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SEPT. 81

60p

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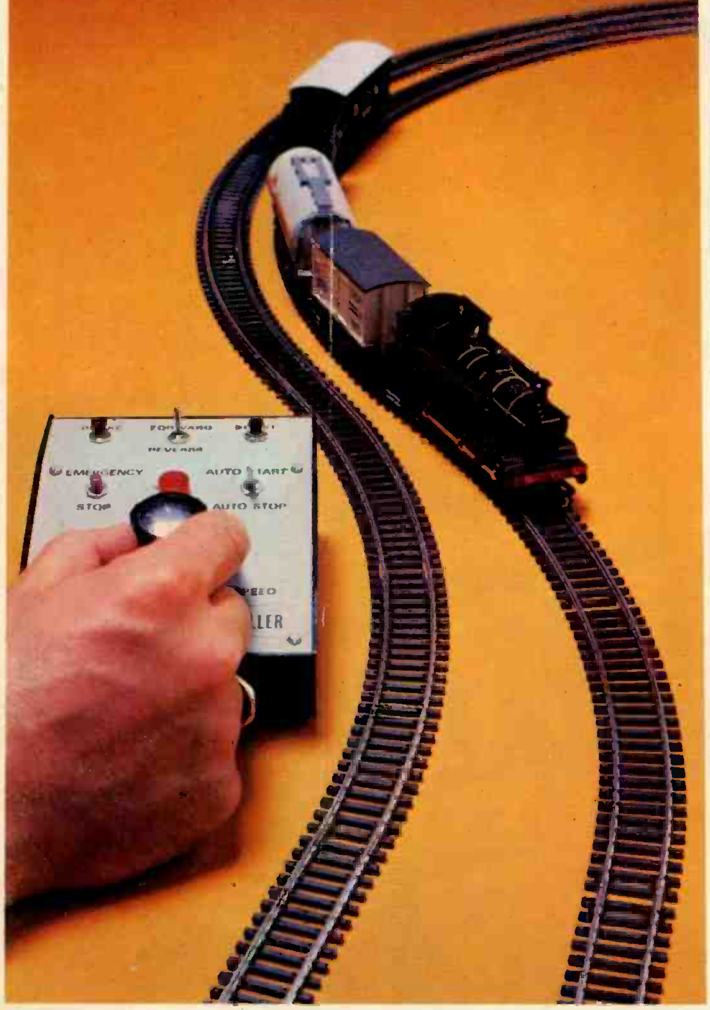

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SEC: 0 12V 0V 12V

TYPE	AMPS 12v	AMPS 24v	PRICE £	P/P £
213	1	0·50	2·65	0·87
71	2	1	2·77	1·10
18	4	2	3·98	1·43
68	3	1·5	3·46	1·43
85	5	2·5	6·06	1·43
70	6	3	6·67	1·43
108	8	4	8·03	1·43
72	10	5	8·66	1·73
116	12	6	9·31	1·90
17	16	8	11·46	2·05
187	30	15	19·23	2·35
232	40	20	27·61	4·50

15/30V RANGE PRI 220/240V
SEC: 0V 12V 15V 0V 5V 9V 15V
VOLTS AVAILABLE 3 → 15—0—15

TYPE	AMPS 15v	AMPS 30v	PRICE £	P/P £
112	1	0·50	2·84	1·10
79	2	1·0	3·29	1·10
3	4	2	6·18	1·43
20	6	3	7·19	1·73
21	8	4	8·52	1·73
51	10	5	10·57	1·90
117	12	6	11·94	2·05
88	16	8	16·14	2·20
89	20	10	18·54	2·35
90	24	12	20·57	2·55
91	30	15	23·63	2·65
92	40	20	33·21	4·50

25/50V RANGE PRI 120/220/240V
SEC: 0V 20V 25V 0V 8V 15V 25V
VOLTS OUT 5 → 25—0—25

TYPE	AMPS 24v	AMPS 50v	PRICE £	P/P £
102	1	0·50	3·29	1·43
103	2	1·0	4·09	1·43
104	4	2	7·65	1·73
105	6	3	9·09	1·90
106	8	4	12·24	1·90
107	12	6	16·15	2·20
118	16	8	22·46	2·55
119	20	10	27·05	2·55
109	24	12	32·44	4·50

30/60V RANGE PRI 120/220/240V
SEC: 0V 24V 30V 0V 10V 18V 30V
VOLTS 6 → 30—0—30

TYPE	AMPS 30v	AMPS 60v	PRICE £	P/P £
124	1	0·5	3·30	1·43
126	2	1	6·36	1·43
127	4	2	7·86	1·73
125	6	3	11·78	1·90
123	8	4	14·72	2·20
40	10	5	17·10	2·20
120	12	6	19·44	2·35
121	16	8	27·70	2·65
122	20	10	32·05	4·00
189	24	12	37·02	5·00

48/96V RANGE PRI 120/220/240V
SEC: 0V 36V 48V 0V 36V 48V
VOLTS 12 → 48—0—48

TYPE	AMPS 48v	AMPS 96v	PRICE £	P/P £
430	1	0·5	4·69	1·43
431	2	1	7·84	1·73
432	4	2	12·94	2·05
433	6	3	14·62	2·20
434	8	4	20·04	2·45
435	10	5	28·75	2·65
436	12	6	36·16	4·00
437	16	8	39·47	5·00

AUTOTRANSFORMERS 240/220—115V
65VA — 10 KVA
0V 115V 220V 240V

TYPE	VA	PRICE £	P/P £
25	65	3·90	1·10
64	80	4·82	1·10
4	150	6·21	1·43
69	250	7·54	1·43
53	350	9·73	1·90
67	500	11·70	2·20
83	750	13·51	2·05
84	1000	18·31	2·35
95	2KVA	34·36	5·00
73	3	64·74	5·00
57	5	97·85	6·50
101	10	179·05	10·00

CASED AUTOTRANSFORMERS
240V LEAD IN 115V 2PIN SOCKET OUT

TYPE	VA	PRICE £	P/P £
56W	20	6·60	0·87
64W	80	8·43	1·43
4W	150	10·86	1·73
69W	250	13·17	1·90
67W	500	20·46	2·20
84W	1000	30·24	2·55
95W	2000	54·83	5·00
73W	3000	78·67	6·50

LINE ADJUSTMENT AUTOTRANSFORMERS
0 200 210 220 230 240 250

TYPE	VA	PRICE £	P/P £
415C	50	2·31	0·87
416C	100	3·46	0·87
417C	200	4·00	1·10
418F	350	6·26	1·43
419F	500	6·74	1·73
420E	750	8·33	1·90
421F	1000	11·64	2·05

MAINS ISOLATORS (SAFETY SCREEN)
PRI 120/220/240V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

TYPE	VA	PRICE £	P/P £
149F	60	8·40	1·73
150F	100	9·71	1·73
151F	200	13·84	2·05
152F	250	16·69	2·20
153F	350	20·77	2·55
154F	500	26·03	2·65
155F	750	36·75	5·00
156F	1000	47·42	6·00

MAINS ISOLATORS (SAFETY SCREEN)
PRI 380/415/460V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

TYPE	VA	PRICE £	P/P £
243F	60	8·40	1·43
244F	100	9·76	1·73
245F	200	13·93	2·05
246F	250	16·69	2·20
247F	350	20·77	2·55
248F	500	26·03	2·65
249F	750	36·75	5·00
250F	1000	47·42	6·80

INVERTER
INV. 1. CASED
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P.C.B· 120/220/240V
0–12–0–12V

	PRICE	P/P
6VA—467 PCB	1·89	0·58
9VA—468 PCB	2·24	0·58
12VA—470 PCB	2·39	0·58
25VA—471 PCB	2·52	0·87
50VA—472 PCB	4·63	1·43

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BC107	10	BC547	10	2N3055	50
★BC108	8	BD131	35	★2N3702	6
★BC108C	10	BD132	35	★2N3704	6
BC109	10	BD139	35		

LINEAR

★741	15	LM380	80	NE556	55
CA3046	60	LM381	120	RC4136	90
CA3080	70	LM382	120	SN76477	150
★CA3130	75	LM1458	40	TL081	40
CA3140	45	LM3900	50	TL084	110
★ICM7555	80	★LM3914	200	XR2206	300
LF351	45	★LM3915	200	ZN414	100
LF356	90	LM13600	120	ZN425E	390
★LM324	40	NE555	17	TBA800	80

CAPACITORS

Polyester. Radial leads. C280 type. 0·01, 0·015, 0·022, 0·033, 6p; 0·047, 0·1, 7p; 0·15, 0·22, 9p; 0·33, 0·47, 13p; 1·0, 23p.
Electrolytic. Radial leads.
1/63V, 2·2/63V, 4·7/63V, 10/25V, 7p; 22/25V, 47/25V, 8p; 100/25V, 9p; 220/25V, 14p; 470/250V 20p; 1000/25V, 28p.

CONNECTORS

Jack	Plug	skt.	DIN	Plug	skt.
2·5mm	10p	10p	2 pin	9p	9p
3·5mm	10p	9p	3 pin	12p	10p
★Stand'd	12p	15p	5 pin 180	13p	11p

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★5mm green	12p
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BEST BUY

Your EVERYDAY ELECTRONICS will cost 70p as from next month's issue. Much as we regret the need for this increase we believe the contents are worth every penny of this by current values.

A good variety of projects, fully described in word and diagram, in-depth articles and series on components and other technical matters of direct interest to the constructor, special features for those making their very first cautious approach to electronics; all well leavened with news features plus entertaining and enlightening comments from seasoned and authoritative writers.

Such is the make-up of EVERYDAY ELECTRONICS and the reason it is the best buy for the constructor and general electronics enthusiast.

CURTAIN RAISER

Next month's issue is a real curtain raiser to the autumn season. For one, there is the first part of *Teach-In 82*. If you have recently come under the spell of electronics and are looking for a good course of instruction into the fundamentals of this subject, then *Teach-In 82* is just tailored for you. It will be a sound refresher course for those more experienced, as well.

All readers will receive a piece of Veroboard with their copy, and inside will be found a coupon that will save you £1 on the normal price of another Vero product.

All this—and a good variety of projects to keep you all busy. Don't leave the October issue to chance, but place an order with your supplier now.

F. G. RAYER

We were deeply dismayed to be informed of the death of F. G. Rayer which occurred last July. This was indeed a shock to me, for only the week previous I had been in communication with Frank concerning future projects.

Long accustomed to seeing his name in our pages, readers are bound to miss him, as will the staff of EE.

In the months ahead a number of previously completed articles of Frank's will be published in EE. But it is difficult to realise this well known author has now laid down his soldering iron and pen, has completed his final project and written his last article (see page 629).

Fred Bennett

Our October issue will be published on Friday, September 18. See page 607 for details.

Everyday ELECTRONICS

VOL. 10 NO. 9 SEPTEMBER 1981

CONSTRUCTIONAL PROJECTS

MODEL RAILWAY SPEED CONTROLLER *All signals go! by E. M. Terrell* **586**

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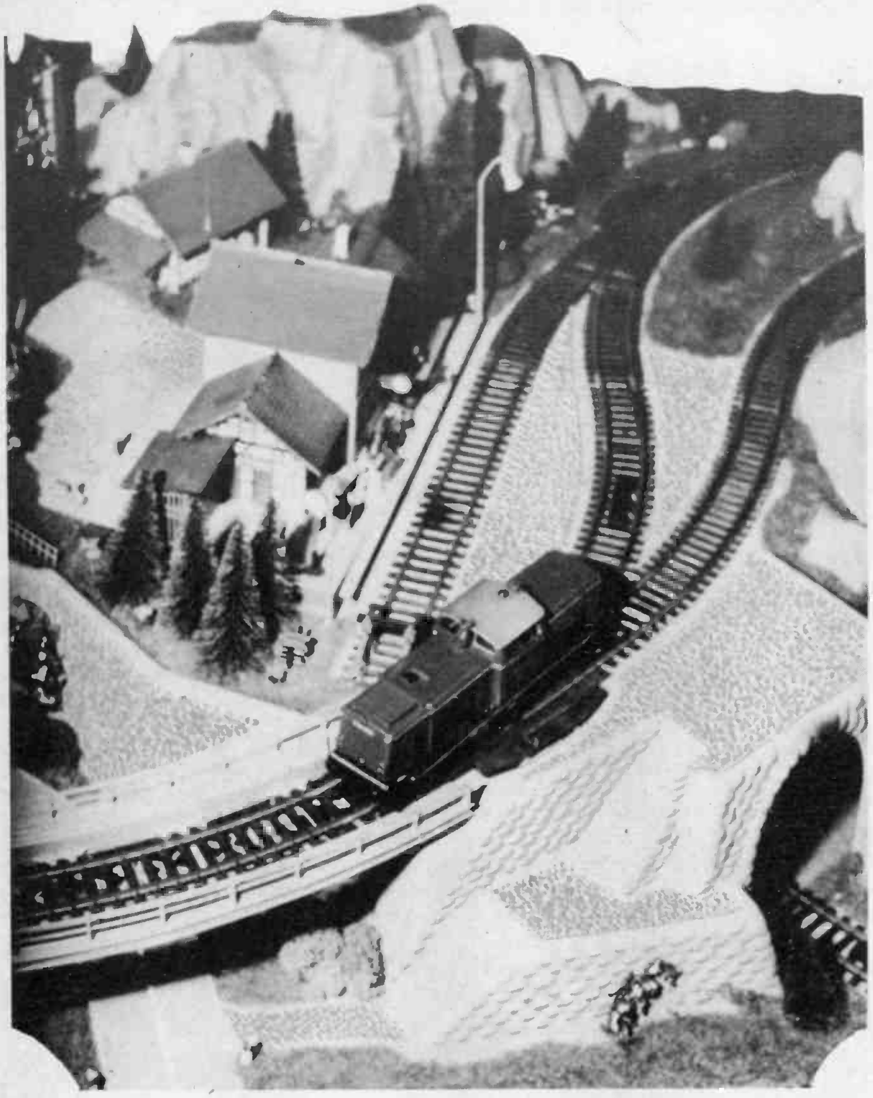
BY E.M.TERRELL



MODEL RAILWAY SPEED CONTROLLER

THE DESIGN for an easy to operate model train speed controller became apparent while watching a youngster find difficulty in selecting speed and direction of his model train on the track when using the controller supplied with the set-up.

This was a mains derived switchable type controller where a small red lever had three positions either side of central off. The train travelled progressively faster with its position from centre, forwards or backwards (according to lever direction).

The problem was that the lever could not always be re-positioned quickly and accurately, and a fast forwards to fast backwards would often result. What was needed was a continuous control of speed with minimum of effort, and a separate reversing switch.

CONTROL FUNCTIONS

The end product is the subject of this article. It is based on a pulse system and has the following features: (1) a single knob operated speed control, anticlockwise fully off, clockwise rotation increases speed up to maximum when fully clockwise (2) a FORWARD/REVERSE direction toggle switch (3) AUTO START and STOP for more realistic starting and stopping (4) BRAKE for slowing down on bends and steep gradients (5) Speed BOOST for extra momentum when meeting steep inclines (6) EMERGENCY STOP for immediate power cut.

With the prototype, the resident controller was not discarded but was used as the mains derived low voltage supply for the new Model Train Speed Controller. The resident controller output is full-wave rectified peaking at 20V (no load) in the fast position. Besides powering the locomotive, this is also used to derive the supply for the electronic control circuitry.

PRINCIPLE OF OPERATION

The operating principle is described with reference to the block diagram of Fig. 1.

The pulsing d.c. from the controller is smoothed to appear at the power switch. This smooth voltage level is stepped down and stabilised to provide a supply to the control circuitry.

The reference oscillator produces short duration negative going pulses at a constant time interval which are fed to the trigger input of a monostable multivibrator.

The periodic time of the oscillator must always be less than the monostable on-time. This on-time is controlled by the voltage appearing at its control input which is linked directly to the speed control knob and "auto" circuitry.

The monostable output operates an electronic switch which passes power to the track/train in sympathy. Thus the model train motor receives rectangular voltage pulses of maximum amplitude.

The mark-to-space ratio (on to off time) in a cycle is a measure of the "average" voltage seen by the train motor whose rotational speed is voltage dependent. Thus the mark/space ratio sets the train speed and since the former is variable over an extensive range, so is the train speed.

The advantage of a pulse system over variable voltage types is the smoothness obtained at slow speeds and its reduced dependence on loading.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Model Train Speed Controller is seen in Fig. 2. In the prototype the input voltage was taken from the output of the resident switchable controller which supplies a full-wave rectified voltage. In its fastest position, the voltage appearing across C1 is about 15 volts when the train is running.

This particular arrangement limits the number of trains running simultaneously to that allowed by the resident controller. However, the output stage is capable of passing current pulses of several amperes and this can be realised by simply hooking up a d.c. voltage source of suitable current capability to the input of the unit, smoothed or pulsed d.c. (full-wave rectified preferably).

A Zener stabiliser composed of R1 and D2 provides a 5·1 volt supply for IC1,2 and TR2. This allows a range of input supplies to be used from about 6 volts to 20 volts d.c. limited only by the rating of the train motor.

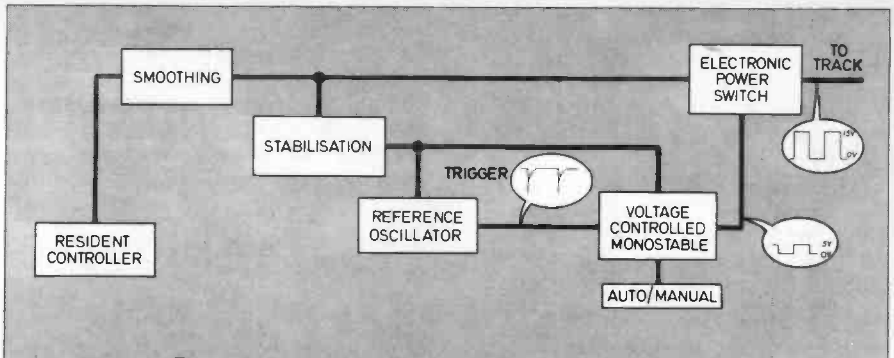


Fig. 1. Block diagram illustrating principle of operation.

IC1 is wired as a standard 555 timer astable multivibrator having a high mark/space ratio. Frequency is set by the values of R2, R3 and C2 and related by the formula.

$$f = \frac{0 \cdot 7}{(R2+2R3)C2} \text{Hz}$$

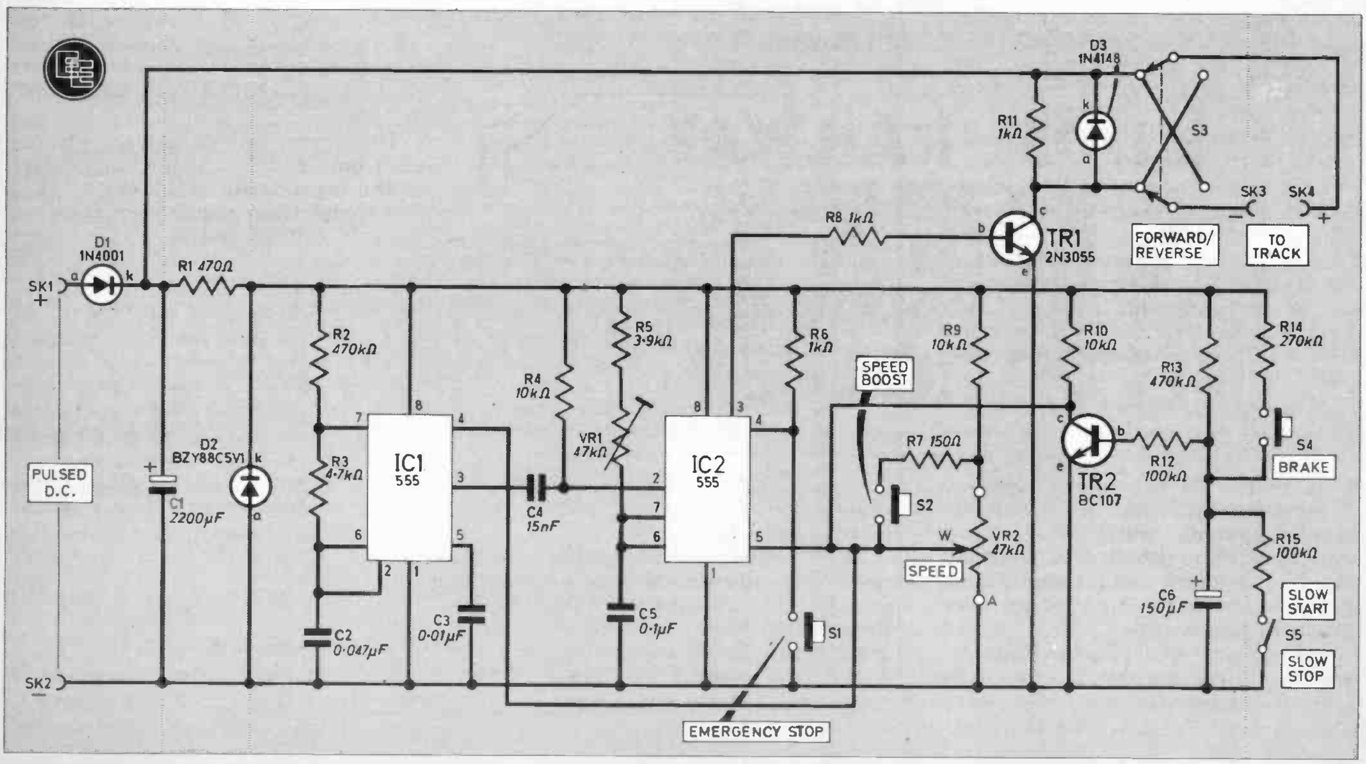
where C2 is in farads and the resistances in ohms.

Components C4 and R4 differentiate the pulses produced at IC1 output to produce negative going spikes. This ensures that each trigger pulse only remains in the trigger region for a very short time and therefore in no way restricts the operation of IC2.

The latter is connected in the usual manner to realise a monostable multivibrator from a 555 timer i.c. Each time IC2 trigger input, pin 2 receives a low voltage from IC1 pin 3, IC2 output pin 3 goes high for a period determined by VR1 R5 and C5 together with the voltage on its modulation input pin 5, before returning to 0V.

With the values determined for VR1, R5 and C5, the mark/space ratio of the waveform from IC2 output can be varied continuously from about 1:10 to 10:1 by turning VR2 clockwise from fully anticlockwise position, which varies the voltage on IC2 control pin, pin 5. That is what would happen normally for a 555 monostable, but here the voltage level on IC2 pin 5 is also coupled to the reset, pin 4 of IC1. When this pin falls below a certain level, IC1 output assumes a low (0V) state. The result of this is that no trigger pulses are being produced so the monostable output stays at 0V.

Fig. 2. The complete circuit diagram of the Model Train Speed Controller.



In fact the mark/space ratio never reaches as low as 1:10 since IC1 reset is activated before this level is reached. This has been done deliberately to eliminate armature buzz in the train motor for this short duration pulse.

Thus with VR2 fully (or nearly fully) anticlockwise no voltage is being fed to the train track. Clockwise rotation of VR2 increases the average voltage fed to the train and so the speed increases.

AUTO START AND STOP

The control voltage reaching IC2 pin 5 is determined by the voltages at VR2 wiper and TR2 collector. With S5 closed, TR2 is off so the constituent from TR2 collector is constant. If now S5 is opened, then C5 will charge up through R13 towards +5V. This will gradually turn on TR2 and its collector voltage will begin to fall resulting in the train slowing down. This is progressive and continues until the train finally comes to rest.

If now S5 is closed again, C5 will begin to discharge through R15 causing the potential of TR2 collector, and hence IC2 pin 5, to rise slowly. This results in a gradual increase in speed of the train up to that set by VR2.

The FORWARD/REVERSE switch S3 merely swops over the two supply lines to the track.

BRAKE AND BOOST

The BRAKE switch, S4 when made completes a lower resistance charge path for C5 and causes it to slowly charge towards the potential set across the supply rail by the resistor chain R14 and R15. This causes TR2 to slowly turn on and reduce the train speed as the voltage to pin 5 reduces. Holding down S4 for 5 seconds or more will result in the train coming to a standstill.

The speed BOOST switch S2 gives an instant increase in speed by effectively raising the potential on pin 5 by the shunting effect of R7 across the upper half of VR2. The effect of this switch will be reduced with clockwise advancement of VR2 and will have no effect whatsoever for full speed conditions.

Finally the EMERGENCY STOP button, S1 grounds the normally high reset pin of IC2 causing the output to stay at 0V for as long as S1 is actuated.

Transistor TR1 acts as a voltage amplifying power switch. It is either fully on or off so power dissipation in TR1 is minimised. The train motor forms the collector load. When the output of IC2 is high (+5V), TR1 is turned on and its collector falls to near 0V. When the output from IC2 is 0V, TR1 collector is at the same potential as the most +ve supply rail (C1 +ve plate). So 0V to 5V pulses on the base of TR1 cause 0V to 15V pulses to be placed across the motor.

D3 is included to protect TR1 from the back e.m.f. generated by the rotating motor and R11 acts as a dummy load useful when setting up.

CONSTRUCTION starts here

CIRCUIT BOARD

The prototype circuitry was assembled on a piece of fibreglass printed circuit board, size 85 x 85mm with cut-outs to suit assembly in the specified case. The layout of the components on the topside of this board is seen in Fig. 3 which also shows the full-size master pattern of the copper tracks (black regions) to be etched on the underside. This board was mounted in a sloping panel metal/plastic case with removable lid and measures 140 x 105 x 55mm. All controls are mounted on the lid with the board and input and output sockets secured to the lower section of the case.

ASSEMBLY

Use of low profile sockets or soldercon pins are advised for IC1 and IC2. Mount these sockets followed by the resistors, preset, capacitors and finally the semiconductor devices. Attach sufficient lengths of flying leads to reach the case mounted switches and potentiometer. Lightweight stranded wire is recommended for this. For the power in and out leads heavier duty p.v.c. wire is advised, especially if the controller is to supply power for more than one train.

The connectors used in the prototype were convenient for the author's use, but some constructors may wish to wire in directly. If direct wiring is decided upon, a suitable sized hole fitted with a grommet needs to be made in the case.

The case is the next item to prepare. There is no need to exactly follow the layout of the switches on the top panel as shown in photographs and Fig. 4, and constructors have complete

COMPONENTS

Resistors

R1	470Ω ½W	R6	1kΩ	R11	1kΩ
R2	470kΩ	R7	150Ω	R12	100kΩ
R3	4·7kΩ	R8	1kΩ	R13	470kΩ
R4	10kΩ	R9	10kΩ	R14	270kΩ
R5	3·9kΩ	R10	10kΩ	R15	100kΩ

All ¼W carbon ± 5% except where stated otherwise

Capacitors

C1 2200μF 25V elect.
C2 0·047μF polyester
C3 0·01μF polyester
C4 15nF ceramic plate
C5 0·1μF polyester
C6 150μF 6V elect.

COMPONENTS approximate cost £10

Semiconductors

D1 1N4001 1A 50V silicon rectifier
D2 BZY88C5V1 5·1V 400mW Zener
D3 1N4148 small signal silicon
TR1 2N3055 silicon *npn* plastic power package TO-3P
TR2 BC107 silicon *npn*
IC1, 2 555 timer i.c. 8-pin d.i.l. (2 off)

Switches

S1 push-to-make momentary action miniature
S2 push-to-make momentary action miniature
S3 d.p.d.t. miniature toggle
S4 push-to-make momentary action miniature
S5 miniature toggle s.p. on/off

See Shop Talk page 598

Miscellaneous

VR1 47kΩ miniature horizontal preset
VR2 47kΩ carbon lin. shafted type potentiometer
SK1-SK4 4mm insulated sockets (red, black, blue, yellow, 1 off each colour).
Printed circuit board size 85 × 85mm; case BIM 6005 or similar; lightweight insulated connecting wire; control knob for VR2; 8-pin low profile d.i.l. sockets (2 off); 4mm banana plugs (red, black, blue, yellow, 1 off each colour)

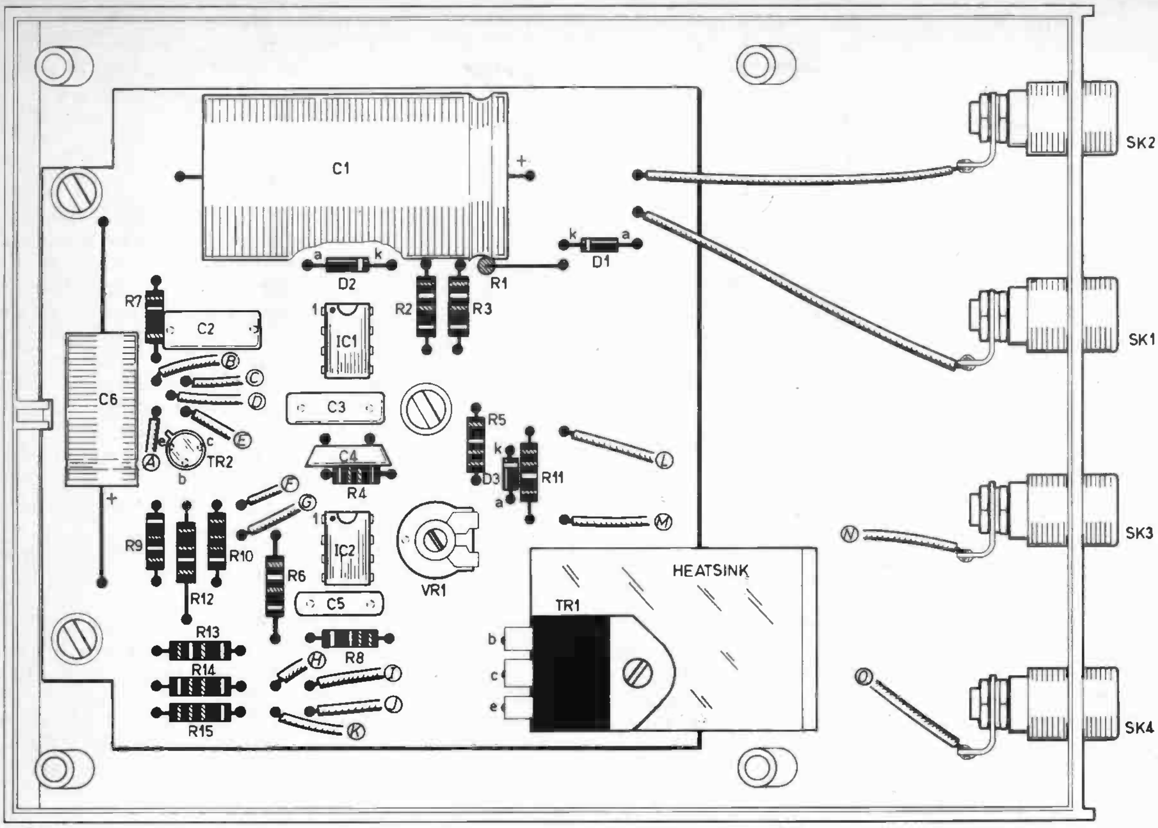
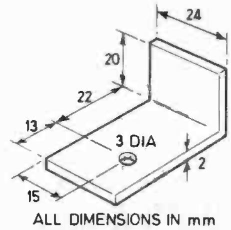
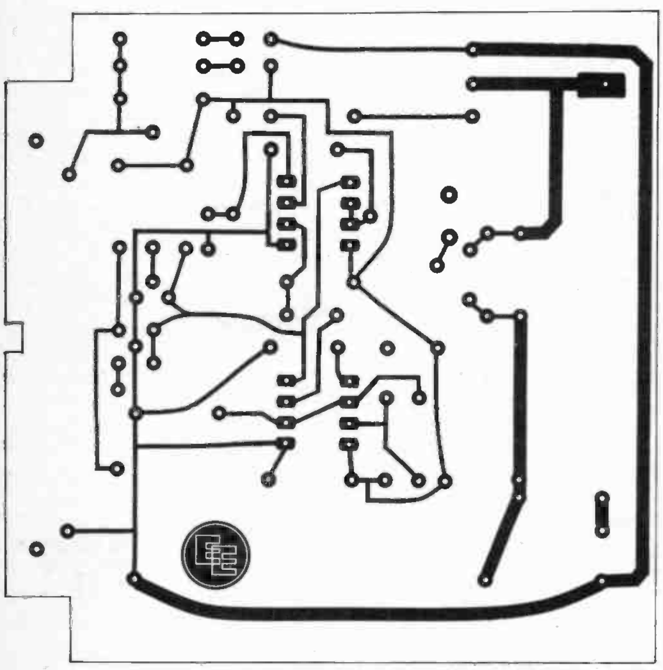
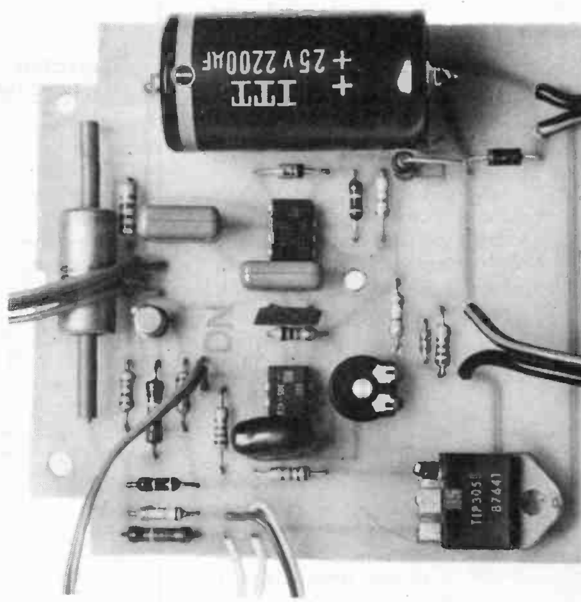


Fig. 3. The layout of the components on the topside of the p.c.b. mounted in specified case. Below shows the full-size master p.c.b. pattern to be etched. Right shows dimensions of heatsink suitable for single train systems.







Close-up view of the fully assembled prototype p.c.b.

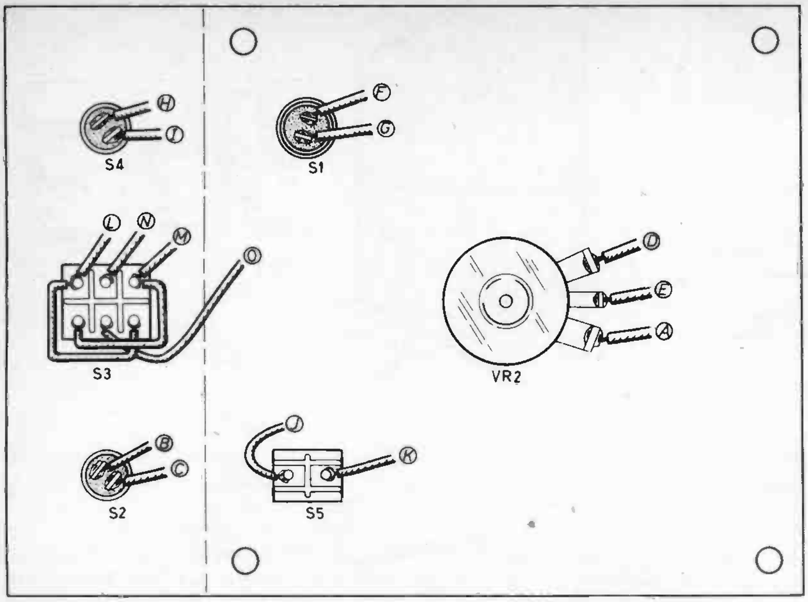
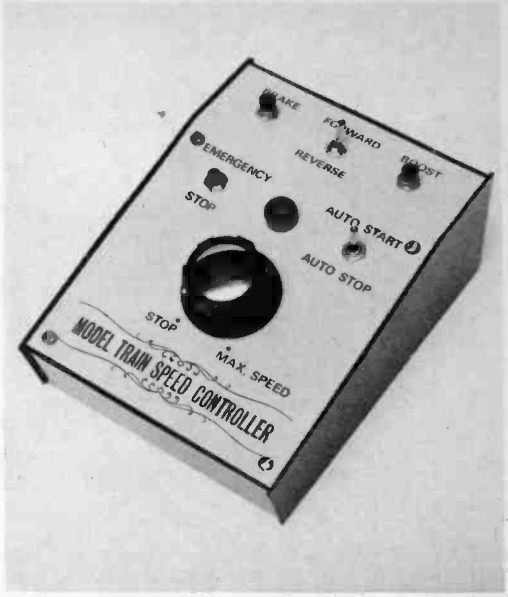


Fig. 4. Position of the controls on the lid of the case and wiring information to p.c.b.



The finished prototype unit with control functions labelled.

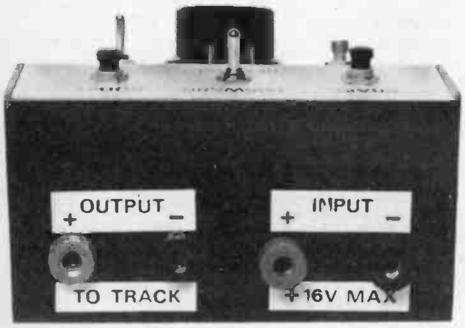
freedom of choice for their position. Similarly with the speed control pot.

When wiring up the controls, allow enough flying lead so that the lid holding the controls can be placed alongside the circuit board to allow access to the preset and controls on the lid when setting up. Fix the chosen in/output connectors to the case followed by the completed p.c.b. with flying leads attached. The two mounting pillars in the specified case were drilled through the case and 6BA fixings fed from beneath were used to securely hold the p.c.b. in place. Lay the assembled lid alongside the case and wire up according to Fig. 4.

SETTING UP

Position VR1 fully anticlockwise and VR2 fully clockwise. Connect a suitable supply at the input and check that the supply pin on each i.c. socket (pin 8) is at 5·1 volts. If so switch off and insert the two i.c.s. paying attention to their orientation. Check with Fig. 3. Connect a meter set at 20V d.c. across the output terminals and make sure that S5 is in the AUTO START position. Switch on and a low reading should be seen on the meter. Now turn VR1 slowly clockwise to maximise this reading. Turning too far will be indicated by the reading sharply falling low. Now turn VR2, the speed control anticlockwise. This should reduce the reading and at or near fully anticlockwise the reading should fall to 0V.

Rear view of the finished unit which shows input and output sockets clearly labelled.



TESTING

The output can now be connected to the track and a train placed on the lines. With the speed control fully off the train should be stationary. Ensure S5 is in the AUTO START position. There should be no buzz heard from the motor. Rotate VR2 and the train should start moving and increase its speed as VR2 is further advanced until maximum speed is reached for full rotation. If there is a reduction in speed at any time during clockwise rotation of VR2, then VR1 will need to be rotated anticlockwise slightly.

Now put S5 to AUTO STOP. The train speed should start to decrease and after about 5 seconds or so come to a halt. The halt may be too sudden in which case VR1 needs to be backed off a little. If the train takes too long to stop, this will probably be accompanied by buzzing from the train motor, VR1 should be advanced enough to remove this buzzing. A too sudden stop will mean also a sudden start whereas a too slow stop will most likely be accompanied by buzzing. Buzz will then be evident at start and may prevent starting altogether. Find the best compromise position for VR1.

With the train stationary due to S5 being at AUTO STOP, set the speed control first at a quarter, then at half and then three-quarters speed, and for each setting check that operation of AUTO START causes the speed to increase up to this setting, and also that VR2 can override the auto speed changes.

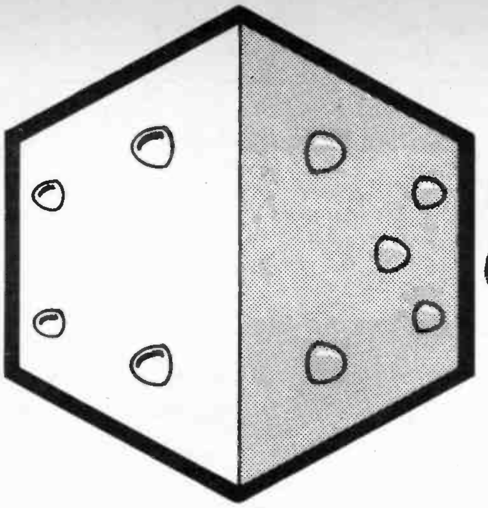
Now with the train running at three-quarter speed check the operation of the BRAKE and BOOST controls. The resistors associated with these controls may be tailored to your individual requirements if their effect is not entirely satisfactory.

At the instant of operating the EMERGENCY STOP control, the train should halt and remain in this condition for as long as the control is operated. Some users may wish to replace this switch with a latching type or miniature toggle. Finally check the operation of FORWARD/REVERSE switch which should cause the train to change direction and travel at the same speed when operated.

HEATSINK

It is important to fit a heatsink on TR1 especially if a high current is expected to be supplied through it, if used to control several trains for example, in which case a larger heatsink than that shown must be fitted. This may require the circuitry to be housed in a larger case. No insulating washer/bush will be required if mounted as shown in the prototype where the heatsink was not in danger of touching any other part of the circuitry.

After all the tests have been carried out successfully, the control panel components may be removed and control functions labelled. In the prototype Letraset was used and a coat of clear laquer applied for protection of these. ⌑

CMOS  DIE

BY O.J. FOLDÖY

A DIE is described in the dictionary as a small cube with each face containing one of the numbers between 1 and 6. Two or more of these (dice) can be used to play the game of dice but perhaps they are more commonly found in use with board games such as Monopoly, Snakes and Ladders, Backgammon and many others.

With each of these games a space needs to be found to roll the die in a position easily visible to all players. This problem is overcome with the CMOS Die described here. It can be left in a central position and because of its display format, is easily read from all angles around the board.

The CMOS Die has a very low current consumption and battery life is maximised by an automatic turn off facility, which effectively disconnects the battery 10 seconds after the "score" is first displayed.

CIRCUIT DESCRIPTION

The complete circuit diagram of the CMOS Die is shown in Fig. 1. TR1 and TR2 form an astable multivibrator which provides a source of pulses to IC1, a decade counter. When S1 is pressed the multivibrator circuit is completed as base bias for TR1 is applied by R2 via D1. At the same time C2 is charged up and so when S1 is released, the multivibrator still operates with the charge on C2 providing the supply voltage.

As the voltage on C2 falls the pulse frequency rate decreases until a threshold value is reached whereupon the pulses cease to be produced. The time for this condition to be reached is dependent on the value of C2.

Also, when S1 is pressed, C4 charges up through D2 and this turns on TR3 and its collector therefore falls to near 0V. This provides the negative supply line to both i.c.s and allows them to function.

C4 discharges through R5 and the base/emitter junction of TR3 and eventually reaches a level that is insufficient to maintain conduction in TR3 and it turns off. Consequently the negative supply line to both i.c.s is removed and they cease to operate. The l.e.d.s are thus extinguished and no power is being supplied by the battery. This is the automatic turn off switch of the system.

The pulses reach the clock enable input on IC1 with the clock input held high. These two pins are readily interchangeable and have been connected in this mode to facilitate ease of p.c.b. design.

The input pulses are counted by IC1 and the corresponding output turns on. There are ten outputs from

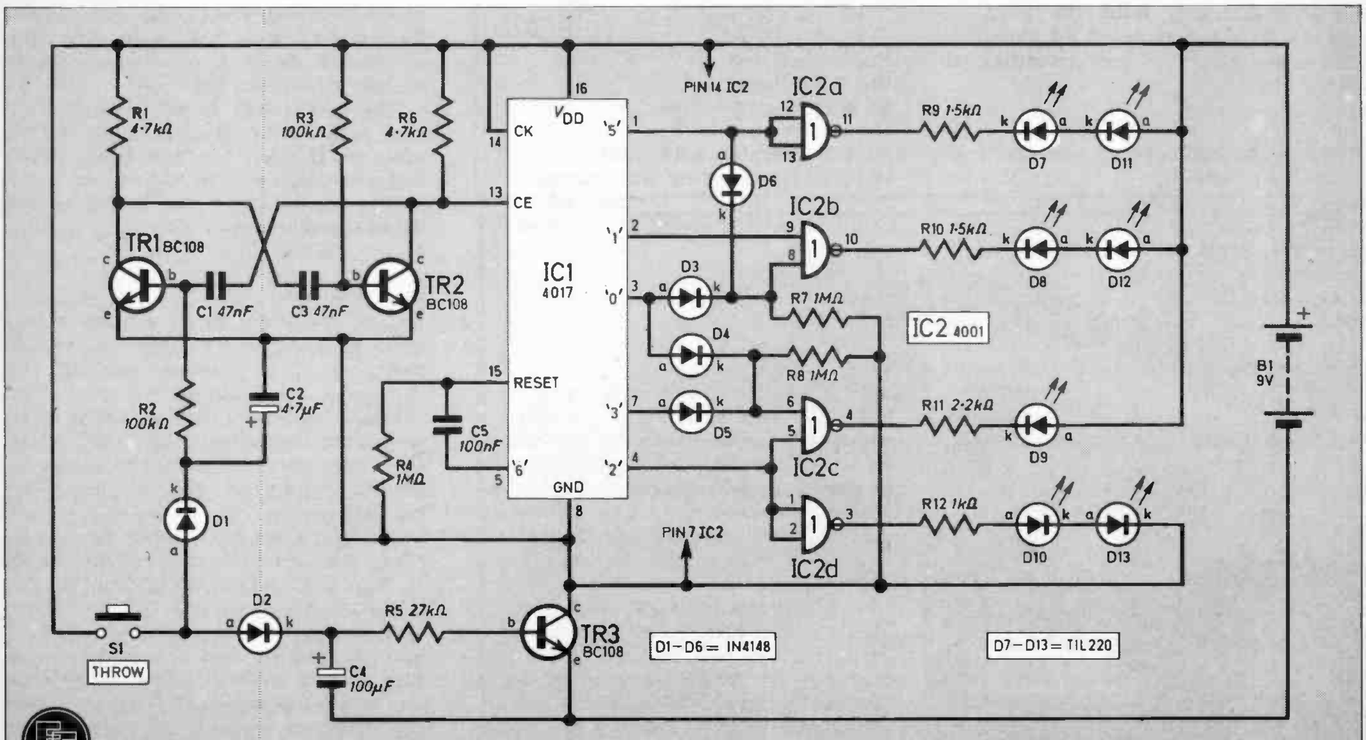


Fig. 1. Complete circuit diagram for the CMOS Die.

the 4017 and which output is "high" (with remainder "low") is determined by the number of pulses inputted to pin 13. The count sequence can be from 0 to 9 and repeat, but in this circuit it has been made to count up to six and repeat to be in accordance with the six numbers appearing on a die.

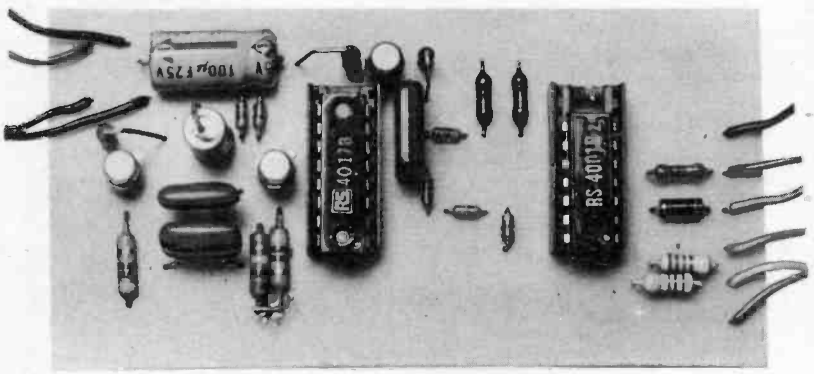
This is accomplished by the seventh count output ("6") being coupled to the reset pin of IC1. The reset pin is normally held low (inactive) by R4, resetting to zeroeth count output when taken high. When the seventh count is made, the voltage step on pin 5 (0V to 9V) is differentiated by C5, R4 to produce a short duration positive spike which immediately resets the counter.

Thus pressing S1 will cause IC1 to count, and display the count at its output. This will be fast at first slowing down in time (about 3 seconds) before the pulse supply is cut off. The count is held at ICI output for another 7 seconds or so due to the auto-switch circuitry.

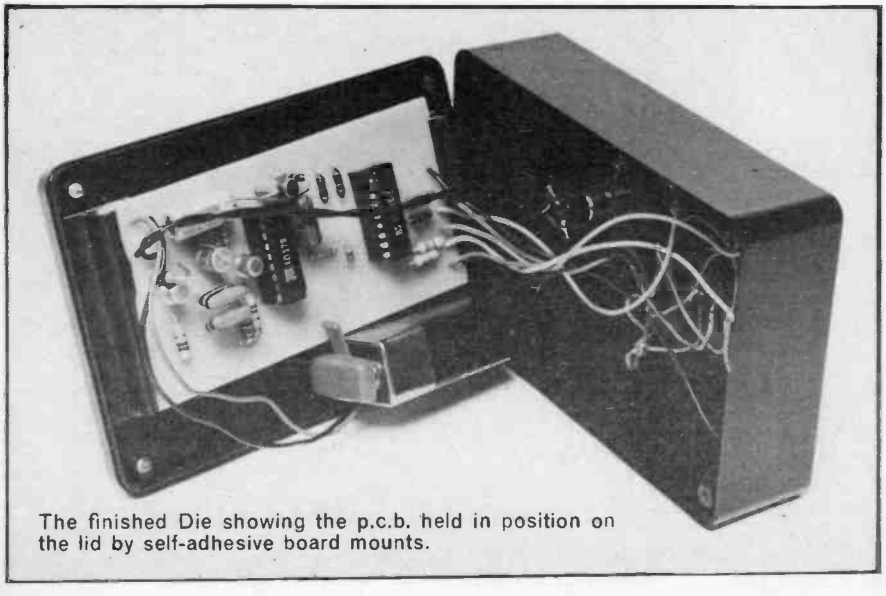
The count position is decoded by the NOR gates in IC2 and diodes D3 to D6 to provide suitable outputs to the four diode groups which have been formatted to be in accordance with the dot positions to be found on a conventional die.

The unit does not count 1-2-3-4-5-6 but in the sequence 5-4-1-3-2-6. This has been done to make the design of the p.c.b. easier and does not affect the chance factor.

Current consumption when the auto-switch circuitry is on is in the range 4·5 to 9mA depending on the number of l.e.d.s on at the time. After the time out of TR3 no current is consumed.



Completed prototype board with the i.c.s plugged into i.c. sockets.



The finished Die showing the p.c.b. held in position on the lid by self-adhesive board mounts.

CONSTRUCTION starts here

PRINTED CIRCUIT BOARD

To make construction simple a printed circuit board has been designed to accommodate nearly all the components. The full-size master p.c.b. pattern is shown in Fig. 2. The layout of the components on the topside of the board is shown in Fig. 4. The latter has been drawn larger for clarity.

Make or obtain the etched p.c.b. and assemble the components according to Fig. 4. Begin with the i.c. sockets (do not insert the i.c.s at this stage) followed by resistors, capacitors, suitable lengths of flying lead and finally the semiconductors. Care should be exercised when soldering in the diodes since these have very short leads. Do not keep the soldering iron on their leads for too long otherwise they may be permantly damaged. Use of a heatshunt is advised.

DISPLAY MATRIX

The next stage is to prepare the case to accommodate the l.e.d.s and switch. Plastic clips are recommended to hold the l.e.d.s in place. With reference to Fig. 3, the l.e.d.s should be pushed into their clips and orientated as shown. The leads should then be cut short and interwired according to Fig. 3 using p.v.c. covered lightweight stranded wire.

The board was fitted to the lid of the case using self adhesive board mounts. If these are not used, fixing holes be drilled in the board.

The completed board should be fitted in place and wired up to the l.e.d. cluster and switch. A self-adhesive foam pad was used to hold the battery in position alongside the board. The assembly was a fairly close fit inside the case and the specified case should be regarded as the minimum suitable size.

When completely satisfied with your wiring the i.c.s. may be inserted in their sockets paying special attention to orientation, see Fig. 4. Finally fit the battery clip to B1.

All l.e.d.s should be off at this stage. Press S1 and all l.e.d.s should light up for a second or two, due to the initial high frequency of the multivibrator and then slow up and stop at one number, and this is displayed for about a further seven seconds or so before extinguishing whereupon the unit is turned off. It is not necessary to wait for this condition before pressing THROW again. ⌑

COMPONENTS

Resistors

R1	4·7kΩ	R9	1·5kΩ
R2	100kΩ	R10	1·5kΩ
R3	100kΩ	R11	2·2kΩ
R4	1MΩ	R12	1kΩ
R5	27kΩ		
R6	4·7kΩ		
R7	1MΩ		
R8	1MΩ		

All ⅛ watt carbon ± 5%

See **Shop Talk** page 598

Capacitors

C1 47nF polyester C280 series
C2 4·7μF 10V elect. radial leads or miniature axial type or tantalum bead
C3 47nF polyester C280 series
C4 100μf 10V elect. miniature axial leads
C5 100nF polyester C280 series

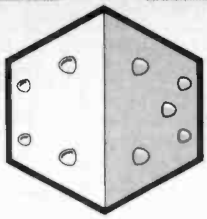
Semiconductors

D1-D6 1N4148 small signal silicon (6 off)
D7-D13 TIL220 red l.e.d.s (7 off)
TR1-TR3 BC108 silicon *npn* (3 off)
IC1 CD4017 CMOS decade counter
IC2 CD4001 CMOS quad 2-input NOR gates

Miscellaneous

S1 push-to-make, release-to break miniature
B1 9V type PP3

Single sided p.c.b. size 95 × 45mm; d.i.l. i.c. sockets 14-pin, 16-pin (1 off each); PP3 battery clip; TIL220 plastic clips/bushes (7 off); lightweight p.v.c. covered stranded wire; case, Vero General Purpose Plastic Box type 202-21390D size 120 × 80 × 35mm or similar.

CMOS  DIE

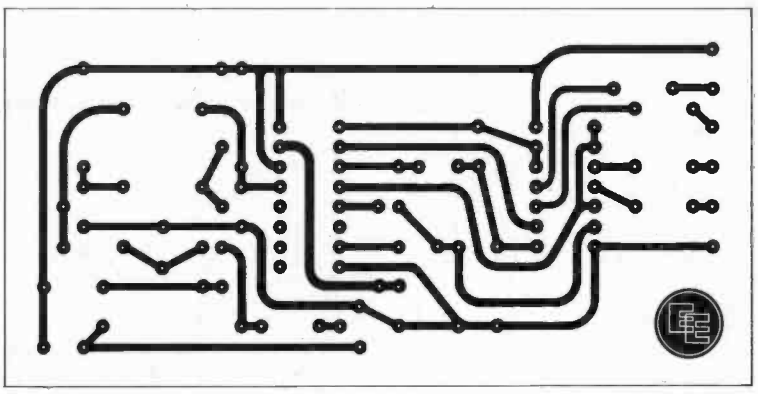


Fig. 2. Full-size master of the printed circuit board.

COMPONENTS approximate cost £5

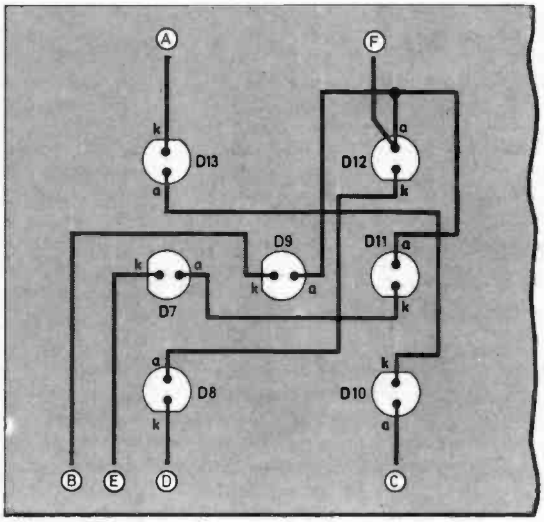


Fig. 3 (right). Wiring details for the l.e.d. display matrix. The letters at the ends of the lead-off wires go to identical points on the circuit board.

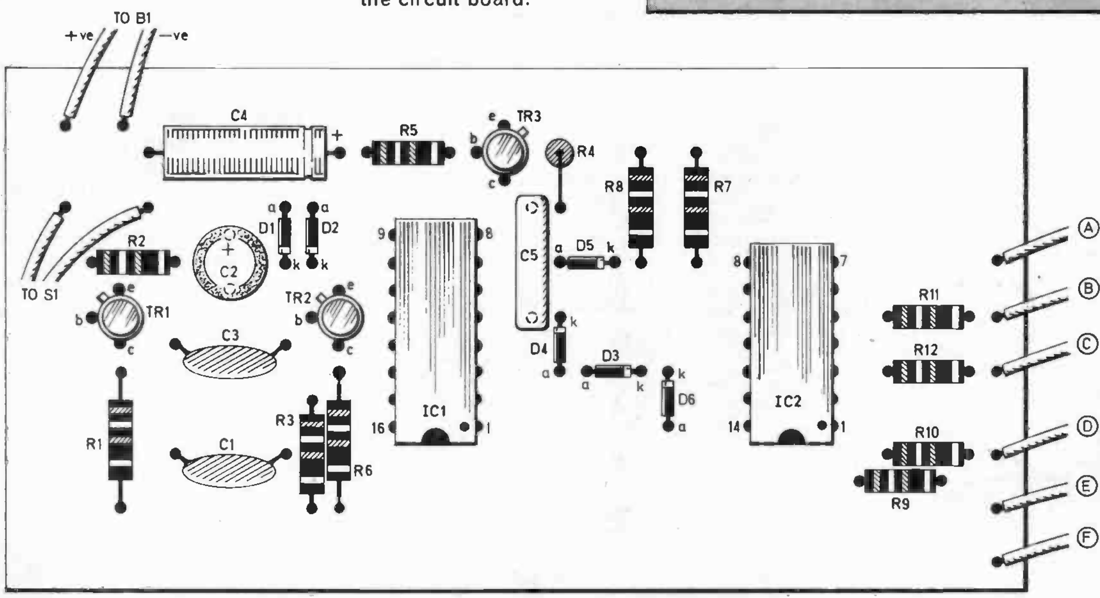


Fig. 4. Layout of components on the topside of the p.c.b. It is advisable to use i.c. sockets for mounting IC1 and IC2.

ANTI~THEFT LINK DEVICE

BY T.R. de VAUX–BALBIRNIE

THIS project has been designed to fulfil the needs of shop owners and others requiring small scale protection of expensive equipment. It is not supposed to be a replacement for larger burglar alarm systems which serve a different purpose. Being battery operated, it may equally well be used in locations where a mains supply is not available.

SYSTEM OPERATION

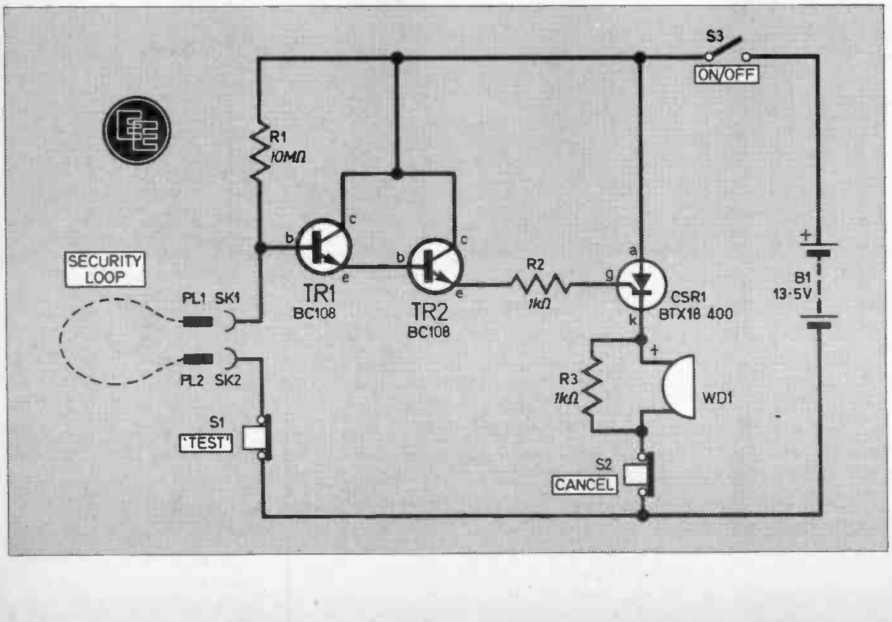
In use, a continuous loop of wire is threaded through suitable parts—handles, and so on—of the goods to be protected. The ends of the loop are connected to two terminals on the unit. An alarm will sound if the wire loop is broken. It should be impossible for a person to remove an item without setting off the alarm.

This system has the advantage that goods are displayed to maximum advantage and they may be handled and operated quite freely. Readers may have seen similar commercially made systems used in discount hi-fi shops, department stores and other similar places.

In the present circuit the wire loop may be as long as required and thin, cheap wire may be used. It is essential, however, to use stranded wire rather than the single-core type. The latter would quickly fail (fracture) in service. It must also be strong enough to withstand the wear and tear of everyday use.

It is necessary to provide plugs and sockets at intervals along the wire so that items may be removed or added to the system conveniently—with the alarm switched off, of course! The alarm unit itself must be positioned in a place inaccessible to the public yet clearly within earshot of wherever the owner is likely to be.

Fig. 1. Complete circuit diagram for the Anti-Theft Link Device.



WARNING DEVICE

The warning tone is given by an "audible warning device" in the unit. This alarm is not so much loud as penetrating. Being of a high frequency, the sound carries well above everyday noise. The author tested the prototype in a large room where people were talking loudly. The audible warning device could be heard quite clearly at a distance of 10 yards at least.

Once the alarm has been triggered on, it will not silence even if the wire loop is remade. It can only be switched off by pressing the CANCEL button on the unit—after the loop has been reconnected of course—or by turning off the power supply.

Particular care in design was taken to achieve very low current consumption during standby conditions. In the prototype this was just over 4 microamps. This is so low that the batteries should last for almost as long as their shelf life providing, of course, the alarm is not sounded excessively. When actually operating, the power consumption is only about 60mA which is still very modest.

CIRCUIT DESCRIPTION

The circuit diagram is shown in Fig. 1 and operates in the following way. TR1 and TR2 are transistors connected together in a Darlington pair arrangement. As the transistors specified are high gain types anyway, the gain of the final arrangement is exceptionally high. The transistors are kept normally off by the grounding of the base of TR1 by the wire loop connected between the terminals SK1 and SK2. Under these conditions, a very small current flows from the battery positive through R1 to negative. Ohm's Law predicts that this current will be 1·2 microamps with a 12 volt supply.

TRIGGER ACTION

When the loop is broken, this minute current flows in the base circuit of TR1. The current is amplified by TR1 and again by TR2 giving sufficient current in the emitter of TR2 to trigger the gate of the thyristor CSR1.

This current is limited to a safe value by R2. If an "out of spec." thyristor is used or a different one than that specified, it might be necessary to reduce the value of R2 to permit sufficient gate current to flow. In fact, the thyristor specified should trigger with a gate current of 5mA and R2 allows about 12mA to flow.

Once triggered in this way, current flows between anode and cathode through the audible warning device. It is necessary to connect R3 across the terminals of the latter so that a current flows through CSR1 continuously—in action WD1 switches on and off and this would interfere with the correct operation of the circuit. If the wire loop is re-made, the transistors switch off but a thyristor, once triggered will continue to conduct and the alarm continue to sound, until its current flow is interrupted or the supply voltage is removed. S2 is used to interrupt the current through CSR1 and silence the system.

Experimenting with the value of R1 showed that if it is too high, insufficient base current will flow in TR1 to switch the arrangement on. If the value is too low then drain on the batteries will be high.

With first grade components, it was found that the circuit would operate reliably with well over 20MΩ for R1. It was thought to be a waste of time finding the highest value for R1 in an effort to minimise the current through it when "leakage" through the other components in the circuit amounts to some 3μA. Although some readers may wish to experiment with the value of R1, the value of 10MΩ used in the prototype worked well in practice.

The push-to-break switch, S1, may be used to test the system at any time. Its action is to effectively break the loop. The really devious owner will label S1 and S2 in the opposite sense to foil the really clever would-be thief. S3 is the on-off switch connected in the main battery positive line. A miniature slide or rocker switch is suggested. It is probably not a good idea to label S3 on-off for security reasons.

COMPONENTS

The audible warning device specified is rated at 12 volts and although it will work from a 9 volt supply the volume will be greatly reduced. For the prototype, three substantial 4·5 volt batteries were connected in series giving a 13·5 volt supply. This voltage is about right allowing for the voltage drop of about 1 volt across CSR1 and a further loss across the battery itself.

Bell batteries with contact strips (type 1289 or equivalent) seemed a good choice. Although these are rather bulky they may be arranged in a number of ways to fit the case available. These batteries should give a very good life unlike miniature batteries whose shelf life is short anyway. It is important to remember that it is the batteries which determine the final size of the project. The two terminals SK1 and SK2 are standard 4mm sockets mounted on the front panel, but smaller sockets may also be used, for example 2mm types. A hole may be cut in the panel to accommodate the front part of WD1. This may then be pushed through from the rear, so that about 13mm protrudes. It may be secured with glue and a collar may be fitted around it for heavier service. This is neater than mounting the device on the front panel as it is rather large and clumsy. The hole normally used for mounting the device was used in the prototype to secure the circuit panel in position.

WIRE LOOP

The wire loop consists of several yards of stranded wire with a pair of 4mm plugs every yard or so along its length; 4mm line connectors are then used to join all the plugs together. Constructors may use other types of connector as available—even coaxial plugs and line sockets may be used. Twisted connections are not a good idea except for testing.

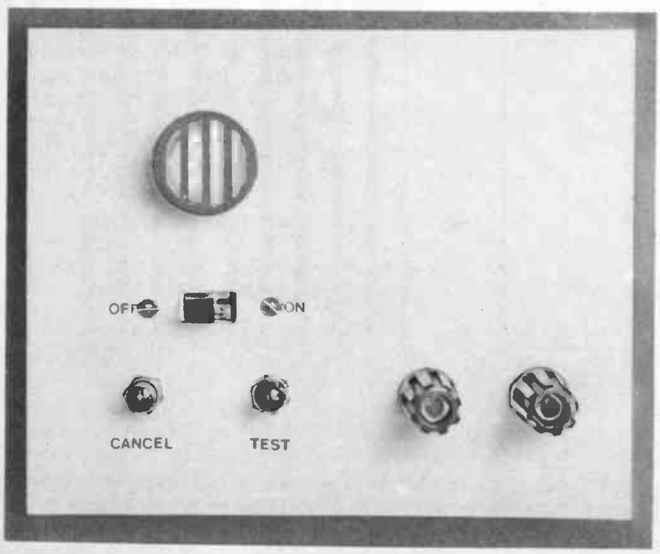
CONSTRUCTION starts here

ASSEMBLY

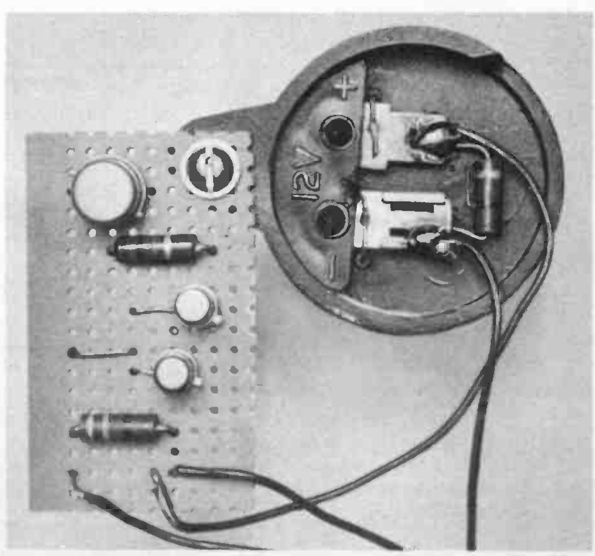
The prototype circuit panel consisted of a piece of 0·1 inch pitch stripboard size 9 strips by 18 holes.

The layout of the components on the topside of the board and the breaks to be made on the underside to isolate the fixing screw are seen in Fig. 2, together with the position

Front panel layout of the completed prototype.



Finished circuit board mounted on the sound transducer.



ANTI-THEFT LINK DEVICE

COMPONENTS

Resistors
- R1 10MΩ
- R2 1kΩ
- R3 1kΩ
- All ¼W carbon ±5%

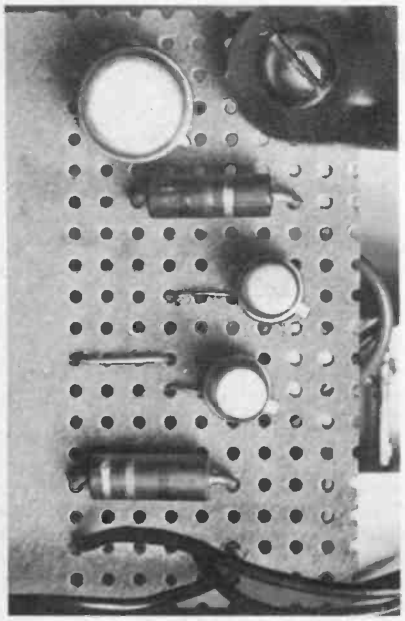
See **Shop Talk** page 598

Semiconductors
- TR1, 2 BC108 silicon *npn*
- CSR1 BTX18-400 or other 1A low voltage thyristor (TO-5 case)

Miscellaneous
- WD1 12V audible warning device (Type RS248-808 or similar)
- S1, 2 push-to-break, release to make miniature
- S3 s.p. on/off miniature slide switch
- SK1, 2 4mm insulated panel mounting socket (2 off)
- B1 13·5 volt (type 1289 or similar) 4·5V battery, (3 off)

Stripboard: 0·1 inch matrix size 9 strips × 18 holes; plugs to suit SK1 and SK2; case; plugs and in-line sockets for loop—see text, quantity as required.

£5 excluding case and in-line connectors



Components mounted on the circuit board. The bolt shown in the top right secures the board to the sound transducer.

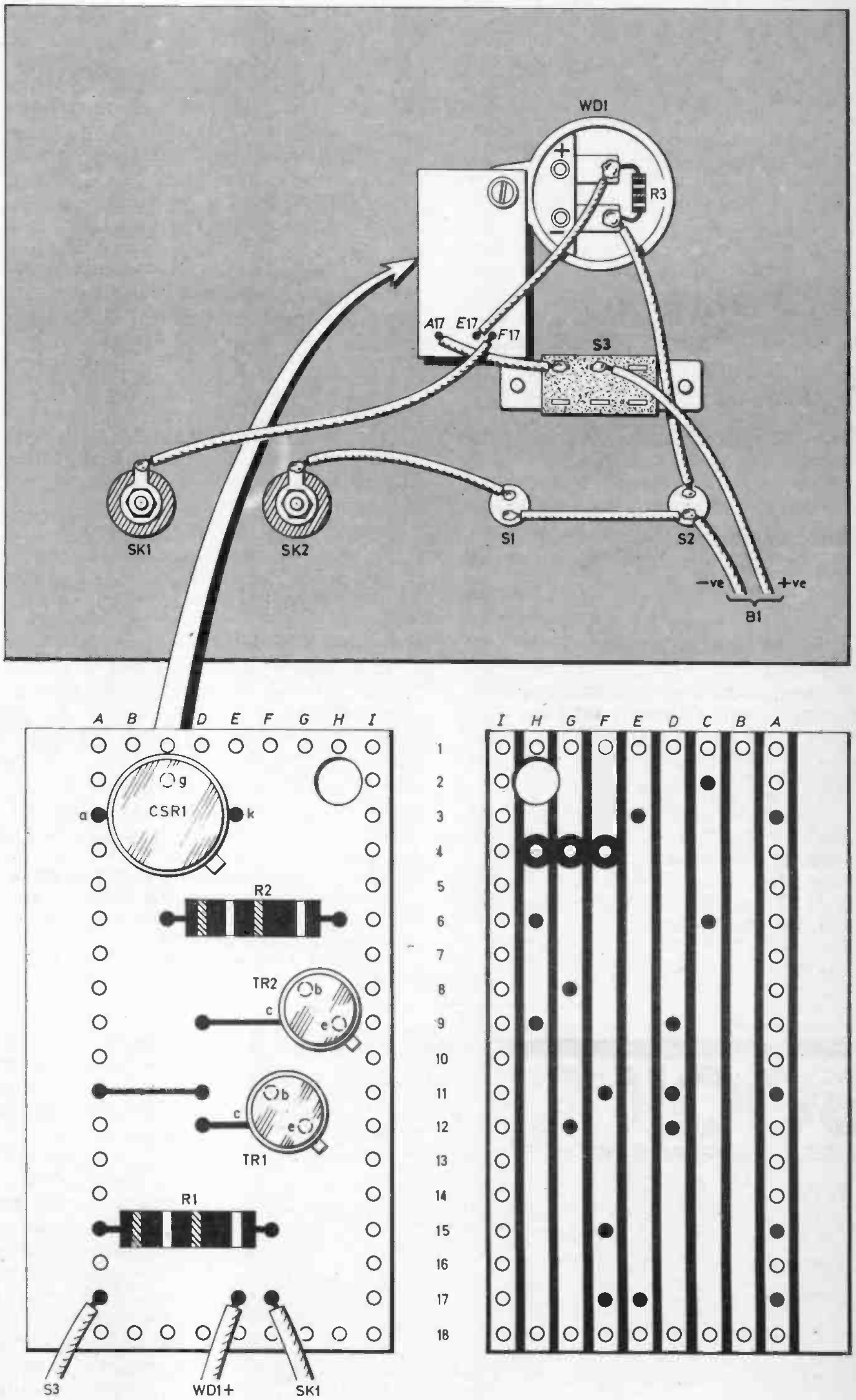


Fig. 2. The interwiring of the Anti-Theft Link Device, with details of component layout and breaks to be made on the copper tracks on the underside of the board.

and wiring of the panel mounted components.

First position and solder all the components on the prepared board including sufficient lengths of flying leads. Great care is required when bending the transistor leads. Care must also be taken during the soldering stage to avoid excessive heat at the connections of the transistors and CSR1. Another point is that "bridging" between adjacent copper tracks must be avoided. Run a screwdriver between all tracks after completing soldering to dislodge any bridges that may have occurred.

Prepare the front panel and fix the components in position. Use a small bolt, nut and washer to hold the circuit board in place on WD1, see Fig. 2, and wire up as shown.

It is necessary to observe the polarity of WD1—it is marked '+' and '−' on the body. R3 and other leads may be soldered direct to the terminals if care is taken or suitable push-on connectors may be used.

TESTING

When the circuit is tested it is a good idea to check that it works with a 9 volt battery (two of the 4·5 volt batteries in series) to make sure that it will work when the batteries are run down (near exhausted).

Connect the batteries and turn on at S3. The alarm should sound and be muted by pressing CANCEL, switch S2. The alarm should, of course, sound when S2 is released. Turn off and connect a lead between SK1 and SK2. Turn on—the alarm should not sound. Remove one end of the wire linking SK1 and SK2. The alarm should sound. Replacing the wire should have no effect. Press CANCEL to mute the alarm. On releasing S2 the alarm should now remain silent. Finally, press S1, the TEST button to cause the alarm to sound. If all the above results are obtained, the unit is ready for installation in its chosen case.

The cost of this project may be recovered quite quickly by not losing stock into the hands of the opportunist thief. ⌑

LETTERS

CB Renegades

May I please use your letters page to reply to the criticism of my letter (see May issue) concerning CB made by "The Prophet" in the July edition.

"Got yer ears on prophet cos I got a 10-44 for you."

To start with, the 10-42 that you were referring to was obviously reported by a breaker who was old enough to drive a car and therefore is totally irrelevent to our indifference.

But let me agree with you that CB has its advantages which I have found by using "The Grumbleweed's" (my brother's) rig. Talking to the natives of strange towns can inform us of 10-43's and 10-13's as you mention.

Let me get to the point that you are most concerned with. The ankle-biters who were causing the trouble were a renegade bunch who were, among other things, using obscene language (much to our disgust), button-pushing (not just SWR'ing) and broad-banding just about every hi fi and radio in the neighbourhood.

Before I go 10-10 you were right assuming that I was Mr Courtney but how did you know that I wasn't a lady reader or even a lady breaker? or don't you have them in Manchester? Quits?

This is the Windhover going down.
Breaker-Break.

S. A. Courtney (Mr)
Chipping Campden,
Gloucestershire

Musical Calculator

I enclose the following idea which I thought that you might like to pass on to your readers.

It is for a musical calculator. All that is required is a calculator of the l.e.d. type, and a medium wave radio.

The radio is tuned to a position with no signal. The calculator is placed on the radio as near to the ferrite rod aerial as possible.

When the calculator is switched on a tone will be heard from the radio. I have found that the more keys that are pressed the lower the tone becomes.

I am not sure what causes this, but I think that it is due to the multiplexer circuits inside the calculator, switching minute currents on and off. The more digits alight, the more time between each digit being lit, and so the lower tone is heard.

I. Davies (15)
Tupsley,
Hereford

Missing Pins?

I have just started to build a project from your magazine and it has a 555 timer i.c. with 7 connections and the timer I have has 4 connections on each side. Which is right?

L. Creer
Altrincham, Cheshire

As with many projects that use i.c.s we do not use every pin on the i.c. so in this case some pins will be unconnected. This can be for one of two reasons. Either we are not using all the facilities that the i.c. can offer on that particular project or there is no internal connection to that pin. This often happens because i.c.s are packaged in standard casings, usually with 8, 14, 16, 20, 28 and 40 pins depending on the complexity of the device. If there are only, say 6 connections to the internal workings of the i.c. it may be still made in an 8-pin package although only 6 pins will actually be used.

BOOK REVIEWS

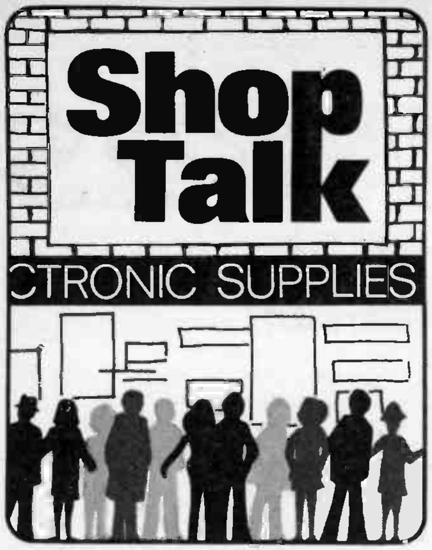
AMATEUR RADIO

Authors	Gordon Stokes, G4HWD and Peter Bubb, G3UW7
Price	£8·95 hard covers
Size	220 × 140mm, 192 pages, 11 photographs and 74 line drawings
Publisher	Lutterworth Press—"Practical Handbook Series"
ISBN	0-7188-2477-6

THE intention behind this new book is a good one. It is to provide those without any previous understanding of electricity and electronics with the relevant background information that will help them prepare for the Radio Amateurs' Examination. No suggestion is made by the publishers that this book alone would be sufficient to see a candidate safely through the exam—G. L. Benbow's "Radio Amateurs' Examination Manual" (RSGB) comes closer to meeting this requirement at significantly less cost but is perhaps a little more difficult going for the beginner.

Unfortunately, though easy to read, the later chapters on transmitters, antennas, transmission lines and safety appear to this reviewer to be much over-simplified and to contain a surprisingly large number of technically incorrect and/or misleading statements. In fact the book serves to draw attention to the unsatisfactory nature of the objectives and syllabus of the RAE. For even though a book like this may help candidates pass the exam it will inevitably leave them with a number of important misconceptions about modern radio communication technology and fundamentals.

It is disturbing to find so many misconceptions set out in a book where one of the authors is an RAE lecturer and coach. If there is a second edition let us hope that the opportunity is taken to revise thoroughly the later chapters: it would then become a worthwhile addition to the Amateur Radio literature. P.H.



By Dave Barrington

Loudspeakers

Sometime ago now we published two designs for hi fi speaker enclosures, these have been very popular and one advertiser is now supplying the cabinets in kit form.

Apart from the EE20 and EE70, to make life easier for the constructor Wilmslow Audio are now offering flat-pack cabinet kits for many popular designs, including the Wharfedale E50, E70 and E90.

All panels are cut to size and baffle boards have the necessary speaker aperatures cut and rebated where required. The cabinets when assembled may be painted or stained, or finished with iron-on veneer.

The company claims to be one of the countries largest stockists of loudspeakers and at their new premises callers can, through touch controls, listen to and put their prospective purchase through its paces before making a final selection.

More information can be obtained from Wilmslow Audio Ltd., Dept EE, 35/39 Church Street, Wilmslow, Cheshire, SK9 1AS.

There used to be a time when readers of hi fi journals, otherwise known as hi fi "buffs", found it both economical and stimulating to build their own loudspeaker enclosures and install one of the many speakers available on the market. But for one reason or another this once popular pastime seems to have gone out of fashion

Now thanks to, believe it or not, the discerning motorist a new company called DiY-HiFi have taken the Pioneer TS107 speaker originally intended for in-car use and produced design plans and full size blueprint for a 50Hz to 20kHz bookshelf unit capable of handling a peak power of 20 watts.

It is claimed that the Cecilia can be built in a weekend for around a total of £35 per pair, subject to finish and cost of raw materials which the constructor obtains from his local timber merchant. The Pioneer TS107 speakers can be purchased from most car radio centres throughout the country and prices seem to vary from one centre to another.

The complete design sheets, including step by step instructions, for the Cecilia cost £2·50 and are available from DiY-HiFi, Dept EE, York House, Swan Street, West Malling, Kent.

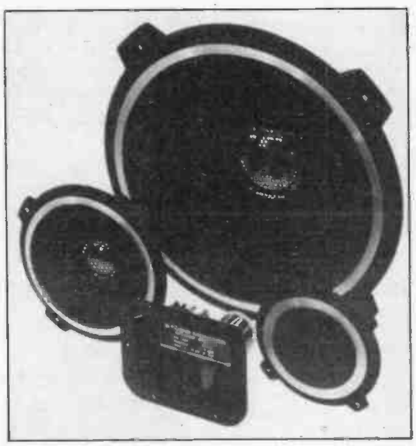
Incidently, if you are looking for a suitable loudspeaker network, we have heard some very good reports of statisfied customers who have purchased the latest offering from BK Electronics.

Consisting of a matching set of three loudspeakers, for high, medium and low frequency response, and a three-way crossover module it enables the constructor to build a 60W system. Each loudspeaker is fitted with cast aluminium fixing escutcheons and a black domed protective mesh front.

The escutcheons/mesh fronts are removable to enable a choice of baffle board construction. For example, they can be mounted directly on to a veneered board or with the protective mesh removed mounted and covered with fabric in the conventional manner.

All speakers are 8 ohm impedance. The frequency response for the units are as follows: 3in "tweeter", 2500 to 1900Hz; 5in "mid-range", 600 to 8000Hz; and 10in "woofer", 35 to 4500Hz. The crossover frequency is at 1300Hz and 6000Hz.

The complete kit including VAT cost £19·95 plus £2·50 p&p. For further information contact BK Electronics, Dept EE, 37 Whitehouse Meadows, Eastwood, Leigh-on-Sea, Essex SS9 5TY.



Matching loudspeakers and crossover from BK Electronics.

In Brief

We have just been informed that once present stocks of 0·15in pitch Veroboard, both plain and copper strip types, have been exhausted it will no longer be produced.

Because the cost of black Paxolin has become so high, Home Radio are now substituting this with black Formica in all future orders.

Experimenters may be interested to know that Electronic Products (Coventry) Ltd., are now running a mains transformer winding service. Further details can be obtained from Electronic Products (Coventry) Ltd., Dept EE, 20 Duke Street, Chapelfields, Coventry CV5 8BU.

A new 6-page leaflet has been published this month by CeKe Works, manufacturers of quality hand tools. Their range of tools includes side cutters, pliers and tweezers. Copies of the leaflet are available from CeKe Works Ltd., Dept EE, Pwllheli, Gwynedd, North Wales LL53 5LH.

Probably new to some readers, Rapid Electronics have just released a new edition of their components catalogue. The range of components in this 24-page catalogue has been extended and includes a larger selection of transistors, linear i.c.s. plus the addition of Low Power Schottky devices.

For copies of the Rapid Electronics Component catalogue send two 14p stamps to Rapid Electronics Ltd., Dept EE, Hillcroft House, Station Road, Eynsford, Kent.

Whilst checking component prices for some of this months projects with Watford Electronics, we were surprised to learn that they were claiming they had recently dropped, yes dropped!, their prices by as much as 40 per cent for TTL, 74LS series and CMOS range of devices.

When comparing prices in our July and August issues we find their claim fully justified.

Please Note

We have been asked to point out that the name "FuelStretcher" (see our article in the July 1981 issue) is a registered trade name of EnviroSystems Ltd.

CONSTRUCTIONAL PROJECTS

Audio Compressor/Mixer

The mains transformer used in the prototype model of the *Audio Compressor/Mixer* is the RS 196-296. This has two 6V secondary windings and these are wired in series. Another suitable type is the MT280 from Bi-Pak, this also has two 6V secondary windings which will have to be wired in series.

The type numbers quoted for the bridge rectifier and the rectangular diode D6 are RS order numbers and available from any RS Components supplier. The rectangular diode D6 can be substituted by most general purpose l.e.d.s, such as the TIL220.

It is quite in order to replace the tantalum capacitors which make up C9 and C10 with single tantalum capacitors of 22μF and 33μF respectively.

Model Railway Speed Controller

A ready made printed circuit board for the *Model Railway Speed Controller* is available from Proto Design, Dept EE, 14 Downham Road, Ramsden Heath, Billericay, Essex, at a cost of £1·58 plus 35p postage and packing.

We understand that Proto Design are also able to supply a p.c.b. for the *CMOS Die* project for the sum of £1·13 plus 35p postage and packing.

We have been told that readers only need to send one amount of postage monies (35p) on any complete order.

The attractive plastics case with sloping metal front is the Bimbox 6005 from Boss Industrial Mouldings Ltd., Dept. EE, 2 Herne Hill Road, London SE24 0AU.

CMOS Car Security Alarm

Almost any 12V relay with a coil rating greater than 180 ohms can be used in the *CMOS Car Security Alarm*. However, it is most important that the contact ratings of the relay can handle the car horn current.

We do not expect any buying problems with the remaining constructional projects in this issue.

DISCRETE

SEMICONDUCTORS EXPLAINED

PART FOUR

BY J.B.DANCE

OPTOELECTRONIC semiconductor devices detect or emit visible light, infra-red or ultra-violet radiation.

A simple *pn* junction in a single crystal of silicon or germanium can be used for the detection of visible and infra-red radiation. Other rather different forms of light detector employ a **polycrystalline** layer of cadmium sulphide or cadmium selenide which changes its resistance with changes in the light level.

Suitably biased gallium phosphide *pn* junctions will emit visible light, whilst gallium arsenide junctions emit in the infra-red. The electrical energy of the applied bias voltage and current is converted into radiant energy.

PHOTONS

Due to the wave-particle duality theory, light may be considered to behave as a large number of particles moving extremely rapidly. These particles of light are known as **photons** and are effectively "packets of energy."

The energy of a photon is related to the colour of the light concerned in the same order as the colours of the spectrum as shown in Fig. 4.1.

When photons of a sufficient energy strike a semiconductor material, they will form **charge carriers** (that is, electrons and holes) in the material. It is the subsequent movement of these charge carriers under the influence of an electric field that enables the incident photons to be detected. This process is depicted in Fig. 4.2.

In a given semiconductor material, a photon must have a certain minimum energy if it is to be capable of producing charge carriers. A single photon of adequate energy will produce only one electron and one hole.

PN JUNCTION DETECTORS

Let us now consider the case of the *pn* junction shown in Fig. 4.3. As in previous articles, the encircled charges are fixed in position, whilst the others are mobile and can carry a current.

If the junction has no bias applied to it from an external source, the *p*-type material becomes negative with respect to the *n*-type material. A potential of the same polarity is present if the junction is reverse biased, but the voltage across the junction is greater and the depletion region is wider.

If light strikes the semiconductor material in the depletion region, the holes and electrons formed move under the influence of the electric field. The holes are swept into the negatively charged *p*-type material and the electrons into the positive *n*-type.

This movement of charge carriers results in a flow of a reverse **photo-current** through the device. The reverse photo-current should be far greater in value than the reverse leakage current which passes through a dark junction. The photo-current is closely proportional to the intensity of the light at the junction.

GERMANIUM PHOTODIODES

The characteristics of a germanium photodiode are shown in Fig. 4.4. The reverse current which passes through the diode increases with the level of

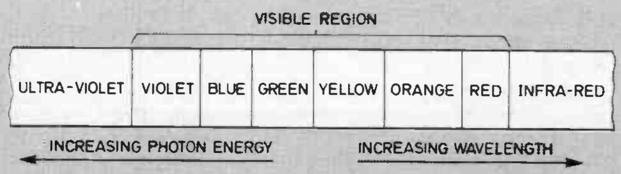


Fig. 4.1. The infra-red, visible and ulta-violet parts of the spectrum.

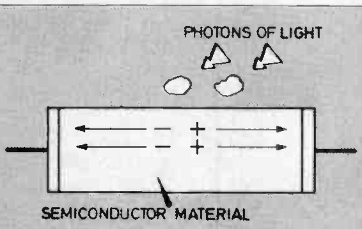


Fig. 4.2. Photons can create charge carriers in a semiconductor material.

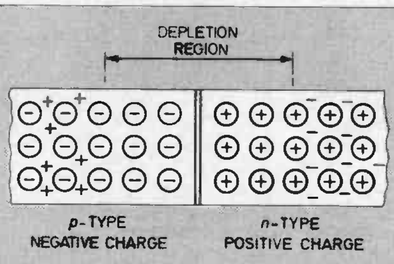


Fig. 4.3. A *pn* junction without bias.

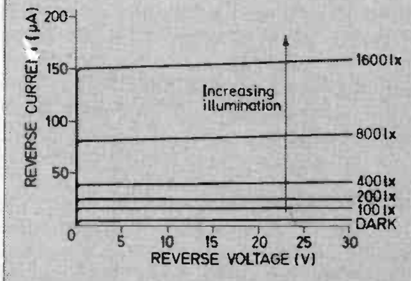


Fig. 4.4. Characteristics of a germanium photodiode.

illumination of the junction area, but is not very dependent on the applied reverse voltage.

The unit used to measure the intensity of illumination is the **lux** (abbreviated lx). One lux is the illumination level produced by a lamp of intensity one candela at a distance of 1 metre.

SILICON PHOTODIODES

The characteristics of a silicon photodiode are shown in Fig. 4.5. It can be seen that when no light falls on the device, the current is zero when the voltage across it is zero.

However, when the device is illuminated, a current will flow *even when no voltage is applied to the device*. In this case, the energy of the incident light is used to produce the electric current.

It can also be seen from Fig. 4.5 that if the current passing through the diode is zero (for example, at point *A*), a voltage appears across the device if it is illuminated. The production of a voltage when a device is illuminated is known as the **photovoltaic effect.**

Either the change in current or the change in the voltage across the diode when it is illuminated can be used as a measure of the light level. The change in current is very sensitive to a change in the level of illumination, but the change in voltage can be used to measure a very wide level of illumination, since the voltage is a logarithmic function of the incident light intensity at the junction.

Silicon cells are widely used for various industrial purposes, such as electronic counting and in computer tape and card readers. They may be used as photovoltaic cells with no applied bias or they may have a reverse bias applied to them.

SPEED OF RESPONSE

The common types of silicon photodiode can respond to a change in the level of illumination in a few microseconds. If the light level changes more quickly than this, the photodiode current will change a few microseconds later.

Special types of silicon planar photodiodes are available which can respond to a change of light level in about one nanosecond (one thousand millionth of a second). They are often used to detect light pulses from lasers.

SOLAR CELLS

Silicon solar cells convert the energy of the light from the sun into electricity for use where there is no convenient power supply. They may, for example, be used aboard space vehicles, in navigational devices in remote places, for operating a radio receiver.

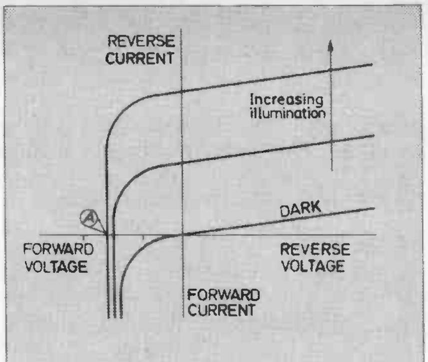


Fig. 4.5. Characteristics of a silicon photodiode.

The devices are similar to silicon photodiodes, but have a far larger surface area so that they can absorb enough light to produce an appreciable output power. The overall efficiency is a little over 10 per cent.

Solar cells may be connected in a series-parallel arrangement in order to obtain any reasonable value of output voltage or current. The maximum voltage obtainable from a single silicon solar cell is 0·55V in full sunlight when no current is being taken from it. Maximum power is obtained when such a current is taken that the voltage falls to about 0·45V per cell.

SPECTRAL RESPONSE

The type of semiconductor material used in a device determines the part of the spectrum to which the device responds most strongly.

The responses of selenium, silicon and germanium is shown in Fig. 4.6. The most commonly used material, silicon, has a good response from the yellowish-green region through orange and red into the near infra-red. The response of silicon reaches a maximum at a point just beyond the visible in the infra-red region.

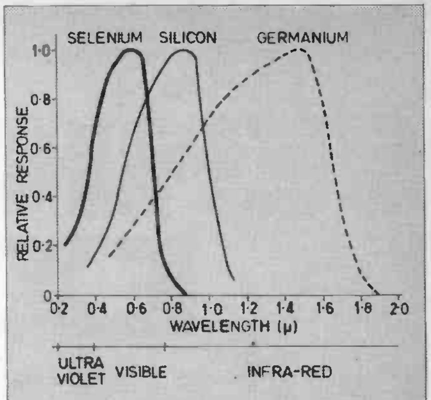


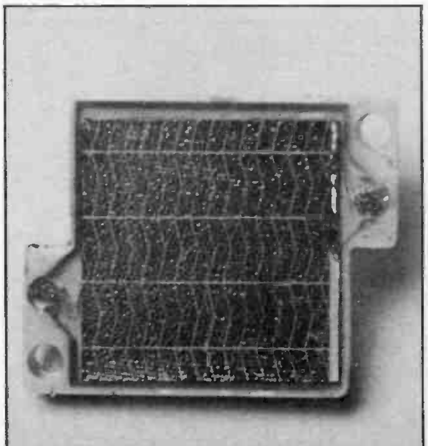
Fig. 4.6. The colour sensitivity of selenium, silicon and germanium.

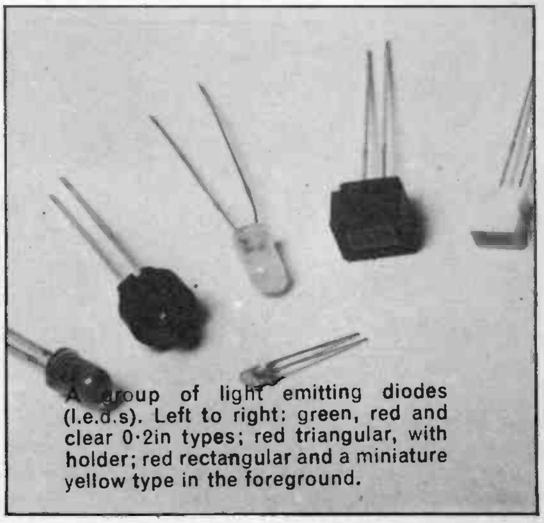
Germanium devices have a good response to orange, red and near infra-red radiation. The peak response is further in the infra-red than in the case of silicon devices.

Silicon and germanium devices are both very sensitive to the radiation from tungsten filament lamps, since this radiation consists of near infra-red radiation as well as visible light.

Selenium has a peak response in the blue-green region. These devices are often used when a response similar to that of the human eye is required. If an optical filter is used to reduce the amount of blue and ultra-violet radiation reaching a selenium cell, a response still closer to that of the eye can be obtained.

Selenium cells are often used in colourimeters and densitometers. A selenium cell may be connected directly to a milliammeter to make a photographic exposure meter. Although selenium cells have been used to power small radio receivers, their efficiency is considerably under


An example of a small solar cell for converting light into electricity.


A group of light emitting diodes (l.e.d.s). Left to right: green, red and clear 0·2in types; red triangular, with holder; red rectangular and a miniature yellow type in the foreground.

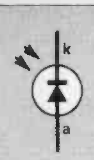


Fig. 4.7. Photodiode circuit symbol.

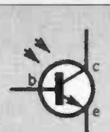


Fig. 4.8. *NPN* phototransistor circuit symbol.

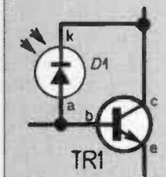


Fig. 4.9. *NPN* phototransistor behaves as if it consisted of the circuit above.

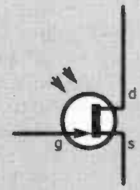


Fig. 4.10. Photofet circuit symbol.

1 per cent, so silicon solar cells are now preferred for this purpose.

Other materials are also used in junction photodetectors, but their applications are more specialised. For example, indium antimonide *pn*-junctions can be used to detect infra-red radiation.

The symbol for a photodiode is shown in Fig. 4.7. It is exactly the same as that of a normal diode, except that several arrows may be drawn as shown to indicate that radiation is incident upon the device. The circle is sometimes omitted.

PHOTOTRANSISTORS

A **phototransistor** is similar to a normal transistor, but is constructed so that light or infra-red radiation can fall onto the base-collector junction.

The charge carriers created in this reverse biased junction behave as in a junction photodiode, but they form the base current which is amplified by the normal transistor action. The collector current of a phototransistor therefore changes much more than the current passing through a photodiode for the same change in the light level.

The symbol for an *npn* phototransistor is shown in Fig. 4.8. It behaves as if it were the circuit of Fig. 4.9, namely a reverse biased photodiode connected between the base and collector of the transistor. The current passed by the photodiode acts as the transistor base current.

The early phototransistors were mainly *pnp* **alloy junction** types, such as the OCP71. However, modern silicon planar phototransistors (normally *npn* devices) have now replaced the germanium types.

Some of the older types of phototransistor were filled with silicon grease to diffuse the light onto the junction and hence to provide reasonable sensitivity for light from any direction. (Indeed, if the black paint is removed from some of the older types of glass encapsulated transistor, they can be used as phototransistors.)

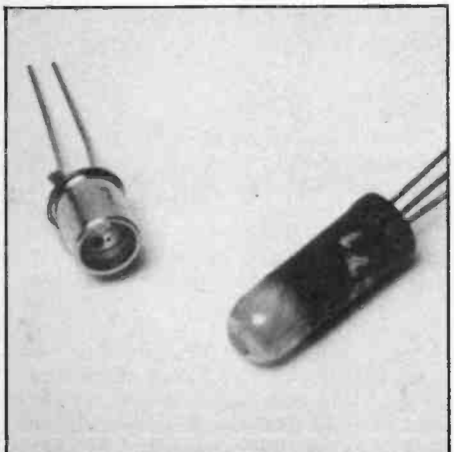
Modern silicon devices are often encapsulated in a TO-5 case which has a flat window in the top for making optical contact or alternatively a lens in the top for focusing the incident light onto the junction.

The leakage current of a silicon phototransistor is far smaller than that of a germanium device. As the leakage current is very temperature dependent, silicon devices are much less affected by changes of temperature than germanium devices.

FREQUENCY RESPONSE

In a phototransistor the charge carriers are formed at various distances from the base-collector junction and therefore take different times to reach the collector. The frequency response and the speed of operation of a phototransistor are therefore much inferior to that of a similar photodiode.

Germanium phototransistors have a cut-off frequency which is usually a few kHz, whereas germanium photodiodes can normally be used at frequencies of up to about 50kHz. Modern silicon planar phototransistors may operate at over 100kHz.



A photodiode and the OCP71 *pnp* phototransistor.

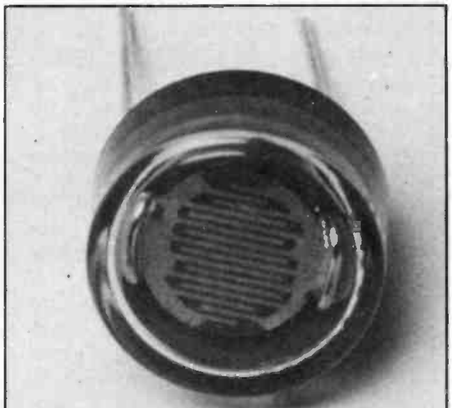


Fig. 4.11. A photoconductive cell. The lighter shaded area is the electrodes. The dark area is the photoconductive material.

PHOTOFETS AND OTHER JUNCTION PHOTO-DEVICES

Light controlled silicon junction field effect transistors or **photofets** are available, although they are not very commonly used. The circuit symbol is shown in Fig. 4.10.

Incident light strikes the region of the gate-channel junction and produces charge carriers. The latter form the gate current the flow of which through a gate resistor causes a change of gate voltage. The value of the gate resistor determines the sensitivity of the device.

Photofets have some advantages over phototransistors, including adjustable sensitivity and a greater gain-bandwidth product.

Various other types of junction photodetectors are available. In particular, one may mention the **LASCR** or **Light Activated Silicon Controlled Rectifier** which is switched from the non-conducting to the conducting state by a pulsed beam of light. The LASCR is a *pnpn* device and is always either fully conducting or switched off.

During the last few years integrated circuit photodetectors have become available in which the detecting device (usually one or more silicon photodiodes) is fabricated on the same silicon chip as a number of transistors and/or MOSFETS. The latter amplify the signal or process it in some way.

JUNCTIONLESS PHOTODETECTORS

One type of photodetector which is very widely used contains no junction. It employs a layer of a semiconductor material which has a lower resistance when light falls onto it than it has in darkness. The material is known as a **photoconductor** because it conducts in the presence of light.

The construction of a typical **photoconductive cell** is shown in Fig. 4.11. The photoconductive material is cadmium sulphide or cadmium selenide which is deposited as a polycrystalline layer (that is, the layer consists of many small crystals).

The electrodes extend into the material so that, when the cell is illuminated, the resistance between the electrodes falls to quite a low value—typically a few hundred ohms.

The semiconductor material is sealed behind a glass window through which one can see the type of structure shown in Fig. 4.11.

AMPLIFICATION

In cadmium sulphide and cadmium selenide materials, a photon of the incident radiation will form an electron and a hole and the electron will move to the positive electrode. However, the hole will almost certainly be trapped in the semiconductor material before it has moved very far towards the cathode.

When the electron has reached the anode, the trapped positive charge will remain in the semiconductor material and will attract an electron from out of the cathode. There is a high probability that this electron will move through the material directly to the anode, after which a further electron will be attracted out of the cathode by the trapped hole.

This electron will also probably reach the anode. A current will therefore continue to flow until eventually one of the electrons neutralises the trapped hole.

This process results in the flow of a far larger current through the cell for a given number of incident photons than if only the electrons and holes formed directly by the photons reached the electrodes.

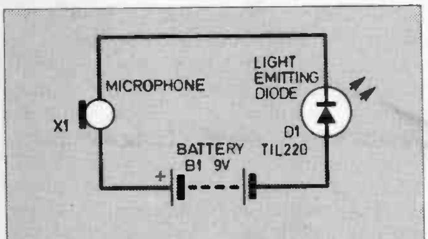


Fig. 4.12. A gallium arsenide infra-red transmitter circuit.

The effect of this charge amplification process is to increase the current (that is, to lower the resistance) by a large factor. A current amplification of 10,000 times is easily obtained.

RESPONSE TIME

Unfortunately a price has to be paid for the current amplification obtained in a simple cell of this type. The price one pays is in a reduction in the speed of response of the device.

If a photoconductive cell is suddenly illuminated, there is a time lag before the resistance of the cell falls to its final value. Similarly, if a cell is suddenly placed in darkness, a short time lag occurs before the resistance of the cell reaches its final value.

The time taken for a cell to respond to a change in the light level depends on the type of cell and on the two levels of illumination concerned. In a typical cadmium sulphide cell, the time for the resistance to reach two thirds of its final value may be about one tenth of a second. Cadmium selenide devices are about ten times faster than cadmium sulphide devices.

The main disadvantage of cadmium selenide devices is that their resistance is very temperature dependent. Cadmium sulphide detectors are more commonly used. Photoconductive cells are also available which employ both cadmium sulphide and cadmium selenide. They have a fairly short response time and a better temperature stability than cadmium selenide.

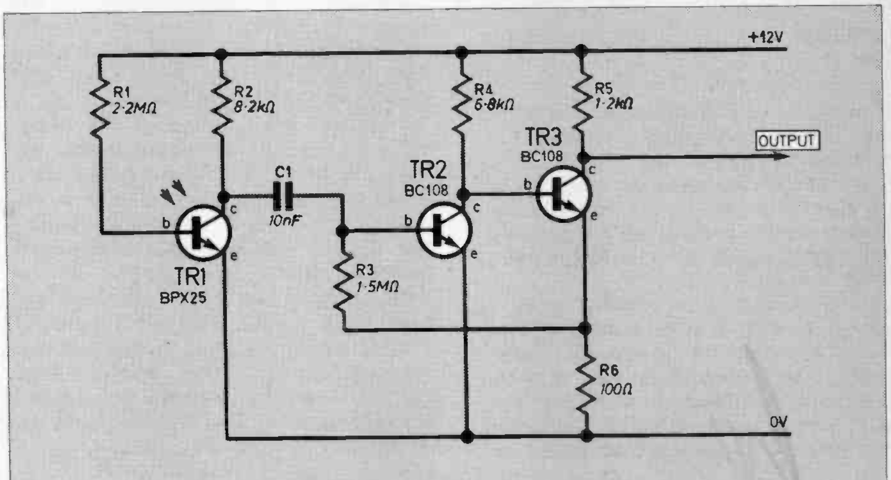


Fig. 4.13. An infra-red receiver circuit.

CADMIUM SULPHIDE

Cadmium sulphide (Cds) cells have a response somewhat similar to that of the human eye. The peak response occurs at about 550 nm in the yellow-green region of the spectrum, but the spectral response varies somewhat with the impurities present in the semiconductor material.

A typical cadmium sulphide photoconductive cell may have a resistance of over 10 megohms when it has been in darkness for some time. However, when the cell is placed in normal daylight, its resistance may fall to a few hundred ohms. The actual resistance values depend on the construction of the particular cell being considered.

Photoconductive cells are adversely affected if moisture enters them and reaches the semiconductor material. The Sylvania Company incorporate a small amount of a blue anhydrous cobalt compound in their cells in the form of a blue dot. If moist air enters the cell, the cobalt compound is converted into its hydrated form which is a pale pink. The blue dot therefore almost disappears.

RATINGS

All types of photoconductive cell have maximum power, voltage and current ratings.

The power dissipation is generally a maximum when only a moderate amount of light is falling on the cell. At very low levels of illumination the cell resistance is very high and therefore the current passing is small and the power dissipation low. At high levels of illumination the cell resistance is relatively low and therefore the voltage appearing across it in most circuits is fairly small, so again the power dissipation is low.

It should be noted that the cell is slightly more sensitive when a constant voltage is applied to it than when the supply is an alternating one. This effect can be explained by the release of some of the trapped holes during periods when the instantaneous value of the alternating voltage is relatively small.

The maximum temperature at which photoconductive cells should be operated is usually about 50 to 60 degrees Celsius.

APPLICATIONS

Cadmium sulphide and cadmium selenide photoconductive cells have the advantage that they can pass a much larger current than other types of photosensitive device, but they are much slower than other types. They can be used for the direct operation of relays without any amplifying device.

The response of photoconductive cells to light is less linear than that of most other types of photosensitive device; they are therefore more suitable for detecting changes in light intensity than for making measurements of light levels.

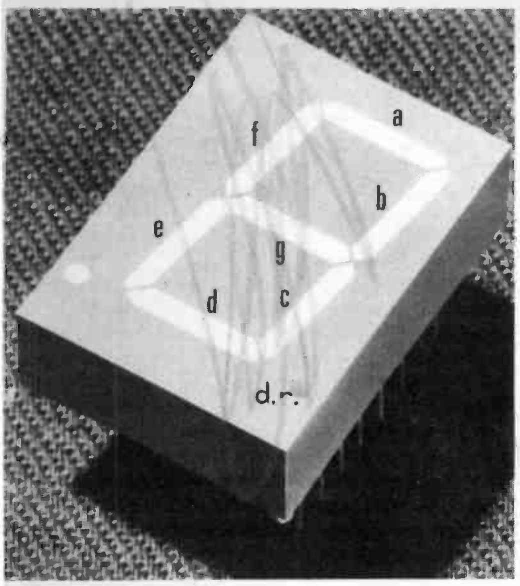


Fig. 4.14. A seven-segment light emitting diode digital indicator with decimal point.

In general, photoconductive cells are cheap, compact and rugged devices which are very suitable for use in industrial automation systems for the direct operation of relays. One of their great advantages is the simplicity of the circuits with which they can be used.

Photoconductive devices are also used in certain lamp-photocell enclosures. When the lamp is illuminated, the photocell resistance falls. Thus one has a very low noise variable resistor with excellent isolation between the input and output. The lamp may be at a very high potential relative to the photocell.

JUNCTION PHOTOEMITTERS

Gallium arsenide diodes emit infra-red radiation when they are forward biased, the amount of radiation emitted being proportional to the current flowing. Little current flows until the applied voltage exceeds about 1·2V.

Gallium arsenide diodes convert the electrical energy into infra-red radiation with very high efficiency, but unfortunately the proportion of the photons which escape from the semiconductor crystal is rather small. The overall efficiency is usually between 0·3 and 10 per cent.

A common application of gallium arsenide emitters is in small, portable infra-red communication systems for use over short line-of-sight distances. A circuit for an extremely simple transmitter is shown in Fig. 4.12 and that for a receiver in Fig. 4.13.

The current passing through the emitting diode is modulated by means of the microphone and the infra-red output radiation is therefore modulated with the speech signal. A suitable lens is used to produce a parallel beam which is directed towards the receiver. In the receiver the beam is focused onto a silicon photodiode and the resulting audio signal is amplified and fed to an earphone.

Such speech communication systems are convenient for use in places such as building sites where one would not require wires to be dangling about. The emitting diodes have a very fast response and can be modulated at frequencies up to about 1000MHz. They can therefore be used for the short range transmission of television signals and in optical fibre telephone links.

PHOSPHIDES

Gallium phosphide diodes emit visible light when forward biased. One type of diode produces green light and others yellow, orange and red light, the difference being the impurities present in the semiconductor material. The efficiency is less than that of gallium arsenide diodes.

Red and green emitting diodes can be used as indicator lamps as warning indicators, and so on. They are also used for placing information at the side of aerial reconnaissance photographs and in other film marking applications.

Another type of gallium phosphide diode emits a weak orange light when it is reverse biased in the avalanche mode. Such diodes are used in the testing of photomultiplier tubes, since the rise time of the light pulse can be extremely rapid.

Diodes which employ single crystals of gallium arseno-phosphide can be made which emit red light with high efficiency. They are used in various types of information display, including the familar type of seven-segment display shown in Fig. 4.14. Seven of the emitting diodes are employed in this display (each providing light to one of the segments *a* to *g*) and an extra emitting diode illuminates the decimal point, d.p.

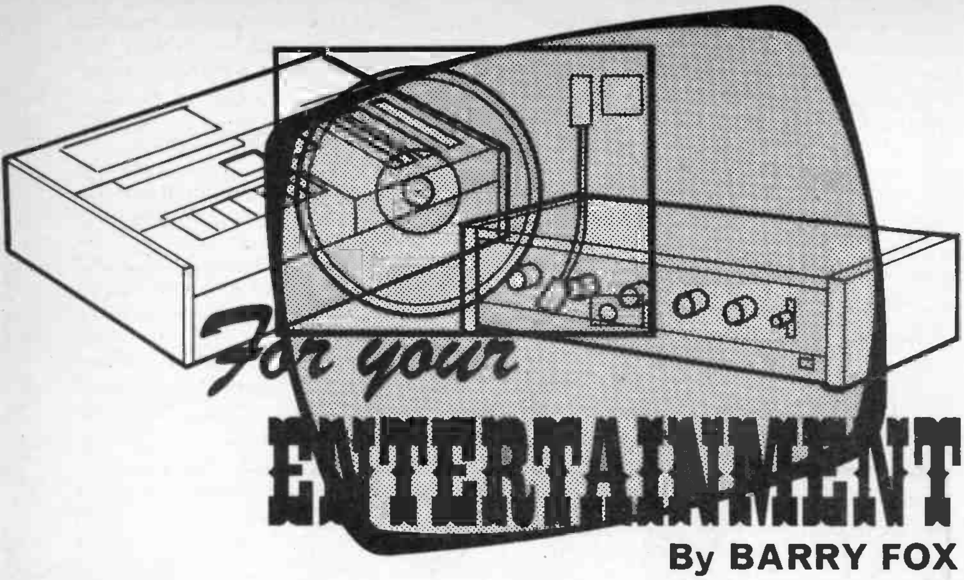
LASERS

Certain forward biased semiconductor junction diodes will operate as lasers when the current passing through them is great enough. Gallium arsenide is most commonly used, but gallium phosphide will not operate as a laser.

Gallium arsenide lasers can operate continuously at liquid air temperatures, but if the device is kept at room temperature, it can be used as a laser only in the pulsed mode of operation. Continuous operation at room temperature would involve too much power dissipation.

The diodes must be specially constructed to operate as lasers, but gallium arsenide lasers can produce infra-red radiation with a very high efficiency.

It appears that the main fields of application of diode lasers will be in communication, for example, in outer space where the radiation will not be absorbed by fog or smoke. They can also be used in aircraft altimeters and in fibre optic telephone links. ⌑



For your ENTERTAINMENT

By BARRY FOX

Piano Roll

Sometimes the full significance of new technology doesn't at first appear. In the 1920's, before audio recording reproduction reached high standards, families used piano rolls to reproduce music in their homes.

A roll of paper with punched holes ran through a mechanical piano machine to control air valves which operated the keys. In this way George Gershwin could play in your living room.

Piano music was killed off by the advent of electronic amplification and higher fidelity reproduction of recorded music from discs. But recently interest has been revived by the Californian firm Marantz-Superscope who have taken, what, with the benefit of hindsight, seems the logical step of converting the old punched hole paper roll into digital code on magnetic tape.

This move is logical because punched hole piano rolls were nothing more or less than digital recordings. Each hole or absence of hole signified a key function, just as a recorded pulse or absence of pulse (one or zero) signifies a coded function on a modern digital recording.

Pianocorder

The Marantz system is called the Pianocorder and although the company has run into financial difficulties over recent years (and been taken over by Philips) the Pianocorder still lives on and is being marketed around the world. The idea is to provide the ultimate in hi fi reproduction of a piano recording.

The instrument is a mechanical piano with an in-built cassette player which replays the pulses from tape and controls the piano keys through relays.

To make a recording for the system a concert or jazz pianist goes into a recording studio and performs on a Pianocorder piano equipped to record his or her keyboard fingerings in digital code. Cassette copies of the master recording are then sold so that purchasers can hear the exact equivalent of the studio performance reproduced in their own front room on a Pianocorder player piano.

Marantz-Superscope have made available digital transcriptions of old paper piano rolls as well as modern studio "recordings". But the really clever idea, mooted by engineers inside the firm and never yet publicly aired, is to transmit the digital code over the radio.

The idea is that a famous pianist performs, say at the Royal Festival Hall, and in addition to the usual "live" sound and pictures the BBC transmits digital coded signals derived from a Pianocorder attachment fixed to the concert piano. These signals convey an exact digital code replica of all the keyboard movements made during the concert.

The coded signal is received in a listener's home from f.m. radio, or even a.m. radio because the digital bit rate is comparatively low. The radio receiver output is plugged into a Pianocorder player so as the pianist performs in the Festival Hall, an exact replica of the performance is reproduced in the listener's home.

Taken a stage further the idea would enable composers to communicate musical ideas across the world by data link. In fact, the Pianocorder transmission bit rate is slow enough to be carried over most conventional telphone links so the composer of a song just plugs into a telephone attachment, plays a tune and sends the signal of digital pulses down the phone line to a lyricist in some far-off city.

The lyricist plugs the incoming phone signals into a Pianocorder player and listens to the melody arriving down the phone from the composer. The incoming digital signals can easily be recorded onto cassette tape for repeated reproduction.

Currently composers must either play low quality audio signals down a telephone line or travel in person to work with their lyricists. The Pianocorder system could provide a near equivalent to personal contact for the price of a telephone call.

Energy Saver

The Lighting division of Thorn claims to have developed "the lamp of the future". It's a miniature gas discharge, or fluorescent lamp which has the light output of a conventional 100 watt bulb but consumes only 21 watts of electricity. It also has five times the life.

The Thorn 2D Lamp doesn't look like an ordinary fluorescent bulb, it's a thin tube formed into a double-D shape to save space. The current limiting ballast is hidden in a one piece adaptor so that the lamp can be plugged into an existing lighting socket.

The ballast consumes 5 watts and the lamp 16 watts. So electricity running costs are a fifth that of normal filament lighting. Guaranteed life of the 2D is 5,000 hours, against 1,000 for a household filament bulb.

Thorn estimate that if every one of the 20 million homes in England had just one, the saving in energy cost to the country would be £120 million a year. So what are the snags? Why don't we all go out and buy one today?

Well, for a start you can't buy one. There aren't even any lamps available for press review. After generating considerable publicity for the 2D, with a press launch in February, Thorn now admits that the company isn't even in production yet and is only "aiming" to launch "around September".

Also not everyone likes fluorescent light. And resistance isn't due just to an emotional dislike of the traditional tube shape.

Although Thorn say they are "not actually aware" of it, there is no doubt that some people do have a physical aversion to gas discharge lighting. Especially when a tube is getting old the flicker can be very irritating. It can even trigger migraines in those who are prone.

The human eye is very sensitive to any movement on the periphery of vision. It all dates back to the days when we lived in caves and hunted for survival. We needed to watch for danger coming up from behind or the side. So our peripheral vision is more aware of motion than detail.

If you are looking at a gas discharge lamp through the corner of your eye any flicker will be immediately noticeable. And in a confined space it can be very disturbing.

In offices and public places lamps are replaced immediately they show any signs of flicker. But will people be prepared to do the same in their homes, especially as one of Thorn's strong selling points is long life and the new lamps are by no means cheap.

It is estimated that the ballast fitting will cost around £5 and the lamp around £3·50. Forgetting for the moment the £5 investment in the ballast fitting, and assuming a full 5,000 hour working life, this puts the capital cost of a Thorn 2D lamp at around twice the capital cost of a filament bulb that lasts 1,000 hours.

Of course anyone who also takes electricity running costs into comparison will opt for the Thorn lamp. The 80 per cent saving of energy means that one pennyworth of electricity will give you around 2 hours of illumination from a 100 watt filament bulb and 10 hours from a 2D lamp. But Thorn will have a hard time getting this message across and persuading householders to invest £8·50 a time (ballast fitting and lamp) to replace the literally dozens of lamps in a home.

SQUARE ONE FOR BEGINNERS

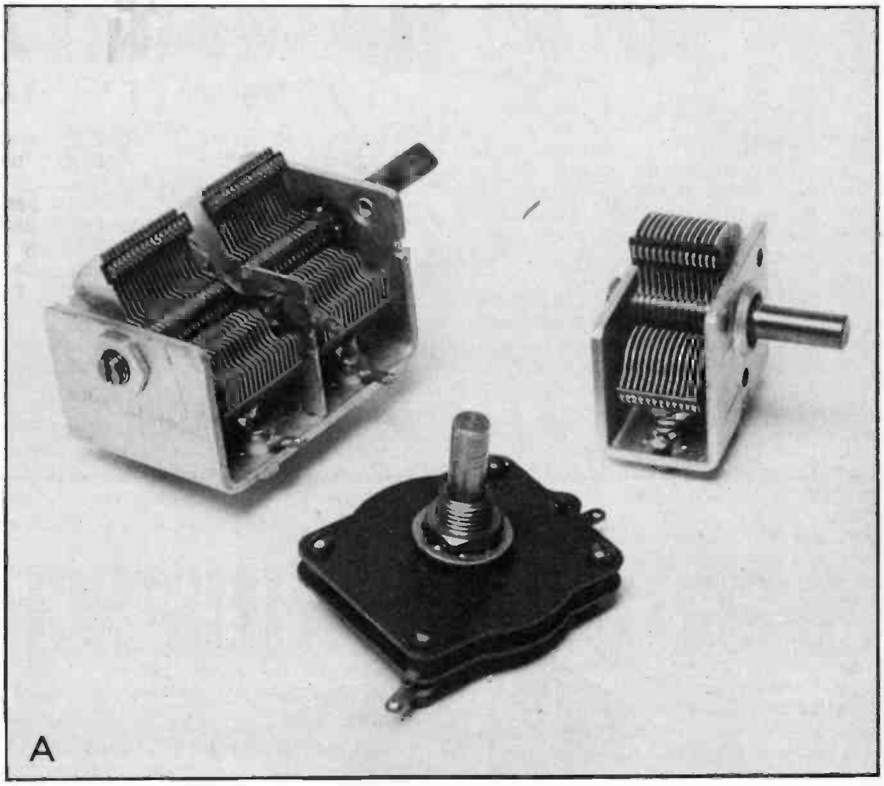
HAVING looked at the nonpolarised and polarised capacitor we now move on to the various variable types available to the home constructor. As with variable resistors, they fall into two main classes: the sort used for major control purposes and presets or trimmers as they are usually called.

Unlike variable resistors, variable capacitors do not come in the same range of values as fixed types. This is due mainly to the fact that techniques used to make high value fixed capacitors cannot be adapted for variable types.

The main control use for variable capacitors is as the tuning control in a radio receiver. Here the variable capacitor is used to vary the resonant frequency of a tuned circuit in the input stage of the receiver. As only low values are required here it is unusual to find a variable capacitor with a value much above 500pF.

Trimmers, as their name suggests, are designed to be used in much the same situation as preset potentiometers, that is to be used in a situation where adjustment may be needed from time to time but not continually.

A low value trimmer may also be used in parallel with a large value variable capacitor to make fine adjustments or to "trim" the final value of the big variable, hence the term "trimmer".



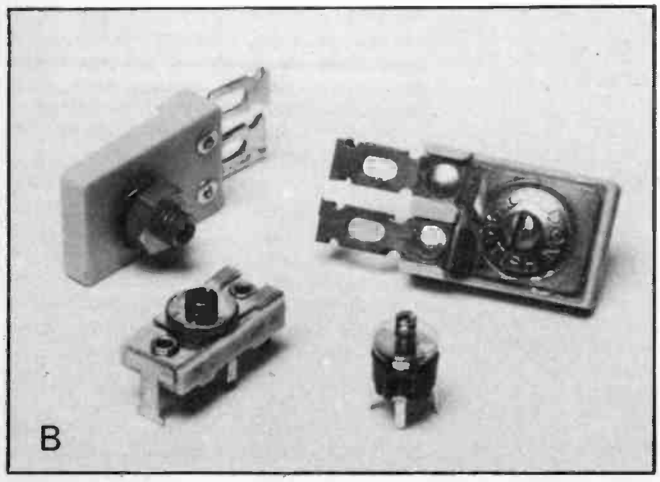
A Three different forms of variable capacitor. The device top right is a single-gang air dielectric type. The capacity is changed by varying the amount by which the fixed and moving plates are intermeshed. This changes the effective area of the plates and hence the capacity.

The device top left is a twin-gang air dielectric type. Like a stereo potentiometer we have two variable capacitors on the same spindle. This is necessary because in many radio receivers there are two tuned circuits in the r.f. stages and the resonant frequency of each one needs changing in step with the other.

In dual-gang types you often find that one connection is common to both stages with a separate connection for the other end of each gang. Another common feature of these types is a built in trimmer for each gang wired across the main stage.

At the bottom of the photo is a solid dielectric type. By using this form of dielectric instead of air, these can be made more compact although they do not offer quite the same electrical performance.

Unlike a potentiometer, the variable capacitor has only two connections. This is because, by its very nature, a variable capacitor cannot be connected to give maximum capacitance between two tags while the wiper is connected to a third. Instead capacitance simply changes from around zero up to the nominal value.



B Presets or trimmers. Uppermost in this picture are two views of a compression trimmer, *left*—underside; *right*—topside. Another similar but smaller device is shown in the bottom left corner.

Compression trimmers consist of two brass plates with a sheet of mica separating them and acting as a dielectric. The value of the trimmer is changed by turning the screw. This allows the top plate to move either towards or away from the bottom fixed brass plate and because capacitance depends on the distance between the plates as well as their area, so the capacitance of the trimmer changes.

Although both these components are compression types, the device at bottom left is obviously much lower in value than the other. In fact it has a nominal value of 40pF whilst the one above has a nominal value of 500pF. The base material in both cases is ceramic.

The trimmer at the bottom right of the picture is more sophisticated than the other two in that it is really a subminiature version of the solid dielectric variable capacitor mentioned above.

It has p.c.b. mounting pins arranged on a 0·1 inch matrix and a polypropylene dielectric for high insulation resistance with a low temperature coefficient. Because of its small physical size, this type of trimmer is only available in nominal values of 10, 22, and 65pF. The value is indicated by the colour of the polypropylene moulding. This type of trimmer is only suitable for low voltage circuits.

in My Class

by
T.R. de Vaux-Balbirnie

GERALD's calculator had stopped working. "I checked the battery with the multimeter and there are still 9 volts in it!" he told me. I reprimanded him for his lack of knowledge then asked him to remove the battery cover again.

Without disconnecting the calculator, I managed to press the pointed probes of the multimeter on to the battery terminals. With the calculator switched *off* the meter read 9 volts. When it was switched *on* the reading was only 5 volts.

I explained that, with no load connected, the multimeter indicated the *e.m.f.* of the battery and that this stays fairly constant whatever the condition of the battery. When a load is connected, current flows not only through this but also through the *internal resistance* of the battery.

As the battery ages the internal resistance rises and leads to less "available voltage" at the terminals of the load. Eventually, the internal resistance rises to the point where the battery is no longer fit for service.

I illustrated this with a diagram showing a 12 volt lamp, resistance 24 ohms, connected to a 12 volt battery with an internal resistance of 12 ohms. The internal resistance is shown in series with the battery within the dotted box, see Fig. 1.

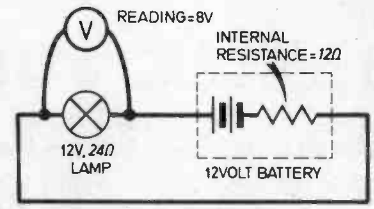


Fig.1.

Ohms Law

Gerald understood that the total resistance of the circuit was 36 ohms and, using Ohm's Law, he was able to calculate the current flowing: $I=V/R=12/36=1/3$ Amp. I then asked him to apply Ohm's Law again to find the "useful voltage" across the terminals of the lamp: $V=I\times R=1/3\times 24=8$ volts. The lamp would be lit only dimly. The other 4 volts or "lost voltage" appears across the internal resistance of the battery.

"So, it was the fault of the battery after all", sighed Gerald and, on replacing it, continued with his calculation.

Purchasing Knowledge

Contacting my network of Component Suppliers recently and asking how they were faring, confirmed the data on my charts that June is the Nadir of the Electronics hobby year. It is the time when our readers pack away their soldering irons and get out their buckets and spades, or sailing gear, according to their age group.

If the truth be told, none of us are idle even if we are not overburdened with customers, it is always a good time to take stock and see what improvements we can make in our service. We can also use it to make good any gaps in our own technical knowledge, especially going back over basics. It is strange, but unless you have an extraordinary retentive memory, in your efforts to keep up to date, you will find basic principles are forgotten.

Today, advancement in technology is so rapid that it is more important to know where to find the information than to try to assimilate it all. My remarks on knowledge also apply today on stock, with the proliferation of different types of items, particularly transistors and i.c.s, it is out of the question for each of us to stock more than a fraction of what is available, so to help our customers it is far more important and practical to know where it can be purchased.

I am sure many of our readers will ultimately wish to take up Electronics professionally and it is interesting to speculate on their chances of success. I would certainly rate it higher than most other hobbies and according to their degree of skill, they may finish up as designers, technical writers, teachers, trouble shooters, or if they are very much below par they could finish up as component retailers. Let us hope they are spared that fate! However, as I have stressed so often we are going to end up with more leisure time and this is where an enduring hobby is all important.

I wonder how many of you read the story of John Patrick recently. A University Professor was offering £375 to couples who would give up watching television for two months. So the Patricks agreed to have their television collected and for two weeks all went well and then rows started breaking out, which finished up with the husband and wife splitting up and are now living apart each with separate TV sets.

They didn't win the £375 and John was fined £100 for breaking the peace and had to pay £300 in lawyers fees. One thing I am certain of, it would never happen to one of our readers for reasons which I needn't go into.

A Word For It

Finally, something to exercise your minds. In the good old days before Electronics, we talked about Electricity and an expert in this field, that is, an Electrical Engineer was called an "Electrician". Can any of our readers think up a word (it must be one word) that would describe an Electronics Engineer? Make up a word if need be.

I will make known the best effort in a later article.

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INTRODUCTION TO LOGIC

PART 5 BY J. CROWTHER

SWITCHES IN PARALLEL

Consider the circuit in Fig. 5.1:

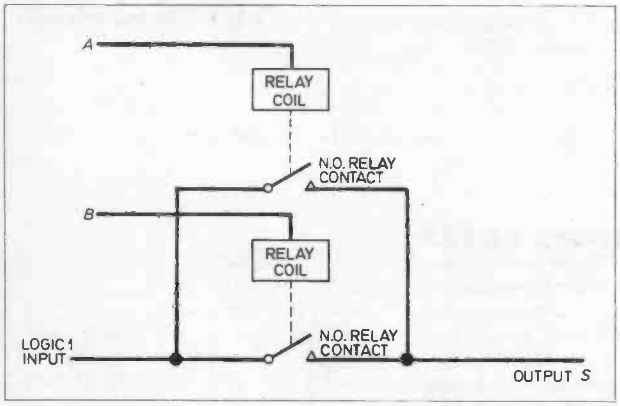


Fig. 5.1. To obtain an output either relay *A* or *B* (or both) must be energised. A 2-input OR gate.

To get an output at *S* relays *A* OR *B* must be energised. In Boolean this is written as:

$$A+B=S$$

A plus *B* in Boolean means *A* OR *B*.

Therefore $A+B=S$ means an input (logic 1) at *A*, OR an input (logic 1) at *B* will give an output (logic 1) at *S*, and represents two normally open switches in parallel

Similary

A+B+C $A+B+C=S$ means to get an output we must have *A*, OR *B*, OR *C*, and is represented in Fig. 5.2.

Also:

$A+\overline{B}+C=S$ means to get an output we must have *A*, OR NOT *B*, OR *C*, and it represents three relays in parallel, with relay *B* a normally closed type.

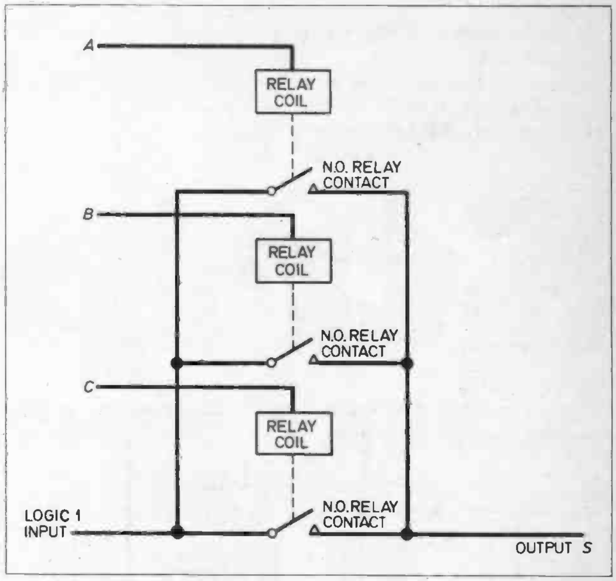


Fig. 5.2. Energising relay A, B or C (or any combination) will produce a logic 1 output. A three-input OR gate.

SERIES/PARALLEL COMBINATIONS

example 1

In the circuit shown in Fig. 5.3 an output will be obtained if: in the top branch,

A AND *B* are energised, the equation being: $AB=S$

or

in the bottom branch,

if *C* were energised, the equation being: $C=S$.

Combining the two conditions, the equation for the whole circuit becomes:

$$AB+C=S$$

which means a logic 1 at *A* AND *B*, OR a logic 1 at *C* will give an output (logic 1) at *S*, and represents *A* and *B* in series, in parallel with *C*.

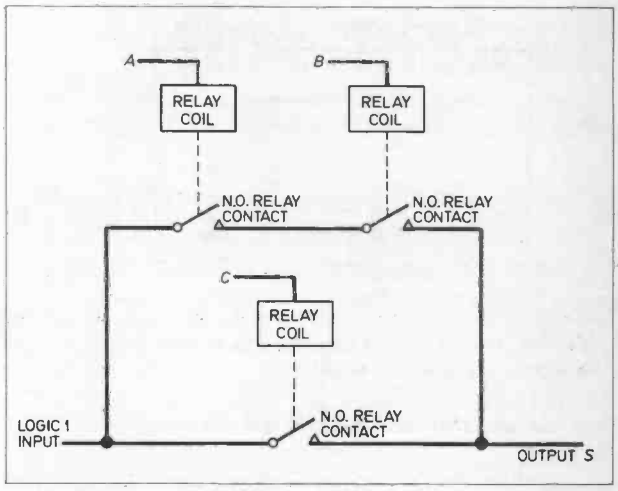


Fig. 5.3. A logic 1 appears at the output when both *A* and *B* relays are energised or when relay *C* alone is energised (or all three).

example 2

To get an output in Fig. 5.4 we must have A, and either B or C energised.

In Boolean this is written as: $A\,(B+C)=S$. which means a logic 1 at A AND, B OR C will give an output (logic 1) at S.

If we multiply this equation out we get:

$$AB+AC=S$$

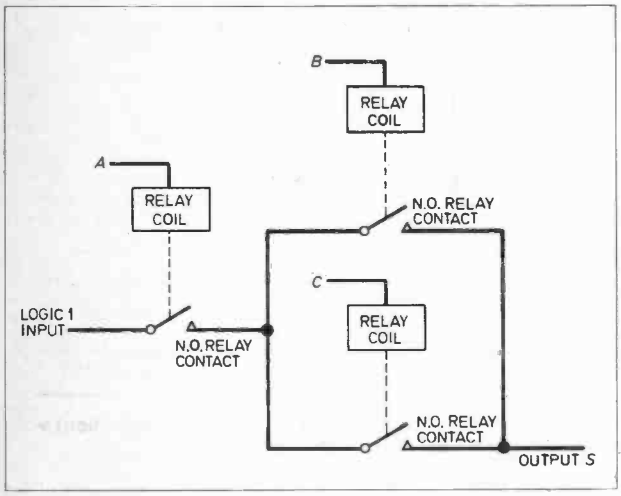


Fig. 5.4. This combination will transmit the logic 1 input only when relay A and either relays B or C (or both) are energised.

This is of the same form as the equation for *example* 1 which represents the following switch arrangement Fig. 5,5, where A is a ganged switch with two sets of contacts.

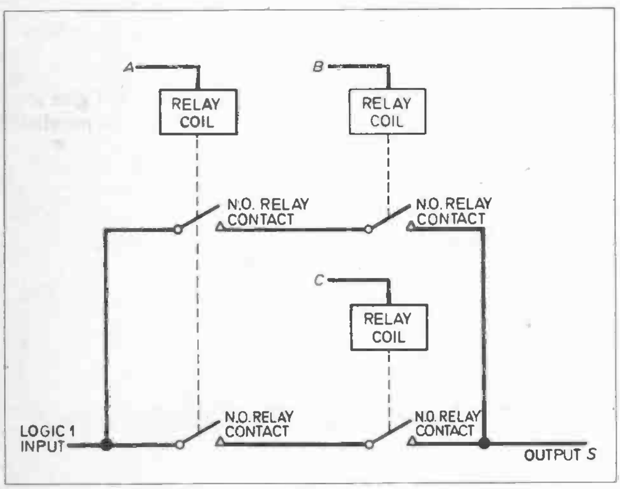


Fig. 5.5. To obtain a logic 1 output, relay A must be energised together with relay B or C (or both).

It can be seen that this circuit will give the same result as the circuit shown in *example* 2, therefore in Boolean Algebra:

$A\,(B+C)=S$ is equivalent to $AB+AC=S$

This shows that ordinary algebra multiplication and addition rules also apply to Boolean algebra without altering the result. Designers use this and other rules in order to simplify equations and cut down the number of switches required.

BOOLEAN ALGEBRA RULES

1) A means a pulse present (logic 1).
   $\bar{A}$ means NOT A, or no pulse present (logic 0).
2) AB means A AND B, and represents switches in series.
   $A+B$ means A OR B, and represents switches in parallel.
3) Only multiplication and addition rules apply.

example

$$A\,(B+C)=AB+AC$$

4) Transposition of formulae is **not** allowed.
5) Bars may be added to both sides of an equation, or transferred from one side to the other, providing they cover the whole expression.

example

$A+B=S$ is the same as: $\overline{A+B}=\overline{S}$

$\overline{AB}=S$ is the same as :$AB=\overline{S}$

6) Double bars of the same length cancel.

example

$$\overline{\overline{A}}=A \text{ or } \overline{\overline{AB}}=AB$$

Note

The bars **must** be the same length.

$\overline{\overline{A}B}$ does **not** equal AB.

7) DEMORGAN'S THEOREM

If a bar is joined, or split, the sign must be changed where the split or join occurs.

example

$$\overline{A+B}=\bar{A}.\bar{B} \text{ or } \bar{A}+\bar{B}=\overline{AB}$$

$$\overline{AB+C}=\overline{AB}.\bar{C} \text{ or } \bar{A}+\overline{B+C}=\overline{A\,(B+C)}$$

8) If a symbol appears by itself, any other term containing that symbol cancels.

example

$$A+AB+AC=A$$

$$AB+ABC+CD=AB+CD$$

LOGIC GATES

There are four generations of logic gates:

1) First Generation (Valves). 1940 to 1953.
2) Second Generation (Transistors). 1953 to 1962.
3) Third Generation (Integrated Circuits: small scale integration, complete circuits or gate in one chip). 1962 to 1973.
4) Fourth Generation. (Medium and large scale integration: medium scale, 10 tc 100 circuits in one i.c. large scale, over 100 circuits in one i.c.). 1973 onwards.

Properties of Logic Gates

(a) An output S (logic 1) is obtained if the inputs satisfy the combination of the switches inside the gate. This combination can be expressed by a Boolean Equation.

(b) The number of inputs can vary from two to thirteen with one input as a special case.

(c) Inputs should be isolated so that no interaction or feedback occurs between them.

(d) The inputs may be connected to each other, or to the input of another gate.

(e) The outputs are not usually connected, but they may be connected to the input of another gate.

(f) Gates may be given a power gain so that one output can drive many inputs.

(g) Gates require power supplies, but unlike circuit diagrams these are not shown on Logic Diagrams.

TO BE CONTINUED

BACK TO BASICS

Electromagnetism

THE fact that a magnetic compass can be used to detect an electric current was mentioned in the first part of this series.

The compass is placed with its needle aligned with a current-carrying wire, as close to the wire as possible (Fig. 4.1a). When the current is switched on the needle is deflected. It works only for d.c. and unless the current is large (a few amperes) the deflection may be too small to see.

When this effect was first discovered, early in the 19th century, nobody could have realised that the first step had been taken towards a goal for which physicists are today striving—the unification of the forces of nature by linking them together. Many of these forces had yet to be discovered. But here was a link between two which had: electricity and magnetism.

CURRENT METERS

It was soon realised that the effect on the compass can be intensified by a simple trick. All you do is wrap the wire round and round to form a coil. Then the same current passes the compass at every turn. Better still, put the compass in the centre of the coil (Fig. 4.1b). The magnetic field made by the current flowing in the upper wires now aids the field round the lower wires.

This arrangement was the basis of an early type of current measuring instrument, called the Tangent Galvanometer. You may still find these in physics labs, though engineers long ago replaced them with more convenient forms of meter.

This article is not about meters, however, but rather about coils of wire.

Coils turned out to be versatile tools for electrical and electronic engineers. You'll find them in **transformers, solenoids, inductors, chokes, deflection assemblies** in TV sets, **relays** and many other applications.

Some of these **"wound components"** contain much more than a coil of wire, but it is the coil that makes them work.

INDUCTION

Why does d.c. in a wire deflect a compass needle? Evidently the current creates a magnetic field. It follows that a coil fed with d.c. must behave like a magnet, and it does. Even today, the most powerful magnets are electromagnets, that means they have coils wound around them.

But if electric current makes magnetism, is the reverse true? Can a magnetic field produce a current in a nearby wire?

In exploring this possibility, Michael Faraday made one of his key discoveries. He found that in a static situation, with nothing moving, magnetic fields have no power to make currents flow in nearby wires. But when there is movement, they do. A magnet lying by a wire has no effect, but move either the magnet or the wire and while that movement is going on current is produced.

WIRELESS

In time, this discovery led to an exciting possibility: radio. To see how, let's look at the situation a bit more closely.

A current in a wire is able to deflect a nearby compass needle. But a compass is not a very sensitive indicator. Is the field really concentrated near the wire or does it extend further, though more weakly?

Faraday's insight suggested that the field must extend for ever, spreading out to fill the entire universe.

In that case, if a current were turned on at one place, the magnetic effect could in principle be detected at a distant place. In other words, signals could be sent by turning the current on and off. The signals would travel through the air, needing no telegraph wires.

Hence the early term for radio, **wireless** telegraphy.

Faraday seems to have had some ideas on the subject, but he was too busy doing other things to follow them up. It was his younger contemporary, Maxwell, who worked out the mathematics of electromagnetic fields and proved that radio communication was possible. The German physicist Hertz clinched the matter by communicating by radio over a few metres, after which engineers moved in and developed practical systems.

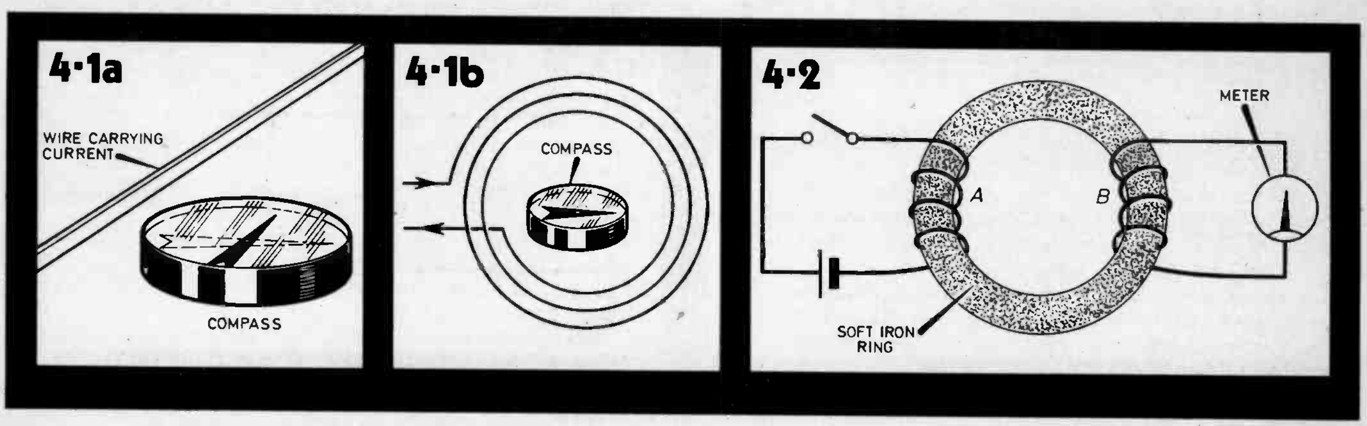
ENTER ELECTRONICS

Electronics was born out of attempts to improve radio. Early detectors of radio signals were insensitive. Some means of amplifying signals was needed. The radio valve provided this and sparked off electronics, which later developed enormously when transistors and integrated circuits came along. But that's another story. Let's get back to coils.

TRANSFORMERS

In radio transmission, every effort is made to encourage the electromagnetic field to spread out into space. But in electronic circuits it is usually desirable to concentrate as much of the field as possible at the spot where it is wanted.

We've seen that a coil intensifies the field locally. It can be intensified and localised still more by filling the centre of the coil with the right sort of magnetic material. Magnetic fields "prefer" to go through these "soft" magnetic materials than air or a non-magnetic substance.



A FOUR-PART INITIATION COURSE FOR NEWCOMERS

4

By George Hylton

In the course of his attempts to make magnetic fields produce electricity, Faraday made a ring of magnetically soft iron and wound a coil round part of it (Fig. 4.2). With the battery switched on, this coil (*A*) acted as an electromagnet. The magnetic field was conducted by the iron ring through a second coil (*B*) which was connected, not to the battery, but to a meter which detected any current flowing in it.

With a steady current in *A* there is no current in *B*. But as Faraday observed, the meter gives a momentary kick when the battery is turned on and another (in the opposite direction) when it is turned off.

The explanation was that when current was switched on, the field made by coil *A* built up from nothing. This is movement of a sort, and so current flowed in *B*. But once the build-up was complete, and the field steady, no current was produced in *B*.

On switching off, the field collapsed to nothing, producing a current impulse in the opposite direction.

By switching the battery on and off rapidly, the successive rise and fall of field in the primary coil *A* could be made to produce a rapid succession of kicks of current in the secondary coil *B*. This secondary current, flowing first one way then the other is a.c.

This sort of arrangement of coils is a **transformer**. It can obviously be used for separating a.c. from d.c. since only the a.c. has any effect at the secondary coil. But if you stay with electronics you'll find that transformers have many other uses as well.

INDUCTORS

Now forget about the "secondary" (*B*) and think only of the "primary", (*A*). This coil must feel the effects of its own magnetic field. Now, we have seen that a changing field tries to drive a current through any wire which feels its influence. This implies that the changing field sets up some sort of driving force.

The driving force for a current is of course an electric force such as the "voltage" of a battery. (The preferred term for this sort of driving voltage is **electromotive force** or **e.m.f.** for short).

When the battery in Fig. 4.2 is switched on, a sequence of events takes place. Some current flows, and this sets up a magnetic field in the primary *A*. This field must start from zero and increase so *A* must feel the effect of this increase. The effect, of course, is to set up an e.m.f. in *A* itself.

INDUCED E.M.F.

On the face of things, this e.m.f. could either help the battery and push more current through the coil *or* oppose the battery and reduce the current.

In practice, the **induced e.m.f.**, as it is called, always opposes the battery voltage and reduces the current. But the current cannot be stopped because if there's no current there's no field and no induced e.m.f.

What happens in practice is that the induced voltage (also called the **back e.m.f.**) slows down the rise of current when the battery is turned on. During this slowed-down rise of current the back e.m.f. gradually diminishes and in the end disappears, leaving just a steady current which depends only on the battery voltage and the resistance of the wire in the coil.

INDUCTANCE

This tendency of coils to oppose a change in current is called **inductance**. As a matter of fact, all circuits show some inductance, whether they contain coils or not, because even a straight wire is in its own field. But in electronics relatively large amounts of inductance are often needed and coils are used.

At low frequencies, **cores** of magnetic metal are often used to increase the inductance. The best shape of core is Faraday's ring or **toroid** and mains transformers with toroidal cores are coming into widespread use because they are efficient and produce very little outside field.

With the core materials used in mains transformers the inductance increases tens of thousands of times. At radio frequencies, these materials cannot be used but **dust-iron** and **ferrite cores** can, and useful though much smaller increases in the inductance result.

THE HENRY

To give a measure of the inductance of a coil a unit has been devised. It works in terms of the power of an inductor to create a back e.m.f.

The back e.m.f. depends also on the speed at which the coil current changes.

To define the unit of inductance the current is supposed to change at the rate of one ampere per second. If the back e.m.f. is then one volt the coil has one unit of inductance, or one **henry** to give it the right name. (Henry was an American engineer).

Practical coils can have inductances ranging from about a thousand henries down to less than a millionth of a henry.

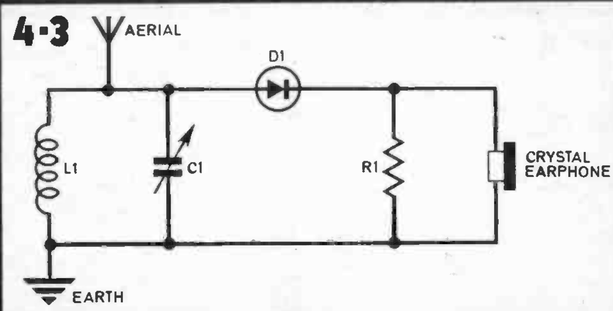
In combination with a capacitance, a inductance forms a **tuned circuit** which responds more to some frequencies than others hence is much used in radio to separate the wanted station from others on different frequencies. The simplest form of radio receiver is shown in Fig. 4.3. ⌑

Fig. 4. 1a. The needle of a compass will be deflected by current flowing through a nearby wire.

Fig. 4. 1b. If the same wire as in (a) is looped to form a coil encircling the compass, the deflection effect will be more pronounced.

Fig. 4.2. A transformer. A changing current flowing in the primary coil *A* induces a current in the secondary coil *B*.

Fig. 4.3. A crystal radio receiver. L1 and C2 form the tuned circuit which selects the required station. D1 is a crystal diode which detects the radio signal.



Everyday News

. . . *NEW OPEN UNIVERSITY INVENTION COULD MEAN JOBS FOR REDUNDANT TUTORS* . . .

CYCLOPS ELECTRONIC BLACKBOARD

It's not the "eye" of Orwell's "big brother", Cyclops is a new development from the Open University with an eye to future learning that is being funded by British Telecom and marketed by Aregon International.

Cyclops is a two-way picture and sound system enabling diagrams and handwriting to be transmitted down an ordinary telephone line and displayed on a TV monitor. Two-way speech communication goes over a second phone link. In its final form it is hoped to transmit both sound and pictures down a single link.

The open university is trying out the system, under a two-year study contract, as an electronic "blackboard" for teaching students in remote locations who would otherwise not be able to attend centres. A tutor using Cyclops at one centre can simultaneously instruct students assembled in as many as nine other centres in the region.

The tutor communicates with his students by voice and through drawings created by moving a light-sensitive pen over a television screen. Light pens connected to the students sets enable them to add to the picture, or alter them by erasing and redrawing. This two-way "sight and sound" communication creates an effective lecture room environment.

The Cyclops project started in 1977 as the fusion of two earlier projects, one storing pictures on cassette tape, and the other using a light pen to send pictures down ordinary telephone lines. Shortly afterwards, the viewdata terminal was added to the system.

The university encouraged the project, because it was looking for ways of adapting its original education methods to the changed conditions it was likely to face in the early 1980s. Primary amongst these was the need to change from a small number of courses with a high average student population to a large number of courses with a smaller average student population.

This switch to more, but smaller classes and more "personal" student contact will certainly offer more exciting job prospects for tutors.

How It Works

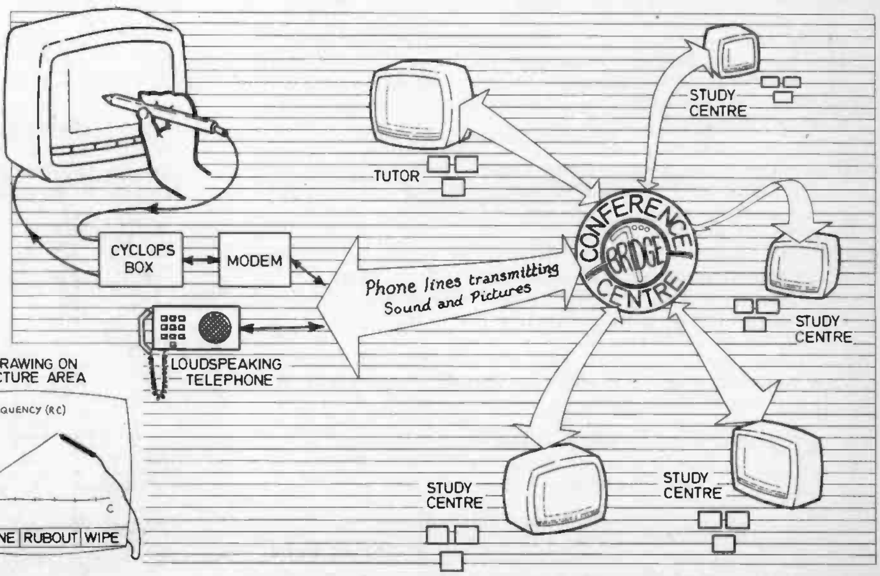
Each study centre will have five pieces of equipment: a Cyclops box, which controls the system; a television set, to display the pictures; a light pen to create and modify drawings and a modem, which transmits the picture information down the telephone link. In addition the students and tutor will be linked by voice through loudspeaking telephones. Using a "conference bridge" up to nine study centres can be linked together with a common picture display.

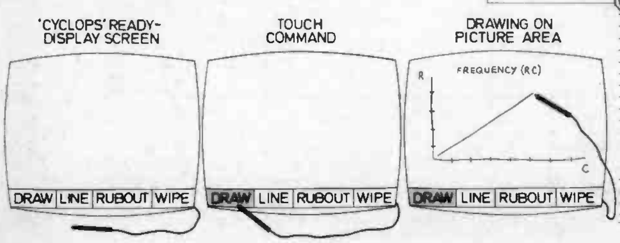
The television screen will show a white picture area and a "menu" of commands, draw, line, rub out and wipe. The tutor or student first touches the tip of the light pen against a command on the screen and then draws on the picture area.

After the "draw" command, for instance, the pen will leave a black trail on the picture area. Thus, the tutor can write a message or create a line drawing, which is transmitted by phone, to each student's TV screen. A student can add to the picture, perhaps by writing in the answer to an equation or "correcting" the tutors drawing.

At any point during the tutorial, the tutor may replay a tape prepared in the Cyclops studio. An ordinary cassette tape holds both a sound track and pictures which can be shown during the tutorial.

Block diagram of the system at present undergoing trials in the Nottingham area.





. . . from the World of Electronics

GOOD HEALTH

Whatever may be happening elsewhere in industry electronics continues to shine. The big four of Ferranti, GEC, Racal and Plessey have all recently reported record turnover and profits for 1980/81 and substantial forward order books.

In the computer field, ICL is struggling against the recession but with new management and a new product line in small computers is by no means terminally ill but clearly needs time for recovery.

—ANALYSIS

THE BODY BEAUTIFUL

In less than half a century applied electronics has helped us to learn more about the way our bodies work and how they act and react to outside stimuli than all the previous accumulated knowledge of centuries.

The electron microscope is infinitely more powerful than optical models. Similarly the electronic body scanner allied with computing techniques reveals far more of our "insides" than earlier X-ray machines. We can measure and display heart rhythms and brain waves, track irregularities in the alimentary tract with a radio pill, stimulate weak hearts with implanted electronic pacemakers, and electronically monitor all the critical functions of a patient under intensive care.

Thus, in bodily ills we see electronics in action as a powerful tool in diagnosis, treatment and after-care. But the normally healthy body, beautiful in construction, more versatile than any man-made robot, and with a brain far more powerful in intelligence than its electronic computing counterpart, has also been studied and we have learned how to exploit both its strengths and weaknesses, particularly in communications.

The human eye and brain are magnificent organs. Yet the eye-brain combination has the defect of persistence of vision, a weakness first exploited by the cinema and later by television to give us the illusion of seeing motion pictures instead of the reality of individual still pictures presented in rapid succession, or a mere fast-moving spot of light.

The ear, another wonderful organ can be exploited in quite a different way. Hearing, a function of ear plus brain, is a "smart" system. At a noisy cocktail party it will filter out our own conversation from the background babble of other voices.

It can also understand and even recognise voices whose waveforms are severely degraded. This fact is used to great commercial advantage in line and radio communications where the voice frequency range is compressed and otherwise tailored to provide the most efficient use of the available bandwidth of the transmission medium. The voice we hear on the telephone is not precisely the voice of the caller but hearing adaptation makes it sound so.

The hi-fi enthusiast, on the other hand, demands a full frequency range, fidelity and, if possible, the illusion of depth and direction of sound. Stereo was the breakthrough which allowed us to sit in a small living room and almost believe we had a seat in the concert hall.

Further realism, it was thought, would be achieved through Quadraphonics. It seemed logical but was a flop which revealed how little we really know of the hearing process and human responses. Ambisonics is the latest attempt at "surround" realism and it has emerged only after some ten years of research and experimental work at Reading University and elsewhere, reinforced by valuable new theory originated by Oxford mathematician Michael Gerzon.

It is remarkable that something as comparatively trivial as a refinement in home entertainment can stimulate deep investigation into body and brain functions. But it is all part of the ceaseless search for truth and scientific knowledge which (who knows?) may one day unravel the mysteries of telepathy and water divining.

Brian G. Peck

Million and a Half Amateurs

More than a million and a half people throughout the world now hold amateur radio transmitting licences, not to be confused with CB operators who legally or illegally number many millions.

A small but increasing number of CB enthusiasts in the UK, already sickened by increasing abuse of the bands and phoney pop culture, are preparing to take the Radio Amateur Examination to qualify for an amateur licence.

One of Plessey's more unusual jobs is modernising Soviet radar installations in Third World countries. A recent contract in this field involved up-date of all the displays and communications at a cost of over £3 million.

Electric Eels

Water temperature in the Bristol Channel near the two nuclear power stations at Hinkley Point is being monitored every ten minutes in a research programme on the water environment.

Cooling water for the power stations is taken from the channel and returned at the rate of 55 million gallons an hour. The warmer water near the outlet pipe has attracted eels and eel farming is increasing as a local industry, the farmers paying rent to CEGB for the spent energy.

Prestel registered customers passed the 10,000 mark last June and with some customers using more than one set the total number of sets in use had passed 11,000. Nearly 9,000 of the sets are installed in business premises.

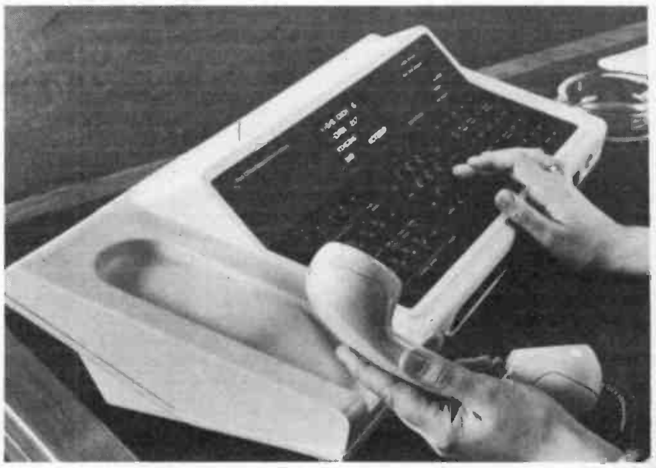
Of the 22 million viewing households in West Germany over half are using communal aerials, thus greatly relieving the more common ugly forest of roof-top masts and aerials.

A century for Monarch

With the 100th installation of the Monarch 120 electronic telephone exchange, British Telecom have announced that it can now be supplied on demand in those areas of the country where it is available.

The Monarch 120 is the world's most advanced business telephone exchange. It employs digital electronics throughout and, offering up to 120 extensions, harnesses the power of its microprocessor control to offer small to medium businesses a wide range of facilities normally available only on much larger tailor made installations.

Monarch should be available all over the country by November.



AUDIO

By F. C. Judd

COMPRESSOR-MIXER

THERE are various ways of obtaining audio signal compression and one commonly used, especially in radio transmission, is the *limiting* system which allows all modulating signals to reach a pre-determined but finite level. Whilst more or less constant high levels can be obtained this way, all limiting or clipping methods introduce excessive distortion.

An alternative, but one which prevents distortion to some extent, involves controlling the negative feedback in an audio amplifier circuit and hence the gain of the amplifier. Although with this arrangement the compression range is not very great and distortion could occur once the point of maximum negative feedback is reached.

COMPRESSION

Use of the term *compression* might seem a little confusing, when in fact the normal purpose of compression is to obtain the highest continuous levels of speech.

All speech and music consists of complex waveforms with amplitude in the waveforms varying over a wide range. In radio transmission for example, it is often desirable to compress the highest peaks of audio signals but at the same time allowing all the weaker components to reach a much higher amplitude than normal, the result being more efficient use of the transmission media.

There are in fact systems that operate the other way round, which *expand* the weaker signal components and which are known as *expanders*. There are also circuit combinations that provide both compression and expansion and which are known as *companders*.

AUTOMATIC GAIN CONTROL

The compression circuit described here, however, operates on the principle of *automatic gain control* of an amplifier stage and aside from the fact that little or no distortion is generated it also has the advantage of a wide compression range of around 30dB. This circuit can also be used either for instantaneous short term compression or for automatic level control in tape recording.

The automatic gain function is obtained by a special i.c. known as an "electronic attenuator" and although there are similar i.c.'s available for this function, the RS type 306-803 (or MC3340P) is probably the most simple one to use.

ADVANTAGES

Of course one may ask what advantage is there in having audio compression. Aside from providing a more consistent level of speech or music, in transmission, a compressor can be used very effectively to reduce high ambient background noise whilst speech is being recorded.

It also has application in suppressing the level of music whilst speech announcements are superimposed, a method commonly used in broadcasting when announcements are made during the playing of music. The music appears to be faded down when speech occurs.

With careful adjustment, the circuit described here can be made to perform the same function and it can of course be used for overall automatic recording level as will be dealt with later.

CIRCUIT DESCRIPTION

Aside from its use as a speech compression system and automatic level control the Audio Compressor/Mixer as shown in Fig. 1, has provision for mixing microphone and high level (music) signals, hence the use of a microphone preamplifier IC1. This has an input sensitivity of approximately 0·2mV for a maximum output from the unit of 0·775V or 775mV (reference level of 0dB commonly used in recording and audio applications).

PERFORMANCE SPECIFICATION

With a properly constructed unit the following figures should be obtained. The performance of the unit is therefore compatible with that of reasonably high quality cassette or reel to reel recorders.

Input sensitivity with compression off			
Line	50mV		ref 775mV output
Mic	0·2mV		ditto
Signal/Noise	Mic		50dB
	Line		60dB
Total Harmonic distortion			Less than 0·5%
Compression Range			Approx. 30dB max
Compression Response to ON			Approx. 20mS
Duration of Compression or Auto gain level			Depending on values of C8 C9 or C10 as in text.

This pre-amplifier stage has an input impedance suitable for all dynamic microphones of 200 to 10,000 ohms impedance or very low impedance microphones with suitable low to high matching transformers. The input is not suitable for crystal microphones. Signals from IC1 are taken via the passive mixing network VR1/R5 to the "electronic attenuator" IC2. Line In or high level signals of 100mV or more, are coupled into the passive mixing network VR2/R7.

Both microphone and line input signals can be independently mixed and faded and are taken through the electronic attenuator IC2 which also operates as a normal amplifier but with its gain being automatically controlled by the audio signals themselves.

COMPRESSION AMPLIFIER

To achieve this the signals from IC2 output are taken to a separate amplifier IC3 and thence to the diode D1 rectifier network R11, VR3 and the capacitors C8, C9, C10 with S1.

Audio signals from IC3 are rectified by D1 to provide a *negative* d.c. voltage across VR3 and the capacitors C8 or C9 or C10. This voltage is applied to the gate of the f.e.t. transistor TR1 so as to control the resistance between the source and drain. Thus the resistance of TR1 can be made to vary between zero and maximum as the negative voltage at the gate is varied.

TR1 is connected between the control pin of IC2 and ground. The higher the resistance between these points the lower will be the gain provided by IC2. Any audio signals that produce a negative voltage higher than that determined by the setting of VR3 will immediately reduce the gain of IC2 and thus the level of output signal available at the base of TR2 which is simply an isolating amplifier from which the audio signals out are obtained.

This amplifier has a limited gain because of the negative feedback introduced by the omission of a by-pass capacitor across the emitter resistor R19. The gain required by IC3 is set by the pre-set VR4 which controls the negative feedback between its output and input.

POWER SUPPLY

The supply rail for the circuit is obtained from T1, the bridge rectifier D2-D5 and the smoothing network C15, R22 and C16. An l.e.d. in series with R21 does duty as a power "on" indicator.

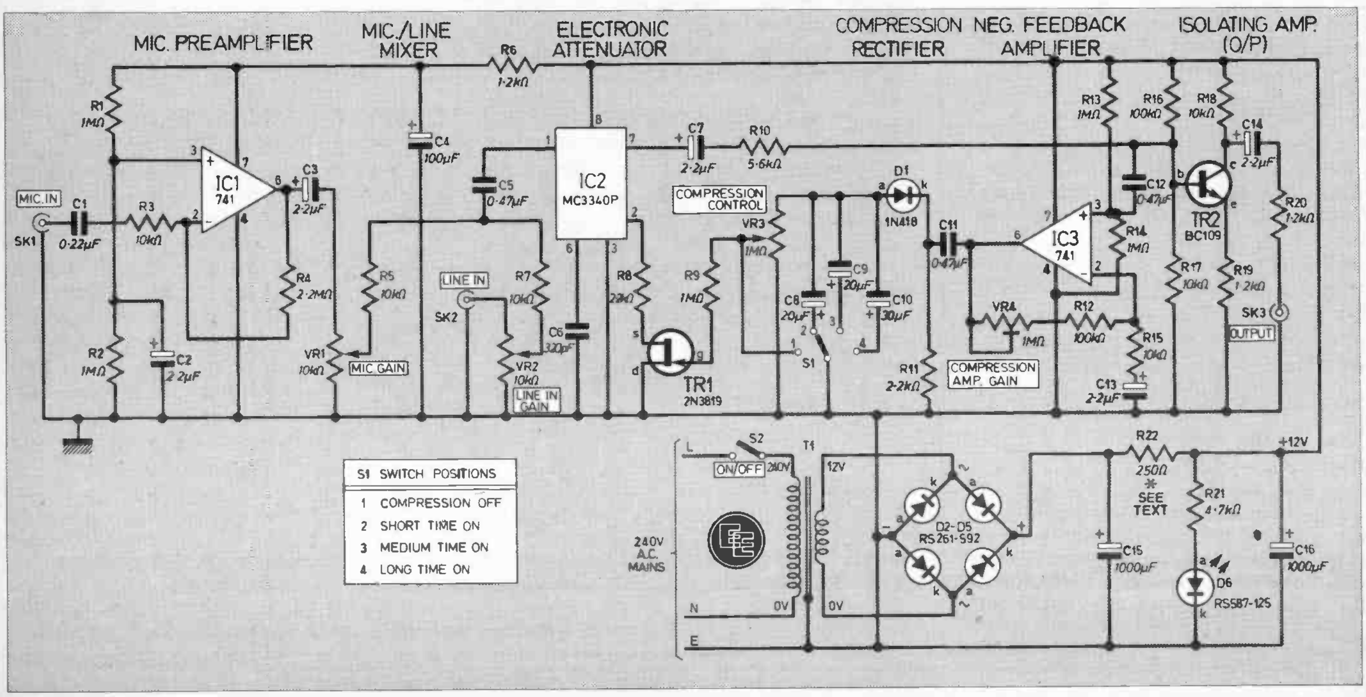
Further details about operation and function of the compressor circuit will be given later.

CONSTRUCTION starts here

CIRCUIT BOARD

Details of the box used for the prototype are included in the components list and the lid of this box is used as the control panel and for

Fig. 1. Complete circuit diagram for the Audio Compressor-Mixer.



COMPONENTS

Resistors

R1	1MΩ	R13	1MΩ
R2	1MΩ	R14	1MΩ
R3	10kΩ	R15	10kΩ
R4	2·2MΩ	R16	100kΩ
R5	10kΩ	R17	10kΩ
R6	1·2kΩ	R18	10kΩ
R7	10kΩ	R19	1·2kΩ
R8	2·2kΩ	R20	1·2kΩ
R9	1MΩ	R21	4·7kΩ
R10	5·6kΩ	R22	250Ω (see text)
R11	2·2kΩ		
R12	100kΩ		

All ¼W carbon film ± 10%

See **Shop Talk** page 598

Potentiometers

VR1	10kΩ log.
VR2	10kΩ log.
VR3	1MΩ linear
VR4	1MΩ linear skeleton preset

Capacitors

C1	0·22µF met. polycarbonate film
C2	2·2µF 63V elect. Small single-ended
C3	2·2µF 63V elect. small single-ended
C4	100µF 16V elect. small single-ended
C5	0·47µF met. polycarbonate film
C6	320pF disc ceramic or silvered mica
C7	2·2µF 63V elect. small single-ended
C8	10µF tantalum
C9	20µF tantalum (2 off 10µF)
C10	30µF tantalum (3 off 10µF)
C11	0·47µF met. polycarbonate film
C12	0·47µF met. polycarbonate film
C13	2·2µF 63V elect. small single-ended
C14	2·2µF 63V elect. small single-ended
C15	1,000µF 25V elect. small single-ended
C16	1,000µF 16V elect. double-ended

Semiconductors

TR1	2N3819 f.e.t.
TR2	BC109 *npn* silicon
D1	1N418
D2-5	Bridge rectifier 50V 1A
D6	L.E.D. red RS type 587-125
IC1	741 op-amp
IC2	MC3340P audio attenuator amp

Miscellaneous

S1	single pole, 4 way miniature rotary
S2	on/off single pole miniature toggle
SK1-3	phono socket (3 off)
T1	mains transformer 12V 100mA secondary

Aluminium box 7 × 5 × 2½in (Bi-Pack type BA7). Three control knobs: 2 calibrated; 1 plain; 1 pointer. Perforated s.r.b.p. 85mm × 150mm, 0·1 matrix. Two 6BA × 1in screws, four 6BA nuts, two ⅝ metal sleeves (circuit board mounting pillars). Three i.c. sockets. Grommet for mains lead.

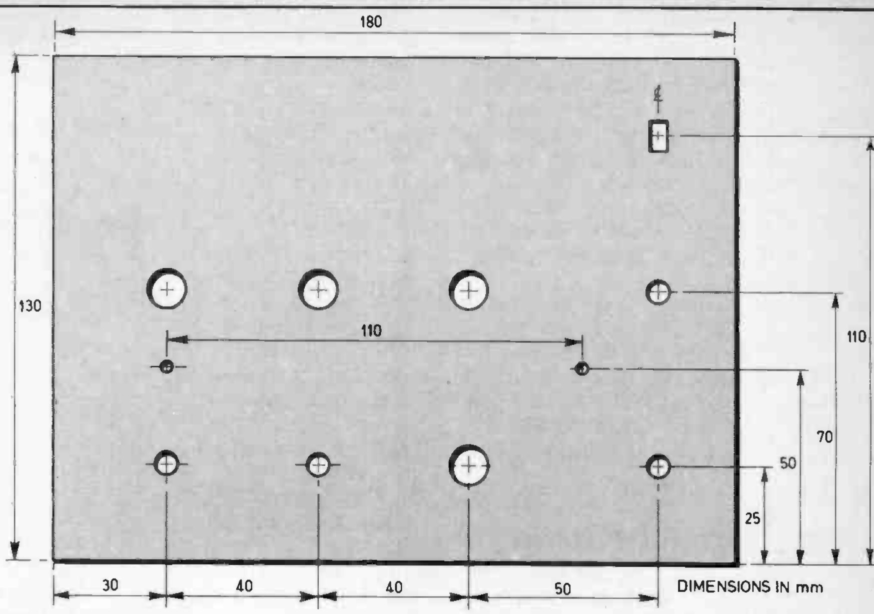


Fig. 2. Drilling details for the front panel. Final size of holes will depend on components used.

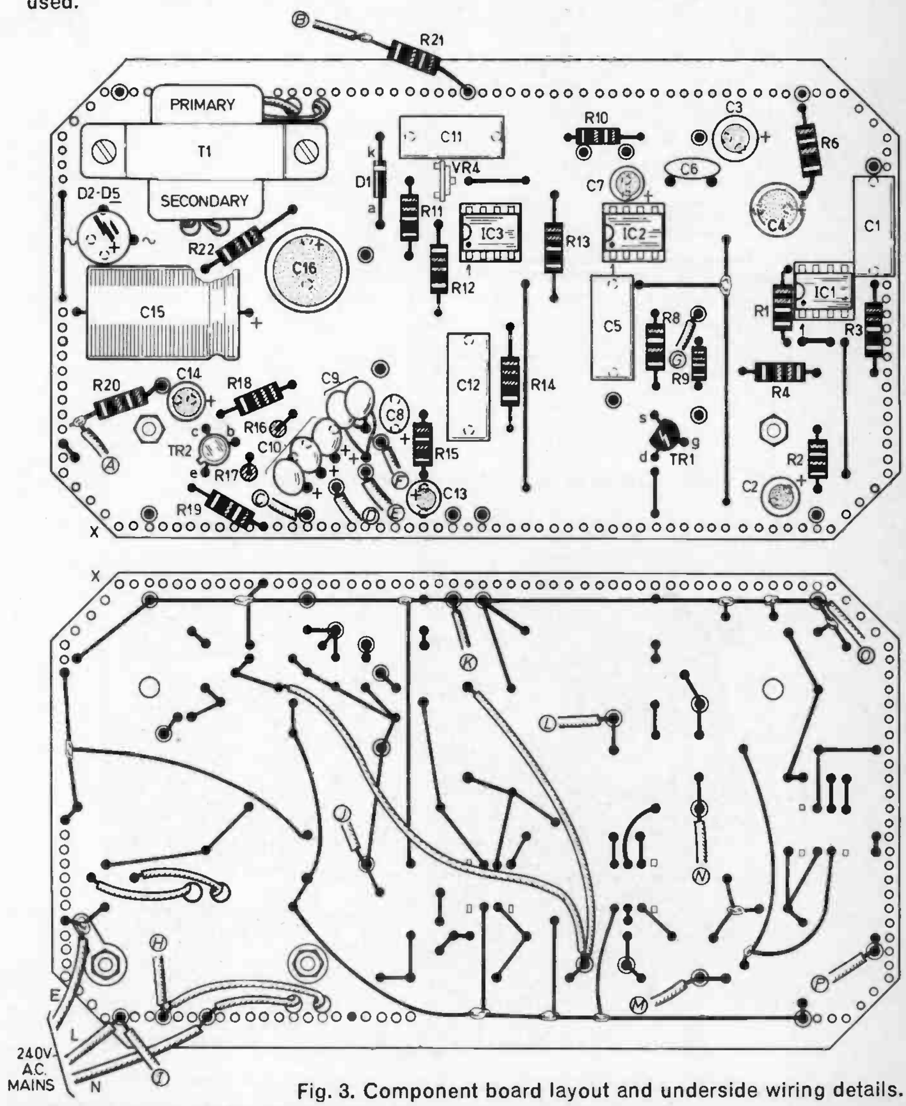


Fig. 3. Component board layout and underside wiring details.

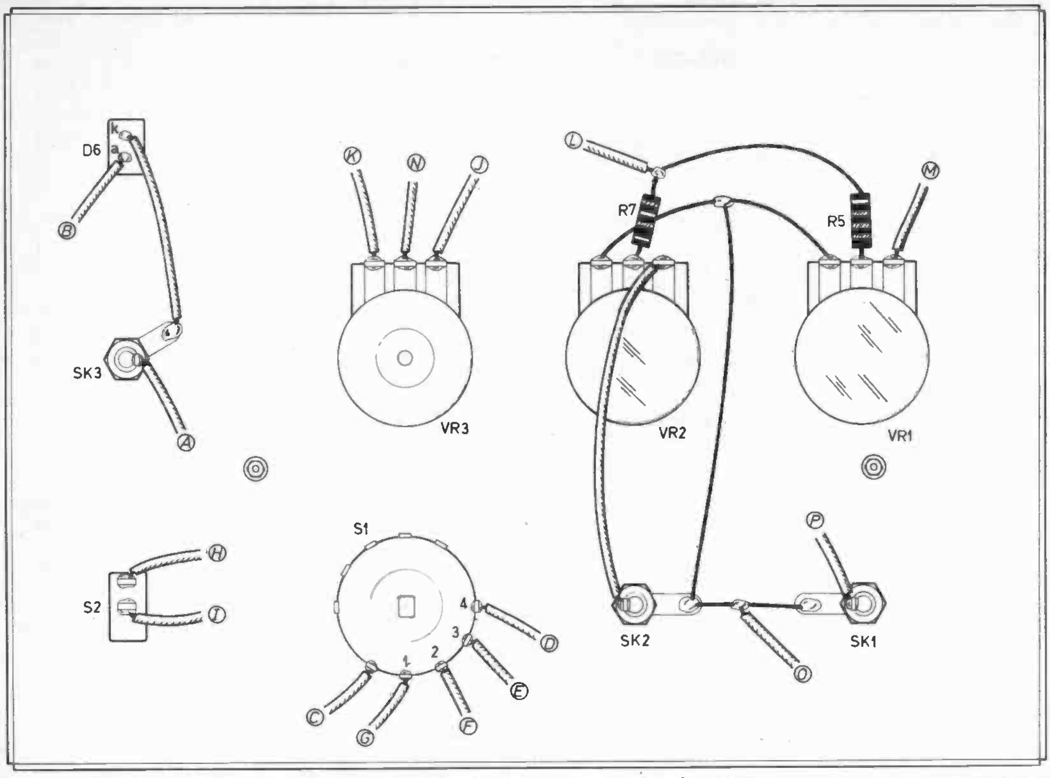


Fig. 4. Front panel wiring details. The letters at the ends of the wires correspond to those on the circuit board.

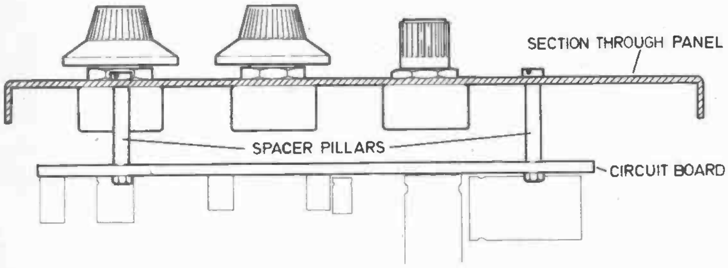
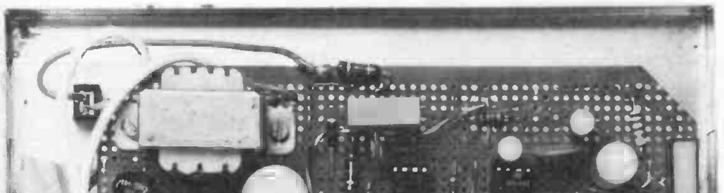


Fig. 5. Method of mounting circuit board on front panel.



The completed circuit board mounted on the rear of the front panel.

COMPONENTS approximate cost £12 excluding cabinet

mounting the circuit board. Details for drilling are given in Fig. 2

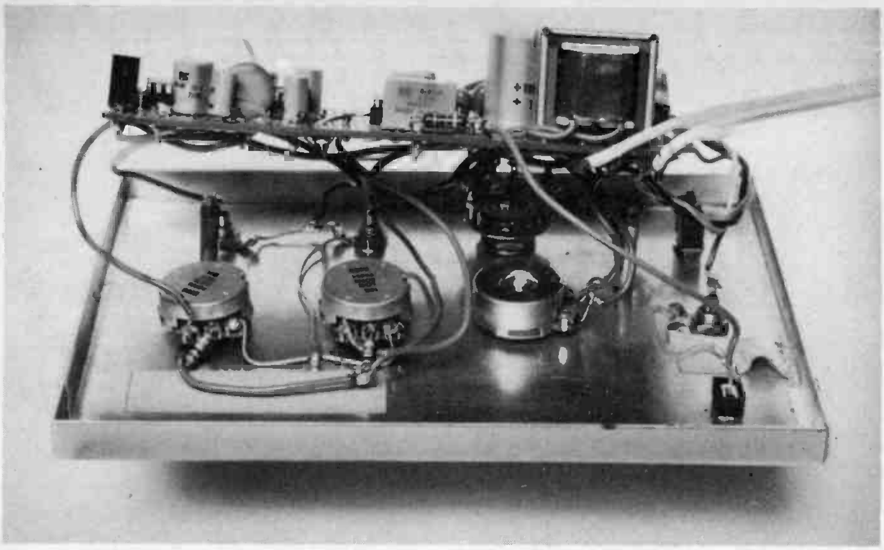
The perforated s.r.b.p. circuit board will comfortably fit within the area of the box lid and the layout for components and wiring on the board are as shown in Fig. 3.

Note here that the compression time capacitors C8, C9 and C10 must be tantalum types. *Do not use ordinary electrolytics as the leakage current in such will seriously effect performance.*

With the values given C8 and C9 will provide compression decay times of approximately 3 and 5 seconds respectively. For the value of C10 as given, the compression time will be about 6 to 8 seconds. *For automatic level control in tape recording C10 should be at least 100μF to provide a longer compression on-time.*

INTERWIRING

Wiring of the panel components controls and sockets is given in Fig. 4. The interconnections between the circuit board and the panel components are best made by putting long enough leads on the panel components and then wiring these to the board when the latter has been mounted in position on stand-off pillars as in Fig. 5.



The completed circuit board lifted clear of the mounting pillars.

SETTING UP

First check the supply rail voltage at the junction of R22 and C16. This should be 12V±1V. If not decrease the value of R22 to 220 ohms to raise the voltage or, increase to 270 ohms to lower the voltage.

MIXER

Set the pre-set VR4 to approximately half-way and the switch S1 to the "off" position which takes the compression action out of operation. The mixer will now function the normal way with signals at either the MIC or LINE input.

If an audio signal generator and audio voltmeter are available a more accurate check can be made. With a signal into the line input of about 50mV (1,000Hz) and the LINE-IN GAIN at maximum, the signal at the output socket should be between 700 and 800mV. A signal of 0·2mV at the MIC INPUT should also produce the same output level, that is with the MIC GAIN control at maximum.

COMPRESSOR

Setting or checking the compression circuit is quite easy with an audio signal generator. Ensure that VR4 is about half-way. Set the line input gain at maximum and the MIC GAIN at zero. Feed a signal of 70mV at 1,000Hz to the line input and with S1 set at position 2, advance the COMPRESSION CONTROL VR3 until the output signal is reduced to about 500mV.

If the setting of VR3 is about half-way no adjustment of VR4 will be necessary. If VR3 is well toward its maximum then the value of VR4 will need to be increased. In practice the amount of compression needed will be somewhat less than obtained by this check.

If no signal generator is available connect the unit to a tape recorder *line input* (do not use a tape recorder mic input).

Set the recording level control on on the recorder to about half to three-quarters. Set S1 on the compressor unit to the "off" position and advance the MIC GAIN until just over full recording level is obtained, that is the recording meter reading just above 0dB on speech peaks. Now set S1 to position "2" and whilst speaking adjust compression control until peaks on speech reach about half-way on the record level meter. Make some test recordings with slightly different settings of the compression control. This will give a good idea of the optimum amount of compression to use. If too much compression is used the electronic attenuator will simply cut off all signals.

Once the right amount has been obtained, the recording level control can be increased a little to obtain normal full level recording. Note that the "compression-on" time is almost instantaneous but the time for it to return to zero depends on the position of S1 and the values of C8, C9 or C10. Tests with different switch positions and compression levels will give a good idea of how the system functions.

CONTINUOUS AUTO RECORDING LEVEL

If continuous automatic recording level is required then C10 should, as already mentioned, be about 100μF so that the compression "on" time extends to 10 seconds or more. The setting up procedure is the same but instead of compression coming off after 2 or 3 seconds, the automatic level function of IC2 will remain in operation for much longer: that means the set level will be maintained until C10 is well discharged and the resistance of TR1 is returned to a low value. As soon as speech or music is resumed compression, or autogain, will immediately return to the level set by VR3.

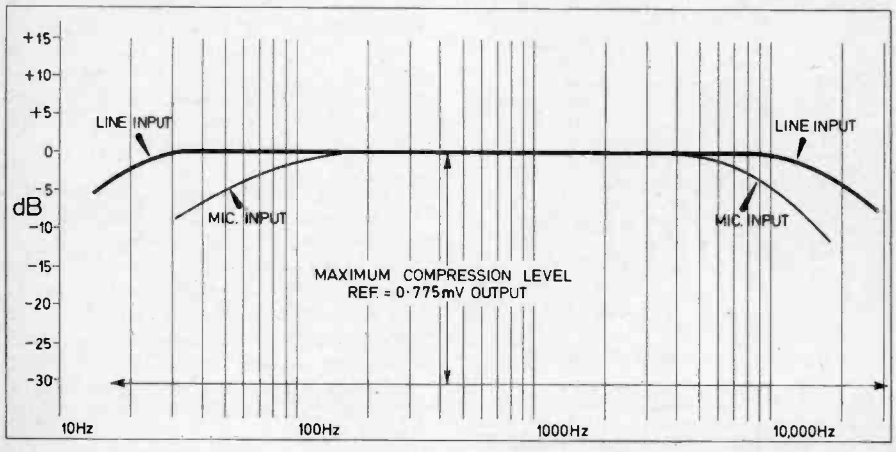
SPEECH OVER MUSIC

Speech control over music can be achieved by careful balance of the level of microphone signals to those of music signals. The compression control should be set so that music signals do not quite produce compression but when the microphone is used the signals from this are high enough to start fairly deep compression so that music signals will appear to be reduced when speaking into the microphone.

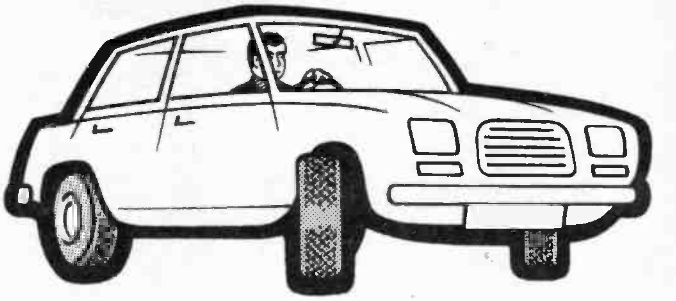
Remember that all the adjustments for various degrees of compression and/or automatic level, have to be made with regard to recording level so a certain amount of initial testing may be necessary to achieve the right combination of control settings.

For those who have audio test equipment the performance specification will be useful. The overall frequency responses for microphone and line inputs and also the total compression range are shown in Fig. 6. ⌑

Fig. 6. Frequency response for microphone and line inputs and total compression range.



CMOS CAR SECURITY ALARM



BY P. HORSEY

Few people fit any security device to their car, often arguing that the determined thief will defeat any type of alarm. It is likely, however, that most car thefts are of a casual nature, by opportunists, and an alarm will deter this type of thief.

If the car is parked outside its owner's house at night an alarm is especially beneficial, and if it sounds like an alarm, and not just the car horn switched on continuously, it will almost certainly attract attention wherever the car is parked.

The features of the alarm to be described are:

1. Inexpensive.
2. Easy to install.
3. Easy to set, switch, off, and de-activate—when the forgetful car driver (speaking for myself) forgets to switch off upon returning to car.
4. Provide time delays to enable the main operating switch to be mounted inside the car.
5. Produce a pulsed output, so that even if wired to the cars own horn, it does not sound as though the horn has merely "shorted on".
6. Suitable for negative earth cars.

TRIGGERING

The alarm is triggered by a negative pulse which may be achieved with any type of switch, or most conveniently, the courtesy light switches already fitted in most cars. Providing the switch connects the alarm circuit to negative when the door opens, the courtesy light itself may be left switched on or off without affecting the alarm.

CIRCUIT DESCRIPTION

The circuit is shown in Fig. 1 and is best understood by starting at the output stage and working backwards.

OUTPUT STAGE

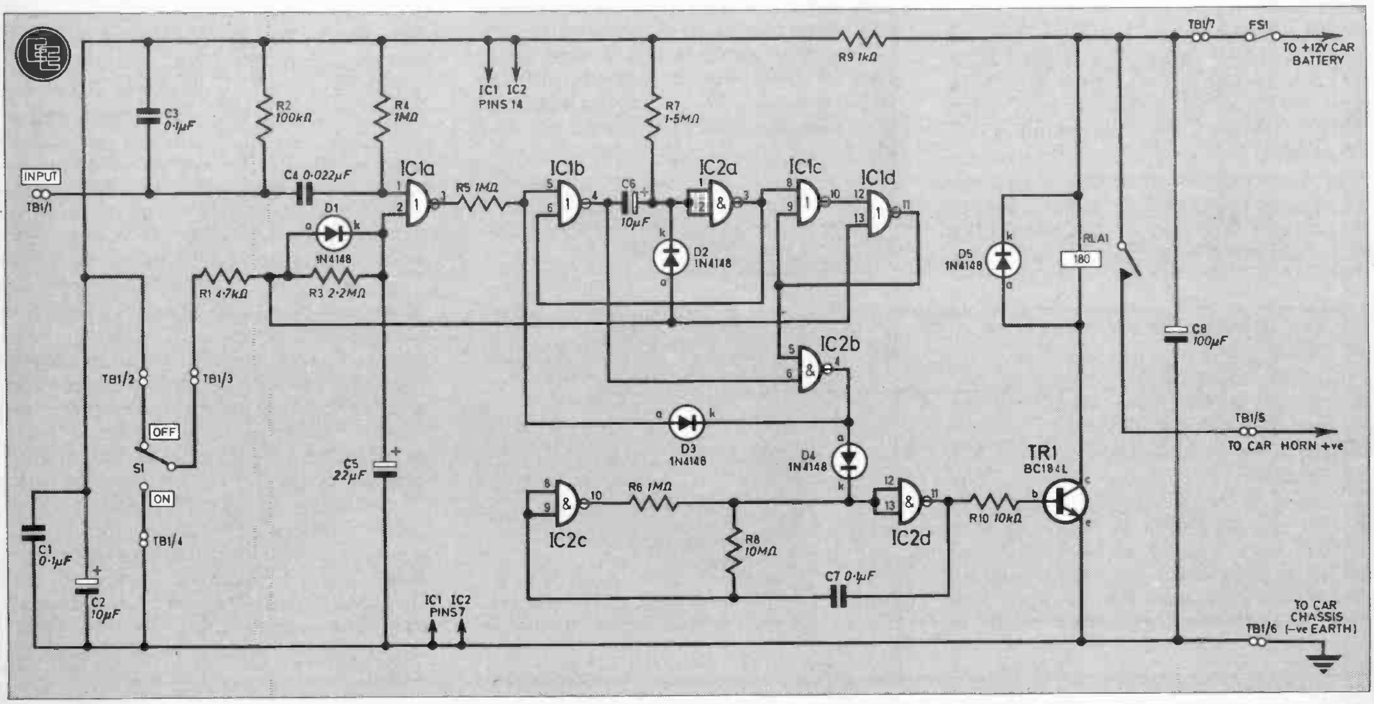
CMOS gates IC2c and IC2d are wired as simple inverters and (assuming the potential from D4 is at zero volts), these gates will oscillate at about 1Hz, the exact rate depending upon the values of C7 and R8. Hence the output at pin 11 will oscillate, and transistor TR1 will switch on and off, as will relay RLA1. This will pulse the car horn, or any other warning device as required.

Diode D5 prevents back e.m.f. from the relay damaging TR1 and R10 limits the current into the base of TR1.

The oscillator may be switched off by holding input pins 12 and 13 "high", (i.e. logic 1). Resistor R6 limits the current draining into gate c, in this situation.

Thus the alarm only operates if the output from gate IC2b is "low" (logic 0). Since gate b is a two-input NAND type, both inputs must be "high" to activate the alarm.

Fig. 1. Circuit diagram of the CMOS Car Security Alarm.



ALARM LOGIC STAGE

Assuming the alarm is switched off, pin 2 of gate IC1a will be high, and since it is a NOR gate, output pin 3 will remain low, regardless of the state of pin 1.

When S1 is switched on, C5 will slowly discharge via R3 and R1, taking about 30 seconds to reduce pin 2 to logic 0. During this time, the driver will have left the car, and locked up. Pin 1 of gate IC1a will be "high", due to R4, and pin 3 will remain at zero.

Resistor R2 will maintain a positive charge on C4, whether or not the courtesy lamp is connected. If the car door is opened, a negative pulse will pass via C4 to pin 1, causing a positive pulse at pin 3.

This pulse will flow via R5 to pin 5 of gate IC1b. Gates IC1b and IC2a are wired to form a simple monostable circuit. Pin 4 will go low, as will pins 1 and 2 of gate IC2a. The logic 1 output from this gate feeds back into gate IC1b thus maintaining this condition for a time determined by R7 and C6. The output from gate b is also connected to pin 6 of gate IC2b and since it is now low, the alarm cannot sound.

MEMORY

Gates IC1c and d form a simple memory and the positive ouput from gate IC2a will cause a similar output from gate IC1d, which both maintains c and d in this state, and holds pin 5 of gate IC2b at logic 1.

The potential on pins 1 and 2 of gate IC2a slowly rises, and after about 15 seconds gates IC1b and IC2a both change state, with the output of IC1b going high. As both inputs to gate IC2b are now high, the alarm is activated.

Should the car door be opened again, further pulses from gate IC1a are conducted via D3 into pin 4 of gate IC2b, which is now at zero volts. This prevents the monostable re-triggering.

If S1 is turned off at this stage, pin 13 of gate IC1d will go "high", causing its output, and hence pin 9 of gate IC1c and pin 5 of gate IC2b to go low. The alarm will therefore de-activate. Capacitor C5 now rapidly charges via R1 and D1, and the circuit returns to its initial state.

Under normal circumstances the alarm will be switched off before the monostable gates IC1b and IC2a have changed state, and the horn will not sound at all.

Diodes D2 and D1 ensure that the circuit is returned to its "off condition" very quickly as S1 is switched off. This prevents confusion should the owner return to the car after setting the alarm—and then wish to leave and re-set the circuit a few seconds later.

Capacitors C1, C2, C3 and C8, together with resistor R9 help to provide smooth electrical conditions for the circuit, bearing in mind its noisy working environment.

DELAYS

When setting the alarm, a delay time of about 30 seconds is provided by R3 and C5. Increasing the value of either component will increase the delay time and vice versa.

When returning to the car, about 10 to 15 seconds is allowed before the horn is activated. This time is controlled by R7 and C6, and increasing the value of either component will likewise increase the time allowed.

MAIN SWITCH

It will be clear at this stage, that the main switch S1 sets the alarm, switches it off, and de-activates it when triggered. At first sight this may seem unwise, since a thief may be able to find the switch after activating the alarm. It is debatable, however, whether anybody would hunt for a concealed switch when most car alarms can be silenced by disconnecting the battery, or cutting the wires to the audio device.

The advantage in having a simple means of de-activating the alarm should not be underestimated since forgetful owners (and there are many of us about) will often fail to switch off the alarm upon entering the car. The personal embarrassment this causes in a crowded area has to be experienced to be believed!

RELAY

The relay RLA must be carefully selected to ensure that the contacts will carry the current required by the car horn or other audio device used. Two or more sets of contacts may be wired in parallel to help achieve this. (As a guide, the current required by the horn on a Ford Cortina Mk. 4 was found to be 3·5 amp). The relay should have a coil resistance of 180 ohms or more, and be designed for 12 volts operation.

CONSTRUCTION starts here

CIRCUIT BOARD

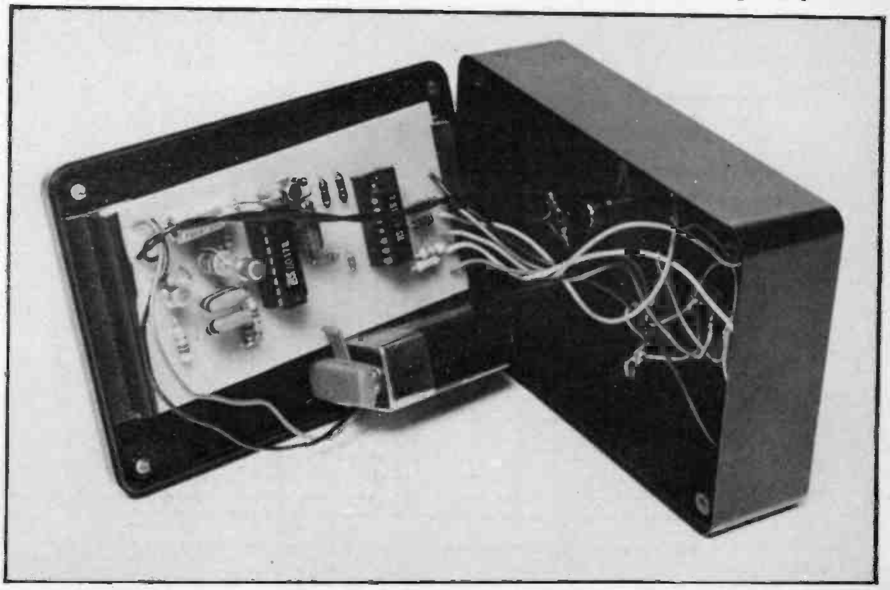
A piece of stripboard measuring at least 32 holes by 23 strips is required, though in practice a slightly larger board 80mm by 70mm ensures an exact fit in the plastic case specified.

Number and letter the board carefully according to Fig. 2 and mark the positions of the breaks in the tracks (14 breaks between the ic pins, plus four extra breaks).

Holders are recommended for the i.c.s, and these should be inserted and soldered at this stage, checking and double checking their positions relative to the numbers and letters, and breaks in the tracks.

Insert the wire links, pulling them tight and straight. This is a very simple operation if a very long piece of bare wire is used, one end soldered into position, and the wire threaded through the appropriate hole, pulled tight, soldered and cut off. A total of 17 links are required; carefully check their positions in relation to the i.c., holders and numbers/letters as mistakes are easily made at this stage.

Solder in the resistors and diodes, checking that the latter are the correct way round. It is good practice



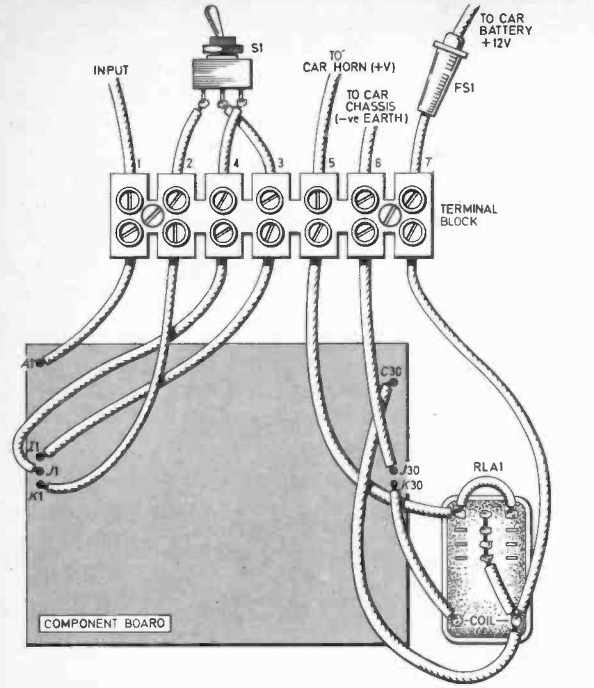
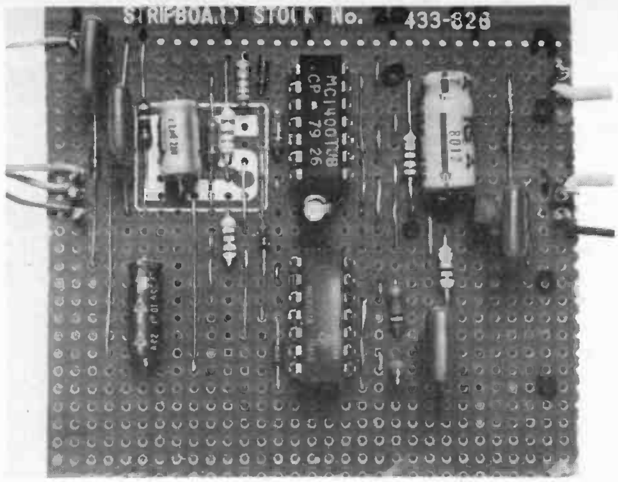


Fig. 3. Inter-unit connections between the circuit board, terminal block, relay and external connections to the car electrical system.



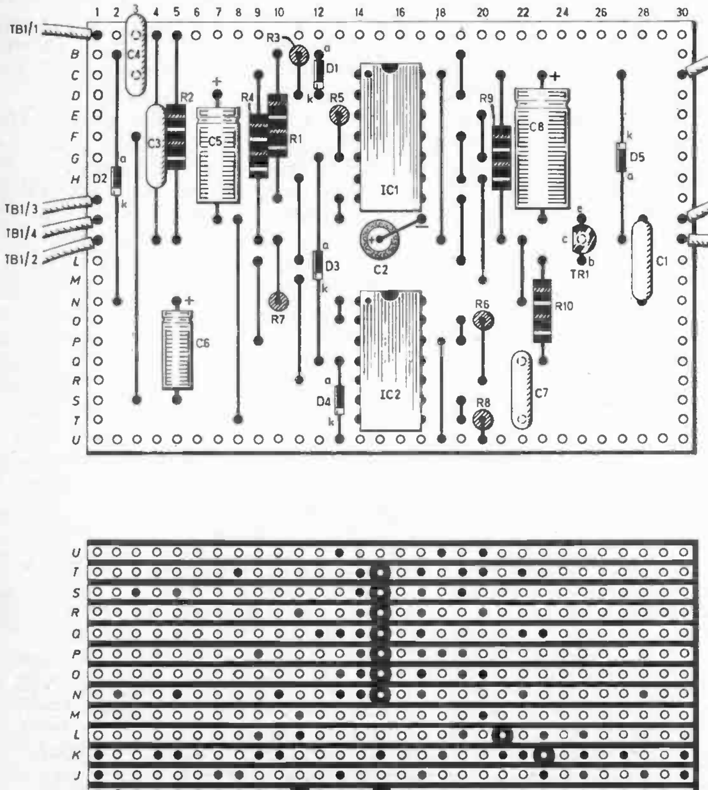


Fig. 2. Topside and underside of the circuit board.

COMPONENTS

Resistors

R1	4·7kΩ
R2	100kΩ
R3	2·2MΩ
R4	1MΩ
R5	1MΩ
R6	1MΩ
R7	1·5MΩ
R8	10MΩ
R9	1kΩ
R10	10kΩ

All ¼W carbon ±5% or ±10%

See **Shop Talk** page 598

Capacitors

C1	0·1μF polyester
C2	10μF 25V elect.
C3	0·1μF polyester
C4	0·022μF polyester
C5	22μF 25V elect.
C6	10μF 25V elect.
C7	0·1μF polyester
C8	100μF 25V elect.

Semiconductors

TR1	BC184L *npn* silicon
D1-5	IN4148 silicon diode (5 off)
IC1	4001(B) quad 2-input NOR gate
IC2	4011(B) quad 2-input NAND gate

Miscellaneous

FS1	fuse, in-line car type; value to suit horn etc.*
RLA	relay, 12V 180 ohms or more; contacts to suit*
S1	single pole, two-way toggle
TB1	terminal block 7-way

Stripboard 0·1 matrix 32 holes by 23 strips (or 80mm by 70mm for an exact fit in case). Case, metal or plastic*. Two 14-pin i.c. holders. Wire for wire links. Connecting wire, insulated, able to carry a larger current than value of fuse. Seven terminal pins.
* See text.

Guidance only Approx. cost £5

to fit resistors all the same way round as well, even though their direction is irrelevant—electrically speaking. This practice saves time if their values have to be checked later, it also looks neater, and forms a good habit on the part of the constructor who may easily forget to check the direction of the diodes and electrolytic capacitors.

Next, solder the polyester capacitors (either way round), electrolytic capacitors (with "plus" as shown) and transistor, ensuring it is the correct way round and a type BC184L, as the leads on a BC184 are in a different order.

Place terminal pins where indicated on the stripboard, and connect the relay and connecting terminal block with wire of sufficient rating to handle the current required to blow the fuse (FS1) chosen.

It will be noted that some parts of the circuit namely C8 and TR1 are not well protected by the fuse indicated in the components list, and a second in-line fuse, rated at about 500mA could be included if desired in the negative lead connected to track J.

Thin connecting wires may be used to connect the alarm input and S1 inputs to their respective terminal blocks.

Carefully check the stripboard for solder bridges, and dry joints, and if all is well, insert the i.c.s the correct way round, taking great care not to touch the pins, in case you are charged with static electricity. Connect switch S1 temporarily so that the circuit may be tested.

TESTING

Connect a 12 volt supply as indicated on Fig. 3. The relay output need not be connected to an audio device since the contacts changing over create sufficent sound for testing purposes.

Switch S1 off and check that the relay remains off. Turn S1 on and again check that the relay remains off. Wait for at least 45 seconds then touch the input lead (track A) to "negative" briefly After about 10 to 15 seconds the relay should click on and off repeatedly.

Switch S1 off; the relay should come to rest in the off position.

Switch S1 on again, and within 20 seconds touch the input lead to negative. This time the relay should not activate. When the circuit has had time to set, touch the input to negative, allow the relay to activate, then check that it remains active, even if more negative pulses are fed to the input.

These tests should establish that all parts of the circuit are working correctly.

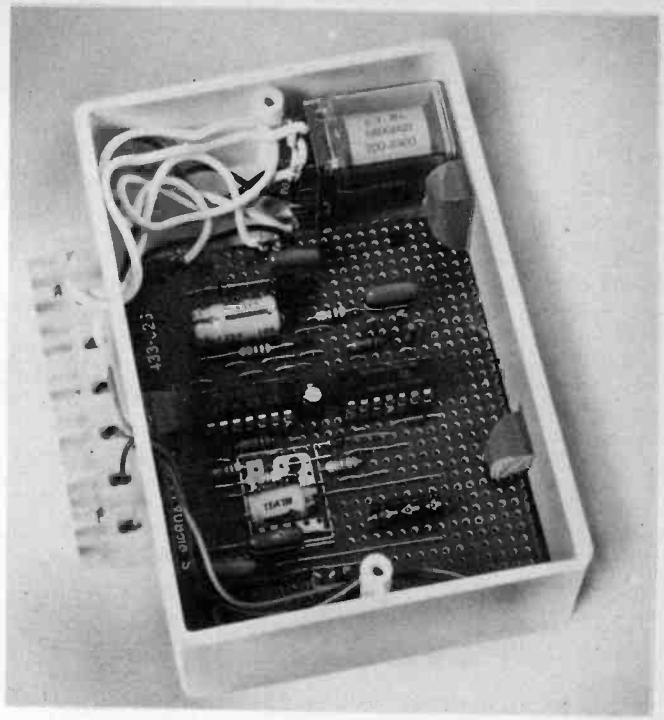
FAULT FINDING

If problems occur with this circuit, some simple voltage checks should quickly establish the fault.

With the negative of a voltmeter connected to the negative of the supply check that the reading on pin 14 of both i.c.s is about 12 volts, with S1 on or off.

Next check that the voltage where R1 joins track 1 is 12 volts with S1 off, and zero with S1 on.

If further voltage checks are necessary, problems may occur with certain gates changing state when touched with the voltmeter probe, To reduce this possibility, a 1kilohm resistor should be connected to the positive probe, and the spare lead on the resistor used to touch the i.c. pins. The resistor should not affect the readings obtained.



GATE OUTPUTS

The gate outputs may now be checked in the following manner:

1. Switch S1 off. Gate outputs IC1a, IC1d, IC2a, IC2c and IC2d should be "low". Gate outputs IC1b, IC1c and IC2b should be "high".
2. Switch S1 on and wait for 45 seconds. Gate outputs should all be as before. Briefly touch the input to negative. Gate IC2a output should change state to "high" for 10 to 15 seconds. If this does not happen, briefly connect pin 5 of IC1 to pin 14 (positive). Gate IC2a output should now change to "high". If so, the circuitry around gate IC1a is at fault. If gate IC2a output still failed to change state, the circuitry around gates IC1b and IC2a check.
3. When the IC2a output is "high" gates IC1d and IC2b should be "high" as well, and gates IC1b, IC1c, IC2c and IC2d "low". This situation should last for only 10 to 15 seconds, after which gate IC2a should change state to "low", but IC1d output should remain high. Gate IC1b output should now be "high" as well.

With both inputs to gate IC2b "high", its output should fall to near zero volts, and the outputs from gates IC2c and IC2d should change state about once per second. Each time gate IC2d output goes "high", the collector of TR1 should fall to near zero volts and switch on RLA1.

THE CASE

Any type of case may be used for this project—even an old tobacco tin —since it will not be visible when installed. The prototype was mounted in a plastic case measuring 4·5 by 3 inches (115 by 80mm).

Begin by drilling two holes for the leads, and holes to secure the terminal block, unless this is glued in position. Having fixed the terminal block, fasten the stripboard and relay with glue and rubber pads, or self adhesive feet.

Label the terminal block and connect it with the circuit board and relay as indicated in Fig. 3.

FINAL INSTALLATION

A suitable location must be found for the circuit, possibly behind the dash board, or inside the engine compartment. The main switch S1 should be concealed, but be reasonably accessible to the driver.

The connection to the courtesy light switch may be made at either door switch, or at the courtesy light itself if more convenient, ensuring that the selected connection is "negative" with the door open, and "positive" or "open circuit" with the door closed.

The positive supply should be taken from the positive lead connecting the horn switch, either at the fuse box, or horn switch end; and the alarm output may be connected to the horn at any point from the horn switch to the horn itself. The negative connection may terminate at any point on the car bare metal.

Finally, connect S1 with the circuit, and test the alarm in situ. ⌑

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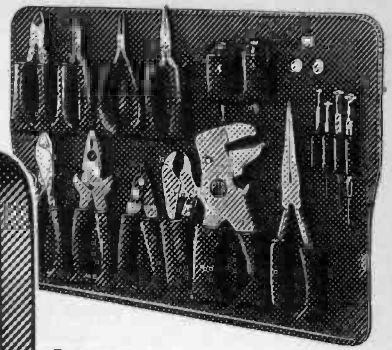

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RADIO WORLD

By Pat Hawker, G3VA

Showers of Meteors

A perennial problem in radio communications is to provide an absolutely reliable means of keeping in contact with stations some 500 to about 1000 miles away, regardless of time of day, state of the ionosphere or any of the other variaables that plague h.f. and v.h.f. systems. Satellites provide one solution but tend to be costly for many applications, while ionospheric scatter systems involve high powers and very large aerials.

Perhaps one of the oddest solutions is to take advantage of the literally billions of meteors that daily plunge into the upper atmosphere from space and then (all but the largest) rapidly burn up. In doing so, they generate trails of highly ionized plasma that often last less than a second, although occasionally persist for several seconds. For many years, some radio amateurs have used these meteor trials to snatch brief contacts on 28, 50, 70 or 144MHz with fellow enthusiasts up to about 1200 miles away, using an agreed procedure that enables callsigns and reports to be exchanged but seldom anything more.

For well equipped amateur stations "meteor scatter" is good fun and advantage is taken of the regular meteor showers that follow a regular pattern: the "Perseids" is a popular period early in August; the "Taurids" in November and the "Germinids" in December. But few amateurs would expect to send real message traffic by this system: not many even know that for over a decade the military, including NATO services, have been using this technique, following work by the Canadian Defence Research Board in the 1950s.

The trick is to send the traffic in a series of high-speed bursts, triggered off only when a suitable trail is present, as indicated by an incoming signal. By this means it is possible to make use of trails lasting perhaps only a fifth of a second or so.

Although such communication is intermittent, it is possible to achieve an average rate of transmission about one tenth that of the burst rate. For example, if messages are transmitted in bursts at say 600 words per minute, the circuit can yield a traffic capacity of about 60 words per minute, or the equivalent of a continuously open teleprinter channel. Of course, you could not use such a system for a "4-minute warning" message since the breaks in transmission may last several minutes, but for many purposes such brief delays can be tolerated, provided that communication is possible throughout the 24 hours.

Professional interest in this type of system has been growing. The American Department of Agriculture has a "Snonet" meteorological meteor-burst system that uses the system automatically to collect data on snow and rain, for example, from remote unattended sensors. The American firm of Telecom Inc has recently set up a demonstration link between Virginia and Tennessee over a distance of about 450 miles, sending data in bursts at a rate of 4800 bits/second, using 1kW transmitters and 5-element Yagi aerials on frequencies in the 30 to 50MHz range.

High-speed "burst" data transmission at very many times this rate is, of course, already part of the domestic scene in the UK. The Ceefax and Oracle teletext transmissions provide information at an average rate of almost 50,000 words per minute, in 50 microsecond bursts some 100 times a second, at a data rate of almost 7Mbit/s. But, of course, even the high power television transmitters do not provide a reliable range of a thousand miles!

Intransigent Valve

Some years ago the entire subject of thermionic valves was taken out of the syllabus for the Radio Amateur's Examination, presumably in the expectation that thermionic devices would soon become as little used in radio communications equipment as they have become in so many other branches of electronics. But it has not happened yet—and indeed may not happen for many years to come, if ever.

Transistors are tricky devices to use in medium or high power r.f. amplifiers and can easily be destroyed—particularly during thunderstorms. Admittedly there are quite a lot of all-solid-state transceivers available to amateurs at powers up to about 100 watts and to professionals to beyond 1kW. But valves still show significant advantages in certain circumstances.

It even seems possible that the valve may show something of a comeback, particularly for military communications and other electronics systems that need to be "hardened" in order to have some chance of surviving the sharp-edged electromagnetic pulse (EMP) or "radio flash" that follows a nuclear explosion in the upper atmosphere. Transistors can be a million times more vulnerable to such pulses than miniature valves, even when protected with the various surge suppression devices that currently provide a degree of protection against lightning strikes.

According to some reports, Russian designers have been very active in hardening their military communications and control systems, even using miniature valves and special screening cages for airborne computers. It has been calculated that a single nuclear explosion in the upper atmosphere could knock out a host of systems depending on electronics throughout half a Continent. Let us hope there is never a practical test of the theory.

Amateur News from Holland

One of the most ambitious services of amateur radio news broadcasts in Europe is that run by the Dutch society VERON from its headquarters station PAoAA. These go out simultaneously, every Friday evening, on 1827kHz, 3600kHz, 14·1MHz, 144·8MHz and 433·765MHz, starting at 19.00GMT.

The 3600kHz transmissions, in particular, are well received in the UK. From 19.00 to 19.30 there is news in Dutch and then English. At 19.30 there are Morse code practice sessions; at 20.30 a radioteleprinter (RTTY) bulletin at a speed of 45 baud, and then between 21.00 and 21.30 the Dutch and English news bulletins are repeated.

On the last Friday of each month, at 21.30 VERON transmits Morse code proficiency runs at various speeds and issues certificates to those who achieve perfect copy without the aid of tape recorders or other mechanical devices.

CB and Interference

The long-drawn-out saga of Citizens Band took another turn recently with the Home Office hinting that, after all, channels in the "international" part of 27MHz may become available in the UK at some "later" unspecified time, giving eventually a choice of some 62 channels in this band. There have even been rumours that a.m. may be permitted after all, but this seems unlikely in view of the strong comments made in the official Home Office annual report on interference to radio and television reception, covering 1980.

This is full of dire warnings that CB interference may soon become "the largest single source of complaints" and is "the most significant factor in the interference field in recent years". The interference investigating teams would certainly not be happy to see legal use of a.m. on 27MHz.

It has also become clear that the draft technical specifications for CB equipment (*Radio World*, July) are even tougher than most of us thought. Manufacturers, to meet the specification fully, would need to reduce out-of-band spurious and wideband noise emission to even lower levels than expected from professional land-mobile equipment.

Many people believe that it will prove impossible to achieve the required standard with low-cost equipment. But equally it would be extremely difficult effectively to enforce such a specification.

0-12V POWER SUPPLY

with Overload Alarm

BY R.A. PENFOLD

WHEN assembling an electronics workshop, even if only of a very basic type, an almost essential item of equipment to include is a power supply of some kind. This will probably be one of the most frequently used items of equipment, taking second place only to the soldering iron in this respect.

The inexpensive power supply described in this article has a well smoothed and regulated output which is adjustable from zero to about 12 volts or so. The maximum output current is 400mA, and the output voltage does not vary by more than about 100mV between no load and maximum output current. The output noise level is only a fraction of a millivolt at all output currents and voltages.

CURRENT LIMITING FEATURES

Current limiting is incorporated in the circuit to protect the unit against damage due to the inevitable accidental short circuits of the output. Apart from the 400mA current limit level for the protection of the supply itself, two alternative current limit levels of 40mA and 100mA are also available. These can be used when experimenting with delicate low current circuitry which would not be given effective protection by the relatively high 400mA limit current.

An additional and unusual feature is an audio alarm which sounds when the current limiting comes into action. This gives a much more effective overload warning than the more usual output current meter or l.e.d. indicator, either of which are easily overlooked.

THE CIRCUIT

The full circuit diagram of the power supply is shown in Fig. 1. The mains supply is connected to the primary winding of step-down and isolation transformer T1 via the on/off switch, S1. Mains neon LP1 is merely the on/off indicator light. The output from T1 secondary is given fullwave rectification by the bridge rectifier which is comprised of D1 to D4, and the resultant pulsating d.c. is smoothed by C1.

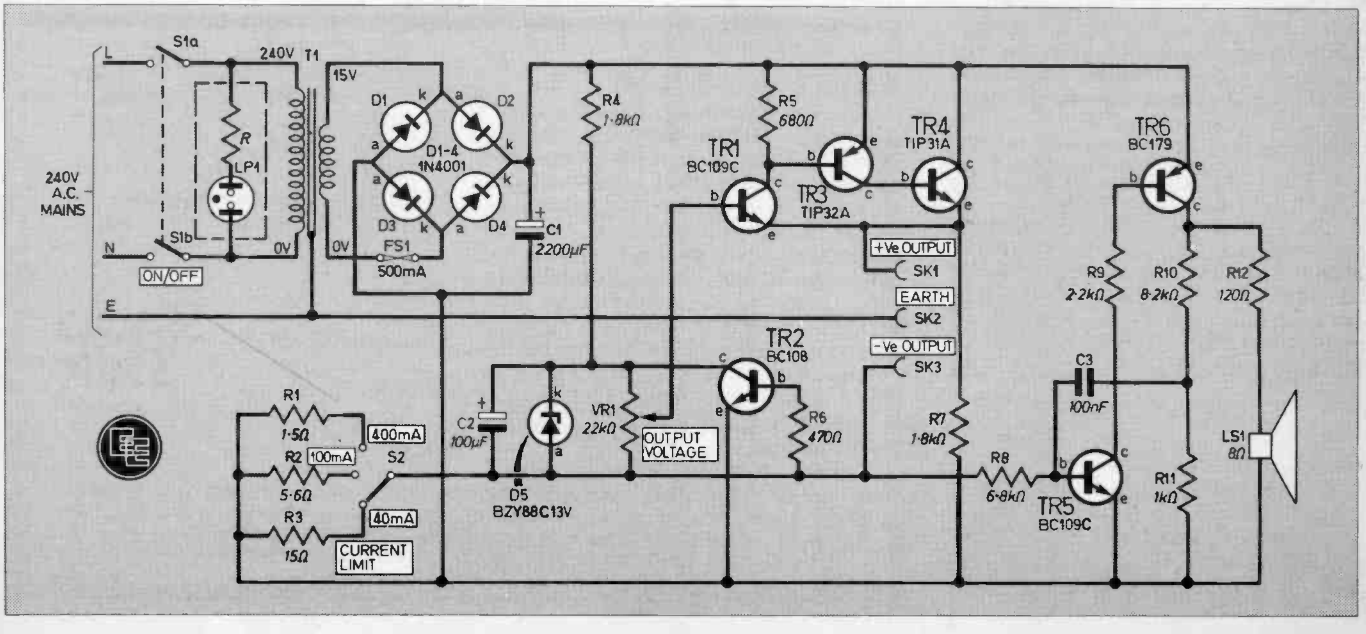
Components R4 and D5 form a straightforward Zener stabiliser circuit which gives a stable 13 volt source. C2 smoothes out any noise spikes generated by D5, and also reduces any mains hum introduced by way of R4 from the unregulated supply. Potentiometer VR1 is fed from the Zener stabilised source, and so a regulated voltage which is variable from about 0 to 13 volts is available at its wiper.

Only a very limited current is available from VR1 slider, and so it is necessary to interpose a unity voltage gain buffer amplifier between this point and the output of the supply. The purpose of the buffer amplifier is to give an output voltage equal to that at VR1 wiper, but with a low output impedance so that currents of a few hundred milliamps can be readily supplied. This amplifier is based on TR1, TR3, and TR4.

These transistors are used in a direct coupled configuration of course, with TR1 and TR3 being connected in the common emitter mode, and TR4 being used as an emitter follower output stage.

Although common emitter amplifiers normally have a fairly high voltage gain, this is not the case here as there is a 100 per cent negative feedback loop between TR4 emitter and TR1 emitter. This gives the amplifier the required voltage gain of unity, and so the voltage set at VR1 slider

Fig. 1. The complete circuit diagram for the 0-12V Power Supply with Overload Alarm.



also appears at the output. In actual fact there is a small voltage drop through the amplifier, and the output voltage is about 0·6 volts less than that produced by VR1. This gives a nominal output voltage range from 0 to 12·4 volts available across output sockets SK1 and SK3.

Resistor R7 is a load resistor for the buffer amplifier, and merely ensures that the amplifier always handles a sufficiently large output current to keep the three transistors functioning normally.

CURRENT LIMIT

The current limiting circuit uses TR2 and its associated components. These include S2 and R1 to R3, which are connected between the negative output of the unregulated supply and the negative input to the regulator and buffer amplifier circuitry. Only one of these resistors is connected into circuit at one time, and the appropriate resistor is selected by means of S2. A voltage which is proportional to the output current will be generated across the selected resistor, and this voltage will forward bias TR2 by way of current limiting resistor R6.

Since TR2 is a silicon device, it requires a forward bias of about 0·6 volts before it will begin to conduct, and then only a fractionally higher voltage to make it fully conductive (saturate). With S2 in the position shown in Fig. 1, and R3 connected into circuit, from Ohm's law it is apparent that an output current of about 40mA is needed before 0·6 volts is developed across R3 and TR2 begins to conduct ($I = V/R$, $= 0{\cdot}6A/15\Omega = 0{\cdot}04A$ or 40mA).

Therefore, with output currents up to about 40mA TR2 will not conduct, and will have no effect on the circuit. At higher output currents it will turn on to some extent, reducing the voltage across D5, and also reducing the output voltage of course. The higher the output is loaded, the more heavily TR2 will conduct, and the lower the output voltage becomes.

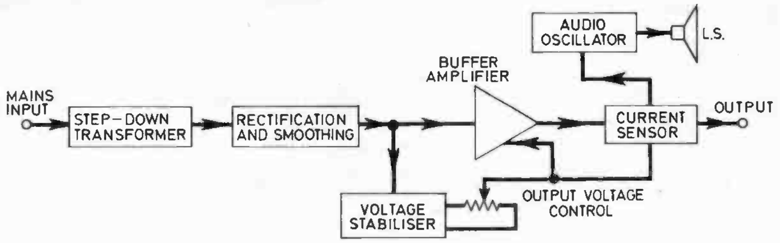
If the output is short circuited, TR2 will be biased into saturation and the output voltage will fall to virtually zero, limiting the output current to little more than 40mA. With R2 and R1 switched into circuit the output limit currents are 100mA and 400mA respectively, due to the lower values of these components compared with R3.

ALARM CIRCUITRY

The alarm circuit is based on a simple two transistor oscillator which uses TR5 and TR6. These are used in a complementary direct coupled common emitter configuration, with R10 and a loudspeaker forming the collector load for TR6. Positive feedback is applied over the amplifier by C3, and this causes the circuit to oscillate at a frequency of a few hundred hertz, but only when a suitable input bias is provided for TR5.

Like TR2, TR5 only receives sufficient forward biasing to produce conduction when the output current reaches the limiting level. Thus the circuit does not actually oscillate until an overload occurs. When oscillation does occur, LS1 emits an audible tone and gives warning of the overload.

HOW IT WORKS



The mains is stepped down to a suitable voltage by a transformer which also provides safety isolation. Its a.c. output is rectified to a pulsating d.c. and smoothed to a steady d.c. in the conventional manner.

Part of this output is fed to a voltage stabiliser. The output of this is connected to a potentiometer which gives an adjustable potential of about 0 to 12V. This can only give a small current, and must drive the output via a buffer amplifier to give a high current drive capability to the unit.

A current sensor connected in series with the output detects any overloads, and when necessary reduces the output voltage to limit the output current to a safe level. It also activates an audible alarm to give warning of the overload.

COMPONENTS

Resistors

R1	1·5Ω	R7	1·8kΩ
R2	5·6Ω	R8	6·8kΩ
R3	15Ω	R9	2·2kΩ
R4	1·8kΩ	R10	120Ω
R5	680Ω	R11	8·2Ω
R6	470Ω	R12	1kΩ

All ¼ watt carbon ± 5%

Capacitors

C1 2,200μF. 25V elect.
C2 100μF. 16V elect.
C3 100nF mylar

Semiconductors

TR1 BC109C silicon *npn*
TR2 BC108 silicon *npn*
TR3 TIP32A silicon *pnp*
TR4 TIP31A silicon *npn*
TR5 BC109C silicon *npn*
TR6 BC179 silicon *pnp*
D1 to D4 1N4001 (4 off)
D5 BZY88C13V 13 volt 400mW Zener diode

Miscellaneous

VR1 22kΩ carbon linear law shafted potentiometer
S1 d.p.s.t. rotary mains switch
S2 4-pole 3-way rotary switch (only one pole used)
LS1 miniature 8Ω impedance type
T1 standard mains primary/15 volt 400mA secondary
FS1 500mA 20mm
LP1 panel mounting mains neon
SK1-3 panel mounting insulated sockets, 1 red, 1 black, 1 green 0·15 inch matrix stripboard size 12 strips × 20 holes; 20mm chassis mounting fuse holder; control knobs (3 off); metal instrument case size 200 × 140 × 65mm approximately; mains lead; cabinet feet; 6BA fixings for circuit board.

COMPONENTS approximate cost £10 excluding case

See Shop Talk page 598

0-12V POWER SUPPLY with Overload Alarm

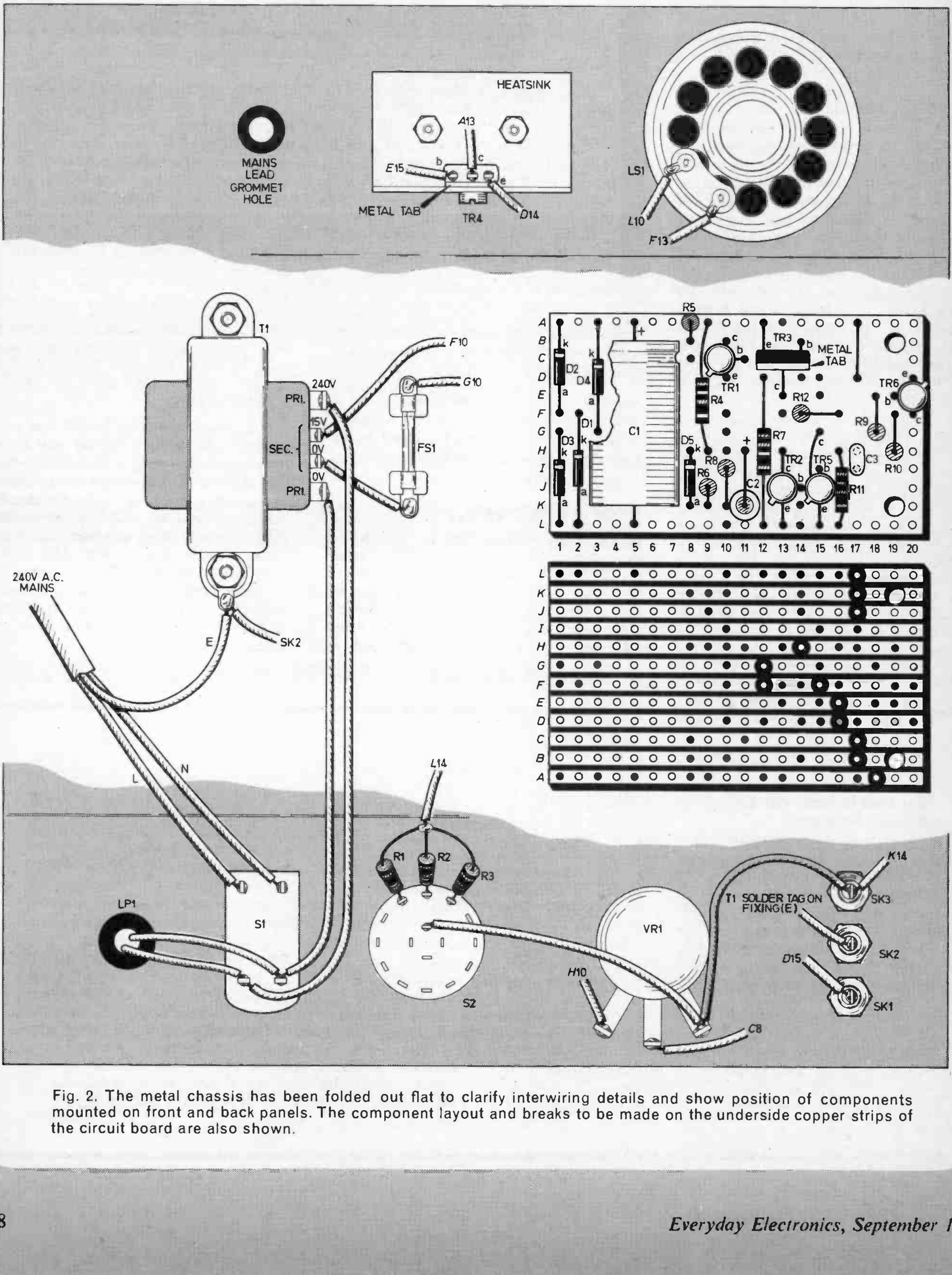
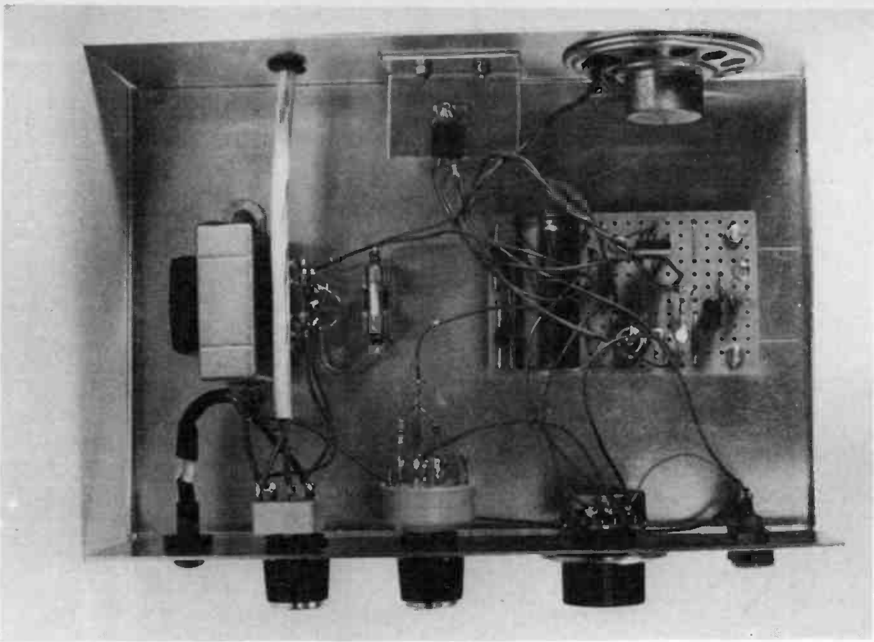


Fig. 2. The metal chassis has been folded out flat to clarify interwiring details and show position of components mounted on front and back panels. The component layout and breaks to be made on the underside copper strips of the circuit board are also shown.

CONSTRUCTION starts here



Interior view of the completed prototype. The mains transformer is mounted on the base of the case. Note the positioning of the heatsink for TR4 and the use of a mica washer.

ASSEMBLY

The prototype unit was built into a metal instrument case measuring about 203 × 140 × 63mm. The general layout of the unit can be seen from the photographs. The precise layout is not critical. The loudspeaker was mounted on the rear panel of the case due to a lack of space on the front panel. A matrix of small holes are drilled to form a speaker grille, and then the speaker is glued in place behind this using a strong adhesive.

TR4 is mounted on an L-shaped bracket which is made from a piece of 18 s.w.g. aluminium having dimensions of about 40 × 50mm. The bracket is bolted to the rear panel of the case, next to the loudspeaker. The bracket and case then act as a heatsink for TR4, which under certain loading conditions has to dissipate several watts. TR4 is mounted with its metal pad facing the mounting bracket, and as this pad connects to its collector terminal, a mica washer and plastic insulating bush are necessary to insulate it from the bracket.

The case connects to the mains earth, and in use one of the output rails will normally be either directly or indirectly (via some other item of equipment) connected to earth. Failing to insulate TR4 from the bracket could therefore lead to either a virtual short circuit on the unregulated supply lines, or the regulator circuit being bypassed, depending upon which supply rail is earthed. It is advisable to check the insulation of TR4 using a continuity tester to ensure that it is fully effective.

CIRCUIT BOARD

With the exceptions of R1 to R3, which are mounted on S2, the small components are assembled on a 0·15in matrix stripboard panel having 12 copper strips by 20 holes. Details of the component panel and all other wiring of the unit are provided in Fig. 2. Be careful not to omit the single link wire from the component panel and to use spacers to hold the board clear of the case base to avoid shorting.

The finished unit could be fitted with a meter to indicate the output voltage, but a simple and inexpensive alternative is to mark a scale around the control knob of VR1 calibrated in terms of output voltage corresponding to the reading obtained on a voltmeter connected across the output terminals SK1 and SK3. Provided this is done properly it will be at least as accurate as using a voltmeter. Either rail may be earthed via a lead connecting to SK2. ⌑

OBITUARY

F. G. RAYER

The well-known writer F. G. Rayer died on July 11, 1981 at the age of 60.

Our very first issue (November 1971) contained a project by F. G. Rayer, and during these subsequent 10 years a steady flow of projects from this contributor have appeared in our pages. For this magazine Frank concentrated in the main on the kind of projects that would be popular with newcomers to electronics. His name will be well remembered with gratitude by thousands of enthusiasts who cut their teeth, electronically speaking, on projects he devised.

Frank was, of course, active in the freelance designing and writing business long before EE appeared on the scene and he contributed to most of the popular magazines in this field at sometime or another during the past 35 years or so. He had an enquiring mind and was fascinated by mechanical as well as electrical devices. This fuelled a large literary output; thousands of articles on building, electrical and electronic subjects flowed from his pen as well as numerous technical books.

Probably less known to readers of technical magazines was F. G. Rayer's work as a novelist. He had a number of fictional works published, mainly of a S.F. nature and the best known was "Tomorrow Sometimes Comes" (1951, republished 1962).

It is very sad to have to report the passing of a regular contributor of such long standing. Though our contacts were by correspondence or telephone, we on EE all looked upon Frank Rayer as "one of us", and not just a business associate. He was always ready to oblige and produce designs and articles to meet specific needs. On behalf of our readers and the staff of EVERYDAY ELECTRONICS I offer our condolences to Mrs. Rayer and sons.

F. E. BENNETT

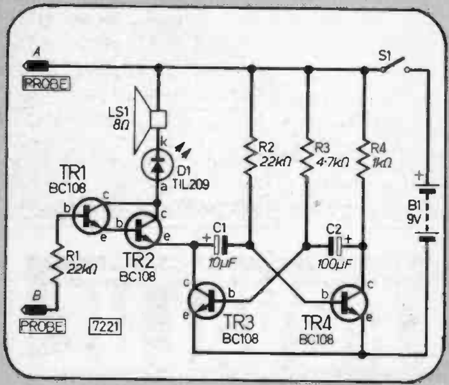
CIRCUIT EXCHANGE

SIGNAL TRACER

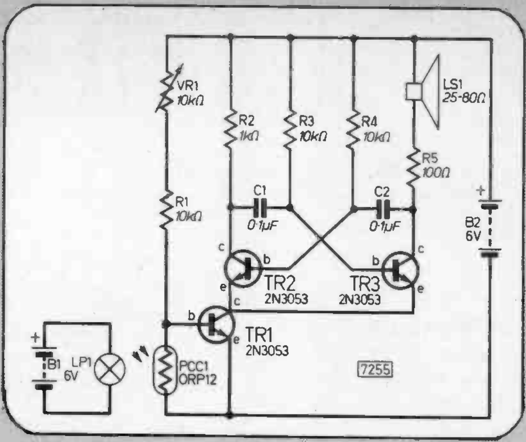
I have built an inexpensive signal tracer using relatively few components, as shown in the circuit diagram. The multivibrator circuit TR3 and TR4 is used to produce a pulse train.

To use the tracer, connect probe *A* to the negative rail of the circuit under test and progress with probe *B* through the circuit towards the speaker (or output) until the signal from the tracer stops. When it does you know that the fault is between the point previous and the point where you are now.

Stephen Nourse,
Bahrain.



LIGHT BEAM ALARM



This circuit is for a light beam alarm. When the light beam is broken the light dependent resistor PCC1 is denied light which causes its resistance to increase to about 10 kilohms. This change is enough to cause the transistor TR1 to switch on and the collector current drive the alarm circuit.

The alarm circuit is an astable multivibrator formed by TR2 and TR3 which also drives the loudspeaker LS1. The timing components for the multivibrator are C1, R3 and C2, R4.

The sensitivity of the "light switch" is adjusted by the potentiometer VR1. A reflector could be used with the lamp LP1 to enable a certain amount of "focusing" of the light beam on to PCC1.

P. Cole,
Lowestoft,
Suffolk

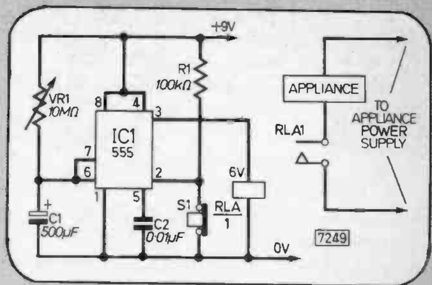
VARIABLE TIMER

The circuit described here will give a variable "on" time for switching electrical appliances via a relay, see diagram. The potentiometer VR1 is the timing adjustment control and a calibrated scale can be added.

The unit is operated by setting VR1 to the desired position and pressing the start switch S1. If all is well, the relay will be heard to close and the appliance should switch on.

After the time set by VR1 the relay will open, thus switching the appliance off, and the circuit will now consume very little current. Turning the control VR1 clockwise will increase the "on" time.

If it is desired the unit could be fitted into a box with a standard



mains socket in the lid, so that any mains appliance can be connected and disconnected quickly. Applications include switching of a cassette, video recorder or nightlight.

With the component values shown, the timing range is from approximately 10 minutes to just over an hour. If longer timing periods are regularly needed, a suitable power supply giving about 100mA of current could be incorporated.

D. Parsons,
B.F.P.O.40.

CMOS LOGIC PROBE

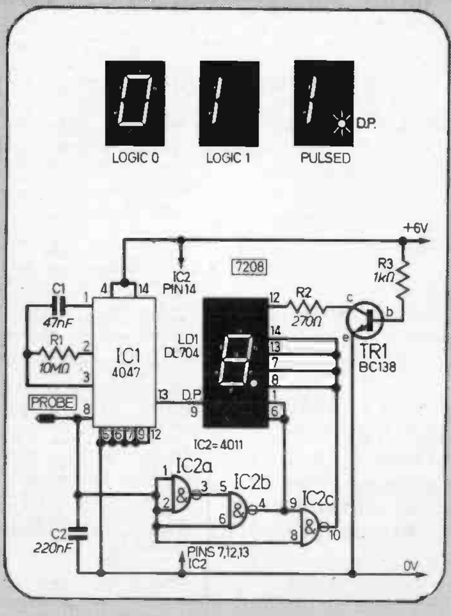
This simple logic probe design is intended for use when trouble shooting CMOS. Indication is given for "high" and "low" logic and pulse detection, all on a single seven segment display, see diagram right.

Detection of logic *0* and *1* lies around the formation of the three NAND gates, operating under certain logic functions. The outputs of the NANDS are directly coupled to the display which is powered through TR1.

The pulse detector consists of a positive triggered monostable. This is connected to the decimal point of the display giving constant indication of any input pulses. The display may also show a logic *0* or *1* when pulse detecting.

Being a CMOS circuit, it can, therefore, be powered from the circuit under test.

I. Smith,
Tewkesbury,
Gloucestershire.



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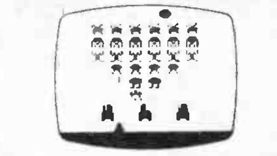

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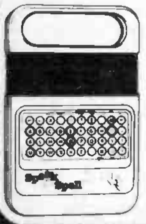

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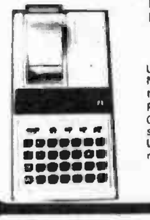

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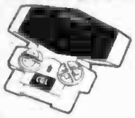

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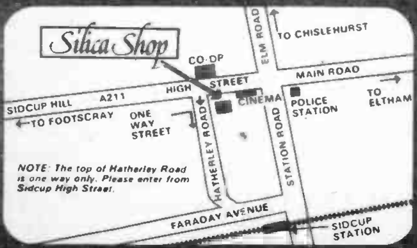

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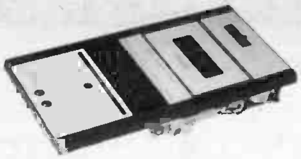

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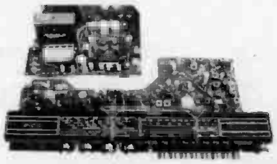

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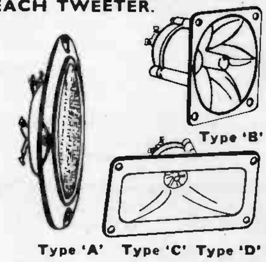

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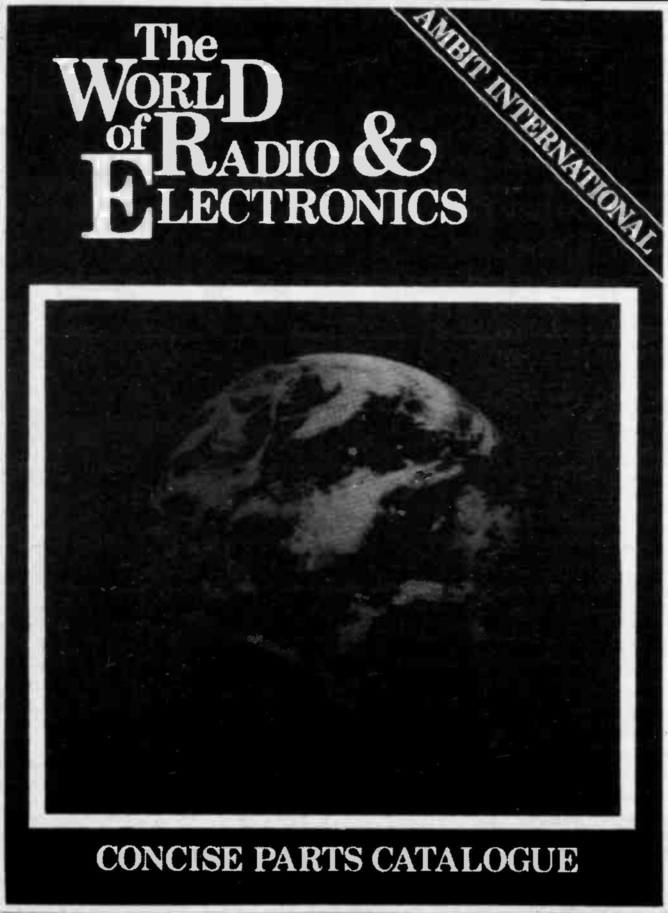

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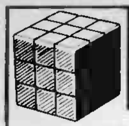

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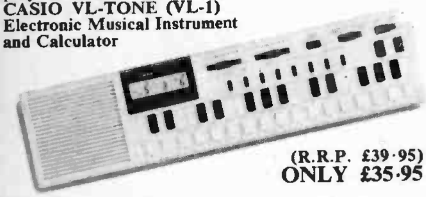

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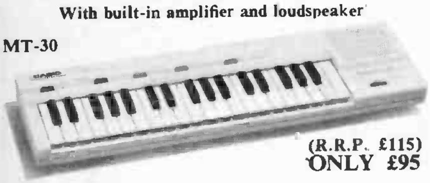

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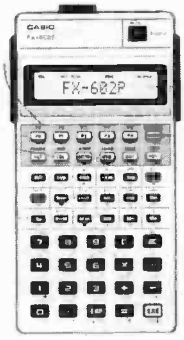

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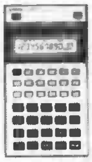

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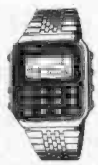

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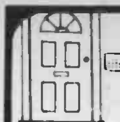

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As featured in E.E. May '81

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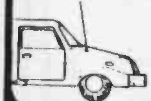

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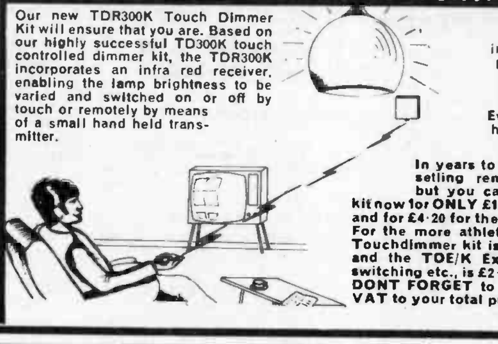

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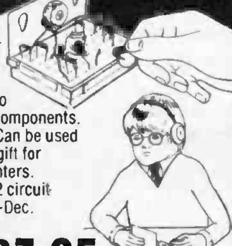

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ECC82	0·55	QQV03-20A		**DUCTORS**		BC461	0·30	R2540	2·48
ECC83	0·60		12·25	AC126	0·22	BC478	0·20	TIP29	0·40
ECC85	0·60	QQV06-40A		AC127	0·22	BC547	0·10	TIP29C	0·42
ECC88	0·85		13·95	AC128	0·28	BC548	0·10	TIP30C	0·43
ECC807	1·30	QV03-12	3·50	AC141K	0·34	BC549A	0·08	TIP31C	0·42
ECF80	0·65	TY2-125A	45·00	AC176	0·22	BC557	0·07	TIP32C	0·42
ECF82	0·60	U19	11·95	AC176K	0·31	BC558	0·07	TIP41C	0·45
ECH81	0·58	UCH81	0·65	AC187	0·26	BD131	0·32	TIP42C	0·47
ECL82	0·58	UCL82	0·76	AC187K	0·28	BD132	0·35	TIP47	0·65
ECL83	1·13	UL84	0·78	AC188	0·22	BD133	0·40	TIP2955	0·84
ECL86	0·74	UY85	0·70	AD149	0·70	BD135	0·30	TIP3055	0·60
EF37A	3·60	Z759	9·00	AD161	0·39	BD136	0·30	TIS91	0·20
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EF94	0·55	6GK6	2·50	BC107	0·10	BF115	0·35	2N3705	0·12
EF95	0·78	6J6	0·65	BC107B	0·10	BF167	0·24	2N3706	0·12
EF183	0·56	6JS6C	2·55	BC108	0·10	BF179	0·34	2N3708	0·12
EF184	0·56	6KD6	3·95	BC108C	0·10	BF180	0·29	2N5294	0·38
EL34	1·54	6L6GC	1·75	BC109B	0·10	BF183	0·29	2N5296	0·48
EL84	0·60	6LD20	0·60	BC140	0·31	BF194	0·11	2N5298	0·38
EM84	0·70	6SN7GT	0·69	BC141	0·25	BF195	0·11	2SC1306	1·25
EZ80	0·56	6V6GT	0·90	BC142	0·21	BF196	0·11	2SC1307	1·85
EZ81	0·56	7S7	2·00	BC143	0·24	BF197	0·11		
GZ32	0·85	12AT7	0·55	BC147	0·09	BF198	0·10	**I.C.'s**	
GZ33	3·25	12AU7	0·60	BC148	0·09	BF199	0·14	MC1307	1·00
GZ34	2·00	12AX7	0·55	BC149	0·09	BF200	0·30	MC1350	1·00
KT61	3·50	12BA6	0·80	BC157	0·10	BF257	0·28	MC1495	3·00
KT66	4·95	12BE6	1·05	BC158	0·09	BF258	0·25	SN76003N	1·65
KT77	5·00	12BH7	0·95	BC159	0·09	BF259	0·26	SN76023N	1·35
KT88	6·00	12HG7	3·25	BC160	0·28	BF336	0·34	SN76033N	1·35
N78	8·90	30FL2	0·95	BC170B	0·10	BFX29	0·30	SN76131N	1·30
OA2	0·60	85A2	1·20	BC171	0·08	BFX84	0·26	SN76227N	1·05
PCF80	0·70	90C1	1·69	BC172	0·09	BFX85	0·28	SN76660N	0·60
PCF802	0·72	807	1·09	BC173B	0·10	BFX86	0·30	TA7205AP	1·95
PCF808	1·48	811A	9·00	BC182	0·09	BFX88	0·25	TAA661B	1·20
PCL82	0·74	813	11·30	BC183	0·09	BFY50	0·21	TBA120S	0·70
PCL84	0·76	833A	47·85	BC184LA	0·09	BFY51	0·21	TBA540	1·25
PCL86	0·76	866A	3·00	BC212	0·09	BFY52	0·25	TBA5500	1·55
PCL805	0·80	2050A	3·90	BC212L	0·09	BFY90	0·73	TDA1004A	2·20
PFL200	1·13	5763	3·20	BC213	0·09	BU105	1·22	UPC575C2	2·95
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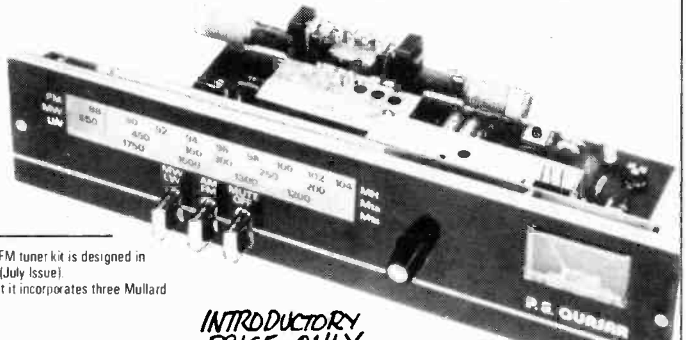
NEW

PRACTICAL ELECTRONICS

STEREO TUNER KIT

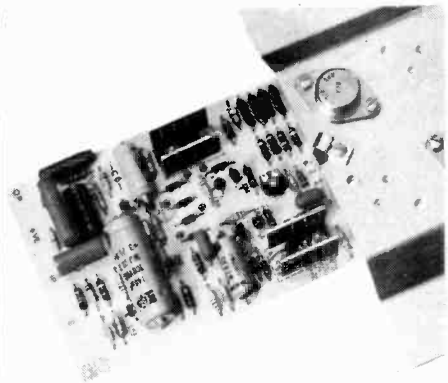


This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with Practical Electronics (July Issue).
For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF System.

Features
VHF - M.W. - L.W. Bands. Interstation muting and A.F.C. on VHF.
Tuning Meter. Two back printed P.C.B's. Ready made chassis and scale.
Aerial: AM - Ferrite Rod, FM - 75 or 300 ohms.
Stabilized power supply with "C" core mains transfomier.
All components supplied are to P.E. strict specification.
Front scale size 10½" x 2½" approx.
Complete with circuit diagrams and instructions.

INTRODUCTORY PRICE-ONLY

£17.95
plus £2.50 p&p



HIGH POWER MODULE KITS

125 WATT MODEL £10.50 plus £1.15 p&p (Illus)

200 WATT MODEL £14.95 plus £1.15 p&p

SPECIFICATIONS

Max. Output power	125 watt RMS
Operating voltage (DC)	50-80 Max.
Loads	4-16 ohms
Frequency response measured at 100 watts	25Hz-20KHz
Sensitivity for 100 watts	400mV @ 47K
Typical T.H.D. @ 50 watts 4 ohms load	0.1%
Dimensions	205 x 90 and 190 x 36 mm

The power amp kit is a module for high power applications—disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, result, a high powered rugged unit. The PC Board is backprinted, etched and ready to drill for ease of construction, and the aluminium chasis is preformed and ready to use. Supplied with all parts, circuit diagrams and instructions.

ACCESSORIES

Suitable LS coupling electrolytic for 125W model **£1.00** plus 25p p&p

Suitable LS coupling electrolytic for 200W model **£1.25** plus 25p p&p

Suitable Mains Power Supply Unit for 125W model **£7.50** plus £3.15 p&p

Suitable Twin Transformer Power Supply for 200W model **£13.95** plus £4.00 p&p

MULLARD LP1183 STEREO PREAMP *FREE!*

Original listed price over £5.00. Suitable for ceramic and auxiliary inputs, when you purchase 2 power module kits.

PRACTICAL ELECTRONICS CAR RADIO KIT (Constructors pack 7)

2 WAVE BAND MW LW
* Easy to build * 5 push button tuning
* Modern styling design * All new unused components
* 6 watt output * Ready etched & punched P.C.B.
* Incorporates suppression circuits * Now with tape input socket

All the electronic components to build the radio, you supply only the wire and solder as featured in the Practical Electronics March issue. Features: Pre-set tuning with five push button options, black illuminated tuning scale, with matching rotary control knobs, one, combining on/off volume and tone-control, the other for manual tuning, each set on wood simulated fascia.
The P.E. Traveller has a 6 watts output, neg ground and incorporates an integrated circuit output stage, a Mullard IF module LP1181 ceramic filter type, pre-aligned and assembled and a Bird pre-aligned push button tuning unit. The radio fits easily in or under dashboards.
Complete with instructions. **£10.50** plus £2.00 p&p

CONSTRUCTORS PACK 7A

Suitable stainless steel fully retractable locking aerial and speaker (approx. 6" x 4") is available as a kit complete **£1.95** per pack. p&p £1.15

£14.95 plus £2.90 p&p

10+10 WATT STEREO AMPLIFIER KIT

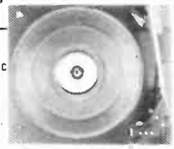
- Featuring latest SGS/ATES TDA 2006 10 watt output I.C.'s with in-built thermal and short circuit protection.
- Mullard Stereo Preamplifier module.
- Attractive black vinyl finish cabinet. Size 9" x 8⅜" x 3⅝" approx.
- Converts to a 20 watt Disco amplifier.

To complete you just supply connecting wire and solder. Features include din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs—tape, speakers and headphones. By the press of a button it transforms into a 20 watt mono disc amplifier with twin deck mixing. The kit incorporates a Mullard LP1183 pre-amp module, plus power amplifier assembly kit and mains power supply. Also featured 4 slider level controls, rotary bass and treble controls and 6 push button switches. Silver finish fascia panel with matching knobs and contrasting ready made black vinyl finish cabinet and ready made metal work. For further information instructions are available price 50p. Free with kit.

SPECIFICATIONS

Suitable for 4 to 8 ohms speakers

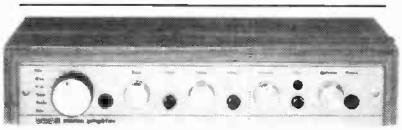
Frequency responce	40Hz — 20KHz
Input Sensitivity	P.U. 150mV Aux. 200mV Mic. 1.5mV
Tone controls	Bass ± 12db @ 60Hz
	Treble ± 12db @ 10KHz
Distortion	1% typically @ 4 watts
Mains supply	220-250 volts 50Hz



BSR chassis record deck with manual set down and return, complete with stereo ceramic cartridge. **£8.50** plus £3.15 p&p when purchased with amplifier.
Available separately **£10.50** plus £3.16 p&p.

8" SPEAKER KIT 2 8" approx. twin cone domestic use speakers. **£4.75** per stereo pair plus **£1.70 p&p** when purchased with amplifier. Available separately **£6.75** plus £1.70 p&p.

STEREO MAGNETIC PRE-AMP CONVERSION KIT. All components including P.C.B. to convert your ceramic input on the 10+10 amp to magnetic. **£2.00** when purchased with kit featured above. **£4.00** separately inc. p&p.



30 + 30 WATT STEREO AMPLIFIER BUILT AND TESTED

Viscount IV unit in teak simulate cabinet silver finished rotary controls and pushbuttons with matching fascia, red mains indicator and stereo jack socket. Functions switch for mic magnetic and crystal pickups, tape and auxiliary. Rear panel features fuse holder. DIN speaker and input socket 30 + 30 watts. RMS 60 + 60 watts peak for use with 4 to 8 ohm speakers. Size 14¾" x 10" approx.

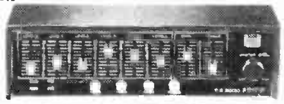
READY TO PLAY £32.90 plus £3.80 p&p

HI FI STEREO AMPLIFIER MODULES

- Mullard LP1183 built preamplifier suitable for ceramic and auxiliary inputs. £1.95 plus 70p p&p.
- Mullard LP1184 built preamplifier suitable for magnetic/ceramic and auxiliary inputs. £4.95 plus 80p p&p.
- Matching I.C. 10 + 10 Stereo Power amplifier kit. £3.95 plus £1.15 p&p.
- Matching power supply kit with transformer. £3.00 plus £1.96 p&p.
- Matching set of 4 slider controls complete with knobs for bass, treble and volumes. £1.70 plus 80p p&p.
- Complete with application notes.

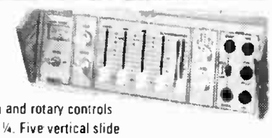
50 WATT MONO MIXER AMPLIFIER

Six individually mixed inputs for two pick ups (Cer. or Mag.), two moving coil microphones and two auxiliary for tape, tuner, organs etc. Eight slider controls - six for level and two for master bass and treble, four extra treble controls for mic and aux. inputs.
Power output 50 watt R.M.S. (continuous) for use with 4 to 8 ohms speakers. Finish: Attractively styled black vinyl case, with matching fascia and knobs. Complete and ready for use.



£39.95 plus £3.70 p&p

100 WATT MONO DISCO AMPLIFIER



Brushed aluminium fascia and rotary controls.
Size approx 14" x 4" x 10¼. Five vertical slide controls, master volume, tape leverl, mic level, deck level. PLUS INTER DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre fade level controls (PRL) lets YOU hear next disc before fading it in. VU meter monitors output level. Output 100 watts RMS 200 watts peak.

£76.00 plus £4.60 p&p

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