

SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 100.

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Introduction

For our lecture on laboratory safety given recently to Central Region science teachers we prepared a bibliography of over 50 references which we will send free to anyone sending 7p for postage. The references have been roughly sorted into biology, chemistry, physics, legal and general, and we have tried to classify the welter of material further by indicating those publications which we consider specially suitable or necessary for school science departments and science advisers respectively. We have not given any prices, because these are so much subject to change, and as some of the material is quite expensive we would advise anyone to verify the cost either with us or with the publisher before plunging in.

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Our centenary issue should be an occasion for celebration, and indeed we are pleased to reproduce below the sentiments of the A.S.E. as expressed by its chairman, Mr. John L. Lewis. He writes:

"As Chairman of the Association for Science Education, I would not like the occasion of the 100th Bulletin to pass without extending to you the congratulations of the Association.

Although your bulletin is intended primarily for Scotland and thereby benefits A.S.E. members North of the Border, copies do penetrate into Sassenach territory and I know how much they are appreciated by all those who manage to see a copy. You do a very real service for science teachers, meeting an important need. The bulletin always makes good reading, perhaps because you are not afraid to say forthright things, but also because it is always given that touch of humour which adds flavour to it.

On behalf of the Association, I would like to extend to you and to your team our warmest congratulations on this centenary occasion."

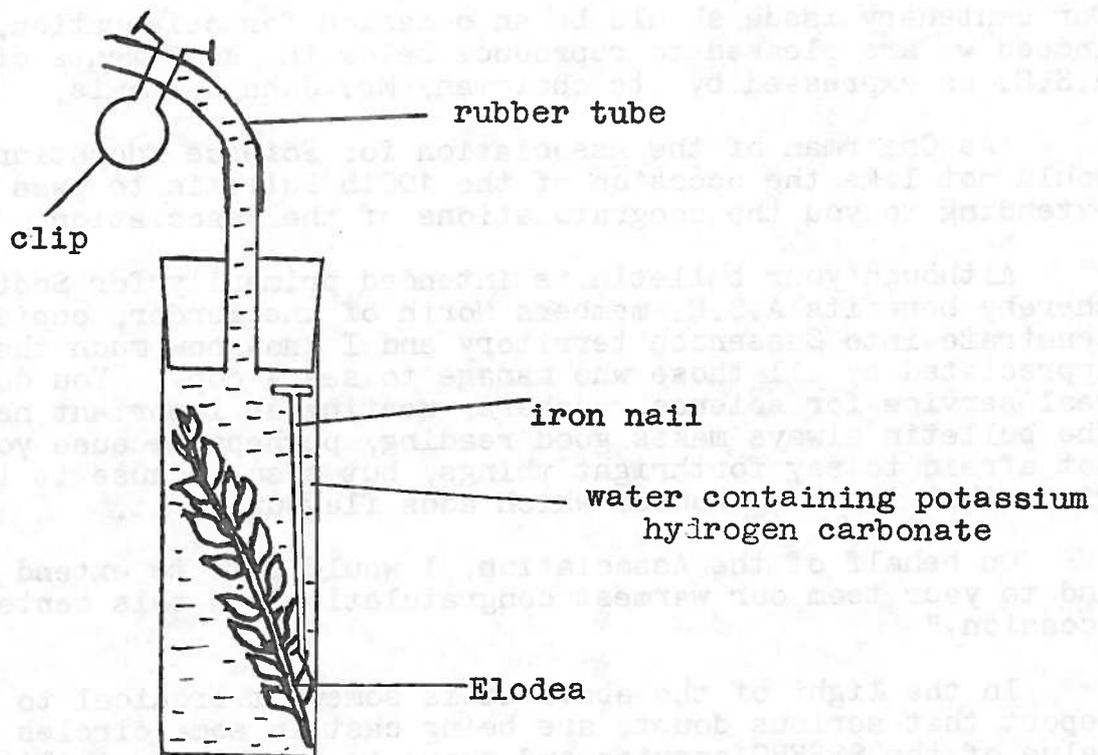
In the light of the above it is somewhat ironical to have to report that serious doubts are being cast in some circles on the value of the SSSERC service and there is a real possibility that the organisation might cease to exist for lack of financial support. The argument has been put forward that local science centres and science advisers can provide the same service as we do. While we are putting up counter arguments to this in places where decisions have to be taken, our Development Committee felt that we should seek here in print the support of those readers who believe that we do provide a worthwhile service by asking them to make their views known to their science adviser, their Divisional or Regional Education office, or to ourselves.

* * * * *

We repeat our reminder given in Bulletin 99 that the Centre will be closed on Saturday mornings of 19 and 26 November, 17, 24 and 31 December, and 21 and 28 January.

Biology Notes

The Elodea experiment as a means of demonstrating that photosynthesis liberates oxygen is a classic. Almost every text-book has a diagram of a filter funnel inverted over the plant in a beaker of water, with a test-tube to collect the gas. Every so often someone is forced into print over the unsatisfactory nature of the experiment, discussing why it fails or suggesting alternatives. The impetus for our investigation was provided by Peterhead Academy which is developing individualised learning in S1 and S2 science and required a pupil scale experiment which would show convincingly that an illuminated plant gives out oxygen. It took us a week of failure before we realised that use might be made of a property of oxygen, viz. its ability to rust iron to demonstrate its presence. This would have the advantage of building on knowledge the pupil already has, of the requirement for oxygen to produce rusting.



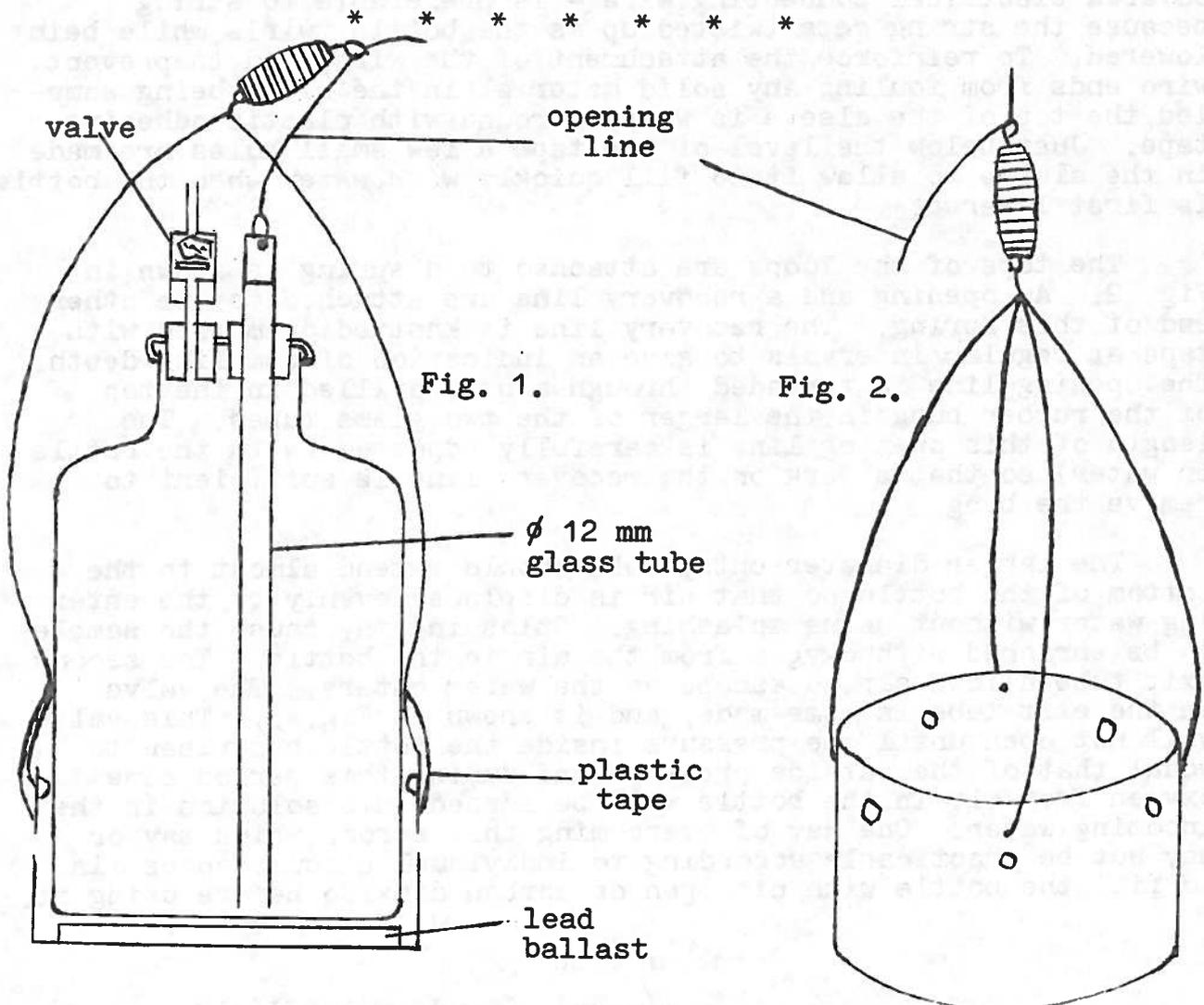
We used two 17 x 70 mm plastic specimen tubes, one as a control, both being fitted with No. 17 rubber stoppers. Probably any small transparent container would suffice. If the volume of water is kept small in relation to the amount of Elodea present then the concentration of dissolved oxygen should rise fairly rapidly.

Both tubes contain a 50 mm wire nail cleaned with emery paper, and a small amount (ca. 0.5 g) of potassium hydrogen carbonate dissolved in boiled, cooled water. The illuminated tube contains a sprig of Elodea which has been actively photosynthesising. The control tube contains a similar sprig which has previously been kept in the dark. The length of rubber tubing on each tube allows them to be completely filled, the surplus being expressed when the bung is fitted. The tubing can then be closed using a spring or screw clip. The control tube is completely enclosed in a tin can or similar light proof enclosure, or it can be wrapped in

aluminium foil.

We used a Phillips 'De-Luxe' fluorescent tube, 2 feet, 20 W, as a light source, although sunlight when available serves equally well. This tube was mounted in a box with a Perspex front and could be placed very close to the plant material without warming it appreciably. The experiment works equally well with illumination from tungsten filament lamps but some kind of heat filter is then advisable. The use of a fluorescent lamp as light source in a pupil scale experiment should not be thought of as a needless extravagance. One such source placed on the bench with the perspex face uppermost can accommodate over 30 specimen tubes containing the Elodea, lying side by side on the perspex. Also the same box can be used as a microscope illuminator, serving 3 - 4 microscopes.

The nail in the experimental tube corrodes rapidly whilst that in the darkened tube remains bright. Detectable rusting occurs in the illuminated tube within a fairly short time, typically after half an hour but it may take longer depending on the level of illumination and the vigour of the plant.



Dissolved oxygen measurements are often of importance in ecological studies and sometimes it is important to know how oxygen concentration varies with depth. With the oxygen meters available for school use this presents problems, because the electrodes are affected by pressure changes. In addition the sample should really be stirred, something which is difficult to arrange at depth.

With the wet chemical methods, analysis in situ is impracticable. We have designed a simple sampling bottle (Fig. 1) which allows samples to be taken at known depths, with some confidence that the sample has not been contaminated with water of differing oxygen content as the bottle sinks, and has not had significant amounts of oxygen added to it from the air in the bottle. In principle, these aims are achieved by using a closed container with separate water entry and air exit ports. The entry is sealed by a bung, released when at the required depth by a sharp tug on the lowering rope, and the air exit is closed by a valve which prevents water entering while the bottle is being lowered.

The basis of our design was a 500 ml, screw top, glass specimen jar but adaptations can be made to suit containers which may be available. The bottom of the jar is fitted with a sleeve cut from the bottom of a plastic container, which contains the ballast needed in the form of folded lead sheet. At four points round the rim of the plastic sleeve two long loops of flexible wire are attached (Fig. 2). The loops must be long enough to rise above the bottle, and wire - we used multi-strand p.v.c. covered electrical connecting wire - is preferable to string because the string gets twisted up as the bottle twirls while being lowered. To reinforce the attachment of the wire, and to prevent wire ends from fouling any solid material in the water being sampled the top of the sleeve is wrapped round with plastic adhesive tape. Just below the level of the tape a few small holes are made in the sleeve to allow it to fill quickly with water when the bottle is first lowered.

The tops of the loops are attached to a spring as shown in Fig. 2. An opening and a recovery line are attached to the other end of this spring. The recovery line is knotted or marked with tape at regular intervals to give an indication of sampling depth. The opening line is threaded through a hole drilled in the top of the rubber bung in the larger of the two glass tubes. The length of this opening line is carefully adjusted (with the bottle in water) so that a jerk on the recovery line is sufficient to remove the bung.

The larger diameter entry tube should extend almost to the bottom of the bottle so that air is displaced evenly by the entering water without undue splashing. Splashing may cause the sample to be enriched with oxygen from the air in the bottle. The second exit tube allows air to escape as the water enters. The valve on the exit tube is home-made, and is shown in Fig. 3. This valve will not open until the pressure inside the bottle has risen to equal that of the outside pressure and during this period some oxygen from air in the bottle will be forced into solution in the incoming water. One way of overcoming this error, which may or may not be practicable according to individual circumstances, is to fill the bottle with nitrogen or carbon dioxide before using it.

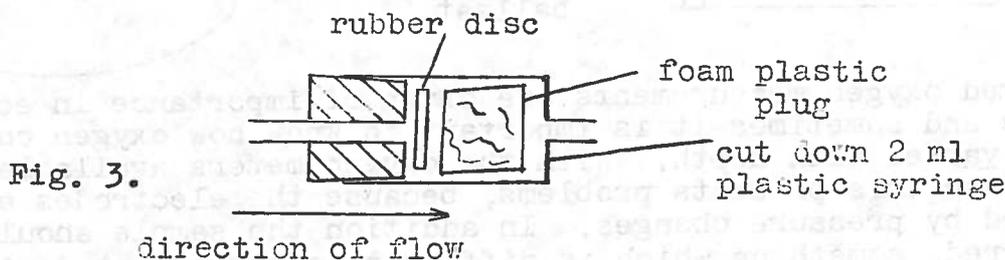


Fig. 3.

The sampling bottle was tested both in the field (Leith Docks) and in a transparent test tank where it could be seen to be operating satisfactorily. The results for the former were: percentage oxygen saturation at surface 70%; at 4 m depth 50%. These results are the mean of several determinations at each depth.

Physics Notes

The following items of surplus equipment are offered for sale, and from Item 786 onward we give details of newly available stock. Items from No. 786 onwards will be subject to the ballot procedure described in Bulletin 91. Items before No. 786 are unsold stock from previous lists and are not subject to the ballot.

Our apologies to any reader who may justifiably have become confused over the duplicate numbering of some items in Bulletins 92 and 97. All the items in Bulletin 92 are out of stock save the dry cells, which are re-offered under Item 786 here, and there are new supplies of photographic paper listed under Items 803 - 809.

- | | | |
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| Item 541. | (Bulletin 77) | Prodox developer, 20p. |
| Item 542. | (") | Colour film chemical, 50p. |
| Item 544. | (") | Colour film chemical, 50p. |
| Item 545. | (") | Colour film chemical, 50p. |
| Item 660. | (Bulletin 89) | Hour meter, £1.50. |
| Item 665. | (") | Large micro-ammeter, £3. |
| Item 683. | (Bulletin 91) | Dual range kilovoltmeter, £3. |
| Item 684. | (") | McLeod gauge, £10. |
| Item 686. | (") | Vacuum/pressure gauge, £2. |
| Item 701. | (") | Electrolytic capacitors, 2p. |
| Item 702. | (") | Potentiometer pack, 30p. |
| Item 704. | (") | Toggle switch, 5p. |
| Item 706. | (") | Toggle switch, 5p. |
| Item 707. | (") | Power diode, 1p. |
| Item 716. | (") | Hydroquinone, 50p. |
| Item 718. | (") | Developer, 20p. |
| Item 724. | (") | Acetic acid, 10p. |
| Item 726. | (") | Distillation flask, 5p. |
| Item 736. | (") | Standard cell, £2. |
| Item 740. | (Bulletin 97) | Developer, 20p. |
| Item 741. | (") | Fixer, 10p. |
| Item 743. | (") | Filter plates, 2p. |
| Item 744. | (") | Capillary tubes, 5p. |
| Item 745. | (") | Capillary tubes, 2p. |

- Item 746. (Bulletin 97) Glass tubes, 1p.
- Item 751. (") Oscilloscope, £15.
- Item 752. (") Power supply, £2.
- Item 753. (") Power supply, £1.
- Item 761. (") Time interval meter, £3.
- Item 762. (") Titling unit, 50p.
- Item 764. (") Meter chassis, £3.
- Item 767. (") Meter chassis, £1.50.
- Item 768. (") Control circuit, £2.
- Item 769. (") Control chassis, £1.
- Item 771. (") Earphones, 50p.
- Item 773. (") Three phase motor, £3.
- Item 775. (") Three phase motor, £2.
- Item 776. (") Three phase motor, £2.
- Item 777. (") Three phase motor, £3.
- Item 779. (") Electric bell, 20p.
- Item 784. (") Display panel, 50p.
- Item 786. (3000) Dry cell, SP2, 5p each, £1 for 24, or £5 per gross.
- Item 787. (13) Relay test set; contains two bridge rectified supplies, one variable, from a single 53 V transformer, 3 milliammeters, switches; in wooden case, £4.
- Item 788. (30) Test set; this is a 5-0-5 μ A, 2.5 k Ω moving coil meter in anti-vibration mounting, together with variable sensitivity control, apparently for use in null deflection circuits. Meter has 40 mm radius pointer and quadrant scale, £4.
- Item 789. (30) Low voltage variac; 50 V, 10 A. Only a few have handles, £1.25; without handle, 20 mm dia. shank, £1. We will allocate the handled version on a first come, first served basis.
- Item 790. (3) Cathode follower valve voltmeter 2 mV - 200 V f.s.d. in 6 decade ranges. Frequency response level 1 - 100 kHz, £5.
- Item 791. Ratemeter and integrator, type 1161B by General Radiological. With e.h.t. high impedance output and meter to 2 kV, £10.
- Item 792. 50 VA power amplifier by Goodmans; 100 - 300 mV input, £3.
- Item 793. (3) Kent chart recorder -0.1 - 1.0 mV x 10 μ V. Chart speeds 1, 2, 4, 15, 30, 60 in/hr, £4.
- Item 794. (6) Air blower, consisting of a 15 cm dia. fan, multi-tapped mains transformer, and dust filter. These would make suitable units for wind tunnel experiments. Air flow 50 m/min at 30 cm distance; £4.
- Item 795. Scaling unit 1009B by Dynatron Radio. Not fully working. Contains 10 decastrons, 6 of which register time to 10,000s x 0.1 s from mains frequency, £5.

- Item 796. E.H.T. power unit; + or - polarity. 3 switched ranges 0.2 - 2.1, 1.0 - 2.9 and 3.0 - 4.9 kV, all x 100 V step. Potentiometer fine control 0 - 100 x 1 V, £5.
- Item 797. Leeds and Northrup potentiometer, 0 - 64 x 0.2 mV. Contains standard cell, £5.
- Item 798. Test chassis with 100 μ A meter, toggle switches, potentiometers, multi-way connectors, £3.
- Item 799. Avo d.c. amplifier type 1388A; not in working order. Contains a 100 μ A moving coil meter, £3.
- Item 800. (100) Sodium street lamps, 35 W (see Bulletin 79 for applications), 20p.
- Item 801. (4) Typewriters, sold against a schools requisition order only, £3.
- Item 802. (5) Hysteresis motor, speed 15 rev/min clockwise or anti-clockwise depending on the connection. For use on 110 V; we supply a suitable resistor to make the motor usable on 240 V. 3 mm dia. spindle, fitted with a cog wheel, £1.
- Item 803. (10) Kodak photographic bromide paper, WFL3S (hard), 12" x 15", box of 100 sheets, £3.
- Item 804. (4) Ditto, WSG3S (hard), 8" x 10", box of 100 sheets, £2.
- Item 805. (18) Ditto, WSG3S, 5½" x 5½", box of 100 sheets, £1.
- Item 806. (12) Ditto, WSG2S (normal), 8" x 10" box of 100 sheets, £2.
- Item 807. (10) Ditto, WSG2S, 8" x 13", box of 100 sheets, £2.50.
- Item 808. (5) Ditto, WSG1S (soft), 4¾" x 6½", box of 100 sheets, £1.
- Item 809. (7) Ditto, WSG1S, 12" x 15", box of 100 sheets, £3.
- Item 810. (8) Fixer, M and B Super Amfix concentrate, dilution 1 in 4; 5 litre plastic bottles, £1.20.
- Item 811. (100) Fixer, Ilford Hypam concentrate, dilution 1 in 4, 2.25 litre plastic bottles, 35p.
- Item 812. (18) Polaroid 3000 ASA type 47 film, 80p.
- Item 813. Stopwatch; 60 x 0.2 s scale and 30 min auxiliary scale, £3.
- Item 814. Ditto; 3 x 0.1 s and 2 min auxiliary scales, £4.
- Item 815. Ditto; 6 s and 5000 yd scales, the first is marked only every second, the distance scale has 100 yd divisions. Pointer movement sounds to be in 0.1 s steps, £2.
- Item 816. Ditto; 60 and 0.2 s scale, with two pointers for split timing, 30 min auxiliary scales. This watch goes only when held horizontal, £2.
- Item 817. (20) G.P.O. type telephone handsets, 40p.
- Item 818. (6) Field telephone sets, with hand generator. These require 3 or 4½ V dry battery, £2.

* * * * *

Following a query by a teacher we wrote to all the suppliers of

3 cm wave equipment asking if the e-m radiation from their apparatus could interfere with heart pace-makers. While the matter is still under investigation, the consensus of advice we have received is that anyone fitted with a pace-maker should not operate such equipment, nor should he be in a room in which the equipment is operating. One manufacturer mentions that the risk is probably greatest where the received radiation is modulated at or near the heartbeat frequency; this is something which could happen to a person crossing a room in which a standing wave pattern had been set up. The Radio Society of Great Britain have reports of trouble arising from the association of pace-maker wearers and radio transmitters, and while the risk in the school situation is probably small, the consequences are so serious that it would be foolhardy to submit oneself to it.

* * * * *

The reason for constructing this piece of equipment is that the tuning fork is the only accurate frequency source usually found in a school, and moreover it is one which will vary in frequency very little unless it is subjected to gross mechanical damage. One can be confident that its frequency is within 1% of its quoted value, and probably within 0.1%. If an electrical signal at this frequency can be continuously generated, it opens up the way for the frequency division techniques of digital integrated circuits to be used to compare any unknown frequency against the fork, certainly to an accuracy of 1%.

The pick-up coil is a telephone earpiece, used with the diaphragm removed, and selected because of its ready availability. As well as being used in the G.P.O. telephone handset, they can be found in the cheaper type of headphone. The drive coil was made from the core of a G.P.O. type relay, of which we have a large number. The normal length of coil in these relays is 60 mm, and this was shortened to 32 mm by taking out the core and cutting it, removing the existing wire in the coil and cutting the former to fit the shorter core. The new former was then filled with approx. 1300 turns of 28 s.w.g. enamelled wire; the resistance was 11.5 Ω . Both coils and the tuning fork have to be rigidly clamped in position as shown in Fig. 1, on some form of baseboard. The gaps between the fork and the drive coil core on one side, and the magnet poles on the other are both about 2 mm. L-shaped brackets made from 3 mm flat bar would probably be a firm enough mounting; we made ours from mild steel sheet and found that we had to reinforce them by brazing on triangular corner pieces as in Fig. 1a to prevent them from vibrating at their own resonant frequencies and so introducing spurious frequencies. The fork had a screwed shank normally used for mounting on a sound box, which made it easy to mount on a bracket. The only mounting terminals we could find on the earpiece were those to which the ends of the coil had been attached, so insulating washers were used to isolate them electrically from the metal bracket.

The driving circuit (see Fig. 2) is very economical; it will work from a 5V supply so that if one wished to use the fork only in association with system 74 integrated circuits, one could fit two pairs of terminals to the arrangement in Fig. 1 and build the driving circuit along with the t.t.l. circuitry, using the same 5 V supply.

There is one difficulty; the circuit is not self-starting and the fork needs a twang with a finger-nail to get it going. When the

circuit is quiescent the current drawn is quite high, about 350 mA, but when the fork starts to oscillate this drops to 60 mA. If therefore the 5 V supply is derived through a voltage regulator or other form of mains supply it may not take kindly to a demand for an extra 300 mA. We have not tried to run the circuit from such a source, using instead a battery of 4 Nife cells, but we have verified by inserting a 100 mA ammeter in the supply lead that if one twangs the fork and then immediately switches on the supply the circuit gets into oscillation well before the meter pointer reaches full scale. There remains the problem of how to safeguard against an accidental stoppage of the fork by a curious pupil's finger for example. Some kind of replaceable cover over the components of Fig. 1, and a printed warning may be enough to stop this, and some might want to include a 100 or 200 mA fuse in series with the drive coil. The final circuit was run for several days (from a battery source), without the fork stopping of its own accord. The output is not strictly square wave, since the 'on' period of the transistors is about one third of the total.

One can check the frequency by feeding the output directly to the Geiger tube input socket of a scaler/timer - with the e.h.t. switched off - and count the pulses over a period which is limited only by the capacity of the scaler. One is using the very high accuracy of the commercial clock or wristwatch together with a large number of observations to get an accurate measurement of the frequency. In our case, we counted 689211 cycles in 30 minutes, which gives $n = 382.9$ Hz for a G tuning fork. Even if one allows a total error of 1 s when starting and stopping the count, this is still only 1 in 1800 or 0.05%.

If the fork is to be left in position when not in use, it will probably be a good thing if the earpiece diaphragm were slid back into place to reduce the amount of magnetisation of the fork, which might alter the frequency over a long period of time.

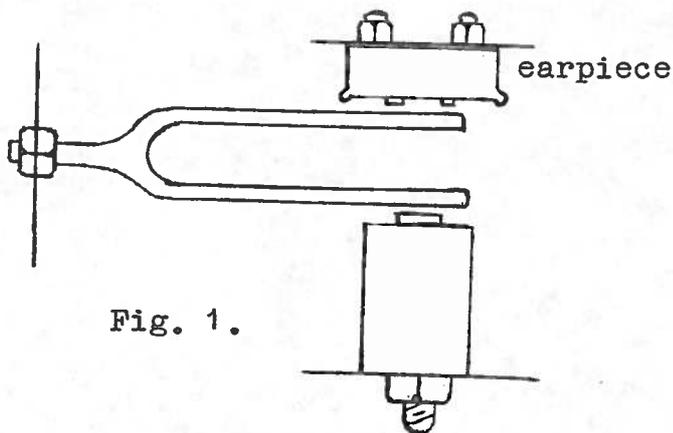


Fig. 1.

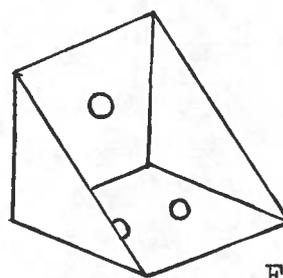


Fig. 1a.

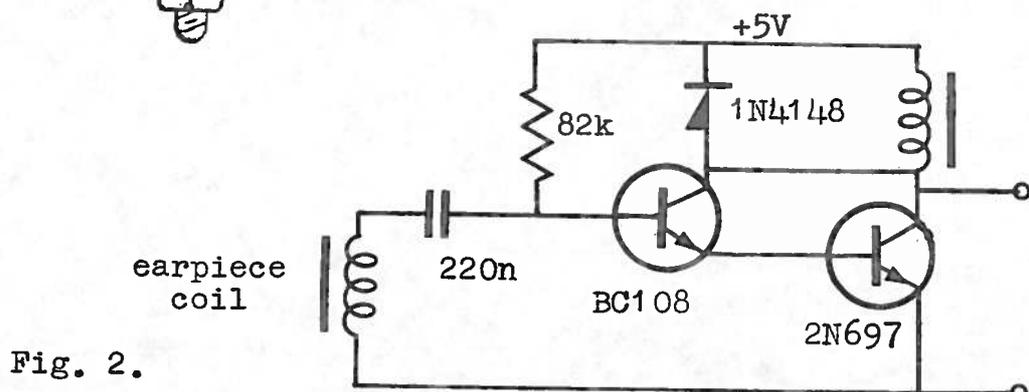
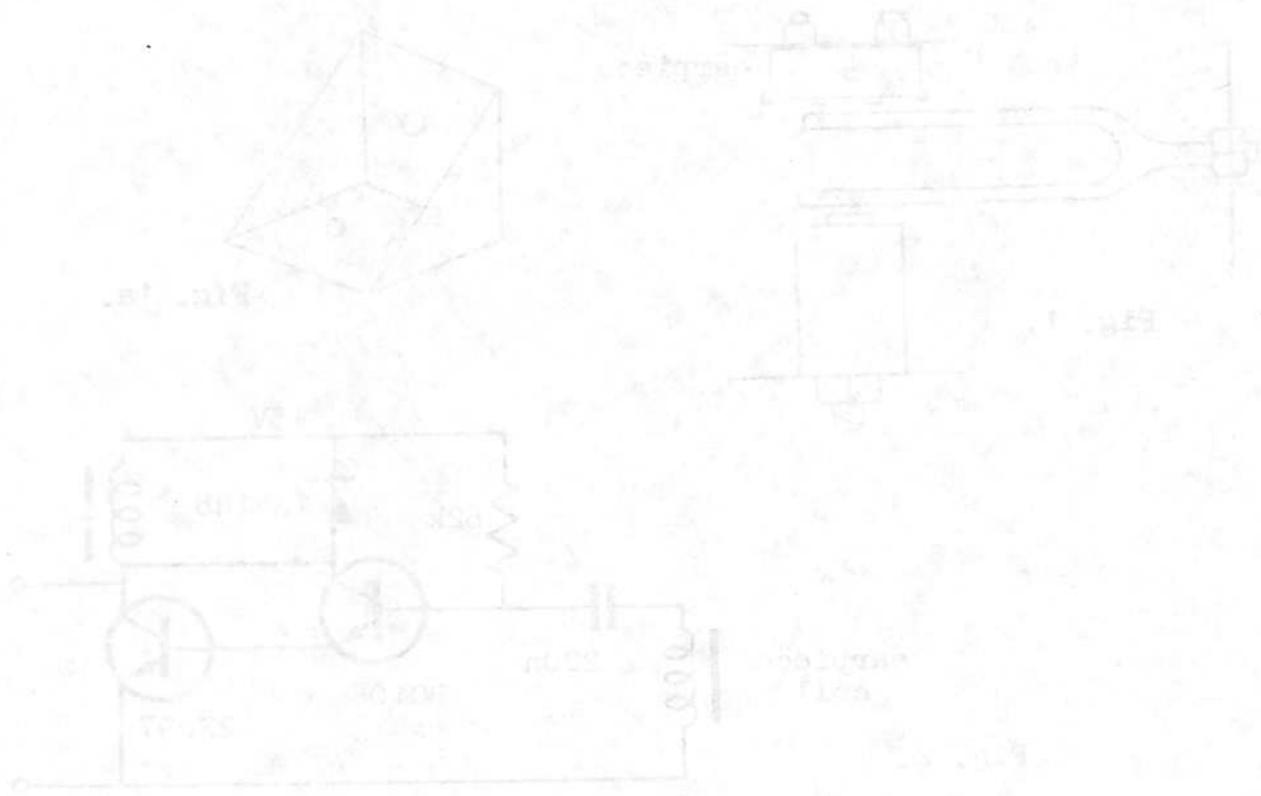


Fig. 2.

The circuit is designed to measure the current flowing in a wire which is connected to a power supply. The circuit consists of a power supply, a variable resistor, a voltmeter, and an ammeter. The voltmeter is connected in parallel with the wire, and the ammeter is connected in series with the wire. The variable resistor is used to vary the current flowing through the wire. The voltmeter reading is used to calculate the potential difference across the wire, and the ammeter reading is used to calculate the current flowing through the wire. The resistance of the wire can then be calculated using Ohm's Law.

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