SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

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Contents

Opinion

It is probably true that something like half our secondary school children are being educated in schools that are under ten years old. Away from the cities, it is commonplace to be directed to the outskirts of the town on enquiring the whereabouts of the local school or academy. The directions tend to be complex, and the informant usually ends up by averring "Ye canna miss it". Regrettably one can, too often, do just that. Schools of pre-war vintage could be readily identified, by a macadamised playground, by bicycle sheds, by 'looking like' a public building. They tended to have a recognisable front entrance, visible from the public road. Now a new school can resemble an advance factory in the middle of a green belt, or a tower block of flats.

One might expect local authorities to be proud of their new schools; they certainly ought to be. If they are proud, would they not be expected to say so occasionally? Would it not be a good thing for them to proclaim, on a notice board where the American tourist and the English visitor can read it, that this is Inversnecky Academy, property of Exshire County Council? In these days when every farmer proclaims the name of his holding at the end of the farm road, most of them suitably decorated with silhouettes of pigs or poultry, could the schools not do the same at their front gate? It would help us to find the front gate.

Once inside the grounds the visitor's troubles are by no means over. The road will divide, maybe two or three times, and there will be nothing to tell him whether he is headed for the administrative block, the kitchens, or the toilets. If he finds a car park, he will wonder whether he dare leave his car in it. One new school I visited has a waiting list for car spaces, one of which the newcomer may hope to inherit in old age when most of his predecessors have been promoted or retired. Out of his car, the visitor will have to find an entrance, any entrance, as he will have long since realised that front, like back and sides are not applicable descriptions.

Most of the building will be one storey up, on stilts, through which the wind blows interminably and the rain drives horizontally. Walled on even three sides, these spaces would provide a measure of wet-weather accommodation; as they are, they become the repository of forlorn desks and worn-out dining tables. Once inside the building there is only one course to follow - open the nearest door and ask to be directed to the secretary's office. If an adult answers, it will probably be by saying "Well, it's a bit difficult from here", implying that one really ought to start from somewhere else. Children are only too happy to set out at once, getting the visitor and themselves completely lost several times in the process, and initiating fierce arguments with pupil passers-by in the corridors.

His business finished, the visitor must be equally wary on leaving. I once spent a Kafka-esque half hour in one of these stilted buildings, descending numberless flights of stairs in a vain/

vain hope that one of the doors would be unlocked - this half an hour after the building had been emptied of pupils for the day. Cleaners were visible in other corridors, through acres of glass across quadrangles; the noise of their work was all around me, but try to make contact, and the sights and sounds retreated as I moved.

Is it all done deliberately, to make the visitor feel at a disadvantage and a little foolish? From the moment of first enquiry in the town - "Aabody kens whaur the school is", the attitude is the Barbie-ish one of 'If you don't know, then you're of no account.' The average irate parent, knowing he has a grievance, is intimidated by the endless, signpostless corridors, through which staff and pupils move with such assurance. If he reaches the secretary's office he may have to wait, a futile observer, while a long queue of pupils buy dinner tickets. He will be lucky if the office staff acknowledge his presence; he is defeated before he starts. So the rift between school and life outside widens, until the child looks on them as two separate worlds.

Chemistry Notes

There have been a series of rumblings, and general unease, regarding the toxic hazard of mercury vapour. Teachers in old laboratories with wooden floors have suspected themselves of being slowly poisoned by an accumulation of mercury in cracks between the floorboards. In industrial conditions, which assumes a workman exposed to the vapour for eight hours daily throughout his working life, the accepted maximum safe concentration, called the Threshold Limiting Value, or T.L.V., is 0.1 mg/m^3. A member of our Development Committee was fortunate enough to be able to borrow the comparatively expensive equipment used to measure this order of vapour concentration. The equipment pumps a known volume of air over a sensitive reagent, and is applicable down to half the T.L.V., the estimation being to count the number of pump strokes required to give a colour change in the reagent.

In the teacher's own school which is of post-war vintage with vinyl flooring, there was no detectable vapour concentration, even after exposing a dish of mercury in the laboratory overnight. We then borrowed the equipment to carry out the tests on two older schools with wooden floors, both of which were known to have been in use for approximately 50 years, although the age of the floorboards might be considerably less than this. Nowhere in these laboratories did we record any detectable concentration.

Back in the Centre we exposed a large tray, measuring 30 x 30cm, with a covering of clean mercury and found that it was necessary to sample the air only 4cm above the surface, to reach the T.L.V. In the experiment to reduce mercury oxide by heating, a sample of air taken 1cm from the mouth of the test-tube showed three times the T.L.V. We conclude therefore that in normal circumstances there is no/

no mercury vapour hazard, and that it would require the exposure of excessive amounts of mercury to constitute one. Should a teacher still believe that he may be at risk, we would recommend him to contact his City Analyst, or the local M.O.H. as it is still possible that these may have necessary test equipment, or may be prepared to purchase it, from Draeger Normalair.

Biology Notes

The specification and test procedure which follow will replace those originally laid down in Bulletins 7 and 9 for microscopes for O-grade work. The format of the test procedure corresponds to that given in the revised H-grade test procedure in Bulletin 46 and will be followed in all future test reports.

Essential Magnification from about 50x to 200x.

Optical performance; the 20x objective must resolve the striations on the diatom Synedra ulna.

Focussing; safety stop.

Desirable Mirror rather than built-in illumination.

Eyepiece; fixable, high eyepoint, widefield with pointer.

Optical performance; the 20x objective should resolve the surface lines on the diatom Gyrosigma attenuatum.

Smoke cell; a smoke cell should be accepted without awkward adjustments.

One microscope to the above specification is required per 2 pupils for O-grade.

Before detailing the procedure we have used to assess whether or not microscopes come up to the above specification, we give a short discussion on what we consider are the desirable methods of achieving the specification.

The most suitable optics are a 10x eyepiece, with 3x - 5x/0.10; 10x/0.25; and 20x/0.40 objectives on a triple nosepiece. No condenser is necessary, though a single lens type may improve the performance of the 20x objective; such an objective can usually be adequately illuminated however, with a concave mirror and a large light source. The safety stop must prevent the 20x objective from touching a slide of normal thickness. It should be adjustable, but not by a pupil, e.g. by use of an Allen screw.

In specifying a mirror in place of built-in illumination, we have in mind the fact that the latter overheats the stage, interfering with observations on living specimens. In any case bench lamps are useful items of equipment for work on photosynthesis, tropic movements etc. Although the eyepiece should be fixable to prevent it from being damaged, it should not be permanently fixed, so that objective back/

back lenses can be inspected. The most satisfactory arrangement is a slit cut in the top of the body, which therefore 'gives' slightly when the eyepiece is inserted and holds it firmly.

The significance of Brownian motion is such that it is desirable if not essential that each pupil should see it through his or her own microscope, yet the experiment - and others such as crystal growth - is insufficient to justify the expense of separate microscopes in each of the science departments in the school. It is necessary therefore that microscopes and smoke cells be bought with a view to compatibility. Our own Musselburgh smoke cell, described in Bulletin 4 requires a maximum clearance of 15mm, and a focussed clearance of 5 - 7mm.

<u>General Construction</u> Shape, dimensions and material of base and limb of the stand are described, together with any accessories, e.g. illumination, built into the stand. The body may be of metal or plastic, fixed upright, fixed inclined, or tiltable. It is assumed to be monocular. It may be rotatable, with or without a lock. The shape, dimensions and material of the stage are stated. The position of the mirror socket is given.

<u>Optical Parts</u> Eyepieces may be permanently fixed, fixable, or free, Huygenian or Widefield, and may have a pointer; if they are removable their outside diameter is stated. Widefield eyepieces not only enlarge the field of view, but also usually have a large eye relief distance, which is an advantage for spectacle wearers. Magnification is specified. Objectives are assumed to be achromatic. They may or may not have standard R.M.S. thread; standard objectives almost always have larger numerical apertures (N.A.) than non-standard types, and hence greater resolving power. Magnification and N.A. are stated, where possible - e.g. 10x/0.25. Magnification is checked by observing a 1/100mm clear plastic gauge through the microscope with one eye, and superimposing the image of this onto a metric ruler held in the same plane and viewed with the other eye. Objective alignment is assessed by using a pointer eyepiece, as follows. Using a pointer or cross wire eyepiece, an object at the centre of the field of view is aligned under the 20x objective. The other two objectives are then viewed through in turn, when the image should remain substantially in focus and should not be more than 100μm off centre. The distance from each objective to a slide in focus - the focussed clearance - is given, as is the maximum distance between each objective and the stage - the maximum clearance.

If a condenser is present, it will usually be a single lens, fixed into the stage; such a condenser will adequately illuminate a 20x/0.40 objective. A substage diaphragm, if present, will usually consist of a rotating disc with various apertures, the larger being used with the higher power objectives. Sometimes such a disc is numbered to indicate which aperture is in position; this adds to the convenience in use. The mirror may be single, or double-backed. Reflectors are specified as 'white' (paint or paper) 'plane' or 'concave' and may be of metal or glass. The latter may be 'rear' or 'front surface reflecting'. A front surface reflector is liable to tarnishing. Mirror diameter is also specified.

<u>Focussing Mechanism</u> Only coarse focussing is required. The usual type is rack and pinion, moving body or stage. Other types will be described in more detail; a diagram may be included. To determine backlash, a blood smear is focussed under the 20x objective, and the focus knob then very gently turned to either side. If there is not an immediate response to the movement, backlash is present. The mechanisms of any stops are described. They may be fixed or adjustable. There may be a stop at the lower end of the movement; occasionally one is present at the upper end as well.

<u>Optical Performance</u> For a full explanation of the purpose of these tests see the 'H'-grade procedure in Bulletin 46. Both resolution and the various forms of aberration are tested for, the latter being assessed qualitatively. As with the 'H' grade tests, certain slides have been selected from the 'O' grade syllabus, and these are used in conjunction with the 'standard' test slides. The 'syllabus' slides are: T.S. compact bone; human blood smear; V.S. lung; T.S. dicot. leaf; T.S. herbaceous dicot. stem; and T.S. dicot. root.

To test resolution, the diatoms <u>Gyrosigma</u> <u>attenuatum</u> and <u>Synedra</u> <u>ulna</u>, mounted in 'Hyrax', are viewed with the 20x objective. The former has lines running parallel to the long axis; the latter has a series of parallel striations in 2 rows, one on each side, rather like the teeth of a comb. Objectives of N.A. 0.40 and above should resolve the lines on <u>Gyrosigma</u>; those of lower N.A. must at least resolve the lines on <u>Synedra</u>.

The tests for aberrations are the same as those given in Bulletin 46 for H-grade microscopes, but for the sake of completeness we repeat that description here. Two test objects are used; a Wild Abbe test plate, and an electron microscope grid mounted in Canada Balsam or similar mountant. The former consists of a silver film deposited on the underside of a wedge shaped coverslip, varying from 0.08 to 0.23mm in thickness, and all tests are carried out at 0.17mm, which is the thickness of the average No. 1½ coverslip. Three sets of parallel lines are ruled in this film, for the three powers of objective, and these are viewed in both direct and oblique light. The lines are focussed in direct light and then viewed in oblique; chromatic aberration shows as red and blue fringes to the lines, while spherical aberration causes them to be out of focus in the oblique light. The same test plate also has small pin holes in the film, and if one of these is viewed in direct light, spherical aberration causes the hole to appear as a ring when above focus, and as a 'cloud' when below. The hole is also used to detect astigmatism and coma.

With the electron microscope grid, spherical aberration can be estimated qualitatively from the clarity of the image of the cross bars, which is also affected by glare. Chromatic aberration causes the entire field to become coloured - green above and violet below focus. It must be stressed that all these tests are qualitative and therefore depend upon the tester having used a range of instruments, and on correlating the results with the images produced from the 'syllabus' slides.

The diameter of the field of view is measured, using a millimetre/

millimetre gauge. The product of this value and the magnification used is a constant, referred to as the FV factor. This ranges from 90 to 190, with an average value of about 130.

Operation The ease of handling of the focussing controls, condenser and objective changer are described. If built-in illumination is supplied, the controls for this are also described. (The tests for body rigidity and stage flexibility are described by A.K. Thomas in the Third Apparatus Report of the Association for Science Education, Education in Science No. 28, June, 1968. What follows is largely taken from this report). Most microscope coarse focussing mechanisms are of rack-and-pinion type, the body or stage moving in a dovetail slide. Badly fitted dovetails are tested for as follows. A stage micrometer scale is viewed under the 20x objective and aligned with a pointer or cross wire. A 1 kgf pull is made to the left and then to the right, on the body or stage. Well fitted stands show a steady deviation of the pointer along the scale, the maximum deflection being no more than 200μm. Badly fitted stands produce a jerky movement.

If the stage is too flexible, hand pressure while moving the slide may cause complete loss of image under the 20x objective. To test for this, the fine adjustment is first calibrated as follows. The thickness of a thin coverslip is accurately measured with a micrometer. It is placed dry on a clean slide and Lycopodium powder lightly dusted onto both.

The 20x objective is focussed on the upper surface of the coverslip, and a horizontal radial line is drawn on the end of the fine focus control knob. Using the fine adjustment only, the instrument is focussed on the upper surface of the slide. A second horizontal radial line is then marked on the control knob; the angle between these marks corresponds to the thickness of the coverslip. While still focussed on the slide, a 1 kg weight is hung from the edge of one side of the stage, using a hook covered in rubber tubing to prevent the stage from being scratched. The focus is then restored, using the fine adjustment, and a third horizontal radial line marked on the control knob. From the angle enclosed by the second and third marks, the deflection of the stage under a 1 kgf can be calculated by simple proportion.

Rigid stages should bend about 10μm, but some have been found with deflections exceeding 50μm.

General Comments The overall performance, robustness, and convenience of use are assessed, and any particular advantages or disadvantages noted. The instruments are assessed as follows: A - most suitable for school use; B - satisfactory; C - unsatisfactory. Price is a major factor in determining whether an instrument is given an A or B grade. Instruments are usually given a C grade because of unsatisfactory optical performance; the full reasons for giving this grade will, however, always be given. Any accessories are described, and servicing arrangements are indicated.

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In the supplement to Bulletin 47 we gave the maximum vertical clearance for the Prior Stereomaster under 10x magnification as 31mm; this was a misprint for 310mm.

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Some biology teachers who wish a more exact or more sophisticated reaction timer than that described in Bulletin 9, may not be aware that the physics department of most schools will possess such an instrument, a scaler/timer. The box has two pairs of terminals usually labelled 'Start' and 'Stop'; shorting each pair in turn carries out the described function. If the observer closes a switch connected to the start terminals, the timer starts counting and provides a visible stimulus to the subject, who must respond by closing the stop switch.

Physics Notes

We get enquiries from time to time for the recipe for the electrolyte used in alkaline accumulators, either nickel-iron or nickel-cadmium types. Our recipe comes from Intermediate Electrical Theory, by Heckstall-Smith, published by Dent and Sons, and is 21g of potassium hydroxide (tech. grade) dissolved in 100ml of distilled or deionised water, together with 50g per litre of solution of lithium hydroxide. The function of the latter is not known, but it increases the cell capacity, a fact which we have verified.

In The Workshop

The wooden test-tube rack, which was always difficult to store, is now being replaced by stackable racks in aluminium, made from sheet metal but into a Z form. Bought from normal school suppliers these cost around 50p each, and teachers have expressed doubts about their resistance to chemical attack.

The rack we describe can be made for about 5p, although it must be admitted that the minimum quantity of the Twilweld material which ironmongers will supply is a roll 20 x 3ft which costs £4.00. (We apologise here for using imperial rather than metric dimensions, unfortunately this is the way the material is made up). We have used the same material for making tops to animal cages, however, and technicians may well find other uses so that when one has made all the test-tube racks the school requires, the rest will not be wasted.

16 S.W.G. Twilweld was the material used; it consists of a rectangular mesh of wire spot welded at each intersection. The spacing between wires is ½ in in one direction and 1 in in the other. To make a rack to hold 12 125 x 19mm test-tubes a rectangular piece 6 x 11 in is cut out in the direction to give 12 wires at 1 in spacing, and 13 at ½ in spacing. Every alternate ½ in spaced wire is then cut out using wire cutters, from the first, second, fifth and sixth inch to give two lots of two adjacent rows of six 1 in square holes, as shown in Fig. 1. The wire is then bent by hand to the profile of Fig. 2, when the set of holes will coincide vertically to take the test-tubes. It is important to avoid bends in the intersections as due to the welding the wire is weaker here. After bending, the rack is dip-coated once or twice in polythene, using the procedure described in this Bulletin, which provides a measure of protection against corrosion and also gives the rack a pleasing, professional appearance.

Teachers and technicians will be able to think up other designs for other types of glassware; we have made a rack for 50ml reagent bottles, using 2 in square holes, to the profile given in Fig. 3.

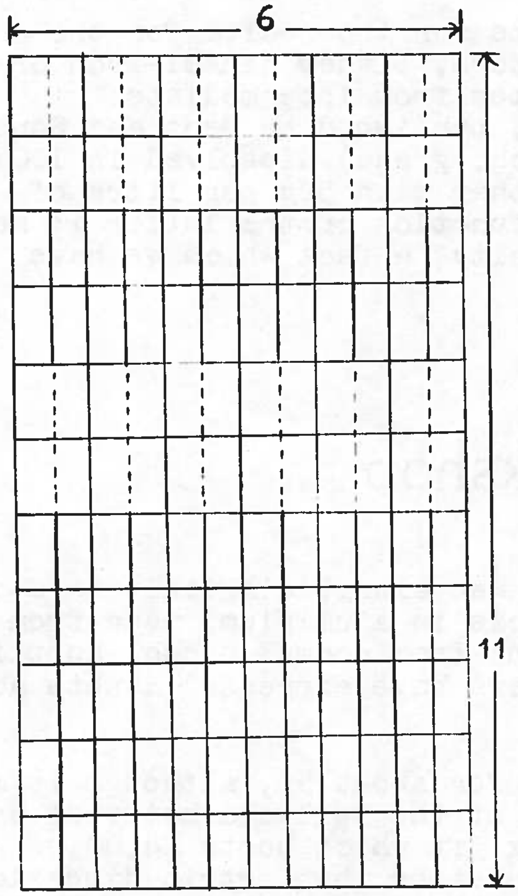

Fig. 1. Dotted lines show where wires have been cut out.

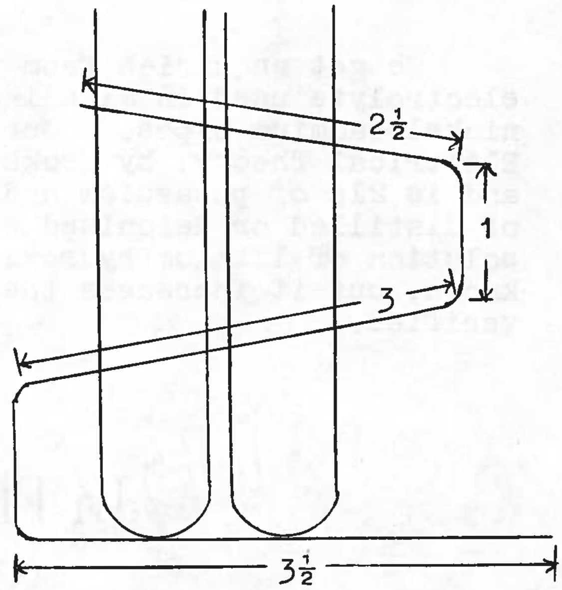

Fig. 2 Test-tube rack

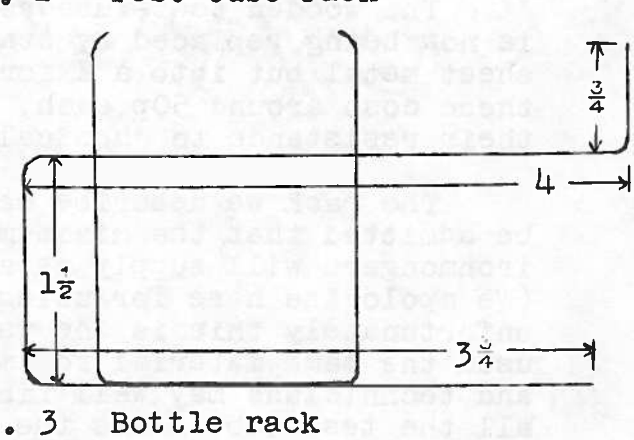

Fig. 3 Bottle rack

All dimensions in inches.

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The compensated respirometer to be described uses two 20ml plastic syringes, the nozzles of which fit directly into three-way taps. These taps are obtainable from Henley's Medical Supplies and are made in plastic. As the name suggests, the tap has three outlets and a lever handle which rotates through 180°. The tap has three operating positions, connecting any two of the three outlets, the remaining one being blocked off. The position in use is shown by a lever, which points towards the blocked outlet.

The manometer part of the apparatus is a 35cm length of capillary tubing, bent in the usual U shape but with the top 2 cm of each leg bent backwards at right angles to the rest of the U to form a horizontal portion for the connection of rubber tubing. It is mounted on a piece of plywood 120 x 80 x 6mm using three Terry clips with an 8cm length of Scalafix mm scaled tape behind each vertical leg of the U. This part of the construction is shown in Fig. 1.

Considering the tap as a T-piece, a short length of rubber tubing joins the manometer to one of the T arms on each tap. The manometer is filled by removing one of the taps and dipping the exposed end of the capillary tubing into a mixture of equal volumes of water and washing-up liquid detergent, to which some congo red has been added. A 2ml syringe is inserted into the remaining tap, which is set to connect the syringe to the tubing, and the necessary length of liquid is drawn into the tubing. The manometer is tilted back to the upright position, the syringe removed and the second tap replaced. Both taps are turned to block the vertical leg so that each end of the manometer is connected to the atmosphere and the levels should equalise.

The plungers of the two syringes are cut off leaving a 60mm length in each syringe. The active one has some soda lime kept in by a plug of cotton wool, and then the respiring organism. Each tap is turned to block the manometer, the syringes are inserted in the vertical legs, and both are lowered into a beaker of water which acts as a constant temperature bath. After about 5 minutes, which allows the syringes to reach water temperature, the taps are turned through 180° which will block off the atmosphere and connect the syringes with the manometer, and the apparatus is ready for use.

When the liquid has travelled to the top of the manometer tube, both taps are turned through 180° and back again, which allows all parts of the apparatus to return to atmospheric pressure, so that readings can be repeated. In one trial using germinating mung beans at 17°C, the average of rate of rise in the manometer level timed over 7 minutes, was 3.7mm per minute, while the same test repeated at 26°C gave an average of 6.2mm per minute.

The use of syringes allows the organism to be changed without removing the cotton wool and soda lime, and the manometer may be stored indefinitely with the liquid in situ.

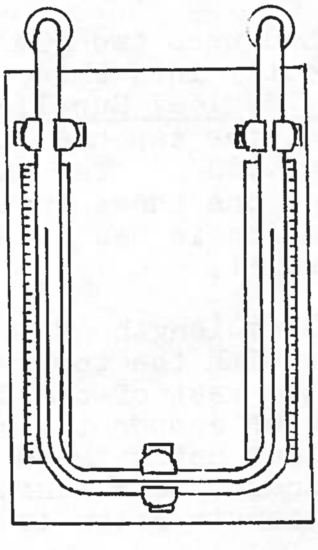

Fig. 1. Manometer

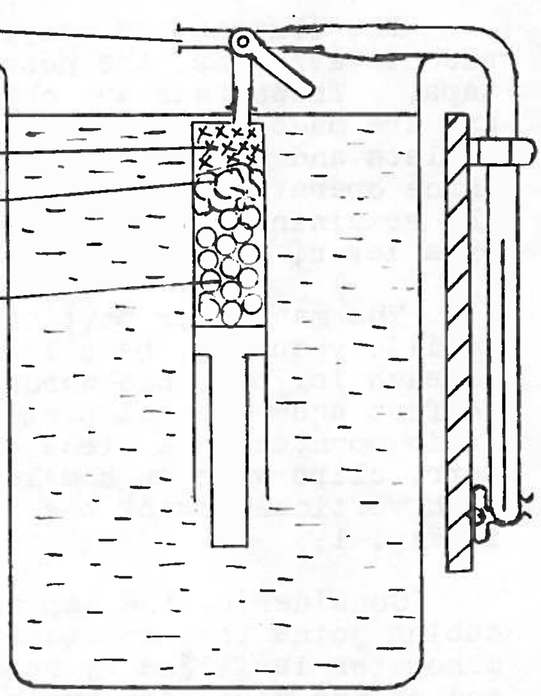

Fig. 2. Side view of respirometer

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As part of their technical studies brochure Griffin and George give details of a dip-coating process which covers metal objects with a layer of polythene, giving them a pleasing appearance. The polythene powder may be bought from Peter Plastics as Polythene Grade 20 dip-coating powder in various colours at 42p per kg. While most of the objects to be coated require the use of a fluidised bed, to be described, in some instances we have been able to dispense with this and use only simple equipment. For example, we have made our own versions of animal cage using plastic trays and washing-up bowls, which require a wire mesh top to complete the cage. To protect animals and pupils alike from scratches, the perimeter of this wire mesh should be covered in polythene.

Where there is this requirement to coat only a straight edge, it is sufficient to play a bunsen burner or blowtorch along the edge for a minute or so, dip it directly into a 2cm deep layer of the powder and withdraw it immediately, with the powder adhering to it. A further application of heat will melt the powder to form an even layer. The technique should be practised once or twice with a scrap material; the most likely fault is to overheat the polythene after dipping, which will cause it to darken or even catch fire.

Where objects in two or three dimensions are to be coated, a fluidising tank is necessary. This allows air to be blown into the powder from underneath, so that the article may be dipped instantly and completely into the powder. Without fluidising, the article would rest on the surface. Our fluidising tank was made from two 4 gallon Byprox detergent tins, which should be obtainable from the school cleaners, unless they use another brand. They are square metal tins and have the advantage of a ridge round top and bottom. The lower tin has the top cut out, leaving only a rim about 2 cm wide around the edge. Into one side of it at a convenient height is soldered a brass tube, 25mm diameter to act as the air inlet. For an air supply we use the same vacuum cleaner as is used to drive/

drive linear air tracks etc., but it must be controlled by a variable transformer or thyristor control module, because when working at full mains power it would blow all the powder out of the upper tin.

A diffusing medium is needed between the lower air reservoir and the tin holding the powder. To make this, a piece of 12mm thick plywood is cut and shaped so that it is a good push fit into the ridged part on the top of the air reservoir. The centre part of the plywood is then cut out so that only a shelf about 3cm wide all round remains. Two thicknesses of cloth - we used an old laboratory overall - each gummed on both sides round the edge are stretched over the top of this shelf. Over this is put another piece of 3mm thick plywood, cut identically to the thicker piece, and this is tacked down all round with panel pins.

The second Byprox tin is prepared by cutting out the top completely and smoothing off any rough edges. A hole is cut out of the base of the tin, leaving a 3cm wide rim all round. When it is thought that the glue has set, holes for countersunk bolts are drilled through the complete arrangement, including the base of the upper tin. On top of the diffusing arrangement, a complete ring of Bostik sealing strip is laid, and then the fixing bolts are inserted upwards into the upper tin and bolted down. The top tin is then push fitted into the lower, a strip of adhesive tape is wound completely round the join, and the fluidising tank is ready for use. The upper tin should be filled to less than half its depth with powder, because the air flow may expand the apparent volume to over twice its normal size.

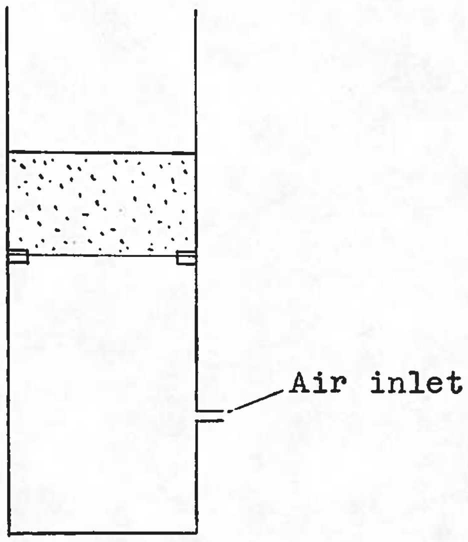

Fig. 1. Fluidising tank

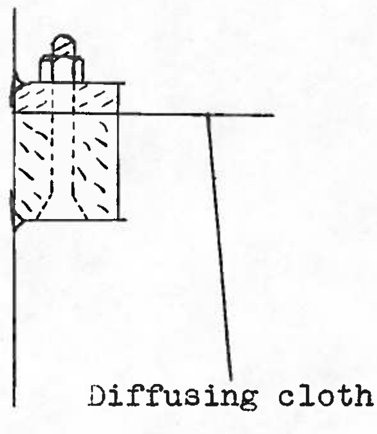

Fig. 2. Detail of join.

S.S.S.E.R.C., 103 Broughton Street, Edinburgh. EH1 3RZ.
Tel. 031-556 2184.

Draeger Normalair Ltd., Kitty Brewster, Blyth, Northumberland.

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

Henley's Medical Supplies Ltd., Alexandra Works, Clarendon Road, Hornsey, London, N.8.

Peter Plastics Ltd., 234 Paisley Road West, Glasgow, S.W.1.

W.R. Prior and Co. Ltd., London Road, Bishop's Stortford, Herts.