	30p	BC148	12p	BFY43	50p	D16P104	40p	D16P105	40p
2N3055	75p	28503	27p	BC149	17p	BFY50	22p	D16P106	40p	D16P107	40p
2N3133	30p	3N128	70p	BC152	17p	BFY51	22p	D16P108	40p	D16P109	40p
2N3134	30p	3N139	11-25	BC157	17p	BFY52	17p	D16P110	40p	D16P111	40p
2N3135	25p	3N140	72p	BC157	20p	BFY53	17p	D16P112	40p	D16P113	40p
2N3136	25p	3N141	72p	BC158	17p	BFY36A	17p	D16P114	40p	D16P115	40p
2N3390	25p	3N142	55p	BC159	20p	BFY75	30p	D16P116	40p	D16P117	40p
2N3391	20p	3N143	67p	BC180	62p	BFY76	42p	D16P118	40p	D16P119	40p
2N3391A	30p	3N152	87p	BC167	15p	BFY77	47p	D16P120	40p	D16P121	40p
2N3392	17p	3N153	87p	BC168B	15p	BFY90	15p	D16P122	40p	D16P123	40p
2N3393	15p	40055	87p	BC168C	15p	BPX25	57p	D16P124	40p	D16P125	40p
2N3394	15p	40244	22p	BC169B	14p	BPX29	41-80	D16P126	40p	D16P127	40p
2N3402	22p	40251	87p	BC169C	15p	BPY10	11-80	D16P128	40p	D16P129	40p

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A precision made pocket sized test meter, ideally suited for testing electronic circuits or electronic appliances. Supplied complete with test lead and batteries.
Ranges—D.C. voltages: 10, 50, 250, 1,000V (1,000 O.P.V.). A.C. voltages: 10, 50, 250, 1,000V (1,000 O.P.V.). D.C. current: 1mA, 100mA. Resistance: 0-150 Kohms. Decibels: -10 to +22dB (at a.c. 10V range).

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MULTIMETER 20,000 O.P.V. MULTIMETER

Features large easy-to-read meter, wide choice of ranges. With test leads, batteries and manual. Size: 4 1/2in x 3 1/2in x 1in.
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Ranges: D.C. voltages: 0, 5, 25, 100, 500/1,000V (20,000 ohms/V). A.C. voltages: 0, 5, 25, 100, 500, 1,000V (10,000 ohms/V). D.C. current: 0, 50 μ A, 0mA, 5mA, 50mA, 500mA. Resistance: 0, 6k Ω , 600k Ω , 6M Ω , 60M Ω . Decibels: -20 to +22dB in 5 ranges.

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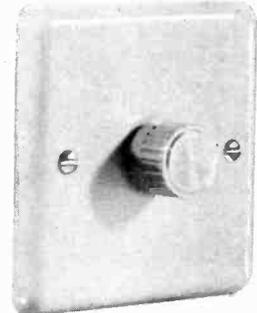
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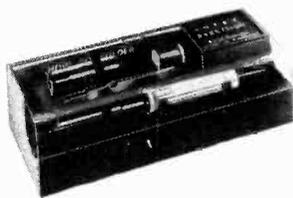
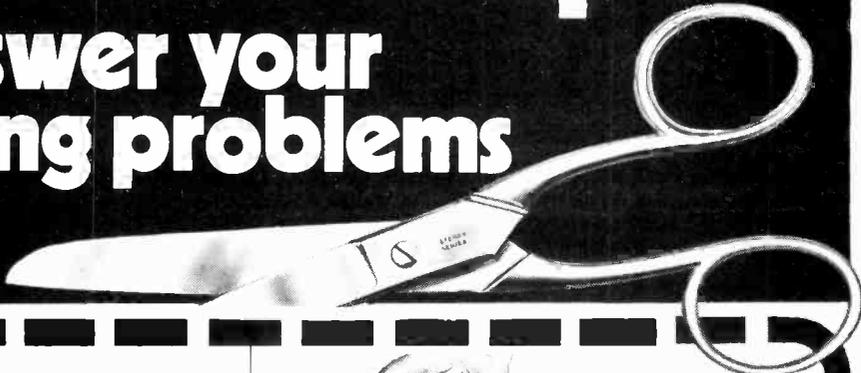


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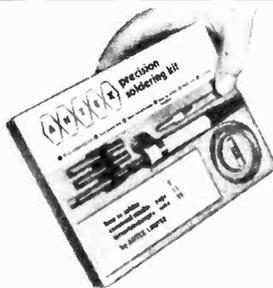


SK1 SOLDERING KIT

In rigid plastic "tool box" containing Model CN - 15 watts - 240 volts miniature iron fitted $\frac{3}{16}$ " bit. Spare bits $\frac{5}{32}$ " and $\frac{3}{32}$ ". Reel of resin-cored solder, heat sink, cleaning pad, stand and booklet "How to Solder".

Send me

kit(s) **£2.75**



SK2 SOLDERING KIT

In polystyrene pack, containing 15 watt miniature soldering iron, 240 volts fitted with $\frac{3}{16}$ " bit, 2 spare bits $\frac{5}{32}$ " and $\frac{3}{32}$ ". Coil of resin-cored solder, heat sink, 1A fuse and booklet "How to Solder".

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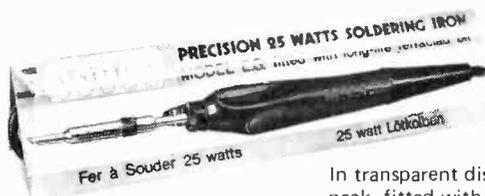


Model CN 240/2
- 15 watts
- 240 volts

Fitted with nickel plated $\frac{3}{32}$ " bit and packed in handy transparent box.

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ES240 D 25 watt
soldering iron

In transparent display pack, fitted with long life iron-coated bit $\frac{1}{8}$ " diam. Interchangeable spare bits $\frac{3}{32}$ ", $\frac{1}{16}$ ", $\frac{1}{4}$ " (extra) available. Improved design to ensure strong and reliable high speed iron. Heats up in 2 minutes.

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Complete with 15 ft (4.50m) lead, 2 heavy gauge clips for instant

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Models 40, 47A, 48A. (Models 47A and 48A are Admiralty pattern.)
D.C. volts: 0-12, 1-2, 12, 120, 480, 1,200.
Amps: 0-012, 0-12, 1-2, 12.
A.C. volts: 12, 120, 480, 1,200.
Amps: 0-012, 0-12, 1-2, 12.
Ohms: 1,000, 10,000, 1,000,000 (external voltage source).
Sensitivity: 166.6 Ohms/Volt, 333.3 Ohms/Volt when divided by two button is pressed on both a.c. and d.c. ranges. £16. P. & P. 70p.



Complete with voltage multiplier for 480V and 3,600V. Current shunts for 120A and 480A. A.C. current transformer for 20A and 60A. In special wooden box. £18-50. P. & P. £1.
Due to demand it may not always be possible to supply a particular model, and a different type to that ordered may be dispatched. These models are electrically identical.

MUMICATOR PRICE LIST

END READING (16mm Fig. Height)	
B13 base	
GR10M/U Clear	0-9 Display
GR10M Amber filter	0-9 Display
Quantity	Price each (less base)
1-3	£1-40
4-10	£1-35
11-25	£1-30
26-100	£1-20

Bases 20p each

SIDE READING (14mm Fig. Height)	
0-9 Display	
XN3F/A	38mm leads Amber Filter
XN3F	38mm leads Red Filter
XN3A/F	6mm leads Red Filter
XN3A	6mm leads Clear Filter
XN11/F	38mm leads Red Filter
XN23/FA	38mm leads Amber Filter

SPECIAL DISPLAYS	
XN9	38mm leads Clear Filter
NX10/C	6mm leads Clear Filter
NX22	38mm leads Clear Filter

Displays Fig. "1"	
Displays "+, - and ~"	
Displays "X, A, Ω, Vmv"	
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SLIDING CABINET LID STAYS



Similar principle to above closed length 1 1/2in, open length 5 1/2in. Finished dull plating brand new. 5 for £1. Post free.

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1 PL 900 6 contacts. 15 Amp. 125/250 volts. Single pole. ON/OFF. Plunger operated. L 1 7/8", W. 5/8", H. 3/4". Price 5 for £1-25. Post free.

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230V, 50Hz, 0.65A, 1/20 h.p., 2,850 r.p.m. Cont. rated. Shaft 3/16in dia. x 1/2in long. Circular clamp mounting. £3-50. Post free.

DELAY LINE LEXOR MDN 2484D

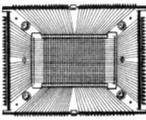
Miniature resin encapsulated module. Total delay 50msec to 10msec. Tapped at 10% intervals. Impedance 75 ohms to 10 kΩ. 30V wkg. Attention 0.5 dB/msec. Also available MDN 2484C 3 micro-sec 600 ohm impedance. 2 1/2in x 1 1/2in x 1 1/2in. £1-50. Post free.

MIDGET POWER RELAY OMRON Mk I

230V, 50Hz. 1PDT new. Faulty plating on frame. 5 for £1-50. Post free.

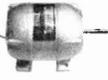
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42 x 52, 2kΩ bit ferrite core store. C/W quantity OAI/O load diodes. Ideal for building computer store, holding information, teaching experiments, demonstrations, etc. Price £25-25. P. & P. 38p.



BRAND NEW CAPACITOR REVERSIBLE SINGLE PHASE PARVALUX MOTORS

230/250V, 50Hz, 2,800 r.p.m.; 130 h.p. cont. rated; 3/16in dia. shaft; 3/16in long foot mounting; wt. 6lb. C/W capacitor. £3-50. Post free.



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1inch coloured displays (ex fruit machines). Operate on rear lamp projection principle. Displaying 12 pictures as follows: 3 cherries, pistol, lemon, barrel, bell, orange, plum, rugby ball, 5 pointed star, man holding glass of ale, BAR and HELD in words. 2 screw panel mounting W 1 1/2" H 2 1/2". Uses 10mm tubular MCC bulbs. Offered at bargain price to clear stocks. 3 units for £1 (less bulbs). P. & P. 30p.

VOLTMETER "AS NEW"

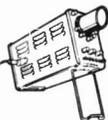
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1T4	0-16	30C15	0-63	DY87	0-28	EM81	0-41	PCL84	0-37	UBC41	0-32									
3S4	0-28	30C17	0-80	DY802	0-40	EM84	0-33	PCL85	0-45	UBF80	0-34									
3S4	0-37	30C18	0-87	EAF80	0-39	EM87	0-37	PCL86	0-41	UBF80	0-35									
5U4G	0-28	30F3	0-76	EAF42	0-50	FY81	0-38	PCL88	0-39	UCB84	0-36									
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5Y3GT	0-30	30FL12	0-72	EB91	0-11	EZ40	0-43	PEN4A	0-42	UCF80	0-36									
5Z4G	0-37	30FL14	0-72	EB33	0-40	EZ41	0-43	PEN36C	0-70	UCH42	0-32									
6J30L2	0-58	30L1	0-32	EBC41	0-54	EZ80	0-23	PPL200	0-58	UCH81	0-32									
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6AT6	0-22	30F19	0-65	ECC82	0-23	KT41	0-77	PL83	0-35	UL41	0-30									
6BA6	0-22	30PL1	0-63	ECC83	0-35	KT61	0-55	PL84	0-33	UL44	1-00									
6BE6	0-23	30PL13	0-85	ECC85	0-28	KT66	0-33	PL500	0-65	UL84	0-35									
6B6	0-42	30PL14	0-70	ECC804	0-60	LN319	0-63	PL504	0-67	UM84	0-22									
6B7G	0-60	30PL15	0-90	ECC80	0-30	LN329	0-72	PM84	0-37	UY41	0-41									
6BD6G	1-10	35L8T	0-45	ECC89	0-36	LN339	0-63	PX25	1-17	UY85	0-28									
6F14	0-45	35W4	0-28	ECH35	0-30	N78	0-37	PY82	0-55	VP48	0-77									
6F23	0-71	35Z4GT	0-25	ECH42	0-63	P61	0-50	PY33	0-55	Z77	0-22									
6F25	0-62	807	0-45	ECH81	0-29	PABC80	0-35	PY81	0-27	Transistors										
6K7G	0-12	6063	0-62	ECH83	0-41	PC86	0-51	PY82	0-27	AC107	0-17									
6K8G	0-17	AC/V P2	0-77	ECH84	0-37	PC88	0-51	PY83	0-28	AC127	0-18									
6Q7G	0-28	B349	0-65	ECL80	0-35	PC96	0-42	PY88	0-35	AD140	0-37									
68L7GT	0-37	EB29	0-62	ECL82	0-33	PC97	0-40	PY80	0-37	AF115	0-20									
6V6G	0-23	CCH35	0-85	ECC89	0-40	PC900	0-37	PY801	0-27	AF116	0-20									
6V6GT	0-32	CL31	1-25	EF39	0-35	PC84	0-32	R19	0-32	AF117	0-20									
6X4	0-28	CY31	0-33	EF41	0-40	PC85	0-30	R20	0-65	AF118	0-48									
6XGT	0-28	DAF91	0-22	EF80	0-24	PC88	0-45	U25	0-68	AF125	0-17									
10P13	0-60	DAF96	0-38	FF85	0-31	PC89	0-47	U26	0-65	AF127	0-17									
12AH8	2-25	DF33	0-38	FF86	0-31	PC8189	0-51	U47	0-68	OC26	0-25									
12AU6	0-28	DF96	0-38	FF81	0-13	PC878	0-30	U50	0-65	OC44	0-12									
12AU7	0-28	DH77	0-22	EF183	0-29	PC82	0-32	U2	0-31	OC71	0-12									
12AX7	0-28	DK32	0-37	EF184	0-32	PC86	0-47	U78	0-24	OC72	0-12									
19BG6G	0-87	DK91	0-28	EH90	0-42	PC800	0-67	U191	0-62	OC75	0-12									
20F2	0-67	DK92	0-42	EL33	0-55	PCF801	0-33	U193	0-42	OC81	0-12									
20P3	0-85	DL96	0-38	EL34	0-49	PCF802	0-45	U231	0-72	OC8D	0-12									
20P4	0-92	DL92	0-28	EL84	0-24	PCF805	0-67	U301	0-52	OC82	0-12									
25L6GT	0-25	DL94	0-37	EL90	0-26	PCF806	0-60	U259	0-51	OC8D	0-12									
						PCF808	0-72	U801	0-96	OC170	0-22									

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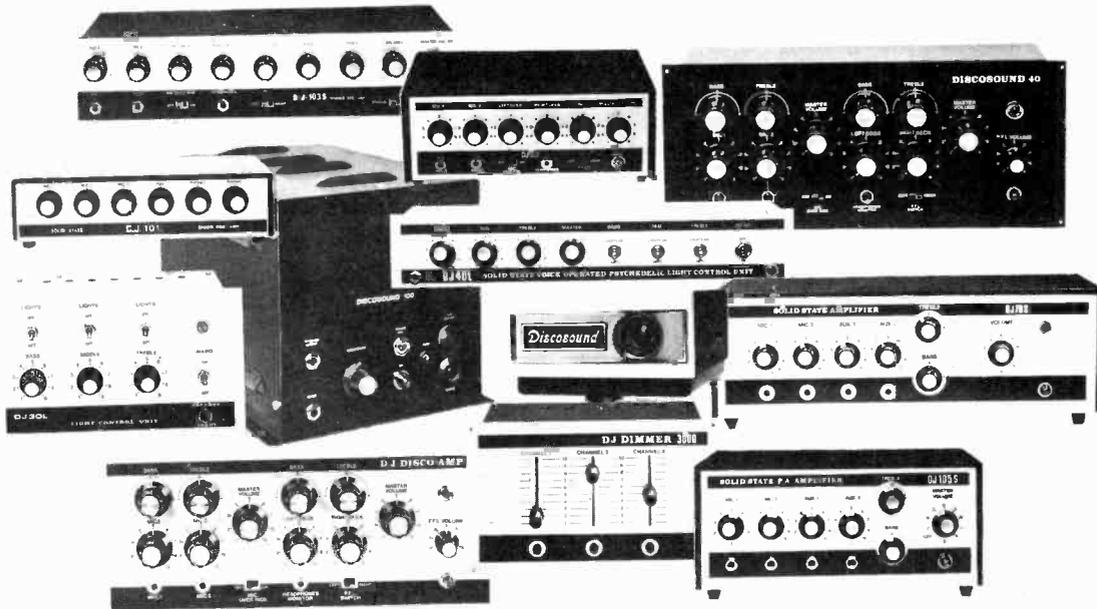
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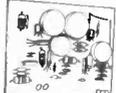
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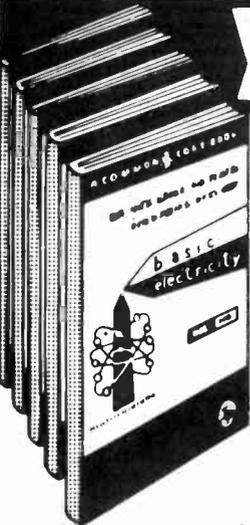


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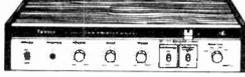
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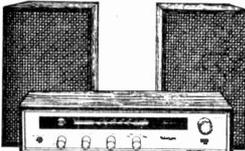
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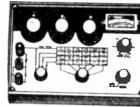
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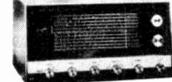
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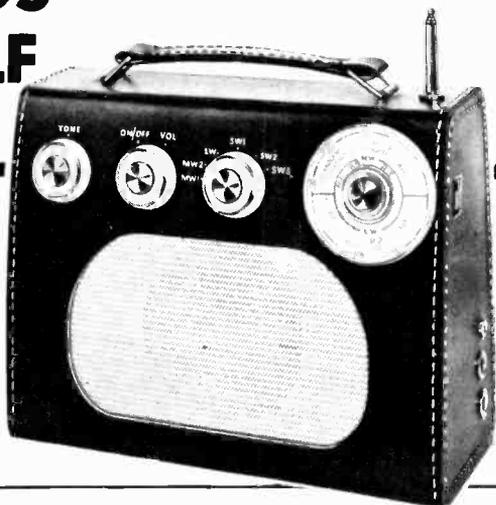
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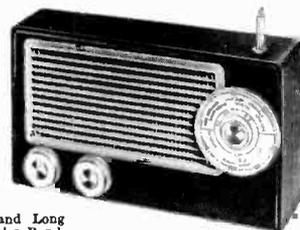
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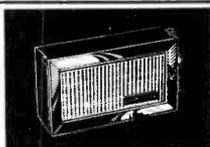
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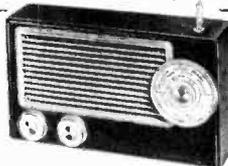


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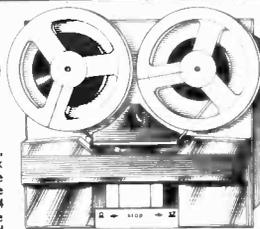
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283710	0-13	BCY33	0-25	GET102	0-30
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AC107	0-38	BF115	0-25	GEX43/1	0-08
AC126	0-25	BF167	0-25	GEX941	0-15
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ON THE ROAD

THE motor car is a wonderful vehicle for electronics. Solid state technology never had a happier hunting ground. Consider that reliable easy-to-tap d.c. supply at 12 volts: just what the transistor ordered. No wonder so many interesting and useful aids for the motorist have appeared in recent times. Many owe their origin to private electronics enthusiasts, their imagination stirred to new heights during long solo drives, no doubt; or, perhaps, during enforced idling caused by holiday season snarl-ups.

The majority of such devices represent electronics in a comparatively simple form. Whether as self-sufficient gadgets or systems, or as ancillary units for coupling to standard car accessories for control purposes, their function is to aid the motorist rather than his vehicle. Useful as they are, such appendages do not represent the limit of electronics involvement in motor cars. This is far from the case. Electronics is destined to become a vital and intrinsic part of the vehicle itself.

The increasing concern over road safety and environmental matters like atmosphere pollution, will bring about more stringent regulations. In order to meet these tough requirements the car manufacturers will have no alternative but to look beyond their own industry and traditional methods. They are already fairly familiar with the possibilities of electronics in the internal combustion engine field. For example, the advantages of electronic ignition and fuel injection have long been known. It is only the initial cost that deters car manufacturers from incorporating such systems in their mass produced models.

Coming now to more life-or-death matters, car designers in the future will have little option but to incorporate more refined and sensitive control systems. Present systems largely dependent upon electro-mechanical and hydraulic linkages will undergo drastic change, if not entire replacement, as electronic control systems are developed. Methods of preventing wheel slide by use of electronic sensing and computing techniques to control the brake have already been perfected. This is a foretaste of the future in motoring.

This revitalizing of the traditional vehicle is all to the good, though even the magic of electronics cannot save the internal combustion engine from ultimate extinction. Indeed, how far on the road towards fully automated driving will we have journeyed before the electric powered vehicle overtakes us? Commercial interests are very reticent about the current state of development in this exciting area, but there have been some ominous (or rather, welcome) rumblings from Detroit, of late. Perhaps the long awaited motoring revolution is nearer than we think.

F.E.B.

THIS MONTH

CONSTRUCTIONAL PROJECTS

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Our October issue will be published on Friday, September 17

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Practical Electronics, Fleetway House, Farringdon St., London, E.C.4. Phone: Editorial 01-634 4452; Advertisements 01-634 4202

THE simple control of power has for a long time been desirable, but it was not until the introduction of thyristors, or silicon controlled rectifiers that such control became convenient in the home constructor field.

The unit to be described here is capable of controlling power levels of up to 1kW and makes use of the "burst fire" system to achieve this. Any attempt to control elements in excess of this rating will result in damage to the controller.

Although the handling of greater power levels might seem to be desirable, it should be borne in mind that most heaters of a greater power output have the facility of switching in and out 1kW at a time. Thus fine control of 1kW will cover most situations; larger power handling would call for a larger unit than that described here.

In order to understand the advantages of the burst-fire system and why it is used in this controller, a brief outline of the alternative method is given. There are, of course, advantages and disadvantages in both systems, as will be seen.

PHASE SHIFT CONTROL DISADVANTAGES

The simplest form of control of power, using a thyristor, is that known as "phase shift". Fig. 1 shows a typical waveform of load current controlled in this way, where switch-on is delayed in each half-cycle, so causing the power level, averaged over a number of cycles, to be less than when no delay is included. Variation of the length of the delay varies the average power level.

Controllers based on the phase-shift principle have been described previously in this magazine. While they are quite satisfactory in enabling the power level to be controlled, there are two disadvantages.

Since the current switch-on is sudden and is repeated at the rate of 50Hz, a large level of radio frequency is generated and careful screening and filtering are called for if interference to radio and television is to be avoided. Loads consisting of motors, such as electric drills, tend to give much lower levels of interference due to the inductance of the windings acting as a built-in filter. In general, the greater the power level being controlled, the greater level of interference generated.

Distortion of the mains supply also occurs as can be seen from Fig. 1, and large scale use of phase-shift control at high power levels—say greater than a few hundred watts—can give rise to difficulties. The Electrical Supply Authorities accordingly discourage the use of phase-shift control for space heaters.

BURST FIRE COMPARED

The burst-fire system causes very little or no interference, even without filtering, and no distortion of the supply voltage occurs. This is because complete half-cycles of current are permitted to flow to the load in controllable trains as in Fig. 2. Alteration of the ratio of "on" time to "off" time, while still maintaining complete half-cycles in the power supplied to the load, varies the average output power.

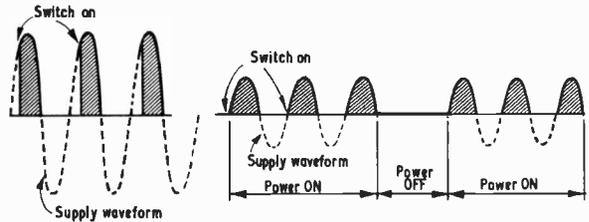


Fig. 1 (left). Phase shift control of thyristor load current. Power supplied can be varied by altering switch-on point

Fig. 2 (right). Current half cycles supplied to load with burst fire control. Note that switch-on occurs at zero point

CHOICE OF PULSE PERIODS

The actual lengths of time employed for "on" and "off" require choosing with care. Both periods should not be too short, for if, for example, the current period was to consist of two half-cycles, then only a slight change in component values, due to load or temperature changes, could alter this to either one or three half-cycles. This represents a large percentage change and smooth stable control would be impossible.

Conversely, too long a period of time in either the "on" or "off" mode would permit a heater element to alternately cool down and heat up. Continuous temperature cycling of this kind might give rise to a shorter life for the element. In any case, it is easily avoided, for with correct timing, the thermal inertia of the element overcomes this.

The unit described here has been arranged to have its output pulsed on and off once per second, that is "on" time plus "off" time is equal to about 1 second. As the ratio of "on" and "off" is varied, to effect a change in average power supplied, this time of 1 second remains virtually constant, due to the circuit configuration employed.

Control of power from 10 per cent to 90 per cent of full is possible; a by-pass switch (which may be omitted if desired) enables full power to be supplied when required.



— — — provides smooth power.

APPLICATIONS FOR THE BURST FIRE CONTROLLER

From the foregoing it will readily be seen that while the Burst Fire Controller is eminently suitable for control of heaters—such as electric fires, aquaria heaters and photographic processing bath heaters—it is not suitable for the dimming of lights, nor the slowing of motor speeds.

However, as was noted earlier, phase-shift control of electric motors is appropriate; the self suppression of interference in motors and the generally lower power levels present in lamp circuits avoid the difficulties mentioned in that system.

Uses for the Burst Fire Controller involving lamps is in those cases where flashing is required. Christmas tree and similar displays are examples; perhaps a cycling period of about 5 to 10 seconds would be more suitable and possible modifications will be given later.

Having thus outlined the need for burst fire control, we can now turn to practical details.

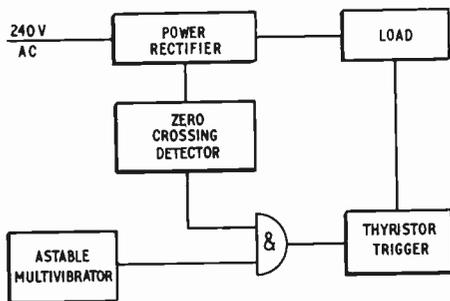


Fig. 3. Block diagram of controller

BLOCK DIAGRAM

In Fig. 3 is given the block diagram of the unit. Here the astable multivibrator has an almost constant frequency, but its on-off ratio can be altered. The output of the multivibrator, together with information from the zero crossing detector, is fed to the AND gate, the output of which turns on the thyristor, and so applies power to the load.

The incorporation of the AND gate in this way ensures that switch-on of the thyristor occurs only at the start of each mains half-cycle, so causing no high frequency radiation.

CIRCUIT ACTION

Full circuit details are given in Fig. 4. In the circuit diagram, transistors TR2 and TR3 form the astable multivibrator, which has two points of interest.

Potentiometer VR1 enables the on-off ratio of the multivibrator to be changed but with a constant repetition rate. This is because while varying amounts of resistance can be included between each base and the positive supply rail, the total amount of such resistance is constant, one base circuit having more resistance included as the other has less.

The inclusion of the diode D7 and resistor R9 to supply rail, isolates the timing capacitor C6 from the collector of TR3 so allowing the voltage at that collector to rise sharply when the transistor ceases to conduct. Consequently, a good square wave is available for passing to the AND gate comprising D8, D9 and R11.

ZERO CROSSING DETECTOR

The second input to the AND gate is derived from the zero crossing detector circuitry.

Inspection of the circuit will show that the upper side of C3 has D3 connected to negative rail; similarly, C4 has D1 connected to the positive rail. This means that the waveforms at the upper sides of C3 and C4 are 90 degrees out of phase with the waveform across D6, this acting as a positive clamp to the negative line and providing positive half-cycles, as shown in Fig. 5.

These provide positive switching of TR1, so giving positive signals, coinciding with zero mains crossing, at the emitter of TR1.

The capacitors C3 and C4 are connected to the mains, and so must withstand full mains potential. For this reason, 750 volts should be considered the minimum working voltage for these components, with 1,000 volt working desirable.

GATE CONTROL

The AND gate comprising D8 and D9 controls the switching of TR4. Suppose TR3, in one of its

--- **BURST-FIRE** ---

POWER CONTROLLER

control up to 1kW

By J. N. Watt

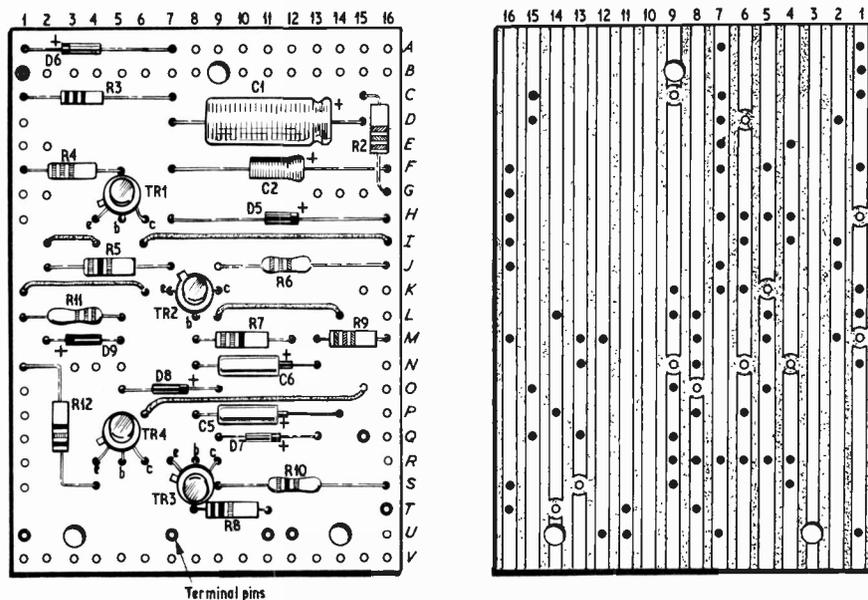


Fig. 7. Assembly and wiring layout of control board

BEWARE OF HIGH VOLTAGES

Practical construction raises some important safety points and it would be as well to mention them first.

All parts of the circuitry are at high voltage, due to direct connection to the mains and under no circumstances should any part be handled directly when live. Disconnect the unit from the mains supply by un-plugging it when making any adjustments or modifications to it.

Since most oscilloscopes are grounded via mains earth at one input terminal, it is essential that any waveform inspection is made through a 1 : 1 isolating transformer. Any direct oscilloscope connections will certainly result in considerable damage to the controller circuitry.

Where control of an electric fire is intended, avoid low mark-space ratio settings of VR1, since short period bursts of power are not sufficient to make a 1kW element glow. This could be dangerous to children with inquisitive fingers who might think the fire is off.

For insulation, the piece of Veroboard carrying most of the components in Fig. 7 is secured by means of 4B.A. nylon screws and nuts, with nylon nuts used as insulated spacers. The heat sinks themselves are earthed, although the components they carry are of course at high potential, with the appropriate insulation.

The need for care, when the cover of the box is removed and the unit is connected to the mains, cannot be too strongly emphasised. Of course, in normal use, no danger should arise.

A strong die-cast box is used to house the controller, and this should be earthed. Such boxes are readily available, easy to drill and, rather important in this case, provide good protection.

COMPONENTS . . .

Resistors

R1	15k Ω	6W wire wound	R7	47k Ω
R2	390 Ω	$\frac{1}{2}$ watt	R8	47k Ω
R3	68k Ω		R9	15k Ω
R4	2.2k Ω		R10	10k Ω
R5	2.2k Ω		R11	10k Ω
R6	10k Ω		R12	120 Ω

All 10% $\frac{1}{2}$ watt except where otherwise stated

Potentiometers

VR1 250k Ω carbon linear

Capacitors

C1 40 μ F elect. 16V
 C2 47 μ F elect. 6V
 C3, C4 1000pF 750V (2 off)
 C5, C6 2.2 μ F elect. 6V (2 off)

Transistors

TR1—TR4 BC107 (4 off)

Diodes

D1—D4 BYZ12 (4 off)
 D6—D9 IN914 (4 off)
 D5 5.6V 400mW Zener

Thyristor

SCR1 BTY79-400R

Switch

S1 D.P.D.T. 5A contact rating

Miscellaneous

LPI-Mains neon, heat sinks and insulating mica for rectifiers, nylon screws and nuts (4 B.A.). Eight way insulated tag strip, 13A mains socket, Die-cast box 7 $\frac{1}{2}$ in \times 4 $\frac{3}{4}$ in \times 2 $\frac{1}{2}$ in.

A high degree of polish can be imparted to the box by rubbing with successively finer grades of emery paper, followed by toothpaste (in lieu of jewellers' rouge) and then metal polish. Alternatively, a painted finish, obtained by making use of one of the many spray aerosols on the market, enables a choice of colour to be made.

MOUNTING THE RECTIFIERS

The four power rectifiers, D1 to D4, and the thyristor are mounted on heat sinks as shown in the wiring diagram of Fig. 8.

These sinks are earthed, and this can be done because mica washers, with insulating bushes, are employed on the diode and thyristor mounting studs as in Fig. 9.

Each of the sinks is painted matt black, to assist with heat dissipation, as are the inside surfaces of

the box. A light smear of silicon grease, if available, should be applied to the surfaces of the sinks that joint with the box.

When fitting the washers, ensure that no burrs are present that could puncture the mica insulation. After fixing, check that the mica washers are still insulating, with an ohmmeter.

FULL POWER SWITCHING

A mains voltage neon lamp across the load indicates when power is actually being applied to it, while the double pole change-over switch S1 enables full power to be applied direct to the load when required.

This switch must be capable of handling the full load current, and for this reason has a rating of 5A or greater.

When wiring up, remember that all leads passing load current can be called upon to carry 4A, so use

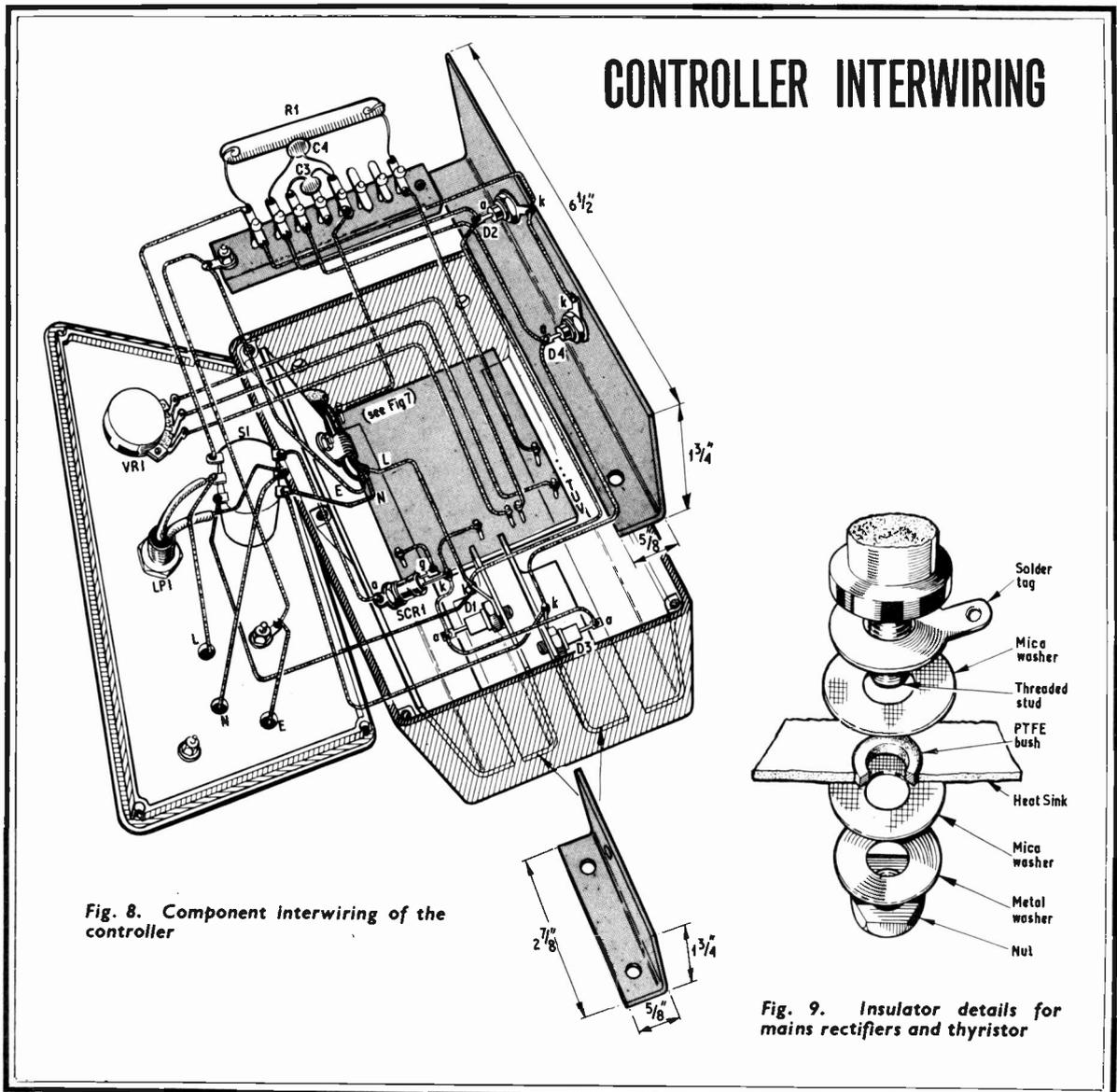


Fig. 8. Component interwiring of the controller

Fig. 9. Insulator details for mains rectifiers and thyristor

wire of an appropriate rating. Leads such as those running to the Veroboard can be of a lighter gauge.

When it has been ensured that all components and connections have been made correctly, power can be applied.

CHECK OUT

A voltmeter should be used to monitor the d.c. voltages present—those given in Fig. 4 are with respect to the thyristor cathode. At the collector of TR3 the voltage will change as the multivibrator oscillates, it depending on the setting of VR1.

A 100 watt lamp is a good load to check the operation of the unit; it will easily be seen that variation of the setting of VR1 results in a short flash at intervals of about one per second at one end of the range, with almost continuous light, punctuated by short term extinguishing of the lamp, at the other end. Settings of VR1 in between give smooth control of average power.

After a few minutes, withdraw the plug of the unit from the mains, and test the running temperature of the diodes and thyristor. With the 100 watt load suggested, they should not be in any way warm to the touch.

At this stage, it would be as well to ensure that the zero crossing circuits and AND gate are working correctly. To do this, disconnect one end of C3. The lamp should continue to flash, but at reduced brilliance. Disconnection of C4 also will give no output at all.

The explanation for this is that with C3 removed, only alternate half-cycles of the mains can be switched through to the load. Removal of both C3 and C4 means that no pulses are fed to TR1 and, with the AND gate working correctly, the output of the multivibrator is unable to switch on the thyristor.

NO INTERFERENCE

Correct functioning of this part of the circuit is essential if no interference is to be caused, for if the thyristor could apply voltage to the load starting at

any time but zero crossing, the resultant sudden flow of a large current would generate considerable r.f. energy.

Switch off of load current at zero crossing is automatic, for the current through the thyristor falls to zero at the end of each half-cycle.

With C3 and C4 replaced and a larger load connected, such as a 1kW fire, there will be a warming of the heat sinks and the box at the higher power settings. This is quite in order. It should be borne in mind that about 30 watts is to be dissipated at the highest setting, and in case this seems excessive, remember that it is only 3 per cent of the total power controlled.

At lower power settings, only slight warming should occur.

Depending on the relative values of the capacitors employed for C5 and C6—remember that electrolytics have a wide tolerance—it will be found that average power levels of from 10 per cent to 90 per cent of full power can be delivered.

SUBSTITUTE COMPONENTS

The question of substitute components will no doubt arise in connection with the Burst Fire Controller.

The transistors specified are BC107, but in fact unmarked *npn* transistors, quoted as being "similar to BC107" worked well, provided those found to be leaky or of low gain were not used.

As for the diodes D6 to D9, germanium or silicon devices can be used, although D8 and D9 should be of a similar type.

The thyristor employed in the prototype was a Mullard BTY79-400R; a BT102-500R also functioned satisfactorily. Unmarked thyristors, of a sufficiently high current rating may require more gate current than this circuit can generate and consequently may not prove to be suitable.

The power diodes are type BYZ12, with cathode stud. Alternatives, provided that they are at least of 400 volt 4A rating, but preferably of a somewhat higher current carrying capability, can be employed.

FLASHING DISPLAYS

As already described, the repetition rate is about one burst per second. An increase in the value of C5 and C6 to say, 4.7 μ F, or 6.8 μ F will slow down the rate of flashing to a suitable rate, while unequal values of these capacitors will enable the relative lengths of "on" and "off" time to be varied over a very wide range, particularly useful for lamp flashing displays.

Should the use of the Burst Fire Controller be confined to such uses, with upper power limits of, say, 200 watts, then some economies in the construction can be made. A 3A thyristor, on a smaller heat sink, and 1A wire ended rectifiers should enable the unit to be constructed in a smaller die-cast box, so making a very compact unit.

Apart from the obvious use of controlling room heaters, constructors may find the Controller useful to run a soldering iron, when on stand-by, at a reduced temperature, with switching to full power for actual soldering. These will increase the life of the iron bit. Other uses will doubtless occur to the home experimenter.

★



Microwave semiconductors

By M. FLETCHER (Mullard Ltd)

MICROWAVE frequencies occupy that part of the spectrum where the circuitry used is comparable in size to the wavelength. In practice this usually means frequencies from 1GHz to 100GHz or possibly higher. Originally exploited for radar at the beginning of World War II, microwaves now have a multitude of applications.

The wide bandwidths possible are utilised in communications, both overland and by satellite. Microwaves form a valuable research tool for performing various physical measurements and the use of high power microwaves is now being applied to cooking.

Until comparatively recent times microwave electronics has been largely the domain of thermionic devices. Within the last decade however a host of microwave semiconductor components have become available. Many of these, because of their simplicity and low power consumption compared to thermionic devices, are stimulating new applications for microwaves not previously considered practical.

POINT CONTACT

In the early development work on radar principles, a sensitive detector was required for the receiver to respond to the high frequencies being used. The

technique adopted was to use a point contact diode either as a detector or as a mixer in a superhet receiver.

The diodes used were really a refined form of the simple cat's whisker semiconductor rectifier used in early radio receivers. The form of construction is shown in Fig. 1. The noise figures obtained were poor by modern standards but sufficed for the purpose. No basic change in technology took place for many years although a steady improvement in materials and techniques brought about improvements in noise performance (Fig. 2).

Although still widely used today the point contact diode remained the only semiconductor element available to microwave engineers for nearly two decades. In the early 1960s, however, the gathering pace of semiconductor technology began to have application in the microwave area. One of the first of these devices was the variable capacitance diode or varactor.

VARACTOR DIODES

The varactor diode depends on the phenomenon of capacitance change under varying reverse bias due to the variation in the width of the depletion region in a *pn* junction. See Fig. 3.

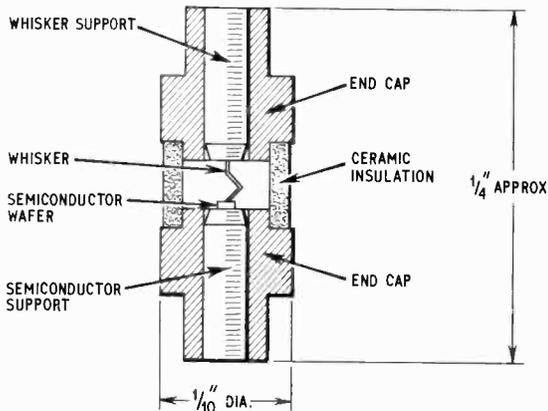


Fig. 1. Construction of a modern point contact mixer diode

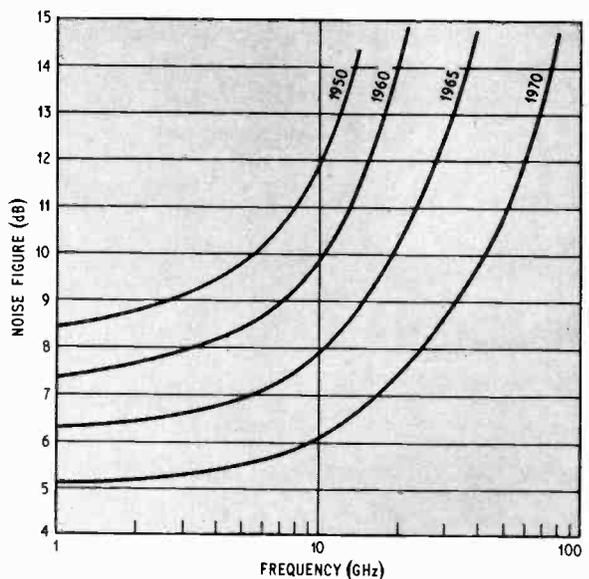


Fig. 2. Improvement in the noise figures of mixer diodes

The capacitance voltage relationship is $C \propto V^{-n}$. The value of n depends on the impurity profiles in the pn junction. It is typically 0.5 (as shown in Fig. 3) but the important point is that the relationship is non-linear.

The junction capacitance of a microwave varactor is normally specified at $V = 6V$ and might be from 0.2pF to 20pF, depending on the application. Various methods are used for fabricating pn junction varactors, two important ones being shown in Fig. 4.

The diodes are usually made with silicon although gallium arsenide is used for some special applications. The manufacturing problem is to define the required area of diffused pn junction since this affects the capacitance value.

In the case of the mesa diode this is done by etching away the unwanted area. In the case of the planar diode areas are defined by making holes in the oxide window of required size prior to diffusion. The holes are made by photolithography and the whole process is similar to that used for making planar transistors.

The advantage with planar construction is that a large number of diodes may be fabricated with one series of operations. When the varactor chip is made it must be mounted in an envelope suitable for use at microwave frequencies.

The varactor diode has numerous applications, not all of them confined to microwaves. Clearly it may be used as a circuit tuning element which is voltage controlled. In this respect it is used for tuning microwave oscillators, T.V. tuners, automatic frequency control systems and so on.

The other applications of the varactor depend on the fact that it is a non-linear circuit element whose response to a large signal differs from that of a small one. The change of impedance at high signal levels may be applied to limiter type circuits.

Under conditions of high signal level the varactor will generate harmonics. If resonant circuits are coupled, tuned to the harmonic frequencies, substantial amounts of power may be extracted at the higher frequency. Using the second or third harmonic, a chain of varactor multipliers may be built up capable of giving powers in the order of 1-2 watts at 8GHz (see Fig. 5).

Of course, losses are present in this system both in the circuits and the varactors and a great deal more power must be supplied at the lower frequencies from, say, power transistors. However it is a useful technique for generating power with solid state devices and is widely used in communications transmitters. Obtainable output powers are shown in Fig. 6.

SCHOTTKY BARRIER DIODES

Another new type of microwave diode to appear in recent years is the Schottky barrier diode. Basically a Schottky barrier is a junction diode with the junction formed between the semiconductor and a metal contact rather than between dissimilar semiconductor materials, as in the case of an ordinary pn diode.

The construction of a Schottky diode is shown in Fig. 7. The manufacturing processes used are very similar to those for planar diodes and many of the same advantages accrue, for example the uniformity arising from making a large number of diodes with a single process.

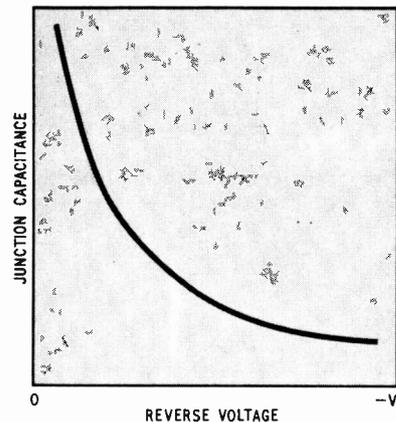


Fig. 3. Relationship of capacitance with voltage $C \propto V^{-n}$

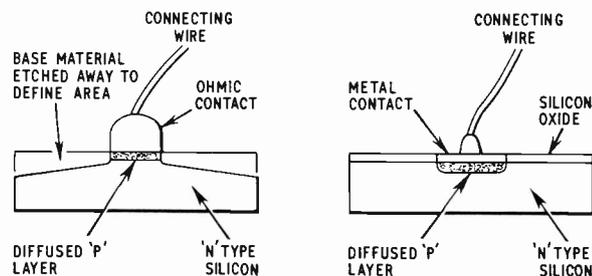


Fig. 4. Construction of (left) Mesa and (right) planar pn diodes. The chips are typically $0.25mm \times 0.25mm$

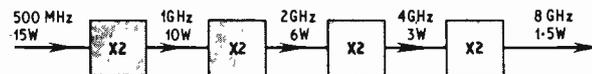


Fig. 5. Chain of varactor doublers producing 1.5W at 8GHz

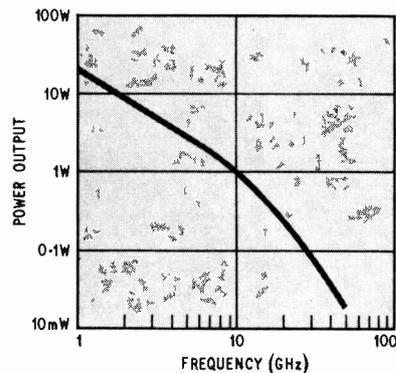


Fig. 6. Output power obtainable from varactor chains

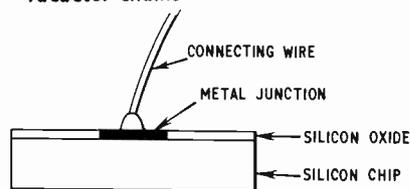


Fig. 7. Construction of Schottky barrier diode. The metal junction may be as small as 0.01mm across

The Schottky diode has the advantage that minority carrier storage effects (present in normal *pn* junction diodes) cannot take place. These limit the switching speed and hence rectification efficiency and are the main reason why *pn* diodes are not suitable for detection or mixing of microwave frequencies.

Thus Schottky diodes are finding application as microwave mixer diodes and have noise figures equal to the best point contact diodes. They are also

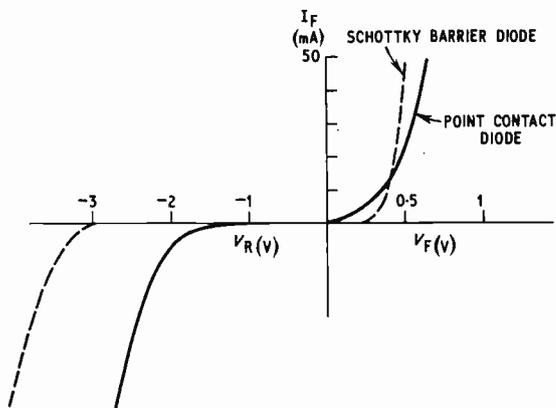


Fig. 8. Voltage/current characteristic of the Schottky barrier diode (dotted) compared with that of a point contact diode

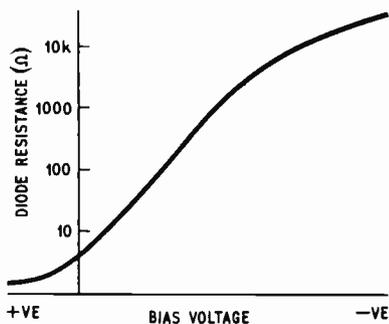


Fig. 9. Variable resistance characteristic of a pin diode

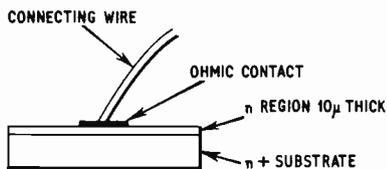


Fig. 10. Construction of a Gunn diode

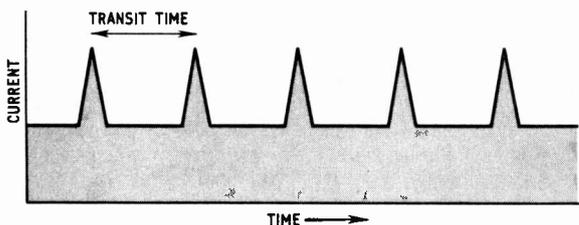


Fig. 11. Current/time waveform in a Gunn diode

mechanically more robust and have several other advantages so that in time they are likely to displace the long standing point contact microwave diode. The absence of minority carrier storage also makes the Schottky diode useful in high speed switching circuitry. The d.c. characteristics of silicon point contact and Schottky diodes are compared in Fig. 8.

THE PIN DIODE

Another new and very useful device is the *pin* diode. These consist of a *pn* silicon junction with a layer of intrinsic or high sensitivity silicon between the *p* and *n* regions. When forward biased the *pin* diode behaves as a resistance from d.c. to microwave frequencies. The value of the resistance depends on the forward current (see Fig. 9). Under reverse bias the resistance is very high.

Thus the *pin* diode may be used as an electrically variable resistance or attenuator. It uses at microwave frequencies are for switching and modulating microwave signals as well as an electrically variable attenuator. It can perform switching in a few nano-seconds and handle peak powers of hundreds of watts.

GUNN DIODE

The Gunn diode is one of the most important forms of a new family of microwave semiconductors which are used for directly generating microwave power from d.c. In view of their simplicity of operation and simple power supply requirements, Gunn diodes present an attractive alternative to the klystron valve.

The Gunn diode requires a power supply of a few volts d.c. which can be obtained from a battery as opposed to the reflex klystron which requires (typically) $-150V$ d.c. for the reflector, $+300V$ for the resonator, and $6.3V$ for the heater. At present Gunn diodes are rather expensive but already a Gunn diode transmitter with its battery can cost less than a klystron with its special power supply. Gunn diodes are available which can give up to $100mW$ of output power.

Gunn diodes are already being used in "mini-radar" systems for small boats, in burglar alarms, for counting, for measuring the speed of road traffic, and for many other applications where small size, simplicity of design and portability are important. Although simple in operation the mechanism of the Gunn diode requires some explanation.

The device is named after J. B. Gunn who discovered the phenomenon now called the "Gunn Effect" at the Watson Research Centre of I.B.M. in 1963.

GUNN DIODE CONSTRUCTION

Gunn diodes contain a tiny wafer of *n*-type gallium arsenide of thickness about $100\mu m$ mounted in a standard microwave diode encapsulation. The faces of the wafer constitute the two electrodes of the device, Fig. 10.

The wafer consists of a thin active layer of *n*-type gallium arsenide grown on a low resistivity substrate of the same material. The substrate is bonded to the anode terminal of the encapsulation and the other face of the wafer has an evaporated cathode contact connected by a bonded gold wire.

The Gunn diode has two terminals called the cathode and the anode. However, it is misleading to

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Once again we are able to make a special bargain offer of these very popular heating units. Tangential heaters although brought out a few years ago are still the latest and best type as nothing has yet been made which could be called an improvement on them. The tangential unit is still the only one used in good quality heaters made by Hoover, G.E.C. and all the famous names. The unit comprises quiet running a.c. induction motor with special bearings, the tangential impeller and a 2 section heater element which allows switching half and full heat in the case of the 2 kW and one-third—two-thirds and full heat in the case of the 3 kW. These heaters are also fitted with a safety cutout to cut the heaters should the impeller stop or the air with flow be impeded. They are free standing and need only the simplest of cases, even a wooden cabinet is suitable or the plinth of the kitchen cabinet. Lots of customers missed our special Summer offer of these heaters last year so order early. 200/240 V 2 kW model £2.50. 200/240 3 kW model £3.50. Control switch heaters only 25p or two-heat, cold-blow and off switch. Postage and insurance 35p on heaters.

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50V 1 1/2 A. Upright mounting with fixing brackets and metal shrouds to contain magnetic field, 50 c/s primary, tapped 100V, 117V, 210V, 230V and 250V. 2 secondaries, one 50V 1 1/2 A, other 6V 1A for pilot light, etc. £1.95, postage 30p.

THIS MONTH'S SNIP

LIGHT DIMMER



For any lamp up to 200W. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price £1.99 plus 20p post & ins.

CAPACITOR DISCHARGE CAR IGNITION

This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago. We can supply kit of parts for improved and even more efficient version, price £4.95 + 30p post. When ordering please state whether for positive or negative systems.

ELECTRONIC IGNITION

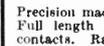
STANDARD WAFER SWITCHES



Standard size 1" wafer—silver-plated 5-amp contact, standard 1" spindle 2" long—with locking washer and nut.

No. of Poles	2	3	4	5	6	8	9	10	12
1 pole	40p	40p	40p	40p	40p	40p	40p	40p	40p
2 poles	40p	40p	40p	40p	40p	40p	40p	40p	40p
3 poles	40p	40p	40p	40p	70p	70p	70p	95p	95p
4 poles	40p	40p	40p	70p	70p	70p	70p	£1.20	£1.20
5 poles	40p	40p	70p	70p	95p	95p	95p	£1.45	£1.45
6 poles	40p	70p	70p	95p	95p	95p	95p	£1.70	£1.70
7 poles	70p	70p	70p	95p	£1.20	£1.20	£1.20	£1.95	£1.95
8 poles	70p	70p	70p	95p	£1.20	£1.20	£1.20	£2.20	£2.20
9 poles	70p	70p	95p	95p	£1.45	£1.45	£1.45	£2.45	£2.45
10 poles	70p	70p	95p	£1.20	£1.45	£1.45	£1.45	£2.70	£2.70
11 poles	70p	95p	95p	£1.20	£1.70	£1.70	£1.70	£2.95	£2.95
12 poles	70p	95p	95p	£1.20	£1.70	£1.70	£1.70	£3.20	£3.20

INSTRUMENT SWITCHES



Precision made with diecast indexing mechanism. Full length 1/2 in spindle 5A and silver plated contacts. Range except for 8 way is as standard wafer switches. Prices obviously higher. For 40p read 60p, for 70p read £1, for 95p read £1.40, for £1.20 read £1.80, for £1.45 read £2.20. Note also 2 way types available up to 36 poles, 3 way 30 poles, 4 way 24 poles, 5 way 19 poles, but 10 and 12 way only available up to 6 poles.

3 STAGE PERMEABILITY TUNER



This Tuner is a precision instrument made for the famous Radionobile Car Radio. It is a medium wave tuner (but set of longwave coils available as an extra if required with a frequency coverage 1620kHz-25kHz and intended to operate with an I.F. value of 470kHz. Extremely accurate. The two small dial enable switch on/off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only £2.50, less than the value of the clock alone—post and insurance 15p.

ELECTRIC CLOCK WITH 25 AMP SWITCH



Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dial enable switch on/off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only £2.50, less than the value of the clock alone—post and insurance 15p.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 x 13A sockets in metal box to take standard 13A fused plugs and on/off switch with neon warning light. Supplied complete with 7ft of heavy cable. Wired up ready to work. £2.25 less plug, £2.50 with fitted 13A plug; £2.65 with fitted 1 1/2 A plug plus 25p P. & I.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. Semiconductor add 5p post. Over £1 post free. S.A.E. with enquiries please.

MAINS OPERATED SOLENOIDS

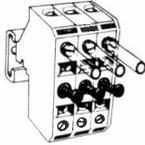


Model 778—small but powerful 1in pull—approx. size 1 1/2 x 1 1/2 x 1 1/2 in 60p.
Model 400/1 1in pull. Size 2 1/2 x 2 x 1 1/2 in 75p.
Model FT10 1 1/2 in pull. Size 3 1/2 x 2 1/2 x 2 1/2 in £1.80 plus 20p post and ins.

XEE 1/c, relays and most parts available. Send for list

MAINS CONNECTOR

A quick way to connect equipment to the mains safely and firmly—L, N, and E, coded to new colour scheme; disconnection by plugs prevents accidental switching on; has sockets which allow insertion of meter (without disconnection); cable inlets firmly hold one hair wire on up to four 7-029 cables. 85p each.



MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 18p.



WATERPROOF HEATING ELEMENT

26 yards length 70W. Self-regulating temperature control. 50p post free.

COMPUTER TAPE

2,400ft of the Best Magnetic Tape money can buy—users claim good results with Video and sound. 1in wide £1.45 plus 33p post and insurance, with cassette. 1/2 in wide £1.25 plus 30p post and insurance with cassette. 1in wide £1 plus 25p post and insurance with cassette. Spare spools and cassettes—1in 1 1/2, 1in 85p, 1/2 in 75p each plus 20p post and insurance.

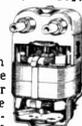


BALANCED ARMATURE UNITS

These capsules are 1/2 in dia. and 1/2 in thick. They will operate as a microphone or loudspeaker so can be used in intercom and similar circuits. 35p, 10 for £3.

MULTI-SPEED MOTOR

Replacement in many well-known food mixers. Six speeds are available 500, 850 and 1,100 r.p.m. from either or both of the nylon sockets (where the beaters of the food mixers normally go) and 8,000, 12,000 and 15,500 r.p.m. (ideal polishing speeds) from the main drive shaft. This drive shaft is 1/2 in dia. and approximately 1in long. A further point about this motor is that being 230/240V a.c.-d.c. series wound its speed may be further controlled with the use of our Thyristor controller. This is a very powerful and useful motor size approx. 2in dia. x 5in long, mains 230/240V. Price 85p plus postage and insurance. 12 or more post free.



MAINS OPERATED CONTACTOR

220/240V 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10A. Extremely well made by a German Electrical Company. Overall size 2 1/2 x 2 x 2in. £1 each.



QUICK CUPPA

Mini Immersion Heater, 350W, 200/240V. Boils full cup in about two minutes. Use any socket or lamp holder. Have at bedside for tea, baby's food, etc. £1.25, post and insurance 14p. 12V car model also available same price. Jug heater £1.50 plus p. & p. 14p.



TREASURE TRACER

Complete Kit (except wooden battens) to make the metal detector as described editorially in Practical Wireless, August issue. £2.50 plus 20p post and insurance.

A New Service to Readers. A bulletin bringing news of new lines, special snips and "too few to advertise" lines will be posted to subscribers during first week of each month. The bulletin will be called "Advance Advert News" and the Subscription is 60p per year. Subscribers will also receive our completed 1971 catalogue when this is published.

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think of it as a diode as it has no *pn* junction and cannot be used for rectification. When a few volts d.c. are applied to make the anode positive with respect to the cathode, the current which flows is d.c. with superimposed pulses as illustrated in Fig. 11.

In the case of a diode designed to work at 10GHz, the current pulses occur at 10^{-10} second intervals and can be used to induce oscillations in a cavity or waveguide resonator.

GUNN EFFECT

The Gunn effect is caused by high field regions called "domains" passing between the cathode and the anode. When the supply is connected a high field domain builds up at the cathode and drifts rapidly through the crystal to the anode. As the domain reaches the anode, a new domain forms at the cathode.

The transit time of the domains through the active layer determines the frequency of the pulses. The velocity of the domains has been measured experimentally and is known to be about 10^{11} $\mu\text{m/s}$ and so a frequency of 10GHz ($\lambda = 3\text{cm}$) is obtained with a $10\mu\text{m}$ thickness.

As is well known, in the energy band diagram for semiconductor materials the valence and conduction bands are separated by an energy gap called the "forbidden gap". Electrons can be excited from the valence band to the conduction band by the application of energy, for example by heating the crystal or by the addition of donor atoms. However, this well-known concept does not explain the Gunn effect.

To explain the effect we must look more closely at the conduction band. This can in fact be divided into two regions—the normal conduction band and a higher energy "satellite" band. In the satellite band the effective mass of the electrons is higher and their mobility lower than in the normal conduction band, Fig. 12.

In *n*-type gallium arsenide the majority of the conduction band electrons can be excited into the satellite band by the application of a field of about 350V/mm. As this critical field is reached the electrons in the crystal become heavier and slow down.

This reduction in average velocity results in a negative resistance characteristic. For this phenomenon to occur, the energy gap between the normal conduction and satellite bands must be considerably smaller than the forbidden gap between valence and conduction bands, otherwise the application of the critical field would result in the transfer of electrons across the forbidden gap, and an increase rather than a decrease in the average velocity would result. Only a few known materials, notably gallium arsenide and gallium phosphide, have a suitable band structure.

ELECTRON MOBILITY

In an ordinary conductor under normal conditions the electron velocity increases linearly with the applied field (Ohm's law). In *n*-type gallium arsenide, however, the average velocity increases at first linearly with the field, Fig. 13 A to B and then, as the critical field of 350V/mm is reached and electrons begin to move into the low mobility satellite band, the average velocity begins to fall (point B). Eventually, as the field continues to increase and all the available electrons have moved into the satellite band, the velocity increases linearly again (C to D).

Clearly the region BC is one of negative resistance. However, the result of applying such a bias field to the wafer is not the same as for conventional negative resistance devices.

In practice the wafer is biased in the negative differential resistance region above the threshold value of 350V/mm. Many of the electrons coming into the crystal at the cathode are excited to the lower mobility satellite band and slow down. The situation where two types of carrier exist simultaneously is unstable and the lighter electrons flow away leaving a concentration of heavy ones behind.

It follows that there is a local increase in the field since, in the negative resistance region BC, a fall in average velocity is associated with an increase in field. Moreover the effect is cumulative since an increase in the field causes a further decrease in average velocity.

Hence a high field E_H builds up at the cathode whereas the field throughout the rest of the crystal falls to a low value E_L . The high field domain (E_H) drifts rapidly across the wafer to the anode.

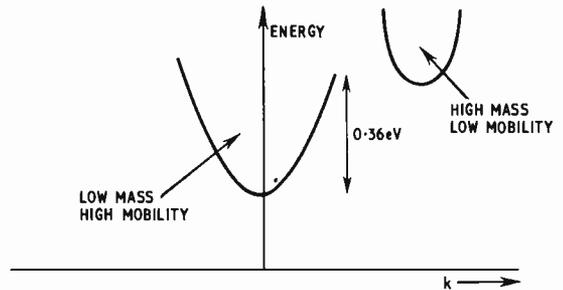


Fig. 12. Energy band diagram for gallium arsenide

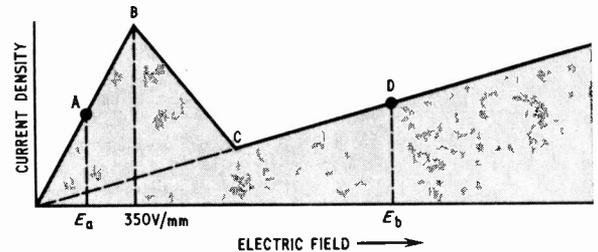


Fig. 13. Current density/electric field characteristic of an *n*-type gallium arsenide diode

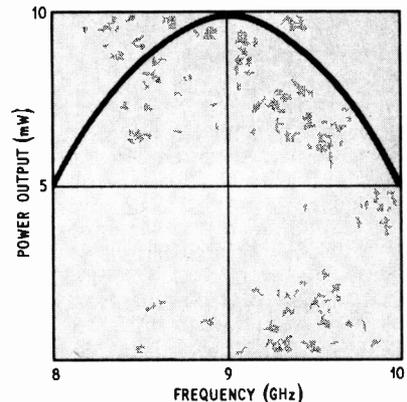


Fig. 14. Tuning characteristic for a Gunn oscillator

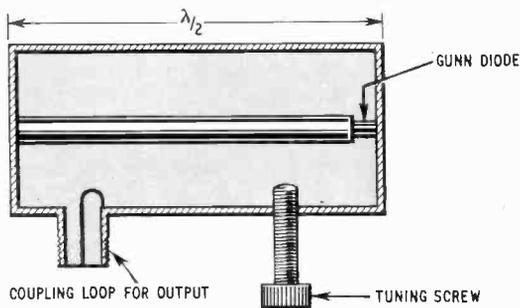


Fig. 15. Sectional view of a coaxial cavity Gunn oscillator

As the domain reaches the anode the bias supply again causes the field at the cathode to exceed the threshold of 350V/mm and a new domain is established. The action repeats continuously.

CHARACTERISTICS OF GUNN DIODES

From the above explanation of the Gunn Effect it is apparent that the frequency of oscillation depends on the thickness of the active layer of gallium arsenide (10 μ m at 10GHz). Whilst this is true, the device must be used in a cavity and the effect of the r.f. voltage in the cavity is to modify the transit time of the current pulses through the diode.

In practice it is found that a Gunn diode oscillator may be tuned up to one octave by tuning the cavity. Maximum power output occurs at or near the "normal" transit time frequency however (Fig. 14). Cavities may be constructed in either coaxial or waveguide form. A simple coaxial cavity is shown in Fig. 15.

By introducing a varactor diode into the cavity electronic tuning of the Gunn oscillator is possible up to a few per cent by varying the d.c. bias applied to the varactor. Such a combination of Gunn diode, cavity and varactor form a solid state equivalent of the klystron with the inherent advantages of modest power supply requirements and solid state reliability.

Gunn diodes are now commercially available from 4GHz to nearly 40GHz with power outputs from a few milliwatts to 100 milliwatts. Apart from being used in the traditional forms of microwave equipment the Gunn diode is already opening new fields of application for microwaves as mentioned above. Although the diodes are currently somewhat expensive for amateur construction projects the possibilities are many.

FUTURE FOR MICROWAVE SEMICONDUCTORS

So much innovation has occurred in this field during the last 10 years that it seems unlikely to be repeated in the 1970s. Although other new forms of device may be introduced there is bound to be an overriding trend to lower cost microwave semiconductors stimulating new microwave applications.

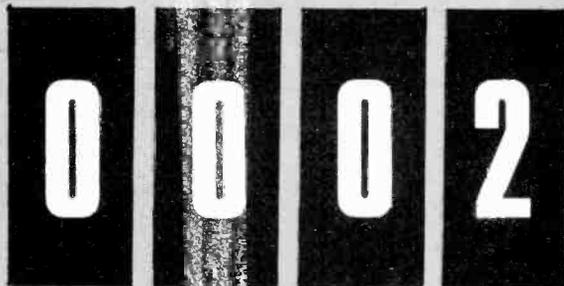
One way of producing cheaper microwave circuits is to eliminate the traditional "plumbing" required and substitute a thin film circuit. Transmission line components may be deposited onto a thin film substrate and microwave semiconductors bonded to this in chip form.

Already being introduced to professional systems, this technique is likely to have considerable impact in microwave applications in the years to come. ★

FOR SPORTS EVENTS
PHOTOGRAPHIC PROCESSING

MACHINE MEASUREMENT
BATCH COUNTING

Range 1/10 second to 16 minutes, or possibly 2 1/2 hours with a digital meter



●
TIMER
with **DIGITAL**
READOUT

THERE are many situations in both recreational pursuits and in engineering, where it is necessary to measure a time interval to one-tenth of a second without employing expensive and complex equipment. The suggested design in this article gives a direct digital reading with tenths of a second and keeps the cost to a reasonably small figure.

MEASUREMENT READOUT

In most digital timers, the designs are based on the accurate generation of a basic frequency; then, with suitable gating circuits, the counting of the number of cycles passed whilst the gate is open. The accuracy of these timers is therefore mainly dependent on the frequency generator.

Although some of the cost is determined by the frequency generator accuracy, the major proportion of the cost is usually involved in the readout system. An inexpensive digital readout device is the electromagnetic counter, several versions being readily available on the surplus market.

The use of this counter does place a limitation on the smallest measurable time interval and hence the number of decimal figures, since the maximum speed of operation is 10Hz. Accepting this limitation allows an inexpensive design based on a minimum time measurement of 0.1 second to be constructed.

Fig. 1 shows the system block diagram. A simple astable or multivibrator circuit generates a square wave of 10Hz. When the gate is opened this square wave supply drives the counter at the same speed. If the gate is held open for 10.8 seconds, the counter will have counted 10 units for each second, i.e. a reading of 108. Marking in the decimal point gives a direct readout of 10.8 seconds.

DRIVE CIRCUIT

The multivibrator circuit is given in Fig. 2. The transistors can be any germanium types such as OC71 or OC72. Potentiometer VR1 controls the frequency of oscillation, and the square wave generated may be taken from the collector of either TR1 or TR2.

Fig. 3 shows a suitable drive circuit for the counter. The additional relay is necessary since the majority of low voltage counters available on the surplus market take currents that are too high for the OC72.

If it is required to eliminate the additional counter battery and relay, then it is often possible to remove the counter coil and replace it with a more suitable coil taken from a Post Office 600 type relay, as was done in the prototype.

CALIBRATION

The unit should be calibrated with the multivibrator driving the counter, so that any loading presented by the relay/counter unit is accounted for. This may be achieved by comparing the collector voltage waveform with that of a signal generator, producing a signal of 10Hz, on a double beam oscilloscope, or a direct reading frequency meter.

An alternative method is to measure the time taken for the counter reading to change from, say 0 to 3,000 (which should take five minutes) with a stop watch. In this case an accuracy of at least 6 counts in 3,000, i.e. 0.2% or better should be obtainable.

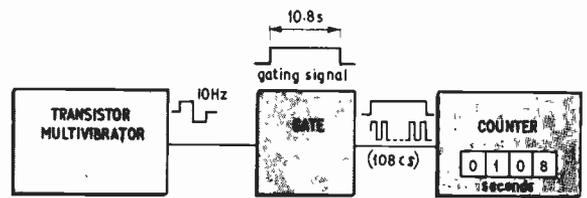


Fig. 1. Block diagram of the basic timing system

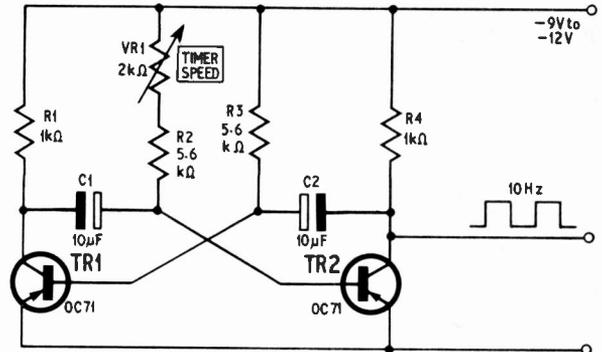


Fig. 2. Multivibrator oscillator used for providing clock pulses

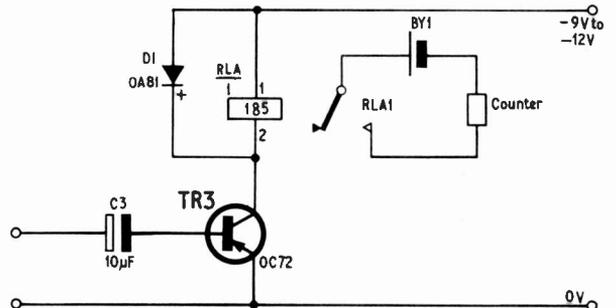
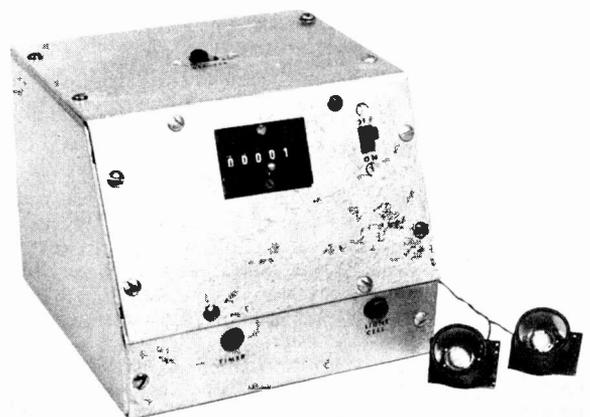


Fig. 3. Relay driver for operating the counter readout



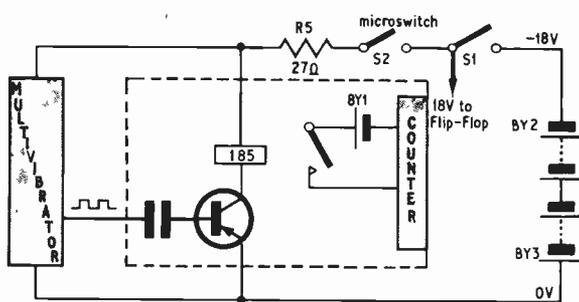
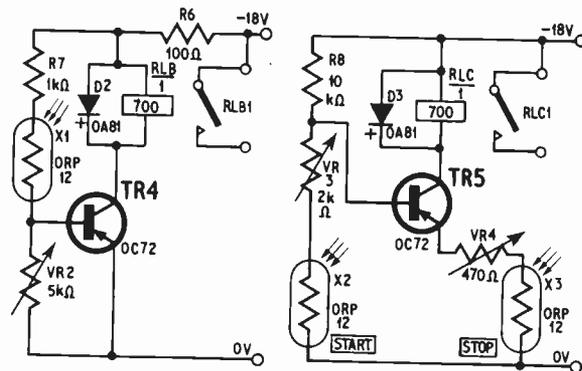
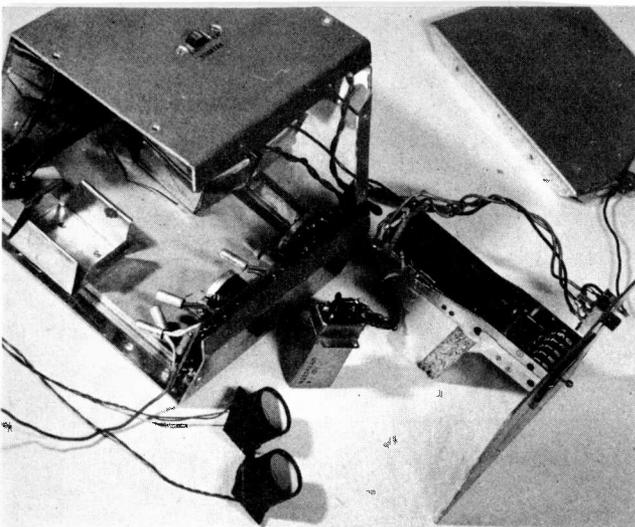


Fig. 4a. Multivibrator system using a microswitch to gate the clock pulses to the driver. The circuit for the multivibrator is in Fig. 2 and the relay driver in Fig. 3

COMPONENTS . . .

MULTIVIBRATOR AND RELAY DRIVER (Fig. 4a)

Resistors

- R1 1kΩ
- R2 5.6kΩ
- R3 5.6kΩ
- R4 1kΩ
- R5 27Ω
- All ± 10%, ¼W carbon

Potentiometer

- VR1 2kΩ linear preset spindle type

Capacitors

- C1, C2, C3 10μF elect. 15V (3 off)

Transistors

- TR1, TR2 OC71 (2 off)
- TR3 OC72

Diode

- D1 OA81

Relay

- RLA 185Ω, 6V operate

Batteries

- BY1 Battery to operate counter
- BY2, BY3 9V type PP9 (2 off)

Switches

- S1 Single pole on/off toggle switch
- S2 Single pole on/off microswitch

Miscellaneous

- Digital Counter (ex-G.P.O. telephone charge meter) (see text)
- Veroboard, 0.15in matrix, 12 copper strips by 38 holes for whole project

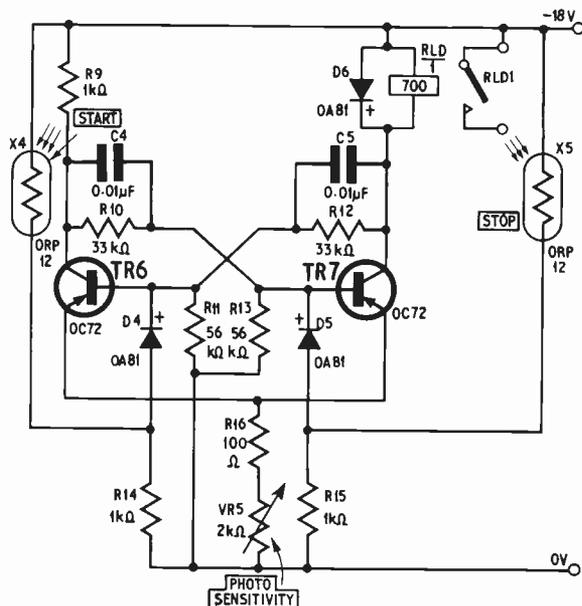


Fig. 4d. An improved stop start light sensitive circuit in the form of a flip-flop. Relay RLD1 is used in place of S2 in Fig. 4a

COMPONENTS . . .

LIGHT-SENSITIVE FLIP-FLOP (Fig. 4d)

Resistors

- R9 1kΩ
- R10 33kΩ
- R11 56kΩ
- R12 33kΩ
- R13 56kΩ
- R14 1kΩ
- R15 1kΩ
- R16 100Ω
- All ± 10%, ¼W carbon

Potentiometer

- VR5 2kΩ linear preset spindle type

Capacitors

- C4, C5 0.01μF

Transistors

- TR6, TR7 OC72 (2 off)

Diodes

- D4, D5, D6 OA81 (3 off)

Relay

- RLD 700Ω, 12V operate

Light sensitive cells

- X4, X5 ORP12 light dependent resistors 2 off)

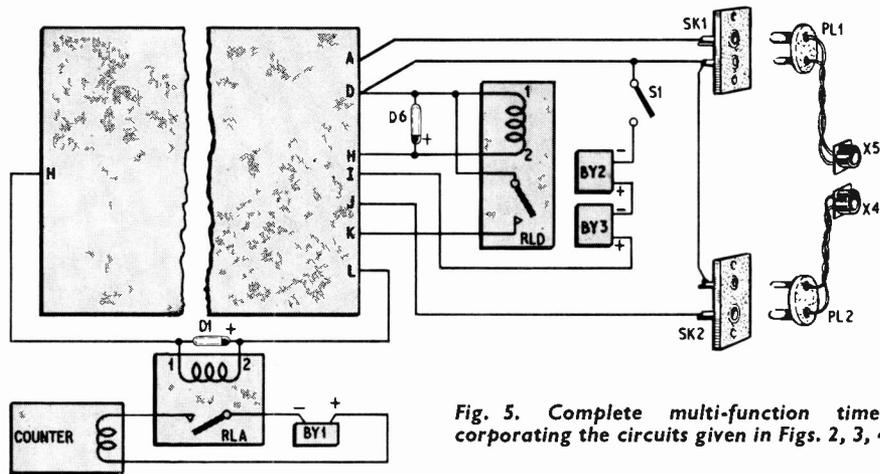


Fig. 5. Complete multi-function timer incorporating the circuits given in Figs. 2, 3, 4a, 4d

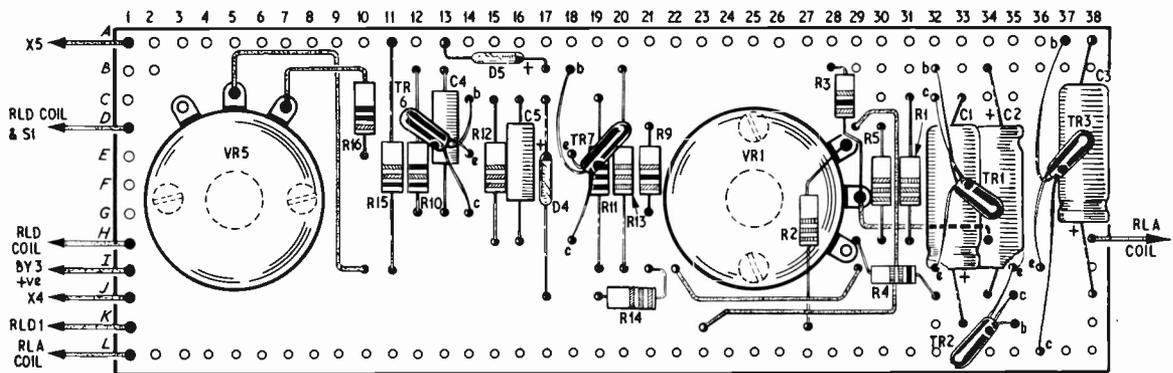


Fig. 6. Layout of components on Veroboard of system shown in Fig. 5. The copper strips must be cut at holes 25A, 25B, 25C, 24D, 25D, 25H, 24I, 25I, 25J, 25K

GATING CIRCUITS

To gate the unit, several methods are possible depending on the application of the timer. Basically, two alternatives are available: firstly, the d.c. supply line to the oscillator may be interrupted; secondly the output from the multi-vibrator may be interrupted. Both methods may have particular advantages, but in the prototype design the negative supply line was switched on and off by a relay.

Four possible gating methods are shown in Fig. 4. The first method (Fig. 4a) is the simplest, and is a single pole on/off switch such as a microswitch. This circuit could be employed for measuring the time taken for a moving object to pass a given point, so that the microswitch is held closed by the object. Alternatively, the switch could be held closed manually when the time for the object to pass between two points could be measured.

Fig. 4b indicates a photoresistor operated gate for a similar situation to that outlined above, the contacts on the relay replace the microswitch contacts. These methods could be used for sports events, photographic processing, machine speed measurement, batch counting and so on.

Fig. 4c shows a circuit whereby the passage of an object in front of the first cell X2 starts the timer, and the passage of an object in front of the second cell X3 stops the timer. This method was found to be satisfactory with the first model constructed, but the setting of VR3 and VR4 was found to be very critical.

Because of this, the more conventional bistable circuit (Fig. 4d) was adopted. Due to the additional transistor, diodes and other components, the circuit is more expensive, but the added reliability justifies its use in the majority of applications.

RESET CONTROL

An improvement may be to use a counter with a reset control, so that all the time reading will commence from zero readout. Unfortunately these units are much more costly, and some applications may not justify this additional expenditure. Resettable counters are obtainable but can cost a few pounds to buy. Further accuracy is possible by modifying the multivibrator to operate at 50Hz and to utilise a high speed counter.

CONSTRUCTION

A complete operational system using the basic system shown in Fig. 4a employs the following circuits for reliability, and the construction of the timer is based on these three: the multivibrator (Fig. 2); a gate unit (Fig. 4d); the drive unit (Fig. 3).

A Veroboard layout for this system is given in Fig. 6 and uses a board that has twelve copper strips each 38 holes long. The preset-potentiometers are fitted directly to the board, so that the only components not attached are the relays, with their associated diodes, the counter and miscellaneous

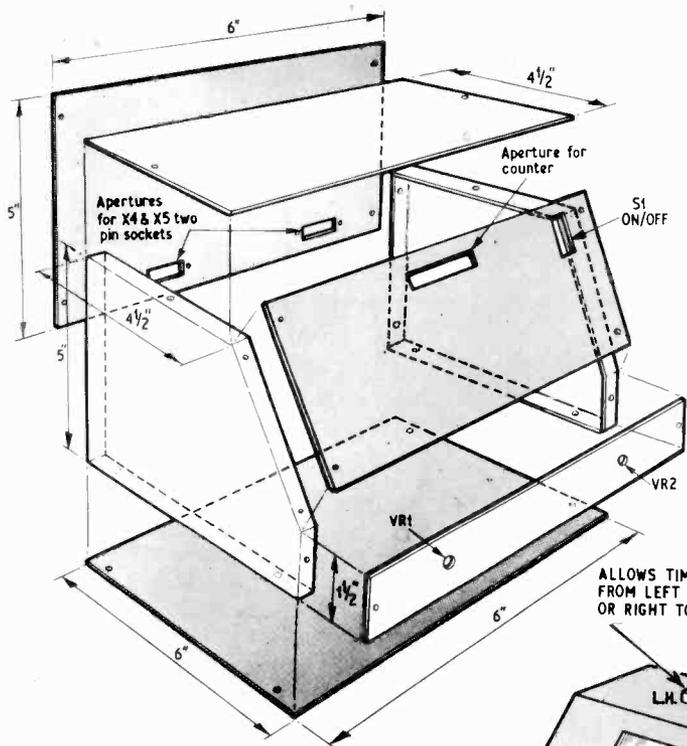


Fig. 7. Exploded view of the case showing drilling and assembly details

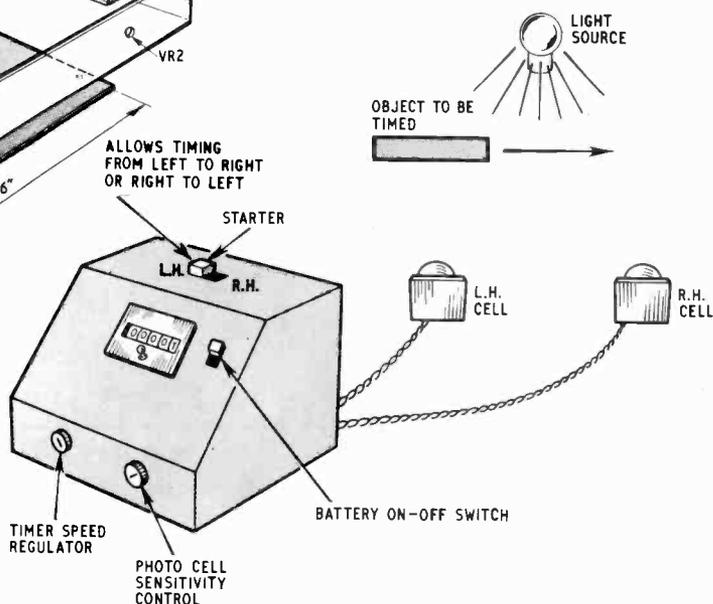
hardware such as switches, batteries, plugs and sockets. The use of "skeleton" or miniature potentiometers would enable a shorter length of Veroboard to be used.

The inter-unit wiring diagram is given in Fig. 5. This assumes that the counter requires the additional relay in the drive unit, and the extra battery. The counter used in the prototype had a coil which took only a few milliamperes, so that this directly replaced the relay RLA.

One suitable form of case (Fig. 7) is constructed from 18 s.w.g. or 20 s.w.g. aluminium sheet. Two end pieces are folded as indicated, and the flat top panel, rear, base, lower front and instrument panels fastened to the end pieces with self tapping screws. Alternatively, if bending proves too difficult, the end pieces may be cut from $\frac{3}{8}$ inch thick plywood, and the panels screwed to them.

A slide switch S1 is used to isolate the batteries when the timer is not in use. One refinement on the prototype was to use a two-pole, two-way slide switch in conjunction with the two cells, so that the triggering sequence of the cells could be reversed. For example, switch position 1: cell 1 starts the timer, cell 2 stops the timer; switch position 2 reverses the operation. See Fig. 8.

Fig. 8. Set-up of timer with two light sensitive cells for timing a moving object



LIGHT SENSORS

Each l.d.r. is soldered to a small piece of Veroboard. Light shields for these may be made from small cardboard tubes (such as is found for containing sweets) and glued to the cells, to keep out unwanted stray light. The leads are fitted with miniature two-pin plugs to fit the sockets on the rear panel of the case.

Penlight torches are used as light projectors for the cells, as they produce a narrow concentrated beam of light, and are easily fitted in the required positions with adhesive tape.

OPERATION

Connect the two photo-sensitive l.d.r.s into the sockets on the rear of the case. Place the cells in bright daylight or average (not brilliant) artificial lighting. Switch on the supply. With the "starter" switch selecting "L.H.", and the right-hand cell covered with the hand or a piece of card, the counter should stop. If it does not, adjust the sensitivity control until it does. This should now be set for normal operation. Normally, when the L.H. cell is covered the timer should start; when covering the R.H. cell it should stop. Moving the "starter" switch to R.H. will reverse the cell effects.



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2N1303	20p	BC119	35p
2N1304	25p	BC121	20p
2N1305	25p	BC135	20p
2N1306	25p	BC136	22p
2N1307	25p	BC137	25p
2N1308	25p	BC138	25p
2N1309	25p	BC147	17p
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2N2147	25p	BC154	37p
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2N2484	25p	BC179	27p
2N2646	60p	BC182L	12p
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2N2906A	25p	BCY31	30p
2N2907	25p	BCY32	30p
2N2926	10p	BCY33	25p
2N3011	25p	BCY34	30p
2N3055	20p	BCY38	40p
2N3054	50p	BCY39	85p
2N3055	75p	BCY40	50p
2N3252	10p	BCY58	25p
2N3702	10p	BCY70	15p
2N3703	10p	BCY71	20p
2N3704	15p	BCY72	15p
2N3705	15p	BCY78	30p
2N3707	15p	BCY79	30p
2N3709	10p	BCZ10	35p
2N3710	10p	BCZ11	35p
2N3819	35p	BD112	50p
2N3820	60p	BD121	65p
2N4058	15p	BD123	80p
2N4061	15p	BD124	75p
2N4547	35p	BD125	50p
2N4549	50p	BD131	75p
2N4550	50p	BD132	50p
2N4551	50p	BD133	62p
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40250	50p	BDY172L	50p
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AA437	10p	BF152	30p
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AC126	25p	BF158	30p
AC127	25p	BF160	30p
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AC176	25p	BF170	35p
AC187	30p	BF173	30p
AC188	30p	BF177	40p
ACY17	30p	BF178	25p
ACY18	25p	BF179	25p
ACY19	25p	BF180	35p
ACY20	20p	BF181	35p
ACY21	20p	BF182	30p
ACY22	16p	BF184	20p
ACY39	60p	BF185	20p
ACY40	15p	BF194	17p
AD140	50p	BF195	15p
AD149	50p	BF196	15p
AD161	37p	BF197	15p
AD162	37p	BF200	37p
AF114	25p	BF274	37p
AF116	25p	BFX13	25p
AF117	25p	BFX20	25p
AF118	62p	BFX37	35p
AF124	25p	BFX44	25p
AF125	20p	BFX85	35p
AF126	17p	BFX86	25p
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IN4002	100	8p	7p	8p	5p	4p
IN4003	200	10p	9p	7p	6p	5p
IN4004	400	10p	9p	8p	7p	6p
IN4005	600	12p	10p	9p	7p	6p
IN4006	800	12p	14p	12p	11p	9p
IN4007	1000	20p	16p	13p	12p	10p

1.5 AMP MINIATURE WIRE ENDED PLASTIC RECTIFIERS

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL4001	50	10p	8p	8p	7p	6p
PL4002	100	11p	10p	9p	8p	7p
PL4003	200	12p	11p	10p	9p	8p
PL4004	400	12p	11p	10p	9p	8p
PL4005	600	15p	13p	11p	10p	9p
PL4006	800	17p	15p	13p	12p	10p
PL4007	1000	20p	17p	16p	13p	11p

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TRIACS

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SC40C	400	6 amps	£1.25
SC45A	100	10 amps	£1.25
SC45B	200	10 amps	£1.35
SC45C	400	10 amps	£1.50
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SC50B	200	15 amps	£1.75
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BOOK REVIEWS

A DICTIONARY OF ELECTRONICS—Third Edition

Compiled by S. Handel

Published by Penguin Reference Books

413 pages, 6½in × 4½in. Price 45p

TO COMPILE a dictionary of any kind is no small task and of those currently available in the electronics field, this Penguin paperback gives by far the best value for money. To add to the data given above, there are 185 designated diagrams plus numerous "thumb-nail" drawings of circuit symbols against appropriate references. All the descriptions and diagrams are concise and easy to understand; cross-references are also given to related expressions in a distinctive type face.

Whilst Mr Handel readily admits in the Preface that omissions are inevitable due either to oversight or the need for avoiding over complication, one must give full credit for keeping up-to-date with such a useful work. Since the second edition was first published five years ago, a great many changes in electronics have brought to light several new entries.

On the subject of acronyms, many have had to be left out; the author feels that he needs a RED PENCIL—a Reliable Electronic Device for Printing Every Name Composed of Initial Letters.

M.A.C.

TEST YOUR KNOWLEDGE OF PHYSICAL ELECTRONICS

By T. Wilmore

88 pages. Price 80p

TEST YOUR KNOWLEDGE OF APPLIED ELECTRONICS

By R. W. J. Barker

92 pages. Price 80p

TEST YOUR KNOWLEDGE OF TELECOMMUNICATIONS

By L. Ibbotson

92 pages. Price 80p

Published by the Butterworth Group.

All 7½in × 4½in.

THREE titles in a series of revision texts designed to cover a first degree course in electrical engineering and HNC, HND and CEI examinations. The books are based on a series of question and answer tests which have appeared over a period of years in *Wireless World*.

The first in the series deals with electron physics and poses questions on electron dynamics, atomic theory and spectra, semiconductor physics electron emission and valves. It concludes with sections on gas discharge processes, devices and lasers and masers.

The second book, probably more pertinent for readers of this magazine, covers rectifiers and regulator diodes, load lines, small signal amplifiers, feed-

back, power amplifiers, oscillator, switching theory and waveshaping.

The final volume in Telecommunications includes principles, Fourier analysis, noise, two part networks, transmission lines, waveguides, radio propagation, aerials and modulation theory.

In each of the books the questions are set on each right hand page with the solutions overleaf. This certainly speeds the learning process.

Since most of the questions require calculations, to work through these texts will undoubtedly reinforce any weaknesses or knowledge of specific matter for examination purposes.

G.G.

INTEGRATED CIRCUIT SYSTEMS

By D. J. Walter, B.Sc.(Eng.), C.Eng.

Published by Iliffe Books (Butterworth Group)

228 pages, 9in × 6in. Price £3.50

FIRST of all let me qualify this title a little because first impressions might assume a complete dossier on all types of integrated circuit. The primary aim of the book is to assist students in the final stages of HND or degree courses in engineering and computer science. The emphasis is on logic systems using monolithic integrated circuits, although operational amplifiers and d-to-a and a-to-d converters are brought in at the end to relate the arithmetic logic to real time and on-line applications.

Having established these details it comes somewhat as a surprise to find Chapter 1 extolling the ins and outs of reliability assessment and statistical analysis of quality control procedures. Chapter 2 goes into manufacturing procedures, and it is not until page 59 that we start to come to terms with the theory and application of logic systems and Boolean algebra in relation to integrated circuits. This, as they say, is the meat, and the book progresses through flip flops and counting circuits to binary calculation, correction and coding in Chapter 5.

Armed with the information gained in these three chapters, the reader can then make an intelligent assessment of the advanced techniques using MOS (Chapter 6) which will undoubtedly figure more prominently in the near future.

Converters (mentioned previously) provide a means of assessing the characteristics of analogue or digital techniques and interrelating both of these to the task in hand.

Generally, this book has been carefully prepared and the author provides a great deal of useful material, assuming that the reader has some mathematical background experience.

M.A.C.

PRICES !!!

Due to recent Government purchase tax changes, all prices quoted in the magazine may be subject to alteration

RADIO ASTRONOMY TECHNIQUES

BY F.W.HYDE · PART 4

*Image of the Sun projected by an optical telescope.
First sunspots ever transmitted over BBC television*



THE first project that will be undertaken will be a Simple Full Power Radio Telescope for the study of Solar Radiation. This project has been chosen because it will be possible to record the sun quite satisfactorily with a minimum of apparatus. Furthermore, it will be possible to use the system for the amateur bands and for the observation of satellites. The design of the aerial system will also be applicable to a more advanced telescope in the form of a simple interferometer and later to the near professional set-up of a complete phase-switching system. All the apparatus of the simple full power telescope will be absorbed as the project advances.

NATURAL PROGRESSION

Those who undertake this programme will be going step by step from the simplest type of radio telescope to the most advanced form that can be attempted by the private enthusiast.

There is a considerable advantage in taking this course, because in moving from the simple to the complex a better understanding of the final results will emerge. It also means that each unit that is constructed or adapted will remain in the project. There will be no redundant parts. This perhaps will be most helpful to the younger group who may have to improvise more.

In the construction of the telescope only common or garden "bits" will be essential, but of course those who wish to put their mechanical engineering skill to work can do so provided the basic parameters are kept in mind. The aerial system can normally be of wood or angle iron, whether the latter be the wrought iron type or drilled constructional angle of which there are a number of proprietary makes. The life of an aerial system constructed of wire and rough sawn timber, even unpainted, is of the order of ten years. In fact the writer has one unit which is still in operation after twelve years.

Perhaps it would be right here to set out the objects of the Project and what is required to implement them.

THE PROJECT

The purpose of this project is the study of solar radiations at a frequency of 137MHz. Time of observations:

- (1) Sunrise to two hours after sunrise
- (2) Two hours before noon (G.M.T.) until two hours after noon
- (3) Two hours before sunset until sunset

Conditions of locality will determine whether the first and last items are practicable. It will add valuable data about the propagation of radio waves if these two periods of observation can be put into operation.

THE TELESCOPE

Aerial System

Ninety degrees Corner Reflector Steerable in azimuth and altitude, or fixed in azimuth but steerable in altitude.

Pre-Amplifier

Valve or transistor, gain preferably 16dB plus, noise level as low as possible, bandwidth about 5-10MHz.

Receiver

A standard communications receiver preceded by a convertor for the operating frequency. A two-position time constant circuit may be added.

Recording

For recording purposes a pen recorder and/or tape recorder will be required. The pen recorder should preferably have two speeds, one inch and three inches per hour. The tape recorder should have speeds sufficient to cover the period of observation and ideally this will be $\frac{1}{8}$ inches per second. If the recorder can accommodate large reels then $1\frac{7}{8}$ inches per second could be used.

Power Supply

The power supply should be stabilised. The preferred form would be a stabilised mains transformer. Some of these are still available on the surplus market. If this is not possible then a voltage stabilised power pack can be employed. Many of the communications units already have in-built stabilisation.

D.C. Amplifier

This will offer a higher sensitivity than the direct recording from the output of the receiving unit. Where the pen recorder is of a low current type then this will be an advantage. If the pen recorder is of the potentiometer type it will have an in-built amplifier.

DATA RECORDING

The manner in which data recordings are stored is most important. It may take the form of an album for the pen recordings or, alternatively, the whole record may be kept on the paper roll and a simple table with spindles used to scan the paper by rolling from one spindle to the other. The advantage of this is that later scrutiny may reveal other items of regular change which may be worth a special study. This is in fact how many new sources of radiation were discovered.

Cassettes are useful to store the tape recordings.

The log book should be arranged in columns so that it contains a record of the times of starting and finishing an observation. The background level of radiation at the start of the observation period and also at the end of the period should be noted. The maximum level that was recorded should also be included. Finally, a column for special remarks which should include a note of the weather conditions at the time of observations.

AUTOMATED OPERATIONS

It should be noted here that in radio astronomy it is not always necessary for the operator to be present. This is perhaps one of its advantages over optical astronomy. Provided certain precautions are taken anyone can be taught the simple methods of setting up and switching on the equipment and merely returning to check at the time the observation ends.

If no help like this is available then the whole operation can be automated so far as the start and stop times are concerned. A time clock arranged to cut in for a sufficiently adequate time for the

equipment to warm up and become stabilised, and then to cut out at the end of the observation time would work out quite well.

Such a procedure will result in a considerable saving in paper and tape, and in the general project that is being used to start the hobby, will not materially affect the results. The day to day variations of local conditions will be known since there will be a preliminary trial period of observation before starting the observations in earnest.

THE CORNER REFLECTOR AERIAL

The corner reflector has been chosen for two main reasons. Firstly, it has a front-to-back ratio which is superior to the ordinary dipole and reflector. Unwanted signals from the rear of the array are at a minimum and the best use of the forward gain can be made.

Setting the size for the lowest frequency that is to be used will allow for even greater efficiency when other projects involving higher frequencies are attempted—this is the second reason for the choice of this type of aerial.

REASON FOR HIGH GAIN

The corner reflector can be regarded as a development of the flat sheet in that it is folded so that single elements may be used for the same effective gain. An analysis of this aerial is not an easy task but some clue as to the reason for the high gain in such a simple aerial can be understood from the diagram in Fig. 4.1.

Angles other than 90 degrees may be used but each has certain individual characteristics. For example, had 60 deg. been chosen instead of 90 deg. there would have been a greater reduction in bandwidth for little advantage in forward gain.

If the diagram in Fig. 4.1 is studied it will be seen that there are three images of the dipole in addition to the dipole itself. The nett result of this configuration is to provide a forward gain of some 10dB over a single dipole. It can be viewed as though the images reinforce the real dipole and add to the gain.

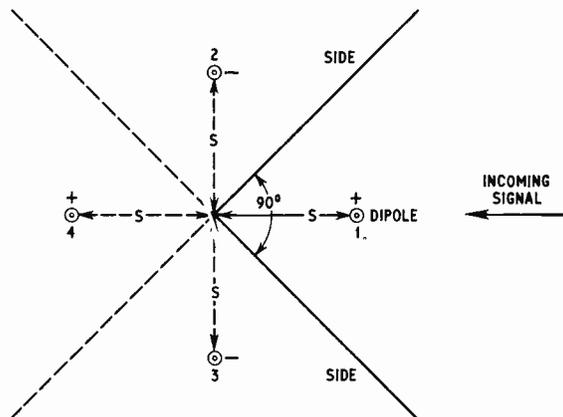


Fig. 4.1. The corner reflector aerial: an analysis diagram showing the reflections of the real dipole. If the reflector was not present the configuration would behave as though there were four separate dipoles. The presence of the reflector can be regarded as the means by which the gain is increased over a half-wave dipole in free space. The result is an increased gain in the forward direction

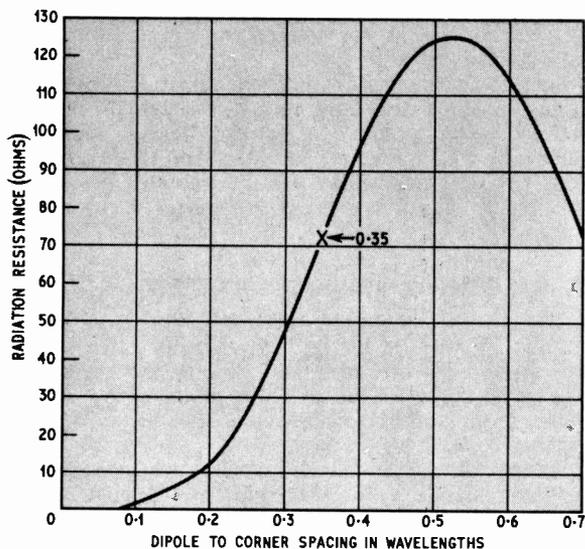


Fig. 4.2. Chart of terminal radiation resistance of a half wavelength dipole in relation to the distance of the dipole from the apex of a 90 degree corner reflector

It is possible to set up an extensive mathematical analysis of the corner reflector but no useful purpose would be served at this time by doing this. The empirical measurements which have been made of this type of aerial yield consistent results and these data will be used for the purpose of this design. The system is quite tolerant in that the gain over a reasonable variation of dimensions remains constant.

AERIAL IMPEDANCE

The chart in Fig. 4.2 shows the variation of the impedance of the dipole at various distances from the apex of the reflector. It will be seen that the optimum value is a spacing from the apex to the centre of 0.35 wavelengths for an impedance of 72 ohms.

If a single dipole is used then standard 75 ohm coaxial cable will be suitable for conveying the signals from the aerial to the receiving system.

PRACTICAL DIMENSIONS

Having chosen a frequency of 137MHz for the project the practical aerial will need to conform to the following dimensions.

The frequency of 137MHz is a wavelength of approximately 2.2 metres. This is about 7ft 2in. The length of the reflector according to the dimensions laid down in Part 1 should not be less than 1.5 wavelengths at the lowest frequency to be used. At the frequency chosen this will be 10ft 9in, but for convenience this can be rounded up to 11ft.

The width of the side of the reflector was given as not less than 0.7 of a wavelength. This works out at approximately 5ft, but as it would be beneficial to exceed this dimension this will be rounded up to 6ft.

With these dimensions it will be possible to use two half-wavelength dipoles in the reflector with the benefit of gain increase by a factor of 2.

AERIAL CONSTRUCTION

The diagrams in Fig. 4.3 show the constructional details for the aerial reflector assembly.

Work begins with the construction of the reflector. This consists of two frames each 11ft by 6ft, see "A". These should be finished with a coat of aluminium paint. Next the reflecting surface is added to each frame. This can consist of either wire mesh or single wires.

WIRE MESH REFLECTOR

If mesh is to be used, then it must be of good quality with a mesh size of not less than one inch. This refers to the normal twisted galvanised wire type. There is another popular type of welded mesh and this is better than the ordinary type previously mentioned. Both types of mesh do however, suffer from certain mechanical drawbacks. This particular type of reflector requires to be pulled very tightly up on the frames and it is doubtful if a really flat surface will be achieved with mesh. A certain amount of buckling is tolerable—say up to one and a half inches—however, it does not look very elegant though the performance of this aerial will not be impaired.

SINGLE WIRES

A more simple and easy method of making the reflector is to use single wires. This can result in a successful unit which is also of satisfying appearance. The single wires may be of standard insulated telephone wire or fencing wire (16 s.w.g.) which should be "half-hard" to hold tension.

The wires should be arranged in parallel rows at one inch spacing. They will run longitudinally and be secured at each end of the frame. If insulated wire is used then on the wooden frames ordinary staples should be used.

Starting at one end the wire is made off with two turns round the staple and a tail of 2 inches or so left, see inset diagram "A". The staple is then driven home tightly. The other end of the wire is dealt with in the same way after tensioning. The intermediate fixings are made with staples driven in far enough to hold the wire but leaving room for movement to take care of expansion and contraction.

If bare wire is used then it would be better to use insulated staples for the intermediate positions since movement in the wire in the supporting staples may give rise to unwanted noise in the aerial system.

CONNECTING THE TAILS

After a frame is completed the tails should be soldered so that there is a continuous connection between all elements of the reflector. It is not good enough to merely twist the ends together for there will be corrosion which could also add to noise in the aerial. The rule again here as with wiring connections is use *no flux other than resin*.

Fig. 4.3a shows how the two frames are bolted together. The accompanying photograph of one type of corner unit shows some of the details of construction. (The supports at the sides of the particular unit shown in this photograph will help to give some alternative ideas for use in cases where the aerial is to be fixed in azimuth.)

The reflector itself has side members bolted on, see "B". The centre strut serves to support the dipole units and also provide the suspension points for the reflector on the main frame support.

It will be necessary to check the centre of gravity of the completed unit so that it is balanced. This will ensure easy adjustment of position in altitude.

RADIO TELESCOPE CORNER REFLECTOR AERIAL Constructional Details

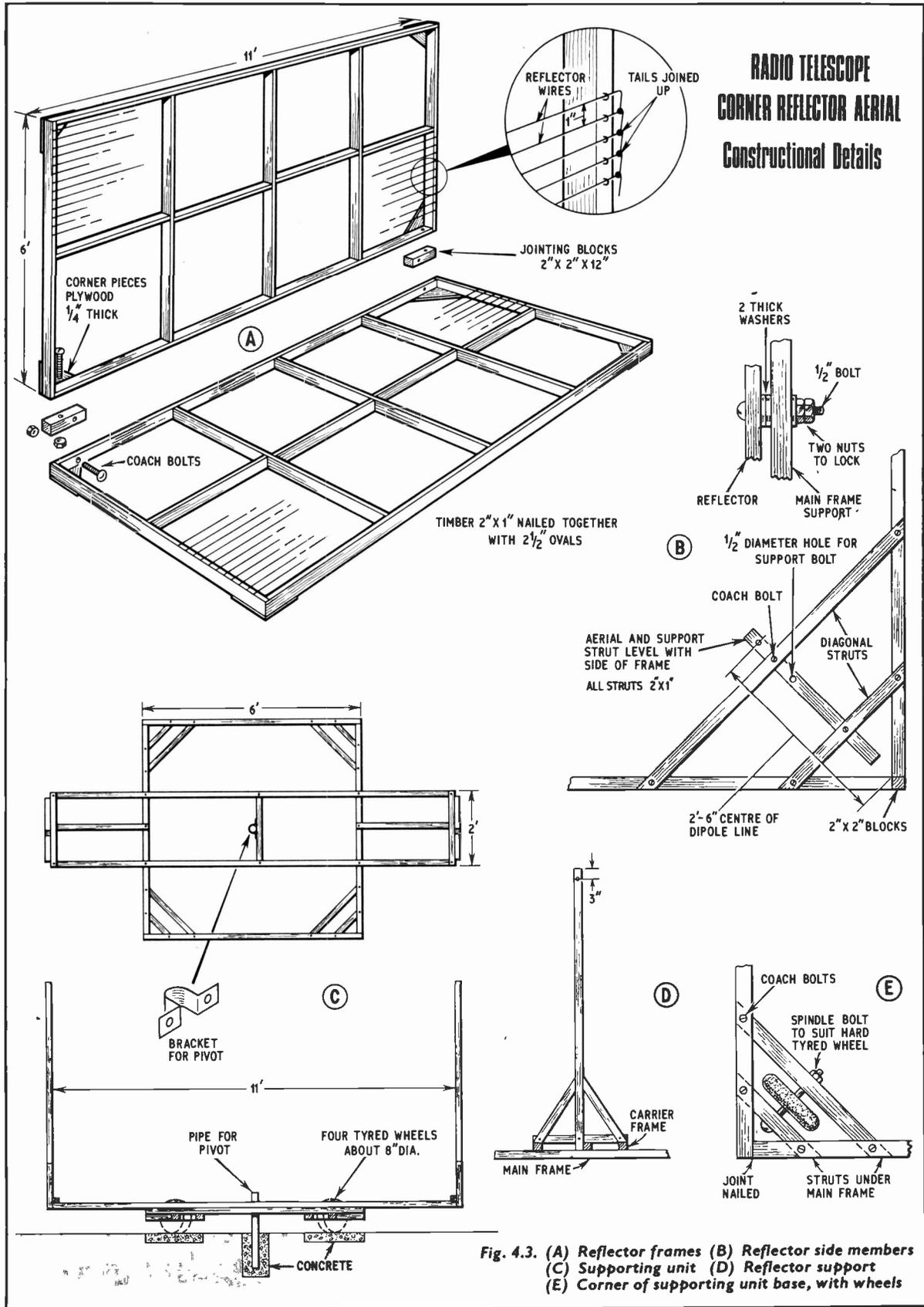


Fig. 4.3. (A) Reflector frames (B) Reflector side members (C) Supporting unit (D) Reflector support (E) Corner of supporting unit base, with wheels

SUPPORTING UNIT

The next task is to make the supporting unit which can be made in either of two forms—fixed or steerable. The basic construction is the same in both cases and is shown in "C". The material used is 2in by 2in timber and the assembly consists of a base and frame-support system. The base is made 6ft by 6ft with corner diagonal members which will serve as supports for the wheels (see "E") as well as providing rigidity for the base frame. If the unit is not to be steerable in azimuth then the wheels can be omitted.

On this base is mounted the aerial support system which is a sub-frame with vertical supports for the reflector, see "D". Again the material used is 2in by 2in timber. Detailed measurements are given in the diagrams.

For main assembly work coach bolts are used as far as possible since these will weather well, make for easy assembly, or if necessary allow easy dismantling for future modification.

If the aerial is to be steerable it is preferable that the wheels should run on a solid surface. Ideally this would be of concrete about 2in thick or, alternatively, concrete paving units could be used provided the base on which they are laid is carefully prepared, see "C". Cost-wise concrete would be the better choice.

If it is decided to make a permanent base and the project is to be carried through to the later developments of the interferometer where a second aerial unit will be required, then place the first unit on the east-to-west base line at one end of the line.

An alternative method of mounting the reflector, which again can be fixed or steerable, is shown in the photograph on page 467 (Part 1 of this series). This arrangement will provide scope for those who prefer to work in materials other than wood. The foundation for the steerable unit is much simpler than for the four wheel system of the first design, described above.

FOLDED DIPOLES

The frequency chosen will enable two dipoles to be used and in order to make the system as efficient as possible folded dipoles will be used. It was stated that the optimum distance from the apex would be 0.35 wavelengths and that this would give an impedance of 72 ohms. As two aerials are to be used

it will be better to make these folded dipoles to take advantage of the increase in impedance that these will provide. By doing this the system can be properly matched and balanced.

A dipole is naturally a balanced system, and the use of coaxial cable to make connections makes it unbalanced. It might be thought that because it is common practice to use coaxial cable for connection between the television aerial and the receiver, that this is also a satisfactory arrangement for radio astronomy. This is not so because the level of signal that is available for television is much greater than that which is received from extra terrestrial sources.

BALUN TRANSFORMER

It is however possible to use coaxial cable for part of the system. In order to do this a balance to unbalance transformer known as a "balun" is used to connect an unbalanced system to a balanced system and vice versa.

To connect the folded dipole to standard 75 ohm cable the "balun" shown in diagrammatic form in Fig. 4.4 will be used. This is a 4-1 step down in impedance and provides a balanced connection at the dipole. Details of the construction are given in Fig. 4.5. The centre core of the coaxial feeder is connected to a half-wave length of cable in a special way. The outer braid of the cable ends are all connected together as closely as possible.

The inner of the main cable and inner of the nearest end of the half-wave section are connected together and to one side of the dipole. The inner of the other end of the half-way section is connected to the other side of the dipole. No connection is required to the outer of the coaxial cable at the dipole end of the system. The other end of the main coaxial lead matches the unbalanced termination at 75 ohms.

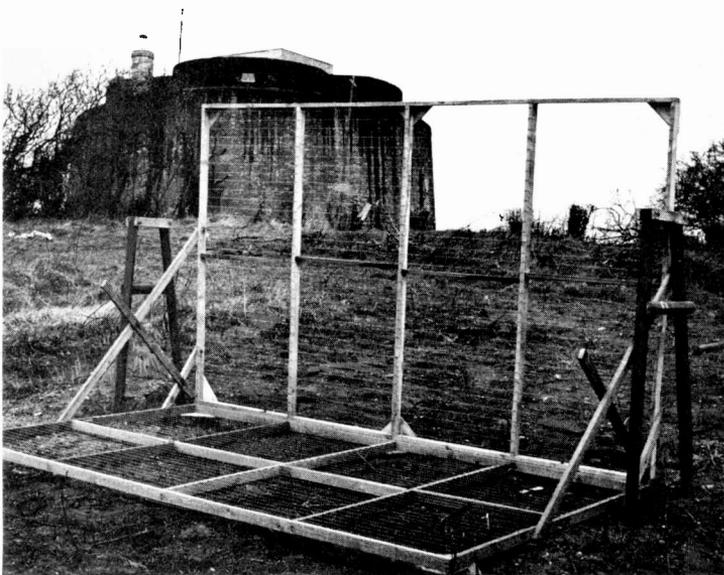
CONNECTING THE DIPOLES

The dipoles can be either of the following types.

They can be made up from copper wire of about 14 s.w.g. The wire should be hard drawn copper, or cadmium copper. This is necessary because there will be considerable strain on the dipoles if they are to remain in the focal line of the reflector without sagging.

Alternatively, the standard commercial folded dipole as used for television can be employed. In this case the dipole can be supported by an aluminium tube of about 0.5in diameter, from the apex of the reflector.

The "balun" on each dipole and the coaxial lead should go straight to the apex of the reflector and the lead taken through without touching the wires of the reflector screen. The free ends of the two cables will be matched to the 50 ohm quarter-wave section which will, in turn, be plugged into the preamplifier. See Fig. 4.6.



A corner reflector aerial built by the author. Note that the side supports are of a different style to those in the described design

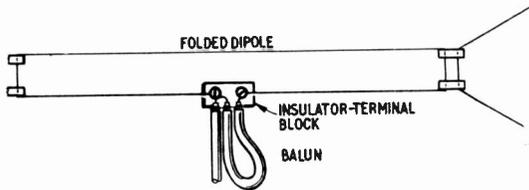
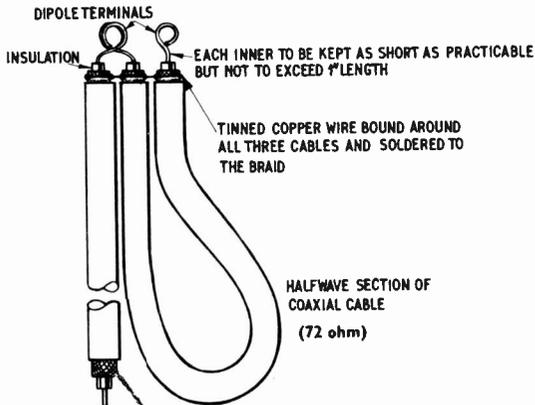


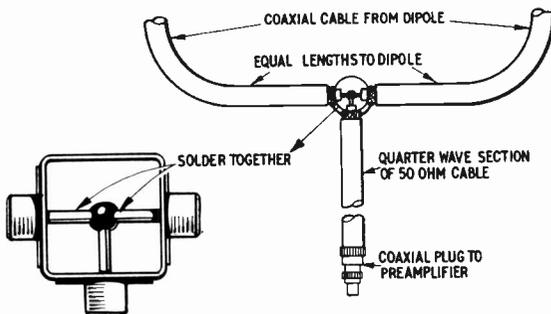
Fig. 4.4. A balance to unbalance transformer or "balun" connected to a dipole



NOTE: The length of the halfwave section will depend on the type of cable insulation :

$$\begin{aligned} \text{Solid polythene} &= \frac{\text{wavelength} \times 0.65}{2} \\ \text{Cellular polythene} &= \frac{\text{wavelength} \times 0.86}{2} \\ \text{Air-spaced} &= \frac{\text{wavelength} \times 0.9}{2} \end{aligned}$$

Fig. 4.5. Constructional details of the balun



CONNECTING BOX SUFFICIENTLY SMALL TO ALLOW COAXIAL SOCKET TAILS TO MEET

Fig. 4.6. Connector of two dipoles to the 50 ohm cable

If wire dipoles are used then a wood support reaching nearly to the dipoles will help to support the balun and cable. The dipoles themselves are supported in the reflector framework between the diagonal struts by means of nylon cords. The assembly of the two dipoles is shown in Fig. 4.7.

If the commercial type of dipole is used then balun and cable can be taped to the tube support.

ASTRONOMICAL TERMS

During this article the terms azimuth and altitude have been used. Though no doubt many will be familiar with these terms it may be of interest to give a short summary of the use of them. They are the coordinates by which the position of a celestial object may be indicated. A diagram of the system is shown in Fig. 4.8.

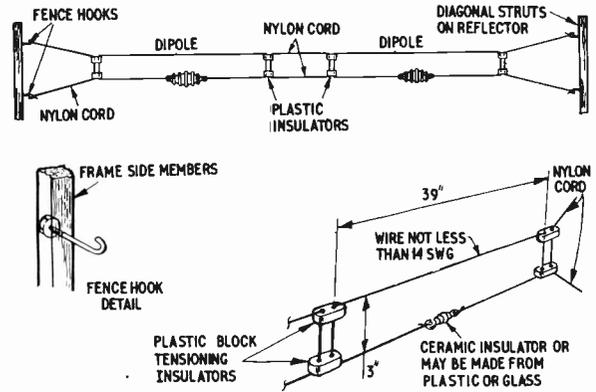


Fig. 4.7. Details of the dipole assembly and mounting

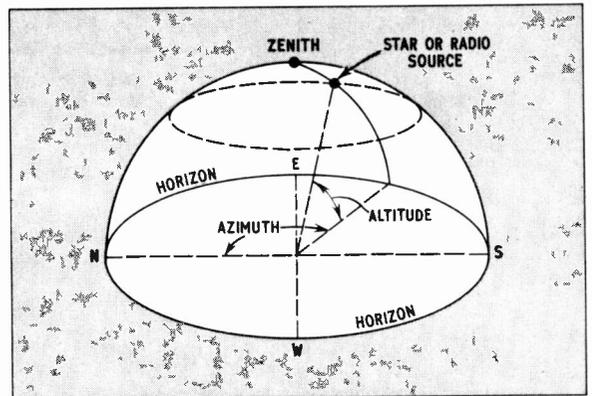


Fig. 4.8. Illustrating the meaning of the terms Azimuth and Altitude

AZIMUTH

This is the distance measured on a horizontal circle which coincides with the visible horizon. It is measured usually from North in degrees through East (90°), South (180°), West (270°), thence up to North again (360°). The logging of a position, for example, would read "Azimuth 202°."

ALTITUDE

This is the distance from the horizon up to the position of the object observed. The greatest altitude is 90° therefore the logging in this case might be "Altitude 52°". This greatest altitude is called the Zenith.

The altazimuth system is known as the Horizon System of Coordinates. It is used where the aerial system in radioastronomy is steerable in these terms and the position so obtained is translated into other celestial coordinates such as equatorial or galactic. Where large radio telescopes are involved it is usual to have direct computerised conversion of altazimuth to the other system of equatorial coordinates, in order that the telescope is kept continuously pointing to the correct position.

Altazimuth coordinates are used mostly for the location of artificial satellites where it is necessary to follow their path.

Next month: The receiver set-up and recording methods will be described, and some elementary Solar Astronomy will be discussed.



PART TWO

SEISMOGRAPH

BY D. BOLLEN

An instrument for the detection and graphing of earth tremors

THIS month constructional details for a 1Hz vertical seismograph are given together with installation and operating instructions.

A 1HZ VERTICAL SEISMOMETER

The spring pendulum seismometer of Fig. 9 is based on a welded mild steel frame. It might be possible to persuade a garage proprietor to weld the frame and also tap threaded holes in the baseplate, but if not, the frame could be built of well seasoned oak. Compared with many other seismometers, the spring pendulum type is one of the easiest to set up and operate.

Any old spring will not do for the seismometer as it must be near zero length. If the turns of a zero length spring were without thickness it would shrink to nothing when untensioned. Of course, an actual spring will only contract to the position where the wire turns touch. Some springs can have a theoretical negative length, depending on how they are wound.

To determine the spring length, tension it with various weights, measure the extension given by each weight, and then plot weight against extension on a graph. When the resulting straight line is projected it should pass through, or close to, the zero co-ordinates.

A spring of the dimensions specified in Fig. 9 can be obtained from most large ironmongers, but it is advised that several should be purchased so that one may be selected which has a zero or negative length.

A negative length spring can be converted to zero length by altering the spring adjuster.

Magnets for the transducer are taken from dismantled loudspeakers. The small bar magnet taped to the seismometer boom, above the calibrating coil, will impart a small force to the boom when the calibrating coil is energised by a 1Hz sine wave input. Approximately 1 millivolt r.m.s. in the coil will produce a zero-peak deflection of 50 nanometers.

The thin leads from the transducer coils are threaded through the hollow boom, and can be terminated by soldering them to a tag strip mounted on the upright section of the frame. Coil the transducer wires so that they do not interfere with the free movement of the seismometer boom.

To make up the seismometer mass, obtain a length of 2in inside diameter cardboard tube and glue this to a cardboard base. Insert and glue in position a dowel of the same diameter as the boom tube, then melt down 2lb of lead and pour this into the mould.

WINDING TRANSDUCER AND CALIBRATING COILS

A bobbin for the transducer coil, shown in Fig. 10, is made up from two 2½in square thin sheets of s.r.b.p., and a 1in × 1in × ¼in plywood former. Make sure that the corners of the former are rounded off, and edges smoothed, before glueing on the s.r.b.p. sides.

Drill a hole in the centre of the bobbin for mounting on a mandril in the chuck of a hand drill. With a sharp spike, make a hole in one s.r.b.p. side to admit L1 start lead. Solder some thin red insulated wire to the 40 s.w.g. enamelled wire and push through the spiked hole. Secure and insulate the joint with a layer of plastics insulating tape.

Wind on 2,000 turns of 40 s.w.g. wire for L1 then make another spiked hole and terminate this winding with a short length of green insulated wire. Insert the wire through the hole and insulate and secure with plastics tape.

A similar procedure is followed for the L2 winding, except that this consists of 500 turns of 40 s.w.g. wire, and has a blue start lead and a green finish lead. Finally, use more plastics tape to protect the windings and transducer bobbin.

A piece of s.r.b.p. or gummed paper tube is glued to one edge of the transducer bobbin to make a push fit mount on the end of the seismometer boom. A hole is drilled to admit the transducer leads.

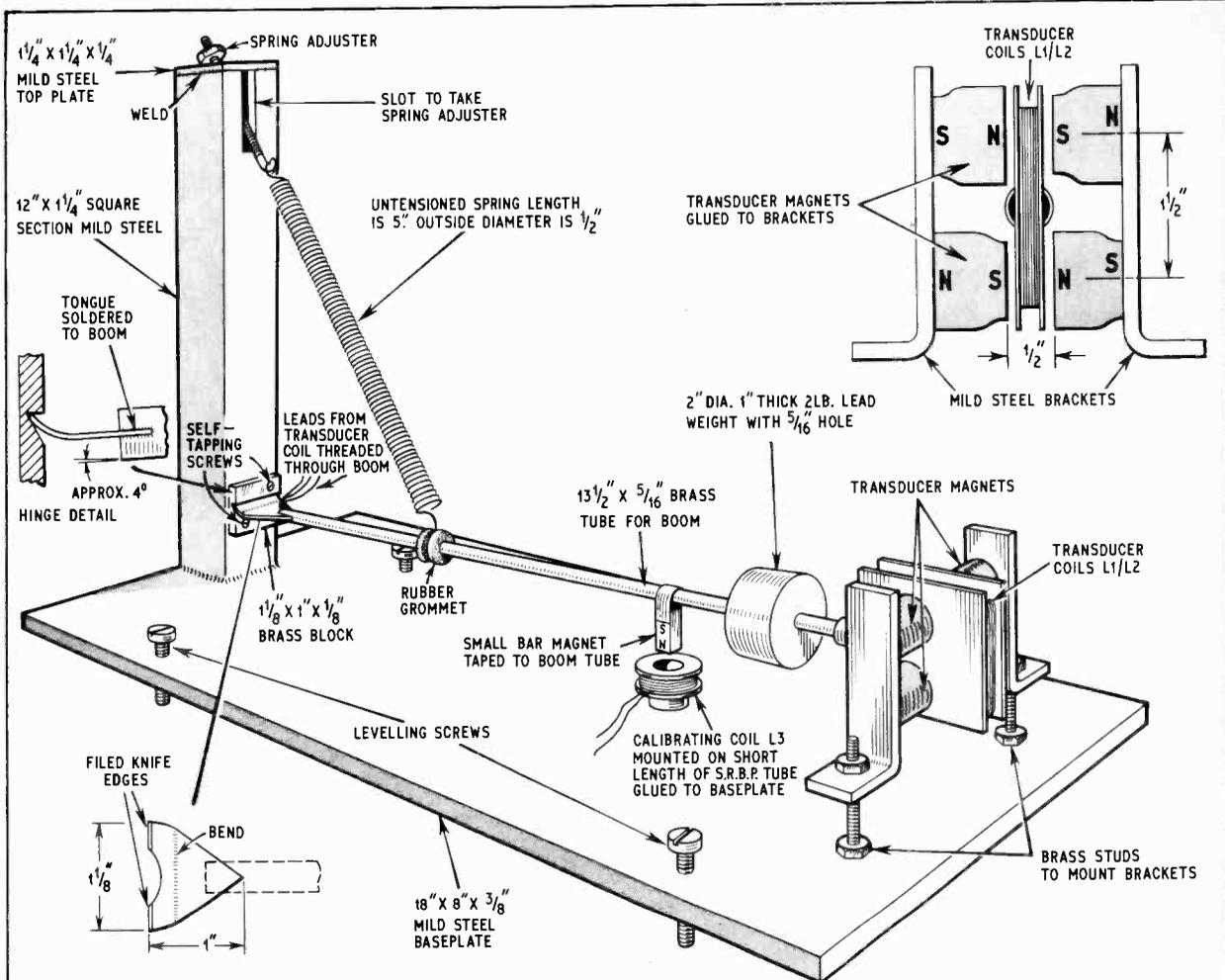


Fig. 9. Constructional details of 1Hz vertical seismometer

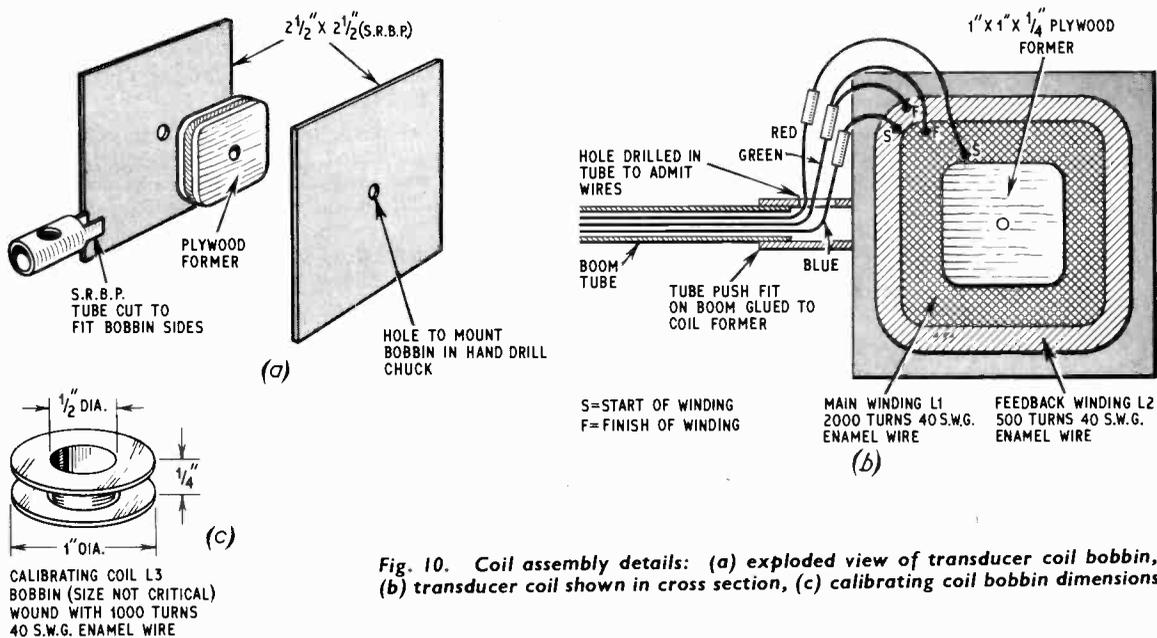
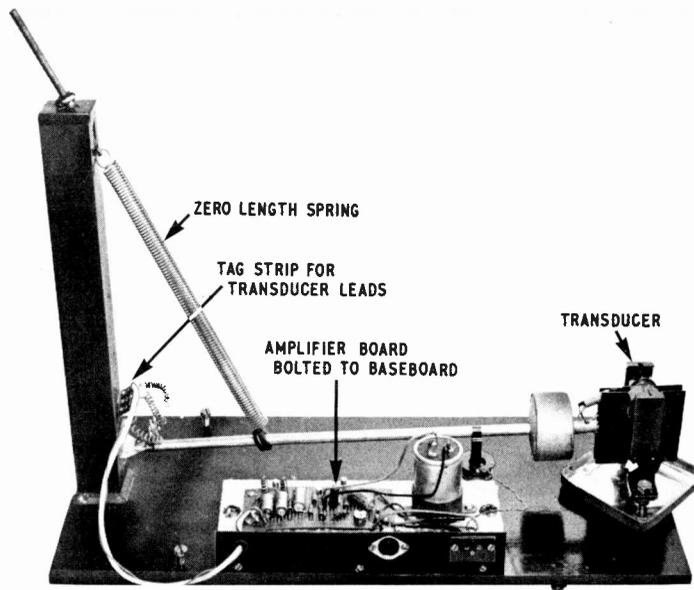


Fig. 10. Coil assembly details: (a) exploded view of transducer coil bobbin, (b) transducer coil shown in cross section, (c) calibrating coil bobbin dimensions



The calibrating coil dimensions are not critical, and the small bar magnet does not have to enter the hole in the centre of the calibrating coil. An LA5 pot core bobbin, or a former of approximately the same shape and size, can be wound with approximately 1,000 turns of 40 s.w.g. enamelled wire to make the transducer coil L3.

CONSTRUCTING THE SEISMOMETER AMPLIFIER

For the seismometer amplifier, prepare a piece of 0.1in matrix Veroboard 19 holes wide by 43 holes long, with copper strips running parallel to the longest side. Drill holes to take panel mounting screws, enlarge the holes for VR1 tabs, and make breaks in the copper strips, see caption Fig. 11.

Insert and solder all terminal pins and proceed with mounting all components, except R2. Take particular care not to overheat transistors TR1 and TR2.

TESTING

To test the seismometer amplifier module for wiring or component faults, solder a 470 ohm resistor temporarily across the terminal pins to which the red and green leads from the transducer coil will later be attached.

Connect the orange and black leads to the module panel as in Fig. 11, and ignore the remaining terminal pins.

Wire the orange lead to the positive terminal of a 12V battery, and the black lead to the negative terminal.

Check the potential between the collector and emitter of TR1 using a 20 kilohm/volt meter. If significantly lower than 0.9V, disconnect the battery and add resistor R2; this should increase the TR1 collector emitter voltage to near the required value. If necessary experiment with the value of R2.

Where the TR1 voltage is found to be much higher than 0.9V, when R2 is absent, the transistor may be faulty.

Now check the voltage between the collector of TR2 and the negative battery terminal. Any serious departure from five volts will probably indicate either a faulty transistor, a wiring error, or abnormally high leakage in C3.

PEN AMPLIFIER CONSTRUCTION AND TESTING

The pen amplifier module is based on a 0.1in matrix Veroboard 19 holes wide by 57 holes long, with copper strips running parallel to the longest side. Drill holes to take the panel mounting screws,

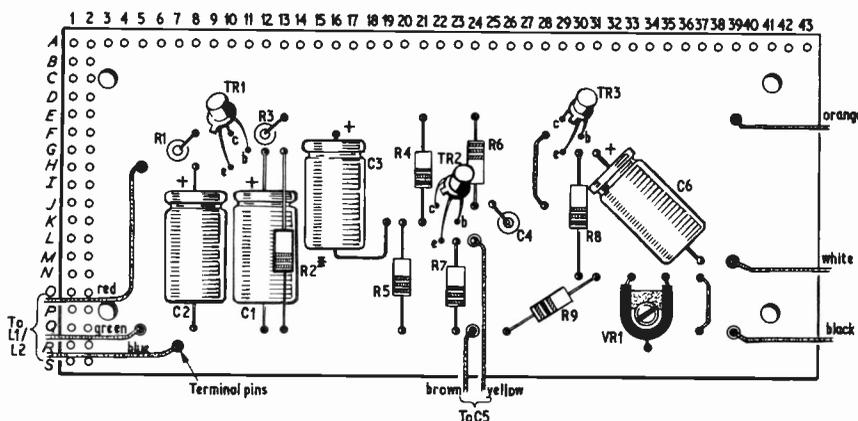


Fig. 11. Assembly and wiring details of seismometer amplifier. Cut copper strips at the following: B4; B40; C4; C40; D4; D40; F18; G14; H14; N34; O5; O40; P5; P40; R5; R40

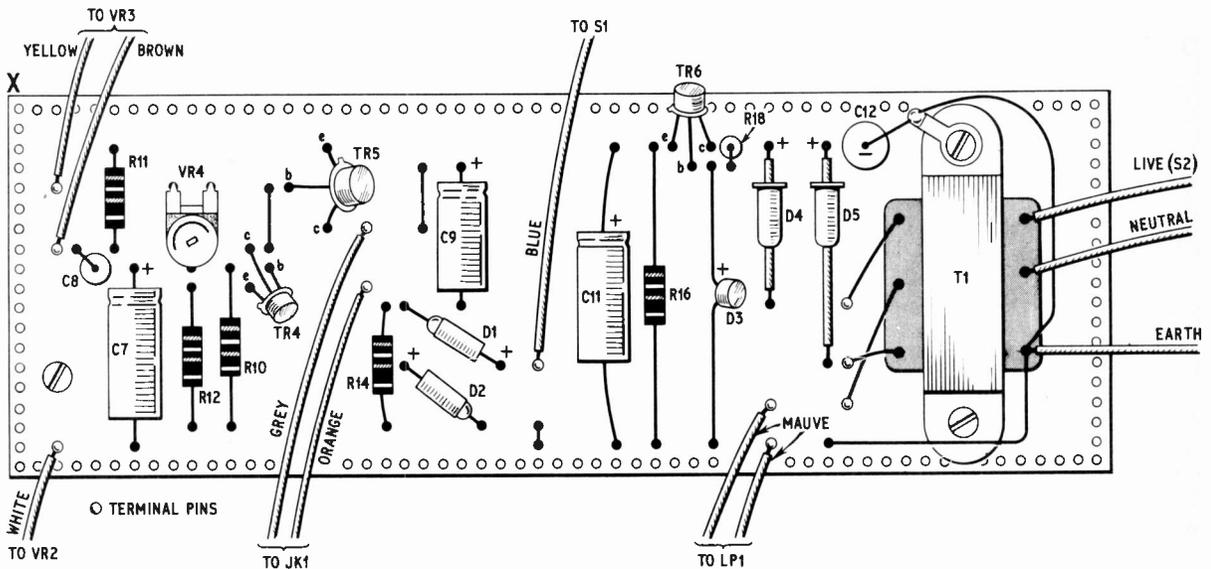


Fig. 12. Assembly and wiring details of pen amplifier. Cut copper strip at following holes: B48; C36; C48; D27; D48; E10; E11; E48; K27; M6; N6; N30; O6; O48; P6; P48; Q48; R9; R48

the miniature mains transformer mounting screws, and enlarge holes for VR4 tabs.

Make breaks in the copper strips as listed in the caption of Fig. 12, and insert all terminal pins before wiring up other components.

Make a preliminary check on the pen amplifier module as follows. Temporarily wire a six volt, 60mA bulb across the terminal pins identified by mauve leads in Fig. 12. Connect a mains lead to the appropriate pins on the miniature mains transformer T1.

Solder a one kilohm resistor across the grey and orange lead terminal pins, and connect a shorting link across the brown and yellow lead terminal pins.

When the mains input to T1 is switched on, look for a dull red glow from the lamp LP1. With the testmeter, check that the voltage across C11 is between 11V and 12V.

Apply the positive voltmeter lead to the grey wire terminal pin, and the negative lead to module earth. Adjust VR4 for a reading of around 6V.

If it is impossible to obtain a reading of 6V, there may be a wiring fault, or something wrong with TR4 or TR5.

INSTALLING THE SEISMOMETER AMPLIFIER

Although insensitive to slow changes of ambient temperature, the seismometer amplifier should be screened against thermal variations which lie within the frequency range of the seismograph, otherwise there will be an addition to the apparent overall noise level. Draughts can similarly produce spurious noise.

Thermal screening is achieved by placing the amplifier module inside a draught proof box which is lined with expanded polystyrene. In Fig. 13, board mounting and interwiring details are shown. Here the aluminium base plate provides a support for the polystyrene lined s.r.b.p. cover. Only the socket panel is shown. SK1 and SK2 are mounted by means of an 8in x 1½in s.r.b.p. panel attached to the side of the 8in x 3in x 1½in aluminium chassis.

A layer of expanded polystyrene is interposed between the top of the chassis, and the amplifier module and C5, to minimise thermal gradients. Leads from the seismometer transducer are taken through a grommet in the s.r.b.p. panel, to appropriate terminal pins on the module panel.

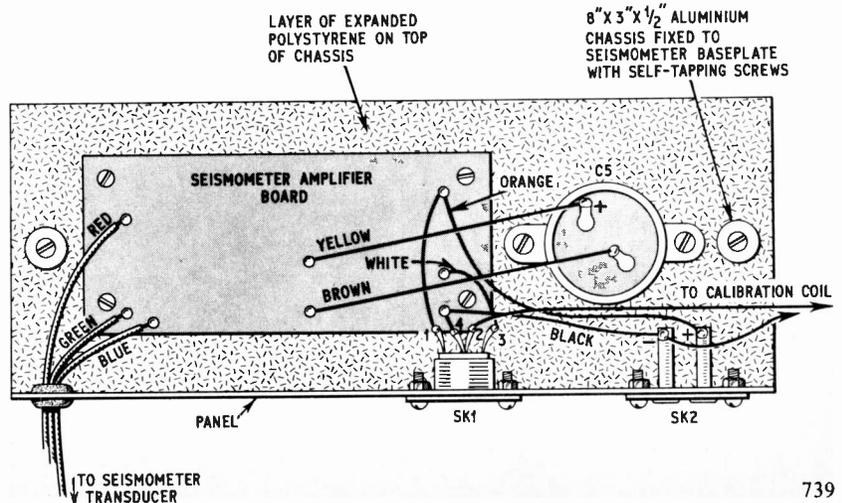
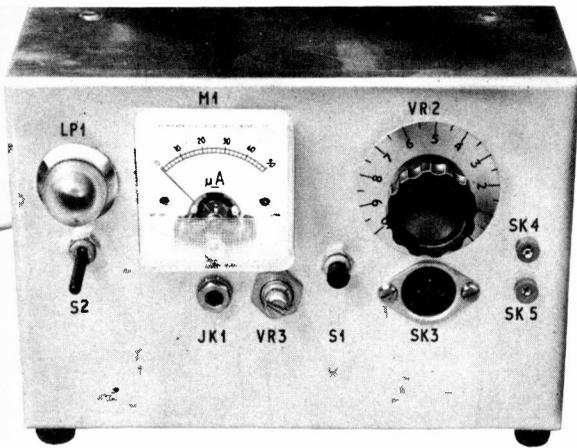


Fig. 13. Seismometer amplifier unit. After assembling the unit should be enclosed in hardboard lined with polythene to exclude draughts, and short term temperature changes



There is sufficient room on the baseplate of the seismometer to accommodate the complete seismometer amplifier and batteries on either side of the boom. The amplifier unit chassis can be fixed with two self-tapping screws. If desired, a battery box can be made up for BY1 and BY2.

CONTROL UNIT CONSTRUCTION

A 6in × 4in × 2½in aluminium chassis placed on its side will serve as a box for the control unit components, and can house the pen amplifier module.

After drilling the box front to take those components shown in Fig. 14, drill holes in the sides of the box to accept the pen amplifier module mounting screws, and mains lead grommet. Install all controls, sockets, and the amplifier module, then proceed with wiring up as shown.

CONSTRUCTING A DISC RECORDER

A prototype disc recorder which incorporates a bell warning circuit and a pen vibrator is shown in Figs. 15a and b. Disc recorder layout will depend on the types of turn-table motor used and on additional facilities.

A start can be made by selecting a suitable motor for one revolution per 24 hour operation. It is essential to have a slipping clutch drive of the type found in mechanisms taken from alarm clocks, electric wall clocks, or time switches.

Most time switches have a spindle with a threaded hole which can be easily adapted to take a turntable, but in the case of a converted clock, a threaded bush must be soldered to the hour hand cog as in Fig. 16a. If difficulty is experienced in making a suitable turntable and fixing it to the motor, try using an old gramophone turntable with a friction drive on the rim; this will also allow a bigger paper disc to be employed, and will give greater trace detail.

Mount the turntable assembly on a baseboard made of plywood or thick s.r.b.p., with space to spare for the pen relay RLA, and RLB and RLC if used (see Fig. 8).

RELAYS

All relays specified for the disc recorder are of the G.P.O. type 3000, with 1,000 ohm windings, operating on 6–12V. Modification details for RLA are given in Fig. 16b.

The pen arm is soldered to a 4B.A. solder tag which is held against the armature by a small pressure spring. The arm is free to move up and down, with the pen counterbalanced by a lead weight, but is driven horizontally by the movement of the armature; in this way the pen is free to follow surface irregularities of the paper and maintains a constant but light contact.

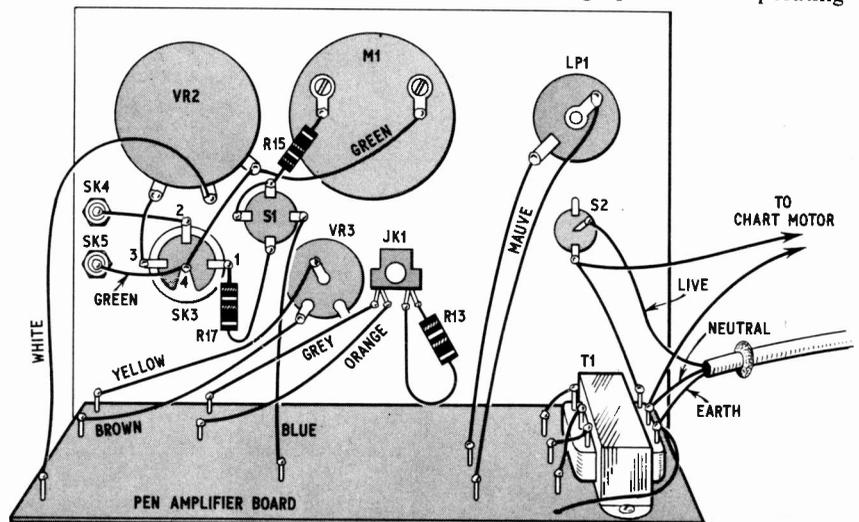
Remove RLA armature and glue two small squares of foam plastic, approximately ¼in × ¼in × ¼in thick, to the relay frame and polepiece, then replace the armature and mount the pen arm. If necessary, bend the relay contacts so that they are just open when the armature is naturally biased by the foam inserts.

Fix RLA to the baseboard beside the turntable and bend the pen arm until the resulting ink trace is in line with the turntable radius. The disc recorder in its basic form will now be ready for use.

EXTRA FACILITIES

It is useful to have some warning of the onset of a tremor when the seismograph is left operating

Fig. 14. Interwiring of control unit



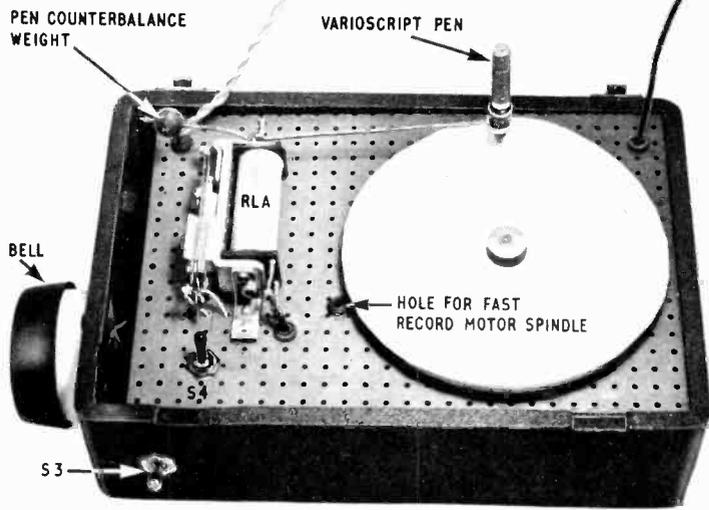


Fig. 15a. Top view of prototype disc recorder

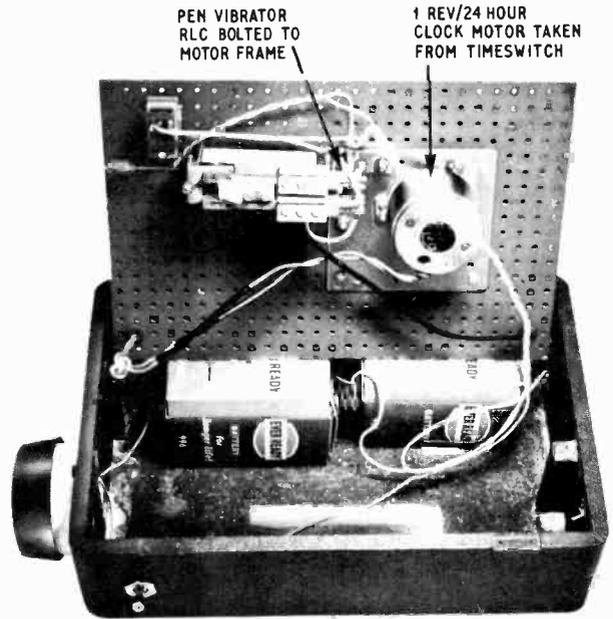
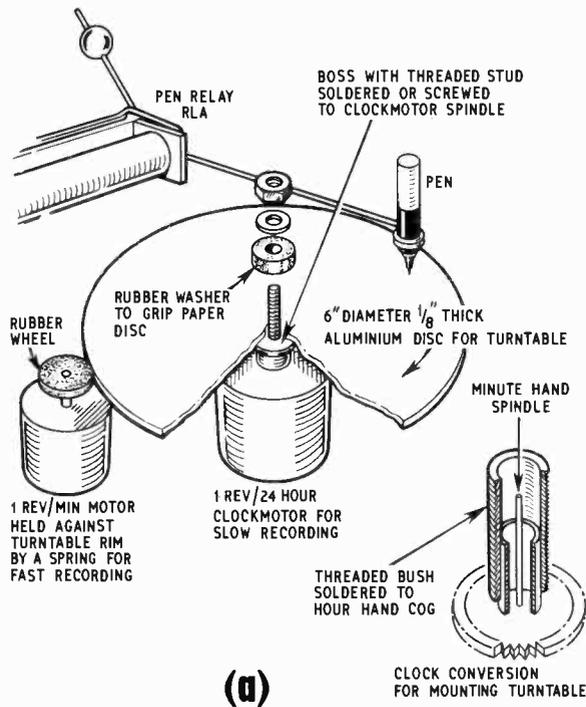


Fig. 15b. Underside of motor board

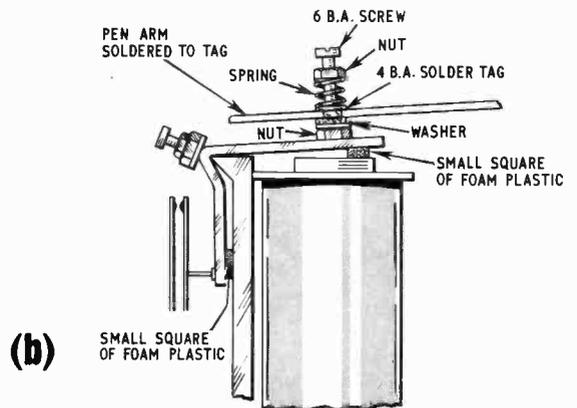
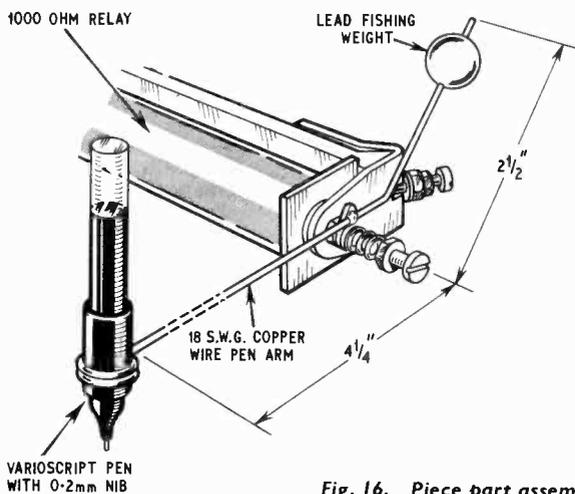


Fig. 16. Piece part assembly details for disc recorder

unattended, perhaps in a separate room. The simple bell circuit wired to the relay RLA contacts as in Fig. 8 can be quickly added to the basic recorder.

One of the bugbears of most pen recorders is unreliable inking. There is nothing more infuriating than finding that the pen has dried up just before the onset of an interesting event. To improve matters, the pen can be filled with watered down ink, but this gives a grey trace.

Further improvement results if the detachable nib is cleaned at the end of each 24 hour recording period, but this is a nuisance, and uses up valuable recording time.

The remedy is to employ a vibrator to keep the point of the nib bouncing up and down on the paper, and maintain a tiny pool of wet ink under the nib, without appreciably thickening the trace. A description of the vibrator has already been given, see also Fig. 8 and Fig. 15.

For triggered, expanded trace recording, a one revolution per minute synchronous motor can be arranged to rim drive the turntable approximately one revolution in every 36 minutes by means of a spring loaded $\frac{1}{2}$ in diameter rubber wheel.

A choice of motor speeds and friction wheel sizes will allow a wide range of recording speeds to be covered.

INSTALLING THE SEISMOMETER

An ideal seismometer site would be a deep pit excavated down to bedrock, somewhere in the middle of a large, unpopulated area of open countryside, devoid of trees, and at least one hundred miles from the nearest seashore. Of course, the ideal site is not available in the United Kingdom, and the best use must be made of available terrain.

In the centre of large towns built on chalk or clay, the "cultural" noise level will almost certainly mask all but the strongest tremors from distant events, but advantage can be taken of reduced human activity in the early hours of the morning. The seismograph will anyway be left running for 24 hours under normal circumstances.

The seismometer can be placed on a large concrete block which is let into the floor of a cellar, as this serves to couple it efficiently to the ground.

A suburban site could be based on a pit—or seismometer "vault" to use the correct term—dug in a garden. See that the pit is either well drained, or rendered completely waterproof with a lining of impervious concrete.

Although rural seismometer sites are obviously the best, the presence of trees can multiply the micro-seismic background noise at least three or four times when a high wind is blowing, and quarry shots have a perverse habit of turning up right in the middle of an interesting recording.

Training areas for the Armed Services are also situated in rural areas. Guns, bombs, depth charges, and sonic booms are all recorded faithfully by the seismograph.

Having decided upon and prepared a seismometer site, the instrument is installed and levelled with the aid of a spirit gauge. Make sure that the transducer coil is correctly aligned, completely free to move, and cannot touch the magnets.

A sharp increase in resonant frequency can be caused by minute whiskers of ferrous metal bridging the gap between magnets and coil. The remedy is to clean the magnets by wiping them with a piece of foam plastic.

A tin can placed over the transducer assembly, with a cut-away to clear the seismometer boom, will prevent dirt collecting on the magnets. It is advisable to protect and shield the seismometer with a heavy box cover of wood or metal, which is in turn covered by an old blanket to keep out drafts and loud noises.

TESTING THE SEISMOGRAPH

Connect the seismometer amplifier to the control unit. Adjust VR1 for minimum damping (slider earthed, and plug in the batteries. With gain control CR2 at zero, switch on the control unit, and wait for a minute or two for the circuits to settle down.

Advance VR2 while watching the zero-peak meter; the pointer should be seen to rise and fall rhythmically at the resonant frequency of the seismometer. If instead the pointer persistently goes to full scale, at low settings of VR2, and the panel lamp LP1 flashes, this will indicate instability.

The instability might have been caused by switch-on surges, in which case a 1.5V d.c. voltage injected into SK4 sockets should kill the unwanted oscillation, and return the seismometer amplifier to normal working.

To check the amplifier noise level, set VR2 to zero and clamp the seismometer transducer by inserting a thickness of cardboard between the coil and the magnets. Turn VR2 to maximum gain and observe the peak meter deflection, this should not exceed $4\mu\text{A}$ on the existing meter scale.

CALIBRATION

The seismologist is not necessarily concerned with the accurate measurement of ground motion amplitudes. Often it is enough to time the tremors, and merely compare relative trace amplitudes. Nevertheless, it is instructive to see how the seismometer responds to a well defined mechanical displacement and there are several methods of attempting this.

Perhaps the best technique is to place the seismometer on a special "shaking table", a precision engineered platform capable of being moved with great accuracy through small distances.

A simpler alternative more suited to the amateur is to impart a small motion to the seismometer boom by applying a known electromagnetic force.

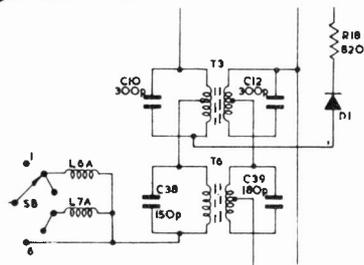
An item of equipment needed for calibration is a sub-audio oscillator, tunable from about 0.5Hz–5Hz, with an output of at least 10V r.m.s., and having a switched attenuator covering 100dB or more.

An ordinary audio signal generator can sometimes be converted for sub-audio use by adding extra large capacitors to the frequency determining network, while at the same time increasing the value of all coupling, de-coupling, and smoothing capacitors to prevent distortion and loss of output at the lowest attainable frequencies.

The Heathkit AG-9U, for example, will work down to 0.1Hz after suitable modification.

To calibrate the 1Hz spring pendulum seismometer, attach a small pointer to the seismometer mass, arranged so that it moves up and down a millimetre scale. Temporarily short-circuit the red and green leads from the transducer coil L1 at the seismometer amplifier input, and make sure that the supply is disconnected.

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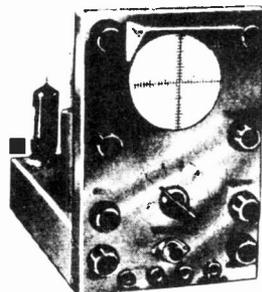
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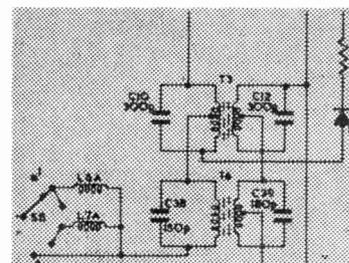
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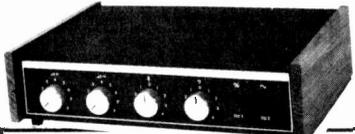
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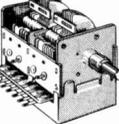
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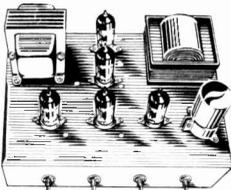
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A top quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. x 3 1/2 in. h. 6h. Ready built and tested. **PRICE £3-75.** P. & P. 40p. **ALSO AVAILABLE** mounted on board with output transformer and speaker ready to fit cabinet below. **PRICE £4-88.** P. & P. 60p.

DE LUXE QUALITY PORTABLE R/C CABINET MK II 1/2 cut motor board size 14 1/2 in. clearance 2 1/2 in. below. 5 1/2 in. above. Will take above amplifier and any B.S.R. or GARRARD changer or Single Player (except AT60 and SP25). Size 18 x 15 x 8in. **PRICE £3-98.** P. & P. 60p.

10/14 WATT HI-FI AMPLIFIER KIT

A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements with output transformer and speaker to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and E280 rectifier. Simple instruction booklet 15p (Free with parts). All parts sold separately. ONLY £7-97. P. & P. 55p. Also available ready built and tested complete with std. input sockets, £9-97. P. & P. 65p.



BRAND NEW TRANSISTOR BARGAINS. GET 15 (Matched pair) 75p; V15/10p, 50p; OC71 25p; OC76 30p; AF17 15p; 3C539 (NPN) 15p. Set of Mullard's sold separately. ONLY £7-97. P. & P. 55p. Also available ready built and tested complete with std. input sockets, £9-97. P. & P. 65p.

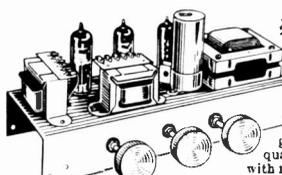
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LIMITED NUMBER ONLY £1-38 Post Free.

DE LUXE STEREO AMPLIFIER



a.c. mains 200-240 volts. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line up—2 x ECL86 Triode Pentodes. 1 x E280 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate "balance" control fitted at the rear of the chassis. Input sensitivity is approximately 300mV for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume level to be used with negligible distortion. Supplied complete with knobs, chassis size 11in. w x 4in. x 6in. Overall height including valves 5in. Ready built and tested to a high standard. **Price £2-92.** P. & P. 45p.

4-SPEED RECORD PLAYER BARGAINS

Mains models. All brand new in maker's packing. **LATEST B.S.R. C109/A21 4-SPEED AUTOCHANGER.** With latest mono compatible cartridge £6-87. Carr. 50p. With stereo cartridge £7-97. Carr. 50p. **SUITABLE PLINTH UNIT FOR ABOVE** with rigid plastic cover. £5-75 complete. P. & P. 50p.

LATEST GARRARD MODELS. All types available 1025, 2025, SP25, 3000, AT60, etc. S.A.E. for Latest Prices! **FLINTH UNITS** cut out for Garrard Models 1025, 2025, 2000, 3000, 3500, etc. With rigid transparent plastic cover. Special design enables above models to be used with cover in position. Also suitable for housing AT60 and SP25. **OUR PRICE £5-75 complete.** P. & P. 50p.

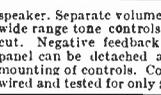
LATEST ACOG GP91/13C Mono Compatible Cartridge with 1/4" stylus for 1/4" EP/78. Universal mounting bracket. £1-50. P. & P. 5p.

SONOTONE STAHC COMPATIBLE STEREO CARTRIDGE T/O stylus. Diamond Stereo LP and Sapphire 78. ONLY £2-50. P. & P. 10p. Also available fitted with twin Diamond T/O stylus for Stereo LP. £3. P. & P. 10p.

LATEST RONETTE T/O Stereo Compatible Cartridge for EP/LP/Stereo/78. £1-65. P. & P. 10p.
LATEST RONETTE T/O Mono Compatible Cartridge for EP/LP/78 mono or stereo records on mono equipment. £1-50. P. & P. 10p.

3-VALVE AUDIO AMPLIFIER HA34 MK II

Designed for Hi-Fi reproduction of records, A.C. line operation. Ready built on plated heavy gauge metal chassis, size 7 1/2 in. x 4 1/2 in. x 4 1/2 in. Incorporates ECC83, EL84, E280 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feedback line. Output 4 1/2 watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only £4-75. P. & P. 35p.



H/L "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. £3-98. P. & P. 40p.

HARVERSON'S SUPER MONO AMPLIFIER

A super quality gram amplifier using a double wound fully isolated mains transformer, rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3.5 watts. Volume and tone controls. Chassis size only 7in. wide x 3in. deep x 6in. high overall. AC mains 200/240V. Supplied absolutely Brand New, completely wired and tested with good quality output transformer. **FEW ONLY.**

OUR ROCK BOTTOM BARGAIN PRICE £2-75 P. & P. 35p.

HANDBOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES

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PLEASE NOTE: P. & P. CHARGES QUOTED APPLY TO U.K. ONLY. P. & P. ON OVERSEAS ORDERS CHARGED EXTRA.

Inject a 1Hz sinusoidal signal of about 5V r.m.s. into the calibration coil L3, via sockets SK4 and SK5 on the control unit front panel.

With the help of another person, tune the oscillator for maximum deflection of the seismometer boom, and then adjust the oscillator output voltage until the seismometer mass is swinging through a vertical distance of 1 millimetre. Carefully note the exact oscillator voltage required to give the above deflection, then switch off the oscillator.

Remove the short circuit from the transducer leads and re-connect the supply. Advance VR2 to make sure that the seismometer is now responding correctly to microseisms, with VR1 set for minimum damping.

With VR2 turned down low, attenuate the previous oscillator output voltage by 80dB and inject this signal into SK5. Adjust the oscillator frequency control for maximum deflection of the zero-peak meter; this is because the seismometer may not have the same point of resonance for very large and very small displacements. Since the original deflection was 1 millimetre peak-to-peak, or 0.5 millimetre zero-peak, the new seismometer deflection should be $0.5\text{mm} \times 10^{-4}$, or 50 nanometres.

Adjust VR2 for a full scale deflection of $50\mu\text{A}$ on the zero-peak meter, and make a note of the VR2 setting for future reference. The calibration obtained will be dependent on the amount of damping applied.

For other settings of VR1, re-calibrate, or prepare a response graph similar to Fig. 2 so that known settings of VR1 can be related to amplitude.

Another factor to be taken into account is that the calibration will only apply at the particular frequency used to deflect the seismometer boom, because the transducer is of the velocity type. It is a reasonable assumption that output will be related to amplitude in the undamped mode when the seismometer can only respond to a narrow band of frequencies centred at resonance.

OBTAINING RECORDINGS

Set VR2 to zero and insert the disc recorder jack plug into socket JK1 on the control unit front panel. Wait for a few minutes for the pen amplifier to settle down, and then adjust VR4 to position the armature of relay RLA at the mid-point of its travel.

Set up the pen, paper disc, and turntable rotation. Advance VR2 until the pen just moves in response to microseisms, and gives a slightly thickened trace. If necessary, re-adjust the pen zero by means of fine control VR3.

Leave the disc recorder running for several hours to check for reliable inking and pen deflection. At the same time, try injecting a range of frequencies from the test oscillator via SK5, to see how the complete seismograph responds to displacements of the seismometer mass.

SEISMOGRAMS

Four seismograms obtained with a simple disc recorder are given in Fig. 17.

A tremor from an epicentre a few hundred miles from the seismograph is depicted in Fig. 17a, recorded at a speed of one revolution every 24 hours. Seismogram Fig. 17b is the result of a rapid succession of small quarry shots at a distance of 6 miles (also clearly audible at the recording station); turntable speed one revolution every 36 minutes.

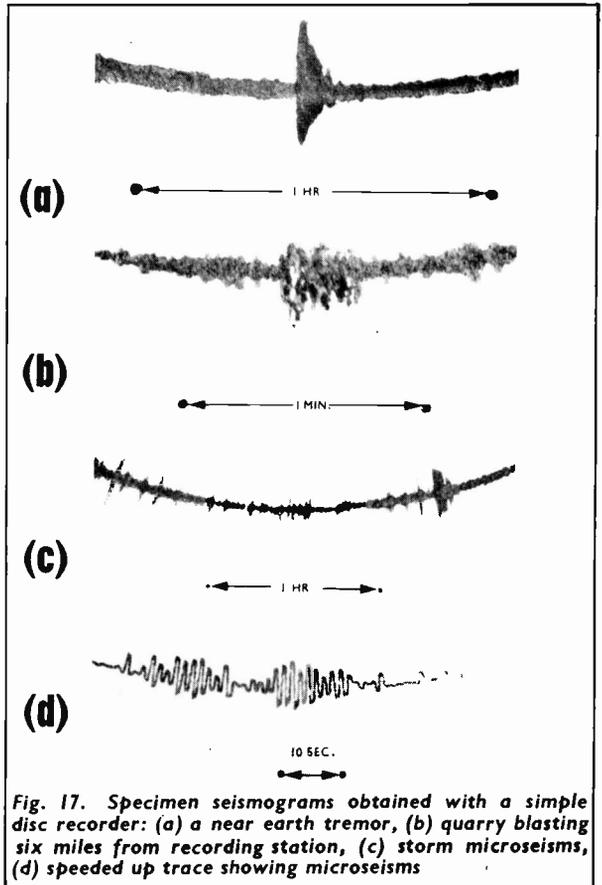


Fig. 17. Specimen seismograms obtained with a simple disc recorder: (a) a near earth tremor, (b) quarry blasting six miles from recording station, (c) storm microseisms, (d) speeded up trace showing microseisms

An approaching area of low pressure, accompanied by high winds produced the seismogram of Fig. 17c; the large amplitude deflections were caused by trees in the vicinity of the seismometer. The recording speed for this was the same as for Fig. 17a seismogram.

Finally, in Fig. 17d, a turntable rate of one revolution per minute gives a detailed record of microseisms, and shows the modulation effect which is sometimes referred to as "string of sausages".

Although not certain, the modulation may be caused by long period oscillations from the continental shelf being added to more local microseisms.

If a strip or helical chart recorder is available, having paper speeds of 10sec/cm or more, it can be connected to the seismograph control unit as shown in Fig. 18, to obtain more detailed recordings.

Serious seismological work demands the use of fast paper speeds with precise timing marks, to fix the arrival times of subsidiary waves reflected from crustal layers.

STRIP CHART RECORDINGS

The two seismograms in Fig. 19 are representative of traces given by a strip chart servo recorder.



Fig. 18. Circuit for feeding output from pen amplifier into an advanced recorder

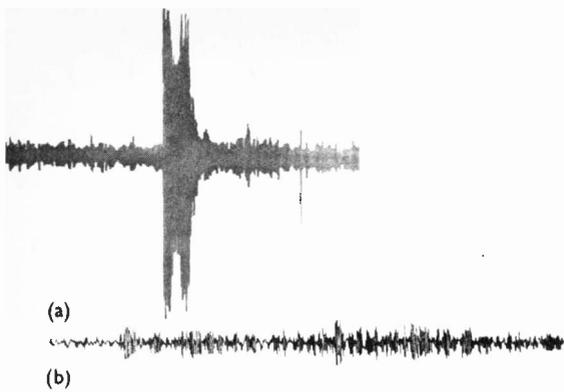


Fig. 19. Seismograms obtained with a strip recorder, (a) earthquake in the North Atlantic Ocean, (b) depth charge recorded at a distance of 250 miles

Fig. 19a is of a confirmed earthquake centred under the North Atlantic ridge, with minimum damping applied to the seismometer, and a fairly slow paper speed of 5.5min/cm.

Clearly shown here are the two peaks produced by the difference in arrival times of major P and S waves.

Fig. 19b gives a good general impression of seismograph sensitivity, and also shows the increase in detail resulting from a faster paper speed of 10sec/cm. To obtain this seismogram, frequencies below 1Hz were filtered out by reducing the value of C14 coupling capacitor (Fig. 18) to one microfarad. The input impedance of the chart recorder was ten kilohms

For this, the response of the seismometer was set to wide-band with near maximum damping, and the major recorded frequencies were in the region of 5Hz.

FILTERING

The seismograph response characteristic can, of course, be tailored to suit a particular situation.

If the main interest is the recording of teleseisms, that is events occurring some thousands of miles away, integrating capacitor C10 in Fig. 7 can be added to attenuate signals above 1Hz; this also partly corrects the inherent transducer response to yield an output more nearly related to amplitude over the full frequency range of the instrument, instead of velocity.

Quarry shots and other explosions can form a study in themselves, as seismic signals revealing something of the structure of the Earth's crust.

For all but explosions approaching nuclear magnitude, the frequencies generally encountered will lie above 1Hz. It will pay, therefore, to improve the signal to microseismic noise ratio by attenuating unwanted frequencies below 1Hz; simply achieved by reducing the value of C14, as was done for seismogram Fig. 19b.

To conclude this short introduction to the subject, the serious experimenter can find plenty of opportunity in the field of seismology for circuit development. Good sub-audio amplifiers, filters, and oscillators are scarce items. Equally, there are few seismological stations run by amateurs in the British Isles, despite the new impetus given to the subject by nuclear explosion detection and Moon quake recording. ★

NEWS BRIEFS

Sub Trainer

A NEW era in the training of Royal Naval submarine crews was signalled by the recent opening of a computer-based Submarine Command Team Trainer (SCTT) at HMS Neptune, the R.N. training establishment.

The SCTT system was developed jointly by the Ministry of Defence and the Electronic & Display Equipment Division of Ferranti Ltd. in Manchester, and is based on two Ferranti Argus computers.

The equipment is designed to train the submarine command team and crew in tactics and operations, and the various degrees of training available in the simulator system range from simple operator training to complex tactical exercises involving a number of target and escort vessels. Realistic simulations of sonar, radar, periscope, fire control and navigation systems are provided.

Lucas Looks Ahead

WITH the formation of an Electronics Product Group under Dr. John E. Maund, Lucas Electrical Limited intend to marry their undisputed engineering skill in automotive electrical systems with the more recent electronics and semiconductor technology and production capacity of their former Semiconductor Division.

This move was considered desirable in the face of a rapidly changing electronics market where integration in both i.c. and hybrid module form are foreseen as major expansion areas, and in particular the acceleration of automotive electronics technology, an area in which Lucas has made a significant contribution. This company sees a greatly expanded market in the future since electronic-based systems will become essential parts of modern cars as a move to meet the new safety and environmental requirements.

Apart from the automotive market, Lucas intends to increase its activities in other areas, including consumer electronics. To this end their recent distributor agreements with two large U.S. component manufacturers, Centralab Semiconductor and Quantrol Electronics, are significant. The optoelectronics market in particular is seen as a major expansion area in the future.

It is of interest to note that the entry of Lucas into the field of semiconductor manufacture started originally in 1955 when, faced with the difficulty of obtaining silicon semiconductors, they decided to develop and manufacture their own.

They achieved fame as the creators of the world's first 500V transistor.

A JOB WITH P.E.?

An unusual opportunity for an electronics enthusiast to enter technical journalism. There is a vacancy for an editorial assistant, age 20 to 30, on the staff of Practical Electronics. Keeness and ability to learn more important than previous experience in publishing.

Write, with brief details of career, to the Editor, Practical Electronics, Fleetway House, Farringdon Street, London, E.C.4.

MARKET PLACE

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

INSTRUMENT CASES

Keeping up with the range of instrument cases available on the market is becoming increasingly difficult for the designer and constructor of equipment.

Adding to this large selection of instrument cases available at present are three new ranges from **West Hyde Developments, Vero Electronics and McArdle and Brainsby**.

With the increase in popularity of anodised aluminium finishes, West Hyde have developed the "Brightcase" instrument case which can be either free standing or rack mounting. The external construction is of aluminium with the exception of the top and bottom panels which are made of black PVC coated steel.

The anodised side panels are held with button head socket screws, which can also be used to carry the rack mounting brackets.

All units come complete with front and back panels in anodised aluminium in either full, half or quarter width. These panels are held by stainless steel Pozidriv screws on to the anodised main rails. Inside there are four aluminium slides on which the equipment can rest.

Details of case sizes and prices can be obtained from West Hyde Developments Ltd., Ryefield Crescent, Northwood Hills, Northwood, Middx. HA6 1NN.

As an addition to their "D" series instrument cases Vero Electronics introduce a 17½in deep series. The cases accept standard 19in front panels or frames and incorporate flush fitting side handles, for ease of carrying.

The cases incorporate all the usual features of the "D" series, such as tilt feet, front trim, and handles and a vinyl paint finish. Ventilation is provided by slots in the bottom and rear panels which are both detachable for easy access to the interior.

Further details of all the Vero cases are available from Vero Electronics Ltd., Chandlers Ford, Hampshire, SO5 3ZR.

The Impex range of cases from McArdle and Brainsby covers 36 different sizes. The case bodies are made from 20 s.w.g. steel coated with stove enamel in green hammer finish.

The detachable front and back panels are 18 s.w.g. satin anodised aluminium and the base is made from 18 s.w.g. passivated zinc plated steel.

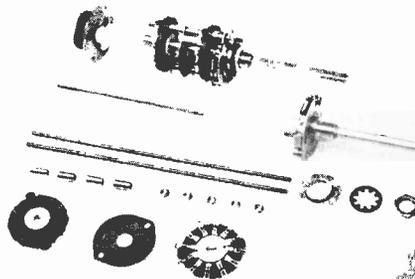
Further information on the Impex range of cases is obtainable from McArdle and Brainsby (Import and Export) Ltd., P.O. Box 2BB, Newcastle-upon-Tyne, NE99 2BB.

SWITCH KIT

Constructors will be delighted to learn that a contender to the famous Maka Switch, which many readers seem to have difficulty in obtaining, is now being marketed through **Home Radio (Components) Ltd.**, by **A.B. Electronic Components Ltd.**

The switch is available in kit form and practically any multiple arrangement of rotary switching can be set-up. The switch consists of a shafting unit with a 6in shaft, wafers, screens, spacers, studding and a mains switch.

Addresses of local stockists and details of wafers available can be obtained from A.B. Electronic Components Ltd., Sutherland House, 5/6 Argyll Street, London, W1V 1AD.



Switch kit made by
A.B. Electronics Components

TREASURE HUNTER

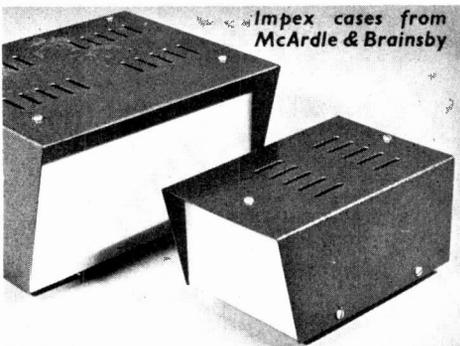
Hunting for buried treasure appears to be one of the popular outdoor pastimes, and the electronic metal detector is an essential part of the equipment of every serious treasure hunter.

A useful little handbook "A Fortune Under Your Feet" by Edward Fletcher has been brought to our attention. Its value is in the lesser known facts it contains about where and how to search. One chapter gives a broad outline of metal locators and suggests the kind of performance one should look for. Available from **Joan Allen & Co.**, Biggin Hill, Kent, price 45p plus 6p post and packing.

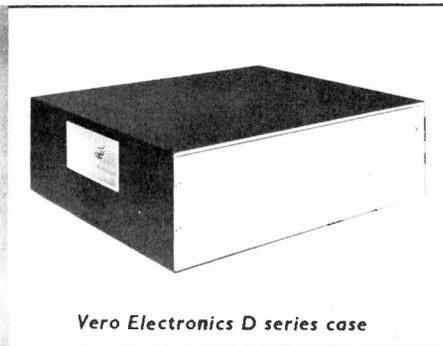
METALS TO ORDER

Happy to meet even the smallest order and advise which metal is best suited for a particular job, **Henry Righton & Co. Ltd.**, of Brookvale Road, Witton, Birmingham 6, have opened a "Cash & Carry" counter for the do-it-yourself enthusiast and model builders in the Birmingham area.

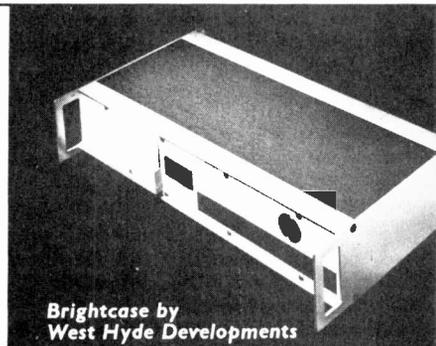
The counter, open from 9.0 a.m. to 5.0 p.m. and 8.30 a.m. to 12 noon Saturdays, is able to supply aluminium, brass, copper, bronze and stainless steel in rod, bar tube, sheet or strips cut to any size, shape or length.



Impex cases from
McArdle & Brainsby



Vero Electronics D series case



Brightcase by
West Hyde Developments

WAR GAMES COMPUTER

PART TWO

By D. R. Daines

IT SHOULD have been possible with last month's article to play in a very limited game using the primary parameter controls in Fig. 8. The SPEED controls would be "slowest" at the higher voltage end of the potentiometers VR4 and VR5; while TARGET SIZE would be smallest when S4 is switched to (d) line and largest on R22, although the labels for these switch positions have no direct importance to circuit function—only to strategy.

SECOND STAGE—PANEL 'A'

Panel A contains the three multivibrators and the gate. The circuit is shown in Fig. 9. TR1 and TR2 form the first "CHANCE" multivibrator, with TR3 added to speed up the rise time.

The frequency of a multivibrator can be changed by altering the voltage applied to the bases of the transistors, which is what is done here. VR1 alters the voltage, while VR2 alters the distribution of that voltage between TR1 and TR2, thereby altering the mark/space ratio (Fig. 8). The large CR combinations result in a slow change-over rate, and can be as low as once in every six or seven seconds.

The RATE OF FIRE multivibrator is formed by TR4 and TR5, with TR6 speeding up the output. Applying a variable voltage to the base of both transistors TR4 and TR5 would result in a varying frequency, but the mark/space ratio would remain the same; what is required is a fixed time pulse output with a variable delay between pulses. To this end TR4 is provided with a fixed base bias, but the voltage to TR5 is varied.

Exactly the same configuration is applied to the PROBABILITY multivibrator formed by TR7 and TR8, but the components are chosen to give a repetition rate somewhere between those of MV1 and MV2. TR9 speeds up the output. In practice TR6 provides a very good square wave, but because of the slow repetition rates of MV1 and MV3, TR3 and TR9 switch on and off very slowly, but the result is good enough for our purpose.

The outputs of the three multivibrators are applied to the gate formed by D5, D6, D7 and R41 (D8 is described later). Any small glass diodes will do for this purpose. If an oscilloscope is available, R41 may be adjusted to give the best output, but a meter may

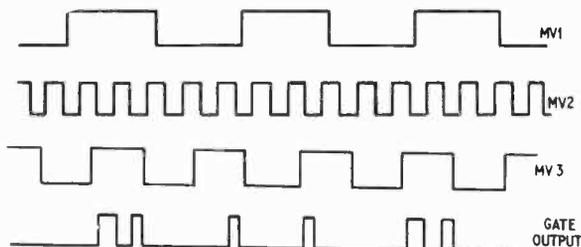


Fig. 9a. The waveforms into each gate diode D5, D6, D7 and the gate output waveform

COMPONENTS . . .

STAGE TWO (Panel "A" Fig. 9)

Resistors

R23	56k Ω	R30	100k Ω	R37	1M Ω
R24	1k Ω	R31	1M Ω	R38	22k Ω
R25	1k Ω	R32	470k Ω	R39	330k Ω
R26	22k Ω	R33	22k Ω	R40	56k Ω
R27	10k Ω	R34	330k Ω	R41	100k Ω
R28	56k Ω	R35	56k Ω		(see text)
R29	22k Ω	R36	22k Ω		

All $\pm 10\%$, $\frac{1}{4}$ W carbon

Capacitors

C3	25 μ F elect. 50V
C4	50 μ F elect. 50V
C5	0.05 μ F polyester
C6	0.05 μ F polyester
C7	4 μ F elect. 50V
C8	10 μ F elect. 50V
C9	0.25 μ F polyester

Transistors and Diodes

TR1 to TR9 any general purpose germanium types (e.g. OC71) all same (9 off)
D4 to D8 any general purpose diodes (e.g. OA81) all same (4 off)

Miscellaneous

Copper strip Veroboard 8in \times 3 $\frac{1}{2}$ in
Dial (ex-P.O. type) with all contacts or components for Alternative Firing Element (Fig. 10)

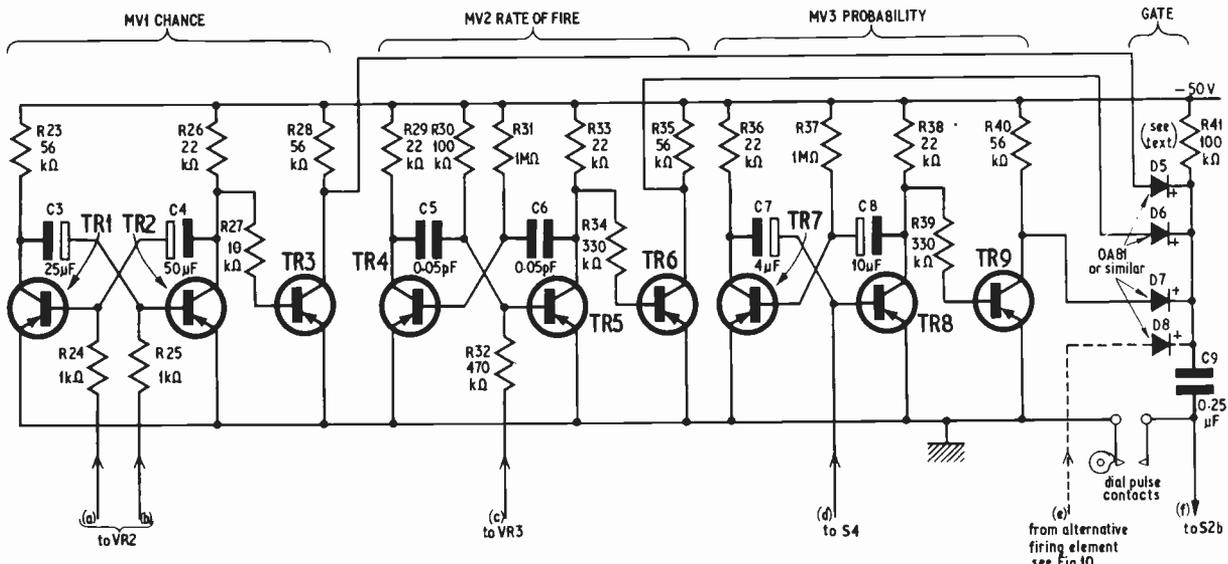


Fig. 9b. Circuit diagram of the multivibrators and gate (stage one) with waveforms (Fig. 9a) showing how coincidence gating is achieved

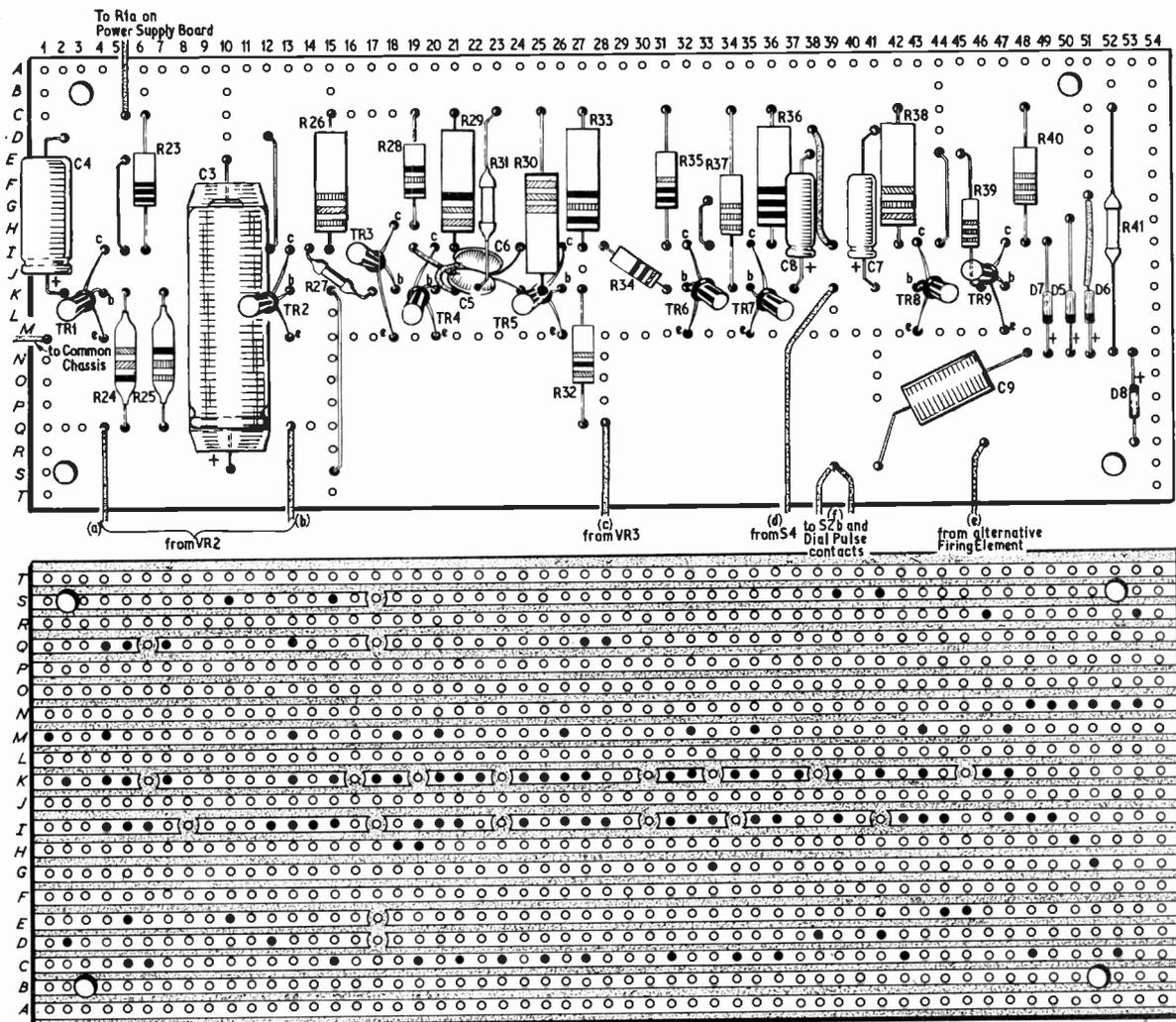


Fig. 9c. Layout of components on Panel A with underside view showing the breaks in the copper strips

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40362	67p	2N2905A	47p	2N4292	15p	BC149	10p	BFX88	26p
2N696	17p	2N2924	20p	AC107	46p	BC153	19p	BFY50	23p
2N697	18p	2N2925	22p	AC126	20p	BC154	20p	BFY51	20p
2N706	12p	2N2926	11p	AC127	20p	BC157	12p	BFY52	23p
2N930	29p	2N3053	27p	AC128	20p	BC158	11p	BXS20	16p
2N1131	29p	2N3055	60p	AC153K	22p	8C159	12p	C407	17p
2N1132	29p	2N3702	13p	AC176	16p	BC167	11p	MC140	25p
2N1302	19p	2N3703	13p	ACV20	20p	BC168	10p	MPS6534	35p
2N1303	19p	2N3704	13p	ACV22	16p	BC169	11p	MPS6534	30p
2N1304	26p	2N3705	13p	AD140	63p	BC177	14p	NKT211	25p
2N1305	26p	2N3706	13p	AD142	50p	BC178	13p	NKT212	25p
2N1306	33p	2N3707	13p	AD149	58p	BC179	14p	NKT214	23p
2N1307	33p	2N3708	10p	AD161	33p	BC182L	11p	NKT274	18p
2N1308	36p	2N3709	11p	AD162	36p	BC183L	10p	NKT403	65p
2N1309	36p	2N3710	13p	AF114	24p	BC184L	11p	NKT405	79p
2N1613	23p	2N3711	13p	AF115	24p	BC212L	16p	OC71	38p
2N1711	36p	2N3819	23p	AF120	24p	BC213L	16p	OC81	25p
2N1893	54p	2N3904	35p	AF124	24p	BC214L	16p	OC81D	25p
2N2147	95p	2N3906	35p	AF127	22p	BCY70	18p	ZTX300	14p
2N2218	34p	2N4058	13p	AF139	33p	BCY71	33p	ZTX301	16p
2N2218A	44p	2N4059	10p	AF239	36p	BCY72	15p	ZTX302	22p
2N2219	38p	2N4060	11p	ASV26	27p	BF115	23p	ZTX303	22p
2N2219A	53p	2N4061	11p	ASV28	27p	BF167	18p	ZTX304	27p
2N2270	62p	2N4062	11p	BC107	12p	BF173	16p	ZTX500	18p
2N2369A	19p	2N4124	18p	BC108	11p	BF194	14p	ZTX501	21p
2N2483	35p	2N4126	27p	BC109	12p	BF195	15p	ZTX502	21p
2N2484	42p	2N4284	15p	BC125	15p	BFX29	31p	ZTX503	22p
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Code	Power	Tolerance	Range	Values available	1 to 9 (see note below)	10 to 99	100 up
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C	1/8W	5%	4.7Ω-470KΩ	E24	1	0.8	0.7
C	1/4W	10%	4.7Ω-10MΩ	E12	1	0.8	0.7
C	1/2W	5%	4.7Ω-10MΩ	E24	1.2	1	0.9
C	1W	10%	4.7Ω-10MΩ	E12	2.5	2	1.9
MO	1/2W	2%	10Ω-1MΩ	E24	4	3.5	3
WW	1W	10% ± 1/20Ω	0.22Ω-3.9Ω	E12	7	7	6
WW	3W	5%	12Ω-10KΩ	E12	7	7	6
WW	7W	5%	12Ω-10KΩ	E12	9	9	8

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MO = metal oxide, Electroasil TR5, ultra low noise.
WW = wire wound, Plessey.

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E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
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two poles of a pushbutton. It should be red and marked "Firing". Depressing the button discharges C11 completely and at the same time turns TR10 off and TR11 on.

The collector of TR11 becomes approximately 3 volts negative with respect to earth, and 6 volts with respect to the negative rail. C11 begins to charge through R47 and as it charges the base of TR12 lowers.

There comes a point (after about five seconds) when TR12 switches off. The voltage at the collector rises towards the negative rail, and this rise is transmitted through R51 to turn TR10 on. TR10 and TR11 together form a bistable and they now assume a stable state in which TR10 is on and TR11 off. The cycle cannot resume until S5 is again depressed, hence the whole circuit is a five-second timer, determined by R47, R48, R50, R51 and C11.

While TR10 is in the off position during the cycling process, the voltage at the collector rises to the negative rail and this is taken out to prime the gate

via D8 (Fig. 9a). Since nothing can pass the gate until all inputs have a 1 (positive), no rate of fire pulses can go forward until the firing button is pressed.

This substitution for the dial would leave the constructor no method of feeding the computer with information regarding the number of guns firing and so it would be necessary to introduce another VR arranged as a voltage divider, and it may be necessary to adjust the gate resistor.

Fig. 10b shows the connections to the dial and lamps on the upper part of the control panel.

THIRD STAGE WIRING

Pulses are now routed and attenuated according to the positions of the remaining controls, S6, S7 and S8 (Fig. 11). Notice that first they go through the second wafer of the CALIBRE switch, S2b. Heaviest calibre pulses pass unattenuated, while others pass through voltage divider networks, for example that formed by R48 and R49.

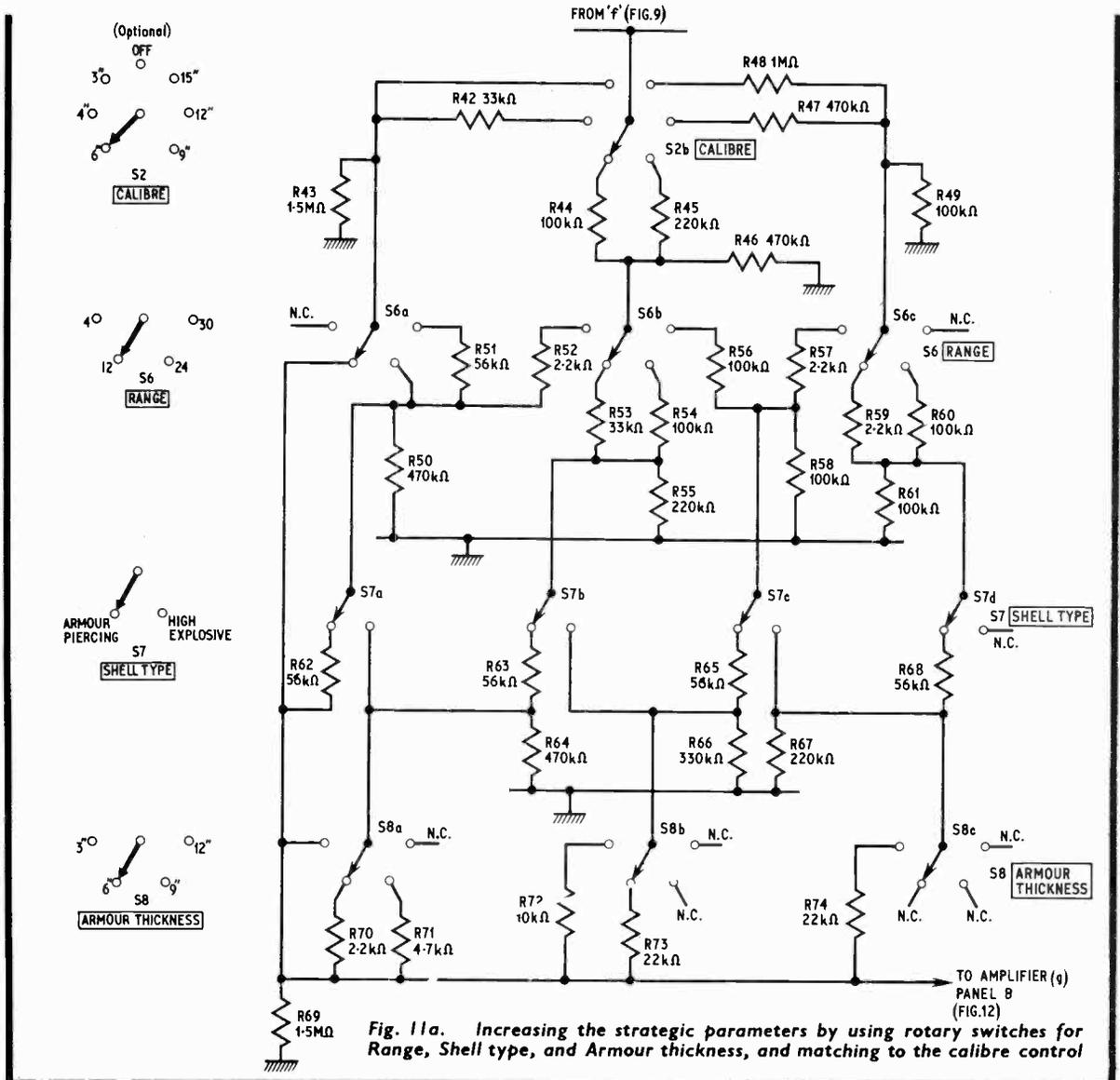


Fig. 11a. Increasing the strategic parameters by using rotary switches for Range, Shell type, and Armour thickness, and matching to the calibre control

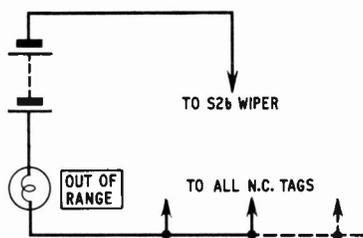


Fig. 11b. How to use n.c. positions to indicate "out of range"

COMPONENTS . . .

STAGE THREE (Fig. 11)

Resistors

R42	33k Ω	R53	33k Ω	R64	470k Ω
R43	1.5M Ω	R54	100k Ω	R65	56k Ω
R44	100k Ω	R55	220k Ω	R66	330k Ω
R45	220k Ω	R56	100k Ω	R67	220k Ω
R46	470k Ω	R57	2.2k Ω	R68	56k Ω
R47	470k Ω	R58	100k Ω	R69	1.5M Ω
R48	1M Ω	R59	2.2k Ω	R70	2.2k Ω
R49	100k Ω	R60	100k Ω	R71	4.7k Ω
R50	470k Ω	R61	100k Ω	R72	10k Ω
R51	56k Ω	R62	56k Ω	R73	22k Ω
R52	2.2k Ω	R63	56k Ω	R74	22k Ω

Switches

- S6 3-pole, 4-way rotary wafer
- S7 6-pole, 2-way rotary wafer (only 4 poles are used)
- S8 3-pole, 4-way rotary wafer

Optional (see Fig. 11b and text)

- Lamp and battery (any voltage) to show "out of range"

The other dividers will readily be discerned. At S6, the RANGE control, lightest calibres are blocked at long range, while heaviest calibres are blocked at short range, it being assumed that such guns will fire over their targets.

If desired, the outputs marked N.C. (no connection) may be taken to illuminate an out-of-range bulb (Fig. 11b). A separate supply will be necessary; four 1.5 volt batteries in series would feed a six volt bulb for months, at the rate of use found here.

The SHELL TYPE switch S7 is unusual in that the player is required to make a conscious choice that is not governed by conditions on the playing board. There are two positions, marked "Armour piercing" and "High explosive", the point being that AP shells pierce thicker armour, but HE shells do more damage.

On the AP side the pulses pass through a divider network such as R63 and R64, but are routed to the left of the diagram to pierce thicker armour, whereas HE pulses pass unattenuated to the right.

The ARMOUR switch S8 is set for armour thickness and again the pulses are blocked if the shells that they represent cannot pierce that thickness at that range. Others are attenuated by voltage dividers as before. Notice that R69 may form a divider with R62 as well as R70 to R74. The clear unattenuated signal path down the left of the diagram means that at optimum range the very heaviest shells whether HE or AP can pierce any armour. At a little longer range the heaviest AP can do so.

TESTING AND USING

Disconnect the chassis wire from the telephone dial (Figs. 9b and 10b), allowing pulses to pass unrestricted, and apply an oscilloscope to the output. There should be a very wide variation in the amplitude and frequency of pulses, and since we now have 12 controls (without the dial), the total number of combinations becomes $6^3 \times 10^3 \times 12 \times 4^2 \times 3 \times 2$ —which is over 60 million combinations. It is obviously impossible to check all these and it becomes necessary to sample in order to satisfy ourselves that all is well.

First repeat the tests of the second stage, ensuring that the sequence pattern alters with the movement of the previous controls. Then set the RANGE switch to position two (short) and ARMOUR to minimum. Under these conditions all calibre settings will produce pulses.

Check that heavy calibres produce large amplitude pulses, and not vice-versa. Switching RANGE to position 1 should block the two heaviest calibres, while switching to position 4 will block the lightest.

Check that pulses are progressively attenuated with range, also in the AP position. Check the progressive blocking of lighter calibres as armour is thickened.

It is really a matter of checking step by step, keeping a clear idea of the principles involved. When all is satisfactory, replace the chassis lead to the dial.

The computer can be used with a voltmeter as before, if necessary with an amplifier stage. Deflection of the needle indicates damage, but it is difficult, to be any more precise about this without becoming complicated. The amount of deflection is not a very good guide to the amount of damage because of the time lag in meter response.

A single heavy pulse of short duration may pass unnoticed by the observer, whereas a longer train of weaker pulses would produce a deflection proportionate to their amplitude and frequency. It is much better at this stage to say that if there is a needle deflection there is damage and to roll a dice to ascertain the extent of the damage.

Next month : Stage four — the start of showing how much damage is made to equipment.

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BLANK ALUMINIUM CHASSIS. 18 s.w.g. 2 in. sides 7 x 4 in. 45p; 9 x 7 in. 50p; 11 x 7 in. 70p; 13 x 9 in. 75p; 14 x 11 in. 80p; 15 x 14 in. 85p; 11 x 3 in. 50p.
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2 p. 2-way, or 2 p. 3-way, or 3 p. 4-way 25p each.
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ALL PURPOSE HEADPHONES

H.R. HEADPHONES 2000 ohms Super Sensitive... **£1.75**
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GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER BRITISH MADE

For Mike, Tape, P.U. Guitar, etc. operation. Size 1 1/2 x 1 1/2 x 1 1/2 in. 200-300V. E.C. operation. Mace 25 c.p.s. to 25 Kcs. 26 db gain. For use with valve or transistor equipment. Full instructions supplied. Brand new. **90p** Post 10p
Guaranteed. Details S.A.E.

NEW TUBULAR ELECTROLYTICS
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CERAMIC THERMISTOR. 250, 300, 500, 50p.
TUNING. Solid dielectric. 100pF, 500pF, 35p each.
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Complete: a die, a punch, an Allen screw and key
1 in. 88p 1 in. 88p 1 1/2 in. 98p 1 1/2 in. £2.20 2 1/2 in. £2.21
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Super quality small size 1 1/2 x 1 1/2 x 1 1/2 in. spin spindle 1/4 in. 385+365 pF with 25+25 pF. British made. Geared slow motion drive 6:1. Plastic dust cover. 6BA tapped front fixing. Cast aluminium frame. **50p** POST FREE

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All post 25p each
250-0-250 50 mA. 6.3 v. 2 amp. centre tapped... £1.10
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HEATER TRANS. 6.3 v. 3a. 70p
Dkto tapped sec. 1.4 v., 2.3, 4, 5, 6.3 v. 1 1/2 amp. 80p
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2 amp., 3, 4, 5, 6, 8, 9, 10, 15, 18, 24 and 30 v. £2
1 amp., 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60. £2
2 amp., 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60. £3
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FULL WAVE BRIDGE CHARGER RECTIFIERS: 6 or 12v. outputs. 1 amp. 40p; 2 amp. 55p; 4 amp. 85p.
All Transformers Postage 25p each

E.M.I. 13 1/2 x 8 in. LOUSPEAKERS

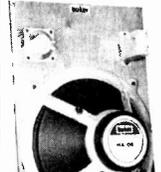
With flared tweeter cone and ceramic magnet. 10 watt.
Bass res. 45-60 cps. **£2.25**
Fix 10,000 gauss.
State 3 or 8 or 15 ohm. Post 15p
And with twin tweeters. **£4**
And crossover. 10 watt. **£4**
State 3 or 8 or 15 ohm. Post 15p
As illustrated.
Recommended Teak Cabinet **£5**
Size 16 x 10 x 9 in. Post 25p.

10W MINI-MODULE £3.25 LOUSPEAKER KIT

Post 25p
Triple speaker system combining on ready cut baffle: 1 in. chipboard 15 1/2 x 8 1/2 in. 272ba Bass, Middle and Treble loudspeakers and crossover condenser. The heavy duty 5 in. Bass Woofer unit has a low resonance cone. The Mid-Range unit is specially designed to add drive to the middle register and the tweeter recreates the top end of the musical spectrum. Total response 20-15,000 cps. Full instructions for 3 or 15 ohm.
TEAK VENEERED BOOKSHELF ENCLOSURE. 16 1/2 x 10 1/2 x 6 in. Modern design, dark grey Teak covered baffle. **£5** Post 25p

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BAKER 12in MAJOR £9



30-14,500 c.p.s., 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwell. Bass resonance 40 c.p.s. Rated 20 watts. State 3 or 8 or 15 ohm. Post Free.

Module kit, 30-17,000 c.p.s. with tweeter, crossover, baffle and instructions. **£11.50**

'GROUP 25' 'GROUP 35' 'GROUP 50'

12 inch **£7** 12 inch **£9** 15 inch **£19**
25 watt 8 or 8 or 15 ohm 35 watt 3 or 8 or 15 ohm 50 watt 8 or 15 ohm

BAKER "BIG-SOUND" SPEAKERS
TEAK HI-FI SPEAKER CABINETS. Fluted wood front. For 12 in. round Loudspeakers... £9 Post 25p
For 13 in. Loudspeaker... £9 Post 25p
For 10 x 6 in. Loudspeaker... £4 Post 25p
LOUDSPEAKER CABINET WADDING 18in. wide, 15p lb

THIS LACONIC NETWEETER IS THE VERY LATEST DESIGN AND GIVES A HIGHER STANDARD OF PERFORMANCE THAN MORE EXPENSIVE UNITS



The moving coil diaphragm gives a good radiation pattern to the higher frequencies and a smooth extension of total response from 1,000 cps to 12,000 cps. Size 3 1/2 x 3 1/2 in. deep. Rating 10 watt. 3 ohm or 15 ohm models. **£1.90** Post 10p

TWO-WAY XOVER NETWORK 3000 c/s.

With variable tweeter attenuator giving accurate high/low frequency balance. Mounted on panel 6 1/2 in. with control knob, tweeter and woofer leads and 1/4 in. Post input terminals. Suitable for 3 to 8 ohm imp. **£1.90** Post 10p

GOODMANS HEAVY DUTY 10in. WOOFER

10w. Large ceramic magnet. 30-12,000 cps. Ideal **£4** P.A., Columns, Hi-Fi Enclosures, etc.

Horn Tweeters 2-16Kcs, 10W 8 ohm or 15 ohm £1.50.
De Luxe Horn Tweeters 2-18 Kcs, 15W, 8 ohm £3.
TWO-WAY 3,000 c.p.s. CROSSOVERS 3 or 6 or 15 ohm 95p.
SPECIAL OFFER: 80 ohm, 2 1/2 in. dia., 35 ohm, 3 in. 25 ohm, 3 in. dia.; 6-4 in; 8-5 in. **£1** EACH TYPE
15 ohm, 3 1/2 in. dia.; 7-4 in; 8-5 in.
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Loudspeakers P.M. 3 OHMS. 6 in. £1.10; 8 x 5 in. £1.25; 8 x 2 1/2 in. 60p; 8 in. £1.75; 16 in. £1.90.
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RICHARD ALLAN TWIN CONE LOUSPEAKERS 8 in. dia. 4 watt; 10 in. dia. 5 watt; 12 in. dia. 6 watt, 3 or 8 or 15 ohm models £1.95 each. Post 15p.
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SPEAKER COVERING MATERIALS. Samples Large 8 A.S.E. GOODMANS OUTPUT TRANSFORMER 5 watt push pull for valves EL84, etc., 3, 8 and 15 ohms 85p. Post 20p.

100 WATT ALL PURPOSE POWER AMPLIFIER

4 inputs speech and music. Response 10-30,000 cps. Matches all loudspeakers. A.C. 200/250V. Treble **£36** Post and Bass controls. Guaranteed. Details S.A.E. Free

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SUPPLIED AT LOWEST PRICES.
ILLUSTRATED EAGLE CATALOGUE 20p. Post free
BARGAIN AM TUNER. Medium Wave. Transistor Superhet. Ferrite aerial. 9 volt. **£4**

BARGAIN 4 CHANNEL TRANSISTOR MIXER. Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output. 9 volt. **£3**

BARGAIN FM TUNER 88-108 Mc/s Six Transistor. 9 volt. Printed Circuit. Calibrated slide dial tuning. Walnut Cabinet. Size 7 x 6 x 4 inch **£10**

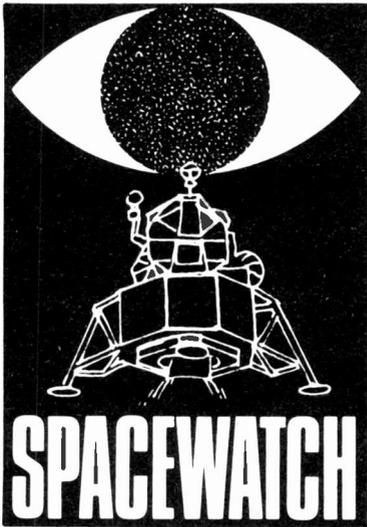
BARGAIN FM TUNER as above. **£7.50**

BARGAIN 3 WATT AMPLIFIER. 4 Transistor Push-Pull Ready built, with volume control. 9v. **£3.50**

COAXIAL PLUG 6p. PANEL SOCKETS 6p. LINE 18p. **OUTLET BOXES.** SURFACE OR FLUSH 25p. **BALANCED TWIN FEEDERS** 5p yd. 80 ohms or 300 ohms. **JACK SOCKET** Side, open-circuit 14p, closed circuit 23p; Chrome Lead Socket 45p. **Phono Plug** 5p. **Phono Socket** 6p. **JACK PLUGS** Sid. Chrome 15p. 3 mm Chrome 14p. **DIN SOCKETS** Chassis 3-pin 11p. 5-pin 19p. **DIN SOCKETS** Lead 3-pin 15p; 5-pin 15p. **DIN PLUGS** 3-pin 18p; 5-pin 25p. **V-LINE HOLDERS.** 8p; CERAMIC 3p; CANS 5p.

E.M.I. TAPE MOTORS. 120v. or 240v. AC. 1,200 r.p.m. 4 pole 135mA Spindle 0.187 x 0.75 in. Size 3 1/2 x 2 1/2 in. (Illustrated). Post 15p. **£1.25**
BALFOUR GRAM MOTORS. 120v. or 240v. AC. 1,200 r.p.m. 4 pole 100mA. Spindle 1 x 3/20. Size. 2 1/2 x 2 1/2 in. Post 15p. **85p**

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BY FRANK W. HYDE

SOVIET PROBE TO MARS

One of the experiments being carried out on the Soviet probe to Mars, which began with the launching of the Russian *Mars 3* on May 28, indicates extensive Russo-Franco co-operation. This is the first time that a Western European country has been able to "thumb a lift" on an interplanetary probe.

The originators of the new experiment J. L. Steinberg and C. Carubalos of the Observatoire de Meudon are studying solar bursts at metre wavelengths.

The particular study of sudden bursts of radiation from the sun is being carried out because the mechanism of their appearance is not fully understood. The bursts which may last from a few milliseconds to a few seconds are not adequately explained by the thermal motions of electrons. There must be some additional mechanism involving energetic electrons interacting with the magnetic field, and the plasma in the corona.

SOLAR RADIATIONS

Solar radiations are classified into different type groups. The two types involved in this study are Type 1 which last for less than half a second and are strongly polarised, indicating interaction with the coronal field; and Type 3 which are indicated by solar flares, terrestrial magnetic disturbances and auroral effects.

Type 3 bursts last for seconds and the particles that are involved move at very high speeds through the corona. Typically the velocity of the particles may be as high as 100,000 km/second. Type 3 bursts are confined to a cone of direction with an axis that lines up with direction of maximum variation of electron density.

From the earth these can be studied only in two dimensions but with the instrumentation on a probe it will be possible to obtain simultaneous observations from earth and a position in distant space. A partial 3D effect can then be secured. For this reason the French have called this a "stereo experiment". It is hoped that the experiment will reveal how the energy of the bursts is distributed in space and also the total amount of energy that is radiated.

The earth based station will be installed at Nancay in France where the 1,500 metre long radio heliograph is in operation. This radio telescope can provide 50 high resolution radio images of the Sun every second.

On *Mars 3* there is a radio telescope mounted on the solar panels of the spacecraft so that it is always pointing at the Sun. Two identical receivers will be in operation, one on *Mars 3* and one connected to the aerials at Nancay. From the probe data will be telemetered to the USSR where it will be processed and then passed on to France for comparison with their data.

MARINER NINE

The ninth of the *Mariner* series on its way to Mars alone, since *Mariner 8* aborted on May 8 for the reasons given in August *SPACEWATCH*, has been modified to give a compromise survey of the planet. It will go into a 65 degree orbit with periaips at 750 miles.

Under the new scheme less than 70 per cent of the planet will be mapped but with the same resolution as was originally intended. The slant range will be greater for some of the photography and some loss of detail will ensue.

Instead of the original plan of looking at six selected areas every five days it will look at several small areas once every seventeen days. Also, two tapes of data per day will be relayed back to earth instead of three as would have been the case with both vehicles operating. The scheduled programme remains the same at 90 days.

INTERSTELLAR MOLECULES

Using the 300 foot radio telescope at Kitt Peak to observe the emission lines in the millimetre-wave spectrum of the object Sgr B2, which is near the galactic centre, Dr. L. E. Snyder and Dr. D. Buhl have identified the molecules methylacetylene ($\text{CH}_3\text{C}_2\text{H}$) and isocyanic acid (HNCO).

They also found another line in the spectra of two other galactic sources W51 and DR21 though identification was difficult. It is thought that the molecule is isocyanide (HNC) but this opinion is based on laboratory work.

Dr. Snyder is from The University of Virginia and Dr. Buhl from the National Radio Astronomy Observatory.

ARTIFICIAL MARS CHAMBER

At the Institute of Microbiology in Moscow a chamber has been set up to simulate Martian conditions in order to examine the behaviour of different types of micro-organisms. The chamber with a pressure of 7mm of mercury and sharp temperature variations ranging from minus 60 degrees to plus 30 degrees Centigrade, with a minimum amount of moisture, represents the conditions that are as near to that which exists on the planet.

Soil bacteria from the Pamirs, the Kara-Kum desert and Dixon Island in the Arctic Ocean was obtained for the experiment. During the experiments it turned out that microbes and bacteria from Dixon Island had the highest survival factor.

It is thought that the main reason for the survival of terrestrial forms in a Martian environment was the low humidity. Also, it turned out that coloured organisms were able to endure the conditions better.

It seems that pigment is a good protection against the effect of ultra violet rays. There are some workers who think that the changing colour observed on Mars is linked with the activity of micro-organisms.

If there is life on Mars then the cycle involving micro-organisms is a necessary part of any organic process.

TELESCOPES IN SATELLITES

The object of the design of telescopes to be carried by satellites above the turbulent and murky parts of the earth's atmosphere is to obtain improved viewing.

Such instruments are costly and tend to be of relatively large size if they are to exceed the performance of the 200 inch reflector at Mount Palomar. Hopes of any unit of suitable size being put into space seemed to be linked to the advent of the space shuttle since the greatest single weight unit is the mirror.

A solution to the problem has been offered by J. Wilczynski of IBM. He suggests that two mirrors 20 inches in diameter could be put into orbit in such a way that the resolution of the 200 inch telescope could be achieved.

The new telescope would consist of two mirrors arranged to have a common focus by mounting them on a common arm which could be rotated with great precision. The image through the two mirrors would be photographed and the position changed. This would continue until the whole area was covered. By this means any point on any picture would be mathematically related to any other.

Readout—

A SELECTION FROM OUR POSTBAG

Correspondents wishing to have a reply must enclose a stamped addressed envelope. We regret we are unable to guarantee a reply on matters not relating to articles published in the magazine. Technical queries cannot be dealt with on the telephone.

Prior notice please!

Sir—Referring to the correspondence published in your July issue, one of the answers to the general problem of constructors being unable to obtain components, is for the authors of the articles in your magazine and others, to ensure that all components are currently obtainable at the time of issue. The name of the manufacturer of specialised components, including semiconductors should be mentioned, as also sources of supply.

In agreement with Mr P. F. Clarke, prior notice to suppliers would ensure that specialised components could be available within a reasonable time from the date of publication of a constructional article.

My firm is able to supply any component manufactured by Mullard Ltd., on a one-off basis, and this covers many thousands of individual items.

For Mr A. J. Sanders, the components he requires in the way of ferrites and associated hardware, can be supplied off the shelf.

I sympathise with Mr H. Boys of Weedon regarding the Mullard LA 2103 which is obsolete, the number having been changed twice since 1968.

I cannot understand Mr Easterfield's difficulties in obtaining Radiospares components, as all items in their catalogue (available to the trade only) can be supplied to retailers generally throughout the country on the day after an order is placed.

A. F. Trinder,
Gurney's (Radio) Ltd.

Reckless design

Sir—We agree that the points you have raised constitute real problems to the amateur constructor. We would, however, like to make the following comments:

Amateurs often obtain components for their circuits from unusual sources, i.e. cannibalising surplus equipment and by buying from surplus dealers. This means that very often the manufacturer is approached for components which are either obsolete or have been made for a specific purpose against a specific contract.

We as a company are in the process of appointing distributors for our components and would suggest that prior to publishing circuits the designer contacts either ourselves or one of our distributors so as to ascertain the availability.

We would mention that we would expect our distributors to deal not only with industrial customers but with amateur customers as well. It is probable, however, that there would be minimum order charges.

If this kind of liaison could be built up, it should in theory then be possible to arrange for our distributors to hold stocks of particular items, and in fact we see no reason why there should not be some reference at the end of the article as to where the components could be obtained.

We are sympathetic towards amateurs as very often amateur designed circuits eventually become professional circuits, but we do consider that some amateurs are reckless in the extreme by designing circuits without having made sure that the components are available.

The other point we would like to make, is that as manufacturers it is really not a practical proposition for us to deal direct with amateurs, as they only usually require very small quantities and the cost of processing their orders costs more than the goods. This of course emphasises the need for distributors.

J. N. Shipton,
Siemens (United Kingdom) Ltd.

Inadequate details

Sir—I refer to the letter published in the May issue concerning the supply of components to electronic enthusiasts.

In my experience the main problems encountered when dealing with private individuals are exactly those outlined by Mr Hughes. Firstly, ascertaining the exact component required and secondly arranging payment. Often orders give inadequate details and describe the application instead of the component which, rather than enter into correspondence, we tend to reject.

The remedy is for anyone requiring our components to detail accurately the unit required, preferably the type number, but if this is

unknown, the value, working voltage, tolerance, size, etc., and; if the price is also unknown to request a Pro Forma Invoice.

On receiving an order in this form, our Distributor Division will be pleased to supply anyone subject to the following conditions which are necessary to cover the cost of non-standard clerical routines and to protect against the unfavourable economics of special small quantity manufacture:—

1. The order has a minimum value of £3.

2. The component required is in stock or available from Work-in-Progress.

Our Distributor Division carries a broad selection of Eric products, manufactured both in the U.K. and overseas, including ceramic, monolithic and trimmer capacitors, r.f.i. suppression filters, semiconductors and integrated circuits, and is able to provide on request full details of its stock programme.

While appreciating that we can only satisfy in part the demand for specialised, new or non-standard items, we can, if given a business-like order, extend considerably the variety of Eric products previously available to the enthusiast.

R. D. Hurrell,
Distribution Manager,
Eric Electronics Ltd.

Good relations

Sir—I hope I am not too late in replying to your editorial in PRACTICAL ELECTRONICS May issue, which at the same time was related to a letter in *Readout* from M. J. Hughes.

On behalf of our company we would be very pleased to help those electronic enthusiasts who are having trouble in obtaining semiconductors. As stockists for many components we may well be able to offer some of those rather special parts which people need from time to time.

In Worcester we have already served a number of amateur radio enthusiasts with their "ones and twos" requirements and we see no reason why this should not be extended to those other branches of electronics which need similar parts.

As a licensed "ham" I appreciate the feelings of those unable to complete a project for the want of a small part. If readers care to send us their "wants lists", particularly for all types of semiconductors, integrated circuits, capacitors, miniature transformers and so on, we should be glad to do our best to help. What we value most is a satisfied customer whether he buys one part or one thousand, and we have no minimum order charge on those goods we actually hold in stock.

R. C. Evans, G3LQC,
Thorp Electronic Components Ltd.

TTCC-1051 Meter

Miniaturised version of Model C-1052 employing similar ultra compact slimline impact resistant cabinet. Features—large easy to read 1 1/2 in meter with mirror scale, D'Arsonval movement. Overload protection circuit. Fine calibration gives extremely high standard of accuracy on all ranges. Ohms zero adjustment. Click-stop range selection switch. Colour coded scales.

- DC/V: 0.3 15 150 300 1.2kV at 20k/ohms/V
- AC/V: 0.6 30 300 1.3kV at 10k/ohms/V
- DC current: 0-60μA - 300mA
- Resistance: 0-60k - 6M/ohms
- Decibels: -20dB to +17dB
- Complete with battery and test leads



LASKY'S PRICE £4.25 POST 18p

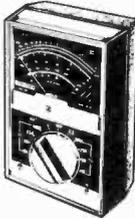
EXCLUSIVE TM-1

MODEL TM-1 MINI-TESTER

The first of Lasky's new-look top value meters, the TM-1 is a really tiny pocket multimeter providing "big" meter accuracy and performance. Precision movement calibrated to 3 in of full scale. Click stop range selection switch. Beautifully designed and made impact resistant black case with white and metallic red/green figuring. Ohms zero adjustment.

Size Only

- DC/V: 0-100-250-1,000 at 1k OPV
- AC/V: 0-10-50-250-1,000 at 1k OPV
- DC CURRENT: 0-1mA, 100mA
- Resistance: 0-150k
- Decibels: -10dB to 22dB
- Complete with test leads, battery and instructions



LASKY'S PRICE £1.95 POST 13p

TM-5 5K ohms/V POCKET MULTIMETER

Another new look pocket multimeter from Lasky's providing top quality and value. The "slimline" impact resistant case, size 4 1/2 in X 2 1/2 in X 1 1/2 in, fitted with extra large 2 1/2 in square meter. Readability is superior on all low ranges; making this an excellent instrument for servicing transistorised equipment. Recessed click stop selection switch. Ohms zero adjustment. Buff finish with crystal clear meter cover.

- DC/V: 3-15-150-300-1,200 at 5k OPV
- AC/V: 6-30-300-600 at 2.5k OPV
- DC Current 0-300μA, 0-300mA
- Resistance: 0-10k/ohms, 0-1M ohm
- Decibels: -10dB to +16dB
- Complete with test leads, battery and instructions.

LASKY'S PRICE £2.95 POST 13p

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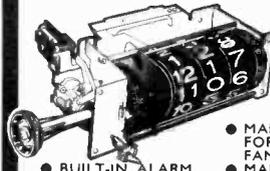
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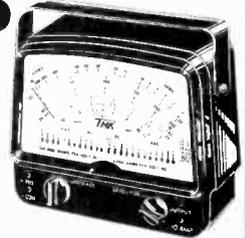
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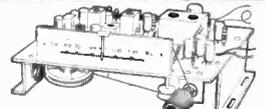
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AC115	23p	AF117	17p	BC142	45p	BCY33	17p	BF274	30p	MAT100	15p	ST140	12p	2N930	25p	2N2904A	30p	2N3706	12p
AC125	17p	AF118	30p	BC143	40p	BCY34	20p	BF308	35p	MAT101	17p	ST141	17p	2N931	20p	2N2905	30p	2N3707	12p
AC126	17p	AF124	21p	BC145	45p	BCY70	17p	BF309	37p	MAT120	15p	T1543	40p	2N932	22p	2N2905A	30p	2N3708	8p
AC127	17p	AF125	20p	BC147	17p	BCY71	30p	BF316	30p	BF316	30p	MAT121	17p	2N933	27p	2N2906	25p	2N3709	8p
AC128	17p	AF126	20p	BC148	12p	BCY72	15p	BFV10	15p	MPF102	43p	V405A	25p	2N934	20p	2N2906A	27p	2N3710	10p
AC141K	17p	AF127	20p	BC149	17p	BCZ11	20p	BFX29	27p	MPF105	30p	OC19	30p	2N935	20p	2N2907	25p	2N3711	10p
AC142K	17p	AF139	33p	BC150	17p	BD121	85p	BFX84	20p	OC19	30p	2G301	19p	2N936	22p	2N2907A	30p	2N3711A	10p
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AC155	17p	AF180	50p	BC153	27p	BD131	80p	BFX87	25p	OC23	33p	2G304	20p	2N939	20p	2N2910	25p	2N3714	10p
AC156	17p	AF191	50p	BC134	30p	BD132	80p	BFX88	22p	OC24	45p	2G306	35p	2N940	20p	2N2911	25p	2N3715	10p
AC157	17p	AF186	45p	BC137	20p	BDY20	£1	BFY50	20p	OC25	25p	2G308	35p	2N941	20p	2N2912	25p	2N3716	10p
AC165	17p	AF239	37p	BC158	17p	BF115	22p	BFY51	20p	OC26	25p	2G309	35p	2N942	20p	2N2913	25p	2N3717	10p
AC166	17p	AF211	37p	BC159	20p	BF117	45p	BFY52	20p	OC28	40p	2G339	40p	2N943	20p	2N2914	25p	2N3718	10p
AC167	20p	AFZ12	45p	BC167	13p	BF118	60p	BFY53	17p	OC29	40p	2G339A	15p	2N944	20p	2N2915	25p	2N3719	10p
AC168	20p	AL102	85p	BC168	13p	BF119	70p	BSX19	15p	OC35	33p	2G344	15p	2N945	20p	2N2916	25p	2N3720	10p
AC169	14p	AL103	85p	BC169	13p	BF152	35p	BSX20	15p	OC36	40p	2G345	15p	2N946	20p	2N2917	25p	2N3721	10p
AC176	23p	ASV26	30p	BC170	13p	BF153	35p	BSY25	15p	OC41	20p	2G371	13p	2N947	20p	2N2918	25p	2N3722	10p
AC177	20p	ASV27	30p	BC171	13p	BF154	35p	BSY26	15p	OC42	22p	2G371B	10p	2N948	20p	2N2919	25p	2N3723	10p
AC187	30p	ASV28	25p	BC172	13p	BF157	45p	BSY27	15p	OC44	15p	2G374	17p	2N949	20p	2N2920	25p	2N3724	10p
AC188	30p	ASV29	25p	BC173	13p	BF158	25p	BSY28	15p	OC45	12p	2G377	17p	2N950	20p	2N2921	25p	2N3725	10p
ACY17	25p	ASV50	25p	BC174	13p	BF159	30p	BSY29	15p	OC70	15p	2G378	15p	2N951	20p	2N2922	25p	2N3726	10p
ACY18	20p	ASV51	25p	BC175	22p	BF160	30p	BSY38	15p	OC71	9p	2G382	15p	2N952	20p	2N2923	25p	2N3727	10p
ACY19	22p	ASV52	25p	BC177	17p	BF162	30p	BSY39	15p	OC72	13p	2G401	30p	2N953	20p	2N2924	25p	2N3728	10p
ACY20	20p	ASV54	25p	BC178	17p	BF163	35p	BSY40	15p	OC74	12p	2G414	30p	2N954	20p	2N2925	25p	2N3729	10p
ACY21	18p	ASV55	25p	BC179	17p	BF164	35p	BSY41	15p	OC75	15p	2G417	25p	2N955	20p	2N2926	25p	2N3730	10p
ACY22	19p	ASV56	25p	BC180	20p	BF165	35p	BSY95	12p	OC76	15p	2N388	30p	2N956	20p	2N2927	25p	2N3731	10p
ACY27	18p	ASV57	25p	BC181	22p	BF167	22p	BSY95A	12p	OC77	25p	2N388A	30p	2N957	20p	2N2928	25p	2N3732	10p
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ACY29	30p	ASV58	25p	BC182L	10p	BF176	35p	CI11E	60p	OC81D	15p	2N404A	30p	2N959	20p	2N2930	25p	2N3734	10p
ACY30	25p	ASZ21	40p	BC183	10p	BF177	35p	C400	30p	OC82	15p	2N404A	30p	2N960	20p	2N2931	25p	2N3735	10p
ACY31	25p	BC107	10p	BC183L	10p	BF178	45p	C407	25p	OC82D	15p	2N527	60p	2N961	20p	2N2932	25p	2N3736	10p
ACY34	18p	BC108	10p	BC184	13p	BF179	50p	C424	17p	OC83	20p	2N696	12p	2N962	20p	2N2933	25p	2N3737	10p
ACY35	18p	BC109	11p	BC184L	13p	BF180	30p	C425	40p	OC84	20p	2N697	15p	2N963	20p	2N2934	25p	2N3738	10p
ACY36	30p	BC113	25p	BC186	27p	BF181	30p	C426	30p	OC139	15p	2N698	24p	2N964	20p	2N2935	25p	2N3739	10p
ACY40	15p	BC114	30p	BC187	27p	BF182	30p	C428	20p	OC140	17p	2N699	55p	2N965	20p	2N2936	25p	2N3740	10p
ACY41	18p	BC115	30p	BC207	11p	BF183	30p	C441	27p	OC170	15p	2N706	7p	2N966	20p	2N2937	25p	2N3741	10p
ACY44	35p	BC116	35p	BC209	11p	BF184	30p	C442	35p	OC171	15p	2N706A	7p	2N967	20p	2N2938	25p	2N3742	10p
AD140	40p	BC117	35p	BC209	11p	BF185	30p	C444	37p	OC200	25p	2N708	45p	2N968	20p	2N2939	25p	2N3743	10p
AD142	40p	BC118	25p	BC212L	11p	BF188	30p	C450	17p	OC201	27p	2N709	40p	2N969	20p	2N2940	25p	2N3744	10p
AD149	43p	BC119	45p	BC213L	11p	BF194	23p	C720	12p	OC202	27p	2N711	40p	2N970	20p	2N2941	25p	2N3745	10p
AD161	35p	BC125	35p	BC213L	11p	BF195	24p	C722	25p	OC203	25p	2N717	42p	2N971	20p	2N2942	25p	2N3746	10p
AD162	35p	BC126	35p	BC214L	12p	BF196	30p	C740	25p	OC204	25p	2N718	24p	2N972	20p	2N2943	25p	2N3747	10p
AD161		BC132	25p	BC225	25p	BF197	35p	C742	17p	OC205	35p	2N718A	50p	2N973	20p	2N2944	25p	2N3748	10p
16Z(HP)	63p	BC134	30p	BC226	35p	BF200	45p	C744	17p	OC309	35p	2N726	27p	2N974	20p	2N2945	25p	2N3749	10p
ADT140	50p	BC135	30p	BC317	12p	BF222	80p	C760	17p	P346A	17p	2N727	27p	2N975	20p	2N2946	25p	2N3750	10p
ADZ11	£2	BC136	30p	BC318	12p	BF257	35p	C762	17p	P397	45p	2N743	17p	2N976	20p	2N2947	25p	2N3751	10p
ADZ12	£2.10	BC137	35p	BC319	12p	BF270	25p	C764	60p	OCP71	43p	2N744	17p	2N977	20p	2N2948	25p	2N3752	10p
AF114	17p	BC139	45p	BCY30	20p	BF271	17p	CE401	15p	ORP12	43p	2N914	17p	2N978	20p	2N2949	25p	2N3753	10p

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40p	BA126	22p	BYZ16	35p	OAG1	7p
42p	BY100	15p	BYZ17	35p	OAG5	7p
15p	BY101	12p	BYZ18	30p	OA200	6p
50p	BY105	15p	BYZ19	25p	OA202	7p
27p	BY114	12p	OA5	17p	SO10	4p
27p	BY126	15p	OA10	22p	SO19	4p
17p	BY127	15p	OA47	7p	IN914	6p
17p	BY130	15p	OA70	7p	IN916	6p
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Duty bound

Sir—I am following with considerable interest the correspondence and your remarks in P.E. relating to supplies of special electronic components to the amateur.

It may be of interest to your readers to know that the British Amateur Electronics Club appears to anticipate the demand by amateurs in some cases. This is probably because we are an amateur organisation, and the problems relating to minimum economical orders do not apply.

As an example, when the British Amateur Electronics Club started in 1966, silicon controlled rectifiers available in this country were very expensive. However, the B.A.E.C. was able to obtain good quality SCR's in America at very low prices, even after paying duty and additional postage.

Members of the B.A.E.C. are able to obtain specialised electronic components either at cost or, if they are required for experimental purposes and the member undertakes to write an article on his experiments for the B.A.E.C. Newsletter, they are provided free of charge.

The B.A.E.C. has recently been able to obtain very cheap but perfect voltage regulator integrated circuits and also inexpensive infrared and visible-light semiconductor generators (L.E.D.) and receivers (photo-transistors).

These, as you know, are available in this country at relatively high prices, but I think that if any supplier in this country, who is interested in the amateur market, were to study the advertisements in amateur electronic magazines published in America, they, too, would be able to supply sophisticated and up-to-date electronic devices at reasonable prices to the amateur.

However, this does not apply to the well-known SN74 TTL integrated circuits which are in fact cheaper in this country than in America.

C. Bogod,
British Amateur Electronics Club

Opposite view

Sir—Having been a home constructor for a number of years, I would like to present the opposite view in your correspondence on the subject of components, and their availability.

I have rarely, if ever, experienced difficulty in obtaining components I require, even by mail order. Having lived in an area close to the majority of component retailers, I received, with few exceptions, courteous assistance and good service during personal buying of parts.

As I am no longer able to shop personally, due to a change of resi-

dence to another area of the country, I have, for the past year been buying by mail. Parcels received have been well packed, again with few exceptions, and refunds for out of stock items cheerfully and promptly given. In the case of the exceptions, a simple, well worded letter of complaint direct to the sales manager has usually cleared matters in a fortnight or less.

Considering the amount of business done by mail order, it is surprising that the service of most retailers is as good as it is, indeed, it could be far worse.

While I would also concur with the view that "one-offs" and highly specialised components are a loss maker for the firm who are prepared to deal with them, I would express surprise that the people who complain about being unable to obtain them, while deeming themselves capable of constructing, testing and setting to work a piece of often complex equipment, are unable to write to suppliers for their catalogues and find a replacement.

The one possible exception to the last paragraph is the amateur radio enthusiast, who, following the demise of the only manufacturer (Electroniques) in the country supplying r.f. coils to tune the amateur bands, has the dubious choice between bodging commercially available coils or winding his own.

To conclude, if components cannot be bought, begged or borrowed for the special project, there is a solution—set up in business and supply your own components!

P. J. Brent,
Helensburgh,
Scotland.

Final tip

Sir—I have just received PRACTICAL ELECTRONICS magazine July issue, and after reading *Readout* I cannot understand why a number of your readers have such a problem trying to obtain parts for various circuits.

For instance, a 6-pole 5-way switch (letter on page 585), an advertisement for this appears on the opposite page 584, I think that a lot of readers do not take enough trouble to read the various advertisement pages for items wanted.

I have always found most manufacturing companies or large distributors very helpful regarding where to obtain special parts providing you keep your request brief, enclose an s.a.e. and make sure that your letter can be read.

A final tip, always keep by your side a number of catalogues from various companies, this can make life a lot easier.

D. J. Brown,
Coventry.



CLAIM!

I have information which may help Sheriff Maynes-Humm, our lively guardian of the peace. Last night I was standing on the Wheatstone Bridge on the Newton by-pass near to the p-n junction. I had been to the "Silicon" chip shop to bring some feedback when Current passed me at some speed. He showed no sign of stopping and in the minority carrier on his megacycle I noticed the mentioned joules.

May I say that the frequency of this type of crime committed by Current is something that, socially, Hertz. I recall that not long ago the same thing happened to two other pretty dynes, the lovely Cath Ode and her cooler sister An Ode.

It is to be hoped that all who know the much loved Milli will help to get back to health, transformer situation, and insulator from any future attacks. Watts more, I trust that Current will be put on charge and if not given the potential drop then made to walk the Planck.

I am sorry if my reaction seems unusually strong but the core of the matter is that Eddy Current is one of my two ill-begotten sons who have always wasted energy. I could never control them and many are the times that I have had to cover up for them. But to no avail, and matters that for Eddy and his equally heated brother I squared no losses. This has always peaked me and as far as I am concerned both are transients.

R. M. S. Current,
Waverley.

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1/4	5%	4.7Ω-2.2MΩ	E24	1.0p	0.8p
1/4	10%	3.3MΩ-10MΩ	E12	1.0p	0.8p
1/4	10%	1Ω-3.9Ω	E12	1.0p	0.8p
1/4	5%	4.7Ω-1MΩ	E12	1.0p	0.8p
4	10%	1Ω-10Ω	E12	7.5p	7.5p

Quantity price applies for any selection. Ignore fractions on total order.

DEVELOPMENT PACK

0.5 watt 5% Iskra resistors 5 off each value 4.7Ω to 1MΩ.
E12 pack 325 resistors £2.50.
E24 pack 650 resistors £4.80.

MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0.001μF, 0.0015μF, 0.0022μF, 0.0033μF, 0.0047μF, 2.2p, 0.0068μF, 0.01μF, 0.015μF, 0.022μF, 0.033μF, 3p, 0.047μF, 0.068μF, 0.1μF, 4p, 0.15μF, 6p, 0.22μF, 7.5p, 0.33μF, 11p, 0.47μF, 13p.
160V: 0.01μF, 0.015μF, 0.022μF, 0.033μF, 0.047μF, 0.068μF, 3p, 0.1μF, 0.15μF, 0.22μF, 4p, 0.33μF, 6p, 0.47μF, 7.5p, 0.68μF, 11p, 1.0μF, 12.5p.

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0.01μF, 0.015μF, 0.022μF, 3p, 0.033μF, 0.047μF, 0.068μF, 3.5p, 0.1μF, 4p, 0.15μF, 0.22μF, 5p, 0.33μF, 6.5p, 0.47μF, 8.5p, 0.68μF, 11p, 1.0μF, 13p.

MYLAR FILM CAPACITORS

100V: 0.001μF, 0.002μF, 0.005μF, 0.01μF, 0.02μF, 2.5p, 0.04μF, 0.05μF, 0.068μF, 0.1μF, 3.5p.

CERAMIC DISC CAPACITORS

100pF to 10,000pF, 2p each.

CAPACITOR DEVELOPMENT PACK

Selection of 100 ceramic and polyester capacitors, 100pF to 1.0μF, £2.90.

ELECTROLYTIC CAPACITORS—One Price—5p Each

Mullard C426 series (μF/V): 25/6.4, 50/6.4, 100/6.4, 200/6.4, 320/6.4, 16/10, 32/10, 64/10, 125/10, 200/10, 10/16, 20/16, 40/16, 80/16, 125/16, 6.4/25, 12.5/25, 25/25, 50/25, 80/25, 4/40, 8/40, 16/40, 32/40, 50/40, 2.5/64, 5/64, 10/64, 32/64.
Miniature P.C. mounting (μF/V): 10/12, 50/12, 100/12, 200/12, 5/25, 10/25, 25/25, 100/25.

POTENTIOMETERS

Carbon track 5kΩ to 1MΩ, log or linear (log 1/4W, lin 1/4W). Single, 12p. Dual gang (stereo), 40p.

SKELETON PRESET POTENTIOMETERS

Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C. mounting (0.1 matrix). Sub-miniature 0.1 watt, 4p each. Miniature 0.25 watt, 5p each.

SEMICONDUCTORS

AC126	15p	BFY52	22p	OC81	15p	2N3055	72p
AC127	15p	BSY56	30p	OC82	15p	2N3702	15p
AC128	15p	BSX21	25p	ORP12	47p	2N3703	14p
AD140	40p	BY124	7.5p	IN4001	7.5p	2N3704	17.5p
AF115	17.5p	BY210	30p	IN4002	10p	2N3705	15p
AF117	17.5p	BY213	20p	IN4003	11p	2N3706	12p
BC107	14p	OA95	7.5p	IN4004	12.5p	2N3707	18.5p
BC108	10p	OA91	7.5p	IN4005	14p	2N3708	10p
BC109	10p	OA202	7.5p	IN4006	15p	2N3709	11p
BFY50	22p	OC71	15p	IN4007	16p	2N3710	12p
BFY51	19p	OC72	15p	2N2926	11p	2N3711	14p

ZENER DIODES

400mW 5% 3.3V to 30V, 17p.

VEROBOARD

	0.1	0.15		0.15	0.1
2 1/2 x 3 1/2	22p	16p	17 x 3 1/2 (plain)	52 1/2p	—
2 1/2 x 5	24p	24p	17 x 2 1/2 (plain)	37 1/2p	—
3 1/2 x 3 1/2	24p	24p	2 1/2 x 5 (plain)	17 1/2p	—
3 1/2 x 5	27p	27p	2 1/2 x 3 1/2 (plain)	15p	—
17 x 2 1/2	75p	57 1/2p	Pin insertion tool	47 1/2p	47 1/2p
17 x 3 1/2	100p	75p	Spot face cutter	37 1/2p	37 1/2p
17 x 5 (plain)	—	75p	Pkt. 50 pins	20p	20p

ROTARY SWITCHES

2P2W, 1P12W, 2P6W, 3P4W, 4P3W, 22.5p.

PLUGS AND SOCKETS

Standard 1/4 in screened	17 1/2p	2.5mm insulated	7 1/2p
Standard 1/4 in insulated	14p	3.5mm insulated	7 1/2p
Stereo 1/4 in screened	35p	3.5mm screened	12 1/2p
Standard 1/4 in socket	15p	2.5mm socket	7 1/2p
Stereo 1/4 in socket	17 1/2p	3.5mm socket	7 1/2p

BRUSHED ALUMINIUM PANELS

12" x 6" = 25p; 12" x 2 1/2" = 10p; 9" x 2" = 7p.

C.W.O. please. Post and packing, please add 10p to orders under £2. Data sheets are available for most of the components listed, and will be sent free on request.

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Complete Installation Kit for 12-volt vehicles £12.95 + 35p P. & P. State earth polarity of vehicle POSITIVE or NEGATIVE earth. Unit Construction Kit also available for the radio electronics constructor £9.95 + 35p P. & P. The construction kit includes instructions and all components for wiring as positive or negative earth, and is complete with the stove enamelled steel case and aluminium base. All components are available separately.

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BUILD THIS WAH-WAH PEDAL KIT



AND SAVE £££'s

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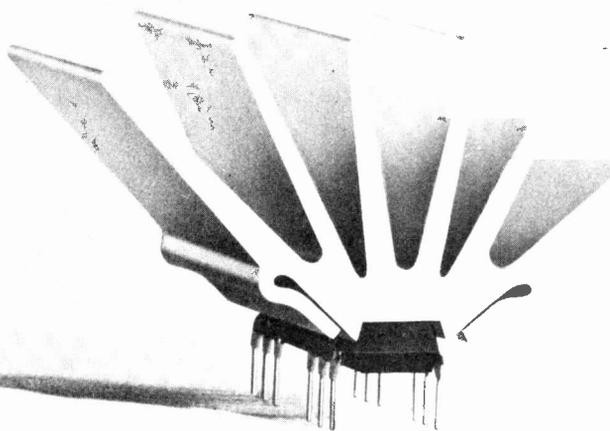
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The Wilsic Wah-Wah pedal comprises a SELECTIVE AMPLIFIER MODULE KIT, containing all the components to build a two transistor circuit module, which may be used by the constructor for his own design or fitted to the FOOT VOLUME CONTROL PEDAL (as photo) converting it to Wah-Wah operation. This pedal is in strong fawn plastic and fitted with output lead and screened plug.

new

Super IC-12



High fidelity Monolithic Integrated Circuit Amplifier

Two years ago Sinclair Radionics announced the World's first monolithic integrated circuit Hi-Fi amplifier, the IC.10. Now we are delighted to be able to introduce its successor, the Super IC.12. This 22 transistor unit has all the virtues of the original IC.10 plus the following advantages:

1. Higher power.
2. Fewer external components.
3. Lower quiescent consumption.
4. Compatible with Project 60 modules.
5. Specially designed built-in heat sink. No other heat sink needed.
6. Full output into 3, 4, 5 or 8 ohms.
7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

Output power 6 watts RMS continuous (12 watts peak).

Frequency Response 5 Hz to 100KHz \pm 1 dB.

Total Harmonic Distortion Less than 1%. (Typical 0.1%) at all output powers and all frequencies in the audio band.

Load Impedance 3 to 15 ohms.

Power Gain 90dB (1,000,000,000 times) after feedback.

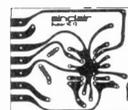
Supply Voltage 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).

Size 22 x 45 x 28 mm including pins and heat sink.

Input Impedance 250 Kohms nominal.

Quiescent current 8mA at 28 volts.

With the addition of only a very few external resistors and capacitors the Super IC.12 makes a complete high fidelity audio amplifier suitable for use with pick-up, F.M. tuner etc. Alternatively, for more elaborate systems, modules in the Project-60 range such as the Stereo 60 and A.F.U. may be added. The comprehensive manual supplied with each unit gives full circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include car radios, oscillators etc. The very low quiescent consumption makes the Super IC.12 ideal for battery operation.



Price, inc. FREE printed circuit board for mounting.

£2.98 Post free

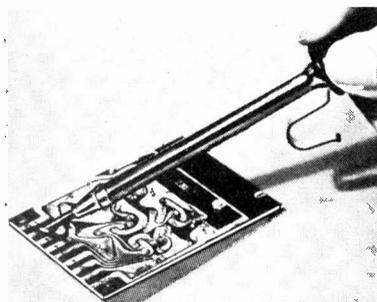
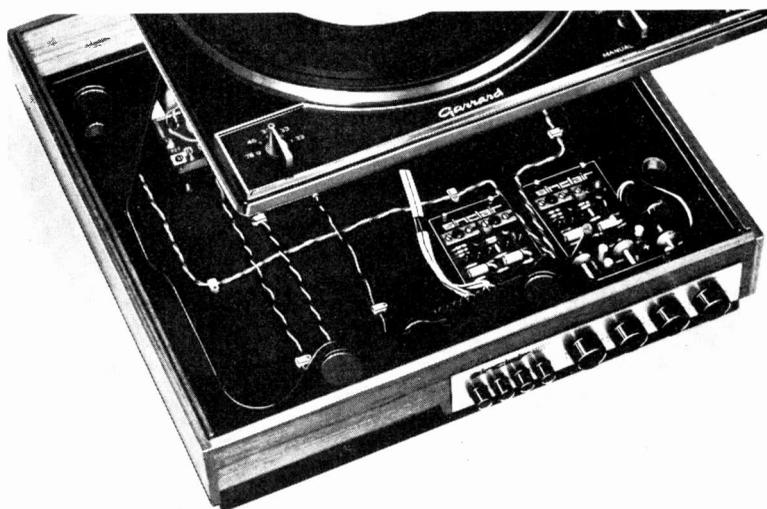
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Sinclair Project 60

The World's leading range of high fidelity modules



Project 60 offers more advantage to the constructor and user of high fidelity equipment than any other system in the world.

Performance characteristics are so good they hold their own with any other available system irrespective of price or size.

Project 60 modules are more versatile – using them you can have anything from a simple record player or car radio amplifier to a sophisticated and powerful stereo tuner-amplifier. Either power amplifier can be used in a wide variety of applications as well as high fidelity. The Stereo 60 pre-amplifier control unit may also be used with any other power amplifier system, as can the AFU filter unit. The stereo FM tuner operates on the unique phase lock loop principle to provide the best ever standards of sensitivity and audio quality. Project 60 modules are very easily connected together by following the 48 page manual supplied free with all Project 60 equipment. The modules are great space savers too and are sold individually boxed in distinctive white and black cartons. With all these wonderful advantages, there remains the most attractive of all – price. When you choose Project 60 you know you are going to get the best high fidelity in the world, yet thanks to Sinclair's vast manufacturing resources (the largest in Europe) prices are fantastically low and everything you buy is covered by the famous Sinclair guarantee of reliability and satisfaction.

Typical Project 60 applications

System	The Units to use	together with	Cost of Units
Simple battery record player	Z.30	Crystal P.U., 12V battery volume control	£4.48
Mains powered record player	Z.30, PZ.5	Crystal or ceramic P.U. volume control etc.	£9.45
20 + 20 W. stereo amplifier for most needs	2 x Z.30s, Stereo 60, PZ.5	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	£23.90
20 + 20 W. stereo amplifier with high performance spkrs.	2 x Z.30s, Stereo 60, PZ.6	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	£26.90
40 + 40 W. R.M.S. de-luxe stereo amplifier	2 x Z.50s, Stereo 60 PZ.8, mains trsfrmr	As above	£34.88
Indoor P.A.	Z.50, PZ.8, mains transformer	Mic., guitar, speakers, etc., controls	£19.43

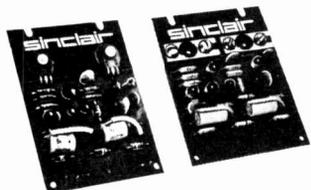
*F.M. Stereo Tuner (£25) & A.F.U. Filter Unit (£5.98) may be added as required.

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Tel: St. Ives (048 06) 4311

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from a simple amplifier to a complete stereo tuner amplifier with Project 60 modules

Z.30 & Z.50 power amplifiers



The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS (Z.50 units are interchangeable with Z.30s in all applications).

Power Outputs

Z.30 15 watts R.M.S. into 8 ohms using 35 volts; 20 watts R.M.S. into 3 ohms using 30 volts.

Z.50 40 watts R.M.S. into 3 ohms using 40 volts; 30 watts R.M.S. into 8 ohms using 50 volts.

Frequency response: 30 to 300,000Hz \pm 1dB.

Distortion: 0.02% into 8 ohms.

Signal to noise ratio: better than 70dB unweighted.

Input sensitivity: 250mV into 100 Kohms.

For speakers from 3 to 15 ohms impedance.

Size: 14 x 80 x 57 mm.

Z.30

Built, tested and guaranteed with circuits and instructions manual. **£4.48**

Z.50

Built, tested and guaranteed with circuits and instructions manual. **£5.48**

Power Supply Units

Designed special for use with the Project 60 system of your choice. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stabilised supply is essential.

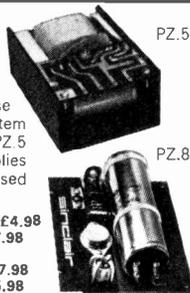
PZ.5 30 volts un stabilised **£4.98**

PZ.6 35 volts stabilised **£7.98**

PZ.8 45 volts stabilised

(less mains transformer) **£7.98**

PZ.8 mains transformer **£5.98**



Project 60 Stereo F.M. Tuner



First in the world to use the phase lock loop principle

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Good reception is possible in difficult areas, and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108 MHz. **Capture ratio:** 1.5dB. **Sensitivity:** 2 μ V for 30dB quieting; 7 μ V for full limiting. **Squelch level:** 20 μ V. **A.F.C. range:** \pm 200 KHz. **Signal to noise ratio:** > 65dB. **Audio frequency response:** 10 Hz—15 KHz (\pm 1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2 μ V. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S.

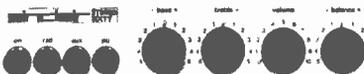
Operating voltage: 25-30 VDC. **Indicators:** Mains on; Stereo on; tuning.

Size: 93 x 40 x 207 mm.

Built and tested. Post free.

£25

Stereo 60 Pre-amp/control unit



Designed for Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

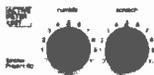
SPECIFICATIONS—Input sensitivities: Radio—up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A curve \pm 1dB: 20 to 25,000 Hz. Ceramic p.u.—up to 3mV; Aux—up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE + 15 to -15dB at 10 KHz; BASS + 15 to -15dB at 100Hz.

Front panel: brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207 mm.

Built tested and guaranteed.

£9.98

A.F.U. High & Low Pass Filter Unit



For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less

loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two filter stages—rumble (high pass) and scratch (low pass). Supply voltage—15 to 35V. Current—3mA. H.F. cut-off (-3dB) variable from 28KHz to 5KHz. L.F. cut-off (-3dB) variable from 25Hz to 100Hz. Distortion at 1 KHz (35V supply) 0.02% at rated output. **Size:** 66 x 40 x 90 mm.

Built tested and guaranteed.

£5.98

The Sinclair Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

To: SINCLAIR RADIONICS LTD LONDON ROAD ST. IVES HUNTINGDONSHIRE PE17 4HJ

Please send

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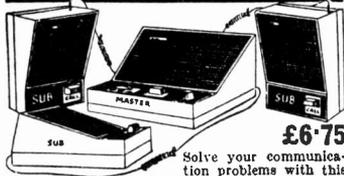
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AC128	20p	BYZ12	30p	NKT10519	22p	IN4148	7p
AC151	12p	BYZ13	20p	NKT20329		2G302	19p
AC176	25p	BZ2788/		0013	31p	2G371	15p
AC187	30p	C23	15p	NKT80111	67p	2G374	25p
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AC188	30p	C3V6	15p	NKT80113	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80114	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80115	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80116	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80117	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80118	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80119	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80120	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80121	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80122	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80123	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80124	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80125	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80126	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80127	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80128	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80129	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80130	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80131	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80132	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80133	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80134	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80135	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80136	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80137	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80138	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80139	83p	2N404	23p
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AC188	30p	C3V6	15p	NKT80142	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80143	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80144	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80145	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80146	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80147	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80148	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80149	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80150	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80151	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80152	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80153	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80154	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80155	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80156	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80157	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80158	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80159	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80160	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80161	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80162	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80163	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80164	83p	2N404	23p
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AC188	30p	C3V6	15p	NKT80166	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80167	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80168	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80169	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80170	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80171	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80172	83p	2N404	23p
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AC188	30p	C3V6	15p	NKT80199	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80200	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80201	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80202	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80203	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80204	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80205	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80206	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80207	83p	2N404	23p
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AC188	30p	C3V6	15p	NKT80209	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80210	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80211	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80212	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80213	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80214	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80215	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80216	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80217	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80218	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80219	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80220	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80221	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80222	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80223	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80224	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80225	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80226	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80227	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80228	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80229	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80230	83p	2N404	23p
AC188	30p	C3V6	15p	NKT80231	83p	2N404	23p
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AC188	30p	C3V6	15p	NKT80236	83p	2N404	23p
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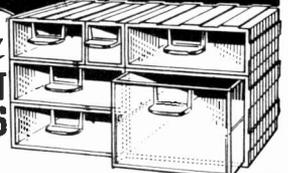
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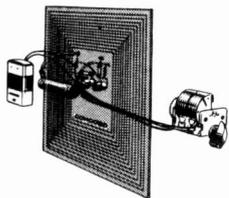
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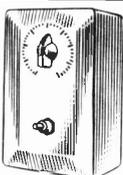
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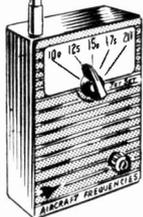


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100	0.25	0.33	0.53	0.58	0.63	1.40
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100	0.04	0.06	0.05	0.13	0.16	0.23	0.75
200	0.05	0.09	0.06	0.14	0.20	0.24	1.00
400	0.06	0.13	0.07	0.20	0.27	0.37	1.25
600	0.07	0.18	0.10	0.23	0.34	0.45	1.85
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Full Tested 1,000... 9.00
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ADI61 NPN

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T6	8 2G344A OC44
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U2	60 Mixed germanium transistors AF1RF	0.50
U3	75 Germanium gold bonded diodes sim. OA5, OA47	0.50
U4	40 Germanium transistors like OC81, AC128	0.50
U5	60 200mA sub-min. Sil. diodes	0.50
U6	30 Silicon planar transistors NPN sim. BSY95A, 2N706	0.50
U7	16 Silicon rectifiers Top-Hat 750mA up to 1,000V	0.50
U8	50 Sil. planar diodes 250mA, OA/200/202	0.50
U9	20 Mixed volts 1 watt Zener diodes	0.50
U11	30 PNP silicon planar transistors TO-5 sim. 2N1132	0.50
U13	30 PNP-NPN sil. transistors OC200 & 2B104	0.50
U14	150 Mixed silicon and germanium diodes	0.50
U15	25 NPN Silicon planar transistors TO-5 sim. 2N697	0.50
U16	10 3-Amp silicon rectifiers stud type up to 1000 PIV	0.50
U17	30 Germanium PNP AF transistors TO-5 like ACY 17-22	0.50
U18	8 6-Amp silicon rectifiers BYZ13 type up to 600 PIV	0.50
U19	25 Silicon NPN transistors like BC108	0.50
U20	12 1.5-Amp silicon rectifiers Top-Hat up to 1,000 PIV	0.50
U21	30 A.F. germanium alloy transistors 2G300 series & OC71	0.50
U22	30 Mat's like MAT series PNP transistors	0.50
U24	20 Germanium 1-Amp rectifiers GJM up to 300 PIV	0.50
U25	25 300Mc/s NPN silicon transistors 2N708, BSY27	0.50
U26	30 Fast switching silicon diodes like 1N914 micro-min	0.50
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U32	25 Zener diodes 400mW D07 case mixed volts, 3-18	0.50
U33	15 Plastic case 1 amp silicon rectifiers 1N4000 series	0.50
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U35	25 Sil. planar trans. PNP TO-18 2N3906	0.50
U36	25 Sil. planar NPN trans. TO-5 BFY50/51/52	0.50
U37	30 Sil. alloy trans. SO-2 PNP, OC200 2B322	0.50
U38	20 Fast switching sil. trans. NPN, 400Mc/s 2N3011	0.50
U39	30 RF germ. PNP trans. 2N1303/5 TO-5	0.50
U40	10 Dual trans. 6 lead TO-5 2N2060	0.50
U41	25 RF germ. trans. TO-1 OC45 NKT72	0.50
U42	10 VHF germ. PNP trans. TO-1 NKT687 AF117	0.50

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

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Coded GP100. BRAND NEW TO-3 CASE. POSS. REPLACEMENTS FOR—OC25-28-29-30-35-36, NKT401-403-404-405-406-451-452-453, T13027-3028, 2N250A, 2N456A-457A-458A, 2N511 A & B, 2G220-222, ETC.

SPECIFICATION VCB0 80V VCE0 50V IC 10A PT. 30 WATTS HFE 30-170. PRICE 1-24 25-99 100 up 43p each 40p each 30p each

GENERAL PURPOSE SILICON NPN POWER TRANSISTORS

Coded GP300. BRAND NEW TO-3 CASE. POSSIBLE REPLACEMENT FOR—2N3055, BDY20, BDY11.

SPECIFICATION VCB0 100V, VCE0 60V, IC 15AMPS, PT. 115 WATTS. Hfe 20-100. FTI MHZ. PRICE 1-24 25-99 100 up 55p each 50p each 47p each

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Q4	6 Matched trans. OC44/45/81/81D	0.50
Q5	4 OC75 transistors	0.50
Q6	4 OC72 transistors A.P.	0.50
Q7	4 AC126 trans. PNP high gain	0.50
Q8	7 OC81 type trans.	0.50
Q9	7 OC71 type trans.	0.50
Q10	2 AC127/128 comp. pairs PNP/NPN	0.50
Q12	3 AF116 type trans.	0.50
Q13	3 AF117 type trans.	0.50
Q14	3 OC111 H.F. type trans.	0.50
Q15	5 2N2926 sil. epoxy trans.	0.50
Q16	2 GCT860 low noise germ. trans.	0.50
Q17	3 PNP 1 8T141 & 2 8T140	0.50
Q18	4 Mat's 2 MAT 100 & 2 MAT 120	0.50
Q19	3 Mat's 2 MAT 101 & 1 MAT 121	0.50
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Q22	20 NKT trans. A.F. R.F. coded	0.50
Q23	10 OA202 sil. diodes sub-min.	0.50
Q24	8 OA81 diodes	0.50
Q25	6 1N914 sil. diodes 75PIV 75mA	0.50
Q26	8 OA80 germ. diodes sub-min. 1N697	0.50
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Q28	2 Sil. power rect. BYZ13	0.50
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Q32	3 PNP sil. trans. 2 x 2N1131, 1 x 2N1132	0.50
Q33	3 Sil. NPN trans. 2N1711	0.50
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Q35	3 Sil. PNP TO-5 2 x 2N2904 & 1 x 2905	0.50
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Q39	7 NPN trans. 4 x 2N3704, 3 x 2N3705	0.50
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BF04 = 7404	Hex Inverters	0-23	0-20	0-15
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BF13 = 7413	Dual 4-input Schmitt trigger	0-35	0-32	0-29
BF20 = 7420	Dual 4-input positive NAND gates	0-23	0-20	0-15
BF30 = 7430	8-input positive NAND gates	0-23	0-20	0-15
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BP95 = 7495	4-bit up-down shift register	0-87	0-77	0-67
BP96 = 7496	3-bit parallel in parallel out shift register	1-10	1-00	0-90
BF100 = 74100	8-bit bistable latches	1-75	1-65	1-55
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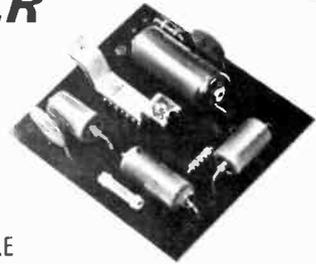
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UIC05 = 12 x 7405N 50p	UIC72 = 8 x 7472N 50p	UIC92 = 5 x 7492N 50p
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UIC20 = 12 x 7420N 50p	UIC74 = 8 x 7474N 50p	UIC94 = 5 x 7494N 50p
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Type No.	Case	Leads	Description	Price
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BP 701C—SL701C	TO-5	8	OP Amp	63p 50p 45p
BP 702C—SL702C	TO-5	8	OP Amp Direct OP	63p 50p 45p
BP 702—72702	D.I.L.	14	G.P. OP Amp (Wide Band)	53p 45p 40p
BP 709—72709	D.I.L.	14	High OP Amp	53p 45p 40p
BP 709P— μ A709C	TO-3	8	High Gain OP Amp	53p 45p 40p
BP 711— μ A711	TO-5	10	Dual comparator	58p 50p 45p
BP 741—72741	D.I.L.	14	High Gain OP Amp (Protected)	75p 60p 50p
μ A 703C— μ A703C	TO-5	6	R.F.—I.F. Amp	43p 35p 27p
TAA 263—	TO-72	4	A.F. Amp	70p 60p 55p
TAA 293—	TO-74	10	G.P. Amp	80p 75p 70p

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BP932	Expandable dual 4-input NAND buffer	25p 23p 20p
BP933	Dual 4-input expander	25p 23p 20p
BP935	Expandable Hex Inverter	25p 23p 20p
BP936	Hex Inverter	25p 23p 20p
BP944	Dual 4-input NAND expandable buffer without pull-up	25p 23p 20p
BP945	Master-slave JK or RS	35p 32p 29p
BP946	Quad, 2-input NAND	23p 20p 15p
BP948	Master-slave JK or RS	35p 32p 29p
BP954	Monostable	80p 85p 80p
BP955	Triple 3-input NAND	23p 20p 15p
BP9093	Dual Master-slave JK with separate clock	80p 75p 70p
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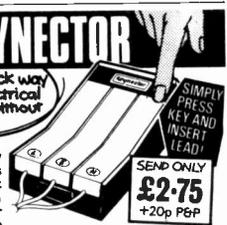
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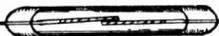
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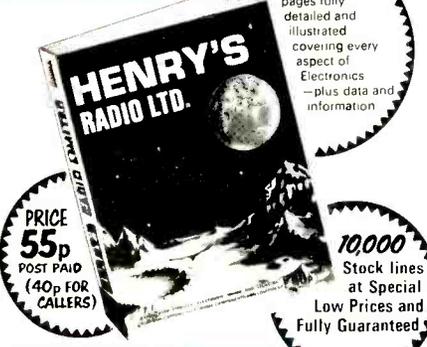
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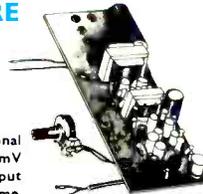
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