SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 113. June, 1979.

Contents

Introduction

As this Bulletin is being prepared, and possibly for some time after it has reached the schools, all the staff at SSSERC will be missing the presence and very considerable contribution of its Director, Joe Stewart. Unfortunately Mr Stewart was taken ill in mid-April. At the time of writing he is recovering in the Royal Infirmary, Edinburgh.

We all very much hope that he will soon return to once again give us the benefit of his considerable technical and administrative expertise. We know that his many friends in science education in the UK and overseas will join us in wishing him a speedy and full recovery.

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Despite the proximity of the school holidays the ballot for the surplus equipment listed in the Physics Notes section of the Bulletin will be held as usual, in the manner indicated in Bulletin 91. Successful parties will be notified as usual but if necessary, in accordance with our normal practice, we will hold materials for collection until after the holidays or longer if required to do so. Those who wish to have materials sent to them should consult the Introduction to Bulletin 105.

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As was the case last year, the Centre will be closed on Saturday mornings during the summer holidays, from the 30th June to August 11th both dates inclusive. We are still open on weekdays throughout the summer, and on each Saturday morning, 9 a.m. - 1 p.m., outwith the holiday period.

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We have to apologise for two mistakes in the address list for the Integrated Science Equipment List distributed recently. We gave incorrect addresses for Comber and Son and GBI Laboratories. The correct addresses for these firms will be found on page 12.

Opinion

Many commercial organisations have Marketing departments with a senior executive in charge as Marketing Director who reports directly to the Managing Director. Great importance is attached to this marketing function which is considered to be very different, and separate, from 'mere selling'.

Marketing is not, despite its popular image, merely launching a product with fingers crossed and then pushing it very hard with doubtful claims on expensive, glossy paper. Marketing starts very much earlier than that and, despite appearances, does have important and legitimate functions. The real role of a marketing manager is to assess the needs of customers and to liase with other departments so that products or services can be developed which properly fulfill these needs.

Readers, if they are still with us at this stage, are propably asking themselves, "What has all this to do with SSSERC?" The answer is a great deal, because there are close parallels between the functions of SSSERC and those of a commercial concern. SSSERC exists not just to be the rice-bowl of its staff but to provide Regional Authorities and their teachers with a range of services. This range of services has grown over the years. Some of them are relatively new and some we have offered since the centre opened nearly 14 years ago.

Since the Centre was set up the educational environment has changed considerably, and, to paraphase Lamarck, "Environmental changes call forth new needs". In the past the main ways in which we have assessed these changing needs for services i.e. fulfilled our marketing function, have been by talking to individual teachers at exhibitions and elsewhere, through our Development Committee which consists mainly of serving teachers and, very importantly, from the number of requests for help with a problem, or suggestion and ideas for particular apparatus received by letter or 'phone.

For some time now we have doubted whether our 'marketing' efforts were adequate. We have begun examining the problem within the context of the internal organisation of SSSERC, but we believe our readership also has an important role to play.

We have never thought that we have any monopoly of 'good apparatus ideas' in Scottish science education. This was re-emphasised by the recent members' and technicians' exhibition of school-made apparatus at the Scottish ASE meeting in April. In the past we have relied heavily on teachers and technicians for designs and ideas for the 'Bulletin' and for suggestions for new, better or safer ways of doing experiments or using equipment.

Of late we have noted a falling off in this supply of ideas and suggestions. This makes our work much more difficult. We can sit here with our brains in neutral awaiting inspiration. We do get ideas - eventually. We are then never sure that a design or service has a market and is fulfilling a real need. It is infinitely more satisfying to work on a project suggested by teachers at the chalk face, and we would like to hear your suggestions much more frequently than we have recently.

Safety Notes

Over the years there have been several reports of explosions occurring in food and fuel combustion calorimeters. The latest one reported to us occurred in a school and, with permission, we quote the teacher's report:

"1) Apparatus had been used with 1g of glucose to show energy release from a carbohydrate.

2) Apparatus was refilled with cold water and set up to repeat with oil.

3) 0.5g of oil weighed into crucible. A small piece of rocksil was added and placed in oil so that most of it soaked into the rocksil.

4) Apparatus was assembled and ignition coil turned on with 6V supply D.C. Coil glowed red and was lowered into the oil soaked rocksil; it smouldered with some smoke escaping from the top of the copper heat transfer coil and some from the base of the apparatus.

The oxygen supply was turned on slowly to encourage ignition and an immediate explosion followed. The calorimeter was lifted about 18" in the air but fortunately did not shatter.

5) On examination there still appeared to be some unburnt oil in the crucible plus rocksil."

In the Centre we repeated this procedure as described using liquid paraffin or glyceryl trioleate (propane-1,2,3-triyl tricis-octadec-9-enoate!) soaked into either rocksil or ceramic fibre wool and an explosion was obtained every time.

The experiments were repeated with the two different absorbents, this time following the supplier's recommended sequence, turning on the oxygen supply prior to switching on the ignition coil and no explosions occurred.

The most probable reason for the explosions is that the chamber becomes filled with an aerosol of hot particles of the oil and its products of cracking. Admission of oxygen or even air can then produce an explosive mixture. It is for similar reasons that manufacturers of oil-fired central heating furnaces advise that ignition of a boiler which has failed to light should not be immediately re-attempted.

Incidents with food and fuel calorimeters similar to that described above have been reported. In one of these cases a peanut failed to ignite on the first attempt and an explosion occurred on the second, presumably for the reasons given above.

Since explosive mixtures can, in some circumstances, form inside the combustion chamber of these calorimeters, we would stress the need to follow the recommended sequence and for the following precautions:

(i) The oxygen or air current must be turned on <u>before</u> the ignition coil.

(ii) In the event of failure to ignite a foodstuff the calorimeter should be lifted off the base, allowed to cool and cleared of any remaining vapours by drawing air through it before making a second attempt.

(iii) The calorimeter itself be located inside a rubber covered retort ring so that in the event of an explosion the calorimeter can "lift off".

(iv) A safety screen should be used.

(v) Oxygen is not always required and air should be used when trying a foodstuff for the first time.

(vi) If rocksil wool is used it should first be roasted in air. Whilst we think it most unlikely that the presence of oxidisable impurities in rocksil wool constitutes a hazard in this situation, clearly such impurities, if present, would add a contribution to the heat given off and hence produce an error.

We have been in contact with two of the main suppliers of these calorimeters and have suggested that points (i) and (ii) above be more strongly emphasised, possibly with the instructions in simplified form, or a warning being given on the lid of the calorimeter. It might be prudent for schools to place a warning on existing equipment with dymo tape. Another possible development we shall be looking into is the provision of pressure relief vents, possibly in the form of a spring loaded door in the base of the calorimeter.

By coincidence we have for some time been developing designs for heat of combustion calorimeters, an account of which will appear in the 'Chemistry Notes' section of the next Bulletin.

Biology Notes

Resolving power, the ability of a lens system to resolve fine detail, largely depends on two major factors:

(a) The quality - freedom from aberrations, and the numerical apertures of the lenses themselves and

(b) the quality of the illumination.

Since (a) is largely determined by the designer and manufacturer we have little real control over this factor except at the time of purchasing a microscope. In order that we obtain the best possible performance from the instruments purchased it is important that we understand how the illumination of the object may affect the quality of the final image. A great deal has been written in the Bulletin about purchasing microscopes. Much less has been said about getting the best out of them. We hope the following notes will be useful to teachers and to older pupils who are at the stage where they need to improve their basic technique in using the microscope.

The substage disc diaphragm of elementary instruments is mainly used to control glare. It is employed, with or without a simple single lens condenser, to try to ensure that the object is illuminated only over the area under observation. It is imaged in the object plane and acts as a field stop by limiting the effective size of the source, so reducing glare and improving contrast. (Fig. 1).

On more advanced instruments with a focussing condenser, a cone of light sufficient to fill the aperture of the objective is focussed on the object. The iris diaphragm of the condenser is imaged in the plane of the back lens of the objective and acts as an aperture stop, not as a field stop. This is because the primary function of the condenser is not so much to control glare as to control a more fundamental aspect of the illumination. The condenser is used in an attempt to make the object being examined behave, as far as this is possible, as though it were self-luminous.

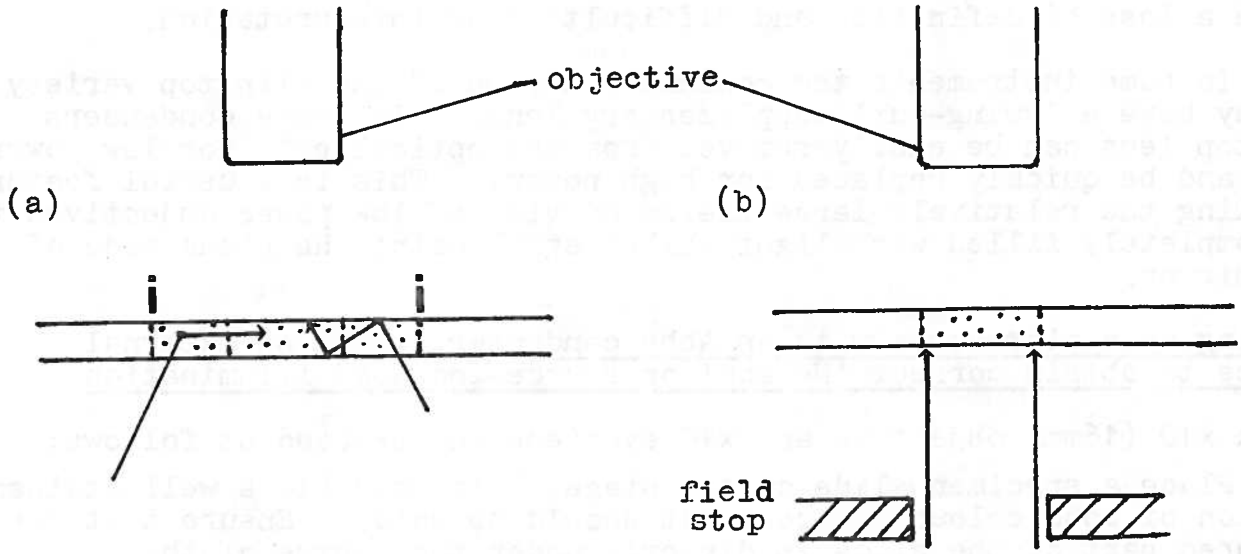

Fig. 1. The control of glare. In (a) the illuminated area i-i is significantly larger than the area actually under observation. Light diffracted by objects outside the immediate field of view and light reflected from the underside of the cover-slip and the slide may enter the objective, causing glare and reducing contrast. In (b) the illuminated area is restricted to that which is actually being observed.

Much of the optical theory behind the use of the microscope assumes self luminosity of the object, when light emitted by each point is quite independent of that coming from every other point. However in routine microscopy, thin, transparent or partially transparent objects are illuminated by 'borrowed' light from an external source. Here different parts of the same object may receive light from the same point on the external lamp. Because of diffraction at the object, light waves arising from different points on it will not be completely independent of each other and interference effects may well occur.

Such effects may make image interpretation very difficult, and resolution would be generally much less than that predicted theoretically for a self-luminous object. Therefore much of the effort to improve microscope illumination has been directed towards eliminating interference effects by making the object behave as nearly as possible as if it were self-luminous. Difference of opinion as to how best to achieve this aim have occasionally made microscope illumination a very controversial subject. It is usually accepted that the best way to achieve illumination approaching self-luminosity, is to focus an image of the external source onto the object, using a condenser lens with a numerical aperture equal to that of the objective.

The Abbe condensers on student instruments are very poor optically, being simple two lens systems with poor correction. However they do give a significant improvement in the performance of x40 objectives and are necessary if an oil immersion objective is to be used. The resolving power of a microscope depends primarily on the quality and N.A. of the objective lenses. The condenser only influences resolution in so far as it affects the degree of independence of light waves from neighbouring points on the object. Without a condenser, resolution for two adjacent points drops to about two thirds of its optimal value. In addition, because of interference effects, the image detail tends to be surrounded by fuzzy rings and haloes which cause a loss of definition and difficulties of interpretation.

In some instruments the condenser may be of the flip top variety or may have a 'swing-out' supplementary lens. In these condensers the top lens can be easily removed from the optical path for low power work and be quickly replaced for high power. This is a useful feature, enabling the relatively large fields of view of low power objectives to be completely filled with light whilst still using the plane side of the mirror.

Setting up a microscope with an Abbe condenser, using an external source to obtain correct 'Nelson' or source-focussed illumination.

Use a x10 (16mm) objective and x10 eyepiece and proceed as follows:

(a) Place a specimen slide on the stage. If possible a well-stained section of good colour and contrast should be used. Ensure that the coloured part of the slide is directly under the centre of the objective.

(b) Place the external lamp about 15-20cm away from the instrument and square to it. Ideally the lamp should have an opal or pearl bulb and should possess a circular field stop. Very often such lamps are not available and an ordinary bench lamp has to be employed. If this is the case, then the lamp should be used to illuminate ground glass or draughtsman's tracing paper fixed to one side of a hole cut in a piece of blackened cardboard or hardboard. This illuminated area then functions as a secondary light source.

(c) Focus the slide and manipulate the plane mirror to centre the illumination.

(d) Focus the microscope condenser. The aim is to focus the image of the source in the object plane. If a field stop is fitted to the lamp then the condenser may be focussed on the edges of this. If there is no field stop, or if at its narrowest setting it more than fills the field of view, the condenser can be focussed on a pencil point or mounted needle held just in front of the lamp. The position of the condenser should be adjusted by means of its focussing mechanism until the image of the field stop or pointed object is in sharp focus at the same time as the image of the object on the microscope stage. An image of the surface of the bulb (possibly even of the manufacturer's names etc.) may be thrown into the field of view. To avoid this the condenser may be slightly defocussed.

(e) Change to the x40 (4mm) objective.

(f) The aperture of the iris diaphragm should now be adjusted to suit the numerical aperture of the x40 objective. This is done by removing the eyepiece and inspecting the illuminated circle at the back of the objective lens. This can be done either by direct inspection, or using a centring telescope focussed on the back lens of the objective. As the iris diaphragm is closed, the image of its edge will be seen at the periphery of the illuminated area. The diaphragm should be closed until the illuminated area occupies two thirds to three-quarters of the diameter of the back lens of the objective. It is usually recommended that this aperture adjustment be carried out for each objective on each occasion it is brought into use. However a single setting for the x40 lens will usually also serve adequately for the x10 objective and this saves time and trouble (1). Re-adjustment of the iris aperture (in the same way) may well be needed when the x4 or x5 low power is brought into use. There is a quicker method of aperture adjustment which is used by experienced microscopists for routine work. This is called the 'threshold of darkening' technique and is well described by Casartelli (2).

(g) Replace the eyepiece. The microscope is now correctly adjusted and ready for use. If the light is too bright, (not usual with a 60 or 100W bulb) the intensity should be lessened by the use of neutral density filters or by changing the bulb for one of lower wattage, or by altering the field stop on the lamp if one is fitted. The iris diaphragm of the condenser should not be used to control the intensity of illumination nor should the condenser focussing controls be adjusted. Slight adjustments of these controls may sometimes be necessary to control glare and obtain better contrast but as a general rule, intensity of illumination should be adjusted at some point in the light path between the lamp and the iris diaphragm of the condenser.

Illumination without a condenser - Setting up a typical 'O' - grade microscope using an external source.

For optimum illumination and resolution the aperture of the objective should be filled or nearly filled, with light. This is most satisfactorily achieved by having a condenser with a properly regulated iris diaphragm. In the absence of such a condenser, the apertures of medium and high power objectives may be very much underfilled and resolution will suffer. For the very obvious reasons of economy and ease of use, the vast majority of microscopes used up to 'O' grade are not fitted with such condensers. This is not a serious matter as long as the limitations of these stands are recognised.

As a general rule such stands should not have fitted objectives of greater magnification than x20. This is because of considerations of illumination and because simple stands do not usually possess a fine focussing control which is needed for objectives of higher power than x20 because of their small depth of focus.

When setting up this simpler type of instrument steps (a) and (c) as described above are followed. This part of the procedure is straightforward and little difficulty should be experienced in obtaining some kind of image. The difficulties experienced in using the simpler kind of microscope most often lie in obtaining optimal illumination with the simple controls available. The field may be difficult to illuminate evenly and there may be lack of contrast with excessive glare.

The most common form of sub-stage assembly for the control of illumination in lower school microscopes is the disc-diaphragm. This takes the form of a rotatable metal or plastic disc with a series of circular holes of various diameters. Most pupils, and many teachers, are unsure of the purpose and mode of operation of the disc diaphragm. An additional complication is that manufacturers frequently take insufficient care in the design of such diaphragms and of the five or six apertures provided; possibly only one or two make any appreciable difference to the illumination of the object.

Unlike the iris diaphragm of a more advanced instrument, which is imaged at the aperture or back lens of the objective and is therefore called an aperture stop, a hole in a sub-stage disc diaphragm is mainly used to limit the effective size of the source in order to reduce glare and improve contrast. The holes in a disc diaphragm should be used to limit the area illuminated to the diameter of a field of view, that is they act as field stops. Therefore one should usually select the smallest size of hole that will illuminate evenly the field of view. In fact on many 'O' grade instruments only the three smallest holes need to be used and on some instruments only the use of the x4 or x5 objective necessitates a change from the use of the smallest hole available. Occasionally it may prove difficult to illuminate the whole field of view with the x4 or x5 objective. In this case the concave mirror may have to be used and the lamp moved nearer to it in order to produce an effectively larger source. This is acceptable for low power work but produces a distorted image of the source. On an 'advanced' instrument it may be necessary to remove the condenser. Even if it can be left in place it may be difficult to focus accurately.

The use of daylight illumination.

Ordinary daylight is often the most readily available of all sources of illumination and is used a great deal for routine microscopy. Many authors condemn this use of daylight as a source, but there is no real reason why it should not be used, provided its limitations are understood (3). Daylight is a very diffuse source of virtually unlimited extent so that light enters the microscope at all angles and from every direction. It is therefore difficult to know when the 'source' is focussed on the object and to restrict the illuminated area to the field of view. Thus there is a greater tendency towards glare than with the more controllable artificial sources. Apart from this problem of glare there are few serious objections to the use of daylight, provided care is excercised in properly illuminating the aperture of the objective.

The setting up of the microscope is much the same as described already.

(a) Place the microscope near a large window preferably one without too many glazing bars.

(b) Focus the x10 (16mm) objective in the usual way using a well stained slide.

(c) Remove the eyepiece and inspect the back lens of the objective.

(d) If fitted, the substage condenser should be racked up and down until (i) a fairly sharp image of the condenser iris diaphragm can be seen at the back lens of the objective and (ii) when the diaphragm is fully opened, the back lens can be fairly evenly filled with light.

(e) Replace the eyepiece. A reasonable good image should be seen and minor adjustments of the iris diaphragm can be made to reduce glare. With a simple '0' grade instrument step (d) has to be omitted and the sub-stage disc diaphragm used in an attempt to control glare.

Obviously with daylight the source cannot actually be focussed on the object. However it can be helpful to hold a pointed object 15-20cm from the mirror and to focus this in the field of view. This often ensures fairly good illumination of the back lens. Because the source is of almost unlimited size the exact position of the mirror is not very critical. The imaging of glazing bars in the field of view can often be avoided by tilting the mirror slightly or placing the microscope closer to the window. In summary then, while daylight provides a very convenient, and useful source, giving adequate illumination when 'contrasty' specimens are used, the more readily controllable artifical external sources are generally to be preferred.

References

(1) Bradbury, S., 'The Optical Microscope in Biology', Studies in Biology Series No. 59, Edward Arnold, 1976.

(2) Casartelli, J.D., 'Microscopy for Students', McGraw-Hill, 1965.

(3) Barer, R., 'Lecture Notes on the Use of the Microscope', Blackwell Scientific, 1968.

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We have recently prepared an equipment list for 'O' grade Agricultural Science. Because of the small numbers of presenting centres for this subject we have not made a general distribution of this list. Copies can be obtained by writing to the centre enclosing a postal order or cheque for 20p to cover printing and postage costs.

Physics Notes

The following items of surplus equipment are offered for sale. From Item 947 onwards we give details of newly available stock. Items from No. 947 to 986 will be subject to the ballot procedure described in Bulletin 91. Items before No. 947 are unsold stock from previous lists (relevant Bulletin number in brackets) and are not subject to the ballot.

In addition to the items listed below we still have large stocks of electronic components, resistors, thyristors, switches, capacitors etc, all of which are sold at 'rock-bottom' prices. Enquiries are invited from any school having requirements for such components.

Item 665.	(Bulletin 89)	Large microammeter. £3.
Item 707.	(Bulletin 91)	Power diodes. 2p.
Item 718.	(" ")	Developer. 20p.
Item 741.	(Bulletin 97)	Fixer. 10p.
Item 762.	(" ")	Titling unit. 50p.
Item 788.	(Bulletin 100)	Test set. £4.
Item 789.	(" ")	Low voltage variac. £1.
Item 800.	(" ")	Sodium lamp. 20p.
Item 811.	(" ")	Hypam fixer. 35p.
Item 856.	(Bulletin 105)	Pump plate. £25.
Item 861.	(" ")	Gold-leaf electroscope. £4.
Item 863.	(" ")	Large compression spring balance. £6.
Item 869.	(" ")	Cooling fans. £2.
Item 870.	(" ")	Motor. £2.
Item 871.	(" ")	Motor. £1.
Item 872.	(" ")	115V motors. 50p.
Item 876.	(" ")	Photographic paper, 5½ x 5½", WSG1S soft, box of 100 sheets. 75p.
Item 890.	(" ")	Sodium hydroxide. 30p.
Item 891.	(" ")	Planetol. 50p.

Item 901. (Bulletin 107) After the success of our pilot scheme for selling 'Perspex' offcuts obtained from I.C.I. we have ordered another 500kg pallet. By the time this Bulletin arrives in the schools the material should have been delivered to the centre. The mixture will be as before but we will have rather more coloured material available in order to satisfy the demand from Technical and Art/Craft teachers, enquiries are invited. Prices will be slightly higher than those given in Bulletin 107, reflecting the increased prices charged by I.C.I.

Item 913. (Bulletin 107) Galvanometers. £2.

Item 917. (" ") Interference suppressors. 20p.

Item 918. (" ") Heavy duty relays. 25p.

Item 919. (" ") Mercury wetted relays. 10p.

Item 921. (" ") Finned heat sink with resistor. 50p.

Item 934. (Bulletin 110) Transformer 240/110V. £2.50.

Item 936. (" ") Telephone. £2.

Item 939. (" ") Self-energised microphone/earphone. 30p.

Item 940. (" ") Head and breast set. 60p.

Item 944. (" ") Co-axial cable. 5p/m.

Item 945. (" ") Multistrand heavy duty cable. 5p/m.

Item 947. Electronic calculators, desk type, various makes. £3.

Item 948. Electronic calculators, large desk type, nixie tube display. £5.

Item 949. Battery chargers, by Davenset Model G1A 226/250V 50Hz input, 6-30V D.C. output, 5A max., with meter and overload cut-out. £5.

Item 950. Galvo lamps, various makes, complete with stand and integral transformer. £3.

Item 951. Micro-film reader by Datagraphix. £5.

Item 952. Decade Current and Voltage Generator, 1482A by Redcliffe, 0-10V x 100uV steps, current through 10 - 10 Ω or in decade ranges providing DC of either polarity. £5.

Item 953. Airmec Voltmeter, DC ranges 5,50 and 500V AC ranges 1.5, 5,15,50,150V; number of Ohms ranges up to 10 Ω. £5.

Item 954. Valve Maintained Tuning Fork by Muirhead. £3.

Item 955. H.T. Power Unit, ± 3.5kV fixed, with meter reading 5kV f.s.d. £2.

Item 956. A.C. Range Box, by Cambridge Inst. C. 1-1000V in 7 ranges, 1mA - 10A in 9 ranges. £4.

Item 957. D.C. Range Box, by Cambridge, 0.1 - 1000V in 9 steps, 0.2mA-10A in 10 steps. £4.

Item 958. Budenberg pressure gauge, 0-30lb/in^2, with overload switches and electrical output. 50p.

Item 959. Liquid level/differential pressure gauges, various ranges, large dials. £1.

Item 960. KDG combined vacuum/pressure gauges. £1.

Item 961. N and Z temperature gauge, 0-200°C x 2°C, with x ft. of tubing and sensor. £1.

Item 962. As above but 0-120°C x 1°C. £1.

Item 963. Multimeter by Victoria Instrument 0-1.5V and 0-3V, 0-60mA and Ω with external 1.5V cell, 250 Ω meter. £2.

Item 964. Wattmeter, non-recording, 0-1.5kW, 200V max. £3.

Item 965. As above, 0-2kV, 240V max. £3.

Item 966. As above, 0-4kW, 240V max. £3.

Item 967. Water bath, Baird and Tatlock, thermostatically controlled but unstirred, with cover. £5.

Item 968. Dry cell, 6V bell type, spring terminals. 20p.

Item 969. Standard cells. £2.

Item 970. Intercom set, 1 master and 1 slave unit. £2.

Item 971. Telephone amplifiers, small microsphone to attach to handset with one loudspeaker. 50p.

Item 972. Electrosensitive recording paper, substitutes for Teledeltos paper, also makes salt bridges, 2 sizes of roll. 2p and 3p/roll.

Item 973. Dry cell, 4.5V, Ever Ready 126. 15p.

Item 974. Dry cell, 1.5V Vidor 'Flag Cell'. 15p.

Item 975. Dry cell, 1.5V Admiralty pattern. 5p.

Item 976. Meter, small edge scale type 0-1mA. £2.

Item 977. Meters, circular face, panel mounting, 0-5mA, 0-10mA, 0-50mA, 1-0-1mA. £2.

Item 978. Meters, rectangular face, 0-1mA, 0-10mA. £3.

Item 979. Dry cell, 9V Admiralty pattern. 20p.

Item 980. Transformers, primary 200/250V, secondary 2V-47V-51V, 1.2A. 50p.

Item 981. Micro-switches heavy duty. 10p.

Item 982. Micro-switches small. 5p.

Item 983. Aldis slide projector 300W, 230V in working order, not quartz-halogen, with slide carrier and film-strip attachment. £5.

Item 984. Portable frequency standard, type G415 by Furzehill Laboratories, 10 , 10 , 10 , 10 Hz. £5.

Item 985. Timer, type 1350-A by Labgear, intervals-minutes down to .01s - displayed on 5 decatrons. £5.

Item 986. Scaling unit and timer by Dynatron. Not fully working. Contains 10 decatrons, 6 of which register time to 10,000s x 0.1s from mains frequency. £5.

Item 987. Plastic carboy 25 litre capacity. 40p.

Item 988. Plastic screw-cap bottle 1 litre. 1p.

S.S.S.E.R.C., 103 Broughton Street, Edinburgh EH1 3RZ
Tel. No. 031 556 2184.

Comber and Son, 490 Manchester Road, Stockport SK4 5DL.

GBI Laboratories, Shepley Industrial Estate, Audenshaw,
Manchester M34 5DW.