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ABSTRACT

This bulletin of the Scottish Schools Science Equipment Research Centre provides information to teachers on a variety of topics relating to the use of equipment in science instruction. An editorial opinion argues that science curricula developed in England should not be adopted unchanged in overseas countries (such as Iran), but should be carefully adapted and modified to suit national requirements. The section entitled "Physics Notes" describes two sets of apparatus for measuring moments of inertia and force on a conductor. The section dealing with biology outlines two techniques suitable for use in the classroom for determining the energy content of foods. One technique is recommended for student use, while the other is more suited to teacher demonstration. "Chemistry Notes" provide suggestions on the apparatus used for the preparation of producer gas, and "Trade News" give information on equipment available from supply houses together with a list of the names and addresses of the major supply companies. (JR)

SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 63. May, 1973.

Contents

Introduction

It is barely three years since Colin Weatherley joined the Centre as assistant director in charge of biology. During that time he has made many friends amongst Scottish biologists, and has established himself as an international authority on microscopes, a claim we can substantiate by pointing to the fact that the Japanese have been known to modify their designs as a result of his representations. His interests however have always been wider than the specialised field of apparatus. He is a member of the Joint Working Party of the Central Committee on Biology and the SCEEB which is examining the syllabus for Anatomy, Physiology and Health, and also a member of the CCB sub-committee preparing the syllabus for CSYS biology. In his spare time he also performs very competently on the guitar, and sings. As if this were not enough, his new job, to which he has been seconded from the Centre for a year, has little to do with any of these activities.

It began in a very small way when the SCEEB asked SSSERC if we could produce some form of raised diagram for the structured questions to be introduced into the Anatomy, Physiology and Health 'O' Grade examination, which could be felt and interpreted by blind children. These diagrams we produced, with braille lettering of the various parts, in plastic by a vacuum forming technique. In his thorough way, Colin decided that the only way to assess the usefulness of the diagrams was to use them in the teaching of the subject, and for over two years he has been teaching A.P. and H. to blind children, much of it in the evenings. Now money has been made available by the S.E.D. to enable him to follow up this work full time at the Royal Blind School in Edinburgh, to extend it to the presentation of blind candidates for O grade biology, and hopefully to lay the basis for teaching Integrated Science. All our readers who know Colin will join us in wishing him success in what is a worthwhile, and should be a very rewarding task.

Opinion

Is the rabbit indigenous to Iran? If not, then it may have been somewhat incongruous to have the managing director of one of our better known apparatus firms seated behind a rabbit skeleton gazing far-seeingly into the Middle East, where he had just sold £12m - who will ever persuade the commercial world that the correct symbol should be M? - of package deal apparatus, and featuring in the business news section of a national Sunday newspaper. This section of a newspaper is of course concerned with commercial success and failure, the hard sell, the world of tough competition, where the Latin tag of 'Buyer Beware' is the rule. This may be valid and indeed has long been acceptable when one is dealing in inanimate objects, bargaining say for the construction of a super tanker. Nor is the financial section of a paper the place to raise moral issues. But I am left with a niggling doubt that it is not enough when dealing with children's education, even, one might say, human lives. This is not to say that this aspect was not considered in the present instance. But, to quote from the article "it is the only time a country has made up its mind to buy a complete educational package on this scale, throwing out its previous text books and starting from scratch with the Nuffield Foundation Combined Science". I am tempted to add 'Thank God it is the only time' and I believe the Nuffield Combined Science team would echo the sentiment. I am reminded of Rousseau's reply to the monsieur who enthused over that author's Emile, and claimed that his own son had been brought up according to the principles expressed in the book - 'Tant pis pour vous, et surtout pour votre fils'!

The point at issue is simply that no educational scheme originating in England's green and pleasant land can be transplanted holus-bolus into Persia and succeed to the same extent as here; it may go better, it is more likely to go worse. It needs adaptation, modification, maybe throwing out whole chunks of it, as time goes on and it progresses through the schools, or we are in danger of perpetuating anomalies like obliging foreign candidates to know the floral formula for buttercups they have never seen. And as the faults of the Combined Science are found out, and with expensive apparatus already bought and delivered to the schools, there is going to be considerable pressure on those responsible for buying the Combined Science scheme to paper over the cracks. In these circumstances I think it not enough that the buyer should beware; the seller also should be aware of them.

It is, moreover, tackling things from the wrong end, though I doubt if the seller put this point to the Iranians. Having had some experience in the Far East, it seems to me very desirable that the national requirements of the society should come first, the curriculum second, and the apparatus last. In Thailand the teams preparing the biology, chemistry and physics curricula examined many educational schemes and borrowed parts from almost as many, but it is perhaps not without significance that the discipline which showed the greatest chance of success and aroused the greatest team spirit and enthusiasm was that which owed least to foreign influence and where many of the experiments were developed by the team members themselves.

Physics Notes

The idea for this apparatus came from Moray House College of Education. After the sixth year student has learned about moments of inertia, and that the kinetic energy of a rotating body is $\frac{1}{2}I\dot{\theta}^2$, this apparatus examines his ability to use that knowledge to predict how the available potential energy of a body rolling down an incline is distributed between rotational energy about its mass centre, and translational energy of the centre of gravity. The mathematics is taken out of the problem, and numeracy inserted, by providing a pair of similar objects with different dimensions and asking the student to predict which of the two will have the greater acceleration down the incline. The prediction is then tested by rolling both objects together, firstly with A behind B, then with B behind A. If the faster is in front, the pair will separate as they roll down, whereas if the faster be behind, they will stay together, with the rearward object pushing the forward one.

Suitable pairs of objects are solid metal cylinders having the same mass but with one shorter and broader than the other; a solid and hollow cylinder of the same external dimensions, and two spheres (ball bearings) of different diameter. In the case of the spheres a further parameter can be introduced by making a slot in the inclined plane so that they can either be rolled down the slope, or in the slot.

The inclined plane is formica on top of 19mm thick blockboard. The horizontal base length of the plane is 1 metre, and it is raised 130mm at one end, giving a $7\frac{1}{2}^{\circ}$ angle of inclination. Because of the 25mm wide slot near one side of the plane, a support of 10mm thick plywood is needed at top and bottom. The sides are 7mm thick plywood. Fig. 1 shows the high end elevation, and Fig. 2 the side elevation of the plane.

The two solid brass cylinders which have the same mass (about 480g) have the following dimensions: A - 50mm long, 38mm ($1\frac{1}{2}$") diameter; B - 28mm long, 50mm (2") diameter. The hollow cylinder which also pairs with A is taken from the same rod, with a 25mm hole drilled out centrally on the lathe. This has a mass of around 260g. The steel ball bearings are $1\frac{1}{2}$ and 2 inches diameter, and weigh about 225 and 535g respectively. These are available from the Skefko Ball Bearing Co. which has branches in the larger towns.

When the smaller sphere is rolling down the slot, its axis of rotation is proportionately nearer its centre of mass. The effect of this on the acceleration can be more effectively shown by reverting to the cylindrical shape, and making a wheel and axle which will roll down the slot. This is made from the same brass rod as A, to the dimensions given in Fig. 3. On the slope, it travels with nearly the same acceleration as A; in the slot it is obvious that it is accelerating much more slowly.

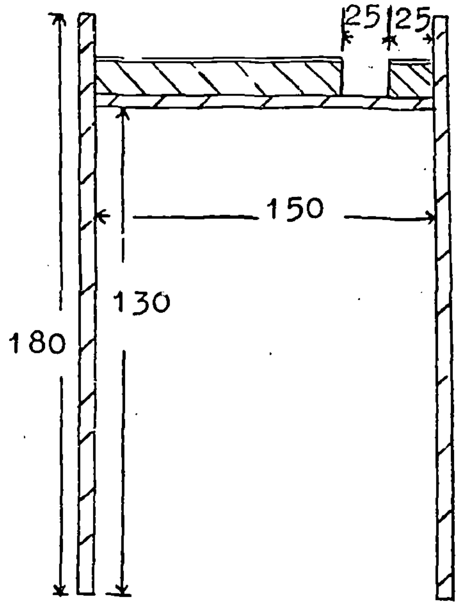


Fig. 1 High end elevation

All dimensions in mm.
Not to scale

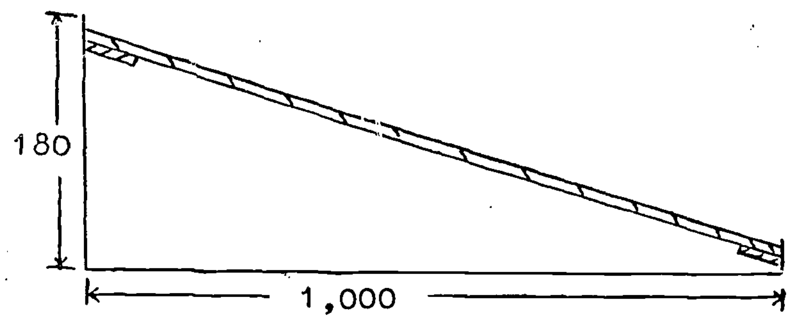


Fig. 2 Side elevation

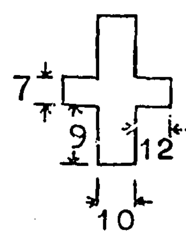


Fig. 3 Wheel and axle

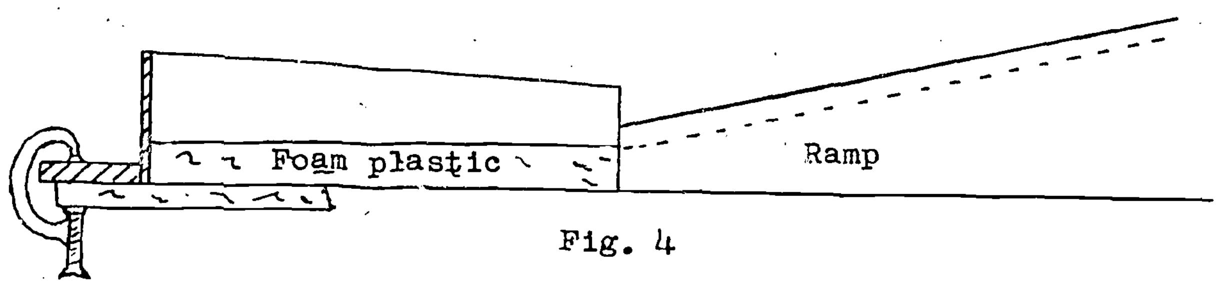


Fig. 4

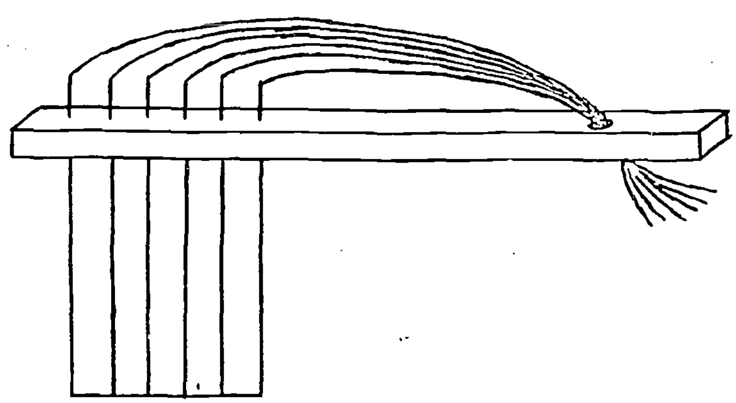
All dimensions in mm. Not to scale

A catcher tray (Fig. 4) for the objects as they roll off the ramp is desirable, and because of their momentum it is necessary to clamp it to the bench. A piece of thick foam plastic in the tray helps to deaden the sound, but it is still advisable in order to prevent deformation of the objects to remove them from the tray before one is rolled down and so prevent collisions.

* * * * *

A top pan balance with a 10mg sensitivity can be used as a force-on-a-conductor balance, provided, that is, that the students and the teacher are sufficiently clear as to the distinction between mass and force, and will accept that the balance will register comparative values of force even if these are counted in units of mass. Two magnadur magnets from the Westminster kit, fitted on the steel yoke from the same kit–have a mass about 130g and are placed on the balance pan. The wire framework which carries the current is soldered up as shown in the sketch from 16SWG copper wire, pushed through a wooden handle which can be held in a clamp so that the lower edge of the frame is horizontal and in the magnetic field. The vertical limbs of the frame are 10mm apart, and each is taken by flexible connector lead to 4mm terminals on a plug board. This arrangement allows current to be passed through different known lengths of wire, to investigate the dependence of force on length.

The remainder of the circuit consists of a low voltage supply, 0-12V, 0-5A ammeter and toggle on/off switch. If a continuously variable supply is not available then a battery of Nife cells in series with a 10Ω wirewound rheostat will serve equally well. With current switched on, the supply or rheostat is adjusted to give 1, 2, 3 etc. amperes of current, which is then repeated for 10, 20 ... 50mm length of wire. The change in balance reading to be expected is of the order of 30mg per ampere cm. This experiment was demonstrated on the <u>Oertling</u> stand at the A.S.E. meeting.



Biology Notes

We have had several discussions with teachers over the past year about the problems involved in investigating the energy content of food stuffs. One particular difficulty which has been mentioned is in using the Nuffield food calorimeter. Our investigations have produced the two techniques described below; we believe the former to be very suitable for pupil work and the latter for teacher demonstration. Both give satisfactory results for the comparative energy content for a variety of foods.

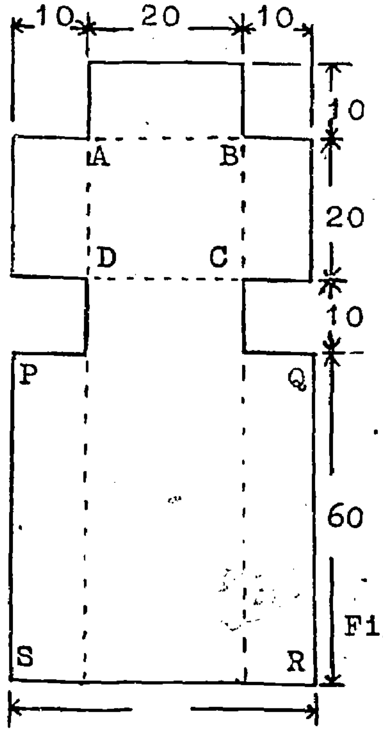


Fig. 1

Dimensions in mm.
Not to scale

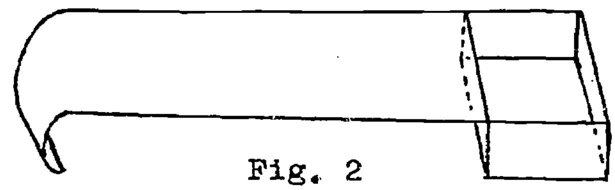


Fig. 2

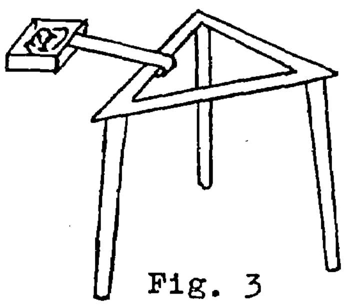


Fig. 3

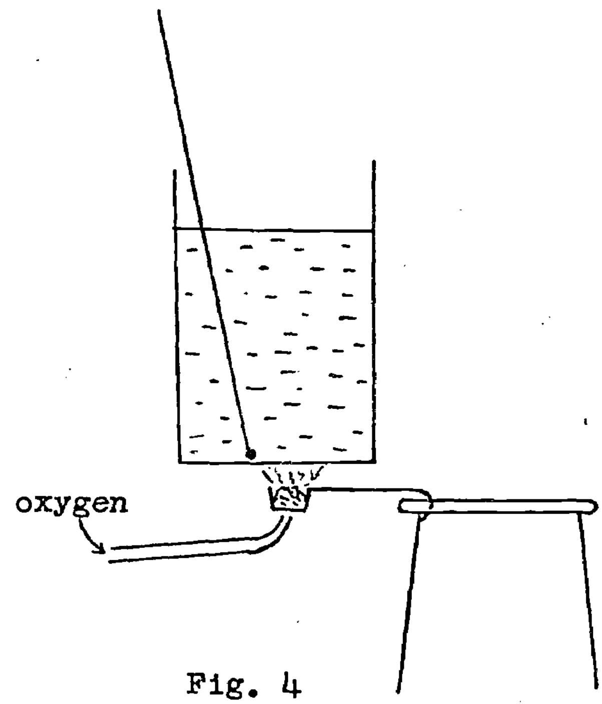


Fig. 4

Figs 1 to 3 show a basket made of bunsen gauze, in which we have burnt a range of common foods. Referring to Fig 1, ABCD shows the bottom of the basket, the gauze around it being bent up on all four sides. PQRS forms a handle, the long sides being folded along the dotted lines to form a flat double-thickness piece. This is hooked round one side of a tripod stand as in Fig 3. The procedure was to heat the food with a hot bunsen flame until it caught fire. This usually involved heating from below until the gauze was red hot. and then directing the bunsen flame onto the food from above. The bunsen was then removed, and the supply of air through the gauze was sufficient to burn a substantial proportion of the food.

The following foods burnt well in this way: sweet biscuit; peanut; dried bread; potato crisps; cheese; butter; dried mincemeat. No doubt there are several others which burn equally well. Interesting comparisons should be obtained if pupils test them in suitable pairs, e.g. bread and butter. Fatty foods such as cheese and butter are best placed on a small pad of Rocksil wool lying in the basket. The bread was dried by heating it in a metal tray over a bunsen flame. Table 1 shows the results of burning 0.5g of various foods by this method. Once the food had ignited, a 25mm boiling tube containing 10ml of water was held in the flame and the maximum temperature rise recorded.

Food (0.5g of each)	Temperature rise (C°)	Energy absorbed by water. (Joules per gram of food)	Quoted energy content (J/g)	% of quoted value
Biscuit	43	3600	23400	15
Peanut	62	5200	25330	21
Butter	71	5900	33480	18
Bread	30	2600	10220	25
Crisps	47	4000	Not known	-

Table 1 Energy content of various food stuffs.

The values in column 4 are quoted in the Nuffield Biology Year III Text, and have been converted from kilocalories per ounce!

After this relatively simple, pupil-scale work, it will probably be worthwhile to move on to teacher demonstration of a more sophisticated method in which heat losses from the system are reduced, and more complete burning is achieved by using oxygen. The apparatus is shown in Fig 4. 0.5g of each foodstuff was set alight as before with a hot bunsen flame and the retort stand moved to bring the tin can into position over the gauze. A gentle jet of oxygen was then played by hand onto the food to ensure that it burnt completely away. Some care is needed here; too strong an oxygen jet may result in burning steel from the gauze itself. The open nature of the gauze basket makes this a very straightforward procedure. If the can contains, say, 250 or 500ml of water, and if we ignore the heat absorbed by the can, calculations are again fairly simple. As can be seen from Table 2, the results show a marked improvement on the boiling tube method, and this could lead to a valuable discussion as to how various errors have been reduced. The method also works well for starch and olive oil.

We suggest that practical work need be taken no further than this, and that a brief discussion of the bomb calorimeter could if necessary round off the work. The principles involved in the bomb calorimeter are to our mind relatively easy for pupils to understand. On the other hand, even with the much less accurate Nuffield calorimeter, the practical procedure and calculation of results are in our opinion sufficiently complicated to prevent many pupils from fully understanding energy content and its measurement.

Those teachers who nevertheless wish to use a more sophisticated calorimeter will be interested in the results of some further work which we carried out. In this we compared the energy content of peanut and sweet biscuit, as measured by 6 different methods, as follows:

<u>Method 1</u> A 19mm test tube with 10ml water held over burning food.

<u>Method 2</u> As in 1, but using a 25mm boiling tube.

<u>Method 3</u> The tin can method, with 250ml water. Oxygen used to aid burning.

<u>Method 4</u> As in 3, but the tin can was wrapped in a layer of Rocksil.

<u>Method 5</u> Using a 'home-made' calorimeter similar to the Nuffield type.

<u>Method 6</u> The Nuffield food calorimeter.

Food \ Method	1	2	3	4	5	6
Peanut	3550	5200	11800	13200	17100	21100
Biscuit	2300	3600	9000	9100	12600	14900
Peanut / Biscuit	1.5	1.4	1.3	1.5	1.4	1.4

Table 2. Energy (J/g of food) absorbed from peanut and sweet biscuit as measured by 6 different methods.

It will be seen that whatever method was used, the ratio of energy absorbed from the two foods varied only between 1.3 and 1.5. Among further tests we carried out, were some in which the energy absorbed from peanut, biscuit, butter, bread, and crisps was measured by methods 2 and 3.

Food	Method 2 Boiling Tube	Method 3 Tin Can	Method 2 / Method 3
Peanut	5200	11800	2.3
Biscuit	3600	9000	2.5
Butter	5900	13400	2.3
Bread	2600	7500	2.9
Crisps	4000	9700	2.4

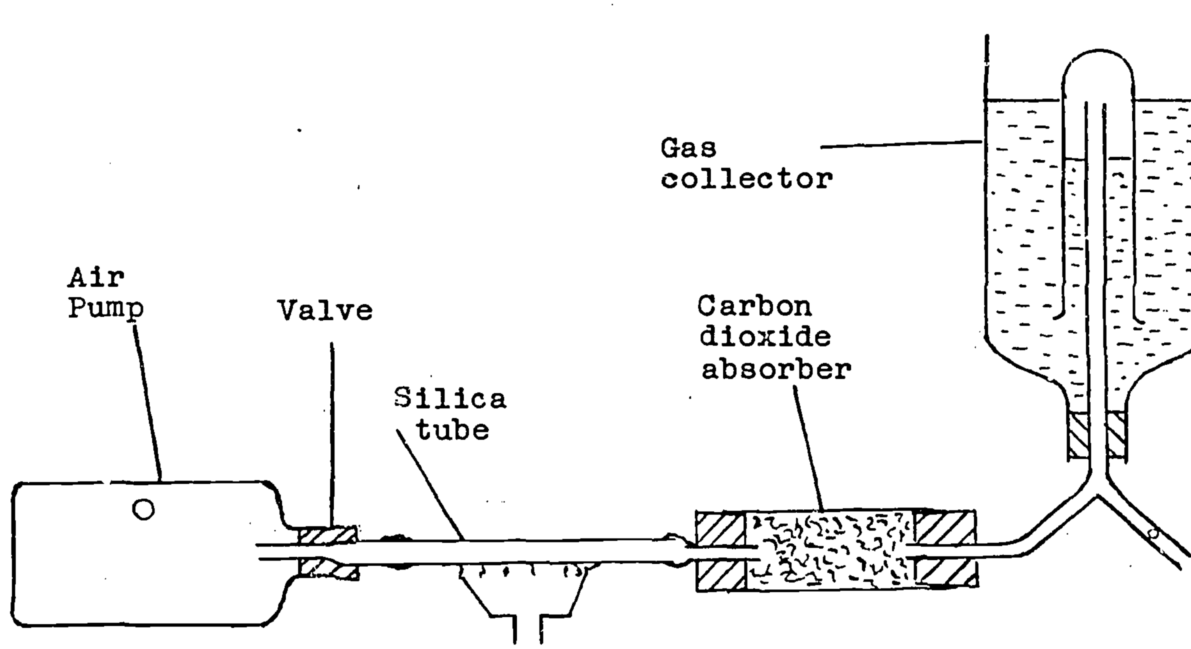
Table 3 Energy absorbed by boiling tube and the tin can methods.

Tables 2 clearly shows that the more sophisticated type of experiment does not produce more accurate relative values of energy content. Justification for the use of, e.g. the Nuffield calorimeter must therefore rest on the claim that pupils will be better able to appreciate the problems inherent in making accurate measurements. In our view this is not a strong claim since, as already stated, we feel that the marked contrast between the results obtained with the boiling tube and tin can methods provides all the necessary material for a full discussion of these problems, and of how they are overcome in the bomb calorimeter.

Chemistry Notes

By using small diameter and bore silica tubing as a combustion tube, it is possible to carry out experiments successfully which would not be possible when using larger 25mm bore glass or silica combustion tubes. With the latter heat dissipation is considerable but if silica tubing of external diameter 7.5mm and bore 5mm is used a higher temperature is attained because of the much lower heat dissipation during heating. This size of silica tube has application in a number of experiments including preparation of producer gas, water gas, reduction of oxides, burning of pyrites etc. There is no danger of cracking or breaking during heating or cooling; the tube when red hot can be plunged into cold water without suffering damage.

The preparation of producer gas is not usually a pupil experiment but the apparatus we used here is simple enough for this. The diagram shows a small bore silica combustion tube in use and the opportunity is taken of illustrating at the same time the use of the plastic bottle pump described in Bulletin 62 and the gas collector which was described in Bulletin 47.



The silica tubing should be at least 200mm long so that when red hot at the middle the ends do not get hot. The tube should be packed with small charcoal granules for a length of at least 60mm and contained in position by plugs of rocksil or asbestos wool.

It is worthwhile having a carbon dioxide absorber included. The absorber can be as shown or a filter tube can contain the absorbing material which may be soda lime or, as used by us, pumice granules moistened with 10% sodium hydroxide solution.

The gas collector normally has a bead valve in each tube which is joined to the 'Y' piece, but for this experiment the bead should be removed from the tube carrying the producer gas to the collector. The valve in the pump is essential here since the gas would pass back from the test-tube in the gas collector when the finger was not covering the hole.

The silica tube is heated as strongly as possible at the middle and after about 3 minutes the pump can be operated to give a slow flow of air through the hot carbon. The tube becomes red hot to a length of about 40mm and with an air flow of 15ml per minute there is quite complete conversion of the oxygen in the air to carbon monoxide. The gas is collected in a 150 x 25mm test-tube and the first two test-tubes of gas collected should be discarded; the third test-tube should contain a good sample of producer gas. To show burning of the gas the test is best done in subdued light to show the blue coloured flame. We found it possible to burn the gas at a small jet attached to the exit end of the carbon dioxide absorber when an aquarium aerator was used for air supply.

Material Fused silica tubing, translucent, Harris C2072/07, £1.20 per metre.

Trade News

Philip Harris have opened office and warehouse accommodation in East Kilbride, the address of which is given in the address list to this bulletin. All orders for Scottish Schools should be sent there, and a useful facility which the firm provide is a reversed call charge service by telephone. Anyone asking the operator for Freephone 836 will be connected to the East Kilbride office without charge, provided they are within a 100 mile radius of the office.

Following the merger between Griffin and George and A. Gallenkamp and Co. a division of the market has been agreed whereby the former will supply the schools market and the latter will concentrate on further education and industry. The practical significance of this to schools is that any Gallenkamp items can be ordered, quoting the Gallenkamp catalogue numbers, from Griffin and George at East Kilbride where they are now carrying stocks of Gallenkamp materials. Schools which order from Gallenkamp direct will have their orders sent to Griffin and George for processing. When their new catalogue is ready next year, Griffin will have incorporated in it those items in the Gallenkamp range which have found a market in the schools.

The wooden circuit boxes which we described in Bulletin 27 for mounting small electrical components, including the MR38P size of Japanese meter, are not now available from the firms specified there. Instead they may be obtained from Webster Products at a cost of £6 per 100, and should be described as 1 gang circuit box, 1½ inch deep.

Two items of equipment were displayed for the first time at the A.S.E. Scottish Branch annual meeting recently. One was a double beam oscilloscope from Tektroniks, (formerly Telequipment) which will sell to schools at a nett price of £99. It has several notable features; for instance there is an input-to-ground switch on both 'Y' channel amplifiers so that if the trace has disappeared it can quickly be brought into view. Also both 'Y' gain controls, and the time base speed control are switched, which means that the 'X' and 'Y' sensitivities are known at all times and it becomes an easy matter to determine the amplitude of signal or the duration time of the trace. Finally when the time base is switched off, the Y_2 signal with its amplifier are automatically switched to the 'X' plate thus providing instant Lissajou figures. Anyone who has struggled with input signal and 'X' gain control to produce a Lissajou figure of acceptable aspect ratio will welcome the ease with which the trace can be controlled in both directions through the use of the amplifier controls.

The other piece of apparatus has taken three years to develop, having been shown in the members' exhibition by a lecturer from Jordanhill College of Education at the A.S.E. meeting in Edinburgh in 1970. It is a circular motion air bearing by Griffin and George. The bearing and control unit will cost £40, but the accessories necessary to teach such principles as the parameters affecting centripetal force, moment of inertia, and angular momentum bring the cost up to £87.50. Other accessories not specifically required for our CSYS course are available for such purposes as converting the system to an orrery. A prototype apparatus was shown at the exhibition; delivery has been promised for August. In the Centre we have been promised a model for examination and display which should have arrived by the time this bulletin appears in print. An associated item of apparatus, which has no dependence on the air bearing, but is the circular analogue of the collisions between two vehicles on the linear air track, and consists of two bars rotating independently about a common centre, was also shown, costing £23.

In Bulletin 62 we omitted to give the address of A.W. Young, the suppliers of photographic paper. This address is now given at the end of this bulletin.

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

A. Gallenkamp and Co. Ltd., Portrack Lane, Stockton-on-Tees,
Teeside, TS18 2PT.

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

Philip Harris Ltd., 30 Carron Place, Kelvin Industrial Estate,
East Kilbride.

L. Oertling Ltd., Cray Valley Works, St. Mary Cray, Orpington,
Kent, BR5 2HA.

Skefco Ball Bearing Co. Ltd., 117 George Street, Edinburgh,
EH2 4JN.

Tektronik UK Ltd., Beaverton House, P.O. Box 69, Harpenden,
Herts.

Webster Products (Chiswick) Ltd., 192 Chiswick High Road,
London, W4 1PP.

A.W. Young, 159 Chatsworth Road, Clapton, London, E5 OLB.