SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 61. February, 1973.

Contents

Introduction

The Scottish Branch of the A.S.E. will hold their annual meeting in Jordanhill College of Education, Glasgow, from 12th to 14th April. As usual, we will stage an exhibition of apparatus constructed and developed in the Centre, which will be open during the period of the meeting, closing at 11.30 on the Saturday morning. At that time we shall give a lecture demonstration on the uses of apparatus for science teaching, this being a blanket title which will not commit us too firmly to any one line of approach.

Teachers may like to note other public appearances which SSSERC are to make during the remainder of the session. On March 8th in Dundee, and March 16th in Aberdeen, we shall give a lecture demonstration on the uses of chart recorders in schools. Teachers in these areas will be given details of the lecture in due course. On April 27th and again on May 25th we shall hold apparatus exhibitions in Jordanhill College of Education, specifically for college students. On 20th June we shall have an apparatus exhibition in conjunction with the in-service course in chemistry at St. Andrews University.

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In Bulletin 60 we published details of circulars on various aspects of safety issued by the Scottish Education Department, and we have been asked by them to point out that Circular 759 on the use of carcinogens in schools has been withdrawn and replaced by Circular 825 (June 1972) having the same title and at the same price.

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Our Development Committee has suggested that SSSERC investigate examples of bad after-sales service to schools, and to that end we are appealing to teachers to send us details of any example of this of which they have had experience. Our aim would be to take the matter up with the firm concerned, and then to publish both the details of the case and the firm's explanation in the Bulletin. While we are sceptical of the effect on the manufacturer which such a threat might have, it might help the situation by showing the teacher the other side of the picture and make him more sympathetic towards the difficulties facing the manufacturer. We ourselves have been waiting for months for information on the malfunctioning of a device which we bought from the Scottish agent of a U.K. firm which imported the device from Japan and our enquiry has had to go through each of these channels. A teacher who believed that the information was on his doorstep in the agent's files might be understandably incensed at the delay.

Opinion

Those readers who are familiar with the aims of the Centre will, we hope, forgive us for restating what is possibly the most important. We are financed collectively by all the Scottish Local Education Authorities, and in return attempt to provide them with an effective advisory service on the purchase of school science equipment. We see our task as being to ensure the Local Authority money is spent as effectively as possible, and in many cases this probably results in an actual saving of money. In all cases, we hope, our advice results in more effective teaching.

To this end, we attempt to keep continually up-to-date in our knowledge of science equipment, while testing the more important items such as power supplies, balances, microscopes, etc. Our published test procedures for these can, we think, fairly be called rigorous; certainly we attempt to assess as accurately as possible the suitability of each item for school use.

We stress that our service is advisory. We cannot, and do not attempt to, compel teachers or authorities to buy specific items. Nevertheless, we do think that when equipment is being purchased our advice should be sought, and weighed with other relevant factors before a final decision is made.

In many areas local teachers' groups have formed to advise their authorities on which items of equipment should be bought. This we believe to be a very worthwhile move, enabling teachers to discuss all aspects among themselves and thus arrive at more rational decisions. Indeed, we should be most grateful if such groups were to inform us of their decisions and the reasons for them. In particular, we should like to know of any special features which they look for, and which we may not be taking into account. We could then pass such information on through the Bulletin. We hope, however, that these groups are not intended to replace our services, but to ensure that our advice is most effectively used to meet local requirements. A group of teachers may be able to view a large selection of equipment, but they would probably be the first to agree that they have neither the time nor the facilities to scan the whole equipment field continually, nor to test in the detail that we do.

It may seem to many that it is quite unnecessary for us to state all this. We do so, because we have recently heard of one or two cases where large purchases of important equipment have been made without our advice being sought. As it happens, in those instances where we know some of the details, the items selected appear to have been ones which we would not have recommended, and we believe that overall perhaps several thousand pounds have been spent on various instruments which we consider to be unsuitable for school use. The point we are making, however, does not rest on these details. It is the more general one that local authority money is apparently being wasted, because advice has not been sought from an organisation, set up and financed by the local authorities specifically to provide this advice.

Biology Notes

Bicarbonate Indicator We have received a complaint from a school that has had trouble with this indicator - most particularly in bringing it to the correct equilibrium colour. As a result of investigations we conclude that there are probably three major factors involved. Firstly, it is important to use 'Analar' sodium bicarbonate. Comparisons with 'Analar' and non-Analar showed that using the latter, the indicator was always more yellow, making detection of carbon dioxide more difficult. Secondly, it is important to weigh out the quantities of the constituent chemicals carefully. Thirdly, the indicator should be carefully aspirated before use.

The respiration module described in Bulletin 60 is useful for aspirating the indicator. One simply aspirates through it with an empty syringe immediately before starting the experiment. If the indicator is to be used to detect photosynthesis one first aspirates it in the module, then removes the caps and tubing, inserts the leaf, and stoppers the tubes with entire caps. A further important factor here is that the volumes of indicator and air involved are small so that results are obtained more rapidly.

Trade News

Activion Glass will supply pH electrodes direct to schools. To enable the firm to provide the correct termination connection and inner filling for the electrode it is necessary to state the make and model number of meter with which the electrode will be used. The types of electrode we would ask schools to consider are:

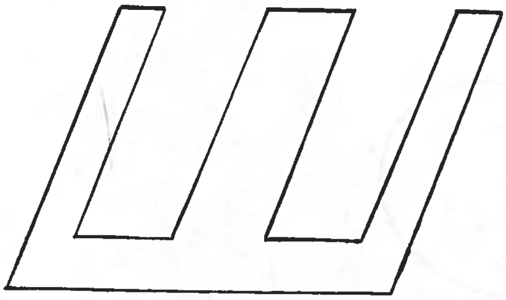
For general use, the "Rugged Student" model, No. 003-11-207, price £8. It has an outer case of plastic instead of glass and a protective plastic shield which remains in position during use. Its range is 0-14pH and 0-80°C. For portable pH meters, model 003-11-204, price £7. This has a removeable plastic shield, and a plastic cup holding approximately 2cm^3. The range is 0-14pH and 0-70°C. For measuring pH of semi-solids, e.g. soil, model 003-11-203, price £7.50. The range is 0-11 pH and 0-50°C.

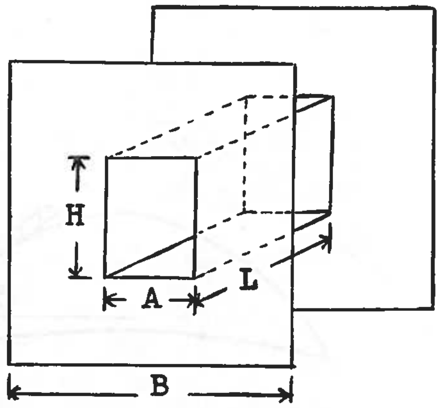
Two items in a new Electroplan catalogue may interest physics teachers and technicians. One is a battery-operated soldering iron, which when not in use fits into a stand which automatically recharges the battery. As up to 60 joints can be made before the battery is fully discharged, it is unlikely that it would get discharged during normal working use. It would appear to eliminate two nuisances associated with conventional irons, the erosion of a bit left on continuously, and the shortness of any length of flex which you care to fit. Current price of the iron is £9.25. The second item is a nickel cadmium cell which has the same physical dimensions as the U2 type dry cell. The cell has the obvious advantage of being rechargeable, and although they cost £2.23 each, this would require less than 40 charges (discounting the cost of the charger and the electricity) to make them more economic than a dry cell. Moreover, since the dry cell, discharging at ½A has a capacity of just over 1Ah compared with the 4Ah of the rechargeable cell, this makes the latter even better value. We believe that these cells could be very beneficial in Worcester circuit board work, and intend that they shall be tried out with the board, to see whether the reduced e.m.f. - 1.25V instead of 1.5 - makes it necessary to modify any of the experiments. Because the cells have a very low internal resistance of the order of a few milliohms, they must be charged by a constant current supply, and the firm provide one which will take up to 8 cells in series, charging at 200mA, for £4.70.

We have purchased the kit, and completed the construction of the desk calculator featured in the October issue of Wireless World, No. 1444, and which is marketed by Advance Electronics at £40. The calculator uses integrated circuits, has an 8-digit capacity, and can be constructed by any technician who is a competent solderer, and has a steady hand and a miniature soldering iron. The latter is essential because at one stage 81 joints have to be soldered in a space 55 x 13mm. Full and clear instructions are given for the construction. The calculator may be examined by anyone visiting the Centre

We have frequently expressed the opinion to R.S. Components which used to be Radiospares, and latterly to Farnell Electronics that it would pay them to add to their range bobbins for coil winding, and transformer laminations to fit them. Every time a technician has to wind a coil he must waste a great deal of time making a bobbin on which to wind it either by turning it from solid tufnol rod, which is wasteful, or by cutting the central tube and cutting and cementing cheeks to fit. If technicians in science centres and schools have felt the same need, may we ask that they add their voices to ours in urging these companies to consider stocking a small range of bobbins? Somewhere there must be a firm injection moulding these in plastic since the writer has found them abroad, and they should be available for a few pence.

Meanwhile we have unearthed a source of bakelite bobbins, of which the firm, Hurstford, will supply a minimum quantity of 10 in any one size. Specification of sizes is complicated because the bobbins are made to fit transformer laminations.

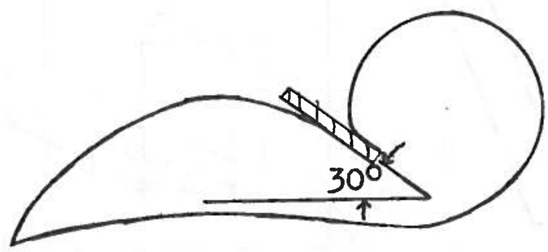




Referring to the diagram, dimensions A, B and L are fixed by the lamination, but H is variable, depending on how many laminations are fitted into the core. In the table below we give a few specimen sizes and prices for plain bobbins. In the column headed 'Size', the first figure is a pattern number, the second is the dimension H in inches, regrettably, since we doubt if the firm would recognise the metric equivalent. The columns headed A, B and L give these dimensions of the laminations, and it should be borne in mind that the winding space available for putting on the wire will be less than this by the thickness of the bobbin material itself. The final column gives the price for 10 bobbins. These are only a small selection from the firm's range, given in a 15 page price list.

Size	A	B	L	Price
291 x $\frac{3}{4}$	8 mm	24 mm	19 mm	40 p
291 x 1	"	"	"	40
291 x $1\frac{1}{2}$	"	"	"	45
40 x $\frac{1}{2}$	10	29	16	40
40 x $\frac{3}{4}$				40
40 x 1				40
39 x $\frac{1}{2}$	10	29	23	40
39 x $\frac{3}{4}$				40
39 x 1				40
21 x 3/8	11	25	17	35
21 x $\frac{1}{2}$				40
21 x $\frac{3}{4}$				40
293 x $\frac{1}{2}$	11	35	26	35
293 x $\frac{3}{4}$				35
293 x 1				35
403 x $\frac{3}{4}$	13	26	19	40
403 x 1				45
403 x $1\frac{1}{2}$				50

In The Workshop



This device which was suggested to us by an Australian headmaster, seems to catch the wonder of the school pupil more than other similar centre of gravity "tricks". It has also puzzled hardened teachers, even if only momentarily. The shape shown is cut out of 20 mm thick hardwood or tufnol. The only important part is the notch, which should be about 5-6 mm deep, 2 mm wide and angled at about 30° to the long axis of the shape. Into the notch is fitted a leather trouser belt and provided it stays in position it will be found possible to balance the shape on its sharp end at the extreme tip of one finger, with the belt hanging down on either side, and with the shape horizontal. If the notch angle is made less than 30°, and depending on the rigidity of the belt, it is possible to attain stability with the thick end of the notch dropping below the horizontal, but one can be too clever in this respect, and find that it always slides off the finger. The sketch shows the belt in cross-section in position.

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In Bulletin 13 we published a design for a perspex sheet bender, using resistance wire heated by a low voltage power supply. The wire was kept taut by a 1 kg weight, and sometimes broke. A new design which eliminates this and other disadvantages has been given to us by the technician in St. Paul Street Centre, Aberdeen, following an exhibition we held there. This uses a mains operated heating element, and the heat is restricted to a narrow slit by an asbestos board.

It may still be possible to buy a 500W single bar electric fire element, in which case the design should be altered to suit its physical dimensions. We used a ceramic former from an old 1 kw fire and wound our own element on it. This former was 260 mm long, 14 mm outside diameter, and the pitch of the thread on which the element was wound was just over 1 mm, there being 47 threads in a 50 mm length. The reason for specifying these dimensions is that the former will give a suitable resistance when filled with 30 SWG Brightray 'C' wire which has a resistance of 12.9 ohms per metre. The important part of the specification is that the element should have a resistance of between 120 and 150 ohms, and be evenly wound on the former to give a heating coil 20-24 cm long.

The former is fixed, using two angle brackets (Fig. 2) to the under side of a sheet of 6 mm asbestos millboard such as Sindanyo, under a slot 240 x 6 mm. All the fixing screws in the asbestos are countersunk to provide a flat surface on which to lay the perspex, and in addition those fixing the angle brackets referred to above should be covered over with Araldite, as they are at live mains voltage. The cutting details of the asbestos sheet are given in Fig. 1. The angle brackets are made from 15 x 40 mm pieces of 22 SWG brass sheet, bent to a right angle along the mid line. The hole for mounting the element, which has a screwed fitting must be positioned to suit the heater and hold it just clear of the asbestos sheet.

The sheet, measuring 150 x 360 mm, is fixed to two wooden ends of 150 x 60 x 18 mm blockboard, covered on the inside face with asbestos sheet. A shield of 22 SWG aluminium sheet, bent to a semi-cylindrical shape is fitted over the heating element. The sheet, measuring 180 x 240 mm, is bent to a semi-circle 50 mm radius, with a fixing ledge 10 mm wide at each side. The sheet is earthed by a wire connection from one of the fixing bolts to the earth lead of the mains cable.

A single pole on/off switch and a 3-terminal block for the mains cable are mounted on the asbestos sheet at the back. If it is thought to be necessary a cable clip may also be mounted there. A backplate of 3 mm hardboard with a grommeted hole for mains cable exit can be put on the rear side of the work as additional protection against the fingers coming into contact with mains voltage on the terminal block or switch. Switch and heater are wired in series to the mains. The ends of the heating element will be in electrical contact with the angle brackets; connections between these and switch or terminal block should be by means of single, not stranded wire, bolted to the bracket with one of the fixing bolts. A solder tag and soldered connection will not do, as there is a risk of the solder melting.

To bend a perspex sheet along a straight edge, the element is switched on and allowed to get to red heat. The perspex is laid on top with the bending line along the slot. 20-30s exposure should soften the perspex sufficiently to allow it to be lifted off and bent over a right angled edge, e.g. the bench edge, where it is held until cold. Alternatively, it can be water cooled. For sheet greater than 3 mm thick it is advisable to heat each side in turn; this gives a nicely rounded bend. If a large number of bends are to be made the asbestos sheet may get too hot, when the element should be switched off between one operation and the next.

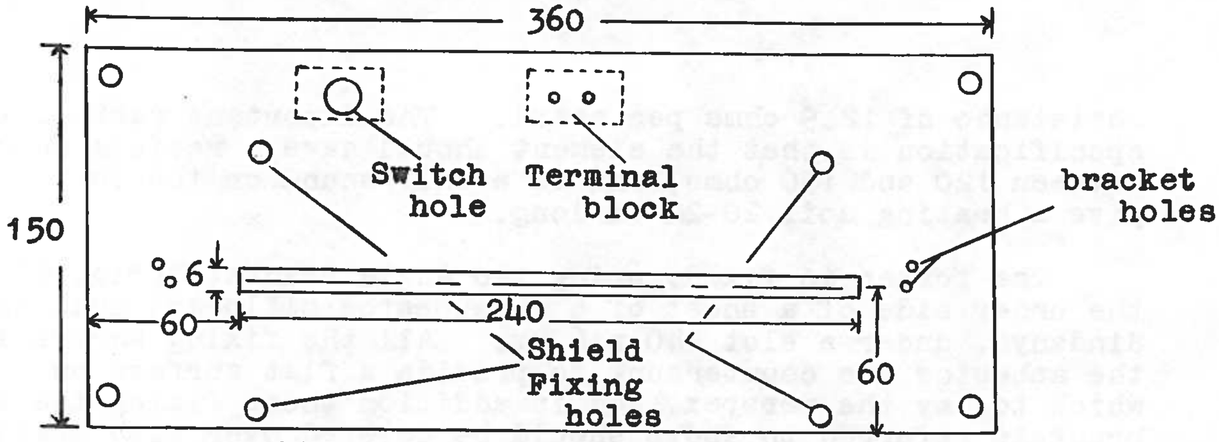


Fig. 1 Asbestos sheet detail

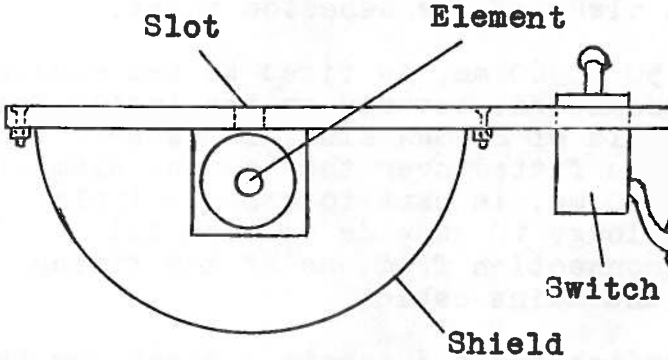


Fig. 3 End elevation

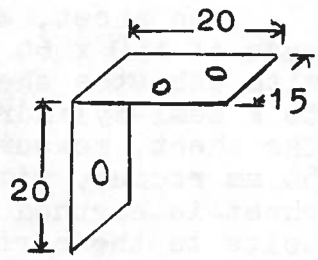
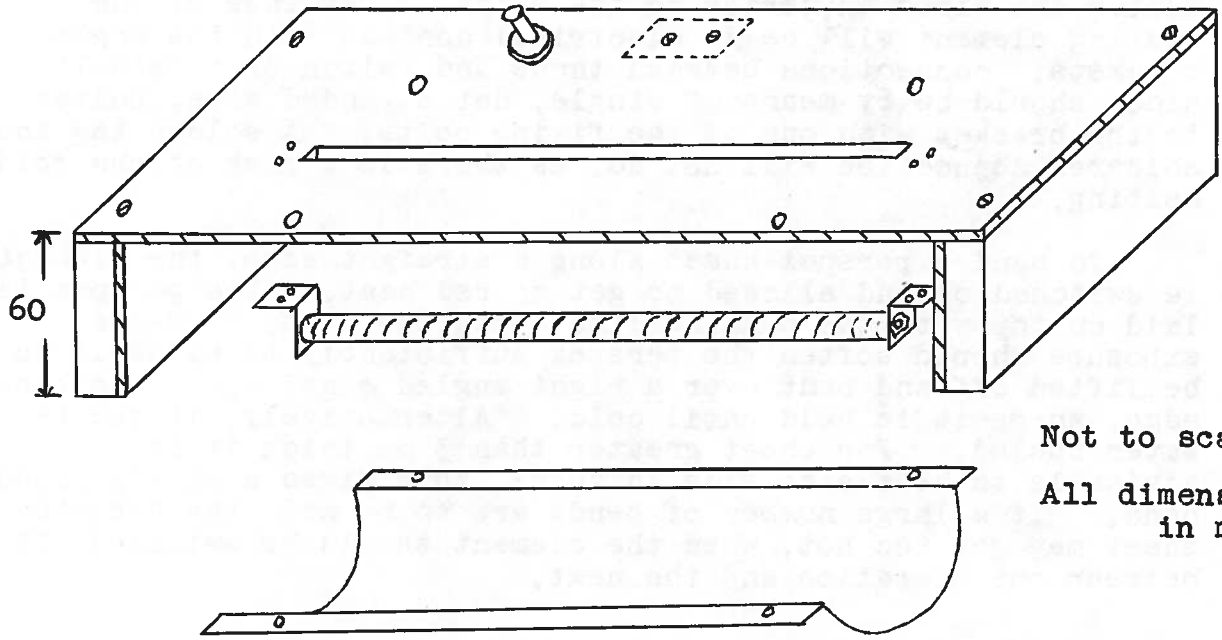


Fig. 2 Angle bracket



Not to scale.

All dimensions in mm.

Fig. 4 Assembly

This metronome is based on the oscillating advertising sign often seen in shop windows. It could be used as a short interval timing device although it is not additive, and one pupil requires to count metronome swings while the other counts the phenomenon to be measured. It is interesting as an example of energy conversion both at an elementary and at senior level. In the latter case, a discussion can be generated on how the cell is persuaded (?) to supply the additional energy needed to work continuously against friction in the pivots.

The principle of operation should be evident from the diagrams. A permanent magnet, mounted as part of a semi-circle swings through the core of a coil. As it does so it switches current into the coil so that the field of the coil interacts with that of the magnet to give the latter the necessary pull at each swing to keep the motion going. The fields are anti-parallel, and current flows when the pendulum is within about 15° on either side of the stable vertical position. Hence the descending magnet is pulled into the coil when current switches on.

Initially we constructed a model identical with the shop advertising sign, where a metal tongue attached to the pendulum wipes against a phosphor bronze spring contact, in order to do the switching action. This proved unreliable in the long-term, because the contacts became dirty, and in one or two instances they broke. We thus abandoned this in favour of a magnetic reed switch which is driven by the magnet itself. A 25 g mass which can be adjusted on the pendulum varies the frequency between 106 and 136 oscillations per minute, so that the system can be set to give a ½s period. No great accuracy is claimed for the metronome; a failing battery will give reduced amplitude of swing and reduced period, since the amplitude is too great for the period to be independent of it, as in the simple pendulum. On test, a change in applied voltage from 1.0 to 2.0V gave a change in period from 0.49(7) to 0.51(8)s. It is unlikely that a U2 cell, which will cease to operate the device when it begins to fail, will give more than a 1% variation during its lifetime. Compared with this, temperature changes have much less effect, less than 1% difference in the period between 5 and 22°C. As well as making the model described, which uses the 32 mm long magnet of the Westminster electro magnetic kit, we tried a smaller version using the magnet of the Worcester current balance kit, which is 13 mm long. This failed to work, and we found the reason to be that the magnet must be appreciably longer than the core of the coil through which it passes.

Fig 1 shows the assembly of the main parts of the model. The baseboard is a 15 mm high piece of PVC, 10 cm long, cut from the longer side of 2½" x 2" Marley drainpipe. At one end is fixed a U-bracket bent up from a 230 x 30 mm sheet of 16 SWG aluminium to give a 30 mm separation between the vertical sides. Two nylon bushes (Fig 2) fit two holes at the top of the bracket to carry the pendulum, which is a 130 mm length of brass rod 10 SWG (1/8in dia.). The coil and reed switch are both glued to the bracket in positions which are best found by trial and error. Fig. 1 shows this part of the construction.

The coil former dimensions are given in Fig. 3 . It was turned from a piece of solid tufnol rod in our case, but any method of construction, such as cementing discs of plastic on to the ends of a plastic tube, which gives the same physical dimensions is satisfactory. The coil is filled with 32 SWG enamelled copper wire, which will give about 900 turns and have a resistance of approximately 19Ω. The magnet, 32 x 6 x 6 mm is either soldered or cemented with Araldite in the symmetrical position into a semi-circle 96 mm diameter made from 16 SWG brass, copper or steel wire. This must be done after the semi-circle has been passed through the core of the coil, since the two are then linked together. The semi-circle is soldered at its centre to the upper side of the horizontal part of the pendulum shaft, so that when the shaft is in position the magnet is mid-way between the sides of the bracket. and therefore swings through the centre of the coil.

Two brass discs, 4 mm thick and 10 mm diameter are used as stops on either side of the rear limb of the bracket to keep the pendulum shaft in position. The discs were drilled and tapped for a 6BA x 1/8in Allen grub screw which locks the disc to the shaft. It is not necessary to secure the shaft in this way; two spring clips similar to, but smaller than Meccano clips could be made to serve the same purpose. A 10 mm thickness of 20 mm dia. brass rod is used as a weight to bolt on the vertical part of the pendulum shaft, in order to vary the period. A sector of this was cut away to allow a knurled screw to be fitted to lock the weight to the shaft. Again, any adequate means of locking this so that it can be easily adjusted is suitable.

The U2 cell wedges between the rear of the aluminium bracket, which acts as one electrical contact, and a bracket fixed to the rear of the baseboard. Dimensions for cutting the cell bracket, which is of 20 SWG sheet, are given in Fig 1. One fixing bolt on each of the brackets carries a solder tag for the electrical connection.

The reed switch is an R.S. Components type 4-RSR-A and it is placed horizontally on one side of the U-bracket above the coil. The height given in Fig 1 is only approximate and the best position should be found by trial and error. If the switch does not work, and a faint click can be heard when it does, it should be turned about its long axis to a new position. We fixed ours with plasticene until the best position had been found, and then glued it to the bracket. The coil is similarly wedged in the bracket until it can be located so that the magnet passes centrally through it, then it too is glued to the bracket.

As mentioned earlier, switch, coil and cell are connected in series. If the unit does not oscillate and it has been checked that the reed switch is working, then the battery should be reversed. The pendulum should swing equally well with or without the adjusting weight.

Finally it may be desirable to make the timing audible as well as visible. With an earlier version of reed switch not now obtainable from R.S. Components it was not necessary to make special provision for this, as the click of the switch was sufficiently audible in itself. The one specified is almost silent in its operation. We solved this by sealing a steel ball bearing inside a 13 mm length of brass or copper tube, 8 mm diameter, soldering thin copper sheet to each end of the tube.

The tube was then placed in a Terry clip, which had another clip made from thin copper sheet soldered to it. This last clip was a push fit on the pendulum shaft. Thus as the pendulum swings the ball rolls from end to end of the tube, clicks being made when it hits each end.

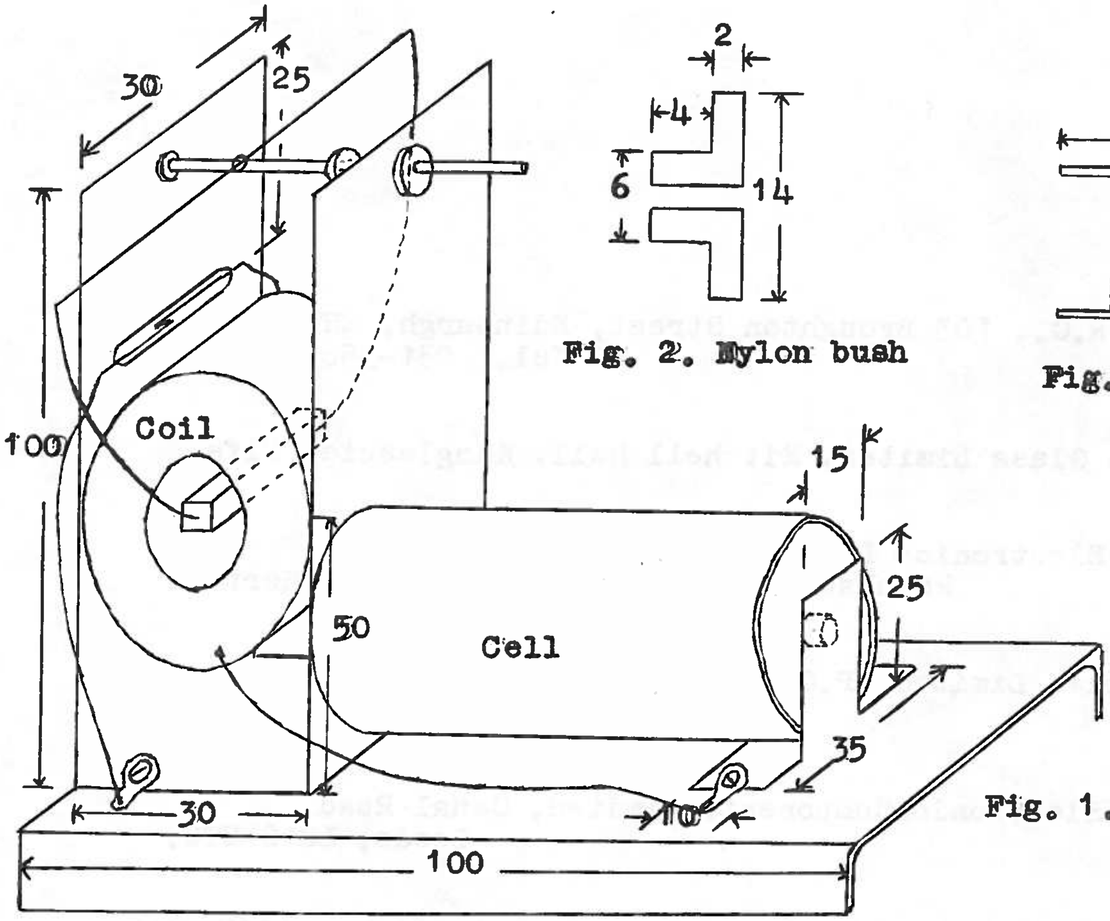


Fig. 2. Nylon bush

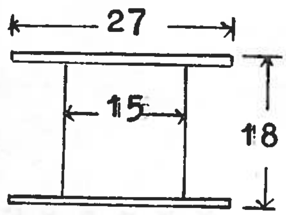


Fig. 3. Coil former.

Fig. 1. Assembly.

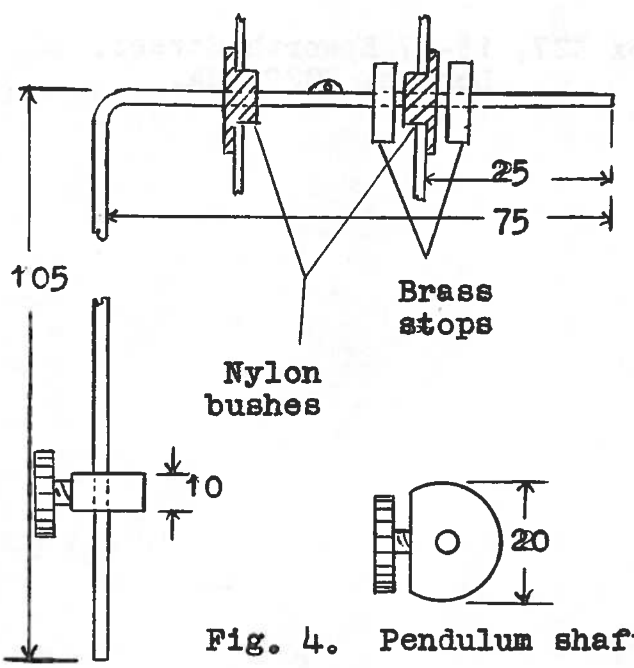


Fig. 4. Pendulum shaft.

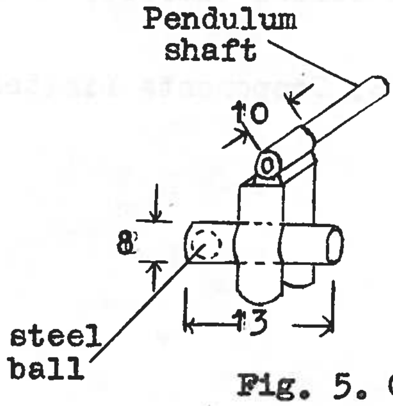


Fig. 5. Click generator.

Not to scale.
Dimensions in mm.

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

Activion Glass Limited, Mitchell Hall, Kinglassie, Fife.

Advance Electronics Limited, Calculator Division,
Raynham Road, Bishop's Stortford, Herts.

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

Farnell Electronic Components Limited, Canal Road,
Leeds, LS12 2TU.

Hurstford Limited, 12 Dalston Gardens, Stanmore, Middlesex.

R.S. Components Limited, P.O. Box 427, 13-17 Epworth Street,
London, EC2P 2HA.