SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

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Contents

Introduction	- future exhibitions	Page 1.
	- new general science course	1.
Opinion	- servicing of apparatus	2.
Physics Notes	- "pearls in air" experiment	3.
	- radioactive sources	3.
	- hysteresis loop correction	3.
	- surplus components	4.
The Constant-Load Balance		4.
Display Laboratory		8.
Trade News		10.
Supplement	- Balances Summary	11.
Address List		12.

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Introduction

It is estimated that about eighty Ayrshire teachers attended the exhibition which we staged in the Science Centre, Ayr, on the evening of Tuesday, 6th December last. That this number of teachers took the trouble to come and see the exhibition is very gratifying to us, but it would be presumptuous of us to suppose that on this, the first occasion when we have staged a full-scale exhibition furth of Edinburgh, all were satisfied with what they saw. We therefore now ask any who attended and who have complaints or suggestions for improvements to take the further trouble to write and make them known to us. Only in this way can we ensure that future exhibitions will fulfill the purpose for which they are mounted, namely, to serve the teachers' needs.

Because the testing and development work of the Centre must not be unduly interrupted by extra-mural exhibitions, we think it a realistic compromise to limit these to two per month. Readers may care to note that we have the following definite bookings for exhibitions in the future:-

Hawick	11th March
Brechin	15th March
Aberdeen (A.S.E. Scottish Branch Annual Meeting)	3rd - 5th April

Teachers in these areas are invited to come and see us, and to send suggestions for apparatus which they might want to see at least a fortnight before the meeting is due to take place. Teachers in other areas considering a visit to the Centre may think it worthwhile telephoning us in advance in case a particular item which they wish to see is out on exhibition.

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The Centre has been involved during the past year in the development and assessment of apparatus for a general science course covering, at the moment, the first two years of the secondary school. Under the direction of a Working Party, this course has been piloted in upwards of one hundred schools, some of them now being in their second session. SSSERC has prepared equipment lists to serve the needs of the course, and it will be necessary from time to time to issue amendations as some items of equipment are superseded, or are found to be unsatisfactory by the pilot schools. The best medium for issuing this information is through these Bulletins. We therefore give this statement now to put teachers not in the pilot schools "into the picture". Our equipment lists are available to any teacher writing in to ask for them, and it is felt that they may be of use where new schools are being equipped but we attach hereunder a statement from the Working Party which clearly indicates the provisional nature of the work being undertaken.

"A Scottish Education Department Working Party has been studying the structure of an integrated science course (physics, chemistry and biology) based on the concepts embodied in Circulars 490 and 512 and the Memorandum on Biology in the First Two Years of the Secondary Course, which might possibly be suitable as a common course for all pupils at the beginning of their secondary schooling in comprehensive schools. The course is at present being piloted in about a hundred schools throughout the country. SSSERC has prepared lists of equipment for use in connection with the pilot scheme. It should be understood that this test syllabus is not yet available to all schools, and it will not be published until the reports of pilot schools have been fully considered and taken into account."

Opinion

Two of everything! This is the title of an article by J.M. Osborne in the No. 2 issue of Physics Education. Briefly, the writer makes out a case for every item of complex equipment in the school being duplicated. From the teachers' point of view, this has two advantages. The first is that with both items in use by pupils one group can learn from the other since no two set exactly the same conditions on the instrument. The truth of this is evident when one recollects the speed with which a class issued with wash bottles for the first time, discovers their efficiency as minor offensive weapons, a speed which, if anyone ever troubled to measure it, would be proportional to the number of wash bottles issued.

It is the second advantage with which I am concerned here. Faced with a faulty apparatus, direct comparison with a working model can very often pin-point the fault. Items such as valves can be swopped to identify a dud. Mr. Osborne is at pains to point out that this principle can apply only to generalised equipment used for a variety of experiments such as signal generators, oscilloscopes and the like. The specialised apparatus, e.g. for Millikan's oil-drop experiment, must remain single.

Many teachers, struggling as they will be at this time of year with the annual requisition, must think I am asking for the moon. Some may admit to themselves that this is what they do at present, without its having any effect. They apply what a recent writer to "The Scotsman" terms the principle of maximum effect, i.e. to over-state one's needs and so allow a margin for concession and still leave the basic requirement unimpaired. Most bureaucrats handling the teachers' requisitions have been teachers themselves, and recognising the existence of the principle, write down the demands to a level which nullifies the original intention.

There is an alternative, and I make no apology for restating what I said in Bulletin 5. We need local science centres in every Education Authority to perform the two basic functions of training their own laboratory assistants and maintaining the county equipment, whether it be in science or any other subject. Even in those few Centres which do exist, I have seen no attempt to put the second purpose into action. Is it too much to expect that for an authority which cannot - and few can - afford "Two of Everything" in every school. its buying principle should be "One plus of everything"? - the extra one to go into reserve in the Science Centre so that it can be used as Mr. Osborne suggests for comparison, or even more mundanely to take the place of the defective instrument in the school until such time as the manufacturer can effect a repair. The ideal is obviously to staff the local centre with an engineer who could maintain the electronic equipment of all the schools, be it the signal generators of the science departments, or the tape recorders of the primary schools. He would have no dearth of work. Until such a time as we can get these individuals entering the school technician field, a depot of reserve items would be invaluable in an authority. Elsewhere in this Bulletin we make reference to the excellent loan service provided by Advance Electronics; until other firms follow suit, local authorities could help themselves by occasionally buying "one plus" for the reserve.

There are disadvantages to this scheme; when the reserve develops a fault, it always happens at the previous school, never the one in which the fault is discovered; plugs may go missing or knobs may drop off. I still think the scheme worth a trial where it can be responsibly supervised by a technician in a local centre.

Physics Notes

The "pearls in air" experiment has never been considered particularly easy to set up because it called for strapping a rubber tube carrying the water supply to an earphone. Firstly not all earphones are alike, and there is no standard type, and also the tightness of the coupling between phone and tube could only be determined empirically. What we feel is an easier method, using standard equipment has been notified to us from George Heriot's School.

A piece of thin string (mechanics cord. L21-950 from Griffin and George or similar is adequate) is tied to the spindle of an Advance V1 vibrator and to the glass tube which produces the water jet and is attached symmetrically with respect to the three-pronged, rubber lined clamp holding the tube. Thus the string passes between the two lower prongs and is in contact with the upper, opposing single prong. The clamp is raised until the string is taut, and almost any frequency below 100c/s (or should this be Hz?) will produce synchronous drops. A constant head of around 30cm of water is a desirable, but not a necessary addition. The diameter of jet is something we have not been able to ascertain with any accuracy, but one which produces a water stream about 1mm diameter gives good results.

An interesting effect - damped oscillation in reverse - is produced if the string is attached to the glass tube on the jet side of the clamp, and the apparatus tuned to the resonant frequency of the tube. The effect can be increased by clamping the glass tube so that only two of the clamp jaws are in contact on the glass portion, the third being on the rubber tube joined to the glass. This gives the system more flexibility and allows high amplitude oscillations at resonance. A Dawe stroboscope was used to illuminate the drops and we use no sink in the experiment; the water squirts into a polythene washing-up bowl.

* * * * * *

We have a note from Mr. J.L. Lewis, Associate Organiser of the Nuffield Physics Project, on the supply of radio-active sources. Recent developments at the Radiochemical Centre have made it possible to produce a 5μc plutonium source, and it is likely that the production of the 0.1μc plutonium source, source B of Item 32 in our list of physics equipment in Bulletin 7, will be discontinued. It will be more expensive than the alternative 5μc Americium source, source A of our list, but the latter suffers from the disadvantage that some 2% of its disintegrations give rise to gamma rays. This is enough to give a count rate of 2-3 thousand per minute on a Geiger tube and scaler, and will disconcert any teacher who thinks he is dealing with a pure α source and that the tube window should block the α particles, as indeed it will unless a special thin window tube is bought.

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In Bulletin 8 we wrongly stated that the hysteresis loop display could not be set up on a Telequipment S51E oscilloscope, as it has no X input. Both X and Z inputs (the latter being a beam modulation terminal) are at the rear of the instrument. The X input is now being provided on the smaller Serviscope Minor-see Trade News.

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Due to the generosity of one or two industrial firms and a similar number of university departments, we have huge quantities of electronic components, free to personal callers and at the cost of postage to others. In stock are most values of resistor in power ratings from 1Ω upwards, useless for miniature work with transistors, but ideal for class verification of Ohm's law or to make a display panel showing how power rating affects the size of a resistor; also large quantities of silver mica capacitors, in most pf values. For block paper condensers $1\mu F$ and upwards, we charge 6d. each. We also have large stocks of valves, mostly CV type numbers, and a few dozen cathode ray tubes. Other miscellaneous items include relays, printed circuits which can be stripped down, potentiometers etc. Teachers intending to visit future exhibitions should make a note of their needs; we take a selection of these items to every exhibition. Those ordering by post should include 3/6d. to cover cost of postage.

The Constant Load Balance

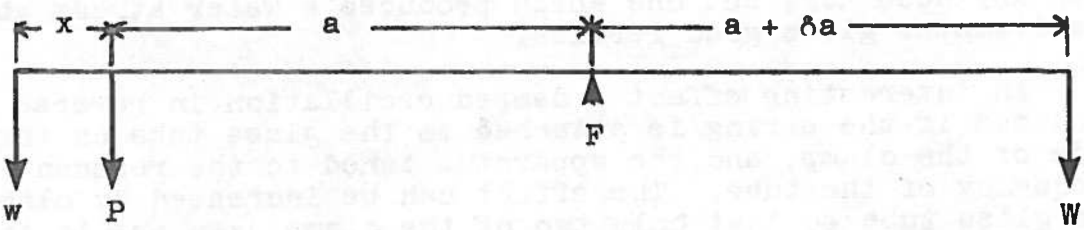


Fig 1.

The fore-runner of the constant-load, single-pan balance was the equal arm beam balance, still to be found in many chemistry laboratories. In principle this assumed that an unknown force P was equal to a known force W applied to the opposite arm by means of standard masses and of course only applied of the distances between the three knife edges were exactly equal. Since this was a condition impossible to achieve in practice - agates have to be cemented to the beam which is not a precision operation - an adjusting screw, or more commonly two such were provided at the outer ends of the beams. Considering only one of these for simplicity the equation for moments about F becomes (see Fig 1)

$$Pa + w(a + x) = W(a + \delta a) \quad \ldots\ldots\ldots\ldots \quad (1)$$

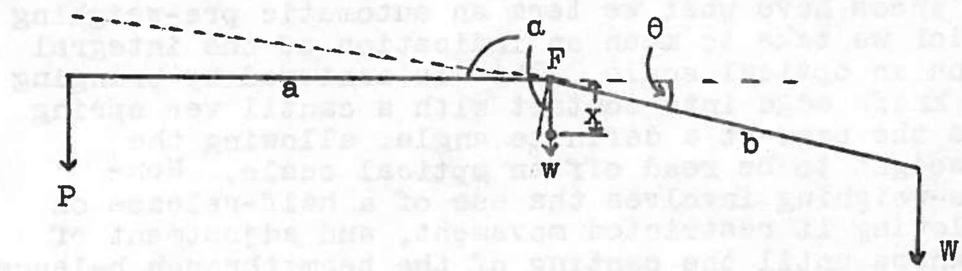
If the distance x is to be adjusted for some load W' so that the balance will read true, $P = W'$ at this value of load, and we get

$$w(a + x) = W'.\delta a \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

In practice x was usually set with no load on the balance, i.e with W' representing the scale pan weight only. Thereafter the left hand side of equation (2) remained constant. The right hand side of course varied whenever one attempted to use the balance because of the increased load in the scale-pan, and hence in practice equation (2) was always invalid, which of course invalidates the assumption $P = W$ at balance except at this one special(and useless) value $W = W'$, the scale-pan weight.

The constant-load balance overcomes this difficulty by arranging that the forces on the knife-edges at balance shall be constant irrespective of the load being weighed. A fixed mass is permanently attached to the right hand side of the fulcrum F, removing the need for a third knife-edge. With no object in the scale-pan this is counter balanced by a force P which derives from most of the masses normally found in the box of 'weights' suspended from a weight carrier bearing on the same knife-edge as the scale-pan. When an object is placed in the pan, balance is restored by lifting masses off the carrier to the value of the unknown mass. Cam-operated levers are used to raise the masses off the carrier, at the same time operating the digital read-out dials on the balance. This is substitution weighing, with the standard and unknown forces bearing on the same knife-edge, each being complementary to produce a constant sum.

On most constant load balances within the school price range the standard masses attached to the carrier go down as far as 1g, fractional grammes being indicated on an optical scale. This scale is attached to the beam, a magnified image of it being projected on to a ground glass display. The principle here employed is that if the system is unbalanced by a small amount, it will reach equilibrium when the beam has rotated through an angle proportional to the unbalanced torque which in turn is proportional to the unbalanced force. Thus angles are proportional to unbalanced (or residual) forces and a linear scale which rotates with the beam can be marked off in milligrammes.



Suppose a constant-load balance is in equilibrium with a force P acting on the scale-pan knife edge and with this arm horizontal: then

$$Pa = Wb.\sin\theta \quad .. \; .. \; .. \; .. \; .. \; .. \; .. \; .. \; (3)$$

If the balance be upset by removing a small force δP from the left hand side, the beam tilts through an angle α, (shown for simplicity on the left hand side only). The small force w is provided by the weight on an adjusting screw which alters the balance sensitivity. In the new equlibrium position,

$$(P - \delta P)a.\cos\alpha + wx.\sin\alpha = Wb.\cos(\alpha + \theta) .. \quad .. \; (4)$$

Expanding $\cos(\alpha + \theta)$ and using equation (3), this reduces to

$$\frac{\delta P}{\tan\alpha} = \frac{\delta P}{\alpha} = w.\frac{x}{a} + W.\frac{b}{a}.\sin\theta \quad .. \; .. \; .. \; .. \; .. \; (5)$$

The first approximation is justified because α is a small angle.

If δP. the unbalanced force. is to be proportional to the angle of deflection α, the right hand side of equation (5) must be constant /

be constant, which again can be true only if W is a constant. Thus optical scaling for the final two or three decimal places in the result is possible only on a constant-load balance.

In passing it may be noted that by making $\theta = 0$, the dependence on load can be removed. With the twin pan balance this means arranging that the three knife edges are in line, a condition that would apply only when the balance was new, before wear of the bearings, or deformation of the beam had occurred.

The expression in equation (5) is the inverse sensitivity. For high sensitivity we require a large angle α for small δP, i.e. the right hand side of equation (5) must be small. Sensitivity is adjusted, i.e. the optical scale is made to 'fit', by varying the distance x. Wear on the knife edges or deformation of the beam will alter the value of θ, and this can also be corrected when a balance is serviced by adjusting the sensitivity screw.

The treatment given above has been simplified because friction at the knife edges has not been considered. This adds a third term to the right hand side of the equation (5) and as friction will depend on the beam loading, again its constancy can only be obtained with a constant load.

Some balances have what we term an automatic pre-weighing facility, which we take to mean an indication of the integral gramme mass on an optical scale. This is achieved by bringing an auxiliary knife edge into contact with a cantilever spring which arrests the beam at a definite angle, allowing the approximate weight to be read off an optical scale. Non-automatic pre-weighing involves the use of a half-release on the beam, allowing it restricted movement, and adjustment of the control knobs until the canting of the beam through balance is shown by the sudden movement of the optical scale. The control knob on the smallest range - usually unit grammes on the balances designed for school use - is then turned back one position, and when the release is turned full on, the fractional grammes show on the optical scale. This will give two figure accuracy and the third decimal place is obtained by estimation or by vernier.

Taring is a facility included in some balances and means counterpoising an object such as an empty beaker without using the standard masses so that the balance will then register the mass of the beaker contents. Taring can be made automatic, which means that the counterpoise is achieved by adjusting some control on the balance, but in all the balances reviewed, the taring process consists of adding ballast to a small tare container to counterpoise the beaker, etc. Since the tare container is suspended from the pan knife edge, a standard mass, usually 100g, is raised when the control knob is set to "Tare". The taring range is then 100g less the mass of the tare container itself.

The optical scale on these balances is engraved on a transparent sheet attached to the beam; its actual physical size is of order 5 - 8mm. Mechanical magnification is obtained from the lever action due to its distance from the main bearing. In all cases the lamp compartment is isolated from the rest of the balance /

balance and ventilated, thus eliminating convection heating. A condenser lens concentrates the beam on the engraved scale; a second adjustable lens focuses the beam, after several reflections on the ground glass screen for read-out. The longer the path length of the beam, the higher is the optical magnification achieved, but the more critical is the focus adjustment of the projection lens. The complexity of the reflecting system depends on the balance design, particularly the siting of the read-out screen. Simplest is the Mettler design, requiring only one right-angle reflection.

Setting the zero on the optical scale is carried out either by an adjustable mechanical pointer behind the read-out screen, or by moving the light beam either by tilting a mirror in the beam path, or by refraction through a glass block. In the latter case rotation of the block gives a variable lateral displacement to the beam.

The constant load principle introduces considerable difficulties for the balance designer. Attached to the forward knife edge, in addition to the scale pan, and a reasonably roomy weighing cubicle, must be a weight carrier and a variety of standard masses. Provision must be made to raise any or all of these without affecting balance performance. Against this is the need to design a balance which is compact and easy to operate and read. Hence while it is permissable to allow a scale-pan to swing when eccentrically loaded, any similar tilt on the part of the weight carrier, say by the raising of a 100g eccentrically placed mass, would undoubtedly cause it to foul the various impediments arranged round it e.g. raising hooks or their associated lever, control knob spindles or cams etc. In most cases this has lead to further complexity in the splitting of masses greater than 9g into two equal and diametrically placed halves, so that their common centre of gravity falls below the knife edge. This increases the number of standards used and their associated raising mechanisms, but has the advantage that instead of carefully polishing each standard after machining until it is within the required tolerance, masses can be selected in complementary pairs. An exception to this principle is the Mettler balance which uses only eight standards, admittedly at the expense of restricting the maximum range of the balance to 160 rather than the more common 200g. These are in the form of concentric rings horizontally arranged with their common centre below the forward knife edge. The complexity of the lifting system is again a matter of siting. Where both control knobs and standards are at the same level, either above the weighing chamber as in the Mettler, or below it as in the Oertling design the lever system is simple. In the other designs bell-crank levers are used to operate longish rods running vertically to the raising hooks. In all cases the levers are cam operated.

The read-out associated with these masses seems unnecessarily complicated. Undoubtedly the simplest system is that of Oertling, who paint numbers on a flange attached to the control knob itself. Other firms resort to belt or gear wheel drives rotating numbered discs for the advantage which it gives in placing the digits side by side.

No teacher buying in this price range expects the balance to be anything but accurate, and it might seem pointless to check this. Nevertheless we subjected each balance to a weighing cycle which consisted of repeated additions of our own Grade 1 N.P.L. tolerance /

tolerance adjusted weights up to the maximum capacity of the balance, thereafter removing the weights in sequence to zero. This was done some twenty times but failed to reveal any hysteresis in the balances, all of which were accurate within the limits to which they could be read.

Similarly the ability of a balance to withstand rough usage, or even ordinary wear and tear, is something which we cannot establish within the laboratory. It is worth pointing out that with the exception of the Oertling, there are no safety devices to prevent weight changing with the beam in the release position. On the question of durability, we thought that some indication might be given if we were to determine the constant load which the balance carries, i.e. the force on the main bearing. This involved amongst other things weighing the weight carrier in situ and hence although we have attempted to be as accurate as the technique would allow, we quote only a lower limit to the constant load.

After sales service is an important feature of the purchase of any balance, particularly of those of foreign manufacture, and where this has been supplied to us we have incorporated information on the extent of the service in the individual reports.

It is impossible for us to give a 'best buy' or anything approaching it when considering a balance purchase. So much must depend on the circumstances and preferences of the individual teacher. Some may want a balance which can be quickly immobilised for transport from one laboratory to another; others may prefer the increased speed of automatic pre-weighing to the increased accuracy of a third place vernier. Still others may be prepared to pay the higher price to obtain both these advantages. What we do suggest is that a teacher seeking guidance on balances should borrow a copy of the reports on each and compare them; only in this way is he likely to find the balance which most closely suits his requirements.

Display Laboratory

The following are new items which have been added to the range since this section last appeared in a Bulletin, i.e. No. 7.

Item	Manufacturer
Weightlessness in Free Fall	SSSERC
Hot Air Engine	SSSERC
Perspex Hot Wire Bender	SSSERC
Colour Vision Wheel	SSSERC
Photo-diode Timing	SSSERC
Pearls in air Apparatus	SSSERC
Flexible Eye Lens	SSSERC
Direct Vision Spectroscope	SSSERC
Condenser charging from solar cells	SSSERC
Artificial Stream	SSSERC
Heart Circulation Model	SSSERC
Biceps/Triceps Model	SSSERC
Sound/	

Item	Manufacturer
Sound Powered Intercom	SSSERC
Hysteresis Loop Display	SSSERC
Transistor Bias Experiment	SSSERC
Flywheel Energy Conversion	SSSERC
Thermistor Thermometer	SSSERC
Projection Electrostatic Field	SSSERC
Geospecimen Sets	R.F.D. Parkinson
3cm Microware Apparatus	Griffin and George
4 tube Centrifuge, Simplex	Griffin and George
4 tube Centrifuge, Minette	Griffin and George
Water Bath	Griffin and George
Moulinex Liquidiser	Griffin and George
Linear Air Track	Griffin and George
Wulf Electroscope	Griffin and George
Otter Water Pump	Griffin and George
Vital Capacity Apparatus	Griffin and George
35mm Slide Holder and Viewing Box	MacFarlane Robson
Sartorius 2748 Balance	MacFarlane Robson
Dual Range Butchart Balance	Philip Harris
Piezo-electric effect	Philip Harris
Wulf Electroscope	Philip Harris
Model 71 Balance	Oertling
OS12 Oscilloscope	Advance Electronics
Ripple Tank	W.B. Nicolson
Magnetic Display Apparatus	W.B. Nicolson
Demonstration Meter	Weir
Pupil Meters	Weir
Pupil Meters	Unilab
D.C. Amplifier	Unilab
Polypropylene Beakers	A.R. Horwell
Russian Microscopes MBR1E	Andrew H. Baird
Microscope Microsystem 70	Watson

The following items have been removed from the display laboratory since the last entry:

Item	Manufacturer
Gade Microscope	W.B. Nicolson
Photodiode	W.B. Nicolson
Linear Air Track	W.B. Nicolson
ESM x40 Microscope	Bausch and Lomb
ESM x100 Microscope	Bausch and Lomb
ST2 100 Zoom Microscope	Bausch and Lomb
Junior Student Microscope	Prior
Science Master Microscope	Prior
Advanced Student Microscope	Prior
Diamax Microscope	Griffin and George
Xenon Stroboscope	Griffin and George
Swift 950	Andrew H. Baird
Fluid Flow Model	Andrew H. Baird
Simor Senior Microscope	L'Optic Moderne
Skybolt SR62 Microscope	L'Optic Moderne
Skybolt x30 Stereomicroscope	L'Optic Moderne
Skybolt N12 Zoom Microscope	L'Optic Moderne
Dyeline /	

Item	Manufacturer
Dyeline Photocopier	George Anson
Solid Materials Kit	Philip Harris
Demountable transformer	Philip Harris
Sartorius 2433 Balance	MacFarlane Robson
Potentiometer	Educational Measurements
Standard C and R Boxes	Educational Measurements
Galvanometer Amplifier	Educational Measurements
Helium Neon Laser	Ferranti
Decade Resistance Box	Derritron
Multi-Range Meter	Derritron
Micro-Galvanometer	Derritron

Trade News

Graduated polypropylene beakers with non-drip pouring edge are available from A.R. Horwell at prices which probably make them cheaper to throw away than clean for anything requiring a non-aqueous solvent. Per 100, prices are as follows;

50ml x 5ml graduation	£1	12	6
100ml x 10ml	2	5	-
250ml x 10ml	3	15	-
400ml x 20ml	4	15	-
800ml x 50ml	9	-	-
1000ml x 50ml	11	-	-

In response to teacher demand, Telequipment have modified their Serviscope Minor oscilloscope to provide an X input through terminals sited at the rear of the instrument. The sensitivity of the X deflection is between 0.4 and 0.5V per graticule division. There is no increase in price as a result of this modification.

For the benefit of teachers who have not received, or have forgotten the contents of Bulletin 1, we are bringing up to date an item from that issue. Advance Electronics have provided one or two of their current production instruments for stand-by use in schools. It is their intention that, should an Advance instrument break down in service, the school concerned would borrow the stand-by replacement until the original instrument has been repaired and returned. For this purpose we in S.S.S.E.R.C. have one H1 and one SG65 signal generators, a V1 vibrator, a VM77B valve voltmeter, and an OS12 oscilloscope. Similar provision has been made to serve the West of Scotland by leaving these models with the Physics Department of Allan Glen's School, Glasgow. There is also a J1 signal generator in the Gordon Schools, Huntly, and it is hoped to add other equipment to this depot to serve the needs of the North. The firm make only one stipulation; that an intending borrower should notify their Scottish representative of the school and the instrument borrowed, either by telephone or postcard to Mr. J.R. Wilson, 15 Murchland Way, Irvine, Ayrshire. Tel. Irvine 2222. Since this is a regional service, none of the centres concerned can undertake to dispatch these instruments to the school; they must be collected personally.

As from 1st February, the prices of the Mettler H3 and H4 Balances, marketed here by A. Gallenkamp, will be reduced, the H3 from £108 to £94, and the H4 from £115 to £98 10s.

S.S.S.E.R.C., 103 Broughton Street, Edinburgh, 1. Tel. WAV 2184

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

George Anson and Co., Ltd., 62 Hanover Street, Edinburgh, 2.

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

Bausch and Lomb Optical Co., Ltd., Aldwych House, London, W.C.2.

Dawe Instruments Ltd., Western Avenue, Acton, London, W.3.

Derritron Instruments, Ltd., Parklands, Cainscross, Stroud, Gloucestershire.

Educational Measurements Ltd., Brook Avenue, Warsash, Southampton.

Ferranti Ltd., King's Cross Road, Dundee.

A. Gallenkamp and Co., Ltd., Technico House, Christopher Street, London, E.C.2.

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

Philip Harris Ltd., Ludgate Hill, Birmingham, 3.

A.R. Horwell, Ltd., 2 Grangeway, Kilburn High Road, London, N.W.6.

Jencons Ltd., Hemel Hempstead, Hertfordshire.

Macfarlane Robson Ltd., 3A St. Vincent Street, Edinburgh, 3.

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

L. Oertling Ltd., Cray Valley Works, St. Mary Cray, Orpington, Kent.

L'Optic Moderne Ltd., 71 Great Portland Street, London W.1.

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

W.R. Prior and Co., Ltd., London Road, Bishop's Stortford, Herts.

Scientific Instrument Centre, 1 Leeke Street, London, W.C.1.

Stanton Instruments Ltd., Reliance House, Copper Mill Lane, London, S.W.17.

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

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

W. Watson and Sons Ltd., Barnet, Hertfordshire.

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