

## APPENDICES

### QUESTIONNAIRE FOR PROBE OF APPARATUS MARKET

#### Part 1

1. Name of school:
2. Name of person to whom correspondence should be addressed:
3. Telephone number:
4. Type of school:
5. Number of pupils in school:
6. Level to which pupils are taught:
7. Number of parallel streams:
8. Are the following subjects taught separately? physics; chemistry; biology:
9. Is general science taught as well as, or instead of, above separate subjects?
10. Average number of pupils per class:

#### Part 2

11. How much money, if any, is spent at present on apparatus annually for  
(a) physical sciences? (separate into physics and chemistry, if possible)  
(b) biological sciences? (c) general science?
12. Are you interested in the samples of apparatus shown?
13. At the prices asked, how much would you buy?
14. How much would you spend annually if told/shown what was available?
15. Is there any particular time of year when it is easier to buy apparatus because of availability of funds?
16. If there were an apparatus fair at some accessible centre once a year, would you (a) find it useful? (b) attend?
17. Could you, under any condition, pay cash on delivery? If not, what period would be needed for payment?
18. Would you welcome, and use, a periodical pamphlet saying what apparatus is available and outlining its uses, and giving prices and availabilities?
19. For expensive apparatus which is beyond your financial reach, would you welcome the establishment of a pool of apparatus at some local centre from which you could borrow?
20. For the use of the pool outlined in 19, would you be willing to pay a small annual charge to cover the cost of maintenance?

BASIC EQUIPMENT FOR A LOW-COST  
SCIENCE EQUIPMENT PRODUCTION CENTRE

For design and development activities combined with an average production worth £100,000 (on no profit, no loss basis), a modest requirement of equipment is given below for a workshop having nearly 2,000 sq. metres of covered area and employing nearly 100 persons. The list may prove uneconomical for small countries. In such cases neighbouring countries may decide to establish a common regional centre to cater for their needs.

A. Design Section

1. Drafting machine, drawing board, instrument box, set squares etc.
2. Ammonia printing equipment.
3. Electronic stencil cutter.
4. Duplicating machine.
5. Screen printing equipment.

B. Development Section

1. Tool room lathe - Height of centre - 150 mm  
distance between centres - 500 mm
2. Precision lathe - Height of centre - 100 mm  
distance between centres - 300 mm
3. Screw cutting lathe - Height of centre - 200 mm  
distance between centres - 1 metre
4. Drilling machine - Capacity - 18 mm  
Height of work - 200 mm
5. Padestal tool grinder - Wheel dia - 400 mm
6. All types of handtools for fitting jobs

C. Machine Shop

1. Screw cutting lathe - Height of centre - 200 mm  
distance between centres - 1000 mm
2. Screw cutting lathe - Height of centre - 200 mm  
distance between centres - 1 metre
3. Precision lathe - Height of centre - 200 mm  
distance between centres - 1.5 metre
4. Screw cutting lathe - Height of centre - 175 mm  
distance between centres - 1.2 metre
5. Shaping machine - Stroke - 600 mm
6. Padestal tool grinder - Wheel dia - 400 mm - 3 Nos.
7. Power hacksaw - Max. dia of work - 150 mm
8. Universal milling machine - Vertical travel - 300 mm  
Horizontal travel - 320 mm  
Cross travel - 200 mm
9. Vertical milling machine - Swivel head, travel of head - 200 mm  
Vertical travel of bed - 300 mm
10. Horizontal milling machine - Vertical travel - 800 mm  
Horizontal travel - 800 mm  
Cross travel - 500 mm

- |     |   |   |
|-----|---|---|
| 11. | Universal tool & cutter grinder                         | - Longitudinal traverse - 400 mm<br>Cross traverse - 150 mm<br>Vertical movement of wheel head - 100 mm |
| 12. | Cylindrical grinder                                     | - Max. work diameter - 150 mm   |
| 13. | Surface grinder   | - Table travel - 710 mm<br>Vertical travel - 300 mm<br>Cross travel - 235 mm                            |
| 14. | Engraving machine                                       | - Horizontal travel - 200 mm<br>Vertical travel - 300 mm<br>Cross travel - 200 mm                       |
| 15. | Turret lathe  | - Bar capacity in collet - 18 mm  |
| 16. | Semi-automatic capstan lathe                            | - Bar capacity in collet - 18 mm<br>Bar capacity in chuck - 50 mm                                       |
| 17. | Pillar drilling machine                                 | - Capacity - 25 mm  |
| 18. | Bench drilling machine                                  | - Capacity - 12 mm  |
| 19. | Spring winder   |   |
| D.  | <u>Die Stamping Section</u>                             |   |
| 1.  | Punch press   | - Capacity - 40 ton   |
| 2.  | Hydraulic press   | - Pressure - 400 kg./cm <sup>2</sup>  |
| 3.  | Lathe (gap bed)   | - Height of centre - 200 mm<br>distance between centres - 1 metre                                       |
| 4.  | Fly press, hand-operated                                | - No.4 and No. 6  |
| E.  | <u>Sheet Metal &amp; Fitting Section</u>                |   |
| 1.  | Power-operated sheet cutting machine (guillotine shear) | - Length of cut - 2 metres<br>Max. thickness of sheet - 3 mm  |
| 2.  | Power-operated sheet bending machine                    | - Length of bed - 2 metres<br>Max. thickness of sheet - 3 mm  |
| 3.  | Hand-operated shear                                     | - Max. thickness of sheet - 16 SWG  |
| 4.  | Drilling machine  | - Capacity - 12 mm  |
| 5.  | All sheet-metal and fitting hand-tools                  |   |
| F.  | <u>Carpentry Section</u>                                |   |
| 1.  | Wood turning lathe                                      | - Height of centre - 100 mm<br>distance between centres - 1.2 metre                                     |
| 2.  | Thickness planer  | - Max. thickness of work - 150 mm   |
| 3.  | Foot-operated fretsaw                                   |   |
| 4.  | Band saw  |   |
| 5.  | Circular saw  | - Diameter - 400 mm   |
| 6.  | Disc and belt sander                                    | - 300 mm disc   |
| 7.  | All carpentry hand-tools                                |   |
| G.  | <u>Plastic Moulding Section</u>                         |   |
| 1.  | Plastic injection moulding machine (manual)             | - 200 gms. capacity   |
| 2.  | Plastic injection moulding machine (manual)             | - 60 gms. capacity  |
| 3.  | Plastic injection moulding machine (semi-automatic)     | - 100 gms. capacity   |

4. Plastic injection moulding machine (manual) - 30 gms. capacity
5. Blowing-moulding machine (manual) - 100 gms. capacity
6. Blowing-moulding machine (manual) - 30 gms. capacity
7. Plastic scrap cutting machine -
8. Vacuum forming machine - 450 x 450 x 200 mm capacity
9. Plastic coating equipment
- H. Optics Section
  1. Glass blowing equipment - Set of glass blower tools - 2 sets  
Blast burner - 2 Nos.  
Small air blower with air flow and pressure valve - 1 No.
  2. Lens grinding machine
  3. Polishing machine
1. Electro-plating Section
  1. Rectifier/motor generator
  2. Tanks, salt accessories
  3. Polishing machine
- J. Welding Section
  1. Gas welding equipment
  2. Arc welding equipment (transformer, electrodes etc.)
  3. Spot welding machine - Max. sheet thickness - 18 SWG
- K. Foundry
  1. Blower and pit furnace for floor moulding
  2. Crucibles and all foundry tools
  3. Die casting machine (medium)
- L. Painting Section
  1. Spray gun
  2. Air compressor
- M. Electrical Section
  1. Coil winding machine
  2. Multi-meter and other metres
  3. All hand tools for electrician

- N. General
- 1. Measuring tools
- 2. Inspection tools and gauges
- 3. Cutting tools
- 4. Portable drilling machine with accessories for converting it into other powered tools
- 5. Conveyor belt for inspection and assembly purposes
- 6. Sundries

EVALUATION OF WORKSHOP\*

BACKGROUND INFORMATION

1. Name of country .....
2. (a) Position .....
- (b) Designation .....
- (c) Place of Work .....
3. Academic Qualification: Graduate  
   (Bachelors or above) ..... Diploma .....
- .....
- Others .....
4. Working Experience: 1-5 years ..... 6-10 years .....
- 11-15 years ..... over 15 years .....
5. Attendance at Low-Cost Science Teaching Equipment Seminars/Workshops

Frequency	National	International
Once	.....	.....
Two Times	.....	.....
Three Times	.....	.....
More than Three Times	.....	.....

6. How did you receive information about this Workshop?

Contacted by the Commonwealth Secretariat	.....
Contacted by National Government	.....
Contacted by National Ministry of Education	.....
Contacted by Academic Institution	.....
Contacted by National Science Teachers' Association	.....

\* Please tick wherever applicable

7. Who is responsible for paying your bills for this Workshop?

	Commonwealth Secretariat	National Government	Self Supported
(a) Round-trip Fare	.....	.....	.....
(b) Hotel Accommodation	.....	.....	.....
(c) Feeding	.....	.....	.....

8. How did you travel to this Workshop?

By Air ..... By Road ..... Not relevant .....

SPECIFIC ASPECTS OF WORKSHOP

How would you rate the following aspects of the Workshop?

	<u>Good</u>	<u>Fair</u>	<u>Poor</u>
Arrangement for obtaining flight ticket	.....	.....	.....
Arrangement for meeting you on arrival at Lae	.....	.....	.....
Hotel accommodation	.....	.....	.....
Arrangement for visits to schools	.....	.....	.....
Arrangement for excursions	.....	.....	.....
Daily transportation	.....	.....	.....

Laboratory Sessions

Organization:	Satisfactory	.....	Fair	.....	Unsatisfactory	.....
Experience gained:	Useful	.....	Fair	.....	Not Useful	.....
Materials provided:	Adequate	.....	Fair	.....	Inadequate	.....
Tools provided:	Adequate	.....	Fair	.....	Inadequate	.....

How would you assess the Lead Papers?

Lead Paper 1: 'Training for the Production of Low-Cost Teaching Equipment'

Content:	Adequate	.....	Fair	.....	Inadequate	.....
Presentation:	Satisfactory	.....	Fair	.....	Unsatisfactory	.....
Time allocation for presentation:	Adequate	.....	Fair	.....	Inadequate	.....

Time spent on group discussion:	Adequate	.....	Fair	.....	Inadequate	.....
Presentation of group reports:	Satisfactory	.....	Fair	.....	Unsatisfactory	.....
Time spent on plenary discussion:	Adequate	.....	Fair	.....	Inadequate	.....

Lead Paper II: 'Low-Cost Science Teaching Equipment: Training for Use'

Content:	Adequate	.....	Fair	.....	Inadequate	.....
Presentation:	Satisfactory	.....	Fair	.....	Unsatisfactory	.....
Time allocation for presentation:	Adequate	.....	Fair	.....	Inadequate	.....
Time spent on group discussion:	Adequate	.....	Fair	.....	Inadequate	.....
Presentation of group reports:	Satisfactory	.....	Fair	.....	Unsatisfactory	.....
Time spent on plenary discussion:	Adequate	.....	Fair	.....	Inadequate	.....

Lead Paper III: 'Commonwealth Co-operation in Education with Special Reference to Science Education'

Content:	Relevant	.....	Fair	.....	Not relevant	.....
Presentation:	Satisfactory	.....	Fair	.....	Unsatisfactory	.....
Time allocation for presentation:	Adequate	.....	Fair	.....	Not adequate	.....
Time allocation for discussion:	Adequate	.....	Fair	.....	Not adequate	.....

YOUR PERCEPTION OF LOW-COST SCIENCE EQUIPMENT

	Agree	Not Sure	Disagree
1. Low-cost science equipment will be inadequate for teaching Primary Science in my country	.....	.....	.....
2. Low-cost science equipment will be <u>adequate</u> for teaching <u>High School Science</u> in my country	.....	.....	.....
3. At the present moment, the production of low-cost science equipment will be feasible in my country	.....	.....	.....

	Agree	Not Sure	Disagree
4. Teachers in my country will not be enthusiastic in the use of low-cost science equipment	.....	.....	.....
5. The use of low-cost science equipment will help students become interested in future work in science	.....	.....	.....
6. The use of low-cost science equipment will make science more relevant to the environment of the learner	.....	.....	.....
7. Teachers in my country are not sufficiently trained to use low-cost science equipment	.....	.....	.....
8. In-service workshops should be frequently organized for teachers who use low-cost science equipment	.....	.....	.....
9. Classroom science teachers should be involved in the mass production of low-cost science equipment	.....	.....	.....
10. Results obtained using low-cost science equipment are grossly inaccurate	.....	.....	.....
11. Low-cost science equipment should only be used in Teacher Training Colleges	.....	.....	.....
12. The use of low-cost science equipment is inappropriate in industrially advanced countries	.....	.....	.....
13. The production of low-cost science equipment should not be undertaken at the regional level but at the national level	.....	.....	.....
14. Low-cost science equipment is not suitable for practical examinations	.....	.....	.....
15. Low-cost science equipment leads to a cheap but ineffective way of teaching science	.....	.....	.....

FREE RESPONSE

1. What is it you like best in this workshop?
  
2. What is it you dislike most in this workshop?
  
3. What is it you would have liked to see done in this workshop which was not done?

4. What would you suggest for inclusion in a workshop of this nature in future in the Pacific?
5. How useful has this workshop been to you personally?
6. What would you plan to do as a follow-up to this workshop in your country?
  - (a) In your official capacity?
  - (b) In your professional capacity?

## WORKSHOP CONSTRUCTION EXERCISES

One of the aims of these sessions was to enable the participants to experience the tasks involved in designing and constructing a piece of apparatus. The participants, working in groups, selected two topics (one primary and the other secondary) from the Papua New Guinea material on display. They decided what apparatus they would need to teach the topic, designed and constructed it, and prepared a teachers' guide about its construction and use. Finally each group presented its apparatus and materials for discussion and evaluation by the participants. A brief summary follows.

Group A constructed two pieces of apparatus. For their primary-level topic, a rotating colour disc was made using a tin can, a piece of rod, cardboard and string. The group reported on the difficulty experienced in getting the correct colours, and in colouring the disc in the required manner to obtain white when the disc was rotated. For their secondary-level topic, the group chose to construct a hydro-electric generator. Difficulties were experienced in obtaining a suitable electric motor to use as a generator, and in constructing the water wheel.

For their primary-level topic, Group B chose to construct apparatus to enable simple electric circuits to be investigated. The bulb holders, switch, and battery holders were made from tin lids, strips of tin cans, bamboo and plywood. The group showed how robust apparatus could be made easily from materials brought to school by pupils. The topic chosen for the secondary level was the 'expansion of liquids'. The apparatus required was constructed from two identical bottles, two empty plastic tubes (taken from ball-point pens), and a paper screen. During discussions two difficulties were considered. One was that of getting identical items so as to make a true comparison and the other was that the concept of unequal expansion of liquids might be hard for an inexperienced teacher to explain.

A piece of apparatus to demonstrate electro-magnetism was constructed by Group C for their primary-level topic. The apparatus involved winding a coil and making a stand to support a suspended rod inside the coil. Discussion took place on the construction techniques and also on the versatility of the apparatus in relation to other topics on electricity. A hydro-electric generator was constructed for the secondary-level topic on energy transfer. The apparatus consisted of a tin can with a water wheel and jet, connected to a bicycle dynamo which, in turn, was connected to a torch bulb. Considerable discussion took place on both of the above items, particularly in relation to the skills needed for the manufacture, and the time involved. It was felt that the services of a production unit would be needed if all schools were to have such items. Another point referred to was that a school would need running water to use such a piece of apparatus. This highlights the problem of developing apparatus to suit the facilities available.

Group D chose to investigate alternative designs for a pin-hole camera for use when teaching 'light' at the primary level. Various designs were made using tin cans, bamboo, cardboard and ruled paper. For the translucent screen, typing paper with some oil on it was found to be effective. An alternative was a plastic lid found on some tin cans. For their secondary-level topic the group constructed two forms of insect cages and a simple

potometer using a syringe, plastic tubing and a broken rule. In addition, a storage box for 12 spirit burners was constructed and presented as an idea whereby teachers could store their apparatus in boxes and easily ensure that all items were returned at the end of a practical session. Discussions revolved around the need to incorporate such activities in teacher training courses as all of the above items were well within the capabilities of any teacher who had had some basic training in construction techniques.

Group E took the field of electricity as its overall topic and constructed apparatus for three levels - primary, lower secondary and upper secondary. For the primary level an electric buzzer was constructed. For the lower secondary level a piece of demonstration apparatus was made for showing the magnetic effect of an electric current. As a third item the group constructed an electric motor using nails, screws, wire and other easily obtainable materials.

Discussions took place on the suitability of the apparatus for demonstration purposes particularly in relation to the size of apparatus for large group viewing.

Before considering the specific activities of each group some general observations are worth mentioning. These are provided to highlight areas which need particular attention when incorporating such activities in teacher education, and to reinforce the need for appropriately trained personnel when considering the design, development and production of school science equipment.

1. It is interesting to note that, for the primary level, all groups selected a physics topic for their activity even though material was also available on chemistry, biology and mathematics. For the secondary-level topics all but one group again chose physics. Whether the selection of physics was due to the pre-conditioning (when considering apparatus construction) is not quite clear. It is a point for consideration when introducing construction activities in teacher education programmes. Free choice of activity may not provide a balanced cross-section particularly for teachers of integrated science.

2. Though each group was expected to produce a design and list the necessary materials before the construction of the prototype commenced, it is probably true to say that many of the 'designs' came after the construction (i.e. development was based on 'trial and error'). This approach is acceptable but it is usually used to perfect a design rather than create a new one. By listing the requirements and working to a sketch, a number of 'false starts' can be avoided, thus saving time and preventing material from being wasted. A point to bear in mind is that enthusiasm can sometimes hinder rather than help. Good initial planning and design avoids unnecessary procurement of items which may not be used. In this particular workshop the technical staff and resource personnel often found themselves stretched to provide items and constructional details as 'good ideas' grew.

3. As can be seen from the presentations of the groups, preparation of the guide for construction and use is a most difficult task. Even when a prototype has been produced, the task of making instructions for other people to follow requires considerable skill. Much discussion took place on this aspect during the plenary sessions.

4. Basic training in simple constructional techniques must be given before a teacher can be expected to develop his own apparatus.

5. Time and physical resources limit what an individual teacher can do. For example, is it possible to obtain 40 tins for one class activity?

6. The size of a piece of apparatus is important if it is to be used for demonstration purposes.
7. When preparing teachers' guides for constructing and using apparatus, step-by-step instructions are needed to avoid any misunderstanding or ambiguity.
8. Diagrams should be clearly drawn, labelled, and related to specific parts of the text, particularly when constructing a number of items which will have to be assembled for one piece of apparatus.
9. A clear indication of sizes should be given for the benefit of the inexperienced teacher.
10. A basic kit of tools should be available in every school to enable teachers to construct items. An example is shown on page . The workshop construction exercises which follow are presented as similarly as possible to those that were submitted; slight alterations in the drawings and text have, however, been made where a little extra clarity was needed.

## GROUP A.

Topic: LIGHT

Sub Topic: Making Colours White

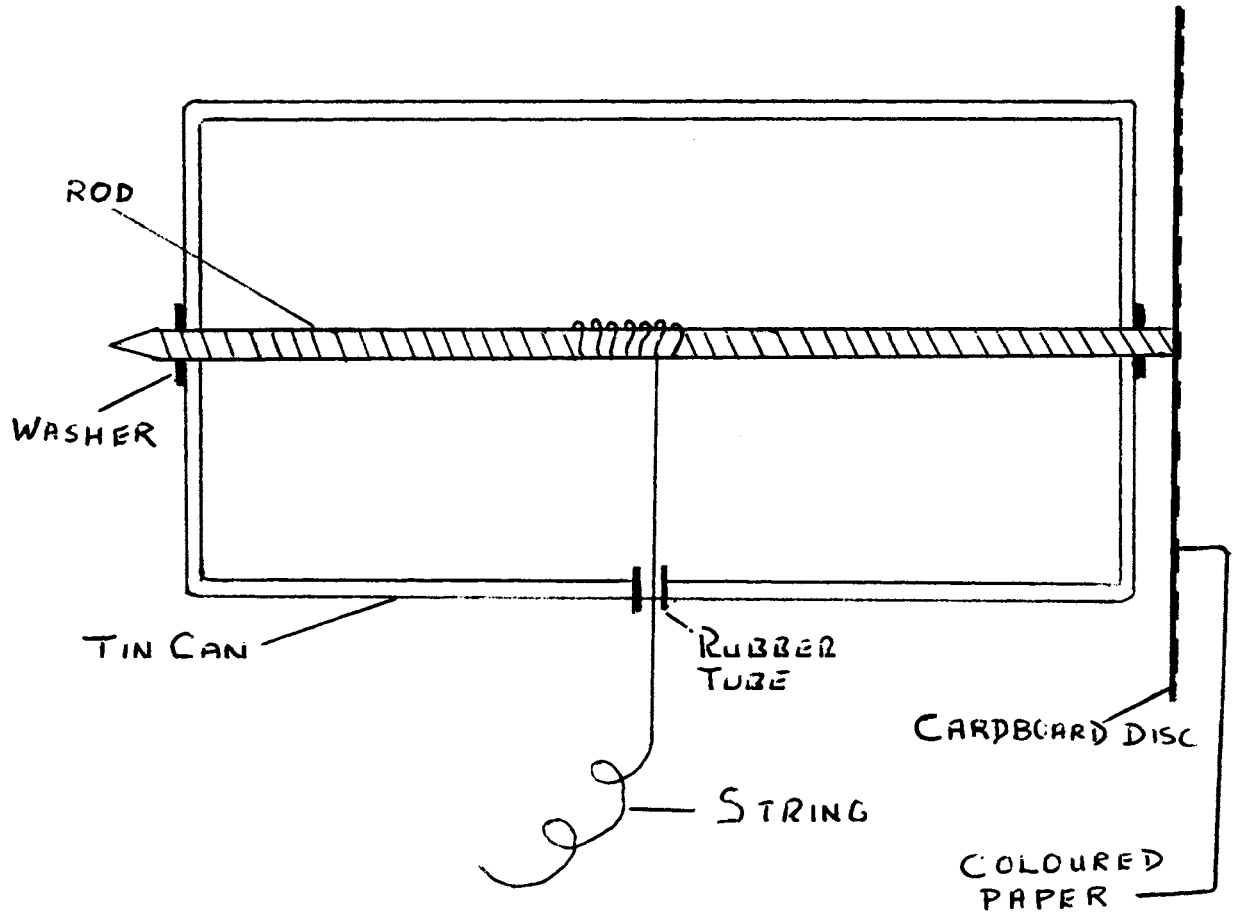
### Materials Needed

Empty Can (e.g. coffee tin) with a lid.  
Strong thin string (about 1 metre in length).  
Circular cardboard (e.g. plywood, masonite) about 14 cm. dia.  
Wood dowel (circular stick, metal rod, etc.) about 5 to 7 mm dia.  
White paper to fit circular disc.  
Glue to stick paper onto cardboard.  
Small washers or discs to fit rod.

### Steps in Construction

1. Make circular holes in the centre of the lid and base of the can. They should be slightly larger than the diameter of the rod.
2. Bore a small hole in the side of the can about half way along.
3. Cut out two circles about 14 cm. in diameter, one from the cardboard and one from the white paper.
4. Divide the circular white paper into seven equal segments and colour each segment in the following order of colours:  
  
Red; Orange; Yellow; Green; Blue; Indigo; Violet.
5. Glue the coloured circle onto the cardboard circle.
6. Make a hole in the centre of the disc so that the rod is a tight fit in the hole. Glue them together. (Araldite).
7. Place a small washer on the rod and fix it a short distance from the disc. Feed the rod through the lid.
8. Firmly attach the string to the centre of the rod and feed the string into the tin and out of the hole in the side. Fit the tin lid with the disc and rod, carefully fitting the rod through the hole in the base of the tin and fit second washer.
9. Wind the string onto the rod by turning the cardboard disc.
10. Tie a knot or loop on the end of the string so that it cannot enter the tin.
11. Give an even pull on the string to rotate the disc. Leave the string to hang loosely so that it is able to rewind onto the rod. Repeat this action for further rotations.

# APPARATUS FOR MAKING COLOURS WHITE



## GROUP A.

Topic: ELECTRICITY

Sub Topic: Hydro-electric Power.

Note: Hydro-electricity is a source of power in most countries. In some it is the most important single source of electricity. It is therefore desirable for students to understand the basic technology.

### Materials for making the prototype

Flat circular tin sheet or a large tin lid.

No. 8 wire or a metal rod about 2mm dia., and about 18cm. long.

Flat metal strip.

Two pulleys.

One motor from a toy or tape recorder.

A piece of timber for the base; about 15cm. x 30cm. x 2cm.

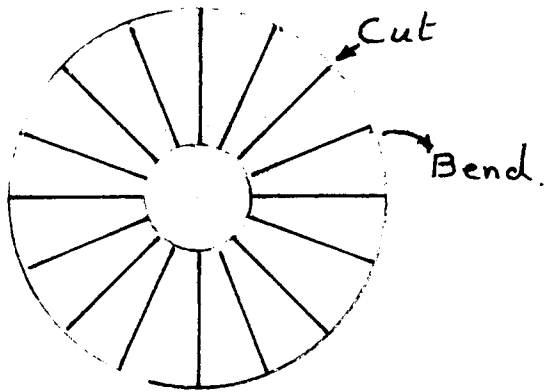
Nails or screws.

### Steps in Construction

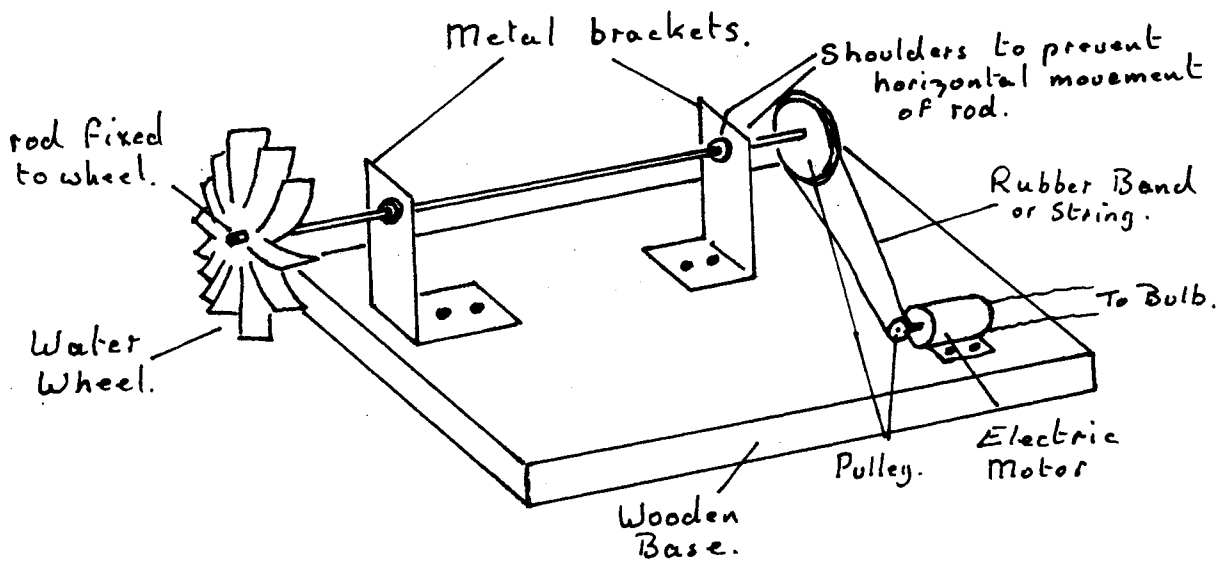
1. The base is prepared using a suitable piece of timber.
2. The water wheel is constructed from the circular piece of tin (tin lid), as follows:
  - i) From the centre of the lid, and using a radius of 2cm. scribe a circle. Then scribe a second circle using a radius of 4cm.
  - ii) Carefully cut out the 4cm. radius disc and, using a drill or nail make a hole in the centre of the same diameter as the rod available.
  - iii) Now divide the circle into 16 to 18 parts of equal size and cut down to the 2cm. scribed circle.
  - iv) Twist the cut so as to form a blade for catching water. All twists need to be in the same direction.
  - v) Fix one end of the rod to the water wheel and solder it in place. (Alternatively use a suitable adhesive such as Araldite).
3. Make two brackets from the flat metal strip exactly the same height. Bore a hole in each at the same height and having a slightly bigger diameter than the metal rod. Fix the brackets to the base.
4. Place a small spacer or shoulder on the metal rod and pass the rod through the hole in the first mounting bracket and then through the second bracket.
5. Place a second spacer (or shoulder) on the rod and fix a pulley onto the rod of about 8cm. diameter using Araldite. (Before fixing the pulley adjust the spacers so that the rod runs freely without sticking.)

6. Mount a toy electric motor (or home-made motor) onto the baseboard and fix a pulley of about 1cm. diameter onto the motor spindle. (The pulley should be in line with the pulley on the metal rod, see the diagram).
7. Make a belt (using string (or some other suitable material such as rubber) and connect the two pulleys together.

As can be seen from the diagram, the water would drive the water wheel which in turn, drives the motor (dynamo). This can then be connected to an electric circuit to light some bulbs.



Construction of the Water Wheel.



Arrangement of Apparatus for Demonstrating Hydro-electric Power.

## Group B.

Topic: ELECTRICITY

Sub Topic: Let's find out how to light more than one bulb at the same time.

### Materials Needed

Battery holder with terminal wires.  
Two bulb holders with wires attached about 20cm. long.  
One switch with wires attached about 20cm. long.  
Two 1.5 volt dry cells (batteries).  
Two 2.5 volt screw-type bulbs.  
Two thin lids.  
Flat wood about 10cm. long x 10cm. wide x 4cm. thick.  
Screws, nails and insulated wire.  
Bamboo of an internal diameter to take the batteries.  
Thin metal strip (e.g., as found on packing cases).

### Construction of the apparatus

#### A. Sockets (Two required)

See Sketch 1.

1. Cut the wood to make a 10 x 10cm. square piece.
2. Remove the insulation from the end of a 20cm. length of insulated wire.
3. Screw a small screw (preferably brass) into the wood somewhere near the centre. Wrap the bare end of the wire around the screw and tighten down.
4. Using a 6" nail lay it down horizontally and hammer it into the piece of wood, so that it makes a groove from the centre out.
5. Punch a hole in the centre of one of the metal lids with a nail. Enlarge the hole until the bulb can be screwed into the lid.
6. Nail the lid on to the piece of wood using 3 x 3cm. nails, making sure that the hole is directly above the screw. Leave  $\frac{1}{2}$ cm. of one nail above the lid.
7. Connect the bare end of another length of insulated wire to the nail and hammer it in.
8. Screw one of the bulbs into the hole by turning it until it touches the screw below.
9. Now make a second similar socket.

B. The Switch (one required)

See sketch 2.

1. Cut a piece of the wood to make a 7cm. square piece (approximately).
2. Cut a piece of the metal strip into a piece of about 6cm. x 1cm. using a pair of tin snips.
3. Make a hole in one end, using a nail and hammer. The hole should be made to the size of an available wood screw.
4. Screw one of the screws into the wood. Before screwing down wind one bare end of another length of the insulated wire around the screw and then screw firmly down.
5. Push the second screw through the hole in the metal strip and screw into the wood. The position should be such that the other end of the metal strip should overlap the screw already in the wood. As for the first screw the second one should have a bare end of insulating wire connected to it. Cut the lengths of wire off at about 2 cm. lengths.

C. Battery Holder (one required)

(See sketches 3 & 4)

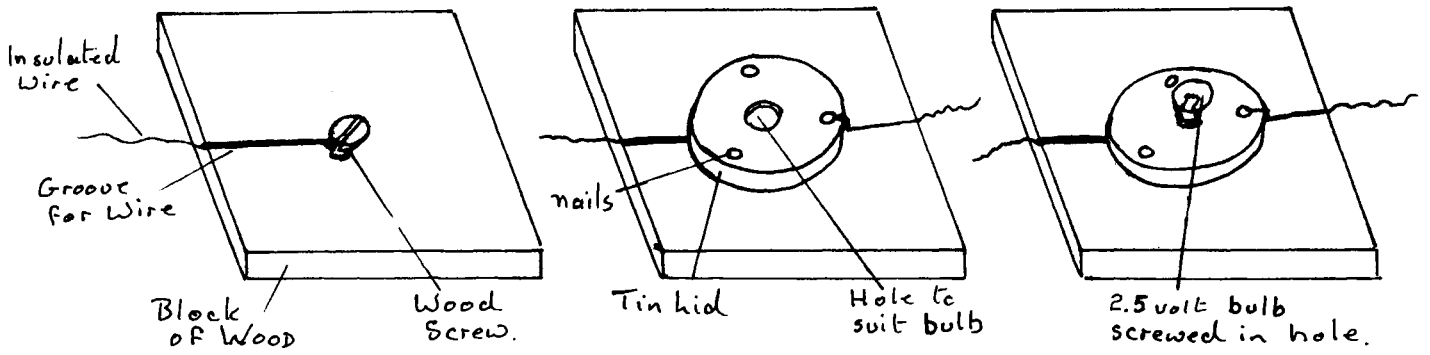
1. Having chosen a suitable piece of bamboo which allows the batteries to pass easily through it, cut it to about 17 - 18cm. in length.
2. Make the battery terminals as shown in the sketch 4.
3. Cut a slot in each side of the bamboo to take one of the terminals (see 'A' in sketch 3). Insert one of the cells and mark off the position for the second pair of slots (b). add a second cell and mark off the position for the third pair of slots (c). Remove the two cells and cut the slots.
4. Insert the terminals and cells and ensure that the terminals are firmly in contact with the cells.

Circuit for Use

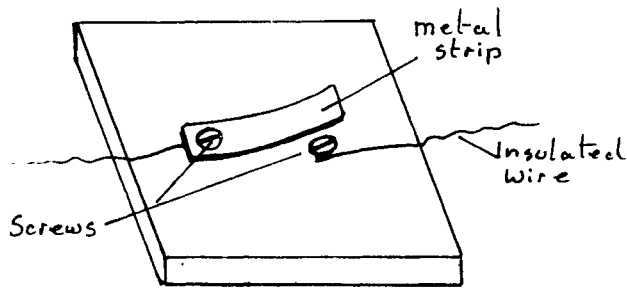
By joining the ends of the wires connect up the sockets, switch and battery holder as shown in sketch 5. The bulbs show light. If they do not check that:

- (a) Terminals are in contact with the cells. The negative one may require bending a little more to make a firm contact, or
- (b) Check that the terminals are not rusty where contact is made. Remove any rust by scraping with a knife or rubbing with sand/emery paper (this also applies to the switch).

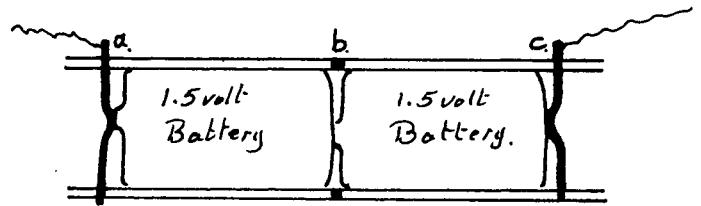
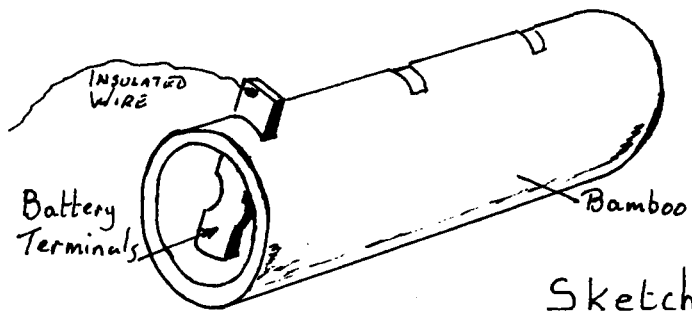
- (c) The bases of the bulbs in the socket are touching the tops of the brass screws beneath.
- (d) None of the wires is loose.



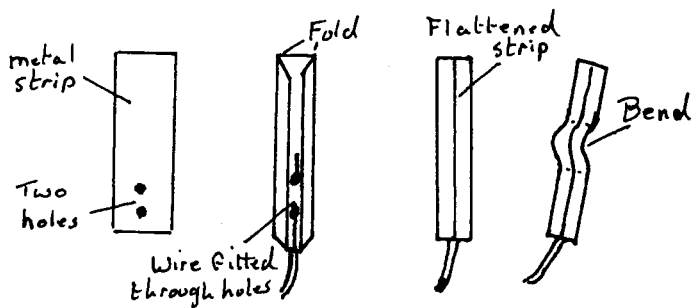
Sketch 1.      BULB HOLDER.



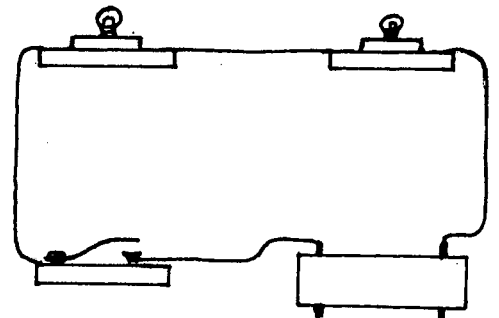
Sketch 2.      SWITCH.



Sketch 3.      BATTERY HOLDER.



Sketch 4.      Making the Battery Terminals.



Sketch 5.  
COMPLETED CIRCUIT

## Group B.

Topic: EXPANSION

Sub Topic: Expansion of liquids

### Materials needed

Two identical bottles of approximately 50cm.<sup>3</sup> capacity, with screw-on caps.  
Two empty ballpoint pen refills (or similar transparent tubes).  
One liquid container with height greater or equal to that of the bottles.  
Thin rubber strip (e.g. from a bicycle inner tube) to make the seal under the lids.

Cardboard, approximately 15cm. x 10cm.

Graph paper approximately 15cm x 10cm.

Piece of stick approximately 20cm. long to act as a stirrer.

Paper and glue.

Liquids to be compared, e.g. water and alcohol.

### Construction of the Apparatus

1. Make a small hole in the lids of each of the two bottles so that the plastic tubes fit tightly into them.
2. From the rubber sheet cut two discs so that they fit tightly into the lids of the bottles. Make a small hole in these rubber discs such that the plastic tubes fit tightly into them. (These discs act as seals to prevent the escape of liquids).
3. Stick the graph paper onto the cardboard and, using small strips of paper, stick the plastic tubes evenly to the graph paper (see diagram).
4. Carefully fit the tubes into the bottles, having filled the bottles with the liquids to be compared. Check that the tubes are strong enough to support the cardboard, if not, construct a suitable additional support.
5. Place the apparatus in the water container, it is then ready for use.

### Using the Apparatus

This apparatus can be made by a number of groups in the class with each group providing its own materials to do so. As with all apparatus, it is recommended that the teacher tries it out to observe any problems or difficulties.

1. Make sure that both tubes fit tightly into the caps and rubber seals.
2. Fill the bottles to overflowing with the chosen liquids. Screw on the caps so that (a) no leakage occurs, (B) a column of liquid appears in the tubes, (c) no air is trapped in the bottles.
- 3) If a leak appears where the tube enters the lid it can be sealed with mud, plasticene or candle wax. Alternatively a new rubber seal with a smaller hole can be used.

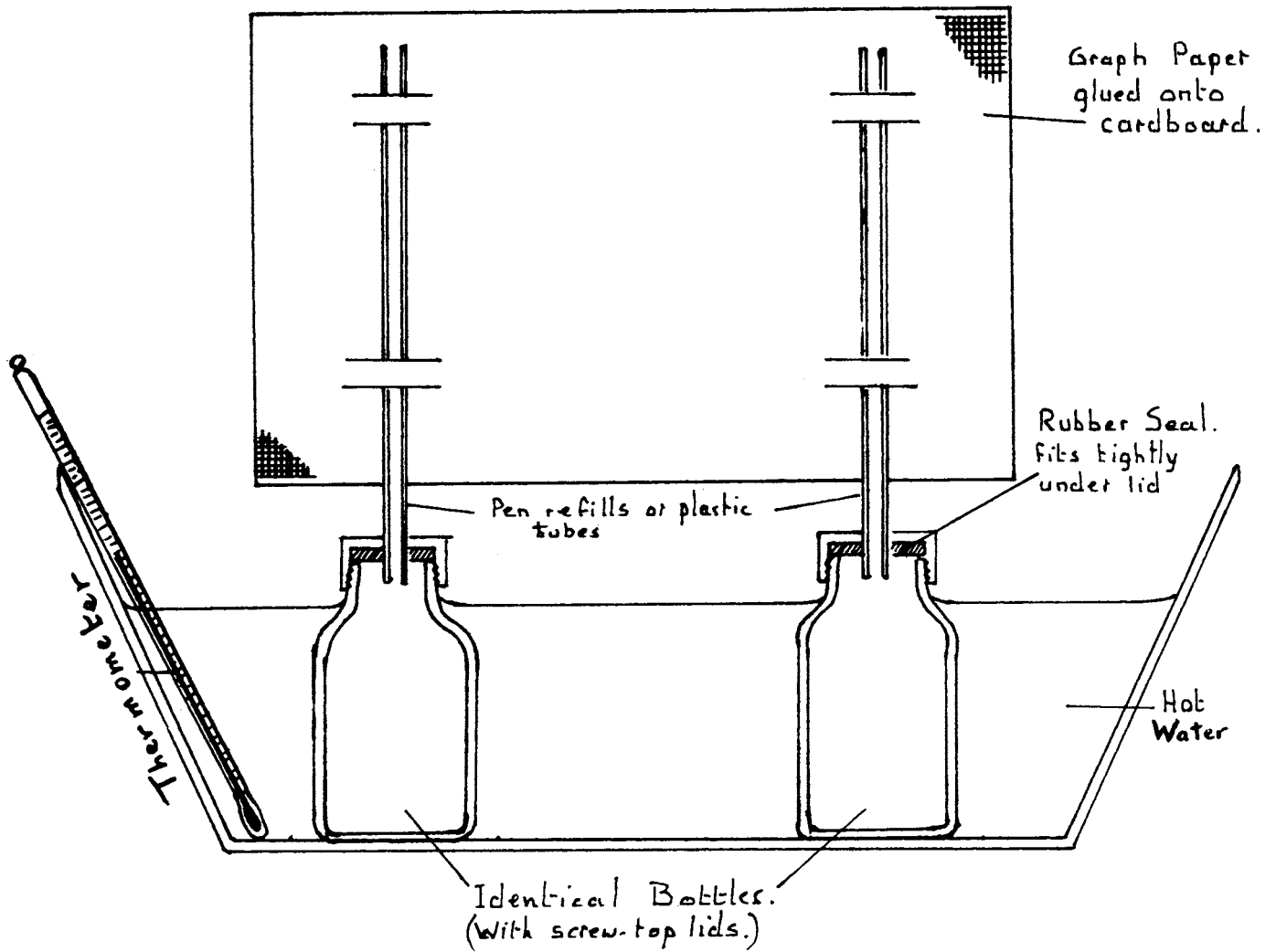
4. Ensure that the columns are initially the same height, if one is lower than the other an adjustment can be made by screwing the lid tighter on the bottle with the lower column.
5. Heat the water for the container in the sunshine until the group is ready to perform the experiment. Then place the bottles in the water stirring gently and continuously.
6. A single thermometer can service all groups by having each group request the thermometer only when they are ready to take the temperature reading.

### Evaluation

The narrower the tube the greater will be the height of the liquid rise. If there is overflow from the top of the tube then the following modifications can be adopted.

Use a tube of larger diameter, e.g. plastic transparent drinking straw, or the transparent barrel of a ballpoint pen. (Seal side hole). Do not warm the water in the container so much.

All the apparatus used in this experiment except the thermometer, one of the liquids, the graph paper and the glue, are 'discards' hence it is possible to have many sets of the apparatus constructed.



Arrangement of Apparatus for Observing the Expansion of Liquids.

GROUP C.

Topic: ELECTROMAGNETISM

Sub Topic: To show a novel use of electromagnetism and demonstrate some practical applications.

Materials Needed

Copper Wire (insulated)

Timber and board scraps

Tube - about 2 cm. diameter or paper and glue

1 rubber band

Nails

Tin can

Iron rod or bolt

Solder - if available

Tape - cello tape, insulation tape or adhesive tape, etc.

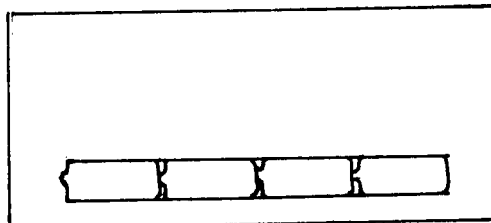
String

Dry cell batteries - 4 of 1.5 volt (large torch batteries, type D.)

Construction of the Apparatus (refer also to diagram)

1. Base

Obtain a piece of wood or ply about 30 cm. long by about 20 cm. wide. It must be about 30 cm. long so that the four batteries can be placed in series as shown here:



2. Support Stand

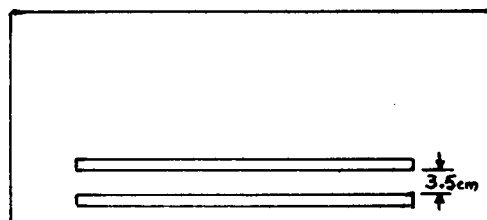
Any suitable piece of wood, e.g. 4 cm. x 2 cm. about 40 cm. long. This should be nailed to the base in the middle at the back edge so that it stands vertically.

3. Solenoid Support

Any piece of rigid metal, plastic, wood or plywood, (e.g. 3 ply 10 cm. x 2 cm.). It should be nailed to the support stand about 8 cm. above the base.

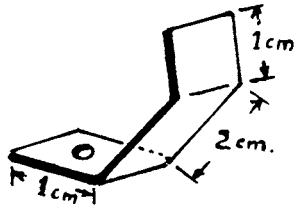
4. Battery Holder

Two pieces of wood about 2 cm. x 2 cm. and 24 cm. long. Nail them to the base so that they are 3.5 cm. apart and so that the batteries will fit in.



## 5. Battery Connectors

Cut two pieces of tin about 4 cm. long by 1 cm. wide. Bend them as shown below. With a nail or drill, make a hole in each. Nail one connector to each end of the holder so that they are 14 cm. apart. Place the batteries in and bend the connectors to suit. Solder the wires to the connectors; the wires can be nailed to the connectors if no suitable solder is available.



## 6. Switch

Cut strip of tin 1 cm. wide. Cut off two lengths, one 5 cm. long and the other 2 cm. long. Bend as shown below.



Connect wires with solder and secure with nails to the base. (Wire may be nailed under switch pieces if it is not possible to solder).

## 7. Solenoid

Solenoid about 2 cm. diameter and 8 cm. long.

PVC conduit or pipe, a length of thin-walled bamboo, or a cardboard tube. It is also possible to roll paper or cardboard into a tube and glueing or taping it together.

### Details for winding the coil

Take about 50 cm. of 0.5 mm enamelled copper wire or cotton insulated wire or bell wire and:

- i) Leave about 10 cm. free at one end and tape the wire to the former about 0.5 cm. from one end.
- ii) Start winding the coil closely and wind until about 0.5 cm. from the other end.
- iii) Put on another two layers of turnings and tape the wire at the opposite end to the first tape. Leave about 10 cm. before cutting the wire.

The solenoid can then be tied onto its support with string, rubber bands or wire.

## 8. Hanging Rod

Iron Rod - a reinforcing rod from a building site or bolt with the head cut off. This should be about 15 cm. long and between 1.0 cm. and 1.5 cm. in diameter. Make sure it can fit loosely inside the solenoid.

Hanging Loop - Fix a loop at one end of the iron rod with wire or string so that a piece of rubber can be tied to it.

### Rubber Band

Cut a medium sized rubber band and tie one end to the wire loop on the rod and the other end to the nail on the stand. Check that the rubber band can

stretch easily and that the iron rod moves easily through the solenoid. Also when the iron rod is hanging at rest the bottom should be just level with the bottom of the solenoid.

Large Nail (about 7 cm. long)

Nail this into the support stand at a convenient height depending upon the length of the piece of rubber. The nail can be bent so that the iron rod is centred in the solenoid.

Connecting the Circuit

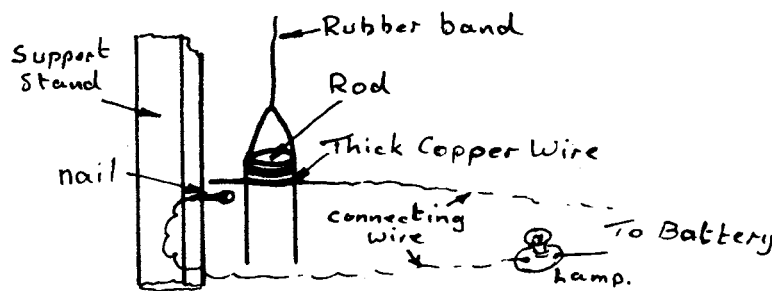
1. Connect one wire from the solenoid to the battery lead, and the wire from the other end of the solenoid to the switch wire.
2. Connect the other wire from the switch to the wire from the other end of the battery. The circuit is now ready for use.

Teachers Notes (Refer to the diagram)

- i) When the switch is pressed on the solenoid becomes magnetic and tries to draw the bar inside so that the middle of the iron bar is in the middle of the solenoid. The solenoid will pull the bar until the rubber band stops it going any further.
- ii) When the switch is then let off the rubber band will pull the rod up.
- iii) When the switch is pressed on and then let off repeatedly the rod will jump up and down.

Extensions

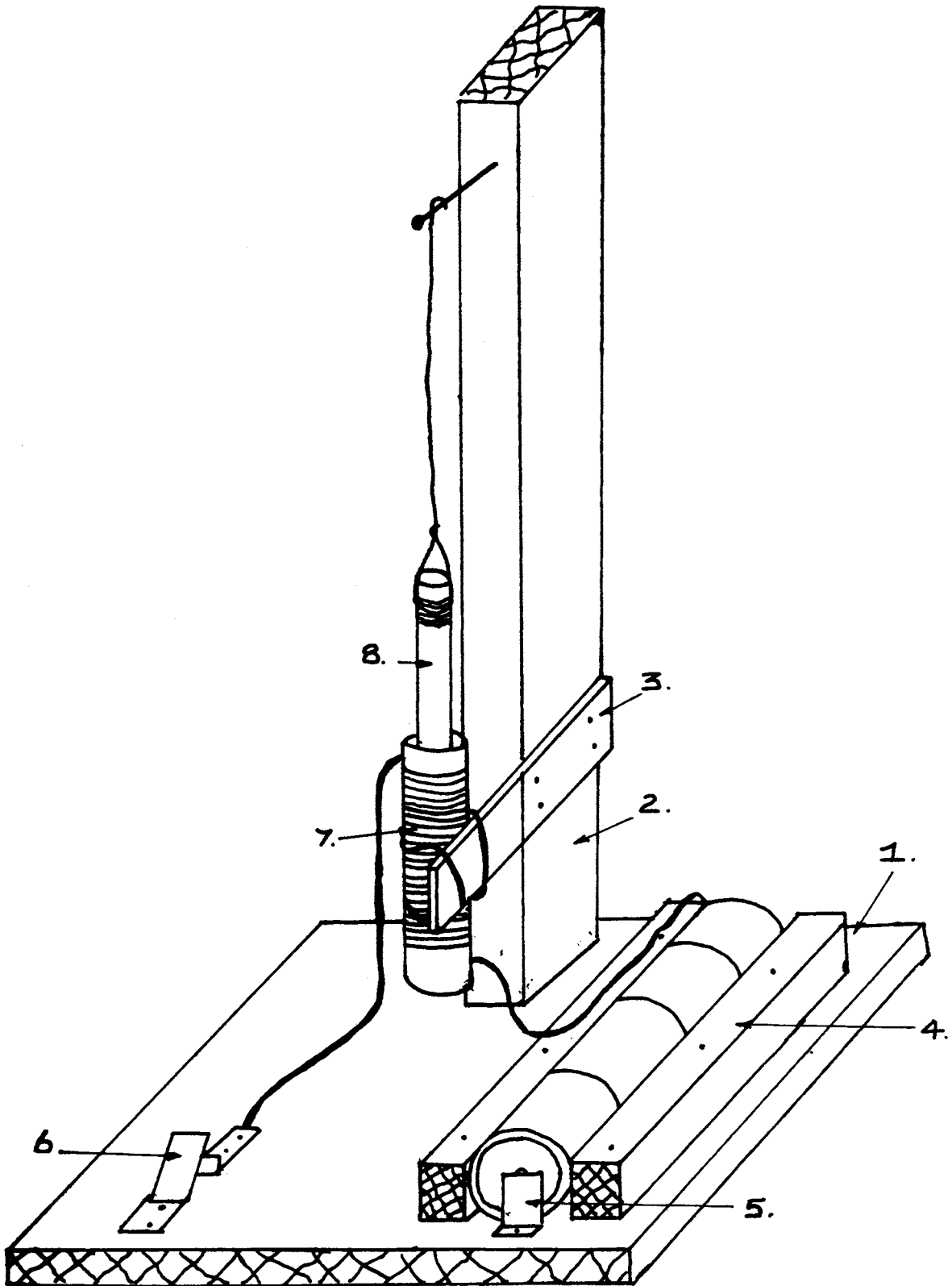
- i) This model can be related to the solenoid in a starter motor for cars and trucks which pushes the cog of the starter motor into gear with the flywheel when the key is turned on. A set of simple contacts could also be hooked onto this model to show how it can become an electrically operated switch as shown in the diagram. When the bar moves down, the circuit for the lamp is completed and the lamp will light up.



- ii) This device can also be used for picking up metal objects.

Place a few small nails under the solenoid. While the switch is pressed on pull the rod down until it touches the nails then slowly let it rise up. The nails will be lifted up too. Now let the switch off and most of the nails will fall off as the iron bar is no longer magnetised by the solenoid.

# 'Jumping Rod' Demonstration Apparatus.



## GROUP C.

Topic: TRANSFORMATION OF ENERGY

Sub Topic: To design a low-cost prototype using readily available materials to illustrate the principle of a HYDROELECTRIC GENERATOR

### Plan

The plan was to construct a turbine using a tin lid supported on a thin metallic rod as the axle. The turbine should be free to rotate inside a tin can, the axle passing through the centres of the closed end and the lid. A hole is to be cut out at a suitable place in the tin can for a water jet to strike the turbine blades. The turbine needs to be coupled with a generator (bicycle dynamo). A light bulb to be connected to the generator. Water entering the can through the jet strikes the blades and turns the armature. The current lights up the bulb.

### Materials Needed

One metre hose (plastic or rubber tubing)  
20 cm. plastic tubing (small)  
One medium sized milk can (10 cm. length and 10 cm. diameter)  
2 lids preferably off the same type of milk can.  
One 1.5V bulb.  
20 cm. insulated wire (2 pieces)  
One 18 cm. metal rod.  
One bicycle Dynamo (or generator)  
One stand made of timber and plywood (50 cm. verticle timber and base - a flat piece of plywood/rectangular or square preferable.  
One hammer  
One soldering iron and lead (or use strong glue or Araldite)  
One 7.5 cm. nail  
One 1 cm. diameter pipe, one end squashed in.  
One tin snip.  
Nails and screws.

### Construction of Apparatus

- a) Use a 7.5 cm. nail and with a hammer punch a hole through the centre of the bottom of the can and also in the centre of the can lid.
- b) Remove the lid of the can, and with a cold chisel and hammer (or tin snips) cut out the parts of the lid that are not required. The part that is to be cut out is marked in dotted line (See Sketch 2)
- c) Construct the support stand by nailing the 50 cm. upright to the base as shown in the diagram of the apparatus.
- d) Making the Water Wheel
  - i) Using tin snips reduce the diameter of the second lid. Make sure it is circular and will easily fit into the can.
  - ii) Mark a circle about 2 cm. diameter from the centre of the tin lid. Divide the lid into 16 segments and cut down the lines as far as the 2 cm. circle. (See Sketch 2.)

- iii) Punch a hole in the centre of the lid. The size of the hole should just fit the rod available for the spindle.
- iv) Now bend each of the segments in the same direction to form the wheel as shown in Sketch 2.
- v) Push the water wheel onto the rod bar a distance of about 3 cm. Solder (or use Araldite Adhesive) the wheel to the spindle.
- vi) Push the 2 cm. piece of small-bore plastic tubing (or similar spacer) onto the rod from the 3 cm. side and insert the rod into the can so that it protrudes through the bottom of the can by 1 cm.

e) Making the Jet

- i) Mark on the outside of the can the position of the wheel inside the can. Remove the wheel from the can.
  - ii) Punch a hole in the side of the can on this mark.
  - iii) Beat one end of the piece of metal tube to make it narrow so that water comes out as a narrow jet.
  - iv) Replace the wheel in the can. Fit the jet into the hole and adjust the angle of the tube so that when you blow into the tube the wheel rotates freely.
  - v) Having found the correct position, seal the tube into the can with solder (or Araldite).
- f) Place another piece of small-diameter plastic tubing onto the top of the spindle and cut to a suitable length so that when the lid is inserted over the spindle it fits back into position in the can.
- g) Solder (or Araldite) two lengths of tin onto each side of the can. The can may now be fixed to the upright of the stand by nailing through these metal strips. The lid of the can facing downwards.
- h) Using suitable fixings mount the bicycle dynamo onto the stand. Before firmly fixing connect the dynamo spindle to the spindle of the water wheel with a short length of plastic tubing. This connector must be straight and not bent in any way. Adjust dynamo fixing to correct position and firmly fix in position.
- i) Mount a bulb holder on the top of the support stand and connect to the dynamo. Screw in a 1.5 volt bulb.

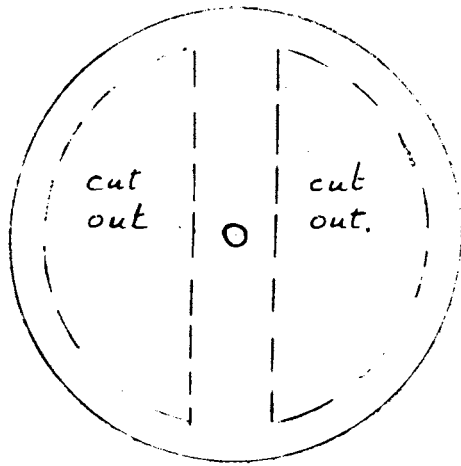
j) To use the Apparatus

Attach the long hose to the metal tube and connect the other end to a water tap. The apparatus should preferably be stood in a sink. Open the tap and give the dynamo a little turn and it should start to revolve. The speed depends upon the water pressure. The lamp should light when the wheel turns the dynamo.

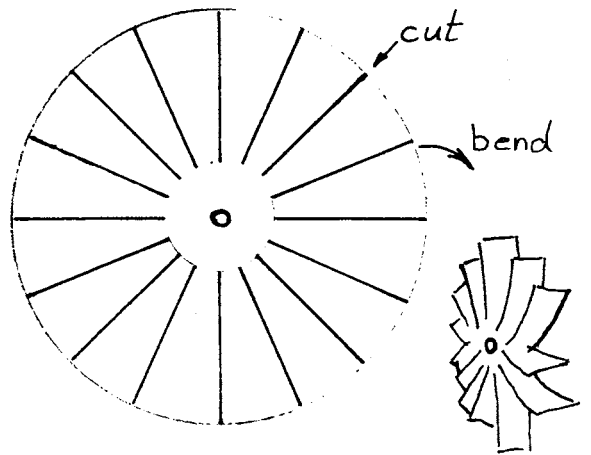
NOTES

- a) Care should be taken while fixing the tube to the tin so that a proper angle is maintained to ensure the striking of the water jets on the correct side of the blades.
- b) The coupling between the turbine disc and the dynamo must be aligned straight to ensure free rotation.

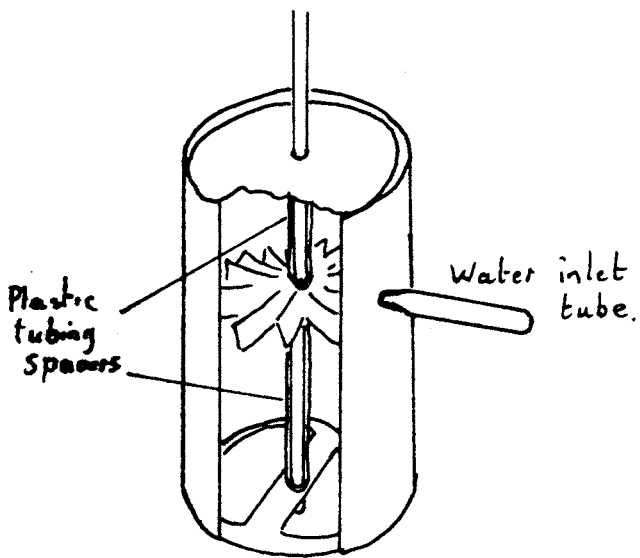
- c) If a bicycle dynamo is not available, a suitable generator can be substituted.
  - d) The current can be used to light a lamp or ring a bell or buzzer.
  - e) Change the water pressure and observe the changes in the brightness of the bulb.
  - f) While the dynamo is running, disconnect the bulb and observe the change in the speed of rotation. Connect the bulb and notice the change.
2. This apparatus is designed to demonstrate the transformation of energy in grade 8 unit, force, work and energy. With this design it is envisaged that the teacher will be able to demonstrate the concept of energy being transferred; using this apparatus, of course, to illustrate water energy converted to light energy (electricity) mechanical energy - electrical energy - light energy.



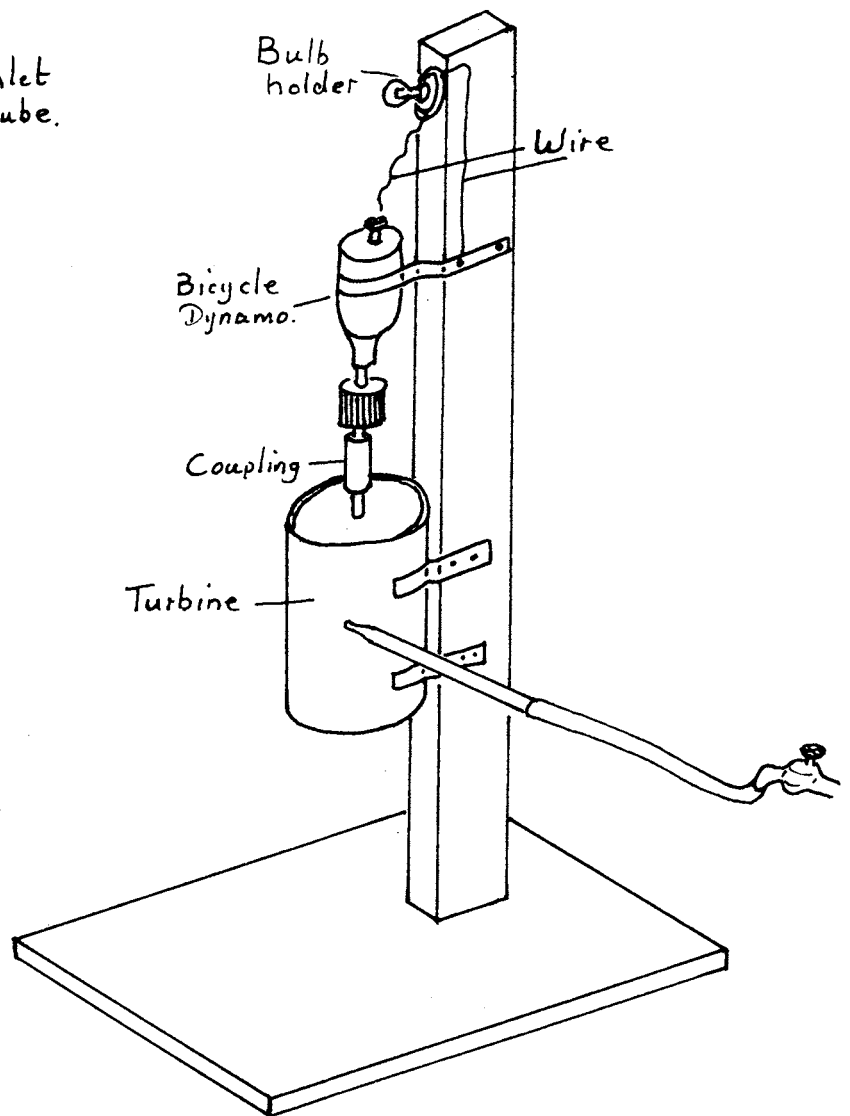
Sketch 1.



Sketch 2.



Turbine Arrangement.



Hydro-electric Generator.

## GROUP E.

Topic: ELECTRICITY

Sub Topic: The Operation of an Electric Buzzer

### Materials

One large piece of plywood (15 cm. x 12 cm. x .9 cm.)

Enamelled Copper Wire (2½m)

2 pieces of Plywood (3 cm. x 3 cm. x .9 cm.)

One large nail (6 cm.)

6 small nails (2 cm.)

4 Screws (2 cm.)

4 Metal strips (5½ cm. x 1½ cm.)

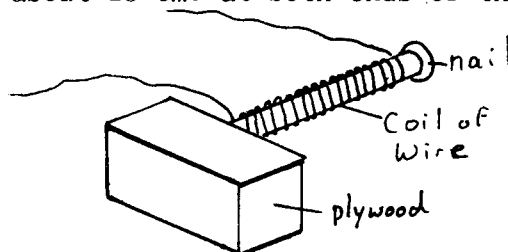
1 tin strip (6 cm. x 1 cm.)

1 Contact (adjusting) screw (3 cm.)

1 Dry Cell (1.5 v)

### Electro-Magnet

1. Take one of the small pieces of plywood (3 cm. x 3 cm. x .9 cm.) and hammer in the large nail (6 cm.) through its centre, leaving about ⅞ of the nail out.
2. Wind the long piece of wire around the nail (following one direction only) leaving about 15 cm. at both ends of the wire.



3. Nail this piece of plywood onto the large-size piece of plywood - the base for the buzzer. Use two small nails.

### 4. Battery Holder

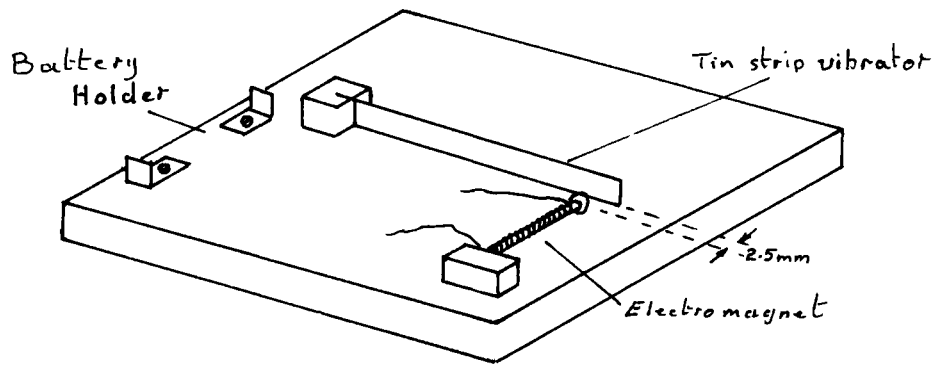
Take two of the metal strips and bend each of them at the middle into a right angle.

5. Make a hole at one of the ends of each metal strips. (The hole should fit the wood screws)
6. Screw these metal strips onto the base as shown in the diagram. They must grip the dry-cell firmly.

### 7. Vibrator

Make a cut at the other small piece of plywood to fit in one end of the tin strip. Glue the tin strip into place if it is not very firm.

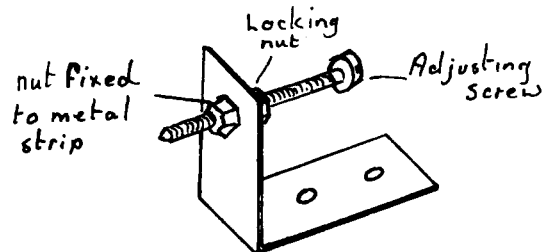
8. Nail the piece of plywood attached to the vibrator. See diagram. (The end of the tin strip should be 2.5 mm. away from the electromagnet.)



9. Contact Point

Get the other metal strip and bend it into a right angle.

10. Make a hole on one of the ends of the metal strip. It should fit the adjusting screw.
11. Solder one of the nuts on one end of the hole. The nuts hole and the other hole should be in line.
12. With the other nut on the other side of the hole, screw the adjusting screw in.

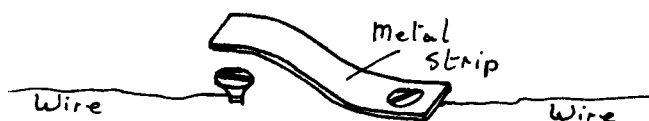


13. Nail the above part in place onto the base. The tip of the adjusting screw should be just barely touching the vibrator.

14. Tap Key

Bend the last metal strip into the shape shown and make a hole at one end to fit in the wood screw.

15. Screw the metal strip onto the base using a wood screw.
16. Using another wood screw, screw into the base but at a position under the free end of the metal strip. This is the switch.

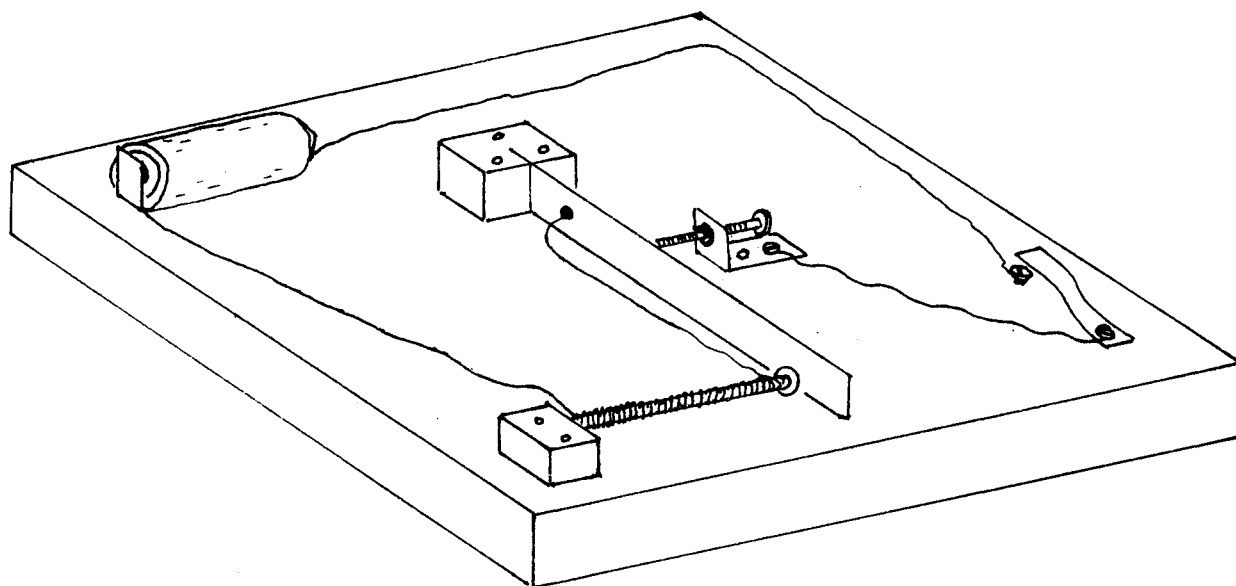


17. Wiring

Use solder to join your wirings. See the diagram for wiring connections.

### To Operate Buzzer

Press the tap key after placing the dry cell in the holder and see whether your buzzer works. If it does not, adjust the contact point by either tightening or loosening the adjusting screw.



Arrangement of Apparatus for the Electric Buzzer

## GROUP E.

Topic: ELECTRICITY

Sub Topic: A simple electric motor

### Materials Needed

1 Baseboard approximately 20 cm. x 10 cm. x 1 cm.  
3 nails x 7 cm.  
1 nail x 15 cm.  
2 screws x 4 cm.  
2 screws x 2 cm.  
Glass rod. 5 cm. long x 0.7 cm. diameter  
Cork 3 cm. x 3 cm.  
Insulated Wire (approx. 24 guage)

### Instructions for Assembly

1. Drill a small hole through the centre of the base board and drive a 7 cm. nail through it from the underside. Cut the end off the nail so 5 cm. is protruding through the wood. Drive the other two 7 cm. nails into the baseboard and screw the screws into place as shown in Sketch 1.
2. Wind 200 turns of insulated wire on the two nails leaving about 15 cm. of free wire at each end. The wires from the beginning of each coil are soldered to the small screws. The free end of each coil is now wound several times around the screws and bent so that it rests in contact with the centre nail. The insulation must be removed for 1 cm. either side of the contact point (see Sketch 2).
3. Constructing the armature: Drill a .5 cm. hole halfway through a cork and fit the piece of glass tubing into the hole. Force a 15 cm. nail through the top of the cork. (Or use two 7 cm. nails) Wind 200 turns of insulated wire onto each end of the nail as shown in Sketch 3.
4. To construct the commutator take two pieces of thin sheet copper or tin 1.3 cm. x 1.0 cm. Bend them to fit around the glass tubing so there is a 3.4 mm. gap between them. Solder one of the armature wires to each and then bind the commutator plates into position top and bottom with adhesive tape.
5. Place a washer over the centre nail and set the armature on the centre nail so the brushes make contact with the commutator. Turn the glass tube in the cork until the brushes lie across the gaps in the commutator when the armature is in line with the field magnets.
6. Now connect the motor to some dry cells. About 6 - 9 v. will be required. Give the armature a spin and it should continue to rotate.

NOTE: If the motor does not run smoothly you may have to:

- a) adjust the contact of the brushes with the armature.
- b) check and adjust the position of the commutator.
- c) balance the armature.

If the motor does not run at all check carefully all the wiring in accordance

with the diagram.

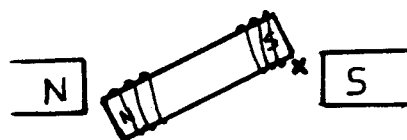
### FUNCTIONING OF AN ELECTRIC MOTOR

The teacher should become familiar with the operation of an electric motor. A brief explanation is given below.

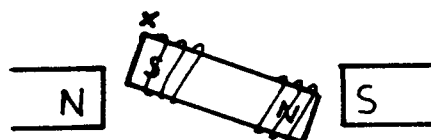
An electric motor consists of a rotating electromagnet, (called armature) and two fixed magnetic poles which may be permanent magnets or electromagnets. When a current is passed through the armature it becomes an electromagnet and is attracted (or repelled) by the fixed magnetic poles causing it to rotate. Each time the armature rotates  $180^\circ$  a device (called a commutator) reverses the current direction in the armature enabling it to rotate continuously in one direction.

In the diagrams to follow point X serves as a reference point on the armature.

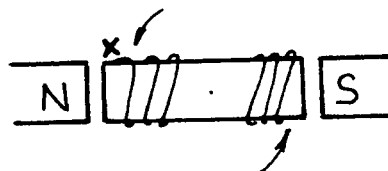
1. If the current in the armature is switched on in the position the armature would begin to rotate in an anti-clockwise direction since like poles repel.



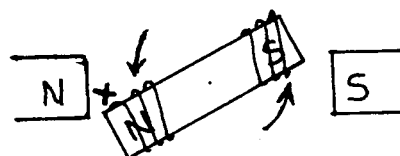
2. After rotating  $90^\circ$  the unlike poles are beginning to attract; causing the armature to continue to rotate anti-clockwise.

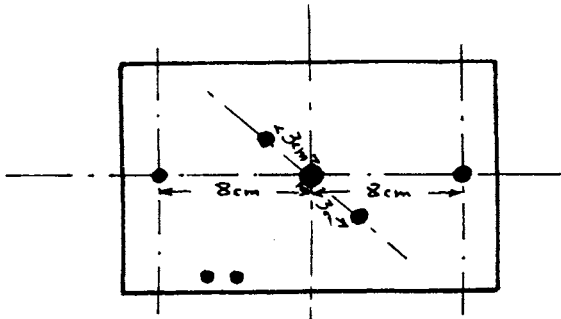


3. As the armature passes between the fixed poles the commutator reverses the direction of the current in the armature and hence the poles repel, and the armature continues to move in an anti-clockwise direction.

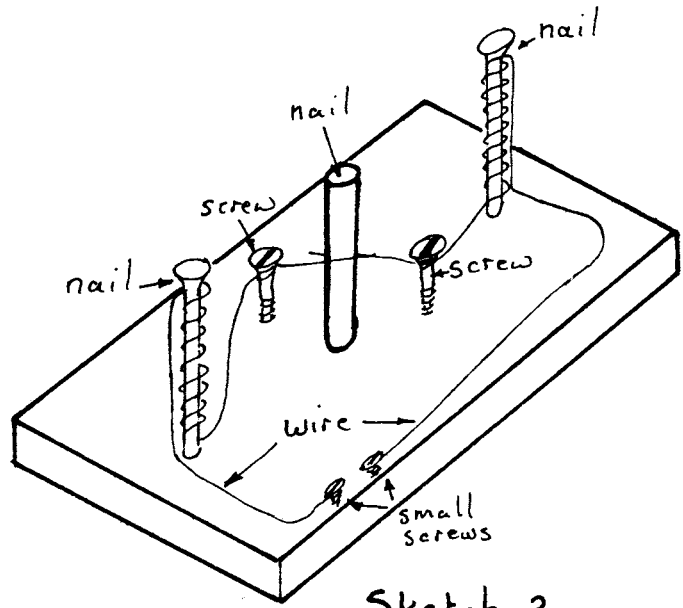


4. After rotating a further  $90^\circ$  the poles of the armature are attracted. The attraction of unlike poles now causes the armature to continue rotating in an anti-clockwise direction.

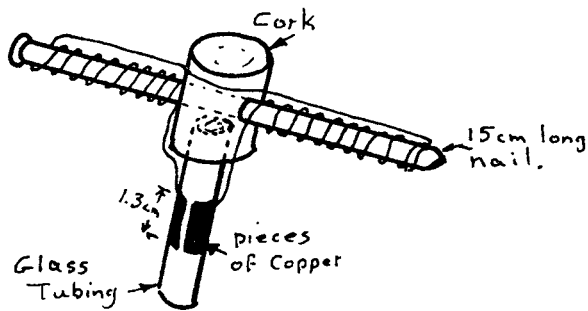




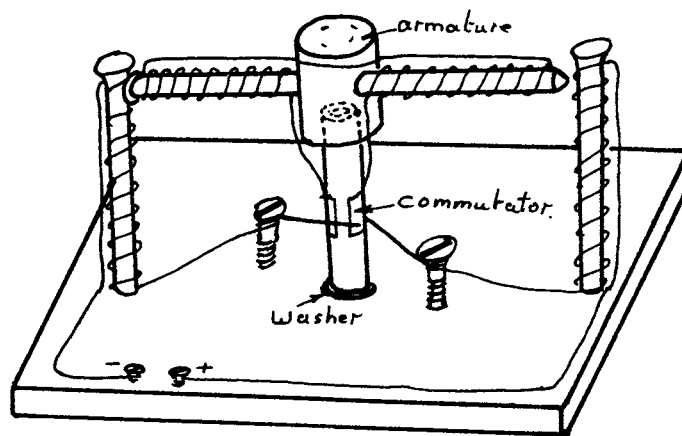
Sketch 1.



Sketch 2.



Sketch 3.



Sketch 4.

A Simple Electric Motor.

## GROUP E.

Topic: ELECTRICITY

Sub Topic: Detection of induced current (Electro-Magnetism)

### Materials Needed

Flat Wood (Plywood)  
4 Woodscrews  
1 Match Box (inside only)  
Copper Wire (3 metres)  
Sticky Tape (Cellotape)  
1 Magnetic Compass (to fit into match box)  
Bamboo  
6 Nails (2 cm.)

### Construction of Apparatus

#### 1. Base

Cut a piece of suitable wood (plywood) to approximately 25 cm. x 8 cm.

#### 2. Compass Mount

Cut a piece of suitable wood (plywood) to approximately 5 cm. x  $3\frac{1}{2}$  cm. to fit into the matchbox. Make a hole in the wood of approximately 2 cm. diameter so that a plotting compass can be fitted into the hole. Insert the wood and compass into the matchbox. Using the sticky tape, tape the wooden block to the matchbox.

#### 3. Compass Coil

This coil is made of a few turns of copper wire, and wound carefully in one direction only. The coil should be taped to the box to prevent it springing apart. Bare the two ends of the wire for later connections. Fix the whole arrangement (current detector) to the base at one end (see diagram)

#### 4. Magnet Coil or Solenoid

Cut a piece of small diameter bamboo to a length of about 4 cm. (the diameter should be of size which is able to allow an available magnet to pass into it). Wind the copper wire onto the bamboo (about four layers) and leave a length of about 10 cm. of wire from each end of the coil. Fix the coil to the other end of the base board using the small nails or screws (see diagram)

#### 5. Switch (This can be omitted from the apparatus)

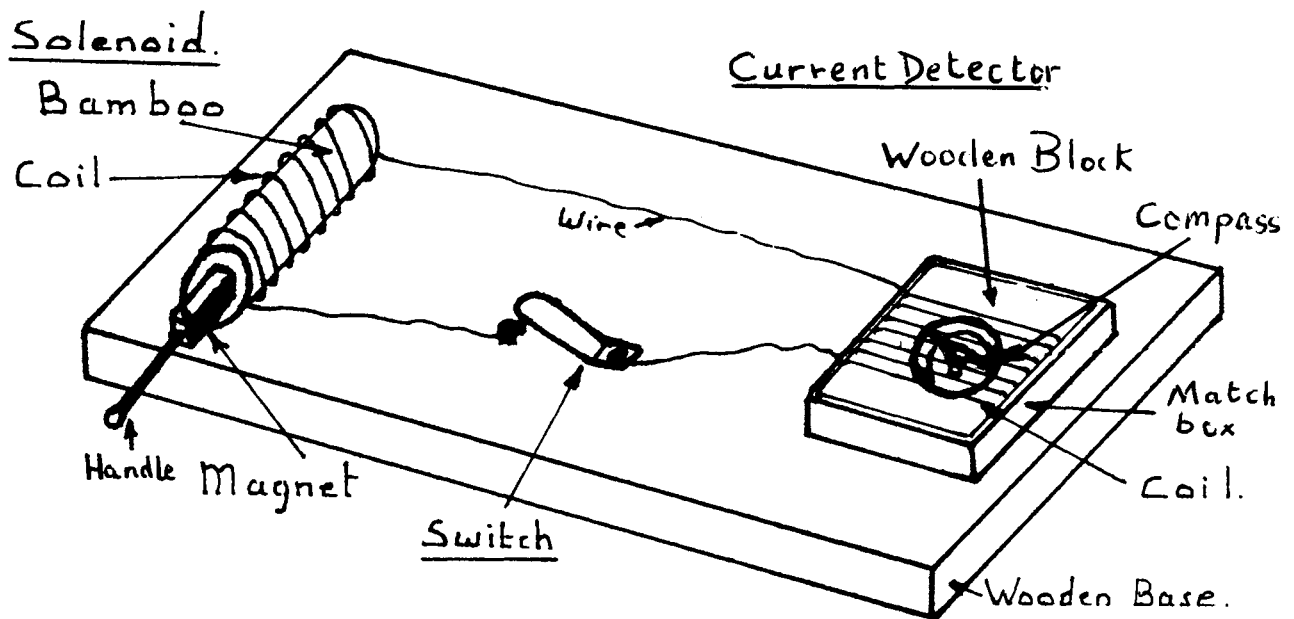
Take a piece of metal strip and make a small hole in one end. Using the small screws, pass a screw through this hole and wrap one of the bare ends of wire from the compass coil around the screw. Screw this screw into the base at a suitable position. Using a second screw (or nail) connect one bare end of wire from the solenoid to the screw and screw it into the base in a position where the metal strip can touch it if

if pressed down.

6. Connect the wire from the other end of the solenoid to the lead from the compass coil (current detector).

7. Operation

When a magnet is moved into and out of the solenoid there should be a deflection on the compass needle indicating that an electric current has been induced in the circuit.



A Simple Electric Current Meter.

GROUP D.

Topic: LIGHT

Sub Topic: Pinhole Camera

Materials

Various size tins, e.g. milk tins  
Plain Paper, Newspaper  
Rubber band  
Cardboard  
Oil, i.e. cooking oil, motor oil.  
Black paper

Alternatives:

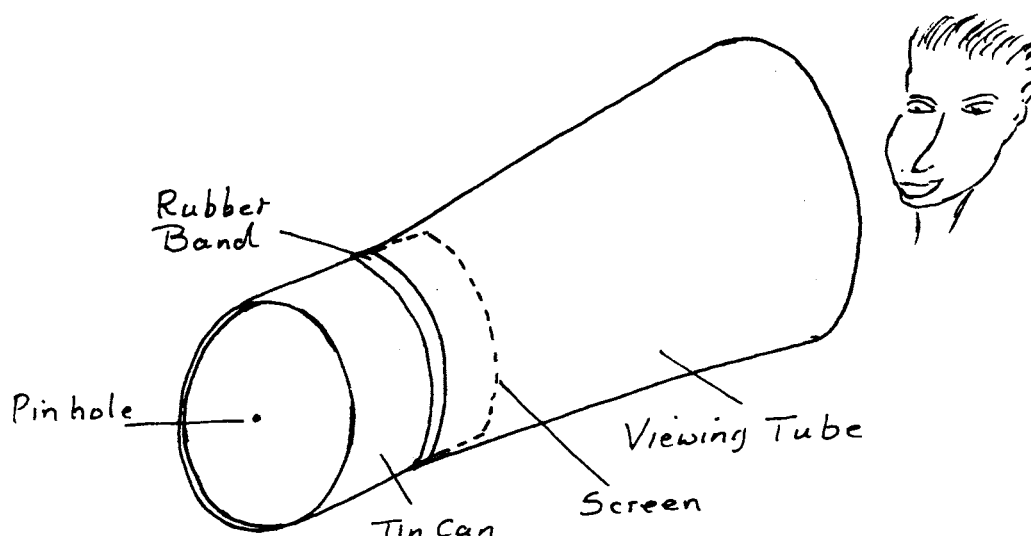
Length of bamboo  
Stone or any object to hit with  
Tissue paper  
Sticky tape, string, vines  
Newspaper, plastic, banana leaf  
Black paint, Black texta, charcoal

Construction Details

1. Make a nail hole in the middle of the bottom of the tin.
2. Blacken inside of the tin, using paint or charcoal.
3. Fix a screen of greased or oiled paper, or plastic, over the open end of the tin with an elastic band or sticky tape.
4. Make a viewing tube of cardboard or newspaper and put your eye to the open end.

Teachers Notes

1. Camera works best if you are inside the classroom looking at a bright object outside.
2. Camera works best when the inside of the tin is blackened.
3. Experiment with different sized holes. If the hole is too small the image will be dim. If the hole is too large the image will not be clear.
4. The best screen is thin paper with some oil rubbed on it.
5. Two holes will give you two images.



GROUP D.

Topic: LIVING AND NON LIVING THINGS

Sub Topic: To construct an insect cage

Materials

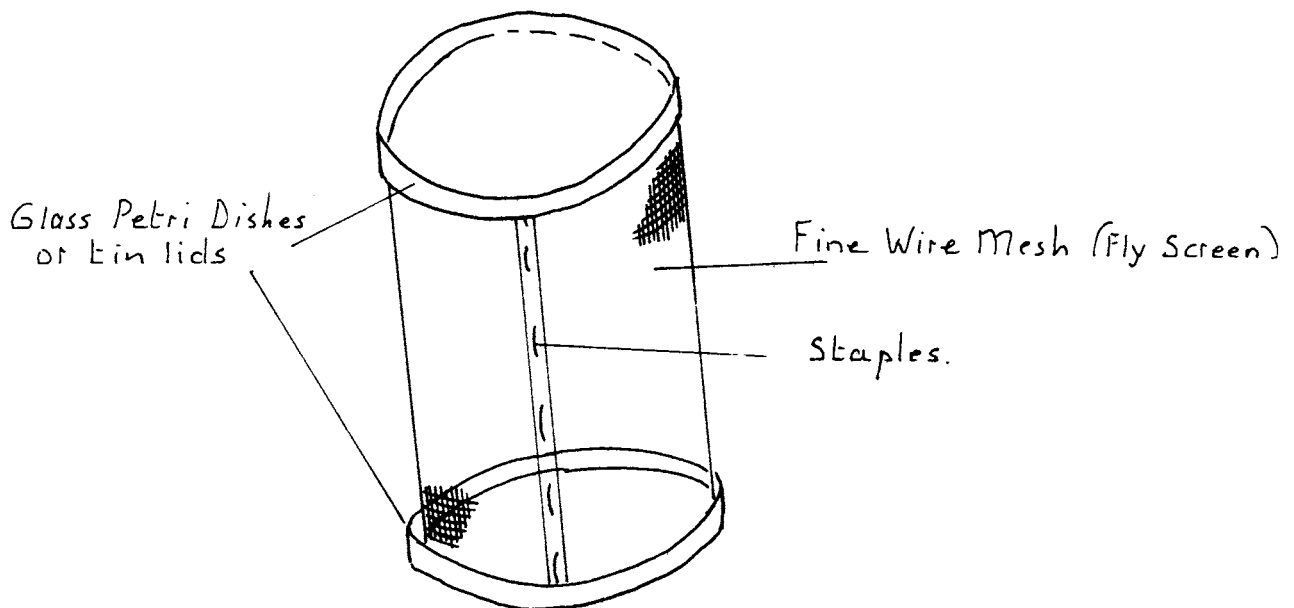
Two tin lids of the same size, or two petri dishes

Fine mesh wire or plastic sheet

Staples or sticky tape

Construction Details

1. Using the fine mesh wire make a cylinder which will fit snugly into the lids at either end.
2. Staple the cylinder to hold its shape or use the sticky tape.



GROUP D.

Topic:        TRANSPIRATION

Sub Topic:    To construct a potometer

Materials

Wood for base and sides

Ruler (wooden or plastic) or any means of measurement

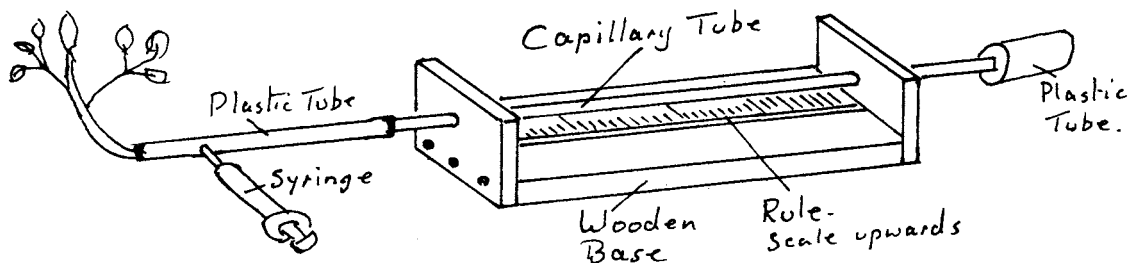
Capillary tubing glass (at least 150 mm. total length)

Two pieces of rubber tubing (at least 10 cm. total length)

One Syringe (20 cm<sup>3</sup>)

Construction Details

1. Cut wooden base to length and width 25 mm. x 150 mm. x 200 mm.)
2. Cut board to fit base. (see diagram)
3. Cut appropriate length of ruler to fit base and glue to base and allow to dry.
4. Drill holes of correct diameter and position for capillary tubing to fit. Tube must extend past end boards at least 30 mm.
5. Cut capillary tubing and fire polish ends.
6. Screw and glue end boards to base.
7. Gently push capillary tubing through holes into position.
8. Place tubing over ends of capillary tubing.
9. Insert syringe into rubber tubing at end which plant will fit.



GROUP D.

Topic: SPIRIT BURNERS

Sub Topic: Storage of apparatus

Materials Needed

Pieces of suitable wood

Nails

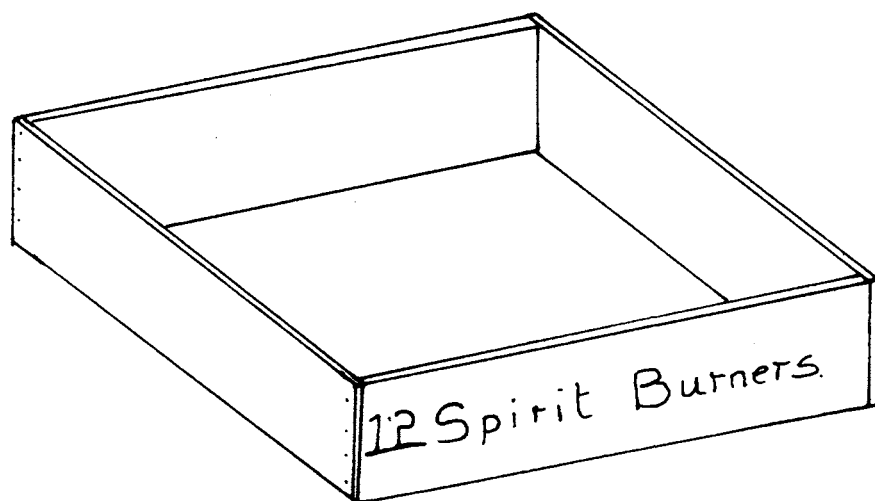
Hammer or stone

Sandpaper

Construction Details

To make a storage box for your burners decide on the number of burners you wish to conveniently store in one box. Work out the size of the box necessary to store these burners and cut the pieces of wood to make the box. Remember to make the height slightly higher than the height of the burners. Nail the sides and the base together and sandpaper to box to remove rough edges.

Note: The purpose of such a box is to provide safe storage for apparatus and readily identify if any items are missing at the end of practical sessions. This idea can be used for a wide range of pieces of apparatus.



AN EXAMPLE OF A BASIC KIT OF TOOLS FOR CONSTRUCTING  
LOW-COST SCIENCE TEACHING EQUIPMENT

BITS, DRILL, TWIST, SET OF 13. High speed, round shank. For use in 3-jaw chuck. Set contains 13 bits, viz 4 of 1/16, 4 of 3/32, 2 of 1/8, 1 each of 3/16, 7/32, 1/4 inch. (For wood or metal. To fit in 40 380 00 DRILL...)

BLADES, HACKSAW, 30 CM. (Approx.). Low tungsten steel. Package of 12.

BLOW TORCH. Pump action pressure type. 2 pint. With kit of spares. (Blow Lamp).

BRADAWL, 5 CM BLADE. (M). Round pattern, beech handle. (For making rough round small holes in wood such as for starting screws, etc.)

CLAMP, C, 75 MM OPENING. (M) (Approx.). To act as simple vise to hold work.

CUTTER, GLASS, SINGLE WHEEL TYPE. With tungsten carbide wheel. (For cutting sheets of glass.)

DRILL, HAND; CAPACITY 1/4 INCH (6MM). Double pinion, with three-jaw chuck. = Stanley (UK) No. 803. (Needs BITS, DRILL ... 40 106 00).

FILE, ROUND, MACHINISTS, 15 CM. (Approx.). Smooth cut.

FILE, TRIANGULAR, 12 CM. (M) (Approx.). Single cut, extra slim, taper. (For cutting glass tubing.)

HAMMER, NAIL 225 G. (M) Bell face, with curved claw. Head approx. 225g. (Light carpenters hammer with claw to draw out nails.)

HAMMER, NAIL, 450 G. Bell face, with curved claw. Head approx. 450g. (Carpenter's hammer with claw to draw out nails.)

NAILS, WOODWORKING, ASSORTED. (M) Up to 64mm. Round wire with flat head. In package of approx. 500g.

PLIERS, ELECTRICIANS, 15 CM. (M) (Approx.). Insulated handles. With wire-cutter.

PLIERS, SLIP JOINT. Side wire cutting, approx. 19 cm with two joint positions.

RULE, STEEL, 12 INCH. Grad in cm and mm. Also in 1/16, 1/32 and 1/64 inches.

SAW, HACK, ADJUSTABLE, FRAME ONLY. To take blades of 25 or 30 cm. (Needs 40 151 02 BLADES).

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\* The following has been taken from the Unicef Publication - Eve Science Revision 2. The Second Revision of the Science Teaching Sections of Unicef Guide List "Eve" published in 1973.

If a school has no laboratory or similar adequate working space given over to science with a suitable cupboard and bench usable for constructional work, then only the simple tools marked on the list by an (M) for minimal, should be requested.

SAW, HACK, JUNIOR, (M) Blade length approx. 15 cm. Overall length approx. 25cm. Depth between blade and bow approx. 5 cm. = Gleave No. 14 J. (Versatile small saw for wood, metal, plastic, etc.)

SAW BLADES FOR JUNIOR HACK SAW. (M) 15 cm long with pinned ends. In package of approx. 12.

SCREWDRIVER SET, STANDARD, 5-PIECES. (M) Chrome-vandium alloy steel blades. Plastic handles. Shafts approx. size in mm (l x dia) 200 x 10, 150 x 8, 100 x 6, 80 x 5 (Electrician's type), 40 x 6 (Stubby size).

SCREWS, WOOD, CSK, 19MM NO. 4. In package of gross.

SCREWS, WOOD, CSK, 19MM NO. 6. In package of gross.

SCREWS, WOOD, CSK, 32MM NO. 8. In package of gross.

SCREWS, WOOD, CSK, 38MM NO. 10. In package of gross.

SNIPS, TIN, STRAIGHT BLADE, 3 INCH CUT. (M) Approx. 8 cm cut. Overall length approx. 20 cm. (Very useful for making articles of tin rejected from kitchen etc. in conjunction with soldering iron.)

SOLDER, TINSMITH, SOLID WIRE. In approx. 450g pack. For use with SOLDERING IRON. (Needs 51 698 03 SOLDERING PASTE.)

SOLDERING IRON, ELECTRIC 110V 160W.

SOLDERING IRON, ELECTRIC 220V 160W. (Alternative to 110V item).

SOLDERING IRON, NON-ELECTRIC. Weight of head approx. 250g. Copper. Complete with handle (Soldering Copper). (To be heated over a gas flame or in a clean fire or with Blow Lamp or Bunsen Burner.)

SOLDERING PASTE. Approx. 100g in can. (Flux) (Suitable for tin, but not for electronic work nor for zinc coated iron.)

SPANNER SET, BOX 0 TO 10 BA. 6 Spanners, viz 0, 2, 4, 6, 8 & 10 BA with tommy bars. = Buck & Hickman set 53B.

SQUARE, CARPENTERS, COMBINATION. 30 & 45 deg. adjustable approx. 12 cm blade graduated in inches and cm. = Stanley 122.

WRENCH, ADJUSTABLE, 20 CM. American pattern, rounded head. Forged steel.