SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 8 September, 1966.

Introduction

Because of the large number of workshop projects and useful ideas which are queuing up for publication, a number of the regular bulletin features have been considerably cut, or excluded altogether, which in itself may be no bad thing. Let us hope that with the start of a new session, the number of laboratory technicians to assemble these projects will also have increased, and that at least some of them will be properly supervised while doing so, not by an overworked head of department teacher in a broom cupboard, but by a skilled technician in a properly equipped workshop, even if he is the only one in the county.

Some teachers may know that one direction in which we have wished to extend the activities of SSSERC lay in making the facilities of our display laboratory available to as many teachers as possible. We have now acquired a van in which we can transport up to 200 cu. ft. (pace the metricophiles) of equipment throughout the country. We therefore invite Directors of Education, Colleges of Education lecturers, practising teachers who may be planning a meeting of science teachers in the months ahead to consider whether we can assist by putting up a display of available equipment. We should normally require a full-sized school laboratory with adequate services, particularly electric points, and access to it on the day previous and the day following that on which the meeting would be held. Any such organisers are asked to get in touch with us at an early date.

Trade News

Advance Electronics have commenced production of two new educational items, a pupil oscilloscope and a low voltage power supply. The oscilloscope will retail to schools at £20 and has a 7cm diameter tube and automatic synchronisation. The power supply will give A.C. output in 1 volt steps up to 20V at 5 amperes. Maximum D.C. output which is also variable, is 15 volts at 5 amps. Price £15.

Drybrough and Co., Edinburgh have a Christie and Becker chainomatic balance which they are prepared to sell cheaply to a school. Capacity 200g. sensitivity 0.05mg. The vernier is coupled to a chain and registers on a scale reading to 100mg in 0.1mg divisions. Enquiries direct to the firm marked for the attention of Miss Blodgett.

Chemistry Notes

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There must be many practical tips which the individual teacher may have used for years and which he would be astonished to learn were not common knowledge. Having used one such at school, it surprised us to find that many teachers visiting the Centre and seeing it in commercial form found it a new idea. Instead of the usual stopcock or pinch clip on the burette, control can be easily achieved by means of a glass bead in a rubber or latex tube. Squeezing the bead causes the tubing to bulge across the diameter perpendicular to the direction of pressure and the liquid escapes. In the E-mil burettes on display here, the squeezing is done by a plastic screw which, and we give this as a warning to any who have bought the burette, has a left-hand thread. One of ours has been wrenched off completely by someone who thought the screw had jammed in the closed position. Of course, the burette still works perfectly with manual squeezing.

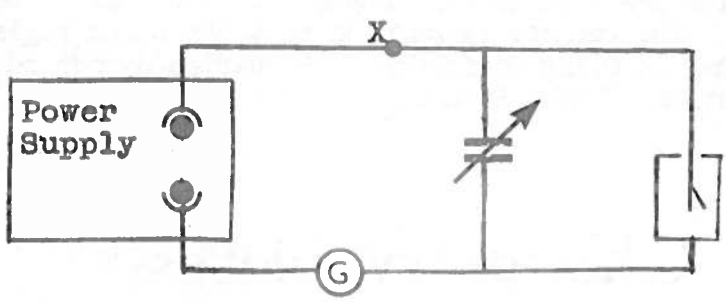
From Wallace Hall Academy comes a suggestion for preparing plastic sulphur by a method which does not appear in many of the text-books, but which has the advantage that the solid obtained looks like sulphur. Add 5ml of conc nitric acid to 5g hypo (sodium thiosulphate) crystals in a beaker in the fume cupboard. The ratio is the one which gives the best yield of plastic sulphur, which should be washed thoroughly before handling. If 10g or more hypo are used, the section is explosive.

Physics Notes

We pass on to manufacturers a suggestion from a visiting teacher. While pupils continue to make histograms with ticker tape it ought surely to be possible to make the tape in a colour other than white which would still give a reasonable contrast both with the black carbon dots and the white of their notebook paper - or should we press for notebooks in pink and blue?

A very elementary experiment to demonstrate infra-red (heat) radiation is for the pupil to hold one of the large parabolic reflectors (Griffin and George, L45-260, or Philip Harris P8264) so that his face is in the principal focal plane.

From Moray House summer course on electronics comes what we consider to be a demonstration of fundamental importance in electrostatics, in the way in which it illustrates the relationship between charge and potential, and incidentally teaches that a G.L.E. measures potential and not charge. The circuit is below:



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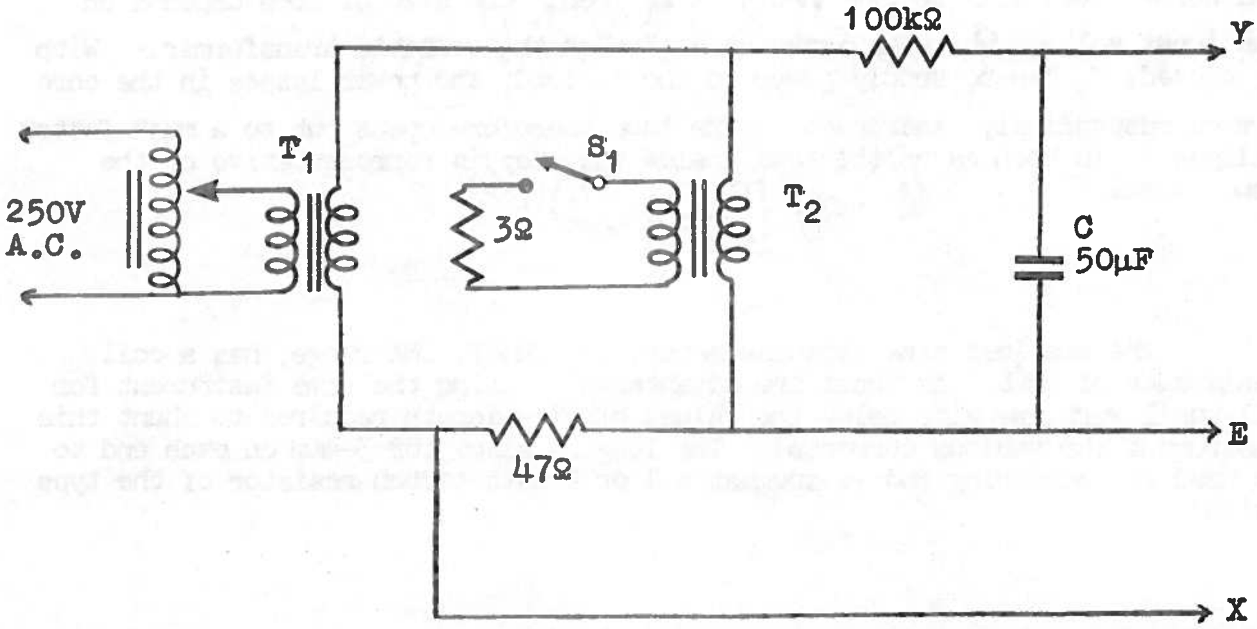
The essential component is the variable condenser which should come out of as old a radio set as possible, since in the early days physical size was no drawback and the air-spacing between the vanes is likely to be greater. Clean it thoroughly by spraying organic solvent or proprietary switch cleaner between the vanes and mount on 6mm thick perspex base. Even after these precautions you will find that some leakage will occur, which is in itself a good teaching point. The galvanometer is a Pye Scalamp, the power supply should be variable up to 1 Kv and with an output meter, and any gold leaf electroscope will serve. The connecting leads on the "live" side should be short and entirely self-supporting, not sagging on to bench tops.

To start, set the galvanometer at centre zero on its most sensitive range, the condenser vanes half-open and the power supply connected in circuit through its high resistance. Turn up the power supply slowly to 500V, watching the galvanometer. The direction of throw of the spot will show the 'sense' for charge flowing on to the condenser. The condenser vanes are now either opened or closed when the galvanometer will show charge flowing off or to the plates respectively, probably together with a continuous deflection due to leakage. During this time the G.L.E. remains at a steady deflection, showing constant potential.

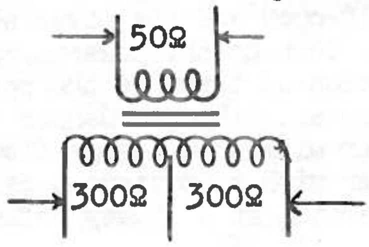
The complementary experiment is performed at constant charge (if we ignore leakage) instead of constant potential. As before, have the condenser vanes half-open, reduce the power supply to zero and remove the connection between the supply and condenser at X. Turn the supply up to its previous value, momentarily touch its live contact to the condenser and then quickly, before all the charge has leaked off, open the condenser vanes more fully while watching the G.L.E. A rising leaf shows rising potential as the plate area is reduced, and with a good condenser the experiment will reach a triumphant climax as the air dielectric between the plates breaks down and the capacitor discharges with an audible spark.

A large, old-fashioned condenser ought to take 1 Kv between its plates before breaking down, but it is as well to test for this breakdown voltage with the galvanometer short circuited, before setting up the experiment.

From the Post Office Research Station we give the circuit below for showing hysteresis loop on an oscilloscope. Teachers visiting the centre can see the circuit in operation in the display laboratory.



T_1 is the mains transformer from an old radio, the primary (input) winding being the original mains primary. The secondary of T_1 is one half of the original high voltage secondary which ought to give at least 250V; it does not matter if the output voltage is higher than this. As a rough guide to a teacher facing a transformer which he has just extracted and looks to be a mass of uncoded wires, test between various wire ends with a resistance meter. The mains primary will give a resistance which usually lies between 10 and 100ohms; a further help is that if the entry point can be seen, the primary is the winding next the transformer core. The secondary can usually be identified by its centre tap which means that the resistance between the secondary ends is twice that between either end and the tap (see below):



The resistance of either half is usually greater than the primary winding; the figures given in the diagram are typical values. When these windings have been identified ignore all others; other wire ends will either give no reading, showing no connection, or zero resistance, showing a low voltage heater winding. The wire ends should of course be taped up or cut off short to prevent their coming into contact with the rest of the circuit.

T_2 is the loudspeaker transformer which if taken from an existing set will have its secondary connected to the speaker itself. It is this winding which is connected through a switch to the 3ohm resistance. The primary winding can be identified as the one which has other leads connected to it. If, as may happen, the primary is centre tapped, the circuit should be connected to the full winding. Again a centre tap can be identified by measuring resistance.

C is a 50uF, 25V working electrolytic condenser; the resistances are all ½ watt values, although T_2 load could be suitable length of wire.

The Advance OS15 or Daystrom 10-12U oscilloscopes can be used to display the loop; the telequipment S51E cannot be used as it has no X-input. X- and Y- amplifier gain controls should be adjusted to give a suitably sized loop. The normal loop will be obtained with S_1 open; the size of loop depends on the input voltage which is adjustable through the variable transformer. With S_1 closed, T_2 has to supply power to the 3Ω load, and power losses in the core are correspondingly increased. The loop therefore opens out to a much fatter ellipse. In both cases the area inside the loop is representative of the power loss.

The smallest size Japanese meter, No. MR38P, 1MA range, has a coil resistance of 60Ω. As there are advantages in using the same instrument for all pupil work, we give below the values of wire length required to shunt this instrument for various currents. The lengths allow for 3-4mm on each end to be used for soldering and we suggest a 1 or 2 watt carbon resistor of the type which/

which has 'shoulders' of wire at each end, as a suitable former. Provided its resistance is greater than 1KΩ, it will not shunt the shunt to any noticeable degree. These are then soldered across the meter terminals. We are currently examining the problem of how to convert these shunts to 'plug-in' units, so that the MR38P could be made into a universal indicator type of meter.

Full-Scale Deflection	Wire Type	Length
0 - 10mA	30 SWG Contra	107 cm
0 - 50mA	38 SWG Copper	130 cm
0 - 100mA	36 SWG Copper	105 cm
0 - 500mA	26 SWG Copper	117 cm
0 - 1A	22 SWG Copper	145 cm

The copper will be enamelled wire and can be close wound on the former. The Contra wire used for the lowest range is bare, and must be carefully wound in a space winding to avoid shorting between adjacent turns. After winding and checking it should be varnish or shellac coated to keep the turns in place.

To convert the instrument to a voltmeter, the basic requirement is to provide a total resistance of 1000Ω per volt of scale range. Thus for a voltmeter range 0-1V, what is required is a total of 1000Ω, made up of 60Ω inside the meter and 940Ω series resistor. This can be made up from two Radiospares metal oxide resistors of 910Ω and 30Ω in series. These have a quoted tolerance of 2%.

Voltage range	M.O. Resistors required
0 - 1V	910Ω, 30Ω
0 - 5V	4.7KΩ, 240Ω
0 - 10V	9.1KΩ, 820Ω

For higher voltage ranges, the same number of Kilohms resistance will be sufficiently accurate.

The experiment to measure g by a freely falling body is enjoying a certain vogue just now in view of the accuracy with which the small time interval involved can be directly measured with electronic or mechanical timers. So enthusiastic have the experimenters become that there are suggestions for using the apparatus to investigate the effects of air resistance, streamlining, viscosity. All the designs we have so far seen, including at least one commercial version have a built-in and totally unnecessary error which raises doubts about the ability of the apparatus to do anything more than measure g to an accuracy of some 2%. All employ an electromagnet release for a steel ball and assume that any piece of cardboard or plastic tape stuck over the end of the e-m core is going to release the ball at the instant the current is switched off. (Some years ago, before the days of electronic timers, the A.S.E. published a list of manufacturers' howlers, one of which was that the coat of paint on their magnets would undoubtedly have a shielding effect!).

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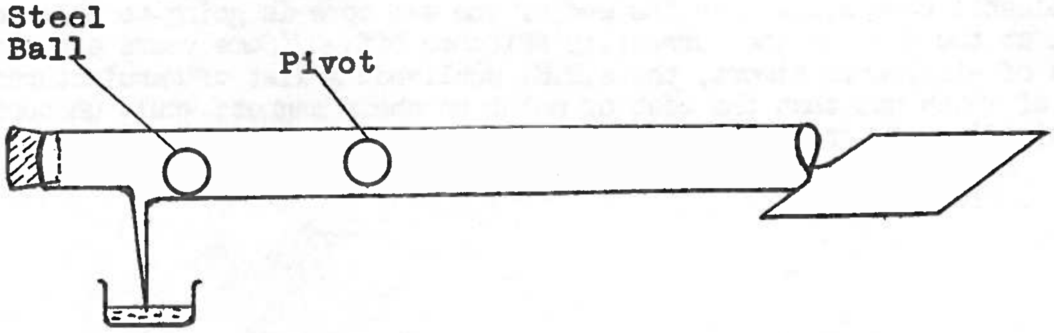
It is a simple matter to ensure that the timing starts at the instant of ball release, by using the steel ball itself as part of the timing circuit. Two lengths of bare 22 SWG copper wire are bent into a U-shape over the end of the electromagnet and taped into position. Over the core end the spacing between the wires should be 2-3mm and the steel ball, held by the magnet shorts the two wires which are connected into the timer. The electromagnet current can then be any value. We would still have reservations about the accuracy with which g can be measured, let alone extending the experiment in various 'open-ended' directions. There is the question of whether, in the initial stages and in the presence of a residual magnetic field, the ball is actually falling freely and we have not yet considered how accurately the timing is switched off. It is instructive on any home-made switch which is magnetically held to take a few strobe photographs of the impact of the steel ball. The amount of rebound is a good guide as to whether the switch is releasing freely or not. A design which has been so checked and which does not involve the use of a magnet, is given in our In the Workshop section.

In The Workshop

Wallace Hall Academy have sent a simple design for an impact switch which does not involve a magnetic latch and which operates within 6ms, as checked by strobe photography. This is within the working limits of the Venner clock or Griffin Centisecond Timer, but not of course, of the electronic timer-scalers recommended by Nuffield.

The switch uses copper tube, 25cm long and 12mm outside dia. At one end the last 4cm are cut almost through and then hammered out to form a flat plate 40 x 37mm. This will receive the dropping ball. At the other end, and on the same side as the plate, a tongue of metal 4mm wide and 35mm long is cut out and bent down at right angles to the tube. The tongue is then filed to a blunt point.

At the centre of gravity of the tube a 5mm dia. hole is drilled in a direction parallel to the plate to take the pivot, which is a brass rod 8cm long and which push fits into a similar hole in a retort stand rod, drilled at a convenient height. The tongue dips into a dish or small beaker of mercury, which carries one contact to the timer. The second timer contact is taken off the brass pivot. To prevent the switch from bouncing back from impact, e.g. if it strikes the bench, a steel ball similar to the one used in the drop, 7.5mm dia., is held in the tongue end of the switch by a cork. When the switch tilts the ball rolls towards the centre, thus bringing the centre of gravity on to the plate side of the pivot.



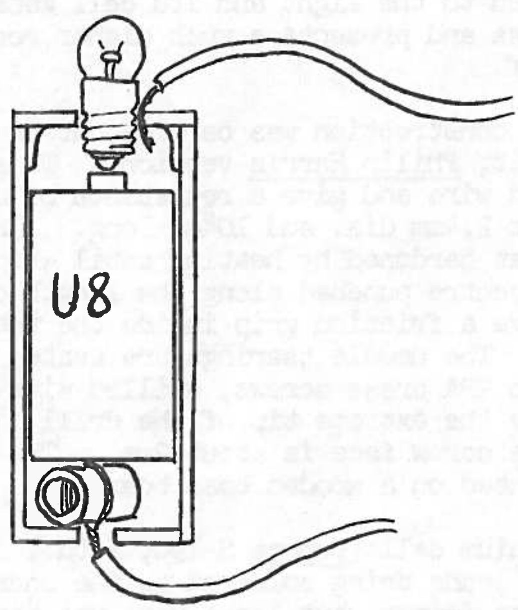
Continuity Tester. This consists of a cell, lamp bulb and two long flex leads. When the lead ends are joined either directly or through a low resistance conductor, the bulb lights up. Its use by a pupil includes the checking of mains plug wiring (needless to say with the plugs disconnected) and simple circuit tracing such as the electric bell. The tester is simple enough to be made by the pupils themselves..

Materials.

Polythene specimen tube 75 x 24mm, TW650	Gallenkamp
12mm dia. rubber tubing	
½ U8 battery	
1.5V bulb	
Two metre lengths PVC covered wire.	

The specimen tube has a hinged lid; cut the hinge off and drill an 8mm dia. hole centrally to take the lamp bulb. The bared end of one of the wire lengths is placed in the hole before screwing in the bulb to make contact with one side of the bulb.

The tube top is cut off to give an inside height of 55mm. A 3mm dia. hole is drilled centrally in the base to allow entry of the second metre length of wire. Cut off a 15mm length of rubber tubing: bare sufficient wire end to encircle the rubber and twist together in a joint and feed through the base hole until the rubber tube is located at the bottom. Insert the single cell from the U8 battery and press the lid down into place. The rubber tubing spring loads the cell against top and bottom contacts. Bare a short length at the free end of each wire.



Direct Vision Spectroscope. The cheapest commercial D.V. Spectroscope costs over £4, yet diffraction grating replicas can be purchased for as little as ¼d. per sq.cm. Using a replica grating, the cost of the spectroscope is therefore largely that of the auxiliary material.

Basically, pupil spectroscopes can be made out of any hollow tube, the only essential requirements being length between 35 and 50cm, and a well-blackened/

blackened interior to reduce reflections off the inside walls. We have constructed them out of Dexion Speed-Frame, electrical conduit, even an empty thermometer case. The wider the tube, the longer the slit can be made with a correspondingly deeper spectrum. The longer the tube, the broader will be the spectrum.

Cover one end of the tube with some opaque material in which a narrow slit has been cut, e.g. aluminium kitchen foil, cutting with a razor blade, or aluminium sheet with a hacksaw cut. The narrower the slit, the better will be the resolution, but the width is not critical. Drill a 5mm hole in a similar cover at the other end, and stick a piece of grating replica over the hole, so that the slit and grating line are parallel. Here again, exact parallelism is not essential; the result of their not being parallel will simply be that the spectrum lines will not be perpendicular to its breadth. If a round tube is being used, it will be a simple matter to rotate either slit or grating close up to the eye in telescope fashion. The direct slit will first be seen, with the first order spectrum at one side or the other. If more than one direct slit is visible, wall reflections are the cause and the interior of the tube should be paint-sprayed matt black, or a tube of black paper can be rolled up and inserted.

One of the more interesting members' exhibits at the A.S.E. meeting in Edinburgh this year came from Gordonstoun school. Called a 'solar' motor, it was actually revolving under a 100 watt electric light bulb. Driven by selenium photo-electric cells, the motor dispenses with commutation by the simple expedient of mounting two cells on the motor itself. The cells are connected in parallel with the coil and stuck on each face of the coil former. Thus when one face is exposed to the light and its cell generating maximum emf, the other is in near darkness and presents a much higher resistance than the coil itself to the driving emf.

Our first construction was carried out on the former from a Westminster electromagnetic kit, Philip Harris version. This will take about 400 turns of 40SWG enamelled wire and give a resistance of about 90Ω. The axle is a silver steel shaft 2.4mm dia. and 104mm long. The ends are sharpened on the lathe and then heat hardened by heating until white hot and quenching in water. Several dots are centre punched along the length of the shaft to roughen the surface and so give a friction grip inside the tube axle which is supplied with the former. The needle bearings are seated inside shallow depressions on the ends of two 2BA brass screws, drilled with a BS2 centre drill again on a lathe. Only the extreme tip of the drill is used, so that the aperture of the hole at the screw face is about 2mm. The screws are threaded into brass pillars mounted on a wooden base board.

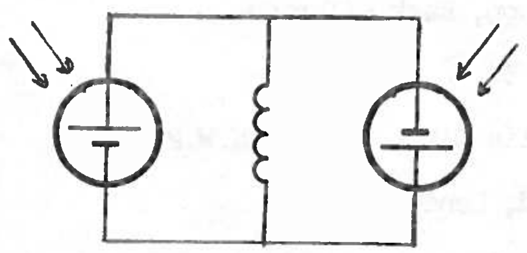
Each selenium cell (Proops S-190, 3/6d.) is stuck on to the former with Evostik, the cell leads being soldered to the ends of the coil. No supports were used for these joints, but loose wire was taped up where necessary so that it would not foul any projections while rotating.

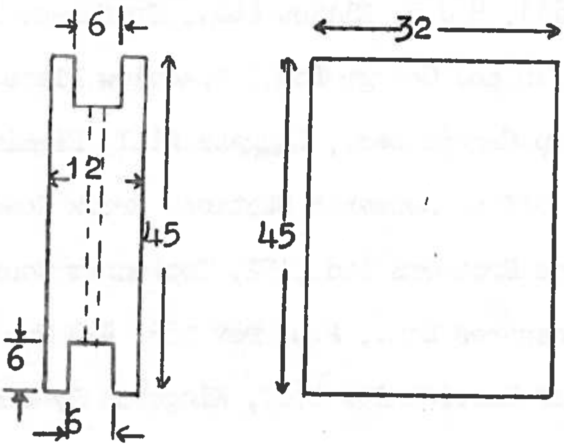
The centre of gravity can be brought on to the axle by sticking on small pieces of plasticene where necessary; but it is just as convenient to mount the motor with the axle vertical when the balance does not matter so much. If this fails to rotate when placed near or between the poles of an Eclipse Major magnet and illuminated by direct sunlight, the sharpened ends of the axle should be examined under a low power microscope for any 'hooks', which can/

can then be rubbed off carefully with emery cloth. Our own version rotated merrily in direct sunlight, and idled at slow speed in ordinary daylight.

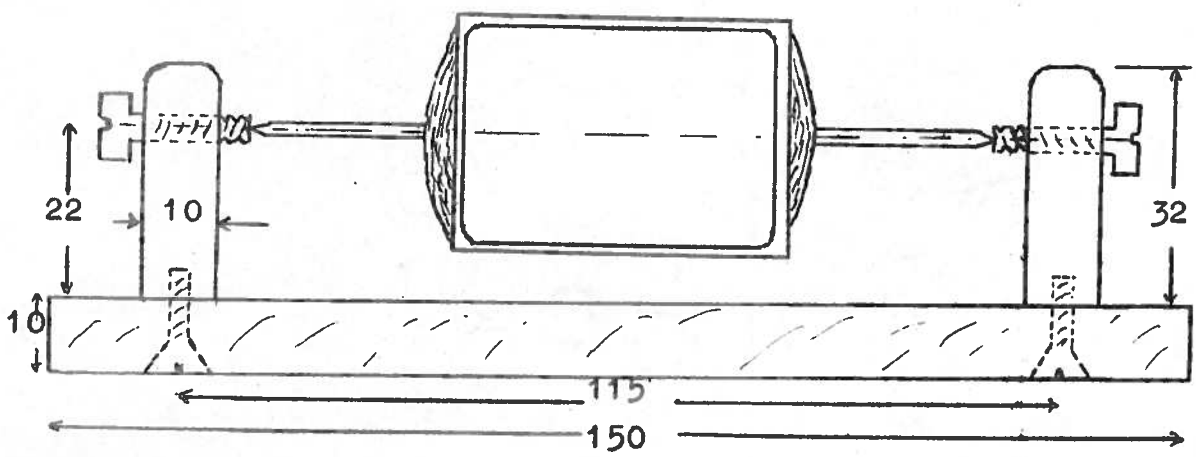
We then made a slightly more powerful version but cutting a former with a deeper slot which would hold ca. 750 turns of the same gauge wire. Dimensions are given in the diagrams. By using a brass axle, hysteresis is reduced. Bearings were made from two old fashioned steel gramophone needles push fitted into holes drilled on the lathe into each end of the brass axle, using a normal twist drill. This model will rotate in sunlight or ordinary daylight using the yoke and two magnets from the Westminster kit. As an additional boost, the wooden frame to support the magnets can be made to carry a plane mirror will reflect a little more light on to the cells. The wooden baseboard of the motor and all other parts to the rear of the cell as viewed with the incident light were painted black to reduce any "dark side" current.

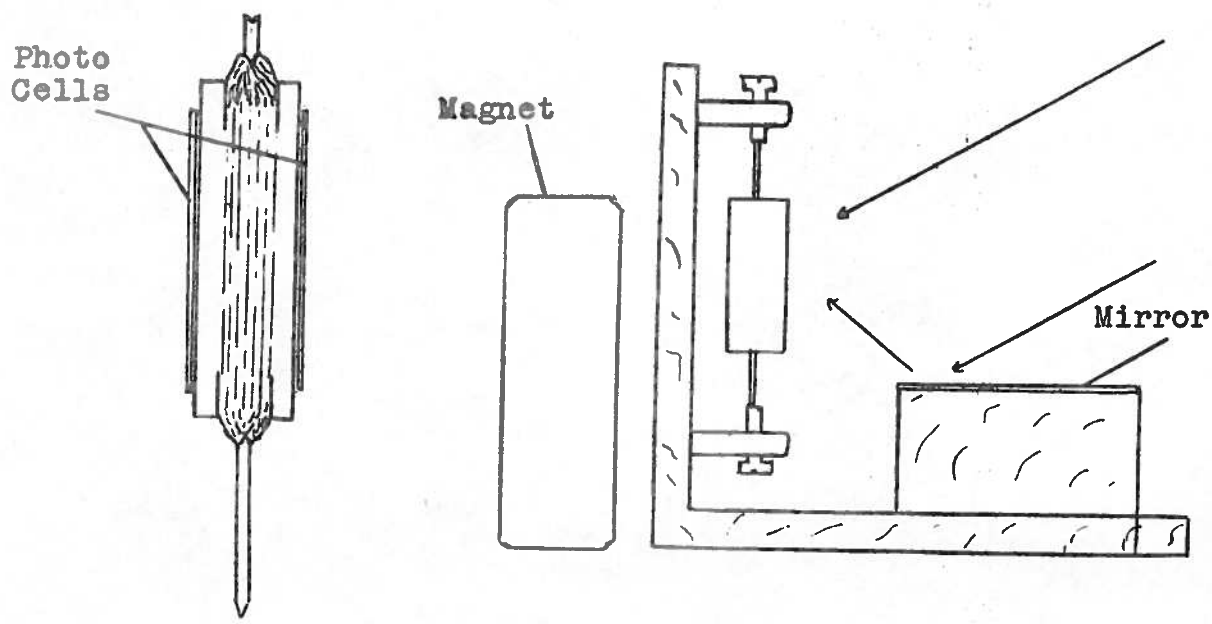
While illustrating energy conversion at an elementary level, the motor should promote discussion with senior pupils when asked to explain why the maximum motor speed is not obtainable in the strongest magnetic field, i.e. with the motor between the poles.





All dimensions in mm.





S.S.E.R.C, 103 Broughton Street, Edinburgh, 1. Tel. WAV 2184.

Advance Electronics Ltd., Roebuck Road, Hainault, Ilford, Essex.

Daystrom Ltd., Gloucester.

Dexion Ltd., 2-4 Empire Way, Wembley Park, Wembley, Middlesex.

Drybrough and Co. Ltd., Craigmillar, Edinburgh, 9.

(E-Mil), H.J.E. Elliot Ltd., Treforest Industrial Estate, Pontypridd, Glamorgan.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride.

Philip Harris Ltd., Ludgate Hill, Birmingham, 3.

Post Office Research Station, Brook Road, Dollis Hill, London, N.W.2.

Proops Brothers Ltd., 52, Tottenham Court Road, London, W.1.

Radiospares Ltd., P.O. Box 268, 4-8 Maple Street, London, W.1.

Venner Electronics Ltd., Kingston By-Pass, New Malden, Surrey.