SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 80. May, 1975.

Contents

Introduction

We have just sent to all our U.K. readers a copy of our basic and workshop equipment list. The list purports to cover the needs of any science laboratory whatever subjects may be taught there, and deals with such items as burners, clamps and stands, test-tubes etc. In the workshop section we have placed items, mainly expendable, which would normally be kept in the technician's store and drawn from as needed. It includes things like glass tubing, mains cable, crocodile clips. Also in the workshop list we have included a representative list of what we think is required by way of wood, plastic and metal, together with glues, paints etc. if the technician is to be employed in the maintenance and repair of equipment, or in the construction of new designs of apparatus.

The list was priced in November, 1974, which is why it carries that date, and, to give some idea of the cost then of equipping a laboratory from scratch, the total cost of the items on the list, taking the lower of the two quoted prices where this is applicable, is as follows.

Basic equipment	£560.
Workshop equipment	£830.
Workshop materials	£250.

The figures are not exact but have been rounded up to the nearest £10. What they mean is that at the prices ruling at the time, it would have cost an authority £1,100 plus £560 per laboratory designed for 20 pupils to instal the basic equipment. To this must be added the equipment required for Integrated Science, or for the separate science subjects.

Although the list has been sent to U.K. readers only, we will supply anyone from abroad who wishes a copy, on receipt of 15p (or the equivalent in their own currency) with a clearly printed address to which the list should be sent. The same charge, which includes postage, applies to anyone in the U.K. who is not on our address list, or to anyone wishing additional copies.

Biology Notes

In Bulletins 71 and 74 there was some discussion of the problem of plastic Petri-dish disposal. If our information is correct, some teachers are solving the problem in a potentially hazardous manner. It would seem that they may be soaking used dishes in Lysol, washing them in soapy water, and then re-using them for non-microbiological work - as storage containers, crystallising dishes etc. It cannot be emphasised too strongly that treatment with Lysol does not sterilise the dishes. Lysol, in common with other phenolic solutions and derivatives, is not sporicidal and any dishes washed in it may well remain contaminated. Used dishes should be disposed of by the recommended methods. There is, as far as we are aware, no reliable way to ensure that dishes are completely sterilised except by autoclaving or some other form of heat treatment, after which they are in no state to be re-used. If teachers are upset by the waste of material and environmental contamination inseparable from the use of plastic dishes, they can always join with a number of their colleagues who have returned to using non-disposable, but highly breakable glass Petri-dishes.

The misuse of Lysol has lead us to consider the general problem of disinfection. A large number of different chemicals can be used to kill or control micro-organisms. Their action can be fungicidal, bactericidal - killing bacteria but not necessarily their spores, virucidal, sporicidal, or germicidal. The last is strictly, a misnomer. A germicide kills almost all micro-organisms, there being no known liquid germicide which is completely effective against all organisms. Some chemicals act merely as bacteriostats, preventing the growth of bacteria without necessarily killing them. For school usage the choice of disinfectant has to be made after considering several factors. The most important and most obvious of these is that the chemical(s) used should be known to be effective against the organisms involved, under the conditions likely to be encountered. For example, it serves little purpose to use a non-sporicidal compound which is inactivated by the presence of organic matter when cleaning cages. Another important consideration is that the substance used must not be harmful to the user or to livestock. Toxic preparations and, as far as this is possible, those which act as irritants, should not be used in schools. Lastly there is the issue of cost. This involves two factors, the price of the liquid disinfectant itself and the normal working concentration, which will determine the actual cost per unit volume of disinfectant solution as used in the laboratory. When making up dilutions from concentrated disinfectants it is advisable to use distilled or freshly boiled water, so lessening the risk of any contamination with resistant organisms. Bottles used to store the diluted solutions should never be fitted with corks, as these can inactivate many disinfectants.

The table below summarises some of the relevant information on those disinfectants encountered in laboratories.

<u>Key</u>.

<u>Action</u>.

- B - bactericidal
- Bs - bacteriostatic
- F - fungicidal
- V - virucidal
- Tb - effective against tubercle bacilli
- Sp - sporicidal
- hd - at high dilution

<u>Recommended Uses, Dilution</u>.

- D - dirty equipment, cages etc.
- G - general disinfection of 'clean' glassware, equipment etc.
- I - instruments
- Sk - skin disinfection
- C - swabbing of 'clean' surfaces, hard floors etc.

Disinfectant	Approx. cost per litre of working solution and working concentration (v:v aqueous solution).		Action	Recommended uses, toxicity.	Notes
<u>Hypochlorites</u>					
'Chloros' 'Milton' Maws 'Simpla'	1p	Solutions containing at least 200 p.p.m. available chlorine should be used.	B, Sp	G, C Irritant to skin and mucous membranes. Corrosive to metal, should not be used on cages. Bleaching action precludes use on clothing.	Good for general micro-biological use. Irritant, corrosive properties mean use is restricted to disinfecting clean glassware, spillages and pre-treatment of materials prior to disposal. Heavy contamination with organic matter means using solutions with up to 20% available chlorine. Wear protective gloves.
<u>Alcohols</u>					
Ethanol	£8.75	1:1 to 2.5:1	B, Tb	Sk, I (inoc. loops). Some risk of toxicity. Potential fire hazard.	Use usually restricted to microbiology - as aerosols, swabbing 'clean' surfaces, flaming loops etc. Used to disinfect skin before taking blood samples. Activity reduced in presence of organic matter. Not sporicidal.
Methylated spirits (Industrial spirits)	25p				
<u>Phenolics</u>*					
'Lysol' (cresol/soap mixture)	½ to 2p	1: 100 to 1: 20	B, F, Bs(hd), V.	Toxic, irritant. Potentially very hazardous in the undiluted state.	No longer recommended for school laboratory use. Compatible with soap but not fats or oils. Not sporicidal.

Disinfectant	Approx. cost per litre of working solution and working concentration (v:v aqueous solution).		Action	Recommended uses, toxicity.	Notes
Iodophores					
'Wescodyne'	1-2p	Solutions with 25 - 150 p.p.m. available iodine; up to 1000 p.p.m. in areas heavily contaminated with organic matter.	B, Sp, F, Tb, V.	G, I, C. Relatively non-irritant if used correctly.	May be used on cages but plastics and rubber can absorb much of the available iodine. Corrosive to metal at high concentrations. Colour indicates level of activity. Not greatly affected by change of pH or organic matter.
Quaternary Ammonium Compounds (QACs)					
'Task' 'Savlon' liquid antiseptic 'Savlon' hospital concentrate 'Aseptopol'	1p	D; 1: 100 Sk, G, C; down to 1: 200 or less depending on circumstances and individual product.	B, Bs(hd), Tb(hd).	D, Sk, G, C. Virtually non-toxic at working concentration. Skin sensitization and irritation reported but not common.	Activity reduced by organic matter. Active film left on treated surface. Compatible with methanal and alkalis, not with anionics or soaps. Often more active against gram +ve types but preparations with 'Hibitane' are more active against gram -ve organisms. Not sporicidal.
Ampholytes**					
'Tego MHG'	1½p				
'Griffin ASAB'	3½p	1: 100	B, Bs, F, Sp, Tb.	D, G, I, Sk, C. Virtually non-toxic and non-irritant.	Good all-round disinfectant. Useful for cages etc. Compatible with many surface active agents, including QACs, but not with soap. Leaves active surface film; deodorising; activity not reduced by organic matter.
'Harris BAS'	3p				

Disinfectant	Approx. cost per litre of working solution and working concentration (v:v aqueous solution).		Action	Recommended uses, toxicity.	Notes
Chloroxylenols					
'Dettol'	5p	Sk, I; 1: 20	B, Bs	Sk, G, I, C. Little toxicity. Can be irritant when undiluted.	Good for use in relatively 'clean' areas. Activity reduced in presence of organic matter.
Boots 'Family Antiseptic'	2½p	G; 1: 40			
'Izal Antiseptic'	1p	C; 1: 150			
Aldehydes+					
Methanal (Formaldehyde)	1p	Usually 1: 50 to 1: 20	B, Bs, F, Sp, V.	Highly irritant and toxic. Vapour may combine with hydrochloric acid vapour to form a carcinogen.	Not recommended for school use because of toxicity and irritant properties.

* Phenolics. 'Lysol' is the phenolic preparation most commonly encountered in school laboratories. Whilst we advise against the use of Lysol, some preparations contain only the higher phenolics and are less irritating and toxic. The main advantage of such disinfectants is their relative cheapness and the retention of activity in the presence of organic matter. We would not rule out their use in some situations, e.g. floors, footpaths and other large dirty areas.

** Ampholytes. These are also active against some viruses, particularly the larger pox types, e.g. animal pox viruses. There is some confusion between laboratory and field trial results as to the efficiency of action against other viruses and therefore we have not described these compounds as being virucidal although they do show considerable anti-viral activity.

\+ Aldehydes. 40% methanal solution on filter paper can be used to provide methanal vapour to kill micro-organisms in Petri-dishes by treatment overnight before inspection of cultures by pupils. However such inspection is rarely necessary and if attempted the procedure recommended by M.I.S.A.C. should be followed (School Science Review, No. 195, p.248). (M.I.S.A.C. = Micro-biology in Schools Advisory Committee; names and addresses of local advisers in Scotland are given in the Journal of Biological Education, 9, 1, February, 1975.).

Local pharmacists will usually be able to supply Dettol, Boots Family Antiseptic, Izal Antiseptic, Chloros, Milton, and Maws Simpla. Other suppliers are; Tego MHG - Hough, Hoseason and Co.; Griffin ASAB - Griffin and George; Harris BAS - Philip Harris Biological; Task and Aseptopol - British Hydrological Corporation; Savlon products - I.C.I. Wescodyne - Ciba-Geigy.

In The Workshop

The origin of this design came from the Berwickshire High School, Duns. The use of an oscillating shaft in a flask shaker is not new; it features for example in the Griffin and George version. Where we have departed from custom is in the method of linking the shaft to the drive mechanism. The usual connecting link system couples the shaft to the drive permanently. We have noticed that on some commercial versions this tends to move the liquid bodily, which produces relative motion and presumably solution between the liquid and any heavy particles lying on the bottom of the flask, but does little for any that are in suspension. We decided therefore that we would use the drive only to displace the shaft from its gravitationally stable position, and use gravity to effect the return of the shaft for the next stroke. This produces a jerky motion which really shakes up the material in the flask; in fact we have found that if the stopper is not secure it can be shaken loose and the liquid spilt. At the same time we built in a quick method of adjusting the degree of shaking by varying the amount of displacement of the shaft. The principles will be seen in Fig. 1.

At one end of the shaft carrying the flasks is keyed a long pin, like a knitting needle, which projects downwards. Near base level this is in the path of two projecting pins sited on a disc which is turned at a speed of about one revolution per second by a motor. Each pin in turn impinges on the needle and moves it to one side. When the rotation of the disc carries the pin beyond the end of the needle, the weight of the flasks causes shaft and needle to drop back until the needle strikes the second pin. This sudden arrestment of the return produces the jerky motion, and turbulence of the flask contents. The position of the needle on the shaft relative to the 'rest' position of the flasks may be altered, moving it to one or other side of the vertical, and this produces more or less vigorous shaking.

The oscillating shaft is a piece of oak or other hardwood, 300 x 25 x 25 mm. On each of the sides are screwed three Terry clips to hold the flasks, six of size 4 and six size 3 in all. The size 4 clip will take a 250 ml conical flask, while size 3 fits the necks of 250 or 350 ml round flasks. The clips are not screwed directly to the shaft; instead, small pieces of wood, used solely as spacers so that flasks on opposite sides of the shaft will not be in contact are placed under each clip. Pieces of hardboard were used under the size 4 clips, and of 5 mm thick plywood under the size 3 clips. Also, to avoid weakening the shaft by having four screws entering at the same cross-section plane, the placings of the clips on the four sides of the shaft are offset by a small amount relative to each other. Clips on the same side of the shaft are about 10 cm apart. For balance the same size of clip and flask must be put on opposite sides of the shaft. The capacity of the shaker is therefore six flasks of the same size. If only one flask requires shaking, it must be balanced by a similar water-filled flask on the opposite side.

At each end of the shaft a 10 mm dia. hole is drilled 25 mm deep. Into these are fitted two lengths of 10 mm dia. mild steel rod, so that they project 25 mm at one end, and 40 mm at the other. In our case these were secured with Araldite. These rods support the shaft on two L brackets, made from 6 x 25 mm mild steel bar, so that it is about 18 cm above the baseboard. Two nylon bushes are used between the rod and brackets. Details of this part of the construction are shown in Fig. 2.

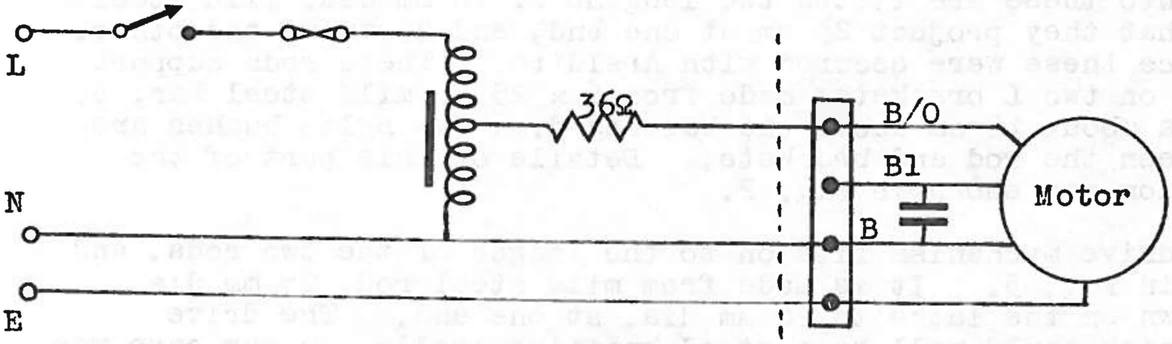
The drive mechanism fits on to the longer of the two rods, and is shown in Fig. 3. It is made from mild steel rod, 25 mm dia., turned down on the lathe to 20 mm dia. at one end. The drive needle, which could well be a steel knitting needle, in our case was a length of 3mm mild steel rod brazed into the bush to a depth of 5 mm. The length of the needle is about 15 cm; it should be made so that the end is level with the drive shaft of the worm gear. One or more Allen type grub screws are used to lock the bush onto the shaft of the shaker. The end 20 mm of the needle is covered with a length of polythene or polypropylene tubing, largely to reduce noise from the drive pins striking the needle. Thus when the grub screws are loosened, the position of the needle on the shaft may be adjusted so that the needle is in contact with the drive pins for only a small fraction of the rotation, producing gentle shaking, or over almost the whole of the rotation cycle, giving more vigorous shaking. Again, when changing from one size of flask to the other, the screws are loosened and the shaft turned through 90°.

The motor drive is shown in Fig. 4. Two 25 mm long 4 BA bolts are fixed 40 mm apart and diametrically opposite on a 45 mm brass disc which has been silver soldered to a brass bush suitable for fitting the motor shaft. The bolts are covered with nylon tube, again to reduce noise and for good wearing. These sleeves are a loose fit on the bolts so that they rotate when in contact with the needle. Any motor which will provide the necessary torque and run continuously will be suitable. A final speed of one revolution per second indicates that one with a worm gear may be best. Amongst our surplus material we have a motor of this type, in sufficient numbers to be able to offer it to any who wish to construct the flask shaker. Unfortunately it is designed for intermittent use at 115 V and requires additional components to be bought to adapt it for 240 V continuous running. Despite this we think that it is still possible to construct a cheap and effective flask shaker using the motor. The remainder of this article will therefore deal solely with the adaptations necessary to use our motor with the shaker.

The package as supplied - cost 50p plus postage - will consist of motor, 4-terminal connecting block, starting capacitor, and worm gearing. The following additional components will be required.

Auto-transformer,* 240/115 V	K. R. Whiston	3107	£1.62
Toggle switch	R.S. Components	316-563	26p
Fuse holder	"	412-021	23p
500 mA fuse	"	412-138	18p
Power resistor, 36Ω, 0.7 A	"	154-438	21p

*An alternative auto-transformer is the R.S. Components 207-116 at £2.70. The electrical circuit of the motor is shown below.



Connections to the right of the dotted line will normally have been made on the equipment as supplied by us, although in some cases the earth connection to the motor may be missing. There are a number of screw holes in the motor case to which this connection may be made. The colour-coded leads between the motor and the connector block are B/O = black/orange; B1 = blue; B = black. The auto-transformer leads have standard coding on both primary and secondary, i.e. brown = live; blue = neutral; green/yellow = earth. The power resistor was included in the motor input to reduce energy dissipation so that the motor, even when boxed in, would run continuously without overheating. It has the same beneficial effect on the transformer, and it does not affect the performance of the motor. Using the resistor, the p.d. applied to the motor is about 100 V and the current 0.5 A.

The motor shaft is threaded for a worm drive. The worm gearing supplied consists of a worm wheel on a shaft and two other connected gear wheels, all on a U-bracket. The gearwheels are not needed and should be removed. One is fixed to its shaft with a circlip, the other is secured by a pin through the wormshaft which must be pulled or hammered out. A spacer, also pinned on the worm shaft should also be removed. The worm wheel is fixed to the shaft with an Allen grub screw; this should be loosened and the wheel moved so that it is at the end of the shaft. This allows the shaft to be pushed further into the U-bracket so that its far end projects far enough beyond the bracket for the attachment of the brass disc of Fig. 4. The worm shaft is 6.4 mm ($\frac{1}{4}$ in) diameter, and the dimensions given in Fig. 4 should fit it. It will be necessary to drill two holes in the base of the bracket to allow it to be screwed to the baseboard. Fig. 5 shows the final appearance of the worm drive.

Our base was a piece of 20 mm blockboard measuring 60 × 25 cm. This is large enough to contain the shaker, the motor, and its associated circuitry. We think that the motor is powerful enough to drive a total of 8 250 ml flasks, four to a side, and if this were done the baseboard and oscillating shaft eould require to be lengthened. We made a cover for all the driving mechanism except the disc and drive pins, using 16 s.w.g. mild steel sheet. This serves the double purpose of insulating pupils from contact with high voltages, and protecting the equipment from spillages from the flasks. The cover carries the switch and fuseholder at one side, but all other components are mounted on the baseboard. The remaining sides of the cover have gauze-covered ventilation holes and it was also painted matt black to help heat dissipation. In fact none of the components runs so hot as to be uncomfortable to the touch. After all components have been mounted the baseboard and L-brackets should be given a protecting coat of varnish. To date our shaker has run continuously for six weeks with a load of six 250 ml flasks each containing approximately 150 ml water.

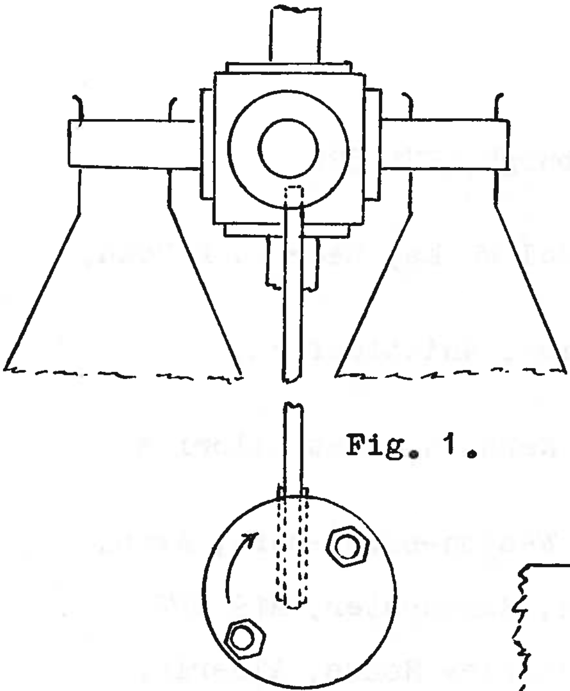


Fig. 1.

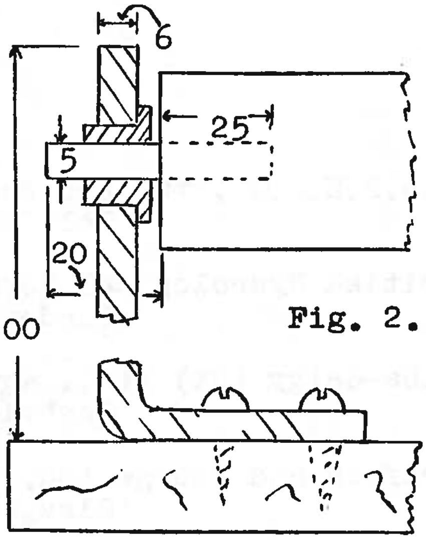


Fig. 2.

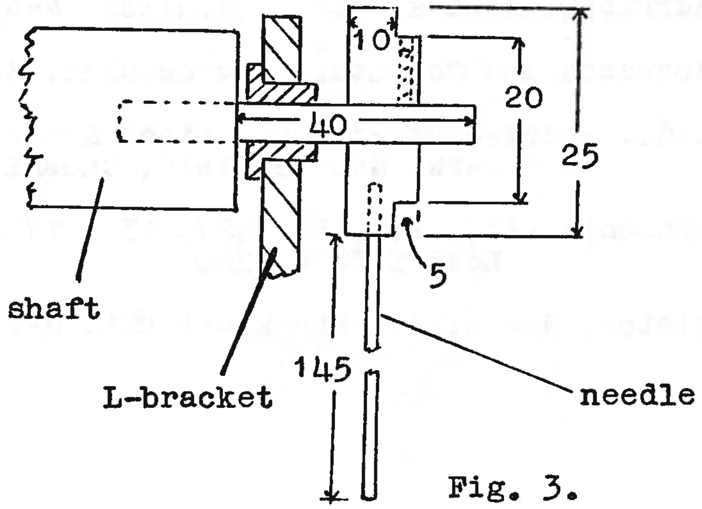


Fig. 3.

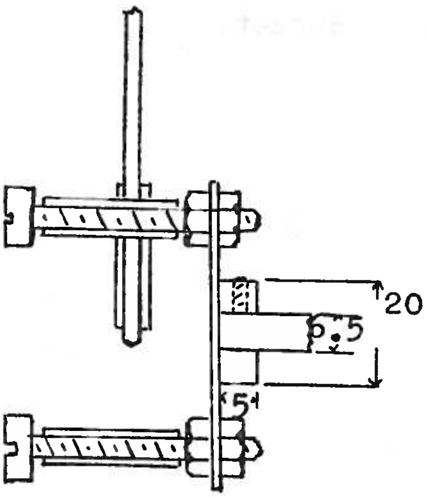


Fig. 4.

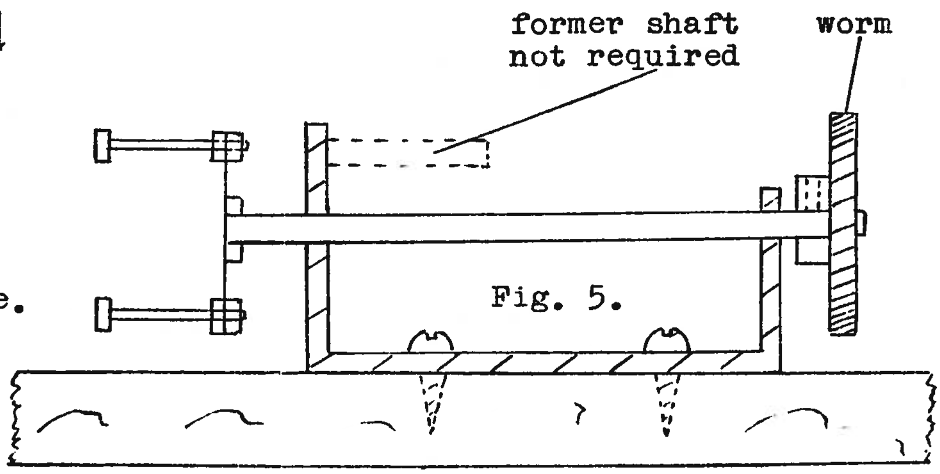


Fig. 5.

Figures not to scale.
Dimensions in mm.

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

British Hydrological Corporation, Colloidal Works, Deer Park Road, London, SW19 3UQ.

Ciba-Geigy (UK) Ltd., Agrochemical Division, Whittlesford, Cambridge, CB2 4QT.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride, Glasgow, G74 3XJ.

Philip Harris Biological Ltd., Oldmixon, Weston-super-mare, Avon.

Hough, Hoseason and Co. Ltd., Levenshulme, Manchester, M19 3PT.

I.C.I. Ltd., Pharmaceuticals Division, Alderley House, Alderley Park, Macclesfield, Cheshire.

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

K. R. Whiston, New Mills, Stockport SK12 4PT.

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