SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 3. February, 1966.

Foreword

by Mrs. Judith Hart, M.P., Joint Parliamentary Under Secretary of State for Scotland.

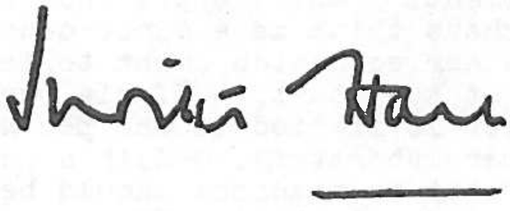
Just a quick glance around the Centre would be enough to stagger parents used to the days of bunsen burners and litmus paper. For the exciting array of wind tunnels, light measuring devices, thunder simulators and even a laser ray illustrate in dramatic fashion what rapid progress is being made in the scientific education of Scottish schoolchildren.

The new science syllabuses of Scotland have over the past three years become the normal courses for almost all schools. Our children are being given the opportunity to explore the wonders of the world of today. And the task of this Centre is to ensure that the equipment they use is up-to-date, right for the job and value for money.

This is no easy task, involving as it does a partnership of teachers, manufacturers and education authorities in developing equipment of novel and ingenious design which will open up for our new-look generation of pupils the fascinating field of scientific discovery.

Until one has visited the Centre it is hard to realise how stimulating and absorbing is the whole business of research and testing. I was certainly tremendously impressed during my visit by the enthusiasm of the Director, Mr. J. R. Stewart, and his staff in meeting the challenge which faces them. I earnestly hope that teachers will take every opportunity of calling there. I am certain they will be heartened by the backing which is being given to their new classroom ideas.

My best wishes!



Development Committee. This has been formed to advise the staff of the Centre on the testing programme, on the standards and requirements of the apparatus being tested, and to assist where necessary with field trials of apparatus. The membership is as follows:

Chairman:	Professor W.H.J. Childs, Heriot-Watt College, Edinburgh.
Secretary:	J.R. Stewart, Director, SSSERC.
Members:	
Biology:	Miss A.K. Hetherington, Whitehall Secondary School, Glasgow, E.1.
	Mr. J. Haddow, Morgan Academy, Dundee.
	Mr. S.S. Skillen, H.M.I., Glasgow.
Chemistry:	Mr. J.D. Gallaher, The Academy, Dumfries.
	Mr. W.A. MacKenzie, The Academy, Peterhead.
	Mr. A.J. Mee, H.M.I., Edinburgh.
Physics:	Mr. R.B. Dunphy, Allan Glen's School, Glasgow.
	Mr. R.H. Graham, Dalziel High School, Motherwell.
	Mr. W.R. Ritchie, H.M.I., Edinburgh.

The major part of Bulletin No. 4 will be given over to a review of apparatus, both manufactured and members', shown at the Annual Meeting of the Association for Science Education held at Cambridge from 28th to 31st December.

We apologise to members who may have been inconvenienced, and to the firm themselves, for omitting the address of James Scott (Electronic Agencies) Ltd. from Bulletin No. 1. This is given in the address list in this Bulletin.

Opinion

Since assuming the post of Director of an organisation the function of which is to advise teachers on the use of scientific apparatus I have thought almost continuously about the functions which the equipment must fulfil. Ignoring for the moment the specialist demands of post-Higher work, the use of equipment would appear to fall into the two categories of teacher demonstration and pupil experimentation.

This distinction seems to me so important that no manufacturer ought to set out on the development of a new product without first asking himself whether he is aiming at teacher demonstration or pupil experiment. Quite apart from satisfying his customers, which some teachers think is a minor consideration with a manufacturer, sheer economics ought to lead him to make this decision right at the start. If his product is a demonstration piece, his market is limited to one per school or perhaps if he is lucky, one per laboratory. With a pupil apparatus the minimum requirement in a school should be between six and ten, and there may be schools taking 50 or more. Yet even in the face of this distinction I am continually being surprised by firms' representatives who, trying to interest me in a new product, cannot/

cannot give a straight answer to the question "Who is going to use it; teacher or pupil?"

In Bulletin 2 I attempted to set out criteria for demonstration apparatus, the main one being that it must be large enough for all to see. I repeat this even at the risk of boring the reader, because it appears to be an elementary criterion which is too often forgotten by both manufacturer and teacher.

The only way in which small scale apparatus can be made suitable for demonstrating to pupils would appear to be by using magnification aids such as overhead projection or CCTV, both somewhat expensive and not always suitable for the purpose.

In passing it should be noted that although a change in design from pupil apparatus to teacher demonstration usually increases the cost of the article, it does not follow that the demonstration equipment is necessarily better. In fact it may sometimes be worse, as I pointed out in the case of moving coil voltmeters in Bulletin 2.

Pupil equipment needs to be robust and it needs to be cheap. If it cannot be both, and frequently the two requirements are in conflict, then I would place cheapness before robustness, to the point of making the equipment semi-expendable. Teachers require to condition themselves to the idea it may often be sound economics, and sound teaching to throw away and immediately replace a defective part rather than mess around with a long and costly process of repair, costly not only in £.s.d., but in the time for which the equipment is out of use. Manufacturers with an eye to the future tell me that it will not be long before all the complex electronic circuitry at present obscuring the teaching of physics will be replaced by plug-in modules interconnectable so as to produce any required function.

While the chemists have long accepted the principle that glassware is semi-expendable, the physicists may be more reluctant to apply the same principle to their equipment. I suggest they make a start with pupil resistors and meters. Regarding the former, I indicated in Bulletin 2 that a suitable resistance could be obtained from <u>Radiospares</u> for as little as 3½d., and made up for pupil use. <u>Mullard</u> Educational Service Design No. 14 shows how this idea can be extended to make resistance boxes. None of these cost very much and are a good use of a laboratory technician's time.

In the meter field, Japanese panel-mounting, moving-coil meters are available for as little as 21/- in a variety of current and voltage ranges. The most ready source of supply is probably <u>G.W. Smith and Co</u>., advertising in Wireless World, although there are Scottish importers. These instruments have already been used to good effect in Allan Glen's School and St. Mungo's Academy, Glasgow in the teaching of Sections 10 and 11 of the alternative syllabus. At this price a teacher can afford to mark down his meter stock by 30% each year, giving it an expected life of some 3 years, and still be in pocket compared with his colleague who buys the next cheapest equivalent meter e.g. the <u>Weir Electrical Instrument Co</u>. range at £3.15/-.

Once again, the choice for the teacher lies between the ready-to-use but expensive instrument, or the cheaper version which must be assembled for pupil consumption by a laboratory technician. If he has no technician he must of course buy dear - or use this argument as a lever on his local authority to get laboratory technicians in the schools.

Display Laboratory

We are rapidly building up a stock of display material to such an extent that it is now no longer possible to put all items on display at once. This is our intention, so that we can change the contents of the laboratory periodically, and teachers who visit us regularly can be assured of seeing something new. We are also very conscious of the fact that material on the chemistry side is woefully sparse, and are making efforts to build this up. Teachers wishing to see a particular item which has not been listed here or in Bulletin 2 should write or telephone in advance of their visit.

The following items have been removed from the display laboratory:

Item	Manufacturer
Westminster Electromagnetic Kit	Philip Harris
Micro-balance kit	Philip Harris
Electrostatics kit	Philip Harris
Solid Materials kit	Philip Harris
Crystals kit	Philip Harris

The following have been added since Bulletin 2;

Item	Manufacturer
Kidney Model	S.S.S.E.R.C.
Musselburgh Smoke Cell	S.S.S.E.R.C.
Hall Effect Apparatus	Unilab
OS15 Oscilloscope	Advance Electronics
Whitley Bay Smoke Cell	Philip Harris
Whitley Bay Smoke Cell	W.B. Nicolson
Gas Chromatography Apparatus	Griffin and George
Ionisation Chamber	Philip Harris
Thoron Generator	Philip Harris
Power Unit for e-m Kit	Philip Harris
Demonstration Meters	Andrew H. Baird
Demonstration Transformer Kit	Andrew H. Baird
Fluid Flow Model	Andrew H. Baird
Rotary Resistor	White Electrical
Dynamics Carts	Philip Harris
Ticker Timer	Philip Harris
Bourdon Gauge	Philip Harris
Edinburgh Smoke Tunnel	Philip Harris
Solid Block Calorimeters	Philip Harris
Single Objective X 100 Microscope	Prior
Skybolt N1Z Zoom Microscope	L'Optic Moderne
Skybolt X 30 Stereo Microscope	L'Optic Moderne
Skybolt SR 62 Microscope	L'Optic Moderne
Simor Senior Microscope	L'Optic Moderne
Swift 950 Microscope	Andrew H. Baird
Russian M B R 1 Microscope	Andrew H. Baird
Britex Pioneer Microscope	A. Brown and Sons

Physics Notes

Valve Characteristics. As we mentioned in Bulletin 2, pupils can carry out work on diode and triode characteristics without the use of H.T. Power units using Mullard EA50 and EF98 valves. Full information on the EA50 diode characteristic is given in Mullard Useful Ideas Series, No. 1. To show saturation characteristics, they suggest under-running the heater at 3.2V instead of the rated value of 6.3V. EA50 diodes are obtainable from P.C. Radio Ltd. for 1/- each; they were being given away at the A.S.E. meeting in Cambridge.

Published information on the EF98, which is a pentode valve is as follows:

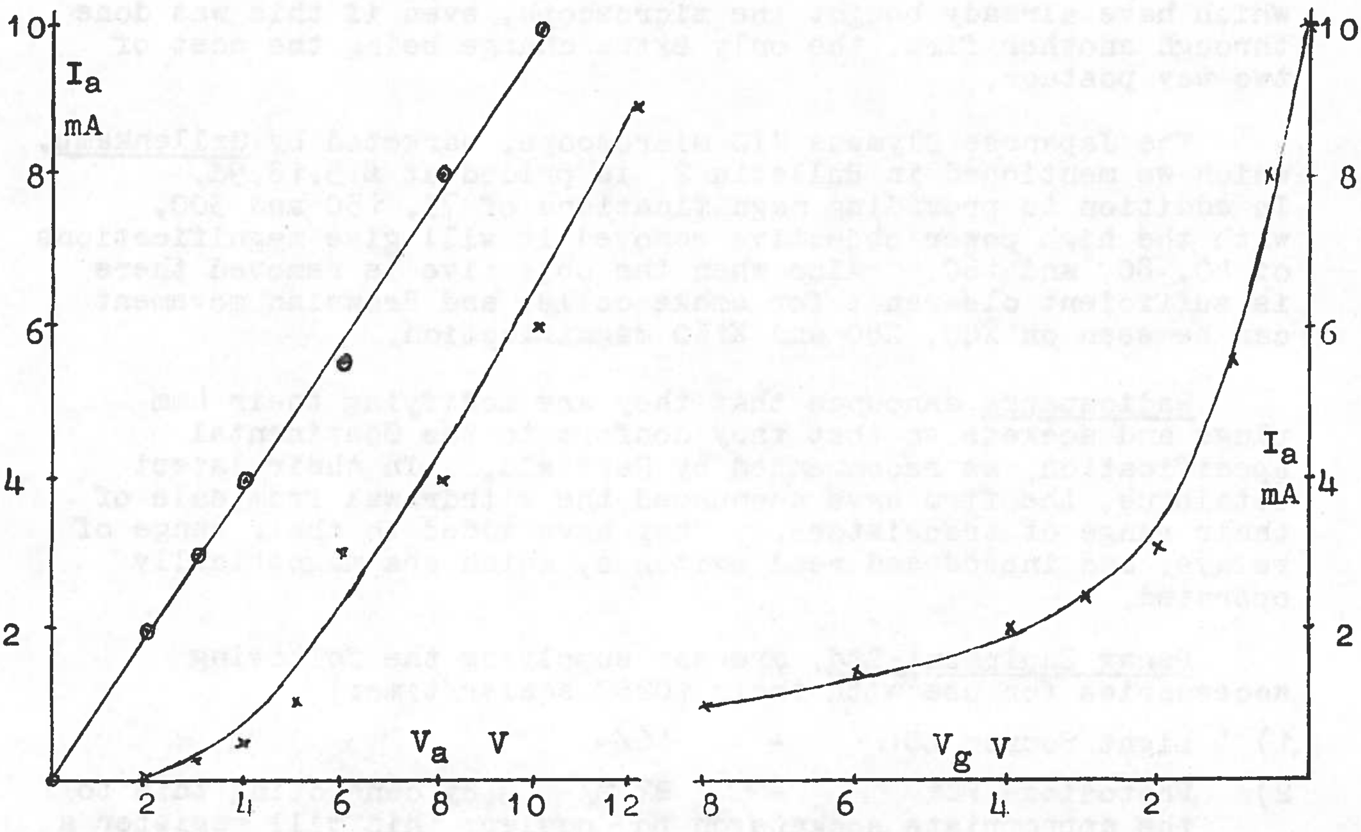
Heater $V_h = 6.3V$ $I_h = 0.3A.$

Base B7G.

Base Connections (pins numbered clockwise from the gap, viewed on the underside of base):

1	2	3	4	5	6	7
g_1	k	h	h	a	g_2	g_3

By connecting pins 5, 6 and 7 together, the valve can be converted to a triode, using 5, 6 and 7 as a common anode connection. The graphs given below were obtained using a grid-bias battery and 10KΩ radio-type potentiometer to vary V_g, and a low voltage power unit to vary V_a. Anode current was measured on a 0-10mA moving coil meter. One disadvantage of the valve when used as a triode is that it does not show a sharp cut-off with increasing grid voltage. A note on this experiment is included in the School Science Review No. 161, P. 209.



⊘ At V_g = 0V   At V_a = 12V

× At V_g = -1.2V

Nuffield Version of Boyle's Law Apparatus.

Several teachers visiting the centre have commented on two features of this apparatus which might well be clarified. The first concerns the question of units; the Bourdon gauge is calibrated 0 - 50lb/in^2 which I think every-one agrees are anachronistic. But what is the alternative; 0- 350,000 newtons per square meter? The volume scale runs 0 - 55 in what I suspect are ml; should we change this to 0 - 0.000055m^3? Certainly this will give a pV product in Joules, and this should set the pupils back on their heels. What kind of energy is this?

Pre-occupation with units obscures the point of this experiment, and I suggest the easiest solution is to get inside the Bourdon gauge and paste over the offending lb/in^2.

The other comment concerned the use of the apparatus for sub-atmospheric pressures. This is perfectly feasible if one fills the oil column to around the 30 mark at atmospheric pressure. The pV constant is then 30 X 15 = 450 and allows the volume scale to vary between 9 and 55, and the pressure scale between 8 and 50. Sub-atmospheric pressures can easily be obtained by water pump suction.

Trade News

We mentioned in Bulletin 2 that the Czech Meopta AZ-1 Microscope had insufficient clearance to accommodate Whitley Bay Smoke Cells. One of the suppliers of this equipment, Instrument Division (D.R. Grey) Ltd., advise us that they will modify the microscope to make the high power objective removable, thus enabling smoke cells to be used. at an extra cost of 35/- per microscope. The firm will also provide this service for schools which have already bought the microscope, even if this was done through another firm, the only extra charge being the cost of two-way postage.

The Japanese Olympus MIC microscope, marketed by Gallenkamp, which we mentioned in Bulletin 2, is priced at £15.18.9d. In addition to providing magnifications of 75, 150 and 300, with the high power objective removed it will give magnifications of 40, 80, and 160. Also when the objective is removed there is sufficient clearance for smoke cells, and Brownian movement can be seen on X40, X80 and X160 magnification.

Radiospares announce that they are modifying their 4mm plugs and sockets so that they conform to the Continental specification, as recommended by Nuffield. In their latest catalogue, the firm have announced the withdrawal from sale of their range of transistors. They have added to their range of relays, and introduced reed switches. which are magnetically operated.

Panax Equipment Ltd. are now supplying the following accessories for use with their 102ST scaler/timer;

1) Light Source LS1 - 16/-

2) Photodiode PD1 - £2.2/-. By connecting this to the appropriate sockets on the scaler, this will register a count for the period of either illumination or non-illumination of the photodiode.

3) Gating Unit GU1 - £6.10/-. With two photodiodes PD1 and the gating unit, the circuit can be arranged so that one diode switches the count on, and the second switches it off, e.g. in the measurement of g by free fall.

4) Solid State Alpha Detector and Amplifier AD1 - £15.15/-.

Panax equipment can be obtained through A.R. Bolton or Elesco Electronics.

Kodak Ltd. offer the following packs for thin layer chromatography for school use;

Silica gel coating, box of 50 sheets, 10 X 10cm .....£5.15/-.
Silica gel coating, box of 20 sheets, 20 X 20cm .....£9.5/-.
Polycarbonate coating, box of 50 sheets, 10 X 10cm ..£6.12.6d.
Polycarbonate coating, box of 20 sheets, 20 X 20cm ..£10.10/-.
Polyamide coating, box of 50 sheets, 10 X 10cm ......£6.12.6d.
Polyamide coating, box of 20 sheets 20 X 20cm ......£10.10/-.

We have to correct an impression which we may have given in Bulletin 2 that A.R. Bolton are the sole Scottish agents for Radford power units. To avoid future confusion, it should be understood that unless the word "sole" is used, there may be agents other than those specified. Should they feel aggrieved at not receiving mention, it is up to them to bring this to our notice. At the moment, we would point out that Elesco Electronics also supply Radford equipment.

When the Radford Labpack Type ML was increased in price from £18.18/- to £22.10/- we wrote to the firm protesting at what we considered was a bad change in design from the use of fuses to a magnetic cut-out, assuming that this was the reason for the price increase.

We give below the firm's reasons for increasing the price:

"1) To ensure that the unit remained profitable to us.

2) To make it profitable to distributors. Previously we have distributed the unit mainly from our own Organisation and the discount allowed on education equipment supplies was very marginal and quite insufficient to enable them to sell the unit as a business proposition.

3) To enable discounts to be given to bulk purchasers. Councils and other organisations insist on discounts for bulk purchases.

4) The mains transformer has been redesigned to enable it to operate from 100 to 250V A.C. input. This was necessary in order to establish the Labpack in the export market.

5) The School Science Committee (now the Nuffield Project) have recommended from the commencement the inclusion of a cut-out instead of fuses. This is stated as a universal requirement for schools and we have had no consumer advice from universities and technical colleges who buy only very small quantities. The total cost on the selling price of the Labpack due to the cut-out alone was just under £1."

Quoting from the Nuffield Guide to Apparatus and Equipment;

"L.T. Variable Voltage Supply. This is a general purpose item of demonstration equipment providing up to 25 volts both D.C. and A.C. at 8 amperes and an essential requirement for the course. Where a school has a built-in low voltage supply, (e.g. Legg Unit) capable of giving this current, this item is not essential, though it would be useful.

H.T. Power Supply/

<u>H.T. Power Supply</u>. An H.T. Power Supply giving 0 to 250 or 300 volts D.C. output with an additional supply from 0 to about - 25 volts D.C., both continuously variable. It should also give two 6.3 volt A.C. outputs for heating filaments. The D.C. outputs should both give about 60mA maximum current. Fuses should be incorporated for safety or preferably an automatic cut-out."

The Vacuum Pump

The principle upon which the pump operates is that gas from the vessel being evacuated is taken into the body of the pump and compressed by two rotary blades to a pressure just above atmospheric, when the exhaust valve opens and the trapped gas escapes. It follows that when pumping condensible vapours, e.g. water vapour, condensation due to increased pressure may occur within the pump, causing the pump oil to become contaminated. Trapping such vapours before they enter the pump involves the use of equipment not normally found within a school laboratory, e.g. a mercury vapour trap requires immersion in liquid oxygen.

Pump manufacturers therefore adopt two complementary methods to keep the oil in a clean condition. One is to design the pump so that it runs warm; by raising the temperature the saturated vapour pressure may be raised above atmospheric, this preventing condensation. The other is to gas ballast the pump. Gas ballasting means admitting a quantity of atmospheric air into the pump body so that it mixes with the vapour. This enables the pressure to be raised to atmospheric and the gas expelled before the partial pressure of the vapour present has reached saturation value. It should be evident that admitting air into the pump body will lower the ultimate vacuum attainable from the pump.

The practical points which follow from the description of pump action are these;

(1) Where possible avoid the use of the pump in situations where contaminating vapours are likely to enter the oil. Many experiments now being carried out with the rotary pump are perfectly satisfactory if done with a plastic filter pump connected to mains water. If mains water is available it pays to try out such experiments first with a filter pump; probably the only elementary experiment requiring rotary pump suction is the Magdebury hemispheres. In passing, why do manufacturers nowadays make their hemispheres approximately 3" diameter? Even assuming perfect conditions, the maximum lift will be $15\pi r^2 = 106$ lb. An increase in the diameter to 4" would raise this figure in the ratio of 16 to 9, and allow some factor of success in what is a vital and uplifting experiment.

(2) Wherever it is desirable to obtain the lowest possible vacuum, use a 'clean' system, and close the gas ballast valve. In deciding what is a clean system, a general rule to be applied is: if it smells, avoid it. Rubber tubing, if new, should be blown through by air blower (not by mouth which introduces water vapour) to remove french chalk. Where long couplings are required, clean glass tubing connected by short lengths of flexible tubing are better than all rubber jointing.

(3)/

(3) If grease has to be used to seal a joint, use proper vacuum grease, not vaseline, the water content of which will render a high vacuum impossible.

(4) In all cases when pumping condensible vapours, allow the pump to run with the gas ballast valve open, and the normal air intake closed (to prevent dust entering the oil) for some 15 minutes before using the pump. This is called running on gas ballast and allows the pump to warm up before use. Similarly after pumping, run the pump on gas ballast for half an hour to clear the oil.

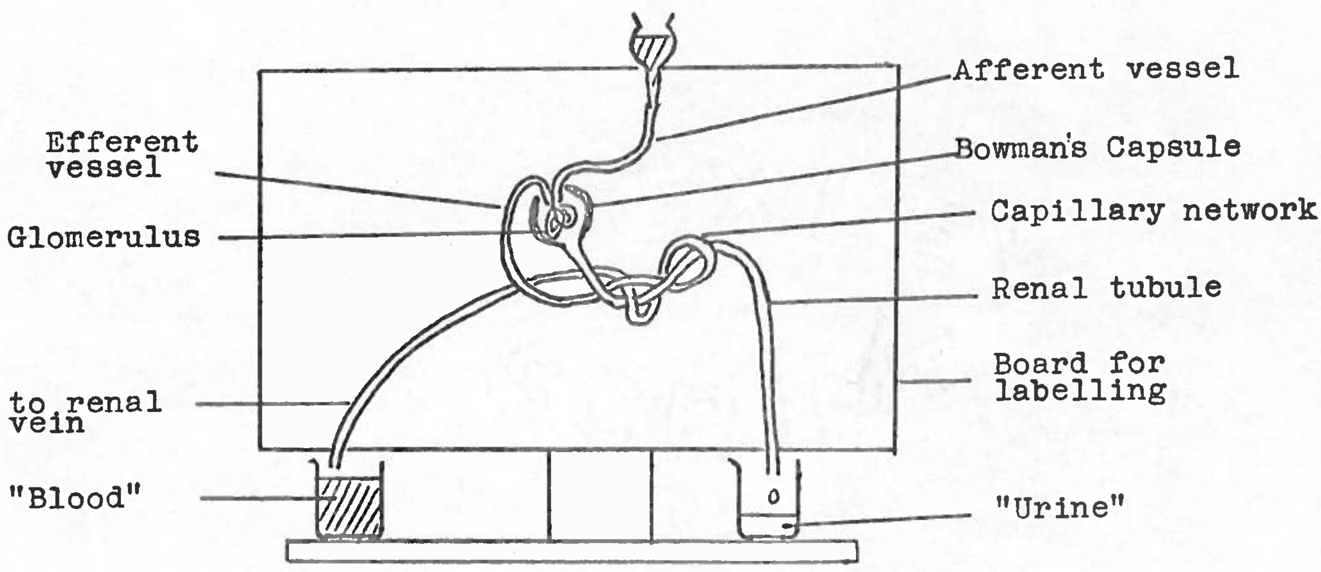
(5) Even when not in use, the pump should be run for 30 minutes on gas ballast periodically - once weekly is not too often - to keep the oil clean. On the question of storage, the store room is better than the prep. room, which is better than the laboratory, but if it must be the last, keep the pump well away from the blackboard and chalk dust.

In The Workshop

A simple but effective piece of apparatus for demonstrating the action of the Renal tubule can be made from two thistle funnels and a 30" length of 1.5mm inside diameter polythene tubing.

Construction. One of the thistle funnels has the wide lip cut off with glass-cutting file or hot wire and the sharp ends rounded off in the bunsen flame. (Alternatively a broken pipette at least 25ml in size is cut through the middle of the bulb and again the ends rounded off). This is the "Bowmans capsule" and the tube part is then bent to form a wide S shape, - the tubule.

The other funnel is drawn out to a fine tube near the thistle, so that the 1.5mm tubing will fit firmly. The tubing from this leads into the capsule, where it is tied in a couple of knots to form the glomerulus - a few pin holes are driven through the tubing to accomplish filtration. The polythene tubing is then wound round the tubule and leads away to a separate beaker.



The pieces are then attached by fine wires to a vertical board ideally supported 4 ins off the bench to allow easy access of beakers.

Operation./

Operation. If a drop of concentrated acid is admitted into the capsule, and pink phenolphthalein solution poured into the top thistle funnel to simulate the flow of blood, some filtration will occur and the acid will of course de-colourise the indicator. Thus a flow of blood is shown, and a trickle of "urine" will flow into the other beaker from the tubule. If difficulty is experienced in initiating the blood flow because of the narrow tubing a drop of detergent added to the indicator is sufficient to overcome this.

The indicator can be coloured by adding a small quantity of alkali or by blowing ammonia over it. Obviously if too much is added the acid will soon lose its power to decolourise the indicator. If the apparatus is to be used several times it may be found advantageous to have some sponge or glass beads etc. to 'hold' the acid.