SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 17. October, 1967.

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Introduction

It is gratifying to us to learn that these Bulletins are prized by the teachers in the schools to which they are sent; it is less satisfactory to learn this from the fact that a teacher moving to a new post has thought fit to remove all past issues with the rest of his furniture. At least we must assume that this is what must have happened when we got an appeal from a teacher saying "Please, can you send me back-numbers of Bulletins; I have moved to a new post and can find only No. 16?"

We in turn can only appeal to teachers about to move not to take this drastic step, and would assure them that every secondary school under the control of an L.E.A. and which teaches any science, however small or remote, will have received Bulletins since their inception. Many non-L.E.A. schools will also have received them. In addition, a copy goes to every Director of Education so that a set of Bulletins should be on file in each Education Office. As we indicated in Bulletin No. 10, once an issue goes out of print there is nothing we can do except photocopy a particular article or articles in which the teacher is interested: the cost of this service is 1/- per foolscap sheet.

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This year we have brought our schools address lists up to date; previously they were the original lists sent to us by Directors of Education in May 1965. There have been many changes since then; new schools have opened, and in others the science departments have closed down. We hope that starting with the present Bulletin all newly opened schools will be on our mailing list; from our point of view this is more important than the few that have closed down and may still be receiving Bulletins. At the same time we have learned from a few of the latter that past issues of the Bulletin have, like the rest of the science equipment, been redistributed throughout the city or county. We would therefore appeal to teachers in any of these schools that should they have spare copies they might care to send them to us in order to help our less fortunate colleagues like the one referred to in the first paragraph; we will gladly pay postage or any other charges necessary in this transaction.

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With the change-over to all figure telephone numbers the new number of the Centre is 031-556 2184. Subscribers in the Edinburgh area do not require to dial the first 031 section.

Chemistry Notes

If rings are cut from a Squezy or other detergent bottle, everted and stretched slightly using hot water to soften them, they can be slid over reagent bottles and trimmed to form a circular label base. Chinagraph pencil or some types of felt and fibre pens can be used for writing on the surface.

* * * * * * *

It was while engaged on the operation described above that we accidentally/

accidentally discovered an interesting property of the material (polythene?) of which these bottles are made. If the rings are pulled to stretch them with a fairly large but steady tension, the material stretches inelastically to some three times its former length, becoming correspondingly thinner and narrower. The action is exothermic, and the stretched portion becomes noticeably warm to the touch. Obviously some molecular rearrangement is taking place, and it is interesting to note that if the stretched portion is heated to 120 - 130°C (we used an oil bath) the action is reversible and the material regains its original condition, so much so that after cooling it can be restretched. We mention this as an interesting homework experiment for pupils to carry out, except probably for the oil bath, but even waving the material over a gas flame will cause it to shrink. The advantage of the ring shape is simply that it makes for greater purchase on the material. A straight piece is difficult to hold without slipping, and a jerky pull breaks the material, probably by melting due to the exothermic nature of the reaction.

* * * * * *

The complexity with which one measures electrode potentials is up to the individual teacher, depending on his inclination and the time available. We had good results with metals immersed in saturated solutions of their salts and connected by a potassium chloride gel bridge, using a valve voltmeter with an input impedance of 50MΩ, but we realise that this is beyond most schools. Nor do we think it necessary to achieve this degree of accuracy; what we wanted is an apparatus which will show that different readings are obtained with different metals, and that the metals can therefore be arranged in an order or series.

At the same time it should be borne in mind that the cells formed will have a very high resistance, and that the connecting of a cheap, low resistance voltmeter (less than 1000 ohms per volt) effectively results in pupils measuring the short circuit current of the cell, rather then the open circuit e.m.f. Even this measurement would give a satisfactory order or series for the metals, if one could be sure that the internal resistance of each cell was roughly the same. Unfortunately this is far from being true, and it is for this reason that some teachers attempt to get closely controlled conditions using rod electrodes all of the same diameter, all immersed to the same depth, and with standard spacing between pairs of electrodes etc.

Using the pupil apparatus described on page 7 we found that the internal resistance varied from under 20 kΩ in the case of magnesium, to 70 kΩ for nickel. Even when an attempt was made to standardise area, immersion depth and spacing by using machined rods etc., there was 2:1 variation in internal resistance. Moreover, the experiments suggest that polarisation, resulting in a gradual increase of internal resistance, has a greater effect on the results than any small irregularities of electrode area or spacing.

To see how internal resistance can affect the result, consider two cells, one with an e.m.f. of 0.7V and internal resistance of 40 kΩ, the other with e.m.f. 0.5V and internal resistance 20 kΩ. If a voltmeter with a resistance of 20 kΩ be placed across each in turn, the e.m.f.s. registered will be

$$(1)\quad \frac{0.7}{3} = 0.23V;$$

$$(2)\quad \frac{0.5}{2} = 0.25V,$$

resulting in a reversal of the correct order. If the meter resistance/

resistance were 2 kΩ instead of 20, the readings would be (1) 0.03V and (2) 0.045V. This explains why less sensitive meters taking around 1mA full scale current, give such low readings. Nor does using the damp sandwich technique as described in Chemistry Takes Shape, Book 3, p.34 give much improvement. Although due to the variation produced by different pressures and by evaporation of the water, it is difficult to measure e.m.f., for the only cell for which we could get a result, viz. the zinc/copper case, the internal resistance was of the same order as that of the beaker type cell.

The design which we give in our "In The Workshop" section of this Bulletin seems to us the best compromise between obtaining good results and the expenditure of a great deal of time and money. It will give an ionisation order with some anomalies, and as the results below, which were taken using the published design, will show, these anomalies depend largely on the pH of the solution.

For the alkali metals we used the damp sandwich technique (Chemistry Takes Shape, Teachers' Guide Book 3, p.20) with a copper reference metal as indicated. Also because of the higher potentials available the meter was ballasted with two of the plug-in series resistors, so that for comparison with other metals the meter readings for potassium, sodium and calcium should be doubled. Even then the comparison will not be exact because of the use of platinum as the reference electrode in the beaker cell. With the alkali metals the most important point would seem to be the wetness of the filter paper. If it so wet that a meniscus can be seen between paper and copper sheet, the results although spectacular are not satisfactory for obtaining a steady reading. We found that 18 mm diameter circles of filter paper (cut with a No. 12 borer) and one drop of water gave good results. The sodium or potassium would remain solid, hiss gently and maintain a constant reading for upwards of 10s. The size of metal pellet used is also important. Pieces cut to 4 mm.x 2 mm.x 1 mm.were satisfactory for sodium and potassium; calcium is not so difficult as it can be held in a crocodile clip and any well cleaned piece is adequate.

We would regard these experiments with the alkali metals as teacher demonstrations, not pupil experiments, and this raises the difficulty of a suitable meter. From what has already been written it will be evident that a demonstration meter of the same or nearly the same resistance as that of the pupil experiment will be needed if a comparison is to be made between the alkali metals and the others. Hence we need a voltmeter with a resistance around 20 kΩ and reading 0 - 5 volts. The nearest one can get to this is with the <u>White</u> INDC meter. High Sensitivity version which on the 0 - 5V range will have a resistance of 16.7 kΩ. The cost of this meter with a 5V D.C. scale, is £28.13s.6d. An alternative is the Russian S36A ammeter, which has a full scale deflection current of 400μA and on 0 - 5V range would have a resistance of 12.5 kΩ. It suffers from the minor disadvantage that, being an ammeter, it will not have a voltage scale nor ballast resistor, and the teacher would require to place a 12.5 kΩ resistor in series with the meter for the experiment. The cost of the S36A from <u>Andrew H. Baird</u> is £12.10s.0d.

Results:

Metal	(1)	(2)	(3)	(4)	(5)
Magnesium	58	85	55	64+	71
Zinc	30	47	21	64	34
Aluminium	12	19	55	19	11

Copper/

Copper	1	3	4	18	3
Iron	6	25	13	37	15
Tin	7	21	12	41	17
Nickel	1	7	3	26	3
Potassium	56	-	-	-	-
Sodium	52	-	-	-	-
Calcium	40	-	-	-	-

Explanation: All readings are meter current in μA (100μA represents 2V). As explained in the text those for the alkali metals require to be doubled to give comparison with the other metals.

(1) readings obtained with tap water electrolyte.

(2) as (1) but made slightly acid by adding 2 drops of 5 molar sulphuric acid to 150 ml. water.

(3) as (1) made slightly alkaline by adding 2 drops of 2 molar sodium hydroxide to 150 ml. water.

(4) molar sulphuric acid.

(5) ammonium nitrate solution, 6 g/1 of solution.

Display Laboratory

The following items have been added to the display laboratory since Bulletin 15:

Item	Manufacturer
Radio Telescope Analogue	SSSERC
Addition of S.H.M. Apparatus	SSSERC
Digital Computer	Electronix Co.
Radio Activity Accessories Kit	Panax
Ratemeter	Forth Instruments
Mass Spectrograph	W.B. Nicolson
Water Pump	Totton Electrical
Linear Air Track	Griffin and George
201 Balance	Griffin and George
TP30 Balance	Oertling
V10 Balance	Oertling
Series 600 Laser	System Computers
KTSG Stereo-Microscope	Myacope
KSS Stereo-Microscope	Myacope
Eye Model	Educational and Scientific Plastics
Heart Model	Educational and Scientific Plastics
Brain Model	Educational and Scientific Plastics

Trade News

An impeller type water pump, model 100S, and driven from the mains electricity supply is offered by Totton Electrical Products for £2.15s.0d. The pump is suitable for circulating water in artificial streams or for trout hatching. Maximum pumping speed is 8l/min. The pump which is mounted on a wooden baseboard is not intended for immersion in the water, and depending on its siting in the laboratory may require a protective cover to prevent pupil fingers being rapped by the fan which air-cools the motor. Electrically the pump would appear to be safe.

Macfarlane Robson are now stockists of the Japanese Myacope range of microscope. One new model is the Myacope Student, with standard eyepiece and objectives to give magnifications of x40, x100 and x200. The price of the instrument, which has no fine focus adjustment. is £20.

Also from Macfarlane Robson comes the news that the Sartorius 2748 school balance is now being fitted with vernier scale to give third decimal place reading at no extra cost. Current price of the 2748 is £117.

Forth Instruments are agents for the NGN vacuum pump system to which we referred in Bulletin 15. The prices from the firm, all less 5% educational discount are: Forevac Unit, £72.12.0d; Highvac Unit, £34; and butterfly valve £7.18.0d.

The same firm have informed us that they are prepared, by arrangement with Telequipment to undertake the conversion necessary on the latter's Serviscope Minor Oscilloscope, to adapt it for an X-input. Cost of a single conversion is £4, dropping to £3.10s.0d. for six or more oscilloscopes. We have one such converted oscilloscope in the Centre at the time of writing for evaluation. This conversion is necessary only on the earlier versions of the Serviscope Minor; later models already have an X-input which will be found at the rear of the instrument.

Also from Forth Instruments we have a ratemeter which has been converted from a Civil Defence Geiger counter. The original model was battery operated; the firm have converted this to mains operation, and have added a transistor amplifier and small loudspeaker. The meter scale is calibrated in milli-rontgens per hour, and the tube, a G5H, has a standard base so that it could be replaced if necessary by a MX168 or similar, although the G5H can currently be obtained from Henry's Radio, price £1.2s.6d. The cost of the ratemeter is £20.

Griffin and George have produced a 50 page catalogue for Junior Science. Almost all the items are extracted from their 66 catalogue; we noticed only one or two more recent items, such as their Nuffield transformer and student microscope. Although the items listed are selected for their suitability for primary school science. teachers in secondary schools may find the catalogue useful for its up-to-date prices, many of which have changed since the issue of the 66 catalogue. Such teachers must write to the firm requesting a copy: it will not be sent automatically.

An improved version of the triangular section linear air track by Griffin and George is now on the market. It is 185 cm. long and made from extruded aluminium. The greater cross section area and absence of joints or seams along its length will give the track additional rigidity. Like the earlier version it is made for strobe photography with a flip-over blind. Catalogue number and price remain the same viz. L22-550, £13.10s.0d.

In The Workshop

A sunshine recorder can be constructed using a water-filled round-bottomed flask as a spherical lens. Details given here are for a Monax 350 ml. flask diameter 92 mm but they will probably serve with other makes not too different in size. The flask is filled and inverted, and focuses the sun's rays on a paper strip supported on a curved shape so that it remains in focus throughout the day. Brown or black wrapping paper is necessary; white reflects the rays and will not burn off.

In its simplest form, the support for the recording paper is a cylindrical strip of metal 2 cm. wide bent into a circular shape of radius 87 mm; if a suitably sized tin can be found the strip would be cut from this. Diagram I shows how this should be mounted relative to the flask. The single rod mount must be in a position where its axis produced passes along a diameter of both the spherical flask and the cylindrical strip. The symmetrical plane of the system should be in the meridian, and as the noon-day altitude of the sun varies between $(90 - L \pm 23\frac{1}{2})^{\circ}$ throughout the year, the plane of the strip must be tilted to the horizontal to correspond to this angle. This can be done by pivoting the strip in its mount; the protractor and plumb bob fixed diametrically opposite the mount enable this to be done accurately. The noon-day altitude of the sun varies with the time of year in a sine or cosine curve about the mean value of $(90 - L)^{\circ}$ as in diagram 2; from this it will be seen that the daily variation is a maximum at the equinoxes, and least at the solstices.

To allow a full record to be obtained at mid-summer, the strip must move through 260° of arc. This has been calculated for schools in the central belt of Scotland, and a teacher in the far North may wish to add a little more to allow for the difference in latitude. In fact the instrument used by the Meteorological Office is a standard design used throughout the British Isles. They also accept that when the sun is within 3° of the horizon it will not record on their instrument, due to the increased thickness of atmosphere through which the rays have to pass.

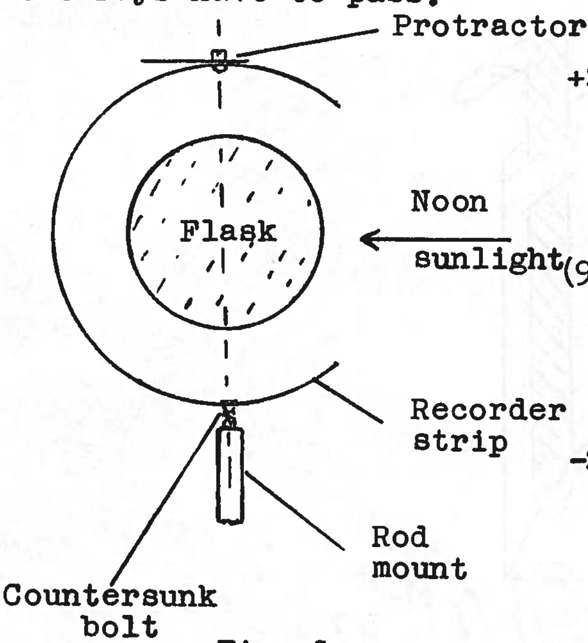


Fig. 1

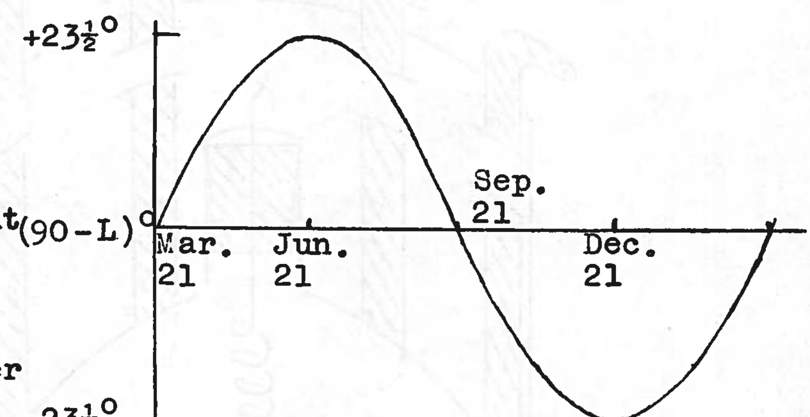
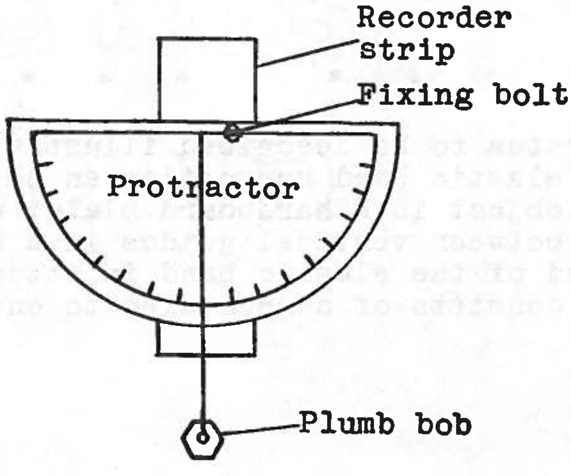


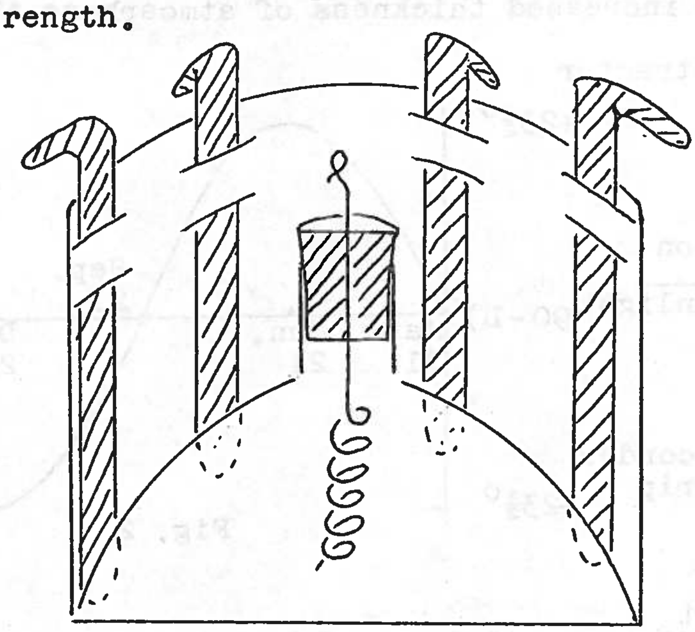
Fig. 2



The beaker type cell which we have used in measuring electrode potentials as described on page 2 of this Bulletin uses a polythene Parazone bottle. The base is cut off to give a container 75 mm. high. Two horizontal cuts 10 mm. long and 10 mm. apart one above the other are made at intervals around the jar, the top cut being about 10 mm. below the top of the vessel. The number of 'bands' thus cut determines how many different metals the cell will accommodate; in our case this was seven. The cuts form a band which holds each metal strip firmly in place. The top portion of the metal is bent outwards to allow an easy connection to a crocodile clip. Little attempt was made to match the metal strips for area or length etc; each was cut roughly 10 mm. wide and the water covers them to a depth of about 40 mm. In the case of magnesium a length of ribbon was doubled twice without breaking it before insertion. The spacer for the platinum electrode which is a spiral 30 mm. long made from a 22 cm. length of 26 S.W.G. wire, is the neck and top of a slightly smaller polythene bottle. A cork bung will hold the straight end of the spiral in place and one or two holes pierced at the joint between neck and top will allow the whole to sink in the water.

The meter used is a 100μA MR 38P Japanese type, obtainable from G.W. Smith for £1.9s.6d. It is mounted in a circuit box MK 3890 from Wootton and Co. (see Bulletin 7 for details) with a Radiospares 18 kΩ resistor in series between the meter and one of the input 4 mm. sockets.

For use with the Russian demonstration meter, a plug-on 18 kΩ resistor can be made up from a Radiospares stackable 4 mm. plug and a similar Griffin and George wire adaptor, L96-490. The resistor with short wire ends is fixed between the two in the same way as a normal lead would be connected, and if a length of adhesive tape is wound over the ends of both plugs at the join this will give the necessary strength.



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The apparatus to be described illustrates that there is no tension in an elastic band supporting an object when both are falling freely. The object is a hardboard plate, which is arranged to be in free movement between vertical guides in a hardboard support, to which the "fixed" end of the elastic band is attached. The remainder of the apparatus consists of a mechanism to ensure quick and clean release of/

of the falling part, also made from hardboard.

Materials

Hardboard, 40 x 20 cm.

Hardboard, 30 x 30 cm.

Other small pieces of hardboard.

2 Softwood blocks, 4 x 2 x 18 cm.

16 SWG Aluminium angle 14 x 18 mm. (outside edge) 40 cm long.

2 pieces 15 x 17 mm. 16 SWG aluminium.

2 small springs 4 mm. dia. x 5 cm. unstretched length.

6 and 4 B.A. countersunk bolts and nuts.

The falling plate and support are shown in Figs.1 and 2. A section 10 x 20 cm. is cut out symmetrically from one edge of the 30 cm. square piece of hardboard. A single thickness of hardboard spacer, and then front and rear guide projecting pieces are nailed on the edges of the cut out section to make a channel. The suspended hardboard section measures 9.5 x 18 cm. and drawing pins are used to attach the elastic band at both ends. The front smooth hardboard face is painted matt black. A white marker line about 5 mm. broad and 5 cm. long is pointed horizontally at one side of the suspended plate to act as a reference mark, and two similar lines are painted on the corresponding guide piece. The upper line shows the plate position when the elastic is unstretched, the lower indicates the plate position when hanging freely.

The whole can be arranged on the release mechanism so that at the start of the fall, the central plate is either supported or hanging freely from the elastic. If the former, the plate marker and the upper reference line will be coincident and should be seen to remain so during the fall. If the elastic is stretched at the start, the lower reference level will be coincident with the centre plate marker, but as soon as the whole begins to fall, the support will move down until once again the upper level coincides with the plate marker. This shows that either way, the elastic is unstretched during free fall, i.e. the centre plate is weightless.

The remaining diagrams give details of release mechanism. The falling plate rests on the aluminium angle which is kept horizontal by two levers bearing on its upright edge at the rear. The upper part of this edge is hinged to a hardboard plate with sellotape. When the levers are released, the aluminium angle gives way under the weight of the plate which then falls freely. To release the plate an operator, standing at one side of the apparatus, pulls on the attached string. To see the effect properly it is necessary that the release mechanism be mounted some 2 m. above ground level. A box containing shredded paper, plastic foam,etc. is useful on the floor to act as an energy absorber and prevent damage to the falling plate. The method of fixing the release mechanism to the laboratory wall, blackboard etc. is left to the individual teacher; we have used two wood screws through each support block.

The support blocks are given a slight taper before attaching the hardboard backing, which then has a slight backward slant. This overcomes the tendency of the falling plate to topple forward when placed on the aluminium angle. An 11 cm.gap is cut in the wider edge of the angle, 10 cm. from one end. This gap is sufficient to allow the centre plate of the falling section to hang freely from the elastic band, while the rest is supported by the angle. By having the gap cut nearer one end then the other, it is also possible to support the whole of the falling section, including the centre plate, on the longer, intact section of the angle, when it is desired to release the apparatus with the centre plate in the supported position.

Reference/

Reference to diagram 4 will show the modus operandi of the trip mechanism. When the string is pulled both trip levers pivot until the tapered edge is horizontal, when both levers are then clear of the aluminium angle. As the weight of the falling plate bears on the falling angle it bends backwards about the sellotape hinge, and the plate falls. When the string is released, the two springs contract to snap the levers back to the upright position, and in so doing they return the aluminium angle to its static position. If the leading inside edge of each taper on the levers is bevelled this assists the lever movement and allows it to exert the necessary pressure to return the aluminium angle. Countersunk 4 BA bolts are used for the lever pivots; all other bolts are 6 BA countersunk. The ring through which both strings pass is the "eye" type screw normally used on the end of expanding curtain rod; a small square of hardboard is used under it to reinforce the screw. The rear surface of the hardboard plate is the smooth surface, and all bolts, etc. on the front face of the plate are countersunk so that nothing catches on the falling plate.

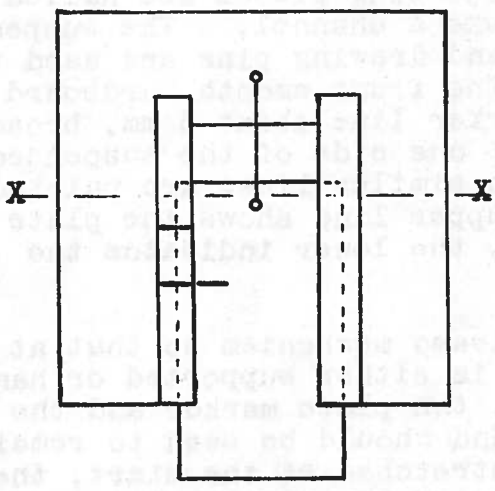

Fig. 1. Falling plate in 'hanging' position

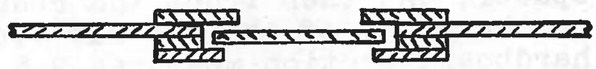

Fig 2. Section through XX.

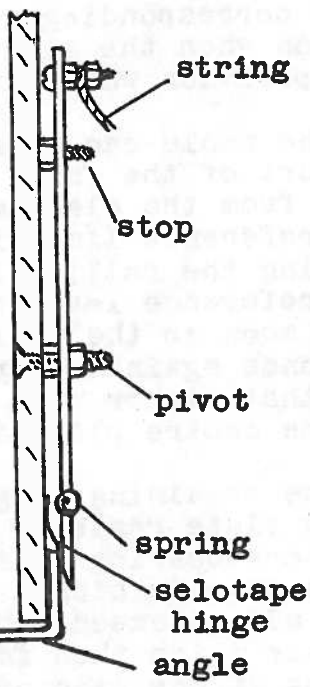

Fig. 3a. Lever, side elevation

Fig. 5. Wall mounting

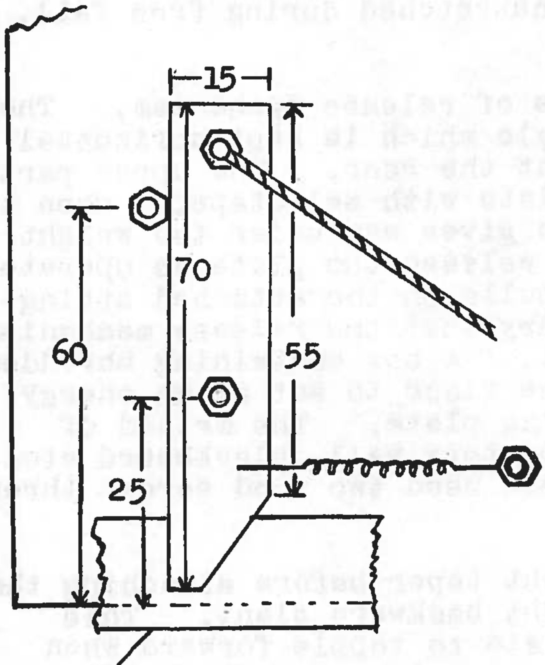

Fig. 3b. Lever, rear elevation

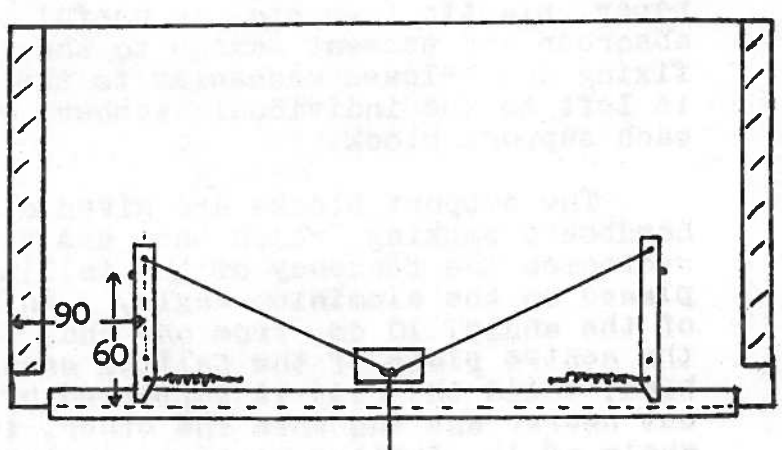

Fig. 4. Support, rear elevation.

All dimensions in mm.

S.S.S.E.R.C., 103 Broughton Street, Edinburgh, 1. Tel 031-556 2184.

Andrew H. Baird Ltd., 33-39 Lothian Street, Edinburgh, 1.

Educational and Scientific Plastics Ltd., Holmethorpe Avenue, Holmthorpe, Redhill. Surrey.

Electronix Co. Ltd., Hamlet House, Champion Hill, London, S.E.5.

Forth Instruments Ltd., 46 King's Road, Portobello, Edinburgh, 15.

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

Henry's Radio Ltd., 303 Edgware Road. London, W.2.

Macfarlane Robson Ltd., 3A St. Vincent Street, Edinburgh, 3.

(Monax) John Moncrieff Ltd., P.O. Box 10, St. Catherine's Road, Perth.

(Myacope) Butterworths Ltd., London Road, Meadowbank, Edinburgh, 7.

W.B. Nicolson Ltd., Thornliebank Industrial Estate, Glasgow.

L. Oertling Ltd., Cray Valley Works, St. Mary Cray, Orpington, Kent.

Panax Equipment Ltd., Holmethorpe Industrial Estate, Redhill, Surrey.

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

G.W. Smith and Co. Ltd., 3-34 Lisle Street, London, W.C.2.

System Computers Ltd., Fossway, Newcastle-upon-Tyne, 6.

Totton Electrical Products Ltd., Windle Works, Southampton Road, Cadnam, Southampton.

Wooton and Co. Ltd., Alma Works, Ponders End, Middlesex.

White Electrical Instrument Co. Ltd., Spring Lane, Malvern Link, Worcs.