# SCOTTISH SCHOOLS SCIENCE

# EQUIPMENT RESEARCH

# CENTRE

Bulletin No. 81. July, 1975.

# Contents

# Introduction

Our overseas readers should have received a notice to the effect that in future they will be required to pay £1 annually if they wish to continue to receive our bulletins. Increasing postage and administrative costs have forced us to take this step. This article is by way of a reminder that if they have not yet remitted the £1, they should do so immediately, as otherwise the supply of bulletins will cease.

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The Development Committee recently decided that SSSERC should prepare 1 - 3 line abstracts of articles in previous bulletins, and that these should be classified and published in a bulletin. The reason is that it may help those teachers who do not have access to a complete set of bulletins, that they may decide whether to order any back numbers, and as a reference guide to those who do have a complete set. While all our back numbers are still in print, the quantities of Nos. 1 - 22 are low, and it is not our intention to reprint them. Requests for back numbers should be accompanied by a remittance of 15p per copy for less than 20 copies, or 12p per copy for 20 or more. This charge includes postage, and applies equally in the U.K. and overseas.

This bulletin contains physics abstracts from bulletins 1 - 80; future issues will deal with chemistry and biology. None of the material has been cross-referenced, so that the specialist may well find items of interest under all three classifications. In arranging the order of items, some attempt has been made to follow the Universal Decimal Classification. Articles on safety have been grouped together and will appear with the chemistry abstracts, and there will also be a general category which includes items like lists of reports, equipment lists, etc.

In referring to an article, the expression 'constructional details' usually implies that sufficient information, including dimensions, is given to allow the item to be constructed to our specification. Other items for construction, where full dimensions are not given, are referred to as 'details'. Readers should recognise that components or materials used in constructing an item may not now be available due to the lapse of time since publication. Any who experience this difficulty are invited to write to us, as we will in most instances be able to advise them on alternatives.

# Physics Abstracts

Mathematical logic.

Constructional details of a mechanical form of binary adder/subtracter. (16).

Account of theory of the game of Nim. (34).

Constructional details of a machine for playing Nim. (34).

Details for constructing a circuit to operate the pelican crossing sequence of traffic lights, using the SN74 series of integrated circuits. (72).

Constructional details for a statistics board using Velcro material. (24).

Measurement.

Constructional details for a metronome operated from a U2 cell. (61).

Constructional details of photo-transistor circuit to operate Venner clock or scaler. (12).

Hint on how to adapt a commercial Polaroid 340 camera for use in stroboscopic photography. (54).

Hint for reproducing stroboscopic Polaroid photographs. (12).

Account of the theory and design of the constant-load balance, and details of SSSERC balance tests. (11).

Correction to article on the constant-load balance above. (12).

Summary of tests on 4 direct reading balances. (11).

Summary of tests on 4 top-pan balances. (35).

Mechanics.

Details of a notch which, used with a strap or belt, becomes a centre of gravity 'trick'. (61).

Constructional details of a simple lever apparatus. (75).

Dynamics.

Constructional details of a ticker timer. (37).

Constructional details of a dispenser for ticker tape. (79).

Constructional details of an apparatus for demonstrating weightlessness in free fall. (17).

Account of an apparatus for demonstrating weightlessness in free fall. (52).

Discussion on timing methods in measuring g by free fall. (8).

Impact switch for g by free fall; switch tilts and breaks a mercury contact. (8).

Postscript to the above from the designer of a commercial form of free-fall apparatus. (9).

Photographic method for showing the independence of horizontal and vertical motions in free fall. (13).

Constructional details of a monkey and hunter apparatus. (14).

"Pearls in air" experiment; an account of how to vibrate a jet of water so that it breaks into drops at the vibrator frequency, which can then be illuminated stroboscopically to give a stationary parabola of falling drops. (11).

Discussion on modifications to commercial dynamics trolleys. Includes details of end plates which can be adapted for various types of collision. (56).

Discussion and details of how to use a high speed chart recorder (a) to measure g by free fall and (b) to measure the velocities of vehicles on a linear air track. (70).

Correction to article on velocity measurement on the linear air track above. (71).

Constructional details of an apparatus to demonstrate kinetic energy $\propto v^2$. (40).

Constructional details of an apparatus to verify the relations between the parameters of the equation

$$\text{Force} \times \text{distance} = \tfrac{1}{2} mv^2$$

Uses elastic to catapult a dynamics trolley. (12).

Details for constructing a ramp and a variety of rolling objects, which pose questions about the distribution of energy between rotational and translational types. (63).

<u>Energy Conversions</u>.

Uses of 10 - 20 mW lamps in energy conversions in (a) driving them directly from photo-voltaic cells; (b) as the load on a small d.c. motor driven as generator by a falling weight; (c) as load on a 'microphone' (8" loudspeaker) driven by sound waves from a similar loudspeaker; (d) showing the exponential nature of current into a 5 mF capacitor. (8).

Oscillatory discharge of water from an inverted flask. (13).

Constructional details for a solar motor. Two photovoltaic cells mounted on the rotor provide power to drive a d.c. motor. (8).

Constructional details for an alternative solar motor which floats on water. (24).

Constructional details of an ether engine which will raise a small mass by repeated vaporisation and condensation of diethyl ether. (27).

Addendum to the article on the ether engine above. (29).

Fluid mechanics, dynamics.

Details for constructing a water barometer. (16).

Hint for constructing a density gradient column. (20).

Note to conserve water when using water operated filter pumps. (64).

Details of a collapsed can experiment, using ring-pull cans. (78).

Constructional details of a fluidising tank for dip-coating specimens with polythene. (48).

Discussion on possible uses as sensitive pressure guage, flow meter and water circuit analogue voltmeter, of an air-speed indicator sold as surplus material. (59).

Waves.

Constructional details of an apparatus to show how circular motion and simple harmonic motion are linked. The apparatus uses 12 lamps in a large diameter circle, and corresponding 'projected' lamps in a straight line. (54).

Addendum to the s.h.m. apparatus above. (56).

Constructional details of an o.h.p. model illustrating standing waves on a spiral spring. (37).

Gas Laws.

Boyle's Law pump. Adaptation of the Nuffield Boyle's law apparatus for use with a cycle pump. (2).

Use of the Nuffield Boyle's law apparatus at sub-atmospheric pressures; discussion of the problem of scales. (3).

Balloon pump. Constructional details of the adaptation of a commercial balloon pump so that it may be used with any piped gas. (1).

Constructional details of an air-table used with an overhead projector to illustrate collision processes. (45).

Sound.

Constructional details of an apparatus for Melde's experiment. The apparatus has a lever system for fine tuning of the tension. (56).

Discussion on validity of the 'bell in bell jar' experiment to show that sound does not travel in vacuum. (52).

Account of (a) an impact, and (b) a resonance technique for measuring the velocity of sound in a metal rod. (49).

Addendum to the experiment on measuring the velocity of sound above. (51).

Details of an experiment to measure velocity of sound in a rod by using the rod as the feedback element in an amplifier circuit. (76).

Optics.

Lens storage. Storage rack for lenses and mirrors, with colour-coded focal lengths. (1).

Constructional details of a pinhole camera in which photographs can be taken and developed. (22).

Details of an 'inverted' pinhole camera; a black dot on a transparent sheet produces a shadow of a lamp filament. (52).

Account of an attempted experiment to use a modulated laser beam to measure the velocity of light, by a phase shift method. (16).

Discussion on the use of sodium street lamps as a spectrum source, and an account of how to dispose of faulty lamps. (79).

Constructional details for a direct vision spectroscope using plastic diffraction grating. (8).

Addendum to above, giving source of plastic grating. (9).

Parabolic reflector held close to the pupil's face which acts as both radiator and detector. (8).

Note on the use of a slide projector as a source of infra-red radiation and the need to remove the heat filter. (5).

Heat.

Hint to fit plastic tabs over thermometers to prevent them rolling off benches; also a quick-check method of storage. (75).

Details of an offer of bi-metallic strip to show expansion. (35).

Construction of low voltage heaters from nichrome wire, with copper plated ends to the wire to serve as leads. (5).

Hint to use a freezing aerosol to mend split mercury threads in thermometers. (20).

Warning against using turpentine for specific heat experiments with plastic Aerocups. (15).

Constructional details of a 4-range electronic thermometer, using an integrated circuit 741 amplifier. (55).

Constructional details of a model hot air (Stirling) engine, using a filter tube and a glass syringe. (57).

Constructional details of an apparatus to show thermo-electric effect. The current generated produces sufficient magnetic field to support a weight of 2 kg. (76).

Correction to article on thermo-electric effect above. (77).

Electro-statics.

Constructional details of a wire cage to be used on a van de Graaf generator dome to show the principle of electrostatic shielding. (67).

Detail of how to illustrate field lines using damp filter paper and potassium permanganate crystals. (71).

Experiments to show how current into, and voltage across an air-spaced capacitor alter as the plate area is changed. A mirror galvanometer and gold leaf electroscope are the measuring instruments. Experiments for constant potential and constant charge are described. (8).

Account of experiments with a large capacitor, viz (i) that $V \propto t$ with constant current charging, (ii) measurement of time constant with exponential charging or discharging, (iii) energy $\propto V^2$. (26).

Details of an experiment using a commercial d.c. amplifier to show how capacitance varies with area for a radio-type tuning capacitor. (54).

Details of an o.h.p. apparatus to verify Coulomb's Law. (38).

Addendum to article on Coulomb Law apparatus above. (39).

Hint for an alternative to using glass springs on the macro-Millikan apparatus. (20).

Account of an experiment with a neon bulb to establish the identity of static and current electricity. (29).

Current Electricity.

Account of the procedure for evaluating e.h.t. power units (5 kV). (28).

Summary of tests on 4 e.h.t. power units. (28).

Summary of tests on 3 e.h.t. power units. (38).

Account of the test procedure for evaluating high voltage power units, 250 - 350 V. (24).

Summary of tests on 4 high voltage power units. (24).

Summary of tests on 2 high voltage power units. (25).

Account of the test procedure for evaluating low voltage power units. (21).

Summary of tests on 4 low voltage power units. (21).

Summary of tests on 4 low voltage power units. (22).

Summary of tests on 4 low voltage power units. (26).

Summary of tests on 3 low voltage power units. (41).

Discussion on the testing of extra low voltage power supplies for use with the Westminster electromagnetic kit. (15).

Summary of tests on 4 extra low voltage power units. (15).

Summary of tests on 4 extra low voltage power units. (16).

Summary of tests on 3 power units (e.h.t., e.l.t., and l.t.). (32).

Constructional details of a d.c. power supply from a 12 V transformer, with variable output. suitable for conductimetric titrations. (10).

Demonstration of the piezo-electric effect; a crystal microphone capsule when squeezed gives sufficient e.m.f. to deflect a mirror galvanometer. (7).

Hint to use plastic drain pipe as a mount for small components. (42).

Constructional details of a U2 cell mount, using a wooden circuit box. (27).

Constructional details of a U2 cell mount, using plastic drainpipe. (51).

Constructional details of a battery box for small nife cells sold as surplus material. (58).

Recipe for electrolyte for nickel-iron or nickel-cadmium cells. (48).

Discussion on the 'short-circuit' current obtainable from nife cells. (52).

Constructional details of a meter mount from aluminium sheet. (30).

Hint to use a bulldog clip to secure trailing cables in mains operated equipment. (13).

Hint to use carbon resistor as a former for winding low resistances (meter shunts). (75).

Account of uses for wooden circuit boxes in mounting small components. (27).

Constructional details of a connector block for parallel connections. (65).

Suggestions for firmly securing 4 mm plugs to connecting wire. (59).

Addendum to article on securing 4 mm leads above. (65).

Details of two methods for storing 4 mm connecting leads. (32).

Constructional details of a rack for storage of connecting leads. (45).

Constructional details of a model to illustrate the ring main circuit. (33).

Details of a ring main circuit using a Worcester circuit board. (36).

Constructional details for a Worcester circuit board. (5).

Two methods for connecting components in a Worcester circuit board. (13).

Constructional details for a continuity tester, using a specimen tube and torch bulb. (8).

Construction of shunts for Japanese 1 mA MR38P to convert to 10, 50, 100, 500 mA, and 1 A, and of multipliers to convert to 1,5 and 10 V. (8).

Postscript to the above. Discussion on variability of coil resistance of MR68P meter. (9).

Electro-magnetism.

Account of the procedure for evaluating low voltage transformers. (29).

Summary of tests on 4 low voltage transformers. (29).

Summary of tests on 3 low voltage transformers. (30).

Account of the difficulties of protection by fusing on low voltage transformers. (32).

Details of a modified rotating wire experiment using electrolytes in place of mercury. (62).

Constructional details of a single-turn model d.c. motor. (31).

Experiment to demonstrate the hysteresis loop for a (valve) output transformer. The loop is shown on the oscilloscope and the increased hysteresis when the transformer is loaded can be shown. (8).

Correction to article on hysteresis loop above. (11).

Details of how a force-on-a-conductor balance may be constructed using a top pan 10 mg balance as the detector.

Details of an astable vibrator using two electro-magnetic relays. (62).

Details of an experiment to demonstrate the inertial effect of inductance in a circuit. (64).

A.C. Theory.

Circuit for displaying damped oscillation on a c.r.o. (15).

Details of an apparatus, using 2 pendulums which swing in an electrolyte, to show that the beat frequency is the difference between the individual frequencies. (47).

Modification of the apparatus above so that it becomes a very low frequency generator. The account describes how to use the apparatus with a pen recorder to show rectification and smoothing. (68).

Details of apparatus for demonstrating current flow in a full-wave bridge rectifier. (77).

Discussion on method for verifying the r.m.s. value of a.c. (77).

Electronics.

Conversion of an EF98 valve to render $I_a/V_g$ and $I_a/V_a$ curves for an anode supply of 12 V. Sample graphs given. (3).

Postscript to the previous item; suggestion to use both halves of a 12AT7 valve, strapped, on a 12 V supply. (4).

Commercial beam switch unit (Heathkit) to produce a double trace on a single beam oscilloscope; mode of operation and application discussed. (4).

Postscript to previous item, discussing the difficulty of showing the correct phase angles in a series CR circuit using the beam switch unit to display $V_C$ and $V_R$. (5).

Method of using a valve filament transformer in reverse to produce a 300 V d.c. power supply. (13).

Details and circuit diagram of a pre-amplifier with low input impedance, for amplifying electro-magnetically induced e.m.f.s. (44).

Constructional details of a d.c. amplifier using an integrated circuit 741 amplifier. (55).

Corrections to article on the d.c. amplifier above. (59).

Details and circuit diagram of a transistor tester which uses a commercial ohmmeter to measure current gain. (54).

Account of how to identify transistor connections by using an ohmmeter to measure inter-electrode resistance. A table of typical resistance values is given. (60).

Details and circuit diagram of a component tester. Used along with an oscilloscope, the tester can provide semi-quantitative information on a variety of linear and non-linear components. (71).

Details of an oscillatory circuit using a tunnel diode and a magnet on a helical spring. (24).

Details and circuit diagram to construct a square wave generator from SN7404 inverter gates. Frequencies up to 3 MHz can be achieved. (79).

Atomic Physics.

Discussion on techniques and possible errors in the Millikan experiment. (9).

Summary of tests on 3 Millikan's apparatus. (9).

Details for taking radio-graphs on dental X-ray film. (14).

Details of a 5 μCi plutonium radio-active source. (11).

Note on the treatment and disposal of radio-active sources. (64).

Meteorology.

Constructional details of a sunshine recorder, using a water-filled flask. (17).

Constructional details of a weather vane which gives a 24 hour record of wind direction. (50).

Workshop Practice.

Vacuum pump. Notes on the care and maintenance of the rotary vacuum pump. (5).

Constructional details of a hot wire apparatus for bending perspex sheet. (13).

Constructional details of a heater for bending perspex sheet. (61).

Constructional details of a battery operated soldering iron. (77).

Details for preparing a wiring diagram for S-Dec and Veroboard construction. (18).

# Trade News

A full range of small d.c. motors. the 'Orbit' series, which will replace the Japanese Mabuchi range for most energy conversions, is available from Harburn Hobbies and other model shops. The details are;

| Model No. | working voltage | approx. speed. Hz | torque, g cm | approx. current | price |
|---|---|---|---|---|---|
| 205 | 1.5 V | 100 - 160 | 8 - 20 | 200 - 300 mA | 44p |
| 305 | 1.5 V | 90 - 110 | 15 - 30 | 200 - 300 mA | 56p |
| 405 | 3.0 V | 140 - 175 | 55 - 75 | 200 - 300 mA | 66p |
| 505 | 3.0 V | 120 - 150 | 70 - 85 | 200 - 300 mA | 78p |
| 605 | 6.0 V | 170 - 185 | 80 - 120 | 500 - 700 mA | £1.30 |
| 705 | 6.0 V | 170 - 185 | 100 - 200 | 3.0 - 3.5 A | £1.84 |
| 805 | 6.0 V | 100 - 120 | 150 - 200 | 3.0 - 3.5 A | £2.60 |

The Russian chart recorder is now being offered by Z and I Aero Services in a new version, the H3020/1 which supersedes the old H320/1. The modifications made do not appear to have any advantages over the old model, and several in our opinion are retrograde steps. Perhaps the price rise, from £55 to £80, was inevitable although this seems a heavy price to pay for inflation. A take-up spool has been provided for the chart paper, which is not likely to be much used in schools. As a result, we have lost the rewind facility which allowed paper to be wound back on to the supply spool, so that much more paper will be wasted. A second event marker, operable either by push button on the recorder or by external contacts has been fitted. Again, we found the single. button operated marker on the H320 to be of little use

and when the makers were installing the external contact marker, the original could well have been omitted. However, the most serious omissions on this compared with the earlier model are the maximum chart speed of 50 mm/s, and a pen switch. On the H320, the pen could be disconnected from the input to allow adjustments to be made to it, and it was also a convenience to be able to switch on the pen at a particular instant. To obtain these facilities on the H3020 the user will need to fit his own switch in the external circuit. The maximum chart speed is now 25 mm/s, which means that for high speed phemomena, such as measuring linear air track velocities, the time sensitivity is halved. As with the H320, a three-channel version, the H3020/3 is available at £130.

Increasing postage and administrative costs mean that more and more firms are obliged to place a minimum charge on mail order dealings. This makes things more difficult for the individual teacher, requiring only one of a particular item. The only way out seems to be for local science centres to aggregate orders from individual schools, to submit a single large order and then distribute the items from the local centre. Thus the sausage balloons obtainable from Aberdeen Joke Factory, and used to make orbital models, can now be purchased only in one gross packs at £1.80. As the balloons have a limited shelf life, it is doubtful if any but the largest schools would get value for money by buying a gross.

Two other firms have each placed a minimum order charge of £10 per order; they are May and Baker, and Henry's Radio.

The firm of Tinsley-Telcon have a minimum order charge of £15; in Bulletin 75 we described a tambour design using one of their strain gauges. To bail out a school which was constructing the tambour and came up against this minimum order charge, we bought £15 worth of this particular strain gauge, type W16/100/G/C/3, which has a nominal resistance of 100 Ω, and we now have about 20 surplus which we will sell to any science department, price 60p each including postage.

Elesco-Fraser are selling a 'Martindale' mains socket tester at £2.80. This uses combinations of three small lamps on the face of the plug to identify a fault in the socket wiring. A key to all possible faults is written on the plug face. The tester fits the 13 A square pin type of mains socket.

MacFarlane Robson are now agents for Swift microscopes.

Philip Harris have been appointed distributors for the Quantan and Quantab range of test strips and tablets.

Plastic Petri dishes, 90 x 15 mm, are available in cases of 500 (minimum quantity) at £11.80 from Nunc UK.

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

Aberdeen Joke Factory, 170 George Street, Aberdeen.

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

Harburn Hobbies Ltd., 124 Leith Walk, Edinburgh, EH6 5DT.

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

Henry's Radio Ltd., 303 Edgeware Road, London, W2 1BW.

MacFarlane Robson Ltd., Burnfield Avenue, Thornliebank,
Glasgow, G46 7TP.

May and Baker Ltd., Dagenham, Essex, RM10 7XS.

Nunc UK Ltd., 16 Salter Street, Stafford, ST16 2JU.

Tinsley-Telcon Ltd., Werndee Hall, South Norwood, London, SE25.

Z. and I. Aero Services Ltd., 44A Westbourne Grove, London. W2 5SF.