SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 87. March, 1976.

Contents

Introduction

The annual meeting of the Scottish Branch of the Association for Science Education will be held in St. Saviour's High School, Dundee from 5th - 7th April. On the morning of the opening day we will give our customary demonstration lecture on new apparatus for science teaching and we will have an exhibition of SSSERC designed and/or built apparatus for the duration of the meeting.

* * * * * * *

After printing in Bulletin 85 a list of F.E. colleges, mainly in the West of Scotland which were prepared to give assistance with CSYS physics projects, we received a telephone call from the physics department of Napier College of Commerce and Technology, Edinburgh, asking that they also be mentioned as providing this service. This is the type of response we had hoped for, and obviously we wish to include all possible sources of help, and not only for physics. Our problem is to locate these sources. Thus we appeal to any teacher who has had assistance from F.E. college, University, or industrial firm for a CSYS project to let us know the institution and individual who provided the help, so that we may contact them to find whether they would be willing to have their expertise offered to other schools in the neighbourhood. Equally, to any F.E. or University lecturer reading this, who has helped and/or would be prepared to help in the future CSYS projects we give them the invitation to let us know of this, for inclusion in a future bulletin.

* * * * * * *

The Centre will be closed on Good Friday, April 16th.

Opinion

Our 'cost of living index' for consumable items of school science equipment has been running for some time now. On the last occasion we carried out the simple calculation to extrapolate the increase in the index to cover the whole year and came up with a figure of 26%. This was roughly in agreement with figures then being published for the general rate of inflation. We are now being told that the rate of inflation is falling and we look forward to a falling off in the rate of increase of our own consumables cost index. All of this paints not a rosy picture but possibly a scenario acceptable to most teachers and their employing authorities.

However we have to confess to a certain disquiet about the rate of price increases in the field of 'capital equipment'. These are not included in our cost index. Comparing new prices with those of two years ago it is not an uncommon event to find increases of 100% over the two years i.e. 50% per annum compared with a general inflation rate of 25 - 30%. Indeed we could point to some increases of the order of 70 - 75% per annum and, admittedly very rare, increases over the two year period of up to 400%. Some, but not all, of these increases can be accounted for by the increase in crude oil price, or by a falling £ in relation to other currencies. However one is left with misgivings as to whether they can all be justified in this way. Now that the general rate of inflation is slowing down but at the same time science departments have much less real purchasing power perhaps we all have an even greater responsibility to question suppliers about their pricing of certain items.

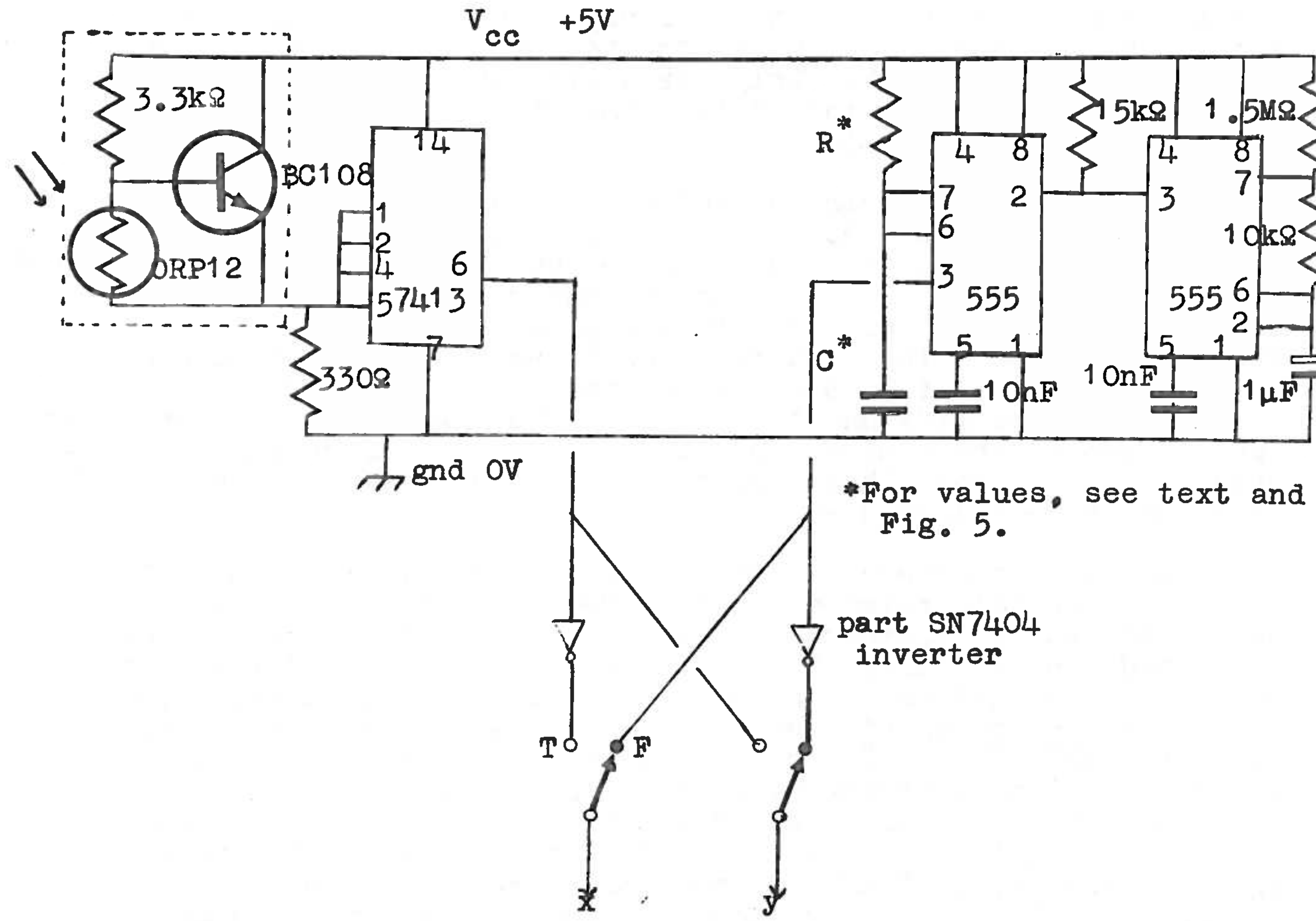
It may be unfair, but we cannot help but hold up the example of one British microscope manufacturer who is still working from price lists issued in May, 1975 and who at the time of writing has no immediate plans to increase prices. If the rate of inflation continues to fall perhaps this is something we all should begin to expect, even demand, from our suppliers.

Physics Notes

This continues the article on the timer and frequency meter, the first part of which appeared in Bulletin 86. The circuit of Fig. 4 gives practical details of the instrument, allowing for three ranges of frequency measurement, theoretically up to 100 kHz, although the 74121 pulse shaper sets an upper limit to this of about 50 kHz. The components within the dotted lines form the photo-resistor, and are contained inside some form of light-proof box, with a hole to allow light to fall on the ORP12 photo-cell. Details of a suitable mounting will be found in Bulletin 12. With the ORP12 illuminated the transistor is cut off, and the input to the SN7413 Schmitt trigger circuit is low. When the light beam is interrupted the BC108 conducts, the 7413 input goes high and the circuit produces a negative pulse with sharp edges, and duration equal to the time for which the light beam has been blanked off. The 7413 is a 4-input NAND gate, and all four inputs must be strapped together.

The two 555 timer circuits are concerned with frequency measurement. The first of these produces a short pulse every 1½ s or so, which triggers the second into generating a gating pulse which is accurately timed to 1 s, 100 ms, or 10 ms, depending on which frequency range is being used. The timing components are R and C, and details of the switching for different frequency ranges and approximate values of these components are shown in Fig. 5. The final values for R for each range can be determined only by trial and error after the circuit has been built, using as accurate a frequency source as the constructor has at hand. If a second switch bank were available on the switch in Fig. 5 it could be used to cut down the waiting time when using the x10 and x100 frequency ranges, by increasing the sampling speed. This can be done by switching a 680 kΩ resistor in parallel with the 1.5 MΩ of the first timer, on these two ranges only. If when adjusting the pulse lengths from the second timer it proves impossible to get a pulse as short as 10 ms, the cause is likely to be in the pulse from the first timer. If it generates a pulse longer than 10 ms it will hold on the second timer for that time, and the timing components on the first timer will require altering.

The input circuits are connected with the decade counter through a d.p.d.t. switch which selects frequency measurement or timing, labelled F and T respectively in Fig. 4. Two inverters are required to feed pulses of the correct polarity to the counter,



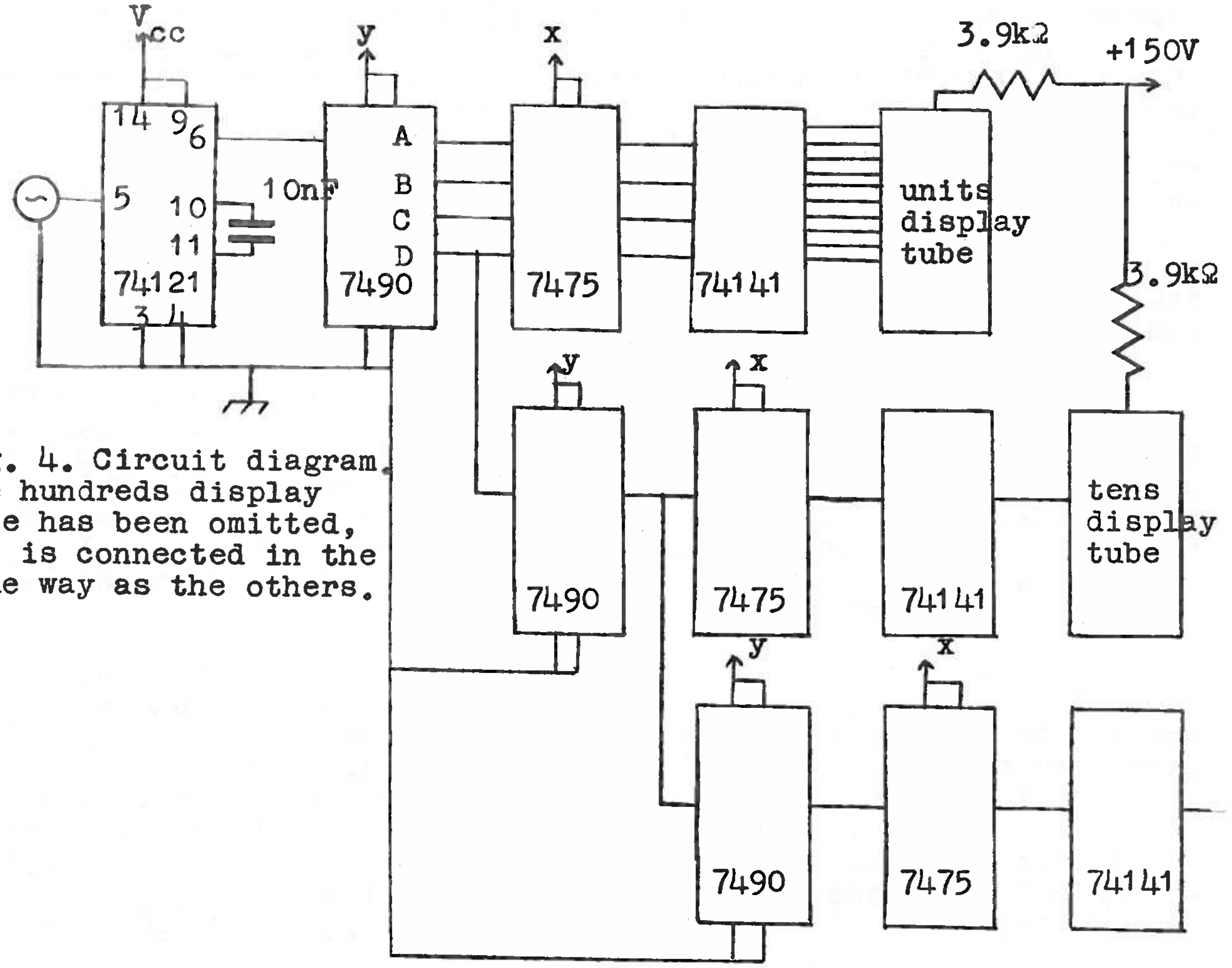


Fig. 4. Circuit diagram. The hundreds display tube has been omitted, but is connected in the same way as the others.

and these are both part of a hex-inverter chip, SN7404. Points x and y on the switch are wired to the corresponding points in the lower part of Fig 4. Only the units decade wiring of the counter has been given in detail, since the wiring of the tens and hundreds count is identical.

Fig. 6 gives the pin connections on the counter. The A, B, C and D outputs from 7490 go to corresponding inputs on the 7475, and these outputs go to A, B, C and D inputs of 74141. The 0 through 9 outputs of the 74141 go to corresponding cathodes on the nixie tube. The D output, pin 11, of 7490 goes to the input pin 14 of the tens counter. The 7490 has pins 1 and 12 connected together, and pins 4 and 13 of 7475 are connected. Any two of the six inverter gates on the 7404 may be used with the change-over switch. Pin connections on the timers, the 7413 and the 74121, have been numbered in Fig. 4; any other pins may be left unconnected, as may those of table 6 marked -.

Various techniques may be used for assembly: it is possible to solder the integrated circuits directly on to 0.1 in matrix veroboard, but we would not recommend it because of the difficulty of unsoldering a faulty chip. At around 1p per pin, d.i.l. sockets will add less than £2 to the cost. It is easiest but expensive, to use the RS Components decade counter board, which is a printed circuit with 7490, 7475 and 75141 already connected for counting. One has only to mount the nixie tube and d.i.l. sockets, wire in four shorting links where shown and provide some form of support so that the digits are displayed vertically. The best support, again expensive, is the RS Components 16-way edge connector, because it allows a faulty decade to be unplugged and another connected in. If the RS board is used, then the connections which link with Fig. 4 are: 'Clock' to x; 'Input' to 74121, pin 6; 'O/P next decade' to input of the next higher decade; 'Zero reset' to y; 'Nine reset' to ground; HT+ to +150 V. The remaining connections may be left blank. For a three digit display, using the RS components described above will add £4.50 to the cost, and this must be balanced against the extra convenience of plug-in boards. If the units count suddenly fails, plug-in boards mean that the hundreds board may be quickly substituted for the faulty one, which allows a two digit count to proceed until the fault is found and repaired.

For a l.e.d. display, a decade counter board is unnecessary. For the same reasons as given above, the seven segment l.e.d. is better fitted to a d.i.l. holder than soldered directly to printed circuit board. Fig. 6 gives the connections of the SN7447 for driving a seven segment display. Connections to each segment cathode should be made through a 100 Ω resistor. If a common cathode display is used, a SN7448, which has the same pin connections as the 7447 is used in place of the 7447.

The combination of 7490 counter, 7475 holding latch and 74141 or 7447 display driver is a common one where decade counting is needed, so that it is not surprising that these three functions have been combined into a single chip, SN74142 (nixie tube) or SN74143 (7-segment common anode). This saves considerable space and wiring time. It is not cheaper, however, as the single chip costs more than the total of the three integrated circuits which it replaces. By the same token, it will cost more to replace a faulty '142 or '143 than if one of the combination of '90, '75

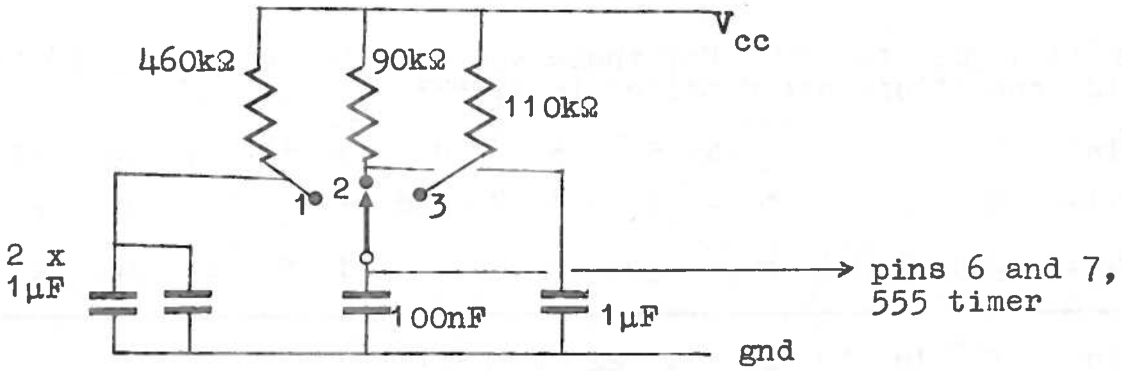


Fig. 5. Frequency range switch. Position 1 = frequency in Hz; position 2, x10; position 3, x100. Resistance values are approximate, and must be adjusted to give 1 s, 100 ms, and 10 ms pulse lengths.

Pin No.	SN7490	SN7475	SN74141	SN7404	SN7447
1	pin 12	-	8 out	1 in	B in
2	y	A in	9 out	1 out	C in
3	y	D in	A in	2 in	V_{cc}
4	-	x	D in	2 out	-
5	V_{cc}	V_{cc}	V_{cc}	3 in	-
6	gnd	B in	B in	3 out	D in
7	gnd	C in	C in	gnd	A in
8	C out	-	2 out	4 out	gnd
9	B out	C out	3 out	4 in	e out
10	gnd	B out	7 out	5 out	d out
11	D out	-	6 out	5 in	c out
12	A out	gnd	gnd	6 out	b out
13	-	x	4 out	6 in	a out
14	Input	-	5 out	V_{cc}	g out
15	-	D out	1 out	-	f out
16	-	A out	0 out	-	V_{cc}

Fig. 6. Pin connections SN7447 and SN74141 are alternatives: 7447 is used to drive a seven segment l.e.d. display, or 74141 a 'nixie' tube display.

or '141 goes faulty. For those who wish to use a '142 or '143, the pin connections are detailed in Fig. 7.

Pin	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
74142	x	7	6	4	5	3	2	gnd	1	0	8	9	y	*	Input	V_{cc}
74143	gnd	Input	x	-	gnd	-	-	-	d	f	e	gnd	g	c	a	b

Pin	17	18	19	20	21	22	23	24
74143	-	-	-	-	y	*	gnd	V_{cc}

Fig. 7. 'Input' is connected to pin 6, SN74121. The pins marked * are the output for connection to the next higher decade. Connections marked 0 - 9 on '142, or a - g on '143 are outputs to the display.

For SN74143, the outputs should be connected to the seven segment display through 100 Ω resistors, but for SN74142, connections are made directly to the cathodes of the nixie tube. The unmarked pins of the '143 are concerned with blanking and latch outputs, and may be left unconnected for serial counting. When we carried out reliability tests on the 1 s pulse generator, using an input frequency of 1 kHz, we found a maximum variation in the count of 1 Hz (four different timers were used, taking 50 readings on each). We also checked the dependence on supply voltage and ambient temperature; between 4.5 V and 5.5 V the mean count differed by 1 Hz, and between 17 and 32°C by 2.5 Hz. These results were obtained using RS Components high stability resistor, and polyester capacitor for the timing components R and C of Fig. 4, and could be bettered if a poly-carbonate capacitor were used, as its temperature coefficient is only a quarter that of polyester.

On the 100 ms and 10 ms pulses, and using inputs of 10 and 50 kHz respectively, there was a variation in the least significant digit of up to ± 3. Since our instrument was built, RS Components have introduced a precision i.c. timer, with accuracy of 0.01%, c.f. the 1% of the 555 timer, and this would doubtless give more accurate results. An alternative, slightly more expensive, is to stay with a 1 s gating pulse throughout, and for the x10 and x100 ranges to divide the input frequency by 10 or 100 respectively. This means switching one or two SN7490 decade counters between the pulse shaper and the counting system. If one uses only the D output from the 7490 to drive the next stage, division by 10 is achieved.

Approximate costs (January Wireless World) of the main components are:

Qty.	Item	Supplier	Price
3	SN7475	Technomatic	£1.35
3	SN7490	"	1.20
3	SN7447	"	2.25
or			
3	SN74141	"	1.95
2	NE555	"	0.90

1	SN74121	Technomatic	£0.30
1	SN7413	"	0.32
1	SN7404	"	0.16
1	ORP12	"	0.50
1	BC108	"	0.90
3	Nixie tubes	RS Components	6.39
or			
3	7-way l.e.d. DL704	Trampus	3.00
3	74142	Semiconductor Supplies	7.80
or			
3	74143	"	8.25
3	Decade p.c.b.	RS Components	1.44
3	16-way edge connector	RS Components	3.06
6	14 pin d.i.l. socket	Trampus	0.78
8	16 pin d.i.l. socket	"	1.12
3	24 pin d.i.l. socket	Semiconductor Supplies	1.26

The minimum cost, that of using 7-segment display and separate i.cs for the decade count, would be £11.84 on the above figures, and this does not include the passive components and power supply. If nixie tubes are used instead of 7-segment display, the cost rises to £19.76 and one must add to this the considerable cost of generating a 150 V d.c. supply.

Chemistry Notes

In the workshop section of this bulletin we give details for constructing a syringe oven from a biscuit tin. This will take a 100 ml Exelo gas syringe or similar, and is in our view a very satisfactory and much cheaper alternative to the commercial model, now costing over £20. The unit is also convenient for drying small items of glassware such as test tubes etc.

The gram formula mass of an unknown volatile substance is found by comparing the masses of equal volumes of the unknown and a known substance when both are vaporised and at the same temperature and pressure. These conditions are achieved by using the syringe oven. Both substances being compared must have boiling points at least 25°C below the temperature of the oven. A 1 ml glass syringe with needle is used to take up about 0.5 ml of the first liquid, and the syringe is then weighed, preferably on a 1 mg sensitivity balance. Into the syringe, which has already reached the steady state temperature of the oven, the liquid is injected through a suba-seal cap covering the nozzle until 80 - 90 ml of vapour is produced. The precise volume is immaterial, but greater accuracy is achieved the greater the volume. The syringe is weighed a second time; the difference is the mass of vapour in the syringe. The procedure is repeated using the second liquid. When injecting the second liquid, vapour can be withdrawn into the small syringe if necessary to reduce the vapour volume to the required value. The calculation is

$$\frac{\text{g.f.m.}_a}{\text{g.f.m.}_b} = \frac{(\text{vapour mass})_a}{(\text{vapour mass})_b}$$

Trade News

May and Baker are closing down their Cumbernauld depot, and are transferring their laboratory chemical stockholding to their Manchester depot, to which orders should now be sent. The address is given on page 12 of this bulletin.

Our recent competition for titles whose acronyms commented on their activity has produced a bizarre result in an unexpected quarter. Ideas for Education have become Lennox Ideas for Education, and have moved to Dublin. Amongst the products made available as a result of this merger are a hand-operated vacuum pump and baseplate. LX150 at £47.25, which will carry out all the experiments expected of this apparatus by the integrated science course, and an aneroid barometer, LX337 at £6.50. The latter is 130 mm in diameter and is mounted in a clear plastic case, so that the parts are visible.

Optical Instrument Services are discontinuing their long-arm version of the Lumiscope S-IRDL stereo-microscope. This is a quality instrument normally selling at £135, and is being offered to clear at £90. Even though the stand has no knuckle joint, this is a bargain. Stocks are limited so that an early enquiry is advisable.

A reasonably priced range of geological specimens is obtainable from Lythe Minerals. They can be bought singly or in sets, and the firm's service includes petrological thin sections, geological survey maps, lapidary accessories and a custom sectioning service. Examples are set of 50 1 x 1½ in mineral specimens, LM1, £12.75: LM2 set of 10 ores of lead, zinc, iron, tin, aluminium, manganese, tungsten, copper, arsenic, antimony, 1 x 1½ in, £2.75: Moh's hardness scale set, excluding diamond, £1.60. The firm have a minimum order charge of £5.

Russian made single-range meters, accuracy 4%, are available from Z and I Aero Services, at £1.90. The ranges obtainable, all d.c., are 1, 2, 5 and 10 A; and 6, 15 and 30 V. These have screw down terminals which will fit only spade terminals or bared wires, but we did not find it difficult to extract the threaded part of the terminal and solder it to the top part of a 4 mm stackable plug, so adapting it to take a 4 mm plug.

The biscuit tin of which the syringe oven is made measures 23 x 22 x 12 cm deep. In use, and in the description which follows, one of the 23 x 12 cm sides becomes the base, so that the box lid forms the front. Two rows of 8 holes, 7 mm diameter at regularly spaced intervals are drilled in the base for ventilation, and the base is also fitted with four rubber feet, secured by 2 BA bolts.

On the left side, 40 mm up from the base is fitted a standard mains lamp socket to take the electric light bulb which is the means of heating the oven. Mains cable for the lamp passes via a rubber grommet through the side behind the lamp socket.

Half way up the oven, two L-shaped pieces of tinned sheet are soldered to the sides to form the supports for a shelf 210 x 100 mm made from perforated zinc. The shelf can be used to support glassware etc. if the oven is being used to dry apparatus, and when in use as a syringe oven it helps to distribute evenly the rising warm air from the lamp.

The axis of the syringe is 60 mm below the top. At this height and midway between front and rear, a hole is drilled to take the syringe nozzle. Opposite this on the other side a much larger hole is needed for the syringe barrel support. The size of this depends on whatever tin cans are to hand. We used one 70 mm in diameter. It is cut down to a height of 60 mm, then a series of cuts 10 mm deep are made with tin shears round the top. The tabs thus formed are bent outwards until they are horizontal (see Fig. 4). In the base of this tin a hole 40 mm diameter is taken out by drilling all round the rim of the hole but slightly under-size with a small drill, punching out the central disc and filing smooth to the final size. This hole will support the syringe barrel.

Using the same technique a 70 mm hole - or other size to suit the can being used - is made in the side of the biscuit tin. The can is inserted and 3 - 4 of the tabs, evenly spaced round the perimeter, are soldered to the side of the biscuit tin.

At the same height as the syringe, but 20 mm from the back of the oven a hole is drilled to take a thermometer. It is supported horizontally by an L-shaped bracket with a hole in it, made from tinned sheet and soldered to the back of the oven. The thermometer is therefore on the same level as the syringe but behind it, so that a window in the top of the oven must be made to allow both syringe volume and temperature to be read. A ring round the top end of the thermometer, cut from rubber tubing is used as a stop to prevent the thermometer dropping inside the oven. It is possible for the thermometer to drop out of the oven when it is being moved, and if this is likely, some means of securing it should be sought. A similar rubber ring inside the oven beyond the support is one possibility, but the oven must be opened up to do this, and the thermometer then cannot be taken out during an experiment. Fig. 5 shows another possibility: to bend over the top of the inside support so that it presses against the stem of the thermometer when it is inserted and the natural spring of the metal gives a measure of retention.

Using tin shears an oblong hole 50 x 150 mm is cut in the top. Fig. 2 shows the location of this hole. On three of the sides, supports made from tinned sheet are soldered to the top, these acting to hold in place a piece of 180 x 60 x 3 mm perspex, which is slipped in from the fourth side. Fig. 3 shows the method of securing the perspex window. The tinned sheet from which all the supports were made is cut from the same type of material as the biscuit tin itself, using any scrap tin cans.

The oven should be allowed 30 minutes to achieve a steady temperature. This will be about 90°C for a 100 W bulb, or 120°C with a 150 W bulb. This of course is only necessary if using it as a syringe oven. For drying glassware, the syringe should be removed and the glassware can be inserted when the oven is turned on.

Dimensions in mm.

Not to scale.

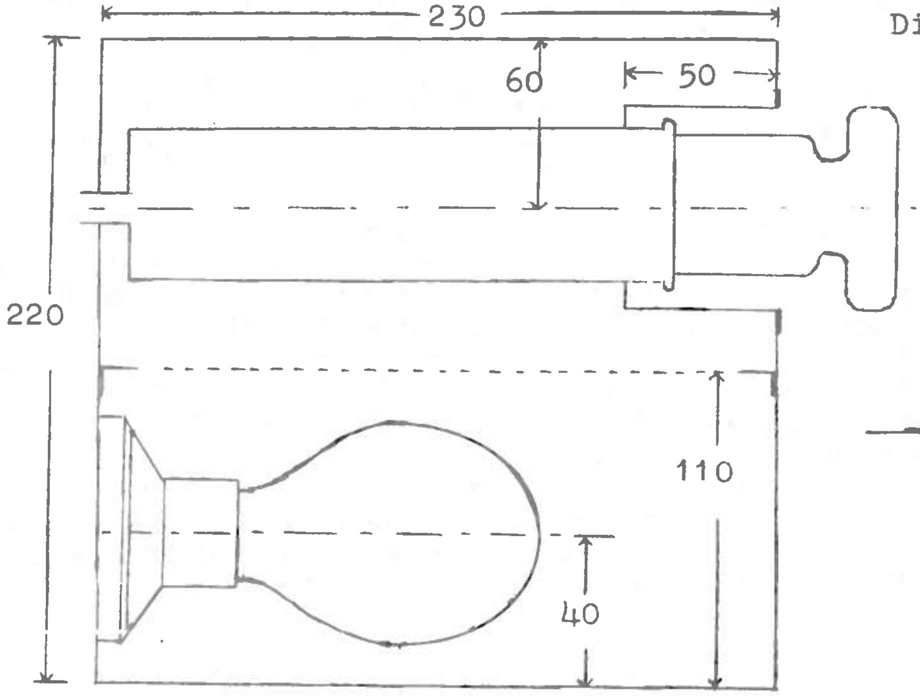


Fig. 1. Elevation.

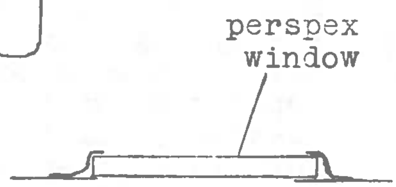


Fig. 3.

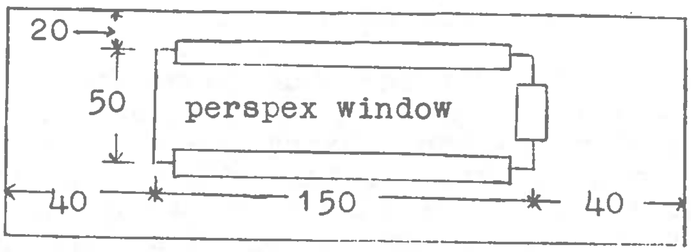


Fig. 2. Oven top.

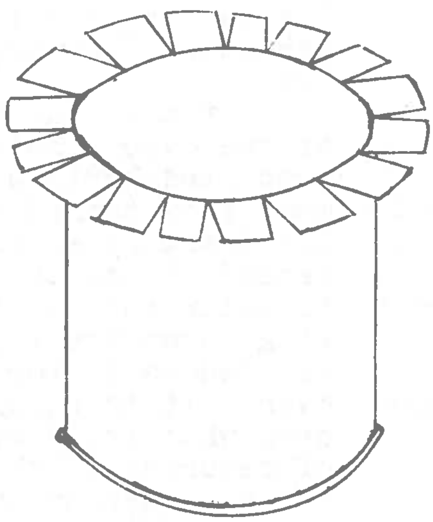


Fig. 4.

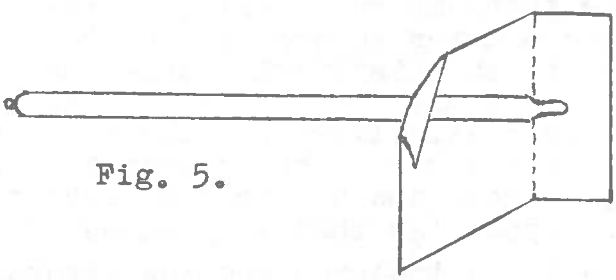


Fig. 5.

Bulletin Supplement

The instruments listed on this page have been tested according to our published procedures for 'O' grade microscopes. Individual, fuller reports on each model can be borrowed for up to one month by writing to the Director. The classifications used are: A - most suitable for school use; B - satisfactory: C - unsatisfactory.

Model	CA	STN	NES 200 x (T)
Manufacturer	Carton Optical	Opax	Opax
Supplier	Parisian Opera	Opax	Opax
Price	£33.00	£23.00(a) £21.50(b)	£35.70(a) £33.00(b)
Eyepiece	10x, Huygenian	10x, Huygenian	10x, widefield
Objectives	4x, 10x, 20x	5x, 10x, 20x non-standard	4x, 10x, 20x
Optical head	Upright	Upright	Upright
Condenser	Fixed lens, recessed in stage	None	Fixed lens in stage
Aperture control	Rotating disc	Rotating disc	Rotating disc
Smoke cell Accommodation	4x and 10x	5x and 10x	4x and 10x
Illumination	Mirror only	Mirror or substage mains or low voltage	Mirror or substage mains or low voltage(c)
Assessment	A	C	A

Notes:

(a) Duty paid; (b) Duty free. Opax microscopes are normally supplied to schools at the duty free price.

(c) The Opax illuminators were tested and found unsatisfactory for use in Scottish courses. Therefore the A assessment refers only to the mirror model of the NES 200 x (T).

The Opax STN was given a C assessment because of an unsatisfactory optical performance.

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

(Exelo) W.G. Flaig and Sons Ltd., Exelo Works, Margate Road,
Broadstairs, Kent.

Lennox Ideas for Education, Steevens Lane, Dublin, 8.

Lythe Minerals, 36 - 38 Oxford Street, Leicester, LE1 5XW.

May and Baker Ltd., Liverpool Road, Barton Moss, Eccles,
Manchester, M30 7RT.

Opax Ltd., 142 Silverdale Road, Tunbridge Wells, Kent, TN4 9HU.

Optical Instrument Services Ltd., 166 Anerley Road,
London, S.E.20.

Parisian Opera and Field Glass Co. Ltd., 24 - 25 Princes Street,
Hanover Square, London, W1R 7RG.

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

Semiconductor Supplies Ltd., Orchard Works, Church Lane,
Wallington, Surrey, SM6 7NF.

Technomatic Ltd., 54 Sandhurst Road, London, N.W.9.

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

Z and I Aero Services Ltd., 44a Westbourne Grove, London, W2 5SF.