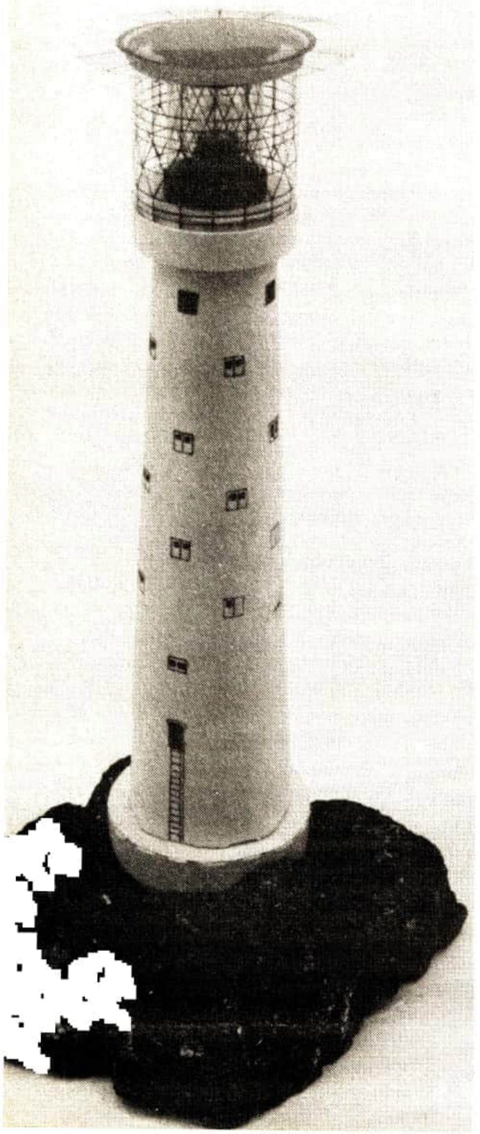
Simple Model Series

BISHOP ROCK LIGHTHOUSE

OWEN BISHOP

PROJECT 7

The last model in a series which combines two hobbies in one – electronics and model-making. Simple electronic circuits combined with easy-to-assemble models that cover a wide range of interests.



STANDING on a pinnacle of rock rising sheer out of the ocean floor in the westernmost Scilly Isles, the Bishop Rock lighthouse is said to be the most exposed in Britain. The rocks are submerged at spring tides and, given that there are an average of 30 gales in this area each year, it is small wonder that this region is a potential danger to shipping. The rock is said to be named after a sailor called Bishop who was one of only two survivors cast up on it after the wrecking of a whole merchant fleet in the Scillies in the 17th Century.

The present lighthouse is Bishop Rock III. The original Bishop Rock I was started in 1847 but was destroyed by a storm in 1850 before it ever became operational. Bishop Rock II was a sturdier and taller structure which was first lit in 1858, but suffered greatly from the storms. Eventually it was encased in further granite masonry and increased in height to its present size. Its design was by James Douglass, and it was built by his son William Tregarthen Douglass. It first came into service on 25 October 1887.

Even in these days of remote operation, Bishop Rock III continues to be a watched lighthouse, operated by Trinity House. The addition of a "helideck", well above the surges of the Atlantic breakers, makes relief operations considerably easier than they used to be, though still hazardous enough.

Bishop Rock III was originally lit by oil lamps, but now uses an electric lamp of 2,600,000 candle-power, with a range of 29 sea miles. It is white and its characteristic signal is two flashes every 15 seconds. The original fog warning was an explosive charge set off every five minutes but nowadays there is a fog-horn, giving two blasts every 90 seconds.

The model is based on the dimensions of the light-house at a scale of approximately 1/200. It reproduces the light character and fog warning of Bishop Rock III, except that we have simplified the logic circuit by sounding the fog-horn every 60 seconds.

In the real lighthouse, the flash is produced by a set of lenses rotating around the lamp; for simplicity we flash the lamp on and off electronically. However, to simulate the effect of the rotating lenses, the lamp takes an appreciable time to acquire full brightness and to turn off.

The circuit can be adapted to produce other light characters should you prefer to base your model on a lighthouse near your home. Similarly, the fog horn has variable pitch and a programmable sounding sequence.

BUILDING THE TOWER

The lower part of the tower is a cylindrical base. Use a plastic or metal cap taken from a domestic spray-can (furniture polish, oven-cleaner etc). The cap should have an external diameter of about 54mm, and an internal diameter of at least 50mm. The exact height does not matter except that, to accommodate the circuit boards and speaker, it needs to be at least 47mm high. Fig. 1 shows the details. Paint the cap a "rocky" granite colour and draw a vertical ladder down from top to bottom, about 2mm wide with rungs 2mm apart.

If you cannot find a suitable cap, cut the base from thin cardboard as shown. Form this into a cylinder and secure the flap with glue. Bend the tags inward. Cut out the base top and glue this to the tags. We used buff-coloured card for the base and main

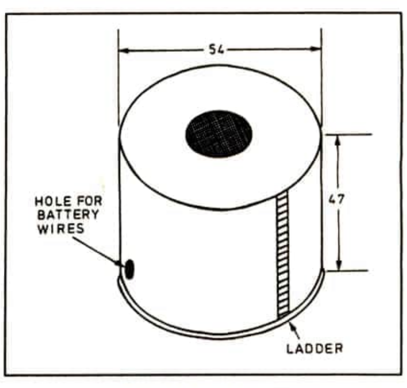
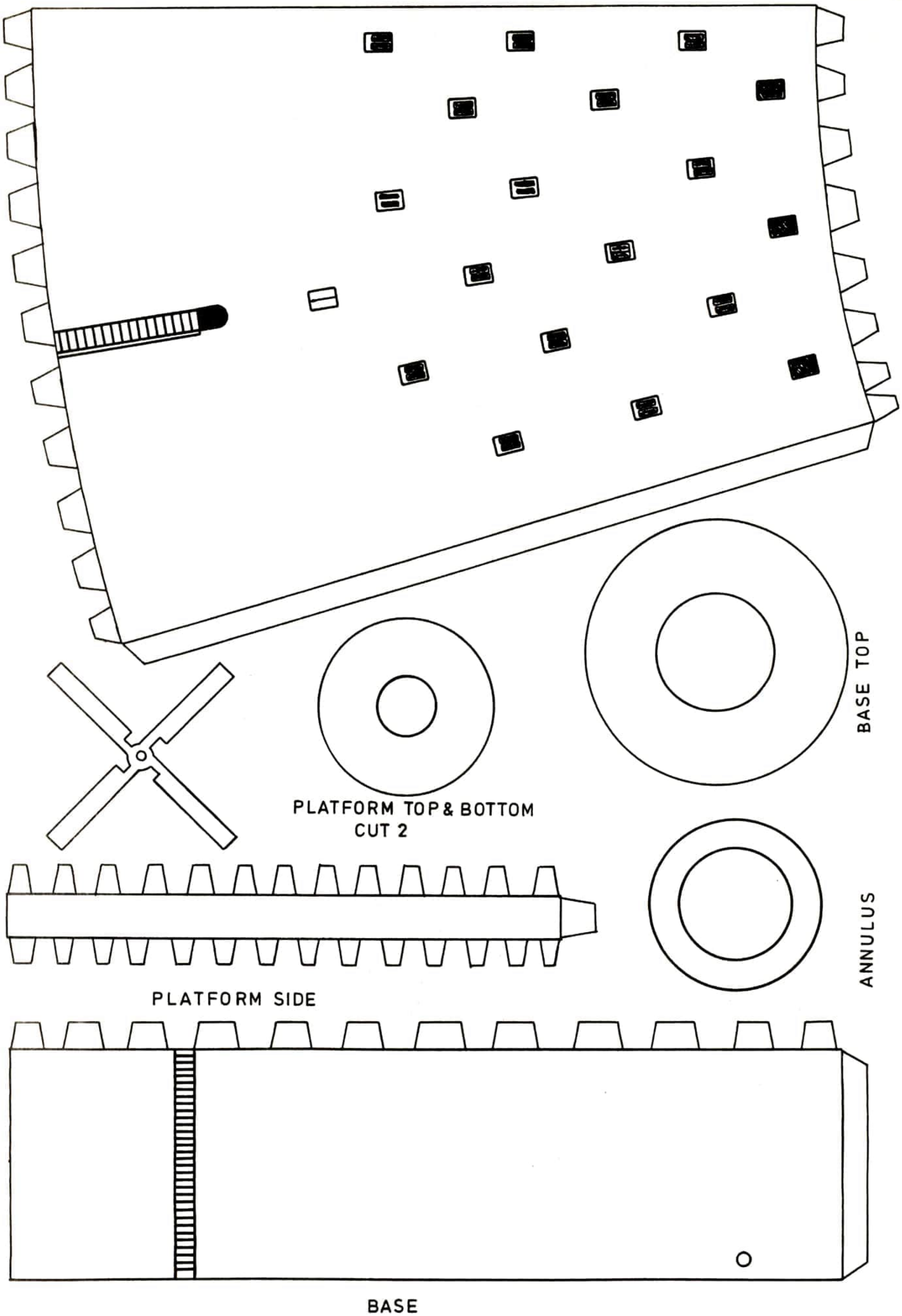
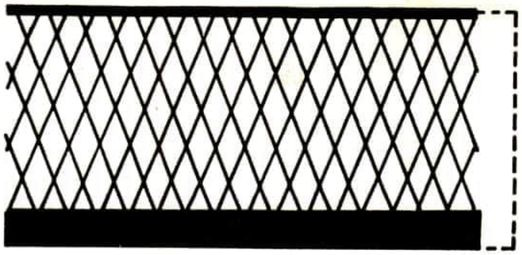
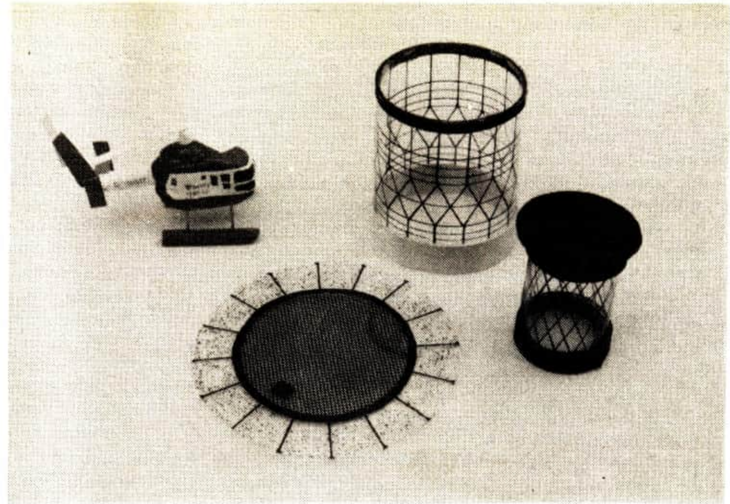


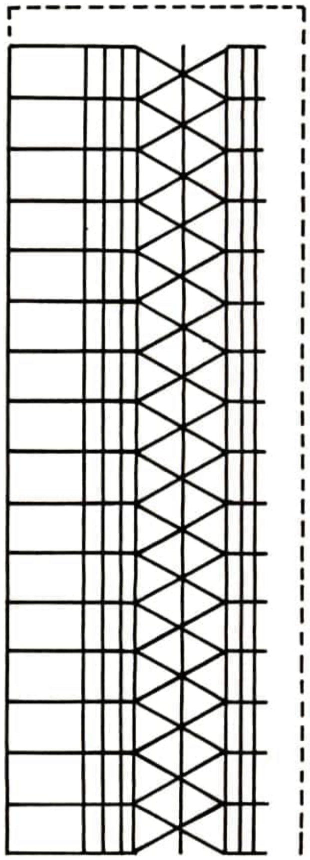
Fig. 1. The base of the Lighthouse.


PLATFORM TOP & BOTTOM
CUT 2
BASE TOP
PLATFORM SIDE
ANNULUS
BASE

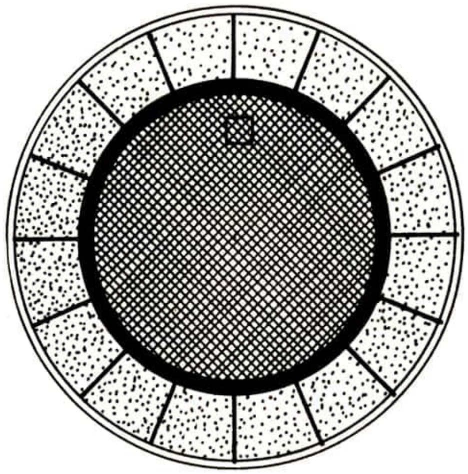


LANTERN





HELIDECK CAGE



HELIDECK

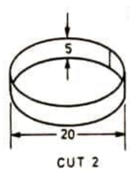


Fig. 2 (left). Card rings for the lantern

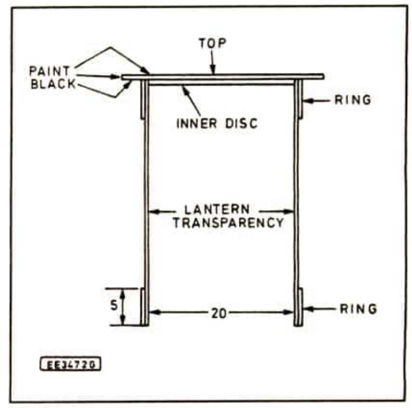


Fig. 3. Formation of the lantern housing

tower, so no painting was needed. If you are using white card, paint the base and draw the ladder on it where shown.

Readers with the equipment and skill could model the main tower by turning it in wood on a lathe. It is 162mm long and tapers from 42mm diameter at the bottom end to 27mm at the top. The tapering is more pronounced toward the bottom of the tower, and it hardly tapers at all near the top. Bore a hole centrally up the tower to take the wires from the base to the lamp.

The tower is topped by a circular platform which can be cut from 9mm plywood, with a hole bored centrally in it. Paint the tower, and draw the door and windows. A ladder leads from the door down to the bottom of the main tower.

The main tower can also be made from thin cardboard, though this inevitably lacks the graceful lines of the real thing, and of the wood-turned model. Form the cardboard into a narrow cone and secure the flap with glue. Make the platform from two card circles glued to two discs which form the top and bottom of the platform. Finally glue the tags at the top and bottom of the main tower to the platform and base respectively.

THE LANTERN

Make a photocopy of the designs for the lantern, helideck and helideck cage on transparent film, in black. Cut out the lantern design. Cut two strips of thin card 5mm wide and about 200mm long. Apply glue to one side of one strip, for half its length. Wind the strip around a cylindrical object 20mm in diameter, to form a ring of about three turns (Fig. 2). The cylinder should preferably taper slightly to make it easier to remove the ring from it when the glue has dried. A small cap from a domestic spray-can was found to be exactly the right size and shape for this. Use a large black spirit-marker pen to blacken the edges and outside surface of the ring. Prepare a second ring using the other strip and blacken this too.

Cut out a card disc 27mm diameter, for the top of the lantern; blacken the upper surface of this, its edge and the outer region of the lower surface (Fig. 3). Cut another disc 20mm in diameter. Roll the lantern transparency into a cylinder and use one ring to hold it rolled, the ring being nearer to what will eventually be the bottom of the lantern. Apply glue to the inside of the other ring and insert the eventual top of the rolled transparency into this. Press the transparency firmly against the inside of this ring to form it into a perfect cylinder.

While the glue is still wet, invert the rolled transparency on the under-side of the lantern top. Then apply glue to the inner card disc and push this down inside the lantern, gluing it to the underside of the lantern top. This helps push the transparency firmly against the inside of the ring. When the glue has dried, remove the first ring, apply glue to its inner surface and push in back on to what will eventually be the lower end of the lantern.

Cut out an annulus of medium-thick card and glue this to the top of the platform. The lantern is a push-fit into this so that it can easily be removed for changing the bulb.

Cut out the photocopied designs for the helideck and the helideck cage. The construction of the helideck cage is similar to that of the lantern, except that the rings are made from strips 2.5mm and 9mm wide. They are wound around a cylindrical object 36mm in diameter. Paint the narrow ring black inside and out. The wide ring is to be the same colour as the tower. Form the cage design into a cylinder and slip the narrow ring around it near the top. Apply glue to the inside of the wide ring and push the lower end of the cage into this so that the lower edge of the cage pattern itself

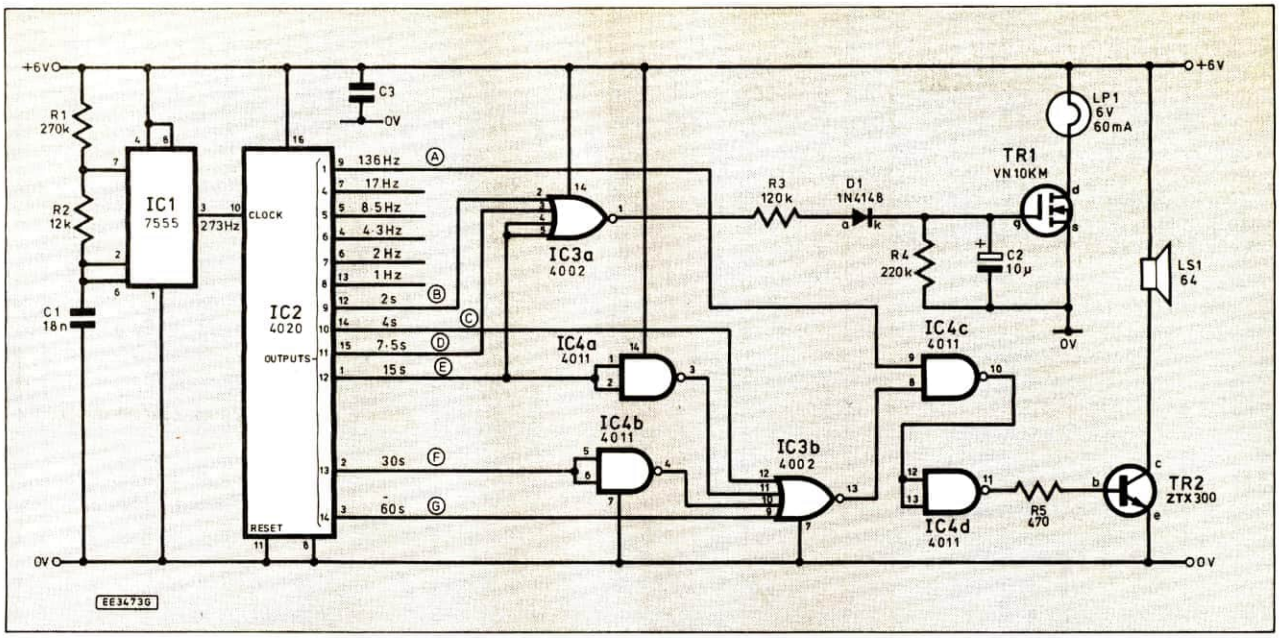


Fig. 4. Circuit diagram for the light and fog horn.

(the triple railings) are *just* visible above the ring. This ring is to be a push-fit over the platform, so that the cage may be removed for changing the bulb.

When the glue is dry, apply glue to the inside and top edge of the narrow ring and slide this into place at the top of the cage. At the same time invert the cage on to the helideck transparency (also inverted), so fixing the helideck to the top of the cage.

HOW IT WORKS

The clock (IC1 in Fig. 4) oscillates at 273Hz. This signal is repeatedly halved in frequency by the 14 stages of the counter in IC2. The outputs from stages 2 and 3 are not available. The available outputs with their frequencies or periods are shown. Any of these outputs can be used to produce the desired character. The logic is explained below in some detail so that readers will understand how to adapt the circuit for producing other characters.

The logic for flashing the lamp depends on the binary sequence of outputs from stages B, D and E, where "0" = low voltage and "1" = high voltage (Table 1). Each count in the table represents slightly less than one second, so the sequence repeats with the period of output E, which is approximately 15 seconds, as required. During this time the lamp flashes twice, each flash lasting one second.

Table 1:
Truth table for lamp flashing

Count	*Output* E D C B	*State of lamp*
0	0 0 0 0	FLASH
1	0 0 0 1	
2	0 0 1 0	FLASH
3	0 0 1 1	
4	0 1 0 0	
5	0 1 0 1	
6	0 1 1 0	
7	0 1 1 1	
8	1 0 0 0	
9	1 0 0 1	
10	1 0 1 0	
11	1 0 1 1	
12	1 1 0 0	
13	1 1 0 1	
14	1 1 1 0	
15	1 1 1 1	

The table shows that the flash occurs if and only if B, D and E are all low. The state of C is immaterial. The state of B, D and E is detected by feeding the three outputs to a NOR gate. A four-input gate is used, so signal E is fed to two of the inputs.

The output of the NOR gate is normally low, but goes high when all three inputs are low. A high output from the NOR gate raises the voltage of the gate of TR1, turning the transistor on. The transistor conducts readily and the lamp lights. The switching action is modified by R4 and C2, which delays the time at which the lamp reaches full brightness. When the NOR gate goes low, the diode prevents the capacitor from discharging. The charge leaks away through R4 and the lamp dims out.

The logic for sounding the fog-horn depends on the binary sequence of outputs from stages C to G (Table 2). Each count in this table represents about four seconds, and the sequence repeats with the period of output G, which is approximately 60 seconds. During this time the fog-horn sounds twice, each blast lasting two seconds. The table shows that the flash occurs if and only if C and G are low and E and F are high. The fact that E has to be high means that there is always an appreciable gap between the horn sounding and the lamps flashing, giving a more realistic effect. The state of D is immaterial.

The state of C, E, F and G is detected by feeding the four outputs to a NOR gate, as before. However, because we are looking for *high* states of E and F, these signals must be inverted. The signals first go to NAND gates (IC4a/b) with their inputs wired together so that they act as INVERT gates, then to the NOR gate.

When C, E, F and G are in the correct state the output of the NOR gates goes high, and this output goes to a NAND gate (IC4c). This gate also receives the 136Hz audio signal A, but this passes through the gate only when the NOR gate output is high. When the NOR gate is low the output from IC4c is continuously high. The signal is inverted once again, by IC4d, so that it is low between blasts, thus leaving TR2 and the loudspeaker switched *off* during the inactive state.

CIRCUIT BOARD A

Circuit board "A" (Fig. 5) holds the timer and counter i.c.s. Like (almost) everything to do with lighthouses, the circuit boards are circular and stack inside the lighthouse base. Drill the holes in the board, then insert the two i.c. sockets and capacitor C1; glue them to the board to make the wiring more secure. Insert C2 and bend its leads and glue the body of the capacitor to the board. Next insert the p.c.b. terminals.

There are more terminals than usual in this project as this makes it easier to customise the circuit design to produce a range of light and fog-horn characters. The beads on the recommended p.c.b pins are in a

Table 2:
Truth table for the fog-horn

Count	*Output* G F E D C	*State of horn*
0	0 0 0 0 0	
1	0 0 0 0 1	
2	0 0 0 1 0	
3	0 0 0 1 1	
4	0 0 1 0 0	
5	0 0 1 0 1	
6	0 0 1 1 0	
7	0 0 1 1 1	
8	0 1 0 0 0	
9	0 1 0 0 1	
10	0 1 0 1 0	
11	0 1 0 1 1	
12	0 1 1 0 0	SOUND
13	0 1 1 0 1	
14	0 1 1 1 0	SOUND
15	0 1 1 1 1	
16	1 0 0 0 0	
17	1 0 0 0 1	
18	1 0 0 1 0	
19	1 0 0 1 1	
20	1 0 1 0 0	
21	1 0 1 0 1	
22	1 0 1 1 0	
23	1 0 1 1 1	
24	1 1 0 0 0	
25	1 1 0 0 1	
26	1 1 0 1 0	
27	1 1 0 1 1	
28	1 1 1 0 0	
29	1 1 1 0 1	
30	1 1 1 1 0	
31	1 1 1 1 1	

COMPONENTS

Resistors

R1	270k
R2	12k
R3	120k
R4	220k
R5	470

Carbon film 0.25W, 5%, or metal film 0.6W 1%.

See SHOP TALK Page

Capacitors

C1	18n polyester miniature dipped case, or metallised ceramic plate
C2	10μ tantalum, 15V
C3	220n polyester miniature layer

Semiconductors

D1	1N4148 silicon signal diode
TR1	VN10KM VMOS *n*-channel power f.e.t.
TR2	ZTX300 *npn* transistor
IC1	7555 CMOS timer
IC2	4020 CMOS 14-stage counter/divider
IC3	4002 CMOS dual 4-input NOR gate
IC4	4011 CMOS quadruple 2-input NAND gate

Miscellaneous

LP1	6V, 60mA MES filament lamp (or similar)
LS1	64Ω speaker, 38mm diam.

16-pin d.i.l. i.c. socket; 14-pin d.i.l. i.c. sockets (2 off); 8-pin d.i.l. i.c. socket; p.c.b. eyelet terminals (21 off); battery connector; insulating tape; p.c.b. lacquer; Easywire pen and tool; insulated connecting wire.

Materials

Thin card, buff or printed white card – see Shop Talk and Special Offer page, (or wood) for tower. Block of expanded polystyrene, approx. 140 x 100 x 50. Red and white enamel paint (e.g. Humbrol); black acrylic paint (e.g. Tamiya Color).

Approx cost guidance only **£6** *(components only)*

range of different colours: it is advisable to adopt a colour code for each of the lines A to G, and to use the same code on board B. For certain variations in the light and sound characters, you may need to wire the p.c.b. terminals to a different set of output pins (see later).

Test the circuit by connecting the battery. The output from IC1 pin 3 is a signal of 273Hz. You can hear this if you connect a crystal earphone to pin 3, by way of a 100n capacitor. Connect the other terminal of the earphone to the 0V rail.

On an oscilloscope, the signal can be seen to have a very high mark-space ratio. Monitor the signals from the terminals of IC2; the important ones are those labelled A to G in Fig. 4. Signal A can be heard with an earphone; a voltmeter is used to check signals B to G.

CIRCUIT BOARD B

Circuit board "B" holds the logic circuits and the transistor switches which control the lamp and loudspeaker. It may be necessary to revise the logic connections if other light and sound characters are required.

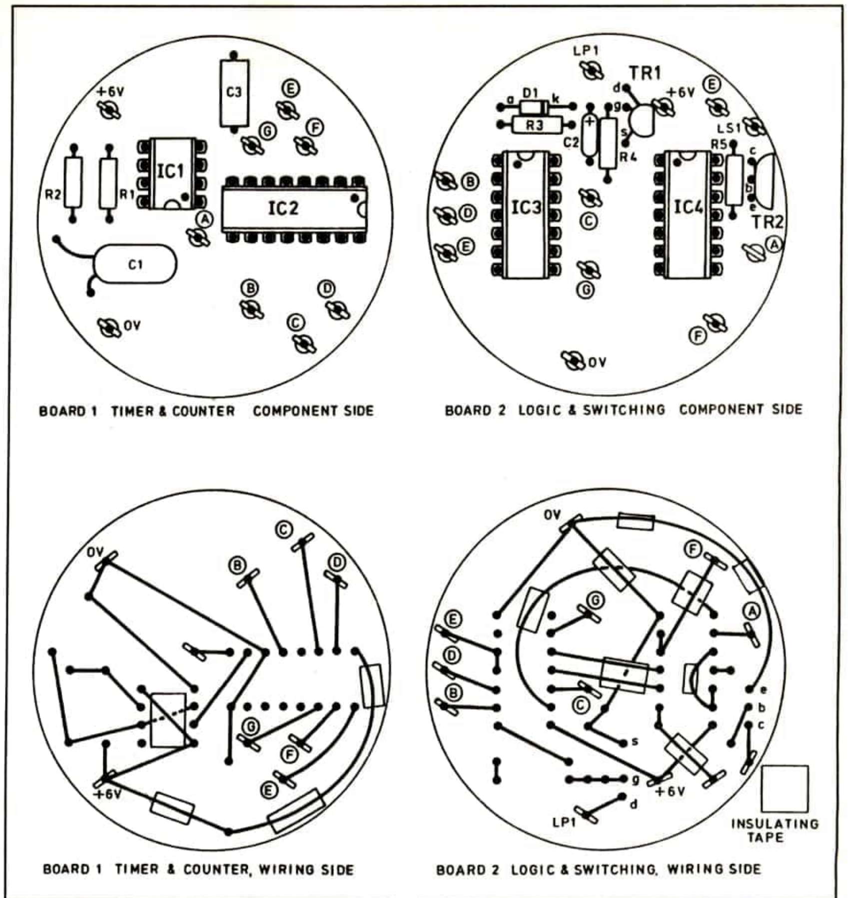


Fig. 5. The construction of the two circuit cards using the Easiwire wiring system.

Wiring up the board is straightforward. The board is tested after wiring the inter-board connections (Fig. 6). Note that there are *two* E terminals on Board B.

Use thin flexible insulated wires, each about 10cm long, except for the lamp and battery is connections. For the battery, you can use a press-stud battery connector, but you may need to extend the wires if the battery to be hidden from sight. The wires to the lamp need to be about 30cm long. If a bulb holder is used, connect the wires to the screw terminals. Otherwise, solder the wires directly to the bulb, or hold them in place with insulating tape. When the battery is connected, the lamp begins to flash and the loudspeaker sounds as described earlier.

ASSEMBLY

The final assembly is shown in Fig. 7, with the circuit boards and loudspeaker stacked inside the base with card separators (discs 50cm diameter) to prevent short circuits. The speaker rests face-down on the table.

If the lamp is in a holder, glue this to the platform. If the wires are soldered to the lamp, wrap black insulating tape around the threaded part of the bulb. Nip the tube of tape below the bulb and wedge it firmly into the hole in the top of the platform. Place the lantern over the bulb; it is held in place by the annulus. Lower the cage over the lantern and push it gently down over the platform. All that is needed now is a helicopter to bring supplies to the keeper.

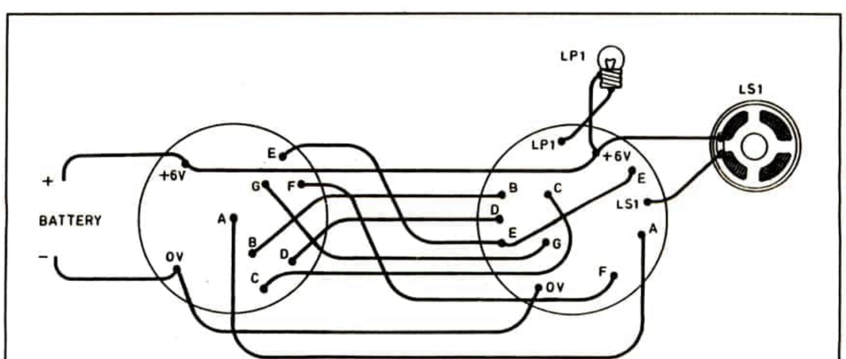
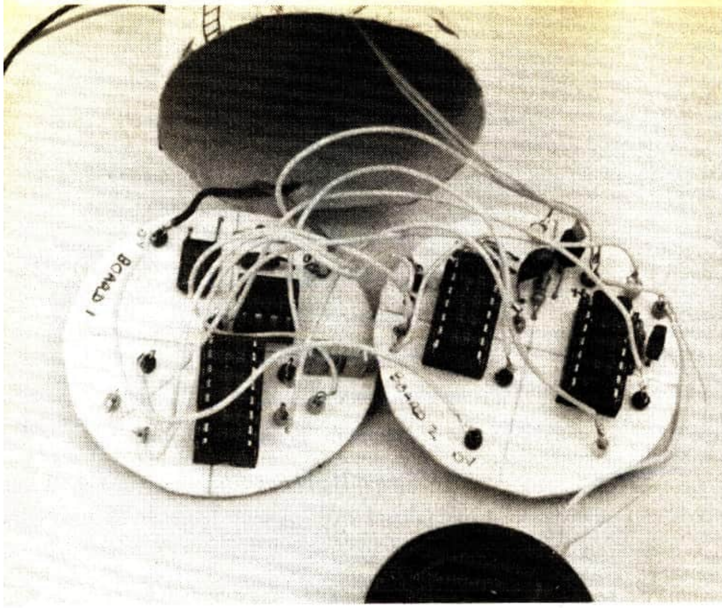


Fig. 6. Interwiring between the board, battery, lamp and loudspeaker.



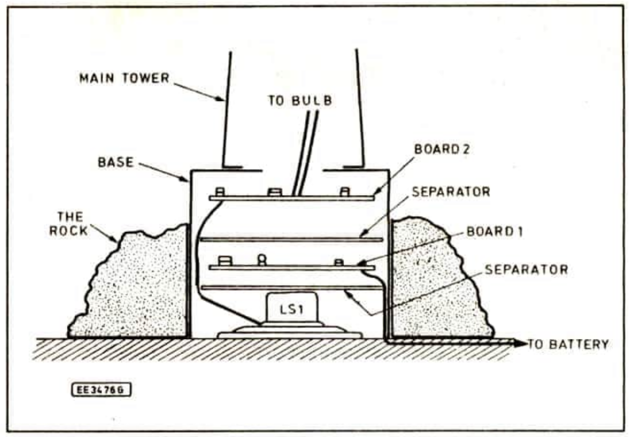


Fig. 7. Fitting the electronics in the base.

HELICOPTER

The supply helicopter used by Trinity House is the popular West German light utility helicopter, the MBB BO105. We made a simple model of this, moulding the main fuselage from Fimo, a modelling material which is fairly soft when purchased but which hardens when placed in an oven at 130°C for about half an hour. To save a certain amount of painting use either red or white Fimo.

Make the rear fuselage from 3mm diameter white plastic rod. Before hardening the main fuselage make a socket in this to accept the rear fuselage. Also push a pin in at four places to make holes ready for the undercarriage struts.

Cut the tail and rudder from thin red card and glue into slots cut in the rear fuselage (Fig. 8). Cut a propeller from thin white card and mount this on the tail-plane as shown; fill the collar with glue before inserting the pin into it. Cut the four-bladed rotor from the same white card.

Carve the floats from plastic strip; bore two holes half-way into each to take the struts. Make the struts from dressmaker's pins; you may have to experiment here, as some types of pins snap in two when you try to bend them. The pins will not be a really firm fit in the holes but, when the model is painted, the paint secures them well enough.

Paint the main fuselage white, with red top and bottom. Also paint windows in black and, if possible the logo "Trinity House" and the registration number of one of its helicopters G-BATC. Finally mount the rotor.

BISHOP ROCK

The rock itself can be carved from a block of expanded polystyrene or timber. It needs a flat bottom, sheer sides and a very rugged top. A circular opening 54mm in diameter runs from top to bottom so that the rock surrounds the base of the light-house, making it less likely to topple over. Cut a groove in the bottom of the rock for the battery wires.

Paint the rock matt black, possibly adding a touch of dark brown here and there. Before painting, test the paint on a spare scrap of expanded polystrene; the solvents of some paints cause the polystyrene to shrink away almost to nothing! A water-soluble acrylic model paint (Tamiya Color, matt black XF-1) gave a very realistic effect on white polystyrene.

OTHER CHARACTERS

Both the light and fog horn can be changed to different characteristics. The first thing to decide is the length of the longest sequence, usually the fog-horn sequence. The length of the shorter sequence (usually the light) must be a binary submultiple (half, quarter, eighth . . .) of this. The actual length of the Bishop Rock fog-horn sequence is 90s but, since the light sequence lasts 15s, it was decided to make the horn sequence 60s, i.e. *four* times the light sequence, instead of six times, which is difficult to arrange.

If the longest sequence is t seconds, and this is to be taken from ouput G, the frequency of the clock must be $f = 16384/t$. The frequency is determined by the values of R1, R2 and C1:

$$f = \frac{1.44}{(R1 + 2.R2)\,C1}$$

If this frequency proves to be suitable for the fog-horn, it can be used direct from the clock; otherwise, use A which runs at $f/2$. If a lower frequency is needed, use output F for the longest sequence, length t, and calculate $f = 8192/t$.

Next set out truth tables similar to Tables 1 and 2 and mark when the lamp is to flash or the horn to sound. Try to mark these events so that they occur when there is a majority of '0's on the line. Then decide the logic requirements. Table 1 gives a double flash, as required for Bishop Rock, but a single flash can be obtained (at count 0) by NORing together all four outputs. A single flash of double the length (counts 1 and 2) is obtained by NORing outputs C, D and E only.

The circuit has two NAND gates (IC4a/b) for inverting outputs that are to be active when they are "1". If either of these gates are not used, their inputs *must* be wired either to 0V or +6V.

This model concludes the series, we hope you have enjoyed making at least one of the models. □

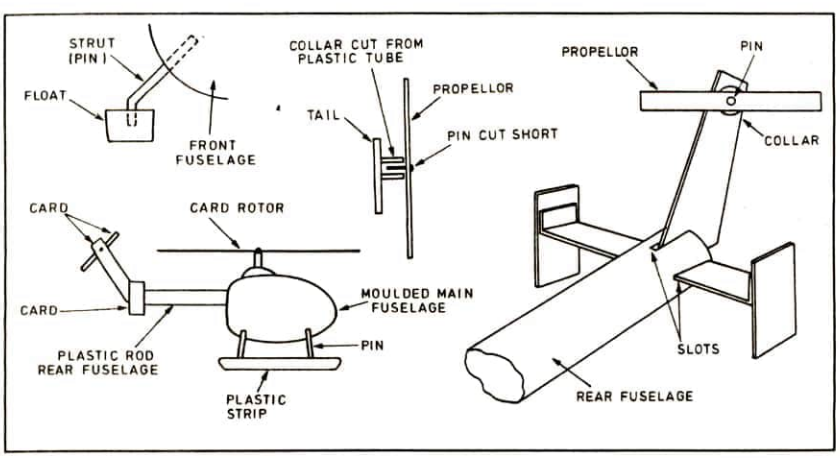


Fig. 8. Construction of the helicopter.