# SCOTTISH SCHOOLS SCIENCE

# EQUIPMENT RESEARCH

# CENTRE

Bulletin No. 19. January, 1968.

# Contents

# Introduction

It is not often that we get teachers writing to us commenting favourably on their dealings with "The Trade"; far more frequent are the letters of complaint. One should not assume from this that occasions for complaint are more numerous than occasions for commendation. It is a tendency on the part of us all to accept good service as no more than our due - which, of course, it is - and allowing it to pass without comment. We are therefore particularly pleased to print extracts from a letter we have received dated 5th December: "I sent away the department's stock of 7 Serviscope Minors to Forth Instruments Ltd. for X modification on 24th November and they came back yesterday (and the oscilloscopes had been trimmed up as well). This would appear to be the sort of first-class service we should encourage." We fully agree. Details of the modification referred to were given in our Bulletin 17.

Almost in the same week we received two letters of a very different kind. Both made essentially the same statement: that through some fortuitous circumstance the writers, both teachers in senior secondary schools, had stumbled across a copy of our Bulletin 18. As this was the first one they had seen, could they have further information on the activities of SSSERC?

It is difficult for us to see what other steps we can take to ensure that Bulletins reach those for whom they are intended. We at present address copies to the Principal Teacher of Science; our schools address lists are based upon information sent to us by local education authorities. These lists were revised, as far as we were able, at the beginning of the current session, although one county, Wigtownshire, did not reply to our circular. Where asked to do so we will send three separate copies to the school, addressed to Principal Teachers of Biology, Chemistry and Physics, and provided that these posts exist. What we cannot do is to devise a foolproof method of ensuring that the information you have just read is going to reach those who so far have been denied access to the Bulletins. We can appeal to members of the Inspectorate, when they visit schools, to enquire whether the Bulletins are being received. We can ask Directors of Education and their staffs to take steps to see that all their science teachers are made aware of our existence. We could, but only once, buy a 10 second spot on Commercial T.V., if we could decide whether to slot it in before Scotsport or Coronation Street.

# Opinion

The advent some five years ago of the cassette loaded film-loop projector was hailed by many teachers, including the writer, as a real break-through in the field of visual aids. Here for the first time was an opportunity to integrate film material with the remainder of the science lesson. The cost of the loops - 25/- to 30/- at that time - made it possible for a school to build up a film library, thus avoiding what for many was an unsurmountable difficulty in the use of 16 mm film - the need to book the film in advance. The imponderables in the school situation - how to forecast the advent of a given lesson some two months in the future, which any of a dozen factors ranging from a flu epidemic to an extra-mural performance of Hamlet or the S.N.O. could/

could nullify - discouraged many teachers from attempting the exercise except on special end-of-term occasions when the emphasis was on entertainment, not instruction. Nor was the projector itself expensive; if memory serves me right it cost £39.

This early enthusiasm has waned considerably in the succeeding years. At the start, sensing the immediate success of the single-concept film, manufacturers flooded the market with loops on every conceivable science topic, without always considering what they hoped to achieve in a given loop. There is still on the market a loop which will demonstrate how a tin can be collapsed under the action of atmospheric pressure. How many tins can one buy for £2.7s.6d.? Too many loops showed the same distressing tendency to display on film what could easily have been done in the classroom by experiment - even sometimes by pupil experiment. Costs have also escalated through the years. Loop films are now priced at between £2 and £4, and devaluation may be expected to send the cost of American loops above the present ceiling of £4.10s.

Likewise the cost of the projector itself has more than doubled over its lifetime, without corresponding improvement in performance. Judging from the comments of a number of teachers, the original 800E-1 projector appears to have been the most reliable back-projection instrument for classroom use. The latest version, the 800E-4 has had its teething troubles.

Within the past year the situation has become even more complicated by the introduction of Super-8 mm film. This material is incompatible with the Standard-8 film, having an increased picture area and provision for a sound track. The battle between the two systems is at present in full swing. "Standard-8 is definitely on the way out. It is going off the market and will soon be as dead as the dodo" - a Glasgow photographic dealer; "We firmly believe that Standard-8 has a long life before it --- finally, no doubt, Super-8 will entirely replace Standard-8, but this will be a long time ahead." - Macmillan and Co. Both these quotations are taken from a very comprehensive review of the situation issued in July by the Scottish Film Office. Their advice would appear to be as follows:

"While all these developments are being weighed and considered it would appear that the best policy for those contemplating the purchase of new 8 mm projection equipment is to mark time for a spell. Within a few months the situation will have become much clearer."

The Centre is frequently asked for advice on cassette-loaded projectors, which is why I have discussed the subject here. My own view of the situation is that time is on the side of the Super-8 film; the longer one waits the more likely it is that Super-8 will be the final choice. The only reason for postponing a decision would then appear to be cost; it is to be hoped that increased sales of Super-8 material may lower production costs. There is also the possibility of new developments; in a rapidly expanding field such as this early models can become obsolete very soon.

Current users of Standard-8 material need not be unduly troubled; cassettes in Standard-8 will continue to be produced for many years to come. The best advice we can give on the subject is to contact the Scottish Film Office, where the staff will arrange an appointment to demonstrate both Standard and Super-8 projectors.

# The Mass Spectrometer

We have had the W.B. Nicolson mass spectrometer in the Centre for some weeks, and although we experienced difficulties in getting the instrument to operate satisfactorily, at the time of writing we can say that we have obtained qualitative results from sodium and the isotopes of lithium. Experiments with the apparatus are continuing, and the main purpose of the present article is to give a simplified theory of the apparatus, both because it is the version most likely to be seen by a school pupil, and because the theory is simpler than those of the Aston or Bainbridge spectrometers normally described in text-books. What follows is therefore an account as one might hope to explain the spectrometer action to a pupil.

If a charged particle of mass m and charge Q is accelerated from rest through a potential difference V, it achieves a final velocity v given by the principle of Conservation of Energy:

$$QV = \tfrac{1}{2} mv^2 \text{ - - - - - - - - - - - - } (1)$$

A moving charge institutes a current, and we can define the current as the rate at which charge passes a given point in a circuit, i.e.

$$I = \frac{\delta Q}{\delta t} \text{ - - - - - - - - - - - - } (2)$$

A charge moving at speed v will cover a distance $\delta s$ in time $\delta t$, where

$$v = \frac{\delta s}{\delta t} \text{ - - - - - - - - - - - - - - } (3)$$

Pupils already know that a conductor of length l in a uniform magnetic field B, the field being at right angles to length l, experiences a force of magnitude IlB when current I flows in it. Using equations (2) and (3), the force on a moving charge $\delta Q$ in such a field will be given by

$$F = IlB = \frac{\delta Q}{\delta t}.\delta s.B,$$

$$= \frac{\delta s}{\delta t}.\delta Q.B,$$

$$= vB\delta Q,$$

and for charge Q, this becomes $F = QvB$ -------(4). The direction of this force is perpendicular to both v and B, both of which are vectors.

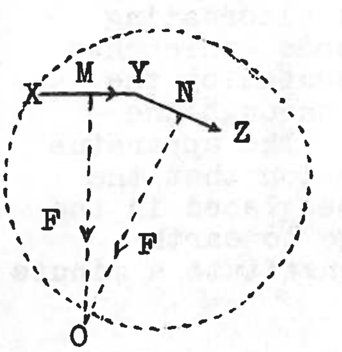


Fig. 1.

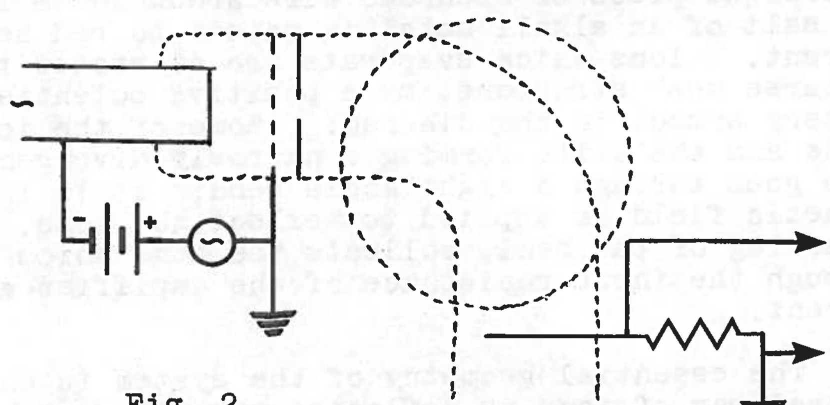


Fig. 2.

If the field B, indicated by the region within the dotted circle in Fig. 1, is directed into the paper, then the force on a charge moving from X to Y will be directed downwards along MO. It can be reasonably assumed that the effect of this force is to deflect the charge/

charge downwards so that its path changes to the element YZ, when, to keep the force perpendicular to v, the direction is along NO. This argument is only valid if points X, Y and Z are very close together and when we combine successive elements such as XY, YZ we get a curved path, with the force being directed always towards a central point O. Reference to whirling objects on the end of an elastic string may then help to convince pupils that under the action of a central force, the "orbit" is a circle. The pupil will then have to accept that the magnitude of this central force is

$$F = \frac{mv^2}{R}, \text{ where R is the orbit radius -- (5)}$$

Proof of this will be found in standard text-books; an excellent discussion at pupil level is contained in Physics for the Enquiring Mind, Eric Rogers, chap. 21.

Combining equations (4) and (5),

$$QvB = \frac{mv^2}{R},$$

and by using equation (1) we can eliminate the velocity v, and get

$$\frac{m}{Q} = \frac{B^2R^2}{2V} \text{ - - - - - - - - - - - - - - - - - - (6)}$$

As we shall see later, B and R are constants in the apparatus; Q can differ only by the unit electronic charge, and can be regarded as constant for all singly ionised atoms, e.g. the alkali metals. Under these conditions $m \propto \frac{1}{V}$, and a graph of these two quantities ought to be a straight line passing through the origin and with slope $\frac{1}{2}B^2R^2e$.

It is possible to measure B and R, assume e, and hence determine any m once the appropriate value of V has been measured. It is probably easier to assume one value for m, say sodium (m = 23), and from two measured values for V calculate other masses, since

$$\frac{m_1}{m_2} = \frac{V_2}{V_1}$$

Fig. 2 gives a diagrammatic representation of the Nicolson mass spectrometer. For the sake of clarity the filament and probe have been drawn perpendicular to their actual positions; in both cases the axis should be at right angles to the paper. The filament, which is a straight piece of nichrome wire about 10 mm long and is coated with the salt of an alkali metal is raised to red heat by an alternating current. Ions which evaporate are attracted to the anode, which has a coarse mesh structure, by a positive potential represented by the battery symbol in the diagram. Some of the ions pass through the anode and the slit, forming a narrowly divergent beam. The apparatus then goes through a right angle bend; it is in this region that the magnetic field is applied to deflect the ions. A probe, placed in the other leg of the bend, collects the ions which discharge to earth through the input resistance of the amplifier and so constitute a minute current.

The essential geometry of the system is shown in Fig. 3. The central ray of ions is deflected through a right angle by the field B, which in turn means that the radius R of equation (6) is also the radius of the magnetic field. It is not difficult for a pupil to verify by a construction that the extreme rays of the beam, which also execute circular paths of radius R within the magnetic field region will/

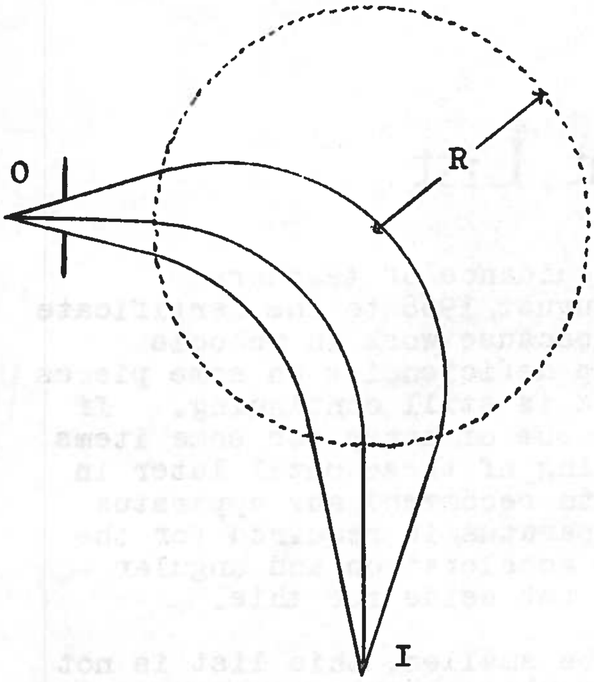


Fig. 3.

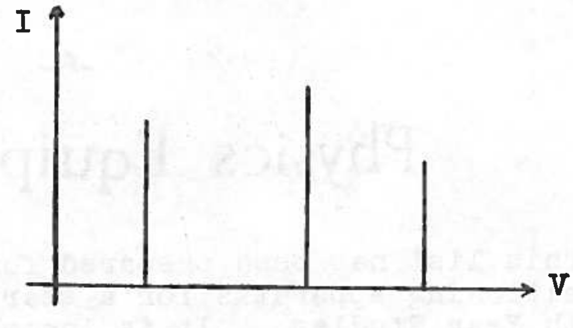


Fig. 4.

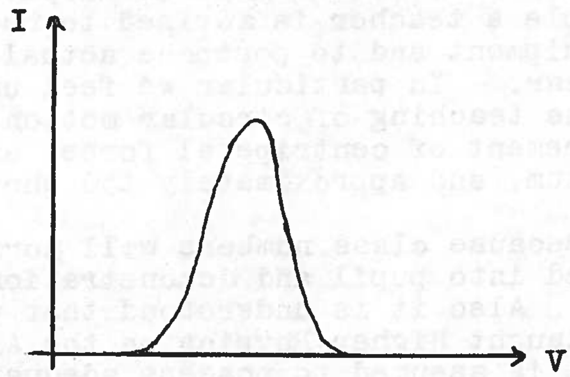


Fig. 5.

will be brought to focus at a point I. We suspect, although it has not been mathematically proved, that for rays not too divergent the lens formula will be found to apply, i.e.

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{R}$$

Certainly if the source is situated on the perimeter of the field B the emerging beam is a parallel one. If this were the whole story then the results of graphing probe current against anode voltage V would be a series of sharp peaks corresponding to different ions, and otherwise zero, as in Fig. 4. Fortunately this is not the case as the peaks would otherwise be easily missed. Firstly, the magnetic field is not uniform within a given radius and zero without. It exhibits a fringe effect which will affect the ions even as far back as the filament source. Secondly the probe is not a "point" receptor as represented at I in Fig. 3. but a V-shaped notch of appreciable width so that it will pick up central ray ions which have been deflected through slightly more and slightly less than $90^o$. Thirdly. ions may leave the source with greater than zero velocity.

For these reasons the sharp peaks of Fig. 4 are broadened out into something resembling a normal distribution curve about a mean value of V. as in Fig. 5. This curve could be plotted by measuring probe current on a suitable meter for different settings of V until one is through the "hump". An alternative, which provides a visual display of the graph, is to superimpose on the direct voltage V an alternating voltage at 50Hz frequency and to apply a similar A.C. voltage to the X plates of an oscilloscope. The spectrometer is then swept through the useful portion of the voltage range, and the C.R.O. trace is swept across the screen in synchronism. If the probe current, amplified to an appropriate level, is applied to the Y plates, the trace will then be that of the graph, i.e. Fig. 5. In the Nicolson spectrometer power supply, provision is made for coarse and fine variation of the direct voltage V, and for a series of switched values of alternating voltage to be superimposed on the D.C. A point which puzzles some teachers who see the apparatus working is that they get two humps on the trace instead of one. This must occur when a sine wave trace is applied to sweep the CRO and the spectrometer anode. The probe will pick up a response both when the anode voltage is on the way up, and on the way down. The CRO trace will show both responses, one on the forward movement, and one on the "flyback." These humps should, of course superimpose and show as one. but more frequently than not there is some phase shift in the system, and a phase shift control is incorporated in the power supply to bring both peaks into coincidence.

# Physics Equipment List

This list has been prepared for the guidance of teachers requisitioning apparatus for a start in August, 1968 to the Certificate of VIth Year Studies. It is incomplete because work in schools already teaching the syllabus has shown up deficiencies in some pieces of equipment, and because development work is still continuing. If possible a teacher is advised to budget a sum of money for some items of equipment and to postpone actual ordering of these until later in the year. In particular we feel unable to recommend any apparatus for the teaching of circular motion. Apparatus is required for the measurement of centripetal force angular acceleration and angular momentum, and approximately £50 should be set aside for this.

Because class numbers will normally be smaller, this list is not divided into pupil and demonstration equipment as other lists have been. Also it is understood that pupils taking this course will have been taught Higher Physics on the Alternative Syllabus so that the school is assumed to possess adequate equipment for that course, particularly the items in the Year IV list published in Bulletins 6 and 7. For this reason these items have not been listed here.

Variable Speed Motor This is Nuffield Item 150, comprising a motor for use on 12V D.C. and with reduction gear box, enabling a variety of speeds to be obtained.

| | | |
|---|---|---|
| Griffin | GN150/100 | £15.15. -. |
| Nicolson | K95/1745 and | £15.10. 8. |
| | K95/1745/11 | £7. 6. 3. |
| Harris | P7134 | £23. -. -. |
| Morris | 95-150 | £13.10. -. |

Note. Morris and Griffin versions are without gear boxes, others are complete.

Demonstration Double-Beam Oscilloscope

| | | |
|---|---|---|
| Advance | OS25 | £80. -. -. |
| Telequipment | D52 | £99. -. -. |

This is in addition to a single beam 5" and pupil oscilloscopes. The use of oscilloscopes to examine waveforms across individual components in a series circuit is complicated by the earthing arrangements on the input terminals. The larger oscilloscopes, OS15 and S51E have the non-live input side directly earthed to chassis and mains earth; the Minor and OS12 are similarly earthed to A.C. through 0.1μF capacitors although not directly. Hence with a mains-operated signal generator, the non-live output side of which may be similarly earthed, it is possible that components in the circuit could be shorted out.

3 cm Wave Kit This includes all accessories to demonstrate interference, and diffraction.

| | | |
|---|---|---|
| Unilab | 044.571 transmitter | £12.10. -. |
| | 044.871 power unit | £12.10. -. |
| | 045.671 receiver | £16. -. -. |
| | 045.673 diode probe | £3.15. -. |
| | 045.171 metal reflector (2 needed) | -.15. -. |
| | 045.172 narrow reflector | -.10. -. |
| | 041.179 paraffin wax lens | £4.10. -. |
| | 053.842 amplifier/loud speaker | £6.10. -. |
| Nicolson | N4/1880 | £82.10. -. |

Note. Nicolson apparatus is complete with accessories; uses hollow perspex/

perspex lenses and prisms which have to be filled with paraffin.

4. <u>Signal Generator</u> See Item 22, Year IV list.

5. <u>Sonometer</u> This must have facilities for variation and measurement of tension.

| | | |
|---|---|---|
| Harris | P9924 | £7. 5. -. |
| Morris | 61-140 | £5. 5. -. |
| Griffin | L61-520 | £6.18. 6. |

6. <u>Discharge Lamps</u> A sodium and a mercury discharge lamp will be required; pupil work can be carried out using a tungsten filament lamp with suitable filters.

| | | |
|---|---|---|
| Griffin | L59-300/05 (Hg) | £4. 4. -. |
| | L59-300/55 (Na) | £4. 4. -. |
| Harris | P8871S (Hg) | £4. 4. -. |
| | P8871M | £4. 4. -. |

7. <u>Discharge Lamp Accessories</u> Consisting of lampholder and stand, adjustable cover, and transformer for 250V A.C. mains operation.

| | | |
|---|---|---|
| Griffin | L59-310/05/15/20 | £18. 3. 6. |
| Harris | P8871 | £15.17. 6. |

8. <u>Grating and Prism Spectrometer</u>

| | | |
|---|---|---|
| P.T.I. | 2300 | £55. -. -. |
| Harris | P8846 | £57.10. -. |
| Griffin | L54-400/402 | £48.12. 6. |
| Nicolson | N4/1425 | £42.10. -. |

9. <u>Dense Flint Glass Prism</u>

| | | |
|---|---|---|
| Harris | P8848 | £1.11. 3. |
| Griffin | L52-125 | £3.12. 6. |
| Nicolson | N4/1430 | £1.16. 3. |

Note. The P.T.I. version spectrometer is supplied with prism.

10. <u>Diffraction Grating for Spectrometer</u>

| | | |
|---|---|---|
| Griffin | L55-822 | £3. -. -. |
| Harris | P8798 | £3.17. 6. |
| Paton Hawksley | Standard Transmission Grating | £2.10. -. |

11. <u>Set of Demonstration Grating Slides</u> Three gratings with different rulings.

| | | |
|---|---|---|
| Griffin | L55-805 | -.16. -. |
| Paton Hawksley | Diffraction Grating Slides | £2.15. -. |

12. <u>Vernier Microscope</u> An instrument reading to 0.02 mm is essential, and to 0.01 mm is desirable.

| | | |
|---|---|---|
| Harris | P6062 (0.02) | £59.10. -. |
| Griffin | S31-910 (0.02) | £63.10. -. |
| Nicolson | N4/1650 (0.01) | £76. 2. -. |
| P.T.I. | 2152 (0.01) | £39.12. 6. |

13. <u>Michelson Interferometer</u>

| | | |
|---|---|---|
| Griffin | L55-870 | £54. -. -. |
| Harris | P8779 | £21.15. -. |

The first of these is the Beck Interferometer which is recommended where project work on wave optics is contemplated. Otherwise the Harris version will be adequate.

Newton's Ring's Apparatus

| | | |
|---|---|---|
| Harris | P8794 | £3.12. 6. |
| | P8796 | £21. 5. -. |

The second of these includes travelling microscope.

Optical Bench The Nuffield telescope mount. Item 115, will be suitable where no form of optical bench is already available.

| | | |
|---|---|---|
| Morris | 95/115 | £2.10. -. |
| Nicolson | K95/1575 | £2. 2. -. |
| Griffin | GN115 | £2.19. -. |
| Harris | P8902 | £2. 2. -. |

Compact Light Source This is Nuffield Item 21.

| | | |
|---|---|---|
| Morris | 95-21 | £6. 5. -. |
| Harris | P8759 | £7. 2. 6. |
| Griffin | GN21 | £7. -. -. |
| Nicolson | K95/1105 | £7. -. -. |

Coulomb Law Determination This requires the Leybold Torsion Balance with coulomb accessories, or alternatively a home-made apparatus as suggested in the S.E.D. memorandum on the syllabus.

| | | |
|---|---|---|
| Leybold | 516.01 | £46. 5. 9. |
| | 516.20 (accessories) | £21. 5. -. |

Epinus Condenser

| | | |
|---|---|---|
| Harris | P7903 | £8.17. 6. |
| Griffin | L81-725 | £6. 5. -. |

Selection of Three Dielectrics for above

| | | |
|---|---|---|
| Griffin | L81-728 | £1. 1. 5. |

The Harris condenser includes three different dielectrics.

Electrostatic Fields Apparatus See Item 6. Year IV list.

Teledeldos Field Plotting Paper This is a conducting paper used to map out electric fields.

| | | |
|---|---|---|
| Servomex | Teledeltos paper roll, 50 ft. x 29 ins. | £4. 5. -. |

Silver Conducting Paint Used to coat the electrodes of the field plotting apparatus to give a good equipotential surface.

| | | |
|---|---|---|
| Servomex | Silver conducting fluid, ½ oz. pot | £1. -. -. |

Galvanometer Lamp and Scale Needed to provide an optical pointer for use with the coulomb balance. Any version is suitable.

| | | |
|---|---|---|
| Griffin | L84-741 (scale) | £8.10. -. |
| | L84-746 (lamp) | £6.19. -. |
| Harris | P7254 (combined) | £13.17. 6. |

e/m Deflection Tube The Leybold fine beam tube is considered very desirable for determination of e/m but is expensive and it is doubtful if its purchase could be justified for an individual school; it would however be suitable for an authority to obtain and circulate throughout its schools.

| | | |
|---|---|---|
| Teltron | TEL525 | £14.14. -. |

Rank/

| | | |
|---|---|---|
| Rank | 3030340 | £18. 5. -. |
| Leybold | 555.57 | £46. 8. 6. |

25. Stand and Supports for Item 22

| | | |
|---|---|---|
| Teltron | TEL501 | £6.14. -. |
| Rank | 3030337 | £4. 1. 6. |

26. Deflecting Coils for Item 22

| | | |
|---|---|---|
| Teltron | TEL502 | £8. 8. -. |
| Rank | 3030330 | £4.17. -. |
| Leybold | 555.58 (includes stand) | £34. -. 9. |

27. Demonstration Meter These should already be in the school. Versions with interchangeable scales are recommended. The Russian meters from Andrew H. Baird are particularly suitable since it would not be difficult to construct shunts or multipliers to give any desired range.

| | | |
|---|---|---|
| White | INDC | £17. 6. 6. |
| Weir | 9"/UNI | £17.17. -. |
| Baird | S36A (ammeter) | £12.10. -. |
| | S36V (voltmeter) | £12.10. -. |

Weir and White versions are exclusive of scales; S36A gives 500μA D.C., 3 and 10A A.C. and D.C. S36V gives 5 and 15V D.C. 15 and 250V A.C. and 75mV D.C.

28. Demonstration Meter Scales The Weir meter above has interchangeable dials and separate shunts/multipliers. In the White meter the shunt/multiplier is incorporated in the plug-in scale. The White F.S.D. is 5mA; the Weir 10mA. Suitable scale ranges are 0-10mA. 0-100mA, 0-500mA D.C.; 0-5 and 0-20V D.C. and A.C., and 0-100mA, 0-500mA A.C.

| | | |
|---|---|---|
| Weir | Dial | -.16. 3. |
| | Shunt Units | £1.11. 6. |
| | Multiplier Units | £1.11. 6. |
| | Rectifier Unit | £1.19. 3. |
| | Current Transformer | £2.12. 6. |
| White | D.C. shunts and multipliers | £3.13. 6. |
| | A.C. currents | £6.16. 6. |
| | A.C. voltages | £4.12. -. |

The Weir current transformer in conjunction with their rectifier unit will measure alternating currents. Sensitivity is 10A per turn with probably a maximum of 500mA due to the difficulty of threading through more than 20 turns of wire.

29. M.K.S. Electricity Apparatus

| | | |
|---|---|---|
| Harris | P7701 solenoid (two required) | £6.19. 6. |
| | P7702 (rotating disc) | £5.12. 6. |
| | P7706 (low resistance) | £2.10. -. |
| | P7712 (search coil) | £2.17. 6. |
| | P7716 (charge-discharge switch) | £7. -. -. |
| | P7718 (capacitor) | £3.15. -. |

30. Parallel Wire Current Balance

| | | |
|---|---|---|
| Harris | P7746 | £11. 2. 6. |
| Morris | - | £15. -. -. |

Both items have been developed very recently and have not so far been tested.

31./

Biot-Savart's Law Accessories   These are used in conjunction with the torsion balance, Item 17, as an optional alternative to the Hall effect probe. Item 35.

| | | |
|---|---|---|
| Leybold | 516.23 | £17.12. 3. |

Force-on-a-Conductor Balance

| | | |
|---|---|---|
| Griffin | L82-850 | £16. 5. -. |

Ballistic Galvanometer   The mirror (Scalamp) galvanometer will be suitable.

Hall-effect Apparatus

| | | |
|---|---|---|
| Unilab | 091-603 | £1.15. -. |
| | 091-604 | £1.15. -. |

Hall Probe   In conjunction with an amplifier this uses the Hall effect to measure magnetic flux and so can be used in place of search coils to investigate Biot Savart's Law, etc.

| | | |
|---|---|---|
| Avo | BH700 | £6.10. -. |
| Unilab | - | ca. £5. -. -. |

The Unilab version is at present under development.

Electronic Millivoltmeter   Used to amplify the Hall probe signal, and also in A.C. experiments.

| | | |
|---|---|---|
| Linstead | M1 | £26. -. -. |

D.C. Amplifier   This requires a 1mA output meter.

| | | |
|---|---|---|
| Unilab | 003.811 (amplifier) | £15. -. -. |
| | 016.211 (input resistor $10^{11}\Omega$) | £5. -. -. |
| | 016.212 ( - - - - - - - - $10^{10}\Omega$) | £3. -. -. |
| | 016.213 ( - - - - - - - - $10^{9}\Omega$) | £2.15. -. |
| | 016.215 ( - - - - - - - - $10^{8}\Omega$) | £2.10. -. |
| | 016.811 (ionisation chamber) | £3. -. -. |

Only the amplifier and highest value resistance will be required for the syllabus, but the other resistors extend the current range of the instrument to a point where it overlaps that of the mirror galvanometer (Item 33), making the purchase of other D.C. amplifiers superfluous  The ionisation chamber has been included to make a variety of experiments on radio-activity possible, and eliminate the need for a pulse electroscope.

Centre Zero Milliammeters   Four required for very low frequency A.C. demonstration, 1-0-1 or 2-0-2 mA sensitivity.

| | | |
|---|---|---|
| Smith | Japanese MR85P (1-0-1) | £2. 5. -. |

Centre Zero Voltmeters, 10V D.C.   These can be converted from the milliammeter of Item 38, using appropriate multipliers.

Decade Resistor Box, Three Decade

| | | |
|---|---|---|
| Derritron | S991 (10-9,990Ω x 10Ω) | £5.15. -. |
| Morris | 73-825 (10-11,110Ω x 10Ω) | £11.15. -. |
| Heathkit | DR-1U (Four decade 10-111,100 x 10Ω) | £10.18. -. |
| Jay-Jay | J5 (10-11,100Ω x 10Ω) | £7.12. -. |

Derritron is 5% accurate, Heathkit and Jay-Jay 1%, and Morris 0.2%.  Heathkit version has to be assembled.

A.C. Milliammeter, 0-10, or 0-50mA   Both ranges are not required;  the frequency/

frequency range can be adjusted to bring the measurements within the meter range.

| | | |
|---|---|---|
| Harris Electronics | V2 (10mA) | £2.12. 6. |
| | V2 (50mA) | £3.12. 6. |

42. **Capacitors**, paper or polyester dielectric, from 0.2µF to 2µF

| | | |
|---|---|---|
| Radiospares | 250V P.D.C. | 1/3d. - 4/9d. depending on capacitance |

43. **Inductor, ½H (2 required)**

| | | |
|---|---|---|
| Unilab | 011.438 | £2.10. -. |

44. **Large C Core for above**

| | | |
|---|---|---|
| Unilab | 011.431 | £3.15. -. |

45. **Inductor, Nuffield Item 128**

| | | |
|---|---|---|
| Unilab | 011.421 | £1. 1. -. |

46. **Small C Core for above**

| | | |
|---|---|---|
| Unilab | 011.121 | -.17. 6. |

The above two items needed in pupil quantity.

47. **Capacitor, 500µF, 15V**

| | | |
|---|---|---|
| Radiospares | Sub-Mins (500µF) 15V | -. 2. - |

48. **Electrical Oscillations Apparatus**

| | | |
|---|---|---|
| Unilab | - | £40. -. -. |

Note. The large C core, Item 44, is part of the electrical oscillations apparatus, but not the ½H inductor.

49. **Hirschmann 4 mm Stackable Plugs** in various colours

| | | | |
|---|---|---|---|
| Neoflex | VQ20 | per 100 | £3.18. 6. |

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

Advance Electronics Ltd., Roebuck Road, Hainult. Ilford, Essex.

Avo International, Avocet House, Dover. Kent.

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

Derritron Instruments Ltd., Parklands, Gainscross, Stroud, Glos.

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

Philip Harris Ltd., St. Colme Drive, Dalgety Bay, Fife.

Harris Electronics Ltd., 138 Gray's Inn Road, London, W.C.1.

(Heathkit) Daystrom Ltd., Gloucester.

(Jay-Jay) Educational Measurements Ltd., Brook Avenue, Warsash, Southampton, SO3, 6HP.

(Leybold) Scientific Teaching Apparatus Ltd., 27-37 Broadwick Street, London, W.1.

Linstead Electronics Ltd., 35 Newington Green, London, N.16.

Morris Laboratory Instruments Ltd., 96-98 High Street, Putney, London, S.W.15.

Neoflex Ltd., 115a Cricklewood Broadway, London, N.W.2.

W.B. Nicolson Ltd., Thornliebank Industrial Estate, Glasgow.

Paton Hawksley Electronics Ltd., Rockhill Laboratories, Keynsham, Bristol.

(P.T.I.) Precision Tool Instrument Co. Ltd., 353 Bensham Lane, Thornton Heath, Surrey.

Radiospares Ltd., P.O. Box 268, 4-8 Maple Street, London, W.1.

Rank Audio-Visual Ltd., Woodger Road, Shepherd's Bush, London, W.12.

Scottish Film Office, 16/17 Woodside Terrace, Glasgow, C.3.

Servomex Controls Ltd., Crowborough, Sussex.

G.W. Smith and Co. Ltd., 3/34 Lisle Street, London, W.C.2.

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

Teltron Ltd., 239 Acton Lane, Chiswick, London, W.4.

Unilab Division, Rainbow Radio Ltd., Mincing Lane, Blackburn, Lancs.

Weir Electrical Instrument Co. Ltd., Bradford-on-Avon, Wilts.

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