SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 24.   August, 1968.

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Introduction

With this issue we have to say farewell to Mr. Dennis Belford, the Assistant Director of the Centre, who leaves us shortly to take up the appointment of Principal Teacher of Biology at Liberton Secondary School, Edinburgh. Dennis joined the staff of the Centre from Musselburgh Grammar School in December, 1965, and scored an early success with the development of his smoke cell, which we published in Bulletin 4. Since then the majority of the items which we have featured in our "In The Workshop" section have owed something to his influence, if in fact he has not been the sole originator of the idea. Two of his products, the auxanometer in Bulletin 12 and the direct vision spectroscope of Bulletin 8 have been taken up for production by manufacturers. Other designs from his fertile imagination, some already published and some promised but still to appear in future Bulletins will probably be the reason why our back numbers will continue to be eagerly sought after by those unfortunate enough not to secure a copy when the Bulletin is published. We - and here I join the staff at the Centre with the readers of the Bulletins - shall miss him very much.

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In the previous issue we gave notification of some of the exhibitions to be held in the autumn. We can now confirm these dates and give additional information on the type of exhibition being shown on the various dates. This information should benefit not only those in the vicinity of the exhibition who may visit it, but also those who may wish to arrange to visit the Centre concurrently with an exhibition. The well-known Macpherson's Law always seems to operate on these occasions so that at a time when most of the biology apparatus is out of the Centre at an exhibition, together with the staff who can most competently deal with enquiries on biology, a crowd of biologists independently decide to visit the display laboratory here. In the past there has been some unavoidable disappointment, as exhibitions have been comparatively hastily arranged - a Bulletin requires at least a month between its being drafted and its appearance in the school. We hope that the list below will go some way towards reducing the inconvenience to intending visitors. It should be borne in mind that packing and unpacking exhibits requires 2-3 days on either side of an exhibition date, and that during that time the apparatus will not be available for inspection in the display lab. On the other hand, the display lab. is always kept stocked up, different apparatus being substituted for that going on exhibition.

Type of Exhibition	Place	Date
New Syllabus Biology	Glasgow	Thu. - Fri. 12th, 13th September
Post Higher Physics	Nairn	Saturday, 28th September
General and Post Higher Physics	Kirkcudbright	Fri. - Sat. 4th, 5th October
Integrated Science Course Years I and II	Falkirk	Tuesday, 15th October
General Chemistry and Biology	Falkirk	Tuesday, 29th October
General Physics	Falkirk	Tuesday, 12th November
New Syllabus Biology	Kirkcaldy	Saturday, 30th November

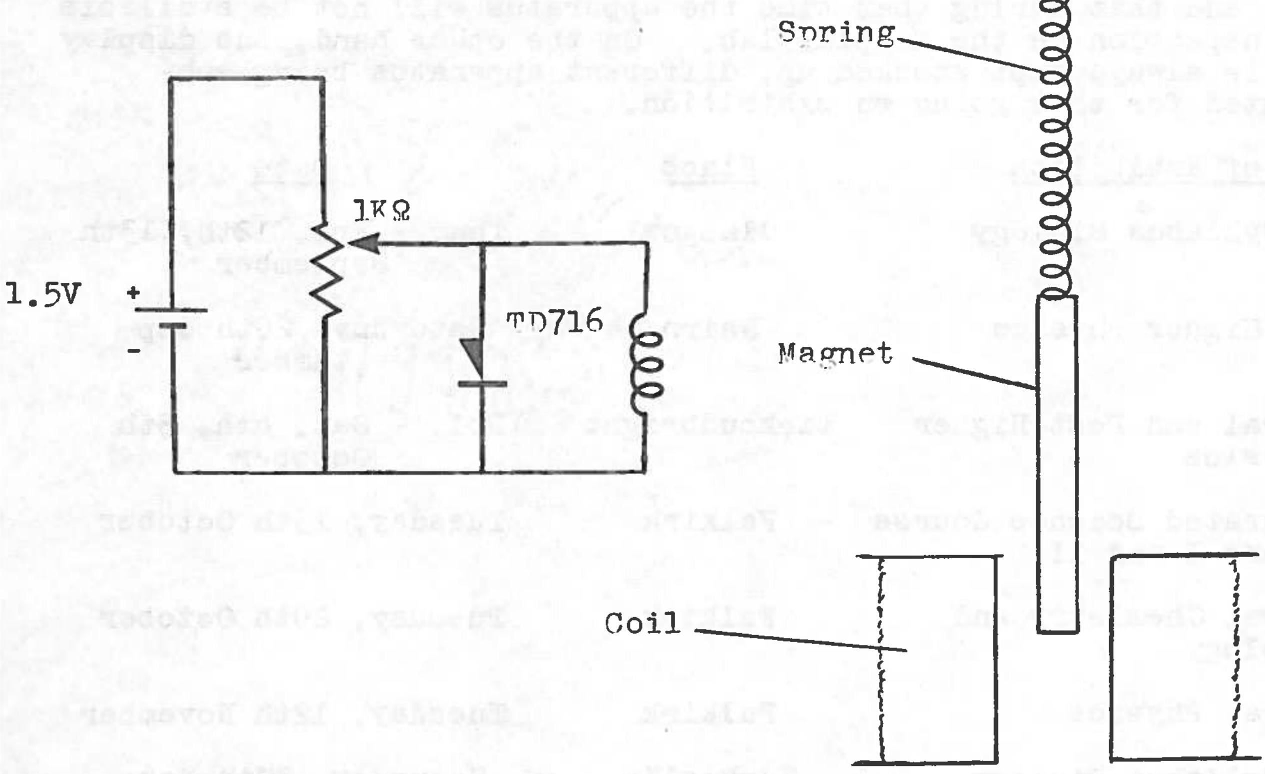
Physics Notes

Teachers seeking suitable projects for post-Higher work in the coming session are reminded of the equipment which we are prepared to lend to schools for this purpose and which was detailed in Bulletin 18. Excepting the Airmec oscilloscope and camera, and the Airmec frequency standard, all items are still available. In addition we can offer an Ericsson Telephone type 1221C five dekatron scaler, about which we have no other information at the moment.

* * * * * *

A physics project which is cheap, simple and yet bang up-to-date can be found in the tunnel diode oscillator. The TD716 tunnel diode, which operated at about 5mA current is obtainable from L.S.T. Components for 12s. Tunnel diodes exhibit negative resistance over one part of their characteristic, i.e. the current through the diode decreases when the P.D. is raised, and this enables them to be used in the simplest oscillatory circuits, one of which is sketched below. When the bias current has been correctly set by the potentiometer, the magnet once started will bob up and down continuously at the resonant frequency determined by the spring. Our coil was wound with approximately 2,000 turns of 34 S.W.G. enamelled copper wire on a former whose only critical dimension is the diameter of the central hole. This must be large enough to allow freedom of movement to the magnet. The coil resistance and inductance were 100Ω and 100mH respectively. It is probable that coils wound with thicker gauge wire to give a lower resistance for the same inductance would give less critical bias adjustment. The magnet used was KN654 from E.J. Arnold.

Tunnel diodes of course are not limited to operation at mechanical frequencies only. If a series tuned circuit is inserted in place of the coil of our diagram, the frequency may be pushed up to 10^9 Hz. A very good account of the theory of the tunnel diode, as well as of other semiconductor devices will be found in Physical Electronics by R.L. Ramey, published by Prentice-Hall International at £2.10s.



High Voltage Power Supplies

When the programme of testing power supplies was laid down there was a need for a high voltage power unit to be used in connection with electronic valves. Since then Circular 490, which specifies the syllabus for the S.C.E. Alternative Physics, has been revised and one of the topics which it is proposed to omit is the triode valve. The need for a high tension power supply has therefore diminished, except where valve work is being undertaken in post-Higher projects, or the chemistry department require it for electrophoresis.

The H.T. power supply which most manufacturers provide has been designed to meet the specification for Item 15 of the Nuffield Physics Project list. This calls for two continuously variable outputs of 250 - 300V D.C. and -25V at 60mA maximum current, together with two 6.3V A.C. outputs for heating filaments, maximum current unspecified. Output voltage must be smoothed to 1% at 50mA.

The units we have examined to date are Advance Electronics PP13; Griffin and George GN15; Philip Harris P7996; Labgear D4160; W.B. Nicolson 70/1531; and Unilab 022.321. All of these except the first, which was not in production at the time, were approved by Nuffield in June, 1966, the last publication we have on approved apparatus. We should, however, point out that most of the units have undergone modification since the date of their approval by Nuffield. The results of tests on some of these models are summarised in the Supplement to this issue; others will follow in a later Bulletin.

All the units examined meet the Nuffield output specifications; most exceed them by providing either higher voltage or current, or both. The Nuffield ripple specification is comparatively lax; a radio set operating with 1% ripple on the H.T. supply would have objectionable hum, and in fact all the models examined give fundamental R.M.S. ripple voltages at least one order of magnitude smaller.

The majority of the units use double pole switching on the mains, and all have a neon indicator wired across the mains transformer primary. Most units also have a mains voltage selector plug; two of these, the D4160 and 022.321 incorporate the mains fuse in the plug. Besides being an uncommon location for the mains fuse, and using a fuse size which is not an A.S.E. recommended standard, this has the disadvantage that the selector plug must be readily accessible to the teacher for changing the fuse, making it as accessible to pupils to change the input voltage tapping. As the D4160 has a tapping for 110V the could be disastrous.

All the power units tend to under protect the circuits by using an output fuse of too high a rating. It is worth pointing out that the common glass catridge fuse will tolerate a 50% overload for a period of an hour or longer. We may thus find a unit which on maximum power draws ½A from the mains protected by a 2A fuse so that due to a fault either inside the power supply or on the load, a mains current of 3A, or 500% overload, could be drawn for an hour before the fuse acted. This standard of fusing is effective only against a very serious fault such as a direct short on the main transformer. While the D.C. outputs from the unit are separately fused, only one, the P7996 fuses the 6.3V A.C. outputs. With the remaining units a direct short of one A.C. output using a double thickness of 20 S.W.G. copper wire, failed in every case to blow the mains fuse. Fortunately the majority of manufacturers/

manufacturers have accepted our recommendation to fit a 1A anti-surge fuse in this position, and it is this type which we recommend be substituted for the existing fuse in power units already in schools.

All the units use bridge-connected semi-conductor diodes to rectify the high voltage supply; for the low voltage D.C., bridge full wave and half wave connections are to be found. In most cases the smoothing is the conventional Π network of two capacitors and inductance. Two models, the D4160 and PP13 provide voltage stabilisation on both D.C. outputs, using a valve and transistors. This gives better regulation; i.e. the output voltage of the unit is less dependent on load current. In addition the D4160 is stabilised against mains voltage fluctuation. Using voltage stabilisation the output voltage is controlled at a low power level by varying the voltage applied to a grid of the valve, or by adjusting base current in a transistor.

Two other forms of voltage control of the H.T. are to be found. The simplest and cheapest is a wire-wound potentiometer across the output. This, however, has the disadvantage that the potentiometer may have to dissipate considerable power in that section of its winding which is carrying the load current. To examine behaviour under these circumstances we connected a milli-ammeter across the output, then adjusted the voltage control to give the maximum specified current. In two cases this produced sufficient heat to make the varnish smell, but otherwise produced no ill effects.

The third method of voltage control is by variable transformer, and is more expensive since it requires the provision of two further transformers, one for the H.T. supply which has its input controlled by the variable, and one to provide the other outputs and which must be operated direct off the mains. These three types of control we have listed in the Supplement as electronic, potentiometer and variable transformer respectively.

All units except those with voltage stabilisation i.e. the PP13 and D4160 have all outputs isolated from each other and from earth. The PP13 has a common zero volts terminal for its two D.C. supplies, but is isolated from earth. The D4160 is similar, but earths the zero volts termination. This introduces the hazard that if the 25V supply is being used to power a transistor circuit, for which it is very suitable, in conjunction with other mains operated equipment such as oscilloscopes, faulty earthing on the auxiliary equipment could ruin both transistors and power supply.

An output voltmeter is an optional extra which, together with dual range switch. appears on all models except the D4160 and P7996. While a meter is a convenience and possibly an essential for project work, in a demonstration experiment even the largest meter used is useless for pupil visibility. While all the meters can measure either D.C. output using the range-switch, only the 70/1531 has an additional switch position allowing the meter to register output current on either range. Unfortunately our tests showed this range to measure 25% low. The manufacturer's explanation is that a wrong shunt had been supplied them, and an unknown number of such power units have been supplied to customers. Teachers with this model, also listed in catalogues as K95/1070 and N7/1531, are advised to check the accuracy of the current ranges on their model. If the shunt has this fault, the manufacturer will replace it with the correct value free of charge.

In testing the power units the mains input was adjusted by variable/

variable transformer to 240V. Regulation curves for the maximum and several other settings of the output control were taken for both D.C. outputs up to the maximum specified current and are reproduced in the individual reports. Voltages across the A.C. outputs were measured on open circuit and at the maximum specified current. The ripple voltage, i.e. the residual sawtooth A.C. which appears on the output as a result of the periodic nature of the charging process on the capacitors, was measured with a calibrated oscilloscope as a peak-to-peak value, and converted to an equivalent R.M.S. value at the fundamental frequency of 100Hz. The reports give the ripple in mV at maximum voltage for various load currents.

As explained earlier, we also examined the effect of feeding the maximum specified current into a low resistance load represented by a milliammeter, using thermo-couples on output potentiometers to determine how hot they would become on continuous load. This could not be done with the D4160, which uses a magnetic cut out in place of fuses to protect both D.C. supplies. Under our load conditions the cut out operated at about 50% of the maximum permissible current.

The accuracy of the output meter was checked on both ranges, using a digital voltmeter accurate to 0.2%. The reports specify the maximum meter error found over each range. We also considered it worth while to measure the decay time constant of the supply. Smoothing capacitors which retain their charge for some time after a unit is switched off can give a nasty shock to anyone touching the terminals or their associated load, and we consider the maximum safe time constant, after which the voltage will have dropped to 37% of its original value, to be 3 - 4s. Some power units were found to have decay time constants 2 - 3 times this value.

Our reports give the circuit diagram of each supply, excluding the switching arrangements associated with the output meter. The majority of the units have the circuit diagram pasted to a panel on the unit, either at the rear or underneath.

Chemistry Notes

The Vuespec spectrometer, produced by Morris Laboratory Instruments has aroused considerable interest during last session, having been widely exhibited and demonstrated at teacher meetings throughout the country. Unfortunately the impression seems to have got around that the auxiliary apparatus, i.e. motor drive and pen recorder, required to make full use of the spectrometer is going to cost considerably more than the spectrometer itself. Arguments are being advanced that a pen recorder is a valuable general purpose tool and can be used equally well with other instruments. With this we would agree, but most of the alternative uses suggested for the recorder appear to be in sixth year chemistry, i.e. concurrent with its use on the spectrometer.

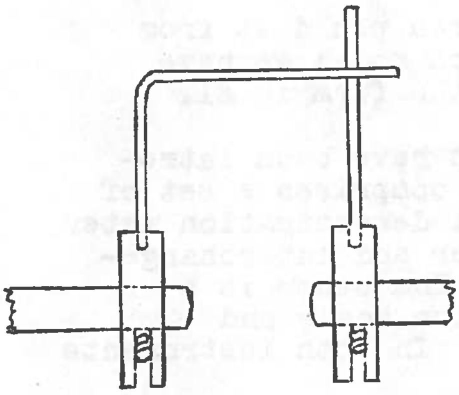
The purpose of this note, however, is not to discuss whether or not to purchase a recorder, but to point out that equipment which in our view is adequate for the purpose, already exists in the/

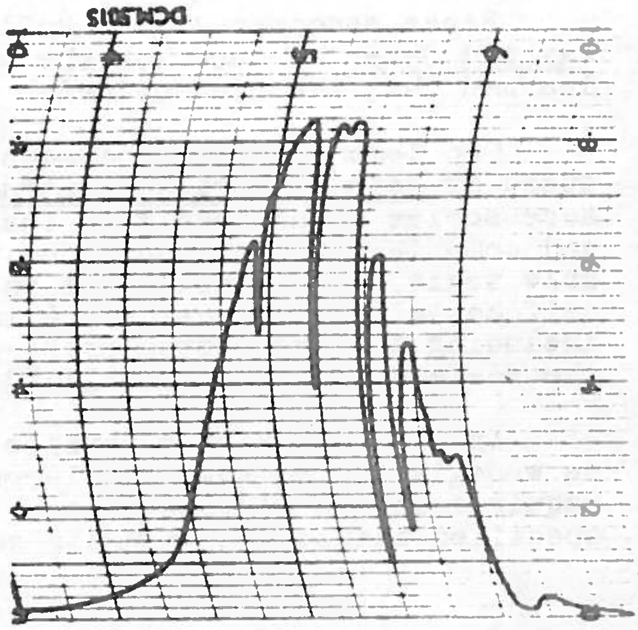
the surplus market at prices far cheaper than the £15 suggested for a motor, and £110 for a suitable pen recorder. Our own tests were carried out using a Vuespec lent to us by Moray House College of Education, to whom we are indebted. We used an Elliot pen recorder already in the Centre, which is still available from Z and I Aero Services Ltd., costing £40.15s. inclusive of packing and carriage. This has a full scale deflection of 1mA, and chart speeds of 1 inch and 6 inches per hour. The chart paper is 3 inches wide and is ruled in curves to take account of the fact that the pen operates in an arc of about 13cm radius. It can be bought under catalogue number DCM5015 at 15s.9d. per roll from A. Gallenkamp.

A very similar pen recorder, using the same paper but with a chart speed of 12 inches per hour, which in some ways is more convenient, and with clockwork instead of mains drive, is currently available from Service Trading Co. for £15.5s. inclusive of carriage. This recorder we have seen but not used.

To obtain a profile of an organic compound in 1 - 2 hours using these recorders, a motor with final speed in the region of 1/5 to 1/10 r.p.m. is necessary. (If between 1 and 2 hours is too long a period to wait for a result, then the teacher must pay for the saving in time. The expensive pen recorder is expensive because of the high writing speed of which the pen is capable). Two surplus motors, adapted to drive the micrometer screw of the Vuespec have been tried successfully. One is catalogue number 3144 price 17s.6d. from K.R. Whiston, who has over 70 motors in stock. Teachers buying this motor will find that one of the pin wheels driving a lever arrangement has the correct final speed, and the remainder of the gear wheels must be removed to enable a drive to be taken from this wheel. Anyone who is in doubt should consult us concerning this adaptation. The other motor is a type MA23 hysteresis motor from Electronic Brokers, costing £1.5s. These are obtainable in a number of final speeds of which 1/5 and 1/10 r.p.m. would seem to be most suitable. Other information on this motor can be got from the firm's advertisement in Wireless World, July 1968, p.71.

As with any motor it will be necessary to couple it to the micrometer screw in a fashion which not only rotates the screw at a steady speed but also allows it freedom of axial movement so that it may be screwed in or out without dragging the attached motor along the bench. The movement to be expected for a complete profile can be greater than 1cm so that a straight coupling, even with rubber tubing, is out of the question. In any case the flexibility of the tubing gives rise to a jerky operation of the screw, unless the two axes are very well aligned. We have found suitable the coupling sketched on page 7, which consists of a bent arm rotated by the motor bearing on a straight arm attached to the screw. It has the advantages that neither motor nor screw are subject to off-axis stress, and it can accommodate slight misalignment of the two axes so that the motor may be simply rested on the bench. The sketches are largely self-explanatory. Two discs are drilled to fit the shafts of motor and screw; for the latter the micrometer ratchet is first removed. If the discs are carefully drilled they can be simply push-fitted on to the shafts although a locking grub screw in each is preferable. The lever arms are 2mm steel or brass rod, soldered or brazed into the side of the disc. No dimensions have been given since none are critical, the only requirements being that the horizontal section of the motor arm should be about 2cm, and the whole should be small enough to prevent its fouling any part of the spectrometer when the screw is turned fully home.





Above: Coupling between motor and micrometer screw shafts.

Right: Profile of chloroform obtained with the equipment described. Time 30 mins.

Trade News

Microwave Systems have been appointed exclusive agents in Scotland for Cossor Instruments.

A Griffin and George scaler/timer now on the market costs £60, cat. No. L91-206. The timing facility can be controlled by the photo-electric control unit which we described in Bulletin 12 in both senses, i.e. counting when illuminated or when blacked out.

New from Philip Harris is a pH meter with electrode for £32.10s. Scaled 0 - 14 in steps of 0.2pH, the meter can also be used for Redox measurements.

An oscilloscope camera, based on the Polaroid Land system and using Type 20 film has been made by the firm of D. Shackman and Sons. Supplied with a fitting cone the camera costs £19.10s. In a sample print which they display there is some distortion of the image at the edges, which they claim is limited to 15% or less. Model Junior A fits the Telequipment S51E; Junior B fits Advance OS15 and OS25.

Graduated Pyrex beakers in sizes from 5ml to 5l are now being produced by James Jobling at no extra cost over the ungraduated alternative.

Prices of equipment from Edwards High Vacuum have recently risen. The educational EQ4C kit, comprising rotary and diffusion pump, base plate and bell jar assembly now costs £140. The accessories kit for 20 experiments in low pressure physics now costs £50. Elesco Fraser are agents for Edwards equipment in Scotland.

Since recommending in Bulletin 21 that iron pin dust from May and Baker be used for the mass spectrograph model we have learned that the minimum order acceptable to the firm is £1.

Two demonstration thermometer instruments have been introduced by Weir Electrical Instrument Co. One comprises a set of accessories to be used with their 9" Multidial demonstration meter, and comprises thermistor probe, meter amplifier and interchangeable scale. The total cost is £14.11s.3d. The other is a self contained unit using a 6 inch demonstration scale and including the thermistor probe costs £17.5s. In both instruments the scale range is -5 to +120°C.

In the post-Higher physics equipment list in Bulletin 19 we wrongly stated that the large C core from Unilab, Item 44, was required for the ½H inductor. The latter has in fact the specified inductance when air-cored.

Display Laboratory

The following items have been added to the display laboratory since this section was last included in Bulletin 22.

Item	Manufacturer
Wave Machine	SSSERC
Electron Shell Model	SSSERC
Reaction Kinetics Model	SSSERC
Doppler Effect	SSSERC
Tunnel Diode Oscillator	SSSERC
Polar Molecules Experiment	SSSERC
Student Kymograph	S.R.I.
Car Electrics Model	Lucas
Physics Apparatus Kit	Serinco
SN3D Balance	Stanton
Coulomb Law Apparatus	Philip Harris
Direct Vision Spectroscope	Philip Harris
Standard Capacitance Box	Jay-Jay
4D DiaZoom Microscope	Myacope
Double Demonstration Eyepiece	Myacope
Half Skeleton	Adam Rouilly
Model Eye	Adam Rouilly
Plastic Anatomical Charts	Adam Rouilly

In The Workshop

Some teachers may have been discouraged from constructing the solar motor which we published in Bulletin 8 by the need to construct the bearings and to balance the motor carefully. The floating alternative on page 9 has been designed in Frederick Street Secondary School, Aberdeen, and requires little more than a cutting knife and soldering iron in its construction.

Wind approximately 750 turns 30 S.W.G. enamelled copper wire on a cottom reel. With an elastic band, strap two selenium cells - Type 1 from <u>Proops Brothers</u> at 5s each - face outwards, one on each end of the reel, and connect up as in Fig. 1. Mark out a 10cm diameter circle in expanded polystyrene, 2cm thick and cut with a trimming knife or other means. Push fit a short length of glass tube half-way through the disc at the centre of one side; on the other side, and also centrally placed, cut two slots to locate the shorter sides of the selenium cells so that they fit to a depth of 2-3mm. A wire or nail fixed with plasticene to the bottom of a glass dish and passing up into the glass tube stops the floating motor from wandering. The motor will rotate in normal classroom conditions if placed between the poles of two bar magnets.

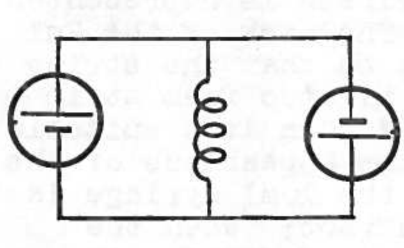


Fig. 1. Circuit

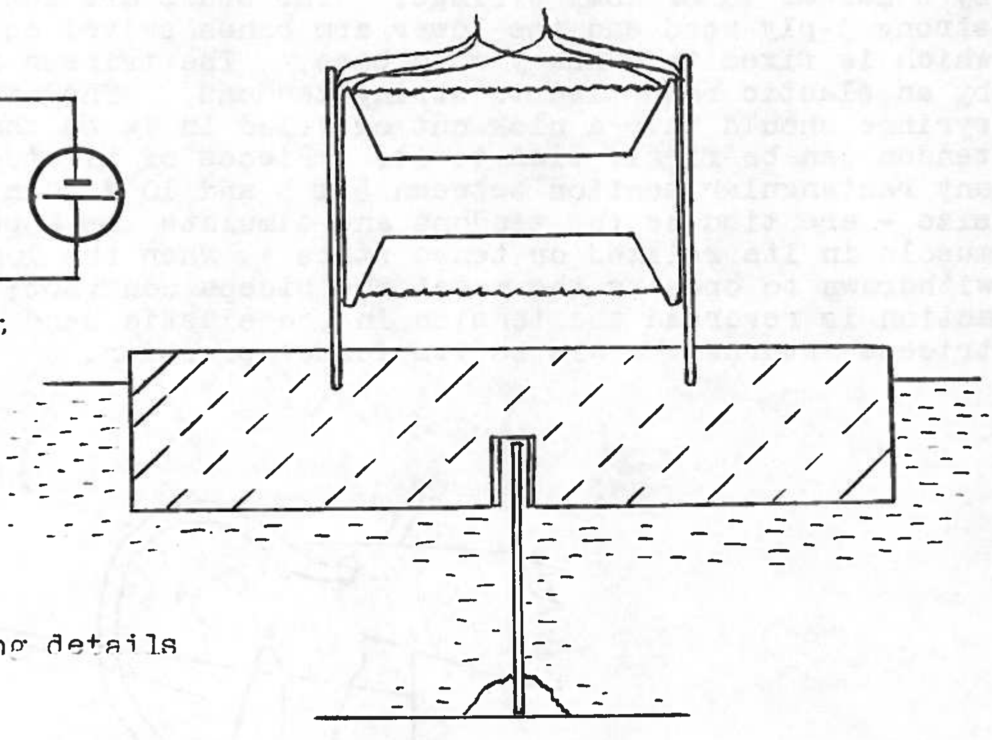


Fig. 2. Mounting details

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A statistics frame for displaying the results of class experiments is one of the items produced by the Nuffield Physics Project. It consists of a vertical board with slots to take brass penny-size discs so that a histogram of results could be built up to determine the most probable value say for the density of a material. Another similar item for combining class results is the Nuffield graph plotting board, consisting of a transparent or translucent sheet with square ruling on to which results are plotted with chinagraph pencil.

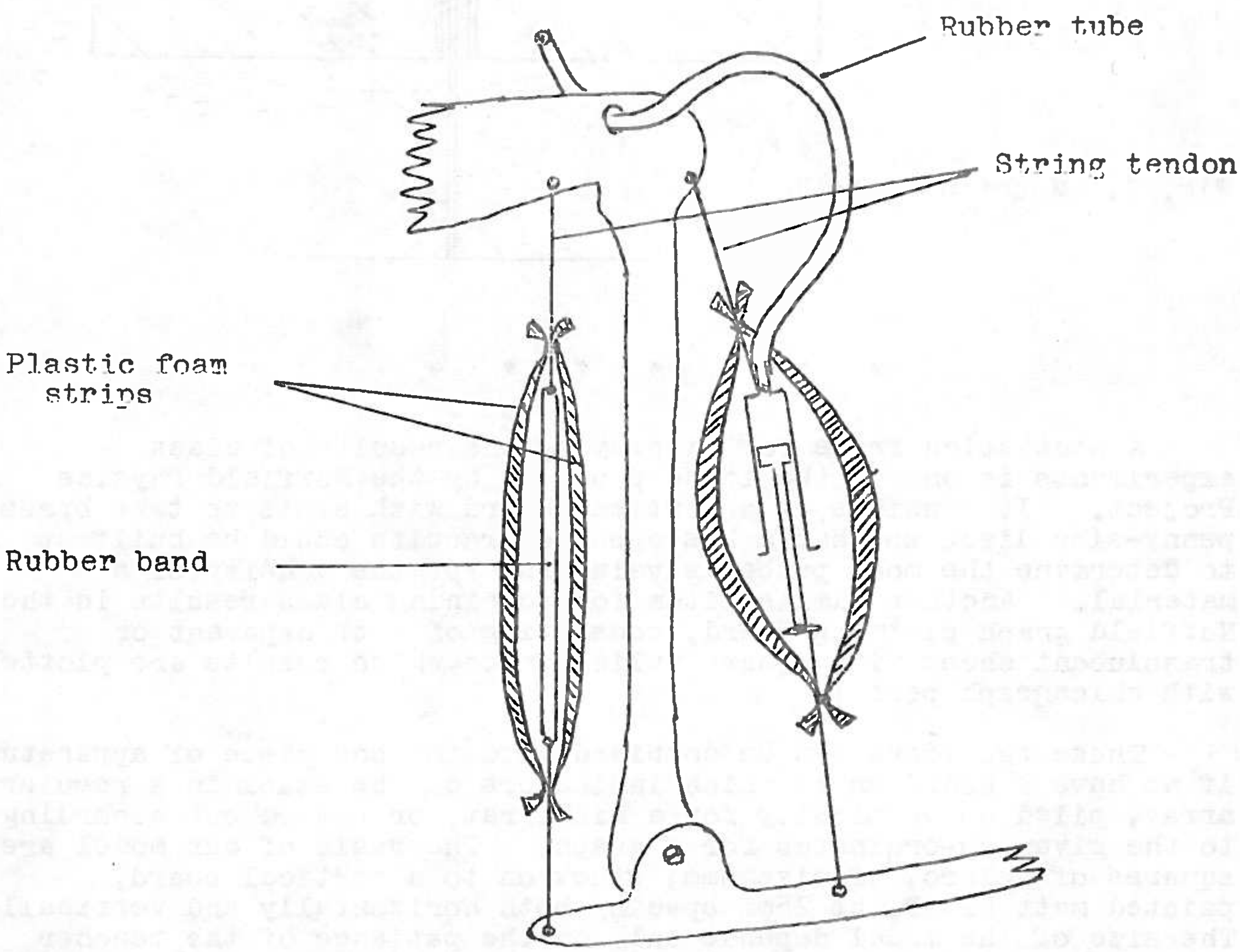
These two ideas can be combined into the one piece of apparatus if we have a board on to which indicators can be stuck in a regular array, piled up vertically for a histogram, or spaced out according to the given co-ordinates for a graph. The basis of our model are squares of Velcro, of size 5mm, stuck on to a vertical board, painted matt black, at 25mm spacing both horizontally and vertically. The size of the model depends only on the patience of the teacher or technician who has to stick all the small squares of Velcro on to the board. Our own version was made of plywood 40 x 40cm with an array of 12 x 12 squares. The board needs 10cm wide edges around the array so that the graph axes can be drawn and enumerated.

The/

The indicator discs are 15mm circles cut with a cork-borer from polythene detergent bottles, each having a square of the opposite type of Velcro stuck on the outside bottle face of the disc, so that the white inside face is presented for viewing. When pressed on to the plotting board, the two Velcro pieces adhere, but can be easily pulled off. Two pieces of wood, slotted to take the plywood sheet, make supporting feet and complete the model.

* * * * * * *

A realistic working model of the forearm which is an improvement on that described in Bulletin 13 employs a 2ml disposable syringe which represents the biceps and is connected to and operated by a larger 10 or 20ml syringe. The bones are cut from 5- or strong 3-ply wood and the lower arm bones swivel on the humerus which is fixed to a heavy wood base. The triceps is represented by an elastic band tied to string tendons. The neck of the 2ml syringe should have a nick cut or filed in it so that the string tendon can be firmly tied to it. Pieces of plastuc foam strip - any rectangular section between 5 x 5 and 10 x 10mm is a suitable size - are tied to the tendons and simulate the appearance of the muscle in its relaxed or tense state. When the 10ml syringe is withdrawn to operate the model the biceps contract; when the action is reversed the tension in the elastic band forming the triceps returns the arm to its former position.



Bulletin Supplement

Below is a summary of the results of tests carried out on high voltage power supplies. For reasons of space, only some models are included; the remainder will be summarised in a future Bulletin. Individual reports on these models can be borrowed by writing to the Director. The classifications used are: A - most suitable for school use; B - satisfactory for school use; C - unsatisfactory.

Model No.	GN15	022.321	PP13	70/1531
Supplier	Griffin and George	Unilab	Advance Electronics	W.B. Nicolson
Price	£22. -. -.	£32. -. -.	£28. -. -.	£43.10. -.
High Voltage Control	Potentiometer	Potentiometer	Electronic	Variable Transformer
Maximum outputs at zero current	390V D.C. 38V D.C. 2x6.8V A.C.	517V D.C. 80V D.C. 2x6.2V A.C.	332V D.C. 26V D.C. 2x6.6V A.C.	473V D.C. 87V D.C. 4.1, 6.6 and 13.2V A.C.
Maximum Current	60mA D.C. 2A A.C.	100 and 50mA D.C.* 3A A.C.	60mA D.C. 2A A.C.	50mA D.C. 2A A.C.
Outputs at maximum current	320V D.C. 35V D.C. 6.5V A.C.	425V D.C. 49V D.C. 6.0V A.C.	300V D.C. 25.7V D.C. 6.3V A.C.	393V D.C. 73V D.C. 3.9, 6.2 and 12.3V A.C.
Output Meter	0-400x10V	0-500x10V	0-300x2V	0-500x10V 0-50x1mA
Meter Error	3%	6%	4%	25%**
R.M.S. ripple at full load	11mV	200mV	86mV	130mV
Assessment	A	B	A	B

* 100mA on HT, and 50mA on LT

** See explanation on p.4.

S.S.S.E.R.C., 103 Broughton Street, Edinburgh, 1. Tel 031-556 2184.
Advance Electronics Ltd., Roebuck Road, Hainault, Ilford, Essex.
E.J. Arnold and Son Ltd., Butterley Street, Leeds, 10.
Cossor Instruments Ltd., The Pinnacles, Elizabeth Way, Harlow, Essex.
Edwards High Vacuum Ltd., Manor Royal, Crawley, Sussex.
Electronic Brokers Ltd., 8 Broadfields Avenue, Edgware, Middlesex.
Elesco-Fraser Ltd., 36 St. Vincent Crescent, Glasgow, C.3.
Ericsson Telephones Ltd., Beeston, Nottingham.
A. Gallenkamp and Co. Ltd., Portrack Lane, Stockton-on-Tees.
Griffin and George Ltd., Braeview Place, Nerston, East Kilbride.
Philip Harris Ltd., St. Colme Drive, Dalgety Bay, Fife.
James Jobling and Co. Ltd., Wear Glass Works, Sunderland.
(Jay-Jay) Educational Measurements Ltd., Brook Avenue, Warsash, Southampton SO3 6HP.
Labgear Ltd., Cromwell Road, Cambridge.
L.S.T. Components, 7 Coptfield Road, Brentwood, Essex.
Joseph Lucas Ltd., Great Hampton Street, Birmingham, 18.
May and Baker Ltd., Dagenham, Essex.
Microwave Systems Ltd., Bryans, Newtongrange, Midlothian.
Morris Laboratory Instruments Ltd., 96-98 High Street, Putney, London, S.W.15.
(Myacope) Butterworths Ltd., London Road, Meadowbank, Edinburgh, 7.
W.B. Nicolson Ltd., Thornliebank Industrial Estate, Glasgow.
Polaroid (U.K.) Ltd., Queensway House, Queensway, Hatfield, Herts.
Proops Brothers, 52 Tottenham Court Road, London, W.1.
Adam Rouilly, Shropshire House, 179 Tottenham Court Road, London, W.1.
(S.R.I.) Scientific and Research Instruments Ltd., 335 Whitehorse Road, Croydon, Surrey.
Serinco Ltd., 6 Swan Place, Glenrothes, Fife.
Service Trading Co. Ltd., 57 Bridgman Road, London, W.4.
D. Shackman and Sons Ltd., Mineral Lane, Chesham, Bucks.
Stanton Instruments Ltd., Copper Mill Lane, London, S.W.17.
Telequipment Ltd., 313 Chase Road, Southgate, London, N.14.
Unilab Science Teaching Equipment, Clarendon Road, Blackburn, Lancs.
Weir Electrical Instrument Co. Ltd., Bradford-on-Avon, Wilts.
K.R. Whiston, New Mills, Stockport, Lancs.
Z. and I. Aero Services Ltd., 44a Westbourne Grove, London, W.2.