SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 115. October, 1979.

Contents

Introduction

In this bulletin we are re-printing an article from Education in Science on the recommended method of taking a blood sample. The article was prepared by the A.S.E. Safety Committee, Material and Processes Group, of which Allen Cochrane is a member. We do this because there may be many Scottish teachers who do not have access to Education in Science, and the article was prepared after a great deal of discussion with a wide range of interested bodies and gives expert guidance in a difficult area. It has come to our attention that the taking of very small samples, a drop or two, for examination has been banned in a number of schools. We believe that this is an unnecessary restriction. The educational advantages of examining a blood smear far outweigh the tiny risk involved when a correct sterile procedure is used.

We are also somewhat concerned that our articles on micro-biology and on the use of pressure cookers as autoclaves have been misinterpreted by some of our readers. Over-reaction to legitimate concerns about safety standards is almost as bad as under-reaction. We would not like to think that anything we have written has lead any teacher to abandon generally the use of micro-organisms. Indeed we have been at pains to point out the various advantages of micro-organisms as subjects for study at school level (see Bulletin 90).

In adopting any safety policy there has to be compromise between what is educationally desirable and the degree of risk involved. If we had to give a definitive statement of our position on safety in science education we could not improve on the introductory statement made in the Government publication 'Safety at School': (Education Pamphlet No. 53 HMSO).

> "The aim of safety precautions is not to eliminate every possibility of accident, which could only be achieved by stifling a child's natural tendency to be venture-some and independent. It is rather to avoid unnecessary risks and to enable the child to face sensibly and con-fidently those that cannot, or should not, be avoided."

* * * * * * *

Also in this bulletin is a circuit which converts a scaler to a frequency meter, and which can measure any sine or square wave of about 2V amplitude, up to 100kHz frequency. The cost, complete in box with a 9V battery is between £5 and £10, which must make it the cheapest yet. Moreover it is in line with our policy of schools acquiring general purpose instruments and using them frequently rather than allowing them to decay in storage. With a small operational amplifier, the unit should be able to measure directly any frequency from earphone or plucked string, so that the Lissajou figure with its confusing graphics will be seen no more.

Chemistry Notes

Natural gas and L.P. bottled gases (propane/butane) will reduce copper(II) oxide very slowly. It has been brought to our notice that many teachers are unaware of a safe means of effecting rapid reduction both of lead and copper oxides with the aid of 'meta' blocks which consist of ethanal tetramer (metaldehyde). These are available as a camping fuel.

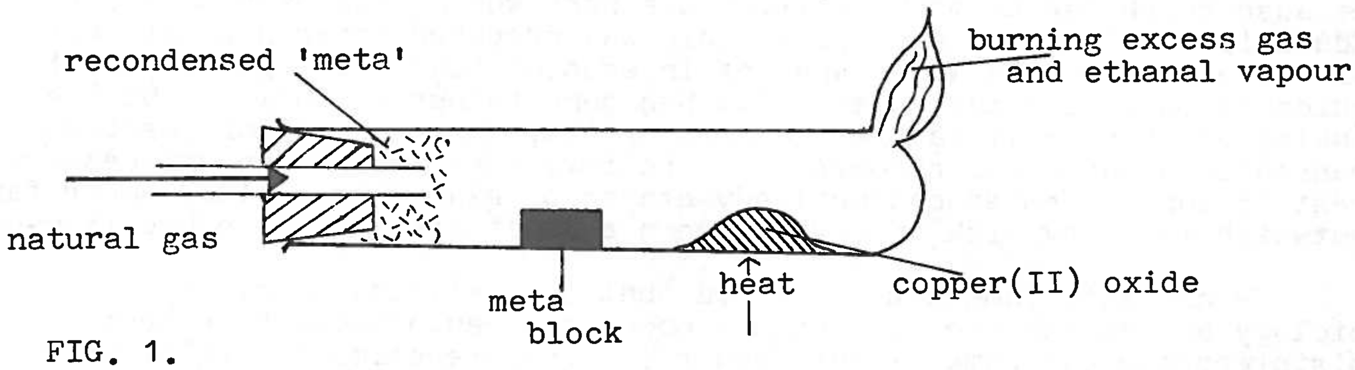


FIG. 1.

The copper(II) oxide is first heated strongly in a stream of natural gas and an occasional flick of the flame onto the 'meta' produces by depolymerisation sufficient ethanal to effect complete reduction within seconds.

The apparatus used in Fig. 1. is excellent for qualitative work, but suffers from the disadvantage that some of the sublimed 'meta' recondenses upstream in the cooler region round the bung and this cannot be removed without partly melting the bung. This would be a considerable nuisance in quantitative work as in section 8.2 of the Ordinary and Higher Grade syllabus.

The simplest solution is to use combustion tubes of the type with a short glass tube fused onto one end, this being intended for the collection of reacting gases. (Fig. 2.)

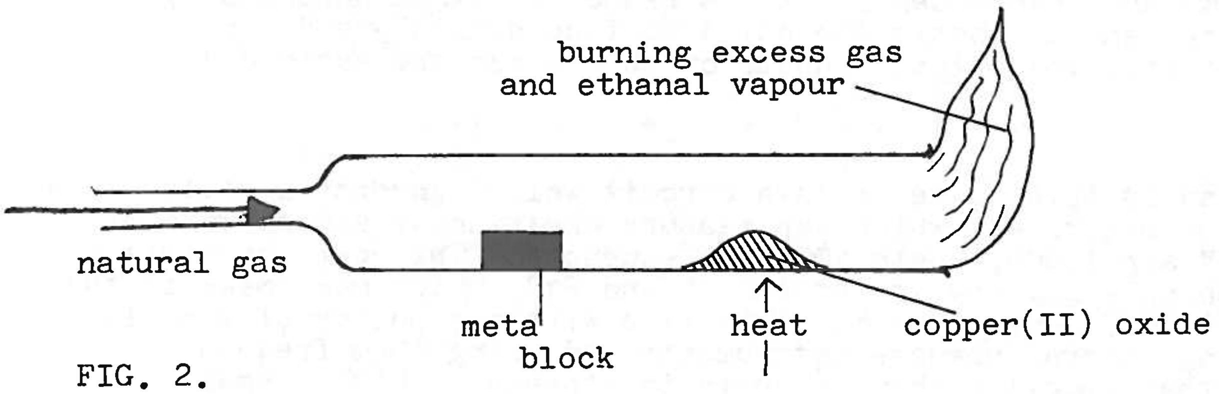


FIG. 2.

Only gentle heat is needed and only gentle heat should be used to remove any condensed meta at the inlet end, which is not designed to withstand sudden temperature changes.

Alternatively a bung may be made of Rocksil (pre-roasted in air) or Kaowool fibre. (Fig. 3.) The pressure of the gas mains is very low and we found the 'bung' to be free of leaks.

The use of an unaltered pyrex test-tube (Fig. 4.) is also possible, the small kink in the delivery tube being in order to hold it off the oxide. This latter method works very well from a practical point of view, but a more prolonged calculation is necessary as shown overleaf:

mass of tube = 1
" " " + 'meta' = 2
" " " + 'meta' and copper oxide = 3
" " copper oxide formed = 4

before the simple format of results can be obtained:

Mass of copper formed = 4 - 1 (=A)
Mass of copper oxide taken = 3 - 2 (=B)
Mass of oxygen removed = B - A

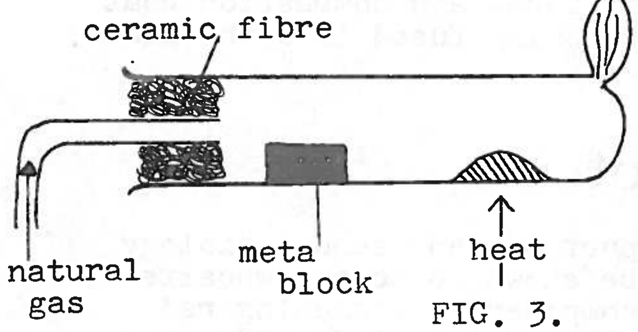


FIG. 3.

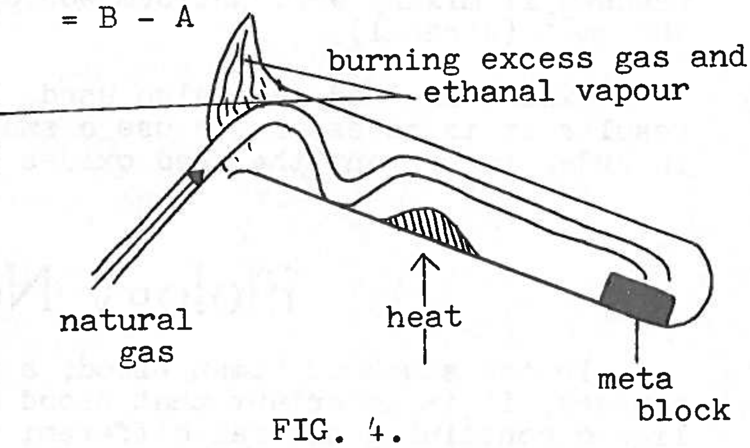


FIG. 4.

One other variation exists for those schools which still have some of the older tubes with two open ends. The tube can be weighed by itself and then with copper oxide before inserting a meta block from the opposite end and then closing it with a firm plug of ceramic or Rocksil wool. (Fig. 5.)

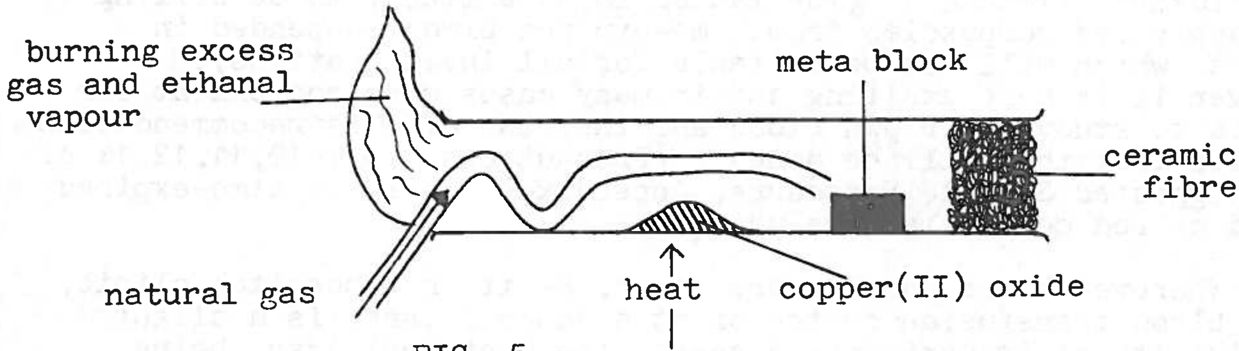


FIG. 5.

The amount of 'meta' block used will obviously depend on its rate of depolymerisation and hence on its rate of heating, but it was found that 0.2g of 'meta' was more than sufficient for the reduction of 1g of copper(II) oxide. The pack of 20 x 5g blocks was purchased from a camping shop for 57p: these bars are easily broken up and should be sufficient for at least 500-600 reductions of 1g lots of copper(II) oxide. The table shows some of our results: only in the last one do we get incomplete combustion due to the small amount of meta used.

Mass copper(II) oxide used (g)	0.89	0.936	0.66	0.737	0.427	0.87
Mass meta used (g)	0.584	0.179	0.13	0.133	0.081	0.03
Ratio of O/Cu (moles)	1.06	1.02	1.00	1.04	1.04	0.847

It would be possible to generate the ethanal in a second combustion tube placed upstream but it is safer to generate it in a stream of gas in the same tube. The blocks can be broken into small sized chunks and these should not make contact with the skin. Ethanal vapour is also harmful by inhalation, but it is most unlikely that anything more than a small amount would escape being combusted in the flame. In fact even if twenty pupils each completely sublimed 0.2g 'meta' without burning any of it, into an unventilated laboratory $(8 \times 5 \times 4)m^3$ the maximum concentration reached if mixing were uniform would be well below the TLV of $180mgm^{-3}$ (ethanal).

Oxides of lead were also used, but to obtain quantitative results it is necessary to use a small porcelain combustion boat in order to prevent the lead oxides becoming fused into the glass.

Biology Notes

In the study of human blood, a part of many school biology courses, it is important that blood be shown to be a composite liquid containing several different components, including red corpuscles. Most pupils are fascinated by the study and eager to look at blood smears under the microscope. However there are minor difficulties in obtaining blood samples, even the drop or two required for this work.

Some schools have found it possible to obtain time-expired blood from a local hospital or blood-bank of the National Blood Transfusion Service. (The latter is more likely to be willing to supply red corpuscles from time-expired blood suspended in saline, which will not be suitable for all investigations). However it is more exciting and in many cases more convenient for pupils to study their own blood and the rest of this recommendation assumes that this will be done. (Precautions 2,3,4,10,11,12,14 of the Suggested Sterile Procedure, Appendix 1, apply if time-expired blood or red corpuscles are used).

Wherever blood samples are taken, be it in a hospital clinic, in a blood transfusion centre or at a school, there is a slight possibility of transmitting disease, the most unpleasant being serum hepatitis, a disease rare in children. (Blood donors are screened for hepatitis but the test is not 100% certain). However it is transmitted only if blood from a carrier or infected person infects another person via, say, a scratch in the skin. THERE IS NO SIGNIFICANT RISK IF THE CORRECT STERILE PROCEDURE IS FULLY CARRIED OUT.

In view of the variation between procedures recommended elsewhere, the Committee believes that a statement of procedure is desirable. It does not wish that this statement, which may appear complicated, should in any way reduce practical work. Indeed it believes that the taking and subsequent investigation of blood samples (of one or two drops) from pupils to be educationally valuable if carried out with due sensitivity and care and that following the sterile procedure outlined is in itself a useful lesson in safety education.

Procedure

1. The approval of the School Medical Officer must be obtained for a sterile procedure (e.g. Appendix 1). It is best if

permission is obtained by a Local Education Authority for all its schools.

2. Teachers must ensure that the pupils understand fully the precautions to be taken and the possible consequences of not taking them. This is valuable as a contribution to general knowledge as well as essential for the blood sampling to be safe.

3. There must be no pressure on a pupil to give a sample. Teachers should make it clear by their attitude that it is perfectly normal for some pupils not to want to have a sample taken and not want to take any part in the practical work involved. If this is done well, it is likely that such pupils will gradually become involved in the work. Pupils should be allowed to change their minds either way.

4. Parental permission must be obtained, well in advance. A suitable form is given in Appendix 2.

5. We would recommend that the teacher take the samples. If the pupils take their own samples, it is much harder for the teacher to ENSURE that the correct sterile procedure is followed by them all. (See Appendix 1). Also, children who are quite willing and eager for samples to be taken often find it impossible to do it themselves. We recommend that teachers ask pupils to sign the relevant part of the form in Appendix 2, or some similar statement.

6. Blood should be taken with a sterile lancet from the back of a pupil's finger, near the nail, using a new lancet for each pupil. We do not recommend that blood be taken from a finger tip because of the risk of subsequent infection nor from the ear lobe because of danger if a pupil jerks his head.

7. Teachers must supervise the issue, use and subsequent disposal of the lancets extremely carefully.

8. The sterile procedure approved by the School Medical Officer (e.g. Appendix 1) should be adhered to.

APPENDIX 1

SUGGESTED STERILE PROCEDURE

BEFORE THE LESSON

1. Slides or any other glassware which might possibly come into contact with the site from which a blood sample is taken should be sterilised by autoclaving to 103.5 kilopascal (103.5 kNm^{-2}, 15 lbf in^{-2}, 121^{o}C) or by heating dry for 3 hours at 170^{o}C.

2. An aqueous solution of sodium chlorate (I) (sodium hypochlorite) should be freshly prepared from a concentrated sodium chlorate (I) (sodium hypochlorite) solution such as Milton, Chloros or BDH sodium hypochlorite solution (10-14% w/v available chlorine). 10cm^3 of one of these should be added for every 1 dm^3 (litre) of solution. Such a solution should have a minimum concentration of free chlorine of 200mg dm^{-3} (or ppm w/v): this concentration will turn starch iodide paper dark blue.

DURING THE LESSON

3. Because of the risk of contamination through broken skin, the participation in this practical work of anyone with any sort of open wound, particularly on or near the face or hands, should be strictly limited: depending on the nature and position

of the wound, the pupil may need to be excluded from the work altogether.

4. Pupils and teacher must thoroughly wash both hands using soap and water. Those giving blood samples must pay attention to washing the site chosen for the sampling. Dry hands using only disposable towels.

   If the teacher is taking the samples, he must wash and dry his hands before taking each sample.

5. Using a cotton wool swab, wipe the chosen site with 70% alcohol (70% v/v, propan-2-ol (iso-propanol) or ethanol)* and allow it to dry.

6. Remove a new sterile disposable lancet from its packet immediately prior to use. Do not allow the sharp end to touch anything.

7. Puncture the skin in the chosen site using the lancet and immediately put it in a strong sealable container. LANCETS MUST BE USED ONCE ONLY.

8. Collect the blood by letting a drop or two fall into a sterile tube or on to a sterile slide. (See 1.) There must be no contact between the area of the pinprick and any apparatus unless the apparatus has been sterilised.

9. Using a fresh cotton wool swab, wipe the site again with 70% alcohol (70% v/v propan-2-ol (iso-propanol) or ethanol).* Apply slight pressure with the swab if necessary to stop the blood flow. Put the swabs in the container with the lancets.

10. Any blood spilt on the bench etc. must be wiped up immediately using the freshly-prepared aqueous solution of sodium chlorate (I) (sodium hypochlorite). (See 2.) Hold the swab with forceps or plastic gloves.

11. The greatest care must be taken to avoid contamination of the skin with blood from another person. If this should occur, however, the contaminated area must be disinfected immediately with the freshly-prepared aqueous solution of sodium chlorate (I) (sodium hypochlorite), DILUTED WITH WATER TO 10 TIMES ITS VOLUME, and then washed thoroughly with soap and water.

12. At the end of the practical, wash both hands using soap and water and dry them thoroughly using only disposable towels.

AFTER THE LESSON

13. The container with the lancets and swabs should be sealed and autoclaved. Alternatively, immerse the swabs and used lancets in the freshly-prepared aqueous solution of sodium chlorate (I) (sodium hypochlorite) and leave overnight. Then dispose of the container so that there is no danger of anyone coming into contact with the contaminated items.

14. All tubes, slides and other equipment contaminated with blood should be soaked in the freshly-prepared aqueous solution of sodium chlorate (I) (sodium hypochlorite) overnight before being washed in the normal way. Rubber or plastic gloves should be worn.

* Or any other antiseptic approved by the School Medical Officer. Sterile injection swabs, impregnated with antiseptic, are obtainable from suppliers.

APPENDIX 2

Dear Parent

During the next few weeks, we shall be studying blood during science lessons. Children usually find it interesting to look at samples of their own blood under a microscope and to carry out other investigations with it.

This letter is to ask your permission for a sample of blood to be taken from your child. Please note that:

1. only a drop or two will be taken from a prick in a finger;
2. the school Medical Officer has approved the sterile procedure we will use;
3. the sample will be taken only if your child wants it to be done and you have also agreed.

Please complete the form below and return it to me as soon as possible.

Yours sincerely

Class Teacher

FOR THE PARENT

I am *willing/not willing* for a sample of blood to be taken from my child for use in a science lesson.

Signed: ....

(Parent or Guardian)

Date: ....

* Please cross out the one that does not apply.

FOR THE CHILD (This section need not be completed until the lesson).

I agree that the teacher may prick my finger to obtain a drop of blood.

Signed: ....

Date: ....

Physics Notes

V.C.O. stands for voltage controlled oscillator, which is an integrated circuit at the heart of many analogue to digital converters, such as digital voltmeters. One such, cat. no. 307-070 can be bought from RS Components at £4.52. By adding a few external resistors and capacitors, a circuit can be built which will give a square wave frequency output very linearly related to an input d.c. voltage, the response curve having a slope of 500Hz/V, to a maximum of 10V. The data sheet R/3021 obtainable from RS Components, has the circuit details. A single transistor amplifier on the output is sufficient to drive an earphone or loudspeaker.

We believe that the circuit could form a useful and satisfying

SYS project to construct a voltmeter for use by blind children. What we have in mind is a reference voltage, variable by means of decade switches with Braille numbering which could be applied to the input as an alternative to the voltage to be measured. With a push-button change-over switch, it would be easy to alternate between the two, and so decide when the frequencies were matched.

If this appears to be all plain sailing with no problems to be solved, consider the response of the ear to pitch variation. The difference in frequency between inputs of 0.4 and 0.5V will be a major third, and easily detectable. But at a higher level of input, a third is the difference between 8 and 10V which raises the question of whether the ear is good enough to distinguish a 0.1V difference when the level is 10V, and the pitch will be around 5kHz. A semi-tone, which is a somewhat gross interval to the musical ear, would represent at 1kHz the difference between 2.00 and 2.12V. But can the average person distinguish between 2.12 and 2.13V? Do we need this degree of discrimination? How do we measure with some degree of accuracy voltages of the order of 0.1V (=50Hz)? Can or should the input be altered by some kind of biassing so that the frequency is made to fall within the range - whatever that may be - where the ear's pitch discrimination is greatest? These are some of the questions we would expect a SYS projecteer to attempt to answer.

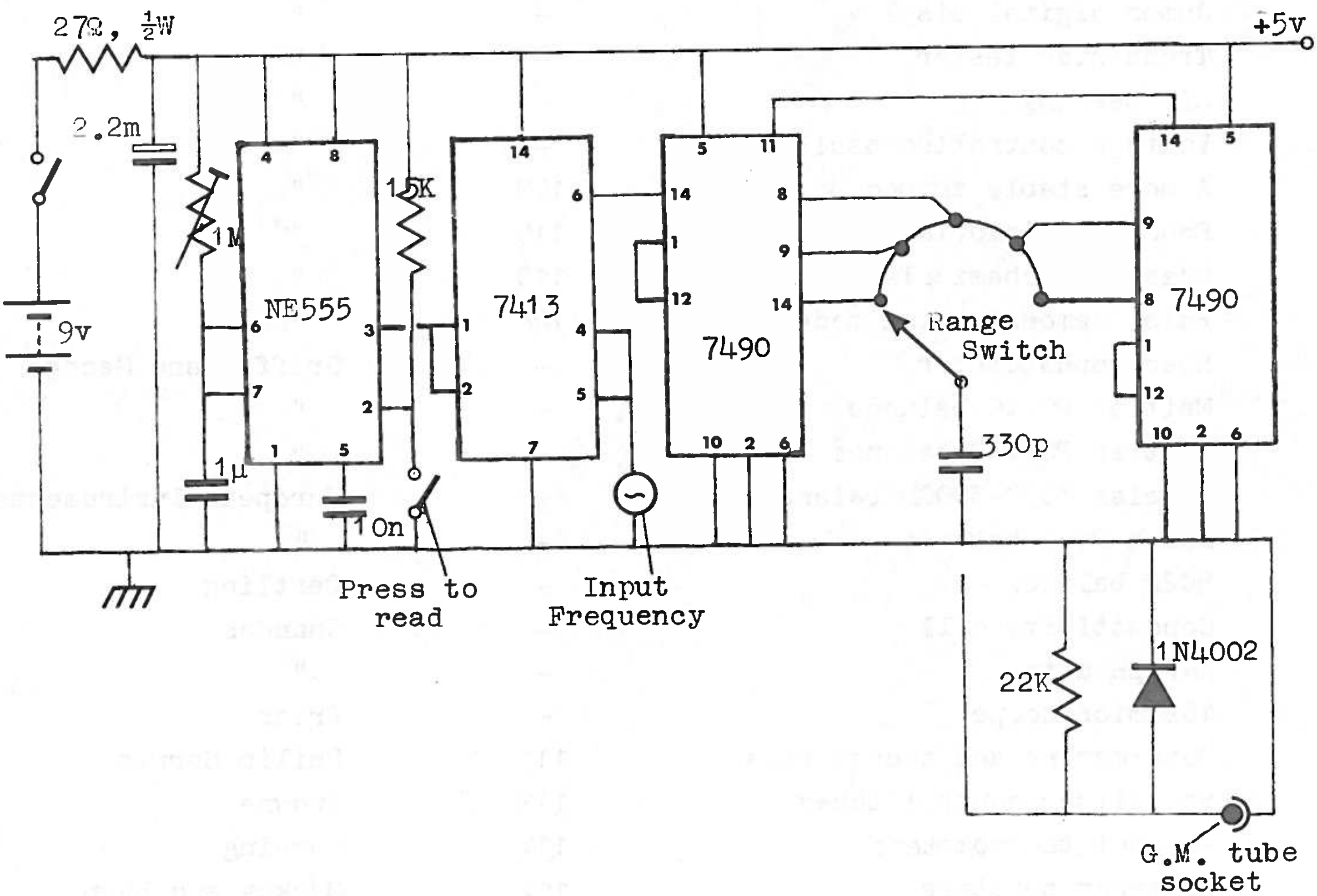
* * * * * * *

Recently we were consulted by a school on how one might adapt the input to a scaler so that it operated as a frequency meter, and found that it was a comparatively simple and cheap process. The circuit is below. A NE555 timer is wired as a 'one-shot' device, operated by a trigger switch which shorts pin 2 to ground. The frequency to be measured, which must be 2V or greater in amplitude, is applied to some of the inputs of a Schmitt trigger NAND gate, and the timer pulse to the rest. When the push button switch on the timer is pressed momentarily, the NE555 produces a 1 second pulse. During it, pulses of the input frequency are fed through the NAND gate, and are counted at the G.M. tube input of the scaler. If the scaler reads zero at the start of the pulse the output count at the end will be the number of pulses of input while the gate was on i.e., the input frequency.

One disadvantage of the system is that the upper frequency limit is about 1kHz because the mechanical register which counts the third and higher digits cannot click round much faster than about ten per second. This is easily overcome by using one or more frequency dividers between the gate and the output. A single decade counter, SN7490, will give the division by 2,5 and 10, and in our circuit we have allowed for two of these in cascade, using only the 5 and 10 division ratios in each. The input then goes via a five position range switch, so that ratios of 1,5,10,50 or 100 are possible. In this way the scaler can measure frequencies up to 100kHz.

The other difficulty is calibration, i.e. how to pre-set the timing components on the NE555 to get an accurate 1s pulse. What we suggest is to get as stable a frequency source as possible, set at around 1kHz, and to count this continuously for 15 or 30 minutes, determined by a stop clock or watch. The stopwatch accuracy can be checked if necessary against BBC time signals, timing for one or more hours. In this way one gets an accurate measurement for the frequency which is then applied to the circuit in order to adjust the value of the timing resistor. While this is shown in the diagram as a pre-set 1MΩ, it can be a fixed resistor in series with a lower value pre-set, say 50kΩ, to give finer control of the final adjustment. If good quality components with low temperature coefficients are used in the timing, it should be possible to achieve an accuracy of 1%. One can do better than this if more expensively, by buying the precision timer 305-850 from RS Components at around £2 instead of the NE555 at 40p. This will give an accuracy of 0.1% or better.

The current consumption is about 70mA at 5V, so that we used a dropping resistor from a 9V battery as the supply. The total cost of the instrument, using the chips and their sockets from Technomatic, and other components from RS Components is about £5. This does not include the battery, or a box to house the circuit. Another expense not included is the PET connector required by the scaler, which is 456-223, costing £2.46 from RS Components. We have verified that the circuit will work with Griffin and George, Philip Harris, and Panax scalers. The scaler switch should be set to 'Count' or 'G M tube', and where it cannot be switched off the h.t. supply to the socket should be turned down to minimum.



The two '14's on one of the 7490 chips is merely for convenience in drawing the diagram; they are the same connection point.

Display Laboratory

The following items have been added since the previous bulletin entry; most are in the display laboratory and others will be demonstrated on demand. The middle column gives the bulletin number on which further information on the various items may be obtained. The absence of a number usually means that the item is in the pipeline, waiting to be published.

Item	Bulletin No.	Manufacturer or Agent
Motor/dynamo conversion	107	SSSERC
Non-commutating d.c. motor	111	"
Bus stability model	111	"
Centre of gravity model	-	"
Moving coil model	114	"
Quiz game control	-	"
Scaler/frequency meter	-	"
Jumbo digital display	-	"
Transistor tester	-	"
Air bearing	-	"
Voltage controlled oscillator	-	"
A more stable tripod	108	"
Food/fuel calorimeters	114	"
Hazardous chemicals manual	110	"
Pulse demonstration model	108	"
Spectrophotometer	-	Griffin and George
Mettler PC440 balance	-	"
Mettler PC4400 balance	-	"
Precisa 300C-3000D balance	-	European Instruments
Bosch P115 balance	-	"
HC22 balance	-	Oertling
Conductivity cell	-	Chandos
A47 pH meter	-	"
462 microscope	-	Prior
Data memory and accessories	111	Philip Harris
Steriliser control tubes	112	Browne
Alcohol thermometers	114	Corning
Moramber burettes	114	Mackay and Lynn
Autolet blood sampler	112	Owen Mumford
Pasteur pipettes	111	Alpha Labs.
Observation incubator	-	N.W. Laing

Bulletin Supplement

Below is a summary of tests on a number of centrifuges. Individual reports on these models can be borrowed by writing to the Director of the Centre. The classifications used are: A - most suitable for school use: B - satisfactory for school use: C - unsatisfactory.

Model	Janetski T5	Spinette	306/0030
Supplier	Copley Inst.	Damon	Educhem
Price	£99.00*	£89.90	£68.00
Head	8-station* angled	4-station angled	4-station swing-out
Test-tube size	100 x 16mm	125 x 16mm	100 x 16mm
Max. speed rev/min	7410(3270)*	2800	2570
Max. acceleration	4610g(1390g)*	955g	910g
Switch on/off	35/50(12/17)*	10/16	8/16
Classification	A	B	B

Model	CFB-500V	C24700/8	3804
Supplier	Griffin and George	Philip Harris	Lab-ap
Price	£92.60	£89.30	£67.23
Head	4-station swing-out	4-station swing-out	4-station swing-out
Test-tube size	100 x 16mm	100 x 16mm	100 x 16mm
Max. speed rev/min	2800	2580	2630
Max. acceleration	1060g	980g	1060g
Switch on/off	20/28	18/7	20/27
Classification	A	A	C

Notes

* The price includes an 8-station angled, and a 4-station swing-out head. The machine has 3 speed positions: values are for maximum speed. Numbers in brackets give corresponding values for the swing-out head.

C classification for the Lab-ap version is because there is no lid-operated switch.

Switch on/off are the times in seconds for the machine to reach max. speed from rest, and vice versa.

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

Alpha Labs., 169 Oldfield Lane, Greenford, Middlesex UB6 8PW.

Asschem (Educhem Agents), Redding Industrial Estate, Falkirk.

Albert Browne Ltd., Chancery House, Abbey Gate, Leicester LE4 OAA.

Chandos Products (Scientific) Ltd., Chandos Works, High Street, Newmills, North Stockport, Cheshire.

Copley Instruments Ltd., Private Road No. 7, Colwick Industrial Estate, Nottingham NG4 2ER.

Corning Ltd., Lab. Division, Stone, Staffordshire, ST15 OBS.

Damon/IEC (UK) Ltd., 178/182 High Street North, Dunstable, Bedfordshire LU6 1AT.

European Instruments Ltd., 80-82 Desborough Road, High Wycombe, Bucks.

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

Philip Harris Ltd., 34-36 Strathmore House, Town Centre, East Kilbride, Glasgow.

Lab-ap (Huddersfield), 177 Lockwood Road, Huddersfield HD1 3TE.

N.W. Laing, 52 Mill Road, Thankerton, Biggar, Lanarkshire ML12 6NY.

Mackay and Lynn, 2 West Bryson Road, Edinburgh.

Owen Mumford Ltd., Medical Division, Brook Hill, Woodstock, Oxon OX7 1TU.

Oertling Ltd., Cray Valley Works, St Mary Cray, Orpington, Kent.

Panax Equipment Ltd., Willow Lane, Mitcham, Surrey CR4 4UX.

Prior and Co. Ltd., London Road, Bishop's Stortford, Herts.

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

Technomatic Ltd., 17 Burnley Road, London NW10 1ED.