# SCOTTISH SCHOOLS SCIENCE

# EQUIPMENT RESEARCH

# CENTRE

Bulletin No. 84. November, 1975.

# Contents

# Introduction

Concurrent with this bulletin we have issued the fourth of our experimental guides to the CSYS physics memoranda, that for Memorandum No. 18, Electrostatics. Those already issued have been on Alternating Current, Electro-magnetism, and Oscillations and Waves. As with previous guides, it has been sent to Scottish schools and other organisations on the circulation list of the Scottish Centre for Mathematics, Science and Technical Education. Other U.K. readers who wish to have a copy of the Electrostatics guide (or any of the other guides we have issued) will have it sent free of charge upon request.

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Fee-paying and independent schools in Scotland, organisations in England and Wales, and manufacturers who subscribe to receive our bulletins should have received a reminder that their £7 annual subscription to SSSERC is now due. This amount includes VAT at 8%, and if any school office should require the information, our VAT Registration number is 269 4490 19.

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The Centre will be closed Wednesday through Saturday, 24th - 27th December, and Thursday and Friday, 1st and 2nd January, 1976.

# Opinion

In order to gauge the extent to which the standard symbols, abbreviations, nomenclature and S.I. units are being used, we offer the following selection, all taken from publicly circulated literature within the past year.

1. From a paper on radionuclides originating in U.S., published August, 1975: "Decay constants can be expressed in reciprocal time units e.g. $sec^{-1}$, $min^{-1}$, $yr^{-1}$ etc". "Rate (refers to disintegration rate of a nuclide) = (formula) dis/sec/gm".

2. From an article originating in an English university on making printed circuit boards, published August, 1975: "Ferric chloride is mixed in the proportion of 150 gms to 250 ccs of water". "A rough guide would be 0.3 amps per 20 cm square of P.C. board".

3. From an article of U.S. origin, date unknown but within the past year: "The standard intensity of gravity at mean sea level, latitude 45°, is 980.7 gals (for Galileo)". "In contrast to the newton is the weight of a kilogram mass under standard gravity, a unit now called the kilopond, and formerly referred to as a kilogram (weight)".

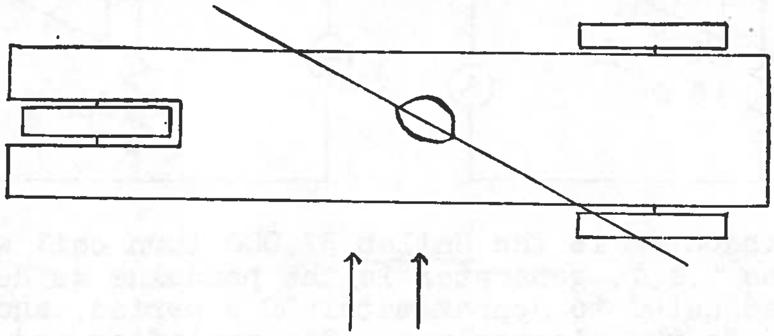
4. From technical literature circulated by a U.K. firm dealing in fluid flow equipment, the following symbols and abbreviations "kp" (=kiloponds). "flow Q in $Nm^3/h$" ($Nm^3/h$ = normal or standard cubic metres per hour). "pv" and "pm" both being used as symbols for pressure - pv = vordruck or upstream pressure, pm = minderdruck or downstream pressure. This collection produced the following correspondence with an employee of the firm. "Regarding your general comments about terminology and accepted standards, I hope you will not consider us presumptuous in suggesting that one must avoid being too pedantic when dealing with practising engineers and technicians. We fully realise your responsibility to teach the correct standards but unfortunately when your students get out into industry they will find much less discipline. We find for instance that many of our customers still insist on pressure gauges calibrated in $Kg/Cm^2$., and that despite official acceptance of the S.I. Standards, the process industry strongly favours bars or psi for pressure, and we are certain that British Industry will think in terms of psi for at least another generation, particularly in the less sophisticated fields of steam and hydraulics."

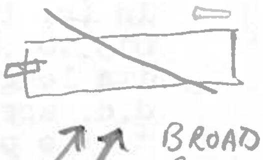
5. From a free circulation journal of laboratory equipment, published September, 1975. "Maximum air consumption is 0.2 $Nm^3/min$ (7 scfm)". The $Nm^3$ has the same meaning as in the extract above, and if one does the calculation, scfm turns out to be standard cubic feet per minute, so that we have the situation that abbreviation m represents both space and time in the same connotation.

6. From the Sunday Times of 5th October: "At present, weight per volume in blood tests is measured in grams and litres. Doctors, nurses and laboratory staff will be required in future to cope with units called "moles" which measure the number of particles in a given volume. Mistakes with insulin injections for diabetics, after blood tests for mole-measured blood sugar levels, have already been made in one London teaching hospital. A consultant said last week: 'It will happen sooner or later. Patients wlll die because of the mole.'". "The French Society of Cardiology responded recently by declaring itself against the pascal, the new SI contender for the millimetre of mercury used in the measurement of pressure. Even the EEC has not yet decided what basic size of pascal to employ and West Germany has unilaterally plumped for a much larger version of pascal than that to be used in Britain."

# Physics Notes

A method of demonstrating the action of sailing on a broad reach, or sailing into the wind, was shown in the members exhibition section of the Scottish Branch A.S.E. meeting this year by the principal teacher of physics at Dunoon Grammar School. For the benefit of those ignorant of nautical terms, sailing on a ~~broad~~ beam reach means travelling at right angles to the wind.






A square sheet of metal, plastic or stiff cardboard, of side 15 - 20 cm, is fixed vertically with a lump of plasticene on a dynamics cart, at an angle to the cart axis. Wind from an air blower is aimed at this 'sail' and the cart should move along the bench. For continuous motion, the blower requires to 'follow' the sail. Both the direction of the wind and the angle of the sail to the boat can be easily altered. For those who want a more realistic shape for the sail than a plane surface, we suggest the plastic car headlamp deflectors which are sold for UK cars to permit night driving in Europe.

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We have to intimate two corrections to our published data. The first concerns our Physics Equipment list of May, 1973. In item 25 we listed a <u>Whiston</u> thermostat as catalogue No. 3032 when in fact it should be 3031B.

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In the description of an integrated circuit apparatus to demonstrate the pelican crossing sequence in Bulletin 72, we gave the quad 2-input AND gate as SN7409, when it should have been SN7408. While the SN7409 is also a quad 2-input AND, it has open-collector outputs. Anyone who had bought the SN7409 for use on the pelican crossing design will require to connect the output of each AND gate to the positive supply rail through a 1 kΩ resistor.

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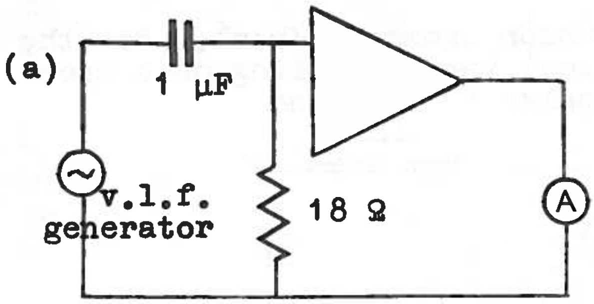
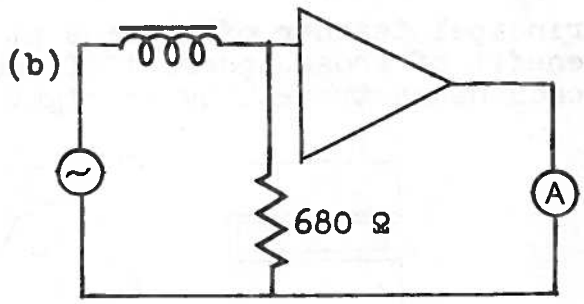
In Bulletin 68 we described how a very low frequency a.c. generator could be constructed from a simple pendulum with its tip moving in a conducting solution, and outlined how it could be used to show diode and bridge rectification and smoothing. The same apparatus may be used, with or without a chart recorder to show the phase relationship between current and voltage for reactive components.

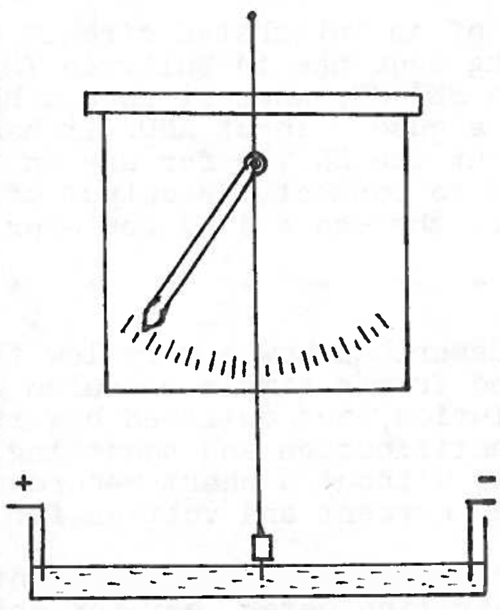
Lacking a chart recorder, the experiments may be performed with a 10 mA demonstration meter, set for centre zero, together with a d.c. amplifier such as that described in Bulletin 55.



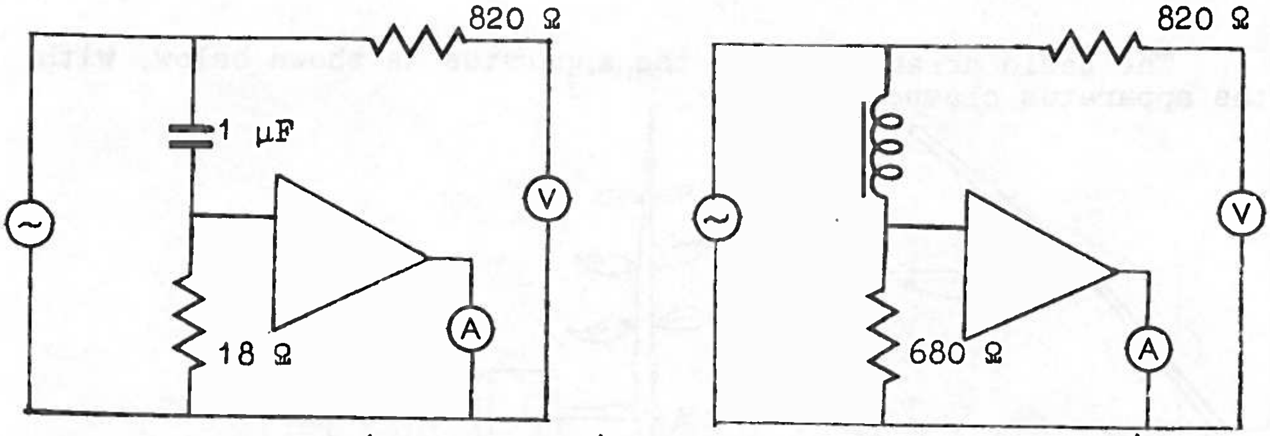




In (b) the inductor is the Unilab 37,000 turn coil with C core, 013.401. The v.l.f. generator is the pendulum as described above, its length adjusted to approximately 2 s period, and with 12 - 20 V d.c. applied to the electrolyte. The amplifier and meter respond to the p.d. across the resistor, which is in phase with the current, so that the meter gives a current indication. To show the voltage phase, we suggest using the pendulum itself. If it is explained to pupils that the electrolyte performs the function of a centre-tapped resistor, they should appreciate that as the pendulum swings its movement corresponds to that of the slider on a rheostat so that it will alternately be +ve and -ve with respect to the centre tap. Hence the pendulum position represents the voltage applied to the circuit. The point requires to be made that because the circuit resistor has an impedance very much lower than that of the reactive component the applied voltage is equivalent to the p.d. across the reactance.

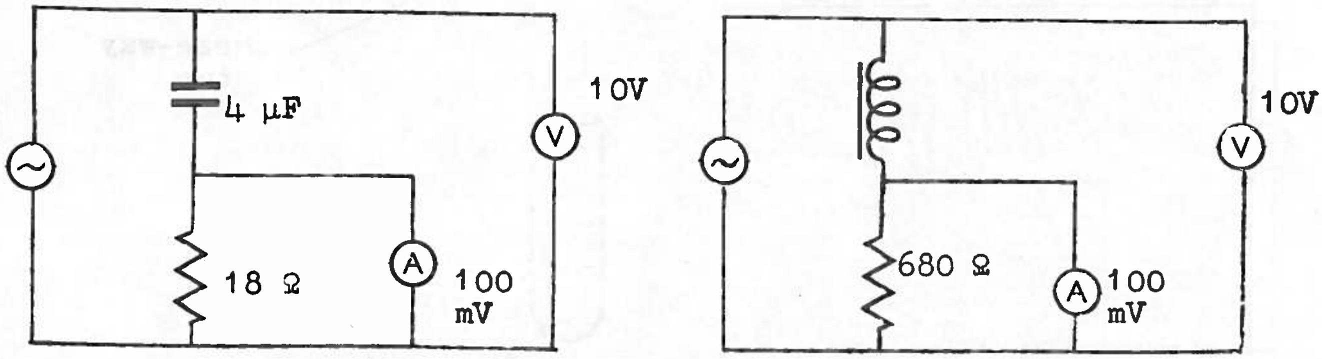
For the demonstration, the meter should be mounted upside down and behind the pendulum, as shown below. Pupils viewing from the front will then see the two 'pointers' moving together and be able to judge whether one shows phase lead or lag on the other. It is not possible by visual examination to see that the phase angle between them is $\pi/2$. If after switching on and suitably adjusting the amplifier gain, the current meter is out of phase with the pendulum, the connections to the meter should be reversed.




For schools with a multi-channel recorder, such as the Russian H320/3 and H3020/3 or the Educational Measurements CR503, the circuits below will give satisfactory results.




Circuits for H320/3 and H3020/3. Chart speed 5 or 10 mm/s.
V and i are recorded on different channels of the recorder.



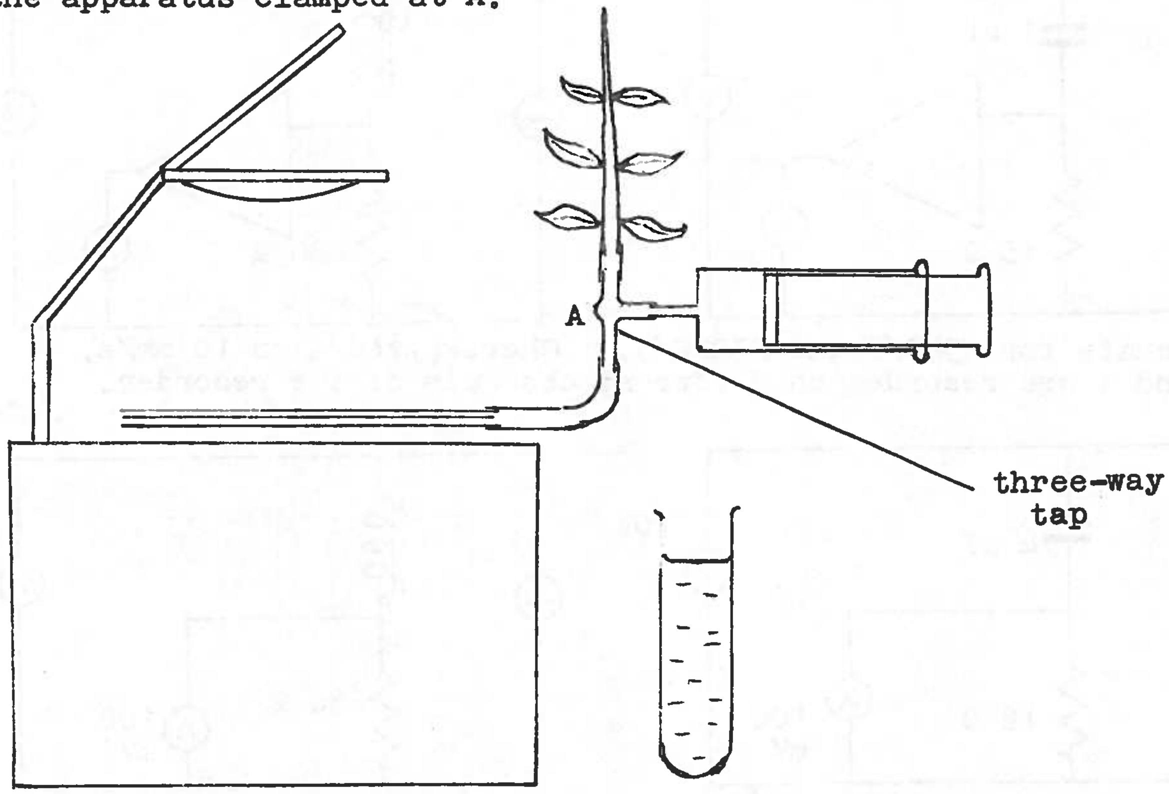

Circuits for CR503. Chart speed 10 mm/s.
10 V and 100 mV are the respective sensitivity ranges for V and i.

With the CR503, the slower pen response may mean that the voltage trace is triangular rather than sinusoidal, and this depends on the trace amplitude. One way out of this difficulty is to lengthen the pendulum, thus reducing the generator frequency. If on the Russian recorders the traces appear broadened or 'fuzzy' at the peaks, the low voltage power supply to the electrolyte is at fault. The pens respond appreciably to the 100 Hz frequency present in unsmoothed, bridge rectified d.c. which many l.t. power units provide, and one should change the unit for one with smoothing, or for a battery.

# Biology Notes

In School Science Review 56, No. 194, Sept. 1974, T. A. Ithell described the use of an 'uptake volume potometer' on an overhead projector platform. We have adapted the potometer described in Bulletin 58, for use on the overhead projector. The pupil scale apparatus described in Bulletin 58 should, in theory, remove the need for a demonstration potometer. However it may be useful to have apparatus set up on an o.h.p., to demonstrate to pupils who, for one reason or another, have not succeeded in collecting their own data, or for revision purposes.

The basic arrangement of the apparatus is shown below, with the apparatus clamped at A.




The use of the three-way tap and the method of setting up and operating a 'Malvern' potometer were fully described in Bulletin 58. The apparatus shown above resembles such a potometer, removed from its backboard, but a number of modifications have been made to allow its use on an overhead projector platform. The bent capillary tube, connected to the three-way tap by a short rubber connector is replaced by a straight capillary joined to the tap by a length of flexible PVC tubing. In our apparatus this flexible tube was ca. 120 mm long, 6.5 mm i.d., 8.0 mm o.d. Using a length of flexible tubing offers several advantages. When the column of water is being returned to the end of the capillary to reset the apparatus, the glass tube can be swung clear of the projector and the platform kept dry. When the water in the syringe reservoir has been exhausted the capillary can again be swung clear, placed in a boiling tube or beaker and water drawn into the syringe with the plant arm of the tap closed. This means that a 5 ml syringe can be used as a reservoir, giving fine control of the water column in the capillary. The tubing is transparent and the whole of the apparatus, except the tap, can be inspected for air bubbles. Initially we tried using polythene tubing but found that air bubbles formed easily and the column tended to break. This problem can be overcome by using polythene tubing of small internal diameter but special arrangements have then to be made to fit the polythene tubing to the glass capillary. We found that PVC seemingly has a better 'wettability' than polythene and its use more or less eliminated the problem.

The glass tube on the projection platform has to be chosen with care. A relatively wide bore capillary works well e.g. 1 mm bore, 75 mm outside diameter. A thin capillary does not project so well, possibly directly because of the thinner bore forming a smaller image and indirectly because of increased spherical and chromatic aberration. A plastic ruler, marked in mm divisions, placed alongside the glass makes a convenient scale for use in timing the meniscus travel. Using the apparatus as described and a large leafy shoot (e.g. from an Epilobium sp.) we have obtained several results for transpiration rate under different conditions in a relatively short time. Certainly a number of worthwhile investigations could be attempted within a double period. Judicious switching of the lamp and deflection of the warm air from the cooling fan are two simple ways of using the o.h.p. itself to change the environmental conditions. If desired another set of apparatus could be fitted with an atmometer disc as described in Bulletin 58 and the two projected side by side. The placing of a sheet of cellulose acetate between the projector platform and the capillary tubes will allow markings and notes to be made alonside them.

# Trade News

We have received the following reports from the CLEAPSE Development Group, copies of which may be borrowed by writing to the Director at the Centre.

L19 - Kymographs and associated equipment.

L53 - Long Form Versions of the Periodic Table.

L117 - Redox potential measurement.

In our review of disinfectants in Bulletin 80 we gave Hough, Hoseason and Co. as suppliers of Tego MHG. Tego business has been transferred to T. H. Goldschmidt. The smallest quantity they will supply is 1 gallon which will make 100 gallons of working solution. Carriage charges may make the ordering of such small quantities uneconomic, and the firm prefer to sell packages of 4 x 1 gallon containers. Bulk discounts are offered and central purchasing by a regional authority would result in considerable saving. In the near future, Tego will go metric and 5 kg containers will become available.

Some firms have recently reduced the range of suba-seal stoppers which they will stock. A full range of sizes, as listed in the Baird and Tatlock 1972 Catalogue, is available from Asschem, with a minimum order of a dozen of any one size.

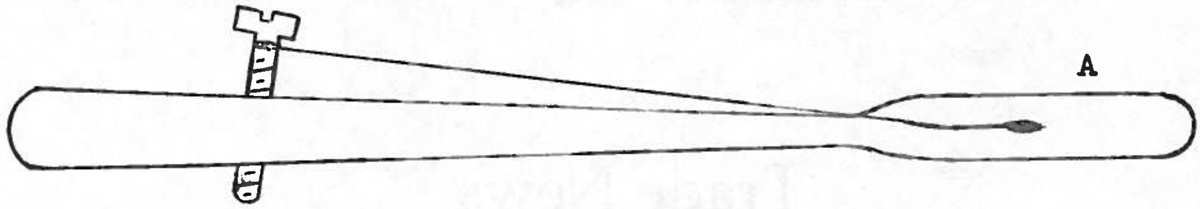
Chemlab Instruments have changed their address to that given on page 12 of this bulletin.

A commercial version of the thermo-electric effect apparatus which we described in Bulletin 76 is obtainable from Ideas for Education, price £13.70.

# In The Workshop

A vibrating spatula is particularly useful when top pan or single pan balances with direct readout are used. In fact if a vibrating spatula is used it gives a speed of weight adjustment to a known reading which makes full use of the balance's rapid weighing facility.

We have fitted the vibrating mechanism to different spatulas. The vibration is produced by the movement of a screw thread along the edge of the spatula. Below we show the arrangement for a nickel "Chattaway" spatula, length 20 cm.




A 10 cm length of 20 s.w.g. nichrome wire is soldered using Baker's fluid to a 25 mm 2 B.A. bolt, and the other end of the wire is soldered to the spatula. Steel wire may be used instead of nichrome, and the only limitation on the type of bolt is that it should not have too fine a thread. The wire is positioned so that the bolt is held with slight tension against the side of the spatula. Operation is by holding the end A of the spatula in one hand and pressing on the wire near the bolt with the thumb or forefinger.

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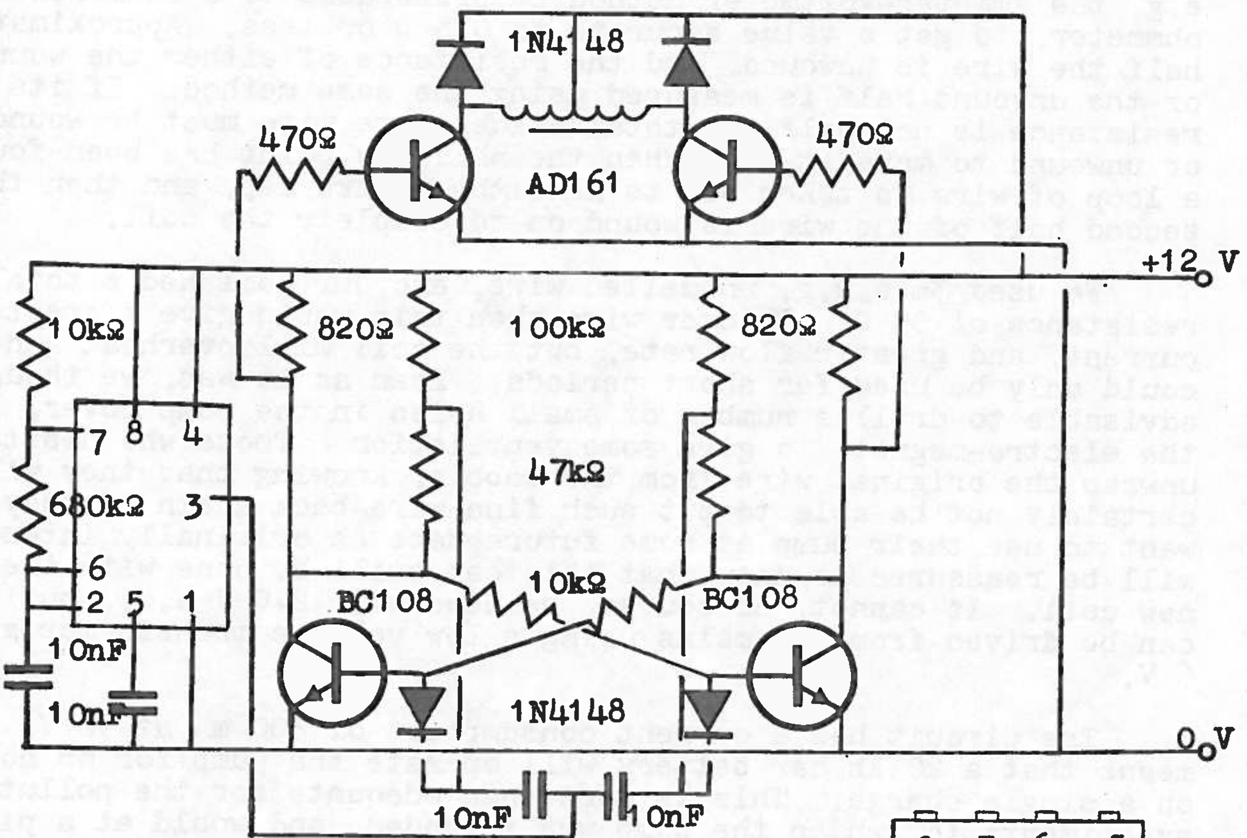
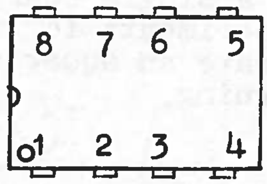
We have produced another adaptation which will allow an aquarium to be aerated from a low voltage supply such as a car battery. This arose not because we are obsessed with the plight of aquatic life when mains power fails or is cut off over the week-end, but from work on pollution. Air sampling to measure pollution levels has become fashionable, but most of the work done at school level suffers from the disadvantage that the pump used to draw air through a detecting system is mains powered, which limits the field work to sites where a mains power point is available. The design described below is capable of drawing air through a Whatman's No. 1 filter paper at a rate of about 1 l/min, when driven from a 12 V supply such as a car battery. The account is confined to the electronics needed to drive the pump; the work we are doing on pollution testing, which requires careful planning to be successful, will be described in a future bulletin.

A standard aquarium pump, the Petcraft (single) model currently available from pet shops at £2.98 was chosen because this had been found to give satisfactory flow rates when used for pollution testing. The principle of its operation is that 50 Hz a.c. flowing in an electro-magnet causes a permanent magnet fixed to an armature to vibrate and the armature drives the pump mechanism. As constructed, the coil of the electro-magnet has a resistance of over 8 kΩ and is suitable only for mains operation. The electro-magnet was taken out, the coil removed and stripped of its wire, leaving only the coil bobbin. This was then re-wound with much thicker wire in a centre-tapped winding and driven in push-pull from a transistor circuit generating 50 Hz square waves.

The electronic circuit is shown below. A type 555 timer generates negative pulses at a repetition frequency of 100 Hz. These are fed to two BC108 transistors in a Schmidt trigger circuit, which divides the frequency by two, giving 50 Hz square waves. Two AD161 transistors are used as power amplifiers driving the coil of the electro-magnet. The circuit wiring should not present any difficulty; ours was built inside a wooden circuit box (see Bulletin 27) except for the coil which must of course be in the pump. With this construction the AD161 transistors were mounted on the box top, and five 4 mm terminals - two for the supply, and three for the coil - on opposite sides. The rest of the circuit was built on Veroboard strip.




Connections to NE555 timer, viewing on top.

Principal components.

| | Trampus | |
|---|---|---|
| NE555 timer | | 55p* |
| BC108 transistor | " | 10p |
| AD161 transistor | " | 33p |
| IN4148 diode | " | 4p |

* All prices excluding VAT.

If the frequency turns out to be other than 50 Hz, its value can be adjusted by varying the 680 kΩ resistor between pins 6 and 7 of the timer; reducing the resistance will increase the frequency. We tried the effect of this on the final circuit with the pump operating, and found that the difference in flow rate was very slight when the frequency varied in the range 45 - 55 Hz. This may not be the case with other pumps: it depends on how sharp is the resonance of the pump armature.

Perhaps the most tedious part of the construction is the winding of the coil. There is no easy way of deciding where the centre tap of the coil is to come; calculations based on published data for wire winding can be inaccurate due to one's inablility to pack the wire adequately. What we recommend, and what we did ourselves, is to fill the bobbin completely with wire, and then measure its resistance. This should be done with some accuracy, e.g. the ammeter-voltmeter method is preferable to a commercial ohmmeter, to get a value accurate to 0.5 Ω or less. Approximately half the wire is unwound, and the resistance of either the wound or the unwound half is measured using the same method. If its resistance is not half the total value, more wire must be wound or unwound to make it so. When the half-way point has been found, a loop of wire is taken out to make the centre tap, and then the second half of the wire is wound on to complete the coil.

We used 36 s.w.g. enamelled wire, and our coil had a total resistance of 59 Ω. Thicker wire than this would give a greater current, and greater flow rate, but the coil will overheat and could only be used for short periods. Even as it was, we thought it advisable to drill a number of small holes in the pump cover, above the electro-magnet, to give some ventilation. Those who hesitate to unwrap the original wire from the bobbin, knowing that they will certainly not be able to put such fine wire back again if they want to use their pump at some future date as originally intended, will be reassured to know that this can still be done with the new coil. It cannot, of course, be used with 240 V a.c., but can be driven from the mains using a low voltage transformer giving 6 V.

The circuit has a current consumption of 300 mA at 12 V, which means that a 20 Ah car battery will operate the pump for 66 hours on a single charge. This is more than adequate for the pollution experiments for which the pump was intended, and would at a pinch aerate an aquarium from 4 p.m. on Friday until 9 a.m. on Monday morning.

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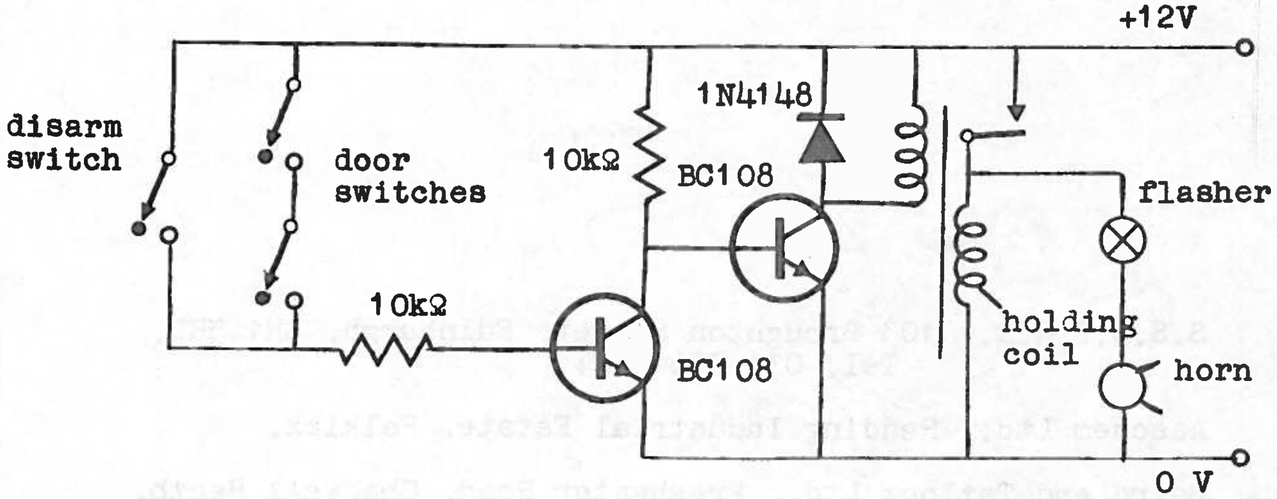
For reasons which will be obvious, the school which installed this room protection device does not wish to be named. The principle of the alarm system is that doors to the room have each a reed switch embedded in the door frame, and a magnadur magnet in the edges of the doors. If any door is opened, the corresponding reed switch opens and through a transistor circuit triggers off a relay which in turn sets off an alarm. A holding coil on the relay is used so that the alarm cannot be shut off again by closing the door.




The following is the school's account, modified in some respects to use currently available components.

Power supply: we use a battery charger (12 V 5 A), although a car battery no longer fit to use on a starter is an obvious alternative. One reason for preferring the charger is that it can be controlled by an "off-peak" electricity time switch which we happened to have. This automatically switches on at night and off in the morning (allowing access by cleaners), except at weekends, when it keeps the alarm on all the time (it has day settings as well as hour settings).

Relay: SSSERC has a small stock of double wound relays, type L287126 which will operate off 12 V. If one of these is used, the 2000 Ω coil should be made the holding coil. The relays have a variety of contacts; what is required is a normally open contact, and although not shown on the diagram, there is no reason why separate contacts should not be used for the holding coil and the alarm.

Door switches: we bury reed switches (RS Components type 6-RSR-A) in the woodwork of the doorframes and embed magnadur magnets using Evostick in the edges of the doors. If you can drill a 6 mm hole in the doorframe from the back, without coming through to the surface, the switch can be completely invisible. If you must drill from the front the small hole is easily covered with putty. The top of the frame is best, as the magnet is then not visible embedded in the top edge of the door. When the doors are all closed the switches (all in series) hold the alarm off with a very small current (mA) flowing through the switches. Opening any door will sound the alarm which cannot be shut off again by closing the door.

Disarm switch: this was an afterthought which allows one to enter during "prohibited" hours without setting off the alarm. A reed switch is concealed behind a wall in another part of the building A magnadur magnet is used as a "key", being placed against the secret part of the wall and left in position while one enters the protected part of the building. This has possibilities where a time switch is not available - indeed it is necessary if one is to be able to leave the premises after switching on the alarm!

Both horn and flasher were obtained from a car breaker's yard. The horn is mounted high on the outside of the building. The rest of the equipment mounted on a board is placed inconspicuously inside the room.

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

Asschem Ltd., Redding Industrial Estate, Falkirk.

Baird and Tatlock Ltd., Freshwater Road, Chadwell Heath,
Essex.

Chemlab Instruments Ltd., Hornminster House, 129 Upminster Road,
Hornchurch, Essex, RM11 3XJ.

CLEAPSE Development Group, Brunel University, Kingston Lane,
Uxbridge, Middlesex.

Educational Measurements Ltd., 1 Brook Avenue, Warsash,
Southampton, SO3 6HP.

T. H. Goldschmidt Ltd., York House, 353A Station Road,
Harrow, Middlesex.

Ideas for Education Ltd., 87A Trowbridge Road,
Bradford on Avon, BA15 1EE.

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

Trampus Electronics Ltd., 58/60 Grove Road, Windsor,
Berks.

Unilab Ltd., Clarendon Road, Blackburn, Lancs, BB1 9TA.

K. R. Whiston, New Mills, Stockport, Cheshire, SK12 4PT.