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SCOTTISH SCHOOLS SCIENCE EQUIPMENT RESEARCH CENTRE

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Radon in buildings
Sensor review

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ANNOUNCEMENT

Future of SSSERC

1. First - the Good News

For some while there have been persistent rumours, counter-rumours and indeed the odd hint in these pages as to the possible expansion of the Centre's staff and activities.

We can reveal that SSSERC has been negotiating over recent months with first the Manpower Services Commission, then the Training Commission and now the Department of Employment : The Training Agency. Although the title of the Company may have changed the dramatis personae have not - Agency Watchers will recognise these three as but different manifestations of the same organisation. We can only trust that by the time this appears they won't then be called something else.

We have recently agreed a contract based on a proposal for a "Joint Support Activity" (JSA) to be based on this Centre. JSAs were first suggested in a White Paper called "Working Together", which had an emphasis on training. This allowed for the funding of collaborative programmes involving several different EAs. They were intended to concentrate on support for applied science and technology teaching particularly within the context of TVEI and TVEI extension. There are to be ten such JSAs in the U.K. That based on SSSERC will be the only one in Scotland. It is unique also in that it builds on existing collaboration - of that between every Scottish Regional and Islands Council, all of whom are already committed to supporting the existing Centre.

For years SSSERC has been under pressure to expand and to allow greater access to its services for Technology Departments and their teachers. This latest development will allow us to take on a small number of extra professional and support staff for the next three years or so. That should relieve the currently intolerable pressure on existing staff members and allow us to offer a better and broader service. This may include technical resource support and development work for Technological Studies as well as for SEB Short Courses and SCOTVEC modules. The existing services for the separate sciences will continue.

2. Now - the Not-so-good News

Taking on extra staff and functions means a move to alternative premises. There are a host of other organisational problems with which we will have to deal. All of that is bound to have a serious short-term effect on the service. Production of Practical and Technical Guides for the Standard Grade Sciences will continue, but after this issue "Bulletins" may get scarce for a while. You may also suffer delays in getting answers to enquiries. We have therefore to ask you to be patient with us.

Nonetheless, we believe that we had little choice but to make such formal moves to support technology teaching in Scotland. We are sure that in the medium to longer term it will prove a wise development and become an essential service to Scottish education.

Biotechnology Symposium

Despite the postal dispute and a few other minor difficulties this national event took place more or less as intended on the 19th to the 21st of September. As to its success only the delegates can judge. That the discussion sessions were the only ones to over-run may have been a good sign.

It is the organisers' intention to produce a report on the outcomes of the meeting. It may be that SSSERC will get lumbered with the distribution of such a report. In that case many readers of this "Bulletin" should, eventually, receive a copy.

Thanks, Nick

This summer, with special funding from SED, we employed a student, Nicholas Lumb, to assist Centre staff research experimental work for the revision of Higher Grade Physics. The article "Radon in buildings - a simple detection method" was written by Nick, and is one of the fruits of this venture. We trust you find it useful.

Nick, a former pupil of the Douglas Ewart High School, Newton Stewart, reads physics at Edinburgh University and is now in his final year. He is clearly a lad o pairts. We thank him for his work and wish him well.

Christmas closure

If you have read the Announcement preceding this "Introduction" you will appreciate why we are giving the following unseasonally early notice. The Centre will close late in the morning of Friday, 23rd of December 1988 and not re-open until the morning of Wednesday the 4th of January, 1989.

Technical Resource Support for Standard Grade

Some readers will already know that we have been preparing "Practical Guides" or "Technical Guides" for the separate sciences at Standard Grade. The first of these, "Standard Grade Chemistry Practical Guide, Volume 1", covers Topics 1-3, 4/7 and 5. It was printed some weeks ago. At the time of this 'Bulletin' going to press distribution by SCCC had been delayed because of the postal dispute although a few readers may have received copies directly from SSSERC.

Volume 1 of the Standard Grade Physics "Technical Guide" should be back from the printers well before you read this. It covers Units 1 & 2 of the new syllabus. Again one copy will be distributed free to each secondary school in Scotland with further copies of both Guides are available at £4 each (inc. post and packing).

Comment

"Computer Crime? From the letters column of "The Scotsman".

Sir, - In the past three weeks some of the wordsmiths in the North Bridge seem to have gone gyte. Rain is now "teaming", wares are being "pedalled", "hoards" of fringe performers are about to descend upon us.....Or is it just that journalists are investing in those computers that "correct" your spelling? Considering that they make their living by words, you would think that they would care for them a bit.

Yours etc. ...."

And - how about this priceless, Amstrad spell-checked, piece on of all things the National Union of Journalists General Secretary Harry Conroy; a Blackpool conference; the EETPU and Rupert Murdoch etc.:

"NUN general secretary Hairy Control was to standby at the Blackmail Confess to add his voice to the death on the conservation of the electrical union EMPTY for its role in helping Ruder Murder to launch his Warping plant and sack the 5,000 print workers..."

Having recently been dubbed "Rich arse don" by an Apple Mac. spell-checker, I know just how "Hairy Control" must feel. Perhaps there is a lesson here for all those would-be instant, desk-top publishers out there. Quality of presentation matters little in the absence of quality content. It's a great pity they don't yet "bundle" writing, editing and proof reading skills with the software packages.

Radioactive sources - leakage tests

As a requirement of the Ionising Radiations Regulations many schools have now for the first time tested their sealed radioactive sources for leakage. From enquiries and reports to the Centre we know that some teachers are seeking further advice and are interested in the patterns emerging. This article describes how things now stand.

Sample results

The following (Table 1) is a typical set of measurements of uncorrected count obtained in tests of cobalt-60, strontium-90 and radium-226 sources. The measurements are then used to obtain the test results (Table 2).

source	count	count period (s)	average count
background	30	100	
background	31	100	31
Sr-90	30	100	
Sr-90	23	100	
Sr-90	38	100	
Sr-90	27	100	29
background	31	100	
background	36	100	33
Co-60	26	100	
Co-60	22	100	
Co-60	20	100	
Co-60	26	100	23
background	35	100	
background	33	100	34
background	266	1000	
background	266	1000	266
Ra-226 (2)	292	1000	
Ra-226 (2)	303	1000	297
background	291	1000	
background	299	1000	295
Ra-226 (3)	375	1000	
Ra-226 (3)	367	1000	371
background	300	1000	
background	282	1000	291

Table 1 - Leakage test measurements

source	corrected count	test result
Sr-90	-3 $(100\ s)^{-1}$	pass
Co-60	-10 $(100\ s)^{-1}$	pass
Ra-226 (2)	17 $(1000\ s)^{-1}$	pass
Ra-226 (3)	78 $(1000\ s)^{-1}$	fail

Table 2 - Leakage test results

Notice that the radium-226 test measurements have been made over periods of 1000 s rather than 500 s, which was stipulated in the description of the test in the Explanatatory Notes. The longer counting times make use of the 1000 s period automatic counts which are available on certain modern scalers, e.g. the Harris S-Range Digicounter (P67410/8) and Unilab Digital Scaler Timer (512.023). References to Ra-226 (2) and Ra-226 (3) relate to two separate sources held by the Centre.

Fluctuation in background

Continual measurements of background radiation show changes from one period to another which cannot be satisfactorily explained as random variation. For instance background radiation increased by around 10% during the course of the radon emanation tests (Table 1) from 266 to 295 $(1000\ s)^{-1}$, and dropped by about 30% during the wipe tests from about 33 to 23 counts $(100\ s)^{-1}$. A likely cause for such variations is advection, or the horizontal flow, of natural radon in the room where the tests were carried out. Radon accounts for roughly one half of natural background radiation. But as shown in another article in this Bulletin amounts of the gas can vary manyfold periodically, caused by the presence or absence of ventilation. It would seem that advection of radon either into or out of a room can be the mechanism whereby natural background radiation fluctuates.

Leakage tests should therefore if possible be carried out in a room with uniform ventilation. Ideally neither doors nor windows should be opened or closed during the test period. A ground floor or basement room is likely to have a higher concentration of radon than upper floor rooms.

The effect that variation in background count might have on the radon emanation test has been studied. The count was repeatedly measured over 1000 s periods, measurements being taken on each of three successive half-days (Table 3).

number of samples	average count $(1000\ s)^{-1}$	standard deviation $(1000\ s)^{-1}$
15	394	15
15	398	24
10	379	17

Table 3 - Variation in background

The change in the mean count in the final set, and the largish standard deviation in the second set, are presumed to be caused by fluctuations in radon levels.

The radon emanation test has a pass/fail mark which is of comparable magnitude to random variation in background count. The measurements show that the size of the standard deviation is roughly one half of the pass/fail criterion, namely 40 counts $(1000\ s)^{-1}$. Interpretation of the test results therefore requires care. Repetition may be necessary to establish whether a statistically significant difference is being detected.

Cobalt-60 and strontium-90 tests

The results shown (Tables 1 and 2) would seem to be typical of what most schools are getting for these types of sources. Count rates from wipes of cobalt-60 or strontium-90 sources are almost invariably indistinguishable from background.

However we have had reported to us one single instance of a significant corrected count from a wipe test. This was a corrected count of 70 $(100\ s)^{-1}$ from a wipe of a cobalt-60 source. By comparison a corrected count of 1000 $(100\ s)^{-1}$ from such a wipe would show that leakage had reached the statutory limit of 185 Bq on the wipe, which signifies that the source must be disposed of.

Any sizeable leakage from a school source would seem to be intolerable. It would indicate that the sealed integrity of the source had gone and that further deterioration should be expected. The cobalt-60 source reported with an appreciable wipe test count should therefore be disposed of, and perhaps replaced.

Radon emanation test

A sealed radium-226 source whose sealed integrity holds will not emit radon gas, contrary to the information given the Explanatory Notes (section 74). The emanation of radon is a sign that the source is leaking.

Radium-226 sources have an extremely thin metallic layer covering the source. Once this layer ruptures, due perhaps to being subjected to continuous irradiation, the source emits the gas, radon. In this condition solid particles of radium and its other daughter products can fall out.

In the radon emanation test the source undergoing testing is placed in a glass tube together with a piece of polyethylene. If the source is leaking, radon diffuses through pores in the polyethylene. Some of that radon decays to polonium-218, which attaches itself to the polyethylene. This nuclide decays in turn to lead-214, and so on down the uranium/radium (4n+2) series. The nuclide whose radiation is detected by the Geiger Muller tube is almost certainly bismuth-214. This is an emitter of 3 MeV beta radiation, which is sufficiently energetic to penetrate the glass walls of the test tube.

Pattern of failures

Returning to Tables 1 and 2, the tests on the two radium sources show that one is leaking, the other probably not. Radium source (2) gives a corrected count of 17 $(1000\ s)^{-1}$. This is not significantly different from background radiation, which has a standard deviation of around 20 counts $(1000\ s)^{-1}$, and falls below the pass/fail mark of 40 counts $(1000\ s)^{-1}$. However radium source (3) gives a corrected count of 78 $(1000\ s)^{-1}$, and fails.

Several test measurements on three radium sources, including these two, show a worsening trend with ageing (Table 4).

The National Radiological Protection Board (NRPB) have carried out a leakage test on radium source (3). They confirmed that the source is leaking slightly.

date of test	corrected count $(1000\ s)^{-1}$ Ra-226 (1)	Ra-226 (2)	Ra-226 (3)
Oct 86	13	-4	41 46 63
June 88	63	17	78 110

Table 4 - Radium source test results - influence of ageing

Many failures by radium sources have been reported to us. One region that has tested all its sources has found that 15 out of 27 radium sources have failed. Most such sources were manufactured about twenty years ago. It appears that since many have lost their sealed integrity these sources have in general come to the end of their lifespan.

Further tests on radium sources are being carried out for the Centre by NRPB. Once these tests are over, advice will then be circulated to schools as to what action to take on sources that are suspect. If sources have to be disposed of a mechanism for such disposal will be devised and you will be informed. In the meantime if you have in your school a radium source that is suspect, do not let it be used. Enclose the source and its receptacle in a polythene bag and keep it locked away in your school's radioactivity store.

Labgear sources

A number of schools have sources made by the firm of Labgear, which is now out of business. These sources are sandwiched between perspex plates about 5 cm square. Obviously a wipe test can still be carried out on appropriate sources as detailed in section 73 of the Explanatory Notes. If a radium source is to be tested follow the instructions in section 74, but substitute a glass Petri dish for a test tube.

Further advice

Should you need further advice or assistance on implementing the Ionising Radiations Regulations please contact the Centre.

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BIOLOGY NOTES

Modern instrumentation in biology teaching

Abstract

Specific biological illustrations are provided of more general concepts and principles set out in the "Instrumentation Notes" section of this bulletin issue. In particular the need to use electronic sensors is discussed together with educational arguments on requirements for "transparency" of operation.

Introduction - modern sensors

It is our belief that part at least of the reluctance of some biology teachers to use modern, electronic instruments is that they are put off by the technical mystique and jargonistic terminology. The "Instrumentation Notes" article in this issue gives useful technical definitions of terms like "sensor" and "transducer". Biologists, at least at the outset, may prefer plain-English, dictionary definitions. For example the "Concise Oxford English Dictionary" defines "sensor" thus:

> "A device giving a signal for detection or measurement of a physical property to which it responds".

We may as well also define "modern" which the OED puts as:

"Of the present and recent times; in current fashion, not antiquated".

"In current fashion" points to a possibly poor perception that some teachers may have of the need to become more familiar with modern instruments. If the sole reason for their use was because of "current fashion" then biologists would have every right to be suspicious and reluctant. In the absence of a sound educational rationale it may be difficult to persuade folk to make the effort to acquire knowledge and skills in the use of modern instrumentation.

Why do we need sensors?

Biology students should learn early on that there are five major sets of human senses :

- sight (light),
- hearing (sound),
- touch (pressure etc.),
- taste and smell (chemo - receptors).

We use these senses to monitor directly our immediate environment and to make simple measurements, such as of physical dimensions.

The need for sensors arises because the typical discrimination or resolution of the major senses of even the best of us is relatively poor. This explains why many of the scales of measurement associated with such human faculties are logarithmic. For example environmental measurements in the workplace of factors such as light level or of noise, use weighted logarithmic scales with units such as the lux and the decibel (decibel A scale). An article on "Resolution and the human senses" in the "Physics Notes" of Bulletin 156 pointed to the failure of humans to resolve differences in the weights of artefacts unless these were greater than about 10%.

It was this lack of resolution in human facilities for direct observation and measurement which led man long ago to the development of instruments. These central principles have not changed with the advent of modern solid-state electronics and other technologies. Qualitatively the central purpose of a modern electronic sensor and, say, a mercury-in-glass thermometer are the same. They both allow us to detect differences or changes of which we could not otherwise be aware.

"Transparency"

Despite these essential similarities of purpose, some science educationists still express great concern over what they call "transparency" in measurements. We would broadly suport the contention that at least in their early dealings with physical quantities children should make measurements which are clearly related to those quantities. There is however considerable confusion here and relationships are often not as simple as they seem.

Transparent or familiar?

Going back to the Concise OED we find "transparent" defined as:

"Easily seen through....evident, obvious"

but just how "obvious" or "evident" are many of the devices or tests we have happily and routinely used in science classes for many years?

Take, for example, the liquid-in-glass thermometer. Is there really an immediately obvious relationship between the measurement of temperature and the movement of the liquid in the column? We don't normally directly discuss with our younger pupils the need for calibration at at least two fixed points or the relationship between temperature and co-efficients of expansion.

Better examples are provided in biology by the battery of biochemical tests we seem content to use without ever explaining their theoretical basis. A classic case is provided by test strips such as Clinistix. In this case, we wager, many teachers and technicians may be unaware of how the test actually works.

A Clinistix test strip consists of a stiff piece of absorbent cellulose one end of which is impregnated with a buffered mixture of two enzymes - glucose oxidase and a peroxidase - and a dye called ortho-tolidine for short (but by a longer IUPAC name with which we will not bore you). The biochemistry of the test is complicated. There are two major reactions, the equations for which are as follows:

$$\text{Glucose} + O_2 \xrightarrow[\text{oxidase}]{\text{glucose}} \text{gluconic acid} + H_2O_2$$

$$\underset{\text{(leuco form)}}{H_2O_2 + \text{o-tolidine}} \xrightarrow{\text{peroxidase}} \underset{\text{(blue form)}}{\text{o-tolidine} + H_2O}$$

Thus in the presence of glucose (representative, only, of reducing sugars) a Clinistix strip develops a blue colour and there is a rough relationship between the depth of that colour and the concentration of glucose present. Is all that of course immediately obvious and evident to our students - and thus "educationally transparent"?

If we take the somewhat cynical view given expression in that last sentence we might then translate "transparent" as "familiar" and "obscure" as "unfamiliar". It could be that some of the so-called pedagogical objections to the use of modern sensors (especially electronic sensors) may be nothing more than biologists' excuses for corporate task avoidance.

Proper, educational, uses

There are two major sets of educational opportunities offered by the use of modern sensors in science teaching :

- we may use them merely as tools to more efficiently teach basic scientific principles and enhance practical activities;

- we can use them in their own right as vehicles to teach the scientific principles on which the operation of the sensors themselves are based, and to get over fundamental ideas such as calibration and the nature of error and precision.

An example of the former type of use is given at the end of this article. That example also happens to illustrate what a "transducer" is, as distinct from a sensor (the two terms being often sloppily and confusingly used).

But one example should serve to illustrate the second type of educational application. Today's biology students will increasingly meet instruments with digital displays. This is true whether or not they go on to be professional biologists, doctors or take up a para-medical occupation. Because such instruments display a number and can be read without interpolations, or the uncertainties of parallax, there is a tendency to believe them.

For example : many of the less expensive digital thermometers on the educational market can be read to 0.1 °C. At best they may be accurate only to plus or minus one whole degree. This is because of the vagaries of analogue to digital conversion and other factors. It is a seminal scientific idea, the distinctions between readability, accuracy and precision. It is one we have a duty to convey, and counsel caution thereon.

A teaching application for a transducer

Figure 1 shows a position transducer in a general applicational set-up to monitor a reaction using the rate of production of a gaseous product. This has a number of possible uses in biology. They include monitoring enzymically mediated reactions such as the breakdown of hydrogen peroxide by catalase from tissues. There the factor monitored is the rate at which oxygen is evolved.

The rate of a fermentation by yeast may be monitored by following the production of carbon dioxide. Carbon dioxide evolution may begin quickly if a glucose rather than a disaccharide solution (4 - 5% w:v) is used as substrate, together with one of the modern "active" strains of yeast. We have compared several proprietary dried yeasts and fresh yeast for the shortness of their lag stages before fermentation gets properly underway. The best of these was undoubtedly DCL's "Active Dried Yeast". This brand is available from several retail outlets, including 'health food' shops.

For such biological applications the use of relatively small glass gas syringes, say 10 or 20 cm^3, also assists obtaining results fairly quickly. The system finds similar applications in chemistry in monitoring rates of reactions with gaseous products (see Standard Grade Chemistry Practical Guide Vol.1). Larger syringes are often needed, up to 100 cm^3 for such chemistry applications because of greater rates of gas production.

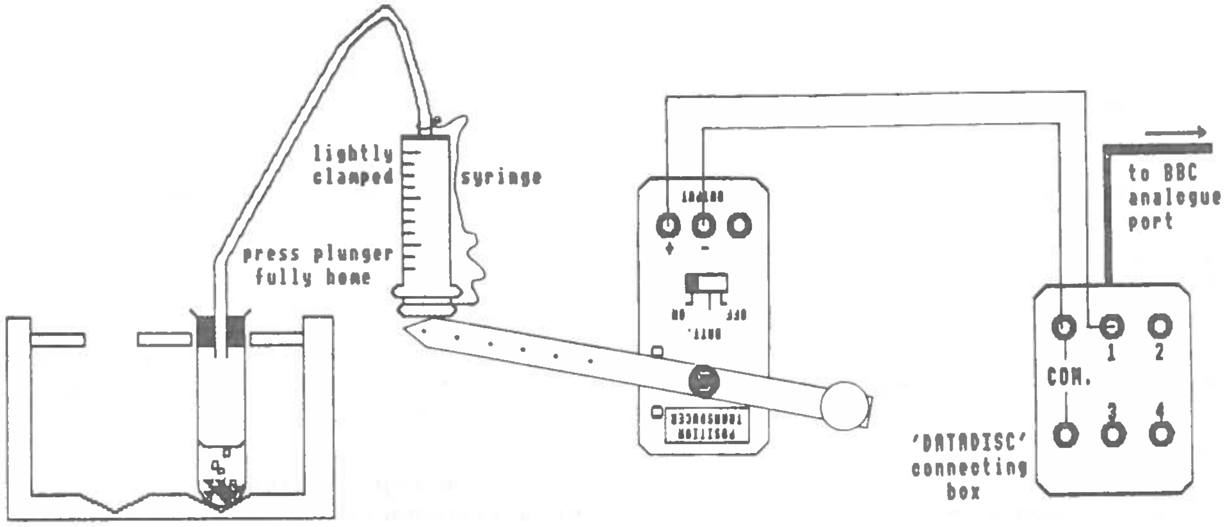

Fig.1

Why is the position detection system shown in Fig.1 a "transducer" and not a "sensor" or a "probe" etc.? A simple definition of a transducer is that of "a device that converts variations in one quantity into those of another" (useful things dictionaries).

The device shown meets this definition admirably - especially in this application. Its operating principle is based on varying resistance (it is basically a "resistive" device - see "Instrumentation Notes"). This in turn results in a varying voltage at the output. In our application we use the calibration facility of the Datadisc software package to convert that voltage so that volume versus time graphs may be plotted (see Figures 2 & 3).

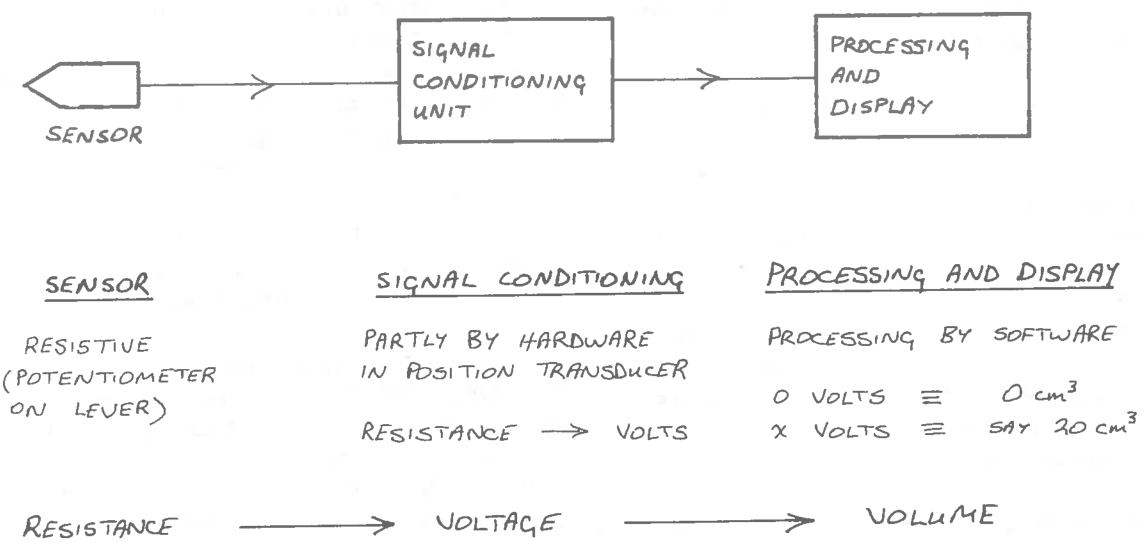

Fig.2

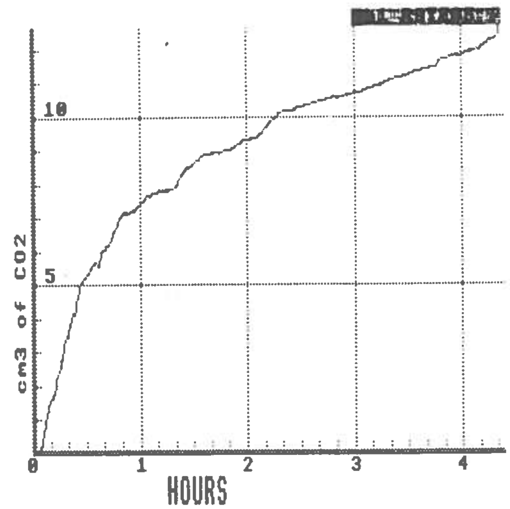

Fig.3

More technical criteria for sensor usage

Two broad educational aims for sensor usage are set out and illustrated above. There are however other factors to consider when deciding between an electronic sensor or a more educationally conventional device (and indeed between types of sensors). Such criteria are listed as follows:

It may be particularly appropriate to select an electronic sensor when:

- it is impossible or inconvenient to take direct readings, e.g. removing the sensor from the sample would alter the reading, or the sample to be measured is remote (e.g. a tree canopy or crevice in field work);

- a small inflection is sought in a gross trend or otherwise steady state;

- a rapid change (a transient) has to be detected and measured;

- a number of variables are to be simultaneously monitored or controlled.

Endpiece

We hope to have succeeded in persuading you that there are good reasons for a biologist to acquire knowledge and skills in this area. Should that be the case then further technical explanation and purchasing information are to be found in the "Instrumentation Notes" of this issue.

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P H Y S I C S N O T E S

Radon in buildings - a simple detection method

In recent years there has been an increased interest in the subject of natural background radiation. This has led to the identification of radon as the major source of man's exposure to radioactivity. A survey, sponsored by the Institute of Physics, into radon levels has been conducted by schools throughout the U.K. This survey uses the alpha - sensitive plastic TASTRAK to monitor radiation levels (Camplin [1]).

There are two common radon isotopes - radon-222, formed in the decay of uranium-238, and radon-220, which appears in the decay chain of thorium-232. Together these nuclides contribute about half of a person's annual dose of natural radiation.

Of these two radon isotopes, the most important contributor to natural radiation levels is radon-222. The source of this gas is the ground. Soil, sub-soil and rock generally contain natural uranium-238 and its daughters. Radon seeps up from the soil through the foundations of buildings and is trapped in the interior airspace by the surrounding walls.

Radon detection

The presence of radon in the atmosphere can be indirectly detected by pumping air through a membrane, which is then monitored for radioactive contamination (Thomsen [2]).

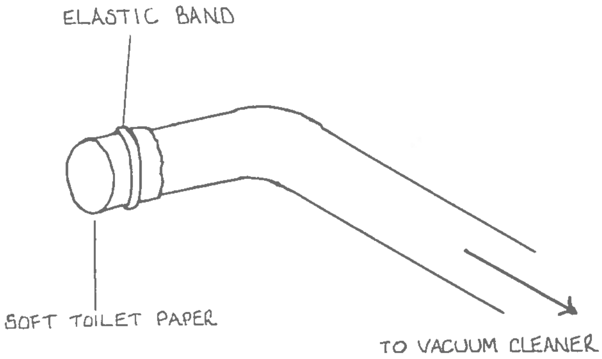


Fig.1 - Collection of sample

The air in a typical room contains a small amount of radon-222. The radon decays with a half-life of 3.8 days, and radon daughters stick to dust particles in the room.

If a membrane is placed across the collection pipe of a vacuum cleaner, and air from the room is sucked through it (Fig.1), the contaminated dust particles adhere to the membrane. The radon daughters can then be detected on this membrane using a Geiger-Muller (G-M) tube. The radioactivity level of the contaminated membrane gives an indirect indication of the abundance of radon in the air.

A number of preliminary trials showed that an inexpensive, readily available material - soft toilet paper - is a good membrane for this application.

Clearly the running time of the vacuum cleaner affects the number of radon daughter nuclei collected on the membrane. Table 1 shows the radiation counts from contaminated membranes after runs of 1, 3, 5, 10 and 15 minutes. Counts were made over 100 second intervals using a Geiger-Muller tube. The samples were taken in succession and at the same location. The results shown in Table 1 are displayed graphically in Fig.2.

Running time (min)	**G-M count(corrected)** (100 s)$^{-1}$
1	28
3	113
5	161
10	335
15	606

Table 1 - Counts after various running times

Notice that the counts in the above table have been corrected for background radiation - typically 30 for a 100 s count. All counts subsequently quoted in this article are corrected 100 second counts.

Fig.2 indicates that the radiation count of the contaminated membrane increases more or less in proportion with the running time of the vacuum cleaner.

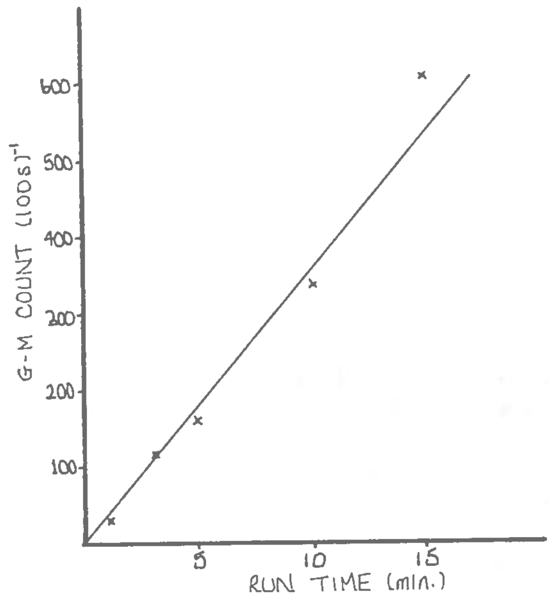


Fig.2 - Count rate versus running time

Effect of ventilation

Table 2 shows the results of a similar experiment, performed at the same location, but on a different day.

Running time (min)	G-M count $(100\ s)^{-1}$
1	0
3	32
5	33
10	64
15	81
25	127

Table 2 - Counts when room is well ventilated

On the day this second set of samples was taken, the doors of the room were left open for long periods of time. The effect of this ventilation is dramatic : the counts are down to as low as a fifth of their previous values.

Effect of location

The sampling method as described can be used to compare the radon concentrations in various parts of a building. Table 3 shows the G-M counts from membranes after air was drawn through them in various locations around a building. The runs were each of 10 minutes duration.

Location	G-M count $(100\ s)^{-1}$
Basement	308
Ground floor	83
First floor	23
Outdoors	55

Table 3 - Counts for various locations

The results support the introductory statement that the main source of radon in buildings is the soil on which they are built. It is thought that air currents in the rooms did not have a significant effect on the results.

Decay of radon daughters

The decay of radon daughters can be studied by monitoring the radiation from a contaminated membrane over a period of a few hours.

Air was drawn through a membrane for 15 minutes. Fig.3 shows a plot of the G-M count for the contaminated membrane at various times after sampling.

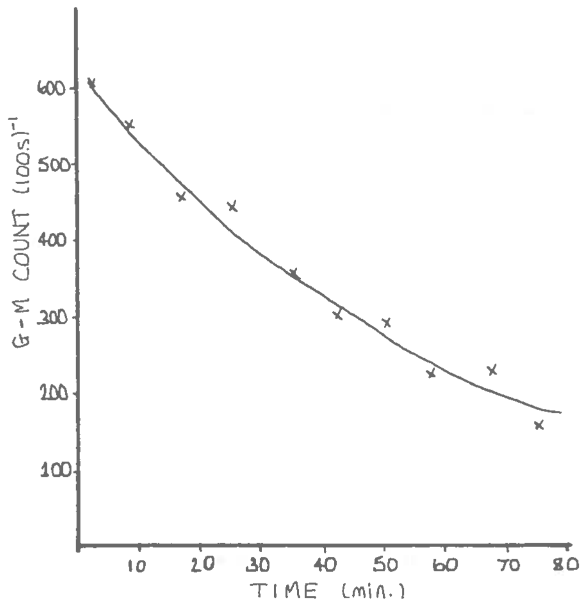


Fig.3 - Decay curve of count rate

The decay curve shows that the radiation diminishes by about 50% 45 minutes after collecting the sample.

It was initially assumed that radon gas itself, and not the radon daughters, was absorbed onto the membrane. Attempts were therefore made to contain the gas and to measure its half-life. Firstly, a contaminated membrane was sealed in a small test-tube and the G-M count monitored for a couple of hours. A second attempt to "contain the radon" involved cutting out a small section of contaminated membrane, placing it on a microscope slide and sealing a cover slip over it, using the mounting medium D.P.X. A half-life of 3.8 days was expected (this is the half-life for the decay of radon-222 into polonium-218). But in both cases the radiation dropped by about half its initial value after 40 to 45 minutes, and resembled the decay curve seen in Fig.3.

Type of radiation emitted

Another clue to the identity of the nuclei from which the detected radiation is emitted is provided by determining whether this radiation is alpha, beta or gamma. This can be done by observing the effect of placing sheets of typing paper (80 g/m²) between the membrane and the G-M tube. Table 4 shows the G-M counts for several different numbers of intervening sheets. The run time of the vacuum cleaner was 30 minutes.

No. of sheets of paper	G-M count $(100\ s)^{-1}$
0	283
1	149
2	119
3	118
4	107
6	88
8	82
10	67
12	55
14	45

Table 4 : Absorbing radiation with sheets of paper

The insertion of the first sheet of paper produces a sharp fall in the G-M count. The addition of further sheets reduces the count more gradually. This suggests that the radiation emitted from the sample is a mixture of alpha and beta particles. Note however that no conclusion can be drawn as to the proportion of alpha to beta particles, because the efficiency of the G-M tube differs for each type of radiation.

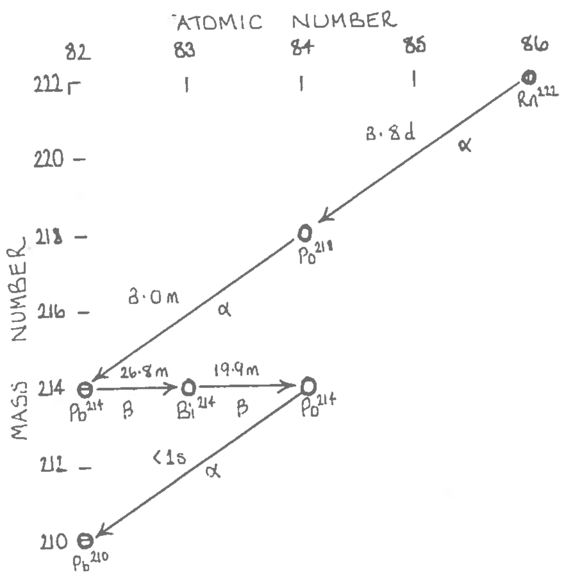


Fig.4 - Part of uranium/radium - (4n + 2) series

Radon-222 is formed in the uranium/radium - (4n + 2) natural decay series. Part of this series is shown in Fig.4.

From the decay scheme it would seem that the radioactive isotopes deposited on the membrane are polonium-218 and subsequent isotopes in the decay series. The half-life of polonium-218 is 3 minutes and it decays by alpha emission to lead-214, which in turn decays by beta emission to bismuth-214. The half-lives of these last two isotopes are 27 minutes and 20 minutes respectively. The compound effect of these half-lives is presumed to produce the halving of initial radiation in 45 minutes as obtained by experiment.

Note that both alpha and beta emissions are a feature of the decay chain. The fact that both types of radiation are emitted from a contaminated membrane supports the hypothesis that it is polonium-218 and subsequent daughters, but not radon-222, that is deposited on the membrane. In the case of the latter possibility, few beta particles would be detected near the membrane within the first few hours because radon-222 has a half-life of 3.8 days and is a 100% alpha emitter.

Acknowledgements

Mr. Keith Black, of George Watson's College, Edinburgh (until recently of Stromness Academy, Orkney), for information about his work on this subject.

The National Radiological Protection Board, for elucidating the method by which radon daughters are deposited on the membrane and for commenting on our observed decay times.

References

[1] Camplin G. et al 1988 Physics Education 23 212 ff.

[2] Thomsen P. 1982 Hong Kong Science Teachers Journal 10 106 ff.

* * *

A chain reaction - with mousetraps

A collection of twelve or so mousetraps are set and placed in the bottom of a large clear plastic tank, such as an aquarium tank (Fig.1). Two ping-pong balls are loaded on the spring of each mousetrap. A hard cover is placed over the top of the tank and a ball is aimed at one of the traps and projected into the interior. The chain reaction that follows models a nuclear fission explosion.

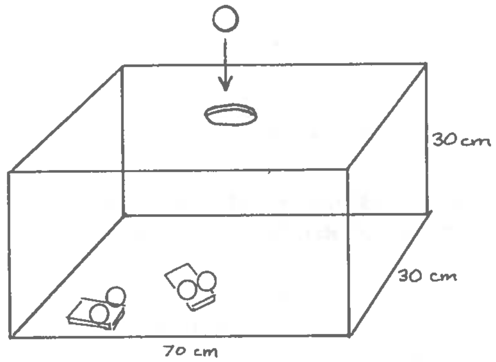


Fig.1 - Layout of model

The success of the model depends on a certain amount of adjusting of the cross-sectional area of the model nuclei so that the chain reaction is sustained. The usual trigger of a mousetrap consists of a couple of metal prongs.

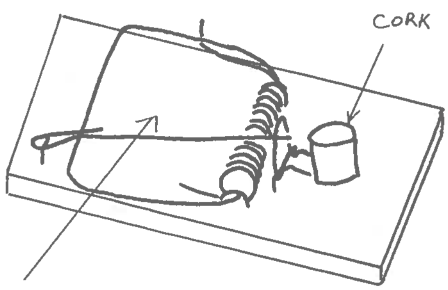


Fig.2 - Increasing the sensitivity

This trigger proved to be too insensitive for the chain reaction to work reliably. Corks - about 15 mm diameter - were cut in half and stuck on the prongs (Fig.2). The extra weight and surface area increased the sensitivity of the trigger to give a reliable chain reaction.

The cork should be angled slightly so that it does not catch on the base of the mousetrap (Fig.3).

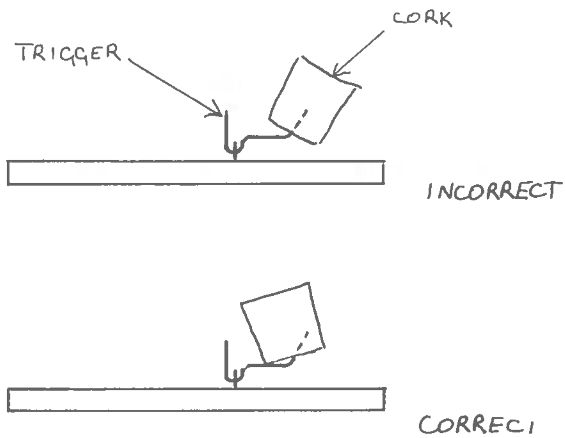


Fig.3 - Angling of cork

The startup of the reaction was found to be more reliable if a slightly heavier ball of polystyrene was projected into the tank.

Acknowledgement

This idea is believed to have been around for some time. We recently came across it in 'A demonstration handbook for physics', 2nd edition, 1981, by G D Freier and F J Anderson, published by, and available from, the American Association of Physics Teachers, UK price $15.00 ppd.

* * *

Ring main models - further comments

The circuit diagrams in the article on ring main models in Bulletin 158 have been criticized by two readers. Please note that these were diagrams of models, not of behind-the-wall wiring circuits. What our article unfortunately did not make explicit was the role of the power supply in representing a power station rather than a distribution board or 'consumer unit' (Fig.1).

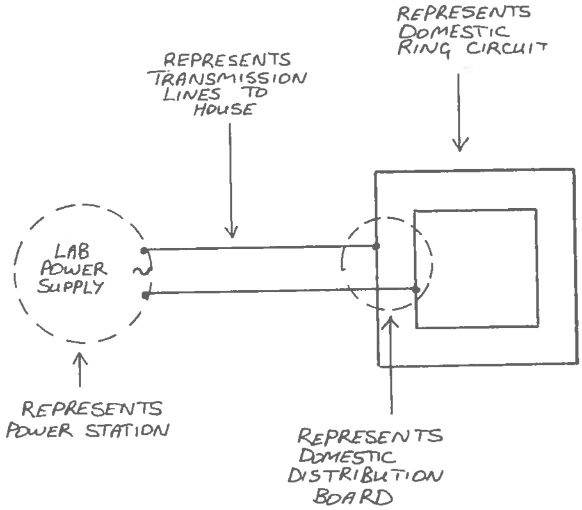


Fig.1 - Metaphorical representations

If readers prefer the other role the circuits should be redrawn to show their different interpretation (Fig.2).

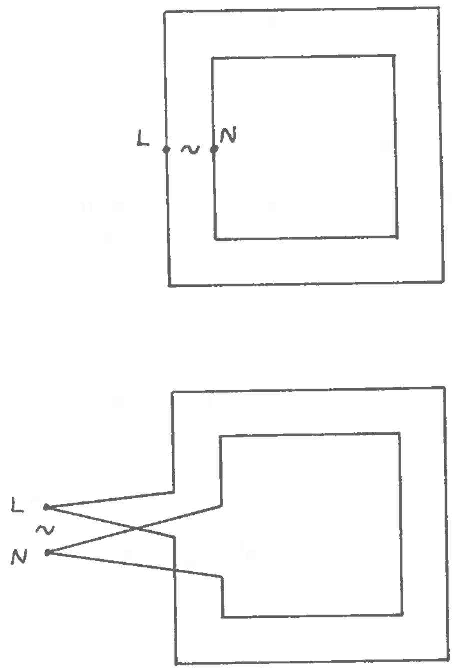


Fig.2 - Ring circuit and distribution board - two versions of diagram

Readers may be interested to see how official technical documents might lay out this circuit. A simplified adaptation of ring circuit diagrams as contained within the IEE Wiring Regulations is shown in Fig.3.

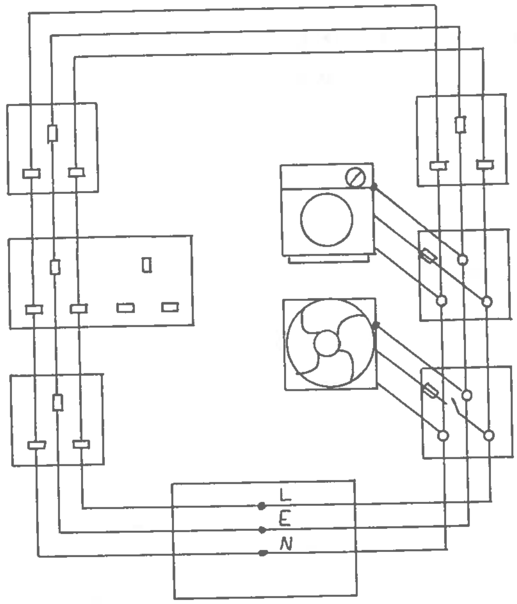


Fig.3 - Adaptation of ring circuit from IEE Wiring Regulations

Implicit in the criticism is the assumption that physics teachers should give exact circuits when dealing with mains electricity. I challenge this assumption. In my view physics teachers should not in general instruct pupils in behind-the-wall wiring techniques. They are not qualified to do so. The physical principles of such circuits should be explained, but the technical details should be left out. If this view of physics teaching is accepted it would be meaningless to describe such circuit diagrams as exact or inexact - they would be general representations.

The point to watch is the influence we might have on d-i-y house rewiring. Suppose a person rewiring his house were to hark back to that which he had been taught ten or twenty years earlier. If the teaching had been in exactitudes it is important that what was taught was indeed exact, and continues to remain exact. If the teaching is in generalisations it is important that the generalisations do not stray into giving technically wrong details, and moreover that the pupil realises they are generalisations. There is an ethical point here, which teachers should perhaps reflect upon.

* * *

Digital multimeters and blown fuses

We have had several reports of fuses blowing in digital multimeters - not just in one or two meters - but in part class sets of meters. None of the reports has been accompanied by firm evidence as to why a fuse has blown. What might, therefore, be going wrong?

Our bench tests on multimeters indicate that the sole probable cause of fuse-blowing is over-current on one of the current ranges protected by a fuse. This could be caused by any of a number of means, some of which are listed:

- attempting to measure voltage while switched to a current setting;
- attempting to use the multimeter as an ammeter, but placing it in circuit as a voltmeter so that it short circuits the power supply or load resistor;
- working with too small a load resistor, or too large a current.

To reiterate, it seems from our inspections of many models of multimeter, that a fuse can be blown only if the meter is switched at one of the current settings. As a corollary, if switched at either resistance or voltage the fuse cannot be blown by ordinary school means.

It is recommended that when pupils are shown how to use digital multimeters these fault conditions are discussed.

Fuse types

The fuse protects the meter shunt, which could be expensive to replace. It would be rashly inadvisable not to comply with the current rating specified by the manufacturer.

Some meter manufacturers specify using a quick-acting fuse. These cost 20p a fuse, compared with 6p for a standard fuse. But if a particular type has been specified it should be used.

Other manufacturers make no recommendation as to fuse type. Were money no object their products, too, ought to be protected by the quick-acting type. But as money usually is in short supply, and the specification being absent, you should get away with the cheap, standard type of fuse. Do not however try to reduce your department's incidence of blown fuses by using either a semi-delay or anti-surge type. You might then end up with a damaged shunt!

* * * * *

** STOP PRESS **

Trade News - Change of address

Please note the change of address of the equipment manufacturers and suppliers, Unilab Limited. Their new address and telephone number can be found on the inside front cover.

INSTRUMENTATION NOTES

Electronic sensors

Abstract

Modern electronic sensors are reviewed. The general structure of sensory instruments is described. Sensors are classified according to physical method of operation. A market summary of commercial sensors for éducational use is given. There is advice on matching commercial sensors to displays or recorders.

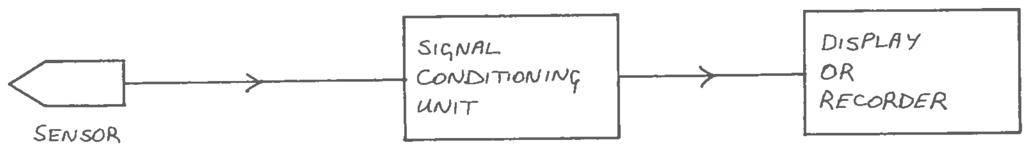
Generalised instrument structure

The generalised structure is built out of three parts: sensor, signal conditioning unit, and display or recorder (Fig.1).

Sensor The sensor converts the physical signal being measured into an electrical signal. It is a transducer that changes one physical quantity into another, the end result being always an electrical quantity, such as current, resistance, or voltage. Some examples illustrate this:

Photodiode - a sensor of light, converting light intensity signals to electric current. It is based on the p-n junction. This is highly sensitive to light, and can cause a reverse leakage current to flow that is linearly dependent on light intensity.

Thermistor - a resistor whose resistance is temperature dependent.



common types of sensors

resistive
capacitive
inductive
charge or e.m.f. generator
semiconductor material
digital mechanism
waves mechanism
quantum device
ionisation device

signal conditioning unit might include

amplifier
d.c. offset (summing amplifier)
difference amplifier
chopping amplifier
high input impedance buffer
passive or active bridge
filter
integrator or differentiator

might be done by

analogue processing
digital processing - hardwired or software based

input to display or recorder is always a voltage

display or record on

voltmeter
oscilloscope
storage oscilloscope
chart recorder
computer with interface
data logger

Fig.1 - Generalised instrument structure

pH probe - a sensor which converts a hydrogen ion concentration into an e.m.f. It consists of a pair of ion sensitive galvanic electrodes, operating like a simple cell. The e.m.f. generated across the electrodes is a function of pH and temperature.

Signal conditioning unit This part shapes and manipulates the signal from the sensor into a form that the display or recorder is able to recognise. Modern displays and recorders measure voltage. Therefore in many instruments a necessary part of the signal conditioning is the conversion from one electrical quantity into voltage. For instance, depending on the sensor type, the conversion might be from capacitance, or inductance, or resistance, or current, or frequency, into voltage.

Other signal shaping that could take place within this part of the instrument includes amplification or attenuation, level shifting, impedance matching, linearising, filtering, noise reducing, and compensating for unwanted signals, etc.

Some instruments make use of integration or differentiation in the signal conditioning to convert from one physical quantity to another. For example an instrument with a position sensor might employ single stage differentiation to measure velocity, and double differentiation to measure acceleration:

$$v = ds/dt \qquad a = d^2s/dt^2$$

or an instrument with a force sensor might use integration with respect to time to measure impulse:

$$p = \int F.dt$$

Signal conditioning units invariably contain some analogue processing. They are often entirely analogue. However it is increasingly common to find some of the processing to be done by digital means - either by hardwired circuitry, or by software processing. If there is software processing then it could be carried out either by a dedicated microprocessor based system to be found within the signal conditioning unit, or by an intelligent display or recorder, such as a microcomputer or data logger.

At the leading edge of sensor technology are so-called 'smart sensors', which might typically comprise the sensor element, signal conditioning, sample and hold, A to D conversion, digital processing, memory, and serial transmitting port, all on a single piece of silicon. But there is no single preferred architecture. Sensor technology advances on a broad front, in many diverse ways, each with their own advantages.

Display or recorder By present day standards the quantity measured by this device is voltage. It may be an LCD display, voltmeter, oscilloscope, or chart recorder. Or it may have memory and intelligence, such as a storage oscilloscope, microcomputer with interface, or data logger.

There is no sole recognised standard of input range to displays and recorders, but there are several common standards:

-250 mV to +250 mV
0 to 100 mV
0 to 1 V

Classification of sensors

In Table 1 sensors are classified according to the electrical quantity which they sense. For example, sensors are classified as resistive, capacitive, etc. The purpose of this classification is that each grouping can, in many instances, use the same type of signal conditioning. For instance the sensors in the resistance column can all be used in bridge circuits. Alternatively, or additionally, they might all be used with a similar form of digital processing.

Classification is according to transduction properties rather than physical make-up. Neither thermistors nor piezoresistive pressure sensors appear in the semiconductor column, though both are made of semiconducting materials. They are instead in the resistance column since the one converts from temperature into resistance, and the other from pressure into resistance.

By grouping sensors thus, patterns of modes of usage can be identified, which is of particular interest if you design your own circuits.

	R	C	L	V	semiconductor	other
displacement	potentiometer	variable area/ separation capacitor	linear variable differential transformer (LVDT)	electromagnetic generator $x = \int v.dt$		encoder disks ultrasonic echo-finding interference fringes Moire patterns
velocity	potentiometer $v = dV/dt$			electromagnetic generator		encoder disks ultrasonics microwave Doppler shift self-heating current
force/ acceleration	strain gauge			piezo-electricity		force compensation
pressure	piezo-resistance	variable dielectric manometer				aneroid barometer
temperature	platinum film resistor thermistor			thermo-electricity (thermocouple) pyro-electricity	p-n junction (silicon diode)	

Table 1 - Classification of sensor types (continued over)

Commercial sensors

The numbers of types of electronic sensors has increased considerably in recent years. Gone is the age of one-off designs. Sensors now come in families, with similar electrical outputs, similar styles of cases, similar colours and stripes.

There are four ranges being marketed directly at schools, one range each from the companies Educational Electronics, Griffin and George, Philip Harris and Unilab. The Griffin range was specified through the Microelectronics Education Programme (MEP). Over and above these four homogeneous ranges are ad hoc designs that do not belong to any range. A few of these are included in the review. WPA products, which tend now to be primarily marketed in higher education, are not included. However some WPA products are of use in secondary schools. Consult their catalogue, if interested.

Educational Electronics range There are thirteen sensors in their range. Each sensor is connected to its own unique signal conditioning box, both sold together as a single catalogue item. The box has an 11 pin, male-type, valve connector, which connects to a Sensor Base Unit (also called Sensor Adaptor Module (SAM)). The Base Unit is a separate catalogue item. There are two types of these:

SAM 1: This Base Unit has one socket for accepting any one single transducer. It is powered off two PP3 batteries. It has two electrical outputs: 0 V to 1 V, for general purpose use - it can be connected to any standard voltmeter, recorder or display; and -250 mV to +250 mV, for connection to VELA.

	R	C	L	V	semiconductor	other
chemicals	polarographic electrode - ion selective (O_2 electrode)			galvanic electrode - ion selective (pH electrode) (O_2 electrode)	chemically sensitive dopings	
light/ short wave infra red radiation	light dependent resistor (LDR)			photovoltaic cell	p-n junction (photodiode) (photo-transistor)	photoemissivity (phototubes)
long wave infra red radiation	bolometer			thermo-electricity (thermopile) pyro-electricity		heating effect
magnetic field			fluxgate magnetometer	electro-magnetic induction	Hall effect	proton precession magnetometer
ionising radiation					p-n junction	G-M tube scintillator
sound				piezoelectricity (ceramic) electromagnetic induction (dynamic)		

Table 1 - Classification of sensor types (continued)

SAM 4: This Base Unit has four sockets for accepting up to four transducers. It is powered off the mains through a transformer. SAM 4 has been designed to be used exclusively with VELA, into which it plugs as an add-on module.

If sensors from this range are being used with VELA a specialised EPROM 2015 should be fitted to that instrument. This comes with the SAM 4 Unit, or may be ordered separately if using SAM 1.

Griffin and George range There are twelve sensors in the MEP range. Each connects to its own particular signal conditioning box. For most of the range the sensor and signal box are sold as a single catalogue item. The voltage output from the signal conditioning boxes is 0 V to 1 V. It may be connected to any standard display. A ± 5 V dual rail power supply is an essential accessory. There is one in the Griffin MEP range, off which several sensors can be operated.

Printed circuit boards are available for all the signal conditioning units. If constructing your own circuits you would require to purchase the MEP Sensor Manual.

Philip Harris range There are fifteen sensors in the Harris range, supplemented by some additional probes. The comments made about the Griffin MEP range apply also to this range except for three differences:

(1) each unit has two separate electrical outputs: 0 V to 1 V, which suits many standard displays or recorders; and -250 mV to +250 mV, for VELA or other instruments using that standard;

(2) each unit is battery powered (one PP3 in most units) - they may thus be used outdoors;

(3) there is neither a printed circuit board version nor construction manual for this range.

Unilab Environmental Kit There are seven sensors in this range, whose design pre-dates MEP. The kit has a modular structure, with parts interconnecting. Each sensor requires a specific signal conditioning box, which for most sensors is sold as a separate item. The other essential item, of which there are two kinds, is the Meter/Battery Box: 423.002 with dB and pH scales, and 423.003 with 0-100, 0-30 and 0-50 scales. This requires a 9 V PP3 battery. An invaluable additional feature on the Meter/Battery Boxes is the electrical output, the range of which is 0 mV to 100 mV. Through this, sensors in the kit can be connected to microcomputers or other data loggers.

A summary of commercial sensors is given in Table 5 at the end of the article. If a sensor is in one of the four families of sensors reviewed above it is marked with an asterisk (*). A few other sensors are included in the table, the criterion for inclusion being that they have an electrical output that can be taken to any standard form of display or recorder.

Matching commercial sensors to displays or recorders

If the voltage output from the sensor is compatible with the designed voltage input of the display or recorder then the one can be connected to the other. Output ranges from sensor families are summarised in Table 2. Input ranges to some common displays or recorders are summarised in Table 3.

Sensor family	Standard output voltages
Educational Electronics	-250 mV to +250 mV 0 V to 1 V
Griffin	0 V to 1 V
Harris	-250 mV to +250 mV 0 V to 1 V
Unilab	0 V to 100 mV
WPA	0 V to 1 V

Table 2 - Electrical outputs from sensor families

Display or recorder	Input voltage range
digital voltmeter	several ranges, but use 0 mV to 2000 mV for greatest accuracy
BBC Computer Analogue Port	0 V to 1.8 V
Unilab Interface	0 V to 100 mV, or $\pm$50 mV 0 V to 1 V, or $\pm$500 mV 0 V to 10 V, or $\pm$5 V
VELA (Educational Electronics)	-250 mV to +250 mV -2.5 V to +2.5 V -25 V to +25 V
Easy Memory Unit (EMU) (Harris)	0 V to 1 V
chart recorder	0 mV to 100 mV is common

Table 3 - Electrical inputs to displays or recorders

If the output does not match the required input then some form of signal conditioning might be required by way of an amplifier, attenuator, or d.c. offset. It makes obvious sense to buy to suit.

Sensor	Content	Reference
balance	T M	B.155
conductivity	T M	B.150
	C	B.159
fluxgate magnetometer	T E	B.148
light meters	M	B.147
	T M E	L
magnetic pick-up	T C E	Memo.2
optical encoder	T C	B.146
oxygen probe	T M	B.102
	T E	B.106
	T C	B.110
	T	B.117
piezoelectricity	T C E	B.155
pH	T C E	B.143
	T M	B.153
	T C M E	P
photodiode	T C E	B.145
phototransistor	C E	B.129
	C	B.136
	T E	B.145
pulse sensor	T M E	B.145
pyroelectricity	T C E	B.155
resistive sensors, bridge circuits	T C	B.150
semiconductor temperature sensor	T C E	Memo.3
strain gauge	T C E	B.75
tachogenerator	C E	B.160
thermistor	T C E	B.141
	T C	B.150
	C	B.156
thermocouple	C	B.133
	T C E	B.158

code:

T theory, guidance on care
C d.i.y. construction details of instruments
M market review
E ideas for, or examples of, usage

B Bulletin
Memo Microelectronics Monograpgh
L "Light Meter Guide"
P "School pH Meters and Probes"

Table 4 - Sensor references in SSSERC publications

Further information

This article has not attempted to give specific details of how any type of sensor functions, how to design appropriate signal conditioning circuits, or how to use them. Such details are necessarily lengthy.

Many sensors have been written about in past bulletins or other SSSERC publications. The adjoining list (Table 4) should help to remind you.

Table 5 over/

	Educational Electronics	Griffin	Harris	Unilab
Temperature	* silicon diode -50°C to +150°C 2210 £49 * silicon diode 0°C to 50°C 2211 £49 * thermocouple Type K -100°C to +750°C Amplifier 2212 £58 Probe 2213 £20	* silicon diode -50°C to +150°C CRB-166-020V £30.50 * thermocouple Amplifier to 400°C CRB-166-040P £27.30 Probe XHE-860-T 90p * platinum resistance 0°C to 100°C CRB-166-060J £46	* silicon diode 0°C to 100°C -10°C to +40°C T12180/1 £58.43 extended probe T12185/0 £48.36 glass case probe T12190/4 £14.25	* thermocouple 0°C to 30°C 0°C to 100°C Control Unit 421.014 £37.20 Probe 424.015 £21.56
Humidity			* 0% to 100% relative humidity T12000/6 £83.44	
pH	* Amplifier 2250 £38 Electrode 2251 £38	* Amplifier CRB-156-020F £35 Electrode PHP-100-010Y £30	* Amplifier T12060/2 £41.80 Electrode C58030/5 £37.26	* Amplifier 421.010 £19.39 Electrode 424.011 £23.20
Oxygen	* Amplifier 2290 £42 Electrode 2291 £60		* Amplifier T12020/1 £43.17 Electrode T12025/0 £56.75 Thermistor T12030/4 £9.55	* Amplifier 421.008 £15.66 Electrode 424.009 £55.99
Hydrocarbons		* Gas Sensor CRB-146-020M £54.50		
Conductivity		* CRB-142-020N £37.50	* T12090/0 £53.28	* Amplifier 421.004 £20.75 Probe 424.005 £26.33

	Educational Electronics	Griffin	Harris	Unilab
Salinity				* Salinity Unit with Probe 421.015 £44.90
Light	* 2220 £44	* photodiode CRB-152-020G £32	* Light Sensor LDR T12110/2 £38.89 * Linear Light Sensor photodiode T12150/3 £60.96 Extension Probe T12115/1 £65.56 Infra-Red Filter T12155/2 £15	* selenium cell 421.006 £26.81
Pressure	* piezoresistive 0 kPa to 200 kPa 2260 £68	* piezoresistive 0 kPa to 100 kPa CRB-160-020L £96	* Pressure Sensor MkII piezoresistive 80 several ranges up to 200 kPa T12310/9 £77 can be used with Stethograph B72485/9 Electronic Barometer aneroid 950 to 1050 mbar T12290/8 £90	
Volume/ Pressure			* Electronic Manometer T12330/5 £48.75 Manometer Tubes - wide T12335/4 £47.25 - narrow T12340/8 £35.02 Potometer/Manometer B63590/6 £45.83	
Displacement/ Position	* potentiometer 50° rotation 2270 £65		* potentiometer 30° rotation T12250/7 £49.25	

	Educational Electronics	Griffin	Harris	Unilab
Force	* Strain gauge and Amplifier 2280 £105	Strain gauge Amplfr. KRB-220-K £71 Strain Gauge Kit KRB-200-B £55.12	Strain gauge Amplfr. T12210/6 £84.76 Strain gauge Kit T12225/8 £23.05	
Ionising Radiations		* G-M Tube Interface CRB-148-020A £45 tube extra	* Ratemeter Sensor T12440/1 £58.85 tube extra	
Magnetic Field	* Hall probe -25 mT to +25 mT 2240 £54	* Hall probe CRB-150-020S £40	* Hall probe 0 mT to 10 mT 0 mT to 100 mT T12420/6 £61.95	Hall probe 0 mT to 10 mT 0 mT to 1000 mT five ranges 612.002 £91.09 single range 613.004 £43.05
Sound		* (sound waveforms) Microphone Amplifier CRB-154-020R £25 Microphone XER-100-N £15.34		* Sound Level Meter 421.012 £34.20
Current	* DC Current Sensor -10 A to +10 A 2230 £25 * DC Current Sensor -1 A to +1 A 2231 £25		* Ammeter Sensor 1A, 2A, 5A, 10A T12380/9 £40 * Milliammeter Sensor 100 mA, 200 mA, 500 mA, 100 mA T12400/0 £40	
Resistance		* Resistance Meter CRB-162-020W £23		
Voltage	* Voltage Sensor -25 V to +25 V -2.5 V to +2.5 V 2222 £16		* Voltmeter Sensor 2V, 5V, 10V, 20V T12360/3 £40	

	Educational Electronics	Griffin	Harris	Unilab
Essential Accessories	* Sensor Adaptor Module either SAM 1 2000 £35 or SAM 4 2100 £85 batteries	* Power Supply CRB-140-010F £30	batteries	* Meter/Battery Box dB and pH scales: 423.002 £25.67 0-100, 0-30 & 0-50: 423.003 £25.67 batteries
Other Accessories	* Variable Gain & Offset Amplifier gain: x1 to x100 offset: -5 V to +5 V 2310 £66	* Differential Input Amplifier CRB-144-020B £19.50 * Sensor Manual CRB-190-010Q £15.60 * printed circuit boards for all MEP sensor rang:		
BBC Interfaces				
Four channel, Analogue Port	cable connector 2005 £15	* with protection CRB-180-020U £29.50	with protection A29022/1 £34.75	
Single channel, for fast logging		* CRB-184-020T £46	A29110/9 £65 (with software)	
Four channel, for fast logging				Unilab BBC Interface 532.001 £198.90 software: Grapher 532.052 £17
Data Logger	VELA 4 channels 1000 £225 (recommend use Harris Datadisc software A29015/4 £56.75		Easy Memory Unit (EMU) 4 channels with BBC software T10200/4 £196	
Connecting lead to BBC Computer	1040 £24		T10205/3 £11	

Table 5 - Review of commercial sensors and accessories

INTERFACING NOTES

Screen dumps from 'Grapher'

Abstract

The 'Grapher' data aquisition software for use with the Unilab Interface has no facility for screen-dumping graphs directly to a dot-matrix printer. A short program in BBC Basic is shown here with suggested custom modification to users' requirements.

Introduction

The 'Grapher' program supplied by Unilab (Cat. No. 532.052, £17.00) is a program suite designed for use with the Unilab Interface. A review of this interface and associated software including 'Grapher' was published in Bulletin 154.

We sometimes get enquiries from teachers looking for a 'hard-copy' of graphical data from 'Grapher'. Page 22 of the 'Grapher' manual gives a clue as to how to go about it.

Saving a screen to disc

When data has been captured and displayed graphically on screen press the **<SPACEBAR>** to get to the 'output panel'. Six commands should appear on the left hand side of the screen. Only one of these i.e. **<DSPOUT>** will save the screen information required.

Press **<D>** to enable this command and enter a filename when prompted, e.g. **<GRAPH1>**, using no more than six characters. Put a blank, formatted disc in the disc drive and press **<RETURN>**. The software actually saves four files to the disc catalogue using "GRAPH1" as a stem, i.e.:

"GRAPH1"	all internal variables
"GRAPH1X"	up to 250 bytes with last X values
"GRAPH1Y"	up to 250 bytes with last Y values
"GRAPH1S"	screen memory from &5800 to &7FFF

Hardware and software needed

The last file corresponds to the screen memory of a screen displayed in MODE 4. It is this file that can be called by another suitable program which contains a MODE 4 'screen-dump'. Alternatively it can be called by a screen-dump program held in a ROM (read only memory) chip. The example shown here uses the latter method, but can be easily adapted for other screen-dump programs.

The ROM used in SSSERC is the 'Printmaster' (Epson version) from Computer Concepts. They also do a version for 'Star' dot matrix printers. There are many other ROMs around which do the same job (try Watford Electronics).

```
10 MODE 4
20 PROCset_up
25 REM Main Program
30 REPEAT
40 PROCtransfer
50 PROCany_more
60 UNTIL ans$<>"Y" AND ans$<>"y"
80 END
90 :
100 DEFPROCtransfer
110 CLS
120 PRINT TAB(8,10);"Enter Unilab screen name"
130 PRINT TAB(14,13);"(ends in S)"
140 INPUT TAB(10,24);NAME$
145 REM Just like using *LOAD <filename>
150 OSCLI "LOAD " + NAME$ +" 5800"
155 REM Part of the screen only can be printed
160 *WINDOW
165 REM Sideways A4 format dump configuration
170 *GDUMP 1 0 4 2 0
180 CLS
190 ENDPROC
200 :
210 DEFPROCany_more
220 PRINT:PRINT:PRINT"Any more (Y/N) ";
230 INPUT ans$
240 ENDPROC
250 :
260 DEFPROCset_up
265 REM Sets up a parallel printer & linefeed
270 *FX5,1
280 *FX6
290 CLS
300 ENDPROC
```

D.C. amplifier with offset

Abstract

The circuit described has a gain of 5 and an offset of -2.5 V. It can be used as a general purpose voltage amplifier or as a means of tailoring the standard 0 to 1 V outputs from transducers to the ±2.5 V input range of VELA.

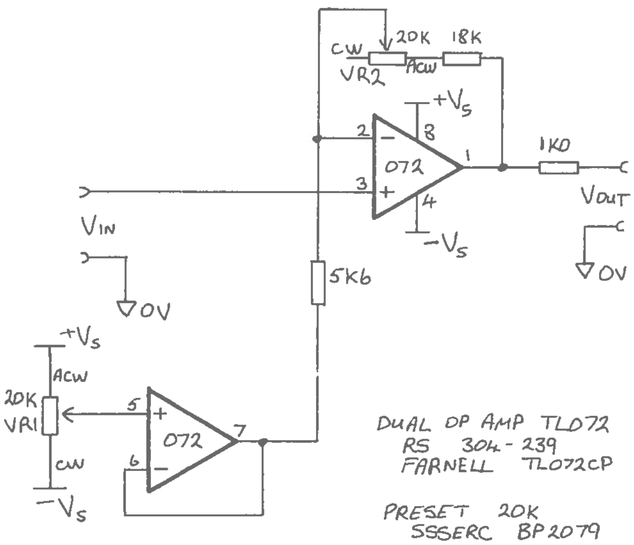


Fig.1 - Circuit diagram

Specifications

input range	0-1 V
output range	-2.5 V to +2.5 V
gain	x5
offset	-2.5 V
power supply	±5 V to ±18 V

Calibration

You will require two digital multimeters (DMM) and a potentiometer (say 10K multiturn), which is used to generate a variable test voltage applied to Vin. This is referred to as 'pot' in the instructions which follow - not to be confused with the presets in the published figure.

1. Connect clockwise (CW) end of pot to +Vs and the anticlockwise (ACW) end to -Vs. Connect the wiper to Vin.

2. Connect one DMM across Vin and 0 V and the other DMM across Vout and 0 V.

3. Turn pot until Vin DMM reads 500 mV and adjust offset preset (VR1) until Vout DMM reads 0.000 V.

4. Turn pot until Vin DMM reads 1.000 V and adjust gain preset (VR2) until Vout DMM reads +2.5 V.

5. Turn pot until Vin DMM reads 0.000 V and check that Vout DMM reads -2.5 V.

* * * * * * * * *

SURPLUS EQUIPMENT OFFER

This offer is subject to our general conditions of sale as revised in Bulletin 158.

Please note that items are not necessarily arranged according to the item number. They may be grouped because of similarity of application, or for other reasons. Often the item number serves only for stock identification by us in making up orders.

Motors

Item 590	Stepper motor, single phase, 5 V manufactured for clock or other timing device. Delicate gearing with 40 tooth plastic wheel as output. Suitable for demonstration, or as a method of digital input for control or timing. Unidirectional. Dimens. 30 x 25 x 10 mm. Circuit diagram supplied.	£1.20

Item 591 Stepper motor, 4 phase, 12-14 V d.c., 400 mA, 27.5 R coil. Step angle 7.5 degrees. Powerful motor with 15 mm, 6 mm dia. output shaft. Dimens. 40 mm long, 70 mm diameter on 70 mm square mounting plate with fixing holes at 56 mm centres. Circuit diagram supplied. £4.50

Item 626 Precision motor, 0.5-15 V d.c., power output 2.2 W, no load speed & current 7700 rpm, 16 mA, stall torque 11 mN m, 34 mm long, 23 mm dia., output shaft, 14t.steel pinion. £3.50

Item 628 Precision motor, 0.1-12 V d.c., no load current & speed, 18 mA 5200 rpm, stall torque 46 mN m, 40 mm long, 28 mm dia., output shaft 8 mm steel spline. £3.20

Item 627 Precision motor tacho unit, consists of motor unit with integral generator. 0.5-15 V d.c.. 55 mm long, 24 mm dia., output-shaft 10 mm long, 3 mm dia.. £5.00

Item 594 Precision motor, 0.5 - 12 V d.c. no load current and speed, 12 mA 4900 rpm, stall torque 29 mN m, 48 mm long, 23 mm dia., output shaft 10 mm long, 3 mm dia. £3.20

Item 592 Miniature motor, 2.5 to 9 V d.c., smooth running, speed governor. No load current 30 mA. Dimensions 35 x 40 mm dia. 8 mm shaft 2 mm dia. 60p

Item 593 Miniature d.c. motor, 1.5 - 3 V No load current 60 mA, speed 4,500 - 3,700 r.p.m. Stall torque 7 mN m. 30.5 mm long by 23 mm dia. 5 mm x 2 mm dia. shaft. 35p

Item 621 Miniature d.c. motor, 1.5 - 3 V Open construction, ideal for demonstration. Dims. 19 x 9 x 18 mm, double-ended output shaft, 5 mm x 1.5 mm dia. 20p

Item 395 Model maker's motor, 3 V d.c. no load speed & current: 6250 rpm, 350 mA. Stall torque 1 mN m. Dimens. 35 mm long and 30 mm dia. with 15 mm shaft 2 mm dia. Small magnet in base for easy mounting. 40p

Item 630 Miniature d.c. motor similar to item 621 but includes four plastic wheels. 35p

Item 625 Worm and gear for use with miniature motors. Brass worm with plastic gear wheel. 35p

Miscellaneous items

Item 629 Dual-tone buzzer with flashing light, mounted on small P.C.B. The unit has a PP3 battery clip and two flying leads for switch applications. 40p

Item 638 Solar cell with motor. Cell area 45 x 75 mm, output 0.45 V max., 400 mA. The motor operates with a no load current of 250 mA, driving two geared output shafts. Motors and gears enclosed in plastic box. £3.50

Item 313 Thermostat, open construction, adjustable, range of operation covers normal room temperatures. Rated at 10 A, 250 V but low voltage operation also possible. 60p

Item 380 Thermostat, with capillary 500 mm long. Operates at low voltage but rated 10 A, 250 V. Can be activated by heat from human hand. £1.25

Item 385 Pressure switch, operable by water or air pressure. Rated 15 A, 250 V (low voltage operation also). Dimensions 3" dia. x 2". 65p

Item 419 Humidity switch operates by contraction or expansion of membrane. Ideal for greenhouse or similar control project with items 348 and 344. Rated 3.75 A up to 240 V. 75p

Item 507 Optical fibre, plastic, per metre single strand 1 mm dia. Used for the optical transmission of sound. See Bulletin 140 for one such application. 35p

Item 429 Metallised polyester film, one square metre, 12 microns thick (see Bulletin 139 for applications) £1

Item 612 Beaker tongs, metal, not crucible type, but kind which grasps the beaker edge with formed jaws. £1.20

Item 615 Wire, for thermocouples, 1 m of each of 0.5 mm dia. Chromel (nickel chromium) and Alumel (nickel aluminium). Makes d-i-y thermocouple - see Bulletin 158. £2

item 348 Submersible pump, 6 - 12 V d.c. Corrosion free nylon construction. £5.60

Kynar film items

See Bulletin 155 for details of applications such as force/time plots and detection of long wave infra red radiation.

Item 502 Kynar film, screened, 28 um thick, surface area 18 x 100 mm. With co-axial lead and either BNC or 4 mm connectors (please specify type). £20

Item 503 Kynar film, unscreened, 28 um thick, 12 x 30 mm, no connecting leads. 55p

Item 504 Copper foil with conductive, adhesive backing, 1" strip. Makes pads for Kynar film, to which connecting leads may be soldered. 10p

Item 505 Sensifoam, 0.25" thick, 6" x 6" £1.00

Item 506 Resistor, 1 gigohm, ¼ W £1.00

Resistors fixed & variable, components

Item 328 Potentiometer,wire wound, 15R linear, 36 mm dia. 20p

Item 329 As above but 33R. 20p

Item 330 As above but 50R and 40 mm dia. 20p

Item 331 As above but 100R and 36 mm dia. 20p

Item 420 5% carbon film, ¼ watt resistors values as follows: 10R; 15R; 22R; 33R; 47R; 68R; 100R; 120R; 150R; 180R; 220R; 270R; 330R; 390R; 470R; 560R; 680R; 820R; 1K0; 1K2; 1K8; 2K2; 2K7; 3K3; 3K9; 4K7; 5K6; 6K8; 8K2; 10K; 12K; 15K; 18K; 22K; 27K; 33K; 39K; 47K; 56K; 68K; 82K; 100K; 150K; 220K; 330K; 470K; 680K; 1M0; 2M2; 4M7 & 10M. 6p/10

N.B. If anyone is interested in purchasing other values in the E12 range between 1R0 and 10M, which are not listed above, please let us know so that we can consider extending our stock list.

Item 421 d.i.l. resistor networks per 10 following values available: 62R; 100R; 1K0; 1K2; 6K8; 10K; 20K; 150K; 125/139R and 1M0/6K0 30p

Item 322 Germanium diodes 8p

Item 371 Ferrite rod aerial, two coils MW & LW, dimens. 10 x 140 mm. 40p

Item 511 Loudspeaker, 8R, 2 W, 75 mm, resonant frequency 250 Hz. 50p

Item 631 Microswitch, miniature, SPST, normally closed, push to break. 40 mm long actuating arm, 4 mm spade connections. Dims. 20 x 10 x 16 mm. 25p

Item 632 Microswitch, standard, SPST, normally closed, push to break. 28 mm long angled actuator arm. Dims. 27 x 10 x 16 mm. 25p

Item 633	Infra-red sensors, emitter and detector, spectrally matched pair. Data sheet supplied. Priced for pair.		45p
Item 354	Reed switch, s.p.s.t., 46 mm long		10p
Item 508	l.e.d.s, red, green, yellow: each		6p
		or 10 for	50p
Item BP100	Precision Helipots, Beckman mainly 10 turn, many values available. Please send for a complete stock list.		10p to 30p

We also hold in stock a quantity of other electronic components including capacitors, diodes, transistors, etc. To list all of these items would be uneconomical since most articles are priced at 5p or under. If you do have requirements for such items please let us know and we will do our best to meet your needs.

*   *   *   *   *

TRADE NEWS

Harris take over IMS

Please note, if this hasn't already afflicted your summer requisitions and thereby brought itself to your attention, that IMS (Scientific) has been taken over by Philip Harris Ltd.

Resilient foam

Scottish Foam Ltd. have sent us samples of Jiffycel foamed polyethylene. This material has the most amazing resilience and recovers its shape even after repeated impacts. It will clearly be of interests to those who like dropping squash balls, heavy ball bearings or even Cox's Pippins on different surfaces and measuring the height of rebound.

However the intended use is that of allowing you to tailor make packing and cushioning for instruments. Normally such packing is made by moulding a foamed plastic and requires special equipment. Jiffycel can easily be made into any shape. It can be cut, drilled or heat welded with a hot air-gun. Unlike much of the present lightweight packaging polymers, it is not easily set alight.

Change of address

We have notification from John Scott, proprietor of the Scottish Electronic & Calibration Company, that his company has moved home from Neilston to Bridgeton in Glasgow. Please consult the address list. This company has built up quite a reputation for servicing, repairing and calibrating laboratory equipment.

Sounds like Neilston doesn't have a big enough pad for John to lay his iron on!

Special balance offers

If you are low in cash, but needing to purchase an electronic top-pan balance, then Oertling's current offer may be of interest. The following models are available at the prices shown:

Model	Range (g)	Price (£)
OB152	1500 x 0.01	595
OC61	6000 x 0.1	555
RB153	150 x 0.001/ 1500 x 0.01	780
RC62	600 x 0.01/ 6000 x 0.1	740

These prices include the Balance Monitor software and connecting lead to the BBC B or Master. This software and other balances were reviewed in Bulletin 155.

*   *   *   *   *

NOTICEBOARD

A.S.E. Annual Meeting

The U.K. parent-body annual meeting will be held at the University of Birmingham on the 4th-7th January, 1989. The later than usual starting date may ease the problems of travel for Scots, who until now have had to put up with the vagaries of Scotrail travel arrangements a mere day or so after Hogmanay.

*   *   *   *   *

Triumph over the beast

Some two and a half million years ago the climate of the Earth changed abruptly. Mean annual temperatures fell. The first of a series of ice ages affected the Arctic, Europe and North America. Africa became cooler and drier. The tropical forest which had covered most of the land largely disappeared, to be replaced by savannah or desert. From the fossil record it appears there was upheaval in the types of species. Many became extinct. Many others underwent considerable change to adapt to the new conditions. It is hypothesised that one such species of primates, Australopithecus africanus, changed by adaptation into Homo humilis, the ancestor of our own species. The main adaptation was the enlarging of brain size. Why might this have happened?

Consider the stress faced by Australopithecus. It lived in a land that abounded in large carnivores: lion, leopard, cheetah, hyena, and - perhaps most terrible of all - Dinofelis, a cat larger than the leopard, a night hunter that specialised in eating Australopithecus. With the replacement of the forest canopy, and the refuges it provided, by open grassland or desert the odds might appear to have been stacked heavily against this primate species. It faced extinction.

What presumably happened, and it is a hypothesis, is that the species adapted successfully into Homo humilis by the expansion of brain size. Through being more clever Homo humilis was able to outwit Dinofelis. By hunting, trapping and killing, the beast our ancestors must have dreaded over and above all others was destroyed. Dinofelis became extinct. The progenitor of our own species was saved.

Continuing the hypothesis, Homo sapiens is not primarily by instinct a hunting creature, as some would assert. We are a defensive animal, with hunting overtones. Fear of the beast in the night still instinctively grips us, down those two and a half million years.

> 'Whiles glow'ring round wi prudent cares
>
> Lest bogles catch him unawares'

What then, you wonder, has this to do with a SSSERC editorial? Where is the tilting at windmills? The venomous invective? The attacks on the bêtes noir of Scottish science education?

In the murky stew that passes for my mind ideas attach, entangle, and disengage. A long term concern met with and attached to this story of the origin of our species. What has concerned me for certainly five, but more probably ten, years is the lack of intellectual and spiritual content of some of the curricular support material that is in circulation - some indeed from central agencies, some from regions or schools, some from commercial sources. I assert that if a pupil does not regularly in lessons have his intellect aroused, his mind enriched, his spirits uplifted and his heart ennobled, then there is something wrong with the teaching - it could have been better. From inspecting the wads of curricular support materials which arrive at the Centre, it is a judgement which, sadly, seems often only too true.

The typical product that depresses me is parodied below, except that it has not here been Apple Mac'd.

> Title
>
> Read - blah, blah
>
> What you need - list of items
>
> Diagram -
>
> What to do -
>
> 1. Set up apparatus as shown in diagram.
> 2. Do such and such.
> 3. Now do such and such.
> 4. What did you see?
> 5. Measure this.
> 6. Now change this.
> 7. Repeat steps 4. and 5.

8. Copy the table into your notebook and complete.

Questions -

Read - blah, blah, etc.

This type of pupil material is ever so common. I am concerned. I cannot believe that, except at a trivial level, it either stretches the imagination, or enthuses or excites, or fills with awe or wonder, or enriches the mind, or is spiritually uplifting, or ennobles the heart. It is teaching material for a species of cloned dullards.

Some people think we live in the world's first post industrial society. There is a danger we end up as a land of trivial pursuits, where the thrills are limited to garden festivals, a Jean Michel Jarre laser show, or a production of the Kelvinside Amateur Dramatic Society. But why not put thrills in classroom lessons too? It is not worth the bother. Too hard for the weans. We are a post industrial people. Don't ask us to think. Bring on the circus and let our brains atrophy.

We inhabit a fools' paradise.

The beast may be slayen, but other dragons exist:

an epidemic of an incurable disease, AIDS, which is transmuting fast and may one day be transmitted by other than sexual means;

the nuclear weapons possessed by several nations;

the succession of totalitarian governments, which have oppressed many peoples this century;

a country which uses chemical weapons against foreign and national adversaries;

the destruction of much of the soil on the Earth through bad farming methods or land use, or deforestation;

the release of chemical waste into the atmosphere, which is leading to a general climatic warming and a consequent rise in sea levels, and to a reduction in atmospheric ozone.

By muddle, misfortune, ignorance, stupidity, greed, or wickedness, our species, and many of those others our own species has not managed to yet kill off, are under threat of extinction. It will take ingenuity and extreme good fortune to survive. By reacting intelligently and in accordance with moral values we may yet again succeed in securing an existence. But if education does not respond by providing an appropriate intellectual and spiritual uplift it leaves the next generation unprepared for the beasts which lurk in the dark.

Footnote

The story of the origin of our species has been taken from "The Songlines" by Bruce Chatwin (Jonathan Cape Ltd., 1987).

S.S.S.E.R.C.

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October 1988