

Electronics

THE MAPLIN MAGAZINE

This project book completely replaces issue 2 of 'Electronics', which is now out of print. Other issues of 'Electronics' will be replaced by project books as they, too, become out of print.

For kit prices, please consult the latest Maplin price list. The price list also contain details of how to obtain a year's subscription to 'Electronics'.

CONTENTS

Projects	Page
Burglar Alarm 3 <i>A home security system offering reliable, long-term protection.</i>	3
Miles-Per-Gallon Meter 27 <i>Save petrol when you learn to drive economically with the aid of this invaluable meter.</i>	27
Stopwatch 13 <i>Multi-mode stopwatch with 8-digit readout.</i>	13
Train Controller 16 <i>Control up to 14 locomotives on one 2-wire circuit — up to four simultaneously.</i>	16

Editor Doug Simmons
Production Manager Sue Clark
Technical Editors Robert Kirsch
Dave Goodman

Art Editor Peter Blackmore
Technical Artists Roy Smith
John Dudley
Photography Chris Barlow

Published by Maplin Electronic Supplies Ltd,
P.O. Box 3, Rayleigh, Essex
Printed by Mayhew McCrimmon Ltd.
Typeset by Quillset Typesetting

For Personal Service

CALL IN AT ONE OF OUR SHOPS

*We have shops in London, Birmingham
and Southend*

LONDON

159-161 King Street,
Hammersmith W6.
Telephone: 01-748 0926.

BIRMINGHAM

Lynton Square, Perry Barr
(junction of A34 and A4040).
Telephone: 021-356 7292.

SOUTHEND

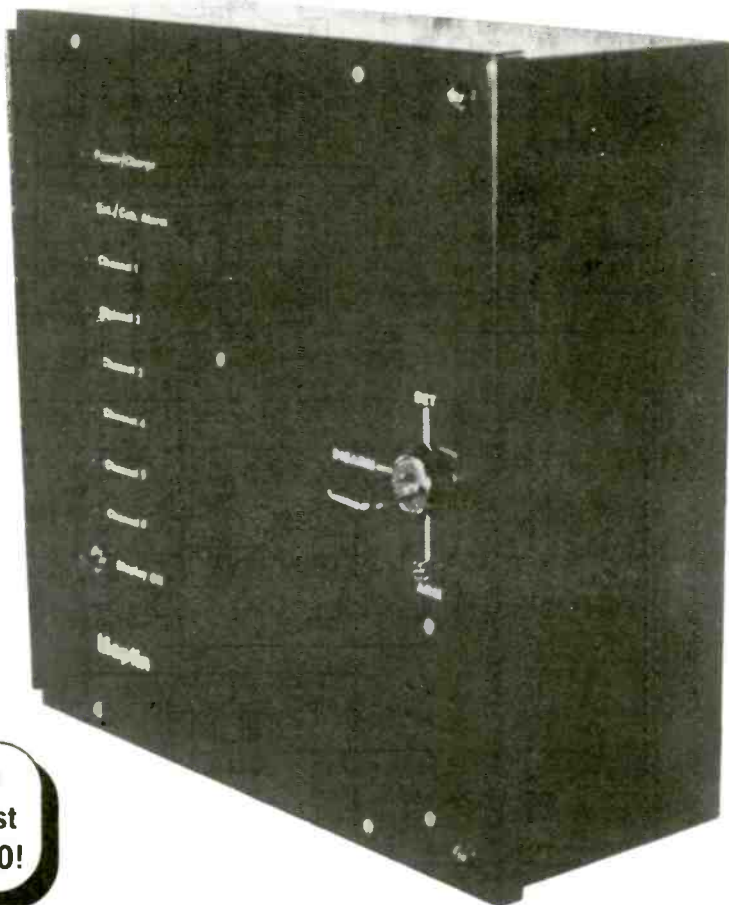
282-284 London Road,
Westcliff-on-Sea, Essex.
Telephone: (0702) 554000.

*Excellent parking at all locations.
All shops open 9 a.m. to 5.30 p.m.
Tuesday to Saturday (closed Monday).*

HOME SECURITY SYSTEM

by Dave Goodman

- ★ Six independent channels with two groups per channel
- ★ Two or four wire operation with line sensing of open or short circuit or resistance change (jumping)
- ★ Tamper-proof main cabinet
- ★ External horn loop control has its own open/short circuit and jumping protection
- ★ Presettable entry and exit delay timers



Minimum
system cost
UNDER £50!

This new home security system offers a high degree of protection for domestic or commercial premises coupled with excellent long-term reliability. The unit is mains operated, but will run off its small internal nickel-cadmium rechargeable battery pack for 2 to 3 days depending on the size of the system. The internal battery is continuously charged when the mains is present and changeover from mains to battery and vice-versa has no effect on the system. CMOS circuitry is used throughout to minimise current drain.

There are sockets for six separate plug-in channels so that for example all downstairs windows could be connected to one input, all downstairs doors to another, all upstairs windows to another and perhaps shed and garage doors and windows to another. When setting the system you know immediately where to look for the window left open accidentally if the system will not set. Or parts of the system only may be set. For example, during the late evenings, the shed and garage circuit only could be set. Whatever your requirements this system offers the fullest possible flexibility for complete security.

The external horn is also fully protected when fitted with dry batteries. Its prominent position alone will deter most burglars, but any attempt to tamper with it will set it off. If the wires to it are cut or tampered with, the horn will sound. Even ripping the box off the wall will not stop the alarm. The recommended dry batteries will sound the alarm at full power for at least four hours even if the wires are cut.

The alarm is extremely easy to build, with internal wiring kept to an absolute minimum. Operation is by a single keyswitch and exit and entry delays

may be preset to suit your requirements. There is an LED for each channel, giving monitoring facilities and an internal sander giving 'alarm condition' tones. Even the main cabinet is protected, by a microswitch fitted to the PSU pcb.

Circuit Description

Mains PCB

The key switch S9, which is shown in Figure 1 with its contacts made, controls the 'disarm' and 'set' conditions of the alarm unit. TR1 is conducting and thus inhibiting the exit delay timer oscillator IC1c and d, and IC2, a 14 stage counter/divider, is held reset.

The oscillator IC1c and d is frequency variable between 25Hz (40ms) and 10kHz (100us). This clock signal is divided down by IC2 by 8192 giving a minimum time out period of 0.8s and a maximum period of 5.5 mins. So allowing for variations in tolerances, IC1c, d and IC2 function as an exit delay timer presettable by RV1 giving periods of between 0 and 6 mins.

IC1a, b and IC3 function as described above but are used as an entry delay timer, presettable by RV2.

In the disarm mode IC2 pin 3 is at 0V and D2 is conducting. Consequently exit delay tone modulator IC5c and d is inhibited. IC10a output is high, holding TR5 and LED9 ('ARM' LED) off. Latch

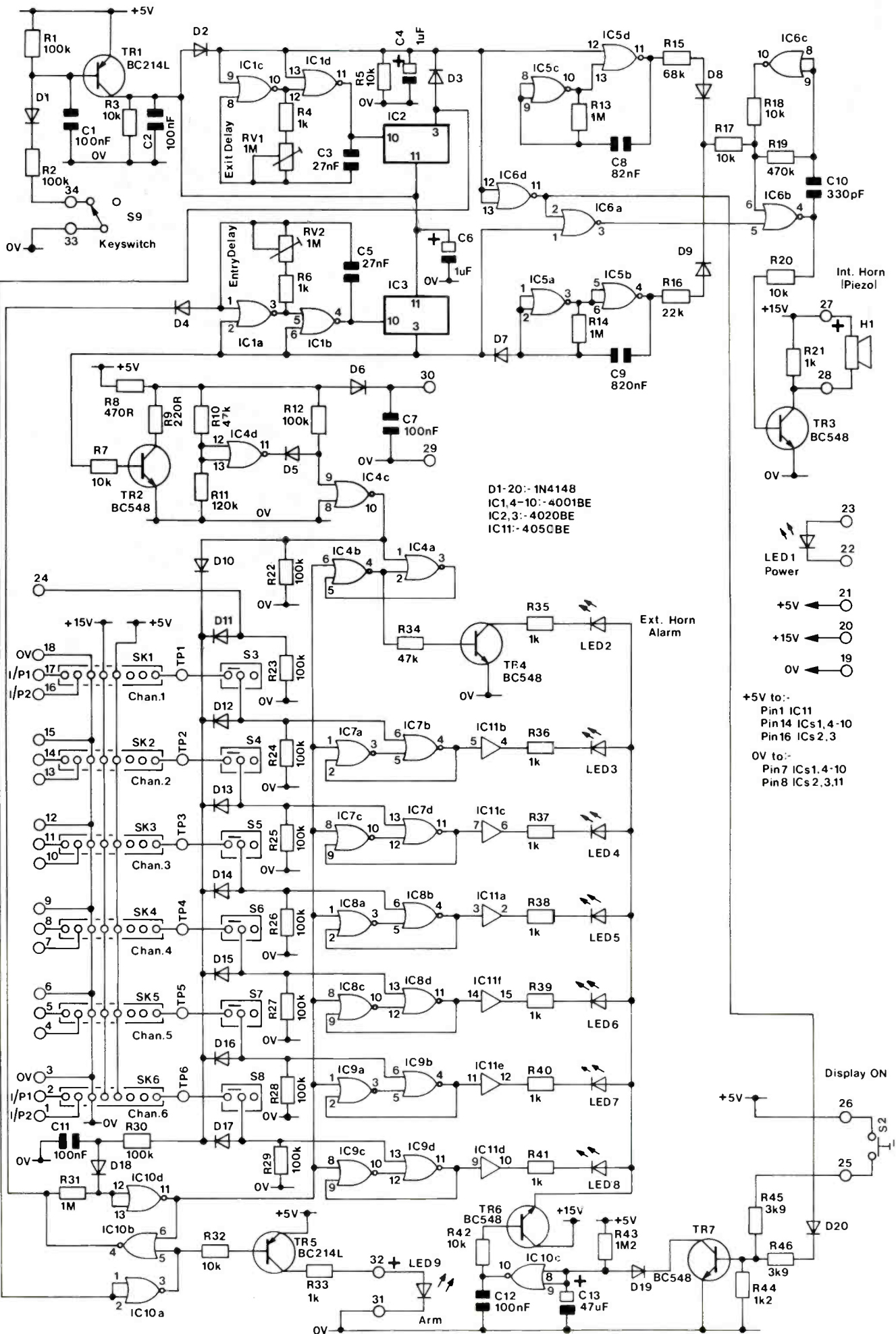
IC10b and d output is high. Entry delay timer is held off via D4 and IC10b output low. Counter IC3 pin 3 is low and alarm tone modulator IC5a and b is inhibited via D7 conducting.

Latches IC7, 8 and 9 have normally high outputs connected to LED buffer IC11 preventing channel LEDs 3 to 8 from turning on. A positive trigger pulse greater than 25ms in duration present at any of the inputs to the latches from switches S3 to 8 allows the channel LEDs to turn on for the duration of the triggering signal.

Switch S2 operates TR7 which discharges C13 and operates TR6, the LED display. TR6 remains on for the time constant set by R43 and C13, approximately 90s.

Operating switch S9 (contacts open) in the 'set' mode turns TR1 off. This removes the inhibit on the exit delay oscillator IC1c and d allowing it to run at the frequency determined by RV1. IC2 divides this signal and IC2 pin 3 goes high. While IC2 is counting, D2 is not conducting and IC5c and d run at a frequency of approximately 8Hz. The inhibit on the tone generator IC6b and c is removed allowing it to run at approximately 3kHz modulated at 8Hz.

At the end of the timing period, IC2 pin 3 goes high, inhibiting IC5d and IC6d. IC10a goes low, TR5 conducts and the 'ARM' LED turns on. IC10d inhibit is removed and a positive trigger pulse from switches S3 to 8 latches



D1-20:- 1N4148
 IC1,4-10:- 4001BE
 IC2,3:- 4020BE
 IC11:- 4050CBE

+5V to:-
 Pin1 IC11
 Pin14 ICs1,4-10
 Pin16 ICs2,3
 OV to:-
 Pin7 ICs1,4-10
 Pin8 ICs2,3,11

Figure 1. Circuit diagram of Main PCB.

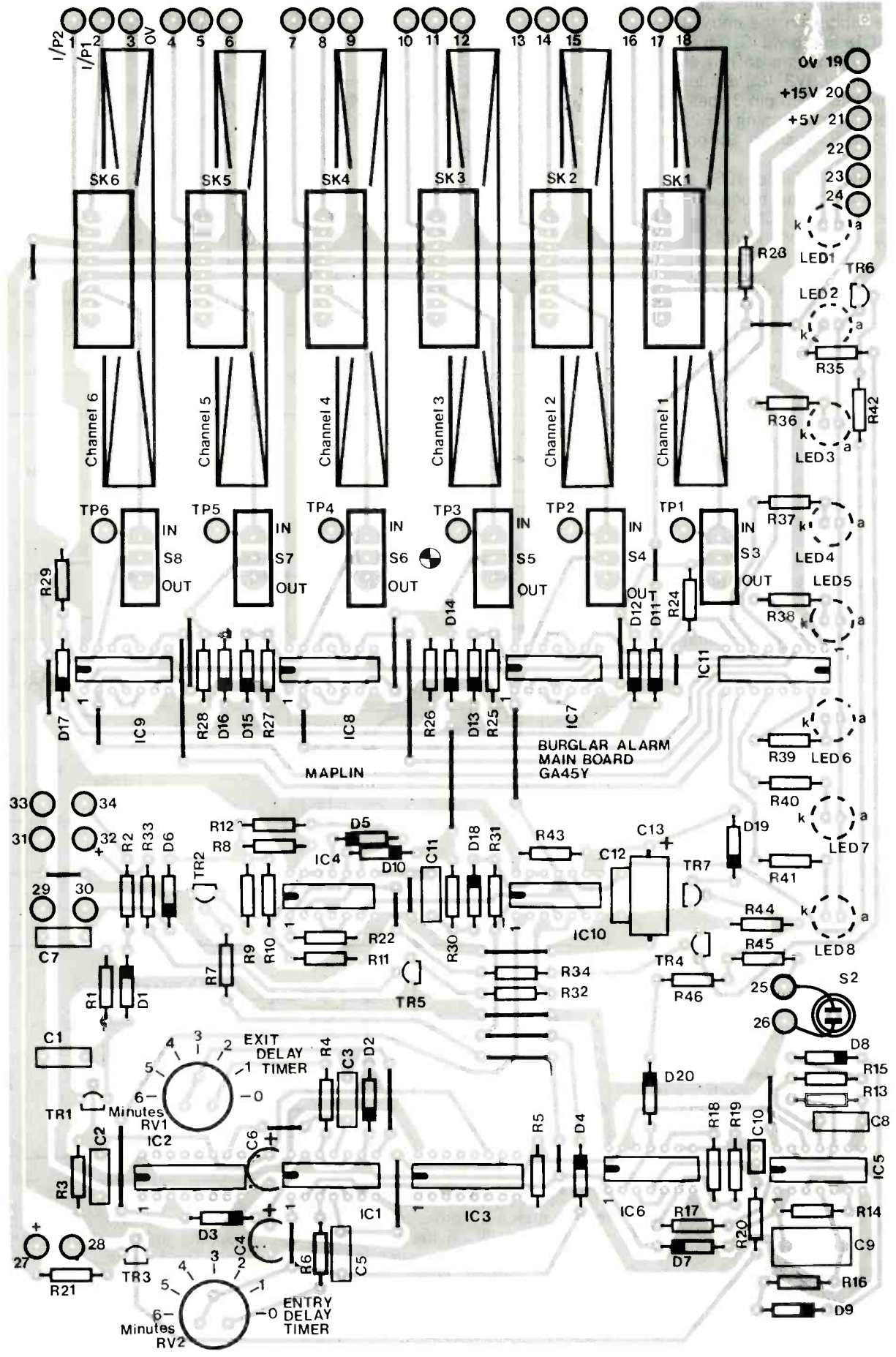
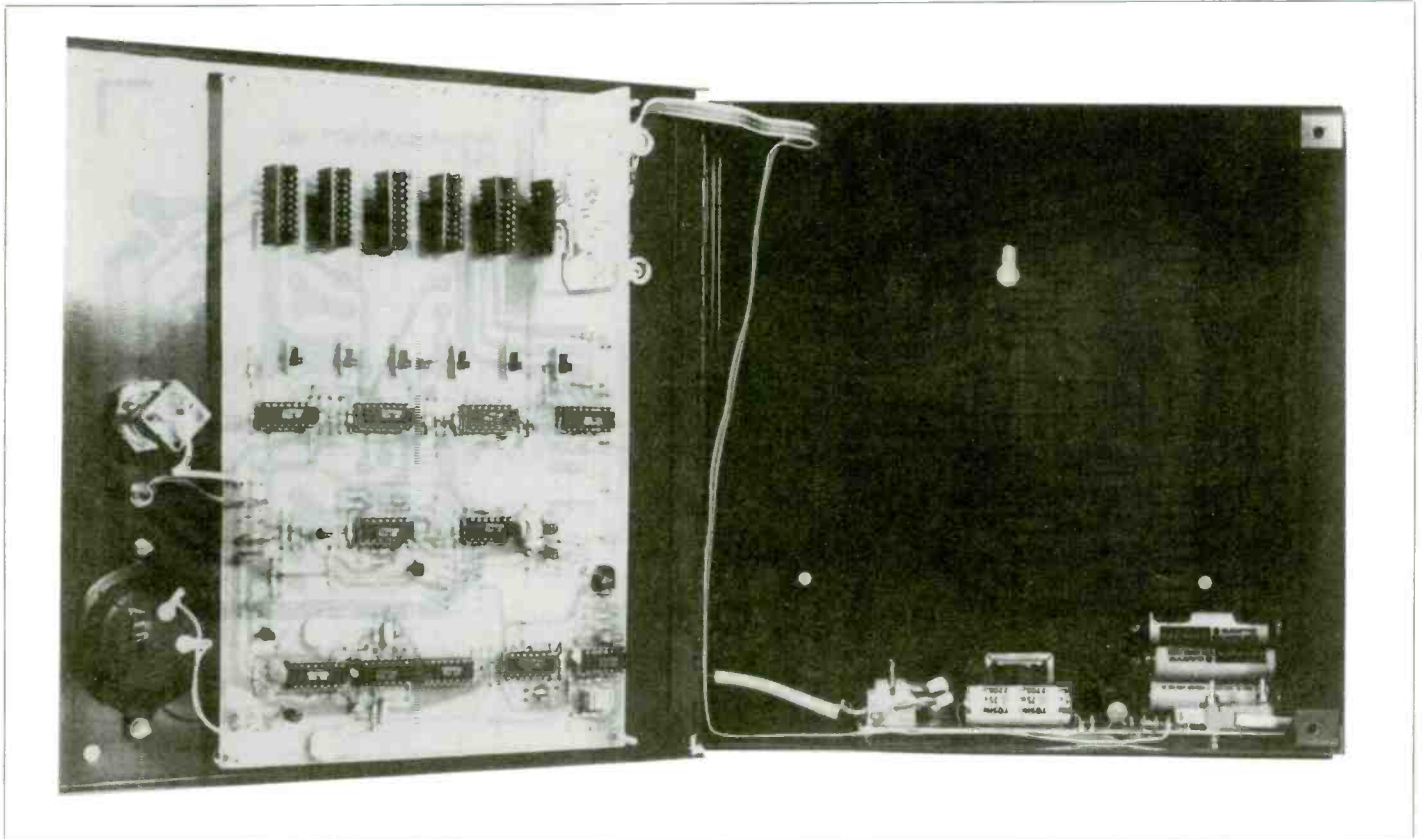


Figure 5. Component overlay of Main PCB.



Pic. A Internal view of control box with Main PCB fitted to the door and the PSU mounted in the base of the box.

Construction

Assembly and Setting Up Main PCB

Refer to the parts list 1 and Figure 10. Use 24 swg BTC (or E/C) wire to make the 28 link straps and fit these first. Next, fit the Veropins and the diodes. (The black tips are shown as white blocks on the legend.) Fit all resistors and capacitors. Note that electrolytic and tantalum types are polarised and have a '+' sign which must be correctly orientated. Fit transistors and IC sockets. Fit the two cermet presets RV1 and 2, and turn fully clockwise, to 0 on the legend. Connect a 1k0 test resistor RT across pins 29 and 30. (Note - this will be removed when using the external horn PCB, but must remain in place

if the external PCB is not in use.)

Refer to Figures 11 and 13 when mounting the channel LEDs. LEDs 1 to 8 are mounted to the PCB from the track side. Figure 13 shows the lead designations. Place the correctly orientated LED into position and insert a spacing strip 8mm x 1.5mm (spare Veroboard etc) between the legs. Bend the legs under the PCB, to hold in position and solder one leg only. Repeat for all eight LEDs.

Figure 12 shows the mounting procedure for fitting the PCB to the inside cabinet lid. Place five 1" x 6BA CSK screws through the lid, tighten down with five 6BA nuts and washers. Place five 6BA x 1/4" spacers over the

screws and offer the PCB to the lid, positioning the channel LEDs in the holes provided. With LEDs correctly positioned, remove the PCB and solder the eight remaining LED legs. Re-check all component values and positionings. Check for dry joints, solder splashes and short circuits on the track face. If all is in order, mount the PCB on to the lid and hold with five 6BA washers and nuts.

Push switch S2 mounts through the PCB and lid and is wired to adjacent pins 25 and 26. Mount LED 9 and connect to pins 31 and 32 (Figure 10). Mount key switch S9 and piezo horn H1 using two 1/4" x 6BA CSK nuts, bolts, washers. Wire H1 to pins 27 and 28.

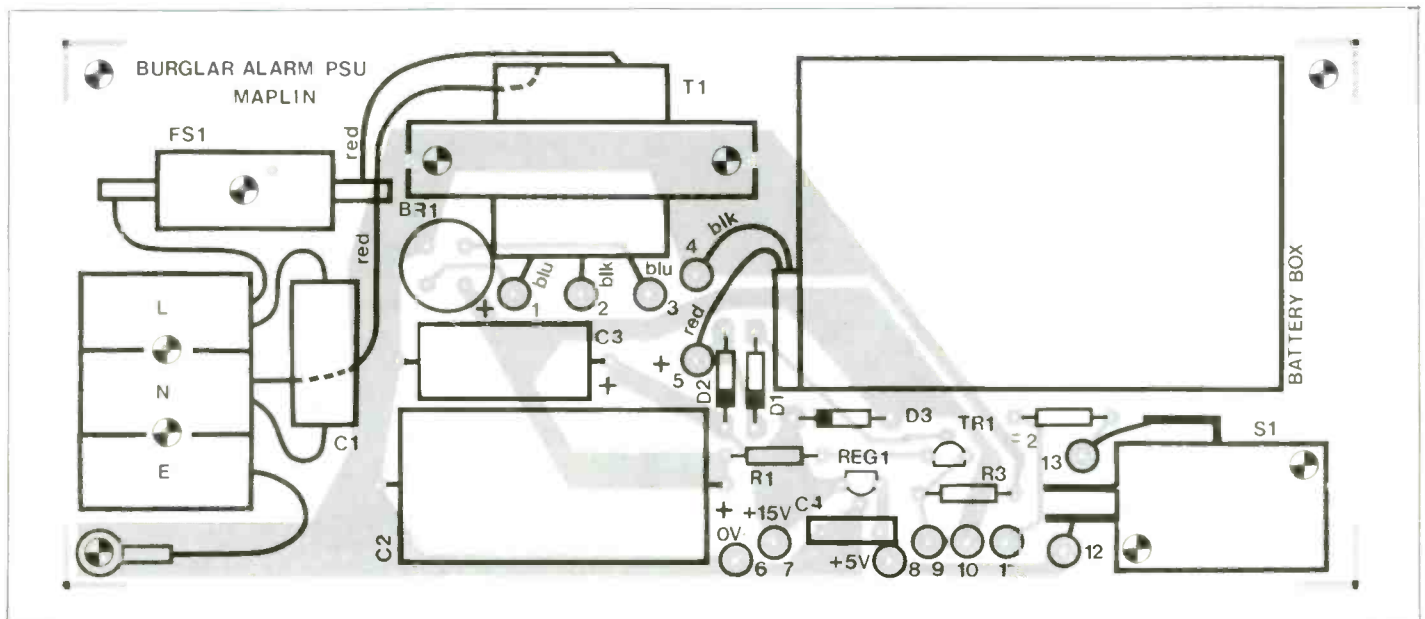


Figure 6a. Component overlay of PSU PCB.

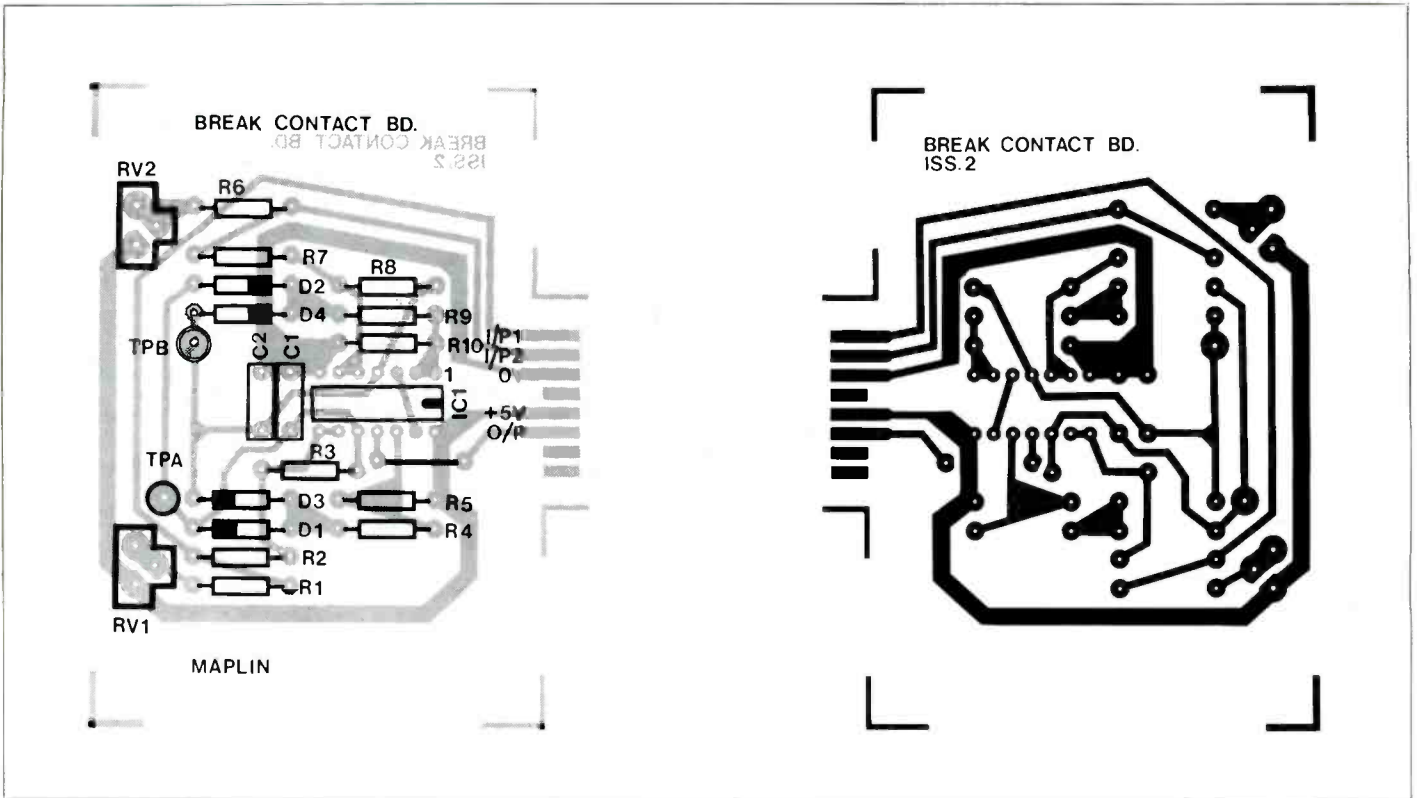


Figure 7. Track layout and component overlay of Break Contact Module.

Power Supply Unit

Next refer to the parts list and Figure 12 and 13 for the PSU assembly. Mount the three resistors, three diodes, BR1, TR1, and REG1. Ensure correct orientation of these components before soldering. Fit the 13 Veropins, C2 and C3 noting the polarity. Mount T1 with two 6BA ¼" bolts, nuts and washers. Mount FS1 using a ¼" x 6BA nut and bolt and three-way terminal block, using two 1" x 6BA bolts, nuts and washers. Wire T1 to FS1 and the terminal block 'N'. Wire the opposite end of FS1 to terminal block 'L'. Place systoflex sleeving over C1 leads, and fit to terminal block 'N' and 'L'. The battery clip (PP3) is connected to pin 5 (+ve lead red) and pin 4 (-ve lead black). The T1 secondaries connect to adjacent pins 1, 2 and 3.

Insert three 6BA x ½" CSK screws through the cabinet base holes (Figure 15), at front left, rear left and rear right hand side. The two front right hand side holes are for mounting the micro switch. Insert two 1" x 6BA CSK screws and tighten all five with 6BA washers and nuts. Place the PSU PCB over the five screws and position the micro switch with the roller arm behind the angle bracket. Tighten down with two 6BA washers and nuts. Place a 6BA tag washer over the front left screw, and two 6BA washers over the remainder. Tighten down with three 6BA nuts. Connect a piece of wire from the 6BA (chassis earth) tag washer to terminal block 'E'. Wire the micro switch (S1) to adjacent pins 12 and 13.

adjacent pins 12 and 13.

Break Contact Module

Refer to the parts list and Figure 7 for the break contact PCB. The board is very simple to construct and requires no explanation. Once assembled, and checked, plug into any one of the six channel sockets on the main PCB. Ensure switches S3 to S8 are 'out' of circuit.

External Horn

Refer to the parts list and Figures 8, 9 and 17 for the external horn PCB and wiring. Again, the construction is simple. Note the orientation of the tantalum C2 and FET TR1. The crinkly heatsinks fits over TR2. Do not connect to main PCB at this stage.

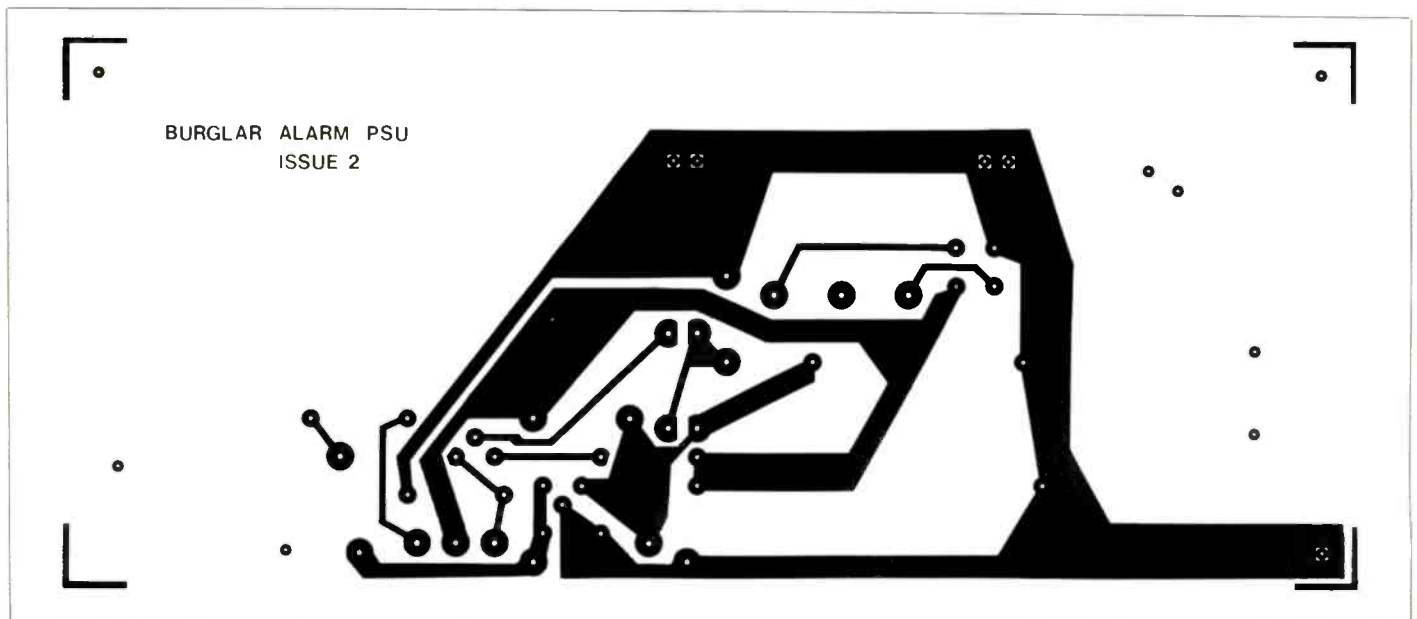


Figure 6b. Track layout of PSU PCB.

Testing

Place a 20mm, 100mA fuse into FS1 position. Connect a length of three-way mains cable to the PSU terminal block. Ensure S1 is fully operated, and that no other wiring is connected to the PSU.

Place a voltmeter between 0V pin 6 and +15V pin 7. Apply mains power to the PSU, and check for a reading of 15V DC. Check for +5V between pin 6 (0V) and pin 8 and between 0V and pin 11 when S1 (micro switch) is released (slacken 2BA bolt). Re-operate S1 and check for 0V on meter. Remove the mains supply.

Connect 22" of six-way ribbon cable between the PSU and main PCB as follows:

	PSU	To	Main PCB
	(0V) P6		P19
	(+15) P7		P20
	(+5) P8		P21
LED1	P9		P22
	P10		P23
(S1)	P11		P24

Set the meter to 'amps' range and connect to pins 4 and 5 (or battery clip). Re-apply mains power and check for a reading of approximately 4mA and ensure LED 1 lights up. Remove the meter and LED 1 should extinguish. If the standby batteries are to be used, connect the nicad pack to the PP3 clip.

A voltmeter connected across pins 4 and 5 should indicate a reading of between 7.2 to 7.8V depending on the batteries state of charge. Note that LED1 will stay on with the batteries part or fully charged, also an incorrectly placed battery, within the pack, will allow LED1 to stay on, but the reading across pins 4 and 5 will be lower than +7V. (Rectify immediately as nicads do not like short circuits or reversed connections placed on them.)

For reliability, ensure that the battery pack is fully charged before use. The trickle charger keeps them topped up over a period of time and is not a fast charger.

Main PCB

With power on, and keyswitch disarmed, LED1 only should be on, and no alarm tones heard. Ensure RV1 and 2 are both fully clockwise, and turn key to 'set'. A high pitched tone will sound immediately lasting for no more than two seconds. When the tone stops, LED9 ('ARM') comes on, showing that the alarm is now primed and ready. Note that the warble tone, sounds for the duration of the exit timer delay period and is presettable by adjusting RV1 anticlockwise. The PCB legend has 'scaled' from 0 to 6 minutes and the small circle, on top of the cermet pot, acts as a pointer. If the exact time out periods are required, check the calibration scale with a watch or clock.

Once LED9 has come on, further adjustment of RV1 will only be effective when the key is turned to 'disarm' and then back to 'set', starting the exit timer again.

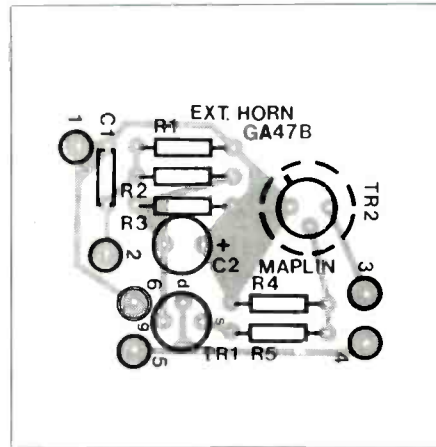


Figure 8. Track layout and component overlay of External Horn PCB.

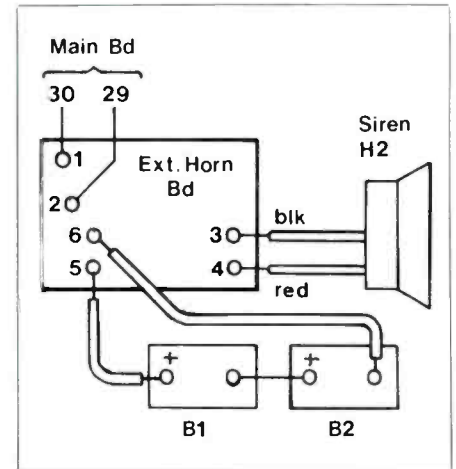


Figure 9. External Horn wiring diagram.

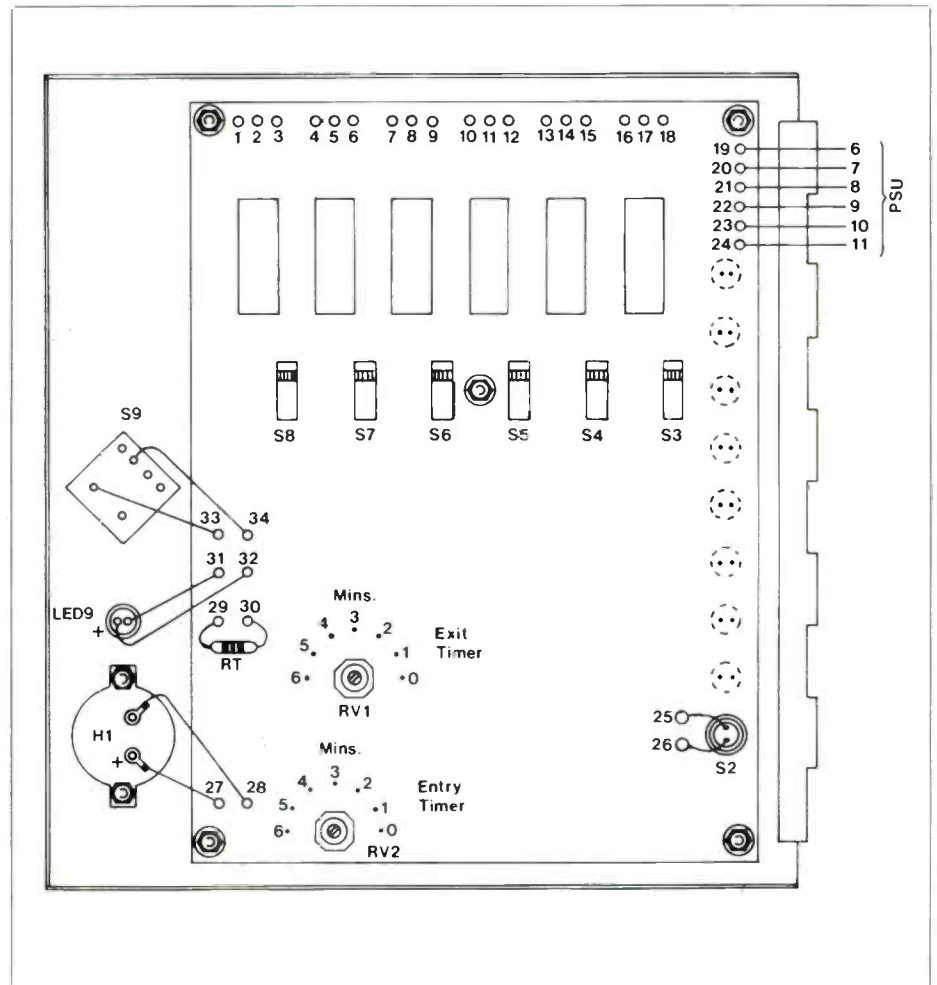


Figure 10. Main PCB wiring diagram.

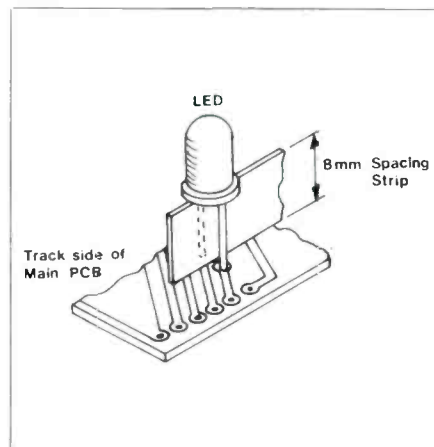


Figure 11. Indicator LED mounting.

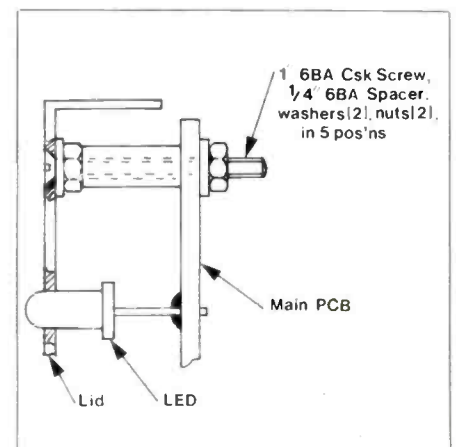


Figure 12. Mounting of Main PCB to cabinet door.

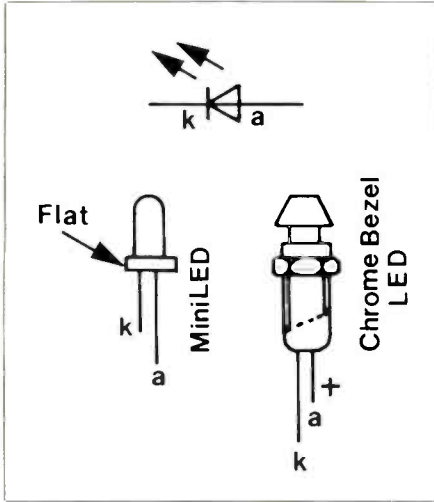


Figure 13. LED lead outs.

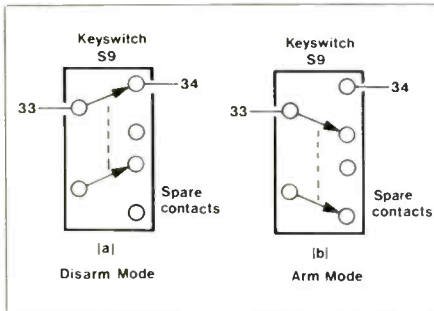


Figure 14. Key switch wiring.

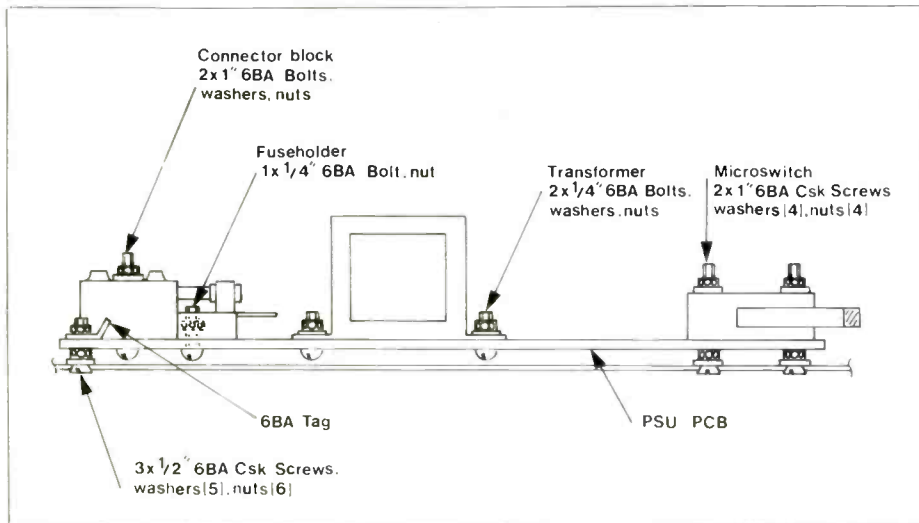


Figure 15. Mounting PSU PCB and components.

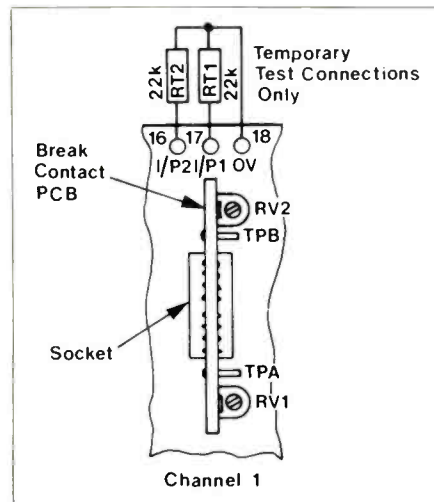


Figure 16. Testing Break Contact Module.

Points

Connect a length of wire from P21 (+5V) to test point 1 (TP1). Operate S3 to the "IN" position. Press S2, display on and release. Channel 1 LED 3 will come on. Place S3 to the "OUT" position. LED 3 will go out. Repeat the above tests from +5V to TP2 to 6 and S4 to 8 checking channel LEDs 4 to 8. Note that pressing S2 allows the channel LEDs to light up, once triggered, for approximately 90 seconds. S2 will have to be re-operated for a continued display etc.

Remove the test lead from the test point, but leave attached to +5V. Turn the key switch to "set". Once the "armed" LED has come on, place switches S3 to S8 to the "IN" position (note — remove any plug-in PCBs). Check that no tone is heard and that LEDs 1 and 9 only are on. Touch the +5V test lead to test points 1 to 6 in turn, all channel LEDs should come on, followed by a slow, two-tone alarm signal. Ext/Cab alarm, LED 2, will come on, indicating that the external horn trigger circuit has been operated. This alarm tone continues until the key switch is set to "dis-arm". Leave the alarm sounding and check that after 90 seconds the display goes off (preserving batteries on standby). The alarm tone should still continue. Press S2, check original display is returned.

Ext. Alarm

Place a short circuit across test resistor RT (1k Ω) between pins 29 and 30. Press S2, LED 2 will light, indicating that the external loop sensing circuit has been tampered with. Remove the short circuit; LED 2 will go out. Remove one end of resistor RT and press S2. LED 2 will, again, come on. Re-connect RT and LED 2 should go out.

Turn the key switch to "set" and replace the short circuit across resistor RT. When the alarm sounds, remove the short circuit. LED 2 will stay on and the alarm will continue to sound. Return key switch to "dis-arm".

Power Failure

Note that if standby batteries are fitted and mains power is removed, LED 1 will go out. If the alarm unit is set and armed prior to removal of mains power, the system will stay armed, unless triggered appropriately. When running on standby power, the alarm tones will be slightly quieter than normal.

Entry Timer

Set RV2, entry delay timer, for the required time out period. Turn the key switch to "set" and trigger any channel (+5V to a test point). The selected channel LED should come on and stay on. The alarm tone will not be present until the time out period has been reached, then the alarm tone will sound and LED 2 will light. Reset the key switch.

Break Contact PCB

This module may be plugged into any of the sockets in channels 1 to 6 on the main PCB. Note correct orientation of the module, when fitting; the component side is to the right and the track side, to the left.

Remove *all* power to the system, turn the key switch to "dis-arm" and S3 to S8 to the "OUT" position. Connect two test resistors, RT1 and RT2 (22k Ω) between pins 17 and 18 and pins 16 and 18, as shown in Figure 16. These resistors are used for test purposes only and will be removed when the circuit is to be used.

Connect a voltmeter between TPA, on the module, and a convenient 0V point, with the +ve lead to TPA. Apply power to the system, and adjust RV1 for a reading of half the supply rail, i.e. +2.5V.

Repeat the test on TPB using RV2, and remove meter. Re-connect the meter between 0V and TP1 to 6 (main PCB) depending on channel chosen for setting up the module, and check for 0V. Short circuit resistor RT1, and check for +5V on the appropriate test point (main PCB). Remove the short circuit and repeat the test for RT2. Set the chosen channel switch (S3 to S8) to the "IN" position. Turn the key switch to "set" and remove one end of RT1. The appropriate channel LED will come on etc. Re-connect RT1; reset the key switch and repeat the test for RT2.

Reset the key switch and remove test resistors RT1 and 2.

Circuit Monitor

Turn the key switch to "dis-arm". The tone and all displays will be cancelled. Note that in the dis-arm mode and with S2 pressed, the unit gives a useful monitor facility of doors, windows etc, which can be checked before arming the system. Loosen the 2BA bolt holding off micro switch S1. Ensure the roller arm releases, and turn the key switch to "set". After the time out period and LED 9 has come on, the Ext/Cab alarm LED 2 will light, showing that the cabinet has been tampered with, and the alarm tone will sound. Reset the key switch to "dis-arm". The alarm tone will cancel, but LED 2 will remain on for 90 secs; display time out. Re-operate S1 by tightening the 2BA bolt and LED 2 will go out.

External Horn PCB

Figures 8 and 9 show the connections for using an external horn. For test purposes remove *all* power from the system (disconnect all batteries) and wire the PCB to pins 29 and 30 (remove resistor RT). Any changes made to these connections will trigger the alarm so ensure correct wiring. Connect the electronic siren to pins 3 and 4; the black lead is negative and the red +ve. Since the siren is inside a box, its own cover is not required and should be removed to assist wiring and make the sound output as great as possible. Connect batteries B1 and B2 to pin 5 (+ve) and 6 (-ve). The battery supply should be 12V and various types of dry cell (6V each) are available. Note that no charging current is available to these batteries.

The horn (H2) will sound immediately, so return power to the alarm unit as soon as possible. Place a short circuit across pins 29 and 30 (main PCB); H2 will sound. Remove the short circuit and H2 will cease.

Turn the key switch to "set" and repeat the test. Both internal and

Continued on Page 31

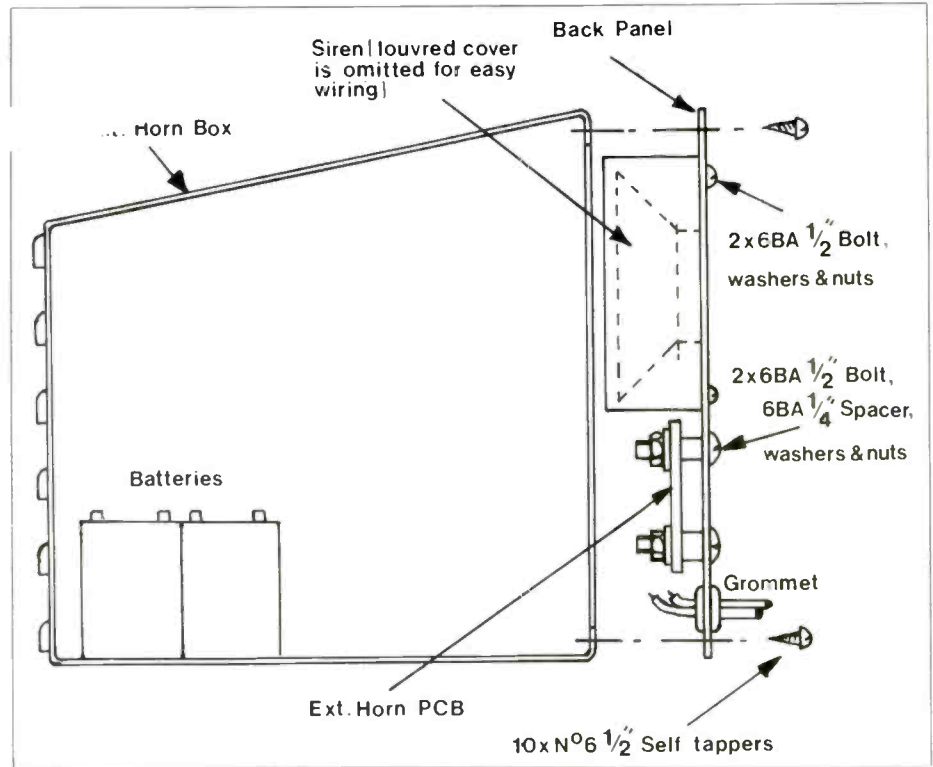


Figure 17. Assembly of External Horn Box.

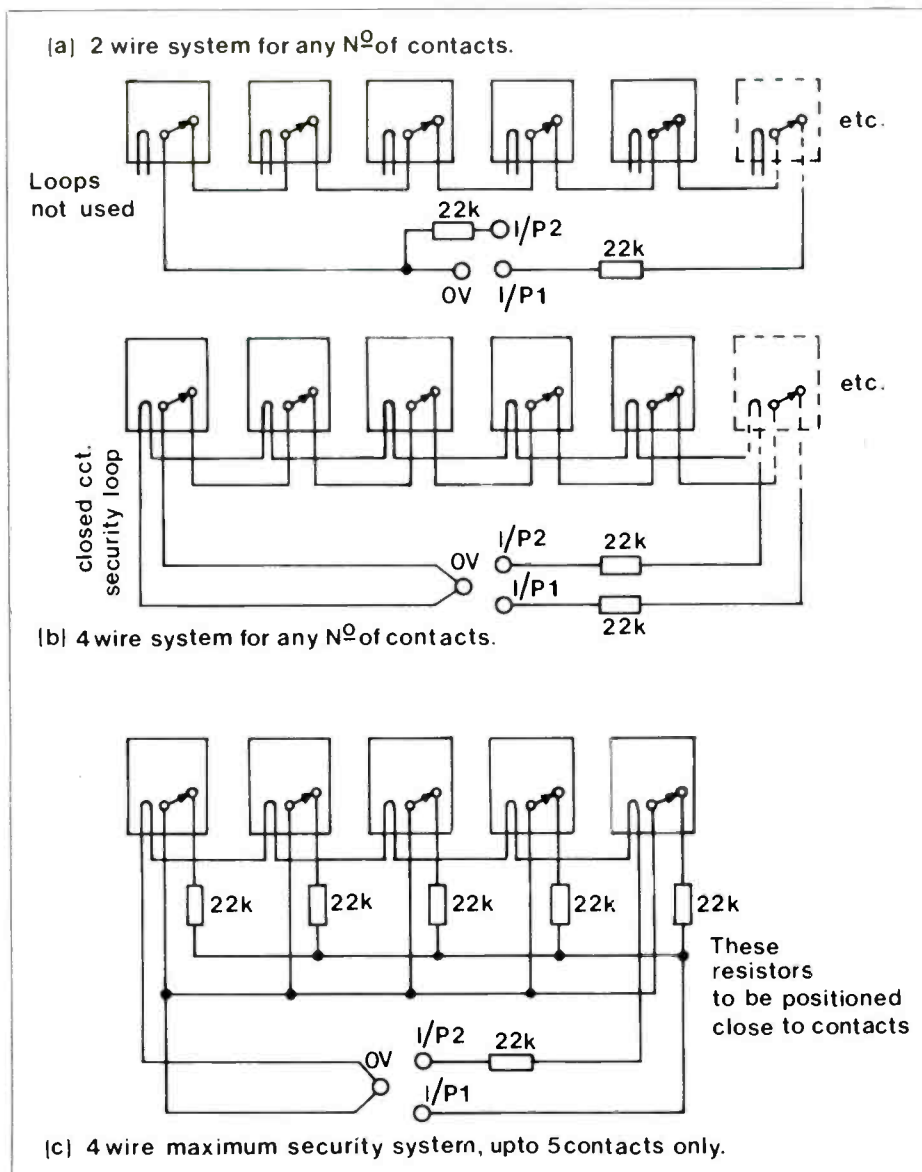


Figure 18. Methods of wiring alarm contacts.

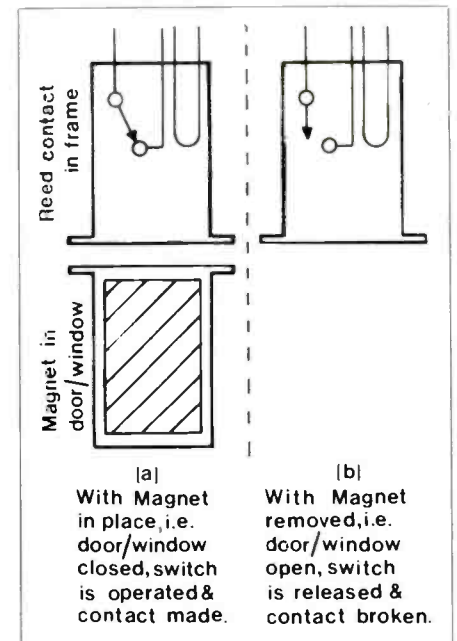


Figure 19. Reed switch connections.

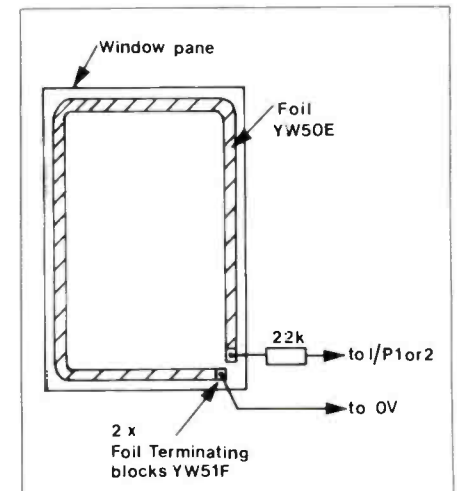


Figure 20. Window foil connections.

BURGLAR ALARM MAIN PARTS LIST

Resistors — all 1/2W 5% carbon unless specified

R1,2,12,22-30	100k	12 off	(M100K)
R3,5,7,17,18, 20,32,42	10k	8 off	(M10K)
R4,6,21,33,35-41	1k	11 off	(M1K)
R8	470R		(M470R)
R9	220R		(M220R)
R11	120k		(M120K)
R13,14,31	1M	3 off	(M1M)
R15	68k		(M68K)
R16	22k		(M22K)
R19	470k		(M470K)
R10,34	47k	2 off	(M47K)
R43	1M2 10%		(M1M2)
R44	1k2		(M1K2)
R45,46	3k9	2 off	(M3K9)
RT (test resistor)	1k		(M1K)
RV1,2	1M cermet	2 off	(WR45Y)

Capacitors

C1,2,7,11,12	100nF disc ceramic	5 off	(BX03D)
C3,5	27nF polycarbonate	2 off	(WW34M)
C4,6	1uF 35V tantalum	2 off	(WW60Q)
C8	82nF polycarbonate		(WW40T)
C9	820nF polycarbonate		(WW52G)
C10	330pf ceramic		(WX62S)
C13	47uF 10V axial electrolytic		(FB38R)

Semiconductors

D1-20	1N4148	20 off	(QL80B)
TR1,5	BC214L	2 off	(QB62S)
TR2,3,4,6,7	BC548	5 off	(QB73Q)
IC1,4-10	4001BE	8 off	(QX01B)
IC2,3	4020BE	2 off	(QX11M)
IC11	4050BE		(QX22Y)

Miscellaneous

LED 1-8	Mini LED red	8 off	(WL32K)
LED 9	Chrome LED small		(YY59P)
S2	HQ push switch		(YR67X)
S3-8	SP slide switch	6 off	(FF77J)
S9	Keypress		(FH40T)
H1	Piezo horn		(YW52G)
SK1-6	8-way edge connector	6 off	(FL83E)
	Burglar alarm main PCB		(GA45Y)
	6BA x 1" csk screw	5 off	(BF13P)
	6BA washer	12 off	(BF22Y)
	6BA nut	12 off	(BF18U)
	6BA x 1/4" spacer	5 off	(FW34M)
	6BA x 1/2" csk screw	2 off	(BF12N)
	2BA x 1" bolt	2 off	(BF01B)
	Grommet small	2 off	(FW59P)
	Burglar alarm box		(XG06G)
	Veropin 2141	40 off	(FL21X)
	Ribbon cable 10-way	1M	(XR06G)
	14-pin DIL skt	8 off	(BL18U)
	16-pin DIL skt	3 off	(BL19V)

As required

Door contact reed	(YW46A)
Window foil	(YW50E)
Window foil terminals	(YW51F)
Surface mounting reed	(YW47B)
Door loop	(YW48C)
Pressure mat	(YB91Y)

For kit see under PSU parts list

BURGLAR ALARM PSU PARTS LIST

Resistors — all 1/2W 5% carbon unless specified

R1	220R	(M220R)
R2	10k	(M10K)
R3	6k8	(M6K8)

Capacitors

C1	100nF suppression capacitor	(FF56L)
C2	2200uF 25V axial electrolytic	(FB90X)
C3	100uF 25V axial electrolytic	(FB49D)
C4	100nF disc ceramic	(BX03D)

Semiconductors

D1,2,3	1N4001	3 off	(QL73Q)
BR1	W005		(QL37S)
Reg 1	uA78L05AWC		(QL26D)
TR1	BC214L		(QB62S)

Miscellaneous

T1	Transformer 6-0-6 100mA	(WB00A)
S1	Microswitch	(FH95D)
FS1	20mm Fuse 100mA	(WR00A)
	Chassis Fuseholder	(RX49D)
	Terminal block 5A (3 sections)	(HF01B)
	Burglar Alarm PSU PCB	(GA44X)
	6BA TAG	(BF29G)
	6BA x 1" bolt	2 off (BF07H)
	6BA x 1/4" bolt	3 off (BF05F)
	6BA x 1" csk screw	2 off (BF13P)
	6BA x 1/2" csk screw	3 off (BF12N)
	6BA washer	13 off (BF22Y)
	6BA nut	15 off (BF18U)
	Insulated sleeving	3" (BF87U)
	Veropin 2141	13 off (FL21X)
	Standby Power if required	
B1-6	Nicad 'AA' cells	6 off (YG00A)
	Battery box	(HQ01B)
	Battery clip	(HF28F)

A complete kit is available which includes all the parts in the PSU parts list (including standby power parts) and all the parts in the main parts list excluding those listed under "As required".
Order As LW57M (Burglar Alarm Kit) Price £44.95.

EXTERNAL HORN PARTS LIST

Resistors — all 1/2W 5% carbon unless specified

R1,5	1k0	2 off	(M1K0)
R2,4	100k	2 off	(M100K)
R3	1M0		(M1M0)

Capacitors

C1	100nF disc ceramic	(BX03D)
C2	1uF 35V tantalum	(WW60Q)

Semiconductors

TR1	2N3819	(QR36P)
TR2	BC441	(QB70M)

Miscellaneous

H2	Electronic siren	(XG14Q)
B1,2	6V lantern battery	2 off
	Heatsink 5F	(FL78K)
	PCB	(GA47B)
	Veropins 2141	6 off (FL21X)
	Case	(XG07H)
	Grommet small	(FW59P)
	Screws self tapping No 6 1/2 inch	10 off (BF67X)
	Bolts 6BA 1/2 inch	4 off (BF06G)
	Washers 6BA	4 off (BF22Y)
	Nuts 6BA	4 off (BF18U)
	Spacers 6BA 1/4 inch	2 off (FW34M)

A complete kit of all the parts listed above (excluding batteries) is available.
Order As LW58N (External Horn Kit) Price £29.95

BREAK CONTACT MODULE PARTS LIST

Resistors — all 1/2W 5% carbon unless specified

R1,2,6,7	2k2	4 off	(M2K2)
R3,4,8,9	100k	4 off	(M100K)
R5,10	180k	2 off	(M180K)
RT1,2 (test resist.)	22k	2 off	(M22K)
RV1,2	22k vert-sub min preset	2 off	(WR72P)

Capacitors

C1,2	100nF disc ceramic	2 off	(BX03D)
------	--------------------	-------	---------

Semiconductors

D1-4	1N4148	4 off	(QL80B)
IC1	4011BE		(QX05F)

Miscellaneous

TPA,B	Veropin 2141	2 off	(FL21X)
	Break contact PCB		(GA46A)
	14-pin DIL skt		(BL18U)

A complete kit of parts is available.
Order As LW59P (Break Contact Kit) Price £2.99

Prices shown here may have changed after 14/8/82.

MULTI-MODE DIGITAL STOPWATCH



- ★ Accurate to 100th of a second.
- ★ Large, eight digit display.
- ★ Times up to 24 hours can be displayed.
- ★ Four modes of operation: Standard, Sequential, Split and Rally.

by L. Harrold

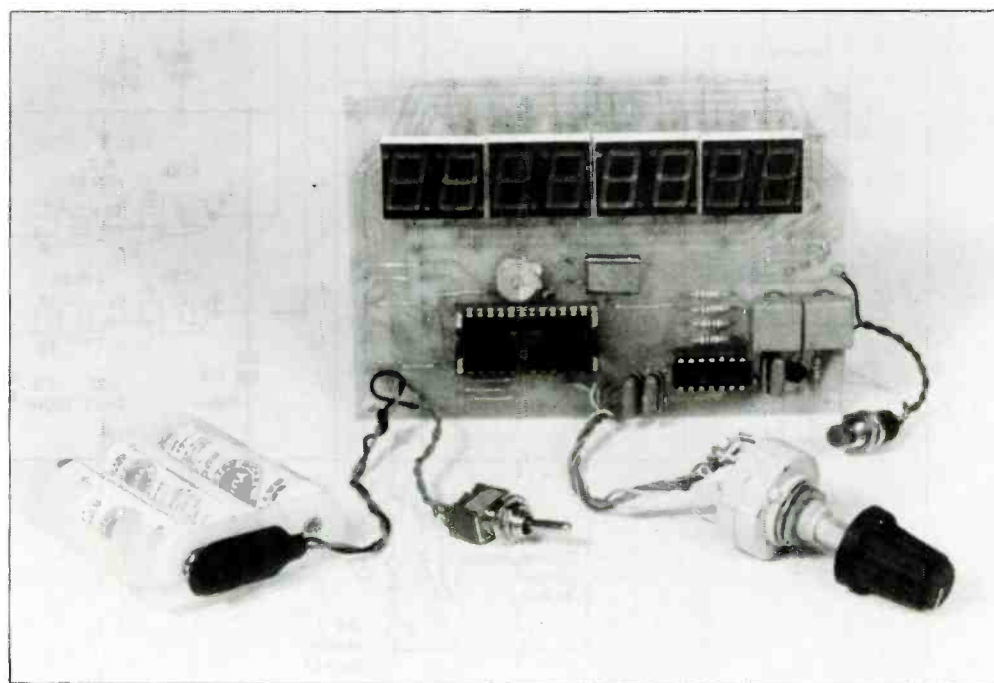
This electronic stopwatch is a comprehensive timer which is more robust than a mechanical stopwatch and can measure accurately to 100th of a second. It has a remote start/stop facility which enables it to be triggered by the interruption of a light beam or the sound of a starting pistol etc.

The stopwatch has a large LED display which can be turned off while the clock is running to save battery power. It has four modes of operation: Standard - each timed event starts from zero, Sequential - the time between each operation of the start/stop switch is displayed (lap times etc.), Split - the timer counts continuously although timings can be displayed whilst this occurs, Rally - the same as Standard except that the clock is not reset to zero but continues from when it was stopped.

Circuit

The circuit diagram of the stopwatch is shown in Figure 1. The main component is the Intersil ICM 7045 IC which contains an oscillator, high frequency divider, low frequency counter, latches, multiplexer, decoder and control circuitry. The oscillator frequency is set by the external crystal and trimmer capacitor to 6.5536 MHz. This is divided down to 100 Hz to drive the low frequency counter. The counter outputs are connected to the latches so that the display can be held and read while the counter is still running. The outputs from the latches are multiplexed to drive an eight digit common cathode display. The ICM 7045 also contains the seven segment decoder and the digit and segment drivers so that the display can be connected directly.

The 4093 and associated components provide de-bounce circuits for



the push switches. When a push switch is operated it discharges the capacitor in less than one millisecond. The two Schmitt trigger gates change state which takes the appropriate pin of IC1 low. The Schmitt triggers are inhibited until the capacitor has re-charged. The time constant of $(R1+R2)$ and C1 is large compared to the bounce time of the switches.

The remote control input switches 5V which turns on the transistor and therefore has the same effect as the start/stop switch. The eight digit display can count up to 23 hours 59 minutes 59.99 seconds. After this the display carries on counting from zero.

The reset button sets the counter to zero, i.e. displays two zeros in the decimal part of the seconds. The seconds, minutes and hours part of the display are blank and remain so until that part of the display is not zero. The display switch turns the LED display on and off.

With the display on the current consumption is 70 to 130mA, depending

on how many digits are on. When the display is off the consumption drops to a maximum of 2mA. Therefore if nickel cadmium batteries are used, which have a capacity of 500mA hours, this should give a life of several hundred hours.

The start/stop switch controls the counter and the four position switch selects the mode of operation.

Construction

The components are mounted on a single sided PCB and should be fitted as follows. The LED displays first: Note that on the side of the displays, that the 'M' of the code number is nearest to pin 1. IC holders should be used, especially for IC1, and these are fitted next. When the click switches are viewed from underneath, one side has a flat, and the PCB legend shows correct mounting orientation. The crystal and trimmer capacitor C5 are mounted next. The crystal should be folded over flat next to the PCB. Next the resistors can be fitted and the switches wired.

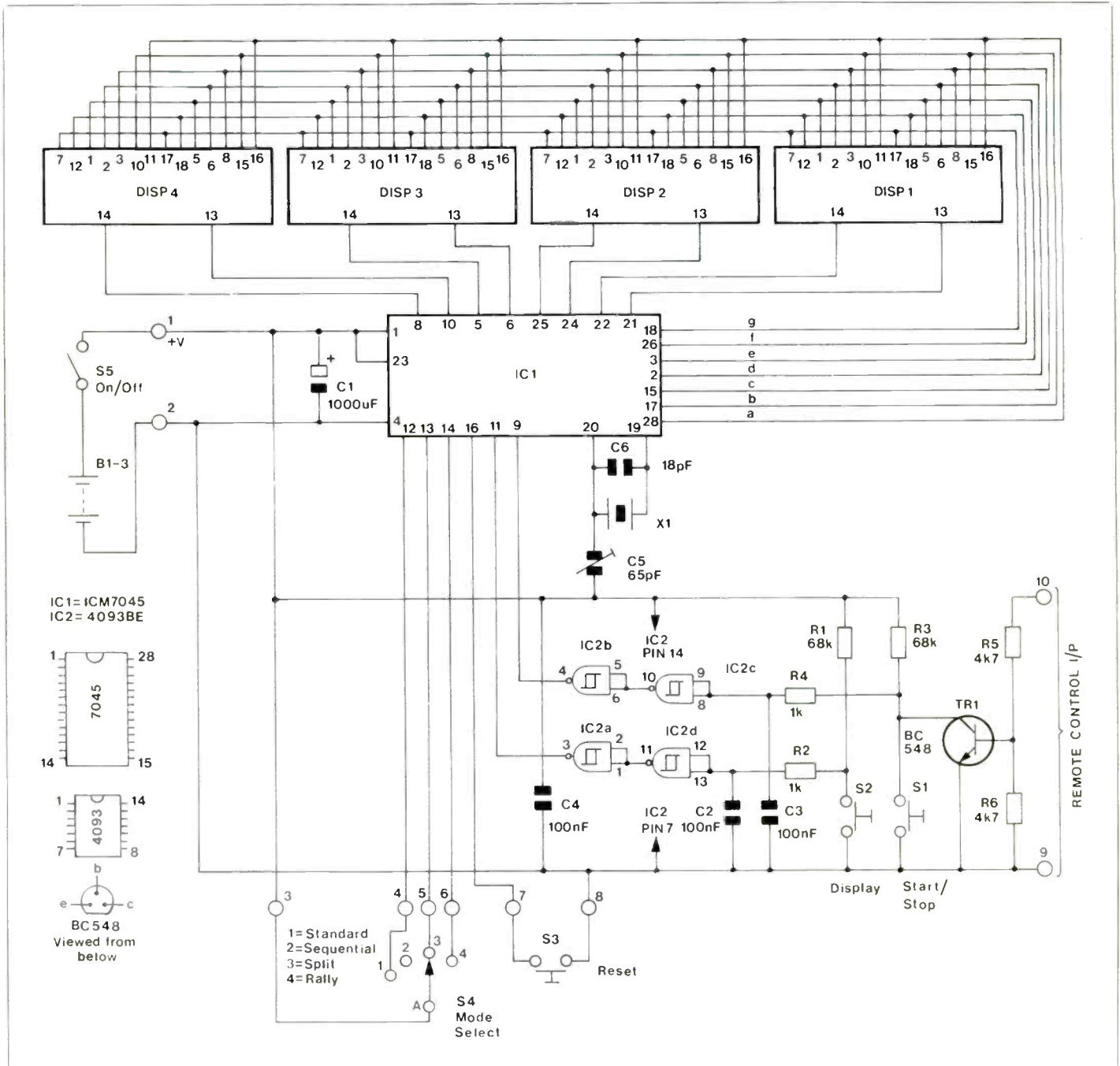


Figure 1. Circuit diagram of stopwatch.

Capacitors C2 to C4 and TR1 should be mounted and bent over at 45 degrees to give enough clearance for a front panel. Finally the wire links are wired and soldered, and C1 fitted underneath the PCB. The LED display is improved considerably when viewed through a red filter and it is recommended that one is used.

Setting up

For accurate timing the crystal should run at 6.5536 MHz and is adjusted by C5. If a frequency counter is available, this is easily checked without loading the oscillator as follows. A 10k pull up resistor should temporarily be connected between pin 22 of IC1 and the positive supply. The display should be switched on and the counter reset. The frequency on pin 22 should be 800Hz. To get the required accuracy, the frequency counter should be switched to period and the period for

one cycle measured as 1250.00 microseconds. Adjust the trimmer capacitor to give the right frequency. If a frequency counter is not available, then C5 should be set half way and the stopwatch checked over several hours, using the radio or speaking clock. C5 can then be adjusted accordingly; more capacitance to slow the stopwatch down.

Operation

Standard Mode

1. Press the reset switch to zero the counter.
2. Start the counter by pressing the start/stop switch.
3. Stop the counter by again pressing the start/stop switch. The time is now displayed. When start/stop is pressed again the counter is momentarily reset then starts timing another event. In this mode the display can be turned off.

Sequential Mode

1. Reset the counter.
2. Start the counter.
3. Press start/stop to read the display. This time is held on the display but the counter continues running. When start/stop is next pressed the time since it was last pressed is displayed. This enables lap times to be taken. The display cannot be turned off in this mode, however, if standard mode is selected it can be, but remember to switch back to sequential mode before pressing the start/stop switch.

Split Mode

1. Reset the counter.
2. Start the counter.
3. Press start/stop to read the display. This time is held on the display but the counter continues running. Each time the start/stop is pressed the display shows the total time since

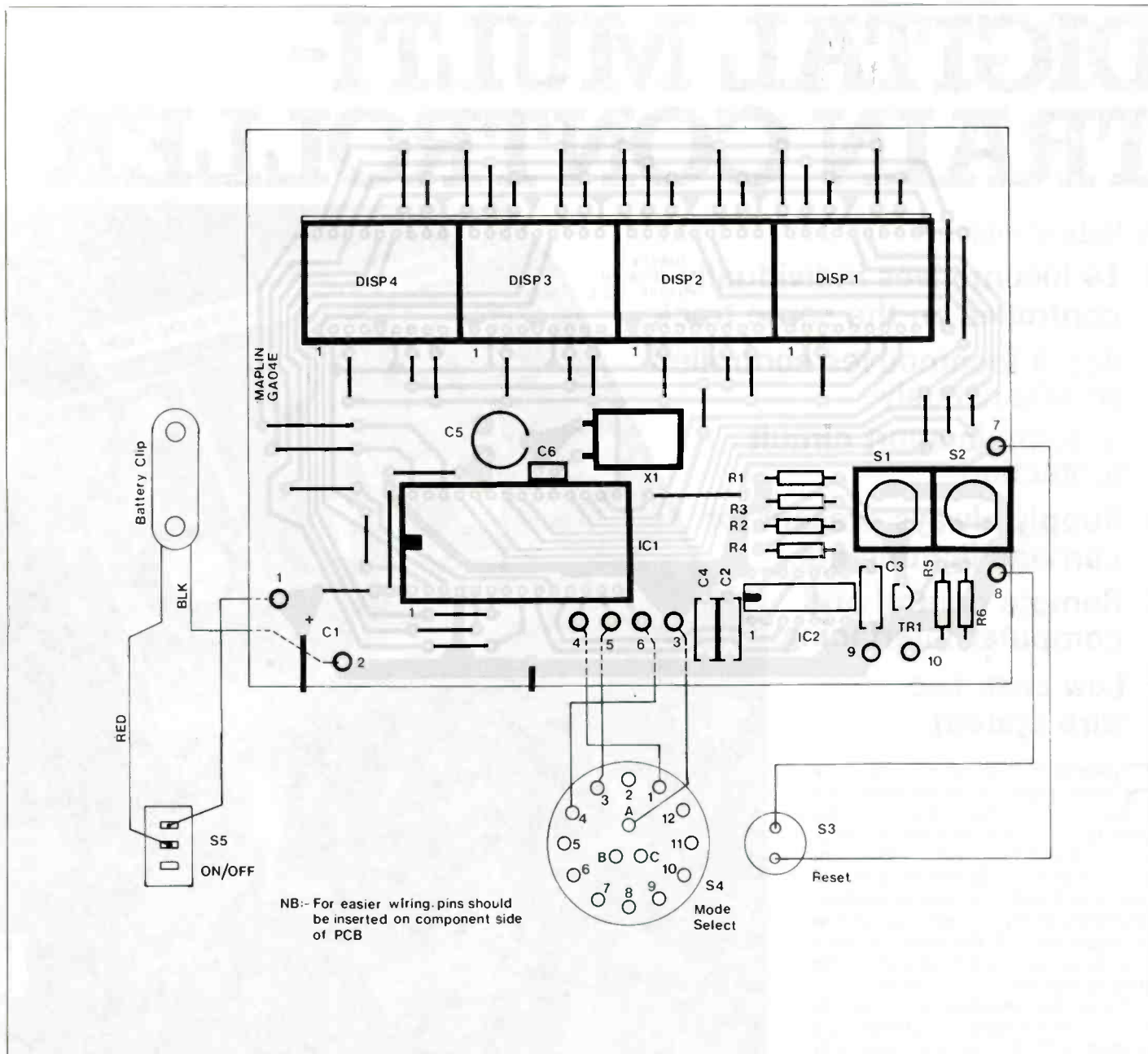


Figure 2. Component overlay and wiring diagram of stopwatch.

the start/stop was first pressed. The count can only be stopped by pressing reset.

The display can only be blanked if the same procedure as described for the sequential mode is carried out.

Rally Mode

1. Reset the counter.
2. Start the counter. The reset switch is now automatically disabled thus preventing accidental resets during long timing intervals.

3. Stop the counter.
4. Press start/stop again allowing the counter to continue.
The display can be turned off in this mode.

STOPWATCH PARTS LIST

Resistors — all 1/4W 5% carbon unless specified

R1,3	68k	2 off	(M68K)
R2,4	1k0	2 off	(M1K0)
R5,6	4k7	2 off	(M4K7)

Capacitors

C1	1000uF 10V axial electrolytic		(FB81C)
C2,3,4	100nF polyester	3 off	(BX76H)
C5	Trimmer 65pF		(WL72P)
C6	18pF ceramic		(WX47B)

Semiconductors

TR1	BC548		(QB73Q)
IC1	ICM7045		(YY93B)
IC2	4093BE		(QW53H)
X1	Crystal 6.5536 MHz		(FY90X)

Miscellaneous

DISP1-4	DD display type C	4 off	(BY68Y)
S1,2	Click switch	2 off	(FF87U)
S3	Push switch		(FH59P)
S4	3 pole 4 way rotary switch		(FF75S)
S5	Sub-min toggle 'A'		(FH00A)
B1-3	Ni Cad AA	3 off	(YG00A)
	4V5 battery box		(YR61R)
	PP3 clip		(HF28F)
	Veropin 2141	10 off	(FL21X)
	Click cap blue	2 off	(FF89W)
	Stopwatch PCB		(GA04E)
	Knob		(YG40T)
	Knob cap blue		(QY01B)
	DIL skt 28 pin		(BL21X)
	DIL skt 14 pin		(BL18U)
	Filter red		(FR34M)

A complete kit for this project is available. Order As LW65V (Stopwatch Kit) Price £34.95

Price shown here may have changed after 14/8/82.

DIGITAL MULTI-TRAIN CONTROLLER

by Robert Kirsch

- ★ 14 locomotives individually controlled on the same track
- ★ Any 4 locomotives controlled simultaneously
- ★ Automatic short circuit protection
- ★ Supply always present for carriage lighting etc.
- ★ Remote control and computer interfacing
- ★ Low cost, two wire system

Railway enthusiasts have for many years appreciated the need for a control system that enables trains to be driven as if the operator were in the driving cab of the locomotive. This not only means control of speed and direction of that locomotive, but also the ability to move anywhere on the layout without the need for track isolating or switching, thus making the wiring of the layout much simpler.

The system described in this article fulfills all these needs by producing a constant 18V DC on the track with digital information superimposed on it, to which only the selected train or trains will respond. The permanent track voltage also means that locomotive headlights, carriage lighting and many accessories may be used unaffected by the speed of the trains.

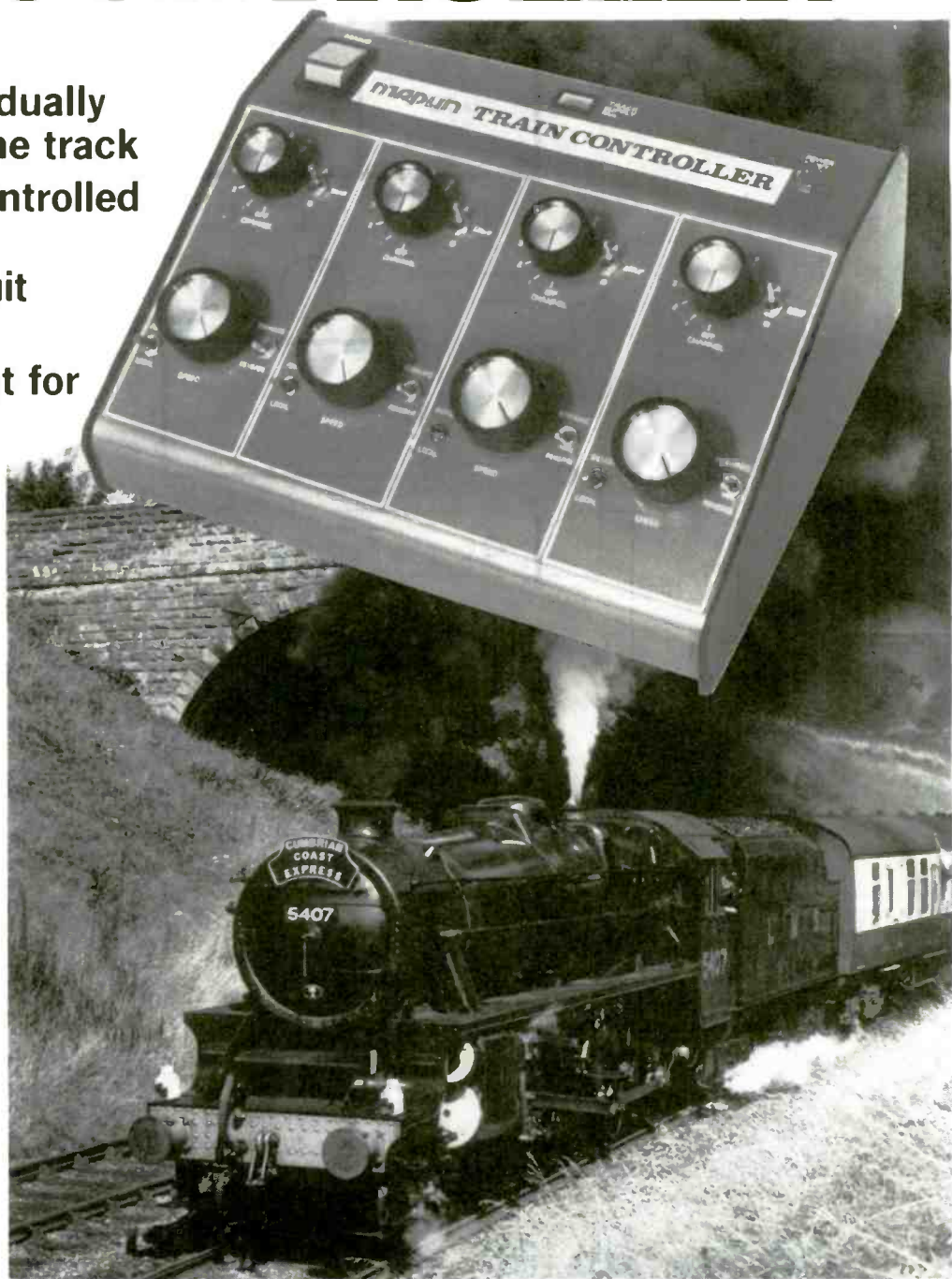
This system can control up to 14 locomotives all on the same track, and any four of these may be driven independently at one time. Provision is also made for any or all, of the four control units to be operated by a 7 bit digital input, thus enabling remote control either from hand-held units (using wire or radio) or from a home computer, giving full control of direction and speed.

Details of the remote control and computer interfacing will be described in later articles.

Circuit Description

Refer to Figures 1 to 5 when following the circuit description.

The most important consideration in the design of a system like this is to keep the receiver module as small as practicable to enable it to fit in as many



locomotives as possible. This has been achieved by using a small 8 pin IC, the ML926/7, IC1 as the receiver. Decoding and control is accomplished by IC2, a 40106 CMOS IC leaving two transistors, TR2 and TR3 as input amplifiers, the six transistors TR4 to TR9 for motor control and one transistor, TR1 as a voltage stabiliser.

The ML926 and ML927 are pulse position modulation (PPM) receivers with built-in error detection circuits. There are four outputs from each IC, three of which are decoded by IC2 to control one of the seven receivers. (000 is used as the all off condition.) The fourth output is used to control the

direction of travel. A fifth bit is transmitted by the control unit to select either the ML926 or the ML927 ICs, thus giving fourteen channels.

As it is only possible to decode one signal at a time the receiver is addressed for one period out of four (called its time slot) and it retains the information received until the next address is due.

The speed of a locomotive is controlled by allowing any number of coded time slots (from 1 to 10) to be transmitted during a period of 10 time slots (TS), thus controlling the on to off ratio of pulses fed to the motor. Minimum speed is with one TS pulse and nine

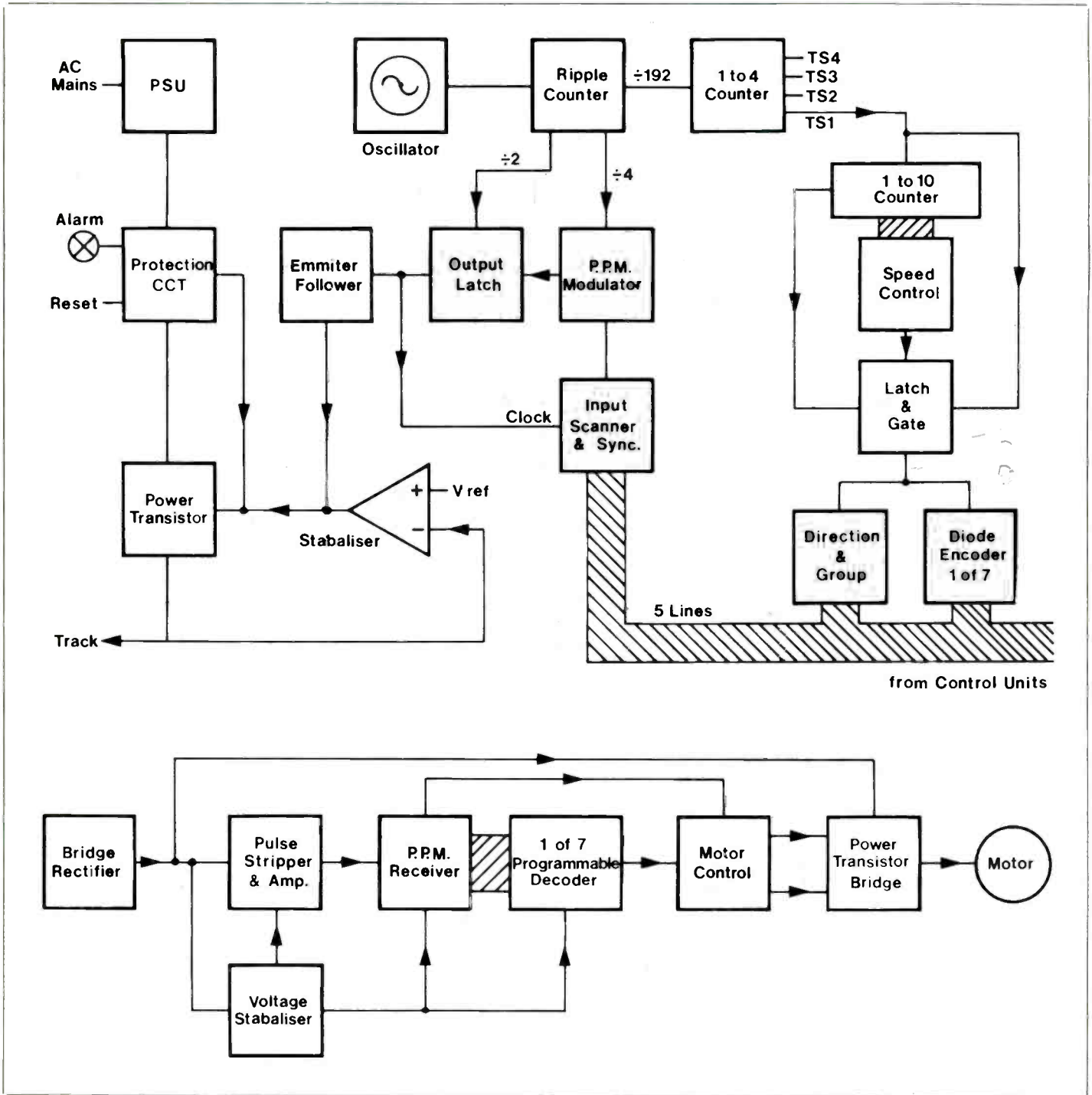


Figure 1. Block diagram. (a) Common and control boards. (b) Receiver.

blank periods, half speed is with five TS pulses and five blank periods and full speed is with a continuous string of TS pulses being sent thus keeping the motor driven at full power.

The transmitter IC normally used with the ML926/7 is the SL490 but several of the built in features of that IC make it undesirable to use in this application.

The PPM system uses a frame of six pulses followed by a sync period. Digital information is transmitted by varying the time between two consecutive pulses in the following ratio: DATA 1 = 2, DATA 0 = 3, SYNC = 6.

The pulse timing is controlled by resetting a counter IC4 after 2, 3 or 6 clock pulses have been received depending on whether the data to be sent is 1, 0 or sync. In order to transmit each one of the five data bits in their correct

order another counter, IC8 scans the five AND gates IC3c and IC7 in turn and then at the sixth count causes the sync period to be sent at the same time resetting the counter for the next scan. The timing point of the pulse to be transmitted is detected by monitoring the resetting point of this counter. This causes the latch IC3d to be triggered which allows a pulse of twice the clock period to be sent.

The ripple counter, IC5 provides all timing pulses required by the controller. It is fed by the CMOS relaxation oscillator formed by IC6 a,b,c and d. This oscillator is divided by 192 by IC5 to produce a TS trigger pulse approximately every 850us. Each frame of data takes about 380us, so that two complete frames can be sent in one TS period.

The trigger pulse denoted above is

used to clock the counter IC9 and produce four separate, consecutive output pulses, TS1-4 each approximately 850us long. Each of the four control boards is fed with one of these TS pulses and this pulse is used to step the counter IC1 (control board). The counter steps from one to ten and then resets itself for the next count. The first output from the counter sets the latch IC2b and c which is reset when the counter reaches the number set by the speed control thus holding the latch open for one to ten pulses. The latch gates TS pulses which are fed to the diode encoder. The pulses are connected onto one or more of the three data lines depending on the code of the receiver being addressed. If the reverse switch is operated or group 2 is selected the TS pulse is switched onto the appropriate data lines.

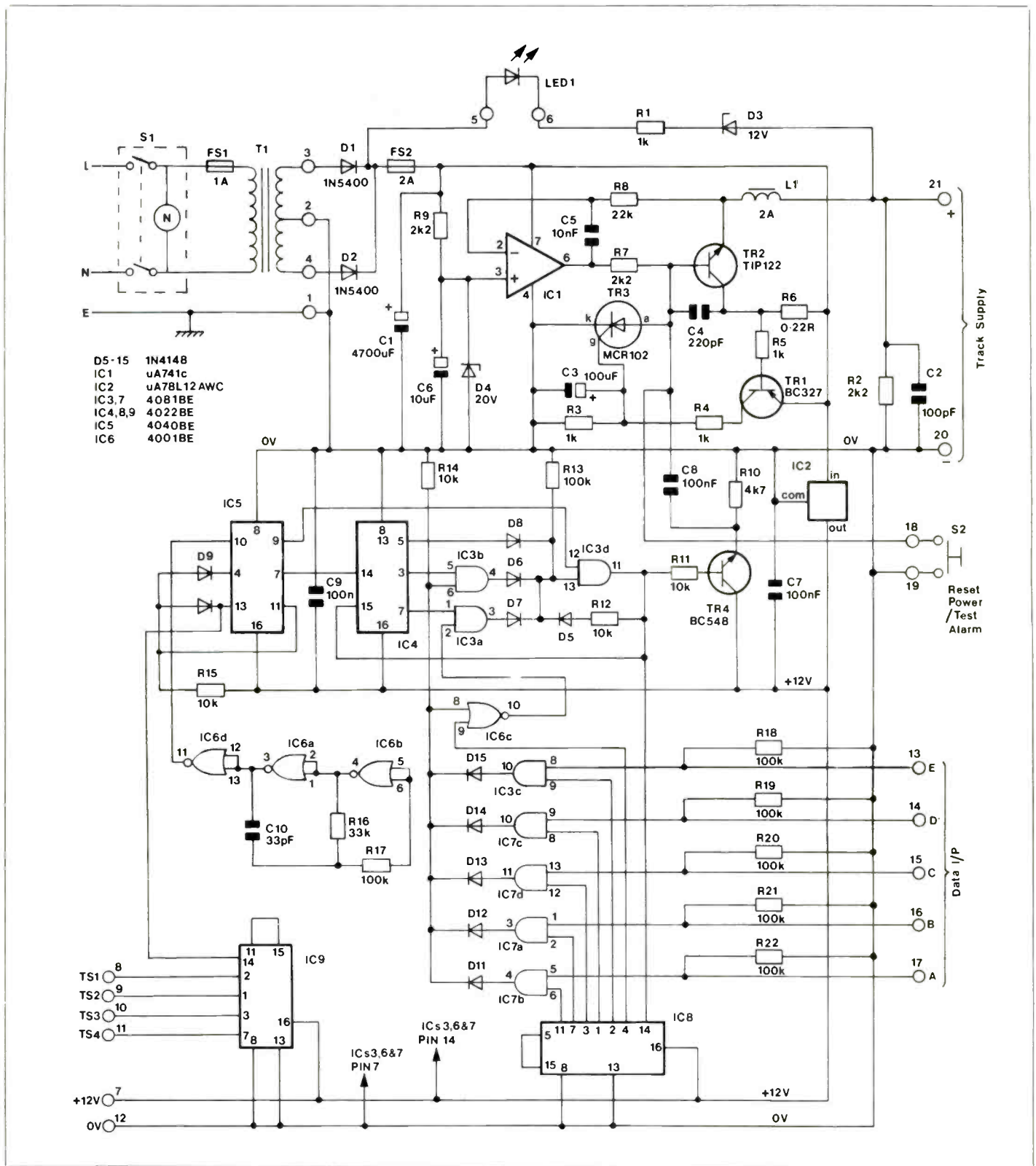
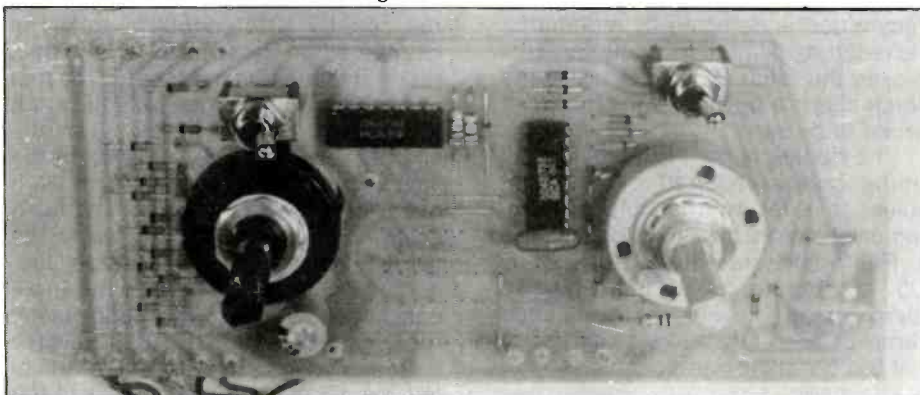


Figure 2. Common board. PSU circuit diagram.



Completed control PCB.

The DC supply fed to the track is stabilised by IC1 (common board) at about 18V and data signals from the emitter follower TR4 are superimposed on it and used to control the power Darlington transistor, TR8 which supplies current to the track. In order to protect the controller from damage due to accidental short circuiting of the track the current flowing through R6 is monitored by TR1. When this current exceeds the preset limit the transistor conducts and fires the SCR TR3 thus removing the drive to TR2 and turning off the supply to the track.

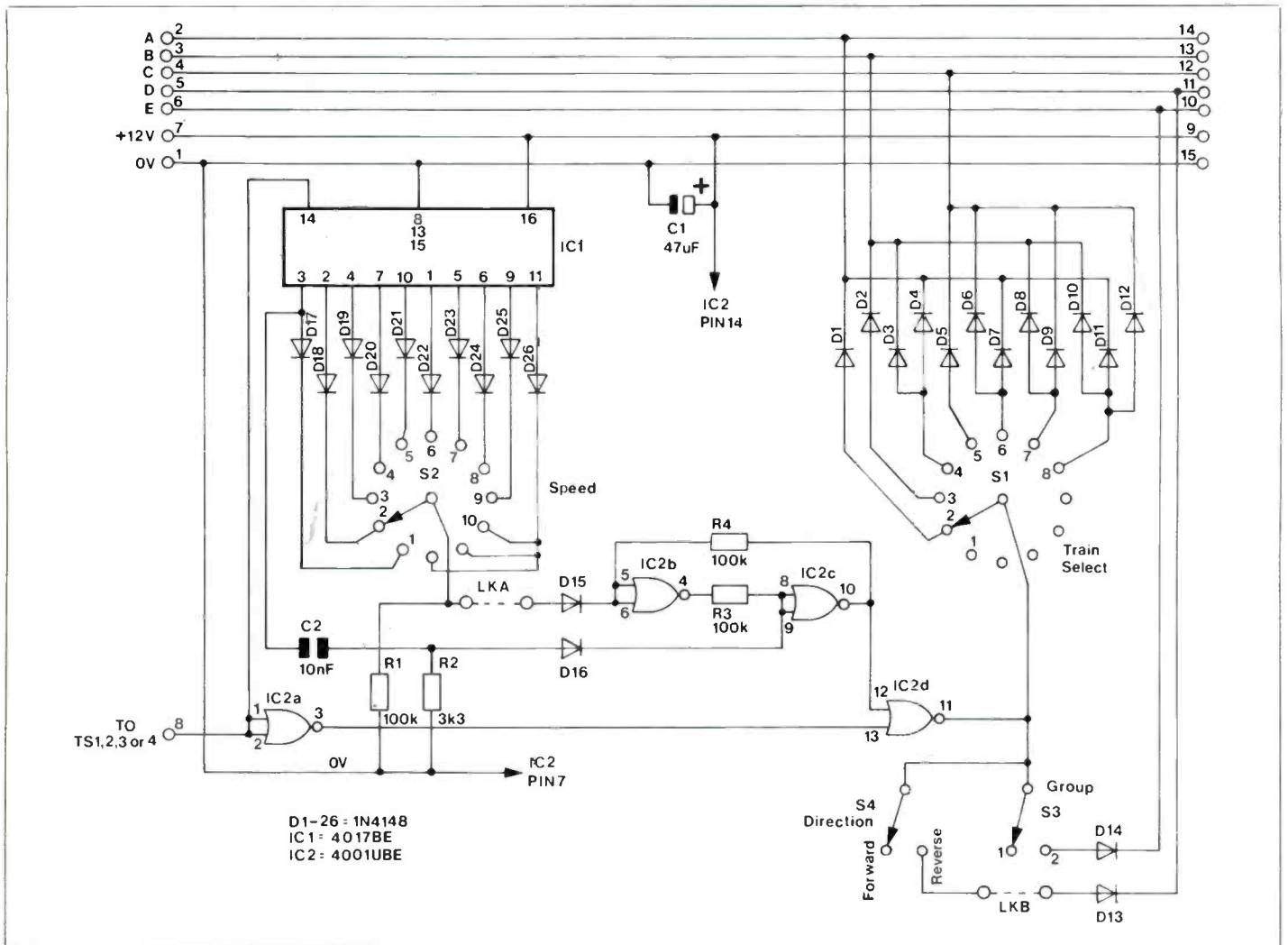


Figure 3. Control board circuit diagram.

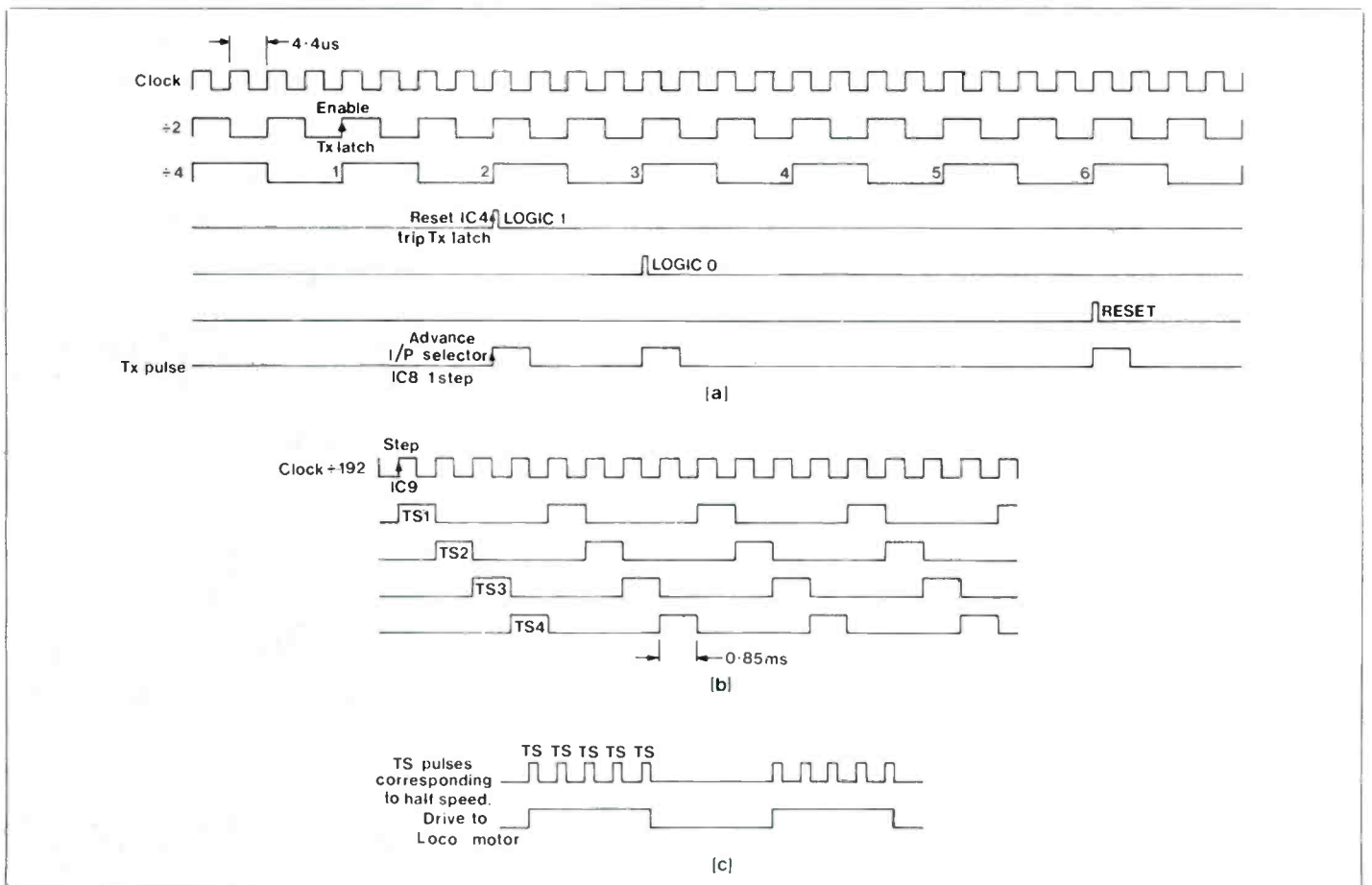
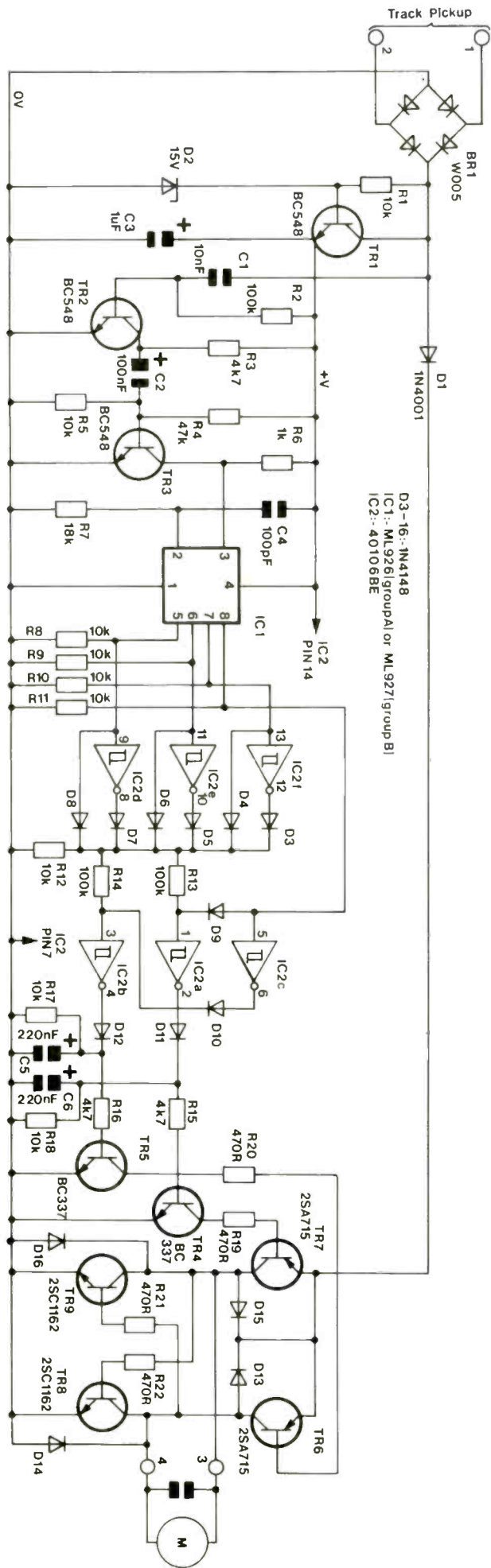


Figure 4. Timing diagram.



D3-16-1N4148
 IC1-ML9261(group A) or ML9271(group B)
 IC2-40106BE

The SCR remains latched until it is reset by shorting it with S2. If the fault is still present the circuit will trip immediately and cause no damage.

When the track supply falls more than 12V below the power units output, either due to the protection circuit being tripped or due to a fuse failure the indicator LED1 will light. Provision is also made for a buzzer to be fitted if an audible indication of track supply failure is required. A timer may be used to reset the protection circuit automatically after a short delay and this will be described in a later article.

Construction

Build all PCBs referring to legends and parts list.

Common Board

The track layout and component overlay for the common board are shown in Figure 6. Fit Veropins and PCB mounting fuse holders and solder. Insert and solder all resistors, diodes, capacitors and the choke. Insert the two plastic transistors, regulator and SCR into their correct positions. Push the leads of the power transistor TR2 through the PCB just far enough to allow it to be soldered and bend the leads as shown in Figure 7. Finally, insert and solder all ICs observing the usual CMOS precautions and making sure that they are the correct way round.

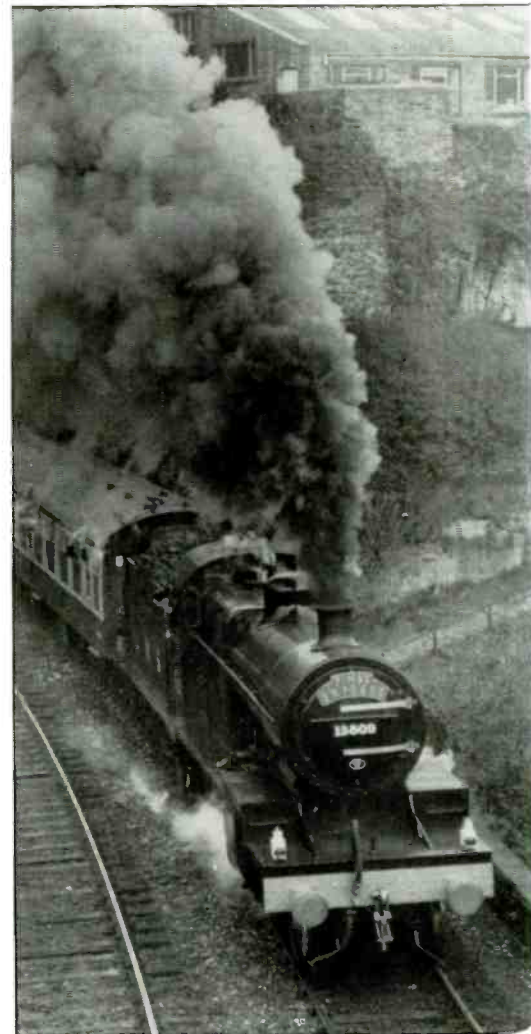


Figure 5. Receiver circuit diagram.

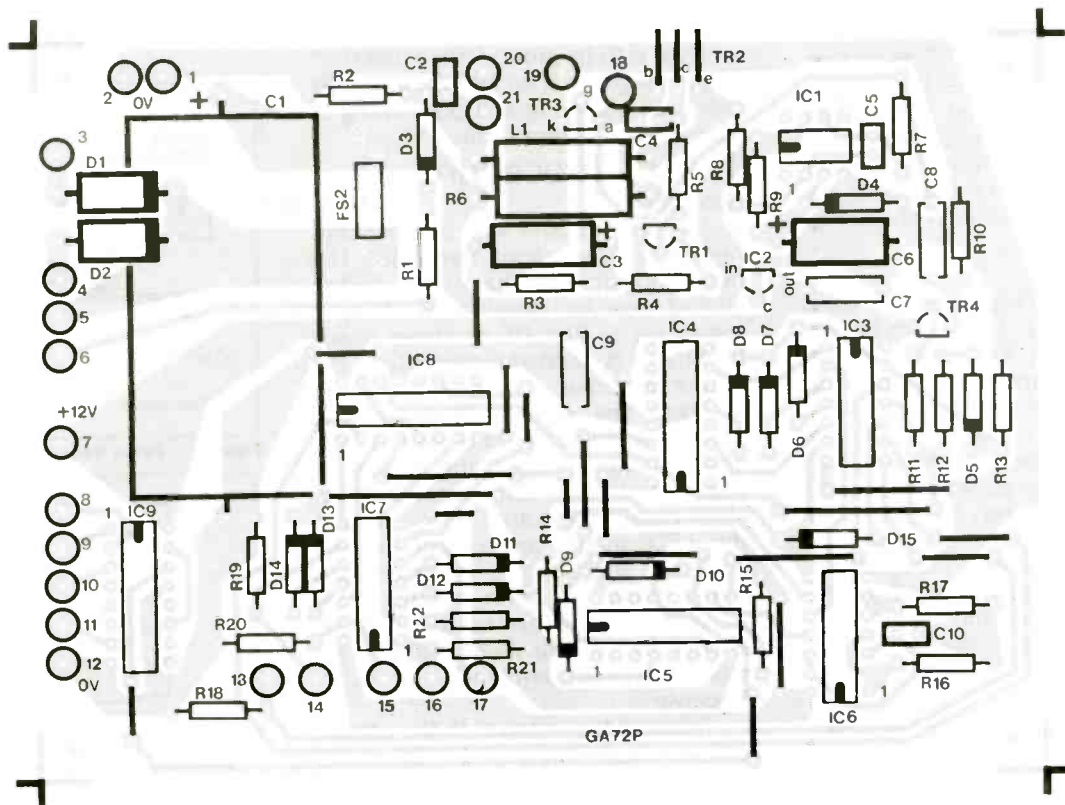
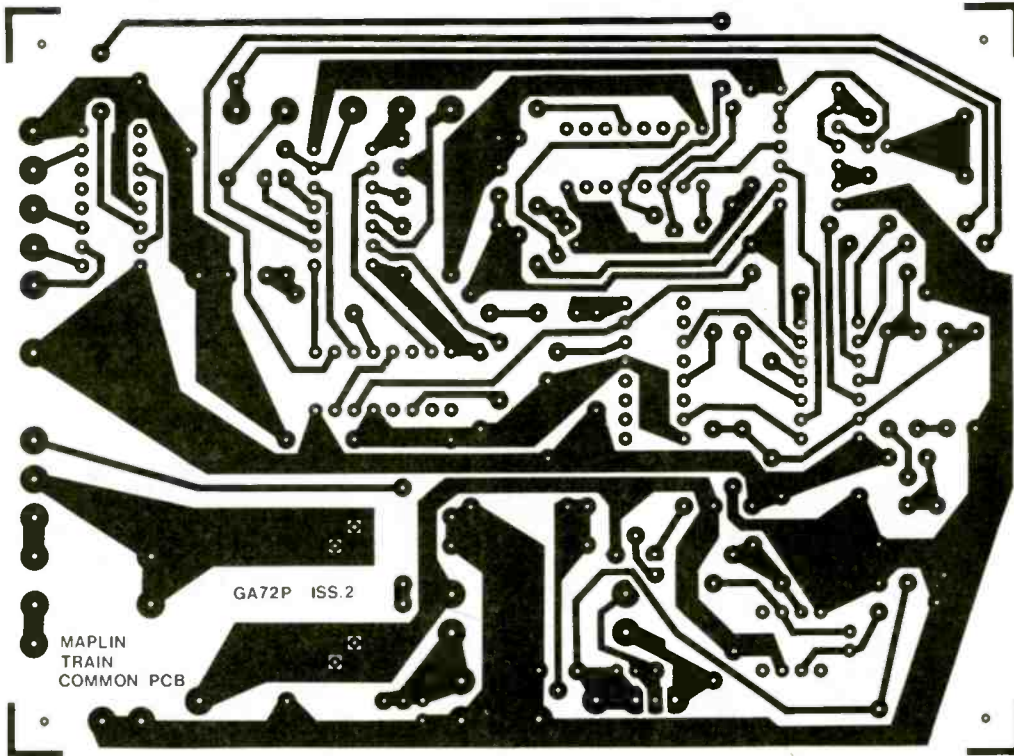
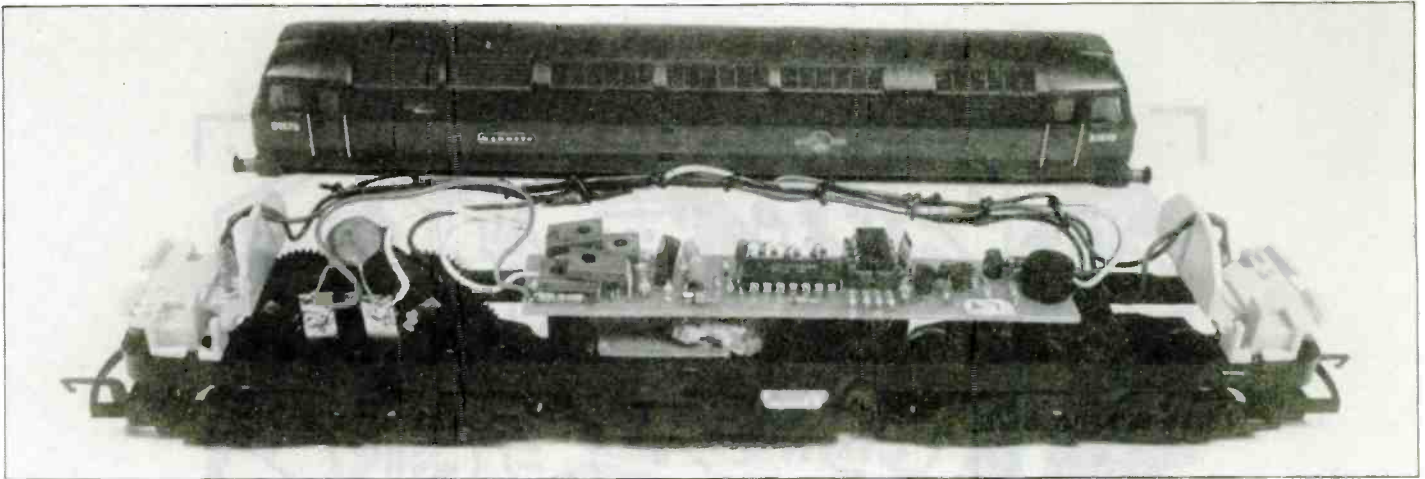
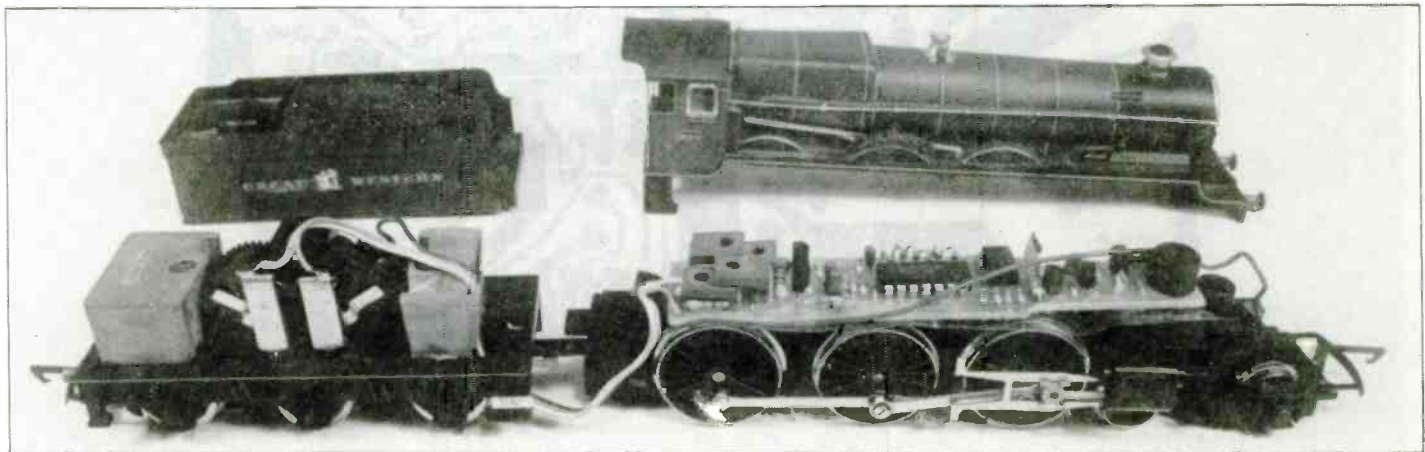


Figure 6. Common board track layout component overlay.



Receiver board 1 installed in diesel locomotive.



Receiver board 1 installed in tender drive locomotive.

Control Board

The track layout and component overlay for the Control Board are shown in Figure 8. Fit and solder all components in order as described above but in this case fit the Veropins from the component side of the PCB to enable ease of wiring when the boards are fitted to the front panel. The rotary switch without the click stops is mounted next to IC1. Note the unused component positions on the board are for the remote control option which may be added later.

Assembly

Mount the transformer, mains switch, fuse holder, LED, push button and terminals on the case. Fit the common board and control boards. (Note that only one control board need be fitted initially.) The self-adhesive penel legend may be used as a template for drilling the front panel or the ready drilled case XG09K may be used. Note that this is not included in the kit.

Wire all boards and components together referring to Figure 13. Insert the fuses noting that the 1 amp anti-surge fuse is fitted in the panel fuse holder.

Receiver board

There are initially two receiver boards available to fit varying size locomotives. See Figures 10 and 11. The dimensions of these boards are shown in Figure 9. Fit and solder all capacitors and resistors noting that some resistors do not lay flat on the board. Insert and solder all diodes other than D3 to D8 and fit all transistors

taking special care with the positioning of TR6, 7, 8 and 9 as shown in Figure 10b/11b. Insert and solder IC2.

Decide which channel the receiver is to use and insert the appropriate diodes referring to Figure 12. If the receiver is to be group A then insert an ML926, if group B an ML927. Carefully check all soldering and positioning of components before testing.

Testing Procedure

Controller

Switch on power with nothing connected to the output terminals. The neon indicator in the mains switch should now be illuminated. Using a meter set to 20V DC or above check that there is approximately 18V at the output terminals.

Press the reset button and the "Track Supply Fail" LED should light and extinguish when the button is released. If this test is satisfactory, short circuit the output terminals and the LED should again light brightly while the short circuit is present and dimly when the short circuit is removed. Press the reset button. The LED should be extinguished and 18V restored to output terminals.

Receiver

Connect the receiver to the control unit as shown in Figure 14. Select the channel number and group of the receiver on a control unit and advance the speed control. One of the two lamps should light with its brightness depending upon the speed set. Switch over the reverse switch to the opposite position and repeat the test. In this

case the other lamp should respond. Switch the control unit to the other channels and groups and ensure that the lights remain extinguished. If these tests are satisfactory the module is ready to be inserted in the locomotive.

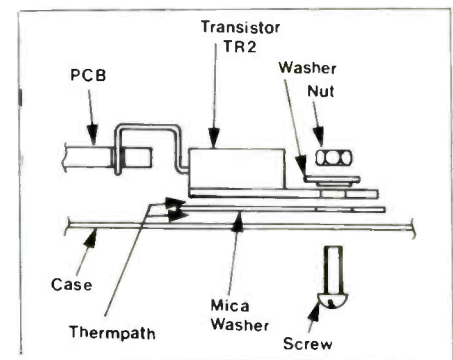


Figure 7. Power transistor mounting.

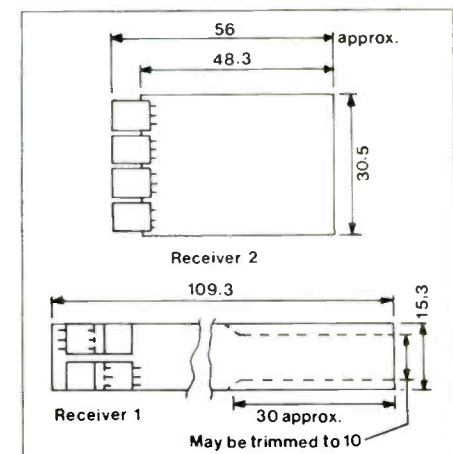


Figure 9. Receiver board dimensions.

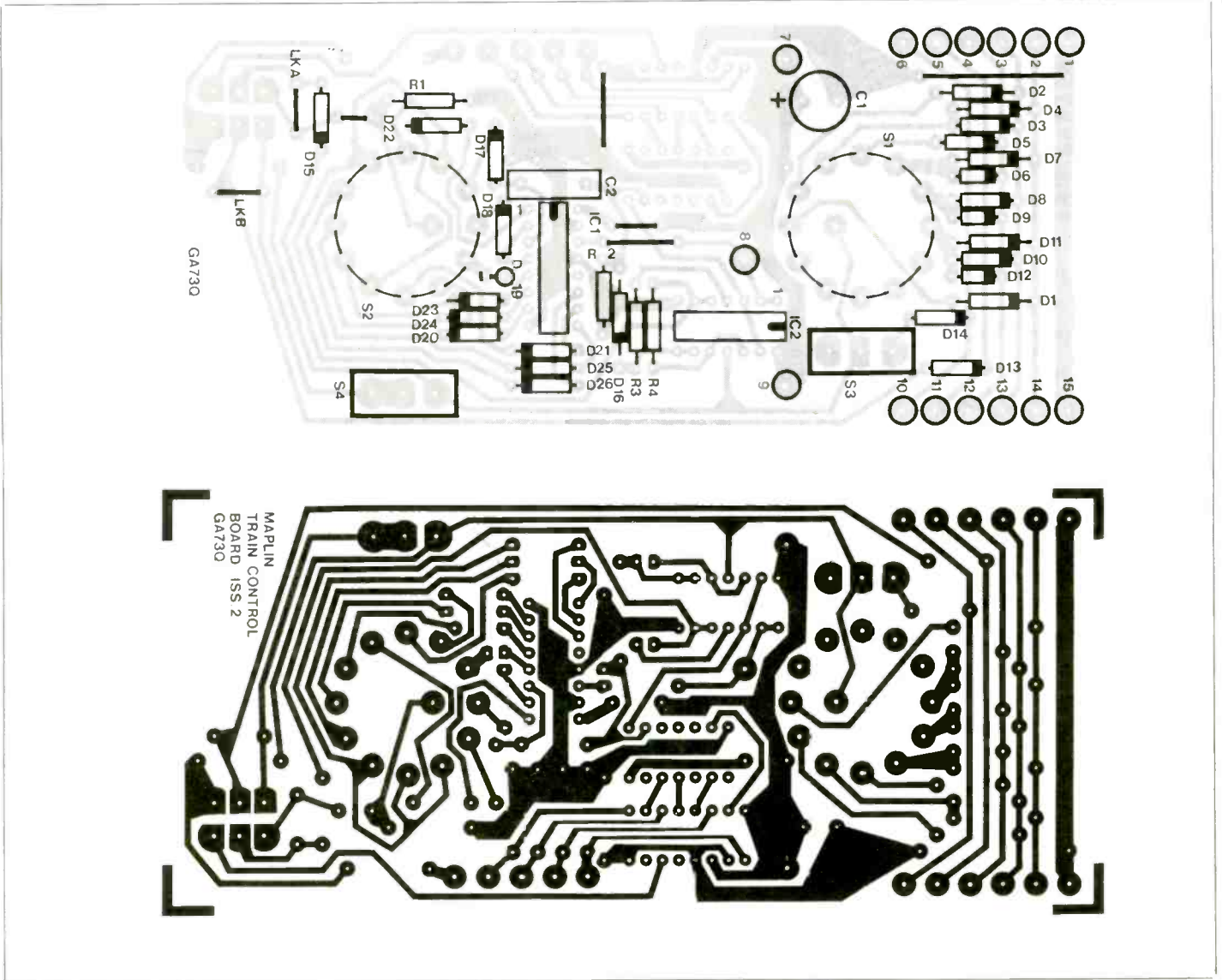
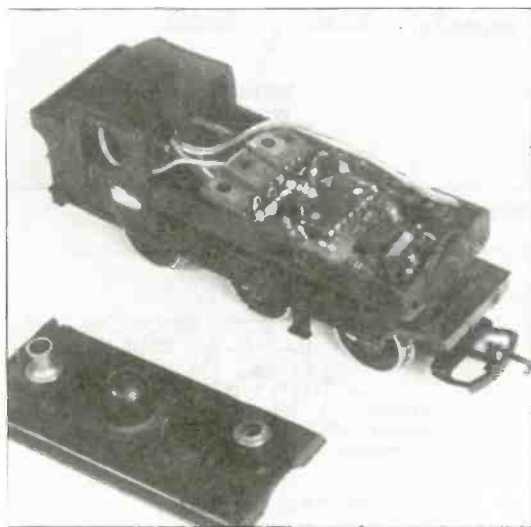


Figure 8. Control board track layout component overlay.



Receiver board 2 installed in tank locomotive.

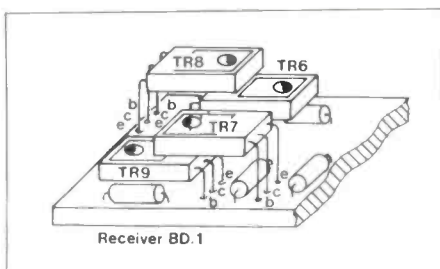
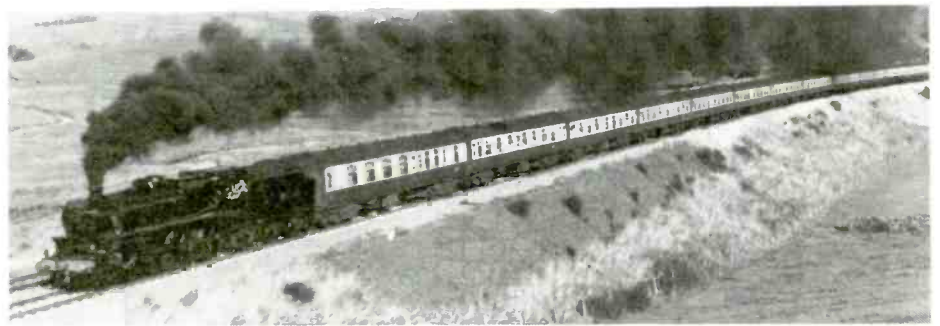


Figure 10(b). Receiver board 1 transistor mounting.

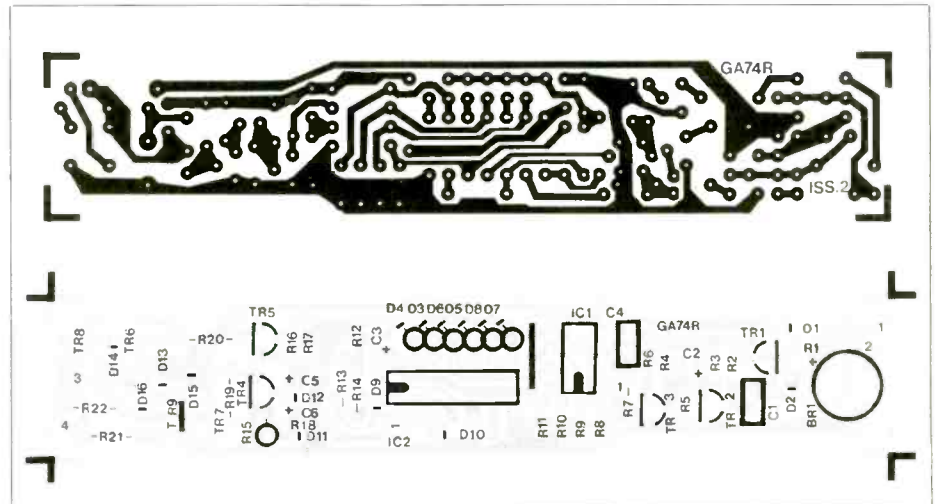


Figure 10(a). Receiver board 1 track layout component overlay.

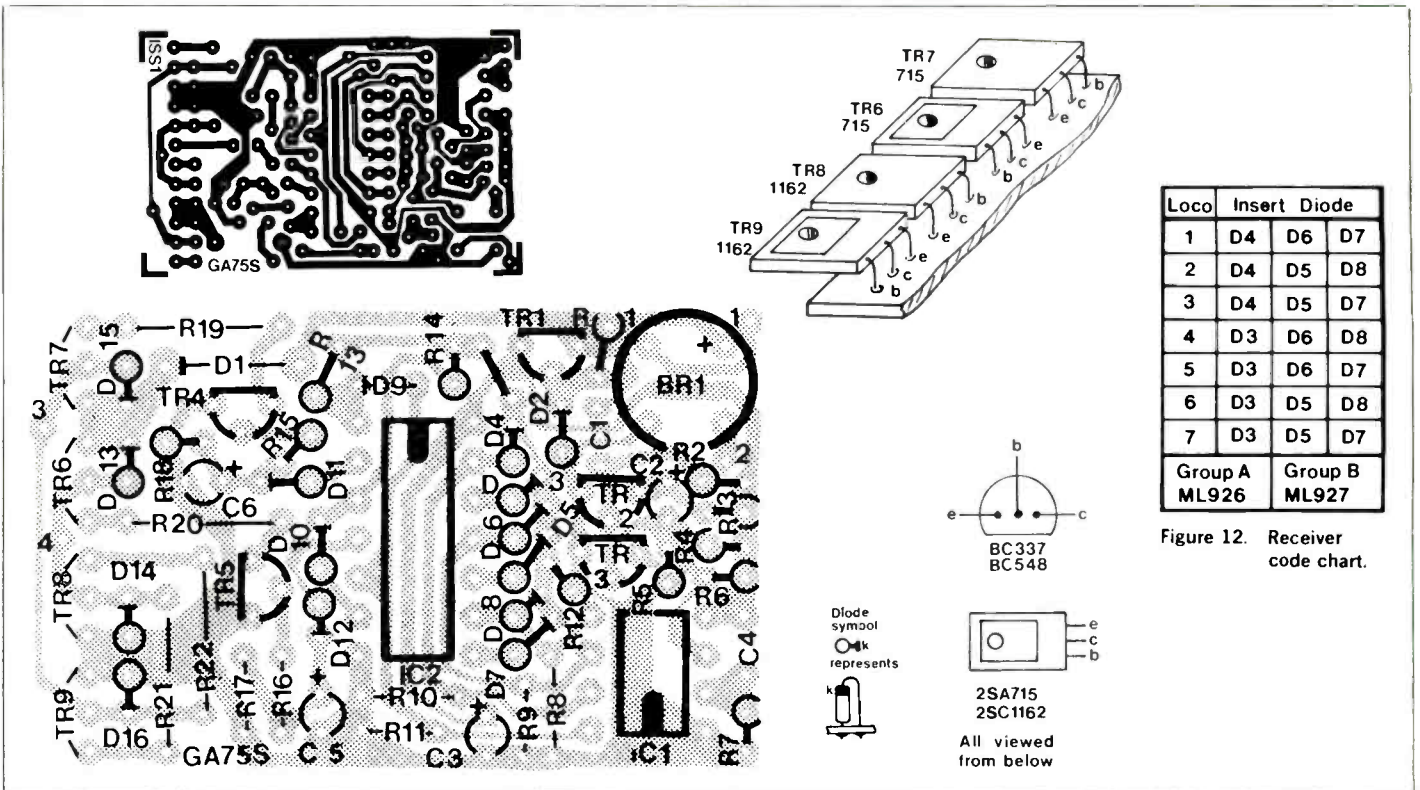


Figure 11(a). Receiver board 2 track layout component overlay. (b). Receiver board 2 transistor mounting.

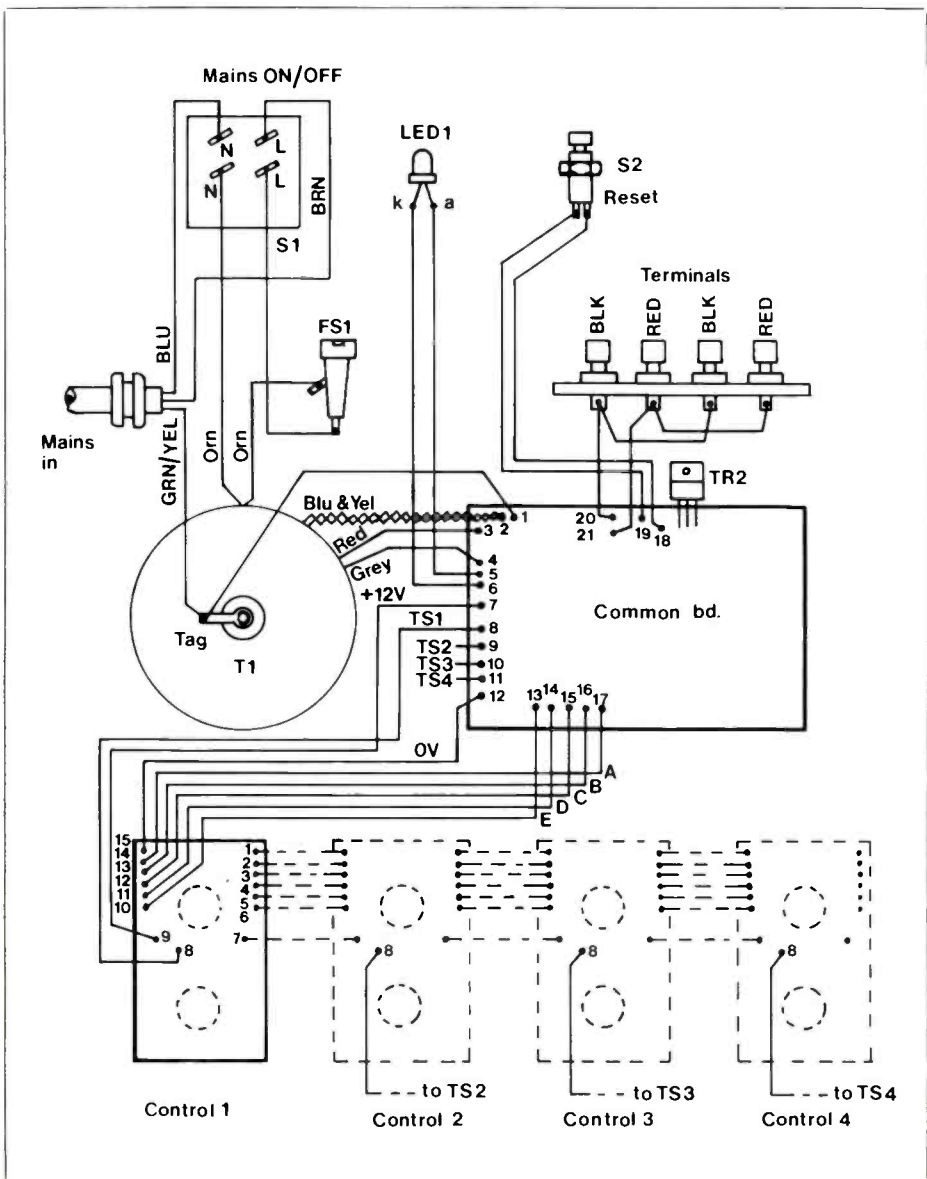


Figure 13. Controller wiring diagram.

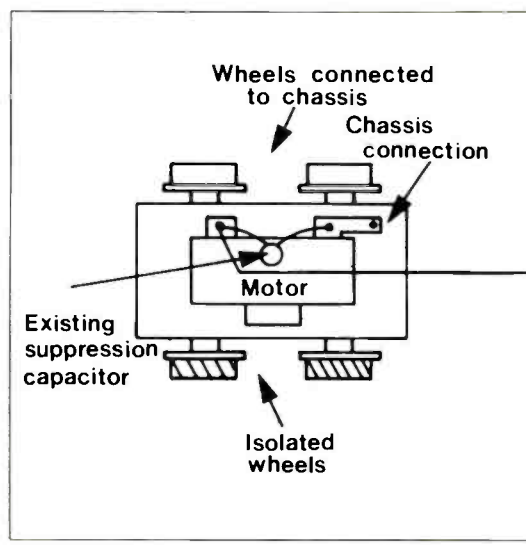


Figure 15. Wiring of conventional locomotive.

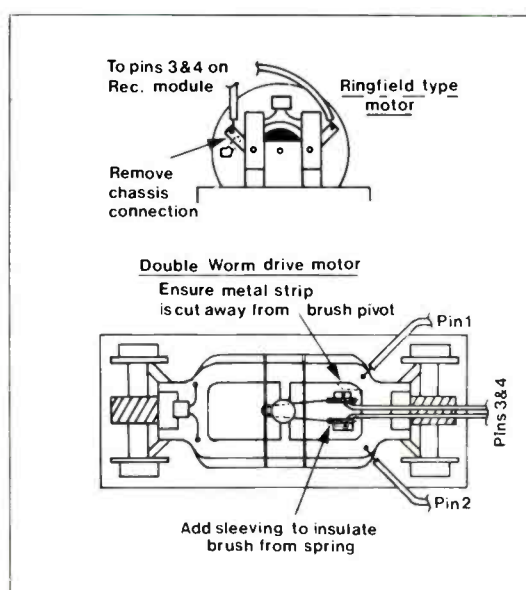
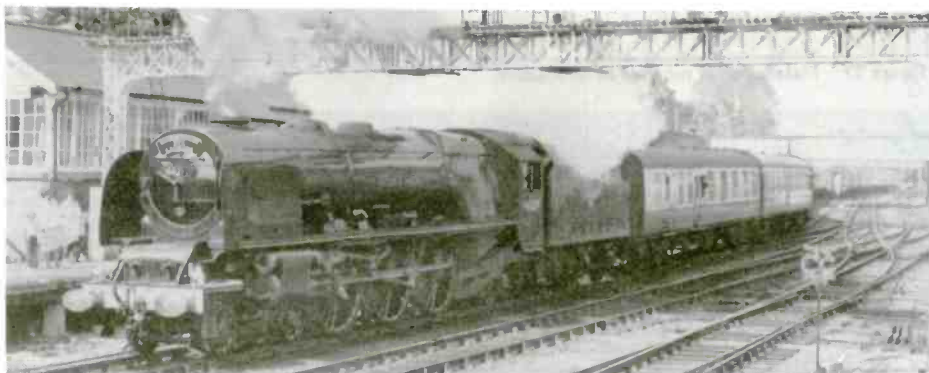


Figure 16. Modifications to various motors.

Installing Receivers in Locomotives

All locomotives designed for use with conventional control systems have the two sides of the motor connected directly to the wheels on each side of the locomotive Figure 15. To install the receiver module, the motor must be completely isolated from the wheels. In many modern models this is accomplished by removing a wire link but in some of the older models there is a permanent connection from one side of the motor to the chassis. In all cases by careful modification this connection



can be removed. Some examples are shown in Figure 16. It is most important to ensure that the motor is completely isolated and it is worth checking this with a meter set to ohms before installing the module.

In most cases there will be a wire coming from one of the pickups, this is connected to one input of the module and the other input is connected to the chassis at a suitable point as shown in Figure 17. After installation, if it is found that the locomotive travels in the wrong direction in relation to the controller switch, the wires to the motor should be reversed.

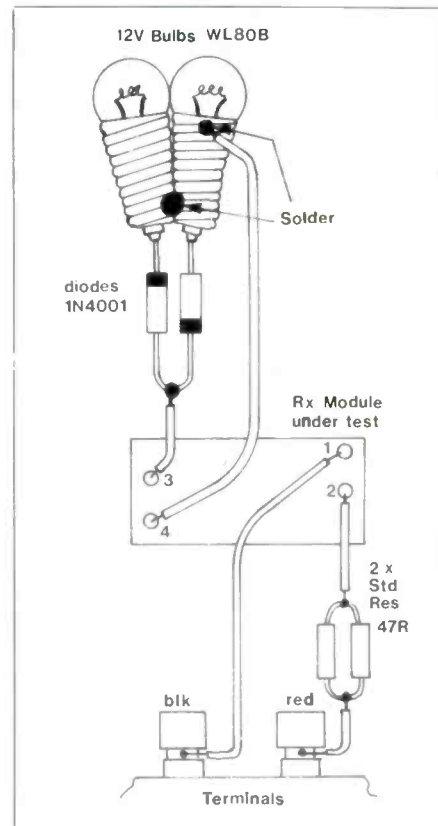


Figure 14. Receiver testing.

KIT PRICES

Complete kits are available for the train controller as follows:

All parts in Train Common/PSU Parts List excluding the case (XG09K).

Order As LW61R (Train Common/PSU Kit) Price £27.50

All parts in Train Control Parts List

Order As LW62S (Train Control Kit) Price £6.45

Four kits are available to make receiver modules as follows:

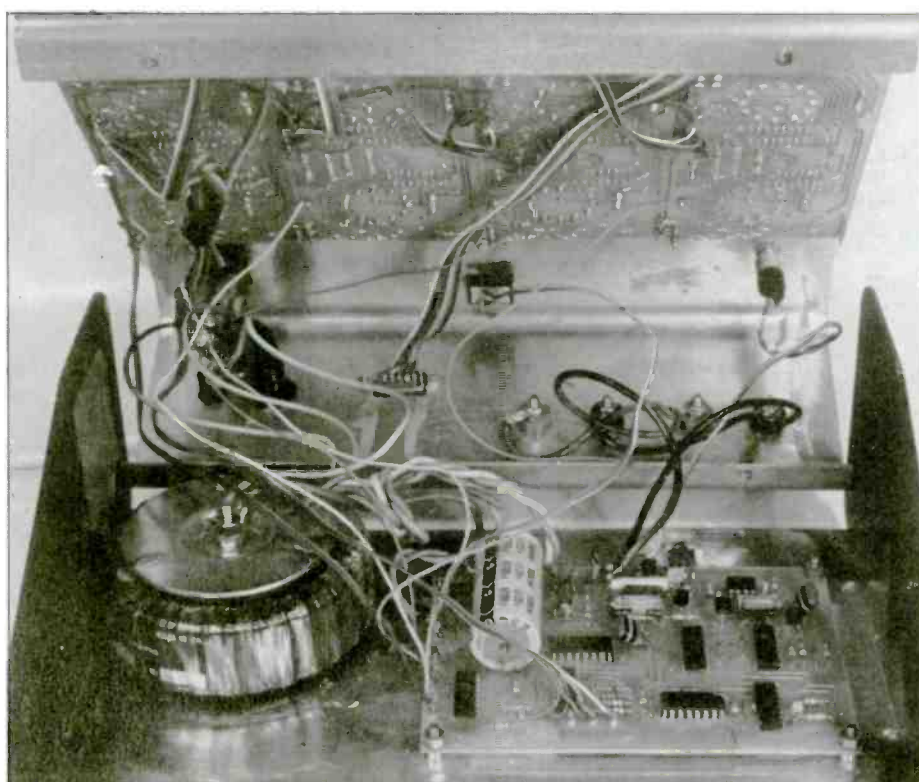
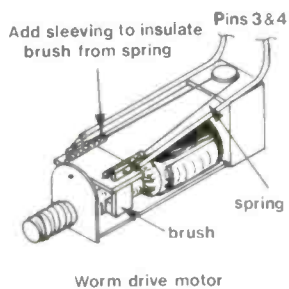
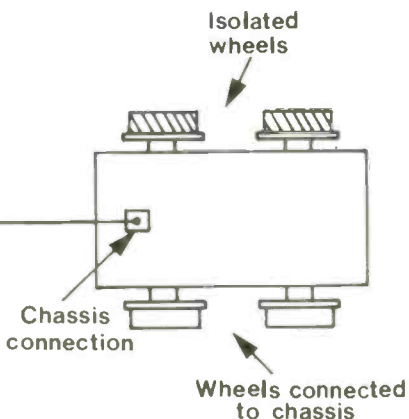
Kit for Group A with long PCB
Order As LW63T (Receiver 1-ML926 Kit) Price £5.95

Kit for Group A with square PCB
Order As LW64U (Receiver 2-ML926 Kit) Price £5.95

Kit for Group B with long PCB
Order As LW68Y (Receiver 1-ML927 Kit) Price £5.95

Kit for Group B with square PCB
Order As LW69A (Receiver 2-ML927 Kit) Price £5.95

Prices shown here may have changed after 14/8/82.



Internal view of main control box.

To ensure reliable operation of this system, as with any other, the locomotives should be in good condition, and it is often worth replacing brushes and cleaning wheels and pickups before use. The track needs to be kept fairly clean although the receiver will respond to signals as long as there is enough power to drive the motor.

The next article in this series will describe the remote control facilities and computer interfacing.

Future articles will describe track circuiting (train position detection) point control and detection of position, interlocking and control of signals, automatic loop switching, and many other useful circuits as well as constructional hints for the railway modeller.

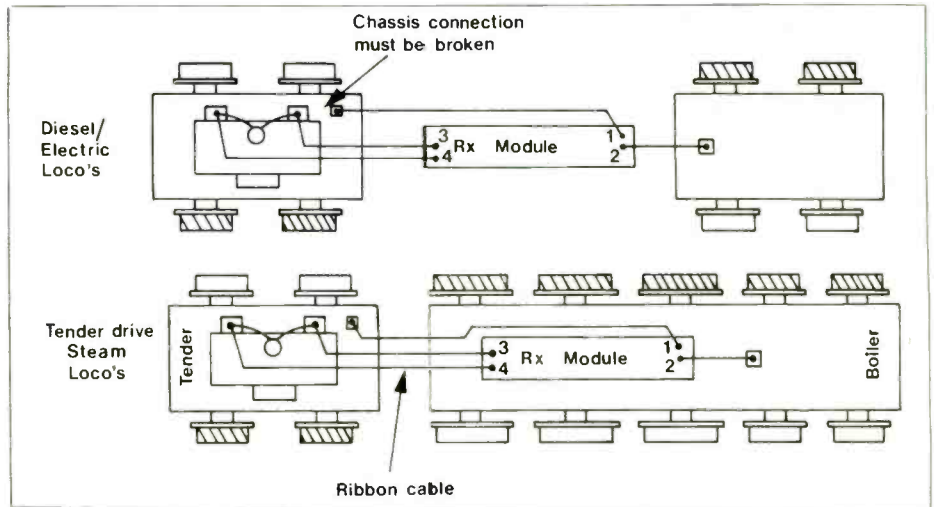


Figure 17. Installation of receiver in locomotive.

TRAIN CONTROL PCB PARTS LIST

Resistors — all 1/2W 5% carbon unless specified			
R1,3,4	100k	3 off	(M100K)
R2	3k3		(M3K3)
Capacitors			
C1	47uF 25V PC elect.		(FF08J)
C2	10nF polyester		(BX70M)
Semiconductors			
D1-26	1N4148	26 off	(QL80B)
IC1	4017BE		(QX09K)
IC2	4001UBE		(QL03D)
Miscellaneous			
S1	Rotary switch 1 pole 12 way		(FF73Q)
S2	Rotary switch 1 pole 12 way special		(XX45Y)
S3,4	Sub-min toggle 'A'	2 off	(FH00A)
	Veropin 2141	15 off	(FL21X)
	Train control PCB		(GA73Q)
	Knob K7B (for S1)		(YX02C)
	Knob K7C (for S2)		(YX03D)

Miscellaneous

L1	RF suppressor choke 2A		(HW05F)
T1	Toroidal transformer 80VA 18V		(YK17T)
LED 1	LED red		(WL27E)
FS1	Fuse anti-surge 1A		(WR19V)
FS2	Fuse 20mm 2A		(WR05F)
S1	Dual rocker neon		(YR70M)
S2	Push switch		(FH59P)
	Safe fuseholder 20		(RX96E)
	Fuse clip	2 off	(WH49D)
	S/R grommet		(LR49D)
	Veropin 2141	21 off	(FL21X)
	LED clip		(YY40T)
	Quickterm push		(BW71N)
	Train common PCB		(GA72P)
	Mains lead	3M	(XR04E)
	10-way ribbon cable	1M	(XR06G)
	Wire 3202 black	1M	(XR32K)
	Wire 3202 red	1M	(XR36P)
	Train control case		(XG09K)
	Kit 'P' plus		(WR23A)
	Bolt 6BA x 1/2"	7 off	(BF06G)
	Washer 6BA	3 off	(BF22Y)
	Spacer 6BA x 1/8"	4 off	(FW33L)
	Nut 6BA	7 off	(BF18U)
	Tag 2BA		(BF27E)
	Small thermopath		(HQ00A)
	Train control front panel		(XX47B)
	Stick-on feet		(FW38R)

TRAIN COMMON/PSU PARTS LIST

Resistors — all 1/2W 5% carbon unless specified			
R1,3,4,5	1k	4 off	(M1K)
R2,7,9	2k2	3 off	(M2K2)
R6	0.22R (3W) wirewound		(W0.22)
R8	22k		(M22K)
R10	4k7		(M4K7)
R11,12,14,15	10k	4 off	(M10K)
R13,17-22	100k	7 off	(M100K)
R16	33k		(M33K)
Capacitors			
C1	4700uF 25V axial electrolytic		(FB96E)
C2	100pF ceramic		(WX56L)
C3	100uF 10V axial electrolytic		(FB48C)
C4	220pF ceramic		(WX60Q)
C5	10nF ceramic		(WX77J)
C6	10uF 25V axial electrolytic		(FB22Y)
C7,8,9	100nF polyester	3 off	(BX76H)
C10	33pF ceramic		(WX50E)
Semiconductors			
D1,2	1N5400	2 off	(QL81C)
D3	BZX61C12		(QF55K)
D4	BZY88C20		(QH21X)
D5-15	1N4148	11 off	(QL80B)
TR1	BC327		(QB66W)
TR2	TIP122		(WQ73Q)
TR3	MCR102		(QH43W)
TR4	BC548		(QB73Q)
IC1	uA741C (8-pin)		(QL22Y)
IC2	uA78L12 AWC		(WQ77J)
IC3,7	4081BE	2 off	(QW48C)
IC4,8,9	4022BE	3 off	(QW19V)
IC5	4040BE		(QW27E)
IC6	4001BE		(QX01B)

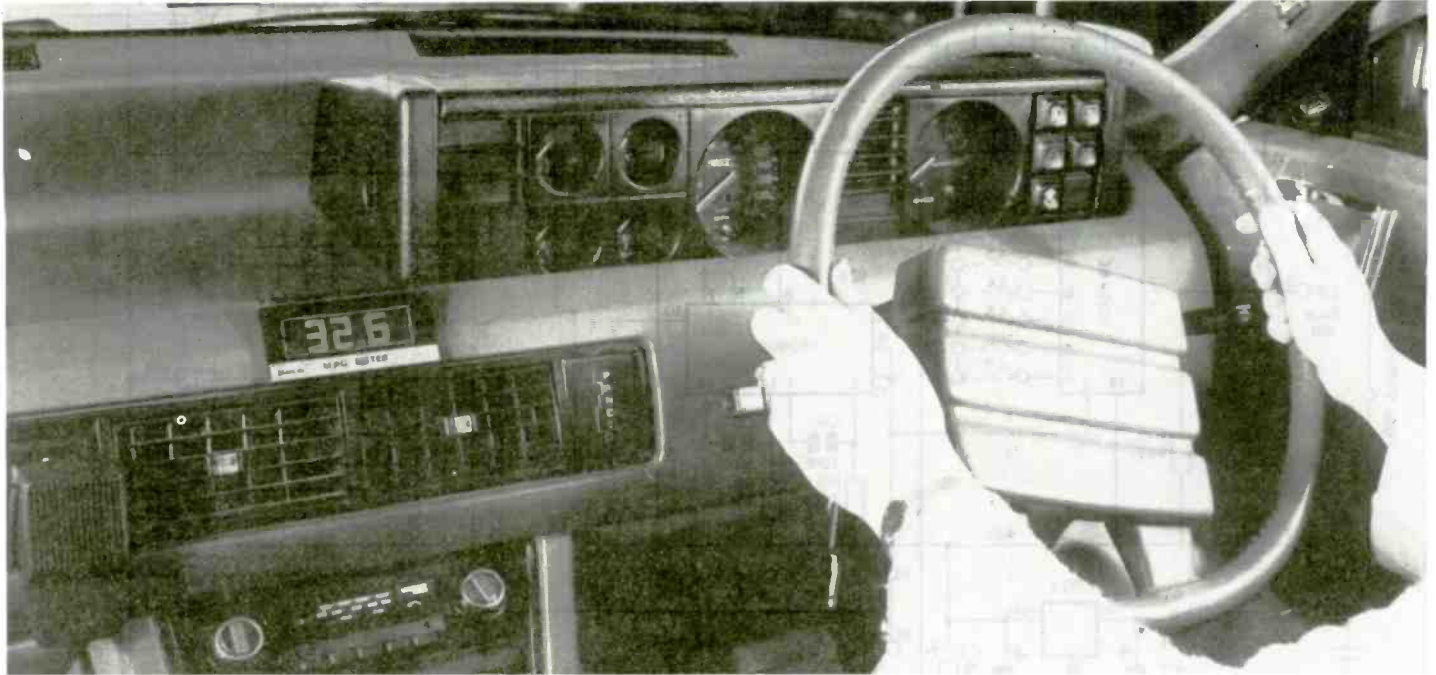
TRAIN RECEIVER MODULE PARTS LIST

Resistors — all 1/2W 5% carbon unless specified			
R1,5,8,12,17,18	10k	9 off	(U10K)
R2,13,14	100k	3 off	(U100K)
R3,15,16	4k7	3 off	(U4K7)
R4	47k		(U47K)
R6	1k		(U1K)
R7	18k (1/2W)		(M18K)
R19-22	470R (1/2W)	4 off	(S470R)
Capacitors			
C1	10,000pF ceramic		(WX77J)
C2	100nF 35V tantalum		(WW54J)
C3	1uF 35V tantalum		(WW60Q)
C4	100pF ceramic		(WX56L)
C5,6	220nF 35V tantalum		(WW56L)
Semiconductors			
D1	1N4001		(QL73Q)
D2	BZY88C15V		(QH18U)
D3-16	1N4148	14 off	(QL80B)
BR1	W005		(QL37S)
IC1	ML926 (Group 'A')		(QR57M)
	or ML927 (Group 'B')		(QR58N)
IC2	40106BE		(QW64U)
TR1-3	BC548	3 off	(QB73Q)
TR4,5	BC337	2 off	(QB68Y)
TR6,7	2SA715	2 off	(QR56L)
TR8,9	2SC1162	2 off	(QR59P)
Miscellaneous			
	Train receiver 1 PCB		(GA74R)
	or Train receiver 2 PCB		(GA75S)

Details of kits are given on page 25

DIGITAL MILES~PER~GALLON METER

by M. Wharton



- ★ Save petrol with this easy to build device.
- ★ Discover your car's most economical cruising speed.
- ★ Large easy to read LED display.

**COMPLETE
KIT
£44.95**

With the price of petrol continuing on its upward spiral, any device which can offer some means of economising on fuel consumption must be a winner! This mph meter uses readily available transducers and produces a continuous display of fuel consumption under all driving conditions. Using the meter, it is thus possible to compare the petrol used when accelerating and cruising at speed; it is also possible to find the driving conditions which yield the optimum fuel consumption.

The basis of the design is two transducers; one transducer produces a signal in response to the flow of fuel, whilst the other is connected into the speedometer drive cable and gives an output which corresponds to road speed. The meter takes these two signals and produces a continuous digital display of miles per gallon of fuel.

Circuit

The signal from the speed transducer is first "cleaned up" and then used to trigger a monostable, formed by IC1c and 1d, which has a very short time constant. At the same time, the signal from the fuel transducer is used to clock the divider, IC6. The chosen output from the divider is then used to trigger the dual monostable, IC5, in the following manner; a positive going edge on pin 4 produces an output positive pulse of about 1ms duration on pin 6;

this is connected both to pin 11 of IC5 and pin 2 of IC6, triggering the second monostable on the falling edge and also resetting the divider. The same output is used as the latch signal for the display counter/divider. The two outputs, Q₂ and Q₃, from the second monostable are used to reset the display counter/divider and inhibit the scaling oscillator circuit via IC2c and IC2d.

The purpose of the oscillator formed by IC1a, 1b and 2c and the gated flip-flop formed by IC2a, 2b and 2d is to enable the display to be calibrated to give a true reading and provides a means of taking into account the variety of different gearing ratios between engine and road wheels and the speedometer drive cable.

During the counting period, set according to the position of link 'A', this oscillator, in combination with IC3 and IC4, produces a series of pulses which are counted by IC7. By selecting a suitable link 'B', a wide variety of gear ratios may be accommodated and the unit calibrated accordingly to give an accurate reading of miles per gallon. The series of pulses counted by IC7 are then displayed at the end of the counting period by applying the latch signal. When IC6 is reset and the whole process commences again. IC7 and the associated transistors TR2, 3 and 4 provides all the necessary signals to drive an LED display.

Construction

Fuel Flow Transducer

This has to be fitted into the fuel line between the pump and the carburettor; it is not sensitive to the direction of fuel flow but it is recommended that it be positioned with the flow axis vertical to allow air bubbles to escape. It should not be mounted where it will be subjected to excessive heat (obviously!) or where ingress of water could be a problem. The connecting cable is colour coded:

Red: to +5V, through a current limiting

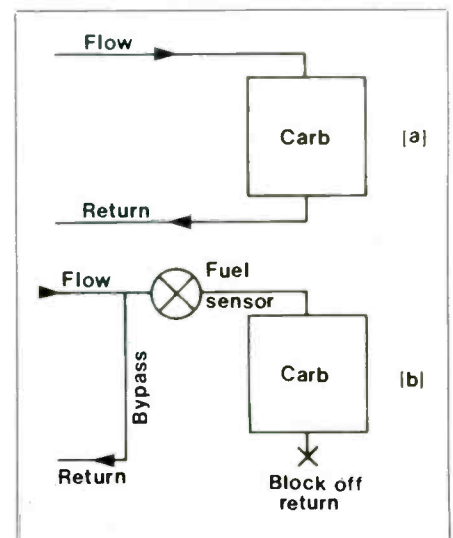


Figure 2. Pipework for fuel circulation systems.

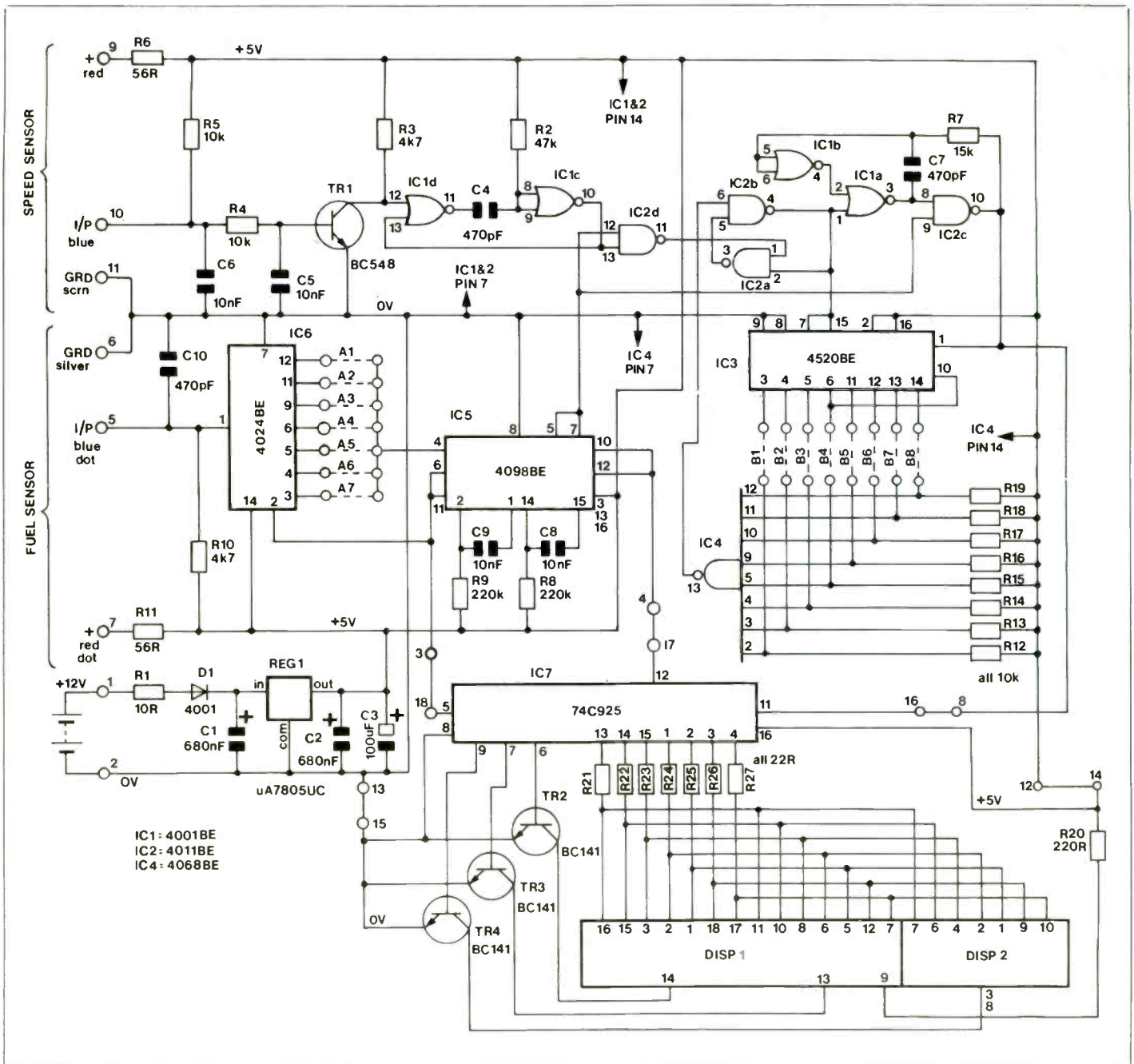


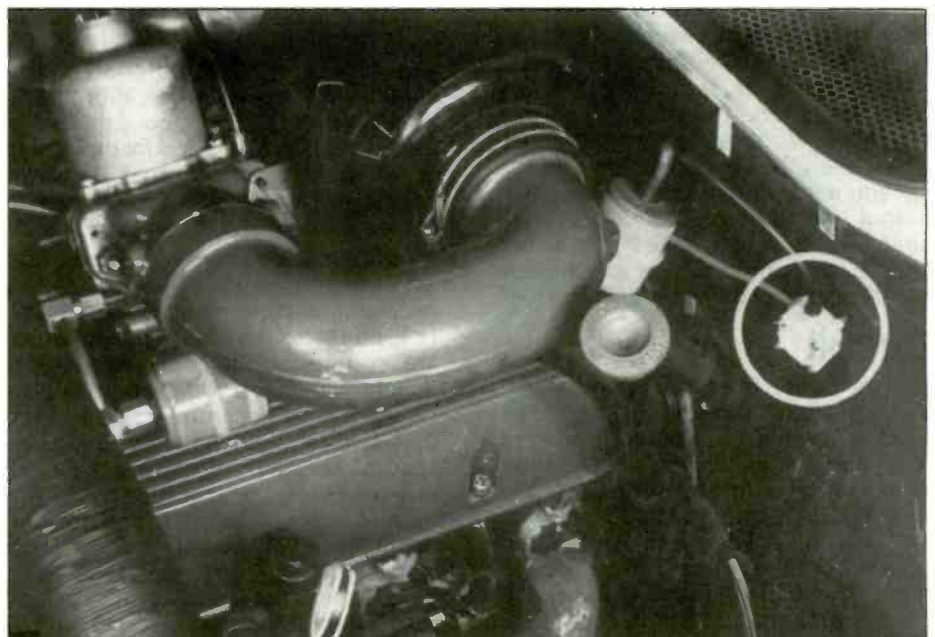
Figure 1. Circuit diagram of mpg meter.

resistor (included in the main circuit). Blue: signal output.

Screening: connected to ground (0V).

Many modern cars have fitted some form of continuous fuel circulation between the tank and carburettor. This is to prevent evaporation of fuel and comply with various Federal and European regulations on emission control. In order to give a sensible reading, the fuel flow transducer must only have fuel passing through it which is used by the engine, and not that in continuous circulation. To achieve this it may be necessary to slightly modify the pipe-work, usually by fitting some form of bypass between "flow" and "return" and fitting the transducer in the arm taken from the "flow" side, as in Figure 2.

This method may also be used on cars fitted with fuel injection, by placing the transducer in same position relative to the metering pump, i.e. in the low pressure feed line. **(CAUTION: Under no circumstances attempt to fit it in the**



Flow transducer fitted in fuel line.

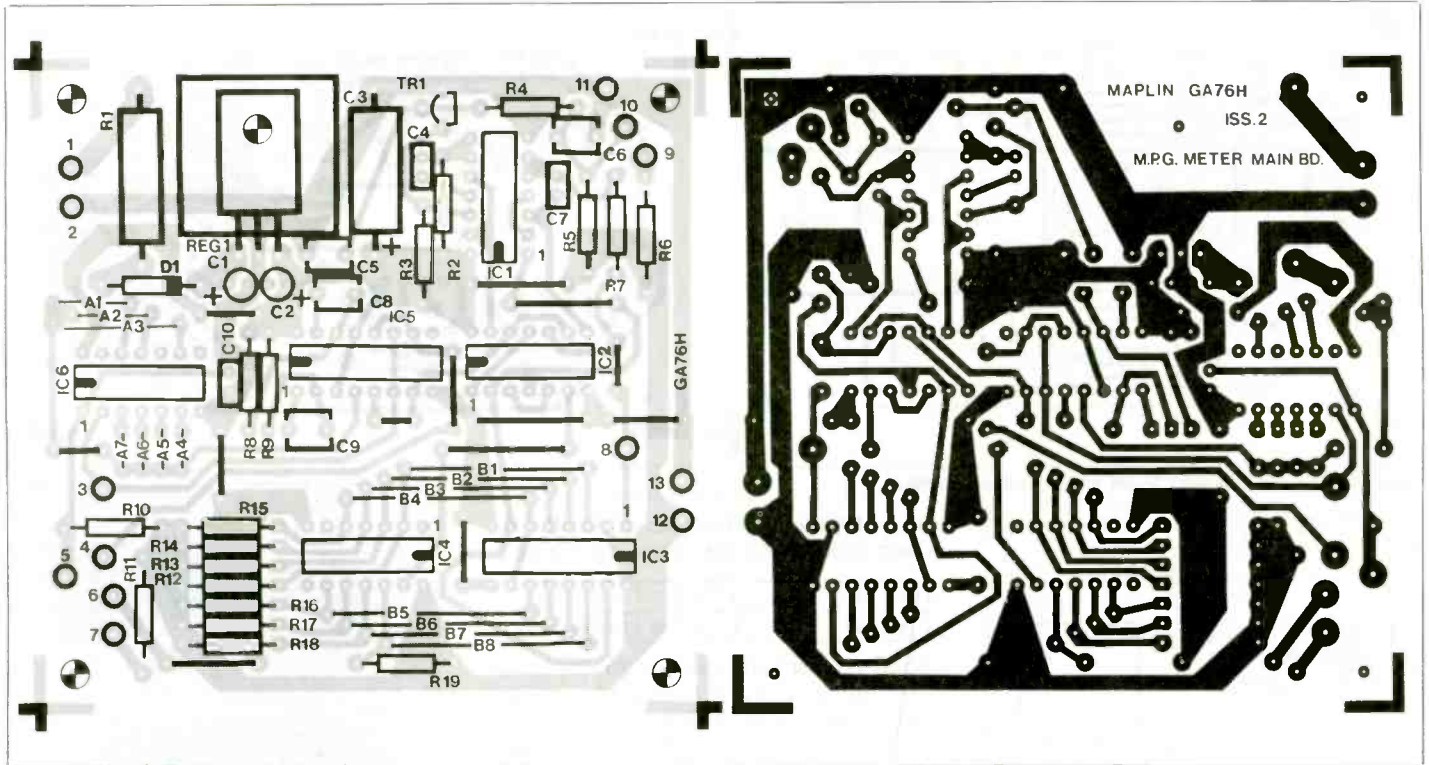


Figure 3. Main PCB track layout and component overlay.

high pressure injector lines!) Care needs be exercised here as the feed pressure is important to ensure correct filling of the metering pump and without a constant flow through the pump, trapped air or vapour bubbles can present a problem.

Speed Transducer

To fit this, remove the speedo cable and cut the outer sheath at the point where it is intended to fit the transducer; again, keep it away from heat and/or water. Make a second cut, removing $\frac{1}{2}$ " of the sheath from one of the cut ends and discard. Remove any burrs from the sheath ends. Remove any oil or grease from the inner core and replace it into the short sheath section. Place the transducer cable clamps (not included in the parts list, but use small jubilee clips or similar) on both ends of the transducer. Insert the loose end of the cable core into the single terminal end of the transducer and push through the internal friction bushing. This can be a tight fit, so take care not to kink or distort the inner cable. Tighten the clamp, but make sure the core is still free to rotate; some sheaths will require insulating tape wrapped over the end to make up the diameter to obtain a firm grip. Feed the loose cable core into the long sheath section until it also seats into the transducer and tighten the clamp carefully. Before refitting the speedo cable to the vehicle make sure the inner core does not bind in any way — there should be about 1mm of free movement along the axis of the transducer. Any tightness or binding will cause excessive cable wear or oscillation of the speedo indicator needle. This is an operation which needs to be performed with care, making sure, for example, that there will be enough room for the transducer in the position it is intended

to fit before cutting the outer sheath.

Two PCBs are required. One is a display board and ideally should be fitted into the car dashboard, the other is the main logic board which holds all the major components and may be mounted in any convenient place out of sight. It is connected to the display board by only 5 wires. Note that one of the corner fixing holes in the main board is in the PCB OV line, so that if the PCB is fixed to the car chassis the OV line will be grounded.

Construct the main PCB. First insert all links (only some of links A1-7 and B1-8 will need to be made). Next fit IC holders, resistors, diode, transistor and capacitors, taking note of polarisation. Mount REG.1 onto the PCB. Smear the mica washer both sides with Therm-path and position onto the vaned heat-sink. Bend REG.1 over onto heatsink and bolt through the PCB. Finally, fit

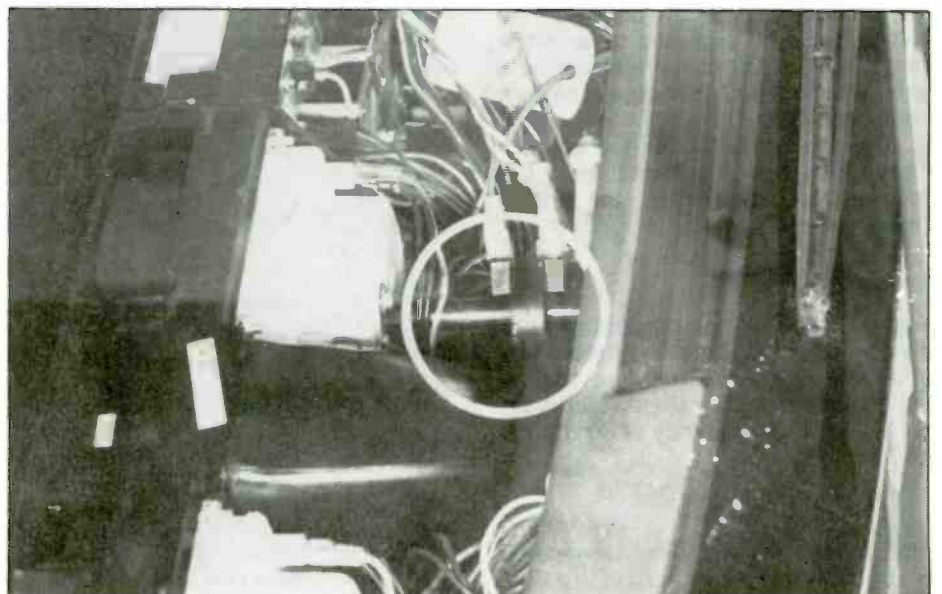
Veropins and ICs.

Now construct the display board. Fit all links, resistors and transistors, then fit displays noting that on the side of display 1, the 'M' in the code number relates to pin 1 and for display 2 the dot on the display is next to pin 4.

Finally fit the IC holder and IC7 and insert Veropins from the component side so they protrude from the rear for ease of wiring.

Calibration

To ensure that the display gives a true reading, it is necessary to set the links between IC3 and IC4 to give the required scaling factor. To do this accurately the speed of rotation of the speedo cable needs to be known at, say, 30 mph. Sometimes it is possible to obtain such information from the manufacturers, when it is often given as



Speed transducer fitted in speedo cable.

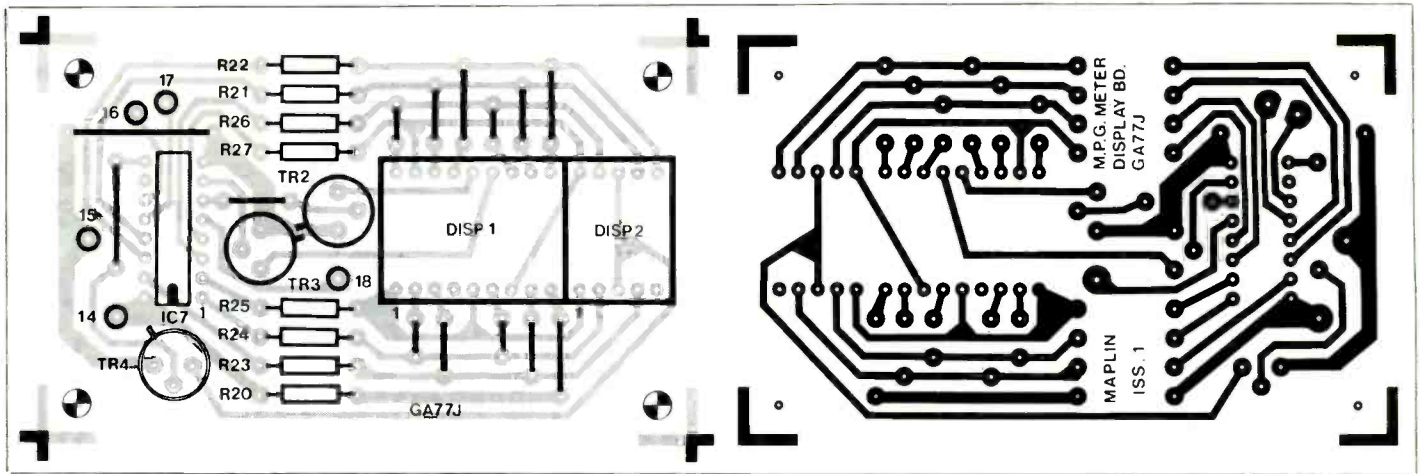


Figure 4. Display PCB track layout and component overlay.

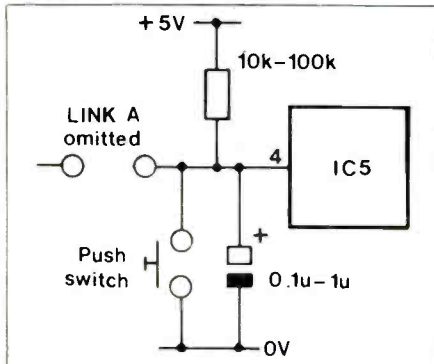


Figure 5. Calibration circuit.

the number of turns per mile travelled. If this is not known, then the meter itself may be used to measure the required output frequency from the speed transducer. To do this, omit IC6 and set link 'B' temporarily to position 'I'. The circuit shown in Figure 5 can then be used to provide pulses for IC5.

Measurement of the output frequency is obtained by first driving the car at a constant speed of 30 mph, indicated by the speedo; the push switch is closed and then opened at the start of a timed interval of 10 seconds. At the end of this time the switch is closed and allowed to open on the ten second mark. The display should then show the required frequency (ignoring the decimal point on the display). The value should be expected to be in the range 100 to 200Hz and it would be a good idea to take an average of several such readings.

The scaling factor for the counter circuit can then be found from the following equation using the appropriate values:

$$\frac{8.5 \times 3000}{X \times Y} = n$$

where X is the division ratio of the 4024 divider selected, Y is the frequency obtained above and n is the scaling factor. For example, if the divider is set on '8' and the frequency at 30 mph is 140Hz, then

$$\frac{8.5 \times 3000}{8 \times 140} = 22.76$$

This must be rounded to the nearest whole number, in this case 23.

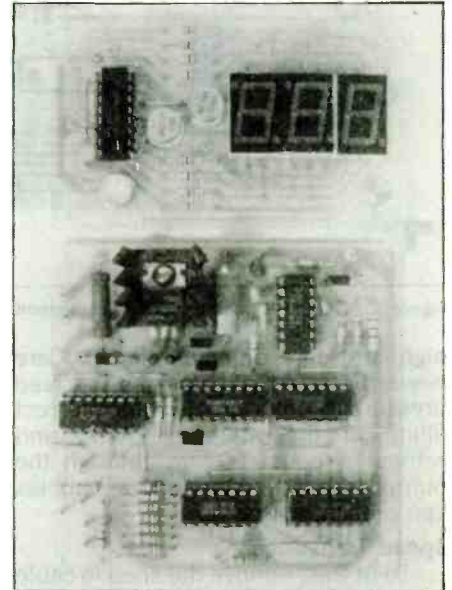
The factor is set by connecting the

appropriate links between IC3 and IC4, each link having the following "value":

LINK B	1	2	3	4	5	6	7	8
VALUE	1	2	4	8	16	32	64	128

So to set a scaling value of 23, the links number 1, 2, 3 and 5 would be made; i.e. value = 1+2+4+16 = 23.

If it is chosen to set the 4024 divider to some ratio other than 8, then the scaling factor would need to be altered accordingly. The choice is not critical, but it should be remembered that whilst low division ratios will give a more instantaneous reading of mpg, such variations as fuel pump surges will give a fluctuating display; higher division ratios will allow more time for these variations to be averaged out, and a ratio of 8 is suggested as a starting point.



MPG METER PARTS LIST

Resistors — all 1/4W 5% carbon unless specified

R1	10R 3W wirewound		(W10R)
R2	47k		(M47K)
R3,10	4k7	2 off	(M4K7)
R4,5,12-19	10k	10 off	(M10K)
R6,11	56R 1/2W	2 off	(S56R)
R7	15k		(M15K)
R8,9	220k	2 off	(M220K)
R20	220R		(M220R)
R21-27	22R	7 off	(M22R)

Capacitors

C1,2	680nF 35V tantalum	2 off	(WW59P)
C3	100uF 10V axial electrolytic		(FB48C)
C4,7,10	470pF ceramic	3 off	(WX64U)
C5,6,8,9	10nF monicap	4 off	(YY08J)

Semiconductors

IC1	4001BE		(QX01B)
IC2	4011BE		(QX05F)
IC3	4520BE		(QX33L)
IC4	4068BE		(QX24B)
IC5	4098BE		(QX29G)
IC6	4024BE		(QX13P)
IC7	74C925		(QY08J)
REG.1	uA7805UC		(QL31J)
D1	1N4001		(QL73Q)
TR1	BC548		(QB73Q)
TR2,3,4	BC141	3 off	(QB38R)

Miscellaneous

DISP.1	DD display type C		(BY68Y)
DISP.2	1/2" display type 4		(FR41U)
	Vaned heatsink		(FL58N)
	Kit 'P' plus		(WR23A)
	Small thermopath		(HQ00A)
	DIL skt 14-pin	4 off	(BL18U)
	DIL skt 16-pin	3 off	(BL19V)
	Veropin 2141	18 off	(FL21X)
	Flow sensor		(YX86T)
	Speed sensor		(YX85G)
	MPG meter main PCB		(GA76H)
	MPG meter display PCB		(GA77J)

A complete kit of parts is available. Order As LW67X (MPG Meter Kit) Price £44.95
Price shown may have changed after 14/8/82.

HOME SECURITY SYSTEM

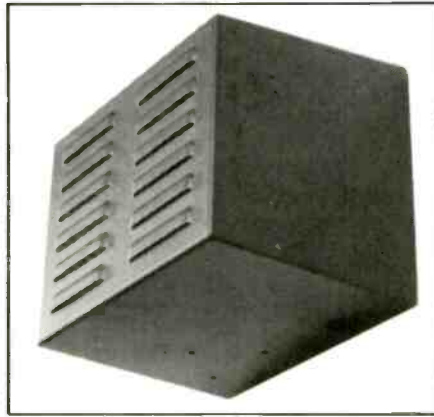
Continued from Page 11

external horns will sound along with LED 2. Turn the key switch to "dis-arm" and both horns should stop sounding. Note that the 12V external batteries supply the horn only, via TR2. When not in use, the current drain from B1 and B2 is approximately 5uA and will not effect the shelf life of the batteries greatly. If the external horn is not loud enough, make R5 on the external horn PCB & R9 on the main PCB into links.

Using The System

Various systems for sensing and triggering the alarm unit are available and are listed in the parts list. Typical connections are shown in Figures 18, 19 and 20. Note that for maximum security only five switches, each with a 22k resistor, should be used per input (10 switches per module) and connected as in Figure 18(C). With 6 modules in

use, up to 60 switches can be accommodated, using a two wire system, or 30 switches using the 4 wire system.

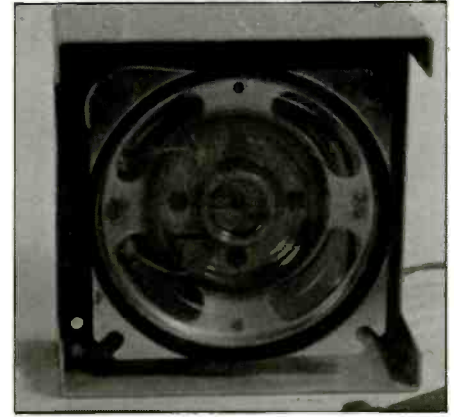


Wall mounted External Horn Box.

Whatever method is favoured, refer to the break contact setting up procedure and adjust RV1 and RV2 on each module for half the supply voltage. Any form of shorting, bridging, reversing or cutting connections will trigger the alarm.

If one input only, per module, is to be used, terminate the remaining input with a 22k resistor (see Figure 16) otherwise the alarm will keep sounding, with that channel switched in.

Magnetic reed switches can be mounted into door frames and the magnet into the door directly opposite. Surface type reeds are available for



External Horn has 104 dBA output at 3m.

metal frame works.

Pressure mats should be placed under carpets etc ensuring adequate clearance from furniture and metal foil strip can be fitted to glass panels. There will shortly be ultra sonic and microwave doppler detectors available and those will interface directly to the break contact module.

Finally, remember that setting the modules to half (+2.5V) supply rail will allow detection of short circuits or open circuits, within the contact loop so make or break contacts may be accommodated, using suitably placed 22k resistors. ■

Copies of issue 1 are still available, and include all these interesting projects:

Universal Timer. A comprehensive programmable controller for up to 4 mains appliances. There is storage for up to 18 program times, ons or offs and relay outputs. Complete construction details.

Combo Amplifier. Superb 120W MOSFET power amp with low-noise BI-FET pre-amp having built-in flanger, inputs for guitars, keyboards or microphones, and five step equaliser. Complete construction details.

Temperature Gauge. Coloured LED indication of 10°C to 100°C. Complete construction details.

Pass The Bomb! Low-cost easy to build electronic version of pass-the-parcel — keeps the kids amused for hours!

Plus six easy to build projects on Veroboard: Car Battery Monitor — Colour Snap Game — CMOS Logic Probe — Peak Level Indicator — Games Timer — Multi-Colour Pendant.

Copies of issue 3 are also available, and include the following projects:

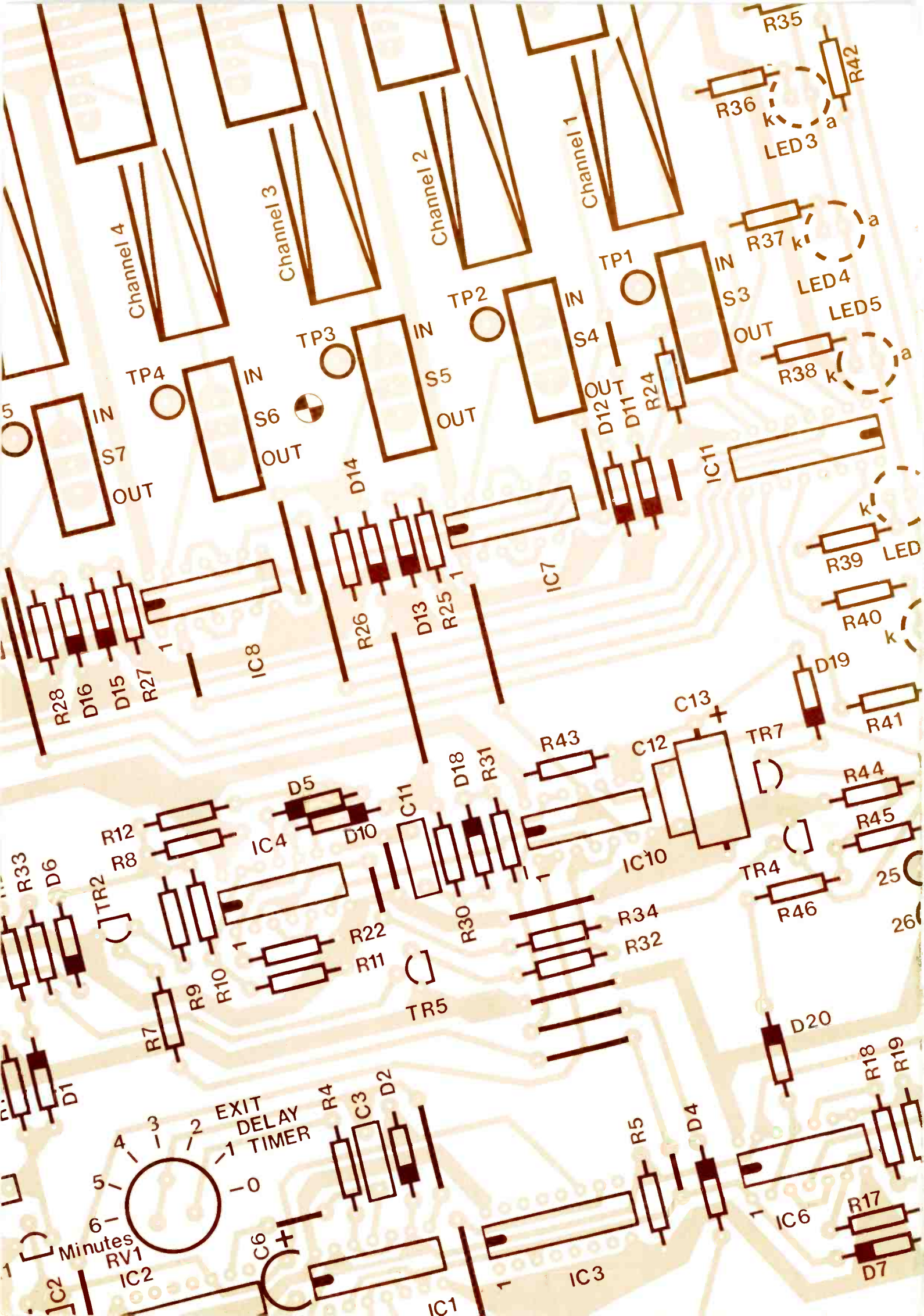
ZX81 Keyboard. A full size, full travel 43-key keyboard with the electronics to make graphic symbols, function mode and shift lock, single key selections. The two-colour legend for the keys is the same as the ZX81 keyboard. The keyboard plugs directly into the sockets in the ZX81 and a special adaptor is supplied to run the keyboard from the ZX81 power supply, so there's no soldering in the ZX81 at all. This full-size keyboard gives you fast, reliable entry — use it once and you won't be able to do without it again!

Stereo 25W MOSFET Amp. Supplied as a complete kit including wooden cabinet and printed and punched chassis, this superb 25W rms per channel amplifier has inputs for magnetic pick-up, tape deck, tuner and auxilliary. The kit is extremely easy to build, all but 5 components mounting directly on the pcb. There are only 7 interconnecting wires in all and when completed, no setting-up is required. With its superb frequency response, low noise, low distortion and the grandeur of MOSFET sound, the amplifier is second-to-none at the price.

Radar Doppler Intruder Detector. Home Office type-approved microwave unit gives coverage adjustable from about 2m to 20m. May be used on its own, or with our Home Security System.

Model Train Controller Remote Control Facilities. Full details of infra-red, radio or wired remote control units for our Digital Multi-Train Controller.





Channel 4

Channel 3

Channel 2

Channel 1

TP4

TP3

TP2

TP1

IN

S7

OUT

IN

S6

OUT

IN

S5

OUT

IN

S4

OUT

IN

S3

OUT

R28

D16

D15

R27

IC8

R26

D13

R25

IC7

D14

D12

D11

R24

IC11

R39

LED

R40

k

R12

R8

IC4

D5

D10

C11

D18

R31

R43

C13

TR7

R41

TR2

R9

R10

1

R22

R11

TR5

R30

IC10

R34

R32

TR4

R46

R44

R45

25

26

4

3

2

EXIT

DELAY

TIMER

1

0

R4

C3

D2

R5

D4

D20

R18

R19

IC6

R17

D7

IC3

Minutes

RV1

IC2

IC1