SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

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Contents

Introduction

Much of this Bulletin is concerned with chemistry and biology, although what we have to say on the subject of natural gas in schools, printed under Chemistry Notes, should be of equal interest to biologists, chemists and physicists. That there were problems associated with the conversion was first brought to our notice by a report of the A.S.E. Apparatus Committee. This was followed by a complaint from a teacher in one of the first Scottish schools to undergo the conversion. Conversation with a 'converted' teacher revealed the fact that there had been a period of about 10 days when no gas of any kind was available in school, and consequently it was difficult to compare subjectively the performances of town and natural gas burners, and no one in the school had done objective tests on the town gas burners before the supply of town gas was discontinued.

As most of the Borders have been converted, and as conversion is going ahead in the West of Scotland we realised we had to act quickly. Throughout the survey we have carried out, and which has still to be completed, we have had the full co-operation of the Scottish Gas Board, who are as anxious as we are that the schools should receive satisfactory replacements for their gas burning appliances. Because time was short, we concentrated our attention on the Bunsen burner, since probably 90% of the use of gas in schools is through these. We have selected two burners as being satisfactory alternatives to the usual town gas burner, one of these being a smaller type for semi-micro work. With the trend towards the use of smaller quantities of chemical reagent, we believe that schools should use the opportunity of this conversion to replace a proportion of their standard Bunsen burners with a type suitable for semi-micro work, instead of persisting in the makeshift practice of removing the chimney of a standard burner and using the jet only.

In Biology Notes we give a specification for stereo microscopes, and follow this with an account of the test procedure to be used in reporting on them. In this connection we would repeat our appeal for statistics on the inter-pupillary distance of younger pupils, made in Bulletin 41. Some schools have informed us as they are proceeding with this investigation as time permits, but we would not like any biologist to feel that it is now too late to make a start; we need as large a sample as possible.

Finally may we throw out a query which could well form the basis of a Sixth Form Biology project; are stereo microscopes really necessary? Some work done for the N.A.S.A. space programme, first brought to our notice by a member of our Development Committee, suggests that we judge the solidity of objects being viewed by such things as shadow patterns, as much as from the binocular component of our viewing. In a simple test carried out in the Centre, that of viewing lycopodium spores through a stereo microscope with oblique illumination so that shadows were cast, a number of people found there to be very little difference whether one or both eyes were used. Could it not be the case that for a majority of pupils, provided such things as adequate depth of field and field of view were achieved, a non-stereo microscope with oblique illumination would serve equally well?

Physics Notes

The existence of a new and inexpensive type of mount for small electrical components, including the smallest type MR38P Japanese meter, has been notified to us by George Watson's College. It is rectangular section plastic drainpipe, made by Marley Tile, and which will be stocked by plumbers and ironmongers. The pipe is made in two colours, grey and white, and is sold in 6, 8 and 10ft lengths. Inside dimensions of the pipe are 64 x 51mm. When cut in half, it gives a U-shaped support; 4mm sockets can be mounted either one on each vertical limb, or both on top. As an example of price, a 10ft length costs £1.2s.6d., which means that a mount for an MR38P meter or any similar small component will cost approximately 3d.

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There is now no camera in the Polaroid range which is suitable for stroboscopic photography. This unwelcome news has been confirmed by Polaroid themselves, as they are now concentrating production on cameras with wholly automatic shutters. Stroboscopic photography requires a 'Brief' shutter setting, so that the shutter may be held open during the whole of the action. It would seem therefore that new schools being equipped at present or in the future have either to look to the second-hand market through advertisements in photography journals, or decide to use 35mm film.

Chemistry Notes

Teachers may have noticed in the sixth report of the A.S.E. Apparatus Committee, published in Education in Science, Vol. VIII, No. 38, an account of one school's conversion to natural gas. Fearing that their problem might be repeated in every Scottish school which has to make the change-over, we decided that we should investigate the operation of whatever natural gas burners we could lay our hands on. As the Borders area has already been converted, and as large parts of the central belt of Scotland are due for conversion in the course of the next few weeks, there was some pressure to get the investigation started, and this is also the reason why we are publishing here what amounts to an interim report, as work is still being carried out, and in some important cases, e.g. flame spreaders, we have been unable to get the necessary equipment.

After some delay, we were able to get from the Scottish Gas Board a cylinder of natural gas, together with the necessary pressure reducing apparatus, and a selection of Bunsen burners. The questions to which we wanted answers for natural gas, and where possible a comparison with town gas, were:

1. Rate of heat supplied.
2. Maximum temperature of flame.
3. Visibility of flame when air hole is open.
4. Will the usual gas lighter (Ever ready $1\frac{1}{2}$V type) work?
5. Diffusion from a balloon compared with hydrogen and air.
6. Density, for floating balloons in air.
7. Use in reduction of metallic oxides, e.g. CuO, PbO.
8. Identification of products of combustion.
9. What is the height of flame with air hole closed, half and full open? Is the standard tripod suitable; if not, is it possible to reduce the height of tripods if other factors are equal?
10. Are the normal flame tests satisfactory?
11. Will the "syrup tin and spark plug" explosion work?
12. Is the temperature high enough for making glazes, blobs of glass etc.
13. Use of flame spreaders.
14. Examination of flame for the identification of unburnt cones etc.
15. Stability of flame.
16. Is it possible to use the jet only for semi-micro work?
17. Stability and robustness of the burner, resistance to corrosion, mechanical performance of burner in general.
18. Sensitivity of the air control.
19. Measurement of flow rate which, together with the quoted calorific value of the gas will give a measure of the efficiency of the burner.
20. Use as a carrier in gas chromatography.
21. Use with a bench blowpipe for glass-blowing.
22. Use with other types of burner, e.g. fish-tail, Meker, etc.

Natural gas has a calorific value of 3.78×10^4 kJm^{-3} (1016 Btu/ft^3) compared with an average value of 1.77×10^4 kJm^{-3} (475 Btu/ft^3) for town gas. The approximate compositions are:

	Natural Gas	Town Gas
Methane	87%	26%
Hydrogen	5%	50%
Nitrogen	8%	14%
Carbon Monoxide	-	10%

The gas will be supplied at a pressure of 2.1×10^3 Nm^{-2} compared to the average town gas pressure of 1.5×10^3 Nm^{-2}, i.e. the natural gas pressure is approximately one third greater than that of town gas. The increased calorific value means that to achieve/

achieve comparable burning rates, jets have to be much smaller. This leads to higher gas velocities and flame instability. To prevent the latter, all Bunsen burners are fitted with a special top to the chimney, comprising an inner and an outer metal wall with a 1mm air gap between them, this gap extending down for the first 10mm of the chimney.

For purposes of comparison we chose two of our own stock of town gas burners, both having a chimney 13mm dia and single air hole. One of these was 12.5cm high., the other 13.2. Because one of the deficiencies of natural gas burners reported in the A.S.E. publication was low heating rates we also sought to determine the suitability of natural gas burners for semi-micro work, comparing them with a town gas semi-micro burner. The town gas burner used for this comparison was the Griffin and George S17-069. As a result of our tests we have selected the two natural gas burners which are nearest in performance to the standard and semi-micro town gas types. We cannot say they are the best buys, since we limited our tests to burners which the Gas Board supplied to us, and are presumably those which the Board are prepared to offer in exchange for existing burners. The burner which most nearly equates in performance to the normal town gas type is made by Flamefast Engineering. The outline and dimensions are given in Fig. 1 below. The base is cast in mild steel and has been stamped '007', as well as having the firm's name embossed on it. Inlet and chimney are of brass; the air control has two oval holes. The burner we have found most suitable for semi-micro work, by comparison with the town gas type, is Model No. 4015M, by R. and L. Enterprises. This burner has no identification markings. It has a pressed steel base finished in grey stoved enamel, with nickel plated brass inlet and chimney. The burner stands 98mm high, and its outline is given in Fig. 2 below.

In the results which follow, the burners have been labelled as follows. A - natural gas semi-micro burner; B - town gas semi-micro burner; C - natural gas standard burner (Flamefast); D and E - the two town gas standard burners.

1. Following the practice used in the A.S.E. article, we measured the effective heating rate, by heating water in a beaker on a tripod with wire gauze. Although we graphed the results to boiling point, we give for comparison the temperature rise achieved in the first ten minutes of heating. These were:

A	B	C	D	E
13°C	18°C	55.5°C	70°C	74°C

2. Maximum temperature of flame. This is difficult to measure, since any sensing device presents a finite area of surface to the flame, and the temperature recorded will be an average value over the surface. We used two methods. Firstly we made a platinum resistance thermometer from a coil of wire, the ends of which were pushed through holes in an asbestos shield and/

and then brazed to thick copper. The resistance was measured on a Wheatstone bridge and temperature calculated assuming the resistivity of platinum. The second method was the calorimetric one of heating a lump of iron in the flame and then dropping it into a calorimeter with water. The results were:

	A	B	C	D	E	
Resistance thermometer	1030	1040	1100	1120	1130	°C
Calorimeter	-	-	1300	1300	1300	°C

3. Visibility of flame. Results here are neither better nor worse than for town gas. There will be as many complaints as before regarding the invisibility of the flame, particularly in sunlight, but at least there ought to be no more.

4. Use of a gas lighter. Natural gas will not ignite from the hot wire type of lighter supplied for town gas. We await a sample of a similar lighter for natural gas.

5. Diffusion from a balloon. The diffusion rate is very slow compared with town gas, and only just distinguishable compared with a balloon filled with air.

6. Floating balloon. If well filled, balloons with natural gas will rise in the atmosphere. Soap bubbles (bubble liquid from toy shops) with natural gas rise almost as fast as those with town gas.

7. Reduction of metallic oxides. Natural gas will reduce copper oxides satisfactorily, but is unsatisfactory for lead oxides.

8. Identification of elements. Both carbon, identified as a sooty deposit from the yellow flame, and hydrogen, in the formation of water on burning against a cooled surface, are as readily identifiable as they are in town gas. What is not obvious is that the hydrogen exists in combination.

9. Height of flame. The results were:

	A	B	C	D	E
Air hole closed	70	105	350	400	400mm
Half open	65	95	280	280	320
Fully open	45	95	210	210	250

The natural gas type C, although generally providing a smaller flame than its town gas counterparts D and E, will therefore in general be suitable for use with the tripod stands already in use. Schools which already have semi-micro burners with associated heating blocks may find some loss of efficiency in using the latter with the natural gas type A burner, because of/

of the 30mm reduction in flame height.

10. Flame tests. These are equally satisfactory with burners C, D and E.

11. Spark plug explosion. No success was achieved with any mixture of natural gas and air in this experiment.

12. Making of glazes. As will be seen from the results of (2), the temperatures are comparable, and as we expected, natural gas is satisfactory here.

13. Use of flame spreaders. We are awaiting delivery of flame spreaders from the Gas Board. The type C burner does not have a flame spreader made to fit it, but the Board are to investigate the possibility of making one.

14. Parts of the Bunsen flame. These are the same in appearance and behaviour as for town gas, but with the natural gas burner C we were unable to ignite any gas extracted with a glass tube from the central cone.

15. Flame stability. This is one of the least satisfactory aspects of natural gas. Displacement and disturbance of the flame by the least draught of air may mean that in many situations it may be impossible to have any windows open in the laboratory. On some occasions, a person walking past the type C burner at a distance of 30cm was sufficient to extinguish the flame. For comparison, we measured the distance at which an air blower, made from a converted vacuum cleaner, would extinguish the flame. The greater the distance, the poorer the performance of the burner.

	A	B	C	D	E
No air	> 200	74	120	18	19 cm
Half air	> 200	40	120	18	23 cm
Full air	>200	36	137	23	23 cm

16. Jet only on semi-micro work. This was satisfactory with type C burner.

17. Mechanical features. The type C burner we have selected is exceptionally robust and stable. The base weighs 350gf, and the tube 50gf. We cannot prognosticate on wear and tear, particularly in respect of clogging of parts of the burner, but a 1mm gap between two metal tubes at the top of the burner will be highly susceptible to blockage by spilt chemicals, with consequent corrosion, and in fact, this point has been made in a letter to Education in Science, Vol. VIII, No. 39, p30. For this reason alone we would expect the natural gas burner to have a shorter life than its town gas equivalent.

18. Sensitivity of air control. There would appear to be no difference in the action of the air control on the two types.

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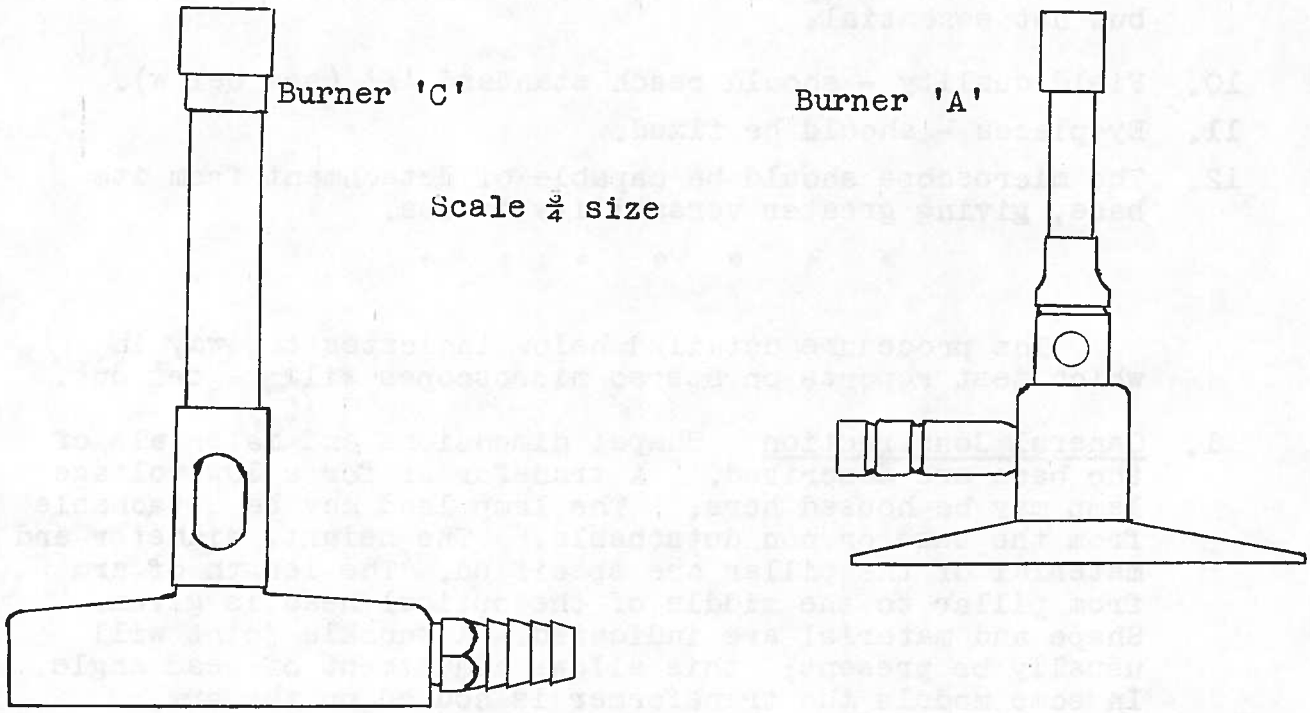
19. Practical efficiency. Flow rates were measured on a meter supplied by the Board. The heating test of Item 1 was used as a rough measure of rate of heat input. The efficiency of town gas was 17.5%, that of natural gas 18%, on this method.

20. Carrier in gas chromatography. With the katharometer detector described in Bulletin 39, natural gas performed satisfactorily. We have not yet tested flame ionisation or thermocouple detectors, but we have reports that these will not operate on natural gas because of the smallness of the flame, and its instability.

21. Bench blowpipe use. This was tried unsuccessfully with the town gas blowpipe we possess; we await delivery of a natural gas version.

22. Other types of burner; as yet untried.



Biology Notes

The following features have been decided upon, by the Development Committee, as the minimum necessary for satisfactory performance on both 'O' and 'H' grade syllabuses, of stereo-microscopes.

1. Three stereo microscopes per laboratory.
2. Magnification - x10 and approximately x20.
3. Field quality - at least standard B on the quality tests (see below).
4. Vertical adjustment - the head should be capable of a considerable

considerable movement in this direction for versatility in use.

5. Horizontal adjustment - the head should be at some distance from the vertical pillar to allow it to be swung, for example, over tanks and dissecting dishes.

6. Safety stop collar - this should be adjustable, to prevent contact of the objectives with specimens or bench top.

7. Stability - the instrument should be sufficiently stable for all positions of the head.

8. Head angle - this should be adjustable, with a good locking device to prevent it from slumping onto a specimen.

9. Focussing mechanism - should be adequately stopped.

The following features are thought to be desirable, but not essential:

10. Field quality - should reach standard 'A' (see below).

11. Eyepieces - should be fixed.

12. The microscope should be capable of detachment from its base, giving greater versatility in use.

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The procedure detailed below indicates the way in which test reports on stereo microscopes will be set out.

1. <u>General Construction</u> Shape, dimensions and materials of the base are described. A transformer for a low voltage lamp may be housed here. The lamp lead may be detachable from the base or non detachable. The height, diameter and material of the pillar are specified. The length of arm from pillar to the middle of the optical head is given. Shape and material are indicated. A knuckle joint will usually be present; this allows adjustment of head angle. In some models the transformer is housed on the arm. Voltage and power of the lamp are given. It may be positioned overhead or to the side. The total weight is stated, together with the dimensions in storage position.

2. <u>Eyepieces</u> These are Huygenian unless otherwise stated. They may be fixed or free, adjustable or non-adjustable. Eyepiece shields may be provided. The manufacturer's stated magnification is given.

3. <u>Objectives</u> The stated magnifications are given. The method of objective changing is described. They may be protected - from dirt and specimens - or unprotected.

4. <u>Focussing Mechanism</u> The mechanism is almost invariably rack-and-pinion, with no fine adjustment. The fit and general finish of the mechanism is also indicated. Stops may be present at either or both ends of the mechanism. A stop at the lower end prevents the head from falling out of the dovetail slide. At the upper end, it can prevent a similar event if the head/

head is in position for viewing a vertical surface, or for storage.

5. <u>Field Quality</u> Two main factors affect the quality of the field of view, namely the extent of distortion and the extent of blurring towards the edges of the field. Distortion is tested for as follows. Millimetre graph paper is viewed under x10 magnification. Any distortion is immediately recognisable by a 'pin cushion' effect due to curvature of the graph lines. It is possible to look at the vertical graph lines through, say, the left eyepiece with the right eye, while simultaneously viewing another vertical line - drawn on a card - in the same plane, with the unaided left eye. By manoeuvring this other line it is then possible to superimpose it on one of the graph lines. The degree of distortion has been arbitrarily divided into three grades, A, B and C; and for each grade an appropriate line has been drawn, thus: Grade A - a straight line; Grade B - a curve of radius 64cm; Grade C - a curve of radius 44cm. Each is about 20cm long. The lines are then superimposed in turn on a vertical graph line 1mm from the edge of the field of view and tested for best fit, to obtain the appropriate grading.

6. Blurring is tested for as follows. A horizontal graph line through the centre of the field of view is observed under x10 magnification. Starting from the centre, the graph mm squares are followed outwards until blurring is first noticed. The number of squares from this point to the edge of the field of view is then counted and this is divided by the total number of squares from the centre to the edge. The degree of blurring has also been divided into A, B and C grades, thus: Grade A - less than 0.2; Grade B - 0.2 - 0.4; Grade C - more than 0.4.

7. <u>Chromatic Aberration</u> A black spot on white paper is examined at the centre of the field of view. Any coloured edges to the spot indicate an inferior lens.

8. <u>Actual Magnification</u> The stated magnifications are checked as follows. A tenth mm scale is viewed through the microscope with one eye while the other views a mm rule in the same plane, directly. The two images are then superimposed in much the same way as when testing for distortion, and the magnification can be determined.

9. <u>Field of View</u> The diameter, in mm, is given for each magnification. The accuracy of colour reproduction and the quality of depth detection are described. The latter is best assessed by observing <u>Lycopodium</u> spores - singly and in small groups. The two halves of the instrument are compared for the following features - magnification; size of field of view; alignment; focus, if there is no adjusting eyepiece. Alignment is tested as follows. A vertical straight line is viewed, with the same eye, through each eyepiece in turn. It should be in the same position in each case. Any difference between the two halves of the instrument not only adversely affect the performance, but can also cause eye strain.

10. <u>Controls</u> The ease of use of the focussing mechanism and of objective changing are described. The objectives may or may not be parfocal.

11. <u>Lamp</u> This may be fixed or moveable, focussable or non-focussable. The effectiveness of the illumination is described.

12. <u>Adjustment of Head Angle</u> The range of movement is described in terms of degrees either side of the vertical. The ease with which the knuckle joint may be locked and unlocked is described.

13. <u>Working Distance</u> This is specified for each set of objectives. The maximum vertical clearance of the objectives from the bench, and maximum horizontal clearance from the edge of the base are stated.

14. <u>Stability</u> It is clearly important that the instrument should not be easily knocked off a bench, even when it is being used with the viewing head in the most unstable position. Stability is tested by fixing the head in the position for maximum horizontal clearance, with the arm 25cm above the bench, and measuring (a) the vertical pull and (b) the angle between base and bench when the instrument starts to tip.

15. <u>Eyepiece Separation</u> A stereoscopic instrument can not perform adequately unless the eyepiece distance can be adjusted to the inter-pupillary distance of the user. The problem is particularly acute with young secondary pupils. With adults the range is about 55 to 70mm. The maximum and minimum possible distances between the centres of the eyepieces are measured.

16. <u>Eye Relief Distance</u> The optimum distance between the top of the eyepiece and the eye of the viewer should allow comfortable viewing with spectacles. Therefore each instrument is tested for comfort by a spectacle wearer.

17. <u>Safety Collar</u> Frequently the arm may have to be raised some distance up the pillar. There is consequently the danger of it falling some way, and of the head being damaged, if the locking mechanism is carelessly loosened. A safety collar slides up and down the pillar, and may be fixed by the teacher just below the arm position, thus preventing accidental damage in this way.

18. <u>General Performance</u> After testing at the Centre, the instruments are put out for 'field trials' in certain schools, and rated A - very satisfactory; B - satisfactory, or C - unsatisfactory on three counts, <u>viz</u>: performance; ease of use; versatility in use.

19. <u>General Comments</u> The overall performance of each instrument is related to the different levels of work in the school. Assessments are then made on three grades; A - most suitable for school use; B - satisfactory; C - unsatisfactory. Any other/

other eyepieces or objectives available are listed, with prices. The latest price of the most suitable arrangement is given, and servicing arrangements indicated. Any accessories supplied with the instrument are described.

20. Manufacturer's Comments A draft copy of the report is sent to the manufacturer, to enable him to comment on any aspect of the report.

Integrated Science

Our search for true or imitation Coddington lenses, mentioned in Bulletin 40, has brought a variety of replies. From P.K. Dutt we have the information that their folding magnifier type MC156 is a Coddington type (although they do not give a definition of what they mean by this, and there is still an area of confusion here). The current prices for these are: x5, 9s; x8, 9s.6d; x10, 10s.6d.

Griffin and George believe that a Coddington lens is virtually a solid chunk of glass with end curvatures and refractive index related in such a way that the lens gave a magnified image for the normal eye when the body being examined was in contact or near contact with the bottom of the lens. They sent us two samples, both in plastic, and both with a built-up support in clear plastic so that when the lens was stood on the object being examined, it was in focus. As the samples cost £1.1s. and £2.8s.6d. each, it is doubtful if teachers would regard these as cheap.

Philip Harris think that Coddington lens is the outdated nomenclature for what we now normally term a doublet-lens, and suggest that their catalogue number B4590/08 at 9s. each would be most useful for schools. The performance of this lens is vastly better than any single lens magnifier without going to the expense of aplanats costing four or five times as much.

According to T. Gerrard and Co. a Coddington lens consisted of a thick double convex lens in one piece, in which a slot had been ground round the periphery. The slot was filled with a black material which reduced the field of the lens to the centre part only. They suggest that their AG1426 costing 8s.9d. (x5); (x8), 9s.5d., or (x10), 10s would be quite as good.

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

P.K. Dutt and Co. Ltd., 115 Lavender Hill, Tonbridge, Kent.

Flamefast Engineering Ltd., Pendlebury Industrial Estate, Manchester.

T. Gerrard and Co., Gerrard House, Worthing Road, East Preston, Nr. Littlehampton, Sussex.

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

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

The Marley Tile Co. Ltd., London Road, Riverhead, Sevenoaks, Kent.

Polaroid (U.K.) Ltd., Roseanne House, Welwyn Garden City, Herts.

R. and L. Enterprises Ltd., Swinnow Lane, Leeds, 13.

The Scottish Gas Board, Granton House, 340 West Granton Road, Edinburgh. EH5 1YB.