SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 55 May 1972.

Contents

Introduction

Our programme of exhibitions has filled up considerably and we shall have difficulty in undertaking other exhibitions. Already one exhibition has been arranged for the beginning of next session.

The following are the dates which have been arranged for exhibitions from now until the end of the session:

Exhibition	Place	Date
Biology	Science Centre, Aberdeen	11th May
S.S.S.E.R.C. Apparatus*	Jordanhill College of Education	19th May
S.S.S.E.R.C. Apparatus	Technical College, Falkirk (For Technicians)	25th and 26th May
Environmental Studies	Teachers' Centre, Alloa	12th-14th June
Chemistry S.Y.S.**	St. Andrews University	21st June
Physics S.Y.S.**	Dundee University	29th June

* College students only
** In service course

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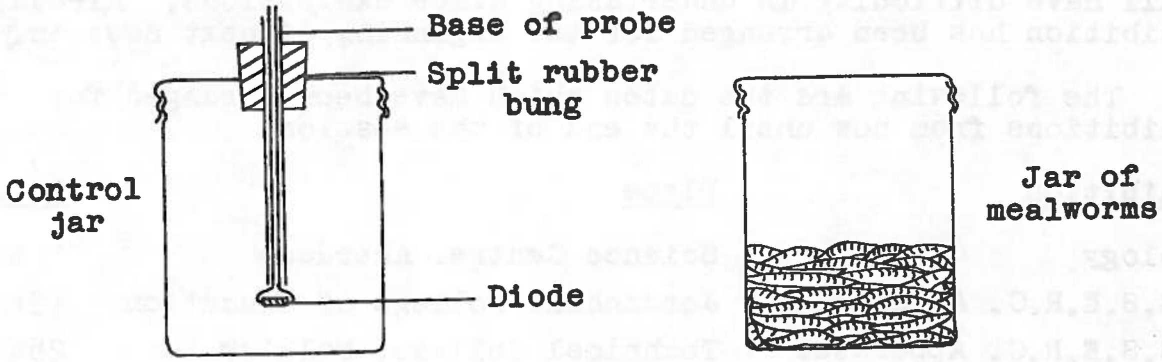
We should like to stress that the meter amplifier, and the silicon diode thermometer described in Physics Notes, particularly the thermometer, will be very useful in biology and chemistry as well as in physics.

Biology Notes

Silicon Diode Thermometer The thermometer which is described in the Physics Notes of this bulletin has several uses in Biology, of which the following are of particular interest:

1. Ecological work The 0-30°C scale makes it particularly useful for this type of work. The diode may be mounted in a probe of any length, to suit the work envisaged. Readings down to -10°C are also feasible by turning the pointer up 10 divisions on the scale, thus changing '10 to 0' to '0 to -10'. Similarly, if readings around 37°C are required on this scale, the pointer can be turned down 10 divisions.

2. <u>Respiratory heat detection</u> Energy output in respiration is commonly detected as heat from invertebrates and germinating seeds, in a differential air thermometer (section III(4)(a) of the syllabus). The diode thermometer provides a more reliable method. The most sensitive range is used, and the probe is fitted into a rubber bung which is inserted into the lid of a screw-top jar as shown:



The reading is first allowed to stabilise, and the pointer zeroed, in the control jar, and then the probe is quickly transferred to a jar of organisms, e.g. mealworms, locusts, etc., when the needle should move rapidly up the scale. If several organisms in different jars are used, the probe should be returned to the control jar between each reading. This makes a particularly effective demonstration if a demonstration meter is plugged into the outlet from the thermometer. The most suitable meter for this purpose that we have found is a 10mA, 10Ω type, though any low resistance meter up to 10mA will probably be satisfactory.

3. <u>Skin capillary contraction</u> This is an important example of a body control mechanism - see section IV(8)(c) of the syllabus. It is very simply demonstrated with the thermometer. Lightly fix the diode (preferably one not mounted in a probe) to the index finger of one hand, with sticky tape. A sliver of cork under the tape will help to insulate the diode. Plug in the diode lead and switch the thermometer to its most sensitive range. Use the set zero knob to bring the pointer to the 100 mark on the scale. (It may take a few minutes for the pointer to stabilise). Then plunge the other arm into a deep bucket of ice and water. The pointer should start to move down the scale within seconds, showing the contraction of the peripheral circulation in the first arm. At the same time a clinical thermometer in the mouth should show no drop in general body temperature.

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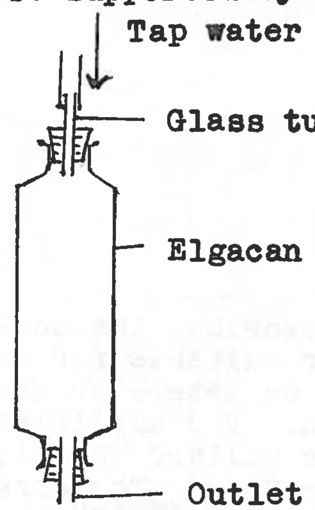
<u>Slides and Transparencies</u> In the supplement to Bulletin 52 the <u>Gerrard and Haig</u> 'O' Grade Pupil Set (OGP) was listed at £17.00. This should have been £27.00.

Chemistry Notes

<u>Cheap Water Purifier</u> This is based on the replacement cans which are available for the Elgacan Deioniser sold by <u>Elgastat Accessories Ltd</u>. The can is thrown away when it is exhausted. A pack of four cans costs £4.75.

The can as received has a screw-on lid at each end. The lids are removed and replaced with suitable one hole rubber stoppers, glass tubes and plastic or rubber tubing as shown in Fig. 1. The can may be supported by a clamp on a retort stand or fitted to a wooden stand using Terry Clips. The volume of water that can be deionised by one can depends on the quality of the tap water used but as a guide, water with dissolved solids of 50ppm as Calcium Carbonate, would yield about 30 gallons of deionised water.

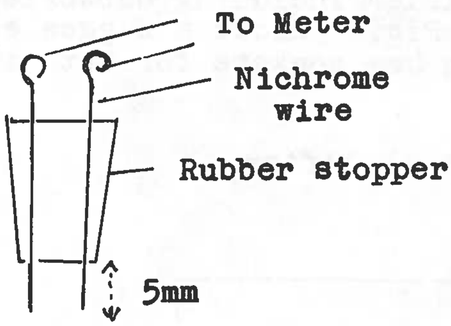
Fig. 1.



The purity of the deionised water should be checked occasionally. This can be done with a conductivity meter if available or as follows:

Nichrome wire, 18 gauge is fitted to a No.17 rubber stopper as shown in Fig. 2. We allowed the wire to project 5mm but this was purely a nominal distance, the idea being to have a constant area of electrodes exposed. The electrodes are then connected to a suitable meter for measurement of resistance. The electrodes are then dipped in the water and the resistance measured in deionised water of known purity say from a fresh can or another deioniser fitted with a purity meter. Thus when tested in future the can may be taken to be exhausted when the resistance is below that determined above.

Fig. 2.



When using deionisers it is very important that they should not be left unattended when operating. If care is taken, one can should produce pure water for a long time.

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<u>Sixth Form Topics</u> These are eight publications from <u>I.C.I.</u> on Catalysts; colloids; colour chemistry; fertilisers; polymers 1, long chain molecules; polymers 2, synthetic fibres; polymers 3,

plastics; spectroscopy and further spectra for teachers. They provide very useful information and should prove of some value to students studying the particular topics. Price is £1.00 for the set. Remittances should be sent to Kynock Works, P.O. Box 216, Witton, Birmingham B6 7BA.

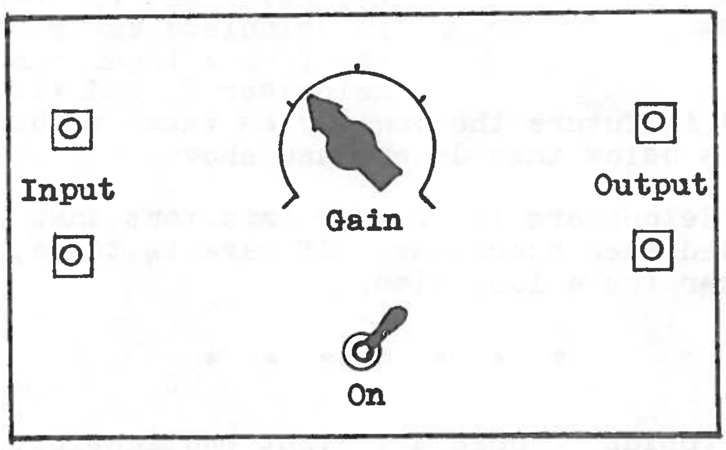
The booklets and sets of spectra produced by Strathclyde University are no longer available from the Centre and we therefore recommend the publication from I.C.I. on Spectroscopy with its accompanying set of spectra.

We assume that many teachers are already using the excellent Worksheets "Introduction to Chemical Spectroscopy" by D. W. A. Sharp and A. H. Johnston which are published by Heinemann.

Physics Notes

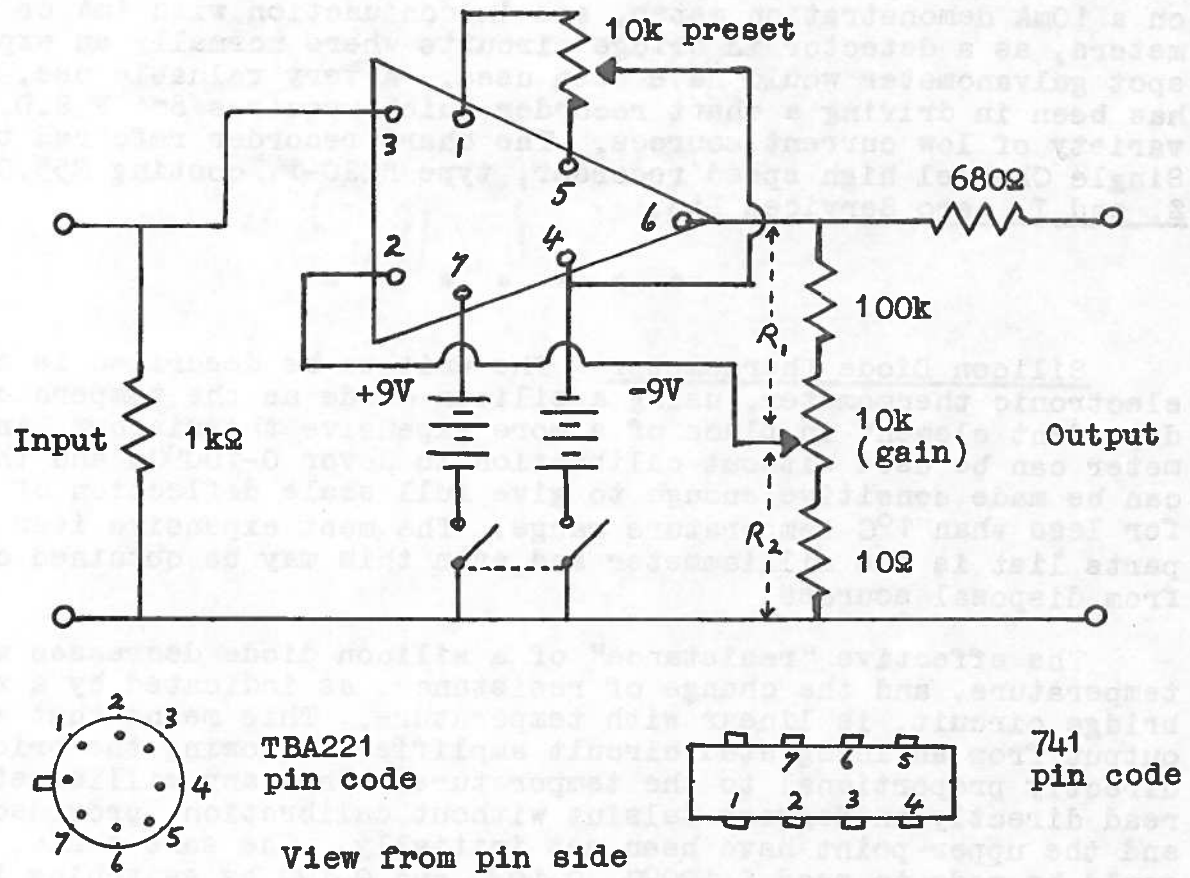
A Simple Meter Amplifier This article describes the construction of a simple but extremely useful D.C. amplifier suitable for detecting or displaying currents of 1 microamp (or less) on meters or chart recorders that require up to 10mA for operation. The amplifier is based upon an integrated circuit amplifier, the Mullard TBA221, but other similar I/C's, such as the 741C, could be used. The arrangement to be described has a voltage gain variable from 10^1 to 10^4, an output of 8 volt at currents up to 10mA, and an input resistance of 1000Ω. The power supply required is two 9V batteries, with an idling current drain of approximately 1mA, and a working drain dependent upon the output current being used. The whole amplifier including batteries can be mounted inside a box 12cm x 9cm x 5cm. Fig. 1 shows a suggested layout of the top panel of the amplifier, using 4mm sockets for both input and output.

Fig. 1. Layout of Top Panel of Meter Amplifier



The circuit diagram is shown in Fig. 2. It should be noted that the gain of the amplifier is given by the ratio R_1/R_2, so that some variation in design is allowable. For the values given, the maximum gain is $\frac{110000}{10} \simeq 10^4$, and the minimum gain is $\frac{110000}{10000} \simeq 10^1$. Similarly the input resistance is determined in this case by the 1000Ω resistor across the input terminal (the inherent input impedance of the amplifier is approximately 1 megohm) and this input resistor may be tailored to suit a school's particular requirements.

Fig. 2.



A full parts list is:

1 TBA221 operational amplifier	Farnell	73p
1 TO-5 operational amplifier holder (optional)	Farnell	30p
1 10k potentiometer linear (or inverse log) ¼W	R.S. Components	12p
1 10k pre-set potentiometer (linear) ½W	R.S. Components	12p
4 4mm sockets (2 red, 2 black)	R.S. Components	13p
1 100k resistor ½W	R.S. Components	10p
1 1000Ω resistor ½W	R.S. Components	10p
1 680Ω resistor ½W	R.S. Components	10p
1 10Ω resistor ½W	R.S. Components	10p
2 9V batteries PP9 or similar	Farnell	23p

4 battery connectors	Farnell	8p
1 two pole S.T. switch	Farnell	28p
1 instrument knob	Farnell	9p
1 case, approximately 12cm x 9cm x 5cm	Farnell	65p
1 piece of veroboard, or mounting strip or aluminium sheet.		

Total cost is approximately £3.00

The amplifier at the Centre has been used to display the microamp current from a photo emissive cell (and other similar small currents), on a 10mA demonstration meter, and in conjunction with 1mA or 10mA meters, as a detector in bridge circuits where normally an expensive spot galvanometer would have been used. A very valuable use, however, has been in driving a chart recorder which requires 8mA F.S.D., from a variety of low current sources. The chart recorder referred to is the Single Channel high speed recorder, type H320-1, costing £55.00, from Z. and I. Aero Services Ltd.

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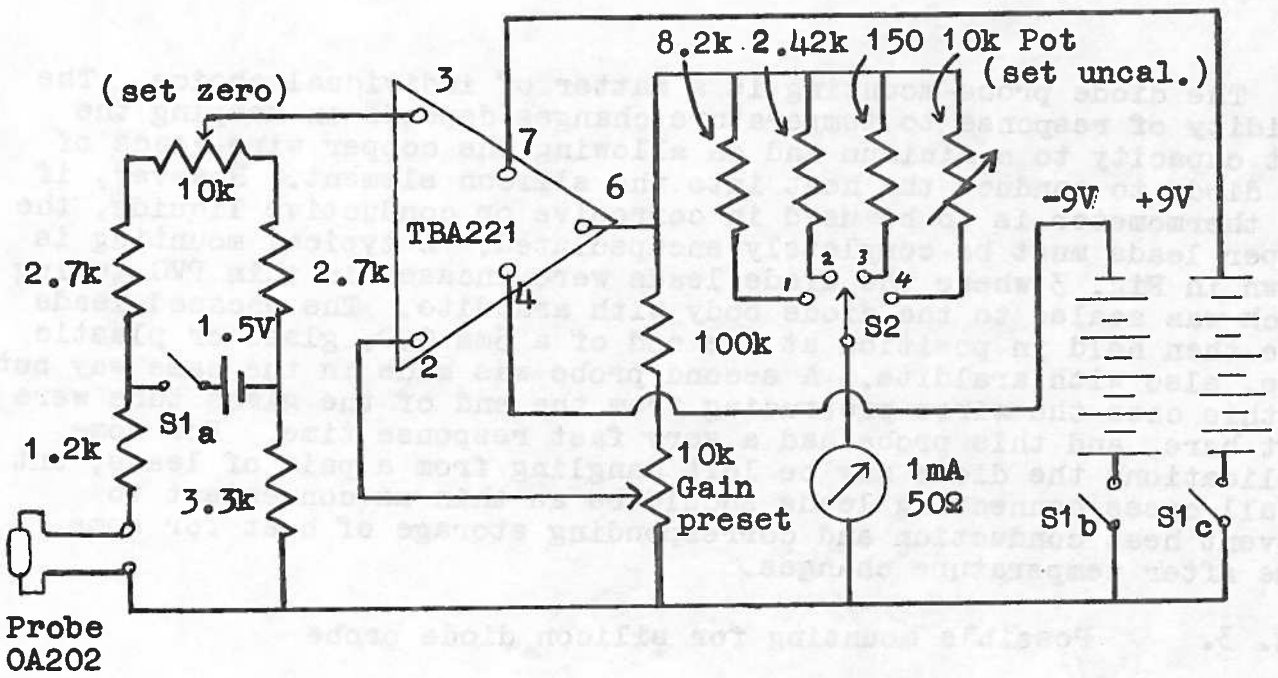
Silicon Diode Thermometer The unit to be described is an electronic thermometer, using a silicon diode as the temperature dependent element in place of a more expensive thermistor. Any 0-1mA meter can be used without calibration to cover 0-100°C, and the unit can be made sensitive enough to give full scale deflection of the meter for less than 1°C temperature range. The most expensive item in the parts list is the milliammeter and even this may be obtained cheaply from disposal sources.

The effective "resistance" of a silicon diode decreases with temperature, and the change of resistance, as indicated by a wheatstone bridge circuit, is linear with temperature. This means that the current output from an integrated circuit amplifier following the bridge is directly proportional to the temperature. Thus any milliammeter can read directly in degrees Celsius without calibration, provided the zero and the upper point have been set initially. The same scale, 0 to 1mA, could be made to read 0-100°C, 0-10°C and 0-1°C by switching in appropriate resistors. The I/C amplifier used in the instrument, a Mullard TBA221 (741), is sufficiently sensitive to give 1mA output for less than 1°C temp change and is powerful enough to drive a 10mA demonstration meter.

The small size of the OA202 silicon diode gives it a low thermal capacity, so that it responds rapidly to changes in temperature, while its sensitivity allows it to display small temperature changes adequately. However almost any type of silicon diode can be used in this arrangement. It should be noted that if more than one diode is to be used with the basic thermometer unit, it will be necessary to adjust the zero set and gain controls for each diode to cater for the slight differences in characteristics. When extreme sensitivity is required over a limited temperature range a thermistor may be used in lieu of the diode and qualitative changes in temperature can be readily demonstrated.

The circuit diagram is shown in Fig. 1. It will be noted that the I/C amplifier section is similar to the meter amplifier described in this bulletin on page 4 with the omission of the offset null potentiometer, as zero setting is here accomplished by balancing the bridge. Fig. 2 on next page shows a typical layout for a top panel, either flat or sloping front, and the prototype was fitted into a die-cast box 18cm x 12cm x 8cm. The ranges selected were: 0° to 100°C (8.2kΩ resistor); 0° to 30°C (2.42kΩ resistor); 2.5°C (150Ω resistor); and an uncalibrated variable range (10kΩ potentiometer). Other ranges could be selected to suit particular needs, e.g. -10° to +40°C could be used to cover the use of the thermometer as an environmental temperature probe in Biology. Similarly for a fixed range instrument, e.g. 0-100°C, the controls could be simplified and a saving in the cost of parts would be effected.

Fig. 1. Circuit diagram for silicon diode thermometer



Switch 1: 3 pole 2 position

Switch 2: 1 pole 4 position

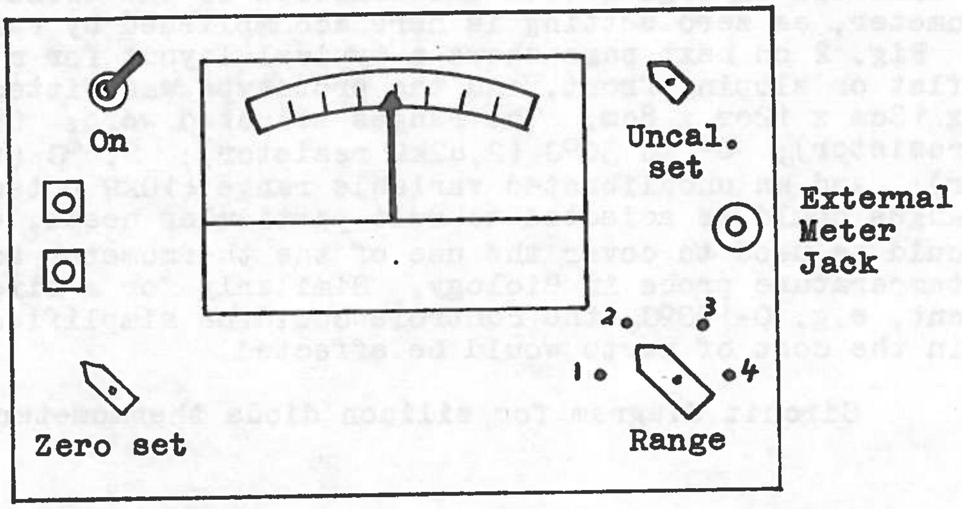
Range 1: 0°-100°C

Range 2: 0°-30°C

Range 3: 2.5°C F.S.D.

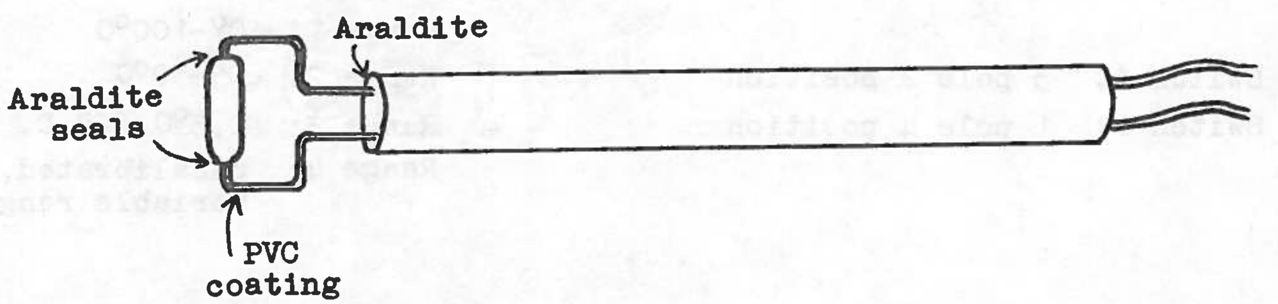
Range 4: uncalibrated, variable range

Fig. 2. Suggested layout of thermometer panel



The diode probe mounting is a matter of individual choice. The rapidity of response to temperature changes depends on keeping the heat capacity to a minimum and on allowing the copper wire leads of the diode to conduct the heat into the silicon element. However, if the thermometer is to be used in corrosive or conductive liquids, the copper leads must be completely encapsulated. A typical mounting is shown in Fig. 3 where the diode leads were encased in thin PVC tubing which was sealed to the diode body with araldite. The encased leads were then held in position at the end of a 5mm O.D. glass or plastic tube, also with araldite. A second probe was made in the same way but in this case the wires protruding from the end of the glass tube were left bare, and this probe had a very fast response time. For some applications the diode may be left dangling from a pair of leads, but in all cases connecting leads should be as thin as convenient to prevent heat conduction and corresponding storage of heat for some time after temperature changes.

Fig. 3. Possible mounting for silicon diode probe



The polarity of the connecting leads must be observed when joining to the diode so that it acts as a resistor of about 1000 ohm under the bridge voltage used.

Calibration is carried out, after the instrument has been completed, by setting the zero control (bridge balance) to give a reading of OmA when probe is immersed in melting ice, then adjusting the gain control to give 1mA (F.S.D.) with probe immersed in boiling water. Several successive adjustments of the zero control and the gain control may be needed before the gain control is finally locked in position. For ranges other than the 0-100°C, individual calibration and adjustment of the range resistors should not be necessary except to allow for the tolerance discrepancies in the resistor selected, and to allow for the internal resistance of the meter used (as this can be significant, especially on the low value ranges). Linearity over any range can be checked against a good mercury thermometer, and at the Centre the linearity of the diode was found to be better than that of the meter being used - a point to be borne in mind when selecting a "cheap" meter for the unit. If a meter other than a 1mA F.S.D. is to be used, such as a demonstration meter or chart recorder, the resistance value needed can be calculated by assuring an 8 volt output at 100°C.

This thermometer has been found to have useful applications in Physics, Chemistry and Biology, and the fact that its output is electrical means that temperature can be fed directly into a chart recorder to give, for example, a direct plot of a melting point curve. Its most sensitive range can be used to show the existence of a vertical temperature gradient in a heated room, or to show that respiring organisms, such as mealworms, are at a slightly higher temperature than their surroundings.

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The following items of surplus equipment listed in Bulletin 53 are still available. These are item numbers:- 17, 25, 49, 50, 51, 56, 68, 69, 103, 107, 128, 129, 130, 131, 132, 139, 143, 149, 150, 154, 175, 176, 197, 200, 203, 205, 210, 213, 233, 234, 236, 261, 288.

The following new items are now available -

Item 290 Tubular steel trolleys. Heavy duty, on large (7in dia.) castor wheels. Trays on three levels. Measuring 21½in. wide, 52in long, 37½in high overall. 3 off. £5.00.

Item 291 Developer. Johnsons D19 Powder for 3galls. 50p
D19 Powder for 5galls. 75p
D16 Powder for 20galls. £2.50

Item 292 Photo Flash Bulbs. 3-30V firing. Edison screw base. 2p ea.

Item 293 Fluorescent lamps. Philips. 2ft. 20 watt. 10p each.

Item 294 Bulbs. SBC base. 12 volt x 8, 12, 16, 24, 30, 48 and 80 watts. 2p each. SBC base. 6 volt x 1.8, 12, 36 and 48 watts. 2p each. SBC base. 3.6 volt x 1.5 watt. 1p each.

Item 295 Bulbs. MES base. 6 volt x 1.8 watt white. 1p.
2.5 volt x 0.75 watt red. 1p.

Item 296 Bulbs miscellaneous. Many odd bulbs with Bosch, Pre-focus and Projector bases in voltages up to 26 and wattages up to 240. 2p each.

Item 297 Glass domes. Flange base, suitable as bell jars. 5in dia x 5in high. 5p.

Item 298 Volt Meter. Demonstration, by G. and G. No. 57127B. £2.00. Also matching ammeter with damaged case. £1.00.

Item 299 Stop watches. 15mins x 1/10sec. £1.50.

Item 300 Blower units. i) Ex electric fire lighters. 240v AC. No element. 50p.
ii) Small centrifugal. 240v AC. £1.50.
iii) Small centrifugal. 12v DC. £1.50.

In The Workshop

<u>Live Mammal Trap</u> The trap shown below was sent from Inverurie Academy, Aberdeenshire. It seems to be very effective and is easy to construct; indeed, it is difficult to imagine a simpler design. The diagrams show the trap as though it were transparent. Food is placed in the trapping chamber. The mammal will usually walk up the see-saw until it tips, when the wire prongs fall and prevent the see-saw from tipping back again.

Fig. 1. Trap shut

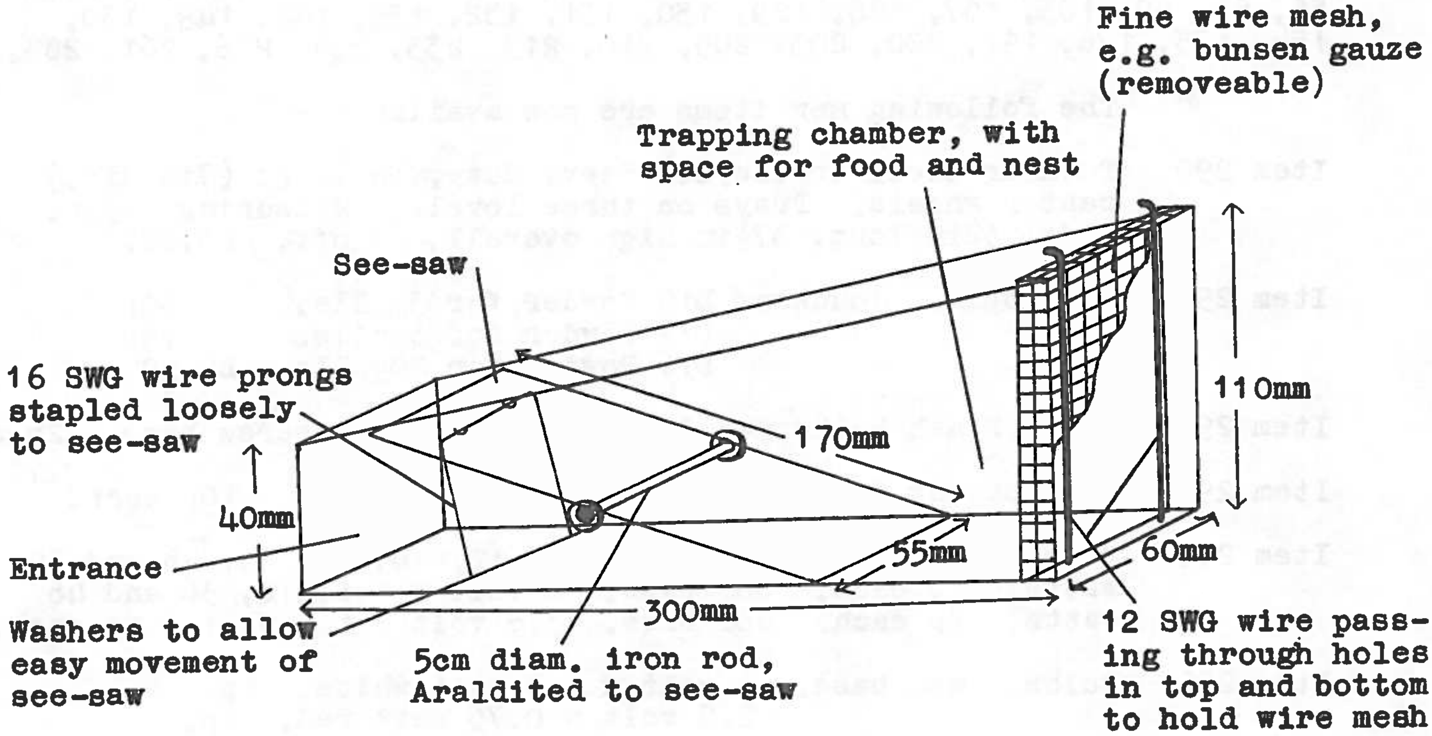
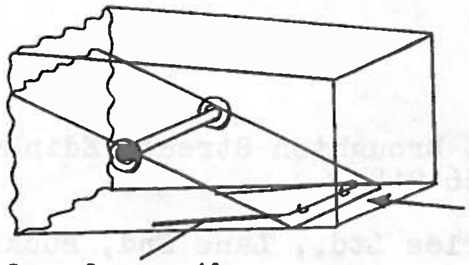


Fig. 2. Trap open (shown other way round from Fig. 1.)



The dimensions given are internal, but are approximate and not critical. The trap was constructed from 9mm plywood and the see-saw from 4mm plywood, but again neither the thickness nor the materials are critical. Indeed, we have also made a trap from the 64 x 51mm rectangular section Marley plastic drainpipe mentioned on page 2, Bulletin 42 and page 10, Bulletin 51, as used for mounting Physics components. In this case, however, the see-saw cannot be pivoted in the middle so must be weighted at the trapping chamber end. Again, wood may have some advantage over plastic in retaining odours and thus attracting further animals. In either case it is probably important to plane away the wood at the entrance end of the see-saw to present the minimum 'lip' to the animal entering. In winter animals may die if left in such a trap for too long. Therefore it is wise to make the trapping chamber long enough to allow adequate bedding to be put in, as well as food.

Trade News

We apologise for an error in the Trade News in Bulletin 54. Texas Instruments Ltd. and R.C.A. will sell cheap transistors (not resistors) direct.

Joseph Lucas (Sale and Service) Ltd. are again supplying the Car Electrical Kit; the price is £57.20. The last price we had for the kit was £85 as quoted in our Integrated Science, Second Cycle equipment list for electric circuits. In addition to the above, Alternator Sets are available; the 11AC Set at £19.10 and the 17ACR Set at £16.30.

Philip Harris now have available a Gas Analysis Kit B.5073, price £5.75. This kit is based on the S.S.S.E.R.C. method for Gas Analysis described in Bulletin 50.

The representative for Philip Harris is now Mr. Peter Vant, 9 Windsor Place, Stirling (Tele. Stirling 3544).

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

Elgastat Accessories Ltd., Lane End, Buckinghamshire.

Farnell Electronic Components Ltd., Canal Road, Leeds LS12 2TU.

Gerrard and Haig Ltd., Gerrard House, Worthing Road, East Preston, Sussex.

Heinemann Educational Books Ltd., 48 Charles Street, London W.1.

Joseph Lucas (Sales and Service) Ltd., Great Hampton Street, Birmingham B18 6AU.

Philip Harris Ltd., Highgate Square, Moseley Road, Birmingham B12 ODR.

R.C.A. (Gt. Britain) Ltd., Lincoln Way, Sunbury-on-Thames, Middlesex.

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

Texas Instruments Ltd., Manton Lane, Bedford.

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