DESIGNING AND MAKING A HI-TECH LAMP

WHAT YOU WILL LEARN

After completing this unit, you should understand:

- What a force is.
- How a force can affect beams within structures.
- The use of simple moments calculations.
- That a structure may have a number of functions.

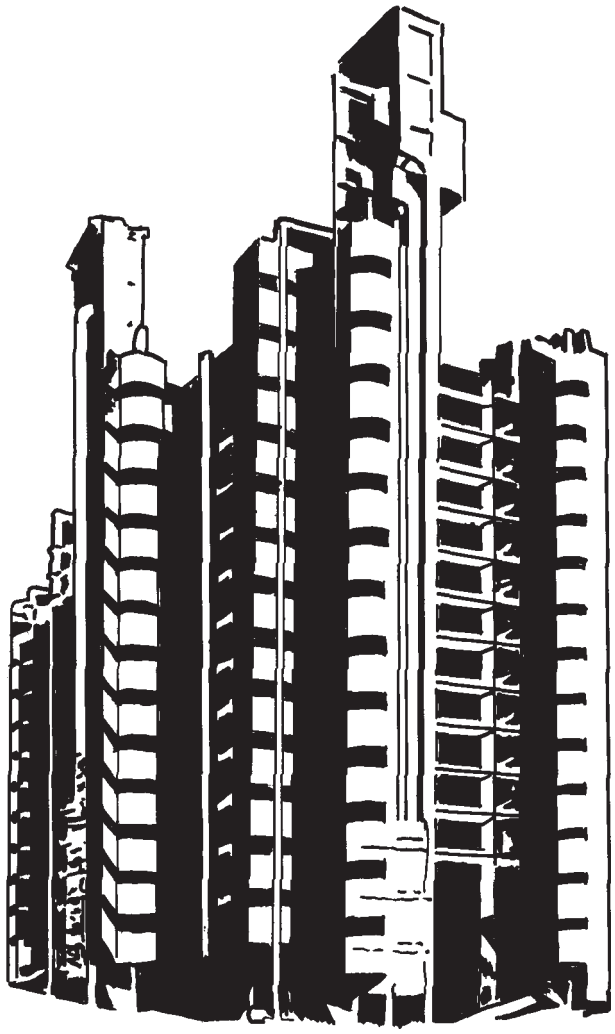
You should be able to:

- Recognise and name the parts of a structure - e.g. ties and struts.
- Work to a design brief and write a specification.
- Recognise constraints when designing.
- Design and make a frame structure low voltage desk lamp.

HI-TECH LAMPS

Frame structures are often hidden from view. Supporting structures, for example, are usually placed inside buildings leaving a smooth exterior. Tent frames are often hidden below the fabric. It is not until quite recent times that designers have exploited the visual interest of structures and deliberately made them visible.

Richard Rogers, a well known architect, has shown through examples of his architecture how structures can be used to create stunning effects. There are also now many small products which show off their structure to good effect. Modern hi-tech lamps are a good example.

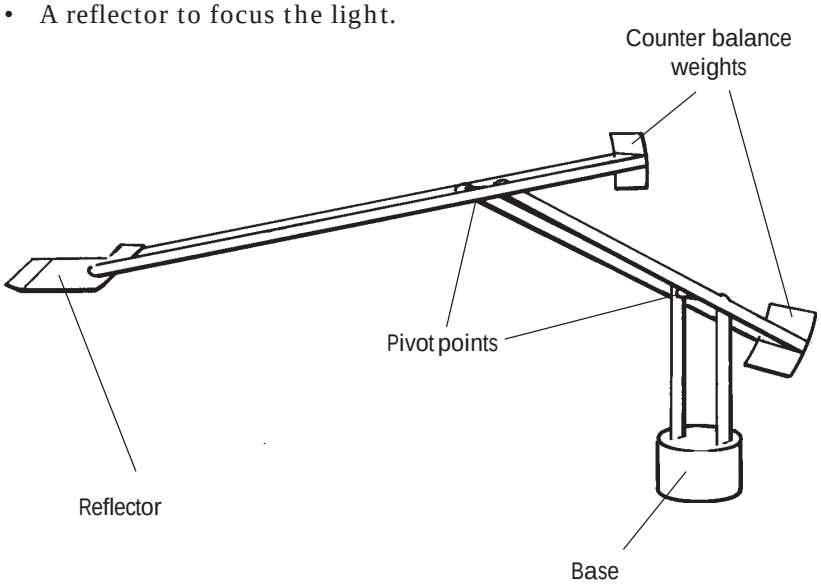


Lloyds building designed by Richard Rogers

LAMPS AS STRUCTURES

The design of desk or table lamps has developed rapidly in recent years. Low voltage supplies are often used in preference to mains electricity. Many 'hi-tech' lamps make use of their structure not only to support the bulb unit but also to conduct the low voltage supply to the bulb. A low voltage lamp often consists of the following.

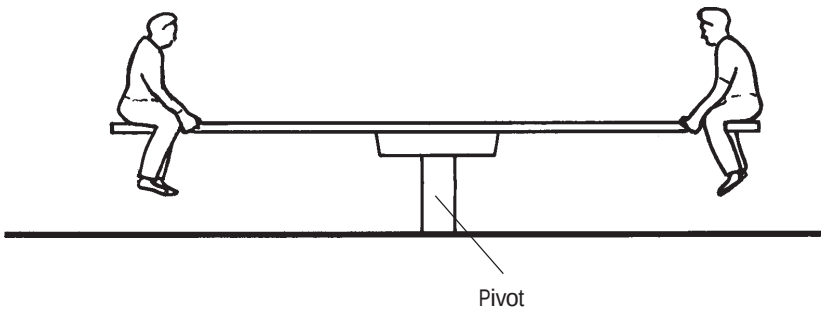
- A base which provides the housing for the power supply and a stable platform for the structure.
- A support between the bulb and the base consisting of two conductive members which may be jointed to achieve adjustment.
- A reflector to focus the light.



Stability is an important factor in desk lamp design. Most desk lights extend over the area to be lit so as not to get in the way of a person working. This can make the light unstable and topple over if knocked or adjusted. Some designs use springs in tension to maintain the position of the lamp. Other designs use a number of beams freely pivoted to allow movement and are balanced to maintain the selected position.

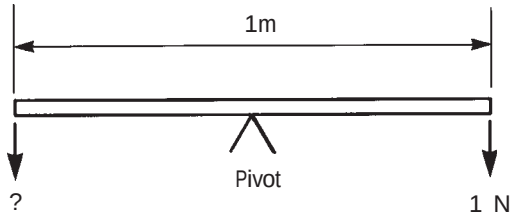
STRUCTURES IN EQUILIBRIUM

The supporting beam(s) in many lamps balance around a given point like a see saw. In this example, the beam is allowed to rotate around a given point (pivot) and positioned so that the pivot is in the centre. As the distance from the pivot and the load applied by the beam is the same on both sides of the pivot the beam will be in equilibrium. However, when a person sits on one end of the beam the force to that end is increased creating an imbalance. Consequently that end of the beam will move down. To re-establish equilibrium an equal load must be applied to the other end of the beam i.e. another person of the same size.



MATHS/SCIENCE OPPORTUNITY

If a beam is used to extend the lamp over a working area it may require a force applied to the opposite end. This is called a **counterbalance** and is used to maintain equilibrium. The forces acting on a beam causing it to turn about a point are called **moments** and these can be calculated. The forces acting at the ends of a beam are called clockwise (CW) moments or anti-clockwise (ACW) moments depending on the direction in which the force is trying to turn the beam.



If a beam is 1 m long and is pivoted at its mid point, it will be in equilibrium. If a force of 1N is applied to one end as shown it then becomes unbalanced. To find the force required to counterbalance the 1N force we use the following formulae:

The formula to calculate moments is:

Moment = Force (N) × distance from pivot (m)

◀ MATHS OPPORTUNITY

Therefore, clockwise moments = 1 × 0.5 = 0.5 Nm

Because the beam needs to be in equilibrium the ACW moments must equal the CW moments. From the previous calculation the CW moments = 0.5Nm therefore the ACW moments must also be 0.5Nm if it is to be in equilibrium. To find the force required to balance the beam we say:

Anti-clockwise moments = Force × distance

Therefore 0.5 = Force × 0.5
Force = 0.5 ÷ 0.5 = 1N

It should be obvious that equal forces placed at equal distance from the pivot will balance but if this is now applied to a desk lamp then a required reach of 0.5 m over a desk would need the beam to extend 0.5 m from the other side of the lamp out from the desk which might not be practical.

To retain a compact solution, the counterbalance should be placed as close to the lamp base as possible. You can now put the moments formulae to good use; by reducing the distance from the pivot of the anti-clockwise moment you can calculate the appropriate load to counterbalance the lamp.

YOUR TASK

◀ DESIGN BRIEF

A plastics company manufactures small boxes for use with electronic circuitry. The company wishes to promote a new range of small boxes suitable for the packaging of 2 'D' type cells and a switch. Design and make an inexpensive desk lamp using the preformed plastic box as the base.

DESCRIBING YOUR TASK

◀ DESIGN SPECIFICATION

You need to draw up a design specification for your High Tech lamp. A specification is a more detailed description of what a product will be like, what it will do and who will use it.

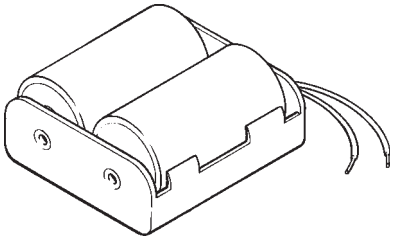
Here are some questions which will help you produce your product specification:

- *Who will use the lamp?*
- *Where will it be used?*
- *Will it need to be adjustable?*
- *What material will you use for the structure?*
- *How will you fasten the structure together?*

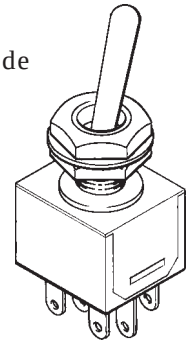
WHAT YOU HAVE TO WORK WITH

◀ DESIGN CONSTRAINTS

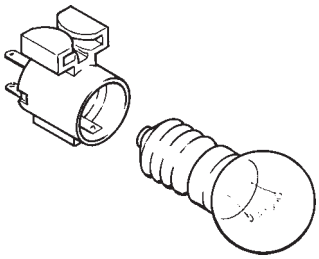
Firstly, you need to know what materials and equipment are available. Your teacher will provide you with some of the materials listed below. Make a note of what there is.



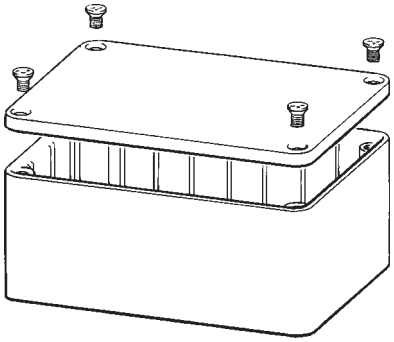
2 'D' type cells and holder



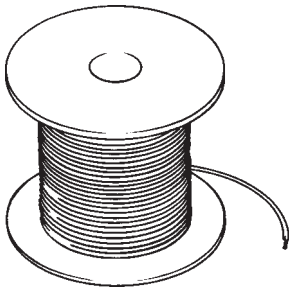
Switch



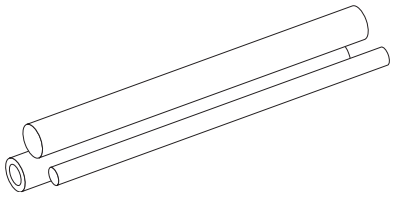
Bulb and holder



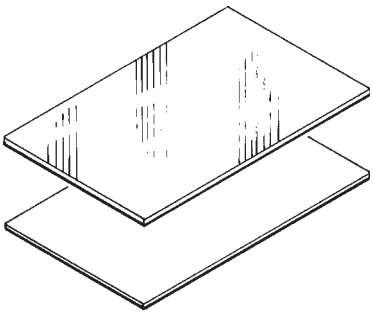
Plastic box



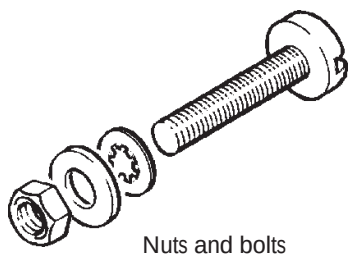
Wire for circuitry



Aluminium / steel rod



Mirrored polystyrene sheet



Nuts and bolts

WORKING OUT YOUR DESIGN

Having considered what is available to make it, you need to think about some ideas for the lamp.

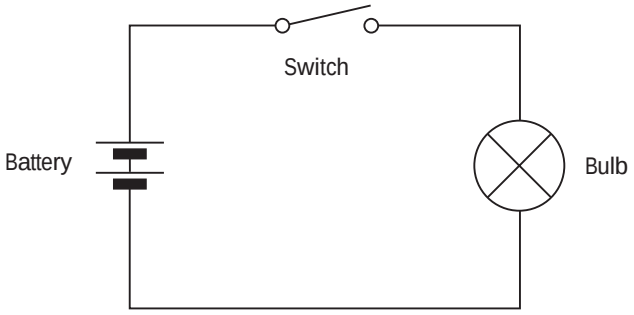
- *Set your ideas down on paper.*
- *Play around with your ideas.*
- *Check your ideas against your specification.*
- *Decide which is the best design.*
- *Do a detailed drawing of it.*
- *You will need to end up with a working drawing from which you or someone else can work to mark out, make and assemble the parts.*

NOTE

See Technology Study File 2.

The following notes will give you some ideas about how the lamp can be designed and made.

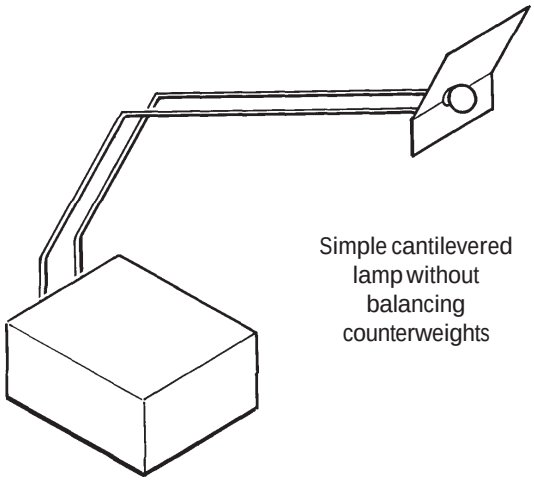
The box provided for the base is just big enough to house a battery holder for two C type cells and a switch. It is made from rigid ABS plastic. The circuit is simple consisting of only two wires leading from the battery box to the supporting structure. The bulb then bridges the gap in the circuit by connecting the two halves of the structure.



SCIENCE OPPORTUNITY

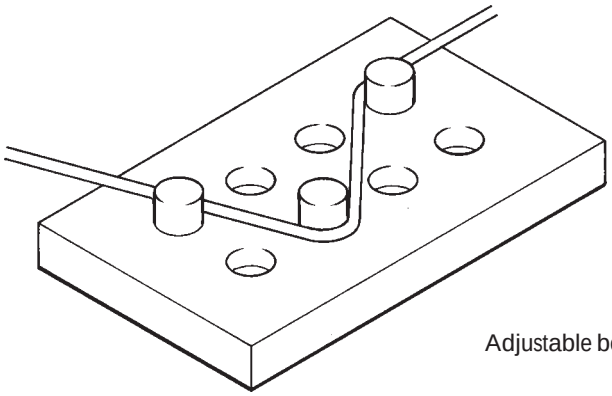
HOW WILL THE BULB BE SUPPORTED?

The support between the bulb and the base might be two conductors jointed for adjustment. Steel or aluminium rods of small cross sectional area are suitable because they conduct electricity and can be easily formed.



Simple cantilevered lamp without balancing counterweights

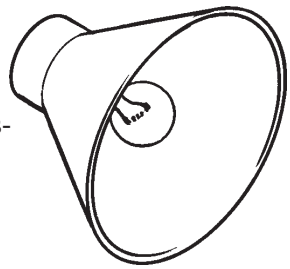
There is a need in some circumstances to ensure that two or more parts are bent to the same shape. This can be easily achieved with a 'jig'. An adjustable jig can be made by drilling holes in a thick steel plate and turning down pegs of the required diameter to fit. The pegs are positioned on the plate and once they have been inserted, wire can be formed around them.



Adjustable bending jig

LAMPS AND REFLECTORS

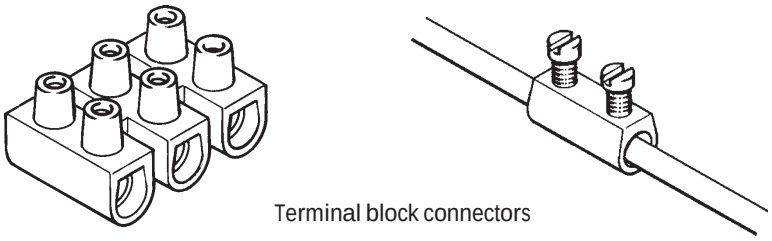
Most lamps make use of a reflector to direct the light given out from the bulb. One method of commercial production involves injection-moulding a thin plastic dome to which a reflective coating is applied. A second method involves press-forming thin aluminium sheet and then smoothing and polishing it to give a good reflective surface.



JOINING SUPPORTS

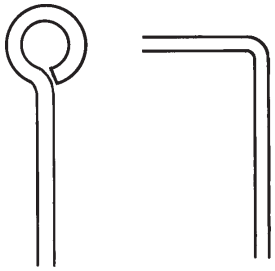
Rigid Joints

A rigid joint can be achieved by using electrical terminal block connectors, which are usually housed in plastic, but can be removed with the careful use of a sharp knife. An appropriate size of connector will allow the rods to be inserted from both ends and secured with the screws.



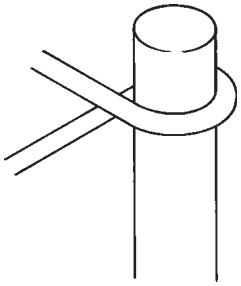
Terminal block connectors

Moving Joints
If a joint is to move, remember that it has to conduct electricity. One method of making a moveable joint is to form a loop or eye at the ends of two rods and bolt them together.



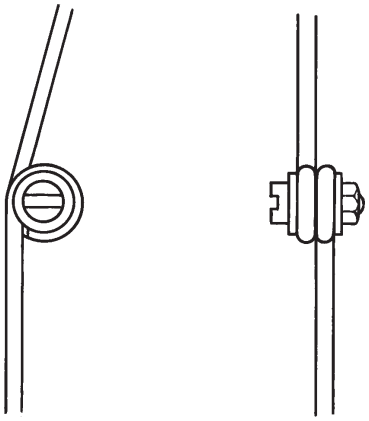
To bend a loop alongside the rod there is no need to create the right angle first.

Alternatively the rod could be bent round a piece of appropriate sized bar to obtain a precise loop. It is worth remembering that the elastic nature of the material will cause the loop to spring back a little making the internal diameter of the loop a little larger than the bar it was bent around.



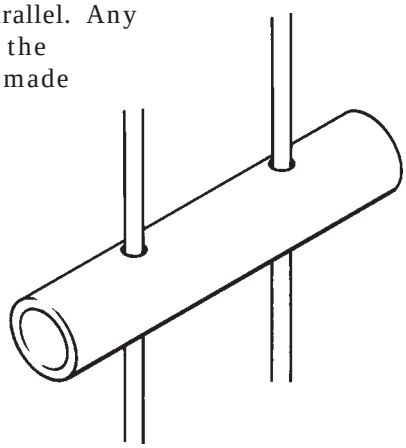
Once a loop has been formed at the two ends to be joined, a bolt may be passed through and a nut used to secure the fitting. The torque (tightening force) applied to the fixing will determine the freedom of the joint.

Alternatively the ends could be flattened with only a small amount of force from a hammer blow against the end of the rod on an anvil. The flattened end can then be drilled and secured.



INCREASING STABILITY

It may be necessary to provide support between the two rods in order to keep them parallel. Any connection between the two with the exception of the bulb needs to be made with a non-conductive material (an insulator). EMA tubing can provide a cost effective solution. A short length, with holes punched or drilled in both ends, can be fastned to both rods maintaining the distance between the two.



MAKING A REFLECTOR

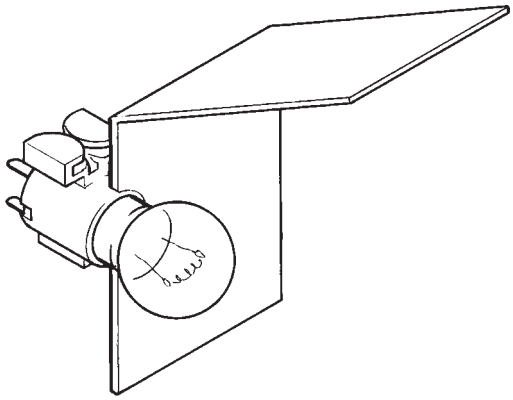
The purpose of a reflector is to focus and direct the beam of light. A prototype can be constructed from a shallow cone of card lined with baking foil. The angle to which the cone is formed will affect the beam. To establish the angle required simply adjust the size of the cone until a satisfactory result is obtained. Once the angle has been decided a more permanent reflector can be made. Vacuum forming mirrored polystyrene or thin mirrored acrylic sheet will give a lightweight reflector with very good reflective properties.

Alternatively, a disc of aluminium may be hollowed using a bossing mallet against a sand bag to form the basic dish shape. Once the shape has been achieved it can be smoothed and polished to quite a good reflective surface.

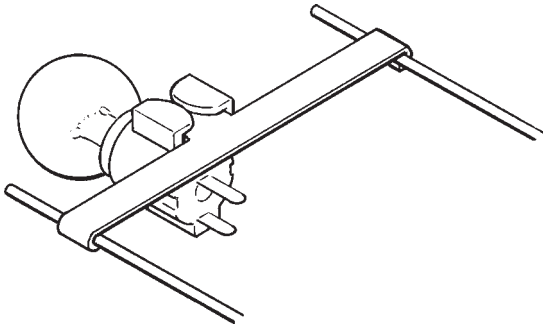
Another method is to form a piece of mirrored acrylic or polystyrene sheet by one or more bends. This type of reflector is now common on many high-tech type lamps.

SCIENCE OPPORTUNITY

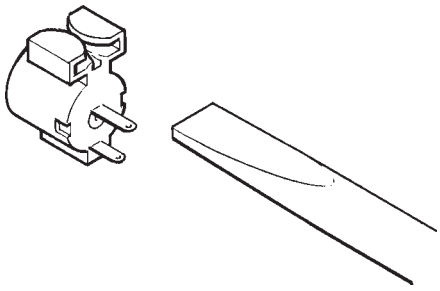
Specular reflection and reflection shapes.



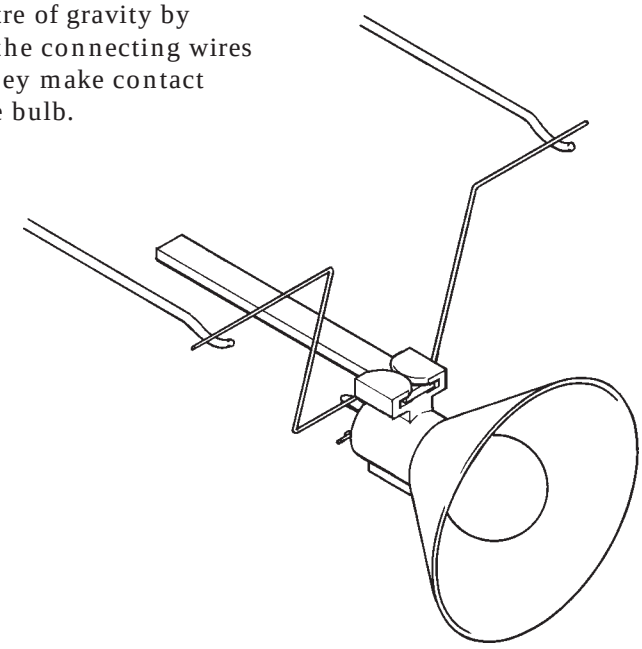
The reflector will need to be attached to the bulb holder or supports. Bulb holders are manufactured in a variety of shapes and forms. One suitable type is the clip-on bulb holder which incorporates a moulded recess. A support can be inserted into this recess, enabling the rigid attachment of the bulb and reflector to the framework. If this support is only to attach the bulb and not connect it to the power supply then it needs to be constructed from an insulating material such as polystyrene sheet. The connections for the bulb should be made separately to each supporting rod.



Alternatively, thick connecting wires to the conductive frame can be used to support the weight of the bulb and reflector. A counterbalance may then be inserted in the rear of the bulb holder as shown.



It may be necessary to lower their centre of gravity by bending the connecting wires so that they make contact above the bulb.



THE LAMP BASE

The supports for your lamp have to be joined to the base box and electrical connections made inside. The box is just large enough to contain the batteries and so you must think carefully about positioning the switch and the supports. These can be fitted by drilling into the box.

PUTTING IT ALL TOGETHER

It should be easy to assemble your lamp if you have thought carefully about the design of the different parts. In particular, take care to ensure battery safety and read the notes below.

Battery Safety Guidelines

- You should not use rechargeable batteries in your lamp because very high currents can flow if they are short circuited. This can lead to the batteries becoming very hot causing personal injury.
- Take care to fit your batteries correctly, observing the plus and minus marks on the battery and appliance. Incorrect fitting can cause leakage or, in extreme cases, fire or even an explosion.
- Replace the whole set of batteries at one time. Take care not to mix old and new batteries or batteries of different types.
- Store unused batteries in their packaging and away from metal objects which may cause a short circuit.
- Remove dead batteries from equipment you know you are not going to use for a long time. Otherwise the batteries may leak and cause damage.
- Never attempt to recharge ordinary batteries, either in a charger or by applying heat to them since they may leak or explode.
- Supervise children if they are replacing batteries themselves, in order to ensure these guidelines are followed.

EVALUATING YOUR LAMP

There are a number of things to consider when evaluating your Hi-tech lamp.

- Does it meet the specification?
- Is it stable?
- Does it illuminate the required area?
- Is it visually interesting and pleasing?
  (When considering visual appeal, it is normal to ask a variety of people.)