SCOTTISH SCHOOLS SCIENCE
EQUIPMENT RESEARCH CENTRE

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April 1984

Beeb analogue port
Fibre optics

ADDRESS LIST

SSSERC, 103 Broughton Street, Edinburgh EH1 3RZ. Tel. 031-556 2184 or 031-557 1037.

Artec (I for E) Ltd., Salewheel House, Ribchester, Preston, Lancs PR3 3XU. Tel. (025484) 215.

Beevers Miniature Models Unit, Department of Chemistry, University of Edinburgh, West Mains Road, Edinburgh EH9 3JJ. Tel. 031-667 1081.

C. W. Cameron Ltd., Burnfield Road, Giffnock, Glasgow G46 7TH. Tel. 041-633 0077.

Centre for Studies in Science and Mathmatics Education, The University of Leeds, Leeds LS2 9JT.

Dennard Rotadrive Ltd., Watchmoor Trade Centre, Watchmoor Road, Camberley, Surrey GU15 3AJ. Tel. (0276) 683558.

Economatics Education Division, 4 Orgreave Crescent, Dore House Industrial Estate, Handsworth, Sheffield S13 9NQ. Tel. (0742) 690801.

Educational Electronics, 30 Lake Street, Leighton Buzzard, Beds LU7 8RX. Tel. (0525) 373666.

Euroclip Ltd., P.O. Box 57, Banbury, Oxon OX16 8TG. Tel. (0295) 55366.

Farnell Electronic Components Ltd., Canal Road, Leeds LS12 2TU. Tel. (0532) 63611.

Frazer Scientific Instruments Ltd., Askival House, Newtonmore, Inverness-shire PH20 1DZ. Tel. (05403) 295/360. Edinburgh Branch 031-332 7559.

Griffin and George Ltd., Ealing Road, Alperton, Wembley, Middlesex HA0 1HJ. Tel. 041 248 5680.

Philip Harris Ltd., 34-36 Strathmore House, Town Centre, East Kilbride G75 1LQ. Tel. (03552) 34983/4.

HMSO, 13a Castle Street, Edinburgh EH2 3AH. Tel. 031-225 6333.

IMS (Interbook Media Services (Scotland) Ltd.), Oakbank Industrial Estate, Garscube Road, Glasgow G4. Tel. 041-332 6088/9296.

Jencons (Scientific) Limited, Cherrycourt Way Industrial Estate, Stanbridge Road, Leighton Buzzard, Beds LU7 8UA. Tel. (0525) 372010.

C. E. Offord (Microscopes), Ticehurst Road, Hurst Green, Etchingham, Sussex TN19 7QT. Tel. (0580) 200739.

Parfitt Electronics Limited, 6 View Road, London N6 4DA. Tel. 01-348 1973.

Quantum Jump Ltd., 98 Queens Drive, Mossley Hill, Liverpool L18 1JN.

RS Components, P.O. Box 427, 13-17 Epworth Street, London EC2P 2HA. Tel. 01-253 3040.

SMA (Scientific Marketing Associates), 37 Mildmay Grove, London N1 4RH. Tel. 01-359 5357.

South West Minerals Resources, 14 Elphinstone Road, Peverell, Plymouth PL2 3QQ. Tel. (0752) 703580.

Technomatic Ltd., 17 Burnley Road, London NW10 2ED. Tel. 01-452 1500.

Unilab Ltd., Clarendon Road, Blackburn, Lancs BB1 9TA. Tel. (0254) 57643/4.

XOB, 131 Grangehill Drive, Monifieth, Angus. Tel. (0382) 533834.

Introduction

Surplus Equipment

Much of the surplus equipment listed in this Bulletin is new, purchased in bulk at discount prices and is not subject to ballot.

Useful addresses and references

Science teachers are busy persons who cannot always find the time to locate particular articles and references at the 'right moment'. A real boon to aid the retrieval of articles are the reference lists compiled by the **Centre of Studies in Science and Mathematics** at Leeds University. The following new titles have recently become available and can be obtained from the address on the inside cover:

— Addresses for Science Teachers (1983) £1.00

— References for Chemistry Teachers (1973-1983). (This is a sequel to an earlier series which covered the previous ten years). £1.50

Earlier lists of references produced by the Leeds Centre are also available.

— Biological References (1960-1972) 70p

— Biological References (1973-1978) 65p

— References for Physics Teachers (1966-1976) 50p

Orders for 10 or more booklets in any combination attracts a 20% discount.

Most of the references for physics, chemistry and biology are from the School Science Review and others come from the Journal of Chemical Education, Education in Chemistry (RSC), the Journal of Biological Education and Physics Education.

All of the entries in the 'references' are classified into categories. The ''Addresses'' is an alphabetical list of equipment manufacturers, suppliers and repairers, publishers, associations and learned bodies. A short note detailing the main points of interest or service provided by each entry makes the list immensely useful. The unusual or exotic, as well as the everyday, can be readily found. Could you easily locate the address of the British Butterfly Conservation Society or of the British Wool Marketing Board, or perhaps that firm which used to supply large expanded polystyrene spheres? They and many others are all listed here.

* * * * * *

Safety Notes

Accident reports

Explosion in a fume cupboard

Last autumn we heard of an accident in a school south of the border in which a fume cupboard was severely damaged. A teacher was heating magnesium powder and copper(II)oxide in a crucible inside a fume cupboard. The mixture had been tried out beforehand and had been found to react with the usual, acceptable vigour.

The cupboard, a double-access type with sashes opening on to two rooms, was also used to store several bottles of chemicals including bromine, silicon tetrachloride, concentrated hydrochloric acid and sulphur dioxide. It is unclear whether these contributed to the final explosion, but their presence could have made the accident worse. The sample of magnesium powder was noticed to be finer than usual and subsequent analysis confirmed the presence of aluminium.

The cause of this explosion is uncertain and one can only speculate and then take appropriate precautions. It is a well known fact that secondary explosions caused by previously settled dust being kicked up by the first explosion can be extremely violent—witness flour mill and coal mine explosions. Fine dust can over the years settle in parts of fume cupboard ducts as fairly thick deposits. It is also well known that many reactions are more violent if confined. When carrying out reactions between powders which are known to react vigorously we would make the following recommendations:

(i) powders used should not be excessively fine; this can lead to faster and more violent reactions or can be more easily scattered possibly leading to dust explosions if a source of ignition is present.

(ii) only small (ie. what will rest on the end of a spatula. 0.1-0.2g) quantities should be used and these should not be confined inside a crucible or other vessel, but placed in a small conical heap on a piece of ceramic paper supported on a gauze;

(iii) such demonstration experiments are best carried out in the open laboratory using two explosion screens and not inside a fume cupboard.

If a fume cupboard is used for reasons of toxicity then a safety explosion screen should still be used inside the cupboard. Some of the older existing fume cupboards may not be glazed with toughened glass and flying shattered glass could pose more of a danger than the original exploding crucible or other vessel.

The Laboratory Safeguards Sub-Committee of the ASE in the EiS of January 1984 reported further on some areas:

(i) implosion of **bell-jars.** The need for safety screens was again emphasised (see Bulletin 139) and the point was made that many bell jars supplied by manufacturers are not designed for evacuation experiments;

(ii) the dangers of explosions from **12V heaters** which may have developed hairline cracks (see Bulletins 114 and 137);

(iii) it was pointed out that in the **preparation of chlorine** using sodium chlorate(I) that acid should be added to the chlorate(I), never the reverse. This minimises the risk of formation of explosive chlorine oxides.

HSE Guidance Notes

Two guidance notes which will be of interest to work in schools are:

(i) EH31 "Control of exposure to polyvinyl chloride dust"

This note is more concerned with the hazards caused by the levels of dust which may be created in industrial handling and processing. However the finishing of PVC articles is mentioned as one likely to give rise to dust. The use of respiratory and personal protection equipment is recommended where exposure to dust cannot be avoided by suitable techniques or methods of control. There is evidence that PVC dust, free of the monomer, may cause respiratory dysfunction and a suspicion exists that there may be an excess of lung cancer among workers exposed to the dust.

(ii) PM 32 "The Safe Use of Portable Electrical Apparatus"

This guidance note deals with much of those areas of electrical safety, which have involved schools in discussion over the past few years. After all most of the mains powered appliances in schools are portable. The document is not very technical and is very readable, listing all those common faults which may develop or happen through carelessness. The Note is positive in that there are listed precautions which should minimise the possibility of accidents. We would recommend that this be included in any inventory of Safety Literature; it is available from HMSO for £1.50.

* * * * * *

Biology Notes

Microprojection and CCTV microscopy

We have published a number of articles on microprojection, using both commercial and d-i-y devices with the emphasis mainly on the latter (Bulletins 35, 66, 67, 73, 86, 88). We still receive enquiries on commercial microprojectors and have evaluated a number of them over the years. In our experience in this field, as in the rest of life, you get what you pay for. Since the withdrawal of the Philip Harris microprojection base we have seen nothing on the school's market with a really satisfactory performance at an affordable price for the average biology department. Indeed we would be willing to lay odds that we could turn up dozens of unsatisfactory microprojectors now gathering dust in biology lab. cupboards.

There is, we suspect, a lot of muddle over the educational use of microprojection. We fear that this muddle may spill over into the use of closed circuit television with microscopes, now that CCTV is slightly more affordable.

Some biology teachers and, judging by the illustrations in their promotional leaflets, most suppliers see the main use of projection and CCTV as being with 'permanent mounts'. Here we mean commercially prepared and stained specimens. We are of the opinion that this is misguided. The suppliers do exercise quality control on prepared slides, discarding grossly untypical 'sections'. However for a school to obtain in its set of slides, a really superb section showing clearly all the typical features, laid out like a textbook line drawing or photograph, is largely a matter of luck. This is not true of commercial photomicrographs from the better suppliers. A reputable firm may have searched literally thousands of sections in order to select the best for photomicrography.

The conclusion to be drawn should be obvious. If we wish to ensure that all the students in a group have seen particularly important features, either in revision or prior to individual microscopic work, we should use a 35mm photomicrograph transparency on a slide projector.

Microprojection comes into its own with temporary mounts, often pupil-prepared. It is particularly useful where pupils attempt, for example, difficult squash preparations. Here out of a whole class, only a handful of pupils may achieve reasonable results. It is then most satisfying to be able to project these slides for the benefit of the class. This is only really successful where a pupil instrument can be transferred to a projection set-up quickly and without fuss. If the slide has to be moved to another special projection instrument, much time may be wasted searching the slide and the moment of interest is lost.

Here is where we see the promise of CCTV. Not wishing to be Jonahs, nevertheless we must point to the major limitation of the currently heavily promoted cheaper systems. Although giving higher resolution than colour systems, monochrome cameras and their monitors have obvious disadvantages when used with coloured specimens. Some cheaper routes to colour CCTV for microprojection will hopefully become available.

In the meantime other routes exist:

(i) Video systems (ie. camera, VCR and monitor) already present in or about to be purchased by schools or by a teachers' centre can be used provided that the zoom lens can be removed from the camera and be replaced by a C-mount. This is true of only some of the makes in the cheaper range of colour video cameras and anyone about to purchase a camera or system should look out for those possibilities. Unfortunately the resolution is inferior to that obtained using a cable directly between camera and monitor.

(ii) Colour cameras fitted with C-mounts, and which can be directly linked to monitors are available for about the same price as a complete black and white system (ie. camera, cable and monitor). Thus, provided suitable monitors are available in the school, a colour CCTV projection system can be obtained for the price of a complete black and white system. Fuller use will also be made of existing equipment rather than have a monitor dedicated for microprojection sitting in a cupboard for much of the year.

The only fly in the ointment here is that the camera and monitor must be electronically compatible. All of the cheap colour cameras (costing £500-£600 ot thereabouts) we have seen output a composite signal. This means that the three colours red, green and blue and their luminance are all transmitted along a single cable and then decoded in the monitor. Many of the monitors used for video work will accept a composite signal, but the RGB monitors presently found in nearly all science departments as VDUs for micros are usually not suitable. Some RGB monitors can be set to receive composite signals by means of a switch. We have come on a simple plug-in adaptor for RGB monitors which makes them compatible with composite signals. Details are given in the Trade News.

* * * * * *

Chemistry Notes

A gaseous equilibrium

The equilibrium N_2O_4 (g) = $2NO_2$ (g) is usually examined as one whose equilibrium position can be altered by easily applied changes in conditions, e.g. temperature and pressure. A common method used for showing the effect of pressure is the compression/decompression of NO_2 in a plastic syringe. It is often the case that teachers notice the change in colour of the gas because they know what to look for. However, pupils remain unconvinced that any changes have occurred, far less any complex 'double change'.

It was this difficulty which prompted the following question:—How could the darkness/lightness of the gaseous equilibrium be graphically displayed? The relative concentrations of nitrogen dioxide, dark brown, and dinitrogen tetroxide, colourless, could therefore be compared.

The obvious answer lay in the operating principles of a colorimeter. A colorimeter itself would be ideal, but the usual cell shape and construction are unsuitable for the application of relatively high pressures. To this end we constructed a crude, but sturdy form of colorimeter with no light collimation or filters.

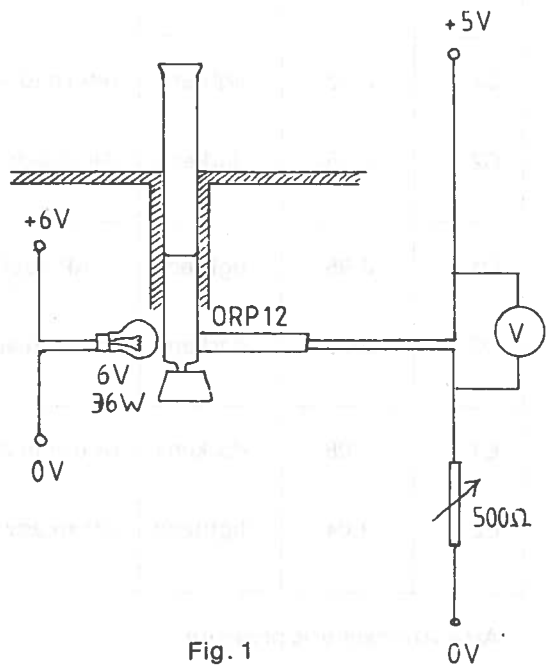


Fig. 1

Fig. 1 shows the approximate position of the glass syringe with metal nozzle (Segma 100cm³ available from Horwell) which is supported during compressions and decompressions of the gaseous equilibrium. It was positioned in the light path between the 6V bulb and the light detector. Constructional details of the 'support rig' can be found in the 'Workshop' section of this issue. As varying light levels are transmitted through the equilibrium mixture, the resistance of the (LDR) light dependent resistor (ORP12) alters. The circuit used to measure voltage is discussed later. The gas was prepared using copper and concentrated nitric acid in a side arm filter tube. It is recommended that a fume cupboard is used during this transfer, as nitrogen dioxide is very toxic by inhalation.

Fig. 2(a) shows a cycle of compressions and decompressions on the syringe with plunger positions A,B,C, D and E. Table 1 shows typical resistance measurements from the ORP12 LDR, obtained using a digital multimeter. Apart from the initial position each has two resistance measurements eg.B1 and B2, as the movement of the plunger produces an initial resistance at the new position and then a final resistance as the mixture finds it sן new equilibrium. The table also describes the observations and chemistry at each position illustrated in Fig. 2(a) and traced in Fig. 2(b).

The change in resistance could also be observed on an analogue multimeter such as an 'AVO'. The difficulty which is experienced by using a meter (analogue or digital) is that they have no offset zero facility. Therefore the change in resistance measured takes place over only a small part of the range. The experiment was tried using the Philip Harris Single Channel Analogue/Digital Interface (Cat. No. P87020/7 £79.50 +£9.50 for software +£27.00 for connecting leads) linked to a BBC Model B micro. This interface has offset zero on both resistance and voltage measurements. The required range over which the changes occur could then be selected and amplified. Fig. 2(b) shows a typical trace produced during the same cycle of compressions and decompressions shown in Table 1.

Plunger position	R(kΩ)	Colour	Pressure	Effect on Gas mixture	Equilibrium Shift
A	3.04	brown	AP	nil-system at equilibrium	(nil
B1	3.40	darkens	>AP applied	initially higher concentration NO	
B2	3.26	lightens	>AP steady	NO_2 associates new equilibrium	$2NO_2 = N_2O_4$
C1	3.13	lightens	return to AP	initially lower concentration NO	
C2	3.05	darkens	AP steady	N_2O_4 dissociates new equilibrium	$N_2O_4 = 2NO_2$
D1	2.95	lightens	<AP applied	initially lower concentration NO	
D2	3.03	darkens	<AP steady	N_2O_4 dissociates new equilibrium	$N_2O_4 = 2NO_2$
E1	3.08	darkens	return to AP	initially higher concentration NO	
E2	3.04	lightens	AP steady	NO_2 associates new equilibrium	$2NO_2 = N_2O_4$

AP—Atmospheric pressure

Table 1

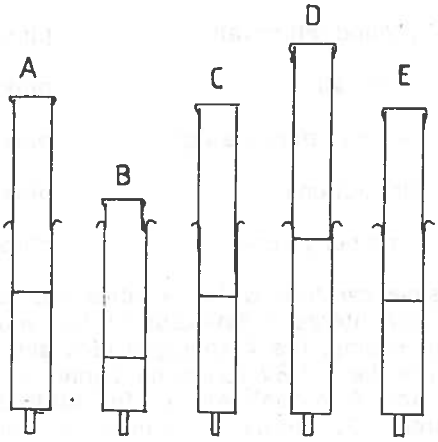


Fig. 2(a)

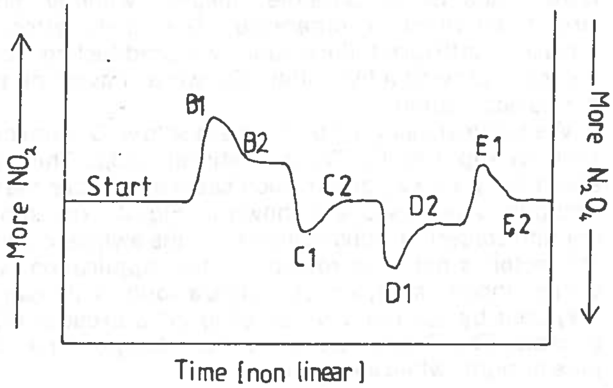


Fig. 2(b)

It is more conventional to measure voltage across the ORP12 and the following methods proved successful. Fig. 1 shows the circuit used to produce a voltage across the ORP12. If required, this may also provide power for the lamp. You will once again have problems with scaling if you use a conventional digital or analogue voltmeter. In this issue an article on the BBC analogue port of the BBC micro describes how hardware can produce an offset zero for measuring small changes in voltage.

As an alternative the offset zero facility on a typical oscilloscope was used to measure the voltage. With the time base off, a vertical line was produced which corresponded to the voltage produced. Changes in resistance across the ORP12 produced changes in the voltage and was seen as changes in the length of the line on the oscilloscope. The screen graticules provide useful reference points. The line length can therefore be related to the relative concentrations of the 'dark' NO_2 and the 'light' N_2O_4. These voltage measurements using the oscilloscope were made with an unsmoothed d.c. supply. A smoother supply is preferred for use with the ADC interface.

It should be emphasised that the best results were obtained when the plunger was compressed as hard and as quickly as possible. This resulted in a larger change in absorbance of the gaseous mixture and consequently a larger change in the resistance or voltage. Conversely, a sharp pull gave a larger change from dark to light. It is essential for the syringe and 'support rig' to be clamped firmly to the bench during these operations.

Rubber rings

You might find Elastrator rubber rings for the castration of lambs and young bulls very useful in science laboratories! These small very tough rubber rings with a bore of ca. 6mm will find numerous applications. They may remind older chemists of the use of rubber rings, which, when fitted on burettes, held them securely in wooden stands.

They are excellent for protecting or suspending thermometers and other rods, and have the advantage of being easily rolled along the stem. A small slice cut off the ring to give one straight edge makes a very effective anti-roll device for thermometers and stirring rods. Applications are legion. Some possibilities are shown below and we are open to receiving other suggestions. The idea was sent to us by Daliburgh School, South Uist.

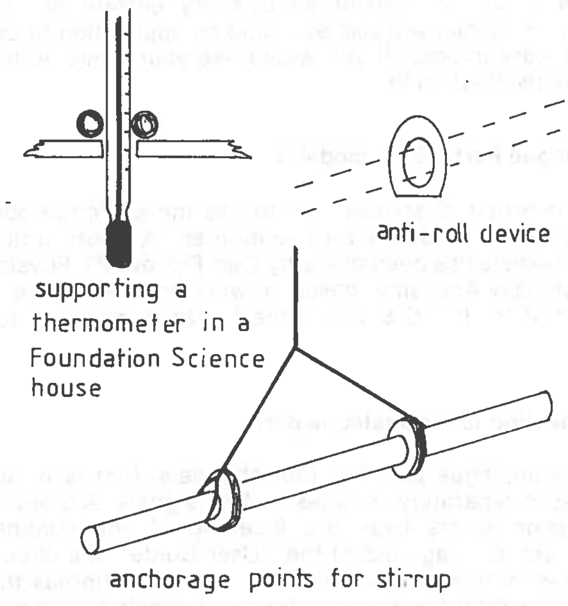


Fig. 1

Interfacing Notes

Introduction

There are two articles under this heading in the Bulletin. The first, as promised a long time back, deals with the BBC analogue port. We regret taking as long as we have done to publish this but we just have not been able to make the necessary time till now. Much of this article deals with calibration, precision and accuracy and will be relevant to other devices such as the I-Pack analogue port for the ZX-Spectrum.

The second article is of a more general nature in that it is relevant to many analogue to digital converters. It deals with an important aspect of analogue signal processing, namely offset zero.

Our Science Interfacing Register has recently been updated for the final time. Please note that we shall no longer maintain this record. When conceived, the Register served the purpose of putting enthusiasts in touch with one another. This age is over, not because the enthusiasts have gone, but because there is nowadays a lot of published work in the press on interfacing and also because there are many, suitable commercial devices.

Finally we can put in a plug for our "Interfacing Extracts", the cullings of journals on articles on interfacing and electronics. The latest Extracts cover the 8 month period up to December 1983 and includes a new section on electronics projects. This issue of the Extracts will be distributed to every entrant on the Register. Copies are also available on application to us, and please indicate if you would like your name added to the distribution list.

Analogue Port—BBC model B

This article describes how to use the analogue port in the BBC model B microcomputer. A contribution to the article has been made by Dan Feeley, PT Physics at Rothesay Academy, based on work done by Kirsteen Macleod for her C.S.Y.S. project. We thank them for that.

Connecting to the analogue port

The analogue port has four channels, that is it can measure separately voltages on four signals. A point of confusion exists over the labelling of the channel numbers. On page 505 of the "User Guide" the circuit diagram refers to channels 0, 1, 2 and 3 whereas the MOS and BASIC software refers to channels 1, 2, 3 and 4. We use the latter reference system in this article.

The analogue port connector is a 15-way D type socket. Facilities provided are:

4	analogue channels (1, 2, 3, 4)	pins 15, 7, 12, 4
	ground return rail	pins 2, 3, 5, 8
	+5V rail	pins 1, 8
	+1.8V reference signal	pins 11, 14
2	fire buttons	pins 13, 10
	light pen strobe	pin 9

Consider carefully which facilities you want to use. If your sole interest is data capture then you only need wire up 5 pins, the 4 analogue pins and 1 ground. Don't use the +1.8V reference signal for the reason given later. Also don't wire up fire buttons and light pen strobe. Furthermore consider carefully whether you want to use the computer's 5V supply rail. The reason for usage is the obvious one, handiness. The reason against is possible misuse, whether short circuit, overload or otherwise. The likely effect of misuse is software failure. Our own predilection would be not to provide a 5V outlet, but we will override that in this description.

We suggest using a 15-way male solder D connector, such as supplied by Technomatic at 105p. This firm also supply 10-way grey ribbon cable at 40p per metre. The pins being used are shown in Fig. 1. You should not find soldering ribbon cable to 6 pins awkward as the connector is not overcrowded in this application. Use 6-way ribbon cable, about 1 metre long. This can be prepared by tearing a 6-way strip off a broader piece of cable. The D connector should be clamped in a vice, pins upright, while soldering.

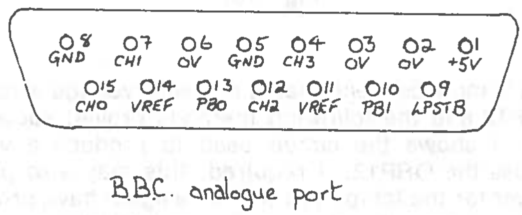


Fig. 1

Wire up the free end of the ribbon cable to six 4mm sockets mounted on a half section of rectangular section plastic rainwater pipe (Fig. 2). This piping should be obtained from local plumbers merchants (see Yellow Pages), but check by telephone for availability. The 4mm sockets should be colour coded:

0V	black
+5V	red
analogue inputs	all yellow, green, brown or blue

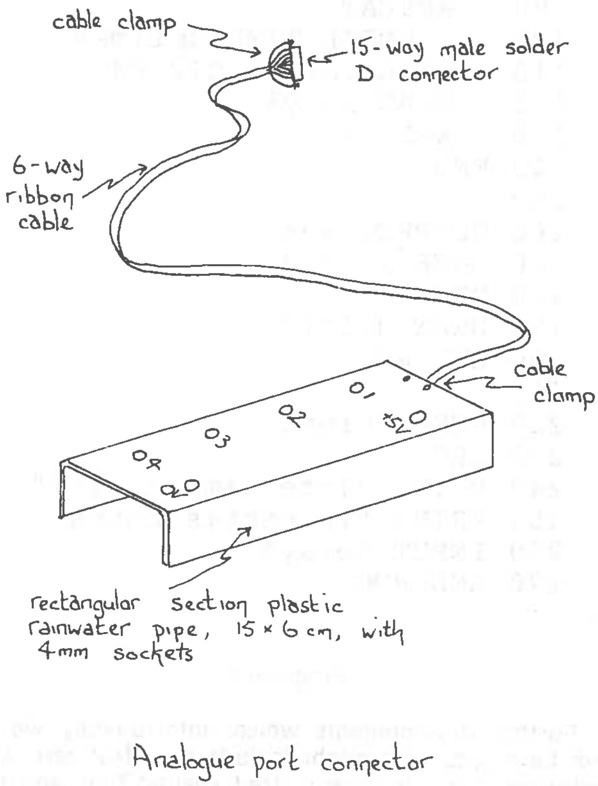


Fig. 2

Finally, the ribbon cable should have strain relief devices at both ends. At the D connector we suggest wrapping three turns of 1/0.6mm wire tightly round the ribbon cable just where the six ways merge. The two free ends of this wire should be secured to the two bolt holes on the D connector shell. At the 4mm socket end bolt a metal strip across the ribbon cable such that the cable is pressed hard flat against the rainwater pipe surface.

The analogue port connector is now complete. Note that it provides 4mm connector access direct to the analogue to digital converter within the microcomputer.

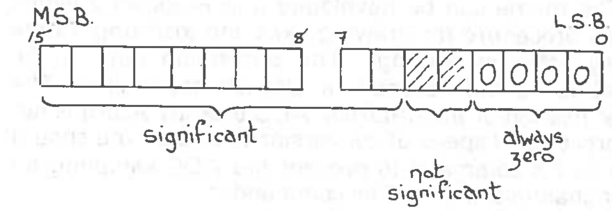
BASIC software and the ADC

The analogue to digital converter (ADC) can provide 8 bit resolution (1 part in 256) or 10 bit resolution (1 part in 1024). If you want to work in both these modes then you will have to use machine operating system (MOS) software. "The Advanced User Guide" explains how. This article does not go into MOS and restricts its description to BASIC. The BASIC instruction which initiates an analogue to digital conversion is ADVAL and gives 10 bit resolution. An example of its usage is given below.

Y = ADVAL(N)

N can be 1, 2, 3 or 4 depending on which channel you are using. Y is a denary number between 0 and 65520, 0 corresponding to 0.0V and 65520 to the maximum permissable input voltage which is about or just over 1.8V. The converter is a linear device, that is the value of Y is directly proportional to the input voltage up to the 1.8V maximum. Number 65520 is significant because it is 15 less than 2^{16}. Because the BBC microcomputer is an 8 bit machine the way it processes the 10 bit resolution of the analogue to digital converter is as a 16 bit number. However only the 10 most significant bits are precise. The 4 least significant bits of this number are always zeros and the 5th and 6th least significant bits are inaccurate. The binary representation of Y is shown below.

Y = ADVAL(N)



The denary number obtained by the conversion should therefore be divided by 64.

Y = ADVAL(N) DIV 64

Y can now take any integer value between 0 and 1023 and these integer values correspond directly with the resolution provided by the electronics hardware.

Analogue—graphics display

Conveniently in MODE 0 graphics 1023 puts the graphics cursor to the top of the screen and 0 to the bottom. x-axis cursor control is from 0 to 1279 (Fig. 3). Note, however, that screen resolution is 640x256.

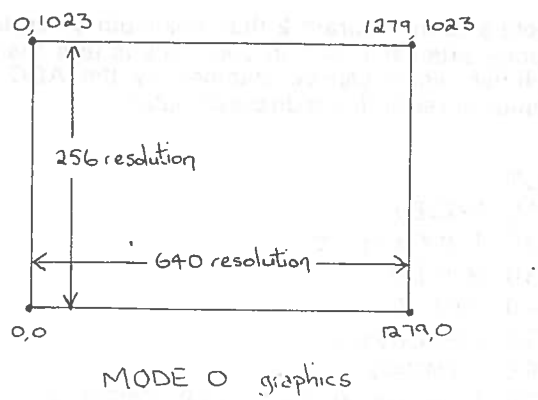


Fig. 3

A simple chart recorder program can therefore be devised on the theme of Program 1. This program records 1280 readings on channel 1 which it plots in real time.

```
    LIST
   10 MODE0
   20 *FX16,1
   30 FOR x=0 TO 1279
   40   y=ADVAL(1) DIV 64
   50   DRAW x,y
   60   NEXT x
   70 END
 >
```

Program 1

The theme can be developed into Program 2 which has a procedure for drawing axes and inserting a time delay between readings. The conversion time of the ADC is 10 milliseconds, a slowish conversion. The specification of the uPD7002 ADC used by Acorn is not impressive. If speed of conversion is critical you should use an FX command to prevent the ADC sampling all four channels in turn. The command is

*FX16, N

where N is an integer between 0 and 4 (User Guide, p 426).

e.g. N = 1, channel 1 only is sampled, intersample time on channel 1 is 10ms.

N = 2, channels 1 and 2 only are sampled, intersample time on each channel is 20 ms.

If you don't use this FX command the minimum intersample time achievable per channel is 40ms. In flat out data capture you would merely get repeats of the data stored in channel 1 converter two or three times over.

Note also in Program 2 that maximum y resolution graphics attainable is 1 in 256. This is less than the resolution which can be obtained by the ADC. The question of resolution is discussed later.

```
LIST
   10 MODE7
   20 PROCinput
   30 MODE0
   40 *FX16,1
   50 PROCaxes
   60 TIME=0
   70 FOR x%=0 TO 1278 STEP 2
   80   uptime%=delay%*x% DIV 2
   90   REPEAT
  100     UNTIL TIME>uptime%
  110   y%=ADVAL(1) DIV 64
  120   DRAW x%,y%
  130   NEXT x%
  140 END
  150
  160 DEFPROCaxes
  170 MOVE 1279,0
  180 DRAW 0,0
  190 DRAW 0,1023
  200 ENDPROC
  210
  220 DEFPROCinput
  230 CLS
  240 PRINT "Intersample time"
  250 PRINT "in centiseconds"
  260 INPUT delay%
  270 ENDPROC
>
```

Program 2

Further developments which unfortunately we do not have space for might include an offset zero with software, two variables plotted against time and two variables, x and y, one plotted against the other. A suite of data capture programs, one for each of these specifications, would be a worthwhile endeavour.

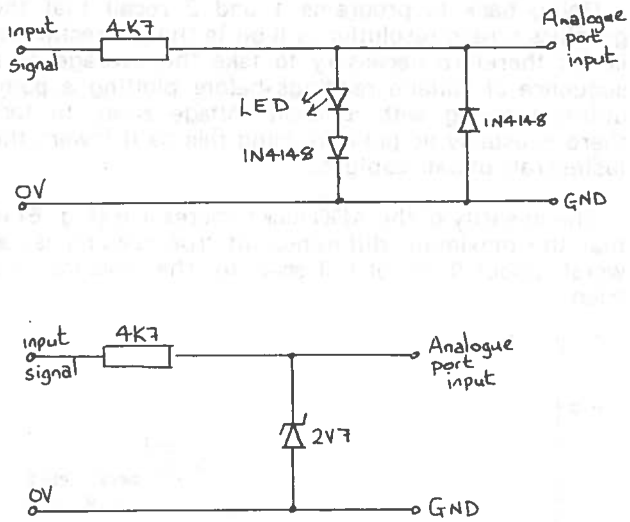
Protection

The ADC inputs are monopolar, + 1.82V maximum. The wrongdoings which you must protect the inputs from are

1. reverse polarity,
2. overvoltage,
3. inductive spikes.

Back emfs are, of course, taken care of by protection methods against reverse polarity and overvoltage. Nonetheless it is worthwhile listing inductive effects so that you don't get caught out with a 1.5V cell and coil. Two circuits are shown (Fig. 4) which both provide adequate protection for voltages up to ± 40V.

The top circuit in Fig. 4 makes use of one LED and two silicon diodes. The former device conducts when a voltage in excess of about 1.8V is applied across it, the latter for a voltage of about 0.6V. This circuit therefore prevents an overvoltage exceeding + 2.4V or a reverse voltage exceeding —0.6V. The 4K7 series resistor limits the magnitude of current being conducted by the protection diodes. Its value ensures that the short circuit current is less than 10mA should the



Overvoltage and reverse polarity protection
top - LED and silicon diode
bottom - zener diode

Fig. 4

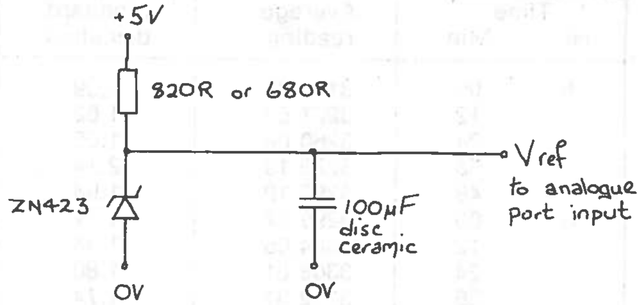
input signal rise to 40V. Signal degradation due to the 4K7 series resistor is insignificant due to the high input impedance of the ADC. The bottom circuit with zener diode works in a similar fashion. Of the two circuits the top is preferable since the LED indicates when something is awry.

There appears to be a fair margin in excess of +1.8V before damage to the ADC chip occurs. We have two independent reports that the upper limit is just over 5.0V. It is certainly worth protecting the ADC chip, partly because of the expense to replace it (at time of writing Technomatic have them in stock at £6.00) and partly because of shortage of supply. On the other hand it is not worth spending overmuch to protect a chip which costs £6.

Calibration

A reference voltage of +1.8V can be obtained from pins 11 and 14 of the analogue port. This reference signal is taken across three 1N4148 silicon diodes, in series. It cannot be used for accurate work, however, as the voltage drifts with temperature. For example at power-on of a cold machine the reference voltage was 1.906V. Two hours later it had drifted down to 1.843V.

A more suitable reference can be made with precision voltage reference ZN423, sometimes called a band gap diode (Fig. 5). These are available from RS Components, 283-233, at £1.00. Reference voltage versus time is shown in Table 1 and seems stable. The value of the series resistor is not critical (Table 2).



Precision voltage reference.

Fig. 5

Time of reading (minutes)	Vref
0	1.281
10	1.281
30	1.281
60	1.281

Table 1. ZN423 reference voltage versus time.

Series resistor (Ω)	I (mA)	Vref
330	11.3	1.283
470	7.9	1.282
680	5.5	1.281
1K0	2.5	1.280
1K5	2.5	1.279

Table 2. ZN423 reference voltage versus series resistor and current.

The ZN423 technical specification quotes an output between 1.20V and 1.32V. You would have to determine the exact voltage output by measurement and thereafter assume it remains constant. An alternative device to ZN423 is the low current bandgap 9491, RS number 283-283.

The value obtained in a conversion is temperature dependent. You can try this out for yourself by leaving a 1.5V cell connected to one of the analogue channels for several hours and running a program which measures voltage every few minutes. The values shown in Table 3 were taken twelve minutes apart. The rapid rise in the first hour is due to the warming up of the BBC micro. Once steady state with surroundings is reached the readings show a slow fall since they were recorded in evening whilst the laboratory was cooling down. If interested in accurate measurements it would be necessary to take account of this temperature effect by a repeated sequence of calibration—measurement—calibration. A teaching point on the handling of errors could be based on this in H grade physics. A draft of an as yet unpublished S.C.D.S. document "Errors in experiments" has been received by us which makes explicit the topic of experimental error. Hitherto this topic has been implicit in physics courses rather than explicit.

Time Hr	Time Min	Average reading	Standard deviation
5	00	3170.87	2.09
	12	3227.69	1.62
	24	3260.06	1.95
	36	3279.19	2.14
	48	3292.19	1.94
6	00	3299.37	1.71
	12	3304.06	1.44
	24	3308.81	1.80
	36	3312.31	1.74
	48	3315.12	2.19
7	00	3317.50	2.31
	12	3319.31	1.66
	24	3320.94	1.84
	36	3321.37	1.96
	48	3321.62	1.96
8	00	3322.44	2.00
	12	3321.25	2.32
	24	3320.44	1.82
	36	3319.50	2.94
	48	3316.81	1.80

Switch-on 4.59pm
Measurements from 5.00pm till 8.48pm
12-bit resolution, reading = ADVAL(1) DIV 16
Average and standard deviation of 16 readings

Table 3. Conversion dependence on temperature.

Accuracy and precision

The 10-bit precision of the ADC claimed by Acorn has come under question by Paul Beverley writing in "Acorn User", March 1984. The conversion appears to give only 9-bit precision. This can readily be determined by repeatedly printing out ADVAL(1) DIV 64 on the screen, a 1.5V cell being connected to channel 1. That the final denary figure changes in a random fashion by 2 proves his point (Table 4).

9-bit precision can be improved on, however, by taking lots of results and averaging. Operating at 10-bit resolution, a set of 16 readings has a standard deviation of about 0.5. In other words there is a 67% chance that the final digit of the average of 16 10-bit readings is precise. This order of precision, 0.1% at full scale, is greater than most of us have hitherto been accustomed working to in schools.

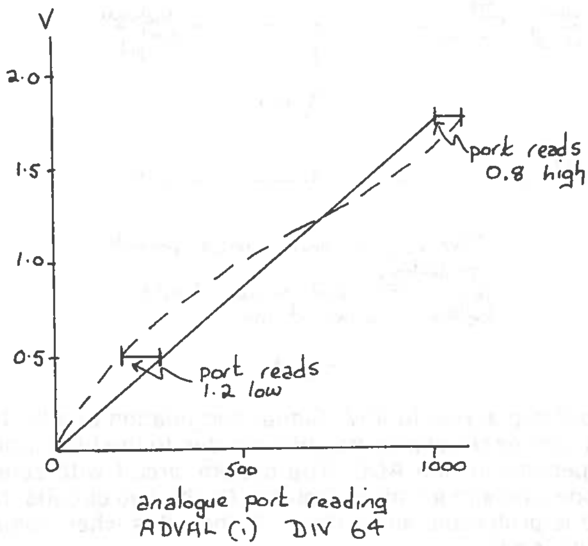
829	828	828	827
828	829	828	828
829	828	828	828
828	829	827	829

average = 828.2
standard deviation = 0.66
number of bits = 10
number in sample = 16

Table 4. Number of significant bits.

Going back to programs 1 and 2 recall that the graphics screen resolution is 8-bit in the y direction. It is not therefore necessary to take the average of a sequence of voltage readings before plotting a point unless working with a small voltage span. In fact there is usually no point in doing this as it lowers the fastest rate of data capture.

The linearity of the ADC looks impressive (Fig. 6) in that the maximum difference off true reading is, at worst, about 0.1% of full scale for the machines we tried.



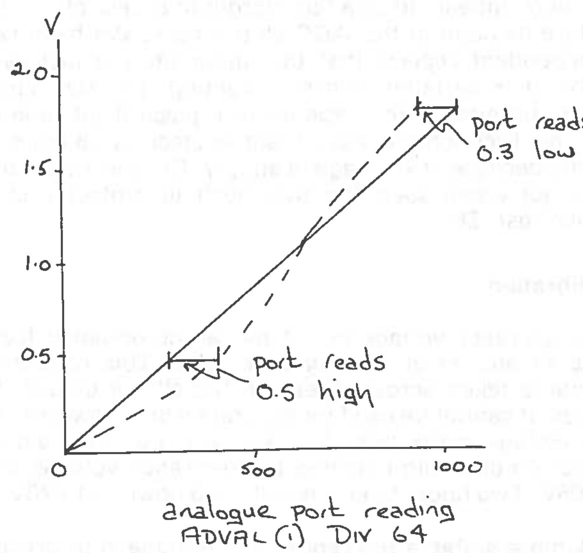


Fig. 6. Linearity of ADC - data from 2 machines

It is therefore possible to calibrate the device at one position only on its scale and be reasonably confident that the entire scale is accurate to within 0.1% of full scale. If the only accurate voltage reference in the school is a standard cell it should be possible by proportion to calibrate a band gap diode which can thereafter be used with confidence as the substandard on which to calibrate on a day-to-day basis the analogue port.

Components

The components mentioned in this article are available from a range of stockists such as Farnell Components, R.S. Components and Technomatic.

Precision voltage references (band gap diodes)

ZN423	RS	283-233	£1.00
	Farnell	ZN423T	0.95
9491	RS	283-283	0.80

Zener diodes, 2.7V

BZY88	RS	282-016	0.33 for 3
	Farnell	BZY88C2V7-DO35	0.06

Silicon signal diodes

IN4148	RS	271-606	0.68 for 25
	Farnell	1N4148	0.024

15-way 'D' plugs

*''Speedbloc''

	RS	467-756	4.80
	Technomatic	male, solder	1.05

15 pole floating plug

	Farnell	DAF15P	2.60

15 pole fixed plug—panel mounting

	Farnell	DA15PB	1.37

*requires the following ''Speedbloc'' assembly tool so that cable termination does not require insulation stripping or soldering.

vice jaw insertion tool

	RS	467-813	16.11

Ribbon cable, Speedbloc, 20m length

10-way	RS	357-851	15.28

Ribbon cable, cut to order

9-way	Farnell	171-9	0.32/foot
10-way	Technomatic		0.40/metre

Endpiece

A photocopy of the notes sent in to us by Mr Feeley is available on application. Please send a stamped, addressed envelope (long manilla) for this. The notes cover the construction of a temperature sensor using the 590kH sensor and how it is linked to the analogue port. Two short programs are listed, one for calibrating the system in degrees celsius, the other for plotting temperature versus time on the screen.

Finally we should mention that Philip Harris retail software on cassette, ''Datastore'' A29950/9, £15.50, which allows you to record and graph experimental results with the BBC analogue port. A connecting lead, P89060/7, is also available giving 4mm socket access to the analogue port pins, price £13.75.

Offset zero control

Many data capture devices and analogue to digital converters have limited usefulness in that they can neither sample negative going signals, nor selectively amplify a small signal superimposed on top of a large d.c. component. This article outlines the principle of operation of an offset zero control which overcomes these limitations.

An examination of the specifications of some of the devices newly introduced to the market shows that few have both facilities (Table 1).

	Bipolar	Offset zero
BBC analogue port	no	no
Educational Electronics		
Measurement Module	no	no
VELA	yes	no
Griffin		
GiPSI	yes	see text
I-Pack Interface	no	no
Philip Harris		
single channel A/D interface P97020	yes	yes
Harris A to D converter P89260/4	yes	no
Harris 4 channel A-D-A unit P87005/0	yes	yes
Meter Box P87100/5	no	no
Unilab interface	yes	no
XOB interface	no	no

Table 1. Analogue channel specifications for commercial data capture devices.

A crude form of offset zero is achievable with software. The user decides on the span of input readings in order that the software subtracts the minimum of that span from every reading and multiplies the difference by a suitable gain factor. Using the BBC analogue port to illustrate this technique, the port provides a resolution of 1 part in 1024 at maximum input of 1.8V. If the signal under examination had an amplitude of 100mV it could be differentially amplified by software such that it filled the screen in a voltage-time graph. However the resolution would only be a poorish 1 part in 50. Smaller inputs exacerbate this problem of loss of resolution. Making a rough rule to go by, if the amplitude of the signal is such that you are left with a resolution of less than 1 in 100 it is not worth using software for differential amplification (Fig. 1).

amplifiers for two particular applications. As the amplifiers can be breadboarded in a matter of minutes it may be simpler to breadboard a particular circuit as the need arises rather than construct an all-purpose amplifier with several control potentiometers whose functions you forget 24 hours after construction.

Specification

Design of circuit to examine the damped oscillations in a capacitor-inductor circuit with the BBC micro analogue port (Fig. 2).

The differential amplifier should be designed to convert the bipolar input into a monopolar signal and provide attenuation (Fig. 3).

The equation for the differential amplifier gain is

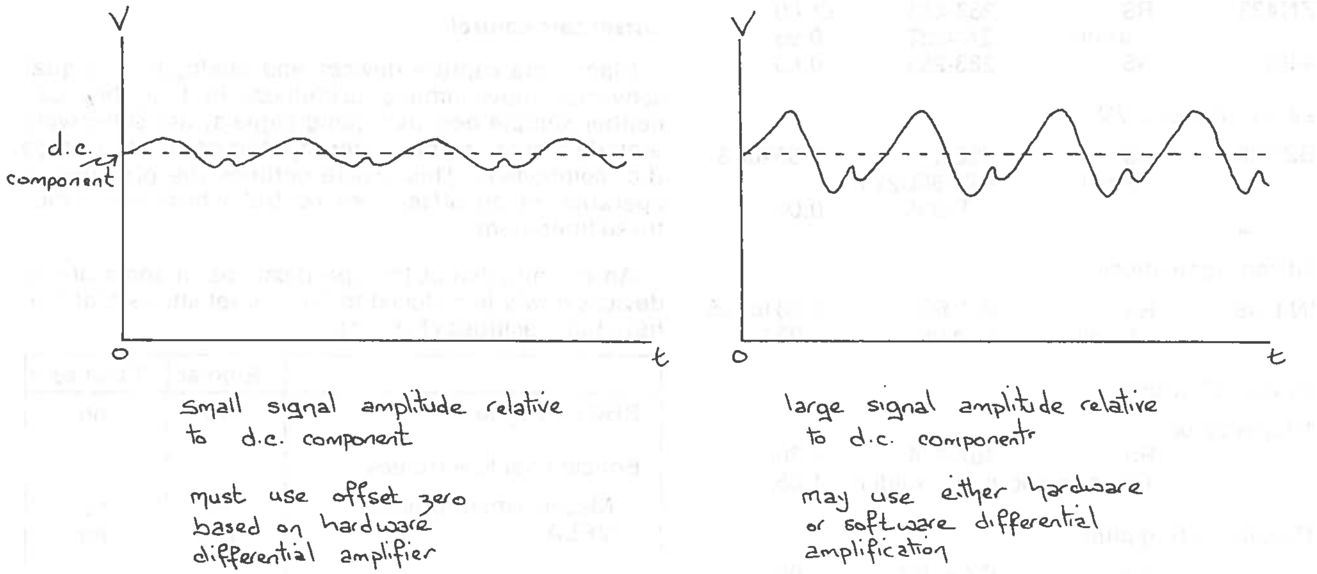


Fig. 1

$$V_0 = -(k_1 V_1 - k_2 V_2)$$

where V_1 = signal from L—C circuit
V_2 = signal from offset voltage pot

and the k factors depend on the values of resistors in the differential amplifier.

If the offset zero pot is adjusted so that the potential on its slider is +2.0V then by potential division across the two 33K resistors between the slider and ground the potential on the non-inverting input of the op amp will be +1.0V. The potential on the inverting input will automatically become this also.

Looking at how this affects the signal from the L—C circuit, V, the resistor network to the inverting input is shown (Fig. 4) with potentials marked

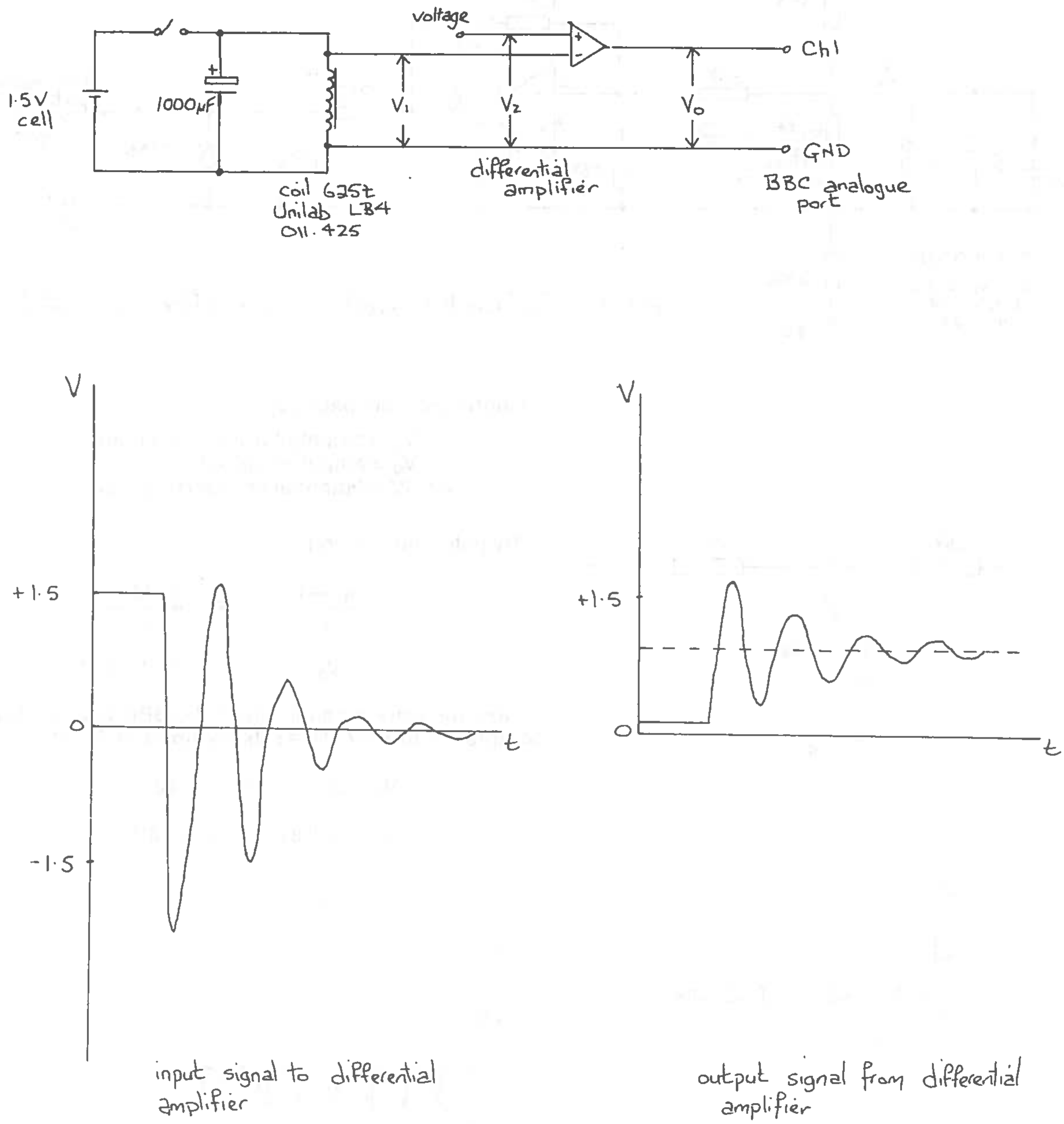
The only commercial device that we have me which has this sort of software offset zero is Griffin's GiPSI. Offset zero of this kind is, in many circumstances, very useful. Nonetheless beware of its limitations.

An offset zero mechanism can be constructed from either a summing amplifier or a differential amplifier.

summing amplifier—add negative offset voltage to input signal

differential amplifier—subtract offset voltage from input signal

We have chosen to use the latter if only that the term "differential" suggests applying an offset voltage. The principle of operation is outlined below. Rather than draw up a generalised circuit with variable gain amplifier and offset control we will describe in detail



Signal from L-C circuit before and after processing by differential amplifier

Fig. 2

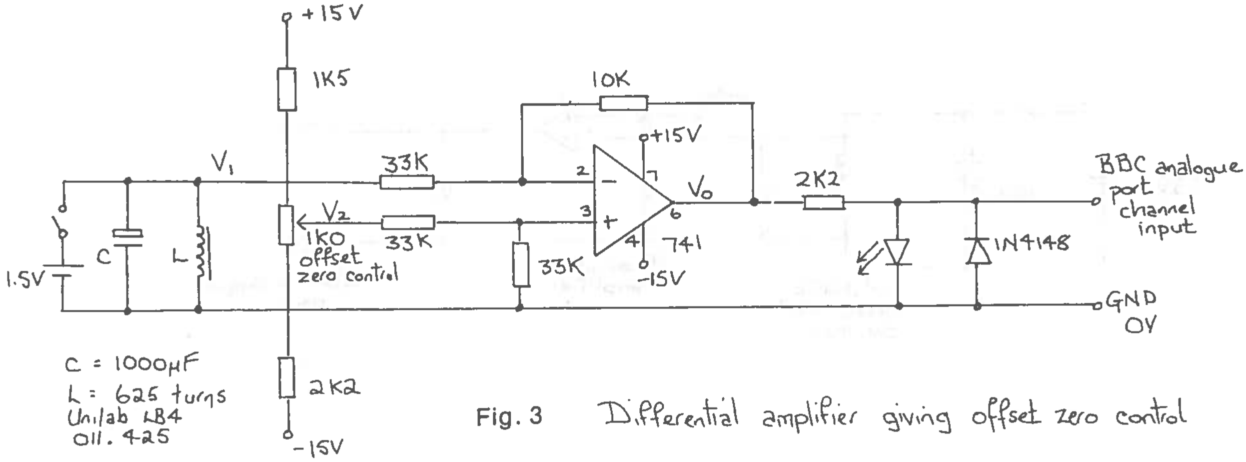


Fig. 3 Differential amplifier giving offset zero control

(continued from page 12)

V_1 = potential from L—C circuit
V_0 = amplifier output
+1.0V = Potential on inverting input

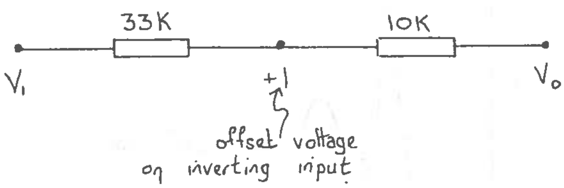


Fig. 4

By potential division

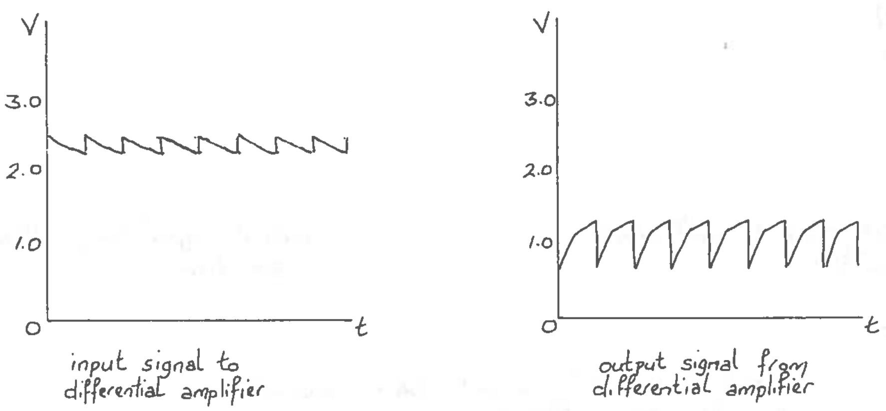
$$\frac{V_0 - 1}{1} = \frac{1 - V_1}{3}$$

$$V_0 = \tfrac{1}{3}(4 - V_1)$$

Now the voltage range which the BBC analogue port accepts is 0 to 1.8V. This sets the limits on V_1 at

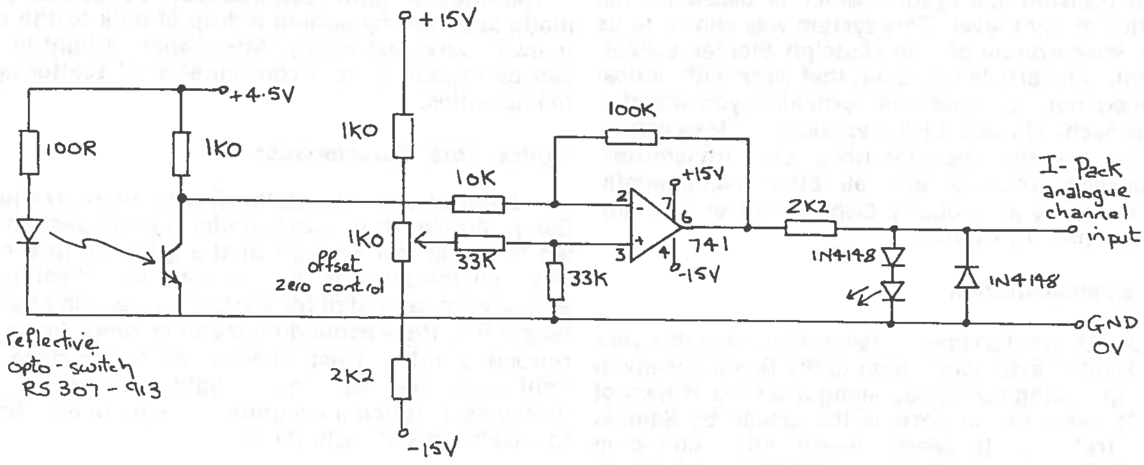
$V_0 = 0V \quad V_1 = +4V$

$V_0 = +1.8V \quad V_1 = -1.4V$



Signal from pulse sensor before and after processing by differential amplifier.

Fig. 5



Differential amplifier tailoring pulse sensor output for ZX Spectrum I-pack.

Fig. 6

This almost fits the output from the L—C circuit and a slight trial and error adjustment of the offset zero pot will do the final correction.

There are three further points to note about the differential amplifier circuit (Fig. 3).

1. Input impedance is 33K and is sufficiently high in this application not to cause much signal degradation.
2. Input signal is inverted at output.
3. Overvoltage and reverse polarity protection is provided by the LED and silicon diodes.

Specification 2

Design of circuit to tailor the signal from a pulse sensor (see Physics Notes, Bulletin 139, on reflective opto switches) so that it can be monitored by a ZX Spectrum with I-Pack interface (Fig. 5).

The I-Pack analogue port accepts signals in the range 0 to 2.5V. Like the BBC analogue port it can all too readily be damaged by either overvoltage or reverse polarity. The differential amplifier should be designed to provide an offset zero and amplification (Fig. 6). The offset zero required is of the order of 2.2V and is obtained by adjusting the 1K0 pot (Fig. 6). The amplitude of the signal from the pulse sensor depends on several human factors, magnitude of displacement of skin and also position and tightness of application of sensor. Bearing these factors in mind a peak to peak signal of 100mV is readily obtainable from the sensor. Our choice of feedback resistor, 100K, gives the amplifier a gain of 10 and provides a sufficiently large resolution to observe clearly the pulse. As with the earlier circuit, (Fig. 3), protection diodes on the output of the op amp prevent damage occuring to the analogue port.

Summary

The absence of an offset zero control is a specific hardware defect of many data capture devices. The article outlines the principle of operation of an offset zero and gives designs for two particular applications.

* * * * * *

Physics Notes

Fibre optics

Introduction

Mention of fibre optics is made in the H grade physics course (Memorandum 56, Optics and Radiation). It merits attention partly as an example of total internal reflection, but more importantly because of the impact this new technology is having on communications. Furthermore it merits attention as an application of electronics. The sort of electronics which should be taught in schools should be on a problem solving, design basis. Fibre optics provides a rich quarry for project based electronics.

The article starts with a mention of light transmission in a water jet, then goes on to outline the characteristics of optical fibres. It concludes with a description of an audio transmission system which is based on the modulation of light level. This system was shown to us by Alan Stinchcombe of The Rudolph Steiner School, Edinburgh. The article bears out that work with optical fibres need not be expensive, provided you adopt a d-i-y approach. The cost of the application described is around £6, and that includes fibre, LED transmitter, phototransistor receiver and all other components. You do not need an Industry Department of Scotland grant to get into fibre optics.

Tyndall's demonstration

We have seen references in several journals this year to John Tyndall's demonstration to the Royal Society in 1870 of light being conducted along a curved stream of water. Of particular interest is the article by Samuel Derman (ref. 1). It seems worthwhile reminding readers of this effect as it is an interesting and simple starting point to fibre optics.

The apparatus required is a spouting cyclinder, e.g. Philip Harris P22280/5, or what the jokose and irreverent might call a "peeing can". If your department doesn't have a peeing can, having searched obscure cupboards, top shelves, under sinks, etc., then you can easily make one from a fruit juice or milk carton. Pierce the carton side about 2 cm above base making a hole of diameter about 5mm. Set up a lamp above the open top of the carton and adjust the flow of water so that an even stream comes out of the hole (Fig. 1). The trick of achieving this depends partly on the height of water level above hole or spout and partly on height the water stream drops. Adjust these by trial and error to obtain a smooth jet. A spot of light should be seen where the stream hits the sink.

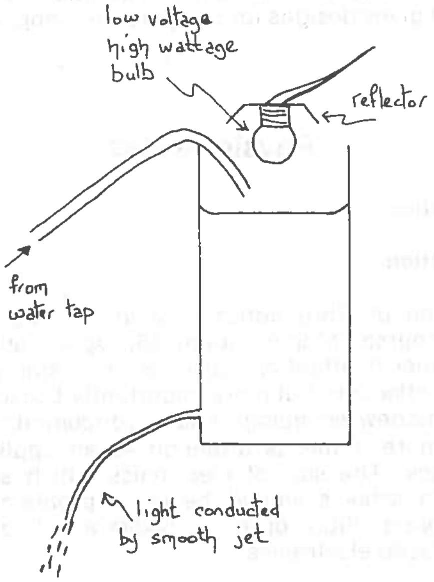


Fig.1. Spouting can.

The effect of light scattered from the stream can be made apparent by adding a drop of milk to the carton (view in darkened room). Attenuation of light in fibres can be explained as a consequence of scattering due to impurities.

Optical fibre characteristics

Light is trapped inside the fibre by internal reflection. Early, simple fibres had a uniform cross section. This led to the escape of light at the glass surface due to flaws on the surface. Also at internal reflection light actually crosses out of the glass by a fraction of a wavelength into the surrounding medium which has a lower refractive index. Dust particles on the surface cause light scattering resulting in light attenuation. These problems resulted in significant attenuation limiting the usefulness of such fibres.

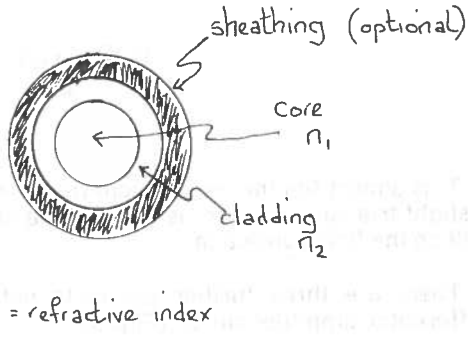


Fig. 2. Cross section of modern optical fibre

Present day fibres overcome these problems by having a layer of low refractive index material which surrounds or clads the fibre core. The terms we refer to are **core** and **cladding**. Cladding should not be confused with sheathing. Some fibres are protected by a sheath or jacket, typically made from polyethylene, which surrounds the cladding (Fig. 2). Two types of optical cladding may be distinguished. With **step index** cladding there is a discontinuity at the core/cladding boundary (high refractive index to low). With **graded index** cladding the refractive index falls continuously from the core outwards. Typical ray diagrams are shown in Figure 3.

As well as the attenuation effects mentioned already light loss will also take place due to impurities in the fibre. These impurities may scatter light out of the fibre or may absorb. In general fibre materials exhibit strong absorption bands and sharp cut offs at certain wavelengths. This is a particular problem to watch out for when working with infra red and the manufacturers specifications should be consulted for details. The near infra red region is the cheapest band to work in

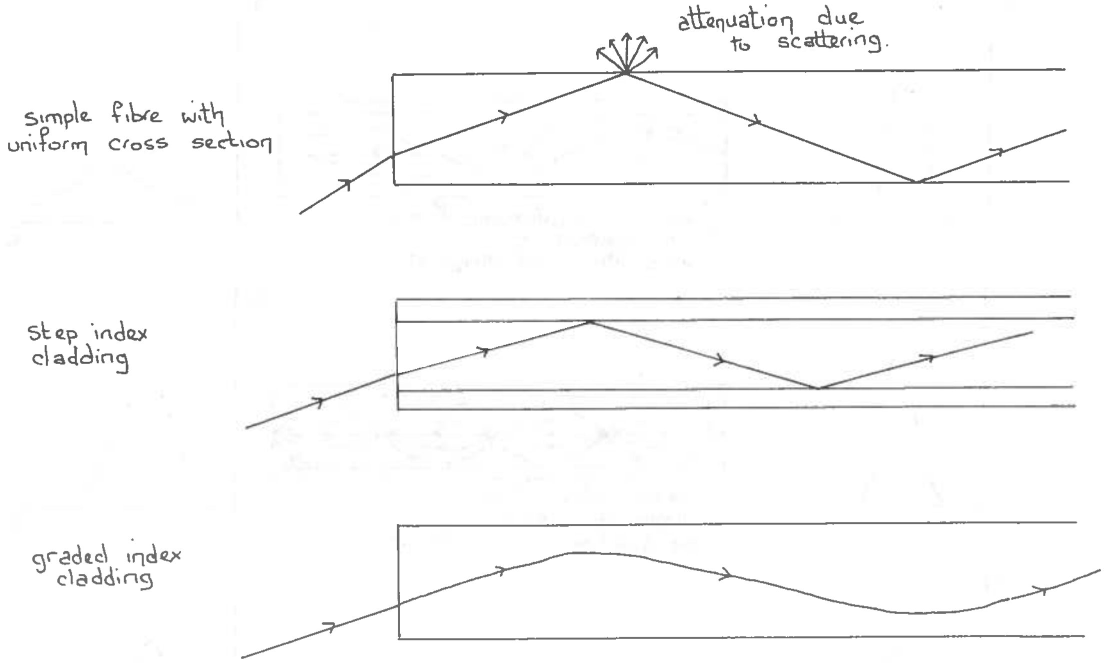


Fig. 3. Typical ray paths in fibres

however since there are many cheap, suitable emitters and detectors. For rough qualitative work over short fibre lengths you possibly won't have to consider attenuation though.

Attenuation in a fibre is measured in decibels per kilometre (dB km^{-1}). As an attenuation of 3 dB is equivalent to losing half the light, therefore an attenuation of x dB is equivalent to losing 2 to the power (—x/3) of the light. If a plastic fibre is rated 1000 dB km^{-1}, then the light loss is 1 dB per metre. With 3 metres of this fibre you lose half your light.

Dispersion is another effect which might upset things. It's caused by different waves travelling at different speeds. One sort of dispersion is wavelength dependent and causes pretty effects such as the spectrum of colours when white light passes through a prism. Also rainbows. Another form of dispersion also takes place in optical fibres. Rays enter the fibre at different angles such that some pass directly along the fibre whereas others zig-zag from side to side and have a longer transmission time, all dependent on the angle of incidence at the fibre end. This limits communication at high frequencies because successive pulses cannot be distinguished as they merge into one another. The fibre property which describes this effect is called the **bandwidth** and is often quoted in units of MHz.km. Fibres with bandwidths greater than 1 GHz.km are available.

This transit time difference of waves in fibres is called **mode dispersion** as distinct from colour dispersion which of course also takes place unless using monochromatic light. Step index fibres are principally affected and a special type of step index fibre which has a very narrow core has been developed to overcome this problem. This fibre is called a **monomode optical waveguide.** As its name suggests waves of only one direction of propagation are transmitted. Monomode fibre cores are typically 5-10μm in diameter. Production difficulties along with difficulties in usage make them expensive (Fig. 4).

Two parameters govern the intensity of light which is accepted into the fibre, core diameter and numerical aperture (Fig. 5). This latter parameter is dependent on refractive index. Both parameters are a measure of the relative difficulty of getting light into a fibre. For example looking at the typical figures in Table 1 it will be very much harder getting a significant amount of light into the quartz as opposed to the plastic fibre. These difficulties call for careful positioning of light emitter relative to fibre end.

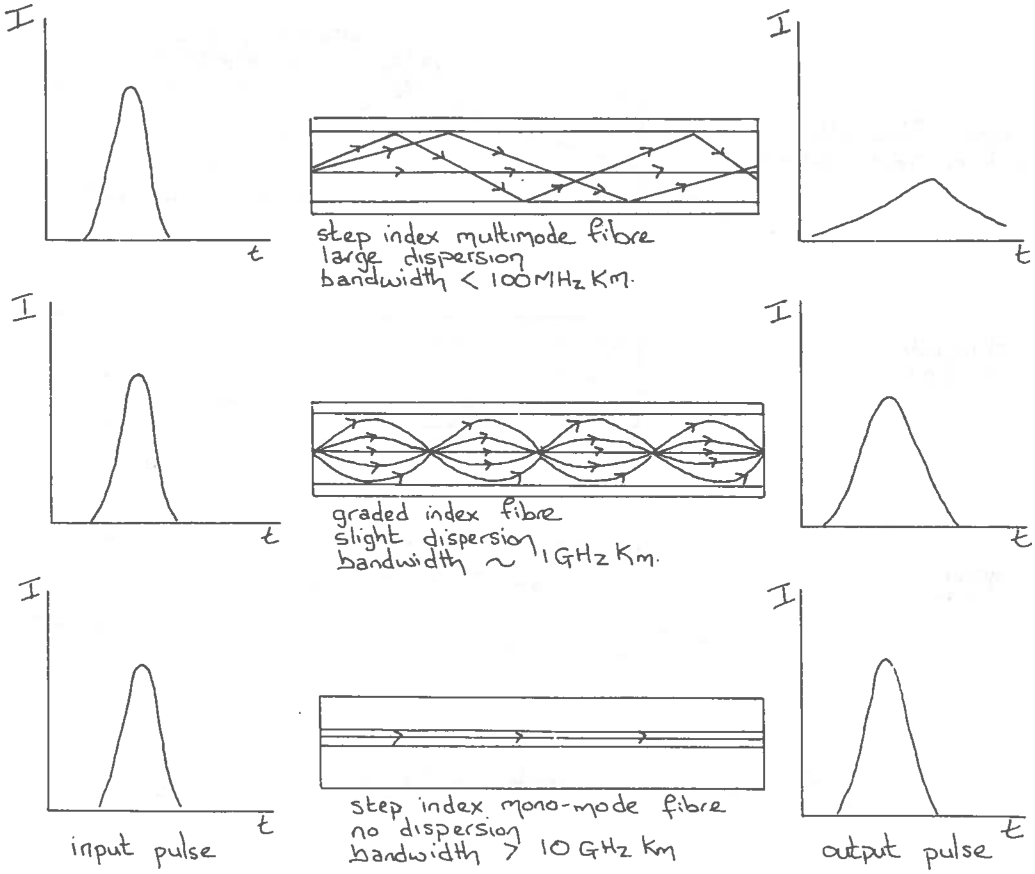


Fig. 4. Dispersion in fibres

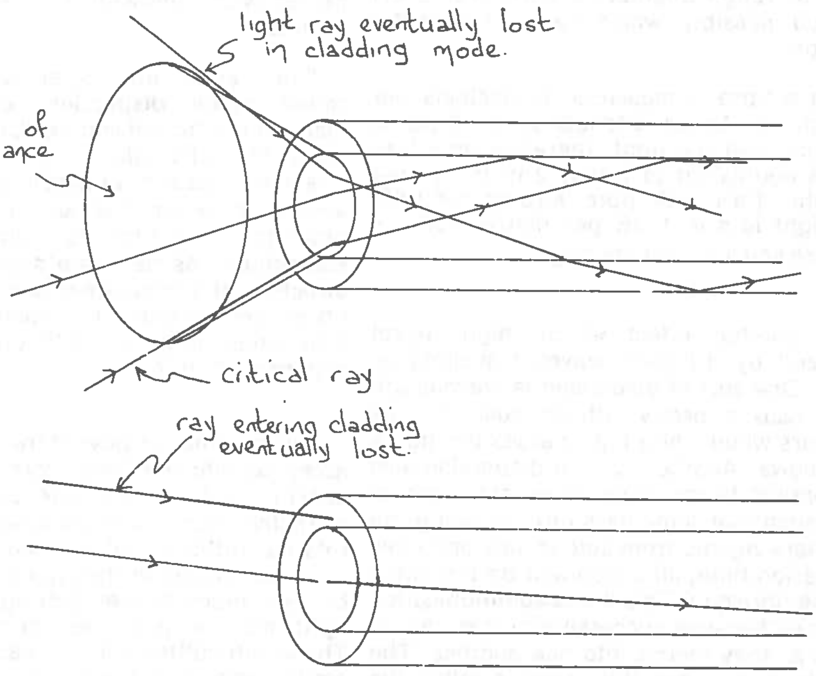


Fig. 5. Getting light into fibres

Fibre material	Core diameter	Numerical aperture	Acceptance cone angle	Comments
plastic step index	1.0 mm	0.50	60°	easy to put light into fibre
quartz gradient index	50μm	0.19	22°	requires precise positioning of emitter and fibre

Table 1. Getting light into fibres.

Material	Spectral response	Attenuation	Temperature range	Bandwidth	Reasons for using
silica or quartz fibre	220-1300 nm	typical value 10 dB km^{-1} (current best 0.2 dB km^{-1}	up to +800°C	3dB width is 22 MHz.km (best 10 GHz.km)	long distance communications ultra violet transmission high temperature work
glass fibre	380-1300 nm	typically 30 to 70 dB km^{-1}	—200°C to +450°C	3dB width is 6 MHz.km	long distance communications poorer performance than silica fibre, but cheaper
plastic	strong infra red absorption bands due to hydrocarbons	300-1000 dB km^{-1}	—30°C to +80°C	not quoted in catalogues	short range communications illumination cheap

Table 2. Typical specifications of optical fibres.

The material from which fibres are made can be classified into three types, silica or quartz fibre, glass fibre and plastic fibre. Typical parameters are given in Table 2.

As a general comment plastic fibres have both large numerical aperture and core diameter whereas glass and silica fibres do not. On the other hand plastic fibres attenuate signals severely. It's therefore easy to get lots of light into a plastic fibre, but that light does not travel very far. Plastic fibres actually give better performance than silica fibres for many types of short distance communication links, up to 40 metres say. Because of this, because of their relative ease of use and because of their relative cheapness, plastic fibres would seem to be the best buy for school laboratory use.

Optical fibres are manufactured in bundles as well as single strand. Bundles may contain hundreds of individual fibres, usually very thin. Advantages over single strand include

1. extra flexibility
2. tighter angle of bend
3. multi-way communication
4. multi-light source
5. image engineering

Disadvantages include awkward end terminations, hazards in handling and high signal attenuation.

Plastic fibre can be cut to length using a sharp knife and the end polished up as outlined in "In the Workshop". Glass fibre requires a different technique. Make a score on it, hold on either side of the cleavage and pull apart.

Fibres will not endure sharp bending. The minimum bend radius is specified by manufacturers and typical values are 6 mm, glass, 10 mm, plastic, and 3 mm, glass bundle.

Safety

There are a few points on safety to caution you about. Plastic fibres are easily set alight, the fire rapidly travelling down the fibre. Therefore do not use plastic fibre near a naked flame or heat source, but use glass or silica instead.

Never look down a fibre if the light source is a LED or laser. Schools are far more likely to use the former as light emitters, but remember that a large fraction of the light which a LED emits can be trapped by the fibre and if the other end is free it is all too tempting to look into it close up. The light flux received may be equivalent to that on placing your eyeball right close up to a LED emitter! This point should also be borne in mind when looking at a fibre optics display being exibited by someone else. Infra red LEDS and laser diodes are commonly used emitters. Need we add that infra red is invisible.

Our last caution refers to working with glass or silica fibre. Use a clean smooth work surface when cleaving fibre so that the surface can be swept clean afterwards, taking care that the sweepings go into a suitable waste receptacle. Furthermore wear safety goggles when working with glass, whether cleaving, grinding or polishing. Be careful when handling that the end does not cause stab injuries.

Emitters and detectors

Two types of emitters are in common usage, LEDs and laser doodes. As the latter are probably outwith your budget we'll only discuss the former. Points to consider when choosing which LED to use are given below.

1. Choose a high intensity LED.
2. Use a LED with a clear, non-diffused case.
3. Check that the switching bandwidth specification is suitable for high speed switching if working with digital transmission.
4. Match the spectral bandwidth to that of the optical fibre and detector.

The trick in setting up an optical fibre link-up is getting as much light as possible into the fibre. It's quite easy getting a little light in, but getting a lot in requires care. There are lots of expensive end connector systems on the market as a glance through the optoelectronics section of the RS catalogue will show. However a satisfactory, inexpensive, end connector can be home made. Please turn to the "In the Workshop" section to see how.

Various types of detectors may be used. Typical specifications of PIN diodes and phototransistors, the common ones used, are given in Table 3. Getting light out of the fibre and into the detector is not as critical as housing was constructed from 1.5mm aluminium sheet and the lampholder was a brass SBC screwed ¾" shade to point the fibre in rough alignment with the principal axis of the lens face. The detector should be shrouded from ambient light and especially from artificial light of the 100 Hz kind. This can be achieved either by slipping electrical sheathing around the detector or by soldering the detector to the internal 3.5 mm jack plug connections so that it sits inside the plug barrel.

Detector	rise/decay time	peak sensitivity	comments
PIN diode	0.5 ns	850 nm	very fast, good linear response to light
photo-transistor	10μs	870 nm	slow, response not very linear, cheap and easy to use

Table 3. Typical specifications of detectors.

Audio signal transmission

This is an attractive project and gives an interesting demonstration of optical fibre communication. An audio signal from a cassette recorder is amplified before going into the base of a low/moderate power NPN transistor, 2N3053, BFY51, or similar (Fig. 6). This modulates the collector-emitter current which the transistor conducts with the audio signal and thereby modulates the light intensity being emitted by a high intensity, red LED, RS 588-263. You will find if you use a 30V supply that 2V is dropped across the LED, 14V across the 620R, 1W, series resistor and 14V across the transistor. The LED current is controlled by this resistor and with 620R this current is 22 mA. You can make the LED brighter by reducing this resistor, but watch specifications for maximum current/power ratings for LED/transistor. The transistor should be fitted with a heatsink. When the collector voltage is monitored with a CRO you should find that the audio signal is typically 100 mV peak to peak. If we assume that the LED has a linear current/light intensity response then light modulation strength is somewhat less than 1% of the carrier component.

It is worth concluding this discussion on the transmitter by telling you that the quality of audio transmission seems to depend more on the carrier signal being as bright as possible than the audio signal being particularly large. There is scope here for a lot of further experimental development.

Various optical fibres have been used for the transmitter-receiver link, all successfully. These include silica, glass and plastic fibre, and glass and plastic bundle. For short distance link-ups almost anything would do, but we would advise using single strand plastic fibre for reasons given above.

Our method for linking the fibre to the LED is outlined in "In the Workshop". The other end of the

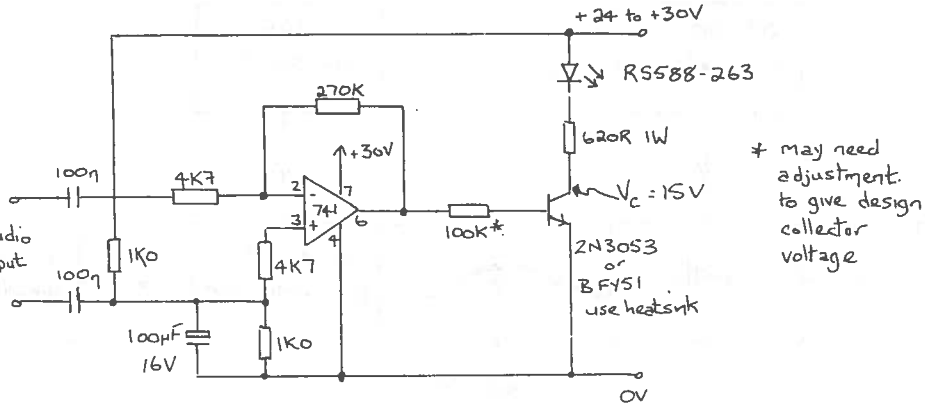


Fig. 6 Transmitter

fibre is left free so as to demonstrate the effect of pointing it from various positions at the light detector.

The receiver (Fig. 7) acts as sensor and preamplifier. Ideally the spectral responses of emitter, fibre and detector should all match. However because of expediency ours didn't. The LED peak wavelength is 635 nm whereas the phototransistor peaks at 940nm. It is desirable for demonstration and safety purposes to work with visible light, which we are doing. However readily available phototransistors are infra red. Their responses overlap nevertheless and the system works satisfactorily. The phototransistor should be shielded from ambient light.

Signal levels which you might expect on the receiver are 15 mV on the phototransistor collector and 200 mV on the BC109 collector, both figures peak to peak. To avoid pick up use screened coax for the short lead between the phototransistor and 100 nF capacitor, and also between the preamplifier and power amplifier.

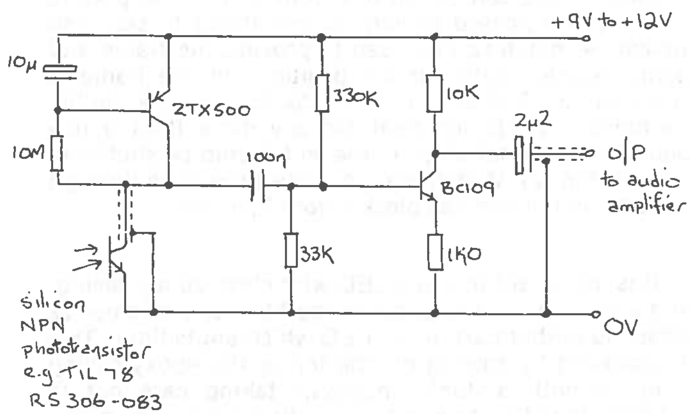


Fig. 7 Receiver

Both transmitter and receiver circuits should be constructed on 0.1" stripboard. We have had requests that we include stripboard layouts in our articles, but regrettably we just do not have the time, at present, to satisfy that demand and we apologize on that account.

The entire system (Fig. 8) requires several, additional, standard items of equipment

- cassette recorder or radio
- audio power amplifier
- loudspeaker
- 24V or 30V smoothed d.c. supply
- 9V or 12V smoothed d.c. supply.

Note that separate power supplies are required for transmitter and receiver to prevent the latter picking up the audio signal via the power rail.

Components

A 10 metre length of plastic fibre is retailed at £3.03 by **Quantum Jump Ltd.**, but add 50p for postage and packing if the order is less than £10. The electronic parts are all available from RS Components Ltd. and part numbers and prices are given below for items other than capacitors and resistors.

transistor	2N3053	293-561	£1.52 for 5
	BC109	293-549	0.96 for 5
	ZTX500	294-463	0.66 for 5
op amp 741		305-311	1.60 for 5
LED, ultra bright		588-263	2.22 for 3
phototransistor		306-083	0.61
transistor heatsink		401-548	1.14 for 10
3.5 mm jack plug		478-481	2.02 for 10
3.5 mm chassis socket*		478-497	0.98 for 5

* bolt a retaining bracket on to stripboard on to which the chassis socket can be fixed.

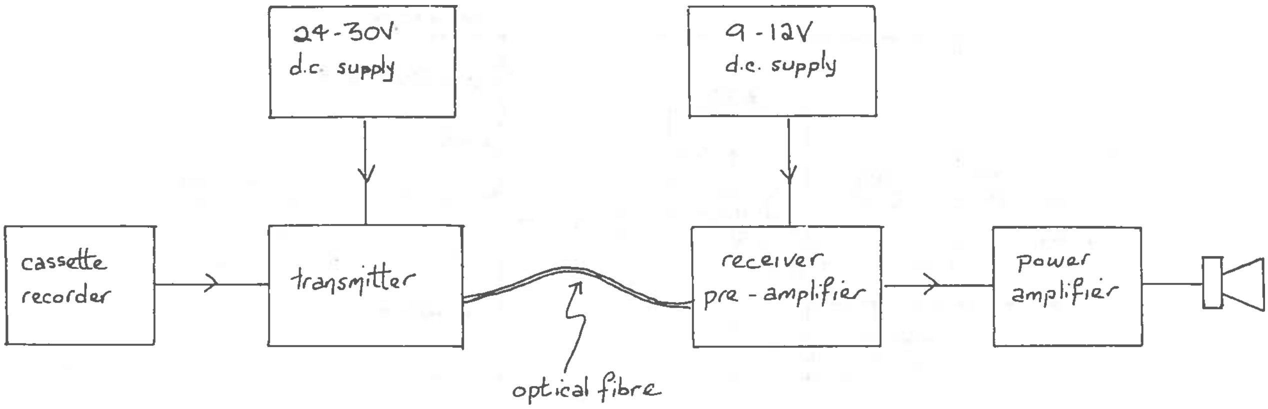


Fig. 8. Audio transmission system

Several firms which lie outwith the usual school suppliers offer introductory packs to fibre optics. We are impressed by the pack which is on offer by Quantum Jump Ltd. (Optical fibres introductory pack, price £5.45). The contents are lengths of five different types of fibre together with an informative 43 page booklet. Simple fare at a budget price.

Reference

"Light pipes, hydrostatics, surface tension and a milk carton", Samuel Derman, The Physics Teacher, January 1984.

* * * * * *

In the Workshop

Gaseous equilibrium—gas syringe support rig

The details of the 'support rig' are shown in Figure 1. All wooden parts of the rig were constructed from 12mm blockboard. The clamp for the glass collar of the syringe was made of Tufnol to afford a small degree of flexibility. Approximately 50mm lengths of 0BA brass studding with brass nuts and wing nuts were used to fix the Tufnol in place. A No. 29 rubber bung was used to support and seal the nozzle of the syringe. The lamp housing was constructed from 1.5mm aluminium sheet and the lampholder was a brass SBC screwed ¾" shade retainer. SSSERC has a large supply of the lampholders which were purchased from John Bull. The ORP12 photocell is strapped onto a plastic ball-pen body with insulating tape. This assembly is then mounted inside a short length of metal or plastic tubing of approximately 14mm internal diameter. More full constructional details of this device can be seen in Bulletin 129, pages 14 and 15. X and Y mark the positions for fastening the rig to the bench. G-clamps proved most suitable.

Getting light into optical fibres

These notes describe the construction of a jig for holding together an optical fibre and LED.

Three rectangular blocks of perspex are cut and drilled as shown in Figure 1, their sizes being 60 x 50 mm, 30x15 mm and 30x15 mm. Dimensions and material are not critical though it is better to use thickish perspex, 6 mm say, for the upright block since it is fastened by screws into an edge. A hole is drilled in the centre of this upright block to retain the optical fibre. In "Physics Notes" we recommend using 1 mm plastic fibre, and for this, use a number 60 drill. A countersink on the LED side of this block is advisable. Use good perspex cement to assemble the jig, liberally coating the 8BA fastening screws. "Tensol No. 6" is ideal cement. Leave the jig to dry overnight before handling.

Plastic fibre can be cut to length with a sharp knife and the end passed through a cool flame to seal and polish. A match can be used to provide the flame and some practice with various positions in the flame is worthwhile. Remember that plastic fibre is highly flammable so do not heat for any more than a few seconds. The final shape of the end should be similar to a rivet (Fig. 2). Watch that you insert the fibre through the hole in the perspex block before flaming.

It is important to use a LED with clear epoxy casing. It's also important to position the fibre end as close as possible to that part of the LED which emits light. This is achieved by sawing off the top of the epoxy casing (Fig. 3) with a Junior hacksaw taking care not to damage the LED. Now rub down the LED on fine grade emery or wet and dry and give a final polish with "Brasso". The jacket (Fig. 4) will give correct depth for safe working.

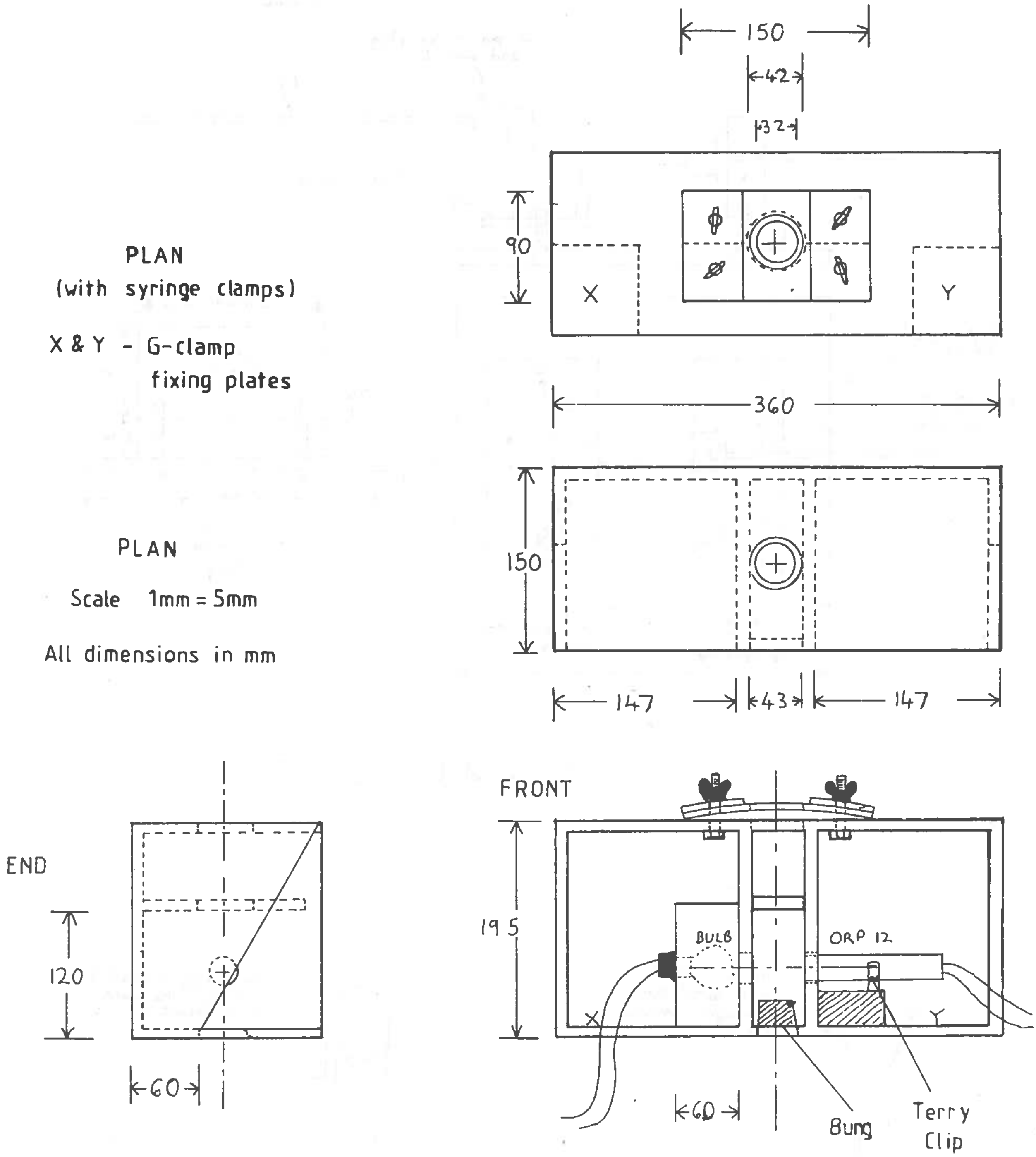

PLAN
(with syringe clamps)
X & Y - G-clamp fixing plates
150
42
32
90
X
Y
360
PLAN
Scale 1mm = 5mm
All dimensions in mm
150
147
43
147
FRONT
END
120
60
195
BULB
ORP 12
X
Y
60
Bung
Terry Clip

Fig. 1

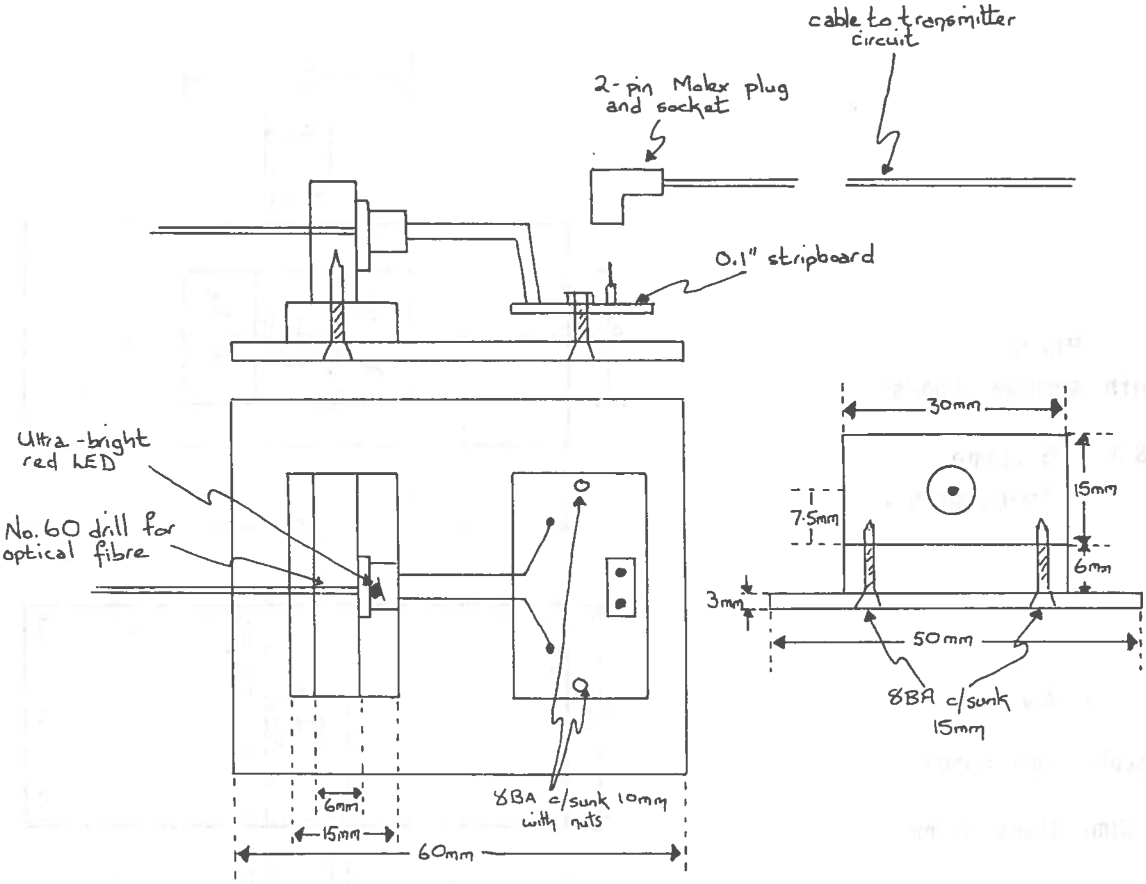


Fig. 1. LED - optical fibre jig.

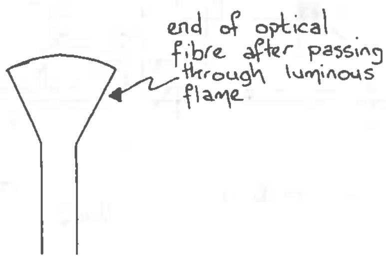


Fig. 2. Plastic fibre end.

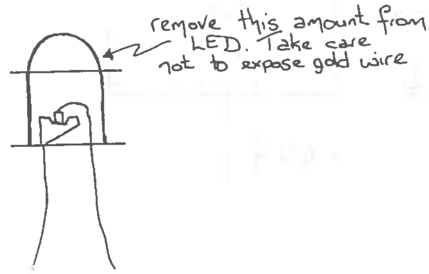


Fig. 3. Removing top of LED.

Before the final assembly the LED should be soldered on to 0.1" stripboard, its legs bent through 90° (Fig. 1). Carefully position and cement the LED and fibre on to the perspex block and leave to dry.

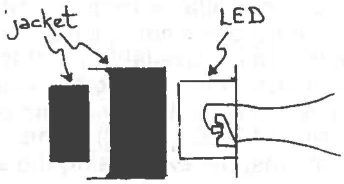


Fig.4. LED housing.

Materials

Tensol No. 6 cement	Griffin and George, ZPE-280-K, 500 cm³ £6.88
8BA screws and nuts	George Boyd, other ironmongers or builder's suppliers

For other items please see "Physics Notes".

* * * * * *

Surplus Equipment offer

The above title is really a misnomer as the goods offered below (Nos. 311 to 355) are in fact brand new and have been purchased in bulk from John Bull at a large discount. These items are not subject to ballot but are to be sold directly on a first come—first served basis. In the event of several schools being disappointed we will place another order with Bull. When sending your order to us please indicate whether the goods are to be collected from the Centre or whether you wish them to be posted/freighted.

Item 311	three level thermostats, (looks like ex washing machine)	40p
Item 312	thermostats, rated 15A, 250V	50p
Item 313	thermostats, 0-100°C, open construction, giving good demonstration of bimetallic switching, rated 10A, 250V	70p
Item 314	bells, 12V, 6" diameter gong	£4.50
Item 315	clockwork motors, up to 1 hour; useful for timing rather than driving, suitable for technology projects, key not supplied	50p
Item 316	miniature relays, 12V d.p.d.t., 700Ω coil, lugs fit p.c.b.	75p
Item 317	ceramic magnets, poles on faces, 26 x 11 x 9mm	15p
Item 318	mini magnets, bar magnets, 18 x 6 x 3mm	20p
Item 319	car bulbs, 12V, 4W, bayonet fit, 9mm dia. single contact	15p
Item 320	phototransistors	8p
Item 321	BC108 transistors, low power NPN	5p
Item 322	germanium diodes	8p
Item 323	panel meters, 1mA f.s.d., centre zero 73mm dia. circular case, 48 divisions	£1.00
Item 324	panel meters, 500µA f.s.d., side zero 70 x 57mm rectangular case, 20 divisions	£1.00
Item 325	panel meters, 0-1µA, 50 x 44mm rectangular case, 25 divisions	£2.90
Item 326	1K pots, 25W ceramic wire wound, rotary, 40mm dia.	60p
Item 327	8R pots, 25W, ceramic wire wound, rotary, 64mm dia.	60p
Item 328	pots, 15R, wirewound, linear, 36mm dia.	20p
Item 329	pots, 33R, wirewound, linear, 36mm dia.	20p
Item 330	pots, 50R, wirewound, 40mm dia.	20p
Item 331	pots, 100R, wirewound, linear, 36mm dia.	20p
Item 332	ultrasonic transmitters/receivers (pair)	£1.00
Item 333	insert microphones 600R	40p
Item 334	washing machine pumps, 240V, nylon corrosion free pump, very strong	£4.50
Item 335	spring clips, internal diameters 17, 23, 43mm	3p
Item 336	resistors, 270R, ⅓W	1p
Item 337	resistors, 100R, ⅓W	1p
Item 338	resistors, 1KO, ⅓W	1p
Item 339	resistors, 2K2, ⅓W	1p
Item 340	resistors, 4K7, ⅓W	1p
Item 341	resistors, 10K, ⅓W	1p
Item 342	resistors, 47K, ⅓W	1p
Item 343	resistors, 100K, ⅓W	1p
Item 344	fans, 12V, possibly ex. heater fans from motors, very quiet, speed controlled by voltage	£4.00
Item 345	drill pumps, for attaching to electric hand drill	£2.50
Item 346	earpieces, 200Ω	50p
Item 347	SBC lampholders; brass, suits low voltage, car bulbs screwed ¾" retainer for panel mounting	20p
Item 348	submersible pumps, low voltage, nylon, corrosion free	£5.60
Item 349	dual action water valves, 12V d.c., nylon, corrosion free	£7.90
Item 350	motors, model BM8, 23mm dia, 35mm long, toothed wheel on drive-shaft	40p
Item 351	motors, low current, 3-12V, 20 x 18 x 7mm, worm gear output, open case useful to demonstrate construction	25p
Item 352	motors, precision d.c. with gearbox - Portescap obsolete stock, suitable for demonstration of servo control	£6.50
Item 353	reed switches, s.p.s.t. length 80mm, large size suitable to demonstrate principle of operation	10p

Item 354	reed switches, s.p.s.t. length 46mm	10p
Item 355	luminous rocker switches, s.p.s.t., mains	30p

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Trade News

For some years now 'Bouncing Putty' or 'Silly Putty', a Dow-Corning product has been difficult to obtain in small quantities. That plasticine like material which has the apparently contradictory properties of being stretchy like Blu-Tak, bouncy like rubber and yet being easily shattered like delph when struck a hammer blow is now available in small quantities from **Artec (I for E)**. Prices £1.25 + post for 100g or £30 + post for 2.5kg.

Beevers miniature models are now available from **Griffin** (page 184 in the current catalogue). These models are accurately scaled down 10 times with 1 cm representing 0.1nm. They can also be purchased directly from **Beevers Miniature Models Unit** at lower prices, but postage will be extra. A catalogue from Beevers is worth examining. A rock salt 'unit cell' with three balls per edge costs £3.80 and a diamond cell with 78 atom centres, £11.80.

Elastrator rings mentioned in Chemistry Notes are available from **Euroclip Ltd.** at a discount price of £1.00 for 100.

Microvideoprojection

Video cameras and accessories for CCTV microprojection were referred to in Biology Notes. Useful sources of these items are **C. W. Cameron** in Glasgow and **C. E. Offord.**

All of the microscopes recommended by us for work up to Higher Grade can be rapidly attached to a video camera if fitted with a C-mount adaptor. Microscope manufacturers and suppliers can provide adaptors at prices ranging from £8.60 to approximately £150, but these are often only suitable for use with a particular make or model. It is certainly advantageous to have a beam splitter head which permits direct viewing down an eyepiece as well as on the monitor. Otherwise difficulties in refocussing can arise if say the objective is changed. One of the Pyser microscopes, the 3201 Tutor (Harris Cat. No. B25150/8), comes with an additional "tutor" tube. The beam-splitter from Offord, referred to in Bulletin 139 is worth considering as it can be fitted to many makes of microscope. For enquiries on particular microscopes Offord will be pleased to advise.

Although cameras are now lighter than they used to be it is preferable, though not essential, that for reasons of strength microscopes with a moving stage and fixed tube are used. For the same reason models with vertical rather than inclined eyepiece tubes are preferred. Unfortunately most of the less expensive colour video cameras do not have a removeable zoom lens and consequently cannot be used for microprojection.

The Hitachi DK81 colour camera selling at £521 plus £30 for the a.c. adaptor (Cat. No. AP4) and £28 for the cable (Cat. No. 10850ASE) is one of the cheapest seen by us. It will soon be available from Offord and C. W. Cameron. This price does not include the C-mount adaptor. No zoom lens is available for this camera to enable its use in the "macro" world. Also available from Camerons is the National Panasonic colour video camera (Cat. No. WVP55, £528). This includes a removeable zoom lens, the extra being the a.c. adaptor at £39.

A plug-in adaptor for RGB monitors which makes them compatible with composite signals is also available from Camerons. What may also be of interest is the switchable plug-in adaptor from Griffins (Cat. No. CRB-524-510M, £68.57) which will convert their composite monitor into a RGB/TTL monitor at the flick of a switch. The Vision-Ex model from **Data Efficiency Ltd.** also accepts PAL or RGB input, price £239.

Stepper motors

Impex Electrical market a range of **stepper motors** which are available from a number of distributors. One of this range, ID35, is stocked by **Economatics** and at £8.99 can be considered good value for money since this price considerably undercuts the official Impex distributors. Model ID35 is a 7.5 degree stepper motor and is used in the BBC Buggy. The simplest method of controlling this motor is with the stepper motor drive chip, SAA1027, at £4.00 from **Dennard Rotadrive Limited.** This latter firm, incidentally, supply the entire Impex range of motors. An alternative supplier of SAA1027 is **Farnell,** price £4.58. Note also that Griffin have introduced a board, with stepper motor mounted on it, to their digital electronics range, price £29.99.

X-Y plotter

If you are looking for an **x-y plotter** for the BBC micro the Parfitt Plotter is impressive. The plotter has three colour pens and works to a resolution of 0.25mm on A4 size paper. It will also handle A3 size. Price including software, manual, 3 pens, packaging and delivery is £270. The accessories available are also impressive. The pens can be changed to accept a sharp-pointed scriber which can be used to etch fine-line drawings on any suitable surface such as wax-coated copper. There is a high resolution light sensor which turns the plotter into a scanner which can scan a picture and display it on the microcomputer screen. This facility is developed by an algorithm which drives the sensor through a maze. Finally a drill attachment can be fitted. As an introduction to design control technology this system has a lot to offer especially as the software allows interactive work between plotting, screening, etching and drilling. The complete kit, plotter, scribe, sensor, drill and power supply costs £480. The firm to contact is **Parfitt Electronics Ltd.** Can you afford it?

Cheap glass stills were mentioned in Bulletin 139. **Jencons (Scientific) Limited** list two borosilicate glass stills at competitive prices. The GP3 can produce 3.5dm³ per hour with a conductivity of 2 μohm^{-1} cm^{-1} and costs £157. The boiler, being of stainless steel, is corrosion free. The larger GP6 has a similar construction and can produce distilled water at twice this rate. The normal price is £234, but there is until 31st May 1984 a special offer price of £180. Jencons have just produced their new catalogue.

A new supplier of general, schools equipment and chemicals has opened up in Glasgow. **IMS** or Interbook Media Services (Scotland) Ltd., has already been supplying to schools in Strathclyde. Using their own delivery vans this service is now extended to other Regions of central Scotland. Comprehensive catalogues showing equipment at competitive prices are available and some special ranges include Russell pH products, Radford power supplies, Weir Electrical meters, Safgan oscilloscopes and as mentioned in Bulletin 139, Limrose Tutorkits.

The Scottish Scientific Instrument Centre have closed their doors, but a new company called **Frazer Scientific Instruments Ltd.**, provides the same service. Their main office is now in Newtonmore with a branch in Edinburgh. Discounts of 15% and 7½% are offered to schools respectively on Ohaus and Sartorious electronic top-pan balances.

South West Minerals Resources, a firm seen for the first time by us at the Exeter ASE meeting, had on display a wide variety of rock and mineral specimens from the British Isles and elsewhere. Some examples of typical prices were as follows for 2" x 2" specimens:

> haematite 66p, tourmaline £1.96, pyrolusite and magnetite both 99p.

Also available were a wide range of sedimentary and igneous rock specimens, fossils and replicas from named locations in the British Isles in both 1:50,000 and 1:63,360 scales. What may be of great interest for 'Integrated Scientists' and for analytical chemists is the sale of bulk samples of more than forty samples of rocks, minerals and ores for 'consumption' rather than examination. Examples of prices per kilo are cerussite £2.50, copper pyrites £3.30 and zinc blende £2.65. A catalogue is available.

The Griffin Microscope Illuminator, (Cat. No. MGT-820-R, £26.00) can convert a normal biological microscope to a metallurgical one, provided that the microscope has standard RMS threads. Thus opaque samples may be examined. A 12V source is needed to power the bulb.

Samples of 'Time-Tape' can be obtained for evaluation from **SMA** (Scientific Marketing Associates). This adhesive tape, obtainable in some 18 colours can be used as an identifying code for sample containers or different batches. We found it could be removed from and restuck repeatedly on most surfaces. Neither did the tape detach itself from the bottom of a test-tube immersed in boiling water for more than five minutes. The material is only sold in a minimum of 6 rolls of any width. Available in five widths from ½" to 2" the prices for a 500" roll range from £1.95(½") to £4.95(2").

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

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