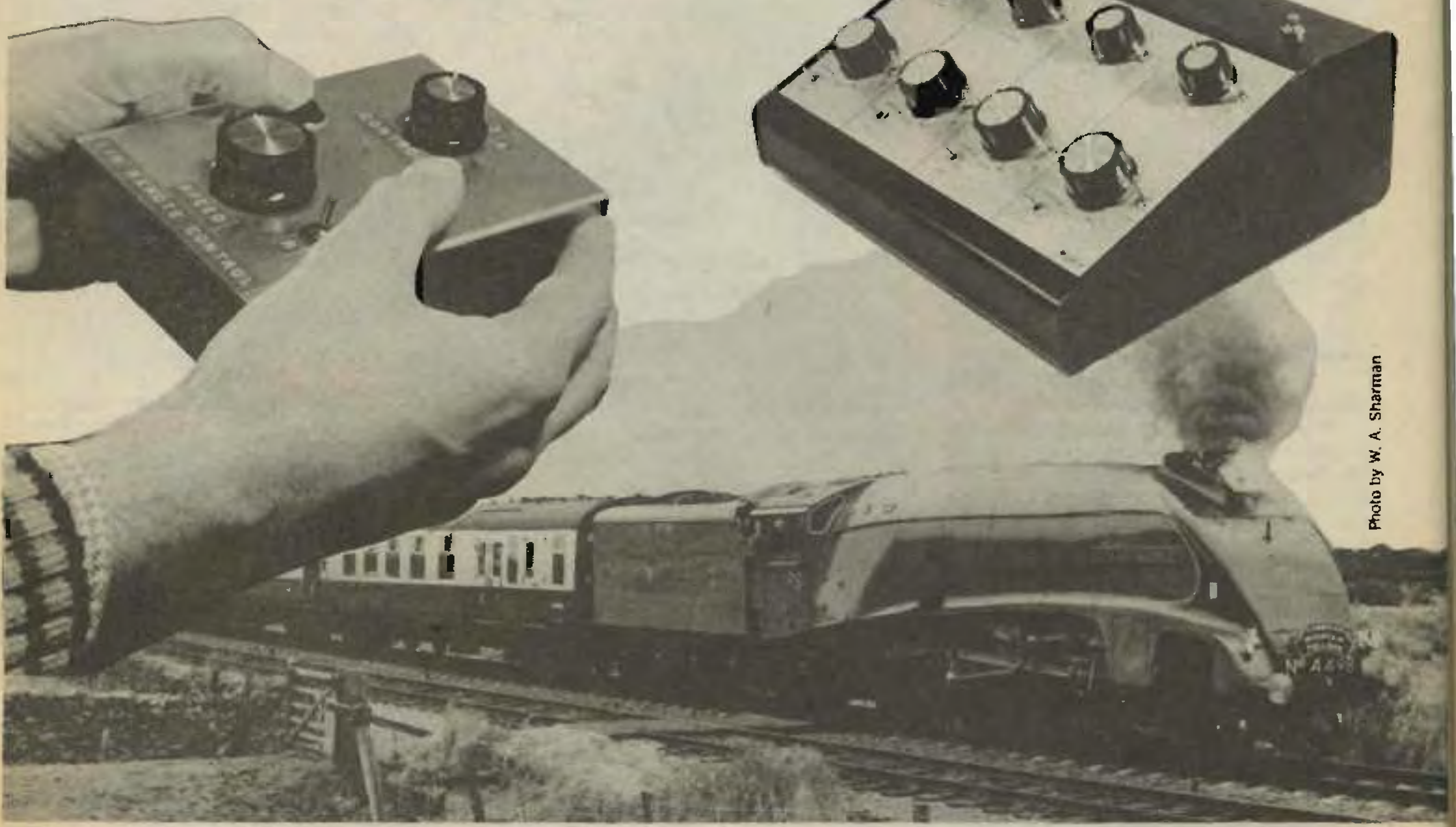
REMOTE CONTROL

for Digital Multi-Train Controller *by Robert Kirsch*

★ **Infra-red, radio and wire remote control systems described**
★ **Any 4 locomotives controlled simultaneously from remote controller**



The second in this series of articles on model railway projects describes the addition of remote control facilities to the train controller described in the previous issue. This addition enables any or all of the four control boards to be commanded by an 8-bit digital input either from the remote controller or a computer. The data for each controller is latched and thus one train can be set running and the command changed to another controller to enable up to four trains to be controlled simultaneously by the external input. Figure 1 shows the block schematic diagram of the remote control system.

Additions To Control Board Circuit

Figure 2 shows the complete circuit of the control board with the extra parts added. As described previously, the board works by allowing a group of TS pulses to be sent to the 6 common lines depending on the direction and train to be controlled. The length of this group of pulses determines the speed of the train; thus with no pulses the train is stationary and with a full ten pulses per group, the train is at maximum speed.

In the local mode, the number of pulses in the group is set by selecting one of the ten outputs from the 4017 decade counter (IC1) and using this to trip the output gate after the appropriate number of pulses have been sent. The same applies in the remote mode, except that in this case the output gate is tripped when the output from the binary counter (IC101) is the same as the 4-bit input from the external source. This is detected by the 4-bit magnitude comparator (IC102). The direction in travel in the remote mode is controlled by simply gating the TS pulses fed to the appropriate line

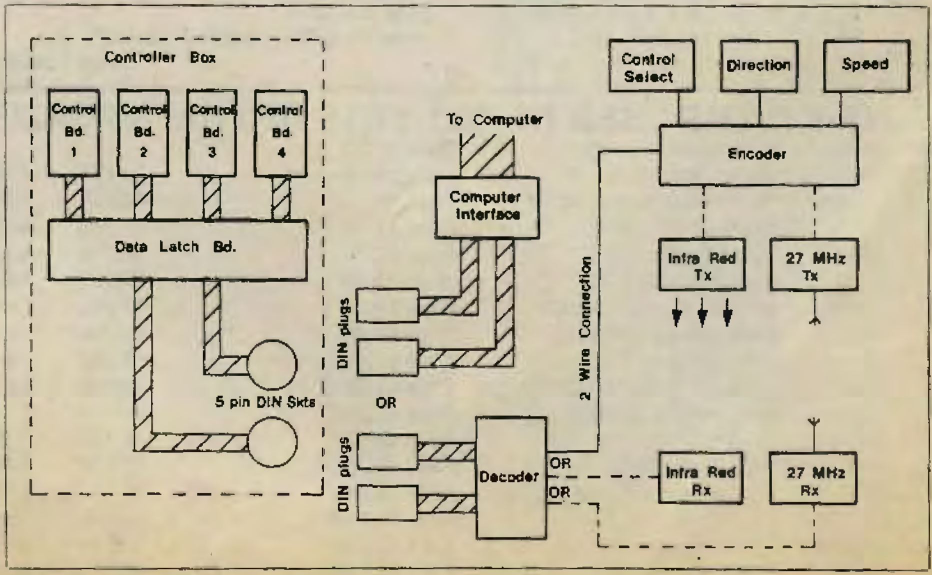


Figure 1. Block schematic showing all options.

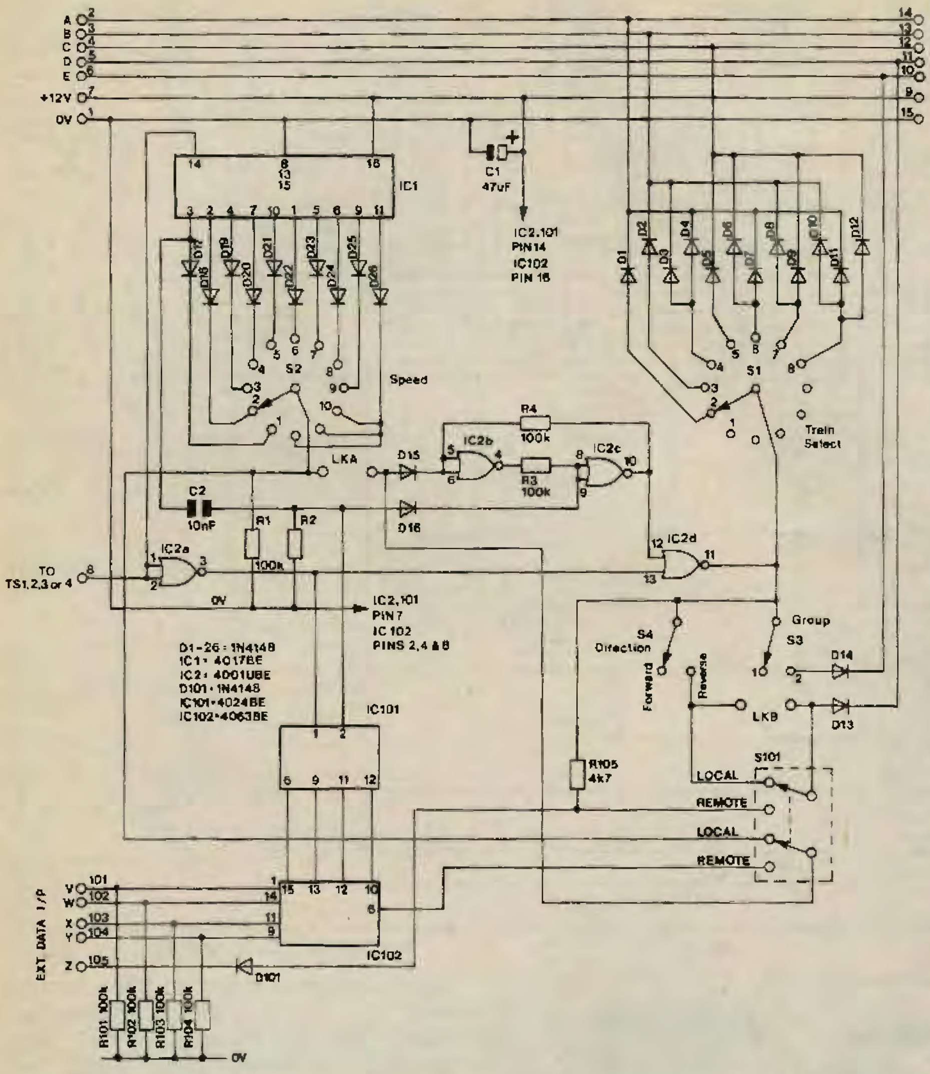


Figure 2a. Circuit diagram of complete Control board.

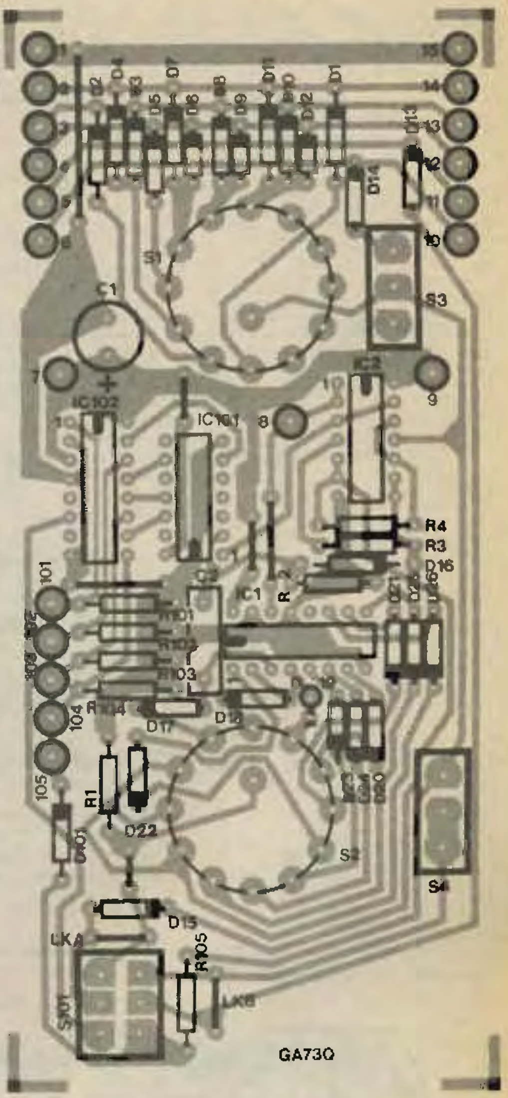
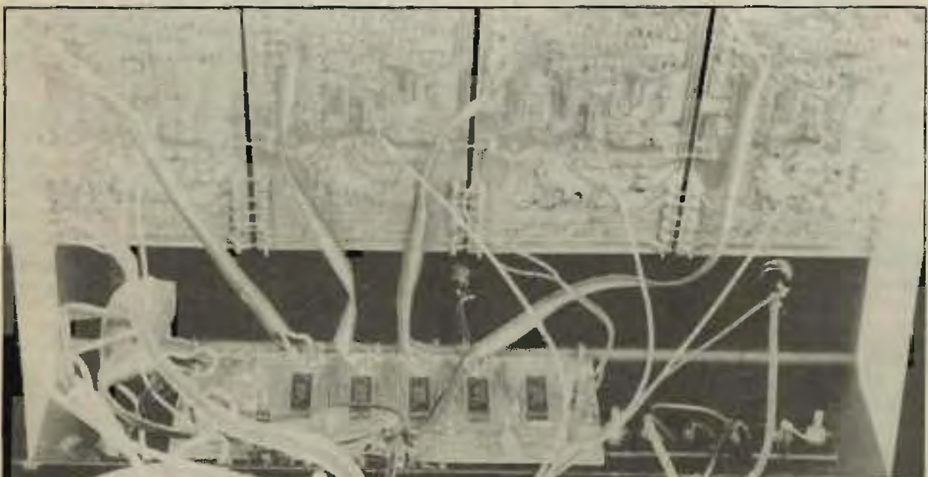


Figure 2b. Component layout of Control board.



Interior view of controller with Data Latch board fitted.

under control of the fifth bit of external data.

Remote Data Latch Board

The data for each of the four control boards is stored by one of the four latches (IC1 to 4); see Figure 3. The control board to be commanded is selected by the conditions applied to the input lines B5 and B6, and this is decoded by IC5 and the diodes D2 to D9 allowing the TS pulse to clock only the required latch.

The eighth bit of the control word may be used for any function required, but we have shown it connected to the power reset circuit. This requires an output only when the button on the remote controller is pressed, so no latch is needed.

Remote Control Data Encoder Board

This board enables any one of the four control boards to be selected and the speed and direction of the train selected by that board to be controlled.

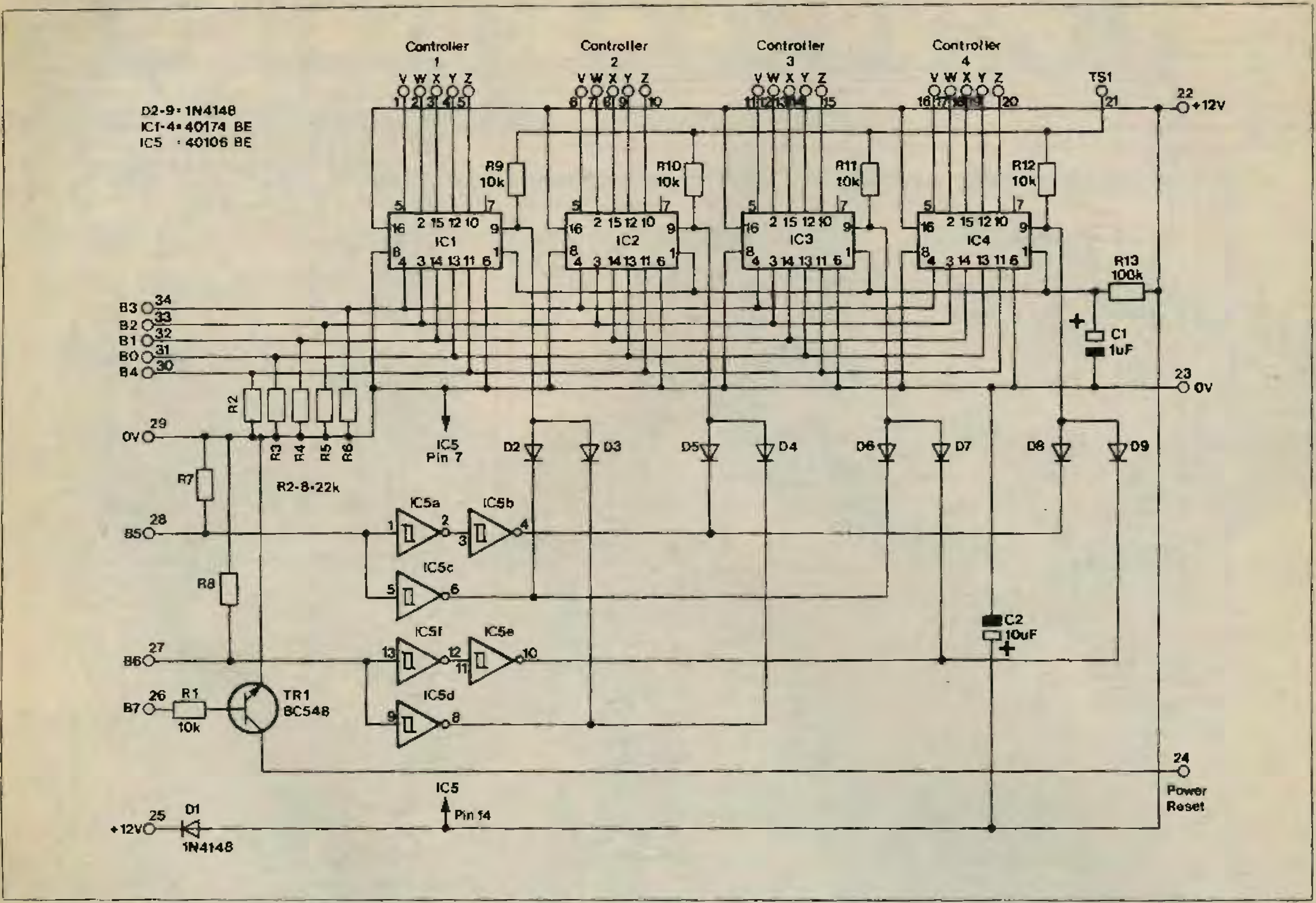


Figure 3a. Circuit diagram of Latch board.

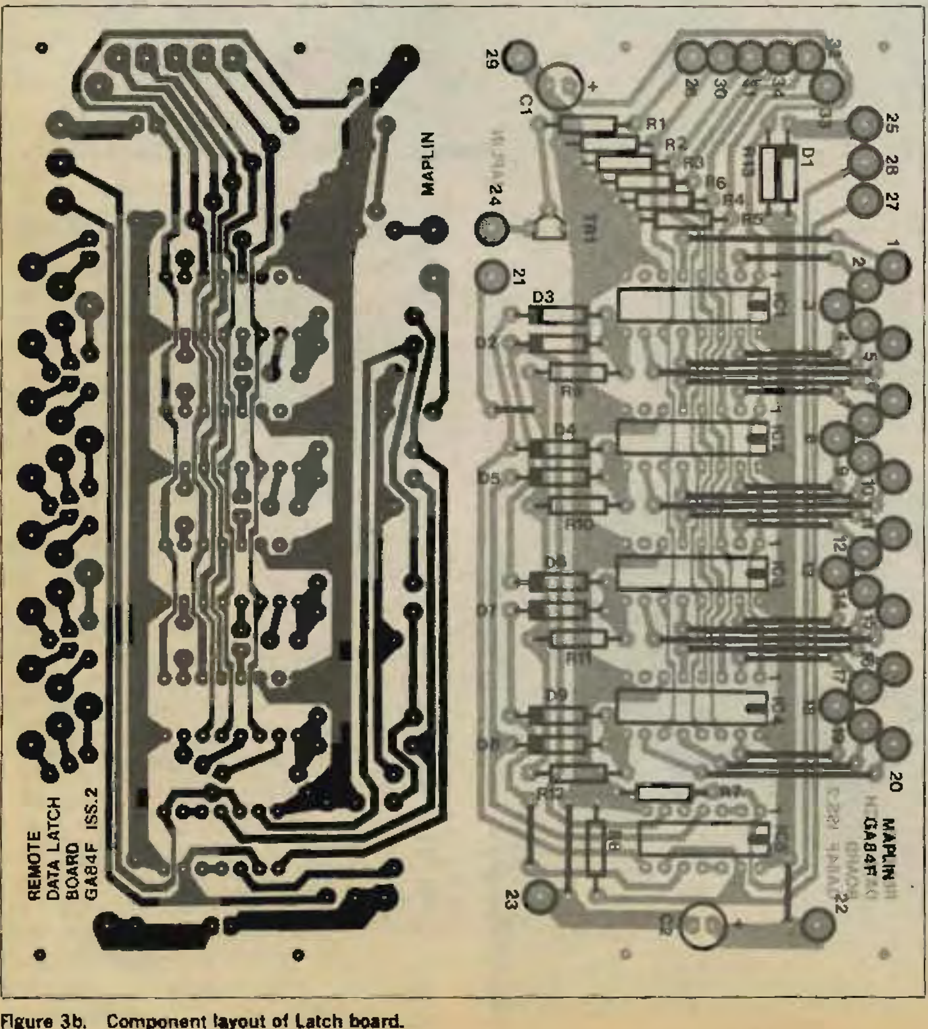


Figure 3b. Component layout of Latch board.

The information is turned into a serial 8-bit word and may be transmitted by radio, wire or infra-red link to the decoder at the train controller.

The serial data sent consists of one long sync pulse followed by eight pulses whose length is determined by whether the bit is at '1' or '0'. A short pulse is sent for 0 and a longer pulse for 1, but a gap is always left between bits to enable the counter in the decoder to step to the next bit.

All the pulses used in the encoder are derived from IC1 (Figure 4) whose mark/space ratio is set to give the critical 'on' period for data '1' transmissions. The output of this IC is fed to the decade counter (IC2) which serves two functions. The first is to select each one of the eight gates (IC3 and IC4) in their correct sequence and at the last two counts, send the sync pulse. The second function of IC2 is to provide sequential pulses to the speed control in decimal form at the same time as the binary counter (IC7) is counting up in binary.

When the decimal count reaches the selected speed, the binary data is clocked into the latch (IC6). The data held in this latch is sent at the appropriate time during the serial word's transmission. A simple diode encoder turns the information from the controller selector into the required two bits to be transmitted. Sync pulses and inter-word gaps are inserted by the gates (IC8) and the output is fed to the emitter follower (TR1).

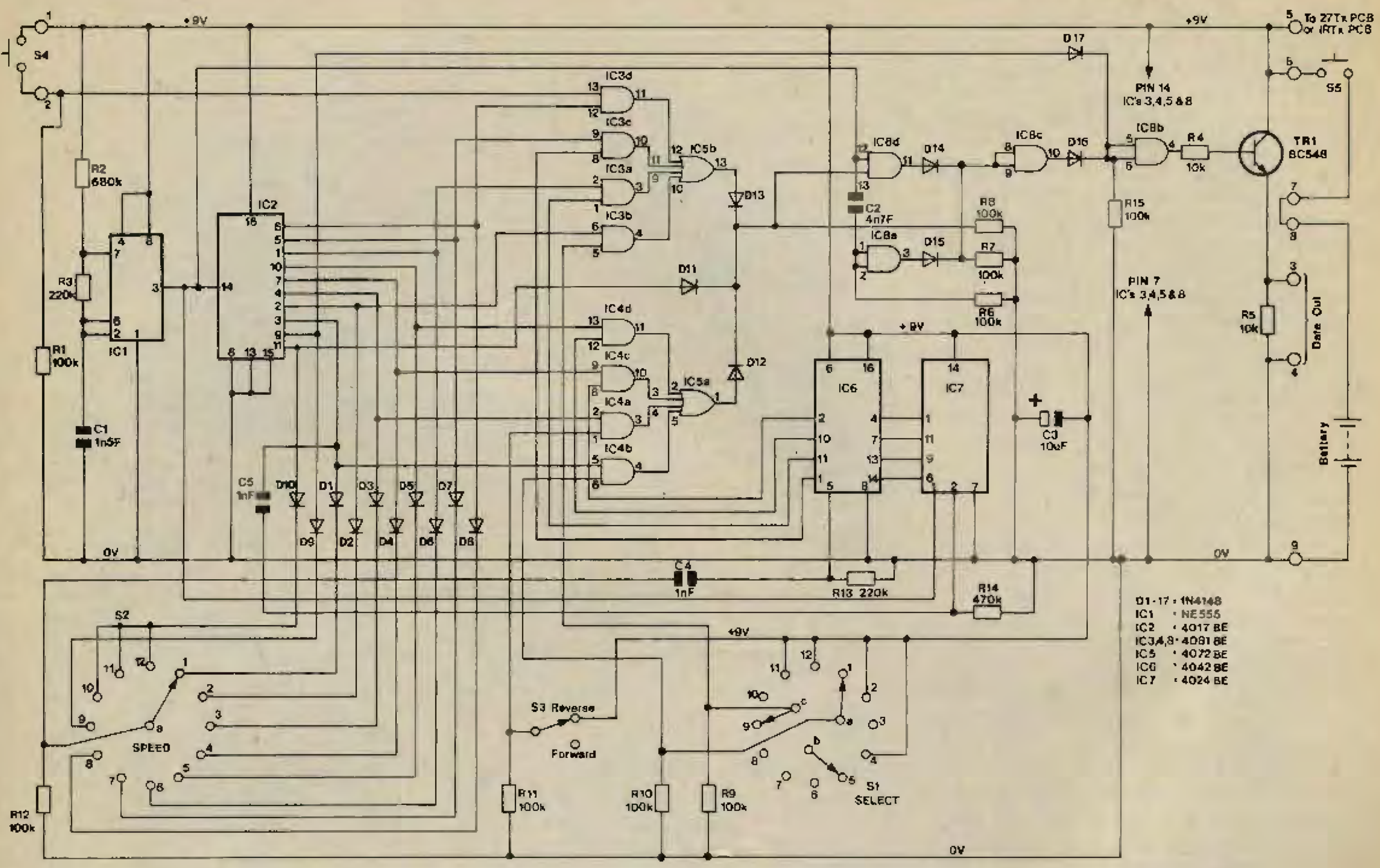


Figure 4a. Circuit diagram of Encoder board.

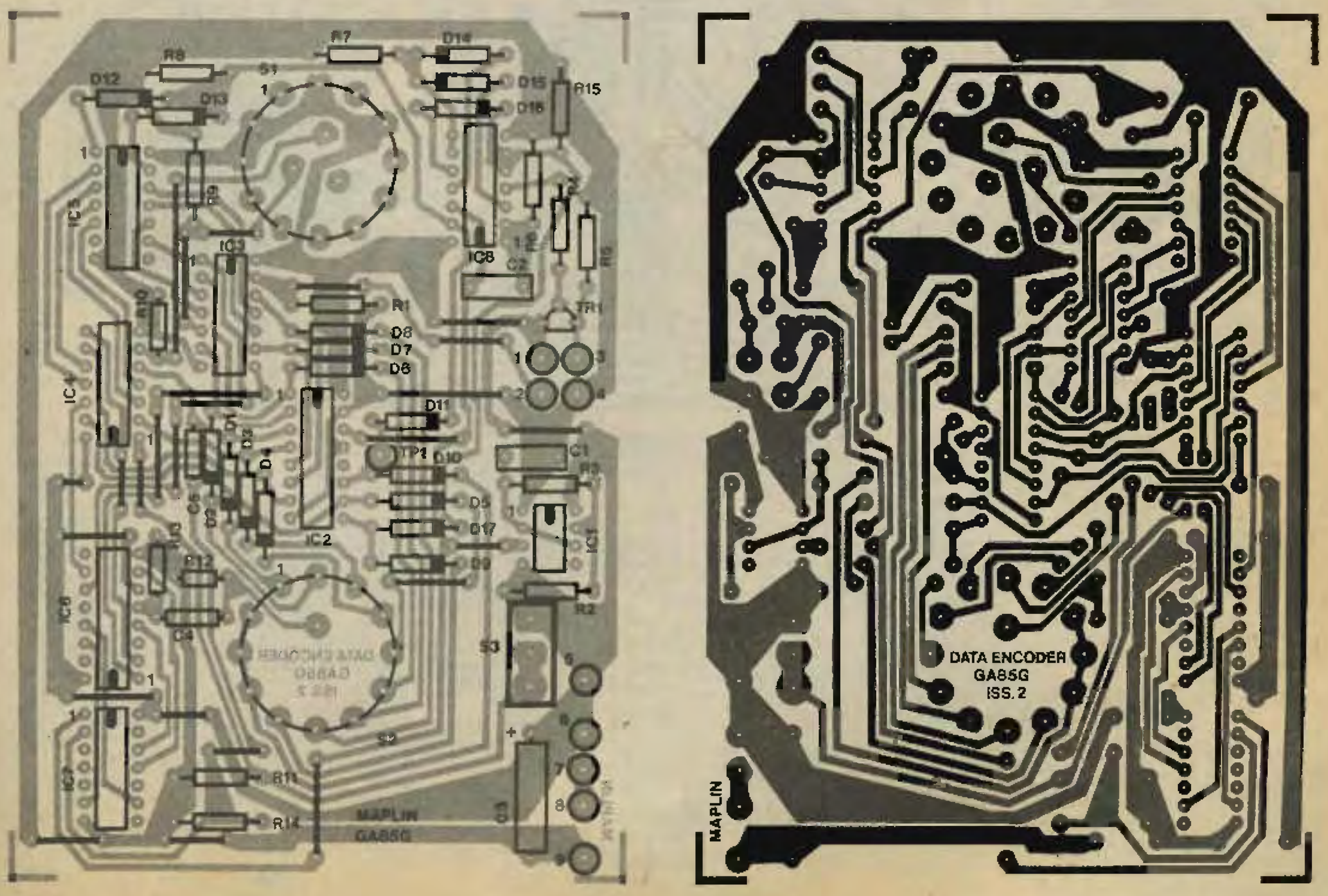


Figure 4b. Component layout of Encoder board.

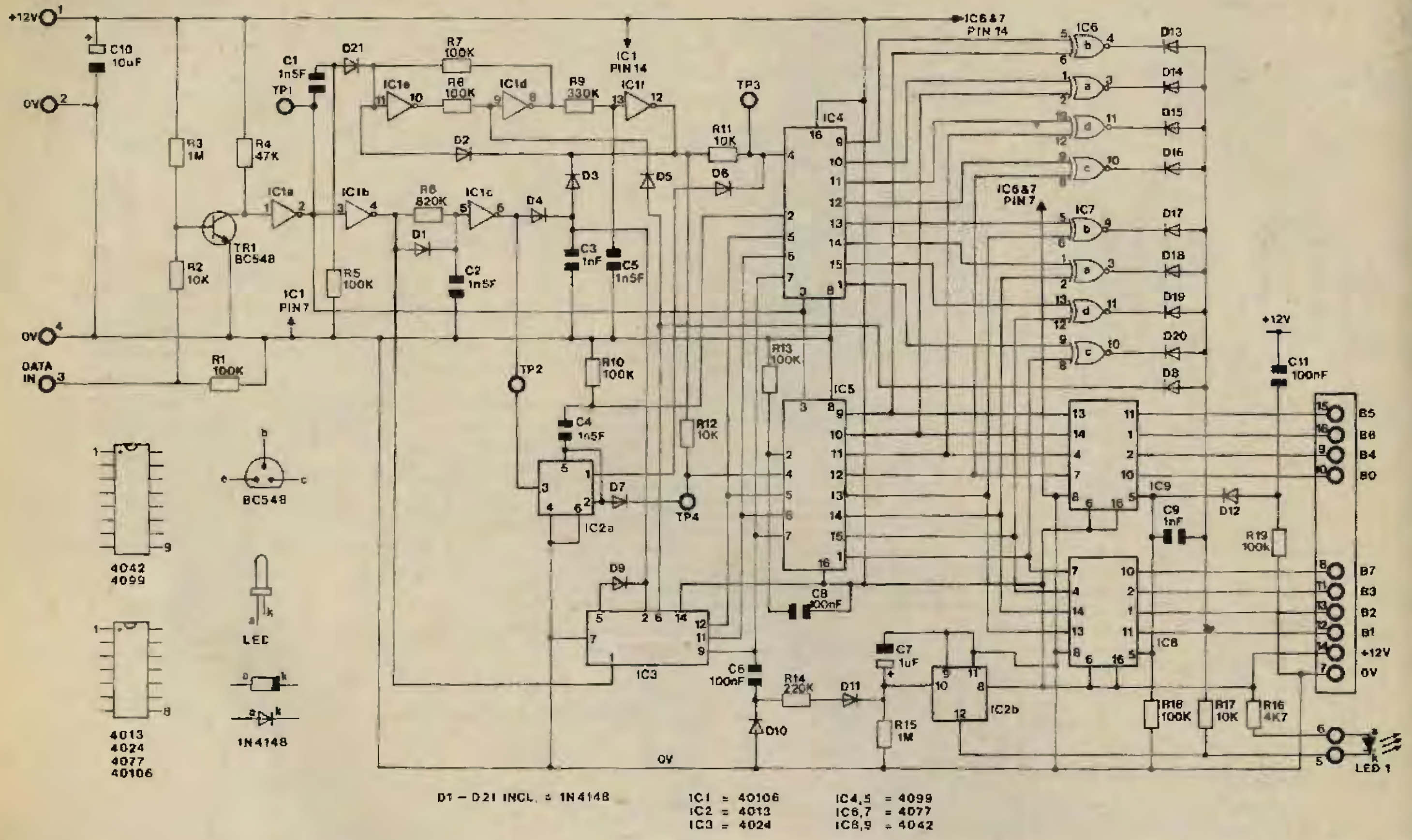
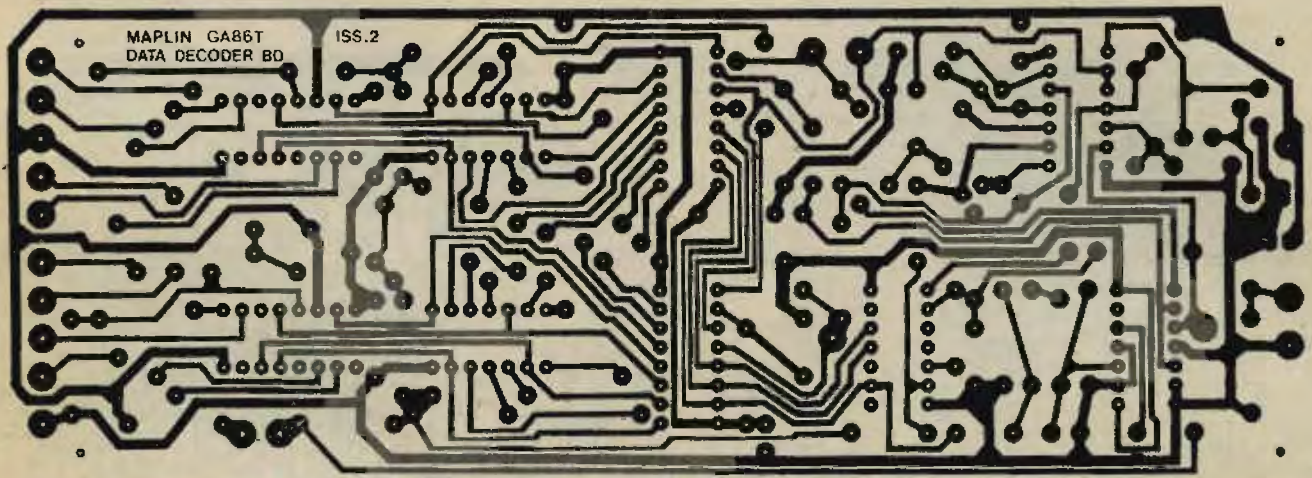


Figure 5a. Circuit diagram of Decoder board.



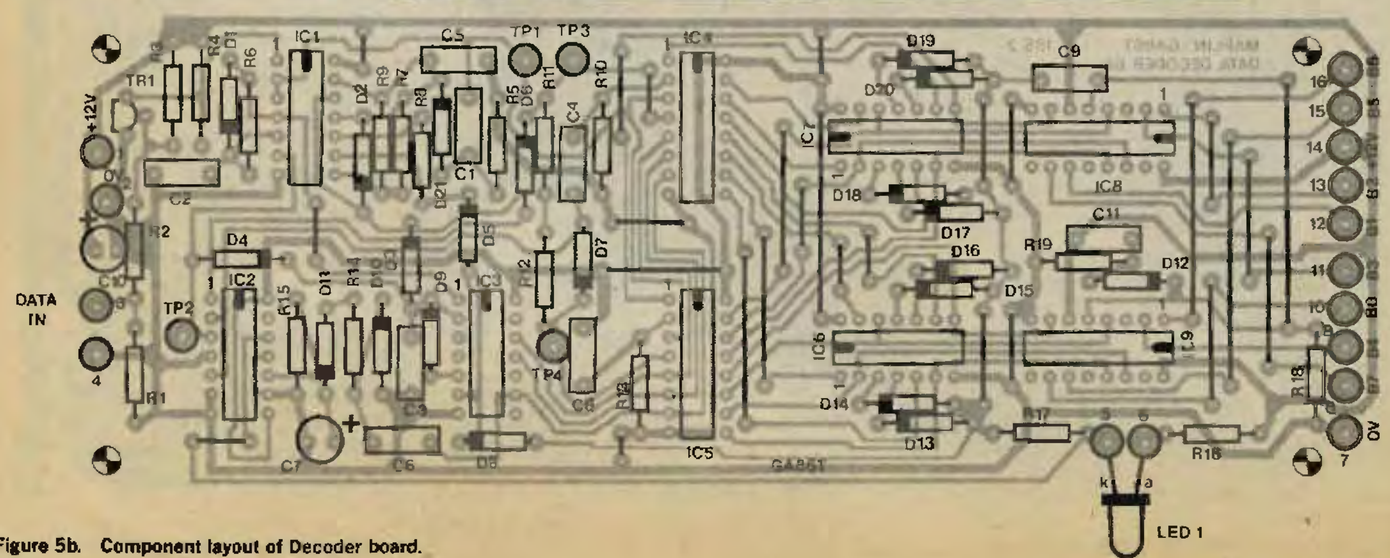
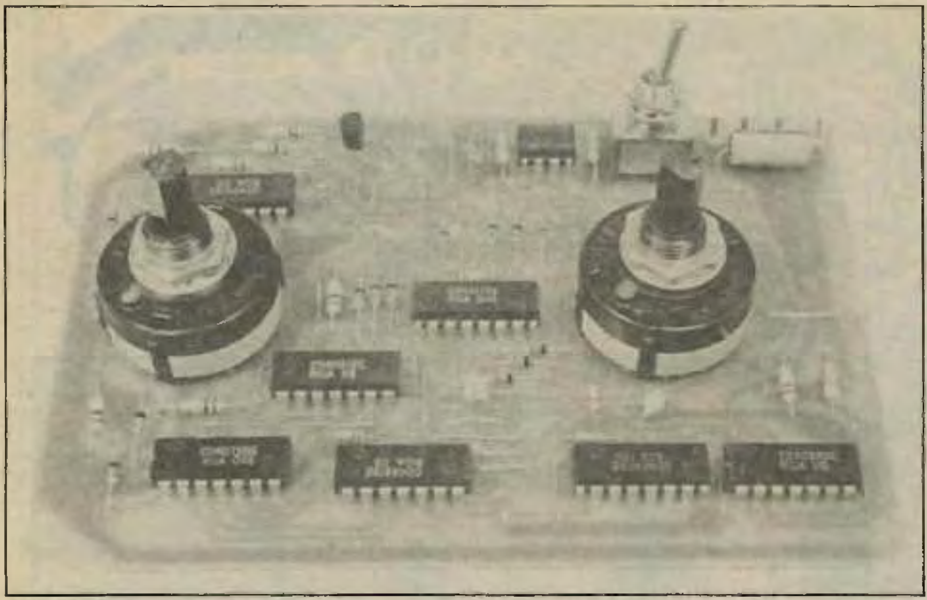
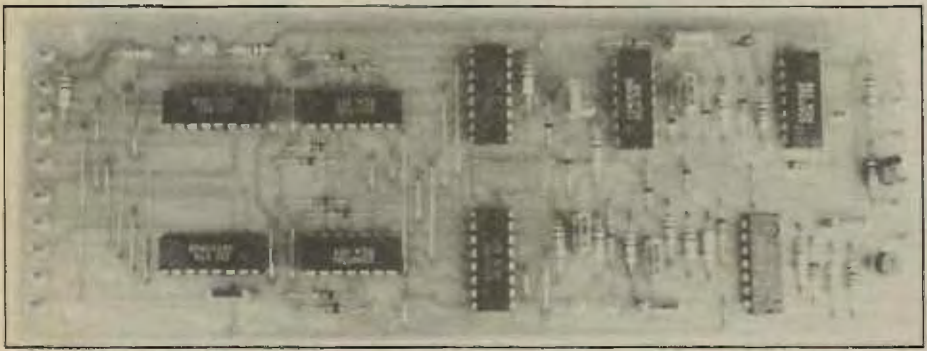


Figure 5b. Component layout of Decoder board.



Data Encoder board.



Data Decoder board.

Remote Control Data Decoder Board

The function of this board is to turn the serial information received from the encoder into a parallel 8-bit word. The system must check that the data received is correct and reject false signals caused by interference. This is done by comparing the data received in one word with the data received in the next word and clocking this data into the output latch only if both words are the same. A detector also monitors the output of the counter and if these pulses are not of the correct timing, the output latches are inhibited and no data transfer can occur.

The incoming signal is first buffered and amplified by TR1 (Figure 5) and then squared and inverted by the Schmitt trigger (IC1A). At this point, the signal should be the same as that leaving the remote encoder.

The signal is now split into three paths. The first is via IC1 B and C which forms a sync detecting unit, giving an output only after the incoming signal has remained at a high condition for the appropriate sync period. This sync pulse is used to reset the binary counter IC3 after it has completed its scan of the addressable latches. This binary counter is stepped by every positive transition of the input signal and its binary output is fed to the two addressable latches (IC4 and IC5); addressing each latch in the same sequence as the incoming bits of the serial signal.

The second path that the input signal can take is via C1. This produces a test pulse, a fixed time after each clocking pulse is received and this is used to enable the selected one of the two addressable latches which are also being fed with incoming data. If the input is high at the time of the test pulse, a '1' is clocked into the addressed latch and if the input is low, a '0' is clocked into the latch.

Each of the two latches is selected alternatively every frame and they are controlled by dividing the sync pulse rate by two in IC2 and using this to inhibit one or other of the latches. At the end of every two frames only one of the latches is cleared back to all low outputs.

The two sets of eight outputs from both latches are compared by the exclusive-NOR gates (IC6 and IC7) and when both latches contain the same data they allow a pulse to clock the data into the two 4-bit output latches (IC8 and IC9). This clock pulse is inhibited if the signal fail detection circuit sees an incorrect input pulse train.

Data Link

There are three methods of connecting the hand-held remote unit to the decoder located at the train controller. The simplest is to use a 2-wire cable which may be connected say, to several sockets located around the layout, to enable the remote unit to be plugged in wherever required.

The second method is by way of a 27MHz radio link and the third via an infra-red link.

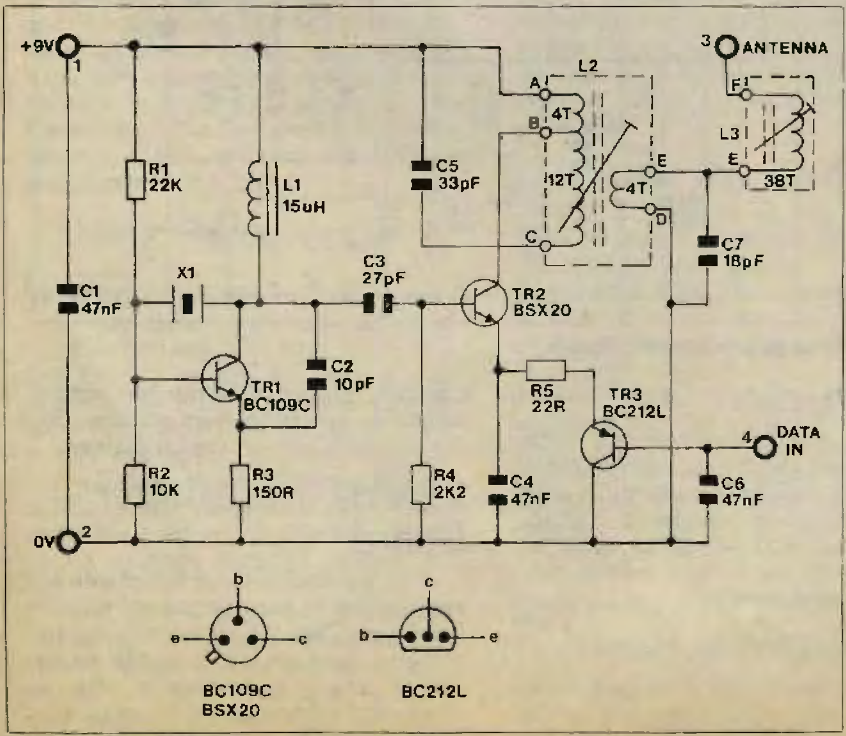


Figure 6a. Circuit diagram of 27MHz transmitter.

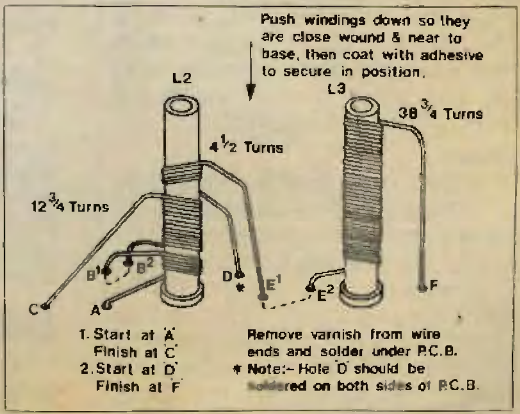


Figure 6b. Coil winding details for 27MHz transmitter.

27MHz Radio Data Link

Transmitter

The transmitter is a low-powered 27MHz crystal-controlled circuit of fairly conventional design. TR1 forms an untuned crystal oscillator which runs all the time that the controller is in operation. The output of this oscillator is fed to the base of TR2 which acts as an output amplifier and modulator. Incoming data is fed to the base of TR3 whose emitter is connected to the emitter of TR2. Thus, when the data is low, TR2 is turned on and passes the rf signal to its collector and the aerial circuit and when the data is high TR2 and TR3 turn off and little or no rf is transmitted.

Receiver

This is built on a standard board designed for model control purposes. Due to the relatively short range required for this application, the rf amplifier in the receiver is not used and is strapped out. This reduces the effect of high levels of external interference. The local oscillator is crystal controlled at 455kHz below the incoming rf frequency and fed to the mixer where it meets the incoming signal from the aerial tuned circuit L1. The 455kHz intermediate frequency is amplified and fed to the detector (D1) via two tuned circuits (IFT1 and IFT2). The signal at the output of the detector is fed via C16 to the data decoder and its DC level is used for controlling the receiver gain (agc).

Licensing Requirements

Please note that a licence is no longer required to transmit and receive signals in the 27MHz band being used for model control. Since the radio link described here meets all the requirements for transmitters and receivers in this band, it is perfectly legal to use it without a licence. Indeed, a licence for this use is simply not available any more.

Infra-Red Data Link

Transmitter

IC1 forms an oscillator running at about 30kHz with a very short, but high amplitude, pulsed output. This output is used to switch TR2 and thus pass high current pulses of about ½A through the four infra-red emitting diodes (D2 to D5) for a very short period. These pulses are turned on and off by TR1 which is controlled by the data input from the encoder.

Receiver

The infra-red signal is received by the diodes D3 and D4 and the 30kHz modulated pulses are amplified by TR1 and TR2. D1 and D2 form a detector and provide a signal relative to the modulation. This signal is amplified by TR3 and any 30kHz is filtered out by its feedback circuit. This signal now feeds TR4 which forms an inverter and output stage.

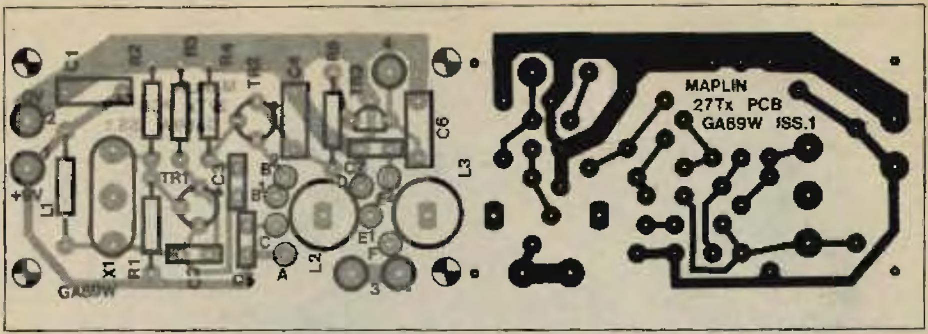
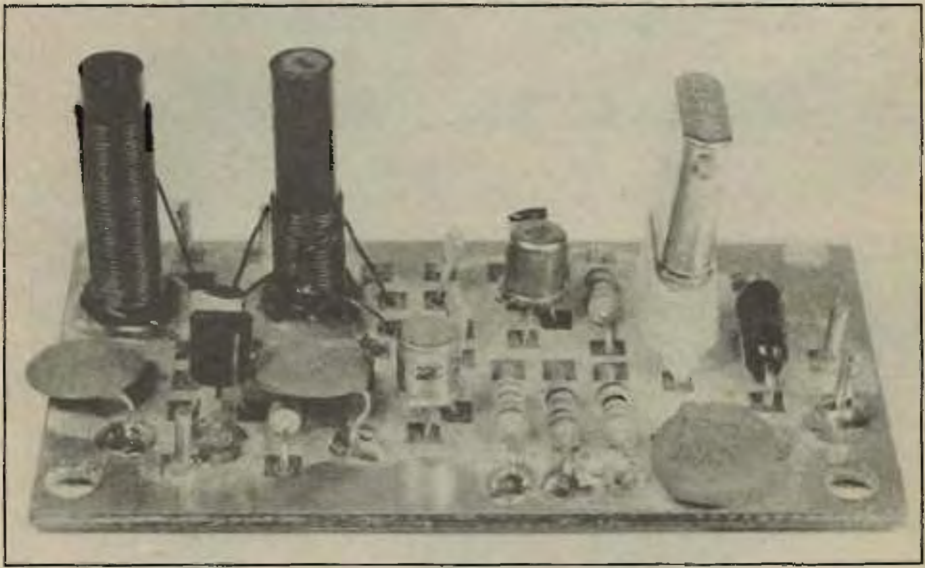


Figure 6c. Component layout of 27MHz transmitter board.



27MHz Transmitter board.

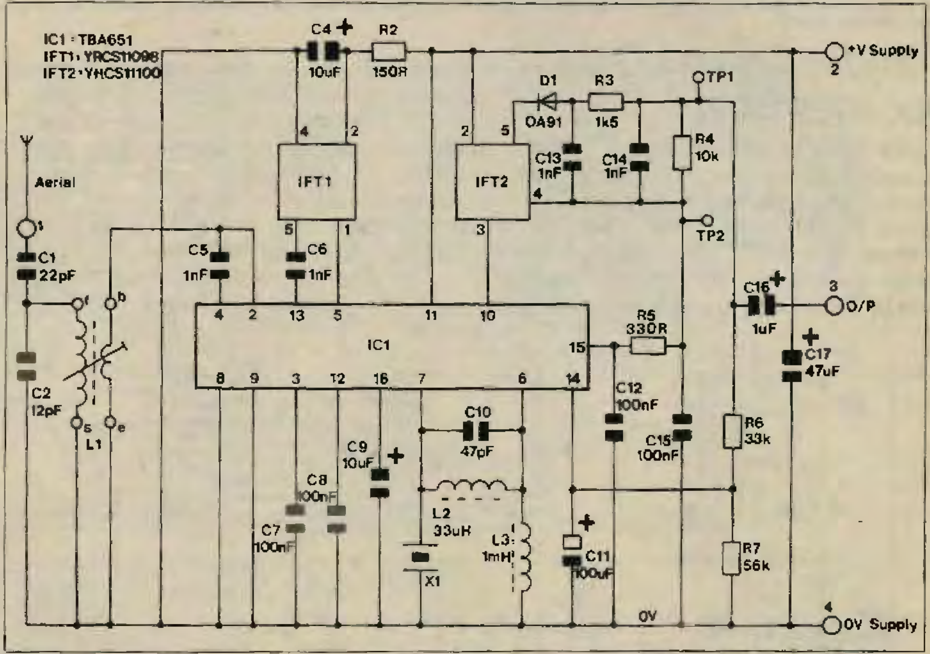


Figure 7a. Circuit diagram of 27MHz receiver.

Construction

Construct all boards referring to the board legend and the appropriate parts list, leaving the insertion of the IC's until last. Refer also to the special instructions below. Add the extra parts to whichever of the control boards you wish to control remotely.

Data Encoder Board

On this board, the Veropins have to be inserted from the component side to aid wiring when the board is mounted in the box. Ensure that the two rotary switches are in the correct positions. S2 is the switch without the click-stops.

27MHz Transmitter Board

This is a double-sided board with an earth-plane on the component side of the board. All the wires should be soldered on both sides of the board except where a clearance hole is provided for component leads on the earth plane side. Insert and glue the two

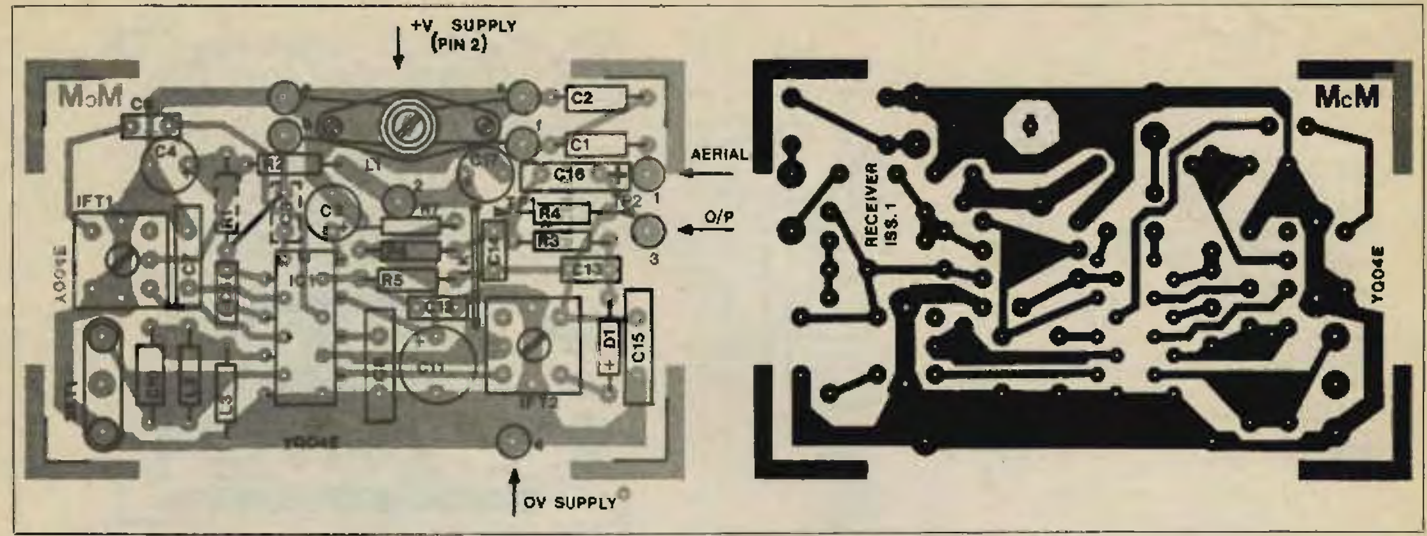
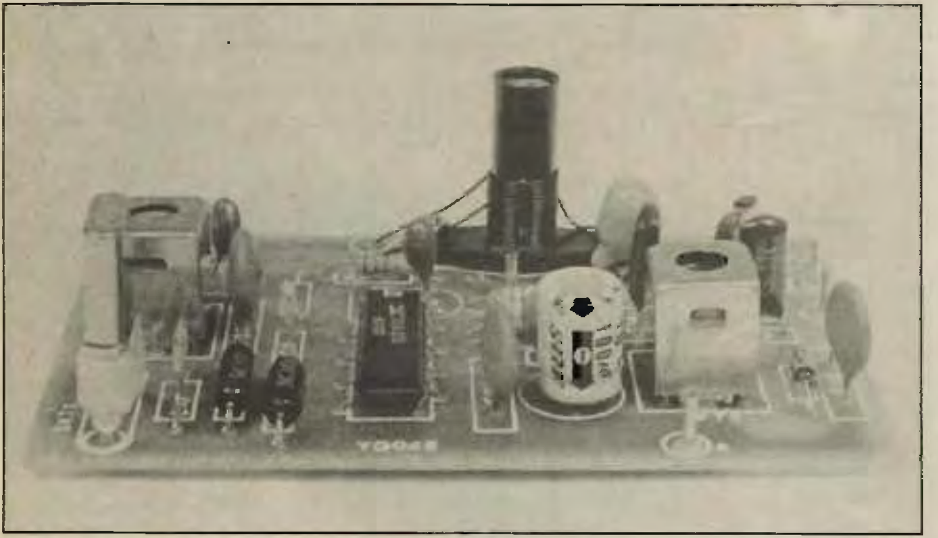


Figure 7b. Component layout of 27MHz receiver board.



27MHz Receiver board.

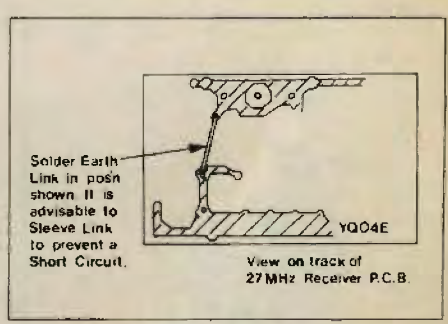


Figure 7c. Addition of earth link to 27MHz receiver board.

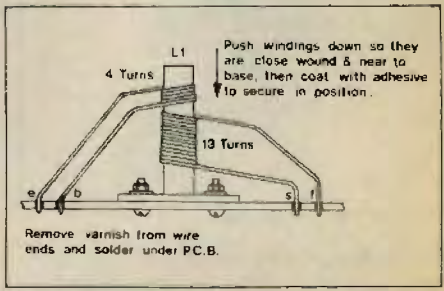


Figure 7d. Coil winding details for 27MHz receiver.

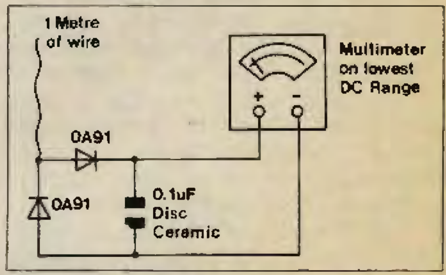


Figure 8a. RF monitor for transmitter alignment.

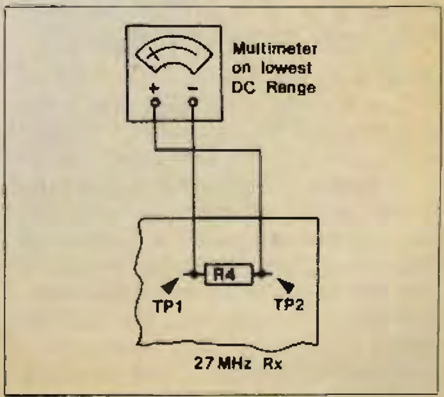


Figure 8b. Meter connections for receiver alignment.

formers for L2 and L3 into the board and wind the coils using 28swg enamelled copper wire referring to Figure 6B.

Start the windings at points A and D and wind up the formers. When the windings are completed they should be fixed with cyanoacrylate adhesive and allowed to dry before setting up the transmitter. The aerial consists of a length of palladium wire about 45cm long connected to pins.

27MHz Receiver Board

Ensure correct positioning of the two i.f. transformers IFT1 and IFT2, and also the two chokes L2 and L3. The positive end of D1 is the end with the band. Note that R1 and C3 are not used in this application and are replaced with a link as shown in Figure 7B. An additional earth strap should be added under the board using a short length of tinned copper wire as shown in Figure 7C.

Wind the coil L1 referring to Figure 7D using 28swg enamelled copper wire. A length of tinned copper wire about 1.5cm long should be soldered to each end of R4 to form TP1 and TP2. The aerial is made from a length of palladium wire about 45cm long connected to pin 1 on the receiver board.

The crystals used in the transmitter and receiver must be a pair, though any colour will do. The crystal with the higher frequency is fitted in the transmitter. The receiver should be sited as far away from the layout as possible in order to reduce electrical interference problems.

Infra-red Receiver

The positioning of the infra-red receiver diodes will affect the range of the system. They should be shielded from direct light both artificial and sunlight. A simple reflector behind the diodes and a lens system will improve the range. Nevertheless, a range of about 6 metres can be expected with no additions with the transmitter pointing directly at the receiver diodes. The receiver must be mounted in a metal box with the box connected to 0V, otherwise the very sensitive circuit will pick up radio interference.

Setting-up 27MHz Transmitter & Receiver

Transmitter

Construct the rf monitor as shown in Figure 8a and connect to a suitable

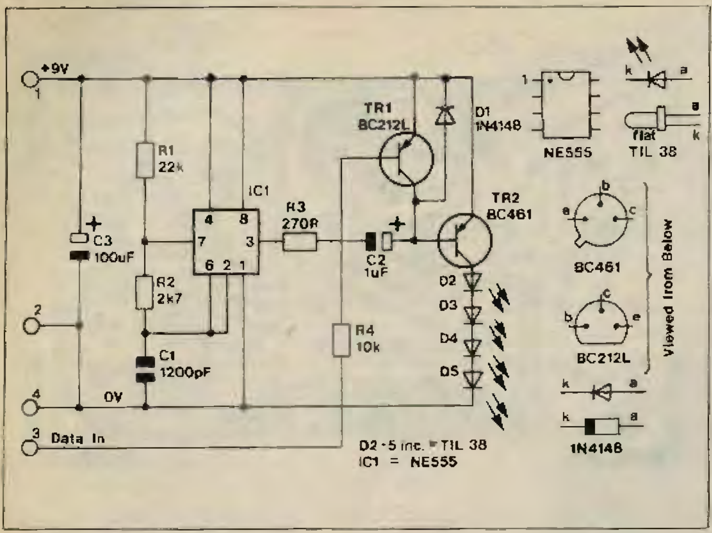


Figure 9a. Circuit diagram of Infra-red transmitter.

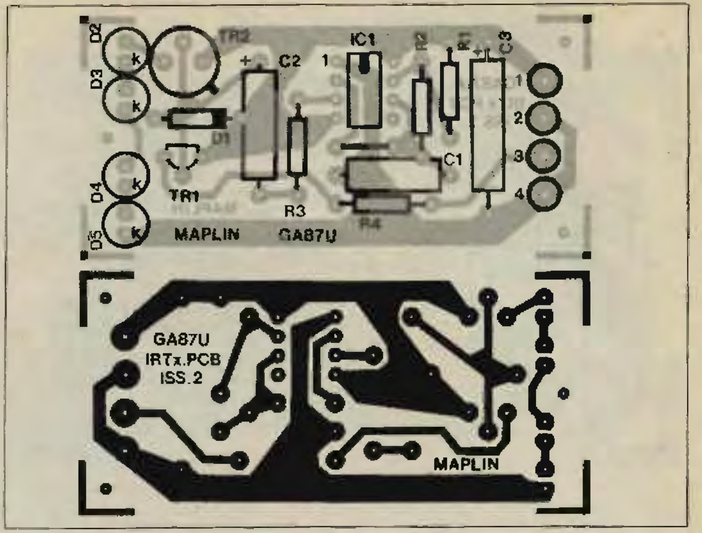
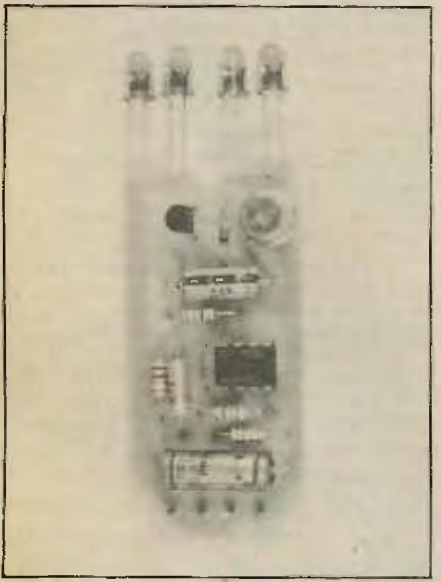


Figure 9b. Component layout of Infra-red transmitter board.



Infra-red Transmitter board.

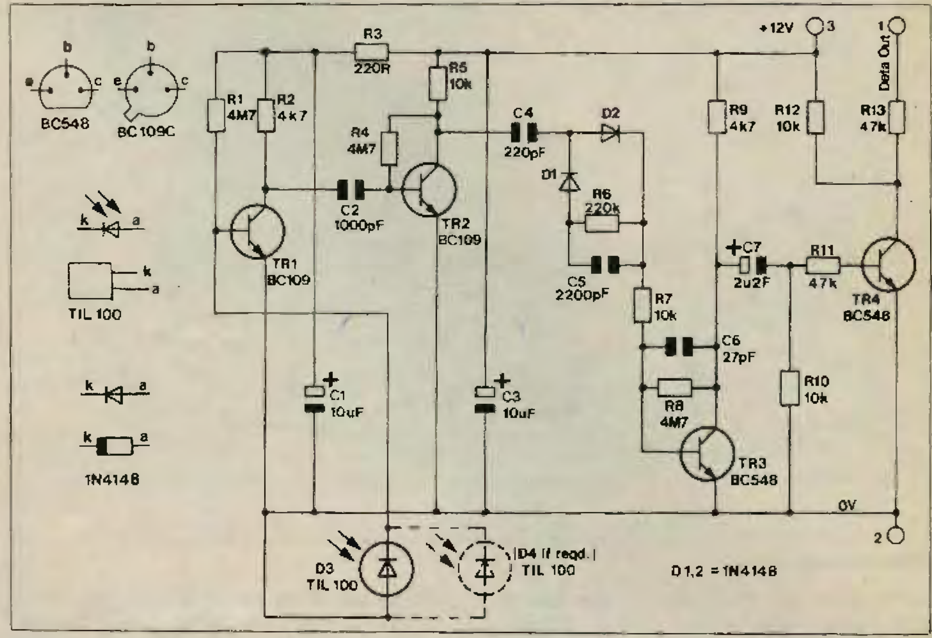


Figure 10a. Circuit diagram of Infra-red receiver.

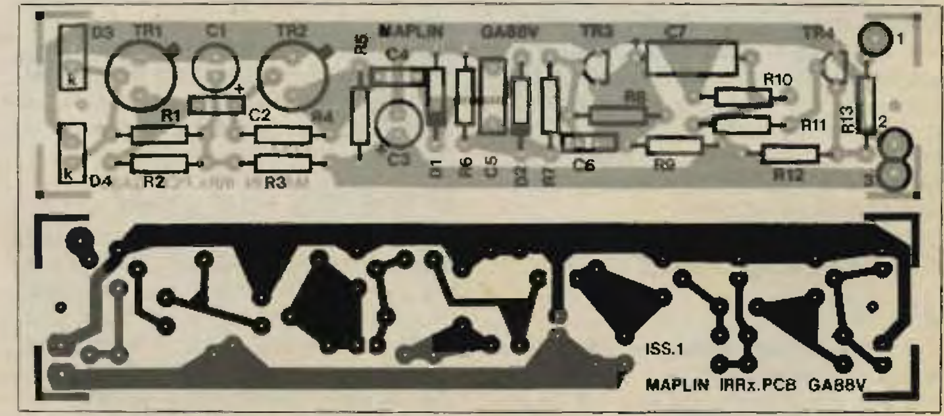


Figure 10b. Component layout of Infra-red receiver board.

Infra-red Receiver board.

meter. Install the battery in the hand-held controller and hold the aerial near the wire attached to the monitor. When the transmit button is pressed, a reading should be obtained on the meter. Adjust L2 for maximum reading.

Move the aerial away from the monitor wire until a reading is just present and adjust L3 for maximum reading. Keep moving the aerial further away until a peak setting is found at the greatest distance away from the monitor wire. The controller should be held in a position as near as possible to that in which it will be used during the setting up of L3 to obtain maximum output under working conditions.

Receiver

Connect the receiver to the train controller and connect a suitable meter to TP1 and TP2 (Figure 8b) on the receiver board. Temporarily short out the transmit push button on the hand-held unit in order to provide a continuous transmitted signal. A reading should be obtained on the meter when the hand-held unit is brought near the receiver aerial.

Move the transmitter away until the reading on the meter falls and then adjust L1, T1 and T2 in turn for

CONTROL CODE CHART							
	SPEED	DIRECTION	CODE No.		SPEED	DIRECTION	CODE No
CONTROL BD 1	0 ↓ 10	Forward	0 ↓ 10	CONTROL BD 2	0 ↓ 10	Forward	32 ↓ 42
	0 ↓ 10	Reverse	16 ↓ 26		0 ↓ 10	Reverse	48 ↓ 58
CONTROL BD 3	0 ↓ 10	Forward	64 ↓ 74	CONTROL BD 4	0 ↓ 10	Forward	96 ↓ 106
	0 ↓ 10	Reverse	80 ↓ 90		0 ↓ 10	Reverse	112 ↓ 122

Figure 11. Table of decimal codes for control functions.

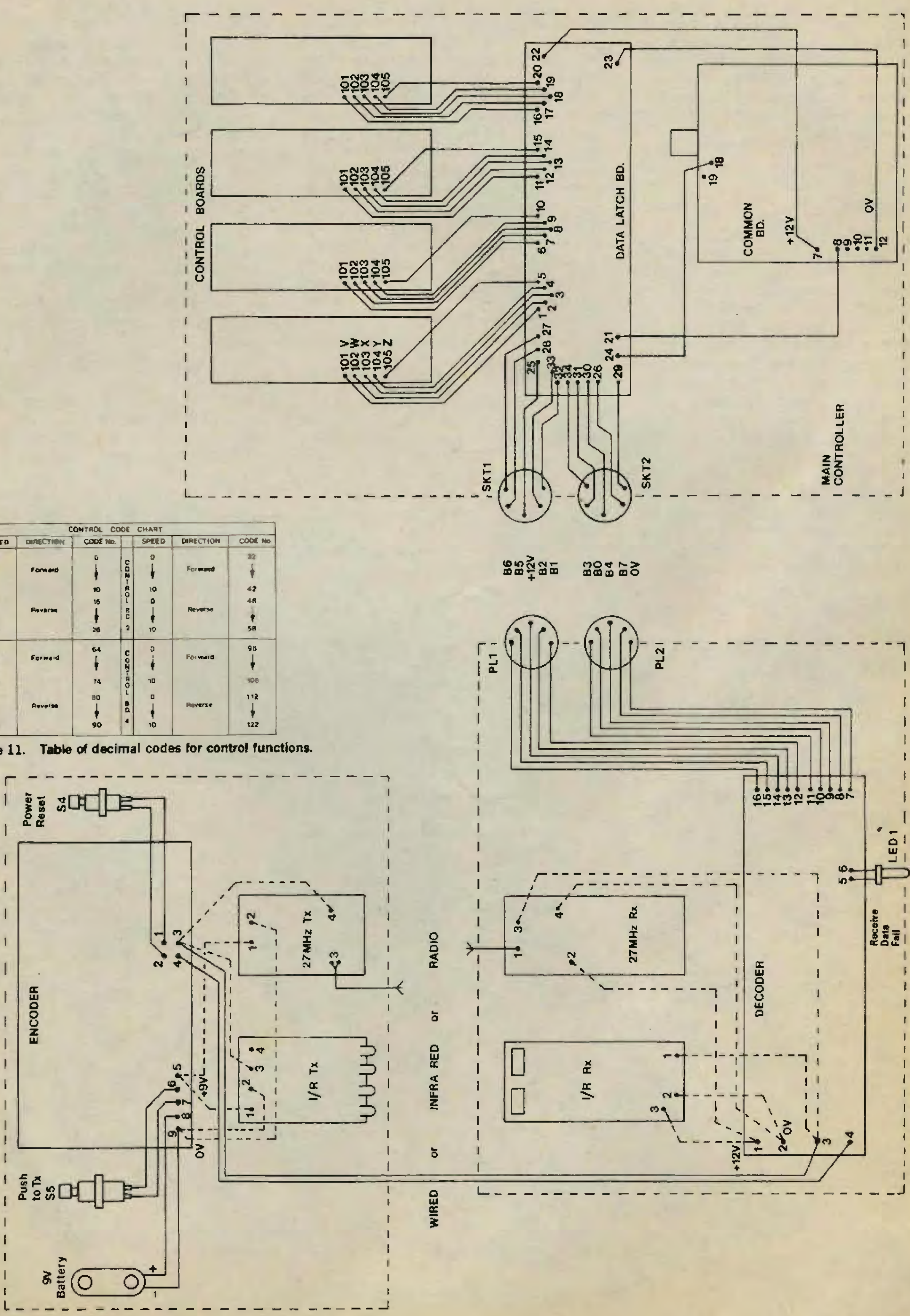


Figure 12. Interwiring diagram.

maximum reading. Keep moving the hand-held unit further away and retuning the receiver until a maximum reading is obtained at the greatest distance. A good reading should be obtained with the transmitter at least 7 metres away from the receiver. Disconnect the temporary link on the transmitter and the system should now be ready for use.

Remote Control Operation

Select the train or trains to be controlled on the train controller and switch the appropriate control boards to 'Remote'. The control board to be commanded may now be selected on the remote unit. Press the transmit button and set the speed and direction of the train as required. Note that there is a short delay of about 1 second before the decoder decides a valid signal is being received, but after this initial delay all information is transferred immediately.

The selected train may be left running and another controlled by first releasing the transmit button and then selecting the next train, pressing the transmit button and controlling the speed and direction of the new train. This process can be repeated until all four control boards are in use.

In the event of the power protection circuit being tripped, it may be reset by first pressing the transmit button, then pressing the reset button on the hand-held unit. This facility may also be used as an emergency stop by releasing the transmit button before the reset button. The power will remain off until a new command is sent. Note that this condition overrides the manual reset control on the train controller, but it may be reset from that end by turning the mains switch off for about 10 seconds before re-applying power.

When using the 27MHz link it should be noted that there is a minimum distance of about 2 metres where the transmitter will overload the receiver and no data will be transferred.

Computer Control

The 8-bit digital input may be fed from any computer via a suitable interface unit. An interface for the ZX81 will be described in our next issue. If the binary word required to control the system is converted into decimal form, programming is accomplished as follows.

The starting number for each of the four control boards is:

0 for Control Board 1
32 for Control Board 2
64 for Control Board 3
and 96 for Control Board 4

To control the forward speed of each board, add a number from 0 to 10 inclusive to the starting number. Zero is minimum speed and 10 is maximum speed. For the reverse direction, add 16 to the starting number and then add a further 0 to 10 to control the speed.

Power reset or 'all stop' may be accomplished by using the number 128. Note that as each train is controlled, the last data sent for that train is held in the associated latch, so to stop all trains, it is necessary to enter the four numbers 0, 32, 64 and 96. It does not matter in which direction the trains are travelling at the time the command is given.

The inertia or speed-up and slow-down rate of each train may be written into the program by arranging for the time taken to step up from zero to the required speed and back to zero to be varied. By using the input ports, the train controller can be made to control the speed of the train dependent on its position on the layout. Future articles will describe suitable detectors and interfacing for this and computer control of signals and points.

PARTS LIST OF ADDITIONS TO CONTROL BOARD FOR REMOTE CONTROL OR COMPUTER CONTROL (1)

Resistors — all ⅓W 5% carbon			
R101 to 104	100k	4 off	(M100K)
R105	4k7		(M4K7)
Semiconductors			
D101	1N4148		(QL80B)
IC101	4024BE		(QX13P)
IC102	4063BE		(QW41U)
Miscellaneous			
S101	Sub-min toggle 2-pole		(FH04C)
	Veropin 2141	5 off	(FL21X)

Note. Links 'A' and 'B' must be removed from pcb.

DATA LATCH PARTS LIST (2)

Resistors — all ⅓W 5% carbon			
R1,9 to 12	10k	5 off	(M10K)
R2 to 8	22k	7 off	(M22K)
R13	100k		(M100K)
Capacitors			
C1	1uF 100V pc electrolytic		(FF01B)
C2	10uF 35V pc electrolytic		(FF04E)
Semiconductors			
D1 to 9	1N4148	9 off	(QL80B)
TR1	BC548		(QB73Q)
IC1 to 4	40174BE		(QW73Q)
IC5	40106BE		(QW64U)
Miscellaneous			
SK1	DIN socket 5-pin A		(HH34M)
SK2	DIN socket 5-pin B		(HH35Q)
	Remote data latch pcb		(GA84F)
	Veropin 2141	34 off	(FL21X)

27MHz DATA RECEIVER PARTS LIST (8)

Resistors — all ⅓W 5% carbon			
R1	Not used		
R2	150R		(M150R)
R3	1k5		(M1K5)
R4	10k		(M10K)
R5	330R		(M330R)
R6	33k		(M33K)
R7	56k		(M56K)
Capacitors			
C1	22pF ceramic		(WX48C)
C2	12pF ceramic		(WX45Y)
C3	Not used		
C4,9	10uF 16V tantalum	2 off	(WW68Y)
C5,6	1nF ceramic	2 off	(WX68Y)
C7,8,12,15	100nF disc ceramic	4 off	(BX03D)
C10	47pF ceramic		(WX52G)
C11	100uF 10V pc electrolytic		(FF10L)
C13,14	1nF mylar	2 off	(WW15R)
C16	1uF 35V tantalum		(WW60Q)
C17	47uF 10V tantalum		(WW75S)
Semiconductors			
D1	OA91		(QH72P)
IC1	TBA651		(BL35Q)
Miscellaneous			
L1	Former 351		(LB17T)
	Dust core type 6		(LB42V)
	Enamelled copper wire 28swg		(BL39N)
L2	Choke 33uH		(WH38R)
L3	Choke 1mH		(WH47B)
IFT1	YRCS 11098		(HX42V)
IFT2	YHCS11100		(HX43W)
X1	Crystal		(see transmitter)
SKT1	Crystal socket		(HX60Q)
	Bolt 8BA ¼in.	2 off	(BF08J)
	Nut 8BA	2 off	(BF19V)
	Washer 8BA	2 off	(BF23A)
	27MHz receiver pcb		(YQ04E)

DATA DECODER PARTS LIST (3)

Resistors — all ¼W 5% carbon			
R1,7,8,10,13, 18,19	100k	7 off	(M100K)
R2,11,12,17	10k	4 off	(M10K)
R3,15	1M	2 off	(M1M)
R4,5	47k	2 off	(M47K)
R6	820k		(M820K)
R9	330k		(M330K)
R14	220k		(M220K)
R16	820R		(M820R)
Capacitors			
C1,2,4,5	1.5nF polycarbonate	4 off	(WW23A)
C3,9	1nF polycarbonate	2 off	(WW22Y)
C6,8,11	100nF polycarbonate	3 off	(WW41U)
C7	1uF 35V tantalum		(WW60Q)
C10	10uF 35V pc electrolytic		(FF04E)
Semiconductors			
D1 to 21	1N4148	21 off	(QL80B)
LED1	Red LED		(WL27E)
TR1	BC548		(QB73Q)
IC1	40106BE		(QW64U)
IC2	4013BE		(QX07H)
IC3	4024BE		(QX13P)
IC4,5	4099BE	2 off	(QW57M)
IC6,7	4077BE	2 off	(QW47B)
IC8,9	4042BE	2 off	(QX19V)
Miscellaneous			
PL1	DIN plug 5-pin A		(HH27E)
PL2	DIN plug 5-pin B		(HH28F)
	Data decoder pcb		(GA86T)
	Veropin 2141	20 off	(FL21X)

DATA ENCODER PARTS LIST (4)

Resistors — all ¼W 5% carbon unless specified			
R1,6,7,8,9,11,15	100k	7 off	(M100K)
R2	680k		(M680K)
R3	220k		(M220K)
R4,5*	10k	2 off	(M10K)
R10,12	100k (½W)	2 off	(U100K)
R13	220k (½W)		(U220K)
R14	470k		(M470K)
Capacitors			
C1	1.5nF polycarbonate		(WW23A)
C2	4.7nF polycarbonate		(WW26D)
C3	10uF 25V axial electrolytic		(FB22Y)
C4,5	1nF ceramic	2 off	(WX68Y)
Semiconductors			
D1 to 17	1N4148	17 off	(QL80B)
TR1	BC548		(QB73Q)
IC1	NE555		(QH66W)
IC2	4017BE		(QX09K)
IC3,4,8	4081BE	3 off	(QW48C)
IC5	4072BE		(QX27E)
IC6	4042BE		(QX19V)
IC7	4024BE		(QX13P)
Miscellaneous			
S1	Rotary switch 3 pole 4 way		(FH44X)
S2	Switchpot 1 pole 12 way		(XX45Y)
S3	Sub-min toggle 'A'		(FH00A)
S4	Push switch		(FH59P)
S5	Press switch		(FH91Y)
	Knob K7B (for S1)		(YX02C)
	Knob K7C (for S2)		(YX03D)
	Battery clip		(HF28F)
	PP3 battery		—
	Data encoder pcb		(GA85G)
	Veropin 2141	10 off	(FL21X)

*If this is to be used with the 27MHz data link then make R5 a Min Res 1k even if you are using IR or wired links as well.

To make the function shown below, you will require all the parts shown in the parts list indicated.

Computer interface : 1, 2.
Wired remote control : 1, 2, 3, 4.
Infra-red remote control : 1, 2, 3, 4, 5, 6.
Radio remote control : 1, 2, 3, 4, 7, 8.

Note that parts list 1 will be required for each control board that you wish to modify.

As there are so many possible different combinations of these parts, it is not possible to offer kits.

INFRA-RED TRANSMITTER PARTS LIST (5)

Resistors — all ¼W 5% carbon			
R1	22k		(M22K)
R2	2k7		(M2K7)
R3	270R		(M270R)
R4	10k		(M10K)
Capacitors			
C1	1200pF 1% polystyrene		(BX57M)
C2	1uF 63V axial electrolytic		(FB12N)
C3	100uF 10V axial electrolytic		(FB48C)
Semiconductors			
D1	1N4148		(QL80B)
D2 to 5	TIL38	4 off	(YH70M)
TR1	BC212L		(QB60Q)
TR2	BC461		(QB72P)
IC1	NE555		(QH66W)
Miscellaneous			
	Infra-red transmitter pcb		(GA87U)
	Veropin 2141	4 off	(FL21X)

INFRA-RED RECEIVER PARTS LIST (6)

Resistors — all ¼W 5% carbon			
R1,4,8	4M7	3 off	(M4M7)
R2,9	4k7	2 off	(M4K7)
R3	220R		(M220R)
R5,7,10,12	10k	4 off	(M10K)
R6	220k		(M220K)
R11,13	47k	2 off	(M47K)
Capacitors			
C1,3	10uF 35V pc electrolytic	2 off	(FF04E)
C2	1000pF ceramic		(WX68Y)
C4	220pF ceramic		(WX60Q)
C5	2200pF polycarbonate		(WW24B)
C6	27pF ceramic		(WX49D)
C7	2.2uF 63V axial electrolytic		(FB15R)
C8	100nF 35V tantalum		(WW54J)
Semiconductors			
D1,2	1N4148	2 off	(QL80B)
D3 (D4 if req'd)	TIL100		(YH71N)
TR1,2	BC109C	2 off	(QB33L)
TR3,4	BC548	2 off	(QB73Q)
Miscellaneous			
	Infra-red receiver pcb		(GA88V)
	Veropin 2141	3 off	(FL21X)

27MHz DATA TRANSMITTER PARTS LIST (7)

Resistors — all ¼W 5% carbon			
R1	22k		(M22K)
R2	10k		(M10K)
R3	150R		(M150R)
R4	2k2		(M2K2)
R5	22R		(M22R)
Capacitors			
C1,4,6	47nF disc ceramic	3 off	(BX02C)
C2	10pF ceramic		(WX44X)
C3	27pF ceramic		(WX49D)
C5	33pF ceramic		(WX50E)
C7	18pF ceramic		(WX47B)
Semiconductors			
TR1	BC109C		(QB33L)
TR2	BSX20		(QF32K)
TR3	BC212L		(QB60Q)
Miscellaneous			
L1	Choke 15uH		(WH36P)
L2,3	Former 722/2	2 off	(LB20W)
	Dust Core	2 off	(LB41U)
	Enamelled copper wire 28swg	½m	(BL39N)
X1	Crystal (supplied in pairs) (any one of HX30H to HX35Q)		
	Crystal socket		(HX60Q)
	27MHz transmitter pcb		(GA89W)
	Veropin 2141	3 off	(FL21X)