SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

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Introduction

In Bulletin 63 we commented on what we thought were some undesirable aspects of 'package deal science courses', following on a newspaper article on the subject, with reference to the use of Nuffield Combined Science in Iran. The opinions expressed there were based exclusively on the information supplied by the newspaper, and were those which we thought a great many science teachers might form had they only that information to build on. Aware that this was unlikely to be the full story, we hoped that the bulletin article might initiate some reaction which would result in a fairer picture being presented.

This it has done, and we are therefore glad to print the following statement from Dr. Gordon van Praagh, Assistant Director for Science with the Centre for Educational Development Overseas.

Your article of the above title raises the broad issue of the involvement of the UK in curriculum development in science in developing countries. Since the Centre for Educational Development Overseas is closely involved with aid to developing countries, we should like an opportunity of commenting on the article. We should all agree with the principle that courses developed in one country are not likely to be suitable for adoption in toto in a different country. It may be thought that, ideally, each country should carry out its own curriculum reform, but we know from experience in the UK, in particular through the Nuffield projects, that this is a very expensive and time-consuming operation, requiring also a great deal of local talent and experience. The compromise being followed in many developing countries is to study the new courses and methods of science teaching which have been produced in the UK, USA, Australia etc. with much expenditure of money and energy and to adapt them to their own needs. This enables the developing country to take many short cuts and introduce improvements in science teaching into schools more rapidly than if the country decided to write courses starting from scratch. The disadvantage of this adaptation procedure, as it has operated in practice, is that insufficient modifications and adaptations may be made. Examples that come to mind are the adaptation of the Nuffield 'O' Level courses in East Africa, and of Scottish Integrated Science in Malaysia. The latter is a particularly clear case of minimal adaptation of a foreign course. After three years of teaching the Scottish course very few changes have been made to the original.

The example of Iran, referred to in your article, should be closer to the ideal, once it gets off the ground. There is no question, as the writer implies, of exporting Nuffield Combined Science with its apparatus and equipment in entirety. The plan, worked out with the Iran Government, is to take a short cut by starting with Nuffield Combined Science and tailoring it as the trials proceed so that it becomes suitable for Iranian schools. This process of adaptation will be carried out by Iranian teachers together with an Adviser who is very well versed in Combined Science and who will be supported by other British science advisers in Iran. He has already paid two visits to Iran, and some leading Iranian teachers will shortly be coming to the UK for a training visit.

The course will be taught in about 25 schools for the first year. To be a proper trial, it is essential to have all the apparatus required for the course. The supply of this apparatus is part of the so-called 'package deal' mentioned by the 'national Sunday newspaper' referred to in your article. The writer should, however, have made himself aware of the whole story, rather than base his article on an already selective and therefore somewhat distorted account from a journalist.

It is hoped that the above account of the proposed science curriculum development project in Iran will put the sale of apparatus, only a part of the whole project, in its proper setting.

Biology Notes

With the advent of the new biology syllabuses there has come much greater emphasis on pupil microscope work. In particular it is now expected that microscopes will be regularly used by pupils from Secondary I upwards, whereas previously it was not unusual for microscopes to be used more or less exclusively by SIV and V pupils. In addition pupils now frequently examine temporary preparations made by themselves. These changes of emphasis require careful consideration to be given to the criteria used in selecting suitable instruments for pupil and teacher use at all levels of secondary education.

The need in the earlier years is for robust instruments which are easy to handle and which also resist, as far as possible, the attempts of our more unscrupulous pupils to dismantle or otherwise incapacitate them. Most important of all however, in our opinion, is that they should be optically sound. One frequently encounters that attitude that instruments for younger pupils do not need to be optically as good as those for more senior pupils. This seems to us to be a mistaken view since it is surely in the early stages of microscope work, when pupils are inexperienced and lack the knowledge to interpret images to the extent that senior pupils and teachers can, that well resolved and relatively aberration-free images are required. While we are adamant that good optical quality is wanted however, we stress that this does not imply great sophistication - rather the reverse; the less demanding the basic specifications of the instrument the more likely is it that satisfactory images will be achieved at a reasonable price. Further, the more sophisticated the instrument the less easy is it likely to be for young pupils to handle.

We believe that nearly all microscope work up to 'O' grade can to accomplished satisfactorily with an instrument magnifying no more than 200X, and that on the few occasions when greater resolution is required this can best be achieved with a teacher demonstration instrument. A maximum magnification of around 200X - preferably by using a 20X objective with a 10X eyepiece - leads to several advantages as follows:

1. The 20X objective has sufficient clearance from a focussed slide to minimise the risk of damage by hitting the slide, particularly if there is in addition a safety stop on the lower end of the focussing movement. Such a stop should not be easily adjustable by pupils - indeed there is much to be said for having a fixed stop.

2. A much larger field of view is seen through a 20X than through a 40X objective. Consequently there is less chance of young pupils 'losing' objects when moving slides.

3. The greater depth of focus of a 20X compared to a 40X objective eliminates the need for a fine focus mechanism.

4. A substage condenser is not required to illuminate a 20X objective satisfactorily. Instead, this can be achieved either with a bench lamp and concave mirror, or with a built-in illuminator and diffuse filter.

5. As a result of the above points instruments with no higher power objectives than 20X commonly cost little more than half the price of those carrying 40X objectives. This point is particularly important when it is realised that microscopes are usually required in significantly greater numbers for work up to 'O' grade than for 'H' grade and CSYS.

6. The greater the number of pupils using a microscope at any one time, the more likely is it to be damaged and the less easy is it to trace the culprit! Further, younger pupils are relatively inexperienced at handling microscopes and consequently more likely to damage them. Therefore it is probably best to choose relatively cheap, robust and unsophisticated instruments for use up to 'O' grade, and to restrict the use of more expensive and sophisticated types to the smaller numbers of more experienced pupils taking 'H' grade and CSYS.

Thus far we have considered only the upper end of resolution and magnification, but the lower end is probably equally important. We consider it very worthwhile for school microscopes to have a low power objective of between 3X and 5X magnification. This, together with a 10X eyepiece, provides a large field of view so that good 'plan' views of objects can be seen. In this way pupils can orientate a specimen and see clearly how tissues are distributed before plunging into the details of individual tissues under higher magnification. In our view, therefore, a suitable instrument for work up to 'O' grade would have a low power objective of about 4X and a high power one of 20X. It could also have an intermediate objective of 10X though in our experience this is not essential. It would have a 10X eyepiece which could be Huygenian or wide field, with or without a pointer. Widefield eyepieces, as the name implies, do give a wider field of view and many teachers feel that they are worth the extra £2-£3 over Huygenian types on this account. On the other hand we have known pupils to be distracted with some wide field types because the eye relief distance is so great that eye lashes can interfere with vision. Widefield eyepieces are often provided with a pointer; a simple way of making a pointer for a Huygenian eyepiece from thin wire is described in Bulletin 52. Further valuable features for junior work are the focussing safety stop mentioned under (1) above, and a fixed eyepiece to prevent accidents if the instrument should be tipped up.

Several instruments are now on the market with simplified magnification changing mechanisms, of which the most common are zoom systems. In these, magnification is continuously altered, and the specimen kept permanently in view, by rotating either the eyepiece or objective end of the body tube. Such systems have obvious advantages, but it must be said that in our experience those which fall in the school price range are markedly inferior optically to more conventional types.

For post- 'O' grade work greater resolution, and hence magnification, are required and in practice this means that instruments need high power objectives of about 40X. In turn this brings the need for a fine focussing mechanism and a substage condenser. There are two main schools of thought on the type of condenser required for such instruments. One point of view is that a simple condenser consisting of a single 'bulls eye' type of lens, usually fixed into the stage aperture, provides adequate illumination for 'H' grade work. Further, such a condenser is simple to operate, the only adjustments required being of the substage aperture disc associated with it. It is accepted that there is some loss of performance with the 40X objective but it is equally felt that such a loss is more than compensated for by the gains in time and convenience through simplicity of use, while such instruments are commonly about £15 cheaper than those with Abbe condensers.

The other point of view is that at this level it is necessary to have an instrument with a focussing Abbe condenser for the following reasons:

1. A 40X/0.65 objective cannot be adequately illuminated by a single lens condenser for reasons which were explained in some detail in Bulletin 46, but are now restated. To use the full resolving power of an objective it is necessary to fill the whole of its front aperture with light from the object in question. This can be done by almost any converging lens system providing that a wide enough beam of light is used. However, the wider the beam of light coming into the condenser the greater the area of the specimen which is illuminated. With single lens condensers, in order to fill a 40X/0.65 objective aperture a wide beam of light is needed and much of this light passes through parts of the specimen which are not in the field of view. This stray light is then scattered so that some of it enters the objective and reduces contrast in the image. An Abbe type condenser on the other hand can focus a narrow beam of more or less achromatic light onto a very restricted part of a specimen and yet still adequately fill the aperture of a 40X/0.65 objective. It will be appreciated that with well stained specimens - including most prepared slides - the differences in performance with the two types of condenser are less apparent because lack of contrast is not critical. However, with pupil-made preparations of, for example, chromosome squashes lack of contrast can be at least as critical as lack of resolution.

2. While a simple condenser can provide fair illumination under many circumstances for a 40X/0.65 objective, an Abbe type is essential for oil immersion objectives which will be used for demonstration and CSYS work.

3. The place of microprojection is discussed later in this article, when it is pointed out that a particularly useful facility is to be able to use the pupils' own microscopes to project an interesting specimen for the whole class to see. For such projection using a 40X/0.65 objective, an Abbe type condenser is essential.

4. Perhaps the most fundamental point is that of understanding the microscope. We have in the past stated our strong belief that items of equipment used in school science courses must be seen solely as means to ends, and not be allowed to become ends in themselves. Nevertheless the microscope is of such overwhelming important in all branches and at all levels of biology, as well as other subjects, that it is felt that senior pupils should have a good working understanding of the basic parts of the instrument. A focussing Abbe condenser must then be considered an essential part of the 'typical' compound microscope. In this connection rack-and-pinion focussing is preferable to the spiral type since it gives greater travel for the condenser, and hence greater versatility.

The optical combination which we would therefore recommend for senior pupil use is: 4X, 10X and 40X brightfield objectives; 10X eyepiece; focussing Abbe type condenser. As with the junior microscopes a stop on the bottom of the focussing movement is a worthwhile feature. If we wish pupils at this level to gain a working understanding of a compound microscope then the eyepiece should be removeable so that the substage aperture can be correctly adjusted. However, even at this level accidents have been known to happen to eyepieces and a useful feature is therefore a slit in the eyepiece tube which allows the tube to hold the eyepiece firmly and yet still allows the eyepiece to be withdrawn.

Another topic on which there is a sharp dichotomy of views concerns the use of mirrors or built-in lamps for illumination. The protagonists of built-in illumination point out that it is more convenient and time saving, because it eliminates the need to align mirror with lamp. Further, the instrument can readily be moved from one pupil to another without adversely affecting illumination. These are valid points, particularly with respect to younger pupils. Nevertheless we favour the use of mirror and external lamp for the following reasons:

1. Instruments with built-in illumination tie one to electrical outlets, whereas mirror models can be used with natural as well as artificial illumination.

2. The cables attendant on built-in illuminants can be troublesome when moving instruments. On two or three occasions in the writer's experience young pupils have swept glassware off benches in this way. Cables and plugs can also make storage in boxes inconvenient.

3. Substage lamps commonly increase the price of an instrument by £5-£6. Satisfactory bench lamps cost about £3, but these are required in any case, for light/dark behaviour experiments, illumination of dissections and fresh-water tanks, photosynthesis and phototropism work, etc.

4. 15-20W mains voltage illuminators do not provide adequate illumination for phase contrast optics, whereas a 100W, 250V pearl bulb in a bench lamp is adequate for most phase systems.

5. The use of pupil or teacher microscopes with compound condensers for microprojection is discussed later. Two sources of illumination are mentioned, one of which is directed vertically up through the foot of the instrument while the other is directed onto the optical axis by a mirror. In the former case the instrument must have an open foot, and mirror or lamp must be easily removeable. Many microscopes with built-in illumination have solid bases which rule out their use for projection in this way. The second projection method clearly requires mirror illumination.

6. If it is accepted that senior pupils should know how to focus an Abbe condenser correctly, it is difficult or impossible to do this with a built-in illuminant.

7. Perhaps the most important objection to built-in illuminants is that many of them heat specimens to a significantly greater extent than does an external lamp with mirror. This in turn poses problems with fresh preparations which tend to dry up rapidly, while living cells such as protozoa are adversely affected by the heat. We have investigated the effect of the two types of illumination on fresh protozoal preparations, and also measured the temperature at the stage aperture. Instruments carrying built-in illuminants can be broadly classified into two groups. The first group consists of those instruments which are designed primarily for use with built-in illumination. These tend to have solid bases which may or may not contain transformers for low voltage lamps; further they are usually more sophisticated types, suitable for senior pupil use. The second group contains almost equal numbers of junior and senior microscopes and consists of instruments designed primarily for mirror illumination, but in which the mirror can be replaced by a substage mains lamp. We have found that overheating is very much more of a problem with the latter type. Thus, in the tests which we carried out the stage aperture temperatures rose by only 1 or 2C° after 40 minutes, with various mirror models and an external 40W lamp. Two solid-base instruments - one with 6V lamp and one with mains lamp - gave similar rises. On the other hand, typical figures when using mains substage lamps on 'mirror model' stands were 8-20C°. Further, with the latter type of illumination we frequently found that the protozoa were visibly affected and the slides beginning to dry up within 10 minutes, and in every case such effects were noticeable long before similar effects were noted with the mirror models. Moreover the latter can be used with daylight which causes no overheating problems at all.

Another general topic which warrants mention is the question of the type of stand. The 'traditional' microscope has an open base - often described as 'horse-shoe'. A curved limb is hinged to the base and the body tube racks up and down on the limb. The limb, and hence the body tube, can be adjusted in angle to the base but this also inclines the stage. A more modern type of stand has a curved or angled limb which is fixed in position relative to the base, so that the stage is permanently horizontal. The upper part of the body tube is then permanently held at an angle of about 45°, the light path being suitably altered by the use of prisms in the optical head. The base of such instruments may be open or closed, the latter probably being the more common.

The advantages and disadvantages of the two types of stand are fairly obvious. Most people find it more comfortable to view with the body tube at an angle to the vertical. This can only be accomplished on the traditional upright type of stand by angling the stage; many people feel that this is a considerable disadvantage when working with fresh preparations, though we have not found this to be the case as long as the angle of inclination is not too great. On the other hand, the viewing height is fixed with angled head instruments, the smaller models of which can therefore be uncomfortable for taller pupils, and teachers.

A final general point concerns the method of focussing, which may be by movement of the stage or of the body tube. The former type has the advantage that the controls are low down and therefore probably more convenient to handle. On the other hand, some stage focussing instruments can be moved out of focus merely by pressure of the hands when moving a slide.

The second half of this article dealing with teacher demonstration microscopes and microprojectors will appear in the next Bulletin.

Chemistry Notes

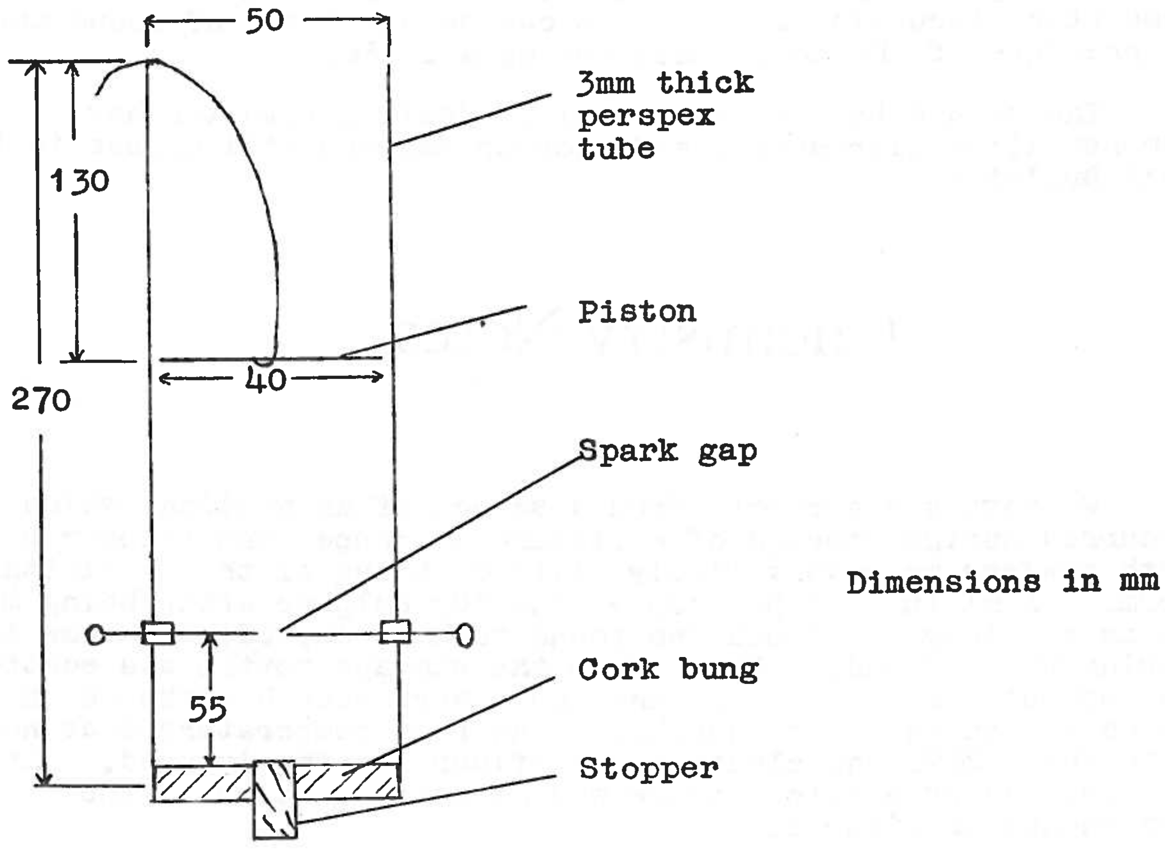
We have had a report from a school of an accident which occurred during storage of a mixture of copper and sulphur powder. Both powders were very finely divided, being of the precipitated form. A mixture of 50g copper and 20g sulphur after being made up on a Friday afternoon was found to have exploded at some time during the weekend. Glass from the storage bottle was scattered throughout the laboratory, and there were scorch marks on the bench and on the floor nearby. The room temperature does not rise above 21°C and electric underfloor heating is used. As far as could be ascertained there was no contamination of the components or mixture.

We have carried out tests on a mixture of 63g copper and 32g sulphur powders. As little as 0.1g of the mixture heated on asbestos tape in a bunsen flame gave a rapid reaction. 0.2g heated slowly in a test-tube reacted violently at 75°C. 9.5g of mixture left in a small vacuum flask showed a temperature rise of 1.5°C in 2½ hours. We refrained from trying this experiment with a larger quantity of the mixture.

We feel it necessary to state that because of the very small particle size of copper and sulphur powders the mixture of these is dangerous and on no account should a large quantity be made at one time. The mixture should be made up at the time of using and since 0.1g is sufficient to illustrate the combination of copper and sulphur then about 1.5g would be sufficient for one class. From the result of our tests it is evident that if a large bulk of the mixture is stored the temperature rise could reach 75°C at which we found rapid reaction taking place. It is probable that this is what happened during the weekend when the accident took place.

In The Workshop

The apparatus described here can be used to show explosion of mixtures of air and petrol, town gas, natural gas, liquified petroleum gas (propane or butane) or a combustible powder such as lycopodium. For ignition we used the spark generator described in Bulletin 49.



Perspex tube, available from Peter Plastics is convenient for showing the explosions, but the tube could be opaque and of metal; even a convenient size of tin can would do provided there were no inner projections at the top to impede movement of the piston. The dimensions given should not be exceeded, as for safety reasons the volume of the explosive mixture should be kept low. Two holes to take No. 9 rubber stoppers are drilled diametrically opposite each other 55mm up from the base. These stoppers carry lengths of 20 SWG nichrome wire which act as a spark plug, their points being 2-3mm apart. Their outer ends are turned in a loop to make it easy to attach crocodile clips from the spark generator.

The base is sealed with a cork bung, in which is a hole for a 15mm cork. If exploding powder or liquid fuel, this cork is kept in, whereas it is removed to allow the stem of a bunsen burner to be inserted when exploding gas. If a tin can is used, only the central hole for the cork need be taken out of the base. The piston is made of thin cardboard (postcard) and is held in position by a piece of wire looped over the upper edge of the tube. The whole apparatus is conveniently held in a clamp.

For petrol or other liquid fuels the piston is removed and 3-4 drops are squirted onto the wall of the tube towards the bottom, the piston replaced, and the spark generator switched on. For gases, the cork in the base is removed and the stem of a bunsen placed so that its top is level with the cork bung. With the air inlet of the burner closed the gas tap is turned on and off again quickly. Gas should have been passed through the burner prior to fitting it in position, to ensure that the tube is full of gas. The same process applies for natural gas and LPG burners. For solids the only powder which we have found to work is lycopodium, which is a pity since we would like to perform the experiment with some known powder of domestic or commercial application which would remove the element of magic which exists even in the name lycopodium. For the powder, the cork is replaced in the base and the piston is removed. About 1 cm^3 of the powder is sprinkled into the tube and allowed to settle, switching on the spark as the first of the powder reaches the spark gap. A reasonable puff is obtained, sufficient to show the explosive character of a finely divided combustible powder.

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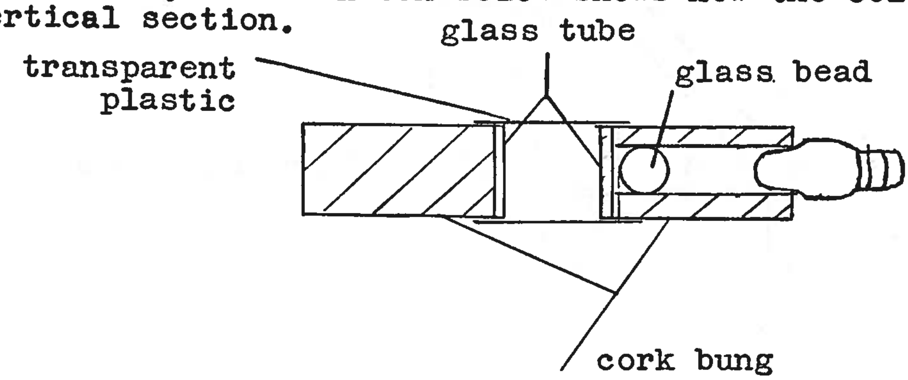
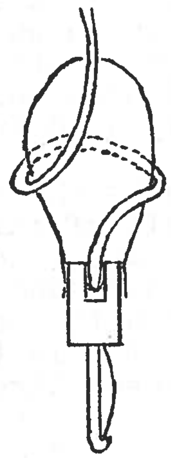
It was as far back as Bulletin 4 that a design for a smoke cell using a two-holed rubber stopper was published. A note from a lecturer who attended a teachers' in-service course in Mauritius says that they found difficulty in drilling a horizontal hole through the stopper, and so resorted to using a cork bung, making the vertical hole larger and inserting glass tubing to form the smoke cell. The sketch below shows how the cell looks in vertical section.



In Bulletin 59 we showed how leads to 4mm plugs could be reinforced by passing them through a hole in the plug so that when pulled the connection would not be stripped from the socket. In the Hirschmann type neoprene plug we brought the lead out through a hole in the side of the plug. A note from Wick High School shows how they have modified the design to allow the wire to leave the plug in the normal way. The sketch below should be self-explanatory.



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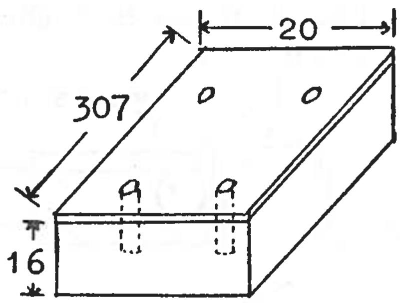
From Stranraer Academy comes a suggestion for avoiding a "spider's web" for connections when two or more components have to be wired in parallel. Briefly it is a connector block carrying three or four, four mm sockets, all of which are in electrical contact through a sheet of metal on the face of the block. Provided the plug penetrates to only half its depth, good connection is made between it and the aluminium sheet.

16 SWG aluminium sheet, cut to size is glued on to the wooden block, and 3-4 holes are drilled with a No. 22 twist drill through aluminium and wood to a depth of 10mm. This is the only dimension which is critical, as it allows the plugs to sink to half their depth, and others can be varied to suit the individual taste.



dimensions in mm

Trade News

In Bulletin 63 we thought we had explained how the merger between Griffin and George and A. Gallenkamp would affect the supply of their materials to educational institutions. We have since received the following note from the former firm. "Depending upon how one interprets the term 'further education' I believe your note could be misleading. Griffin and George will be supplying all Colleges as hitherto up to University and also such departments as Education, Physics, Building Science and Architecture in the Universities as well".

A note from a teacher informs us that the rubber belt on the W.B. Nicolson van de Graaff generator can be replaced by L81-282/005 from Griffin and George, if dusted with talc. Since the former firm have ceased trading, this information may be useful to all science departments which have the Nicolson generator.

A new Avo electronic multimeter, the EM272, is available from Elesco Fraser at £24.85. The fourteen current ranges extend from 1µA to 3A AC and DC; there are 20 voltage ranges from 10mV to 1kV AC and DC; and 5 resistance ranges allowing measurements from 1Ω to 40MΩ. The meter sensitivity is 316kΩ/V.

We have had a number of enquiries for a time switch suitable for incorporation in a light chamber for day-length control work. Such a switch, described as a 24 hour timer may be bought from Service Trading Co. for £2. The switching time can be adjusted anywhere in the range $\frac{1}{2}$ - 24 hours, and the switch contacts will carry up to 15A.

A. Christison have produced a semi-micro kit for organic preparations. The kit comprises 14 parts, with ground glass joints, and an 18 page instruction manual, and costs £12.43.

The sausage balloons which are used to make orbital models, and are obtainable from the Aberdeen Joke Factory will in future be supplied in units of 6 packs, each of 10 balloons, at a cost of £1 per unit, cash with order only.

A new type of electric burner, called the Horo Electroburner is available from Arnold R. Horwell at £12.50. The principle is to heat a stream of air issuing from the burner, and an air temperature of 700°C is claimed. We found it impossible to boil 800ml of water, but 250ml boiled in 12 minutes. The power rating of the burner is 500W.

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

Aberdeen Joke Factory, 170 George Street, Aberdeen.

Avo Ltd., Archcliffe Road, Dover, Kent.

A. Christison Ltd., Albany Road, East Gateshead Industrial Estate, Gateshead, NE8 3AT.

Elesco Fraser Ltd., 36 St. Vincent Crescent, Glasgow, C3.

A. Gallenkamp and Co. Ltd., P.O. Box 290, Technico House, Christopher Street, London EC2.

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

Arnold R. Horwell Ltd., 2 Grangeway, Kilburn High Road, London, NW6 2BP.

Peter Plastics Ltd., 234/6 Paisley Road, Glasgow, G51 1BT.

Service Trading Co. Ltd., 57 Bridgman Road, Chiswick, London, W4 5BB.