SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No 86. January, 1976.

Contents

Introduction

With this issue we say farewell to Hugh Medine, who retires at the end of January. Hugh joined the staff of SSSERC on Hogmanay, 1968, and immediately displayed his immense practicality. Coming from the West of Scotland at an age when most men would have sought a comfortable bungalow in suburbia, he undertook the conversion of two derelict farm cottages into a modern, well-appointed home, he and his family doing all the work themselves, even though this involved them in living on the site in a caravan for some 18 months.

This practicality, coupled with a capacity for 'lateral' thinking which at times has made Edward de Bono look old-fashioned, has led to simple though elegant solutions to knotty problems. Hugh has never recognised the existence of formal subject barriers and as a truly undifferentiated scientist, he is an unpoisoned catalyst. Many of his ideas and suggestions have been published not under the heading 'Chemistry Notes' but in other sections of the bulletin. It has been typical of the man that he is always perfectly happy to let others take any credit. Those of us at SSSERC whose cerebral wheels grind exceeding slow will miss the mental stimulus he provides, as much as we will miss his cheerful physical presence.

With his industrial experience in the explosives factory at Ardeer, he was a natural for all matters connected with safety. The bulk of the work on the loose leaf manual on hazardous chemicals, which has been so long on the way and has been temporarily inhibited by the Health and Safety at Work Act was his doing. His willingness to undertake any part of the Centre's work, including a spell as Acting Director while the Director was on secondment abroad, and his concern that the service provided by SSSERC should be the best possible, made him a pleasure to work alongside. We believe we are voicing the feelings of the many teachers and others he has helped during his time here when we wish him a happy and long retirement.

Opinion

Our competition for acronyms on matters of educational interest found a modest response. Some of the replies had little to do with education, some were enjoyable but unprintable. Having referred to our own august title in the offer of the competition, I had hoped that a number of people might be encouraged to poke fun at us, but alas, only one did so, with Scottish Silly Subjects Educational Rubbish Centre. It can only be because we are beyond a joke. If I were to award a prize, it would be for Fuller Learning through Open Plan, because of its topicality. I think that open plan is an idea ripe for take-over by the whizz-kids, a band-waggon on which someone will ride to fame if not fortune. I have seen open plan in action, ard think it has much to commend it. I can also see how it can reduce to four or six classrooms in which a subject is taught, the usual dividing walls being absent. If the architects get the bit between their teeth, we could have a decade of open plan schools to the exclusion of all else, as we have already had of solaria on stilts.

We have sent with our thanks a parcel of not-very-Christmassy goodies to all who entered the competition.

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I was disturbed and disappointed to hear of a biology teacher somewhere in the East of Scotland who never reads our bulletins "because there is never anything but physics in it". This is just not true, and a slur on one of the hardest working members of SSSERC. John Richardson has done a great deal of work in connection with the trials of CSYS biology, some of which has appeared in the bulletin. The remark caused us to search back through recent issues to tally the items which could be classified into the separate sciences. We found that since Bulletin 70, the comparative space given to each was physics 38%; chemistry 32%: biology 30%. The preponderance of physics in this tally would be reduced if the lists of surplus equipment, which occupy a good deal of space and occasionally have something to offer the biologist, were omitted. Chemists and physicists who read this, please nudge your biology colleague: he could be the one who made the remark.

Chemistry Notes

Hard on the heels of Bulletin 84, which contained a design for a vibrating spatula, and from two independent sources viz. Liberton High School, Edinburgh, and Albert Secondary School, Glasgow, we received the same suggestion for an improvement which needs less time and trouble, and still allows the spatula to be carried in a breast pocket. This is, to file a series of nicks in one side of the spatula at a convenient point to produce a serrated edge about 10 mm long. To use it as a vibrating spatula, the nail of the fore-finger is drawn to and fro across the edge.

This seems such a simple idea that we wonder why the manufacturer has not already taken it up. It would cost very little to make this change, and it in no way detracts from the tool's use as an ordinary spatula. Ladies who used the spatula often might find the action damaging to a fingernail, and for them our original though clumsy suggestion may still have merit.

Biology Notes

Some two years ago, <u>Ideas for Education</u> brought on the market an integrating photometer. It consists of a copper voltameter, powered by a photo-electric cell. The principle is elegantly simple; light falling on the cell causes deposition of copper on the cathode, which can be weighed periodically. The increase in mass should then be proportional to the light energy absorbed by the cell.

This proposition would be difficult to verify directly, but we thought for a start we should find if there were a correlation between mass increment and the total hours of sunshine. For a year we have tried this, and been unsuccessful due to topographical difficulties, and we now appeal to any teacher who would be willing to do or supervise this experiment in his school. He/she should have ready access to a Met. Office recording station, and a 1 mg balance. We would expect the photometer to be exposed alongside the sunshine recorder, and the cathode to be weighed weekly.

We would supply two photometers, which would be changed weekly when the sun record card was changed, and we would expect weekly results for the total hours of sunshine as calculated from the record card, and mass increments on the photometer. The duration of the experiment is doubtful, but we think not less than 12 weeks, and of course the weeks do not have to be consecutive, so that one need not sacrifice their Easter vacation in the interests of this particular bit of science.

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In Bulletins 35, 66 and 67 there were descriptions of various techniques of microprojection using slide projectors as light sources. We have received from Oban High School the suggestion for an attachment which allows an overhead projector to be used for this purpose. The basic arrangement is shown below. It is not possible to give actual dimensions since these will depend upon the particular o.h.p. and microscope used. However the microscope must be of the open base, mirror illuminated type.

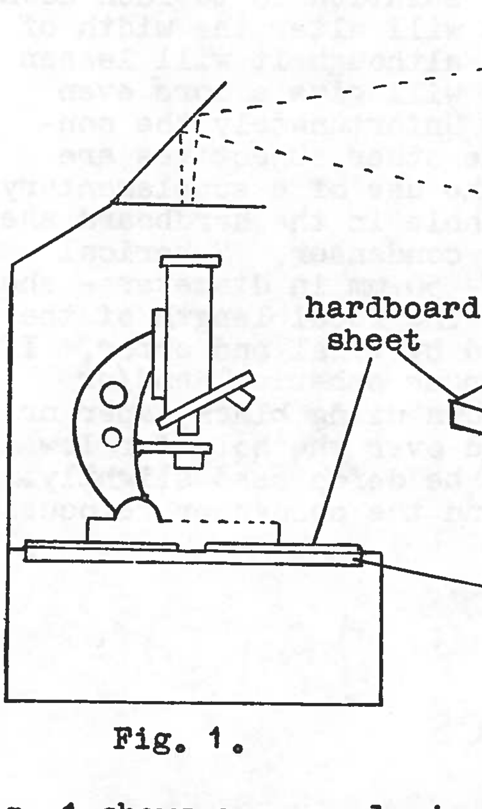

Fig. 1.

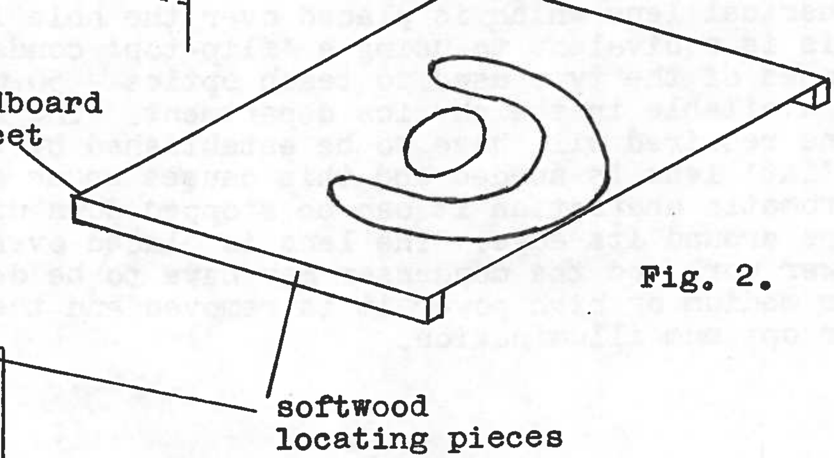

Fig. 2.

Fig. 1 shows a general view of the apparatus with a hardboard sheet covering all but a central, circular section of the Fresnel lens of the o.h.p. The microscope is focussed, the mirror removed and the microscope placed on the board on the o.h.p. stage so that the condenser is located over the hole in the board. Softwood locating strips on the edges of the board assist in ensuring that the hole is in the centre of the Fresnel lens. An outline of the microscope foot drawn or painted on the board similarly helps in locating the condenser over the hole (see Fig. 2). The projection head of the o.h.p. is brought down until it is almost touching the eyepiece lens. The projector is then switched on and any necessary adjustments made to focussing and lighting controls. The final result, in terms of an acceptable screen image, will depend on the projector and microscope, and on the efficiency of blackout used. Some arrangements give good viewing on a normal o.h.p. screen in poor blackout, and in others with good blackout the screen may have to be quite close to the projection head with consequent loss of image size. In these cases, or for daylight viewing, the projection head can be swung away or removed altogether, and a viewing head used on the microscope. Then the o.h.p. is being used essentially as a light source. Both our own flower-pot head (Bulletin 66) and the Philip Harris viewing head give good results in daylight.

A major difficulty with some projection techniques is the proper illumination of the field with the low power objective. This is related to the size of the cone of light entering the condenser lens and also to some extent to light losses between slide and objective. This problem can be solved by the use of a supplementary lens fitted to the top of the condenser which can be moved in or out of the light path as required. Unfortunately this type of condenser - known as a 'flip-top' - is no longer generally available. However there are at least two other solutions to the problem.

The simpler, and less satisfactory, solution is to rack down the condenser away from the slide. This will alter the width of the cone of light entering the objective and although it will lessen the optical performance in other ways it will give a more even and complete illumination of the field. Unfortunately the condenser has then to be refocussed when the other objectives are brought into use. The other method is the use of a supplementary spherical lens which is placed over the hole in the hardboard sheet. This is equivalent to using a 'flip-top' condenser. Spherical lenses of the type used to teach optics - 50 mm in diameter - should be available in the physics department. The focal length of the lens required will have to be established by trial and error. If a 'fat' lens is needed and this causes undue spherical and/or chromatic aberration it can be stopped down using black paper or tape around its edge. The lens is placed over the hole for low power work and the condenser may have to be defocussed slightly. For medium or high power it is removed and the condenser refocussed for optimum illumination.

Physics Notes

The following 'puzzle box' idea came to us from the Education Department, University of Maryland, U.S.A. Although it is applicable to pupils who have completed the electricity part of their 'O' grade syllabus, it could be used with non-science pupils as an exercise in deductive logic. The pupil is given a closed box which has two sets of four terminals, distinctively labelled, e.g. A, B, C, D and P, Q, R, S. He is asked to derive as much information as possible regarding the nature of the connections between the two sets, and is supplied with a tester which patently consists of a 3.5 V lamp bulb and a 3 V 'cycle' battery in series, ending in two wander plug leads.

What goes inside the box is the teacher's own choice, although we recommend the original suggestions as giving a quite searching test of a person's ability to consider all the possibilities. These were (i) a piece of wire, (ii) a diode, (iii) a lamp identical with that in the tester and (iv) a battery identical with the tester, the four components being connected across pairs of terminals in the two sets, not necessarily in order of location on the box. It is surprising how many adults neglect to examine the effects of reversing the polarity of the tester between each pair being tested.

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When measuring velocities on the linear air track, teachers must sometimes wish that they had a second scaler/timer to register transit times of moving vehicles. It is not a difficult matter to construct a millisecond timer which will do this, and using the SN74 series of integrated circuits it can be done for a modest outlay, something like £12 for a 3-digit display. For an extra £3, the unit can also be made to measure frequency. The principle of time measurement is the same as that employed in commercial timers; a circuit is made to count a train of pulses which have a repetition frequency of 1 kHz, i.e. the pulses are 1 ms apart. The count is then started and stopped by interrupting a light beam directed at a photo-diode. At the end of the count, the display will show the duration of the interruption in ms.

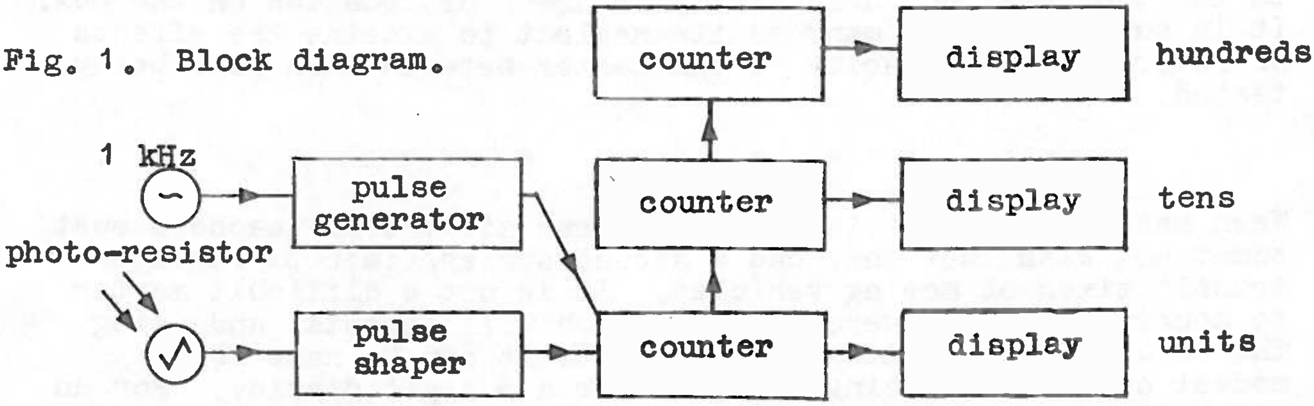
Commercial timers use an internally generated 1 kHz signal to supply the train of pulses, and this cannot be varied. For measuring longer times, in excess of 1 s, these timers usually revert to an electro-mechanical register. What we suggest is that the teacher feed in his own 1 kHz signal from a signal generator. The 3-digit display will then register milliseconds, with a capacity of 999 ms. For times between 1 and 10 s, the generator frequency can be reduced to 100 Hz, and the display will then have a capacity of 9.99 s. For the price of an extra mechanical switch, the decimal point can be inserted in the display. Obviously the accuracy of this method depends on how accurately the generator can be set to give 100 Hz or 1 kHz, but for most timing measurements, what is needed are comparative rather than absolute measurements of time, and for this it will be enough if one can rely on the generator frequency not drifting appreciably during the experiment. Where two timers are being used, their measurements can be made to correspond by feeding the same gating pulse to both, and adjusting the signal frequency input to one to get the same read-out time.

For very little extra outlay, the unit can be made a digital frequency meter. The unknown frequency is fed in at the same point as the signal generator above, an internal circuit generates a gating pulse which is accurately 1 s duration, and the display will show the frequency in Hz. This works for frequencies up to 999 Hz. Between 1 and 10 kHz, one switches to a gating pulse 100 ms long and the display is then multiplied by 10 to give frequency in Hz.

For a x 100 range, the gating pulse is made 10 ms long.

There is scope here for a SYS project. In common with what we believe to be the project ethic, we would not normally recommend the construction of any item of apparatus for a project, because we believe that there is little scientific thinking done along the way, and it becomes largely a cookery book exercise, although the student may very well understand what he is doing and why he is doing it. Here, however, when it is evident that everything depends on producing an accurate 1 s or 100 ms pulse the student must decide on a) how accurately he can measure pulse duration, and b) how stable is his circuit with respect to such parameters as supply voltage and ambient temperature.

Fig. 1. Block diagram.



The schematic diagram of the timer is shown above. TTL circuits are compatible, i.e. they can be interconnected without problems of matching or loading. In normal circumstances the output of any one circuit can be applied to up to 10 other circuit inputs by direct connection. But the circuit operations depend on very fast edges to the pulses so that when sine wave or other slowly changing voltages have to be applied to them, there is a need for circuits which will accept external stimuli of varying sizes and shapes and process them to make them palatable to TTL. These are called interface circuits, and the pulse generator and pulse shaper are examples.

The pulse generator is a monostable multi-vibrator SN74121 which generates one short, fast-edged pulse for every cycle of sine wave applied to it. As the frequency of the input is increased, these pulses come closer together in time, until the duty cycle is about 80%, i.e. each pulse is four times as long as the 'dead' time between pulses. If the frequency is increased beyond this point, the monostable misses a beat, and responds only to every other cycle of input, thus recording exactly half the input frequency. The choice of pulse duration in the monostable therefore determines the upper frequency limit of the frequency meter. Other forms of input such as square, differentiated square or triangular waves are equally acceptable to the monostable. The peak voltage applied should lie between the limits of 0.8 V and 2.0 V; this applies generally to most TTL circuit inputs.

The pulses from the monostable are counted by the next circuit, a SN7490 decade counter. This has four outputs A, B, C and D and counts the input pulses in binary, according to the table below.

Count	D	C	B	A
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	L	H	L	H
6	L	H	H	L
7	L	H	H	H
8	H	L	L	L
9	H	L	L	H
10	L	L	L	L

Fig. 2. SN7490 Count Sequence.

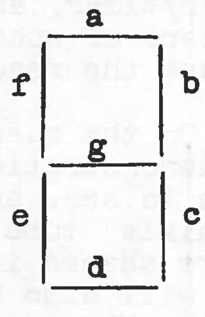


Fig. 3. Seven segment display.

H and L correspond to 'high' and 'low' states of the output; the high state is not less than 2.4 V positive and the low is not more than 0.4 V positive with respect to ground. After the count the sequence repeats, and to count more than 9, the D output is applied directly as input to another SN7490. The D output goes high on count 8, but as the circuits respond to the negative-going edge of a pulse, it is only on count 10, when the D output goes low, that the second SN7490 responds and counts 1. For a three digit display, the process is repeated, using the D output of the second counter to drive a third.

Besides counting input pulses over a period of time, it must be possible to reset the display to zero, and in the frequency mode, to tell the unit when we want the frequency to be measured. This could be done manually with two push buttons, and would be the most economical method. But it would be tedious to require to press two buttons, one to reset, and one to read, every time one wished to read the frequency. We can also see possibilities in regular measurement of a varying frequency e.g. to measure the Doppler shift from a moving object and so determine its acceleration. Hence automatic resetting and reading may be an advantage.

Automatic reset can only be done by using the end of the gating pulse itself, and this provision is built into the 7490. The counter is inhibited through a reset input until this input receives a negative gating pulse. It then counts, and the count stops and returns to zero when the reset input again goes high at the end of the gate pulse.

If the count were applied directly to the display, no one would be able to read it before it reverted to zero. Thus information on the four outputs A, B, C, D, is fed to a bistable latch, SN7475, which also receives the gating pulse. During the pulse the latch output 'follows' the information supplied by the counter but at the end of the gate pulse it holds that information, thus producing a static display and allowing the figures to be read. On the next gating pulse the latch again follows the counter, which has already been reset, so that the display reverts to zero at the start of the next count and one never actually sees a row of 0s on the display. This principle is used on at least one commercial scaler/timer, and the explanation given above may help allay fears by users of such equipment that it cannot be working properly because the read-out never shows zero.

On the question of a digital display, two possibilities exist. For demonstration purposes the digits must be large enough for the class to see, and this requires the use of a gas-filled numericator or "nixie" tube. This has a common anode, and ten cathodes each a wire shaped in the form of the digits 0 through 9. Normally they will also have cathodes for right-hand and left-hand decimal point. When a voltage is applied to one cathode, the gas around it emits a glow, so that that digit becomes visible.

The disadvantage of the nixie tube is that it requires a working voltage of 140 V, and a d.c. power supply must be built to provide this. Also it is customary to make the supply voltage somewhat greater than 140 V, and to include a resistor in the anode lead, its value calculated on the assumption of 2.4 mA anode current. This provides a higher striking voltage for the tube, making it more certain that the gas will ionise, and the resistor also acts as a safety device limiting the current in the event of internal short-circuiting in the tube.

The information regarding the count is carried by the four outputs A, B, C, D, of the 7475 latch, according to the logic table 2. This is converted to a decimal count by a SN74141 b.c.d. to decimal decoder/driver. This chip has four inputs, corresponding to the A, B, C, D outputs of the 7475, and ten outputs corresponding to the 0 through 9 cathodes of the nixie tube, to which they are directly connected. The 74141 outputs are made to withstand any voltages associated with the h.t. nixie tube supply.

The other form of display is the l.e.d. seven-segment, familiar to anyone who has seen a pocket calculator. The figure 8 can be composed of seven straight lines of equal length, four vertical and three horizontal (see Fig. 3). All other digits 0 through 9 may be made up from the 8 simply by omitting some of these lines or segments; e.g. 0 by omitting the middle horizontal bar, 3 by omitting the two left hand vertical bars. Hence a row of 8s on a pocket calculator provides a quick test for the state of the battery, as they consume the most current.

Seven segment displays usually have common anode and separate cathode connection, although the reverse type, i.e. common cathode, does exist. They normally also have either left or right hand decimal point. They operate at 3.4 V and 20 mA per segment, so that a suitable series resistor is included in each cathode lead when the display is driven off the 5 V supply. The display connections fit the same 4-pin dual-in-line format as the SN74 series. The decoder/driver to operate a seven segment display is the SN7447 (common anode display). They have four inputs, corresponding to the A, B, C, D outputs of the 7475, and seven outputs which are labelled a through g and correspond to the segments marked in Fig. 3. The 7447 also has a blanking input, which is used to blank off the display while calculations are being performed, so that only the final result shows. This also helps to conserve the battery of the calculator. In our case these blanking inputs can be permanently connected to the + or - sides of the 5 V supply.

This article will be completed in our next bulletin.

Trade News

In the past the plastics division of I.C.I. have supplied off-cuts of perspex acrylic sheet to schools in 20 kg packs. This service has been withdrawn owing to the cost of transport and packaging, but is replaced by a 500 kg pallet, consisting of 20 x 25 kg packs, which will be supplied at a cost of £155. This is probably too large for an individual school, but certainly comes within the scope of a regional or local science centre. The 25 kg packs are available as clear or mixed colours, 3 - 6 mm thickness. Clear and mixed colour packs may be ordered as required to make up a 500 kg pallet, and both categories may include up to 50% of patterned sheet, at the supplier's discretion. Orders should be placed with Mrs. P. F. Walsh at the I.C.I. address given on page 12, and literature and a sample pack may be obtained from the Academic Liaison Officer, Publicity Dept., I.C.I. Ltd., Plastic Division, P.O. Box 6, Bessemer Road, Welwyn Garden City, Herts AL7 1HD.

The head office of Philip Harris has moved from their Birmingham address to one which is given on page 12 of this bulletin.

We have been asked by Griffin and George to point out that schools possessing their spirometer, L03-496 should obtain medical grade oxygen from British Oxygen. Orders sent to British Oxygen in the normal way, but marked 'for respiratory use' will secure the correct grade of oxygen. This advice applies equally to other spirometers, and although there is no requirement in Scottish syllabuses for a spirometer we know that several biology departments possess one.

In Bulletin 79 we mentioned the repair service which Watson provide for microscopes, and gave the names and addresses of two local representatives. One of these, Mr. Scringeour, has moved to the address given on page 12 of this bulletin.

The following Cleapse reports have been updated, copies of which may be borrowed by writing to the Director at the Centre:

L35 - pH meters
L92 - ratemeters, scalers and scaler/timers.

European Instruments, suppliers of u.v. lamps have moved to the address given on page 12 of this bulletin.

In The Workshop

Much of the work in current electricity in Section 7 of the Integrated Science course can be carried out with this circuit board, which was designed and has been in use for a number of years in Tynecastle High School, Edinburgh. All components are mounted on the board, some being recessed to allow the boards to stack easily, except the cells, which are taped to the underside of the board.

The cells are the rechargeable nickel cadmium type of U2 size, available from Electroplan as NCC400, Griffin and George L82-670/005, or Philip Harris P6766. The principal teacher of physics in the school writes "we have used these cells for 3 years now and with inflation as it is we must soon be showing a profit". The cells, which have solder tag connections are connected to 4 mm sockets through a 9 cm length of 26 s.w.g. constantan wire which has a resistance of 0.3 Ω to act as a short circuit protection. A firmer mounting for the cells would be a Terry clip of 3a or 4 size. The cells are charged through the board terminals, so that they never need be disturbed.

The circuit board is made the lid of a box, made from 8 mm plywood, and measuring 30 x 25 x 4.5 cm deep, outside dimensions. Four wooden blocks 25 x 25 x 12 mm deep, are glued to each corner of the base to form 'feet'; each has a 10 mm dia. hole to key into four pegs on the top of the board for stacking purposes. The pegs are 20 mm lengths of 6 mm dia. dowel rod, glued into holes in the board and projecting 8 - 10 mm above the surface to engage in holes in the feet of the next unit when they are stacked. Inserting these dowel rods in the board should be left until all the components have been mounted, as they must stand up high enough to clear all knobs, lamps etc. on the board.

Fig. 1 shows the layout of components on the board, and the marking of the board top. The lamps are 2.5 V, 0.2 A type; the m.e.s. holders are mounted underneath the board by two wood screws into the plywood (Fig. 2). As the lamp itself is in the direct line between its terminals the lamp symbol is not given on the board. The fixed resistors R_1 and R_2 are 2.5 Ω and 4.7 Ω, made from suitable lengths of wire and wound onto standard resistors as described in Bulletin 75. The variable resistor is a 25 Ω wire-wound preset type, mounted under the board. The size of the switch hole is not given as this depends on the kind of switch being used. In some types, if the threaded shank is not long enough to project through the board, the switch may have to be fixed to a small metal panel bolted to the underside of the board, with the switch toggle projecting through. The hole must then be large enough to allow a good snap action of the switch.

At the bottom of the board are two lengths of constantan wire 26 and 32 s.w.g. respectively, to illustrate the effects of length and thickness. At each end they pass through small holes in the board; their 'free' ends pass under a small plywood block screwed to the underside of the board to keep them taut. The fixture is shown in Fig. 3. All holes in which connections terminate are drilled for 4 mm sockets, and the six small holes round the edges are countersunk for wood screws to fix the board to its base.

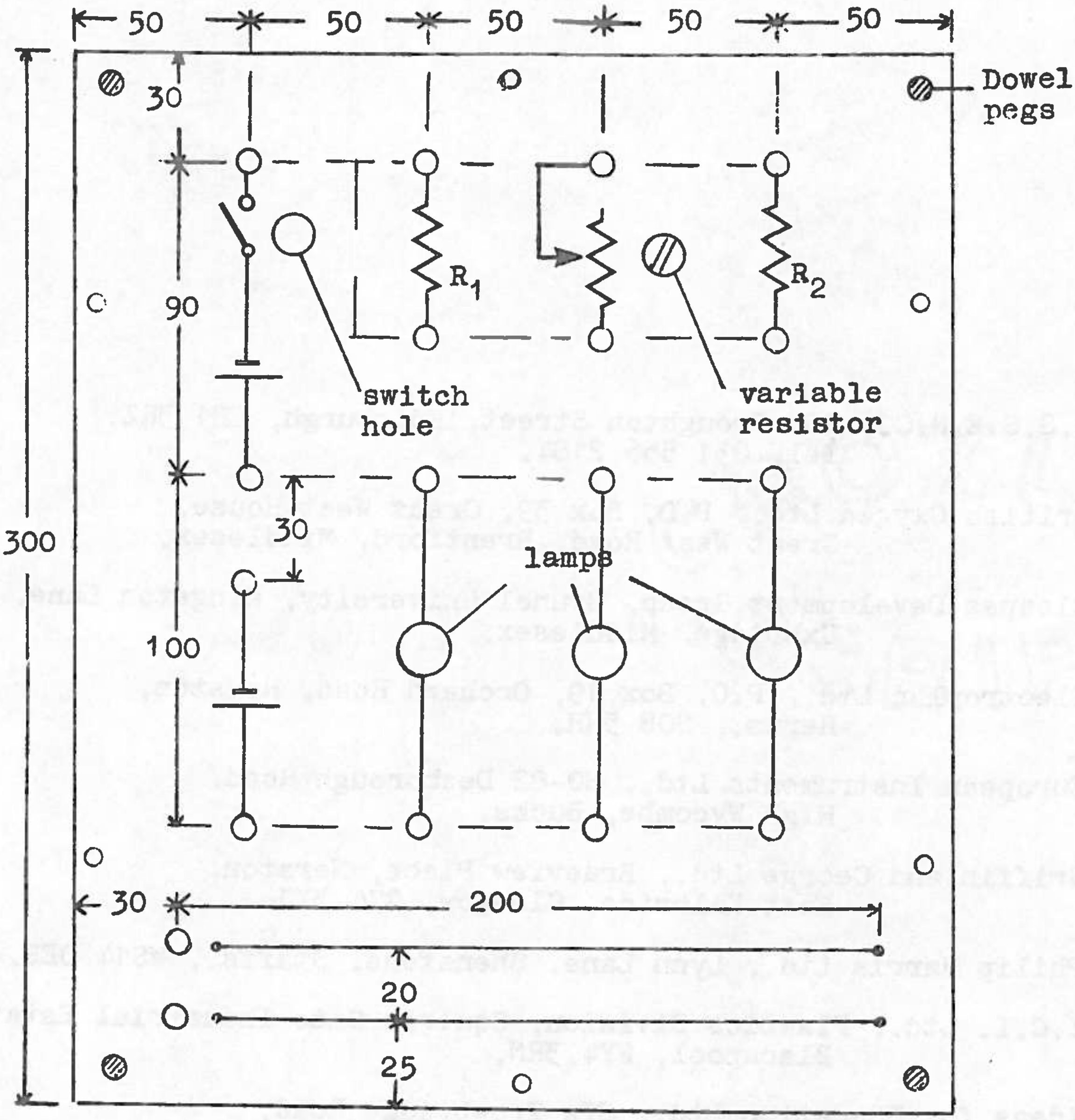


Fig. 1. Component layout.

Dimensions in mm.

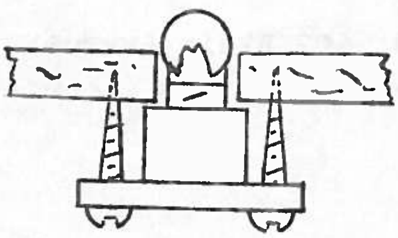


Fig. 2.

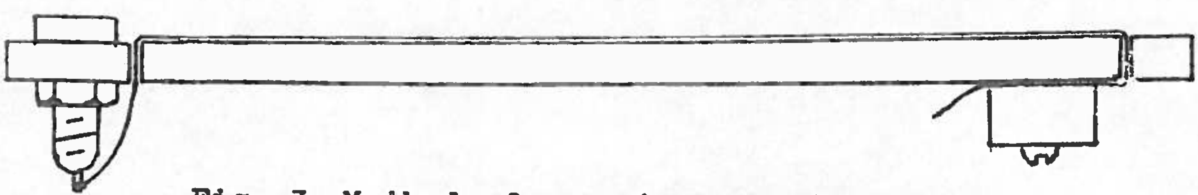


Fig. 3. Method of securing resistance wires.

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

British Oxygen Ltd., P.O. Box 39, Great West House,
Great West Road, Brentford, Middlesex.

Cleapse Development Group, Brunel University, Kingston Lane,
Uxbridge, Middlesex.

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

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., Lynn Lane, Shenstone, Staffs., WS14 OEE.

I.C.I. Ltd., Plastics Division, Squires Gate Industrial Estate,
Blackpool, FY4 3RN.

Ideas for Education Ltd., 87a Trowbridge Road,
Bradford on Avon, Wiltshire, BA15 1EE.

Watson, Optical Division of M.E.L. Equipment Ltd., Barnet,
Herts.

Mr. Scringeour, (Watson M.E.L.), 492 Blair Avenue,
Glenrothes, Fife.