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Registered National Charity No. 256335

B I M E

What it does

The Bath Institute of Medical Engineering fills a role in medical research in a way that is unusual in this country. It uses the multidisciplinary approach of medicine, engineering and science to identify needs of disabled people and hospital patients not being met elsewhere and to provide solutions. The research of the Institute is always directed towards a practical outcome.

The Institute is an independent body. It was founded, and contines to be maintained, by charitable grants and donations. The offices and laboratories are in the grounds of the Royal United Hospital, Bath. There is a close working collaboration with this hospital and also with other hospitals throughout the country. The Institute is managed by the University of Bath and has strong technical links with Schools of the University. All these connections are of great importance to the activities of the Institute.

The Institute designs and tests prototypes and arranges clinical trials of new equipment for hospitals and special aids for sick and disabled people. When these are satisfactorily completed, the Institute collaborates with manufacturers, where it can, for the production and marketing to be undertaken. If a suitable manufacturer cannot be found the Institute produces the aid "in-house" and distributes it on a non-profit basis, often in collaboration with specialist marketing companies. The Institute also provides an information and advice service to the disabled community and manufacturers in the field, and undertakes work to help solve specific aids design problems.

The full-time engineering and technical staff of the Institute's laboratories are guided by an honorary group of medical consultants, university staff, scientists, engineers and industrialists.

Why it began

The Institute came into being in June 1968, launched by its first President, Sir Barnes Wallis, to provide the environment and facilities which enable all disciplines to work together for the advancement of medical treatment and care.

Its foundation had the support ot the (then) Ministry of Health, the Board of Trade, and the regional and local hospital authorities, and it was given national charitable status by the Charity Commissioners.

Many of the project ideas originate within the Institute. Others may be brought to the laboratories by those who have not the resources or facilities to complete their own development of a worthwhile aid or apparatus.

In summary, the aims of BIME are to promote the design, development and manufacture of appliances to help sick and disabled people by collaboration between the staff of the Institute, the medical and dental professions and other professions allied to medicine and industry, whilst maintaining close contact with the patients for whom the appliances are intended.

Chairman's Statement

1998 sees BIME celebrate 30 years of achievement and success. The credit is to be shared by many contributors: the patients and clinical practitioners who have subjected themselves to device evaluation exercises; medical professionals who have brought problems and solutions to BIME and initiated projects; charitable donors who produce those all so essential funds; the suppliers, and subcontractors of raw materials and components; distributors and marketeers who extend the awareness and use of BIME products and designs; the University of Bath for giving BIME its legal entity status and financial administration; the Wolfson Foundation and the Royal United Hospital for providing accommodation in an environment that fosters success; all advisors, clinical, managerial, technical and scientific; and many others.

Others? Well, Stephen Lillicrap in his Director's Report over the page, and Ken Lloyd Williams in his 1997 Chairman's Statement listed several others. (My not repeating the lists, does not diminish their share of the credit). They too, and in particular Ken himself, have all made valuable contributions to BIME's success. Ken is staying on as a member of BIME's Council and, as I succeed him as Chairman, I am most grateful for this continuing support. It will not be easy to match Ken's long undying commitment to BIME. But if BIME is to continue with that achievement and success then such direction, guidance and motivation must continue.

So, what of the future? It has often been said that perception is reality. In today's environment of economic constraint, this is more applicable to BIME now than ever before. Provided the perceptions of all those contributors to BIME (no exceptions) remain high, BIME will thrive. The trick is to understand those perceptions, how they change over time and to adapt to them. Quite a challenge! To become yet more successful requires anticipation of changing perceptions and, better still, guidance of them. To expand on this concept, it might be helpful briefly to speculate on the view points of the user of a BIME product, a project engineer and the funder.

A user of a BIME product can be motivated by the thrill of participating in an evaluation exercise. Feedback on the device will be influenced by excitement, and the will to be seen as positive and helpful. Beyond completion of the project, the device will continue in service only if it is seen to improve the quality of life for the same user. The finding of the user evaluation report might not reflect the in-service reality. Changing perceptions!

Whom does the project engineer try to impress? Whence comes the motivation? It could be from colleagues, supervisor, the clinical collaborator, the patient or the funder. The engineer will perceive that he has done a good job if those whose views he values express their satisfaction with his work. Not the rest. From project to project, dependent on personalities and relationships, he might work to win smiles from different individuals. Changing perceptions!

Whilst I can speculate about the driving forces behind patients and engineers, our charity donors view is less clear to me. What is it that causes them to renew or raise their donations? How do they rate the output and cost effectiveness of BIME? What should BIME be doing differently to further raise its image in their eyes? How do funders choose their priorities and measure the own performance? As soon as possible, I intend to try and find answers to these questions.

BIME is a business though rather unlike most, because the beneficiaries of its products do not comprise the major source of funds. State education and the health service are two other similar exceptions: they too are, nonetheless, businesses. Indeed these latter examples show just how difficult life can become when public confidence is lowered. Restoration is no mean feat. How much easier it is when a profile is maintained in good working order.

Whilst continuing with the excellent work as has been established over the last 30 years, BIME must turn a little attention to these broader issues of image, profile and perceptions. By so doing, the next 30 years should be no less successful. And I do expect to be around then to make my own assessment, and to congratulate BIME on 60 years of success and achievement, though probably as a member, not Chairman.

Oh! And our thanks must be extended to all BIME members for their support and interest too.

April 1998

Peter Lawes, Ph.D., C.Eng.
Chairman

Director's Report

Introduction

This year the Institute celebrates its 30th Anniversary. It was founded in June 1968 and, according to its first Annual Report, began its work of developing new devices to help disabled people on 15 July 1968. Since then numerous aids have been designed and developed by the Institute's staff in collaboration with medical and caring professionals and, of course, with disabled people themselves. Over the intervening years tens of thousands of devices for use in the home, outdoors, and in hospital, have been made available through commercial company manufacture and through our own non-profit production unit.

At the Annual General Meeting in October our Chairman, Mr Ken Lloyd Williams, completed his third term of office and felt it right to retire from the chair while continuing as a Council member. He was a founder member of the Institute serving as Vice-Chairman to the first Board of Governors, continuing in this role when the Council was formed in 1974. In 1988 he became Chairman and has served nine years in that office. Until 1977 he also chaired the Institute's Projects Committee and still serves as a member of that Committee. On a personal note I would like to acknowledge Ken's support and advice over the years since I became Director in 1977. In addition, he played a key part in making possible the move from the original workshops and laboratories to the newly built Wolfson Centre in 1987. We were very pleased to welcome at the AGM our new Chairman, Dr. Peter Lawes, who has served on Council since 1987 and, as Vice-Chairman, since 1988 and look forward to his leadership of Council.

Our aim is to make available our developed devices to disabled people who can be assisted by them and the best indicator of our success in achieving this aim is the number of people reached who are now being assisted by a device developed at BIME. To this end we have had a project, headed by Mr. Tim Adlam, which has now run for 18 months, to promote the awareness of BIME's aids to those disabled people, their carers and therapists who could be helped by them. Brochures and catalogues of the 24 products available from our non-profit production unit have been widely distributed, 140 promotional videos distributed, journal articles published, exhibitions attended and demonstration visits made. As reported later under "Promotions and Marketing" this work has been successful in raising the level of awareness of the help BIME can provide with an increase in interest in and demand for devices listed in our catalogue.

BIME's Sponsors

None of the engineering solutions to the problems of disability which we have been able to provide would have been possible without the magnificent support of our generous sponsors. We are, of course, most grateful to all our benefactors who support our work for disabled people each year, and all our donors in the current year are acknowledged and thanked at the end of this Report. But it seems a particularly appropriate time, at this anniversary, to acknowledge and thank those sponsors who still give regularly to our work each year and who were either founder supporters who helped launch the Institute, or who have given us significant support for much of our 30 year life. It is therefore a particular pleasure in this anniversary year to record our thanks to the following benefactors in this category, here listed alphabetically.

Alchemy Foundation
Arnold Foundation
BBC Children in Need
Barclays Bank plc
Benham Charitable Settlement
Dr. H. Mason Bibby
Mrs. A L. K Cadbury
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Jenour Foundation
Robert Kiln Charitable Trust
John Lewis Partnership
Lloyds Bank Plc
Mercers Company
G. M. Morrison Charitable Trust
Col. W. W. Pilkington Will Trusts
Rank Foundation

Sir James Reckitt Charity
C. Rowbotham Charitable Trust
Sir Samuel Scott of Yews Trust
Smith's Charity
Southern Trust
One sponsor wishes to remain anonymous

Finance and Planning

Returning now to the year under review, at the start of each year an estimate is made of the donations required to maintain our engineering commitment to the programme of aids development put to us through our Projects Committee, who first research the various needs and ideas brought to the Institute. Again we have been most generously supported by our sponsors at a time when increasing demands are being made on their generosity, and I should like to express our warm thanks to our many donors listed on the last page of this report who responded so generously. Our donated support has exceeded our planned target and this generous support will allow us to sustain our increased commitment which we took on last year.

During the year we said farewell and gave thanks to five valuable members of the team. At the beginning of the year we said farewell and wished a happy retirement to Mrs. Pat Holloway, who retired after almost 15 years as part-time secretary for the Department of Health funded infusion pump project. Her post has been filled by Mrs. Ruth Hooper who has become BIME's full-time secretary/ administrator. Mr. Simon Morling, who joined us six years ago and who has led the infusion pump project for the last three, left in January to join a major infusion pump manufacturer as a development engineer. During his time, he has strengthened BIME's position as the leading centre of expertise for these devices in this country. In March we welcomed back Miss Teresa Stather-Dunn, who worked on the project with us 10 years ago, to take over the project leadership. In January 1994, as a result of our Silver Jubilee appeal, we appointed Mr. Stephen Harvey on a three year contract to lead our expanded work on the development of aids for disabled children. He has successfully built this work to become a major activity for us. Stephen left in September to develop his career by undertaking an industrial design engineering course run jointly by the Royal College of Art and Imperial College. In November, we welcomed Mr. Robert Aley to continue the children's work. Robert is a graduate industrial design engineer with experience in designing for disabled people both in this county and overseas. In July we congratulated Peter Laidler, our electronics technician for nine years, who gained promotion and joined our colleagues in the hospital Medical Physics Department. To replace him we welcomed Mr. Simon Gale who has come with seven years valuable experience in industry. Finally, Miss Andrea Harry, also from the DH infusion pump project, left in February to pursue her career with a medical equipment manufacturer and her post has been filled by Mrs. Ann Hill who comes to us with graduate electronics and computing experience.

In order to assess the income and expenditure required to maintain the Institute's work over the short term, an estimate has been made of the income and expenditure levels over a three year period. This has proved most useful in showing our sponsors and members how we propose to use the income already received, and illustrates our need for a regular level of donation income to match the trend of inflation. The three-year estimate prepared for this year's report, summarised as a table, together with a fourth-year projection, is given on page 35.

As in last year's estimates, the table indicates the total staff commitment to the work of the Institute and the effective cost involved. This is done because some of those working at the Institute are employees of other organisations (mostly Royal United Hospital Trust) whose salary costs are not shown in the Annual Accounts. In addition, some of the staff employed by the Institute are partially or wholly funded by project grants from the Department of Health. This support is also shown in the table separately from that provided by our donors. Not shown are the costs of the considerable administrative assistance provided by the University of Bath, to which the Institute is greatly indebted.

As the accounts show, the major source of income for the Institute's projects are the donations it receives from its sponsors. The figures for anticipated income from both donations and grants shown in the table are estimates. The projected grant income is based on the current indications of likely funding from Government grant-awarding

bodies. The figures for anticipated donations have been estimated from promises received for the future and from anticipated donations from regular contributors, with an allowance for some increase each year. The estimated figures are not assured but represent targets for income which we hope our sponsors will provide. Obviously, although the estimated income and expenditure should be fairly accurate for the current financial year, the accuracy will decrease with time and be very approximate for 2001/2002. A figure of three per cent per year has been assumed for the effect of inflation on both salary and non-salary costs after 1998/99. An allowance for the incremental scales has also been made for the salary costs.

The future course and requirements of the Institute have been shown in the table in terms of staff commitments, rather than the individual project requirements, as this can be presented more clearly. It reflects the Institute's policy of keeping together a viable basic engineering team supplemented by short-term appointments, when our income allows, related to individual projects and where extra help is required. Because much of our income comes from individual gifts with no promise of repetition it has been considered prudent to hold a reserve equivalent to one year's support for both the permanent engineering team and the normal running costs of the Institute to complete our project programme, and to assign any excess over this sum to fund the short-term appointments. Thus, together with the part-time occupational therapy post, we now have eight engineers and technicians budgeted for short-term appointments. These commitments are detailed under note 9 in the Accounts and leave an uncommitted reserve of approximately one year's running costs.

All the staff are involved in a number of long and short-term projects. The long-term projects are individually assessed for staff and other funding. Donations given for specific projects are earmarked and recorded separately in the Accounts. Many of the short-term projects are more difficult to assess in detail and are fitted in as the programme permits. The engineering and technical staff are fully involved in the design and production of prototype aids, instruments and devices for sick and disabled people, either at home or in hospital. The table therefore gives an accurate indication of the personnel and engineering effort continuously employed on such projects. It can be seen from the table that more than half of the Institute's projects are funded by donations, and the remainder by direct employment (Royal United Hospital, Bath), and project grants from the Department of Health (DH) and other grant-giving bodies.

Projects

Every member of the engineering team contributes to this report, particularly in the descriptions which follow of the projects they are involved in. We are working on a large number of projects of different scale and type. Where possible these have been grouped under section headings. Projects described are those which have been completed during the year, those started during the year, and the state of development of some longer-term projects. The length of the description in this report should not be taken as a guide to the time commitment of the engineering team to the project. Some of our shorter projects require considerable explanation of their aims, while some projects, where there has been a major time commitment, are quite straightforward, with little background explanation required. For each project, the stage of progress in making the aid or device generally available is indicated; this may be by collaboration with a manufacturer for production of the aid, by publicising or preparing instruction sheets for construction by professional therapists or skilled friends of the disabled, by small scale production by BIME, or by work commissioned by manufacturers or the DH to solve specific problems concerning an aid or hospital device or improve their design.

In all our work on equipment development, we are grateful to the great range of collaborators who help us through the development process to produce aids to help with the problems of many disabled people. Our collaborators include many disabled people and patients, and individual members of many professions: medical, engineering, therapy, nursing, industry and teaching of the handicapped.

Equipment for Children

A number of projects for children have been completed over the year and several others have been started. Some of these are reported under "Individual Equipment".

1. *Car Swivel Seat*

Many disabled children have difficulty in maintaining a safe sitting position when travelling in cars. For this reason they often need to use a special large-child car seat. These seats are commercially available and suitable for children between about 5-10 years. A problem, however, lies with the parents and carers having to lift these heavier children in and out of the seat, whilst having to bend and twist their spines under load. BIME has had many requests from parents and therapists for help to overcome this problem and work is now well advanced.

The prototype car swivel seat under test. It is designed to assist parents with older disabled children.

A prototype device has been developed which enables the child seat to rotate towards the door opening, thus making the lifting and positioning of older children much less strenuous. It also eliminates the twisting of the spine during lifting, and allows semi ambulant children to stand down straight out of the seat rather than struggling to negotiate the car sills. The seat frame is secured in the car using existing seat belts, in accordance with recommendations from the Incar Safety Centre. Following the initial prototype tests the design has been further developed and a new prototype is now ready for user trials in stationary cars. This work is made possible by generous support from: Abbey National Plc, Forte Plc, The Woodward Charitable Trust, The NFC Foundation and The Yapp Welfare Trust.

2. *Bicycle and Tricycle for Children with Restricted Growth*

These are projects which are being generously supported by the BBC "Children in Need" charity, GlaxoWellcome plc and the Mercers Company, for age-appropriate bicycles and tricycles for children with achondroplasia. They are described later in this Report under "Restricted Growth Association Projects".

3. *Potty Chair for Children with Brittle Bone Disease*

Children with Brittle Bone Disease are usually small in stature and need very careful handling to avoid bone fractures. They often experience great discomfort from upright sitting positions and furniture which does not have soft cushioning. For these reasons toileting is a difficult task for these children. To overcome these problems BIME has developed a unique potty seat which has so far proved very successful. It has a range of special features: the seat back is completely reclining and the arm rests slide down to allow the carer full access to support the child during lifting. The whole chair can be dismantled and folded for transportation, and its smooth castors make it easy to manoeuvre when assembled. Careful attention has also been paid to the appearance of the chair so as to make it appealing to the children who need it. The bright colours (yellow and red) and chunky frame have been appreciated by children and adults alike. One father has painted his daughter's wheelchair to match!

Two seats have been constructed and tested by families at home and their observations and suggestions have been incorporated into the latest design.

At present a proposed production model is under construction in BIME's workshops and this seat will be taken for trials to a large number of Brittle Bone children nationally. These trials will be conducted by the specialist Occupational Therapist at Great Ormond Street Hospital for children with severe diseases.

We are very grateful to the Mercers Company and Bath Area Medical Research Trust for generously supporting this project.

4. *Compliant Seating*

There are major problems involved in trying to seat patients who have uncontrollable extensor spasms of their whole body. If a rigid seat is used, the shear rigidity of the support exacerbates the spasm. If a child with such problems is supported on a carer's lap the carer will allow the spasm to run its course and let the child extend. Once the spasm starts to relax the carer will pull the child back to a normal sitting position. The Institute has been approached twice by the Great Ormond Street Children's Hospital to provide seating systems for such children.

The solution adopted for the compliant seat has been to provide a chair that emulates the actions of the carer when dealing with such a child. The seat is hinged in a similar fashion to a sun-lounger so that all the support surfaces can move relative to each other. This hinged system is spring loaded so that it naturally takes up the form of a normal seat and can support the child when it is relaxed. However as soon as the child has a spasm the support surfaces allow the child to extend. Once it starts to relax the sprung surfaces gently return the child to a normal position again. The two chairs developed so far have been very successful and the subject of two engineering papers at conferences. A rehabilitation centre in the USA has taken the design and applied it to their patients. The Institute is developing the design further and is currently looking at a version for adults with cerebral palsy in a form that might be the basis of a general purpose device. We are also involved in generating a clinical paper in conjunction with Great Ormond Street to let other workers know of the advantages of the approach.

We are very grateful to Alison Wisbeach, head OT at Great Ormond Street Children's Hospital, for her enthusiasm and support for the project.

5. *Light Tree*

Hand-to-eye co-ordination training is an integral part of a therapists' work with a disabled child. We have developed an idea of a paediatric occupational therapist to help children in these skills. Lights are arranged on a board, and the handicapped user must push them in the correct order to receive the reward. They are prompted by the next active button lighting up in order to help them understand the concept of sequence. The power supply of the light tree has been re-engineered to improve battery life and reliability and an improved printed circuit board is currently under design to improve radio-frequency emissions to ensure compliance with the electromagnetic compatibility requirements of the CE mark. The new version of the Light Tree will be made available through our Production Unit.

6. *Adjustable Thoracic Support*

Many wheelchair users require extra support for their upper body when seated in their chairs. These thoracic supports are inevitably subjected to quite large loads and need to be firmly mounted. Unfortunately such mounting makes it difficult to provide adjustability, and if a chair is to be tailored to a particular user, adjustability is essential.

BIME has designed a thoracic support system which meets the requirements of adjustability and security under load. The device also has a quick release facility to enable the user to transfer in and out of their chair more easily. Several prototypes have been made and tested with users. Their success has led to a major disability equipment manufacturer, James Lecky Design, taking on the thoracic supports as part of their product range. The device has been subject to some sub-contract product design work to enable it to have a similar visual impact to the company's current product range and was given its first public exposure at the International Wheelchair and Seating Conference and Exhibition in Dundee in September. We are hopeful that many users can now benefit from this development.

7. *Visual Reward Assessment (VRA) Unit*

Testing the hearing thresholds of very young children is routinely done by generating tones of calibrated volumes through speakers on either side of the child under test and watching for head turns towards the sound source. Accurate assessment is often difficult and time-consuming as young children are easily distracted during testing, often turning their heads towards any sound or movement. A technique for improving assessment is to provide a visual reward immediately after applying a test sound. This encourages the child to turn towards the test sound source. After a short time the visual reward becomes associated with the test sound and the child will turn towards the test sound, if it is audible, expecting the visual reward.

In response to a child health doctor's request for an easily controlled visual reinforcement audiometry system, the Bath Institute of Medical Engineering has designed a unit supplied by mains electricity, but operating on low voltages only, which is controlled remotely by a hand-held switch assembly. The VRA unit offers a choice on each side of three illuminated and animated toys, and any combination of the three can be activated. The system has proved particularly useful not only for the 'difficult to test child', but also in obtaining accurate hearing thresholds in the hearing impaired child.

We have received further orders for this device from audiology units around the country. Unfortunately, difficulties in sourcing the animated children's toys, which are an essential part of this device, have prevented us in fulfilling current orders. We have recently found several sources that can now supply the variety of toys, which we require for the V.R.A. unit.

Department of Health - Equipment Evaluation Programme

Infusion Systems and Enteral Feeding Pumps

We are now into our 19th year of support from the Medical Devices Agency (MDA) of the UK Department of Health. We continue to evaluate the safety and performance of volumetric and syringe infusion pumps, ambulatory infusion devices and enteral feeding pumps and to provide advice to the Department of Health, the health service and manufacturers and suppliers of infusion devices.

A considerable portion of this year has been taken up preparing three product reviews; a neonatal pumps product review, a volumetric pumps product review and a syringe pumps product review. These three documents contain large amounts of product information, test results, manufacturer details and product support information. They are follow up documents to the review issues of 1996. As well as covering the current market, for volumetric and syringe pumps, they also include updated information on older infusion equipment which is no longer supported or has become obsolete. Judging by the number of enquiries we have received, there is a great demand for these documents and we anticipate that they will be very well received. They are expected to be published in April 1998 We have also published one single model full evaluation report this year, on a patient controlled analgesia (PCA) syringe pump. We have carried out brief assessments on nine other infusion pumps, this information is summarised in the product reviews and not published in a single model report.

This year has seen an increasing number of enquiries about enteral feeding pumps. It has been several years since any testing was done on these devices, so we have developed a new set of test protocols for the brief assessment of enteral feeding pumps in collaboration with dieticians, based in the Royal United Hospital. We have currently completed six brief assessments and will continue testing the remaining products on the market, with the aim of producing a product review later on this year.

In March 1997, The Devices Technology Safety group of the MDA published a devices bulletin on the safe selection and use of ambulatory infusion systems. BIME assisted a great deal with this publication, and Mr. Morling's help was acknowledged by the group. This paves the way for a product review of all the ambulatory infusion devices on the market, planned for the coming year.

We are offering more and more advice to users and purchasers of infusion equipment in the health service, with regard to the management of infusion pumps in hospitals. As a result of this Mr. Morling has written two articles for the British Journal of Nursing, the first covering the selection and management of infusion pumps (published December 1997), the second covering the risks of intravenous therapy and equipment user responsibilities (published January 1998). The articles are also intended to make nurses more aware that we, and the MDA, are here to offer advice if they should need it.

In September 1997 there was an MDA Marketing Conference for all the evaluation centres in the general medical sector. The conference discussed the objectives of the Device Evaluation and Publications section for 1998/99, including generating an income from the programme, new methods of presenting information, targeting customers and developing new products. BIME's contribution to this conference was to demonstrate the database we have been running for the past six years - containing product information on over 350 infusion devices, manufacturer and supplier contacts, MDA publications, test data and clinical contacts. This was very well received by the

conference and seen as an invaluable tool for the future. A working group has been set up, including BIME, to adapt the database for general use within the evaluation programme. Several other working groups were set up to look at other new ideas and another conference was held in March to follow up the progress of these working groups.

We continue to support the Device Technology and Safety group of the MDA. We have not been involved in any adverse incident investigations this year, but we have provided a copy of our database to the group to assist them with the enquiries they receive relating to infusion pump management.

As reported earlier under "Finance and Planning" this year has seen changes in personnel on the evaluation project, Mr. Morling, however, continues to sit on the British Standards subcommittee for infusion devices, CH/115. The first publication of the international standard on infusion devices and gravity controllers, IEC 601224, was published in March.

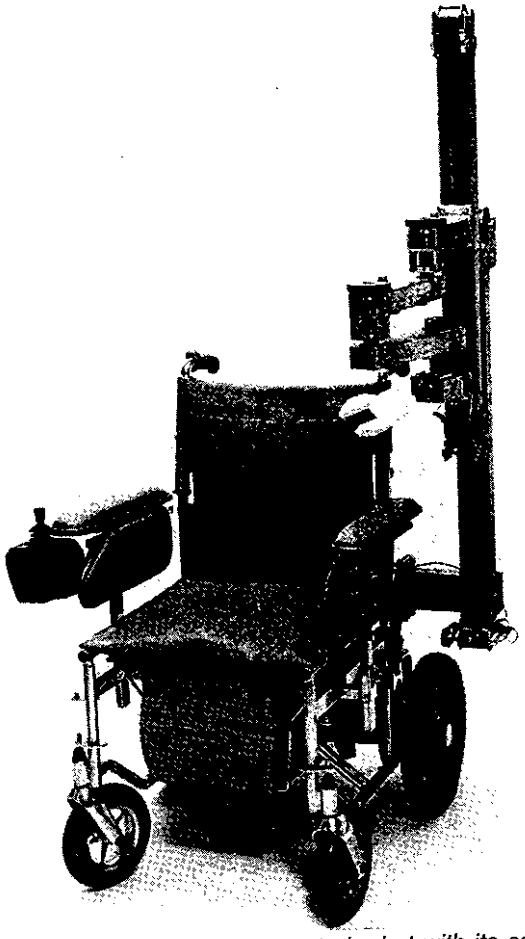
We thank Dr. David Protheroe for his continuing role as medical adviser to the evaluation project.

Equipment for Living

1. *Assistive Robots*

For many years BIME has had an active involvement in the design of robotic devices to assist people with disabilities. The invitation to host the 5th International Conference on Rehabilitation Robotics, as reported elsewhere, was a recognition of our standing within the international rehabilitation robotics community. One of BIME's major projects at the present is the design of the "Weston" wheelchair mounted assistive robot, together with the ongoing work on the "Wessex" trolley mounted robot. The "Wessex" robot is essentially a working system, designed to assist disabled people in their home environment, though there are a number of areas undergoing detailed development. The priority of this work, at the present time, is to prepare the system for further user evaluations.

The particular emphasis of the wheelchair mounted robot project is to provide a powerful and flexible system at an acceptable cost. Earlier phases of the project have involved a lot of interaction with potential users in order to come to an understanding of the constraints involved and to arrive at a detailed specification for a wheelchair mounted system. Over the past 12 months this knowledge has formed the basis for the design and construction of a working system.



The prototype wheelchair mounted robot with its covers removed.

One of the major areas to be considered was the vertical actuator, which needs to raise the robotic arm through a stroke of 1.2m. This is necessary to allow the arm both to pick items up off the floor, while also being able to reach to head height of a seated wheelchair occupant. A novel design provides this stroke using off-the-shelf linear bearings. In its lowest position the actuator presents a low profile, yet is able to rise to the full height required. Counterbalancing the weight of the arm using constant tension springs allows the use of a compact, low-powered motor.

After much consideration it was decided that the best position to mount the actuator is over the rear wheel of the wheelchair. Any position will involve compromises, but in this position it is not visually too obtrusive, is less likely to affect the steering, and can

be kept close to the chair, therefore not increasing the width too much. Currently the actuator exists as a bare mechanism and an important part of the design is to shroud it, both to improve the appearance and protect the mechanism.

The design of the robotic arm itself is closely based on the mechanism of the "Wessex" trolley mounted robot, but the design has been developed to overcome several shortcomings of the earlier system.

The main focus of the work at present is to write the computer software necessary, both for the control of the motors within the arm, and to provide an easy-to-use interface appropriate for the disabled user. We are very grateful to the Southern Trust who have most generously provided all the funding for this exciting project.

2. *Sip Cup*

The sip cup allows someone with swallowing difficulties to receive only a limited volume of fluid each time they bring the cup to their lips. The current design is basically very successful and we have many contacts who would like to either buy or borrow one of the cups. Making the cup available in reasonable numbers and at an acceptable price is however proving problematic. To have the cup components injection moulded would be the obvious solution, but requires a large initial investment in tooling. Over the past year we have been investigating the possibility of licensing the design to an outside manufacturer, but without success. We are currently investigating the potential market size and various methods of producing the cup ourselves.

3. *Bedlifter for Occupational Therapists*

Many elderly or disabled people require their beds or chairs to be raised in height to allow them to get on and off more easily. This is normally achieved by placing simple blocks under the legs of the item of furniture. The bed lifter jack is intended to be used by occupational therapists and others who need to lift a bed or chair to insert such blocks without risk, and with regard to current safety legislation. The bed lifter jack is a screw jack device and several prototypes have been built for the Occupational Therapy Department at the local hospital and have also been used by other local departments and social services occupational therapists. Initially a manufacturer expressed strong interest in producing the design, but has subsequently decided that it did not fit in with their existing product range. We are now planning to produce it ourselves and are approaching several marketing companies who might be interested in marketing it for us.

4. *Flat Pack Commode*

Many disabled people, particularly those with spinal injuries, will use a wheeled commode chair for toileting. This will either be wheeled over a domestic lavatory cistern, or a slide-in pan used. If designed appropriately, the same chair can be used as a shower chair. When travelling, people have the same requirements, but existing wheeled commode chairs are not very transportable. The need for a commode chair which can fold flat for easy transportation, was identified from communication with members of the Spinal Injuries Association.

The commode chair on trial with a volunteer.

The design was initially investigated by the construction of a full scale version of the chair to investigate the robustness of the folding mechanism, to confirm the overall dimensions, and to obtain feedback from potential users. This provided valuable feedback, and subsequently a full working version of the chair was built. This prototype used the same folding arrangement of the earlier version, but was developed in several important areas. Since it is envisaged that the chair will be used by those travelling, a large suitcase was purchased in which the folded device fits.

The prototype has been evaluated by several volunteers. The feedback is generally very positive. We will soon start the design and construction of a production prototype, incorporating comments from users and production considerations.

5. *Standing Transfer Unit*

Many elderly people at home have great difficulty in getting from their bed to a chair or from a wheelchair onto a toilet. Often they only have an equally frail carer to help them transfer. In addition many domiciliary visits from care professionals involve helping frail and sometimes quite heavy people carry out the same transfers. Devices such as hoists can be used to help these people but are often too large or cumbersome to be used. Carers are prevented by recent European legislation from lifting heavy patients in these situations. Some simple and transportable devices are needed.

The Institute was approached by an Occupational Therapist from Poole Social Services who described the kind of device required. The basis of the solution would be a frame placed by the side of the bed that provides a stable support for someone to hold onto whilst they pull themselves to a standing position. This frame would be combined with a turntable-like footplate to enable the patient to be rotated. Using the device the patient can be encouraged to their feet and then rotated through 90 degrees so that they can be lowered again onto the seat or toilet etc.

Several prototypes have been constructed and tested both in Poole and Bristol. The design has evolved to a point where transfers can be carried out very safely and effectively. The device is currently undergoing production development with a view to making it widely available. We are indebted to Mrs Janet Allam for her perseverance and enthusiasm for this development and for getting excellent feedback on the performance of the device and the Anton Jurgens Charitable Trust for their generous support of this project.

6. *Mug Holder*

People who push themselves in wheelchairs do not have a spare hand to carry objects around. Often they will balance things on their laps whilst manoeuvring from room to room. If they want to carry hot drinks or other easily spilt beverages a big problem arises.

Our article in Forward (The Spinal Injuries Association Magazine) elicited a great deal of interest in this problem and, together with consultations with other wheelchair users, confirmed that there is a clear need for an effective product to address this problem.

The Institute has now taken the project on as a full design project and initial concept ideas are being considered.

7. *Saliva Pump*

There are a number of disabling conditions which give poor control over saliva and therefore may lead to drooling. This can be both uncomfortable and socially unacceptable. The Institute is developing a hand held pump, initially aimed at sufferers from motor neurone disease but appropriate for other disability groups, which may be used to drain saliva from the mouth. A batch of pumps was constructed and made available through the MNDA (Motor Neurone Disease Association) Regional Care Advisers. These pumps have proved valuable to a number of people, though in some cases the level of suction has been inadequate to suck up thicker secretions. We will therefore be redesigning the pump to give a stronger suction and therefore make it useful to a wider number of people.

Mobility Equipment

1. *Wheelchair Baby Carrier*

The arrival of a new baby is always a wonderful time for any parents, but for some this joy is tempered by very real concerns about how they will cope with the child. Parents with disabilities find impossible many of the simple tasks that able bodied parents take for granted. The Institute has been working with an organisation called Equipped that is dedicated to examining these problems and finding solutions. A major problem that arose from a survey of needs carried out by the organisation was a device for carrying a baby on a wheelchair.

A feasibility study has just been completed to look at possible solutions to the wheelchair baby carrier. We have been helped by a local couple who have specified and tested out prototypes for us. The device consists of a carrier that has been designed to fit onto the front tubes of the wheelchair such that the baby can be either facing the occupant or the

The prototype wheelchair baby carrier in use.

other way. It has a simple quick release mechanism and fold-down legs that enable it to be free-standing when the baby is being transferred from the wheelchair into a car, for example. The device has been in use for several months and has given a much improved independence for the parents and their baby. The look on the disabled father's face the first time he was able to interact with his young daughter on his wheelchair underlined the value of such simple devices.

A full design programme is now under way building on these initial experiences to provide general purpose designs suitable for a wide range of chairs and disabilities. We are very grateful to Neil and Cathy Froggatt for their help with the project, and to their daughter Daisy. We are also most grateful to Railtrack plc for generously funding this project.

2. *Lever Operated Wheelchair*

Many wheelchair users find great difficulty in using the usual handrims to propel themselves because their hand function is impaired. The problem often arises for people with arthritic joints who cannot grip effectively. There are some solutions to this problem. Capstan handrims can be fitted but few users find them effective. Some wheelchair designs incorporate a lever mechanism to drive the chair and although these mechanisms are excellent they are very expensive. The Institute has been involved in designing a lever operated system that is very inexpensive and is in a form that can be added onto an existing chair.

A lever mechanism has been developed that satisfies all the propulsion and control requirements in a form that is very intuitive to use. Versions have been designed to fit onto sports chairs and to standard national health wheelchairs. A version is currently being tested that enables a user with congenitally short arms to operate her chair from her shoulder-height upper limbs. Work with several wheelchair centres has shown that there is a substantial market for these devices and potential manufacturers are currently being sought to make the device widely available. We are very grateful to the Cotton Trust for providing the funding that enabled the initial development work to be completed.

3. *Foot Operated Wheelchair*

A survey carried out amongst wheelchair users with cerebral palsy showed that 20% pulled or pushed themselves around using their feet rather than the usual wheelchair handrims. These were all people who had poor control of their upper limbs but sufficient strength in their legs to propel themselves by this means. This form of propulsion is difficult to control and leads to a very poor posture in the chair. A project has been started to explore easier means of propulsion for this group.

A feasibility study has been completed which examined a wide range of designs that would enable someone to push with their feet against a footboard, and for that action to provide them with forward propulsion and steering. The solution decided upon is a variation of the lever operated wheelchair design produced by the Institute which has been very successful. The project is currently using a test rig to explore how effectively different embodiments of the design can be used.

We are very grateful to Rotork Ltd. and the Esmee Fairbairn Charitable Trust for funding the feasibility study.

4. *Adjustable Elbow Crutch*

Users of elbow crutches may often need to adjust the length of their crutches, particularly when walking over hilly terrain. In order to make it easy to adjust the crutch a simple, light-weight mechanism has been built which allows the length to be adjusted by pressing a button on the end of the handle. The button releases the pegs which lock the inner and outer portion of the main crutch leg. Preliminary evaluation of the prototype showed that

the device could be very effective, but that there was a significant problem of sand or other contaminants getting inside the mechanism. We have now developed the device further, shielding the mechanism from any contaminants. The prototype now also incorporates the "Cumfy Crutch" handle developed a few years ago at BIME and manufactured by Coopers. The prototype is now on long term evaluation with a user. We are grateful to the Hayward Foundation who provided generous sponsorship for this project.

5. *Lifting Device for People with Muscular Dystrophy*

A new lifting device has been designed to replace the former prototype and will be ready for evaluation by volunteers with muscular dystrophy (the "volunteers") very shortly. The new design provides new solutions for challenging areas of the design specification including the size, manoeuvrability and the manner in which the device folds for storage.

The new device has a footprint (when folded) which is only two thirds the area of the original device's footprint. This greater compactness coupled with the installation of four casters (to replace the original two casters and two standard wheels) makes the device far more manoeuvrable in a domestic environment.

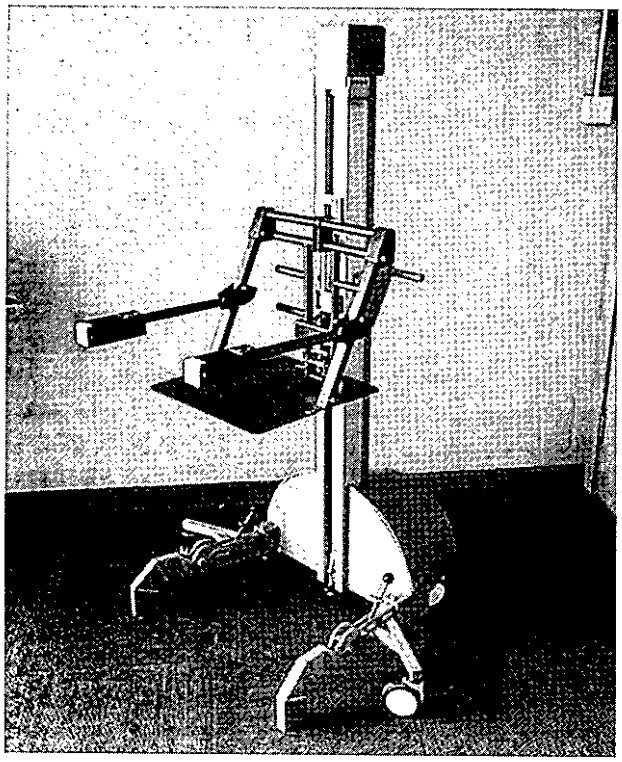
Manoeuvrability and ease of operation has been further enhanced by making the new device battery operated as opposed to mains power operated. The new design carries its own 12 Volt battery and can now be moved into position within the home or outside in the garden, without regard to the proximity of a mains electric socket.

The ease with which the device can be folded and unfolded has been greatly improved. This has been done by using a simpler locking mechanism and by making it more difficult for the carer to make a mistake when unfolding the device.

The new seat has all the advantages of the old design with the added advantage of being easier for the user to slide onto when the user is being lifted up from the floor.

Considerable work has also been done to improve the appearance of the device. Appropriate colours and shapes have been carefully selected so that the device will not look incongruous in a domestic environment.

We would like to thank the Southern Trust for their generous funding of this project and the Muscular Dystrophy Group for their help and advice.



The lifting device designed to help people with muscular dystrophy to get to a standing position from the floor.

6. *Omni-directional Wheelchair*

The Institute has developed a demonstrator of an omni-directional powered base. It is an electrically powered unit that can move forwards, backwards and sideways, and rotate about its axis, and provides great manoeuvrability in a cluttered environment. The device was developed as part of the lifter project described elsewhere but has application for many devices that need to provide manoeuvrability within a domestic environment.

A major application of the technology is indoor powered wheelchairs. The omni-directional base would allow such a chair to have the same degree of manoeuvrability as an ambulant person. The Institute is currently seeking funding to take the project further, and through this work is hopeful about providing an effective solution to indoor powered mobility at a cost that should be no more than current powered wheelchair designs.

Communication Equipment

1. *Partial Hearing Simulator*

Relatives and care staff of partially deaf people often have difficulty communicating with such people for the simple reason that they have very little idea of what their voice sounds like to a damaged ear. Frequently the problem lies in the fact that they have not found how to adjust the pitch of their voice to the optimum level for a given hearing problem. Their lack of appreciation of the effects of hearing loss can sometimes lead to a lack of sympathy for their patient's or relative's predicament.

The BIME Partial Hearing Simulator is a filter unit designed to process a person's voice in a similar way to the ear of a person with a partial hearing disability. It is designed to take the results of a standard audiogram, where hearing loss is determined at several frequencies, and to adjust its bank of filters to closely simulate this audio transfer function. The adjustment of the filters is relatively simple which allows the simulator to be quickly modified for the different hearing characteristics encountered in the course of an audiology outpatient clinic. The user has two options for input. In the first the user may talk directly into a microphone when their voice is processed in 'real-time' with the filtered output heard through a set of closed headphones. In a situation where one member of a family suffers from hearing loss this would allow unaffected members of the family to wear the headphones while the rest of the family speak into the microphone allowing them to appreciate the difficulties experienced by the person with partial hearing. The difficulties of understanding general background conversation can also be appreciated. The second input option is to record a person's voice onto a tape recorder and then to play this recording back through the simulator with the output available via headphones again or a small speaker built into the unit. With either input option, the user with normal hearing can gain a better understanding of the problems associated with hearing loss and can practise modifying their voice until the output of the simulator is more intelligible. The pitch of voice used should then be more intelligible to the hearing loss sufferer than normal unmodified speech.

The latest version of the BIME partial hearing simulator has been designed to address the various inadequacies present in the earlier analogue versions. Because of the consumer drive towards improved cellular telephone technology and multimedia personal computers, the cost of semiconductors for processing audio information using Digital Signal Processing (DSP) techniques has dropped dramatically in the past two years. The extreme flexibility and cost effectiveness of implementing audio filtering in software using DSP techniques was considered very attractive and consequently the new partial hearing simulator is based on this design. After carefully scrutinising all the lower priced products available for DSP design, a development platform based on the Motorola DSP56002 microprocessor was selected. This device permitted the design of the current high specification partial hearing simulator. We are currently building the core processor board into a portable unit and refining the existing firmware to allow full clinical evaluation of the unit in a local audiology clinic before advertising it nationally.

2. *Translator Communication Aid for Cerebral Palsy Impaired Speech*

Existing speech recognition technology can only function when speech is reliably produced in the same way for each utterance. Should someone have lost this ability, they would not be able to have the benefits that voice control of devices can bring. BIME is working on a novel device which will recognise unpredictable verbal input from the disabled user and use this to output synthesised speech in the form of pre-programmed phrases. Speech recognition hardware, particularly suited to the repetitive but unpredictable sounds of the speech of someone with cerebral palsy, has been purchased and set up in a demonstration system for trials. These trials have indicated that the concept and technology will make a significant impact on the lives of severely impaired speakers with other physical disabilities. The system is now functioning well and has had regular trials with a volunteer in Cheltenham. The aim is to produce a portable, Walkman sized translator as a multi-input interface to other devices such as environmental 0.control, communicators, screen displays etc. We are awaiting the provision of custom integrated circuits from the Royal Military College of Science, who are the licence holders of the technology, to realise the size and power reductions required to achieve this aim.

A further possible use for the translator stems from another BIME project, which is the development of a powered wheelchair-attached robotic manipulator. Anticipated users of this assistive device will be severely disabled (e.g. tetraplegics and people suffering from muscular dystrophy) and unable to use a large range of input devices. Control of a robotic manipulator with multiple degrees of freedom is particularly suitable for speech control input. Once the manipulator prototype is complete, investigations as to the suitability of the Tespar system will be undertaken.

Restricted Growth Association (RGA) Projects

The work with the Restricted Growth Association (RGA) began last year following a survey of 100 people with restricted growth. The survey was generously funded by the Southern Trust, and the results indicated the need for a number of assistive devices. The resulting projects have progressed well, with prototypes of the sticks, step, and bicycle out with volunteers for evaluation. We have been invited to and have visited several RGA meetings, including the annual convention in Manchester. These have been very useful, giving us valuable feedback about the developments we have made so far.

Our relationship with the RGA and its members continues to be very valuable and we look forward to working with them on further projects. The RGA have been very helpful with these projects and it is a pleasure to work with them.

1. *ReachStick and ShopStick*

This project has now firmly diverged into two distinct devices: the Reach Stick - a light weight, simple collapsible stick for tasks such as operating switches; and the Shop Stick - a heavier weight, longer stick for reliably retrieving items from supermarket shelves, or from kitchen cupboards, for example.

The ReachStick has become progressively simpler with development; evolving from a fairly substantial folding stick with a hook and prodder to a light and compact telescopic stick with a simple angled end-tool. For evaluation purposes, the prototype has been designed to accommodate interchangeable ends. Further development of this project is focusing on improving the telescoping and locking mechanisms.

A prototype built in January 1998 has proved popular with evaluators subject to a few minor modifications. The next stage of development will be building a batch of sticks with the required modifications built in. This batch will be taken to the RGA Conference at Weston-Super-Mare in October.

The first ShopStick prototype proved the gripper concept that used a loop of plastic tape which was tightened around the object to be retrieved. This novel gripping method will accommodate a wide variety of different shaped objects from bags of porridge oats to tin cans and glass jars. Conventional grippers with jaws have problems gripping smooth surfaced objects (jars, tins, etc) and large objects (cereal packets, frozen peas, etcetera) reliably.

There were some problems with the plastic hinges used on the stick and also with the locking mechanisms. The second ShopStick prototype has improved hinges and a more reliable gripper that retains its shape when extended. It will be evaluated in 1998 with volunteers from the south western RGA region.

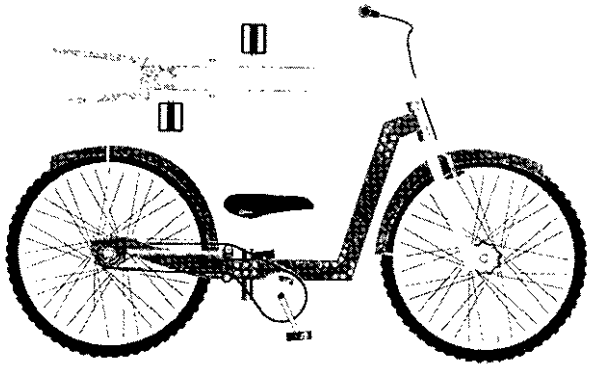
2. *Light Step*

The Light Step is a simple lightweight step that can be easily transported in a bag for school or shopping. We were able to find one folding step in the shops, however this was heavy and did not fold particularly compactly.

We have built two prototypes since starting the project. The first, shown in last years annual report was superseded by a second which is currently being evaluated. The construction is mainly from high specification aerospace alloy. This means we can build a strong step with the lowest practical weight. In its final form it is expected to be about 15cm x 20cm x 3cm when folded and weigh about 0.75kg. It will be suitable for people up to a weight of 135kg.

3. *Bicycle*

One of the highest scoring items from last year's survey of users was a bicycle for children. Having obtained some funding for the project from BBC Children In Need, we proceeded to design and build a first prototype. Children with achondroplasia and other similar conditions have a normal length torso, but short limbs. This means that a conventionally proportioned bicycle is not suitable as the



Design drawings of bicycle for children with restricted growth and the bicycle being tested by volunteer Eugene (at speed!).

handlebars are too far away and not high enough, the cranks are too long, and the seat is too high.

The bicycle we have designed is of the right proportions, and is very adjustable; to accommodate varying degrees of growth restriction. For example, for children with very short legs, the pedals need positioning forward of the saddle for there to be room underneath them when turning a corner. Short fingers mean that brake levers are often difficult to reach, so we have fitted a back pedal brake which removes the need for one of the levers; and the front brake lever was carefully selected to be adjustable towards and away from the handlebars.

Of the volunteers who have evaluated this bicycle for us, one has been particularly helpful - you may have seen him on the BBC Children In Need television programme in November where a short film about BIME and its RGA bicycle was shown. Eugene, our volunteer, has provided valuable input during the design process about the styling of the bicycle, and some features that we had not thought of.

Following a short test ride at BIME, the bicycle was plastic-coated and delivered to Eugene for more detailed evaluation over Christmas.

The bicycle was received well by our evaluators, although, as always there are changes to make. These will be taking place shortly with the bicycle then going out for further evaluation before being made more generally available to potential users. We are very grateful to the BBC Children in Need charity for their support of this work.

4. *Tricycle*

The RGA survey concluded that the need for adapted bicycles was important both for very young children as well as teenagers. The problems are similar for young children as they are for their older colleagues, i.e. the need for different bicycle geometries to cater for their small stature.

The Institute has completed some feasibility work to examine the problem and two small tricycles have been adapted. The programme is to be developed further, initially to look at a very small pedal bicycle with stabilisers, suitable for pre-school children. A survey has been completed in which parents of children needing such a bicycle were sent body diagrams indicating the measurements that were important to the designer. The dimensions supplied by the parents are currently being used to finalise a design that can be tried with some of the local users. We are very grateful to Glaxo Wellcome plc and the Mercers Company for their generous support of this project.

Devices for Developing Countries

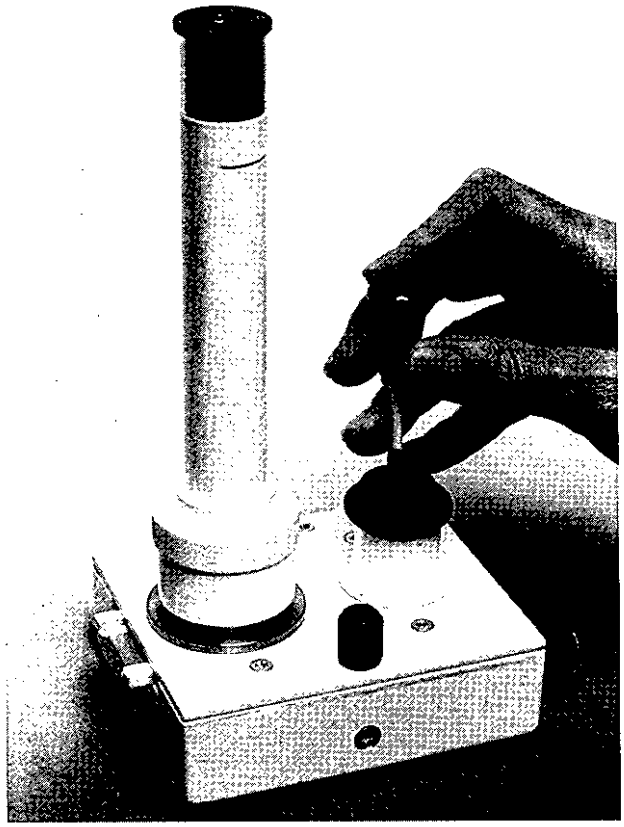
The Institute has been liaising with Primary Diagnostics Ltd, a small company concerned with the development of a range of primary health care devices for developing countries. They have many years experience of working in a number of countries and of the kind of primary health care problems that are prevalent. Equipment for such applications has to take into account the poor working environment, lack of easy maintenance and

spares, and the need for simplicity that are crucial to their success. The partnership between the Institute and the company is a mutually beneficial one in that the company has much experience of the health care needs and field conditions in which devices have to operate, and the Institute can provide original design solutions to meet these requirements. Two devices have been under development at the Institute; a haemoglobinometer to measure levels of anaemia, and a field microscope.

1. *Microscope*

The microscope needs to be powerful enough to be able to detect the damage to red blood cells caused by malarial parasites but cheap enough to build to make it widely available. It also has to be very robust and simple to maintain in the field.

A feasibility study has been completed which demonstrated a successful design approach that it is felt could be manufactured at a very low cost. The design uses interchangeable objective tubes to change magnification up to times 1000. Fine movement of the slide is carried out using a novel joystick mechanism, and the light source is a white light emitting diode. These diodes have only become available in the last few months and are ideal for devices such as the microscope because they have a bright output, are very robust, and use very little current.



The microscope designed for use in developing countries.

The prototype built for the feasibility study is currently being developed for initial tests in the UK before field trials in West Africa. The Institute would like to thank Dr. Roy Rickman, Mr. John Anning and Mr. Tim Watts of Primary Diagnostics for their enthusiasm and dedication.

2. Haemoglobinometer

In many developing countries anaemia is a major problem and is a common and important cause of morbidity in tropical climates. It has many causes such as blood loss, malnutrition, and a wide range of communicable diseases - notably malaria and hookworm and is a good general indicator of sickness and of the degree of urgency of the need for treatment. Anaemia is also very common in pregnant women, nursing mothers and young children in these countries. Primary health care in remote rural communities is often poor due to the lack of appropriate and affordable medical diagnostic tools. Rural health posts are often basic, with no electricity or proper water supply and treatment is often given without confirmed diagnosis which can be wasteful of drugs (that are usually in short supply and expensive) and may be dangerous. Besides identifying many people who are acutely or chronically ill, the accurate measurement of blood haemoglobin levels will also identify those for whom blood transfusion may be an urgent or life-saving necessity. In regions where average haemoglobin levels may be lower then the acceptable minimum for use in transfusions, their accurate measurement, in blood samples from potential donors, is vital.

There exists a real need to produce a simple, low-cost blood haemoglobin meter which can be used anywhere from any available power source including solar power in a rural health care environment. Currently available portable haemoglobin meters are either too heavy, too complicated, only use specific type of batteries (which are normally unobtainable) or, more usually, far too expensive.

BIME has developed a robust and inexpensive instrument for the in-vitro measurement of blood haemoglobin levels in a rural primary health care setting. The instrument is capable of operating from variable mains supplies and 12V sources such as car batteries and solar cells while charging its own internal rechargeable batteries. It is accurate and simple to use requiring the absolute minimum of maintenance. The initial development prototype has recently returned from evaluation at the Haematology Department of North Devon District Hospital. It has been found to be easy to use and very accurate, provided accurate blood samples are taken. We are further investigating incorporating the latest monochromatic light emitting diodes into the instrument to further reduce the price by eliminating a costly optical component. Final modification will be assessed before a small batch of instruments is built specifically for developing country evaluation. The African Medical and Research Foundation (AMREF) based in Nairobi, Kenya has offered to test a batch of instruments.

BIME is developing the instrument jointly with Primary Diagnostics a charity working in developing countries with co-operation from North Devon Healthcare haematology department.

Vibration Diagnosis - Vibrotec

People with diabetes are at particular risk from foot problems. Because of reduced sensation there is the risk of ulceration, possibly leading in the worst cases, if not treated early, to amputation. There are several ways of detecting this reduced sensation. The Institute is developing a portable, low cost battery powered device to measure people's vibration perception threshold. The principle used is to increase the level of vibration until the patient can just detect it. The vibration is produced using an electromagnetic solenoid vibrator. The threshold at which vibration is first detected gives a guide to the patient's risk of developing ulcers.

Vibrotec – vibration diagnosis device for use with diabetic patients.

The BIME device is being developed in conjunction with the Department of Vascular Medicine at the University of Exeter. Following several earlier prototypes the "VibroTec" is being developed to fit more easily into the hand of the clinician, and to allow it to be reliably calibrated to give accurate readings.

Dynamic Wrist Fixator

The dynamic fixator which was Mr. Adlam's M.Sc. project has progressed. It allows the joint (but not the fracture) to be mobile during healing, reducing the problems caused by prolonged immobility of the joint. A first prototype has been manufactured from a high specification aluminium alloy and is fully autoclavable for sterilisation. It will be assessed clinically at Queen Mary's Hospital, Roehampton.

Individual Equipment

Although BIME tries to concentrate on devices which benefit large numbers of people, we are often requested to help individuals with specific problems. As well as providing a service for these disabled people, such help also recognises the fact that solutions to one-off problems can turn out to have wider applications. The majority of the following projects, which have been undertaken this year, are for children.

1. *Computer Keyboard Aid*

Many disabled children use special touch sensitive keyboards, known as Concept Keyboards, when using computers. However children with reduced arm and hand control, or those with involuntary movements often experience problems when using the keyboards. Firstly they may accidentally knock the keyboard which slides about on the desk making its proper use impossible. They also often have difficulty positioning their fingers over the part of the touch sensitive board they want to press and may accidentally trigger adjacent 'keys'.

Both of these problems have been overcome by BIME designers. By the addition of suction pads to the underside of the keyboards the unit can now be firmly secured to the desk top to prevent slipping. A range of clear plastic guards have also been developed which fit over the keyboard surface and help children press the part of the keyboard they want, without accidentally triggering the surrounding touch keys.

These aids have now been tested in the special school class room and proved a great success. Teachers have requested more sets for other classes.

2. *Armrests for Mobile Arm Supports:*

BIME have recently designed and made a pair of armrests for a nine-year-old boy with Muscular Atrophy. This disability affects muscle strength and in this case means that the child has difficulty with the power of his arm movements. He is in a main stream school and it is important that he can participate in all the classroom activities as fully as possible. He therefore uses a commercially available mobile arm support for tasks such as

Armrests for mobile arm support in use.

writing, drawing and using a computer keyboard. The problem however was with the actual forearm rests, which he found uncomfortable and had grown out of. BIME's response was to design a new, made-to-measure, pair of forearm rests, using heat formed plastic with a soft and attractive foam cover. The new armrests also feature an adjustable pivot point that can be set to suit the balance point of the child's forearm. These armrests are now in use in conjunction with his mobile arm supports.

3. *Special Wheelchair Tray/Dynavox Holder*

Some children use electronic push button equipment as an alternative to speech. One such boy wanted his communication aid (Dynavox) mounted in front of him on his wheelchair tray so that it was convenient for daily use. However BIME designers found that his existing tray was too small to allow space for normal activities as well as holding his Dynavox. After consultation with his Occupational Therapist, BIME made and fitted a large (and colourful) new wheelchair tray which incorporated a holder for his Dynavox. The holder offered a secure but adjustable fastening for the Dynavox, and also tilted the display screen to the appropriate angle for the boy's use. It was also easily removable when not in use.

4. *Scoot Mobility Toy*

A physiotherapist came to BIME for help with the mobility problems of a boy with cerebral palsy. He had relatively good co-ordination in his legs but very restricted ability in his arms and some balance problems.

His parents explained that his main mobility aid at home was not his wheelchair, but a baby trike

The "Scoot" mobility toy in use.

which was low to the ground and he could move and steer by "paddling" his feet on the ground. This allowed him to move about with his brothers and sisters, but was now getting too small for him, and a bigger version was not available.

After further observation of the boy's physical abilities and detailed discussion with the parents and therapists, BIME have begun the process of designing a new foot propelled mobility toy. The new toy must be large and stable enough for children of around 10 years, be robust enough for everyday use and have an attractive 'fun' appearance.

5. *Pushchair Oxygen Cylinder Carrier*

Young babies can sometimes require continuous oxygen infusion via nasal cannulae. The treatment is very effective but can prevent the parents from taking their child out of the house because they need to carry the oxygen cylinder with them. A system has been developed to enable such bottles to be transported safely on pushchairs and thereby enable transport of the child. The device has been fitted to a BIME buggy also and has been used on a double pushchair where two twins were both on oxygen therapy.

6. *Recorder Playing for Disabled Children*

We have been asked several times to adapt musical instruments to enable children with disabilities to play them. Recently we have examined the problem faced by two different children who were keen to play the recorder. One of the children had reduced muscle tone and could not support the instrument and play it at the same time. A holder was made for him which enabled the instrument to be supported whilst he played. The second child was only able to use one hand and yet wanted to be able to access all the notes. An approach was explored for her whereby she supported the instrument at the lower end and could access all the lower holes. Separate levers were placed between the lower holes which remotely actuated the upper ones. In this way she was able to activate all the notes without having to move her hand from the lower part of the instrument. Many children gain enormous pleasure from learning to play musical instruments and it is important that a child is not denied this pleasure because of a disability.

Student Projects

The Institute is often asked by many different universities to suggest potential design projects for engineering students, and by many schools for design projects for pupils. We keep lists of potential projects which can be disseminated, and provide more detailed information once a student has decided on the kind of device they wish to work on. Students often arrange visits to discuss their projects in more detail.

Inevitably we have a much closer relationship with our own University in Bath and can act as project sponsors for student activity. A major 10 person project was run with Bath University Department of Mechanical Engineering. The project was carried out by final year students and looked at the design of a powered wheelchair that supported the user in a standing position whilst carrying them around. The work was assisted greatly by software developed within the department by Professor Medland to generate solutions to complex mechanism design. Some aspects of the work are continuing as part of a masters project. Another masters project was run in conjunction with Southampton University to look at the design of an end effector for a rehabilitation robot. The prototype device developed by the students was exhibited at the International Conference on Rehabilitation Robotics in Bath during April. It is hoped that such collaborative ventures with other universities may be run in future.

The BIME Production Unit
Introduction

Many of the devices designed at the Institute benefit a large number of people but do not have a large enough market to enable a commercial manufacturer to take them on. The manufacturer would have to invest in production development of the new product as well as in tooling for its manufacture and in promotion and marketing work. The funding for all these activities has to come from the profits made from sales of the product. If the market for the device is small then it can take a long time for the manufacturer to get back his initial investment. These considerations make it difficult for manufacturers to take on small market devices and yet many useful products in the disability sector have markets of this size. The Institute decided several years ago that any products developed from

its work that came into this small market category, and by definition many of them do, would be made available directly from the Institute itself. The funding needed to carry out production development and the other incidental costs mentioned above would be covered by its charitable income. Consequently the Institute only had to charge the actual cost of manufacture to cover its costs of production. Several of our major sponsors were consulted and were happy with the approach as long as no devices taken on in this way were competing with conventional manufacturers, because of the unfair advantage the charitable funding provided. A production unit was set up and has been a great success with many thousands of products made available to the disabled community. We are most grateful to the Emmandjay Trust for their generous funding of the production unit technician.

Device	Production Development	Being sold	Total sales
1. Bottom wiper		*	25,243
2. Folding bottom wiper		*	5,012
3. Noisy playball		*	447
4. Light action switch		*	46
5. Vaginal dilators		*	388
6. Infant and junior buggy		*	40
7. Wedge straps		*	46
8. Adult walker		*	26
9. Selection box		*	34
10. Car restraint		*	14
11. Hearing assessment unit		*	5
12. Swallowing reminder		*	11
13. ETRAN frame		*	8
14. Food warmer		*	6
15. Kaleidoscope		*	1
16. 'A' frame		*	3
17. Movement reminder		*	2
18. Chin support	*		
19. New toilet trainer	*		
20. Wheelchair exerciser	*		
21. Trace box	*		

This report summarises progress over the last year. It highlights a few specific devices and outlines the current situation with regard to the development of the unit. The general picture is summarised in the chart showing the sales of various products. Some items that appeared in last year's list have been removed due to very low sales, or because we wish to develop them further, and there have been developments with several of the listed products, as discussed below.

Toilet Trainer

The toilet trainer fits inside a normal toilet and plays a tune when the child urinates. It is used to toilet train older children with severe learning difficulties who are still in nappies. Further development of the trainer is now complete and the device has just started being produced again. Feedback during the evaluations of the production device was very encouraging and we are planning to submit a paper to an appropriate journal on the results of its use.

Bottom Wipers

These devices help people with stiff joints or other problems which prevent them from reaching to carry out basic cleansing operations. They continue to sell in very satisfying numbers and a new injection mould tool is proving to be very effective. Smith and Nephew Homecraft, the company that markets the bottom wiper, has started promoting its products outside the UK. An agency has been established in the USA and Australia, and two sites have been established in mainland Europe. It is expected that these efforts will lead to increased sales but we are confident we can meet them with the new tooling in place. The new mould and the ultrasonic welding of the head components is working very well. The moulding-in of the handle has also markedly reduced the production cost and led to a much improved repeatability of the handle joint construction. Loading tests have been conducted on the handle joint, both static and accelerated life tests, and it has withstood these very well.

Chin Support

The chin support is a device that provides a limit to the amount a child's head can tip forward. It enables them to stop their head from flopping onto their chest and limits the movement so that the child can lift its head back up again. Its production development was completed during the year but its launch was delayed whilst we examined further the way that therapists use the device with their clients. Consultations with local Occupational Therapists indicated that the set-up procedure is quite important if the device is to be effective. To ensure that the device is set up properly we are currently producing a comprehensive instruction manual and plan to generate a video. The device is to be sold as the

"Head-Up", a name which reflects its use as a movement limiter rather than a chin support as such.

Rolling Road

Many able bodied people exercise in the comfort of their homes using an exercise bicycle. The Institute has developed an exercise machine along the same lines but suitable for the wheelchair user. The device is in the form of a low platform onto which the wheelchair is positioned up ramps. The chair sits on horizontal rollers that enable it to be operated without moving forwards. The rollers are connected to a flywheel to provide the user with a sense of momentum when operating their chair. A loading device is available to provide the user with different levels of exercise and a meter with a readout of speed and distance.

Some rolling roads have now been in use for some considerable time and have enabled us to check reliability and examine any wear that takes place. The castor wheel clamps that were finally developed have proved to be very effective and secure. The only real problem area has been the flywheel bearing and this component is now being changed to a ball unit. The Institute is currently providing several of these machines for sports centres in the UK using National Lottery Sports funding. A lot of interest has been expressed in the rolling road and as soon as we have more feedback from the lottery funded batch we will start promoting them in earnest. It is hoped that the device will be made available directly from the Institute's production unit after Easter this year.

Movement Reminder

The movement reminder provides a discrete signal to the user to change their posture at regular intervals. It vibrates in a manner which only the user can detect. It has been developed in conjunction with local therapists dealing with lower back pain and has been very effective. The device was very successfully promoted at a national pain management conference which took place in Bath earlier in the year. Production development continued through the year and orders are now starting to be received. It is envisaged that the next batch will be provided with two control buttons, one to increase the time interval between reminders and one to decrease it.

Swallowing Aid

The swallowing aid is a 3cm diameter badge-like device that provides a quiet bleep at regular intervals to remind users with an impaired swallowing reflex to swallow, and thus prevent dribbling. Trial evaluations showed the need for easier-to-use controls and these have now been incorporated. The device is now incorporated in our range of production devices.

Buggies

The buggy is a powered mobility aid designed for young children with cerebral palsy, including pre-school children. Although it is essentially a powered wheelchair it has been designed to have the appearance of a toy to enable it to be better accepted by both the children and their parents. A lot of effort has been expended promoting the buggies, with many promotion leaflets being sent out and around 140 videos describing the device have been circulated. Sales of the device are starting to reflect this increased promotion work and we look forward to making many of the devices available during the next year. Reliability is now excellent with very few problems occurring. We have had to source new motors as the previous ones became unavailable. A new controller has also been needed to drive the new motors and we have taken the opportunity to provide a variable speed control as this has been indicated by many users as being a desirable feature. Several accessories are also in the pipeline; a head rest, head switch controls, switch panel control, attachments for high security harnesses, and a remote control handset. These have all arisen from requests from current users and they will be on sale during the year. We have had discussions with colleagues in North America who are exploring pre-school powered mobility, and who have experienced similar problems to ourselves with the acceptance of putting young children in powered wheelchairs. There is a feeling that a change in outlook is needed because many therapists regard putting a pre-school child in a powered aid as admitting failure on their part. We need to underline the importance of independent mobility at an early age, as has been shown by so many studies, irrespective of whether the child is likely to walk at some stage. A booklet has now been published by RESNA (the Rehabilitation Engineering Society of North America - the major umbrella group world-wide for people working in our

field) discussing the importance of devices such as the buggy, and we hope to capitalise on the emerging consensus about the importance of pre-school mobility.

Production Development

It was mentioned in last year's report that a more carefully controlled procedure for production development activities was being piloted using the chin support. The pilot was quite successful and the procedure has now been adopted for all products undergoing production development. The procedure lets all staff involved in different aspects of the work, from production development to evaluation work and marketing, know when their input is needed. It has also ensured that we do not release details of new devices until we are happy we have removed all problems and a marketing plan is in place.

Quality Control and CE Marking

As from 1 January 1995 all medical equipment placed on the market must have a CE mark to show that it meets the requirements laid down by the European Directive, although manufacturers are allowed until 14 June 1998 to fully comply. The directive is having a major impact on BIME's production effort, and Dr. Michael Hillman has been coordinating our internal work aimed at meeting its requirements. All our rehabilitation products are classified as class 1 devices, which means that we can self-certificate as long as we have made sure that the products meet the requirements. Dr. Hillman has developed a set of guidelines for us to follow to generate the quality assurance and other appropriate documentation, and to carry out the various checks that form the basis of the European requirements, such as risk assessments. The procedures embodied in these guideline have been piloted with the car support harness, and are to be applied to all BIME products that are for sale. Dr Hillman has become quite an expert in the field as there has been considerable confusion throughout the UK over the interpretation of the directive. At a recent seminar in Birmingham on the implications of the directive for rehabilitation equipment he was invited to speak on BIME's experiences.

Staffing and Facilities

We have managed to keep staffing levels at one technician and one supervisor by using outside companies and facilities to make components for us and to carry out subassembly. Many components are now made outside in companies in the Bath area, including machined components, plastic and fibreglass mouldings and electronic assemblies, as well as finishing operations such as plastic coating and plating. We also use our local sheltered workshop for component and sub-assembly production, and at times of peak demand some of their employees have been seconded to work at BIME in our production unit for short periods of time. The arrangement has been very successful. Mr. Simon Adams, the production unit supervisor, has also arranged to provide some of the sheltered workshop employees with training in their own workshops so that they can make up sub-assemblies of BIME products without coming to the Institute.

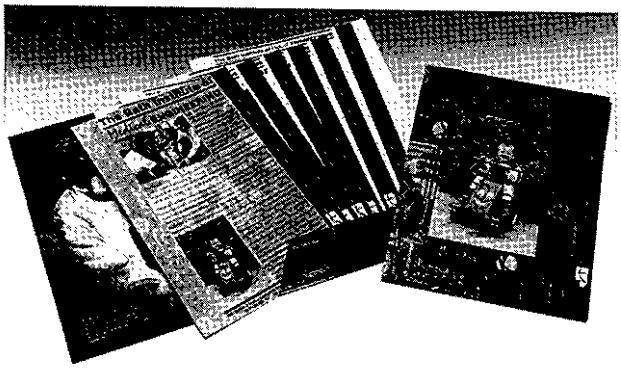
Space at BIME is limited and the storage of components and raw materials for production work has continued to cause a problem. We are currently using dedicated plastic containers to hold components for each product and this approach has worked well. We are currently exploring racking in both the production workshop and the assembly room to hold the containers. Some larger components such as the Buggy body-mouldings have to be carefully stock-controlled to ensure that adequate, but not excess, numbers are stored at BIME.

Promotions and Marketing

The promotions sub-committee has continue to coordinate the promotion and marketing activity. It has been a busy year with new literature and new systems being designed and used for the first time; and also a year of evaluation for the Buggy video and our exhibitions policy. We have learned much about desktop publishing and improved the quality and impact of the presentation of BIME and its products to potential users of our devices.

New Brochure

Much effort has been put into producing a new brochure. It was decided to use a loose-leaf folder format. A folder has been produced that can take any number of product information sheets depending on the interest of the potential buyer. Product sheets have now been completed for all the current range of products. These have been



The new BIME brochure with its loose-leaf information sheets.

designed to a common layout using a standard logo on each sheet. The sheets are in the form of a colour printed blank onto which the information can be photocopied. In addition full colour sheets have been printed for the Buggy information and for the general BIME information sheet. A fund raising sheet has also been produced as this is often quite appropriate for some enquiries. This loose leaf format provides us with the ability to tailor the information sent to different enquirers. A much improved Buggy instruction manual has also been printed. We are continuing to use a sale or return basis for marketing.

Videos

The BIME Buggy video has been successful. We have seen Buggy sales increase significantly since we have been distributing the video to therapists at exhibitions and to enquirers. We have found that therapists are keen to keep the videos and show them to their colleagues and the parents of the children that they work with.

We are currently investigating further videos for other products which could benefit from promotion in this medium - the Robot and the Walker for example; and also a general promotional video showing an overview of BIME.

Internet

The Internet is becoming an increasingly useful tool for finding people and information.

A web site based at the University of Bath will provide product information; dates and details of forthcoming events; links to other biomedical engineering sites, and summaries of BIME projects in progress. It will also provide an easy way for site visitors to send project and information requests to BIME. Links to the BIME home page will be located at the University of Bath web site.

Thanks are due to Paul Wakefield from the University of Bath for volunteering to assemble our web site for us.

Exhibitions

This year we have carefully selected the exhibitions that we attended. We have not exhibited at the large NAIDEX and Independent Living exhibitions, preferring instead the smaller, more targeted conferences such as the National Association of Paediatric Occupational Therapists (NAPOT) and the College of Occupational Therapists (COT) conferences in Bournemouth and Southampton respectively.

The delegates at the NAPOT conference were 200 of the people that we most want to talk to in the United Kingdom. Much of BIME's equipment is for children and their therapists, and conferences such as these generate a large number of enquiries.

Advertising

We have selected a few of BIME's new products for advertising in relevant journals and newspapers. For example, our new 'HeadUp' - a device to encourage children to keep their heads upright when they have poor muscle tone - will be advertised in the NAPOT journal. Again, as with our exhibitions policy, we believe that a number of adverts in smaller, well targeted publications will reach more people in need of our products than an expensive advert in a broader ranging publication.

Disability Publication

Our entries in the Disabled Living Foundation's lists have been kept up to date and have led to many enquiries. The publishers of the Mary Marlborough Lodge booklets (another popular source of information for OTs) have also included several BIME products in their booklets.

General

1. *Council*

As mentioned in the introduction to this Report, at the AGM in October we warmly thanked our retiring Chairman, Mr. K. Lloyd Williams, for all his work chairing Council for nine years, and welcomed

Dr. P. Lawes as our new Chairman and look forward to his leadership. We were very pleased to learn that both Mr. Lloyd Williams and Dr. A. K. Clarke, the Chairman of the Projects Committee, had agreed to serve further terms of office on Council and were re-elected. We also said farewell and warmly thanked Dr. L. R. Redman, who retired at the AGM. Dr. Redman is a founder member of the Institute and served for many years on the early Scientific Advisory Committee and, since 1980, as a member of Council. In his place, we were pleased to welcome Dr. P. Magee who has joined the Council as a member. The assistance and loyalty to the Institute for many years of all our Council members and officers is greatly appreciated.

2. *Projects Committee*

Under the Chairmanship of Dr. A. K. Clarke, the Committee kept all the above projects under active review and contributed their individual experience and expertise in their different fields to the various projects. I would like to record the thanks of the Institute to the members of the Projects Committee for their valuable time and advice given to this work.

3. *Annual Lecture*

The twenty-ninth Annual Lecture was presented in October by Professor Michael Brady, BP Professor of Information Engineering, Oxford University. His subject was "Breast and Brain Image Analysis". Professor Brady described his work to enhance images of the breast obtained using X-ray mammography and magnetic resonance imaging. He also described a system for analysing magnetic resonance brain images to measure brain structures and a system to compensate for brain shift in minimally invasive surgery. It was a fascinating lecture much appreciated by the audience and we are most grateful to Professor Brady.

The Annual Lecture to celebrate our 30th anniversary will be given at the University of Bath on Friday 2 October by Professor Peter Rolfe, Professor of Biomedical Engineering and Medical Physics at Keele University, on the theme of "Biologically Inspired Sensors, Tissues and Organs". We can look forward to another most interesting lecture.

4. *Presentations and Publications*

The work of the Institute has been presented during the year at a number of meetings and through publications. Presentations in other countries were funded by external grant support from the Royal Society, the Fellowship of Engineering, the Department of Health and the Institute of Electrical Engineers.

Presentations

Hagan K., Hagan S., Hillman M. and Jepson J., "Design of a wheelchair mounted robot". 5th International Conference on Rehabilitation Robotics, Bath, April 1997.

Hillman M. and Jepson J., "Evaluation of a trolley mounted robot - a case study". 5th International Conference on Rehabilitation Robotics, Bath, April 1997.

Hillman M. and Jepson J., "Flat Pack Commode". Institute of Physics and Engineering in Medicine Annual National Conference, Dundee, September 1997.

Hillman M., Hagan S., Mawson D. and Tooke J., "A low cost device for measuring vibration perception threshold". Institute of Physics and Engineering in Medicine Annual National Conference, Dundee, September 1997.

Hillman M., "Applying the Medical Devices Directive at a charitably funded design, development and production unit." IPEM Meeting on "In-house manufacture in rehabilitation engineering: Living with the Medical Devices Directive", Birmingham, December 1997.

Jepson J. and Hillman M., "A needs-led approach to the design of new equipment" College of Occupational Therapists, 21st Annual Conference & Exhibition, Southampton, June 1997

Jepson J., "An investigation in the equipment needs of people with restricted growth in the U.K." RESNA 97 annual conference, Pittsburgh U.S.A., June 1997.

Orpwood R. D. and Hagan S A., "Haemoglobinmeter for rural primary health care in developing countries", poster at "Developing World Health Exhibition", Institute of Child Health, University College London, February 1998.

Orpwood R., "The evolutionary design of a simple wheelchair lever propulsion." CORE wheelchair design seminar, Birmingham, July, 1997.

Orpwood R., "The development of a wheelchair exercise machine". International conference on wheelchairs and seating, Dundee, September, 1997. (Prize for best free paper).

Orpwood R., "Physiological modelling - the behaviour of cortical pyramidal neurons". School of Postgraduate Medicine research seminar, Bath University, November, 1997.

Orpwood R., "Team approach techniques in designing disability equipment". Poster at AgeNet foresight workshop: New technology for old age. London, October, 1997.

Publications

Jennings N., Morling S. and Harry A., "Evaluation of IVAC PCAM P5000", Evaluation (DH/MDA) 327, 1-31, June 1997.

Jennings N., Morling S. and Harry A., "Product Review of Neonatal Infusion Pumps", (DH/MDA), 1998 (in press).

Jennings N., Morling S. and Harry A., "Product Review of Volumetric Pumps", (DH/MDA), 1998 (in press).

Jennings N., Morling S. and Harry A., "Product Review of Syringe Pumps" (DH/MDA), 1998 (in press).

Jepson J., "Study into equipment needs of people with restricted growth", Br. J. Occupational Therapy, **61**, 22-26, 1998.

Morling S. and Ford L., "Intravenous Therapy: Selection, use and management of infusion pumps", British Journal of Nursing, **6**, 1094 - 1110, December 1997.

Morling S., "Infusion Devices: Risks and user responsibilities", British Journal of Nursing, **7**, 13-20, January 1998

Orpwood R., "A study of Hebbian learning in cortical pyramidal cells using a compartmental model". Brain Res. Assoc. Abstr., **14**, p68, 1997.

Orpwood R., "Numerical modelling of neocortical pyramidal cells", In "Modelling in the Neurosciences: from ionic channels to neural networks", Chap.13, (RR Poznanski, ed), Harwood Academic:Amsterdam, pp 333-367, 1998.

5. *Educational Activities*

The expertise available at the Institute is a valuable educational resource and members of staff feel it is part of their duties to provide educational support to a wide range of students. Each year we accept students on work placements, although this has to be limited to one day only for school pupils. We try to ensure that the students are motivated to consider medical engineering as a career. Career talks are also given to local schools to provide an insight into both engineering as a career and medical engineering in particular. 1997 was labelled as the Year of Engineering Success (YES) and during the week allocated to medical engineering the Institute provided a number of tours and talks to young budding engineers.

Mrs. Karen Hagan has specific responsibilities as part of the Engineering Council's Neighbourhood Engineers scheme, and provides talks and design projects to local schools to broaden their appreciation of engineering. It is felt important that professional engineers should involve themselves in work of this kind and BIME staff take it very seriously and will use their own time for planning such activities.

Many visitors are also entertained from other organisations working in the medical engineering field. It is important for the staff to be aware of work going on elsewhere and to describe and discuss their activities to visitors. These visits often include people from other countries. During the year we welcomed a representative from Singapore polytechnic, a party of 18 researchers on a fact finding mission from Japan, and a mixed international group of people working in rehabilitation robotics who took part in a visit at the end of the ICORR conference in Bath.

Staff are often invited to present lectures at courses run by other organisations. A recent appointment to the staff, Mr. Rob Aley, has much experience of applying industrial design techniques to the needs of the disabled and his abilities were recognised in an invitation to present a series of lectures to students at the College of Furniture Design on design methodology.

6. *Professional Activities*

The Institute's staff are involved in many outside bodies within the engineering and science fields. It is important for their professional development to

The children's buggy on display on the IMechE stand at the CBI Annual Congress.

play their part in such activities, and it enables communication and interaction with the medical engineering community as a whole. The main professional body for people working in medical engineering and physics is the Institute of Physics and Engineering in Medicine (IPEM) and many members of staff are members of the organisation. Dr. Michael Hillman is secretary of the Engineering Group Board of IPEM and is also a member of the Medical Engineering Board of the Institution of Mechanical Engineers. He is currently responsible for organising their annual student competition and chaired the competition finals in September. As a result of contacts with IMechE Industrial Liaison Organiser, BIME was invited to display the Children's Buggy at the CBI Annual Congress and Exhibition, where it was the centre piece of the IMechE display. Dr. Roger Orpwood is a member of the International Editorial Board of the journal "Engineering and Physics in Medicine", which is one of the IPEM journals. Mr. Simon Morling sits on the British Standards Technical Committee on Intravenous Infusion Equipment. Members of staff are also members of several other medical engineering organisations: the Rehabilitation Engineering Society of North America (RESNA), the Association for the Advancement of Assistive Technology in Europe (AAATE), and the Posture and Mobility Group (PMG).

The Institute's staff are often involved in the peer review of publications submitted to scientific journals, and to grant applications to various grant awarding bodies. Dr Roger Orpwood also sits on the Advisory Panel on Medical Engineering for the research charity Action Research.

During the year staff attended many scientific and engineering conferences and presented several papers, as can be seen from the publications and presentations list. During the year several members of staff were responsible for organising the 5th International Conference on Rehabilitation Robotics (ICORR), which we were invited to host, which took place in Bath at the University in April. The organising committee was chaired by Dr. Michael Hillman and included Mrs. Karen Hagan and Dr. Roger Orpwood, as well as Dr. Sally Clift from BIME's Council. The meeting attracted nearly 100 delegates from all over the world, one of the largest international meetings in this emerging field. It was a resounding success, both in terms of the quality of papers presented, but also in terms of giving the field of rehabilitation robotics a boost through improving and encouraging a sense of collaboration between people working in the field. Many useful contacts were made and ideas shared to solve problems encountered in providing robotic assistance to severely disabled people. As a result of this meeting we were invited to organise a special issue of the international robotics journal "Robotica" based on the papers presented.

Members of staff are also encouraged to enrol on Continuing Professional Development (CPD) schemes. The IPEM scheme is the main one used but some staff members are involved in the schemes run by the IMechE and the IEE. These schemes provide a structure and assessment procedure for members to maintain their professional development throughout their careers. One of BIME's strengths is the high quality and professionalism of the engineers it employs and it is important that this is encouraged and developed.

Conclusions

Thirty years ago the Institute's founders had the vision of providing engineering laboratories and workshops in an environment to enable all disciplines to work together to apply engineering solutions to the problems of disabled and ill people. The aims of the Institute have remained the same throughout this period, and in this report are described all the current projects in progress to help disabled people. Our 30th year has been a most

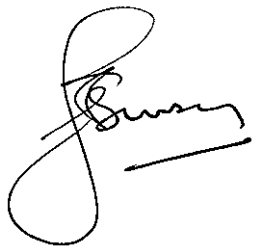
encouraging one in terms of projects completed, projects advanced and in the active output of our Production Unit.

We are greatly indebted to our many sponsors who have supported us both this year and throughout our 30 years life, and who have allowed the work of aids design and production to grow to its present level and provide help to so many people. We look forward to maintaining the momentum of our aids development work and to increasing again the number of devices being provided for the disabled community from our Production Unit. We would appeal to our regular sponsors to please continue their support in order that we may do so. For other or new supporters of the Institute's aims and work, we would request that they consider providing assistance for our work perhaps on a regular basis.

We look forward to welcoming to the Institute, in our anniversary year, as many sponsors, members and other supporters as can join us, to show the work being done and to share ideas for new projects.

April 1998

Professor S. C. Lillicrap
Director



REPORT OF THE COUNCIL FOR THE YEAR ENDED 31 MARCH 1998

The Council submits its report together with the audited financial statements for the year ended 31 March 1998.

Principal activity
The company uses the multidisciplinary approach of medicine, engineering and science to identify needs of disabled people and hospital patients not being met elsewhere and to provide solutions.

Council's responsibilities in respect of the accounts
Company law requires the Council to prepare accounts for each financial year which give a true and fair view of the state of affairs of the company and of the surplus or deficit of the company for that period. In preparing those accounts, the Council is required to:

—select suitable accounting policies and then apply them consistently

—make judgements and estimates that are reasonable and prudent

—follow applicable accounting standards, subject to any material departures disclosed and explained in the accounts

—prepare the accounts on the going concern basis unless it is inappropriate to presume that the company will continue in business.

The Council is responsible for keeping proper accounting records which disclose with reasonable accuracy at any time the financial position of the company and to enable it to ensure that the accounts comply with the Companies Act 1985. It is also responsible for safeguarding the assets of the company and hence for taking reasonable steps for the prevention and detection of fraud and other irregularities.

Auditors
R. S. Porter & Co. have expressed their willingness to continue in office and a resolution to re-appoint them will be proposed at the annual general meeting.

By order of the Council

J. A. Bursey
Honorary Secretary

11 May 1998

REPORT OF THE AUDITORS TO THE MEMBERS

We have audited the accounts on pages 31 to 34 which have been prepared under the historical cost convention and the accounting policies set out on page 31.

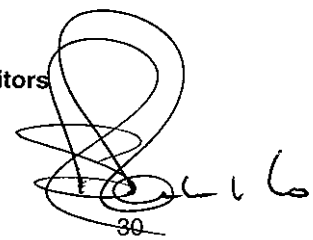
Respective responsibilities of the Council and Auditors
As described on this page the Council is responsible for the preparation of accounts. It is our responsibility to form an independent opinion, based on our audit, on those accounts and to report our opinion to you.

Basis of opinion
We conducted our audit in accordance with Auditing Standards issued by the Auditing Practices Board. An audit includes examination, on a test basis, of evidence relevant to the amounts and disclosures in the accounts. It also includes an assessment of the significant estimates and judgements made by the Council in the preparation of the accounts, and of whether the accounting policies are appropriate to the company's circumstances, consistently applied and adequately disclosed.

We planned and performed our audit so as to obtain all the information and explanations which we considered necessary in order to provide us with sufficient evidence to give reasonable assurance that the accounts are free from material misstatement, whether caused by fraud or other irregularity or error. In forming our opinion we also evaluated the overall adequacy of the presentation of information in the accounts.

Opinion
In our opinion the accounts give a true and fair view of the state of the company's affairs as at 31 March 1998 and of its surplus for the year then ended and have been properly prepared in accordance with the provisions of the Companies Act 1985 applicable to small companies.

R. S. Porter & Co.
Chartered Accountants and Registered Auditors
77/81 Alma Road
Clifton
Bristol BS8 2DP



11 May 1998

STATEMENT OF ACCOUNTING POLICIES

This statement of accounting policies forms part of the accounts.

(a) *Accounting convention*
The accounts have been prepared in accordance with the historical cost basis of accounting and in accordance with Statement of Recommended Practice No. 2 "Accounting by Charities".

(b) *Taxation*
No provision for taxation, deferred or otherwise, has been provided in these accounts as the Institute is a registered charity (registered number 256335) and is therefore exempt from taxation (other than Value Added Tax) under Section 505 of the Income and Corporation Taxes Act, 1988.

(c) *Assets received as donations*
No monetary value has been incorporated in the accounts in respect of assets donated to the Institute, other than those comprising cash and securities.

(d) *Cash flow statement*
No cash flow statement has been prepared as it is considered that no material benefit would be derived from such a statement.

(e) *Sponsored research*
Income from sponsored research is included only to the extent of direct expenditure incurred during the year and overheads relevant to that year.

(f) *Replacement of fixed assets*
Land and buildings are shown in the Balance Sheet at a written-down value and the original cost to the Institute is shown in the Notes to the Accounts. Other fixed assets are excluded from the Balance Sheet and their replacement is met from general income or specific grants made for the purpose of replacement.

(g) *Investments*
Dividends and interest from investments are credited to income on receipt and include the associated income tax credits.

Investments are shown in the Balance Sheet at the mid-market price quoted by the London Stock Exchange. Gains and losses on the revaluation and realisation of investments are credited to the Investment Fund in the Statement of Financial Activities.

(h) *Reserves*
The Council of the Institute exercises its discretion in the creation of reserves to meet future expenditure and in the utilisation of those reserves. The annual surplus on the Statement of Financial Activities transferred to the Accumulated fund is shown after making transfers to and from reserves.

(i) *Stocks*
No account is taken of stocks held by the Institute as these are immaterial.

STATEMENT OF FINANCIAL ACTIVITIES
Year Ended 31 March 1998

INCOME AND EXPENDITURE	Note	Unrestricted Funds £	Restricted Funds £	Reserve Funds £	Total Funds 1998 £	*Total Funds 1997* £
INCOMING RESOURCES						
Donations		**138,550**			**138,550**	*123,943*
Grants for sponsored research			**86,481**		**86,481**	*94,112*
Subscriptions		**298**			**298**	*277*
Interest	4	**68,871**			**68,871**	*62,569*
Consultancies, sales and royalties		**46,243**			**46,243**	*37,442*
Total Incoming Resources		**253,962**	**86,481**	**0**	**340,443**	*£318,343*
RESOURCES EXPENDED						
Direct expenditure on general activities:						
Salaries and wages	5	**142,740**			**142,740**	*135,368*
Materials and equipment		**44,180**			**44,180**	*46,335*
Direct expenditure on sponsored research:						
Salaries and wages	5		**78,658**		**78,658**	*86,204*
Materials and equipment			**1,987**		**1,987**	*2,495*
Other			**5,836**		**5,836**	*5,413*
Indirect expenses:						
Rent	6	**180**			**180**	*180*
Premises		**4,568**			**4,568**	*3,374*
Administration, exhibitions and professional fees	7	**13,409**			**13,409**	*13,738*
Travelling and c onferences		**(937)**			**(937)**	*3,903*
Total Resources Expended		**204,140**	**86,481**	**0**	**290,621**	*£297,010*
NET INCOMING (OUTGOING) RESOURCES For the year from continuing operations		**49,822**			**49,822**	*21,333*
Gains / (Losses) on Investments						
Realised						*(5,930)*
Write-back previous years' unrealised gains						*(1,319)*
Unrealised		**8,085**			**8,085**	*2,383*
Transfer to Reserve for short-term appointments		**(8,700)**		**8,700**		
Net Movement in Funds		**49,207**		**8,700**	**57,907**	*16,467*
BALANCE BROUGHT FORWARD AT 31 March 1997		**203,297**		**659,200**	**862,497**	*846,030*
BALANCE CARRIED FORWARD AT 31 March 1998		**£252,504**	**0**	**£667,900**	**£920,404**	*£862,497*

The notes on page 34 form part of these accounts

BALANCE SHEET
31 March 1998

	Note	Unrestricted Funds £	Restricted Funds £	Reserve Funds £	Total Funds 1998 £	*Total Funds 1997 £*
FIXED ASSETS						
Quoted Investments	9	**0**	**0**	**229,333**	**229,333**	*221,248*
		0	**0**	**229,333**	**229,333**	*221,248*
Current Assets:						
Debtors Sundry		**1,281**			**1,281**	*9,142*
Pre-payments		**30**			**30**	*3,042*
Accrued income		**12,526**	**5,776**		**18,302**	*11,981*
University of Bath	10	**152,408**			**152,408**	*359,632*
Money market deposits		**93,678**		**438,567**	**532,245**	*274,885*
Bank balances		**1,718**			**1,718**	*319*
		261,641	**5,776**	**438,567**	**705,984**	*659,001*
Current Liabilities:						
Creditors Accruals		**(9,333)**	**(5,580)**		**(14,913)**	*(17,752)*
Net current assets		**£252,308**	**£196**	**£667,900**	**£691,071**	*£641,249*
Total assets, *less* current liabilities		**£252,308**	**£196**	**£667,900**	**£920,404**	*£862,497*
Represented by:						
Accumulated fund	9	**252,308**	**196**	**0**	**252,504**	*203,297*
Reserve for short-term appointments	11			**667,900**	**667,900**	*659,200*
		£252,308	**£196**	**£667,900**	**£920,404**	*£862,497*

The notes on page 34 form an integral part of these accounts.

P. LAWES *Chairman*
D. T. PROTHCROE *Vice-Chairman*

11 May 1998

NOTES TO THE ACCOUNTS
Year Ended 31 March 1998

1. **LIMITATION BY GUARANTEE**
The Company is limited by guarantee and as such has no share capital.

2. **CHARITABLE STATUS**
The Company is a registered charity (no. 256335).

3. **COUNCIL**
No remuneration is payable to the members of the Council of the Institute.

4. **INTEREST**

	£
Quoted Investments	19,673
University of Bath	21,838
C.O.I.F	27,121
Abbey National	239
	68,871

5. **EMPLOYEES**
The average number of employees during the year was as follows:

1998	*1997*
14	*14*

No employee earns more than £40,000 per year

6. **LEASHOLD PROPERTY AND FIXED ASSETS**
A lease of the property at the Medical Sciences Centre, was entered into on 26 May 1995.
By the terms of the lease, the annual rent is set at £180. The lease expires on 28 September 2067.

The other fixed assets of the Company have been written down to a nil value in the accounts.

7. **AUDIT FEES**
Audit fees of £176.25 are included under the heading of Administration, exhibitions and professional fees.

8. **DIRECTORS AND OFFICERS LIABILITY INSURANCE**
The Institute has effected directors' and officers' liability insurance cover. The annual premium is £936.

9. **QUOTED INVESTMENTS**

	£
Value @ 31/03/97	221,248
Unrealised Gains/(Losses)	8,085
Value @ 31/03/98	229,333

The investments are shown in the Balance Sheet at market value.

10. **UNIVERSITY OF BATH**
The University of Bath administers the financial affairs of the Company. The balance on the current account with the University attracts interest at the current market rate, as determined by the average rate obtained by the University on its deposits and investments.

11. **RESERVE FOR SHORT-TERM APPOINTMENTS**
The Institute has assigned funds for short-term engineering appointments for specific projects.

Funds for short-term engineering appointments	£	£
Graduate Engineer in post: 2 years and replacement	105,300	
Graduate Engineer in post: 1 year and replacement	82,000	
Graduate Engineer in post: 3 years	82,000	
Graduate Engineer in post: 1 year and replacement	82,000	
Graduate Electrical Engineer in post: 3 years	85,400	
Workshop Technician in post: 1 year and replacement	69,100	
Electronics Technician in post: 3 years and costs	61,900	
Production Technician in post: 3 years and costs	59,100	
Research student: new	22,000	
Occupational Therapist (part-time): 2 years	19,100	
		667,900
Balance on reserve: 31 March 1997		£659,200
Transfer from Income and Expenditure Account		8,700
Balance on reserve: 31 March 1998		£667,900

Estimate of Future Income and Expenditure

Introduction to Table

The estimates in this table are for three years with a tentative projection to the fourth year. An annual rate of inflation of 3% is assumed. Please refer to the Director's Report under 'Planning' for a further discussion of the implications.

	1998/99		1999/2000		2000/2001		(2001/2002)	
	Income	Expenditure	Income	Expenditure	Income	Expenditure	Income	Expenditure
	£	£	£	£	£	£	£	£
Estimated Income								
Subscriptions, Sales, Consultancies, Royalties	50,000		50,000		50,000		(50,000)	
Donations from regular sponsors (see Note 1)	135,000		140,000		145,000		(150,000)	
Interest	70,000		70,000		70,000		(70,000)	
Estimated Effective Expenditure & Offsetting Support (see Note 2)								
Salary commitment for staff working at BIME								
(a) Director (part-time) and 2 permanent engineers		81,100		85,100		89,300		(89,300)
Salary support provided by direct employment and project grants from the Health Authority and DH	66,300		69,600		75,100		(41,000)	
(b) Short-term appointments of 5 engineers and 1 physicist		140,400		147,400		154,800		(76,000)
Salary support provided by project grants	46,700		49,000		51,400			
(c) 5.5 Technicians and Therapists		102,600		107,700		113,100		(57,000)
Salary support provided by direct employment and project grants	22,500		24,100		25,300		(11,000)	
(d) Secretarial		10,800		10,300		11,800		(11,800)
Salary support provided by direct employment and project grants	5,600		5,600		5,900			
(e) Cleaning		2,200		2,300		2,400		(2,600)
Salary support from DH grants	1,100		1,200		1,200			
Materials & Equipment		50,000		50,000		50,000		(50,000)
Support from DH grants	2,000		2,000		2,000			
Premises		4,000		4,000		4,000		(4,000)
Administration, exhibitions etc		14,000		14,000		14,000		(14,000)
Support from DH grants	7,000		7,000		7,000			
Travelling		2,000		2,000		2,000		(2,000)
Support from DH grants	1,000		1,000		1,000			
Fees and Service charges		200		200		200		(200)
	£407,200	£407,300	£419,500	£423,000	£433,900	£441,600	(£322,000)	(£306,900)
Balance on year	–£100		–£3,500		–£7,700		(£15,100)	

Notes

1. The estimates of donations from regular sponsors have been based on promised support and experience of the level recently received. They represent target figures for donated income which we hope our sponsors will provide.

2. The effective expenditure is the cost of running the Institute. Some of the staff working at the Institute are employees of other organisations (Royal United Hospital NHS Trust, University of Bath) and their salary costs are not recorded in the Annual Accounts. The offsetting support under 'income' includes this salary contribution and also the salary contribution provided by the DH grants. Not included in this table is an estimate of the cost of the administrative support provided by the University.

BATH INSTITUTE OF MEDICAL ENGINEERING LIMITED

DONATIONS RECEIVED
Year Ended 31 March 1998

Under £200 : 25 donors

The following were exceptionally generous in their donations:

The Southern Trust
Charity of Henry Smith (Kensington Estate)
The Childwick Trust
Railtrack Plc
Emmandjay Trust
H.B. Allen Charitable Trust
The Dunhill Medical Trust
The John Ellerman Foundation
Hospital Saving Association Charitable Trust
Carrie Rudolf Will Trust
Lottery Sports Fund
The F.H. Muirhead Charitable Trust
Col. W.W. Pilkington Charitable Trust
Bath Area Medical Research Trust
The Anton Jurgens Charitable Trust
Jenour Foundation
The NFC Foundation
The Inverforth Charitable Trust
Friarsgate Trust
BBC Children in Need Appeal
The Ammco Trust
The Mason Bibby 1981 Trust
The D'Oyly Carte Charitable Trust
R.J. Harris Charitable Trust
Lady Hind Trust
The Jane Hodge Foundation
Lazard Brothers & Co. Ltd.
John Lewis Partnership
P.F. Charitable Trust
John Pryor Charitable Trust
The Violet M. Richards Charity
Charles & Elsie Sykes Trust
Thomson Corporation Charitable Trust
Sir James Reckitt Charity
The Freemasons' Grand Charity
The Norman Family Charitable Trust
C. Rowbotham Charitable Trust
G.M. Morrison Charitable Trust
Mrs. R.A. Brinton
The Yapp Charitable Trusts
The Arnold Foundation
Barclays Bank Plc
BTR Plc
Chapman Charitable Trust
General Accident Fire & Life Assurance Corporation Plc
Robert Kiln Charitable Trust
Matthews Wrightson Charity Trust
The Oakley Charitable Trust
Schroder Charity Trust
Smiths Industries Plc
The Sobell Foundation
Jessie Spencer Trust
Sir Jules Thorn Charitable Trust
Ti Group Plc
Dame Violet Wills Will Trust 1965
Bertie Black Foundation
A.M. Fenton Trust
Pall Biomedical
Avon & Somerset Constabulary
IMI Plc
Ravensdale Charitable Trust
Mr. P.G. Davis
Benham Charitable Settlement
J. & C. Bonham Christie Charitable Trust
Ashby Charitable Trust
Mr. & Mrs. C. Leslie Bibby
Miss J.M. Bisgood
Andrew Brownsword Collection
The Richard Cadbury Charitable Trust
The Darby Taylor Memorial Trust
Fenwick Ltd.
Robert Fleming Holdings Ltd.
Novartis Pharmaceuticals UK Ltd.
Rolls-Royce Military Aero Engines Ltd.
Securicor Plc
Transport Development Group Plc
Andrew Anderson Trust
J. & M. Britton Charitable Trust
R. Hickson-Collis Charitable Trust
The Fitton Trust
Jardine Lloyd Thompson Group Plc
The Newby Trust Ltd.
Sir James Reckitt Charity
Tibbett & Britten Group Plc
Dr. J.D. Garnish

One Donor wished to remain anonymous