SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 104. May, 1978.

Contents

Introduction

As was the case last year, the Centre will be closed on Saturday mornings during the summer holiday, from 1st July to 19th August, both dates inclusive. We are still open on weekdays throughout the summer, and on each Saturday morning until 1 p.m. outwith the holiday period.

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Allen Cochrane has attended a meeting on Safety in School Science called by the Association for Science Education at their Hatfield headquarters and chaired by Norman Booth, A.S.E. President. The meeting decided that there was a need for a central body to which teachers can refer for advice on safety matters, and which can give authoritative information, and that there should be wide representation on this body so as to cover all organisations concerned with science education. It decided to recommend itself as the central body, since it fitted the specification it had just drawn up. It also set up three sub-groups to look at different aspects of safety and report back to the next meeting. These were (i) to collect further information on L.E.A. codes of practice and on any particular local safety regulations; (ii) to look at hazardous materials and processes; (iii) to look at the broader aspects of educational safety. Allen is a member of the second group.

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A biology symposium to launch the Scottish Association for Biological Education will be held in Callendar Park College of Education, Falkirk, on 3rd June. SSSERC will have an exhibition of apparatus and experiments for biology at the meeting.

Opinion

It is two years since the Ruthven report 'Ancillary Staff in Secondary Schools', HMSO, was published and, perhaps somewhat uncharacteristically, I did not rush immediately into print on this page, although I had my misgivings at the time. I wondered how it was possible within a school to reconcile two statements in the report, actually two which appear on the same page.

(i) "In the same way as it is wasteful that the teacher should undertake tasks not requiring his professional skills, it is an uneconomic and an inefficient use of resources to expect a qualified technician to spend a part of his time on duties which do not exercise his full range of skills. --- We recognise that there will be times when the technician will have to help out with routine work, but --- we see no reason why selected general auxiliaries should not devote some time to general duties in the science department".

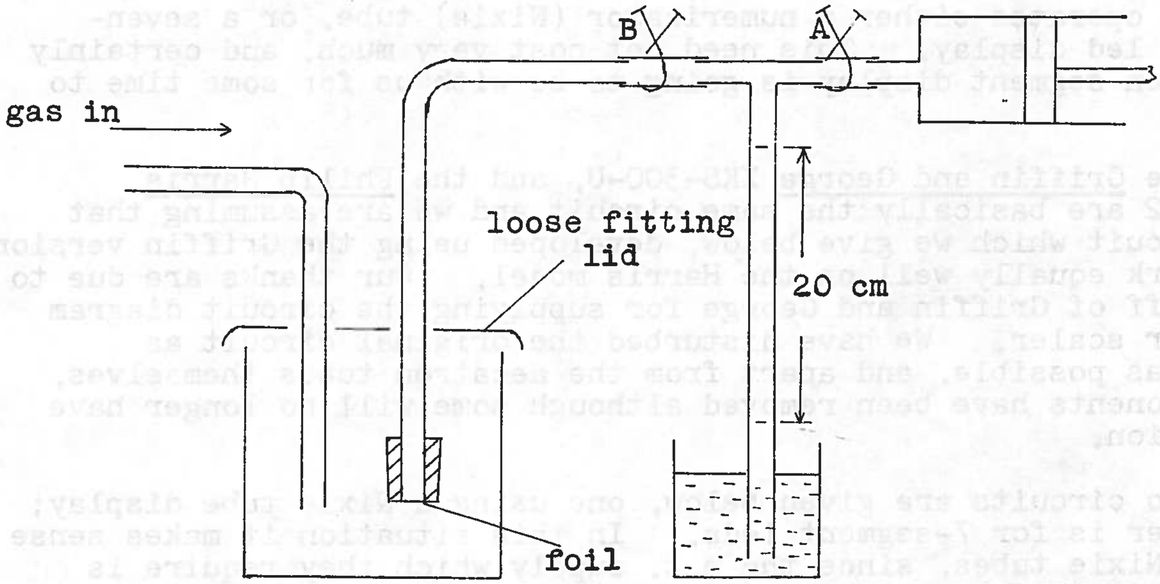
(ii) "We would favour a system under which the total complement of technicians would be deployed on a flexible basis to meet the total needs of the school. Technicians will operate mainly in science departments and their qualifications and training will normally be science based. But we think there would be considerable advantage to the school and to the technicians if they were organised on a team basis to make the best use of their range of knowledge and skills".

I could not see then nor have I learned since, how it was possible to employ a technician outwith the science field, where his qualifications and training are based, without requiring him to spend time on duties which did not excercise his full range of skills.

This appears to have come to pass. Over the few days of the annual A.S.E. meeting in Aberdeen I talked with a number of teachers who agreed that the way in which the Ruthven report recommendations are being implemented is a retrograde step. If technicians who leave for one reason or another are replaced, the appointment is on the 'total needs of the school' basis. The headmaster, deputy or assistant headmaster has charge of the technicians, and usually, it seems, this works to the detriment of both the science department and the technician. The former gets much less use of the technician while the latter gets less job satisfaction but many more opportunities for skiving. Where previously the unscrupulous technician could play off against each other only the heads of biology, chemistry and physics, he now has the whole gamut of promoted posts to choose from. While the Ruthven report envisaged the auxiliary devoting some time to general duties in the science department, I would postulate that it is now a hundred times more common to find the science technician devoting time to auxiliary's duties in other departments. Sadly, the consequence can only be that fewer school leavers who wish to become technicians will come into the schools' service, preferring to seek job satisfaction, career status and responsibility in further education or industry. How can SSSERC, or anyone else, help one head of department I talked to at Aberdeen who gets 33p per capita for equipment, books and stationery, and whose technician has to sharpen the pencils for the art department?

Chemistry Notes

A slight modification of the apparatus designed to measure the permeation rate of gases through a rubber membrane described in Bulletin 103 page 3, gives a simple, rapid way of comparing rates of diffusion of different gases.



A piece of 0.05mm thick aluminium foil (obtainable in chemical reagents catalogues) was glued to a single-holed rubber stopper and punctured with the end of a piece of 28 s.w.g. nichrome wire. We have also done this using a sewing needle and kitchen foil, producing the same effect as far as microscopic examination could tell. The 'manometer' glass tube is 13mm outside diameter. Two arbitrary reference marks were selected 3 and 23cm above the surface of the brine. The clip B was closed, clip A opened and brine drawn up above the top reference mark using the syringe. A is closed, B opened and using a stopwatch the time for the liquid level to fall between the marks is measured, this being repeated several times and a mean value taken. When the syringe piston gets too far down the barrel due to the gases being taken in, B is closed and the excess gas expelled through the brine by pushing in the piston. When a gas less dense than air was used, the system on the left of the diagram was inverted.

Results:

	Air	Carbon Dioxide	Methane
Average time t (s)	11.6	15.0	9.0
Gas density D (arbitrary units)	28.8	44	16
$\frac{\sqrt{D}}{t}$	0.46	0.44	0.44

Physics Notes

A few schools have been in touch with us concerning their scaler/timer, after they have learned that faulty decatron tubes cannot be replaced, or if they can be found will cost about £30 each, as this type of display is no longer being produced. What we suggest to remedy this situation is to change the circuitry so that it operates either a numericator (Nixie) tube, or a seven-segment led display. This need not cost very much, and certainly the seven-segment display is going to be with us for some time to come.

The Griffin and George XKS-300-U, and the Philip Harris P67340/2 are basically the same circuit and we are assuming that the circuit which we give below, developed using the Griffin version, will work equally well on the Harris model. Our thanks are due to the staff of Griffin and George for supplying the circuit diagram of their scaler. We have disturbed the original circuit as little as possible, and apart from the decatron tubes themselves, no components have been removed although some will no longer have a function.

Two circuits are given below, one using a Nixie tube display; the other is for 7-segment leds. In this situation it makes sense to use Nixie tubes, since the h.t. supply which they require is already in the scaler, being needed for the Geiger tube and the decatron tubes. On the other hand, although Nixie tubes are currently being advertised by suppliers in magazines like Practical Electronics and Wireless World, in addition to which we can offer them ex-calculculators at 50p, there may be some who fear that the Nixie tube will go the same way as the decatron all too soon. For them, a 7-segment display is the only answer.

Power for driving the t.t.l. circuitry is derived from a 10-0-10V winding on the transformer already in the scaler. This winding was clearly marked on the model we modified, but even if this is not the case, the winding can be identified using a multi-meter on a.c. volts range. After full-wave rectification the supply passes through a 2N3053 voltage regulator to provide 5V output. The power supply circuit, Fig. 3, is for use with the Nixie tube version, Fig. 1. 7-segment leds require considerable current and this moreover varies by quite an amount depending on how many segments are on. In the Nixie tube circuit, the current consumption at 5V is 100mA. If the 7-segment version, Fig. 2, is made up then the resistors in Fig. 3 require to be changed to 12Ω 1W in the collector, and 180Ω in the base, because of the higher current (average 340mA while counting) of the led version. We would also recommend that the 2N3053 for the led version be fitted with a heat sink (RS Components 401-548) as the power dissipation is of the order of 1W.

These additional power requirements raise the question of whether the low voltage winding on the transformer is able to supply them without overheating. The Fig. 2 circuit is the more demanding, and with this we have run the scaler continuously for a period of 4 hours without the transformer becoming unduly hot.

A pulse input is obtained from the guide A cathode (pin 8) of the units decatron base and passed through at BCY72 buffer transistor to the first decade counter, SN7490. This will drive either a SN74141 or SN7447, depending on whether Nixie tubes or seven-segment display is wanted. A second similar arrangement counts the tens, after which the electro-mechanical counting relay must be brought in.

The D output on pin 11 of the SN7490 goes high on the count 8, and drops low two counts later, at (1)0. The relay must be energised when the 0 registers, i.e. at the end of the D pulse. A monostable multivibrator SN74121 is used to provide this pulse, and its output is connected through an 8.2kΩ resistor to cathode 9 of the tens decatron tube base, which is the input for the relay drive circuit on the original timer.

The reset push button adjacent to the mechanical relay not only sets the relay to zero but operates a single pole change-over switch which resets the electronic display. Existing connections to this switch must be removed, and the wire ends taped up out of harm's way. The switch should then be connected as shown in the circuit diagram so that in the inoperative position (as shown) reset pins 2 and 3 are grounded, and connect to the +ve supply rail through a 1kΩ resistor when the button is pushed. The e.h.t. line, nominally 500V, will be found on the printed circuit board near the top above the decatron tube holders. A multirange meter on 1000V d.c. can be used to locate it. From it a lead is taken to two separate 330kΩ resistors to the anode of each Nixie tube.

In Fig. 1, those parts of the circuit enclosed in the dotted lines are already present on the scaler, and are shown only to aid identification of input and output points etc. All other components of Fig. 1 were mounted on a veroboard strip which was tailored to size to fit the two right-hand pillars joining front and back on the scaler so that the strip occupies the corresponding position to the transformer which is so mounted on the two left-hand pillars. It is necessary to ensure adequate earthing apart from that provided by the centre tap of the transformer winding, and an earth lead was joined between the p.c.b. strip and the earthed 4mm 'start' socket on the front panel. The power supply, Fig. 3 was also fitted on the printed circuit board.

Figs. 1 and 2 are complete in the sense that all the active connections between numbered pins are shown, but there are passive connections where pins are either permanently high or low, as well as supplies etc. These are given in table 1. Pins are not numbered either in Fig. 1 or table 1 may be left unconnected. Fuller information on the pin connections to SN7447 and SN74141 will be found in the table on page 5 of Bulletin 87. In fact the wiring of the counting and display circuits for the scaler and the frequency meter of Bulletin 87 are very similar, the main difference being that here there is no SN7475 latch.

Mounting the display so that it peers through the two holes left when the decatron tubes are removed is left to the ingenuity of the constructor. With one's own scaler it is possible to drill fixing holes in the front panel, but as our model is on loan from Griffin and George we did not want to do this. Instead we wedged the Nixie tubes between the front panel and the decatron bases with two blocks of expanded polystyrene and then used sellotape to hold all three together. Nixie tubes have wire-ended connections, so that there is no question of their requiring a plug-in holder.

7-segment led displays are small enough to drop out through the holes in the front panel so that a slightly different technique was used with them. Slightly undersized square holes were cut using a scalpel, in 12mm thick expanded polystyrene so that the displays were a reasonably tight fit. The polystyrene block measured 100 x 60mm, large enough to cover the front panel in the area around the decatron space so that both led displays were centred in the holes. 14 pin d.i.l. sockets were fitted to the displays and wires taken from the pins to the printed circuit board. Another polystyrene block was placed behind this assembly again to wedge it between the front panel and the decatron bases.

Those with their own scaler can undoubedly improve on this. Holes can be drilled in the front panel to take two fixing screws holding a piece of Veroboard on which the two d.i.l. sockets are mounted, and a clear plastic facing could be provided to stop the curious from poking into the hole surrounding the display.

The approximate cost of components for the conversion is given below, prices being current in April, 1978.

Item		Quantity	Supplier	Price
433-826	printed circuit board	1	RS Components	0.30
261-148	1N4001 diodes	2	"	0.09
102-853	2.2mF capacitor	1	"	0.49
(151-675	12Ω, 2.5.W resistor	1	"	0.12
(143-185	47Ω, 1W resistor	1	"	0.03
-	0.25W resistors, various	10	"	0.17
282-094	BZY88 5.6V zener diode	1	"	0.10
112-838	47nF capacitor	1	"	0.08
102-291	1μF capacitor	1	"	0.08
14 pin	d.i.l. sockets	3	Technomatic	0.42
16 pin	" "	2	"	0.30
SN7490	decade counter	2	"	0.80
(SN74141	Nixie tube driver	2	"	1.50
(SN7447	7-segment driver	2	"	1.70
SN74121	monostable	1	"	0.32
(ZM1080	Nixie tube	2	SSSERC	1.00*
(TIL312	7-segment display	2	Technomatic	2.20
2N3053	transistor	1	"	0.22
BCY72	"	1	"	0.18

additional items for seven-segment display only.

131-160	180Ω resistors	14	RS Components	0.34
401-548	transistor heat sink	1	"	0.07
14 pin	d.i.l. sockets	3	Technomatic	0.42

* An alternative is ZN1000 at £4.60 from Langrex supplies. This tube is not wire ended, but has pins fitting a 0.1" matrix which would make it more difficult to mount. Most RS Components prices are pro rata; it will be necessary to buy packs containing more than is required for the conversion. From the above, the minimum cost of the conversion using a Nixie tube display would be £6.08, and for the led version £8.40. TIL312 has 0.3 inch high characters, and this might be thought too small for class viewing. A 'jumbo' sized 7-segment display DL747 which has 0.7" characters is available from Technomatic at £2.25 each and although this is also common anode the pin connections are different from those shown in Fig. 2.

Finally, we should perhaps point out that for those who wish to make a really professional job of the conversion, there is available from Langrex a ZM1020 Nixie tube, cost £8.55, which is a physical replacement for the Z504S. It is a numerical indicator tube which is viewed end on, and it will plug into the

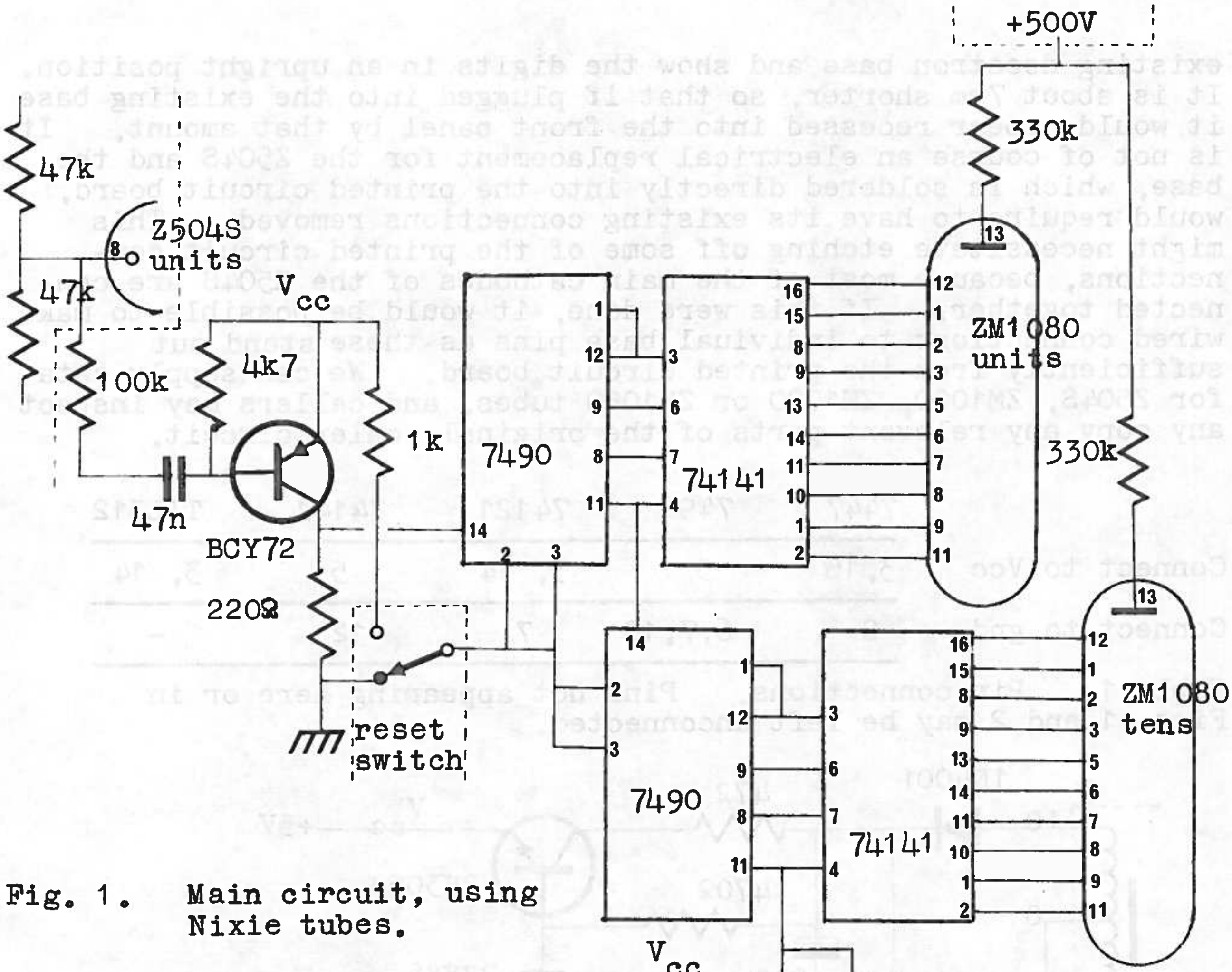
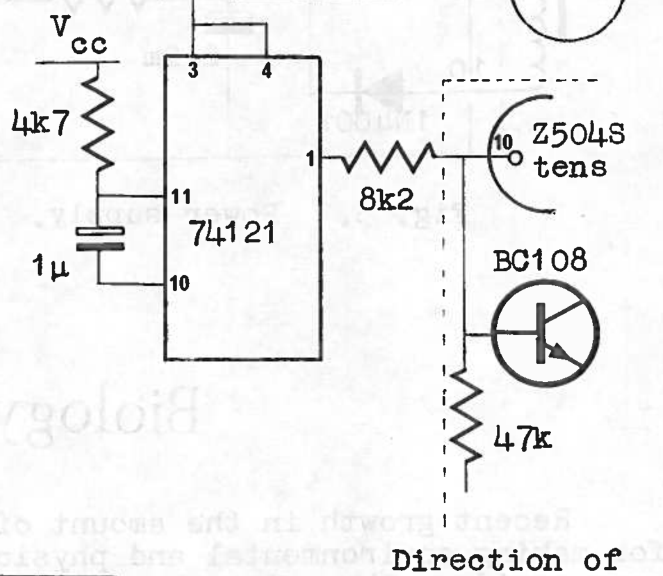



Fig. 1. Main circuit, using Nixie tubes.

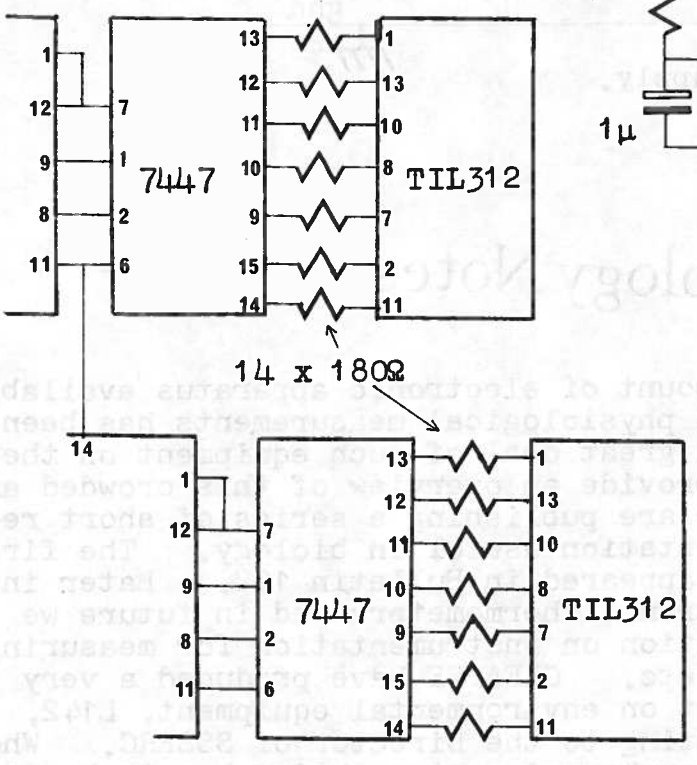
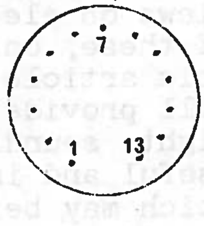


Fig. 2. Alternative circuit termination for 7-segment display.



Z504S and ZM1080 base connections.

existing decatron base and show the digits in an upright position. It is about 7mm shorter, so that if plugged into the existing base it would appear recessed into the front panel by that amount. It is not of course an electrical replacement for the Z504S and the base, which is soldered directly into the printed circuit board, would require to have its existing connections removed. This might necessitate etching off some of the printed circuit connections, because most of the main cathodes of the Z504S are connected together. If this were done, it would be possible to make wired connections to indiviual base pins as these stand out sufficiently from the printed circuit board. We can supply data for Z504S, ZM1000, ZM1020 or ZM1080 tubes, and callers may inspect any copy any relevant parts of the original scaler circuit.

	7447	7490	74121	74141	TIL312
Connect to Vcc	3,16	5	5, 14	5	3, 14
Connect to gnd	8	6,7,10	7	12	-

Table 1. Pin connections. Pins not appearing here or in Figs. 1 and 2 may be left unconnected.

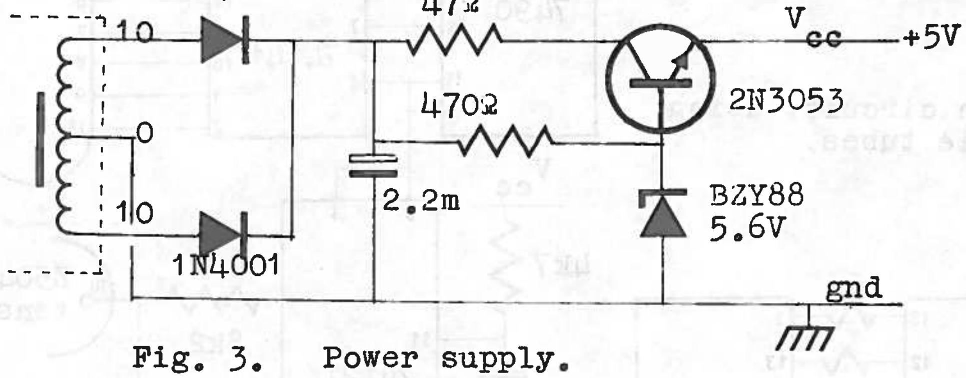


Fig. 3. Power supply.

Biology Notes

Recent growth in the amount of electronic apparatus available for making environmental and physiological measurements has been very rapid. There is now a great deal of such equipment on the market. In an attempt to provide an overview of this crowded and somewhat confusing field, we are publishing a series of short reviews on electronic instrumentation useful in biology. The first of these, on oxygen meters, appeared in Bulletin 102. Later in this article we review electronic thermometers and in future we will provide similar information on instrumentation for measuring light, sound, conductivity, etc. CLEAPSE have produced a very useful and informative report on environmental equipment, L142, which may be borrowed by writing to the Director of SSSERC. When considering the purchase of such equipment a choice has to be made between buying a collection of separate instruments or a comprehensive kit. This decision will depend very much on the parameters most frequently measured. At any one time, an electronic kit can be used only for as many investigations as it has meters. If certain parameters are not likely to be measured, it may prove cheaper, and more convenient for the organisation of concurrent investigations, to buy separate instruments.

At the present time two comprehensive electronic 'environmental' kits are available, one from Unilab, the other from WPA. In addition two multipurpose instruments are available from Griffin and George and for most environmental parameters there are a number of separate single function instruments on the market. The table below gives information on the relevant individual units of multipurpose instruments, as well as details of any separate single function instruments which might be considered suitable for school use.

For some biological applications, particularly in fieldwork, the traditional mercury-in-glass thermometer has obvious disadvantages. There are now available several types of electronic thermometer utilising a range of types of sensing device, these most commonly encountered being thermocouples, thermistors and silicon diodes.

Thermocouples are constructed from two different metals. They act as temperature transducers because the already dissimilar extent of electron freedom in the metals, is differentially affected by temperature. If there are two junctions between the metals and one is kept cold, a potential differnece is developed and a current will flow. The p.d. produced is directly proportional to the temperature difference between the junctions. The advantages of thermocouples are that they can give good reproductability and work over a very wide temperature range. If made small, they can have a rapid response to temperature change. Frequently however probes may have high thermal capacities and relatively slow response times. For absolute measurements accuracy will depend very much on the closenesss of control of variations in the cold junction or the cold junction compensation.

Thermistors are pieces of semi-conductor material whose resistance falls as their temperature rises. Unfortunately, in order to measure thermistor resistance a current has to pass through them, which alters the resistance one is trying to measure. Therefore, any measuring current has to be kept small and constant. Variations in the thermal conductivity of the surrounding medium and air movements may alter the rate of heat loss from a thermistor and effect the reading. Thermistors can be made extremely sensitive so that they show a rapid, but possibly non-linear, response to small changes in temperature. Readings may not be so reproducible as with a thermocouple and recalibration may become necessary.

Silicon diodes, and other semiconductor devices, when supplied with a constant current, develop a potential difference proportional to their temperature. Their response is often not as rapid as that of thermistors but is more linear and absolute measurements made with them may be more reliable.

Reference

CLEAPSE, 1977, Report L142 "Environmental Equipment for Schools".

Manufacturer/ Supplier	Description Cat. No.	Price	Probe type and temperature range	Notes
AWL Electronics	Zero 1 Digital Electronic Thermometer	£39.95	-50° to +150°C (ambient range 0° to 50°C).	Digital liquid crystal display with autopolarity. When probe is disconnected thermometer reads ambient temperature. Battery- 4 x 10L14, claimed life 80 hours, cost £2.50.
BAEP	Edale Instruments Electronic Thermometer Model K probe	£40.00 from £5 depending on type.	Wide range of interchangeable thermistor probes and temperature ranges available. Most useful range for biology -10° to +40°C.	Built-in calibration check. Instrument has 3 input channels. Battery - ZN9C mercury cell, claimed life, up to 2000 hours, cost 63p.
Griffin and George	Environmental Comparator YRC-210-A Laboratory probe YRC-310-560A Field probe YRC-310-580R	£40.60 £8.45 £17.50	Thermistor probes. 5 switched sensitivity ranges. Meter scaled 0-100 in arbitrary units. Overall available range approx. -10° to 120°C.	Instrument must be calibrated by user. Field probe may be extended with fibre glass extension pieces. Batteries - 4 x HP7 estimated life 2000 hours.
Griffin and George	Pocket Environmental Comparator YRC-420-A	£24.00	Thermistor probe. Scale in arbitrary units 0- 10 x 0.2, Linear from ca. -20° to +40°C (about 0 - 7 units on the scale). 0° - 40° = 4.6 - 7.0 units on instrument tested.	Instrument must be calibrated by user. Relatively large minimum temperature change discernible and small part of scale used in indicating temperature range usually met in fieldwork. Battery PP3, estimated life 200 hours.

Manufacturer/ Supplier	Description Cat. No.	Price	Probe type and temperature range	Notes
Philip Harris	Harris Environmental Thermometer B18580/9	£43.50	Diode probe -10 to +50°C and any 10°C span within that range.	Standard probe supplied on 1.5m lead. A probe on a 6m lead and 3m extendable rod is available as an optional extra. Battery PP6, estimated life 180 hours.
Harris Electronics	Mini Z1 Thermometer	£25.00	Thermister probe -40 to +70°C	Batteries 2 x HP7
	Mini Z2 Thermometer	£25.00	Thermistor probe -5° to +105°C.	
Offord	Electronic Thermometer OT/2	£36.00	Thermocouple probe -10° to +40°C	Internal cold junction compensation. Battery PP3, estimated life 200 hours.
	OT/3	£36.00	Thermocouple probe -20° to +40°C.	
Unilab	Temperature module 421.014 and the probe 421.015	£33.61	Thermocouple probe Ranges 0-30°C; 0-100°C, 0 to -100°C and any 10°C span within the range -100°C to +100°C.	Prices shown includes meter/power unit. Part of Environmental Kit. Cold junction compensation. Battery PP3P, estimated life 100 hours.
WPA	Thermometer module E1/T plus probe TP1	£27.25	Silicon diode probe. Ranges 0-30°C; 0-100°C and any 10°C span within the range 0-100°C.	Needs connecting to E1 meter unit of Environmental Multiprobe which has 2 x PP9 batteries, estimated life 500 hours.

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

AWL Electronics Ltd., Tudor Road, Broadheath, Altrincham, WA14 5RZ

(BAEP) BLK Advanced Engineering Products Ltd., 36 Douglas Road, Aylesbury, HP20 1HW

Cleapse Development Group, Brunel University, Kingston Lane, Uxbridge, Middx.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride, Glasgow, G74 3XJ

Philip Harris Ltd., 34/36 Strathmore House, Town Centre, East Kilbride, Glasgow, G74 1LQ

Harris Electronics Ltd., 138 Gray's Inn Road, London, WC1

Langrex Supplies Ltd., Climax House, Fallsbrook Road, Stratham, London, SW16 6ED

C E Offord, Hurst Green, Etchingham, Sussex, TN19 7QT

RS Components Ltd., P O Box 427, 13/17 Epworth Street, London, EC2P 2HA

Technomatic Ltd., 54 Sandhurst Road, London, NW9

Unilab Ltd., Clarendon Road, Blackburn BB1 9TA

(WPA) Walden Precision Apparatus Ltd., Shire Hill, Saffron Walden, Essex.