SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 96.   April, 1977.

Contents

Introduction

Perhaps in reflection of the times, this bulletin contains much
about safety. Our Governing Body at a recent meeting has given
its blessing to the principle that SSSERC should be more invol-
ved in safety matters as they affect schools. The more one
becomes involved with the Health and Safety Executive, the more
one comes to realise that their function is purely negative:
they will tell you when you are doing wrong but not how to put
it right. Presumably this is because if they gave positive
advice it might boomerang back at them through a civil action for
damages following an accident. Hence the teacher or science
adviser must seek help elsewhere, and while we do not yet have a
full knowledge of safety problems in schools, we do have as much
and perhaps more expertise for their solution than the teacher
himself.

We are also concerned that the Health and Safety at Work Act
may not be being implemented to its full extent. Where it lays
down that it is the employer's duty 'to prepare a written state-
ment of general policy with respect to the health and safety at
work of his employees and the organisation and arrangements for
the time being in force for carrying out that policy', we believe
that in many regions only the first part of the mandate has been
fulfilled. We also deprecate that teachers and advisers are
taking individual, unco-ordinated action, e.g. drawing up lists
of prohibited chemicals so that a substance which is permitted
in one school may be banned in another. It is not difficult to
see how this would weaken the case of anyone defending a civil
action where one of these doubtful chemicals was involved. Even
were it not so, prosecuting lawyers could use differences in
safety practice between regions as a means of discrediting the
defence or questioning the competence of the defenders to prepare
and implement an adequate safety policy.

We would like to see a safety policy for schools which is
applied nationally and we will do all we can to bring this about
in areas which are within our remit, through consultation and
discussion with science advisers and teachers. We are in a real
sense the employees of each local authority, and there is there-
fore no legal obstacle to any local authority's making all or
parts of our advice mandatory for its schools. We are prepared
to take responsibility for our advice; we are certainly prepared
to say "the safety buck stops here". We therefore invite any
science adviser, teacher or technician who has a problem on
safety to contact us.

There are two areas in which we hope to act fairly quickly.
We have referred on numerous occasions to our manual of hazardous
chemicals. This lays stress on prevention rather than cure, so
that it gives detailed instructions on how to handle, store and
dispose of dangerous chemicals, before going on to the treatment
of accidents. It can therefore, and we hope it will become
part of the local authority's 'organisation and arrangements for
the time being in force for carrying out their safety policy'.
Copies of the manual will shortly be sent to every regional auth-
ority with the invitation that they reproduce it for use in their
schools. Now that this document is at last going to reach those
for whom it was intended, we would like to pay tribute to the

small group who did all the laborious donkey work of checking the facts for every chemical on the list. It is doubtful if any of them will read this, as they have almost to a man either retired or been promoted out of active science teaching, so long has it been since the work was done.

Our other immediate concern is for pupils and teachers doing experiments in microbiology. We point to some of the risks involved in Bulletins 89 and 90. We now intend to go further and prepare a paper giving advice on safe procedures in microbiology. This will be published in the bulletin, but we will also send copies to Home Economics, Physical Education and Primary Schools advisers in the regions. We hope that the material would be distributed to any school which is likely to undertake microbiological work, as we feel that there is at present a very real risk of pathological organisms being cultivated to infective levels, and that bad techniques may allow the participants to become infected.

Chemistry Notes

Teachers who learned several weeks ago through the media of a mercury hazard in which a classful of children were rushed to hospital may wish to know the details of what occurred. It seems that the marker in a max/min thermometer had stuck and it was suggested that gentle heat might move it so that it was placed in an oven. However, the oven setting had been too high and the thermometer burst, revealing the accident by the smell of vapourised alcohol.

The school attempted to contact the science adviser but he was absent (attending a course on safety!), so the local fire brigade was called. They decided they were unable or inexperienced to deal with the hazard and contacted their regional headquarters. Somewhere in this line of communication the message became garbled, so that it was thought a tank of mercury had been spilled in the hot oven. This resulted in the panic which reached the journalists. As far as we have been able to ascertain, at no time were any of the children at hazard.

In such a situation it is worth remembering that when the oven door is opened the mercury will rapidly cool to room temperature and condense on any available surface. The maximum concentration that will be inhaled will be that produced by mercury at its saturated vapour pressure, and it is worth while making (or having the SYS do it) the calculation of how this relates to the Threshold Limiting Value of 50 $\mu g/m^3$. Bear in mind also that the T.L.V. is the acceptable concentration in an industrial atmosphere which may persist during the working life of the persons involved.

Another mercury scare may have been started by what we would regard as an irresponsible article in the Times Educational Supplement of 4/3/77, entitled "Mercury - one lab in three polluted?". We will not attempt to deal here with the speculations of the report but instead will give a summary of what knowledge we have at present regarding the mercury hazard. Much of what follows is taken from the Department of the Environment's booklet 'Environmental Mercury

and Man' published 1976 by H.M.S.O., price £1.40.

Mercury is present in trace quantities in all parts of the environment. Due to volcanic action and weathering of the earth's crust, up to about 150,000 tonnes are released annually to air and to rain, freshwaters and the seas. Man's annual use of mercury amounts to about 9,000 tonnes so that compared with natural action man's contribution to polluting the environment is negligible except where it may produce high local concentrations.

Food is the major source of exposure to mercury for most people. The average dietary intake in the U.K. totals 5 - 10 μg daily, of which 2 - 5 μg may be in the form of organic mercury compounds. This is well within the provisional tolerable intake of 300 μg weekly, of which not more than 200 μg should be of organic mercury, set by F.A.O. and W.H.O. Fish is the most important item of our normal diet in relation to organic mercury intake. This is because natural processes occurring in sediments can convert all forms of mercury into methyl-mercury compounds which are readily transported and accumulated through the aquatic food chain to edible fish. Nevertheless in the U.K. it would require a 70 kg adult to consume 12.5 kg of fish daily for a period of three months to reach the borderline between toxic and non-toxic body burden. In the case of continuous daily consumption, slightly less than 1 kg of fish per day would produce a steady-state body burden, where up-take and excretion are in balance, which would still be harmless. We give these facts because it is too often assumed that mercury intoxication is cumulative and permanent, whereas in fact the removal of the source of contamination even in cases showing clinical symptoms will result in a cure.

Eating contaminated food has been the source of all major incidences of mercury poisoning. Many readers will be aware of the Japanese incidents where it has been estimated that the aver-age daily intake of organic mercury over a period of several months was about 30 μg per kilogram of body weight. In Iraq, persons eating bread made from grain contaminated by a seed dressing con-taining organic mercury had a daily intake of up to 88 μg per kilogram of body weight, and in an incident in New Mexico where pigs which had been fed on treated grain were the cause, the daily intake was in the range 50 - 60 μg per kg of body weight.

Few cases of poisoning by elemental mercury or inorganic mercury compounds are known. Poisoning by mercury when it occurs as a result of employment is a condition notifiable to the Health and Safety Executive. Over the last 50 years the annual number of cases notified in the U.K. has varied between none and six. One death is claimed in the U.K., that of a dental assistant where the symptoms were not recognised. An autopsy showed a concentration of mercury in the kidney a hundred times that of three controls with no abnormal mercury contact. On the other hand, urine analysis shows that there are many cases of high mercury concent-ration that are not notified because the clinical symptoms are not sufficiently developed to warrant them being defined as mercury poisoning.

The danger from swallowing liquid mercury is negligible. Goldwater (1) claims 'that one could swallow a pound of quicksilver without adverse effect.' Evidence indicates that less than 0.01% of elemental mercury in the alimentary tract is absorbed, and over 99.9% of it is excreted within a few days. Hence a child who

crunches on a clinical thermometer is more at risk from the broken
glass than from the mercury. Inorganic mercury salts are absorbed
to a greater extent; in human volunteers 15% of a dose administered
by mouth was absorbed. Of organic mercury compounds, methyl
mercury given in small quantities is almost completely absorbed
from the gastro-intestinal tract. Of mercury vapour entering the
lungs, up to 80% may be absorbed.

After absorption, all forms of mercury are slowly converted
to the inorganic mercuric form. Mercuric mercury forms soluble
compounds with blood, and becomes widely distributed in tissues,
the greatest accumulation occurring in the kidney and liver. Mer-
cury compounds have a high affinity for sulphydryl groups, pre-
dominently found in proteins and they are therefore potent, non-
specific enzyme poisons. Mercury is excreted in the mercuric form,
mainly in urine and faeces but some is excreted in sweat and
saliva. Of all forms of mercury intake, methyl mercury is slowest
to be converted to the inorganic mercuric form, and it is estimated
that the half life of methyl mercury in the body is 70 - 80 days.
We give these facts to emphasise that as far as is known mercury
is not a cumulative poison, and that when the subject is removed
from the source of contamination, recovery occurs.

There is also no evidence to show that children are specially
at risk of developing mercury poisoning. Those who claim that
children are more susceptible, and therefore that a lower safety
level should be set in school than for industrial workers, usually
base their arguments on similarities between lead and mercury.
A study in the U.S.A. has shown that children in a lead contam-
inated environment significantly improved their I.Q. when the
contamination was removed. Goldwater (2) writes that 'heavy
metals such as mercury and lead produce their chronic harmful
effects through what is known as cumulative action. This means
that over a period of time the material which is absorbed is only
partially excreted and that increasing amounts accumulate in the
body'. On the other hand he also says (loc. cit.) 'that because
of the paucity of toxicological information on many chemical
compounds there frequently is a tendency to assume that compounds
which are closely related chemically will have similar toxic
properties. While this may be true for a limited number of sub-
stances it is by no means universally true'.

Our tolerance to toxic vapour is nowadays expressed as a
Threshold Limiting Value (T.L.V.). This is defined (3) as follows;
'Threshold limit values refer to airborne concentrations and re-
present conditions under which it is believed that nearly all
workers may be repeatedly exposed day after day without adverse
effect ... T.L.V.s refer to time-weighted concentrations for a
7 or 8-hour workday and 40-hour workweek. They should be used
as guides in the control of health hazards and should not be used
as fine lines between dangerous and safe concentrations'.

The T.L.V. as a guide to safe working conditions obviously
applies more to teachers and technicians, who may be continually
exposed to mercury vapour, than to children who are in laboratories
and other areas of contamination for a minor part of their working
week. Both, however, can be at risk from acute poisoning as a
result of exposure to a single massive dose, or to multiple
exposures over a short period. To cater for this situation, T.L.V.s
are allocated an excursion factor, which is the factor by which the
T.L.V. may be multiplied to give the maximum allowable concentration

which should not be exceeded even for short periods. In cases
where not enough is known of the toxicology of the chemical, an
excursion factor of 3 is allowed, and this applies in the case
of mercury. This means that at no time should the mercury vapour
concentration exceed 150 µg/m³, although it is known that exposures
to concentrations in excess of this have occurred without apparent
harmful effects. On the other hand acute poisoning has been known
to occur on rare occasions in the industrial setting following
inhalation of air with mercury concentrations around 1.2 mg/m³.

Those who mutter darkly about mercury in floorboards perman-
ently polluting the air can be seen to be both having their cake
and breathing it. Taking a normal school laboratory of 500 m³
capacity and a ventilation rate of 5 air changes per hour, it
would require annually the evaporation of over a kilogram of mer-
cury to maintain the vapour concentration at the T.L.V. of 50 µg/m³.
5 air changes per hour is the lower limit of ventilation rate
recommended for laboratories in BS3202, Recommendations on Lab-
oratory Furniture and Fittings, but nonetheless there may be many
school labs less well ventilated. If one accepts (4) that a fresh
air supply of 10 ft³ per person per minute is necessary to prevent
body odours becoming perceptible to people who come newly into
the room, then this ventilation rate would require an annual evapo-
ration of 150 g of mercury per laboratory to maintain the T.L.V.
in a lab accommodating 20 pupils and a teacher.

Mercury is a hazardous substance playing no known role in
human biochemistry or physiology, and it is desirable that the
total intake from all sources should be kept as low as possible.
Working with mercury should be done over a spillage tray, and all
containers with mercury should be kept in a spillage tray. Dis-
posable polythene gloves should be worn whenever possible to pre-
vent particulate mercury lodging under fingernails whence it may
be slowly absorbed by the skin. Any spillages to bench or floor
should be treated as they occur by recovering as much of the mer-
cury as possible. A squeeze bulb attached to a short length of
glass tubing narrowed to a point at one end will take up larger
globules, and the pad type of mercury collector (Griffin and George
M6H-400-W, £1.50) will lift the smaller particles. Inaccessible
mercury between floorboards should be treated with zinc dust, with
which it forms a non-volatile amalgam. The floor or bench area
affected should be covered with a slurry made of approximately
equal quantities of sulphur and calcium hydroxide (lime sulphur)
in water, left for a few hours and then swept up.

A technician or other individual should be appointed to
record any spillage, including those from broken thermometers,
occurring in the school. The facts to be recorded would be the
time and place, and an estimate of the amount of mercury lost.
Thermometers rarely have more than 5 g of the metal, and this could
be used as a round figure for a broken thermometer where none of the
mercury has been recovered. The same individual should make an
annual check of the mercury stock in the science department by
weighing it, thereafter recording how much is kept in various
locations. A comparison between one year's figures and the next
is useful in assessing whether there are any high risk areas in the
school, and a record will be invaluable if mercury has been dis-
turbed as a result of vandalism, something which is becoming more
common. Particular care should be taken to assess the amount of
mercury loss occurring in badly ventilated areas such as storerooms,
workshop or preparation rooms. If the mercury stock is monitored

in the manner described above, if spillages are treated immediately and the room well ventilated for a period of time thereafter, then no teacher, technician or pupil will be at risk from mercury contamination.

If a fresh spillage occurs or if as a result of past contamination a teacher has reason to suspect that some part of the school may have a high concentration of mercury vapour, he may obtain from SSSERC a Dräger Normalair pump and two sample tubes which will allow him to measure the vapour concentration for himself. Instructions for making this determination are supplied with the apparatus. We make a nominal charge of £1 for the service and the school will also have to pay return postage for the pump and any unused tubes. We do not intend this to be used for routine testing; unless the science department has a history extending back several years of ordering quantities of mercury to maintain its stock, we do not believe that those using the premises are at risk. Instead, we believe the service may be of use in coping with an emergency where a teacher may wish to know whether to prohibit the use of a room following a spillage until it has been adequately ventilated.

(1) Goldwater, L.J., 1971, Scientific American, 224, 15.
(2) Goldwater, L.J., 1968, Dangerous Properties of Industrial Materials, (edit. N. Irving Sax), Reinhold Book Corporation, p.7.
(3) Technical Data Note 2/75, 1976, Threshold Limit Values for 1976, Health and Safety Executive, p.3.
(4) Technical Data Note 19, 1976, The Ventilation of Buildings, Health and Safety Executive, p.5.

Biology Notes

In Bulletin 78 we described apparatus which could be used for the estimation of dissolved oxygen content of water samples. We have received details of a simpler method, which dispenses with the need for a syringe valve. This apparatus originated in Inverurie Academy and a description has already appeared in the Aberdeen College of Education 'Biology Newsletter' No 27, May 1976.

The apparatus and methods to be described are essentially the same as those in the 'Newsletter' article but we have made a number of small changes to the apparatus in the light of the results of our own field trials. The main item in the apparatus is a 50 ml disposable syringe fitted with a suba-seal stopper. This syringe is used to take up the sample and prevents contact with air and subsequent changes in oxygen content. Various types of syringe and different methods of fitting the stopper can be used - see diagram below.

A glass marble is used to assist mixing of the sample during titration and allowance must be made for its effect on the sample volume, which in this method is only 25 ml. The 50 ml samples used previously meant that when water samples of high oxygen content were used, the addition of the reagents brought the syringe plunger dangerously near to the end of its travel. Recalibration of the syringe to allow for the volume of the marble is straightforward. The piston of the syringe is removed and the barrel

held upright, nozzle down, with a finger over the nozzle. The
barrel is filled with water up to the 25 ml mark. The marble is
added and a mark made at the new level. Plastic tape was wrapped
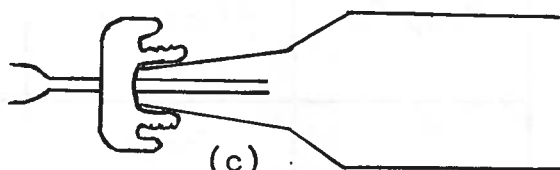around the syringe to mark this corrected level.
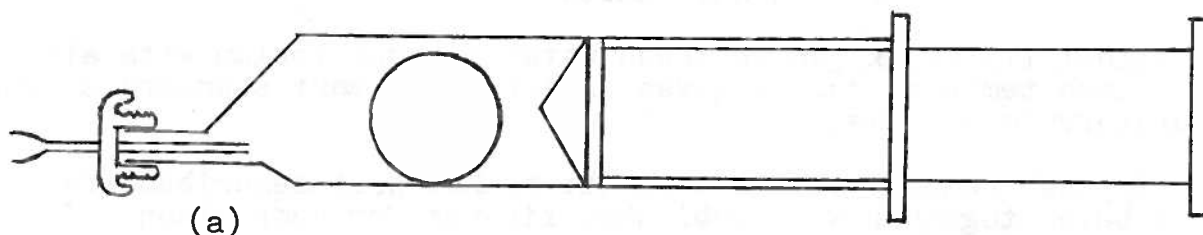
(a)

Diagrams not to scale.

20 mm
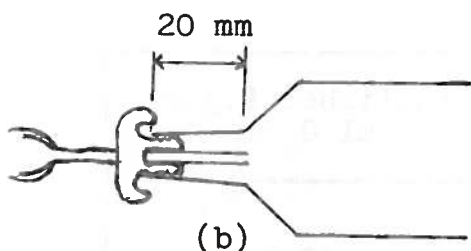
(b)

(c)

a) Luer fitting type of syringe with No.9 suba-seal over the nozzle.
b) Bladder syringe with nozzle cut back and No.9 suba-seal inside
   the nozzle.
c) Bladder syringe with nozzle and No.24 suba-seal over the end.

   The analysis itself is rapid and can be performed easily by
one person. The first step is to obtain a sample of the water
to be tested. The marble prevents full travel of the syringe
piston, so that if a full sample were immediately taken up it would
be mixed with air present in the syringe. To avoid this source
of error, initially enough water should be taken up to cover the
marble adequately. The syringe is then held nozzle upwards
and all air expelled. It is then filled with water to well be-
yond the mark and again held nozzle upwards for expulsion of any
remaining air bubbles as the piston is returned to the mark.
Obviously, which point on the piston is to come opposite the mark
is something which should be decided on when the syringe is re-
calibrated. Operatives should be informed which arrangement has
been used. The syringe is then sealed with a suba-seal stopper
with a hypodermic needle inserted in its centre.

   Using a 2 ml syringe inserted into the Luer fitting of the
needle, inject 2 ml of Fehling's B solution into the sample. Re-
move the 2 ml syringe with one hand, holding the needle head in
the fingers of the other hand. Thus the needle remains in place
in the stopper and wear of the stopper (as well as the risk of
self injection!) will be much reduced. In the same way, but using
a 1 ml syringe add 0.25 ml of phenosafranine solution (0.5 g/l).
While gently rocking the syringe, carefully add the iron(II)
solution through the suba-seal with a 10 ml syringe until the
sample goes colourless. If the recipes given below are used,
then the number of ml of iron (II) solution required to decolour-
ise the dye is equal to the number of ml of oxygen per litre of
water sample. If required the figure can be converted to p.p.m.
by weight by converting the volume of oxygen per litre to volume
at S.T.P. and multiplying by 1.43 (the approximate weight in mg
of 1 ml of oxygen). Figures can be converted to % saturation

using the formula

$$\% \text{ saturation} = \frac{\text{oxygen concentration* x 100}}{\text{solubility*}}$$

(* in same units)

The solubility of oxygen in fresh water in equilibrium with air at various temperatures is given in tables in most standard science laboratory data books.

Typical results obtained by the method just described are shown below together with published figures for comparison. The analyses were carried out on water in equilibrium with the air at the temperature shown.

Temp ^{O}C	Titre, ml	Mean	Published figure ml O_2/1
0	11.5 11.0 11.0	11.2	10.2
10	9.0 8.5 8.5	8.7	7.9
24	6.5 6.5 6.5	6.5	-
30	5.5 6.0 6.2	5.9	5.3

A source of error lies in the use of a 10 ml syringe to inject the titrant. Most 10 ml syringes are only marked at 1 ml intervals and results given as 11.5 or 11.2 ml etc. are only estimates. Happily, for those interested in greater precision, it is a simple matter to substitute a 1 ml syringe filled with titrant as the end-point is neared. In our experience the most important advantages of the method are its rapidity and the ease with which one person can handle the apparatus.

The 50 ml syringe should be regularly lubricated to keep it free moving. Since there is always the possibility of some liquid spurting from the syringe when the connection is broken, this operation should be performed with care. The Fehling's B will be greatly diluted by the water sample, but the mixture is still highly alkaline and somewhat caustic. We made up a field kit with reagent bottles and syringes etc. held in Terry clips in a small wooden box. This proved very convenient in the field work we carried out when validating the apparatus. Useful tips which emerged from this work include putting clear 'Fablon' or other waterproof film over the syringe markings so they are not scratched off, and arrangement of reagents and the correct size of syringe in the box in the same linear sequence as the sequence of use in the

determination. Other refinements are a set of instructions in
the box and an international hazard warning symbol for a corrosive
or caustic chemical on the Fehling's B bottle.

Materials.

Iron (II) solution. Either,
(a) Iron (II) sulphate. Dissolve 1.24 g of Analar hydrated
iron (II) sulphate in a few ml of 1% sulphuric acid and make up
to a litre with deionised water.
or,
(b) Ammonium iron (II) sulphate. As above using 1.75 g Analar
hydrated ammonium iron (II) sulphate per litre. This latter is
preferable because it does not oxidise so readily in storage.

The quantities given above do not tally with those in Bulletin 78
for the 50 ml sample method which were based on information given
in Nuffield Advanced Level Biology Trial materials. The figure of
2.48 g/l for iron (II) sulphate given in Biology by Enquiry, Teac-
hers' Guide 2 is more correct and gives a figure of 3.5 g/l for
ammonium iron (II) sulphate. The concentrations given above for
the 25 ml sample method are half those used for the method given
in Bulletin 78.

50 ml syringes. The syringe used by Inverurie Academy is a B.D.
Plastipak 50 ml bladder syringe supplied by Allardyce and other
surgical suppliers. The syringe used in our apparatus was a
50 ml 'Steriseal' syringe with a Luer fitting from A.R. Horwell.

Hazard symbols. Self adhesive hazard warning labels are available
from Philip Harris cat. no. S2416/20, £1.00 per 4 sheets, each
sheet having 24 assorted hazard labels.

Physics Notes

The R.S. Components waveform generator, 305-844 can readily be made
a very low frequency sine wave generator to show phase lead and lag
in reactive circuits using moving coil centre zero meters as indi-
cators. At £3.66 the price is well below the mechanical version,
which is RT1 by White Electrical Instruments, although it has not
got the simplicity of the hand-cranked generator and must remain a
black box. It has the advantage of versatility however, providing
triangular i.e. $\wedge\wedge$ and square wave voltage outputs as well as
sine wave.

The makers claim a lower frequency limit of 1 mHz, but we
were content to operate at $\frac{1}{2}$ - 1 Hz for meter indication, and 70 -
100 Hz on oscilloscope. The basic circuit is shown in Fig. 1.
A split or centre-tapped voltage supply is needed if centre zero
meters are to be used, as only then are the outputs symmetrical
with respect to the centre tap. Another point to be borne in
mind is that while the peak to peak voltage available for square
wave is almost the full supply voltage, peak to peak for sine
and triangular waveforms are only half this value. The circuit
works well when driven by two 9 V dry batteries, e.g. PP7.

To show current and voltage waveforms on a reactive component,
either the circuit of Fig. 2a or 2b was used. 2a operates at
around 1 Hz and is suitable for meter indication; 2b can be used
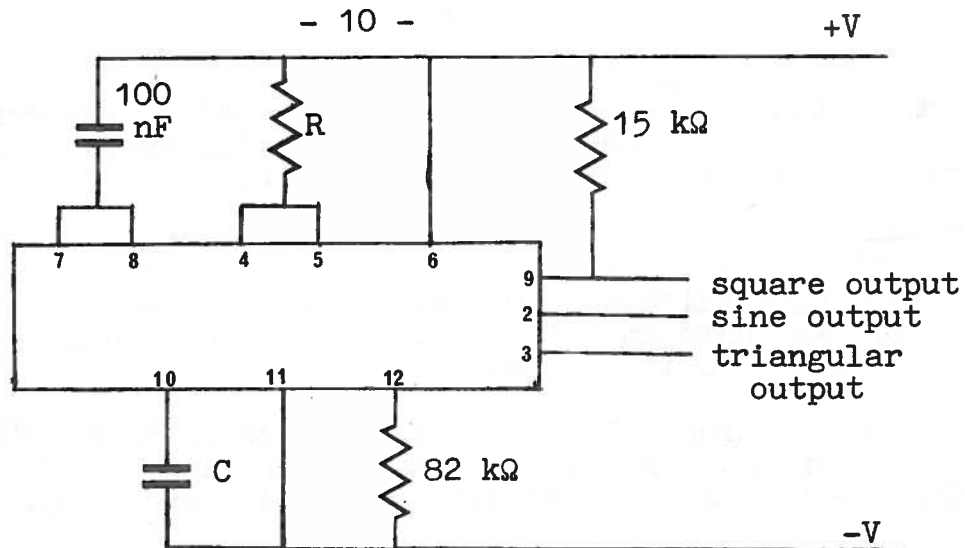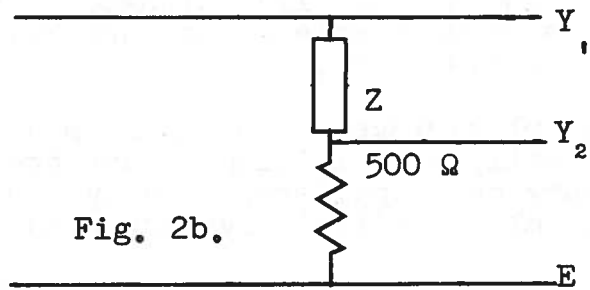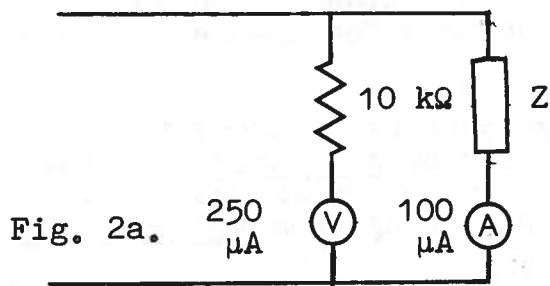in conjunction with a double beam oscilloscope.

Fig. 1. All output voltages are available relative to ground, or
0V, the centre tap of the power supply. C and R are timing com-
ponents; for values, see text.

Fig. 2a.

Fig. 2b.

For the v.l.f. circuit used with meters, the timing components
were R = 33 kΩ and C = 22 µF; this gives a frequency of about
0.5 Hz. For Fig. 2b the corresponding values were R = 3.3 kΩ, C =
1 µF, and n = 65 Hz. On sine wave, phase lead and lag can be shown
using either an 8 µF non-electrolytic capacitor, or the Unilab
large 37,000 turn inductor with core, for the impedance Z. For
the l.f. case the meters we used were 100-0-100 µA for current,
and 250-0-250 µA in series with 10 kΩ for voltage.

Other experiments requiring the use of slow a.c., e.g.
Physics is Fun, 4, chapter 8, can also be carried out with the
generator, provided that the external load presented to it has an
impedance of 10 kΩ or greater. This means that some of the experi-
ments in P.I.F. would require to be modified, using a greater load
and micro- rather than milliammeters.

For S.Y.S., two other demonstrations are possible, viz that
square voltage waveform applied to inductance gives a triangle
current waveform, and vice versa for capacitance. The same values
as above can be used, although for the l.f. case with the inductor,
the core top may have to be removed or the value of R' increased
to get a current waveform large enough to be seen on 100 mV/cm
sensitivity on the oscilloscope. We recommend to those who wish
to construct the generator that they ask for applications sheet
R/2141, available free, when they order the generator, as it con-
tains information on how to 'improve' the basic circuit of Fig. 1
to reduce distortion on sine wave, and improve the symmetry on
triangular wave etc.

Bulletin Supplement

<u>Summary of Stereomicroscope tests</u>. The instruments listed below
have been tested using the procedure published in Bulletin 42.
Individual, fuller reports on these instruments can be borrowed for
up to one month by writing to the Director. The overall assessment
classifications used are: A - most suitable for school use; B -
satisfactory for school use; C - unsatisfactory.

Model	Swift M20E Universal stand	B28605/5	M69(0004)
Supplier	Pyser (Optical)	Philip Harris	Vickers
Price	£95	£85.10	£156.40
Magnifications	x10; x20	x10; x20	x10; x20
Change mechanism	slide-out objectives	slide-out objectives	rotating objectives
Fields of view (mm)	14 7	19 9.5	22.5 11.5
Working distance (mm)	140 115	145 110	110 110
Eyepiece separation (mm)	50 - 72	45 - 95	55 - 77

Stability
   (a) pull (N)
   (b) angle
	5
	22°
		8
		15°
			10
			30°

Distortion	B	A/B	B
Blurring	A	B	A
Lamp	6 V, 12 W	12 V, 6 W	6 V, 72 W
Head adjustment	45° above 30° below almost 360° horizontally	110° above 40° below	wide range but no knuckle joint
Weight (kgf)	9.9	8.2	14.25
Assessment *	(1) B (2) A/B (3) A (4) B/A	(1) A (2) A/B (3) A (4) B/A	(1) B (2) A (3) A (4) B

* (1) Ease of use; (2) Performance; (3) Versatility; (4) Overall
assessment. Assessments 1 - 3 are the results of field trials
in Scottish schools.

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

Allardyce, 9 Bon Accord Terrace, Aberdeen.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride,
Glasgow, G74 3XJ.

Philip Harris Ltd., 30 Carron Place, Kelvin Industrial Estate,
East Kilbride, Glasgow, G75 OTL.

H.M.S.O., 13a Castle Street, Edinburgh.

A.R. Horwell Ltd., 2 Grangeway, Kilburn High Road, London,
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Pyser Ltd., Optical Division, Fircroft Way, Edenbridge, Kent.

R.S. Components Ltd., P.O. Box 427, 13-17 Epworth Street,
London, EC2P 2HA.

Vickers Instruments Ltd., Haxby Road, York, YO3 7SD.

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