SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 92. November, 1976.

Contents

Introduction

We have been asked to intimate the following competition which is open to all sixth year pupils in Scotland who are studying chemistry. It is a competition sponsored by the Royal Institute of Chemistry to celebrate its centenary. Competitors are required to submit a written individual project similar in nature to that submitted for the CSYS examination, and candidates for this exam. will be able to submit the same project. Candidates are required to notify the Hon. Secretary Scottish Region of their intention to compete by 31/3/77 and the project must be in his hands no later than 31/8/77. The winner will receive £50, and the winner's school chemistry department £25 and there are second and third prizes. This information should have reached all Scottish schools directly, but if any have been overlooked the hon. secretary will provide details to any principal teacher of chemistry who gets in touch with him.

* * * * * * *

The following individuals and/or organisations have indicated their willingness to help with CSYS projects:

Mr. G. Morton, Technical Department, B.P. Oil Refinery, Bo'ness Road, Grangemouth, FK3 9XQ.

Dr. T. G. Parker, Chemistry Dept., The Hannah Research Institute, Ayr, KA6 5HL.

Soil Fertility Dunns Ltd., Highfield Factory, St. Quivos, Ayr, KA6 5HH.

Chemistry Department, Jordanhill College of Education, Southbrae Drive, Glasgow, G13 1PP.

Dr. M. R. Moore, Dept. of Materia Medica, Stobhill General Hospital, Glasgow, G21 3UW (lead in biological tissues).

* * * * * * *

The ballot for the surplus equipment in Bulletin 91 seems to have provided a more equitable distribution than any previous. 90 schools submitted requests for items; 23 were wholly unsuccessful and of these 17 requested item 697 only, typewriters. Hence we will continue to operate the priority system used for Bulletin 91, in spite of one visitor who unkindly asked that we programme his pocket calculator so that it could submit his entry.

In this issue we are listing only two kinds of surplus material, although we have much more in stock. We know from enquiries that there is a demand for dry cells for Worcester circuit boards, and for photographic paper. On the other hand, we know that surplus material interests only a minority of our readers and has taken up an inordinate amount of bulletin space recently; hence the compromise. Any who are interested in other items should get in touch with us, or better still, call and rummage.

Opinion

Elsewhere in this bulletin we give the results of a fire test on our own design of wooden flame-proof cabinet, constructed after considering the reports discussed in Bulletins 75 and 78, on wood and metal cabinets. The results confirm our belief that in the early stages of a fire, wood is preferable to metal. It is an opinion supported by Professor Rasbash of the Department of Fire Safety Engineering, of Edinburgh University, who has been in touch with us concerning this problem. It is thus disappointing to hear that at least one inspector of the Health and Safety Executive has declared that only metal cabinets should be used for storing flammable liquids in schools. We need arguments, or better still, evidence, to support such a contention. The only one we have heard so far is that part of the Fire Regulations which states that no container should be of such material that it will contribute to the fire. It is a regulation made for a situation different from that we are considering, the storage of flammables on industrial premises. It is a regulation which could well be reconsidered in view of the application of the Health and Safety at Work Act to schools, or which needs a more lenient interpretation that it would seem to be getting. I know that in the first 10 minutes of an incipient fire, while staff and pupils may be evacuating the building and passing close by a storage cabinet, or while the fire is being fought with such portable extinguishers as are to hand, I should feel much safer from the risk of explosion if the storage cabinet were made of wood. If the fire has not been brought under control in that time, then the arguments of wood versus metal would seem to be irrelevant, since official advice is to close all doors to prevent the fire spreading and leave the issue to the Fire Brigade. It is presumed they are competent to deal with both wood and metal storage systems.

Chemistry Notes

It may be remembered that in Bulletins 75 and 78 we discussed the relative advantages of wood and metal as a material for constructing flame-proof cabinets. At that time we were convinced that the insulating property of wood, added to the fact that it is less likely to warp, made it the superior material, despite the obvious drawback of its adding fuel to the flames. Accordingly we constructed our own storage cabinet and sent it for testing to the Fire Research Station. We have now received the results of this test; what follows is a brief account of the cupboard construction, followed by details of the fire testing and the results.

The cupboard was made of 19 mm blockboard, and measured 1.14 x 0.99 x 0.45 m. There were two doors in the front of the cupboard each of dimensions 1.06 x 0.48 m. Each door was held by 3 hinges and closed by a metal catch and lock which bolted the doors top and bottom. The catches were modified at the Fire Research Station to secure the door at the middle as an additional flame barrier. The door handles attached to the catches were two large wooden knobs, and two exterior locks which bolted into the edges of the knobs were fitted. This rather clumsy method of fitting locks was done to ensure that there would be no conduction path in metal directly connecting the inside and outside of the cupboard. Obviously, bolting a lock to the outside surface of a door is less thief-proof than a properly fitted mortice lock, but may be accpetable for a cupboard which is inside a store-room or laboratory.

The edge of the left hand door only was lined with asbestos tape (which was not so suspect at the time of construction as it is now), covering the hinges, to see by comparison with the right hand side what additional protection this gave. The cabinet was given two coats of fire resistant paint, apart from the back which was left unpainted, again for comparison purposes.

The inside of the cupboard was divided into two compartments by a wooden partition running vertically down the centre line. Each compartment was itself divided into 4 sections by 3 shelves at heights of 228 mm, 571 mm and 863 mm from the base. Each shelf was made of 6 wooden slats running across the cupboard, each slat being of 38 mm x 12.7 mm section, with a space of 38 mm between slats. The slats were joined by two crossmembers in each case. A deep metal tray, 215 mm in depth, designed to retain the contents of broken bottles, was fitted in each of the bottom sections.

Writing to us on receipt of the cabinet, before it had been tested, an officer of the Fire Research Station made the following comment: The type of hinges fitted are similar to those fitted to cupboards that we have tested; a better design would be a longer leafed hinge in which the fixing screws were further into the side wall of the cabinet and the leaf attached to the door was bent at right angles so that the fixing screws entered from the rear of the door. The protection of the pins of the hinges by an incombustible fabric is a useful device; however there might be some objection to the use of an asbestos fabric for this purpose and a ceramic or glass wool fabric would be free from the health hazard associated with asbestos. The steel trays provided at the bottom of each section of the cupboard to contain the contents of bottles, should they become broken, are of adequate size. However it would be advisable for trays to be welded or deep-drawn rather than riveted and soldered.

The cupboard was loaded with three bottles. A Winchester half filled with engine oil was placed on the lower shelf of the right hand compartment. A litre glass bottle of the same oil again half full was placed on the middle shelf of the left hand compartment and another litre glass bottle half filled with dibutyl phthalate was placed on the middle shelf of the right hand compartment. Fluids of high boiling point, having a similar specific heat to more volatile flammable liquids, were chosen to lessen the risk of explosion of released vapour. Thermocouples were positioned in the liquid in each of the bottles. Further thermocouples were attached to the outside of the cupboard on the rear side at the level of the middle shelf and inside the cupboard at a point on the centre partition 50 mm above the middle right hand shelf.

The cupboard was placed in a tray containing 47 litres of kerosene floating on water. The kerosine was ignited and allowed to burn to extinction which was estimated to take between 5 and 10 minutes. Figs. 1 and 2 shows the time-temperature curves of the various thermocouples. The fire developed rapidly and within one minute the cupboard was enveloped in flame. The flames began to die down after 5 - 6 minutes, although the back of the cupboard continued to burn for a short time afterwards.

After 15 minutes the cupboard was examined. It was found to have been severly charred but was still intact. In general the veneer on the blockboard had been burned away and the surface of the core of the blockboard was charred. The doors were found to be in working order; when opened a small amount of smoke was released. The air inside was found to be only moderately warm, but the inside face of the door felt hot. The bottles inside were found to be intact, the liquids still being cool. The inside of the cupboard showed no charring, although the door edges where they met at the centre were charred. The asbestos tape provided on one leaf of the door afforded extra protection at this junction as was noted from the absence of heat marking at this zone.

The time temperature curve Fig. 1 shows a rapid rise of temperature of the outside of the back of the cupboard, temperature of 900°C being reached within one minute. These very high temperatures began to decrease after 4 minutes as the kerosine began to burn itself out. The peak occurring at 7 min can be attributed to the burning of the unpainted back of the cupboard, where this thermocouple was situated.

The time temperature curves of the thermocouples inside the box show however a much slower temperature rise and a much lower maximum temperature being reached. The thermocouple in the inner air space reaches a maximum temperature after 7 minutes of 80°C before falling to 55°C at 12 minutes, whilst the thermocouples in the liquids in the small bottle only approaches 50°C after 12 minutes and the thermocouple in the large bottle only approaches 45°C after the same time.

After examination the cupboard was stored in the open, and the doors fell off in a very short time, indicating that the security of the screws had been seriously diminished. Hinges of the type described above should ensure a more secure fitting after involvement in fire.

The conclusions to the Fire Research Station's report state:

1) The test conducted on the wooden cupboard indicated that it gave good protection for at least the first 5 minutes of a fire. Although considerable charring of the outside surfaces occurred the contents and the interior of the cupboard were undamaged.

2) A well designed wooden cupboard gives better protection to its contents than a non-insulated steel one during the early stages of a fire although the wood of the cupboard contributes some fuel to the fire.

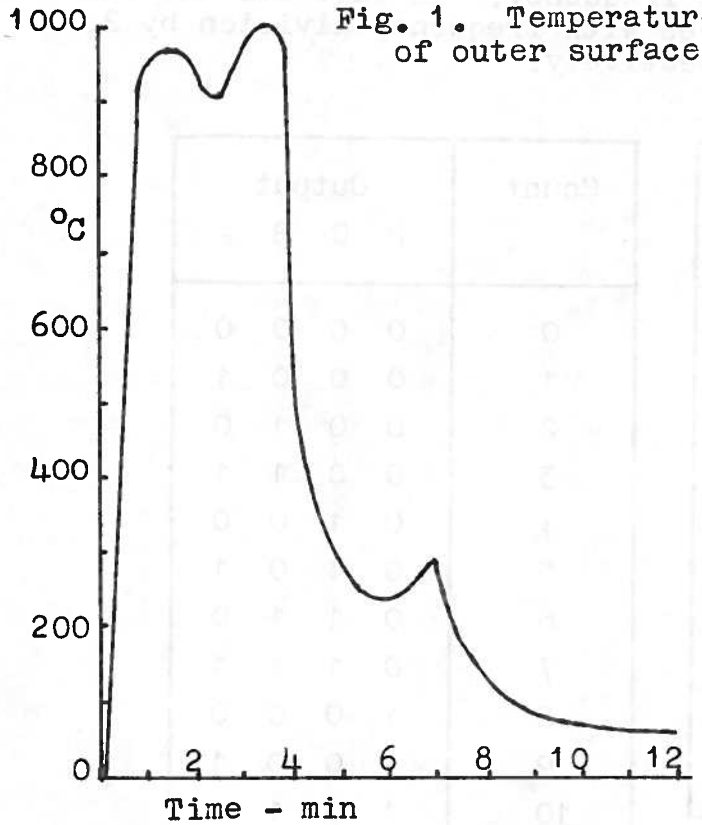


Fig. 1. Temperature of outer surface.

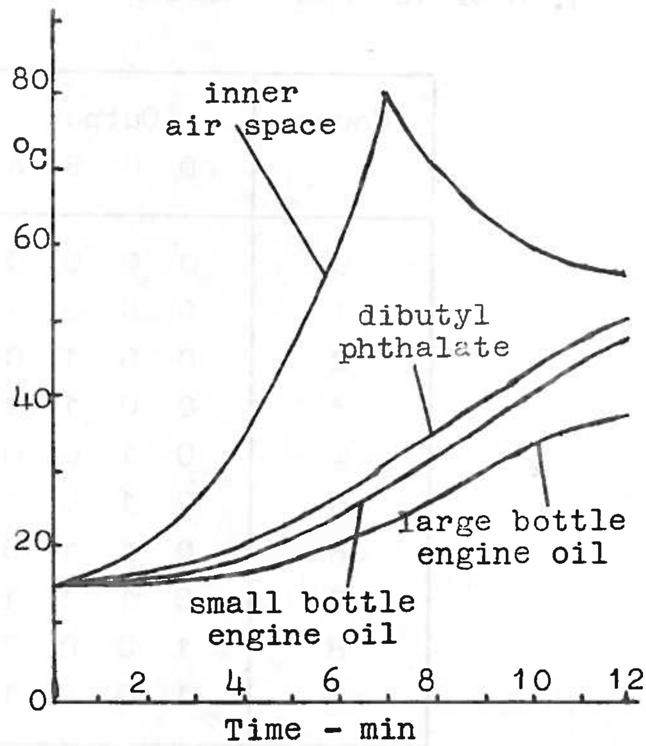


Fig. 2. Inside temperatures.

* * * * * * *

The summer, 1976 chemistry broadsheet from Griffin and George contains a warning against the formation of bis-chloromethylether in an experiment they have described in their Polymer kit booklet to prepare urea-formaldehyde. Bis-CME is known to be a potent carcinogen, and is formed in this experiment. The firm advise against the preparation unless carried out with very small quantities in a well-ventilated fume chamber. We gave the known facts of the carcinogenic properties of bis-CME in Bulletin 85.

Physics Notes

This article describes how to divide down a 1 MHz crystal controlled frequency, to generate the concert pitch A 440 Hz with an accuracy better than 0.05%. The SN7490, 7492 and 7493 integrated circuits are bascially an arrangement of flip flops designed to count positive input pulses. The 7490 is a decade, and the 7493 a 4-bit binary counter. All four flip flop outputs are taken out to connecting pins, and the count sequences are shown in table 1. In this, a high output is designated logical 1, and a low output logical 0.

At the end of the cycle, each counter reverts back to the all zero state, and the cycle repeats. Both these counters can be used as frequency dividers. On the 7490, both the C and D outputs turn on or off only once during the complete cycle, so that they give a ÷ 10 facility. The same is true for the D output of the 7493, but here the switching is symmetrical, on for half and off for half the time, so that the D output is square wave of frequency one sixteenth of input frequency. In fact all the outputs of the 7493 give square waves with frequency division by 2, 4, 8 or 16 from A through D respectively.

Count	Output D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

(a)

Count	Output D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

(b)

Table 1. Count sequence for (a) SN7490 and (b) SN7493 counters.

All the counters possess two 'reset zero' inputs, labelled R_o. These connect internally through a dual input NAND gate to all the flip flops. If either R_o input is low, counting proceeds, and only if both R_o inputs are simultaneously high will the counter revert to the all zero state. This facility can be used to shorten the counting cycle length. To divide by an integer N, we detect the Nth count of the cycle and arrange that it shall feed back to both R_o inputs a logical 1. This sets the counter in the all zero state, and the disappearance of the N state means that R_o revert to zero and counting can again proceed. The circuit of Fig. 1 shows how division by 7 could be achieved using a triple input AND gate for the feedback. Either 7490 or 7493 could be used, and examination of table 1 shows that the C output of the counter would give ÷ 7.

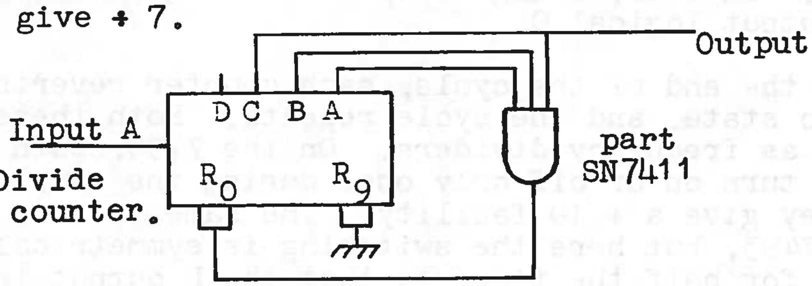


Fig. 1. Divide by seven counter.

Two practical points about the divider; (i) on the 7490 only there are two 'nine reset' connections (pins 6 and 7) and these must be grounded for counting to occur, and (ii) on both versions the A output (pin 12) must be connected to the B input (pin 1) in addition to the connections shown in Fig. 1.

It is this principle of shortening the counting cycle by feedback of a given term which forms the basis of the concert pitch generator.

$10^6/1136 = 880.28$, and $880.28/2 = 440.14$

which is within 0.03% of the international pitch standard A = 440 Hz. We start with a frequency of 1 MHz, crystal controlled, and divide it by 1136. The factors of 1136 are 16 and 71, so that the first stage of division by 16 is done by a 7493 counter operating on a full cycle. Its D output will be square wave of frequency 62.5 kHz. Division by 71 is done by a two stage decade counter using 7490s, see Fig. 2. With the D output of the first connected to A input of the second, this counts in its normal mode, i.e. the left hand chip counts units and the right hand one counts tens. Count 71 resets the counter to zero as follows. The '1' comes from the A output of the first decade and is applied to one of the R_0 inputs on both counters. This will have no effect until the second R_0 input also goes high, which only happens when the AND gate detects the '7' on the second decade. The output of the AND gate will be a single pulse for every 71 applied to input A, i.e. at 880 Hz. As with Fig. 1, the connection between A output and B input must be made for both the 7490s for the count to proceed.

Any bistable circuit which changes its state with each clock pulse may be used for the final ÷ 2 and to produce square wave output. The SN7472 is one such, which will 'toggle' in this fashion if all its inputs, except the clock, are high. The output can be used to drive an earphone through any suitable transistor, and the complementary $\overline{Q}$ output of the flip flop will provide square wave of several volts amplitude for use with an oscilloscope etc.

Finally the 1 MHz clock generator. This uses three inverters of a SN7404, and the circuit is shown in Fig. 3. Its operation may be understood as follows. Imagine that due to the switching action of inverter 3, point A rises in potential. As the charge on a capacitor cannot change instantaneously, point B also rises. The positive feedback applied through inverters 2 and 3 means that a rise at B produces a further rise at A, so that the switch over is rapid, which incidentally means that an output taken from the junction of inverters 2 and 3 will have sharp edges capable of driving other integrated circuits.

As A rises inverter 1 switches, making C low. With B high and C low, a potential difference exists across the resistor and current flows, this current flowing into the capacitor so that the potential of B falls exponentially. At some point, this falling voltage will switch inverters 2 and 3 so that A falls, making B fall further. The process then operates in reverse. As A falls, inverter 1 switches, causing C to rise so that the p.d. across the resistor is now in the opposite direction and current flows out of the capacitor so that point B rises exponentially in voltage.

The range of resistance values for which the circuit works is somewhat limited, so that it is best suited to situations where a fixed frequency generator is required. The values we used to get a 1 MHz oscillation were 1.2 kΩ and 342 pF, the latter being 330 and 12 pF in parallel. These were arrived at by trial and error, using an oscilloscope with a calibrated timebase connected to the output. The crystal 'locks' the system to 1 MHz oscillation better if the natural frequency of oscillation is slightly less than 1 MHz. To verify if the final output is 440 Hz, the square wave $\overline{Q}$ output can be applied to a frequency meter. A more accurate method which does not need a frequency meter is to feed this output via a 0.1 μF, 1000 V working capacitor to the GM input of a scaler, and count the pulses over 1 or more minutes.

Fig. 4 shows the complete circuit of the concert pitch generator, excluding supply connections and those to unused inputs etc. which require joining to logical 0(ground) or logical 1($+V_{cc}$). The unused input connections are detailed in the table below Fig.4. V_{cc} requires to be 5 ± 0.5 V, and may be derived from a 9 V dry battery through a potential divider, adequately decoupled. The current consumption of the i.c. part of the circuit is 130 mA at 5 V: it is not possible to specify what the total current consumption will be as this depends on the impedance of the earphone being used. Although our circuit shows the earphone taken up to the full battery volts, a perfectly acceptable volume can be obtained using a 5 V supply throughout and this would allow one to dispense with the potential divider and decoupling capacitor, at the expense perhaps of making the unit less portable and dependent on an external supply. One final point about Fig. 4: the gate feeding back the 70 state is shown as 7410, and not 7411 as in Fig. 1. 7410 is a NAND gate and its output must be inverted to produce the same result as a 7411. But 7410s are cheaper than 7411s, and we have spare inverter gates on the 7404.

Suppliers and approx. cost of the main components;

1	SN7404	Trampus	0.13
1	SN7493	"	0.43
2	SN7490	"	0.74
1	SN7410	"	0.09
1	SN7472	"	0.22
1	1 MHz crystal	Interface	2.50
			£4.11

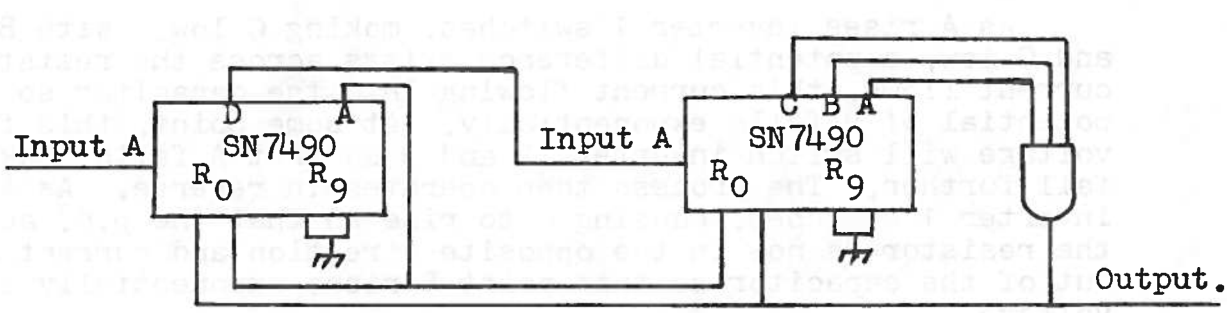
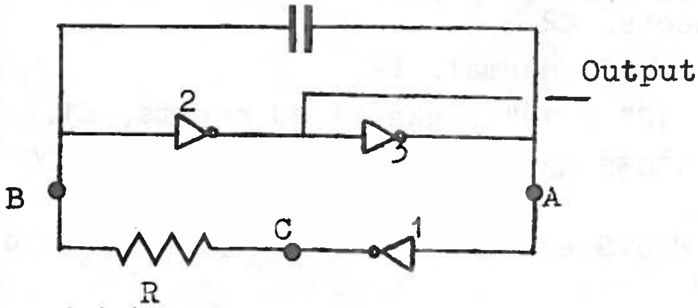
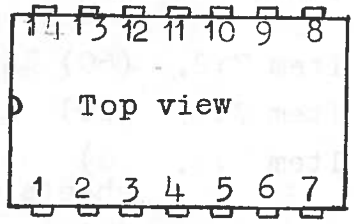


Fig. 2. Divide by 71 counter.

Fig. 3.





Pin connections, all i.cs.

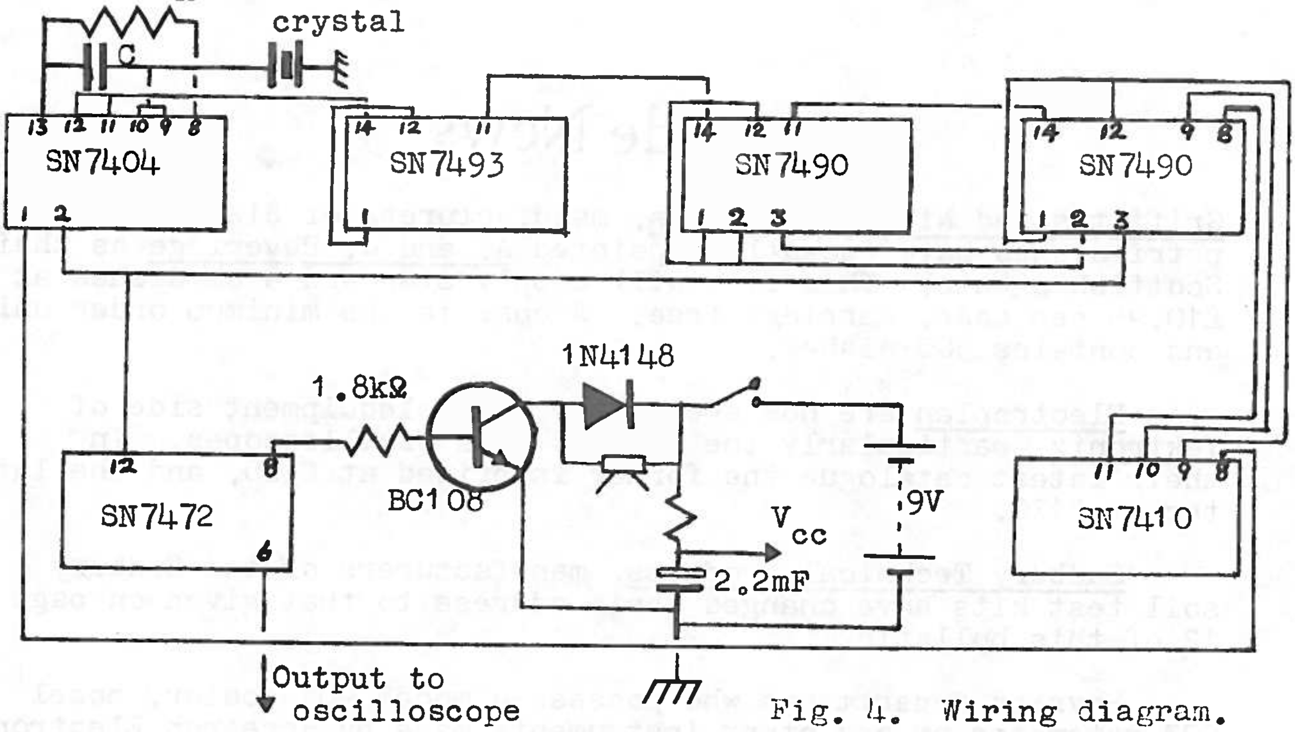


Fig. 4. Wiring diagram.

Unused and supply inputs as below.

	7404	7493	7490	7410	7472
Connect to logical 1	14	5	5	14	2 3 4 5 9 10 11 13 14
Connect to logical 0	3 5 7	2 3 10	6 7 10	1 2 3 4 5 7 13	7

Pins not named in the diagram or in Fig. 4 may be left unconnected.

* * * * * * *

The following items of surplus equipment are offered for sale. The ballotting arrangements described in Bulletin 91 will be used to allocate the material, and customers are asked to refer to these before submitting their requests. May we also ask that customers who were allocated material from Bulletin 91 and who have not yet done so, get in touch with us regarding transport arrangements. We will not send material to a school by parcel post or freight until we have had their confirmation that they will pay the charges involved.

Item 740. (600) Dry cell, 1.5 V, U2(SP2) type, 5p.

Item 741. (5) Photographic bromide paper, WSG1S soft, 8" x 10", boxes of 100 sheets, £2.

Item 742. (60) As above, WSG2S normal, £2.

Item 743. (20) As above, 12" x 15" packs of 20 sheets, £1.

Item 744. (6) As above, WSG3S hard, 10" x 10", boxes of 100 sheets, £2.50.

Item 745. (4) As above, WSG4S extra hard, 5½" x 5½", boxes of 100 sheets, 75p.

Trade News

Griffiths and Nielsen Plastics, manufacturers of disposable petri-dishes have recently appointed A. and J. Beveridge as their Scottish agents. This firm will supply standard 9 cm dishes at £10.95 per case, carriage free. A case is the minimum order unit and contains 500 dishes.

Electroplan are now agents for the Telequipment side of Tektronix, particularly the S61 and D61a oscilloscopes. In their latest catalogue the former is priced at £120, and the latter at £170.

Sudbury Technical Products, manufacturers of the Sudbury soil test kits have changed their address to that given on page 12 of this bulletin.

Physics departments who possess a model 901 scaler, model 903 ratemeter or any other instruments made by Research Electronics, which has now ceased to trade, may like to know that they can have them repaired by Bridage Scientific Instruments. Only if an estimate is asked for will it be supplied before commencing the repair.

L. Oertling are prepared to service most makes of precision balance on a contract basis. Enquiries should state type number and quantity to be serviced.

C.S.Y.S. projects may sometimes suffer from the lack of a specialised and expensive item of apparatus which may be required for only a short period so that its purchase cannot be justified. The solution then is to hire. Livingston Hire will hire equipment, mainly electronic in nature, on a weekly basis. For expensive items the hire charge, which includes delivery and uplifting, is 2½% of the price. For less expensive items the weekly charge will be more, but never greater than 10%. Delivery is promised within 24 hours anywhere in U.K. mainland. Labhire offers a similar service; both firms have a Scottish office.

Walden Precision Apparatus have produced a mark II version of their C065 colorimeter. A three position sensitivity switch marked 'lo', 'medium' and 'hi' replaces the two position switch of the original. A copy of the absorption curves of the filters used is also provided. The C065 mark II costs £48.

Bulletin Supplement

Summary of Stereomicroscope tests. The instruments shown below were tested on the procedure published in Bulletin 42. Individual reports on these can be borrowed for up to one month by writing to the Director. The overall assessment classifications are: A - most suitable for school use; B - satisfactory for school use; C - unsatisfactory. All measurements are in mm.

Model	Swift M20E (universal stand)	B28605/5	M96(004)
Supplier	Pyser	Philip Harris	Vickers
Price	£95	£75	£156.40
Magnifications	10x: 20x	10x: 20x	10x: 20x
Change mechanism	Slide out objectives	Slide out objectives	Rotating turret mount
Fields of View	14 7.0	19 9.5	22.5 11.5
Working distances	140 115	145 110	110 110
Eyepiece separation	50 - 72	45 - 95	55 - 77
Stability a)pull b)angle	5N 22°	8N 15°	10N 30°
Distortion	B	A	B
Blurring	A	B	A
Lamp	6 V, 12 W	12 V, 6 W	6 V, 72 W
Head adjustment	45° above horizontal 30° below	110° above 40° below	wide range of adjustment but no knuckle joint
Mass (kg)	9.9	8.2	14.25
Assessment*	(1) B (2) A/B (3) A (4) B/A	(1) A (2) A/B (3) A (4) B/A) **	(1) B (2) A (3) A (4) B

* (1) Ease of Use; (2) Performance; (3) Versatility; (4) Overall assessment. Assessments 1 - 3 are results of field trials in Scottish schools.

** These assessments only apply to the Mark II model. Models fitted with lock washers on the knuckle joint were rated unsatisfactory because of a poor mechanical performance.

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

A. and J. Beveridge Ltd., 5 Bonnington Road Lane, Edinburgh, EH6 5BP.

Bridage Scientific Instruments Ltd., 117 Knowle Road, Mirfield, W. Yorks.

Electroplan Ltd., P.O. Box 19, Orchard Road, Royston, Herts., SG8 5HH.

Fire Research Station, Borehamwood, Herts.

Griffin and George Ltd., 285 Ealing Road, Wembley, HAO 1HJ.

Griffiths and Nielsen Plastics Ltd., Huffwood Trading Estate, Brookers Road, Billingshurst, Sussex.

Philip Harris Ltd., 30 Carron Place, Kelvin Industrial Estate, East Kilbride, Glasgow, G75 OTL.

Interface Quartz Devices Ltd., 29 Market Street, Crewkerne, Somerset.

Labhire Ltd., Murraysgate Industrial Estate, Whitburn, W. Lothian.

Livingston Hire Ltd., Shirley House, 27 Camden Road, London, NW1 9NR.

L. Oertling Ltd., Oaktree Place, St. Paul's Road, Rockferry, Birkenhead, L42 1NF.

Pyser (Optical Division) Ltd., Fircroft Way, Edenbridge, Kent, TN8 6HE.

Hon. Secy. Scottish Region, Royal Institute of Chemistry, 41 Forfar Road, Dundee, DD4 7BE.

Sudbury Technical Products Ltd., Upper Birchetts, Langton Green, Tunbridge Wells, Kent, TN3 OEE.

Tektronix Ltd., Beaverton House, Station Approach, Harpenden, Herts.

Trampus Electronics Ltd., 58-60 Grove Road, Windsor, Berks, SL4 1HS.

Vickers Instruments Ltd., Haxby Road, York, YO3 7SD.

Walden Precision Apparatus Ltd., Shire Hill, Saffron Walden, Essex, CB11 3BD.