The bathroom: ergonomic factors in the design of bath aids and w.c. pans

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THE BATHROOM - ERGONOMIC FACTORS IN THE
DESIGN OF BATH AIDS AND W.C.-PANS

by

IAN LYALL McCLELLAND, C. Dip. Tech.

A MASTER'S DEGREE THESIS

Submitted in partial fulfilment of the requirements for the award of Master of Science of the Loughborough University of Technology.

JUNE 1973

Supervisor : Mr. R. J. Feeney
Department of Ergonomics and Cybernetics.
CONTENTS

1.00 ABSTRACT 7

2.00 ACKNOWLEDGEMENTS 8

3.00 INTRODUCTION 10

PART 1 A system of Bath Aids for the Disabled An Ergonomics Evaluation 14

4.00 INTRODUCTION 15

4.10 Aim 17

5.00 EXPERIMENTS 20

5.10 Experiment 1 - The position and surface finish of the grab rails 20

5.20 Apparatus 22

1 The Bathroom 22

2 Bath 22

3 Bath Board 25

4 Bath Seat 26

5 External Bath Mat 26

6 Internal Bath Mat 26

7 Grab Rails 30

5.30 Subjects 34

5.40 Procedure 36

5.50 Experiment 2 - The optimum wall to rail clearance distance 40

5.60 Apparatus 40

5.70 Subjects 42

5.80 Procedure 42
10.20 Subjects 76
10.30 Procedure 78
11.00 RESULTS 80
11.10 Measurements 85
12.00 DISCUSSION 91
13.00 CONCLUSIONS 101
14.00 APPENDICES 103
15.00 REFERENCES 124

FIGURES
1 The Bathroom at the MML 23
2 The bath at the MML. The seat and board are arranged for a right hand approach. 24
3 The clamping system used to attach the bath board to the bath. 27
4 The bath seat. The bath seat in position with the rubber mat in the foreground and the board above. 28
5 The bath mats. On the left is the internal mat with the external mat on the right. 29
6 The framework used to mount the rails. 31
7 The special bracket, designed to accommodate angular adjustment of the wall rail. Each wall rail had one bracket at each end and each bracket could be raised or lowered along the vertical pole. The collar holding the wall rail could be rotated about
the axis of the bolt which holds it to the plate of the bracket. By means of the nut on the bolt and the grub screws in the collars, the bracket could be locked in the desired position, thus fixing the position of the rail.

The bath rails. From left to right (1) metal surface, (2) rubber surface, (3) plastic surface.

The apparatus for experiment 2

A plan view of the Experimental Area

A side view of the light path between the camera and the rig.

The three postures adopted for the photographs for women.

The three postures adopted for the photographs for men.

A general view of the Rig to the left, and of the changing area to the right, from in front of the camera enclosure.

The 'Dexion' frame used to mount the platform and mirror.

The camera enclosure. A view from in front of the rig. To the left and to the right are the two lights for the flash unit. In front of the camera enclosure is the remote control device to operate the camera.

The F.24 Aerial Survey camera as mounted for the survey. At the base of the mounting is the power pack for the electronic flash unit.

Height vs weight, women.

Height vs weight, men.

X-ray measuring calipers.
FIGURES
21 The 10 measurements taken from each photograph as applied to posture 2.

TABLES
1 Estimated number of men and women in Great Britain of different ages who are very severely, severely, or appreciably handicapped or impaired.
2 Comparison of the dimensions of the bath at MML with BS 1390: 1947, BS 1189: 1961 and BS 4305: 1968.
3 Distribution of ages and sex of subjects.
4 Distribution of disabilities and sex of subjects.
5 Angle, in degrees, of wall rail to horizontal, initially presented to the subjects.
6 Preference expressed for surface finish.
7 Final angle, in degrees, of wall rail to horizontal with which subjects expressed satisfaction.
8 Table of subjects' height and weight categories.
9 Age/sex distribution of subjects.
10 Comparison of the heights and weights of the survey sample with the heights and weights of the samples of Montegriffo (1968) and Thompson et al. (1973).
11 Posture 1: Means, standard deviations and ranges.
12 Posture 2: Means, standard deviations and ranges.
13 Posture 3: Means, standard deviations and ranges.
The first part of this thesis deals with the evaluation of a combination of bath seat, bath board, and hand rail as an aid to disabled persons using a conventional domestic bath. Previous experimental work under 'dry' conditions had suggested certain positions for a sloping wall rail as being suitable for aiding entry to and exit from a bath. The evaluation was carried out under 'wet' conditions in order to clarify the position of the hand rail. The problem of surface material was also investigated. In the trials disabled subjects used the equipment and their comments and performance were noted. A separate experiment was conducted to determine the clearance distance of the hand rail from a wall. As a result of these tests it is recommended that, subject to further field trials, the equipment be considered as an addition to equipment already available to disabled persons. Certain recommendations are made concerning the positions, sizes and materials of equipment to be used in such an installation.

The second part describes an anthropometric survey conducted in order to obtain basic anthropometric data not available elsewhere on the human body with respect to the use of W.C. pans. The technique used was an adaptation of the somatotype photographic technique. Ten body dimensions were measured from the photographic prints. The subjects were recruited from the general public and consisted of able-bodied adult men and women between the ages of 18 and 81 years. Data on the 10 body dimensions of 140 subjects adopting 3 postures appropriate to W.C. pan use, are given, together with the implications thereof for W.C. seat design. Comparison is made between measurements so obtained and those of currently recommended W.C. seat dimensions.
2.00 ACKNOWLEDGEMENTS

The study in the first part was sponsored financially by the National Fund for Research into Crippling Diseases, Director Mr. D. Guthrie. I am most grateful for this support.

I would also like to express my appreciation for the assistance given me by Dr. P.J.R. Nichols and his staff at the Mary Marlborough Lodge Disabled Living Research Unit where experimental work was carried out.

In particular I am grateful to Dr. P.J.R. Nichols for his valuable help and advice; and to Sister C. Lake and Miss P. Davies, Occupational Therapist, who both gave much of their time to arranging for suitable subjects and assisting in the experiments. I wish also to thank Mr. T.S. Strange, the Chief Technician at the Mary Marlborough Lodge Research Workshop, and his staff for their generous assistance in setting up the experimental rig.

I would like to thank Miss M. Flood, Occupational Therapist, who ran the Day Centre at Coalville for Leicestershire County Council, for arranging the subjects and facilities for the experiment to determine the optimum wall to rail clearance distance.

I also extend my thanks to all the subjects who took part in the experiments, for the interest and enthusiasm which was most encouraging.

Finally, I wish to thank my project supervisor, Mr. R.J. Feeney, Assistant Director of the Institute for Consumer Ergonomics, for his guidance and assistance in the course of this study.
The study in the second part was sponsored financially by the Department of the Environment through the Building Research Establishment. I am most grateful for this support.

In addition, I am also grateful for the facilities provided by the Department of Design Research, Royal College of Art, which enabled this study to be undertaken. I am indebted in particular, to Professor L. B. Archer, the head of the Department and Mr. K. Agnew, Senior Research Fellow, for their help and guidance, and also to Mr. T. Coward, Research Fellow, and Mr. P. Donald, technician, for their contributions to the design and construction of the apparatus.

I would also like to thank Mrs. A. Pycio, the nurse, whose help in conducting the survey was invaluable.

Thanks are also due to the subjects who took part in the survey.

Finally, I wish to thank the supervisor for this project, Mrs. J. S. Ward, Assistant Director of the Institute for Consumer Ergonomics, for her support and guidance in the course of this study.
Modern European concepts of personal hygiene and the means by which these concepts are given expression are, for the broad mass of the population, a relatively recent development (Kira, 1966, Langford, 1965, Palmer, 1973, Reynolds, 1946, Wright, 1960). Current standards of equipment and facilities normally associated with the contemporary bathroom are the result of a combination of a greater awareness of the importance of personal hygiene in increasingly congested situations and the wealth to finance the introduction of the appropriate equipment on a wide scale. The development of the modern bathroom has come about largely on an ad hoc basis with apparently little concern being paid to the need for a systematic examination of the user requirements in the design of the equipment (Claxton 1969, Kira 1966, Pike 1965 and 1966). It is only in recent years that this need has been recognised on a scale likely to create a substantial influence over future designs. The most significant attempt to analyse the bathroom from an ergonomic point of view was that of Kira (1966). However, his report offers inadequate justification, in an ergonomic sense, for the designs he proposed, although it does provide a useful indication of the relevant activities involved in the use of the bathroom. Otherwise ergonomic analysis and data relevant to the bathroom are scarce.

In many instances points of view have been expressed as to the suitability or otherwise of bathroom equipment, for example, Clegg 1971, Hector 1966, Hunt 1966, Pike 1965, 1966, Rayner 1966, and Stubbs 1970. These views often rely on personal experience in the application of particular equipment without reference to ergonomic data, although Clegg and Hunt do offer some evidence for their views within the limited situation of planning bathing facilities for hospital patients. Within the United Kingdom the most important and most recent guide to bathroom design has been the Design Bulletin, in the
series, Spaces in the Home, on bathrooms (Department of the Environment, 1972). This guide, although valuable in highlighting possible variabilities in bathroom layout, does not indicate, other than the studies by Kira, any experimental work carried out on the anthropometric and activity space requirements in the bathroom to support the recommendations made. Claxton (1969) discusses hygiene, how the body is cleaned and the equipment used, also discussed by Goulden (1970), and in a following article discusses ergonomic aspects of bathroom design.

For the handicapped user in the bathroom there is also little information available to guide designers. Lawton (1963) and Lowman et al. (1969) do illustrate possible solutions for the use of the bath, shower and w.c. Goldsmith (1967) in designing for the disabled offers a comprehensive view on the problems and possible solutions for the disabled person in the bathroom as does Walter (1968) to a lesser extent. Goldsmith recommends for the disabled user in the bathroom the installation of rails and poles as aids for which specific positions are given, and also outlines possible layouts for bathrooms and bathroom equipment. Dumas (1971) makes similar recommendations. Jarvis (1970) suggests an arrangement of aids specifically for bathing handicapped children. However, these sources do not appear to base their recommendations on an experimental evaluation of user requirements. Three reports do refer to investigations into the needs of the disabled in the bathroom. The first is a study by Goldsmith et al. (1966), which looks at the needs of the disabled in respect of public conveniences as a result of which they make design recommendations for the layout and equipping of public conveniences without considering detailed ergonomic aspects of the w.c. The second is a report by the Spastics Society (undated) on a survey which investigated "Sluices and their Environment in Centres for severely Disabled People", which makes recommendations for the equipping and layout of sluices. The third is a report by the Research Institute for Consumer Affairs on the evaluation of Bath Aids for the Disabled User (R.I.C.A. 1972) based in part on the work described here and on work previously carried out by
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The Institute for Consumer Ergonomics (Bretten 1971).

With regard to the w.c., there is no published information available on the ergonomic considerations in the w.c. design other than the publications already mentioned. Medical opinion is often quoted as recommending a seat height lower than that normally adopted in the U.K. as the "best" position (Aaron 1938, Bokus 1944, Davenport 1966, Garry 1972, Hornibrook 1963). However, there is no published study to support such an opinion, although a consideration of the physiology of defaecation would make such an opinion reasonable for the able bodied. For many of the elderly and many categories of the handicapped, a low seat would be impractical, even where grab rails were provided. In fact, a higher seat for such users is often recommended (Goldsmith 1967). Kira (1966) does propose a specific design for the w.c. incorporating a squat posture relying on support for the ischial tuberosities but this has been found to be unsuitable in practice (Thomkin 1973).

The techniques adopted for washing the body have also been discussed. In general, for an all over wash, opinion would seem to favour the shower as against the bath, principally on the grounds of water economy and hygiene (for example: Claxton 1969, Kira 1966, Rayner 1966, Stubbs 1970). The equipment necessary for washing the body has also been discussed and opinions have been expressed about the suitability or otherwise of such equipment (Claxton 1969, Goldsmith 1967, Hector 1966, Kira 1966, Pike 1966, Rayner 1966, Stubbs 1970). Particular designs for baths, shower units, basins and bidets have at various times been proposed, notably Kira (1966), but there is no published study of such equipment which has been based on an ergonomic analysis of the activities involved.

Thus there is little ergonomic data relevant to user requirements in the bathroom. This may be attributable to a general reluctance of society to discuss questions of hygiene and associated activities in sufficient detail. However, with the importance that this society now attaches to standards of personal hygiene and the quality of the facilities which are used, there is now a less cautious attitude towards open discussion of the issues involved. Consequently, it is now probably somewhat easier to extract specific information about
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The two projects described here identify specific areas of concern within the bathroom.

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(2) For the second part, an investigation into the ergonomic requirements of the w.c. was undertaken. For some time it has been recognised amongst those concerned with the design and development of sanitary equipment in the United Kingdom that there has been little ergonomic data relevant to the use of w.c. pans upon which to base further developments. Furthermore, it is apparent to those organisations responsible for the care and maintenance of public conveniences that fittings tend to become soiled and unpleasant to use (Crawford et al. 1966). In recognition of the lack of data available and the need for it, the British Standards Institution Committee OC/27/4 initiated a proposal that research be undertaken in order to provide some basic ergonomic data for the evaluation of present, and the development of future, designs of w.c. pans. In response to this proposal the Institute for Consumer Ergonomics, supported by the Building Research Establishment, set up a research project which aimed to obtain relevant basic anthropometric data. This project forms the basis for the second part.
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In general, the sources of information cited in this thesis are the result of a systematic survey of the available literature on ergonomics, rehabilitation, building design and, in particular, Ergonomics Abstracts, Index Medicus, Hospital Abstracts and Building Science Abstracts.
Part I
A system of Bath Aids for
the Disabled
An Ergonomics Evaluation
INTRODUCTION

In considering both aids for the disabled in the domestic situation, it is necessary to bear in mind the characteristics of the population one is considering. As Amelia Harris shows in her survey of the Handicapped and Impaired (Harris 1971), approximately 2/3 of the disabled population living at home are people aged 65 and over, see Table I (adapted from Table 10, page 18, Harris 1971).

Table 1.
Estimated numbers of men and women in Great Britain of different ages who are very severely, severely, or appreciably handicapped

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Men and Women</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 and under</td>
<td>19,000</td>
<td>1.7</td>
</tr>
<tr>
<td>30 - 64</td>
<td>378,000</td>
<td>33.5</td>
</tr>
<tr>
<td>65 - and over</td>
<td>730,000</td>
<td>64.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,128,000</td>
<td>100</td>
</tr>
</tbody>
</table>

Approximately 2/3 of this total are women.

Taking the handicapped and impaired population as a whole, they tend to be in the lower income groups and approximately 2/3 rely on some form of State Benefit for at least part of their income. On page 58 of her survey, A. Harris writes:

"There can be little doubt, however, that the proportion of people with very low incomes is greater than for the non-impaired, even after allowance has been made for the impaired population containing a disproportionate number of elderly." (also Sainsbury 1970)

Buckle (1971) also points out the difficulty that handicapped and impaired persons experience in obtaining permanent employment. This difficulty increases with the increasing severity of disability. Consequently, the
difficulty in finding gainful employment can restrict a disabled person's income to a greater extent compared with the able bodied.

The factors of age and income can have a critical influence over the extent to which bathing is a problem for the disabled. The predominance of the old and poor in the handicapped and impaired population should not be disregarded when one considers the conditions under which a disabled person takes a bath, clearly outlined by Dr. P.J.R. Nichols in his book on the Management of the Severely Disabled, p.188 (Nichols 1971):

"Taking a bath is a difficult and strenuous activity for the elderly and slightly disabled. For the severely disabled, it is often very dangerous. Bathing is usually performed in a small room, difficult to reach and with awkward fitments and corners. The surfaces involved become wet and slippery. The atmosphere is hot and steamy and conducive to fainting, and considerable agility, including the ability to stand on one leg, is necessary to get in and out of a standard bath successfully."

However, in spite of these dangers, the use of a bath to wash the body is a problem with which most disabled people have to come to terms, as a bath is the conventional method in the U.K. for washing the body and as such is a standard piece of equipment in most homes. It is also unlikely that the bath will be replaced on a large scale, in the short term, by any alternative method for washing the body as it is a durable item of equipment which is costly to replace. For the handicapped, who tend to be poor and elderly, any possibility to change such equipment is even less likely than for the general population. Consequently, it is necessary for the handicapped to have available appropriate equipment which will help to remove and or reduce the variety of hazards which they may have to face in the bathroom. The alternatives are a bed bath, or an "all over wash" at a sink, both of which tend to be uncomfortable and inadequate. An alternative might be a shower but, in the domestic situation, it is seldom that one is available. For many, a shower could solve a great number of practical problems, but it may be costly to install even if there is room. One must also consider the resistance to showering as an alternative to bathing, which might be encountered (Nichols 1971).
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1971).
The main aim of this project was to investigate the use of grab rails in solving the problem of the disabled person having independent entry to and exit from a bath which is comparable in general dimensions and location with that likely to be encountered in the domestic situation. It should be noted that independence is only being considered from the point of view of the mobility of the subject in terms of getting in and out of the bath. It is not intended to advocate in any respect that the population whom the subjects of this study represent should necessarily bath entirely independently and unattended. This project arose out of previous experimental work, carried out by Pauline Bretten (Bretten 1971) and sponsored by the Research Institute for Consumer Affairs which made certain recommendations with regard to the importance and use of grab rails in a bathroom.

The study by Bretten first assessed the needs of a number of disabled persons from an examination of their bathing habits and bathing situation using questionnaire techniques. As a result of this, an experimental investigation was carried out to find the optimum position for grab rails around the bath to enable disabled persons to get in and out of a bath independently and safely. This experimental investigation involved fully clothed subjects selecting a rail position which was suitable for their needs, and attempting to get in and out of a dry bath independently and safely. An assessment was also made of the grip strength of the subjects and their preference for the diameter of a circular section rail. One of the main results from this investigation was that the majority of subjects used a seated approach to bathing and preferred a grab rail fixed to the wall at one side of the bath. This enabled many of the subjects to gain access to the bath who, in fact, had been unable to use a bath previously. This grab rail was 1030mm in length, at an angle of 130° to the horizontal and sloped down from the back of the bath in line with the side rim towards the centre of the side rim of the bath. It was also found that an overhead rail sloping down from above the head to the foot of the bath.
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could also be useful for some subjects. The preferred diameter for a circular rail was found to be 32 mm or 38 mm, with a marginal preference for the 32 mm diameter.

The present study sought to confirm Bretten's findings relating to the angle and position in which the grab rail attached to the wall at one side of the bath should be placed. This confirmation was sought using an experimental situation in which disabled subjects actually used water in the bath. It also sought to extend her findings by specifying (1) a desirable surface finish for the rail which was non-slippery and offered good support and grip to the disabled subject; (2) the optimum rail to wall clearance distance which permitted the subject to use the rail without trapping their arm between the rail and the wall.

Dr. P.J.R. Nichols kindly permitted the Institute for Consumer Ergonomics to carry out the necessary experimentation at the Mary Marlborough Lodge (M.M.L.) where suitable facilities and subjects would be made available in order to investigate the grab rail position and the surface finish of the rail.

Mary Marlborough Lodge is a Disabled Living Research Unit, part of the Nuffield Orthopaedic Centre, and administered through the Oxford Regional Hospital Board. As such it is part of the National Health Service and admission to the Unit is arranged on the usual pattern of admission to any specialized unit, by application from the patient's doctor – either General Practitioner or Hospital Doctor.

Mary Marlborough Lodge is not a rehabilitation unit, in the usual sense of this term, but a functional assessment unit, a therapeutic department, a training centre and a research department where physiotherapist, occupational therapist, technician, nursing sister and medical social worker collaborate in the assessment and rehabilitation of the severely
disabled. The average length of stay of patients is between two and three weeks, although in some circumstances patients stay longer, and they may be re-admitted from time to time for further management.

It was also arranged, with Miss M. Flood, Occupational Therapist, to carry out the experiment for the determination of the optimum wall to rail clearance dimensions at the Day Centre for Disabled persons at the Miners Welfare Centre, Coalville.
5.00 EXPERIMENTS

The experimental work was divided into two parts. The first was concerned with the position and surface finish of the grab rails, and the second was concerned with the wall to rail clearance distance. This division was necessary because it was not possible to incorporate the determination of the wall to rail clearance distance into the rig in the first experiment.

5.10 Experiment 1 - The position and surface finish of the grab rails

The essential consideration which governed the design of this experiment was the task which the subject would be required to undertake; i.e., that they would be required to attempt to gain independent entry to and exit from a bath using a simple arrangement of aids incorporating a seated approach to the bath and the use of grab rails similar to those used in Bretten's study. It was, therefore, necessary to use an experimental rig which reproduced the features of the rig in Bretten's study, allowing a comparable range of rail positions to be made available to disabled subjects. A further consideration when designing the rig was that the components used should not involve unnecessary expense. Consequently, where possible they were of a simple design and constructed from materials which are readily available.

The disabled people who were to be considered as suitable subjects were mainly those who would normally require some form of assistance to bath. The very severely disabled were not considered as they would not only have required active assistance from some other person, but also their bathing problems, from the point of view of the provision of aids, would probably have required particular consideration with regard to their own special needs; for example, those with severe spastic paralysis or severe ataxia. Since this study was concerned
with the possibility of a more general solution, it was not possible to consider such cases. Consequently, it was assumed that the subject would have at least the use of either one side of their body or the upper limbs and trunk. This limitation was set bearing in mind the fact that a wheelchair user would probably have been the most severely disabled subject for which a solution along the lines indicated would have been possible. That is to say, anybody who was mobile without the need for a wheelchair would probably have found the aids necessary for a wheelchair user sufficient for their needs. However, there would be the case of the disabled person who for some reason would have been unable to use the seated approach, such as those with severe restriction of spinal and lower limb flexion. Unfortunately, time did not allow such cases to be considered.

Since, therefore, the task could be considered with the seated approach to the bath in mind, the problem of transfer was broken down into 3 components; (i) gaining access to a board mounted at one end of the bath and which extended outside the bath; (ii) transfer across the board and over the bath, during which time the legs of the subject might require lifting over the rim of the bath; (iii) transfer from the bath board down to a level at which the subject preferred to bathe.

Bearing in mind this analysis of the transfer procedure, the aids provided with the bath were: (i) an extended bath board across the top of one end of the bath and out beyond the rim of the bath; (ii) bath seat; (iii) external bath mat; (iv) internal bath mat; (v) provision for a fully adjustable wall rail and overhead rail.

The sources of information in the experiment were threefold: (i) observation by the experimenter of how the subject performed; (ii) the subjective reaction of the subject to
the arrangement of bath aids used and to their performance; (iii) measurement of the position of the grab rail(s) used by the subject. This information was recorded by the experimenter on an appropriate form.

5.20 **Apparatus**

1 **The Bathroom (see Fig. 1)**
The bathroom used at the M.M.L. offered a spacious situation in which to carry out the experimental work. It was one of three purpose built bathrooms normally used for the care of in-patients. The bathroom had a non-slip floor, underfloor heating, and was ventilated and lit by skylights in the ceiling. The heating system was most effective, keeping the bathroom warm. Control over the thermal environment in the bathroom was effected by adjustment of the skylights which allowed a comfortable environment to be maintained for the patients.

2 **Bath (see Fig. 2)**
The bath at the M.M.L. was a cast iron Kent bath, manufactured by Allied Ironfounders. It was of comparable size with those specified in the British Standards for pressed steel baths (B.S. 1390, 1947), cast iron baths (B.S. 1189, 1961), and also the acrylic bath used in Bretten's study (B.S. 4305, 1968), see Table 2.
Figure 1

The Bathroom at the NML

Approximate scale 1:24
FIGURE 2

The bath at the MML.
The seat and board are arranged for a right hand approach.
Table 2

Comparison of the dimensions of the bath at M.M.L. with B.S. 1390: 1947; B.S. 1189: 1961; and B.S.4305: 1968

Dimensions in mm.  

<table>
<thead>
<tr>
<th>Baths</th>
<th>Rectangular pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M.M.L. Bath</td>
</tr>
<tr>
<td>Overall length</td>
<td>1740</td>
</tr>
<tr>
<td>Overall width</td>
<td>720</td>
</tr>
<tr>
<td>Depth inside at waste pipe</td>
<td>460</td>
</tr>
<tr>
<td>Overall height</td>
<td>530</td>
</tr>
<tr>
<td>Interior length at rim</td>
<td>1530</td>
</tr>
<tr>
<td>Interior width at rim above waste pipe</td>
<td>550</td>
</tr>
</tbody>
</table>

The bath used had a depressed rim on the access side, but this was raised by installing a dummy wooden rim which brought the height of the rim to that of the rest of the bath. The bath was panelled with hardboard on the access side, and it was surrounded by walls on three sides. There was some space between the ends and respective walls, but these areas were filled with the frame for the rails. Wooden boards were also attached to the frame, thus simulating the presence of a wall at the end of the bath. The taps for the bath were on the back wall so that it was possible to use one seat and one board to adapt the arrangement to accommodate both left and right hand entry. Consequently, the bath was symmetrical for left and right hand entry, though the bottom of the bath sloped towards the drain pipe.

3 Bath Board (see Fig.2)  
This was made in the M.M.L. workshop. It was one single unit providing a continuous surface from outside the rim of the bath across to the opposite side. This avoided the problem of subjects in wheelchairs having to transfer on to the board,
whilst simultaneously having to negotiate the rim of the bath. The size of the board was 250 mm in width, 1190 mm in length, and 22 mm thick. The top surface of the board was 552 mm from the floor. The board was clamped to the bath at two points with the back edge at the edge of the bath rim (see Fig. 3). The length of the board (470 mm), which extended beyond the rim, was supported by two legs. The board was made of pine, treated with a polyurethane wood seal. This, in the experience of the M.M.L. workshop, gave a most practical surface, both from the point of view of the comfort of the subject and the serviceability of the board.

4 Bath Seat (see Fig. 4)
This was made of pine in the M.M.L. workshop and measured 405 mm long and 240 mm wide. It was designed to be placed approximately midway between the top of the bath board and the bottom of the bath, so that the drop from one level to the next would be the same. The difference in the levels was approximately 230 mm. In front elevation the back edge of the seat was, horizontally, approximately 70 mm from the front edge of the board. This distance was governed by the shape of the bath.

5 External Bath Mat (see Fig. 5)
This gave a surface which was both safe and comfortable. The mat used was a Vitopan mat and had a synthetic fibre surface backed with a ribbed rubber sheet.

6 Internal Bath Mat (see Fig. 5)
The bath mat used was a Croydex 560 mm x 355 mm rubber mat, a model regularly in use at the M.M.L. It was also readily available commercially and was intended to fulfil the essential requirement that it should provide a non-slip surface for the bottom of the bath.
FIGURE 3

The Clamping system used to attach the bath board to the bath.

Approximate scale 1 : 10.
FIGURE 4

The bath seat

The bath seat in position with the rubber mat in the foreground and the board above.
FIGURE 5

The bath mats

On the left is the internal mat with the external mat on the right.
Grab Rails

Provision was made for two types of rails to be available for any one subject: an overhead rail, spanning the length of the bath, and 2 wall rails to accommodate both left and right hand entry. The rails were mounted on a framework which was symmetrically disposed about the bath (see Fig.6). This framework was constructed from 'Keeklamp' steel tubing and brackets. The joints were secured by means of grub screws mounted in the brackets and, together with the application of suitable wedges between the frame and the surrounding walls, provided a strong and rigid support for the grab rails. The wall rails were sufficiently adjustable to allow for a range of angular movement from 0° to at least 20° to the horizontal. In order to attain this range of movement special brackets were manufactured in the M.M.L. workshop (see Fig. 7). The wall rails were approximately 1 metre in length and were positioned approximately 75 mm away from the surface of the wall. Because the bath was built in, however, it was not possible to incorporate the range of movement of the rail relative to the wall necessary to determine the wall to rail clearance distance. This was determined later in an additional experiment. It was also not possible to consider longer wall rails, as the position of the taps limited the length to those used. Circular section rails were used and for the bath trials, 3 options of surface finish were offered (see Fig. 8):

1. 'Metal' - a plain 33 mm diameter galvanised water pipe;
2. 'Rubber' - a 33 mm diameter galvanised water pipe, covered with rubber braemle, giving an overall diameter of 35 mm;
3. 'Plastic' - an unplasticised polyvinylchloride tube pop-riveted to a duralumin tube of 32 mm diameter, giving an overall diameter of 36 mm.

The diameter of the rails was determined on the basis of the
FIGURE 6

The framework used to mount the rails
Approximate scale 1: 20.
FIGURE 7

The special bracket, designed to accommodate angular adjustment of the wall rail. Each wall rail had one bracket at each end and each bracket could be raised or lowered along the vertical pole. The collar holding the wall rail could be rotated about the axis of the bolt which holds it to the plate of the bracket. By means of the nut on the bolt and the grub screws in the collars the bracket could be locked in the desired position thus fixing the position of the rail.
2. Rubber surface & plastic surface.
From left to right: 1. Metal surface
The back rails

Figure 8
recommendations made by Bretten, 32 mm to 38 mm, and also in
the light of the experience of M.M.L., 38 mm to 50 mm, in the
use of circular section rails. Circular section rails and
also the rubber and plastic surface materials were chosen
because they were readily available. The tight schedule
under which the work was being carried out, and the limited
finances available, did not allow a more considered assessment
to be made of what might be suitable as experimental materials
for the rails. However, the materials chosen offered properties which came close to those which can be regarded as desir-
able and were also inexpensive.

A wooden rail was considered, but it was rejected because there
was not sufficient time to develop a rail stiff enough for the
overhead rail. Given the approximate diameter, a wooden rail
would have required a metal insert to provide the necessary
rigidity for such a length.

5.30 Subjects

The subjects in this study were selected from in and out-patients of the M.M.L. and from other patients in external organi-
sations with which the staff of M.M.L. had contact. The
subjects were, in general, described by the M.M.L. staff as
being 'severely disabled' and would have been covered by
categories 4, 5 and 6 in the H.M.S.O. survey of the Impaired
and Handicapped (Harris 1971).

Category 4: contains people who either have difficulty
doing everything, or find most things
difficult and some impossible.

Category 5: contains people who find most things
difficult, or three or four items
difficult and some impossible.

Category 6: contains people who can do a fair amount
for themselves, but have difficulty with
some items, or have to have help with one
or two minor items.
Persons in these categories are described in the survey as severely and appreciably handicapped.

It was not possible to carry out a detailed functional assessment of the subjects and so it was not possible to allocate precisely the subjects to each of the categories, thus giving the number in each. Unfortunately, it was also not possible to assess the subjects' functional disability with regard to the activity of bathing.

Table 3 shows the age and sex of the subject.

Table 4 shows the nature of the disabilities encountered amongst the subjects.

Table 3

Distribution of ages and sex of subjects

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 - 89</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>70 - 79</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>60 - 69</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>50 - 59</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>40 - 49</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>30 - 39</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>20 - 29</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>10 - 19</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

Total number of subjects: 36
Table 4*

Distribution of disabilities and sex of subjects

<table>
<thead>
<tr>
<th>Main cause of impairment</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>II Neoplasms</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>VI Diseases of C.N.S.</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>VII Diseases of Circulating System</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>XIII Diseases of bones and organs of movement</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>XV Injuries, Amputations</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

* Impairment was classified using the International Classification of diseases, 1959, taken from Table 6, Harris 1971.

5.40 Procedure

A member of the M.M.L. staff brought the subject to the bathroom where the experimental trials were being conducted. The subject was then familiarised with the apparatus and informed of the main aims of the study by the experimenter. The experimenter's assistant then asked the subject a series of questions about themselves and their bathing problems. This information was recorded on the appropriate form (see Appendix 1). The experimenter then explained the technique that the subject would be invited to use to gain independent entry to and exit from the bath; that is the subject, once on the board, would be required to transfer down to the level from which they would prefer to bathe using, initially, only the wall rail. The subject would then be expected to reverse the procedure to leave the bath. The subject was also informed that they would be asked questions specifically about the suitability or otherwise of the rail.

The subject was then asked to undress and put on a disposable paper bathing garment in preparation for the practical trial. During this time the board and seat were arranged to accommodate either a left or right hand approach to the bath. This was decided, in the first instance, on the basis of the
arrangement that the subject had at home. If this was not applicable, the decision was based on the individual's stated preference. Water was then run into the bath by the experimenter. In 2 cases subjects refused to undress at all, and in 8 cases subjects preferred to remain in their underclothes. Consequently, water was not used for these 10 subjects. When the subject was ready to carry out the trial, the preferred surface finish for the rail was selected. This was done by the experimenter presenting to the subject 3 short lengths of the different types of rails. These sample lengths were kept on the heated floor so that each tube was at the same warm temperature when presented to each subject. The tubes were also wetted in order to give each subject a better idea of how the presence of water on the surface might affect their choice of surface material. The subject was asked to state his order of preference with regard to the surface finish and its suitability as a surface for the grab rail. This information was recorded on the form for Experimental Information (see Appendix 2). The subject was asked to state his order of preference with regard to the surface finish and its suitability as a surface for the grab rail. This information was recorded on the form for Experimental Information (see Appendix 2). The grab rail with the same surface finish as the subject's first choice was then used in the trial. The subject was asked by the experimenter to enter the bath using initially only the wall rail of the two types available, and any other aids appropriate to his needs. The subject was not necessarily required to use all the aids, and only used those which he felt were appropriate to his needs. In general the subject proceeded with the trial using the technique recommended in the preliminary instructions. If appropriate he was questioned about the wall rail as well as about the arrangement of aids used. In particular, the experimenter drew the subject's attention to the angular position of the rail and asked if he would like it altered in any way. If the subject did, the rail was adjusted to the preferred angle. The subject was also
asked his opinions on the suitability of the rail's diameter and the clearance distance of the wall rail from the wall. Particular reference was made to the possibility of the subjects trapping their elbow between the wall rail and wall. Once the subject had descended to the level at which he preferred to bathe, he was invited, when he felt able, to return up to the board and to complete his exit. The subject then dressed, was thanked, and accompanied from the bathroom by a member of the M.M.L. staff.

The form on which experimental information was recorded was filled in as the trial progressed. Any relevant comments made by the subject were also noted. The position of the rail(s) used by the subject was entered on the form when the trial was completed.

For the first subject the wall rail was adjusted to a position of 4° from the horizontal in accordance with the wishes expressed by her. For the following 2 subjects the wall rail was left at 4°, as it was anticipated that the subjects would require it to be altered to an angle of approximately 13° owing to the preference for this angle expressed in Bretten's study. Since this did not prove to be the case, the wall rail was moved to 13° to the horizontal, as it was necessary to determine how satisfactory the subjects found this angle, as confirmation of the preference for this angle in Bretten's study was sought. As the trials progressed, it was noted that no subject expressed any desire for the angle to be altered. Consequently, the slope of the wall rail was set at various angles initially in order to see how this affected the subjects. The rail was returned to 13° on several occasions. Only two further subjects in the experiment, apart from the first subject, expressed any wish to have the angle of the rail altered from that originally set. In their cases they had the rail lowered from 13° to 6° for one, and 7° for the other. In general, although they were well
aware that the angle could be altered, the subjects seemed well satisfied with the angle presented to them (see Table 5).

Table 5

| Angle, in degrees, of wall rail to horizontal, initially presented to the subjects |
|---------------------------------|-------------------|
| 0                              | 1                 |
| 4                              | 2                 |
| $6\frac{1}{2}$                 | 1                 |
| $7\frac{1}{2}$                 | 1                 |
| 9                              | 7                 |
| 13                             | 11                |
| 14                             | 1                 |
| $14\frac{1}{2}$                | 1                 |
| 16                             | 4                 |

Nine subjects could not gain independent entry to and exit from the bath using the wall rail, no matter what its angle. In these cases the option of the overhead rail was offered. This was done only if it was considered appropriate in the light of the previous performance of the subject, and the feelings expressed by the subject about using the overhead rail. In general, where the use of the overhead rail was considered to be potentially valuable by the observers, it was rejected by the subject. In fact, 2 subjects chose to use it and 1 only briefly.

Following each trial, when the form for experimental information was being filled in by the experimenter, note was taken of why a subject had failed to gain independent entry to and exit from the bath if this had occurred. Note was also taken of any assistance that the subject had required from the experimenter and M.M.L. staff to get in and out of the bath.
It should be noted that at all times during the experiment it was recognised that physical stress to which the subject was exposed, and his consequential fatigue, might have made it necessary to postpone or cancel a trial. Fortunately, in only one case was it necessary to postpone completion of the trial.

5.50 Experiment 2 - The optimum wall to rail clearance distance

A rig was constructed which incorporated a sloping grab rail which, relative to the seated subject, was in a similar position to the wall rail used in the first experiment. The grab rail had to be adjustable in a lateral direction relative to a vertical board which simulated the presence of a wall so that the optimum wall to rail clearance distance could be determined. This dimension was determined using the psycho-physical 'Method of Limits' approach.

5.60 Apparatus

For these trials a 'Keeklamp' framework was constructed using 32 mm steel tubing (see Fig. 9). This framework incorporated a sheet of block board mounted vertically to simulate the presence of the bathroom wall. In front of this board was mounted a grab rail at 13° to the horizontal, arranged to accommodate a right hand approach. The choice of angle was based on the results of Bretten's study, and it was also anticipated that 13° would be the preferred angle for the rail used in the N.M.L. trials. In fact, of the subjects who used the wall rail in the N.M.L. trials, the largest number had the rail at 13°. The arrangement was such that the rail could be moved in and out from the surface of the board. The rail was in a similar position relative to the seated subject as was the wall rail in the arrangement at the N.M.L. The seat used was an office chair, its front edge being 457 mm from the floor, or, where necessary, a wheelchair. The grab rail was approximately 1 metre in length and had a diameter of 32 mm.
FIGURE 9

The apparatus for Experiment 2.
lower bracket was 534 mm, and the upper bracket 813 mm above the floor.

5.70 Subjects

The 20 subjects involved were all disabled. Three subjects were young adults, the other 17 were middle-aged or elderly. Twelve subjects were men, 8 were women, and of these, 4 and 3 respectively were wheelchair users. All of them had at least some function in their right arm, and most had 'normal' function. Time and circumstances did not permit a more detailed assessment of the subjects' functional disability. However, observation indicated that, except for one or two, the subjects were more independent in terms of day to day activities than the majority of the subjects involved in Experiment 1.

5.80 Procedure

The subjects were required to sit by the rail and rest their right arm on it. The experimenter informed the subjects of what they would be required to do and also the nature of the study. The subject was asked to consider the use of such a rail as an aid to entering and leaving a bath including particularly the possibility of getting his elbow caught between the rail and the wall. The subject was informed that the grab rail would be moved in and out during which time he would be asked to indicate his preferred distance between the rail and the board.

The rail was then moved out from the board in 25 mm increments until the subject was satisfied that the clearance distance between the board and rail was satisfactory. The rail was then moved beyond that point and then returned towards the board again in 25 mm increments, until the subject was again satisfied with the clearance distance. Once an approximate position had been determined, finer adjustments were made in
both the inwards and outwards direction. This was continued until the preferred clearance distance was the same in both directions and the subject was completely satisfied that the clearance distance was adequate.
6.00 RESULTS

6.10 Experiment 1

At the time of the experiment 13 subjects of the total sample of 36 were not using a bath regularly at home. Of these 13 subjects, 8 were not using a bath at all, and 5 had not tried to bath at home in the physical condition in which they carried out the trials. Of the 36 subjects, 21 were using their bath at home. Of these 21 subjects only 12 required assistance, 16 used some form of bath aid, and 8 of these 16 subjects required assistance. Two subjects used a shower at home. None of the subjects had previously used the arrangement of aids which were available in this experiment.

1. The Rail Surface Preference

There was a distinct preference for the rubber surface for the rail, since, of the 36 subjects, 32 chose it as their first choice, the remaining 4 choosing the plastic surface. As an alternative to the rubber surface, there was a less distinct preference for the plastic surface over the plain metal surface (see Table 6).

Table 6
Preference expressed for surface finish

<table>
<thead>
<tr>
<th>Surface finish</th>
<th>Frequency of Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Metal</td>
<td>-</td>
</tr>
<tr>
<td>Rubber</td>
<td>32</td>
</tr>
<tr>
<td>Plastic</td>
<td>4</td>
</tr>
</tbody>
</table>

2. The Approach to the Bath

Of the 36 subjects, 17 entered the bath with their left hand side presented and the remaining 19 subjects with their right hand side presented to the bath.
3 The Use of the Bath Board and Seat
Of the 36 subjects: 2 remained on the board
8 went to the seat
26 went to the bath bottom

Of the 26 who went to the bath bottom:
3 used no board and no seat
1 used only the board
1 used only the seat

Therefore, 21 subjects used both the seat and board to get to the bath bottom.

4 The Use of the Grab Rails
Of the 34 subjects who went to the seat or to the bath bottom:
27 used the wall rail
1 used the overhead rail
6 used neither rail

Of the 27 subjects using the wall rail, 1 subject used the overhead rail briefly.

5 The Angle of the Wall Rail
As can be seen in Table 7, there were a wide variety of angular positions for the wall rail, which satisfied the subjects. In fact, only 3 subjects wished to have the angle presented to them altered. In their cases the angles were altered from $0^\circ$ to $4^\circ$ for 1 subject, and for 2 subjects from $13^\circ$ to $6^\circ$ and $7^\circ$, respectively. The subject who was presented with a $0^\circ$ slope was the first subject.
Table 7
Final angle in degrees of wall rail to horizontal with which subjects expressed satisfaction

<table>
<thead>
<tr>
<th>Angle</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>6½</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>7½</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>14½</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>29</strong></td>
</tr>
</tbody>
</table>

6 The Use of the Wall Rail
Of the 29 subjects who used the wall rail:
- 21 went to the bath bottom,
- 6 went to the seat,
- 2 stayed on the board.

Of the 21 subjects who went to the bath bottom using the wall rail, 1 subject did not use the board or seat. Therefore, 20 subjects used the board, seat and wall rail to get to the bottom of the bath.

Of the 6 subjects who went to the seat, all used the board.

Of the 2 subjects who stayed on the board, one was a man in his sixties, obese and left hemiplegic, and the other was a woman in her sixties who had rheumatoid arthritis and could not support her body weight on her shoulder joints. None of the subjects who used the wall rail were dissatisfied with the diameter of the rail used or the clearance distance of the rail from the wall. All the subjects could also satisfactorily grip the rail used.
The Subjects who Required Assistance
Nine subjects required some form of assistance from the observers to enable them to enter and leave the bath. Two required very substantial assistance and could not have performed the task without it. Neither used the wall rail. The remaining 7 used the wall rail and required only limited assistance. These subjects could probably have got into and out of the bath independently, but with considerable difficulty.

Of the 7 who required limited assistance:

- 6 went to the bath bottom
- 1 went only to the seat

Of these 7 subjects:

- 6 were hemiplegics
- 1 was a below knee amputee.

All the 6 hemiplegics required support on their paralysed side, 1 of whom stayed on the seat. The remaining subject had just recently left hospital and was very weak.

The Subjects Who Did Not Use a Grab Rail
There were 6 subjects who used no rail:

- 2 required extensive assistance
- 4 were sufficiently agile to manage without a rail.

The Subjects Who Used No Water
There were 10 subjects who did not wish to have any water in the bath. Of these 10 subjects:

- 2 subjects remained fully clothed
- 8 subjects remained in their underclothes.

Of the 2 subjects remaining fully clothed, both went to the bottom of the bath using the seat, board and wall rail. One was male and the other female.
Of the 8 subjects remaining in their underclothes:

- Of the 4 subjects who used the wall rail:
  - 4 used the wall rail
  - 4 used no rail

- Of the 4 subjects who used no rail:
  - 2 went to the bath bottom
  - 1 went only as far as the board
  - 1 went no further than the seat.
  - 2 required extensive assistance
e 2 were sufficiently agile to get to the bottom of the bath without the need for a rail.

The fact that these 10 subjects did not use water did not appear markedly to affect the results, judged on the experimenter's own subjective appraisal of the situation. However, although water was undoubtedly an important factor, many subjects consciously took care to try and eliminate the dangers it created by using only a minimal quantity of water and drying their hands before leaving the bath.

Of the 36 subjects involved in this study, 31 subjects, given the availability of a bath board, bath seat, sloping wall rail, the two bath mats and limited assistance, were able to attain a position from which they could bathe in reasonable comfort. Of these 31 subjects, 24 could get to the bottom of the bath given the same conditions. If the factor of limited assistance was eliminated, then 24 subjects could bathe in reasonable comfort and 18 could get to the bottom.
6.20 **Experiment 2**

All the subjects were conscious of the possibility of their elbow slipping between the rail and the board, consequently they all preferred to have the rail close enough to the board to avoid this. As a result, all the subjects preferred to use the rail and board in combination to support their forearm.

Of the 20 subjects used, 1 subject preferred 38 mm clearance distance, 12 subjects preferred 50 mm, and the remaining 7 subjects preferred 63 mm. This gives an overall mean of 54 mm.
7.00 DISCUSSION

7.10 Experiment 1

The M.M.L. was in many ways a most suitable site for such an experiment, not least because of the qualified staff whose experience and training were a great asset. The general environmental conditions within the M.M.L. and particularly within the bathroom assisted in the administration of this experiment. The building itself was bright, warm and spacious, added to which the general "hospital atmosphere" undoubtedly helped to gain the subjects' confidence and cooperation. This atmosphere not only assisted in the practical question of the subjects' undressing, but also helped to make discussions of the subjects' bathing problems less inhibited than it might otherwise have been. In addition, most of the subjects were already familiar with the M.M.L. and its work and in some cases were personally acquainted with the staff. A few of the subjects who apparently were visiting the M.M.L. for the first time did not appear to be unduly disturbed by the surroundings. In any event, all the subjects were already accustomed to dealing with the medical services at a variety of levels.

The bathroom itself was easily accessible for all subjects. It was possible for each subject to carry out the entire trial comfortably within the bathroom, even considering the space requirements of a wheelchair user, together with the presence of the experimenter and a member of the M.M.L. staff. The bathroom was also well lit and warm enough to avoid any discomfort for the subjects. The bathroom was also well maintained and clean. Thus, the general conditions encountered in this bathroom were an improvement over the conditions generally experienced by handicapped people at home (Buckle 1971). The subjects were also not expected to bathe. Therefore, the conditions encountered by the subjects in the bathroom did not fully reflect the conditions under which the handicapped may be expected to bathe at home. It would, however, have been unwise to have introduced more realistic conditions, such as severe restrictions on space, a colder environment and expecting the subjects to bathe using soap, etc, as this would have created particularly hazardous and potentially dangerous conditions which were unacceptable in an experimental situation.

It was quite clear that many subjects derived confidence from the fact that the rig could be relied upon, and several subjects were quite emphatic in pointing out the importance of using equipment particularly in the context of the bathroom, which was secure. This it seemed was a particularly important
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It was quite clear that many subjects derived confidence from the fact that the rig could be relied upon, and several subjects were quite emphatic in pointing out the importance of using equipment, particularly in the context of the bathroom, which was secure. This it seemed was a particularly important
feature where loss of stability occurred for any reason and any lack of confidence in the stability of the equipment could then be acute. In the rig used, both the board and the seat were securely positioned. Similarly, the framework to which the rails were attached was securely wedged into position.

The question of security arose again with regard to the bath bottom and a great deal of concern was expressed over the need for a non-slip bottom to the bath. In some instances, the rubber mat used to provide a non-slip surface was not adequate as on more than one occasion it came unstuck partially or completely. This generally occurred when the subject was ascending from the bottom of the bath via the seat to the board. It was during this manoeuvre, when the mat was subjected to the greatest force, that the suction pads would give way under the feet when the subject applied the thrust necessary to move from one level to the next. Only if great care was taken to ensure that the mat was clean, the bath bottom was clean, and that all suction pads were adhering to the bath bottom, could one improve the effectiveness of the mat. In general, subjects felt that they could not have complete confidence in the mat at all times. The situation would have been improved if a non-slip surface had been an integral part of the bath bottom.

All the subjects who used the wall rail were able to get a satisfactory grip on it. For 25 subjects, this was partly due to the rubber surface. It was a rough surface which was also softer than either the metal or the plastic. However, none of the 4 subjects who used the plastic finish complained of any difficulty in gaining a good grip. Both surfaces, and particularly the rubber one, provided resistance to slipping. However, there probably would be maintenance and wear problems with the rubber surface used, as towards the end of the experimental period it was showing some sign of wear.

Only in a few instances did subjects make particular reference
to the value of having a sloping wall rail. However, none of the subjects who used the wall rail indicated that the slope of the rail was undesirable. From the results obtained it would appear that the angle of the wall rail is not critical as long as it is within the range of 4° to 16°. This is perhaps a little misleading in as much as the subjects might have been more definitive about their preferred angle if they had had more time to consider the arrangement. A clearer indication of the preferred angle could also have been achieved if the psychophysical "method of limits" approach had been applied, as was done for the rail to wall clearance distance, rather than the "ad hoc" procedure adopted. However, time was short and it was not reasonable, both from the point of view of the M.M.L. and the subject, to expect the subject to remain in the wet bath, unclothed, longer than was necessary. Consequently, time consuming procedures in determining the angle of the wall rail were avoided to minimise the time that the subject was involved in the trial. On the other hand, most of the subjects were apparently quite satisfied with the angle as it was presented. The exceptions were the three subjects who all wanted the rail at a relatively small angle, 4°, 6° and 7°.

In general, it seemed that the critical factor was not the angle of the wall rail, but whether the subject could physically manage the manoeuvring necessary to transfer from the board to seat, etc. Undoubtedly, the fact that there was a wall rail to grab and that it was sloping, both contributed to the "success" of the arrangement. The one particular deficiency which, no doubt, in practice could easily be overcome, was the need to have a longer rail in approximately the same position. This could allow the wall rail to be approximately in the same position relative to the seat as it was to the board. The absence of this made the ascent from the bottom of the bath more difficult than perhaps necessary. A few subjects who were less mobile also had difficulty in coping with the transfer both from the seat back to the board as well as transferring up from the seat to the board at the same time. This difficulty tended to arise with subjects who could not comfortably support their body weight on their shoulder joints and consequently had difficulty in maintaining control over their movement. Subjects who could not generate adequate thrust from their leg(s) when ascending also had difficulty in this transfer. When ascending, those subjects who were able to used the front rim as additional support.
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Those subjects who found the arrangement most useful all possessed good function in their upper limbs, particularly the shoulders. Some subjects who were hemiplegic could manage to get in and out of the bath, although not so easily, and in some cases a certain amount of assistance was required. This assistance was to give some support to the paralysed side. None of the subjects who used this arrangement expressed any dissatisfaction with it and all of them seemed to like it, even when the subjects had difficulty in using it themselves.

The subjects in general were very well motivated to do well in the trials and in some cases they were exceptionally co-operative. In many cases, there was an obvious sense of responsibility towards the M.M.L. as a whole, as well as to the experimenter and the member of the M.M.L. staff present, and as such these subjects might very well have felt obliged to do well. Indeed, there is a great deal of general encouragement given to patients by the M.M.L. staff to do better. In addition, there is the impact of confronting socially other disabled persons, sometimes less severely disabled, sometimes more severely disabled. The motivation derived from this social interaction was considered by the staff as an important factor in the work of the M.M.L. How far this in fact affected the subjects could not easily be assessed but it would seem likely that it encouraged the subjects to do well in the trials. Consequently, these subjects may have generally extended themselves further for these trials than they would have done faced with the task of using the arrangement regularly. For a few subjects, the task required considerable physical effort, which might not be repeated if it were a daily domestic routine. In a few cases, this did appear to contribute to a waning of interest as the trial progressed, but not to a marked degree. In the cases where the task did prove taxing, it was generally because the subjects lacked strength following their illness. The situation could probably, in part, be eased by practice and suitable training. In only one case was it necessary to interrupt the trial because of fatigue.
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None of the subjects was familiar with the arrangement being used. All the subjects came to it without any opportunity to gain experience in the use of this particular arrangement of aids. The in-patients were also following quite an active routine during their stay at the M.M.L. In many cases where the subject had been recently disabled, they were also as yet unaccustomed to their disability. Consequently, the subjects were not always as relaxed as they might have been had they been following the pattern of a day to day routine, and in some cases a certain amount of excitement was evident.

The level of physical exertion experienced by some subjects related directly to the question of the disabled persons approach to the bath. As has already been pointed out the disabled persons approach is of necessity somewhat different from that of the able-bodied. From the limited discussion with this small selected group of the disabled population, it seemed very clear that bathing and the activities immediately associated with it are viewed with a certain amount of caution. Although some subjects who had been disabled for some time were very confident, all the subjects were very aware of the dangers of the bathroom. For the disabled person, bathing must be regarded as a tiring task which has to be carried out under dangerous conditions. Consequently, many of the subjects were very careful to ensure that they had dry hands when using the rails, and that in some cases, the water was neither too deep nor too warm. In fact, some subjects wanted only a minimal quantity of water.

The subjects who had been disabled for some time had acquired a certain economy of movement and had developed their own techniques which partially compensated for their disability. It would be a very difficult task to predict reliably the capability of any one individual to cope with the bathing situation. Any attempts at such a prediction could be complicated by the influence of the subject's personality over their physical capability. Although in some situations the
physical aspects of some disabilities could make attempts at solving the problems very difficult, if not impossible, it was also clearly illustrated by several subjects that a great deal can be achieved by suitable training and practice.

**Experiment 2**

The trials for the determination of the rail to wall clearance distance involved the subjects only minimally in an active capacity. As a consequence there were few problems of motivation, experience and familiarity, etc. All the subjects grasped very quickly the idea of the use of the rail and none had any apparent difficulty in deciding on their preferred distance. There were 3 factors which governed the subjects' choice of clearance distance: (1) they preferred to grasp the rail, (2) they preferred to use the rail and board together as an arm rest, (3) they wanted to avoid any possibility of getting their elbow caught between the rail and board. All the subjects were able to fulfil these requirements and the preferred clearance distance was less than, though comparable with, the clearance distance of the wall rail in Experiment 1 which caused the subjects in that experiment no trouble.

If this distance had been investigated within a bathing situation there would be fewer reservations about the validity of the trial. However, there is no reason to suppose that the result is invalid. On the contrary there is little reason to suggest that a result obtained within the bathing situation would be substantially different from that achieved in this trial.
CONCLUSIONS

Initially, this investigation was concerned primarily with the use of the sloping wall rail as an aid to handicapped persons using a bath. However, as the trial progressed, it became evident that the arrangement of bath board, bath seat, and wall rail used should be viewed as a whole rather than as a combination of isolated components. Using this arrangement of aids, many of the subjects were able to get in and out of a bath independently. Of the 21 subjects who used a bath regularly prior to the trial, 2 required some degree of assistance in using the aids in the trial, only 4 of the 21 required assistance, which is a notable improvement. Also, given the availability of limited assistance in addition to the aids, 31 of the sample of 36 subjects could get into a position from which they could use a bath to bathe. Thus, this arrangement provided a basis which catered for a wide variety of disability and there is no doubt that for the subjects who were able to use it, it could provide considerable help to them. This confirms in principle the recommendations derived from Bretten's study.

With regard to the sloping wall rail, it could be a useful addition to the aids currently available. It is important, however, that any rail used under such circumstances should have a non-slip surface. It is also important that such a surface should retain its properties whilst subjected to the wear and tear of bathroom use. Unfortunately, it seems unlikely that the rubber used would do so. A wood rail could be a viable alternative. A wood surface can combine the virtues of the rubber surface whilst at the same time tolerating the necessary wear and cleaning. It is unfortunate that such a rail was not tried. The results indicate that an overall diameter of 30 mm to 40 mm is suitable for such a rail, and that its length should be at least a metre in length, but if circumstances permit, extending the length to 1½ m or 1¾ m might prove valuable. The preferred angle for the wall rail
to the horizontal is not clear. It could not be said that there was a distinct preference for 15° as indicated in Bretten's study or for any other particular angle. However, anatomical considerations and observations made during the trials would suggest that the range of angles, 4° to 15°, used in the experiment was adequate and satisfactory for the subjects. The clearance distance between the wall and rail should be between approximately 50 mm and 65 mm.

Since only 2 subjects used the overhead rail, and 1 only briefly, it would not be possible to make any recommendations. It is noteworthy though that only 2 people used the overhead rail at all, and that in a number of cases where it might have been suitable, it was rejected as an undesirable option.

For the hospital situation, or similar institution where the general environmental factors, both psychological and physical, would probably be very similar to the M.M.L., this combination of aids could be extremely useful. In many cases where assistance is necessary, they could help to release from the staff the problem of coping with the patient's body weight. In cases where much less severe disability than that encountered in this experiment might be catered for, this arrangement would help to a considerable extent. It is also an arrangement which is cheap, could be easily installed and would not hinder the use of other aids such as a hoist.

The circumstances in the domestic situation would make the introduction of these aids more difficult to carry out. The general environmental factors in the home would probably be much less favourable. Consequently, the introduction of bath aids into the home should be done in conjunction with a professional assessment of the individual's requirements. It is clear that this is not always possible. However, there will be problems created by the domestic environment which cannot be assessed adequately until the actual situation is known. It will be necessary at some stage for the physical restrictions
imposed by the bathroom, the space requirements of the individual, the demands of the rest of the family, and the extent of these demands, etc., to be considered. Whilst in many instances such considerations may not be critical, they will be relevant to the problem of introducing bath aids into the home. It would be desirable that a professional assessment of the home would include a certain amount of development work, so that techniques for the use of such aids by the patient could be evaluated.

This obviously presupposes services which in the majority of cases would not be available. Quite clearly such an arrangement also would help with many of the difficulties experienced by much less severely disabled persons and also those who find simply stepping over the rim a risky business.

In spite of these reservations, the fact remains that the arrangement taken as a whole did help a great number of the subjects who were all "severely disabled". However, before a general recommendation could be made, it is necessary that the combination of aids should be examined in more realistic circumstances than those at the M.M.L. It is necessary that the dangers and restrictions avoided, in part, in the experimental situation should be incorporated into a further examination involving the use of the aids in bathing situations. It is, therefore, recommended that application of the aids described should be made to both the hospital and domestic situations, for further evaluation in the field. It is important that such trials should use an arrangement which pays due regard to the following:

(1) That all aids are most securely fixed and that there is no suggestion to the user that they may give way.

(2) That all surfaces used by the user, particularly the bath bottom and wall rail, should have non-slip surfaces which will retain their properties during use.

(3) That the seat and board should be positioned, relative to the bath and to each other, so that ascent and descent can be made in regular stages. Both the board and seat should be of acceptable materials and of adequate dimensions to accommodate the seated individual. The board should
imposed by the bathroom, the space requirements of the individual, the demands of the rest of the family, and the extent of these demands, etc., to be considered. Whilst in many instances such considerations may not be critical, they will be relevant to the problem of introducing bath aids into the home. It would be desirable that a professional assessment of the home would include a certain amount of development work, so that techniques for the use of such aids by the patient could be evaluated.

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(3) That the seat and board should be positioned, relative to the bath and to each other, so that ascent and descent can be made in regular stages. Both the board and seat should be of acceptable materials and of adequate dimensions to accommodate the seated individual. The board should
also extend beyond the rim to an extent which will allow the user to sit outside the bath. The seat dimensions of the board, 1190 mm x 250 mm, and seat, 405 mm x 240 mm, used in the first experiment were quite acceptable to all the subjects who used them.

(4) That the wall rail should be at least 1 metre in length, between 30 mm and 40 mm in diameter, between 50 mm and 65 mm clearance from the wall, and at an angle of between 4° and 16° to the horizontal. The wall rail should be positioned approximately above the rim of the bath with the rail sloping down from above the back edge of the bath towards the centre of the rim.

Whilst making these recommendations, it is recognised that circumstances might involve restrictions which may make the application of them difficult. It is also recognised that within the domestic situation, if possible, full account should be taken of the individual’s own requirements and if adjustment made to the recommendations is necessary, such adjustment should be made on the advice of qualified professional services.
PART 2

Ergonomic Factors in W.C. Pans
Following the initial proposal by B.S.I. Committee OC 27/4 that research be undertaken with regard to the ergonomic factors in W.C. pans, the Institute for Consumer Ergonomics undertook to conduct a research project on this topic. It was agreed that the first requirement was that basic anthropometric data be generated which is relevant to the use of W.C. pans. A survey of the literature on anthropometry reveals no source from which such data could be extracted for the U.K. population in general (Benning 1969, Murphy 1972).
THE ANTHROPOMETRIC SURVEY

The survey was carried out in conjunction with the Department of Design Research at the Royal College of Art, London.

The Department of Design Research has been involved for some time in the design of sanitary equipment and, as a consequence, is familiar with the problem associated with acquiring information about the use of such equipment. The Department also had available facilities suitable for the conduct of the survey which, given the geographical location of the College, provided a site within easy reach of potential subjects.

In formulating the experimental design, it was recognised that provision was not made within the terms of the project for a comprehensive examination of the requirements of all categories of user. It was also recognised that, in attempting to gain anthropometric data relevant to the w.c. about the general population by sampling from the general public, there was little guide as to how potential subjects might respond to invitations to participate in such a survey. It was therefore specified in the brief for the work that the survey should exclude the disabled and handicapped and those below the age of majority. Thus, in formulating the experimental design, four basic factors were included:

1. that subjects would be drawn from the general able-bodied adult public, since it was necessary, given the limited time available, to gain information about the principal category of user. Bearing in mind the nature of the study, it was also felt advisable to concentrate on the category of subject which would be the easiest to sample;

2. that subjects should be unclothed from at least the waist down. This requirement was essential since it was necessary to identify the features of the perineum and also to gain a clear view of the buttocks;

3. that, in anticipation of subjects tending to be cautious over being unclothed, the arrangements should be such as to encourage anonymity where necessary and also to emphasise a sense of privacy within the experimental area, particularly during the time that the subject would be unclothed;

4. that it was not intended to provide definitive anthropometric data on the U.K. population but to provide data to guide the design of relevant equipment.
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In formulating the experimental design, it was considered that four basic factors should be included:

(1) that subjects would be drawn from the general able-bodied adult public, since it was necessary, given the limited time available, to gain information about the principal category of user. Bearing in mind the nature of the study, it was also felt advisable to concentrate on the category of subject which would be the easiest to sample;

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(4) that it was not intended to provide definitive anthropometric data on the U.K. population but to provide data to guide the design of relevant equipment.
from the point of view of static anthropometric considerations.

Bearing in mind these factors, it was clear that the most suitable technique for collecting data would be photogrammetry. The alternatives were to take direct measurements from the subjects or to adopt a form of imprinting technique similar to the Schoberth method (Schoberth, 1962). Both these methods would involve the experimenter in close proximity to the subject which, it was felt, would be inadvisable given that the subjects would be undressed from the waist down. An imprinting technique would also necessitate marking the body, and, in addition, would not provide sufficiently detailed data. In the case of photogrammetry, it was considered possible to achieve the level of anonymity desirable and also to obtain the necessary detailed information; therefore, an adaptation of the somatotype photographic system was used. The system comprises an aerial survey camera with a long focal length lens, which is used to photograph the subjects at a minimum 7 metres distance. Subjects adopt a specific posture on a turntable, are photographed from three points of view, and from the resulting prints measurements of the body can be taken to determine the subject's somatotype.

Special accommodation at the Royal College of Art enabled the photographic equipment, the rig, and the space necessary to conduct the survey to be accommodated within the one experimental area. Figure 10 gives a plan view of the experimental area and Figure 11 gives a side view of the light path between the rig and the camera. The arrangement was designed to enable three postures to be devised which offered a clear view of the side and underside of each subject. The highest and lowest of these postures were designed to be indicative of the postures which may be regarded as reasonable extremes for defaecation, the other being that comparable with the present situation. From the highest to the lowest, the three
FIGURE 10- A PLAN VIEW OF THE EXPERIMENTAL AREA.

APPROXIMATE SCALE 1 : 48.
FIGURE 11- A SIDE VIEW OF THE LIGHT PATH BETWEEN THE CAMERA AND THE RIG.

Camera lens to subject distance.

Approximate scale 1 : 48.
postures were as follows:–

(1) "semi-seated", that is with the palms of the hands on the knees, arms straight and knees slightly bent;

(2) "seated", that is with the elbows resting on the knees and the knees bent at right angles;

(3) "squatting".

See Figures 12 and 13 which illustrate the three postures for women and men respectively.

These postures were taken up without external support. This enabled the postures to be adopted by the subjects without any external support dictating the posture. The lack of external support also required the subjects to maintain their balance which involved the use of muscles in the limbs and trunk which would, if the body was fully supported, be relaxed, which may alter the overall dimensions to a small extent. If the subjects were supported under the thighs, the thighs' dimensions would clearly be altered, but the manner and extent of such a change would be largely dependent upon the system of support. Variations in posture did occur, the most frequent being the inability of some subjects to carry out the squatting posture with the soles of their feet on the platform. The alternative was for subjects to balance on the balls of their feet. There was also a certain amount of variation in the level to which subjects could lower their buttocks in the squatting position. In both of these situations, the limiting factor was the degree of flexion which the subjects possessed in their lower limbs. However, these postures were defined by the body of the subject and were postures which might be considered to be those which the subject would naturally adopt and readily understand. From the photographs of these postures, measurements were taken of the subjects which were of relevance to the use of w.c. pans, the principal aim being to obtain dimensions of the main areas around the buttocks region.
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The three postures adopted for the photographs for women.
THE THREE POSTURES ADOPTED FOR THE PHOTOGRAPHS FOR MEN
10.10 **APPARATUS**

1 **The Experimental Area**

The experimental area was divided into 3 sections (see Figure 10):

(1) Reception Area,
(2) Intermediate Area,
(3) Changing Area.

In terms of the general appearance and atmosphere of the experimental area, it was felt advisable to strike a balance between the strictly clinical and a warm intimate environment. Such an arrangement was achieved by constructing a system of screening within the experimental area which divided it into the 3 sections indicated above. Thus, as the subject progressed from entering the experimental area to carrying out the task, the area of immediate relevance became more private. The screening was also attractively decorated and the changing area was suitably appointed. A qualified nurse was recruited to assist in the conduct of the survey. It was therefore possible for a relaxed atmosphere to be encouraged whilst having the facility to impose a more formal atmosphere where it seemed appropriate. Figure 14 gives a general view of the Rig and Changing Area.

2 **The Rig**

The Rig consisted of a platform under which was slung a plane mirror (see Figure 11). The platform and mirror were supported by a metal structure constructed from 'Dexion' slotted angle type 160 (see Figure 15). The platform was a transparent acrylic sheet, 4' x 3' x 1'', upon which the subjects stood. The thickness of the sheet was determined on the basis of discussions with the manufacturers. In order to support the heaviest subjects expected, and also to avoid severe deflection at the centre, 3/4'' thickness was specified as a minimum; however, primarily in the interests of safety, 1'' thickness was
A general view of the rig to the left and of the changing area to the right, from in front of the camera enclosure.
FIGURE 15

The 'Dexion' frame used to mount the platform and mirror.
used. The mirror enabled an underside view of the subject to be photographed. A 10 cm grid was marked on the top surface of the platform, using self adhesive tape, protected by an additional sheet laid on top of the platform. Perpendicular to and at the front of the platform was mounted a further transparent sheet, upon which was marked another 10 cm. grid. Thus a grid was superimposed on the two views of the subject. These grids provided reference values from which corrections for parallax and magnification could be calculated (see Appendix 4). Above the vertical transparent sheet was a baton suitable for use as a hand rail if subjects had need to steady themselves. On 3 sides of the platform white screens were erected; to the right, in front and to the left above the baton. Above the subject, the ceiling was painted white in order to provide a suitable background to the underside view of the subject. Access to the platform was by means of steps from the changing area which approached the platform on the fourth open side.

3 The Camera

The camera used was an F.24 Aerial Survey camera. It was modified in order that an electronic flash unit could be synchronised with the shutter. The shutter blinds were also modified so that a maximum frame was exposed when the flash was triggered. The camera was used with a 14 inch lens at approximately 7 m. subject to lens distance. The camera, together with the power pack for the flash unit, was screened off from the subjects in the camera enclosure (see Figure 10) and operated by remote control. The camera was positioned so that the centre line of the camera was at the same height as the top surface of the platform and was symmetrically disposed about the vertical and horizontal planes with respect to the rig (see Figures 10 and 11). This photographic system was adopted because of the experience gained at the University of Technology, Loughborough, with similar equipment applied to anthropometric studies (Jones et al. 1964) (see Figures 16 and 17).
FIGURE 16

The camera enclosure. A view from in front of the rig. To the left and to the right are the two lights for the flash unit. In front of the camera enclosure is the remote control device to operate the camera.
FIGURE 17

The F24 Aerial Survey camera as mounted for the survey. At the base of the mounting is the power pack for the electronic flash unit.
4 The Electronic Flash Unit

The flash unit was a Model 200/2T speed flash unit manufactured by Ernest Turner Electrical Instruments Ltd. This unit comprised 2 x 200 joule flash guns powered by a single power pack. A pair of Actinotherapy goggles was provided for subjects to wear in order to reduce any disturbance that they might experience in being exposed to these flash guns. The two flash guns were positioned so that they were at the same height as the camera and were similarly disposed about the centre line of the camera. The screening along the sides of the light path (see Fig. 10) were painted white and enabled a reasonably uniform distribution of light to be achieved over the two views of each subject. An improvement in the quality of the photographs could have been obtained if the recommendations of Jones et al. (1964) had been adopted and back lighting incorporated into the construction of the Rig. However, in order to achieve a lens to subject distance of at least 7 metres, it was not possible to include back lighting for the side view in the experimental area. The height of the ceiling in the experimental area similarly did not allow lighting to be included above the subjects for back lighting to the underside view.

5 Additional Apparatus

A clinical weighing machine and an anthropometer were available in the intermediate area to measure the weight and height of subjects.
Subjects

It was recognised that subject selection would have to be restricted, not simply to the general able-bodied adult population, but also related to the more specific criteria of sex, age, height and weight, in order to gather a representative sample within the limits of the time available for the survey (see Table 8). For both men and women two age groups were specified, 18-30 years and 60 years and over; assuming that members of the 30-60 year age group would be accommodated within the two groups specified.

For the height and weight combinations, age-related estimates were made of the 5th, 50th and 95th percentile heights from the available literature (Montegriffo 1968, Thompson et al. 1973), on the general United Kingdom adult population. For each of these height estimates, a corresponding high weight and low weight were also estimated from the literature (Kemsley et al. 1962), for subjects in light indoor clothing. These weight estimates approximate to the upper and lower quartiles respectively for the given height/age/sex combination. The subjects in this survey were recruited from the general public by relying upon potential subjects to respond to notices advertising the survey (see Appendix 5). Several attempts were also made at recruiting older subjects by visits to local social clubs, etc., for old people. This proved to be entirely unproductive and so notices were placed in the local press (see Appendix 5) specifically for the older age group. For the younger age group notices were placed around colleges in the immediate locality and in Central London. The notices appealed for subjects to help with an experiment to gain data on human body size in relation to bathroom equipment. The notices also specified that each subject would not be required for more than half an hour and that they would receive a fee of £3 for taking part. The notices included a copy of the table (Table 8) which specified the categories of subject required. Respondents to the appeal were given a
<table>
<thead>
<tr>
<th>GROUP</th>
<th>HEIGHTS</th>
<th>WEIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>11 st. 10 lbs - 12 st. 6 lbs.</td>
</tr>
<tr>
<td>60 years and over</td>
<td>1</td>
<td>5' 11&quot; - 6'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 9 st. 9 lbs - 10 st. 5 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 st. 8 lbs - 11 st. 4 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 8 st. 8 lbs - 9 st. 4 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 st. 7 lbs - 10 st. 3 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 7 st. 9 lbs - 8 st. 5 lbs.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5' 7&quot; - 5' 8&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5' 3&quot; - 5' 4&quot;</td>
</tr>
<tr>
<td></td>
<td>MEN</td>
<td>6' 1&quot; - 6' 2&quot;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>12 st. 4 lbs - 13 st.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 10 st. 1 lb - 10st. 11 lbs.</td>
</tr>
<tr>
<td></td>
<td>Between 18 and 30 years</td>
<td>5' 8&quot; - 5' 9&quot;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10 st. 12 lbs - 11 st. 8 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 8 st. 12 lbs - 9 st. 8 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 st. 11 lbs - 10 st. 7 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 7 st. 12 lbs - 8 st. 8 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5' 4&quot; - 5' 5&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10 st. 3 lbs - 10 st. 13 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 8 st. 1 lb - 8 st. 11 lbs.</td>
</tr>
<tr>
<td></td>
<td>60 years and over</td>
<td>5' 6&quot; - 5' 7&quot;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>9 st. - 9 st. 10 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 7 st. - 7 st. 10 lbs.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4' 8&quot; - 4' 9&quot;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10 st. 13 lbs - 11 st. 9 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 8 st. 9 lbs - 9 st. 5 lbs.</td>
</tr>
<tr>
<td></td>
<td>WOMEN</td>
<td>5' 9&quot; - 5' 10&quot;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>9 st. 10 lbs - 10 st. 6 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 7 st. 9 lbs - 8 st. 5 lbs.</td>
</tr>
<tr>
<td></td>
<td>Between 18 and 30 years</td>
<td>5' 4&quot; - 5' 5&quot;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>8 st. 4 lbs - 9 st.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 6 st. 6 lbs - 7 st. 2 lbs.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4' 10&quot; - 4' 11&quot;</td>
</tr>
</tbody>
</table>

Note: Height is in bare feet
Weight is in light indoor clothing
leaflet, which gave a full explanation of what the aim of the exercise and the nature of the task was, together with a specific invitation to suitable applicants to participate in the survey (see Appendix 6). For those respondents who were willing, an appointment was arranged. In the case of the younger subjects, many who made enquiries via telephone or by visiting the premises were quite willing to participate without the need for further consideration. A few subjects did take part as a result of personal recommendations from previous subjects.

Response to appeals for subjects was not as good as was anticipated, particularly in respect of the older age group. Consequently, in order to obtain as many subjects as possible, the restrictions on heights and weights were relaxed. The lower limit for the older age group was also dropped to 50 years, and the period for the survey was extended by a month. Thus, all those who fell into the age categories but not necessarily those for height and weight, and who wished to take part were invited to do so, specific encouragement being given to the extremes in height and weight. Many of the subjects in the sample, therefore, do not fall precisely into the categories originally specified.

10.30 Procedure

Once received, each subject was invited to view the experimental area and the equipment with the nurse. The function of each piece of equipment was described, together with the procedure that each subject would be asked to follow. Each subject was then invited to raise any questions about the equipment or procedure.

Once the introduction was completed, the subject was asked to remove his outdoor clothing and footwear in the changing area. Then a record of the weight and height of the subject was made.
in the intermediate area. The clothed subject was next
guided on to the platform via the changing area by the nurse
and, under the direction of the project officer, carried out
a trial run of the three postures to be adopted for the
photographs. These postures were demonstrated in sequence
to the subject by the project officer in front of the plat­
form. The trial run enabled each subject to become accus­
tomed to the postures and the platform which, with the view
of the camera underneath, could at first be disturbing. The
trial run also helped to minimise the time spent on the
platform over adjustments and corrections whilst the subject
was unclothed. Following the trial run, the subjects were
asked to proceed to the changing area and to remove their
clothing from the waist down, put on the goggles provided,
and return to the platform and repeat the postures. During
this time, the nurse returned to the reception area and the
project officer prepared to take the photographs from the
side of the camera enclosure. The subject then returned to
the platform from the changing area and, following vocal
instructions given by the project officer, adopted the three
postures in sequence, a single photograph being taken of each
posture. The subject, on completion of the photographs,
returned to the changing area, dressed, and proceeded to the
reception area to receive payment, and refreshment if desired.

This procedure was generally completed within 20 minutes, but
for the few elderly subjects who took part in the survey, the
procedure was taken at a more leisurely pace, in particular
during the trial run. In a few cases the nurse remained
close to the platform for reassurance where a subject was
particularly nervous.
RESULTS

The total number of subjects who took part in this survey was 166. Table 9 gives the age/sex distribution of the subjects.

Table 9
Age/Sex Distribution of Subjects

<table>
<thead>
<tr>
<th>Age Group (Years)</th>
<th>18–30</th>
<th>31–40</th>
<th>50–59</th>
<th>60+</th>
<th>All ages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>53</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>64</td>
</tr>
<tr>
<td>Men</td>
<td>96</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>102</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>166</td>
</tr>
</tbody>
</table>

The three subjects falling into the 31–40 age group were combined with those in the 18–30 age group, giving totals for the women and men of 55 and 97 subjects respectively. Of these subjects, the photographs of 3 women and 9 men were eliminated as 3 women and 3 men adopted unsuitable postures and the photographs of the remaining six men were inadequate. This left 52 women and 88 men as the final sample for the youngest age group. Figures 18 and 19 give a plot of height vs. weight for the 52 women and 88 men respectively. For the older subjects, 5 of the women and 2 of the men adopted postures which were unsuitable, therefore it was not possible to form a meaningful sample from the remaining 7 subjects.

Table 10 compares the heights and weights of the survey sample with those of the samples of Montegriffo (1968) and Thompson et al. (1973).
\[\text{WEIGHT} \quad \text{Cm.}\]

\[178 \quad 176 \quad 174 \quad 172 \quad 170 \quad 168 \quad 166 \quad 164 \quad 162 \quad 160 \quad 158 \quad 156 \quad 154 \quad 152 \quad 150 \quad 148 \quad 146 \]

\[40 \quad 44 \quad 48 \quad 52 \quad 56 \quad 60 \quad 64 \quad 68 \quad 72 \quad 76 \quad 80 \quad \text{WEIGHT} \quad \text{Kg.}\]

\[\square: \text{Indicates the categories originally specified.}\]

**FIGURE 28**

**HEIGHT VS WEIGHT, WOMEN.**
Indicates the categories originally specified.

Figure 19

Height vs Weight, Men
Table 10

Comparison of the heights and weights of the survey sample with the heights and weights of the samples of Montegriffo (1968) and Thompson et al. (1973).

<table>
<thead>
<tr>
<th></th>
<th>Survey</th>
<th>Montegriffo (1968) 20-29 years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height: Mean</td>
<td>177.83 cm.</td>
<td>176.2 cm.</td>
</tr>
<tr>
<td>St.dev.</td>
<td>6.707 cm.</td>
<td>6.73 cm.</td>
</tr>
<tr>
<td>Range</td>
<td>159.6-193.4 cm.</td>
<td>not given</td>
</tr>
<tr>
<td>Weight: Mean</td>
<td>68.99 kg.</td>
<td>71.25 kg.</td>
</tr>
<tr>
<td>St.dev.</td>
<td>7.291 kg.</td>
<td>8.08 kg.</td>
</tr>
<tr>
<td>Range</td>
<td>54.25-86.8 kg.</td>
<td>not given</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Survey</th>
<th>Thompson et al. (1973) 18-30 years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height: Mean</td>
<td>164.9 cm.</td>
<td>162.49 cm.</td>
</tr>
<tr>
<td>St.dev.</td>
<td>4.973 cm.</td>
<td>6.34 cm.</td>
</tr>
<tr>
<td>Range</td>
<td>151.4-177.7 cm.</td>
<td>124.5-190.5 cm.</td>
</tr>
<tr>
<td>Weight: Mean</td>
<td>56.05 kg.</td>
<td>58.46 kg.</td>
</tr>
<tr>
<td>St.dev.</td>
<td>6.756 kg.</td>
<td>7.96 kg.</td>
</tr>
<tr>
<td>Range</td>
<td>44.55-70.65 kg.</td>
<td>34.96-99.88 kg.</td>
</tr>
</tbody>
</table>

The photographs were printed on waterproof bromide paper so that the prints were distortion free; from the three photographs of each subject the following measurements were taken in centimetres using a set of X-ray measuring calipers (Figure 20):
FIGURE 20

X-ray measuring calipers.
The Measurements

The dimensions measured were aimed at providing an indication of overall static space requirements, the principal body areas in relation to the use of a w.c. seat for defaecation, and the amount of change in the relevant dimensions as the body changes posture. The dimensions were:

1. The total span of the subject from the head to the back of the buttocks.
2. From the front of the knee to the back of the buttocks.
3. From the back of the heels to the back of the buttocks. Where it was possible to differentiate between the position of the heels in relation to the buttocks, the minimum distance was measured.
4. From the back of the heels to the anus. As with measurement 3, the minimum distance was measured.
5. The overall length of the perineum taken from the buttock cleavage to the front of the genital region, in the case of men to the front of the penis.
6. The maximum width of the buttocks taken approximately across the mid point of the perineum.
7. The width of the thigh at the front of the perineum.
8. The maximum width of the perineum.
9. The minimum height of the buttocks from the floor.
10. From the back of the knee to the back of the buttocks. In the case of the "squatting" posture, the back of the knee was taken as the junction between the flesh of the lower leg and thigh.

Measurement 1 gives an indication of the minimum space requirements from front to back of the user. Measurements 2, 3, 6, 9 and 10 indicate the general outline of the body in the three postures and thus indicate the space available for the introduction of a seat and pan together with the relation of this space to the body. Measurements 4, 5, 6, 7 and 8 indicate the minimum dimensions for the seat aperture and dimension 4 indicates the relation of this minimum aperture to the rest of the body.

In some instances, it was necessary to estimate a dimension since it was not always possible to locate the precise points described above, particularly in the case of women, around the region of the perineum. However, where estimates were necessary in the measurements, they did not invalidate the measurements taken. Where taking estimates could possibly produce an unacceptable level of inaccuracy, the prints were rejected as being unsuitable. The position of the buttocks for posture 3 was affected by subjects who remained on the
The Measurements

The dimensions measured were aimed at providing an indication of overall static space requirements, the principal body areas in relation to the use of a W.C. seat for defaecation, and the amount of change in the relevant dimensions as the body changes posture. The dimensions were:

1. The total span of the subject from the head to the back of the buttocks.
2. From the front of the knee to the back of the buttocks.
3. From the back of the heels to the back of the buttocks. Where it was possible to differentiate between the position of the heels in relation to the buttocks, the minimum distance was measured.
4. From the back of the heels to the anus. As with measurement 3, the minimum distance was measured.
5. The overall length of the perineum taken from the buttock cleavage to the front of the genital region.
6. The maximum width of the buttocks taken approximately across the mid point of the perineum.
7. The width of the thigh at the front of the perineum.
8. The maximum width of the perineum.
9. The minimum height of the buttocks from the floor.
10. From the back of the knee to the back of the buttocks. In the case of the 'squatting' posture, the back of the knee was taken as the junction between the flesh of the lower leg and the thigh.

In some instances it was necessary to estimate a dimension since it was not always possible to locate the precise points described above, particularly in the case of women, around the region of the perineum. However, where estimates were necessary in the measurements, they did not invalidate the measurements taken. Where taking estimates could possibly produce an unacceptable level of inaccuracy, the prints were rejected as being unsuitable. The position of the buttocks for posture 3 was affected by subjects who remained on the
balls of their feet rather than squatting on the soles of their feet, particularly in relation to dimension 9.

For men and women approximately 21% and 35% respectively remained on the balls of their feet in posture 3.

Measurements 1 to 8 were taken from the underside view and measurements 9 and 10 were taken from the side view. Each measurement was corrected to take account of the magnification factor and for parallax, in order to obtain the actual dimension (see Appendix 4).

Figure 21 illustrates the measurements taken from the photographs as related to posture 2 for women.

Tables 11, 12 and 13 give the means, standard deviations and ranges for the 10 measurements in each of the three postures.
The 10 measurements taken from each photograph as applied to posture 2.
### TABLE 11

**POSTURE 1**: Means, Standard deviations and ranges

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Cm</th>
<th>Means</th>
<th>Standard Deviations</th>
<th>Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>1</td>
<td>76.11</td>
<td>70.86</td>
<td>8.283</td>
<td>6.556</td>
</tr>
<tr>
<td>2</td>
<td>50.95</td>
<td>49.32</td>
<td>5.656</td>
<td>5.111</td>
</tr>
<tr>
<td>3</td>
<td>23.35</td>
<td>21.09</td>
<td>3.711</td>
<td>3.476</td>
</tr>
<tr>
<td>4</td>
<td>16.29</td>
<td>12.67</td>
<td>4.083</td>
<td>3.911</td>
</tr>
<tr>
<td>5</td>
<td>22.63</td>
<td>17.83</td>
<td>2.264</td>
<td>2.072</td>
</tr>
<tr>
<td>6</td>
<td>36.74</td>
<td>38.1</td>
<td>2.008</td>
<td>2.93</td>
</tr>
<tr>
<td>7</td>
<td>17.83</td>
<td>18.01</td>
<td>1.007</td>
<td>1.786</td>
</tr>
<tr>
<td>8</td>
<td>4.89</td>
<td>4.98</td>
<td>1.002</td>
<td>1.216</td>
</tr>
<tr>
<td>9</td>
<td>68.31</td>
<td>60.97</td>
<td>8.675</td>
<td>6.881</td>
</tr>
<tr>
<td>10</td>
<td>36.95</td>
<td>35.67</td>
<td>5.273</td>
<td>8.277</td>
</tr>
</tbody>
</table>
TABLE 12
POSTURE 2: Means, Standard deviations and ranges

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Means</th>
<th>Standard deviations</th>
<th>Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cm</td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>1</td>
<td>83.98</td>
<td>79.28</td>
<td>6.022</td>
</tr>
<tr>
<td>2</td>
<td>63.26</td>
<td>59.73</td>
<td>2.886</td>
</tr>
<tr>
<td>3</td>
<td>26.97</td>
<td>24.89</td>
<td>4.06</td>
</tr>
<tr>
<td>4</td>
<td>19.73</td>
<td>16.47</td>
<td>4.467</td>
</tr>
<tr>
<td>6</td>
<td>41.54</td>
<td>41.09</td>
<td>2.048</td>
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<td>8</td>
<td>5.61</td>
<td>5.43</td>
<td>0.927</td>
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<tr>
<td>9</td>
<td>40.94</td>
<td>37.35</td>
<td>3.834</td>
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<td>10</td>
<td>46.28</td>
<td>42.06</td>
<td>5.104</td>
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</tbody>
</table>
TABLE 13

POSTURE 3: Means, Standard deviations and ranges

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Means</th>
<th>Standard deviations</th>
<th>Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td></td>
<td>Cm.</td>
<td>Cm.</td>
<td>Men</td>
</tr>
<tr>
<td>1</td>
<td>74.48</td>
<td>71.86</td>
<td>7.562</td>
</tr>
<tr>
<td>2</td>
<td>60.82</td>
<td>59.73</td>
<td>3.803</td>
</tr>
<tr>
<td>3</td>
<td>22.26</td>
<td>19.91</td>
<td>5.666</td>
</tr>
<tr>
<td>4</td>
<td>12.76</td>
<td>10.32</td>
<td>5.897</td>
</tr>
<tr>
<td>5</td>
<td>29.14</td>
<td>22.26</td>
<td>2.66</td>
</tr>
<tr>
<td>6</td>
<td>43.35</td>
<td>43.62</td>
<td>3.424</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>20.63</td>
<td>1.169</td>
</tr>
<tr>
<td>8</td>
<td>5.88</td>
<td>5.7</td>
<td>0.949</td>
</tr>
<tr>
<td>9</td>
<td>15.88</td>
<td>17.64</td>
<td>6.844</td>
</tr>
<tr>
<td>10</td>
<td>31.68</td>
<td>30.32</td>
<td>5.964</td>
</tr>
</tbody>
</table>
DISCUSSION

It was recognised very early in the preparations for this survey that it would be essential, from the subjects' point of view, for it to be conducted in a responsible manner. It was also recognised that however reassuring the arrangements were, it was probable that subjects would tend to be reluctant to carry out the task. It was, therefore, considered essential that the survey and the administration of it was organised so that where subjects were involved, simplicity was the keynote. In the event such considerations proved their worth, although it is notable that more than once it was necessary to allay suspicions as to the authenticity of the survey.

The site loaned by the Royal College of Art provided a convenient location for the survey. It was of adequate size for the equipment and facilities used, and it offered a clean, warm, bright environment for the subjects.

The rig itself was of sound construction and as installed provided a strong and secure platform for the subjects. Since the platform deflected less than $\frac{1}{2}$" with subjects on it, it was an easy task to reassure those who questioned the strength of the platform. From comments made by subjects, it seems clear that the grids used on the platform and the front sheet gave an important sense of security and reduced the sense of exposure. The grid on the platform seemed particularly valuable as subjects, when they stepped out on to the platform, had a view via the mirror of the light path to the camera enclosure underneath their feet, which at first glance could appear to be a vertical drop of 7 m. The grid on the platform tended to attract the eyes of subjects away from the view of the camera enclosure and on to the platform, thus emphasizing the presence of the platform. The front sheet also provided security, acting as a barrier to the possibility of subjects falling from the platform. The wooden rail above the front
sheet provided additional security and was used by a few of the older subjects as a handrail. It was also clear from subjects' reactions that the screening installed on the upper part of the Rig also assisted in reducing the sense of exposure whilst on the platform.

The underside view in the mirror was noticeably duller than the side view seen through the perspex sheet. This was due to the absorption of light in the glass of the mirror. In all other respects, the mirror was satisfactory. Generally, the camera functioned reliably throughout the survey, though on one occasion the trigger mechanism for the synchronised flash unit failed to operate. There was also some inconsistency in the quality of the photographs, but it was not possible to determine for certain whether or not this was due to the camera. The electronic flash units operated without fault throughout the survey. From the point of view of the subjects the general conduct of the survey was quite clearly acceptable. Also the manner in which subjects were acquainted with the experimental area and the task proved to be successful. In spite of this, the recruitment of subjects was not as successful as was hoped. However, particularly in the younger age groups, it was seldom that enquirers refused to participate once they had knowledge of the task and its purpose. As was expected, the level of rejection in the older age group was a good deal higher. It would, though, be misleading to attempt to estimate what in fact the level of rejection was, as no factual information is available on which to base such an estimate. It would seem, judging from the response of subjects who did take part, that the difficulties in attracting subjects were to some extent independent of the task involved. The notices advertising the survey specifically avoided stating in detail what was expected of the subjects, but attempted to attract them by stating that a fee of £3 was paid and that each subject would not be required for more than half an hour. It also seemed that a significant proportion of subjects took part solely on the basis of personal
recommendations from previous subjects. Thus, as far as one could judge, in essence the problem was encouraging members of the public to be subjects for experimental work and more effort should perhaps have been put into publicising the survey.

The sample of the population used in this survey is comparable with the samples of Montegriffo (1968) and Thompson (1973). As can be seen from Table 10, page 83, in the cases of both women and men in the survey, for height the means are larger, for weight the means are smaller, and the corresponding standard deviations are all smaller. The differences with respect to the means are not great. The mean heights are within 2\%, and the mean weights are within 5\% of the reference values. For the standard deviations the differences are clearly greater, except for the comparison between the standard deviations of male height where the difference is less than 1\%. The differences between standard deviations for women's height, women's weight and men's weight are within 20\%, 15\% and 10\% respectively. These differences may be due to the early insistence on observing the categories initially specified and a consequent concentration of subjects around the mean values. However, since the standard deviations are in all cases less than those for the reference values, the sample falls within the general population and thus may be assumed to represent the general population.

The three postures decided upon for the survey proved appropriate and satisfactory as, once having adopted each posture, while clothed, it was not difficult for the subject to repeat the adoption of each posture while being photographed. The postures adopted did require the subjects to maintain their balance. This may have resulted in the overall dimensions taken differing, due to the muscle tension in the limbs and trunk, from those which may have been obtained with the body in a relaxed state. It is not thought, however, that the difference in the dimensions would have been substantial. However, for the body to be in a relaxed state in comparable postures, a body support system for the subject would have to have been provided, the most appropriate being support for the thighs and buttocks. Such support would have had a marked influence over the dimensions recorded around the thighs and buttocks due to the compression of the flesh. This influence would have been determined in part by the extent and nature of the support. With regard to the male subjects in posture two, the extent to which the flesh of the thighs was compressed might also have resulted in
recommendations from previous subjects. Thus, as far as one could judge, in essence the problem was encouraging members of the public to be subjects for experimental work and more effort should perhaps have been put into publicising the survey.

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The three postures decided upon for the survey proved appropriate and satisfactory as, once having adopted each posture, while clothed, it was not difficult for the subject to repeat the adoption of each posture while being photographed. The posture most reliably reproduced was the second. The dimensions taken from the photographs had, in some cases, to be estimates. Better quality prints, particularly with respect to the lighting, could have improved the accuracy with which specific measurements were taken. The main reason for relying on estimates for some measurements was the indistinct nature of the area of the body that was being measured,
a significant incidence of the penis projecting below the line of the thighs, which for the free standing posture was insignificant. The posture most reliably reproduced was the second. The dimensions taken from the photographs had, in some cases, to be estimates. Better quality prints, particularly with respect to the lighting, could have improved the accuracy with which specific measurements were taken. The main reason for relying on estimates for some measurements was the indistinct nature of the area of the body that was being measured, particularly in the case of women, that of the front of the perineum. The accuracy with which the points were located for measurement was also determined in part by the physique of the subject. For instance, it was generally easier to locate points around the buttocks region on the lighter subjects than on the heavier subjects. However, the caliper used to take measurements from the photographs was capable of clearly indicating changes of 0.01 cm, and so the accuracy with which the measurements were taken was within the limits of accuracy for the photographic system (Geoghegan 1953, Jones 1973, Littig 1964).

The accuracy of the system used, in the light of the experience gained with similar equipment at Loughborough University, was estimated at ±2%, taking into account the distortion of the image by the lens system in the camera, the accuracy with which the image was recorded on the film and the distortion derived from the processing of the film.

From the data obtained and presented in Tables 11, 12 and 13, it is clear that the dimensions of subjects taken around the buttock region change as subjects move from posture 1 to posture 3. In general, this alteration in dimensions follows the same pattern for both men and women. The actual values are, as would be anticipated, in general less for women than for men, although in some instances the differences are negligible. To illustrate the above point, mean values from Tables 11, 12 and 13 are presented as follows (rounded to whole figures for simplicity):

<table>
<thead>
<tr>
<th>Dimension 1 from the front of the head to the back of the buttocks</th>
<th>Posture 1 (cm)</th>
<th>Posture 2 (cm)</th>
<th>Posture 3 (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>76</td>
<td>84</td>
<td>74</td>
</tr>
<tr>
<td>Women</td>
<td>71</td>
<td>79</td>
<td>72</td>
</tr>
</tbody>
</table>

As can be seen, the maximum distance from front of head to back of buttocks occurs in posture 2 in order to balance the body. The changes for each sex and the differences between the sexes are the same for posture 1 and posture 2. The difference between posture 2 and posture 3 for men and women differs by 3 cm, and within posture 3 the difference between men and women is only 2 cm.
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<table>
<thead>
<tr>
<th></th>
<th>Posture 1</th>
<th>Posture 2</th>
<th>Posture 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cm</td>
<td>cm</td>
<td>cm</td>
</tr>
<tr>
<td>Men</td>
<td>76</td>
<td>84</td>
<td>74</td>
</tr>
<tr>
<td>Women</td>
<td>71</td>
<td>79</td>
<td>72</td>
</tr>
</tbody>
</table>

As can be seen, the maximum distance from front of head to back of buttocks occurs in posture 2 in order to balance the body. The changes for each sex and the differences between the sexes are the same for posture 1 and posture 2. The difference between posture 2 and posture 3 for men and women differs by 3 cm, and within posture 3 the difference between men and women is only 2 cm.
### Dimension 2 - Front of Knee to the Back of Buttocks

<table>
<thead>
<tr>
<th></th>
<th>Posture 1 (cm)</th>
<th>Posture 2 (cm)</th>
<th>Posture 3 (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>51</td>
<td>63</td>
<td>61</td>
</tr>
<tr>
<td>Women</td>
<td>49</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

For women no difference in values exists between postures 2 and 3, and for men the difference is only 2 cm. For men the values are greatest in posture 2; for women the only difference is the 11 cm increase from posture 1 to postures 2 and 3.

### Dimension 3 - Heel to Back of Buttocks

<table>
<thead>
<tr>
<th></th>
<th>Posture 1 (cm)</th>
<th>Posture 2 (cm)</th>
<th>Posture 3 (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>23</td>
<td>27</td>
<td>22</td>
</tr>
<tr>
<td>Women</td>
<td>21</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

In this case the differences between the values for men and for women for each posture, and the difference in values between men and women in the three postures are the same.

### Dimension 4 - Heel to Anus

<table>
<thead>
<tr>
<th></th>
<th>Posture 1 (cm)</th>
<th>Posture 2 (cm)</th>
<th>Posture 3 (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>16</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>16</td>
<td>10</td>
</tr>
</tbody>
</table>

The changes in the above dimension are similar to those for dimension 3. A comparison of the corresponding values shows that the distance between the anus and the back of the buttocks tends to increase as both men and women move from posture 1 to posture 2. This increase is reversed by both men and women as they move down from postures 2 to posture 3.
Dimension 5 - Length of the perineum

<table>
<thead>
<tr>
<th></th>
<th>Posture 1</th>
<th>Posture 2</th>
<th>Posture 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>23</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>Women</td>
<td>18</td>
<td>19</td>
<td>22</td>
</tr>
</tbody>
</table>

The length of the perineum increases as subjects change from posture 1 through to posture 3. This increase is approximately twice as great from posture 2 to posture 3 as it is from posture 1 to posture 2.

Dimension 6 - Overall width of buttocks

<table>
<thead>
<tr>
<th></th>
<th>Posture 1</th>
<th>Posture 2</th>
<th>Posture 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>37</td>
<td>42</td>
<td>43</td>
</tr>
<tr>
<td>Women</td>
<td>38</td>
<td>41</td>
<td>44</td>
</tr>
</tbody>
</table>

Overall buttock width is almost the same for both men and women within each posture, and for postures 2 and 3 for both sexes.

Dimension 7 - Width of thigh at the front of the perineum

<table>
<thead>
<tr>
<th></th>
<th>Posture 1</th>
<th>Posture 2</th>
<th>Posture 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>18</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Women</td>
<td>18</td>
<td>19</td>
<td>21</td>
</tr>
</tbody>
</table>

There is a slight increase in width for both men and women as the posture changes from posture 1 through to posture 3. It is noticeable that the width of the thigh is virtually the same for both sexes.

Dimension 8 - Width of the perineum

<table>
<thead>
<tr>
<th></th>
<th>Posture 1</th>
<th>Posture 2</th>
<th>Posture 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Women</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
This dimension alters very slightly in a manner similar to dimension 7.

**Dimension 9 - Height of buttocks above floor**

<table>
<thead>
<tr>
<th></th>
<th>Posture 1</th>
<th>Posture 2</th>
<th>Posture 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>68 cm</td>
<td>41 cm</td>
<td>16 cm</td>
</tr>
<tr>
<td>Women</td>
<td>61 cm</td>
<td>37 cm</td>
<td>18 cm</td>
</tr>
</tbody>
</table>

The values for men are greater than for women in postures 1 and 2; the situation is reversed in posture 3. The larger proportion of women than men who squatted on the balls of their feet may have caused the height of the buttocks for women to be greater than for men in posture 3. There is a very considerable decrease, of course, in the values for this dimension in changing from posture 1 (semi-seated) to posture 3 (squatting).

**Dimension 10 - Back of knee to back of buttocks**

<table>
<thead>
<tr>
<th></th>
<th>Posture 1</th>
<th>Posture 2</th>
<th>Posture 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>37 cm</td>
<td>46 cm</td>
<td>32 cm</td>
</tr>
<tr>
<td>Women</td>
<td>36 cm</td>
<td>42 cm</td>
<td>30 cm</td>
</tr>
</tbody>
</table>

This dimension is related to Dimension 2 (front of knee to back of buttocks). Whereas the latter values are essential in the determination of overall horizontal space requirements, dimension 10 is more closely related to the length of the supporting surface offered by a W.C. seat. The values for this dimension are greatest in posture 2, and are in all postures slightly greater for men than for women.

A number of inferences may be drawn from the information derived above from the ten dimensions measured from the photographs.
1. Taking into account dimensions 5, 6, 7 and 8, it would seem that the width of the thigh supporting surfaces of a W.C. seat and the aperture available between such surfaces could be the same for the adoption of both postures 2 and 3. As the mean length of the perineum increases (from 19 cm in posture 2 for women to 29 cm in posture 3 for men), the length of the aperture required may be greater in design solutions aimed at accommodating the adoption of posture 3.

2. An appropriate range of heights of W.C. seats could well be between 16 and 41 cm. above the floor level. This would take account of the mean value (dimension 9) of the height of the buttocks above the floor of men in posture 3, at the lower end of the range, and of the same dimension for men in posture 2, at the upper end of the range.

3. Dimensions 3 and 4 (heel to back of buttocks and heel to anus respectively) are more particularly related to the design of seat, seat pan and pedestal (if any), from the point of view of ensuring that a design affords the individual easy positioning of the body on the seat and rising from it.

4. Some preliminary comparisons between the dimensions of existing W.C. seats (as given in British Standards Institution publications BS.1213: 1945 and 1254: 1971) show discrepancies between existing dimensions and those found in this investigation.

The first point is that BS 1213 and BS 1254 specify that the maximum internal length of the seat should vary between 25.4 - 29.2 cm. and 25.4 - 28.5 cm. respectively.

From the measurements taken of subjects in the second posture the length of the perineum (Dimension 5) is as follows:-
Men: mean = 24.71 cm.
s.d. = 2.637 cm.
range = 17.83 - 31.04 cm.

Women: mean = 19.19 cm.
s.d. = 2.995 cm.
range = 14.66 - 25.43 cm.

Although the specified B.S. seat lengths would, in fact, accommodate most of the subjects as regards length of the perineum, it allows very little clearance, so that for most people fairly accurate positioning would be required. It would also seem that, even for smaller women, access to the perineum by hand is at best restricted and at worst apparently impossible whilst seated.

A second point is that the overall width of W.C. seat is given in both B.S. standards as 38.1 cm (with a maximum internal width of aperture set between 21.59 - 24.13 cm.). The width of the buttocks (Dimension 6) is:-

Men: mean = 41.54 cm.
s.d. = 2.048 cm.
range = 35.02 - 45.7 cm.

Women: mean = 41.09 cm.
s.d. = 2.881 cm.
range = 35.3 - 48.06 cm.

Calculating from the B.S. specifications given above, the maximum width available on the seat for thigh support to be 38.1 - 21.6 cm = 16.5 cm, one can compare this with the values for Dimension 7 (width of thigh at front of perineum):-

Men: mean = 19.19 cm.
s.d. = 1.155 cm.
range = 16.11 - 21.27 cm.

Women: mean = 19.76 cm.
s.d. = 1.414 cm.
range = 16.29 - 22.17 cm.
From B.S.1213, the height recommended for a W.C. pan is 16 ins (40.64 cm). If it is assumed that the posture adopted whilst seated is with the thighs approximately horizontal as in posture 2, then the pan is relatively high, as can be seen by inspecting Dimension 9, posture 2.

Men: mean = 40.94 cm.
s.d. = 3.834 cm.
range = 29.93 - 48.92 cm.

Women: mean = 37.35 cm.
s.d. = 4.544 cm.
range = 27.13 - 46.6 cm.

It should also be noted that the use of the seat will add to the height of the pan. However, the height recommended for the W.C. pan in B.S.1213 is clearly out of keeping with the views that have been expressed on the preferable posture for defaecation being lower (Aaron 1938, Bokus 1944, Davenport 1968, Garry 1972, Hornibrook 1963). Also, some current examples of W.C. pan design do provide for a lower seated posture.

As the second posture was the one most reliably repeated by subjects, data from this posture were used to indicate whether height and weight were a reliable indication of the dimensions relevant to W.C. usage. For both men and women the distance from heel to anus and the length of the perineum were compared with height. None of these correlations were found to be significant. Comparisons were also made for both sexes between weight and overall width of buttocks and the width of the thigh in front of the perineum. For women both correlations were highly significant, between 0.01 and 0.05 levels of significance, but for men only the correlation between thigh width and weight proved to be significant (also between 0.01 and 0.05 levels of significance) (Baumie et al. 1970, Fisher et al. 1953, Spiegel 1961.)
13.00 CONCLUSIONS

This survey provides basic anthropometric information upon which to base evaluation of existing W.C. seat designs and possible future designs. Several conclusions emerge from the investigation:-

1. If the seated posture adopted on W.C. pans is to be physiologically more effective in assisting evacuation of the bowels (suggested in the literature as being a squatting posture), then equipment which complies with the current British Standards, BS.1213:1945 and BS.1254: 1971, is inappropriate. For equipment to accommodate the squatting posture, it is likely that it would differ in height and rake from current equipment.

2. There are few large dimensional differences between men and women; the dimensions, width of buttocks, width of thigh and width of perineum, are very similar for both sexes.

3. The data also indicate that weight is a better indicator than height of the variability in body size with respect to W.C. seat design.

4. Comparison of the recommended dimensions of W.C. seats given in B.S.1213: 1945 and B.S. 1254: 1971, and W.C. pan given in B.S.1213: 1945, and the relevant body dimensions obtained in this study indicates discrepancies. These discrepancies occur principally in the length of the seat aperture, in the area for support of the seated user provided for by the seat, and also the distribution of the available surface area of the seat in relation to the shape of the thighs. There is thus a clear need to explore the possibilities of different designs based upon the body dimensions now available.
5. It is also clear that the data presented here provide only the first stage in determining comprehensive ergonomic criteria for the design of sanitary equipment. The survey has only considered anthropometric requirements of a static nature which need to be considered in relation to the effects of posture change and the habits of W.C. pan usage for any given body support system.

6. The success of this survey in gaining data on such a delicate topic demonstrates that it is possible to obtain such information providing that adequate precautions are taken to avoid antagonising subjects.
14.00 APPENDICIES
APPENDIX 1
Subject Information Form
# Appendix I

## Subject Information

<table>
<thead>
<tr>
<th>Date</th>
<th>AM</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>M</td>
<td>F</td>
</tr>
</tbody>
</table>

|------|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|

**Medical Diagnosis**

**Functional Loss**  
Note areas affected, and nature of loss
Bath Aids used by subject in their own home

Give details if necessary

BATH MAT
BATH SEAT
BATH BOARD
BATH STOOL
BATH RAILS
ANY OTHER

How does the subject get into and out of their own bath?

Enter from their left or right

How do they use their aids

Do they require assistance

If yes, what assistance and how much

Who provides assistance?
APPENDIX 2
Experimental Information Form
APPENDIX 2

EXPERIMENTAL INFORMATION

SUBJECTS NAME

DATE

1. Choice of surface material for rails

<table>
<thead>
<tr>
<th>METAL</th>
<th>RUBBER</th>
<th>PLASTIC</th>
</tr>
</thead>
</table>

2. Description of subjects procedure for entering the bath

3. Describe procedure for exit

4. What Aids were used?

5. Did the subject require any assistance? If yes, what and why

6. What additional aids would the subject like?

7. The measurements of position of rails used.

8. Outline the subjects reaction to the layout of the aids. Details of any comments made on ease of entry and/or exit.
APPENDIX 3

Equipment: Part 1
## APPENDIX 3

### EQUIPMENT

<table>
<thead>
<tr>
<th>ARTICLE</th>
<th>TYPE</th>
<th>MANUFACTURER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bath mat</td>
<td>Rubber mat</td>
<td>Croydex Rubber Products Ltd., Andover, Hampshire.</td>
</tr>
<tr>
<td>Internal</td>
<td>22&quot; x 14&quot;</td>
<td></td>
</tr>
<tr>
<td>Bath mat</td>
<td>Dust Control mat</td>
<td>Vitopan Ltd., 86 Garfield Road, London S.W.9.</td>
</tr>
<tr>
<td>External</td>
<td>Unplasticised polyvinylchloride</td>
<td>Osma Plastics Ltd., Rigby Lane, Sawley Road, Hayes, Middlesex.</td>
</tr>
<tr>
<td>Plastic tube</td>
<td>Duraluminium</td>
<td></td>
</tr>
<tr>
<td>Duraluminium tube</td>
<td>Duraluminium</td>
<td></td>
</tr>
<tr>
<td>Rubber surface</td>
<td>Slow Rubber, Bramble.</td>
<td>Avon Rubber Co. Ltd., Bath Road, Melksham, Hampshire.</td>
</tr>
<tr>
<td>Metal tube</td>
<td>Galvanised water pipe, 1&quot; I.D. 1 1/2&quot; O.D.</td>
<td></td>
</tr>
<tr>
<td>Framework</td>
<td>Tubular steel</td>
<td>Cascoignes (Kee Klamps) Ltd., Berkeley Avenue, Reading, Berks.</td>
</tr>
<tr>
<td>Bath</td>
<td>Kent Bath</td>
<td>Allied Ironfounders Ltd., 23 Brook Street, London W.1.</td>
</tr>
<tr>
<td>Rubber to metal</td>
<td>Neoprene cement</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 4

Calculations to obtain real measurements from the print measurements.
APPENDIX 4

Calculations to obtain real measurements from the print measurements.

A metre length was photographed positioned horizontally in the centre of each view at 80 cm 'behind' the respective grids. From these photographs the metre lengths could be compared with the respective grids and thus an estimate of the error due to parallax could be made as follows (Dixon 1972, Jones 1973):

(1) Side view of subject

1 metre at the grid = 14.38 cm on the print

\[ \text{Magnification factor} = \frac{100 \text{ cm}}{14.38 \text{ cm}} = 6.95 \]

The metre length as measured on the print at 80 cm behind the grid = 12.89 cm.

\[ \text{loss in length} = \frac{6.95(14.38 - 12.89)}{80} = 0.129 \text{ cm/cm}. \]

Now real length = print length \( \times \frac{1}{1 - \text{loss}} \times \text{magnification factor} \)

\[ \text{Real length} = \text{print length} \times \frac{6.95}{1 - 0.129} \]

\[ = \text{print length} \times 7.98 \]

(2) Underside view

Similarly,

1 metre at the grid = 12.55 cm on the print.

\[ \text{Magnification factor} = \frac{100 \text{ cm}}{12.55 \text{ cm}} = 7.97 \]

The metre length as measured on the print at 80 cm behind the grid = 11.35 cm.

\[ \text{loss in length} = \frac{7.97(12.55 - 11.35)}{80} \]
\[ = 0.1195 \text{ cm/cm.} \]

Now Real length = print length \( \times \frac{1}{1 - \text{loss}} \times \text{magnification factor} \)

\[ \therefore \text{Real length} = \text{print length} \times \frac{9.97}{1 - 0.1195} \]

\[ \therefore \text{Real length} = \text{print length} \times 9.05 \]
APPENDIX 5

Notices advertising for subjects.
Measurement Experiment 27 November to 31 December 1972

SUBJECTS REQUIRED

Members of the public are being asked to act as subjects for a survey being carried out by the Institute for Consumer Ergonomics, Loughborough University, in conjunction with the Department of Design Research, Royal College of Art, to obtain data on human body size relevant to the use of bathroom equipment.

Each subject will be required for only about half an hour, and will be paid a fee of £3.

If you would like to take part and if you fit into one of the categories on the accompanying table, your participation in this survey would be very welcome.

For further details please contact:

Ian McClelland
4 Jay Mews
Royal College of Art
Kensington Gore, SW7

Telephone 584 5020, extension 233 or 228
Measurement Experiment 27 November to 31 December 1972
Institute for Consumer Ergonomics, Loughborough University
Department of Design Research, Royal College of Art

TABLE OF SUBJECTS REQUIRED: HEIGHT AND WEIGHT CATEGORIES

<table>
<thead>
<tr>
<th>GROUP</th>
<th>HEIGHTS</th>
<th>WEIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5' 11&quot; - 6'</td>
<td>11st 10lbs - 12st 6lbs or 9st 9lbs - 10st 5lbs</td>
</tr>
<tr>
<td>2</td>
<td>5' 7&quot; - 5' 8&quot;</td>
<td>10st 8lbs - 11st 4lbs or 8st 8lbs - 9st 4lbs</td>
</tr>
<tr>
<td>3</td>
<td>5' 3&quot; - 5' 4&quot;</td>
<td>9st 7lbs - 10st 3lbs or 7st 9lbs - 8st 5lbs</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>GROUP</th>
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<th>WEIGHTS</th>
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<tr>
<td>1</td>
<td>6' 1&quot; - 6' 2&quot;</td>
<td>12st 4lbs - 13st or 10st 1lb - 10st 11lbs</td>
</tr>
<tr>
<td>2</td>
<td>5' 6&quot; - 5' 7&quot;</td>
<td>10st 12lbs - 11st 8lbs or 8st 12lbs - 9st 8lbs</td>
</tr>
<tr>
<td>3</td>
<td>5' 4&quot; - 5' 5&quot;</td>
<td>9st 11lbs - 10st 7lbs or 7st 12lbs - 8st 8lbs</td>
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<th>HEIGHTS</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>5' 6&quot; - 5' 7&quot;</td>
<td>10st 3lbs - 10st 13lbs or 8st 1lb - 8st 11lbs</td>
</tr>
<tr>
<td>2</td>
<td>5' 1&quot; - 5' 2&quot;</td>
<td>9st - 9st 10lbs or 7st - 7st 10lbs</td>
</tr>
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<td>3</td>
<td>4' 8&quot; - 4' 9&quot;</td>
<td>7st 11lbs - 8st 7lbs or 6st - 6st 10lbs</td>
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<th>HEIGHTS</th>
<th>WEIGHTS</th>
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<tbody>
<tr>
<td>1</td>
<td>5' 9&quot; - 5' 10&quot;</td>
<td>10st 13lbs - 11st 9lbs or 8st 9lbs - 9st 5lbs</td>
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<tr>
<td>2</td>
<td>5' 4&quot; - 5' 5&quot;</td>
<td>9st 10lbs - 10st 6lbs or 7st 9lbs - 8st 5lbs</td>
</tr>
<tr>
<td>3</td>
<td>4' 10&quot; - 4' 11&quot;</td>
<td>8st 4lbs - 9st or 6st 6lbs - 7st 2lbs</td>
</tr>
</tbody>
</table>

Note: Height is in bare feet; weight is for light indoor clothing.
SUBJECTS REQUIRED

Male and female subjects are required before January 24th, 1973 for a Government-sponsored survey to obtain data on human body size relevant to the use of bathroom equipment.

EACH SUBJECT MUST BE OVER 50 YEARS OF AGE
EACH SUBJECT WILL ONLY BE REQUIRED FOR
HALF AN HOUR AT THE MOST
EACH SUBJECT WILL BE PAID £1.50

For further information, together with details of your height and weight, please contact:

THE PROJECT OFFICER
MEASUREMENT EXPERIMENT
4 JAY MEWS
THE ROYAL COLLEGE OF ART
KENSINGTON GORE
LONDON SW7 2EU
Tel: 504 3923 Ext. 313 or 320

S.03
APPENDIX 6

Subject Information Leaflet.
Measurements of People to Improve W.C. Design

This survey is being conducted by the Institute for Consumer Ergonomics, Loughborough University. It is sponsored by a Government organisation, the Building Research Establishment, and is being carried out at the Royal College of Art, in Kensington Gore.

It is the first study in a series intended to obtain information to improve the design and manufacture of W.C. pans and seats so that they will be both more convenient and more comfortable to use than most of the existing equipment. The poor design of many W.C. pans and seats is largely due to the fact that there is insufficient information available about the sizes and shapes of the human beings who have to use this equipment. It is most essential, if design is to be improved, that measurements are obtained from living men and women, and not from books or peoples' opinions.

In order to obtain the necessary body measurements, adult members of the public are being asked to act as subjects for this survey. Both men and women are wanted who are either between 18 and 30 years, or 60 years and over. Each person must also come under one of the categories for height and weight given on the attached sheet. (For example, if you are a man of 60 years old or more, if you are between 5 feet 11 inches and 6 feet in height, and if you are either between 11 stone 10 lbs and 12 stone 6 lbs, OR between 9 stone 9 lbs and 10 stone 5 lbs, then you would be an ideal subject). Each person who takes part in the survey will receive a fee of £3, which is intended also to cover any incidental expenses, such as bus fares to Kensington Gore. It is not expected that anyone will be asked to spare more than half-an-hour of their time.

Personal information required will be kept to a minimum. Each subject will have their age noted, and their height and weight will be measured, to be absolutely sure that they do fit into the categories that are wanted. Everyone will have an opportunity to discuss the procedure and equipment after it has been explained to him or her.
Volunteers will be asked to adopt three postures which are comparable with postures used on the W.C. they are:

1. 'semi-seated'; that is with the palms of the hands on the knees, arms straight and knees slightly bent.

2. 'seated'; that is with the elbows resting on the knees and knees bent at right angles.

3. 'squatting'

(Subjects are asked to note that some postures may prove difficult for those whose sense of balance is impaired.)

The nature of the problem requires that this is done with the lower half of the body unclothed. Privacy is ensured, and a special changing room is provided. These postures will be taken up on a platform with a solid perspex top. A mirror at an angle underneath the platform will allow photographs to be taken of each posture from the side and underside simultaneously. The time taken for each photograph is very brief, a few seconds, so subjects will not be required to hold the postures for long. The only purpose of taking photographs is so that measurements can be taken from the photographs instead of from the subjects themselves, which would be embarrassing.

The procedure and equipment has been designed to remove any feelings that a subject is being asked to put themselves on public view. In fact, quite the opposite, as the privacy of subjects will be respected as completely as possible. In addition to the project officer, there will be only one other person who will be directly involved; this will be an assistant who will be a qualified female nurse.

Once measurements from the photographs have been taken, all photographs will be destroyed, and none will be published. All other information about subjects will be treated as strictly confidential. All information that will be published as a result of this survey will be entirely impersonal.

If you would be willing to take part in this survey, or would like further information about it, please contact the project officer at the following address:

Mr. I. L. McClelland,
4, Jay Mews,
Royal College of Art,
Kensington Gore,
London S.W.7.

Tel: No. 01-584-5020. Ex. Nos. 233 or 228.

Yours faithfully,

Mr. I. L. McClelland,
Project Officer,
Institute for Consumer Ergonomics.
<table>
<thead>
<tr>
<th>GROUP</th>
<th>HEIGHTS</th>
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<tr>
<td>60 years and over</td>
<td>1 5ft 11&quot;-6ft</td>
<td>11st10lbs-12st6lbs or 9st9lbs -10st5lbs</td>
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<td></td>
<td>2 5ft 7&quot;-5ft8&quot;</td>
<td>10st 8lbs-11st4lbs or 8st 8lbs-9st4lbs</td>
</tr>
<tr>
<td></td>
<td>3 5ft 3&quot;-5ft4&quot;</td>
<td>9st7lbs-10st3lbs or 7st9lbs-8st5lbs</td>
</tr>
<tr>
<td></td>
<td>1 6ft1&quot;-6ft2&quot;</td>
<td>12st4lbs-13st or 10st11lbs-10st11lbs</td>
</tr>
<tr>
<td></td>
<td>2 5ft8&quot;-5ft9&quot;</td>
<td>10st12lbs-11st8lbs or 8st12lbs-9st8lbs</td>
</tr>
<tr>
<td></td>
<td>3 5ft4&quot;-5ft5&quot;</td>
<td>9st11lbs-10st7lbs or 7st12lbs-8st8lbs</td>
</tr>
<tr>
<td></td>
<td>1 5ft6&quot;-5ft7&quot;</td>
<td>10st3lbs-10st13lbs or 8st11lbs-8st11lbs</td>
</tr>
<tr>
<td></td>
<td>2 5ft1&quot;-5ft2&quot;</td>
<td>9st-9st10lbs or 7st-7st10lbs</td>
</tr>
<tr>
<td></td>
<td>3 4ft8&quot;-4ft9&quot;</td>
<td>7st11lbs-8st7lbs or 6st-6st10lbs</td>
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<tr>
<td></td>
<td>1 5ft9&quot;-5ft10&quot;</td>
<td>10st13lbs-11st9lbs or 8st9lbs-9st5lbs</td>
</tr>
<tr>
<td></td>
<td>2 5ft4&quot;-5ft5&quot;</td>
<td>9st10lbs-10st6lbs or 7st9lbs-8st5lbs</td>
</tr>
<tr>
<td></td>
<td>3 4ft10&quot; 4ft11&quot;</td>
<td>8st4lbs-9st or 6st6lbs-7st2lbs</td>
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Note: Height is in bare feet
Weight is for light indoor clothing
APPENDIX 7

Equipment: Part 2
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<tr>
<th>ARTICLE</th>
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<tr>
<td>Anthropometer</td>
<td>Type 101 +</td>
<td>Abawerk G.m.b.H.</td>
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<tr>
<td></td>
<td>crossbar 102</td>
<td>13a Aschaffenburg Post fach 21, Germany.</td>
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<tr>
<td>Personal Scale</td>
<td>120 kg 3306ABV</td>
<td>W &amp; T. Avery Ltd., Avery House, Clerkenwell Green, London E.C.1.</td>
</tr>
<tr>
<td>Slotted angle</td>
<td>Dexion 160</td>
<td>Dexion Ltd., Dexion House, Empire Way, Wembley, Middlesex.</td>
</tr>
<tr>
<td>Film</td>
<td>Kodak Super - XX</td>
<td>Kodak</td>
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<tr>
<td></td>
<td>Aero Film</td>
<td>P.O. Box 33, Swallowdale Lane, Hemel Hempstead, Herts.</td>
</tr>
<tr>
<td>Mirror</td>
<td>Float Glass</td>
<td>Pilkington Bros. Ltd., Flat Glass Division, St. Helen's, Lancs.</td>
</tr>
<tr>
<td>Transparent Acrylic Sheets</td>
<td>'Perspex'</td>
<td>Imp. Chem. Ind. Ltd., Plastics Division, Welwyn Garden City, Herts.</td>
</tr>
<tr>
<td>Photographic Calipers</td>
<td>Harpenden Range</td>
<td>Haltain Ltd., Brynerian, Crymmyck, Pembrokeshire.</td>
</tr>
</tbody>
</table>
1. AARON, H, 1938
   Our Common Ailment (New York: Dodge Pub. Co.).

2. BENNING, V J, 1969 (Compiler)
   Bibliography on Anthropometry.
   Ministry of Technology, TIL - BIB - 119.

3. BOKUS, H L, 1944
   Gastroenterology (Philadelphia: W.B. Saunders & Co.).

4. BRETTEN, P M, 1971
   An Investigation into the Optimum Position of
   hand rails around the bath for the disabled and
   debilitated subject, An unpublished project report:
   Loughborough University of Technology.

5. British Standards Institution,
   BS 1189: 1961, Cast Iron baths for domestic purposes
   (London).

6. British Standards Institution,
   BS 1213: 1945, Ceramic washdolll pans (dimensions and
   workmanship), (London).

7. British Standards Institution,

8. British Standards Institution,
   BS 1390: 1947, Sheet Steel baths for domestic purposes,
   (London).

9. British Standards Institution,
   BS. 4305: 1968, Baths for domestic purposes made
   from cast acrylic sheet, (London).
Work and Housing of Impaired Persons in Great Britain,
(H.M.S.O., London).

Cleaning the body. The Architect's Journal,

Bathroom ergonomics and planning. The Architect's

13. Clegg, J L, 1971
Bathing of patients. Hospital Engineering, 25,
98 - 121.

14. Crawford, D, and Williams, A, 1966

Basic Statistical Methods, 3rd Ed. (New York:
Harper and Row).

Handbook of Physiology, 4, 2nd Ed., (Chicago:
American Physiological Society).

17. Department of the Environment, 1972
Spaces in the Home: Bathrooms and W.C.s, (London
H.M.S.O.).

18. Dixon, M, 1972
A photogrammetric study of the work space available
to an operator of a coal cutting machine on the coal
face. Unpublished project report: Loughborough
University of Technology.
19. DIMAS, R, 1971
Planning for the disabled: Bath and Bedroom.
Build International, 4, 1, 24-25.

20. FISHER, R A, and YATES, F, 1953
Statistical tables for biological, agricultural, and
medical research, 4th Ed. (Edinburgh: Oliver and
Boyd Ltd.).

21. GARRY, R C, 1972
Personal Communication.

22. GEOGHEGAN, B, 1953
The determination of body measurements, surface area,
and body volume by photography. American Journal of
Physical Anthropology, 11, 97-118.

23. GOBLE, R E A, and NICHOLS, P J R, 1971
Rehabilitation of the Severely Disabled, 1 - Evaluation
of a Disabled Living Unit, (London: Butterworths).

24. GOLDSMITH, S, 1967
Designing for the Disabled, 2nd ed., (London: Royal
Institute of British Architects).

25. GOLDSMITH, S, NICHOLS, P J R, ROSTANCE, B, ANGELL, J,
and ANGELL, L, 1966
Designing a public convenience for the disabled,
Annals of Physical Medicine, 8, 8, 307-317.

26. COULDEN, G, 1970

27. HARRIS, A I, 1971
Handicapped and Impaired in Great Britain, (London:
H.M.S.O.).
28. HECTOR, W E, 1966
   A basic subject, Nursing Times, 7 Jan., 1966, 10 - 11.

29. HORNIBROOK, F, 1963

30. HUNT, M A, 1966

31. JARVIS, C J, 1970
   Bath aid for severely handicapped child, Occupational Therapy, 33, 6, 20-21.

32. JONES, P R M, 1973
   Personal Communication.

   An Advance in Somatotype Photography.
   Department of Ergonomics and Cybernetics, Loughborough University of Technology.

34. KEMSLEY, W F F, BILLEWICZ, W Z, and THOMSON, A M, 1962
   A new weight-for-height standard based on British Anthropometric data, British Journal of Preventive and Social Medicine, 16, 189 - 195.

35. KIRA, A, 1966
   The Bathroom, Criteria for design, (New York: Cornell University).

36. LANGFORD, M, 1965
   Personal Hygiene Attitudes and Practices in 1000 Middle-Class Households (New York: Cornell University).
37. LAWTON, E B, 1963

38. LITTIG, L W, 1964

39. LOMAN, E W, and KLINER, J L, 1969

40. MONTEGRIFIO, V M E, 1968
Height and weight of a United Kingdom adult population with a review of anthropometric literature, Annals of Human Genetics, 31, 389 - 399.

41. MURPHY, J W, 1972

42. NICHOLS, P J R, 1971

43. PALMER, R, 1973

44. PIKE, A, 1965

45. PIKE, A, 1966
46. PIKE, A, 1966

47. PIKE, A, 1966
Product Analysis 4, Supply Fittings and Showers, March, 157 - 159.

48. RAYNER, C, 1965

49. Research Institute for Consumer Affairs, 1972,

50. REYNOLDS, R, 1946.

51. SAINSbury, S, 1970
Registered as Disabled, (London: Bell).

52. SCHOBERTH, H, 1962
Sitzhaltung, Sitzschaden Sitzmobel, (Berlin: Springer - Verlag).

53. Spastics Society, undated,

54. SPIEGEL, M R, 1961

55. STUBBS, V, 1970
Wash or Wallow Nursing Times, 16 April 1970.
56. THOMKIN, D, 1973
Personal Communication.

57. THOMPSON, D, BARDEN, J D, KIRK, N S, MITCHELSON, D L, and WARD, J S, 1973
Anthropometry of British Women, Institute for Consumer Ergonomics Ltd., Loughborough University of Technology.

58. WALTER, F, 1968

59. WRIGHT, L, 1960
Clean and Decent, (New York: Viking Press).