SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 18. November, 1967.

Contents

Introduction

The use of projects in the post-Higher syllabuses means that there may in some cases be a need for apparatus outwith that normally found in the science departments, to be used as tools for completing a given project. At the same time a school may be unwilling to spend money on such equipment since it may be several years before the same need arises. No teacher should be obliged to carry out the same project every year just because he has the necessary apparatus. (In the analogous university situation, how many Ph.D. students may sometimes feel that the only reason for working in their particular field is because the Prof. has bought a gadget and must now justify its use?).

In the two years of our existence, SSSERC has acquired from University or Government laboratories, and from industry, several sophisticated pieces of apparatus which we rarely use and which we are prepared to lend out to schools for use in projects. It goes without saying that these are obsolete items in their particular field, but they are in working order. We also recognise that the few items we can provide must be a drop in the ocean, although throughout the years we can hope to build up a larger stock of such items. They may also help in broadening a pupil's understanding of just how much he can achieve in a given direction when the proper tools are at hand. Details of the pieces of apparatus available are given in the "Notes" sections of this Bulletin. Understandably, all but one of the items are for use in physics, and further, most of these are electronic in nature. There is, however, a very good colorimeter which a chemistry teacher might want to use.

Equipment can only be lent out on a "first come, first served" basis, so teachers are asked to write or telephone their requests as soon as possible. Furthermore, the teacher will have to collect the apparatus from the Centre personally, or make adequate arrangements for its collection not involving public transport. It will be understood that the apparatus is on loan for the current session, and must be returned to the Centre in June, 1968 by the same or similar transport. Where possible operating instructions will be supplied with the equipment, although it is hoped that any teacher obtaining an item will collect it personally so that he may be instructed in its use. No modification or adaptation of the equipment will be permitted without prior consultation with the Director.

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The Centre will be closed on both Mondays, 25th December and 1st January.

Opinion

I am not sure whether it is one of Parkinson's laws that in many aspects of society the public gets the type of service it deserves. It might certainly be argued that it applies to education today, but to narrow the field down a little, does it not also apply to biologists and biology teachers? For long enough the latter have complained in a refined, gentlemanly way that they are the Cinderella of the sciences, that their headmasters pack their classes with the duffers in mathematics (thereby demonstrating how illogical a scientist can be when his thinking becomes emotive). But are they vociferous enough/

enough in insisting on elementary modernisation of their teaching conditions? Are there not too many reactionaries in the ranks, content to jog along in much the same way as they were taught as pupils?

Two recent events have prompted this outburst and are perhaps symptomatic of the lethargy which seems to permeate the tissues of the profession. We have just returned from setting up an exhibition in an institution of further education. The exhibition formed part of a Saturday morning conference of local biology teachers, and was set up on the previous evening in the laboratories of the biology department. It disconcerted us somewhat, but caused no irreparable damage when we learned that the clinostat and the auxanometer had not functioned throughout the night, as the power supply had been turned off. What astonishes me is that biologists should tolerate this petty restriction still far too common in schools.

The other event is the arrival in the office recently of a catalogue of equipment "developed specially for the Nuffield 'A' level Biology project", and presumably with the approval of the Nuffield Biology panel. Except for a stimulator, the basic principles of each piece of equipment were known a century ago; some might have been invented by James Watt. The acme of conservatism is surely reached in a smoking device, costing not far short of £9 which will provide even and rapid smoking of drum papers. It is, of course, easy enough to criticise from outside. There may be very good reasons why smoked drums are still the best means of recording physiological phenomena (although they never feature in the Laboratory Equipment Digest). But did the Biology Panel take a hard look at such things as long-persistence oscilloscopes and other recording devices? If it was possible for the organisers of the Nuffield Physics project to persuade, cajole or even browbeat the manufacturers into producing an oscilloscope for pupil use (and it should be remembered that previously the oscilloscope was such a sophisticated piece of apparatus that few teachers felt confident in using it) could Nuffield Biology not have attempted a similar exercise?

To come nearer home, I believe without being unduly modest that the auxanometer design which we published in Bulletin 12 is an advance on anything the manufacturer can offer. At least it replaces the impermanent smoke trace with a pencil line or a carbon copy. But no manufacturer has written to us saying he would like to make it. Some schools have made one up for themselves, as was our intention when we published the design. Some teachers may have felt that it would be a nice piece of equipment to have, if ever they could find time and facilities to make it. But have they done anything else? Have any of them badgered the manufacturer to see if he is making it? It is time the biologists started making more noise. Pupils who in physics build computers or lasers, or who measure time in microseconds, will treat with contempt the Victoriana which clutter up the biology labs. It is time the biology teachers put their house in order.

Physics Notes

The following are brief descriptions of the pieces of physics apparatus which we are prepared to lend to schools for use in projects, under the terms specified in the introduction to this Bulletin. Other items will be listed as and when they become available.

Cintel Microsecond Counter Chronometer. This is a six decade digital/

digital reading clock or timer. Range 0 - 10,000s; sensitivity 1μs. Accuracy unknown, but the frequency is crystal controlled. The instrument is fitted with start, stop and reset push-buttons; it can also be started or stopped electrically by pulse input of 7V or greater. Supplied without operating instructions.

Muirhead Decade Oscillator, Type D-105-A. This instrument generates sine waves of frequency 1 - 111,100 Hz; selectivity 1Hz. Accuracy at time of writing is 2%, but we hope to improve on this by re-trimming. Output is variable to maximum of 150V into a 8kΩ load. Operating instructions supplied.

Airmec Oscilloscope Type 723 and Camera Type 758. The oscilloscope has input impedance of 100kΩ and frequency range from 0 - 5MHz. Sensitivity 200 or 30 mV/cm. Time base range from 0.5s to 1μs for 7 cm deflection; provision for internal or external synchronisation. The final anode voltage can be switched to 1, 2, or 4kV. The instrument has been designed for photographic recording and although it is an oscilloscope in itself we hope that any school wishing to use the instrument would do so because of the recording facility.

The type 758 camera uses 35 mm film. It can be used on single exposure or for continuous recording in conjunction with a built-in motor giving film speeds of 0.5, 1.5 and 4.5 feet per second. Supplied with operating instructions.

Airmec Decade Counter Type 704. This will count a random or regular series of pulses (including sine waves) between 1 and 25 volts peak amplitude. Capacity 999,999 counts. Maximum count rate is 100,000 impulses per second. The instrument has an input level control; input impedance is 50kΩ. Supplied with operating instructions.

Nagard Oscilloscope Type L103. This is a really massive piece of furniture, comprising oscilloscope and separate power supply, and trolley for their transportation. Time base is calibrated for time and frequency measurement; sweep linearity is within 1%. Sweep velocity is variable from 2 in per 0.1s to 2 in per μs. Frequencies are measurable within 2% from 0.5 to 2 MHz; times within 5% from 1s to 1μs. The input amplifier is voltage calibrated, measuring from 350V to 100 mV at 5% accuracy, and down to 20mV at 20% accuracy. The amplifier response is from 0 - 10 MHz (8 db down); input impedance is 1MΩ and a switched attenuator is provided. Supplied with operating instructions.

Marconi Video Oscillator Type TF 885. The frequency range is from 25Hz to 5MHz; output is variable to a maximum of 1 watt into 1 kΩ load. Also available is square wave from 50Hz to 150 kHz. The apparatus has been slightly modified from the form described in the instruction manual, due to our having managed to burn out the output attenuator!

Foxboro Pressure Recorder. Range 0 - 15 p.s.i.g.; this is a continuous recorder using 10 in dia. charts. Chart motor speed is 1 r.p.m. Supplied with operating instructions.

Fielden Servograph Type RL1. Basically this is a recording milliammeter with a F.S.D. of 1mA, using disc charts 10 in diameter. The chart motor speed is 3 r.p.h. Supplied with operating instructions.

Furzehill Type 1931 stabilised Power Supply. Stabilised outputs of +350, -150, -300V; +500 and -400V unstabilised. Current output unknown but probably 250 mA. Current/voltage output meter. Zero can be earthed, or left floating, so that a maximum P.D. of 900V is obtainable/

obtainable. No operating instructions.

Airmec Frequency Standard Type 761. This gives sine and pulse outputs at five frequencies, viz. 10^2, 10^3, 10^4, 10^5, and 10^6 Hz with a frequency stability better than 1 in 10^6. Sine wave output is between 1 and 5V into 450Ω impedance, except in 100Hz, where the impedance is 2500Ω. Pulse output 10V at 1MHz, 20V at other frequencies. Pulse widths vary between 0.2μs and 20μs. The instrument also has a C.R.O. with circuitry for frequency comparison by lissajou figure or circular time base, and a loudspeaker and circuitry for beat frequency comparison. There is a beat frequency output terminal. The instrument has a built-in clock driven from the frequency standard. and there is also a 125V, 50Hz output for driving an external synchronous motor. Supplied with operating instructions.

British Physical Laboratories Universal Impedance Bridge, Type UB202. This measures resistance from 1Ω to 100kΩ inductance from 0.1mH to 100H. amd capacitance from 100pF to 100μF with an accuracy of 5% or better. Terminals are provided for the connection of an external balance detector, and an oscilloscope is recommended for this purpose for the higher values on all ranges. No operating instructions supplied.

Chemistry Notes

Shallow troughs for demonstrating diffusion can be cut from detergent bottles. If the bottle is cut lengthwise to give a section about 3 cm wide, this is adequate. With care 6 or 8 sections can be cut from one bottle. When full of water and having given time for the water to settle, two crystals of each reagent are dropped in at either end (e.g. potassium iodine and lead nitrate) and after 3-4 minutes lead iodine crystals will appear at the meeting point of the two sets of ions. These scintillate in sunlight, or even in strong artificial light, but it would be rash to conclude that this shows Brownian movement rather than convection.

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We have a note from Mr. Johnstone of the High School of Stirling and co-author of Chemistry Takes Shape disclaiming any attempt to measure electrode potentials in Chapter 8, Book 3, and to which we referred in the previous Bulletin. We hoped we had made it sufficiently clear that we were not attempting this either, since electrode potentials must be measured under carefully controlled conditions and we have to admit to using the term electrode potentials to describe the results of any experiments which measures the potential between a pair of metals in an electrolyte. All that can be expected of the experiments is that they give a foundation for arranging the metals in an order or series. Mr. Johnstone also points out that unless the metal surfaces are freshly prepared by scrubbing with emery cloth polarisation will reduce meter readings practically to zero within 5-15 minutes of immersion in water.

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The colorimeter which we mentioned in the introduction to this Bulletin/

Bulletin is a Leitz model. It has three pairs of sample tubes, and the plungers on the centre pair can be separately adjusted and read to 0.01 mm on a vernier scale. No operating instructions are available.

Trade News

A new range of clear joint apparatus has been produced by Quickfit and Quartz. Joints are made by moulding to very close tolerance, and amongst the advantages over the ground glass joint apparatus claimed for the Clearfit range are greater creep resistance and freedom from the need to lubricate joints. Prices are on average 10% higher than for the ground glass range.

The crude ores required for the Alternative Chemistry syllabus can be obtained from R.F.D. Parkinson, suppliers of geological materials. Prices range from 1s. to 12s.6d. per lb.; teachers are advised to write for the firm's catalogue before ordering.

System Computers have introduced a low priced gas laser, the Series 600. It is possible to align the mirrors on the laser as they are mounted externally and each has three adjusting screws. The laser which is D.C. excited, has no provision for beam modulation.

White Electrical Instrument Co. have moved to new premises near Malvern. Their new address is given in our address list.

Vickers Instruments have introduced a phase contrast unit for use with their M14A microscope. The cost of the various parts are: condenser M151650, £10.8s.; x10 objective MO22318, £5.14s.; x40 objective MO22518, £9.10s.

Schools or local authorities purchasing the Swift 950 series of microscopes should be aware of the considerable saving if duty remission is obtained on Form DFA3, which can be obtained from the Board of Trade, Tariff Division. Duty Remission Branch, Sanctuary Buildings, 20 Great Smith Street, London, S.W.1. This cuts the cost of a 951-R student microscope from £33 to £22, and of the 952-BR from £37 to £24.13s.4d. In quantities of five or more, the firm which supplies the microscopes, Pyser-Britex, will obtain the duty remission on behalf of the purchaser. In these instances Pyser-Britex ask that the order form be marked "Duty Free".

The firm of Telequipment advise us that their S51E oscilloscope can now be supplied to schools with an input trigger terminal, if so desired. Schools are asked to order "S51E, with external trigger". The cost remains the same, £49.10s. when educational discount has been taken into account. This extra facility is available for both normal and long-persistence versions of the oscilloscope.

R.M. Cameron and Sons, who market the Dymo embossed tapewriter and tapes are offering discount of 12½% to any purchaser of a Dymo tapewriter, together with 5 tapes for the machine. For tapewriter + 10 tapes, the discount is 17½%, and for tool + 20 tapes, 22½%. The M6 tapewriter, supplied with one horizontal and one vertical writing head, together with one ¼" and one 3/8" tape, costs £5.19s.6d. Additional tapes cost 6s.11d. and 10s.6d. respectively for the two sizes.

All Russian microscopes purchased from Technical and Optical Equipment or/

or from Andrew H. Baird now carry 10% educational discount.

Details of a wide range of new products are given in the No. 3 brochure of Griffin and George S.T.E.D. (short for Science Teaching Equipment Division). These include environmental chambers for Nuffield Biology, hydrogen sulphide generator, X-ray unit mentioned in Bulletin 14.

The 3M Company have produced a transparent slide rule for use with their overhead projector. It is intended purely for demonstration of slide rule principles and therefore the scaling has been kept to a minimum, giving only the normal A, B, C and D scales. Scale length is 20 cm; price £5.14s.6d.

A "breadboard" for assembly of transistor circuits, called the S-Dec is being manufactured by S.D.C. Products. Components push fit into individual holes in the breadboard and the under-chassis assembly allows five of these holes to be interconnected by low resistance phosphor bronze strip. Fourteen sets of such holes are supplied on a single deck, giving 70 individual connections. A panel to which can be screwed standard potentiometer or variable capacitor spindles is also provided. Keys on each side of a deck allow two or more decks to be fitted together. From the leaflet of diagrams supplied with an S-Dec we have assembled a three transistor reflex receiver wherein all components except the loudspeaker and battery are mounted on the S-Dec or its vertical panel. Cost of the S-Dec is £1.9s.6d.

In The Workshop

A convenient method of employing Visking tubing - or thin cellophane from jam pot covers, which works just as well - is to trap it across the end of a glass tube push fitted into a slightly larger bore of P.V.C. tubing, as in Fig. 1. A satisfactory inside diameter for the P.V.C. tubing is from 3-5 mm. Liquids injected by a syringe pipette will remain in the P.V.C. section by surface tension, so that there is no need to seal this end off. If starch suspension and iodine solution are placed on either side of the membrane this soon shows diffusion of iodine. If the membrane separates a solution of glucose from water, diffusion of glucose can be shown after a few minutes by testing the water side with Clinistix paper (see Bulletin 10).

If a second glass tube, drawn out to a fine capillary, is inserted into the free end of the P.V.C. tube and adjusted so that the liquid level occurs in the capillary (see Fig. 2) osmosis can be shown. Strong sugar solution is used, and movement in the capillary will be seen in under five minutes.

Once a supply of these tubes have been cut, there is no reason why every pupil should not carry out his own experiments. The glass end in contact with the cellophane must be well rounded off to prevent tearing it. The overlap of glass on P.V.C. tubing which sandwiches the cellophane can be about 5 mm long. Although we would expect each pupil to assemble his own apparatus from the bits and pieces, the complete assembly can be stored provided that the glass tube is almost completely withdrawn from the P.V.C. to allow for the shrinkage of cellophane on drying out.

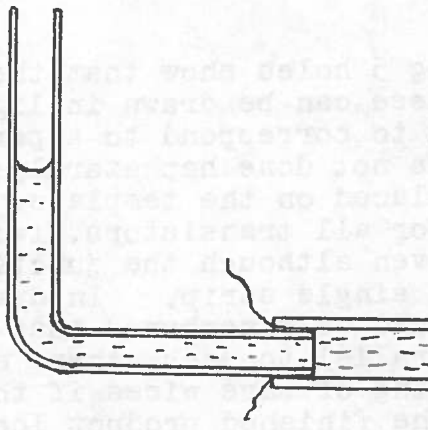

Fig. 1

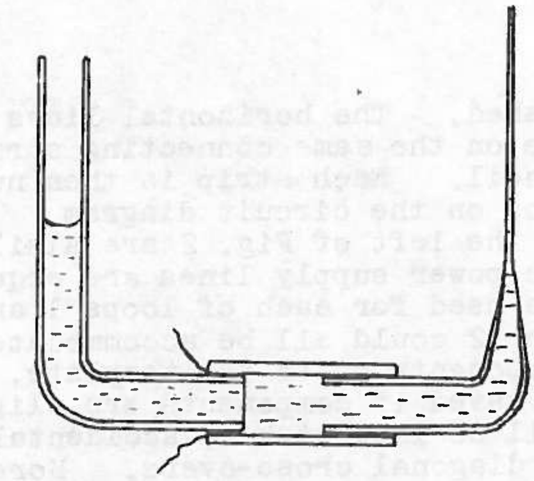

Fig. 2

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In the Trade News section of this Bulletin we give details of an electronic "breadboard", the S-Dec, which can be used to assemble experimental circuits without soldering. Eventually a successful circuit will require to be wired up in a more permanent form; the most convenient type of printed circuit for doing this is Veroboard. This consists of bakelite sheet with thin strips of copper, carrying equally spaced holes deposited on one side. Components are inserted through the holes and soldered to the copper strip. Thus two components soldered to the same strip are thereby electrically connected together. Veroboard is ideal for wiring transistors, capacitors and resistors; in some cases air-cored inductors can also be used. Bulkier items such as switches, lamps, transformers usually have to be mounted on the box containing the equipment and wired to the Veroboard with flexible leads. What follows is an account of how to reduce a circuit diagram to a "template" form suitable for wiring first into an S-Dec, and then on to Veroboard. The circuit has been chosen merely to illustrate the principle of the method, which can be applied equally to any circuit.

The S-Dec configuration of holes is reproduced in Fig. 1. Each set of five holes is interconnected, but is isolated electrically from every other set. There is also an insulating barrier down the middle of the board. The circuit diagram is shown in Fig. 2; the circuit illustrates a multivibrator which will switch the lamps L1 and L2 on alternately, at a rate of about one flash per second. Each junction on the diagram is first circled with a loop which is extended to take in connections to all components which are wired to the junction. These loops have been numbered on the diagram 1 to 8. Usually junctions can be identified by the presence of heavy dots, but notice loop 3 which has only two connections. The junction of switch and battery has not been looped in this way because neither of these components would normally be on Veroboard (although the S-Dec has a panel for mounting switches) and the connection between them would be a piece of wire. Counting the connecting lines which pass out of each loop will then tell how many holes are required on this particular strip of Veroboard. Thus loop 1 needs 7 holes; loop 2 needs 5; loops 4 and 5 need 4; loops 6 and 7 need 3; and loops 3 and 8 need 2 holes. Up to this point the procedure is the same for S-Dec or Veroboard construction, but since the S-Dec limits the designer to 5 holes per strip, whereas on Veroboard the number of holes is unlimited, from this point we will discuss S-Dec construction first, and return to Veroboard later.

The next stage is to prepare the template of Fig. 3a, using the inch or cm intersections on a piece of graph paper. Each intersection corresponds to a hole on the S-Dec into which a single wire can be pushed/

pushed. The horizontal lines joining 5 holes show that these holes are on the same connecting strip; these can be drawn in lightly in pencil. Each strip is then numbered to correspond to a particular loop on the circuit diagram. This is not done haphazardly; loops on the left of Fig. 2 are similarly placed on the template. Because the power supply lines are required for all transistors, two strips are used for each of loops 1 and 2 even although the junctions to loop 2 could all be accommodated on a single strip. In drawing the components on to the template, it should be remembered that space will be saved if components are aligned parallel to each other, and there will be less risk of accidental shorting of bare wires if there are no diagonal cross-overs. Moreover the finished product looks neater and is easier to sceck over if the circuit does not operate straight away. Thus where possible the ends of components should be in the same horizontal or vertical line. As will be seen in Fig. 3a it is impossible to avoid one cross-over with the circuit we are using. Firstly draw in any direct connecting links e.g. at top and bottom centre to join the two strips making up each power line. Then determine the layout of components, starting with the bulkier items, in this case the two capacitors. Their physical size should be kept in mind, hence we use them to link left and right halves of the template together, and on the S-Dec itself they will be placed side by side straddling the centre line. Each component is drawn in, and its value marked. Transistors can be numbered and the connections to collector, base and emitter labelled C, B and E, followed by the transistor number. This is better than drawing a transistor symbol on the diagram, which would in some cases clutter it up and confuse the wiring. The lamp connections are labelled L1 and L2; switch and battery connections are marked S and –. After each component has been entered on the template, a tick should be made against it on the circuit diagram, at the same time checking that it has been drawn between the correct loops. In this way there should be no need to check out the complete template.

Insertion of components into the S-Dec can now begin. Use solid connecting wire for the connecting links, and push the ends home until the wire is hard against the baseboard. It will not then foul any subsequent components. Next insert the capacitors, followed by resistors and transistors. If stranded wire is used to connect lamps, switch and battery, it must be bared of PVC for a 15 mm length and this length must be completely solder-tinned to give it the stiffness necessary to insert it into the holes. The layout of components on the S-Dec follows exactly that of the template of Fig. 3a. Fig. 4 is a full-scale plan view of the wire-up, excluding the components which are external to the board.

Components on the S-Dec will have been taken straight from stores and pushed into the circuit. Since Veroboard is a more permanent construction, more care is required. Wire ends of components must be cut to the correct length, and cleaned with emery cloth before soldering. Fig. 5 shows two methods of soldering a component to the board. Fig. 5a is used where the ends are close together i.e. on adjacent copper strips, or with only one intervening strip. The other method is used when the ends are three or more strips apart. Notice in both cases that the component should not be mounted flush on the board, but about 3-5 mm above it. There are two reasons for this; the additional length of wire gives some protection against overheating the component when soldering it in, and also allows the component to be moved sideways if necessary to allow other components to be inserted in position. Transistor leads should not be shortened, and should be covered with a length of insulating sleeving before soldering, which must be done using a pair of long-nosed pliers to hold the lead being soldered. The pliers then act as a heat shunt, absorbing heat from the soldered joint which would otherwise pass up the/

the transistor lead and might destroy the transistor.

Having drawn loops on the circuit diagram as in Fig. 2, the next step in Veroboard construction is to find the total number of holes required; in the present case this is 30. It is then advisable to double this to get the size of the Veroboard piece. This does mean that half the holes are wasted, but the physical size of the components usually means that anything less than this leads to a very cramped construction. The advantage of Veroboard is that it can be cut to give 60 holes in any rectangular shape to fit whatever box is going to hold the finished article. In the present case we could use an array of 4 strips x 15 holes per strip, or 8 x 8, or 6 x 10. Fig. 3b shows how a 6 x 10 template would be prepared; this is the nearest equivalent to S-Dec. Fig. 3c shows how a 12 x 5 template could be made up. In all these diagrams the numbers at the sides correspond to the loops in the circuit diagram. Figs. 3b and c show that some of the holes have been crossed thus (x); this is done to indicate that these are to be partly drilled through, using a No. 33 or similar suitably sized drill, until the copper strip is broken across its width. The left hand side of the strip is then insulated from the right hand side. This drilling is the first stage in wiring up the Veroboard, and after it has been done the board should be very carefully examined and any copper burrs scraped off to ensure that contact between the two sides of the strip has really been broken.

The circuit will require to be bolted on to some part of the box holding the apparatus; this involves drilling two holes out with the No. 33 drill and bolting to the box with 6 B.A. bolt and nuts. Two nuts are used, the first being a spacer which will keep the soldered joints clear of the box itself which may be of metal. Fig. 6 shows the method of fixing. Holes immediately adjacent to the bolt holes should also have the copper drilled out so that there is no risk of any electrical connection through the bolt head to the box. Wires connecting the Veroboard to other parts of the circuit, e.g. lamps, switch and battery in Fig. 2 are cut from PVC covered stranded wire which is soldered on to the Veroboard before it is fixed to the box. These wires may be colour coded, in which case it helps to mark the colours on the template of Fig. 3b or c, since the positions of the wires may not be so easily identified when the board has been fixed into position in its box.

One final point, Veroboard has to be turned over every time a wire end is soldered on. Since the template shows the layout of components on the bakelite side of the board, and they are inserted from this side, but the board must be turned over to bring the copper side uppermost for soldering. It is therefore very useful during the wiring up to have the board in a clamp which can be quickly turned over. Fig. 7 shows a clamp which can be fixed into a retort stand boss.

Fig. 1

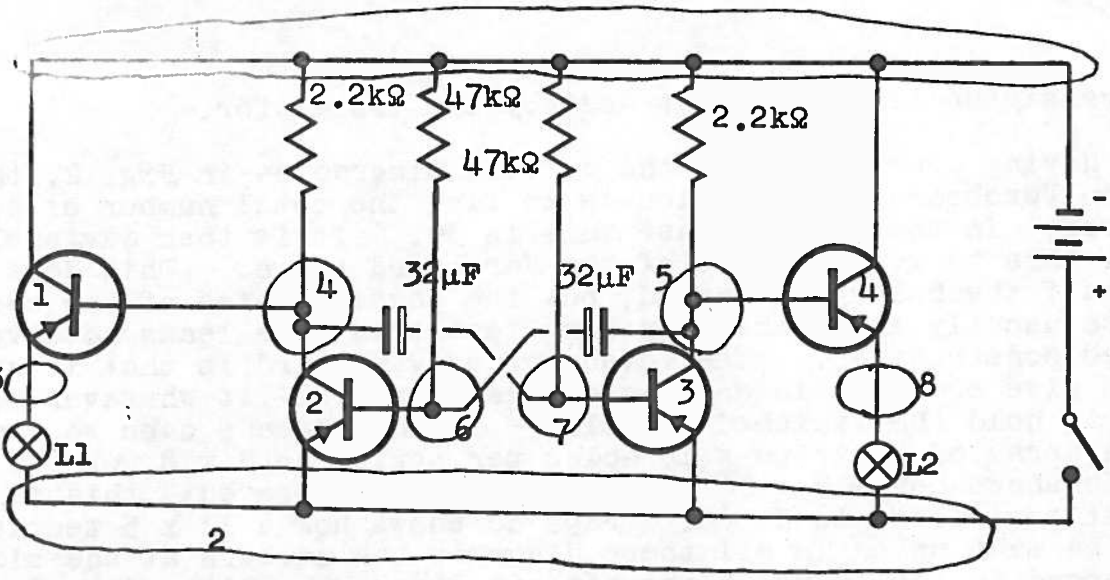


Fig. 2. Circuit diagram. Transistors 1 and 4 are OC72; 2 and 3 are OC71. Lamps L1 and L2 are 6V, 30mA.

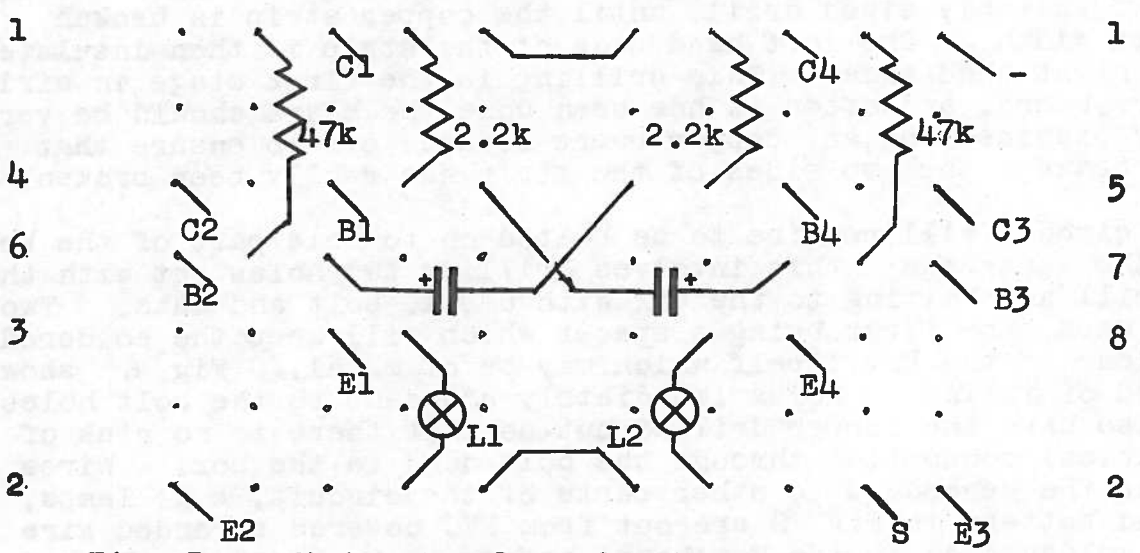


Fig. 3a. Wiring template for S-Dec.

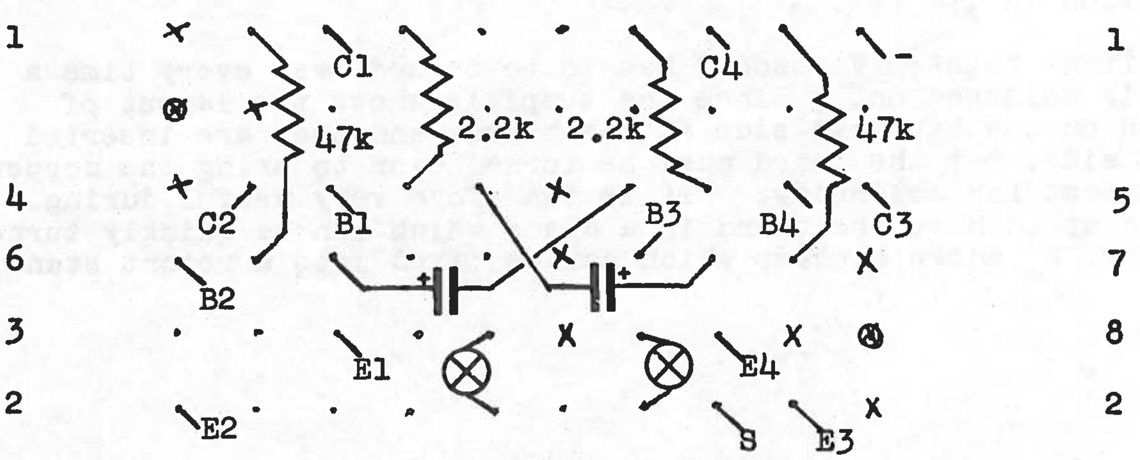


Fig. 3b. Wiring template for Veroboard. Connecting strips run horizontally in this diagram. Holes marked x are partially drilled out to break the copper strip; those marked ⊗ are completely drilled out for fixing bolts.

Fig. 5. Two methods of mounting components on Veroboard.

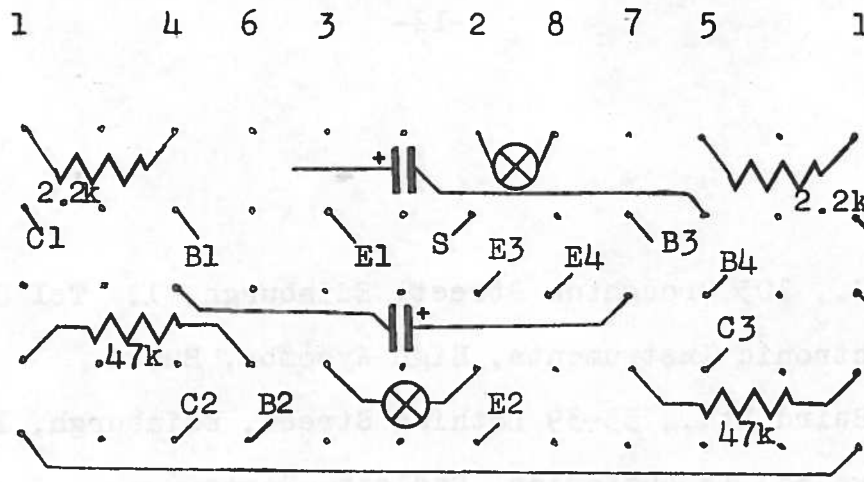


Fig. 3c. Connecting strips run vertically on this board. Notice the wire connecting the two extreme strips.

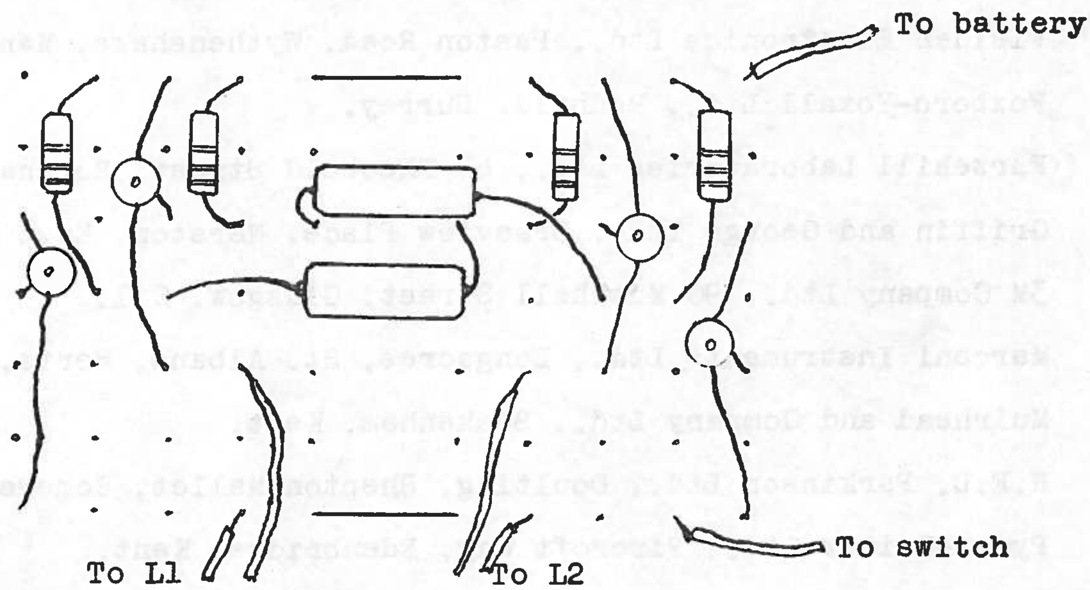
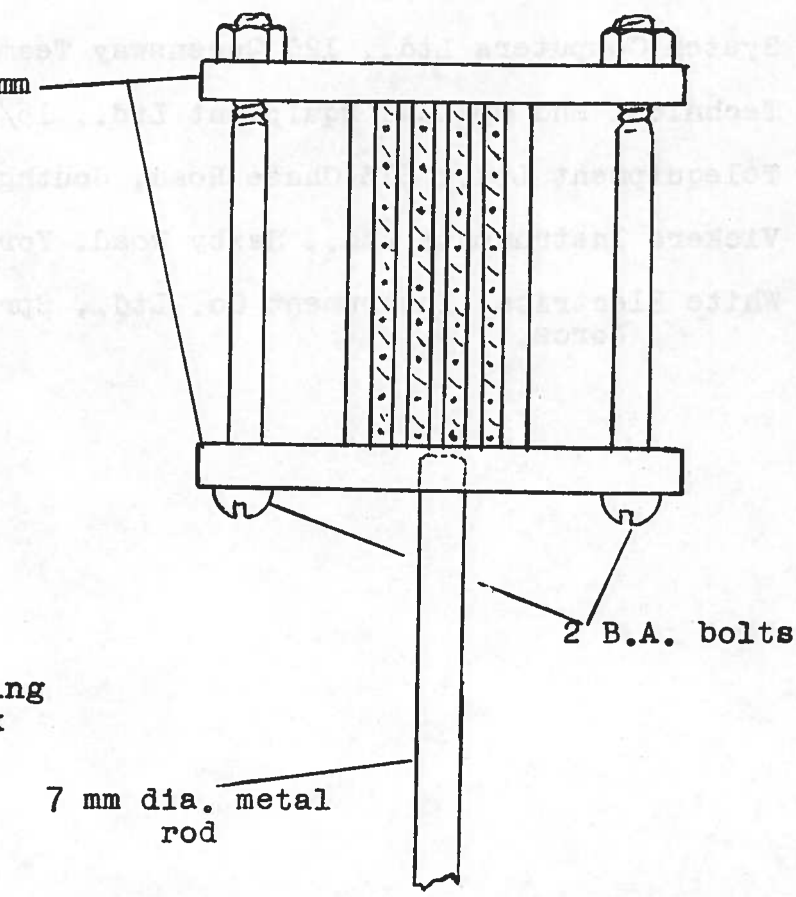


Fig. 4. Layout of components on S-Dec.



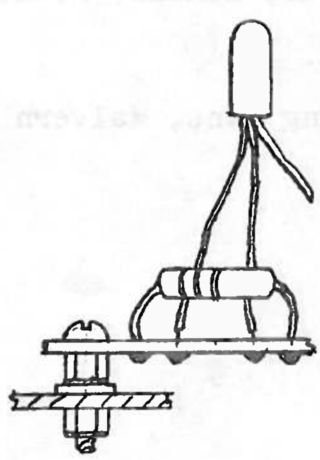


Fig. 6. Method of securing Veroboard to box

Fig. 7. Veroboard clamp

S.S.S.E.R.C., 103 Broughton Street, Edinburgh, 1. Tel 031-556 2184.

Airmec Electronic Instruments, High Wycombe, Bucks.

Andrew H. Baird Ltd., 33-39 Lothian Street, Edinburgh, 1.

British Physical Laboratories, Radlett, Herts.

R.M. Cameron and Son Ltd., 10/11 George IV Bridge, Edinburgh, 1.

Fielden Electronics Ltd., Paston Road, Wythenshawe, Manchester, 22.

Foxboro-Yoxall Ltd., Redhill, Surrey.

Furzehill Laboratories Ltd., 47 Theobold Street, Borehamwood, Herts.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride.

3M Company Ltd., 90 Mitchell Street, Glasgow, C.1.

Marconi Instruments Ltd., Longacres, St. Albans, Herts.

Muirhead and Company Ltd., Beckenham, Kent.

R.F.D. Parkinson Ltd., Doulting, Shepton Mallet, Somerset.

Pyser-Britex Ltd., Fircroft Way, Edenbridge, Kent.

Quickfit and Quartz Ltd., Stone, Staffordshire.

S.D.C. Products Ltd., 1 Grosvenor Road, Sale, Cheshire.

System Computers Ltd., 120 Queensway Team Valley, Gateshead, 11.

Technical and Optical Equipment Ltd., 15/17 Praed Street, London, W.2.

Telequipment Ltd., 313 Chase Road, Southgate, London, N.14.

Vickers Instruments Ltd., Haxby Road, York.

White Electrical Instrument Co. Ltd., Spring Lane, Malvern Link, Worcs.