Note to the Reader:

As the first term was spent in investigating an aid for female incontinency sufferers, a report of the research has been compiled and reads independently to the main Degree Project Report.

INVESTIGATION INTO THE POSSIBILITY OF DESIGNING SOME MECHANICAL OR ELECTRICAL DEVICE THAT WOULD HELP WITH THE MANAGEMENT OF FEMALE URINARY INCONTINENCE

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CONTENTS

1. INTRODUCTION

Selection of a final year project in a paramedical field involved many visits to hospitals, rehabilitation and day care centres and the one ever-present problem was that of incontinence. It would appear that in dealing with this problem there was very little available in terms of aids or equipment.

It was decided, for these and several other reasons, that will become evident later, to tackle this problem with the aim of finding some mechanical or electrical solution that would help with its management.

Definition

Incontinence is the inability to control movements of either bowels or bladder or both. The more common form is the inability to control the bladder, i.e. urinary incontinence. This study is concerned only with female urinary incontinence, the normal problem being that of inability to retain urine. Incontinence is a very unpleasant symptom and leads to serious social and economic problems for the patient.

2. HISTORICAL NOTE

There are very few literary references to the problem of incontinence, medical or otherwise. Because of the primitive living conditions and the extremely low domestic and public standards of hygiene the problem would have gone relatively unnoticed.

One of the earliest references to a treatment dates back to 1500 B.C. in the Egyptian medical Papyrus Ebers and perhaps the earliest reference in an English book written by Thomas Phaer was in 1544. Although this condition in children has generally received more attention than in adults, references have been made in relation to women and childbirth. In 1777, Thomas Leake, a teacher of midwifery described two devices for the management of incontinence.

Note

Being a medical problem considerable time was spent in studying anatomy and physiology. This was necessary in order to discuss constructively the problem and possible solutions with people from the medical profession.

3. WHO SUFFERS FROM URINARY INCONTINENCE?

There are many different causes for incontinence including temporary illness, childbirth, local conditions affecting the bladder or womb (some forms of prolapse), complications of the arteries and injury or disease to the spinal cord. Because of its social and psychological implications the resulting lack of disucssion tends to associate the problem with the elderly and confused and, to disregard the high proportion of young disabled people involved.

Among wheelchair users the incidence of incontinence is approximately one in three - about 2,000 in Ireland.

Table 1 * Disabling conditions causing incontinence

Motor neurone diseases	⬒
Paraplegia and tetraplegia	■
Hemiplegia	⬒
Spina bifida	■
Cerebral palsy	⬒
Multiple sclerosis	■

⬒ Directly associated effect in some cases or slight associated effect in general

■ Incontinence is the associated effect in all cases with the exceptions only where the disease is minimal

* Selwyn Goldsmith, Designing for the Disabled, part of Table 13.1, Hierarchy of disabling condition p.44-46.

As can be seen from Table 1, "Disabling conditions causing incontinence" generally involved lesion of the spinal cord causing paralysis of the muscles controlling urination as with traumatic paraplegia and spina bifida. Generally acute cord lesions are more common in the male than female. Incontinence is also common among people affected by multiple sclerosis, a complaint more prevalent in women than in men.

It is also found among elderly handicapped people where loss of function capacity is associated with the normal ageing process.

In many nursing and old people's homes incontinent patients were refused admission. Many of these patients were either too old and/or too weak to be treated surgically or surgery had been tried and had failed. It also became apparent that there are many emotional and physical factors which, although not connected with urinary function, result in incontinence.

As the management of incontinence occupies a large proportion of nursing staff time, the introduction of any improved aids would be very cost effective.

4. FEMALE URINARY INCONTINENCE

The area of female urinary incontinence was selected because physically, socially and psychologically, the problem is very much more handicapping. For men incontinence appliances are available which, although not ideal are manageable, efficient and sanitary, whereas no efficient appliances for external control for women have yet been devised. It is estimated that 15% of the total female population experiences some degree of incontinence and approximately 25% of the adult female population. It is considered that of this latter category, possibly only 10% of cases are reported. The number of cases are expected to increase when more attention is focussed on the subject.

5. TYPES OF URINARY INCONTINENCE

As incontinence takes various forms depending on the cause, it is important to define the nature of the leakage as this, in many cases, leads to the underlying problem.

a) Stress incontinence is estimated to effect 30-50% of all women at some period of their lives. The main reason for this problem is the overstretching and laxity of the supporting structures around the urethra (bladder neck) and the weakness of the muscles of the pelvic floor.

b) Urge incontinence - a wish to pass water at once which if not satisfied may lead to incontinence. It is often accompanied by the need to pass water frequently.

c) Dribbling incontinence - a term used when urine flows away in drops or in a trickling stream.

d) Overflow incontinence occurs when the bladder is saturated to 3 or 4 times normal capacity, but because sensation is lacking, wetting occurs. Normally found in cases of multiple sclerosis and paraplegia.

e) Fiscivious incontinence can be the result of damage due to radio theraphy or injury at childbirth. Physically it is a hole in the bladder beside the vagina but it is not a very common form.

6. EXISTING METHODS OF MANAGEMENT AND TREATMENT OF INCONTINENCE

There are certain circumstances where urinary incontinence cannot be completely controlled, however there are a few means of protection that help wearers to be comfortable and enable them to lead a normal life. The main types of protection are seen in terms of collection devices and various forms of pants and pads.

It can be categorically stated that + "there are as yet no satisfactory appliances for women to wear". In some cases the indwelling catheter is advisable but there are definite limitations to its prolonged use. The main limitation with it being that in the majority of cases this treatment is accompanies by urinary infection.

A more common solution especially for girls and young women is the ileal loop operation, i.e. an artificial opening is made in the abdomen and urine is passed into a bag attached to a belt.

Stress incontinence because it is due to a mechanical weakness of the spincter mechanism is best managed by surgical procedure designed to reinforce the urethra.

The basic approach in dealing with urgency incontinence is in the utilization of anti-spasmodic drugs.

In cases of spina bifida the recent self-catheterization programme in the National Medical Rehabilitation Centre has had satisfactory results.

The only two mechanical devices found were rarely stocked and both had various difficulties associated with insertion. One device used in cases of stress incontinence was made of a semi-rigid plastic registered and secured by the application of pressure.

+ Incontinence, pg 35.

The other device used in cases of stress incontinence was designed by John Bonnar (see list of personnel contacted) and is an intra-vaginal appliance. The device is made of soft, flexible, inert silicone and can be inserted and removed by the woman. It includes a balloon which, when inflated, raises and supports the upper part of the urethra and bladder neck. The shape is based on anatomical moulds of the vagina. Clinical trials rate its success at 60%.

Current research in the United States tends towards methods of electrical stimulation whereas the European approach relies more heavily for treatment on phaemacology. From a practical viewpoint any form of electrical treatment needs a 1 : 1 therapist/patient ratio and would be a difficult system to incorporate in the working routine of any hospital.

Among a large mobile disabled population whose bladder control was poor, there was a necessity of dehydration whenever they made trips away from home, often resulting in metabolic ill effects. There is no satisfactory solution for patients wishing to spend periods away from home. These factors do frustrate and further alienate the disabled person.

7. RESEARCH AND PROPOSED DESIGN CRITERIA

As research progressed it became apparent-that the approach to any solution apart from being divided by the types of urinary incontinence, there would have to be a further sub division to facilitate ambulant, semi-ambulant, immobile, wheelchair users etc. One device could not possibily have served the need of all incontinent patients. Accepting this as a realistic parameter and also the implied increase in unit cost of production, research continued.

Having talked with Dr. Frank Keane of the National Medical Rehabilitation Centre, who had himself in 1962 designed the urovac device for female incontinence, maintained that, considering the average rate of micturition, a device without a pump could not possibly hope to keep the patient dry.

At this stage having contacted several people from the medical profession (doctors, urologists, gynaecologists, occupational and physiotherapists) the two main problems associated with designing any device were seen as

(i) collection
(ii) registration.

The degree of manual dexterity and mental ability of the patient were also extremely important parameters. It would be necessary also to consider the age group being designed for, I found in many instances that children were prepared to try almost anything whereas in general adults were more conservative.

Having discussed the problem with Mr. J. Bonnar (who designed one of the mechanical devices mentioned earlier) at the Annual Conference of the Federated Dublin Voluntary Hospitals and St. James' Hospital, where he was giving a paper on the gynaecological background of female urinary incontinence, it appeared that any device designed could only be viewed as a temporary measure, e.g. women waiting for surgery, as a diagnostic aid, to facilitate bladder re-education etc.

Other areas of research included material selection considering such parameters as formability, weight, retention of odour, scratch resistance to minimise chance of introducing infection and reaction with chemical compound of urine or other noctious fluids. Any design would have to incorporate a non-return valve. At this stage in my research I had been offered, by a company currently manufacturing prosthetic devices, involving rubber mouldings, any help that would be necessary in building prototypes.

Medical opinion advised that a realistic test period for any test period for the effectiveness of any aid would have to be seen in terms of three to four years, and longer in the area of monitoring conclusively any possible tissue degredation resulting from continuously applied pressure. Prolonged clinical testing for a non medical person would present difficulties.

Registration and its implied application of pressure possibly resulting in internal or external ulceration was one of the main contributing factors in deciding finally to discontinue this line of research.

8. CONCLUSION

Until relatively recently incontinence has not received much specialized attention from the medical profession or the media, hence the allocation of funds towards research in this field has not received priority. Considering increased life expectancy and the general level of educaiton towards fitness and self awareness, this problem will inevitably receive more attention in the future. Perhaps the reason for this apparent lack of attention to date is that although incontinence is unpleasant, it is not a terminal condition and can be endured.

The medical profession is now more actively involved but a greater acceptance and knowledge of the widespread existence of incontinence by the average person, would help not only those who have to endure the condition but also those attempting to find remedies.

The work I have done in this area, in spite of not reaching a satisfactory conclusion, has nevertheless strengthened my interest in the field of rehabilitation engineering.

9. BIBLIOGRAPHY & OTHER SOURCES

1. Aids for Rehabilitation & Physiotheraphy, Wheelchairs/ Incontinence, Cat.No.T002 (Lic.S-17183 Solna-Sweden)

2. BATES, C.P., FRCS, "Continence and Incontinence", Reprint from Annals of the Royal College of Surgeons of England, July 1971, Vol.49, p.18-35.

3. BONNAR, J., 'Gynaecological Background', Information from a paper on "Urinary Incontinence in the Female". Paper read at the Federated Dublin Voluntary Hospitals and St. James' Hospital, Annual Conference and Trade Exhibition 1981. (Prof. J. Bonnar, Professor of Obstetrics and Gynaecology, T.C.D., Consultant Gynaecologist, Rotunda and Adelaide Hospitals).

4. BROCKLEHURST, J.C. (Professor of Geriatric Medicine in Manchester University) Geriatric Medicine and Gerontology.

5. BUTLER, M. Consultant Urologist, Meath and St. James' Hospital. Paper read at Federated Dublin Voluntary Hospitals & St. James' Hospital Annual Conference. 'Urinary Incontinence in the Female. The Urologist's Approach'.

6. CROSBY, Edward G. & KOCHNIS, Stephen N., Practical Guide to Plastic Applications, Boston: Cahners Publishing Co.Inc., 1972, Maple Press Company, U.S.A.

7. Equipment for the Disabled;'Clothing and Dressing for Adults (2)', 3rd ed. Published by the Oxford Regional Health Authority, 1975.

8. GOLDSMITH, Selwyn, Designing for the Disabled, 3rd ed. 1976, Published by RIBA Publications Ltd. England.

9. GUYDON, Function of the Human Body, 4th ed. Published by W.B. Saunders Company, Philadelphia, London, Toronto.

10. HALE, Glorya, ed., The Source Book for the Disabled; published by Paddington Press, London 1979.

11. International Conference on Rehabilitation Engineering Proceedings, 1980, Toronto, Ontario, Canada, published by Conference Committee.

12. MANDELSTAN, N.C.S.P., Dip.Soc.Sc., Incontinence; London: published by Heinmann Health Books for the Disabled Living Foundation, 1979.

13. MARTIN, E., Information from a paper read at the Federated Dublin Voluntary Hospitals and St. James' Hospital Annual Conference and Trade Exhibition, February 1981, "Urinary Incontinence in the Female: Neurological Aspects" (E. Martin, Consultant Neurologist, Adelaide Hospital).

14. Modern Plastics Encyclopaedia 1968, Vol 45, No.14A, 100 Years of Plastics, Published by McGraw-Hill Inc., N.Y.

15. Myles Textbook for Midwives, with modern concepts and neo-natal care, 8th ed. Churchill Livingston, 1975, London, Edinburgh & New York.

16. PEARSE, Evelyn, A General Textbook of Nursing, 19th ed., Faber and Faber, 1974.

17. POMANES, G.J., ed. Cunninghams Textbook of Anatomy, 11th ed., Published by Oxford University Press, 1972.

18. ROSS, Janet S. and WILSON, Kathleen J.W., Foundation of Anatomy and Physiology, 4th ed., Churchill Livingston, 1973.

19. SHUTTLEWORTH, K.E.D., "Urinary Tract Diseases: Incontinence", British Medical Journal; 19th Dec., 1970 (4,pp.727-9)

20. STANTON, S., Female Urinary Incontinence

21. TOOHEY, Medicine for Nurses ed. by Bloom, Arnold, 10th ed., Churchill Livingston, 1971.

22. Urology Digest: July 1977, Article on"Self-Catheterization Programmes"

10. EXPERTS AND INSTITUTIONS CONTACTED FOR INVESTIGATION AND RESEARCH

Dr. Tom Gregg, Medical Director, National Medical Rehabilitation Centre.

Dr. Frank Keane, Spinal Unit, N.M.R.C., Inventor of the Roto-rest Bed and Urovac.

Dr. Mervyn Kidd, Gynaecologist, Assistant Master of Coombe Lying-In Hospital, Dublin

Dr. Ivers, Consultant to Fannins Medical & Surgical Suppliers, Fannin House, Bishop St., Dublin 8.

Dr. Keating, Geriatrician, St. Vincent's Hospital, Elm Park, Co. Dublin.

Dr. Hutchenson, St. Vincent's Hospital, Elm Park, Co. Dublin.

Dr. Jim Malone, St. James' Hospital, Dublin

Dr. E. Martin, Consultant Neurologist, Adelaide Hospital.

Prof. J. Bonnar, Professor of Obstetrics & Gynaecology, T.C.D., Consultant Gynaecologist, Rotunda & Adelaide Hospitals.

Mr. M. Butler, Consultant Urologist, Meath & St. James' Hospitals.

Mr. Eugene Murphy, Engineer, Medical Director of Meedering (manufacturers of prosthetic devices) Cookstown Industrial Estate, Belgard Rd., Tallaght, Co. Dublin.

<u>Occupational Therapists</u>

Dymphna Gilligan, Founder of U.V.O.H., Aids Information Service, Monkstown, Dublin.

Sr. Eugene Butler, St. Anthony's Medical Rehabilitation Centre, Dublin.

Marianne Meany, St. Anthony's Medical Rehabilitation Centre.

Dee Patterson, Physiotherapist, National Medical Rehabilitation Centre, Dun Laoghaire.

Nurses

Mrs. Brid. Murphy, Self Catherization Programme, N.M.R.C.

Mrs. Kavanagh, Assistant Matron, N.M.R.C.

Miss Maria Dolan, St. Vincent's Hospital, Elm Park, Co. Dublin.

Suppliers of Existing Devices for Female Incontinence

Mr. John Hilary, Surgical Distributors Ltd., Stephen's Lane, Dublin.

Mrs. Ann Moore, P.E.I. Surgical Ltd., Fade St., Dublin.

Ms. Oonagh O'Neill, Fannins Medical & Surgical Suppliers.

Disabled Living Foundation, London, England.

DESIGN OF A 'GROWING' WHEELCHAIR
FOR CHILDREN IN THE 4-10 AGE GROUP

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Faculty of Design

National College of Art & Design, Dublin
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June 1981

CONTENTS

1. INTRODUCTION

The approach to this project assumes that the purpose of living is to make the most of being alive. This implies realizing one's potential, making full use of talents and the opportunities and challenges that everyone experiences and to achieve varying degrees of personal fulfillment.

But if we consider the life of a person with a disability we find that he is often doubly handicapped. The first and perhaps the more obvious one is that he does not have the physical capabilities that others have. The extent varies considerably from one individual to another and the individual's personal aspirations, personality and talents do, as for an able-bodied person, determine greatly the quality of a person's life. But, in many cases, the resultant effect of a physical disability is some degree of social, financial or emotional deprivation.

He is, however, secondly handicapped because he is perceived by others as handicapped, with social doctrine dictating that to have a disability is to be impoverished. In many instances associates tend to manage the situation for him so that opportunities can be actually limited and hence his performance matches their expectations.

Much of the first kind of handicap can be alleviated by props, usually of a physical nature and it is in this area that my project basically concerns itself. The second kind of handicap is perhaps more damaging in that its causes are more culturally entrenched and cannot be modified by physical remedies. This raises the whole question of the psychology of disability and the interaction of society and the person with a disability, within its competitive value system. To rectify this situation would call for a total social restructure. But gradually with an increased awareness of disabilities and their implications, and in the designing of aids which bring about greater mobility and participation in every day events by the disabled, disabilities will slowly be accommodated by society causing the disability to be physically and socially less handicapping. But within the constraints of these challenges the commitment is to enhance the opportunities for people with disabilities and to extend the possibilities for their involvement in the ordinary busy world.

However, the designer's aim, by designing aids and systems, to increase independence, or the architect's attempts to structure buildings so as to accommodate handicapped persons must always bear in mind an awareness of the psychological results of their designs to ensure that they do not actually diminish the lives of handicapped persons. The balance can be delicate as policies of segregation are not always undesirable or policies of "normalization", independence and challenge. Perhaps one of the most important facts to keep in mind is that we are all the time designing for individuals who have different resources to draw from and there are many disabled people who do not have the physical or emotional capacity to cope with the challenges of normal living. For these who do prefer to opt out it is necessary that the opportunities to do so are available.

The understandable tendency for a person with a disability to generalise from personal and specific experiences is not as prevalent now, as it is more widely recognised by able-bodied and by people with disabilities that according to their resources individuals who disabled respond in different ways to the same situation. However, in any design situation it is necessary for the designer to be conscientious and objective as an observer if he is to develop an acceptable solution. No-one, unless entirely paralyzed, blind, deaf and irretrievably brain-damaged, is totally disabled, which is why the general term 'disabled' is often inappropriately and even offensively used. 'People with disabilities', 'people who have disabilities' are expressions used through this text for lack of a better or more immediately understood expression.

2. PROJECT PROCEDURE

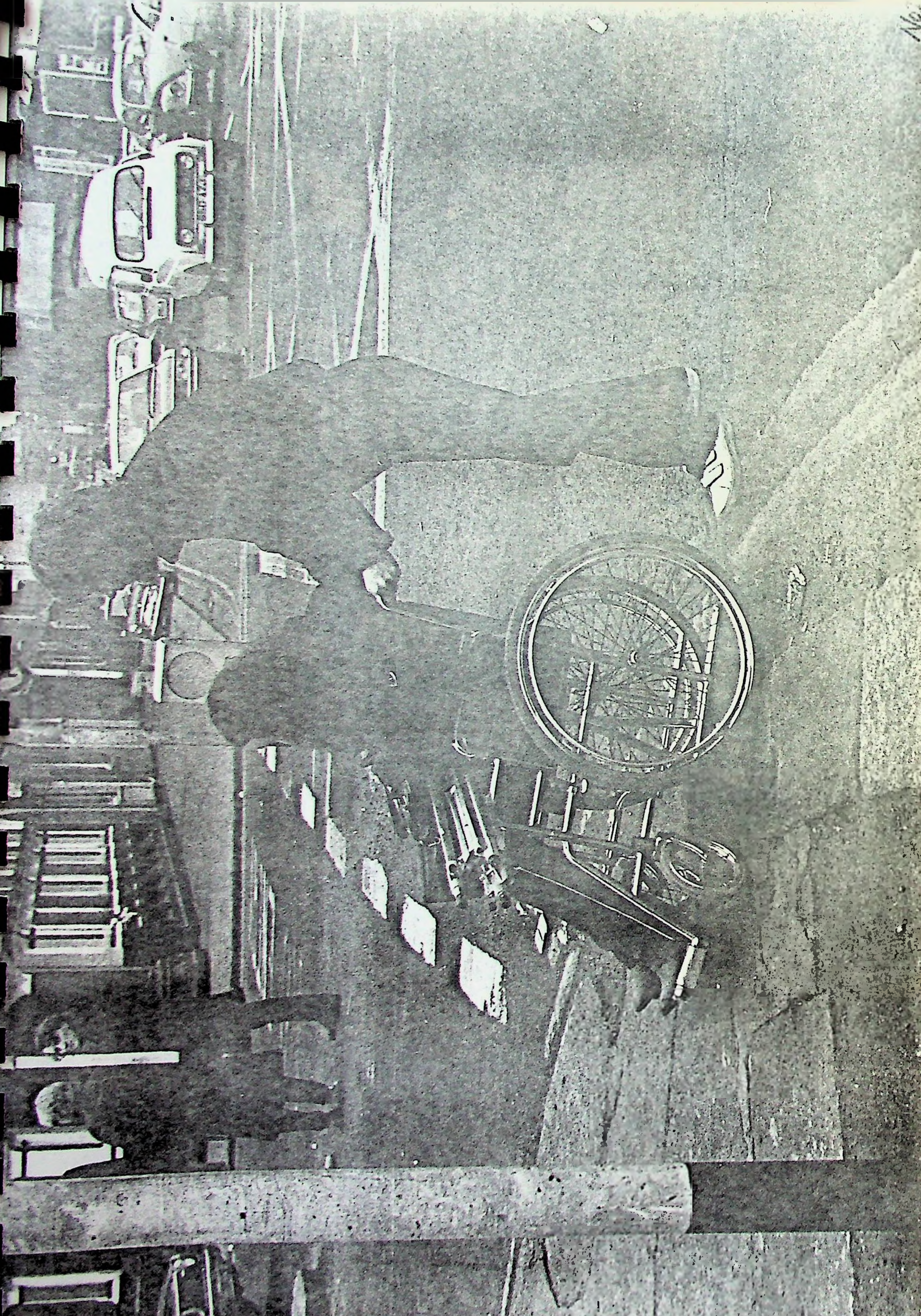
2.1 DATA COLLECTION

At the onset of the project a wheelchair was borrowed from the Irish Wheelchair Association in an attempt to familiarise the designer with the existing wheelchair, and of the problems and challenges encountered by the wheelchair user. It was made freely available to the other students which gave many opportunities for observation and promoted many interesting ideas. It was felt also that the presence of the wheelchair increased the level of awareness of the many other students to the needs of a wheelchair user.

As part of this field research, the chair was taken outside the building one afternoon, with the help of two student colleagues. Attempts to climb and descend pavements alone and attended, to do shopping at a previously arranged supermarket, were some of the items recorded.

The following paragraphs demonstrate some of the difficulties encountered and the problem of carriage of goods by a wheelchair. Observations were noted at the time and in retrospect on seeing the photographs brief summaries of these observations follow the photographs.

DATA COLLECTION



No2

No3

No 1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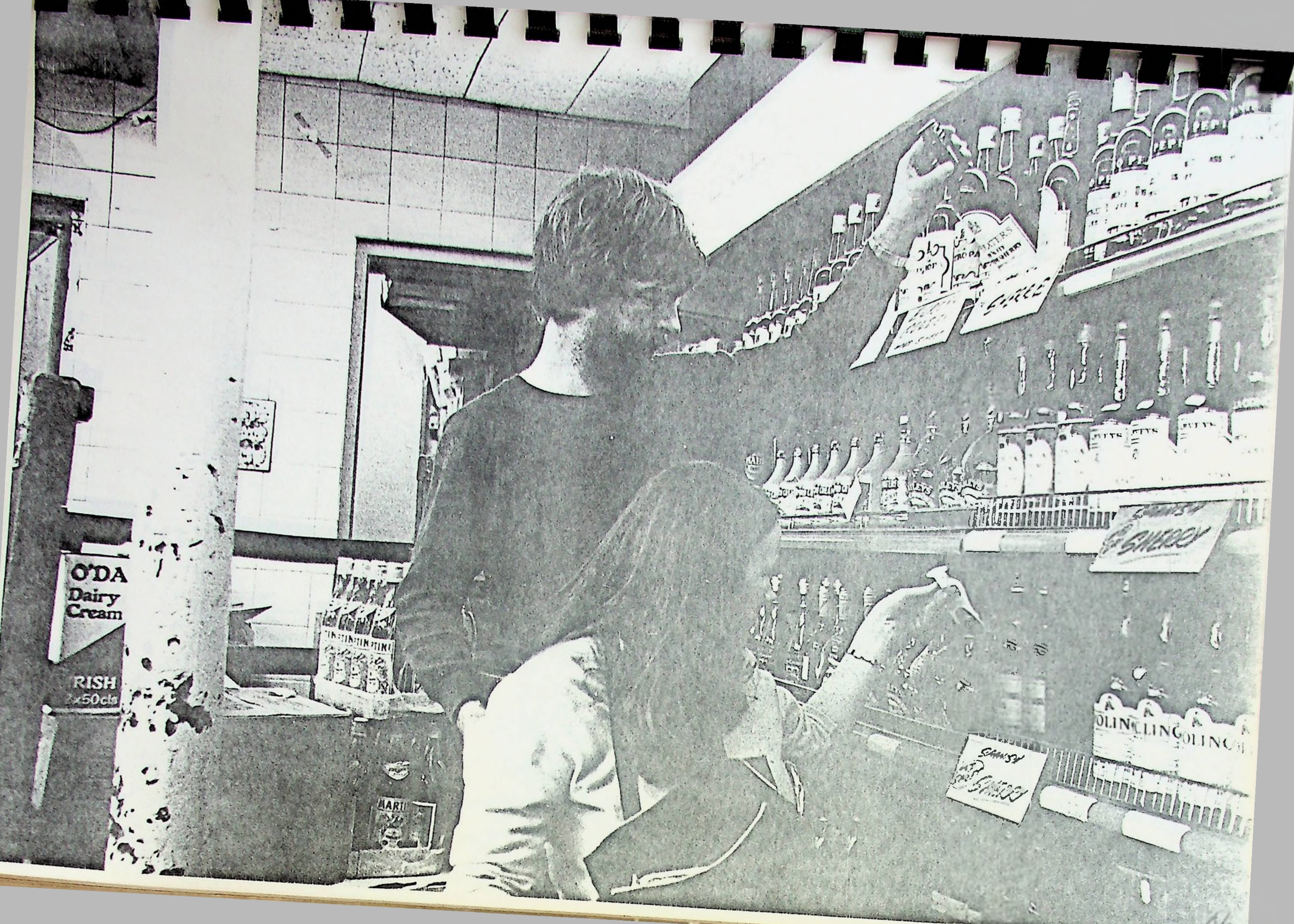
STEAK
Cream Crackers
Cream Crackers
Cream

No.6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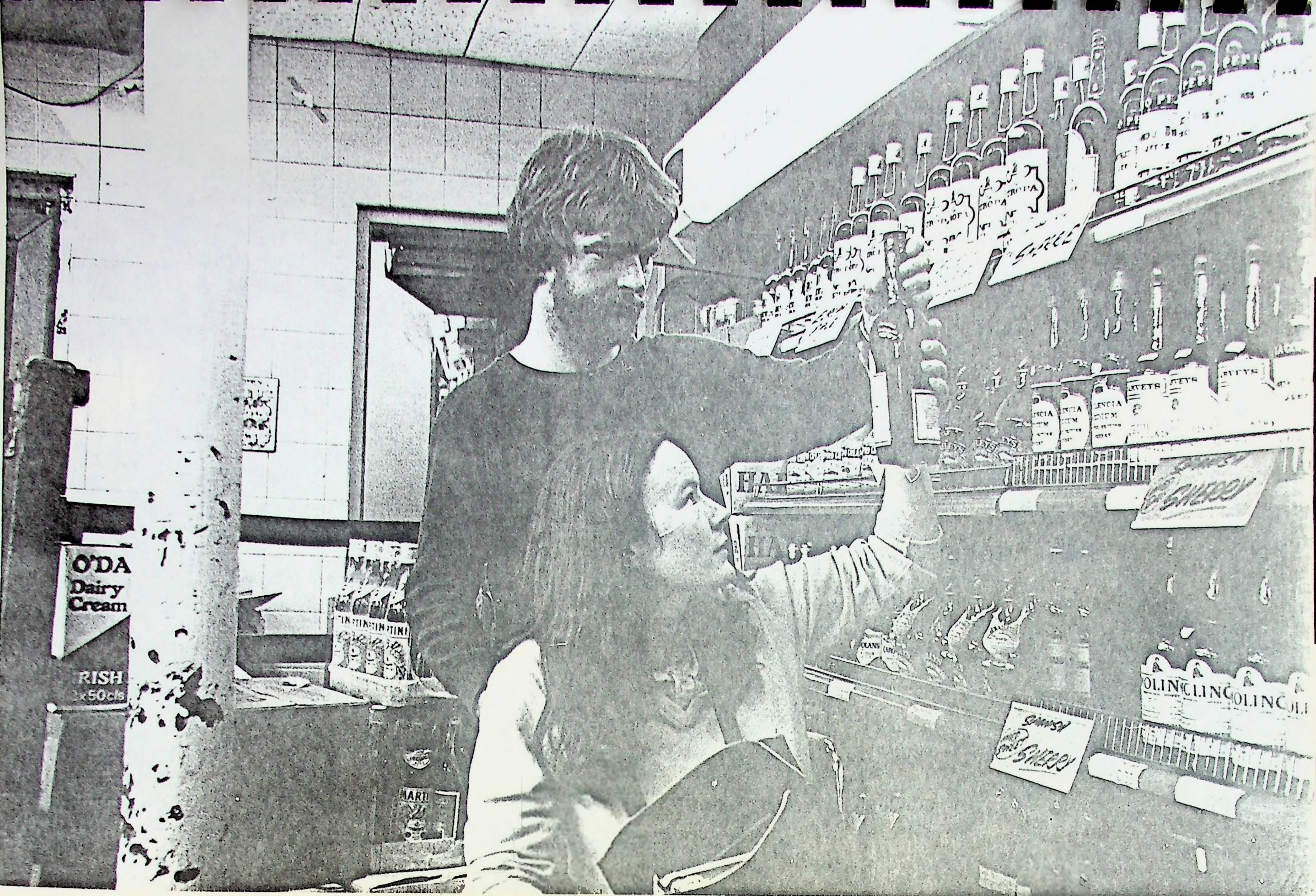
O'DA
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23
33
29
CRACKERS
WIN

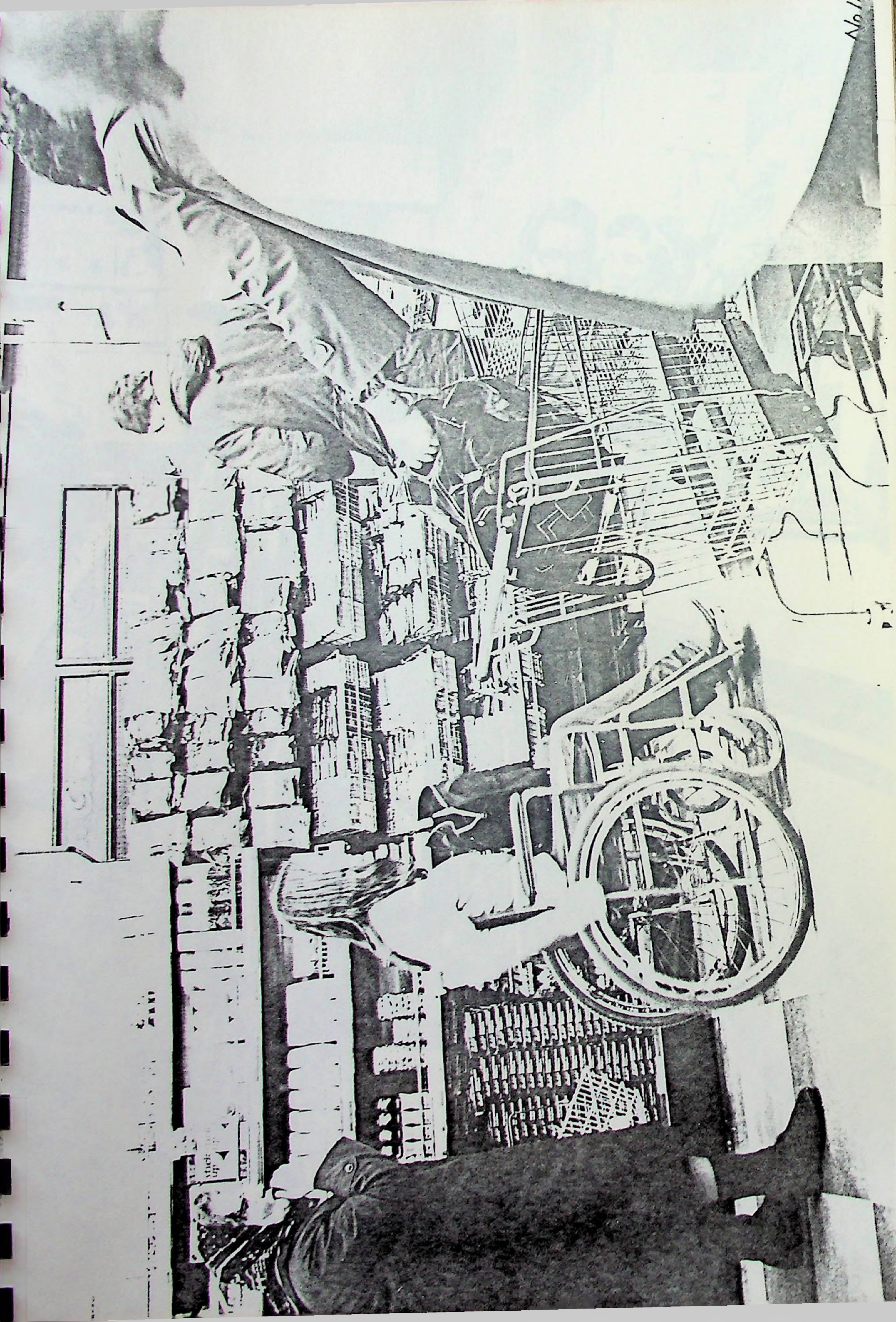
No.11

No12

PHOTOGRAPH
NUMBER:

1.	Attendant was only of average height, yet it was necessary to stoop in order to reach push handles. For hospital orderlies this would, over long periods provide back strain. Many curbs were impossible and dangerour to attempt unattended. Carriage of goods a problem.
2.	Swinging doors a problem, only left one hand for propulsion. Rubber bungs on foot plates were used to push door open. Grazed knuckles on many occasions! Width a constant problem.
3.	Bag around neck and resting in lap one of the most convenient solutions to the problem of carrying goods. Hands were left free to propel chair. Solution may pose a problem for someone with bad balance. Try with straps around chair backrest providing a form of safety belt?
4. & 5.	Depth of shelves often more of a problem than height. Back used as a lever here.
6. & 7.	Foot plate storage comfortable for loading but unloading or changing item in any deep container difficult.
8. & 9.	Often difficult to read labels of products on higher shelves. Incorporated hydraulics? Little difference in shelf height suitable for an adult wheelchair user and smaller older person.
10.	Possible bending capability. From waist downwards immobolized but reasonable grip balance necessary. Stability of chair absolute necessity.
11. & 12.	Increased height was gained by drawing alongside shelves. Would perhaps held if foot plates were nearer main frame but still maintaining space necessary for trail of castors?

No 13



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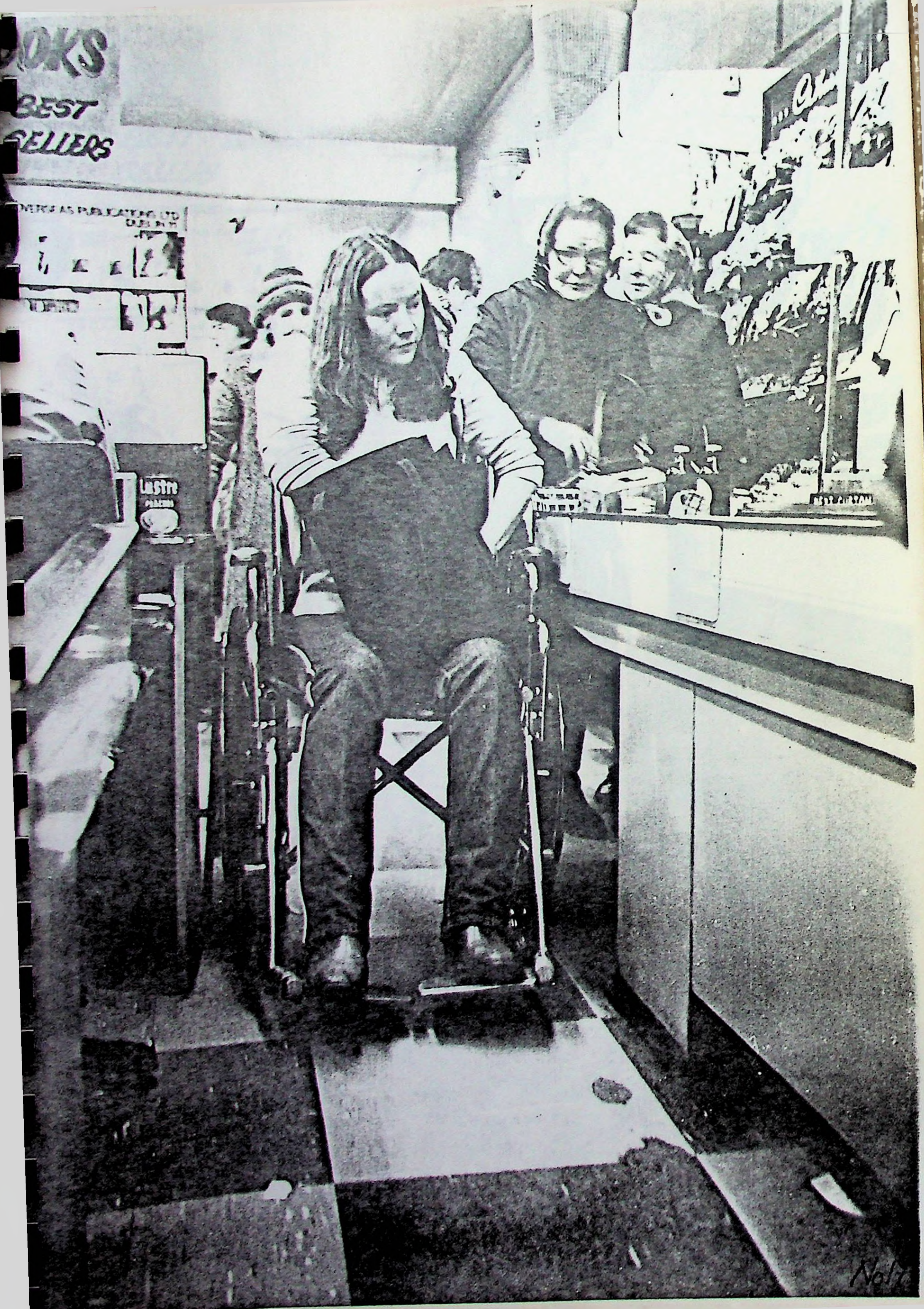
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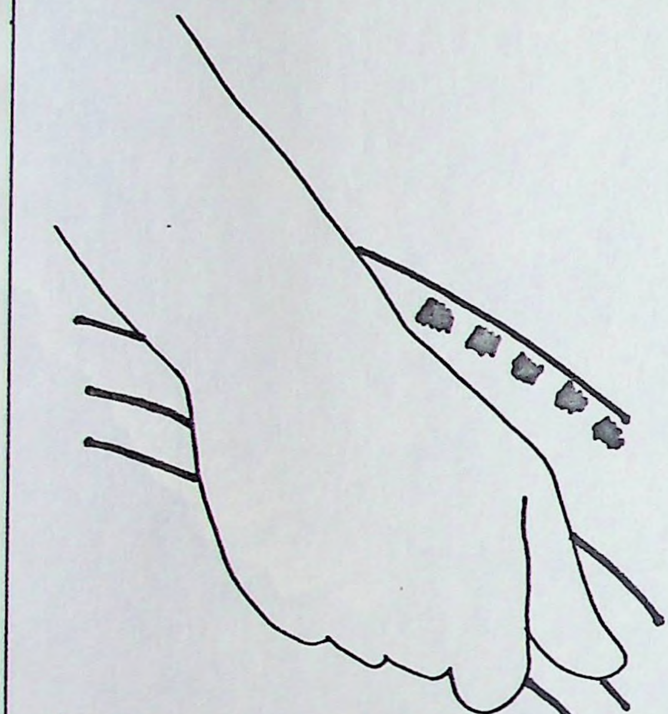
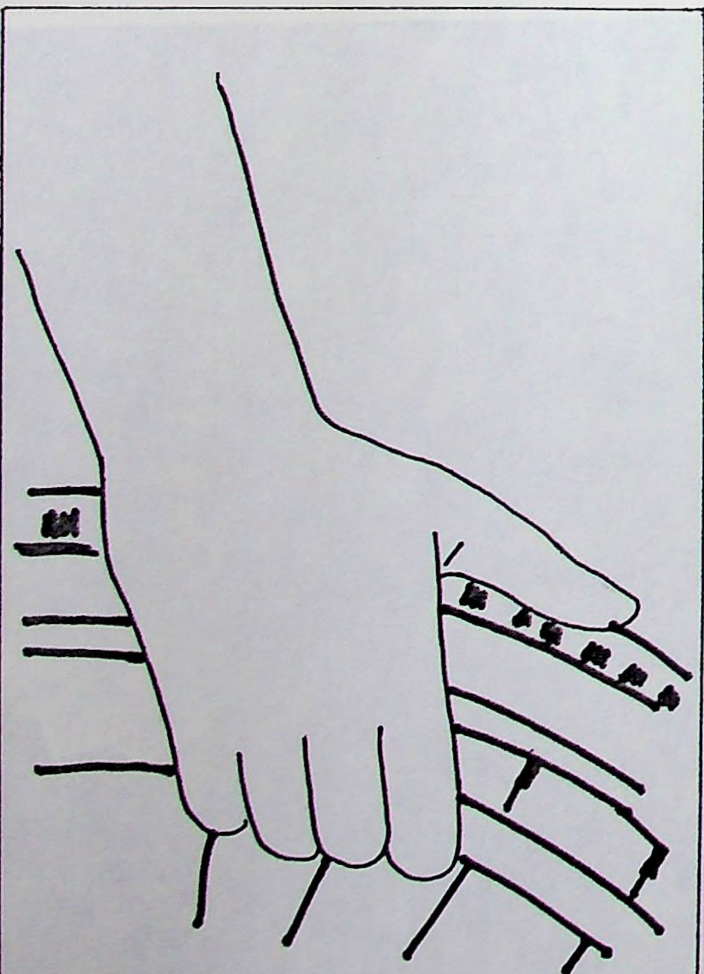
BOOKS
BEST
SELLERS

Fig. 1

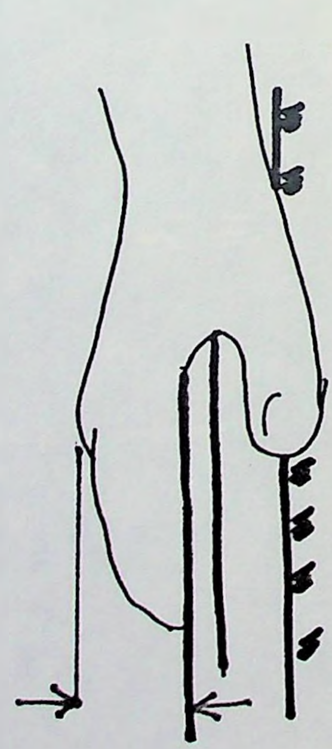


1. INTENDED GRIP ON HAND RIM

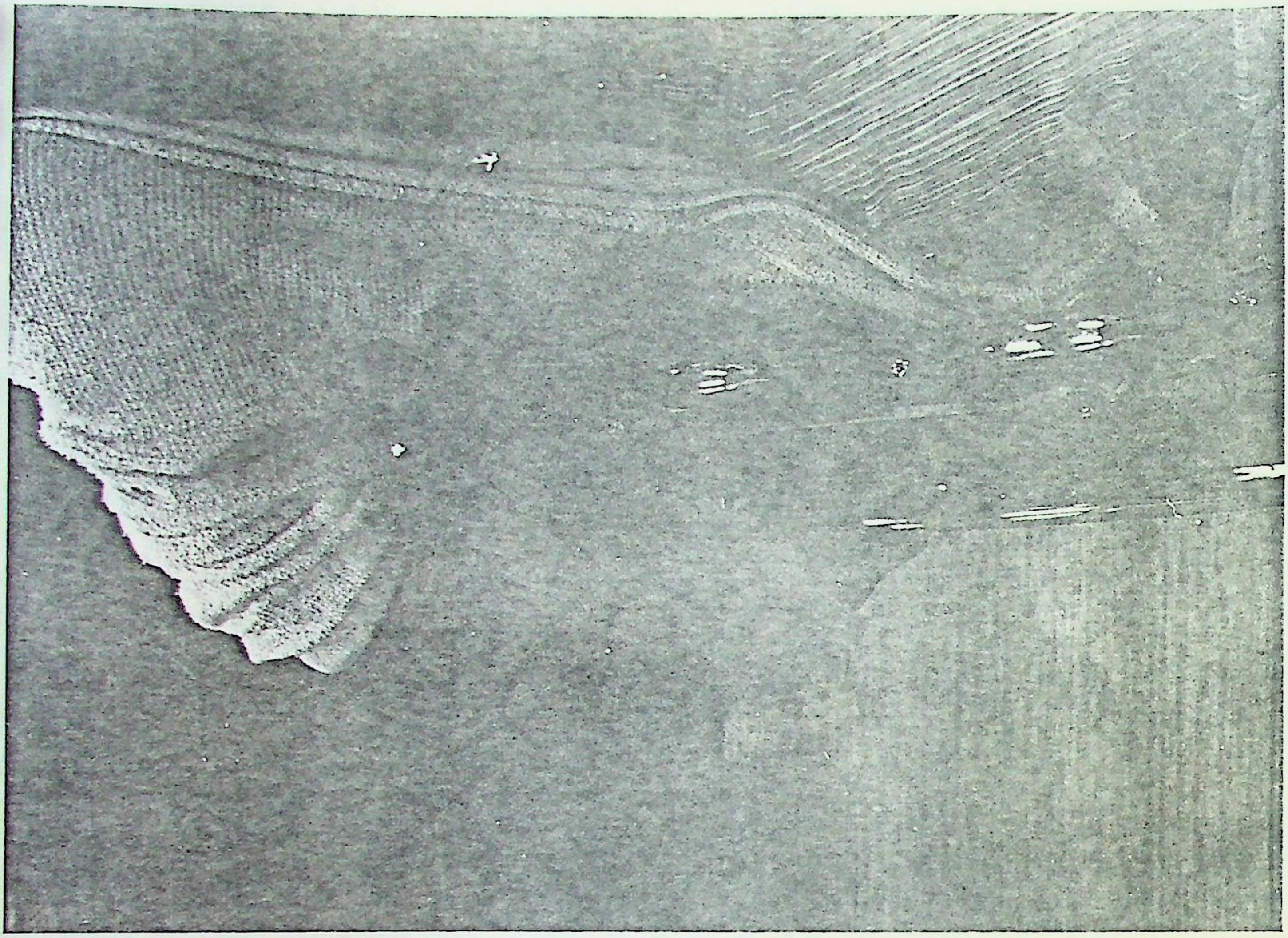
1.A. WIDTH OF HAND FROM RIM USING INTENDED GRIP

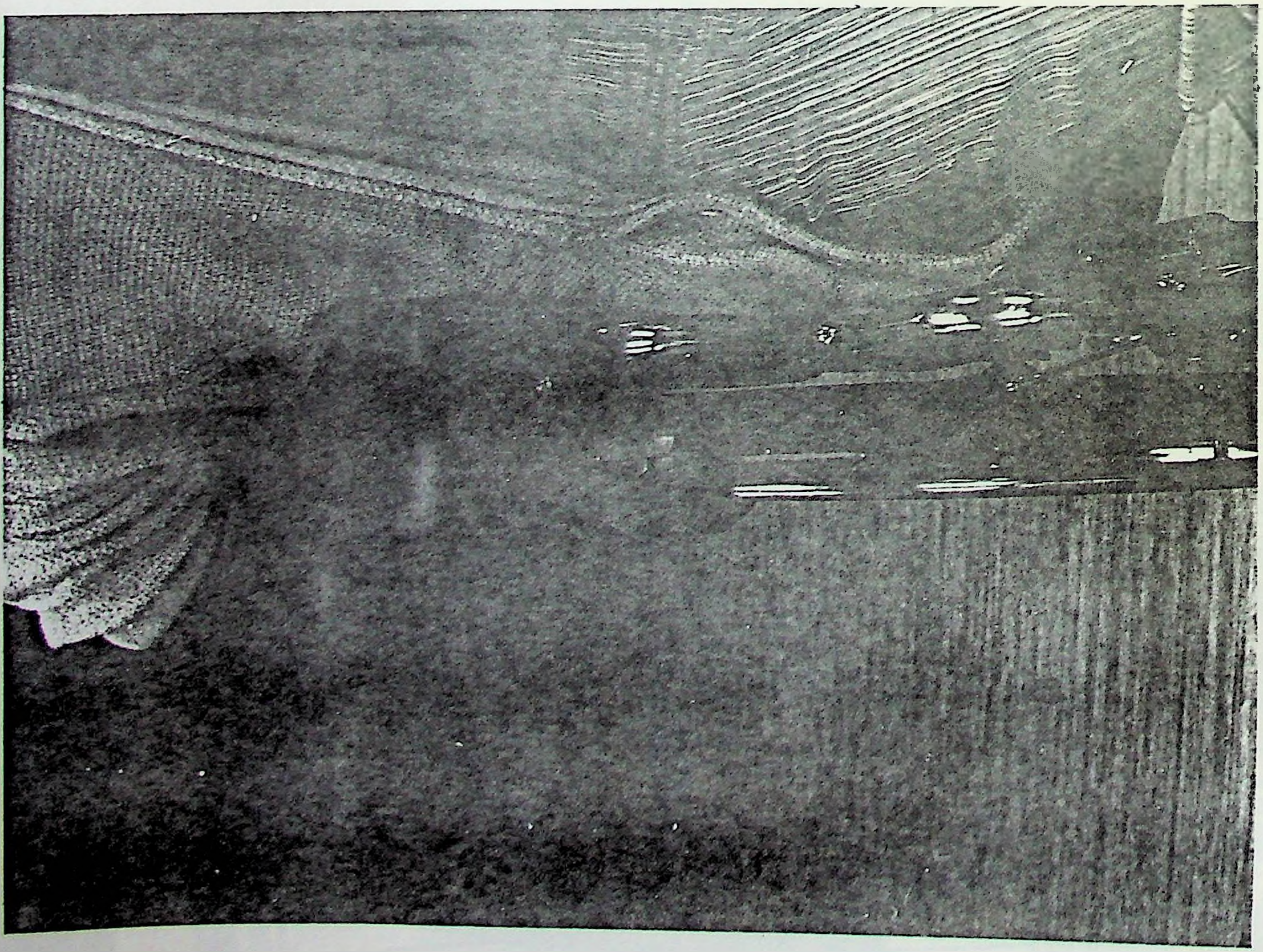


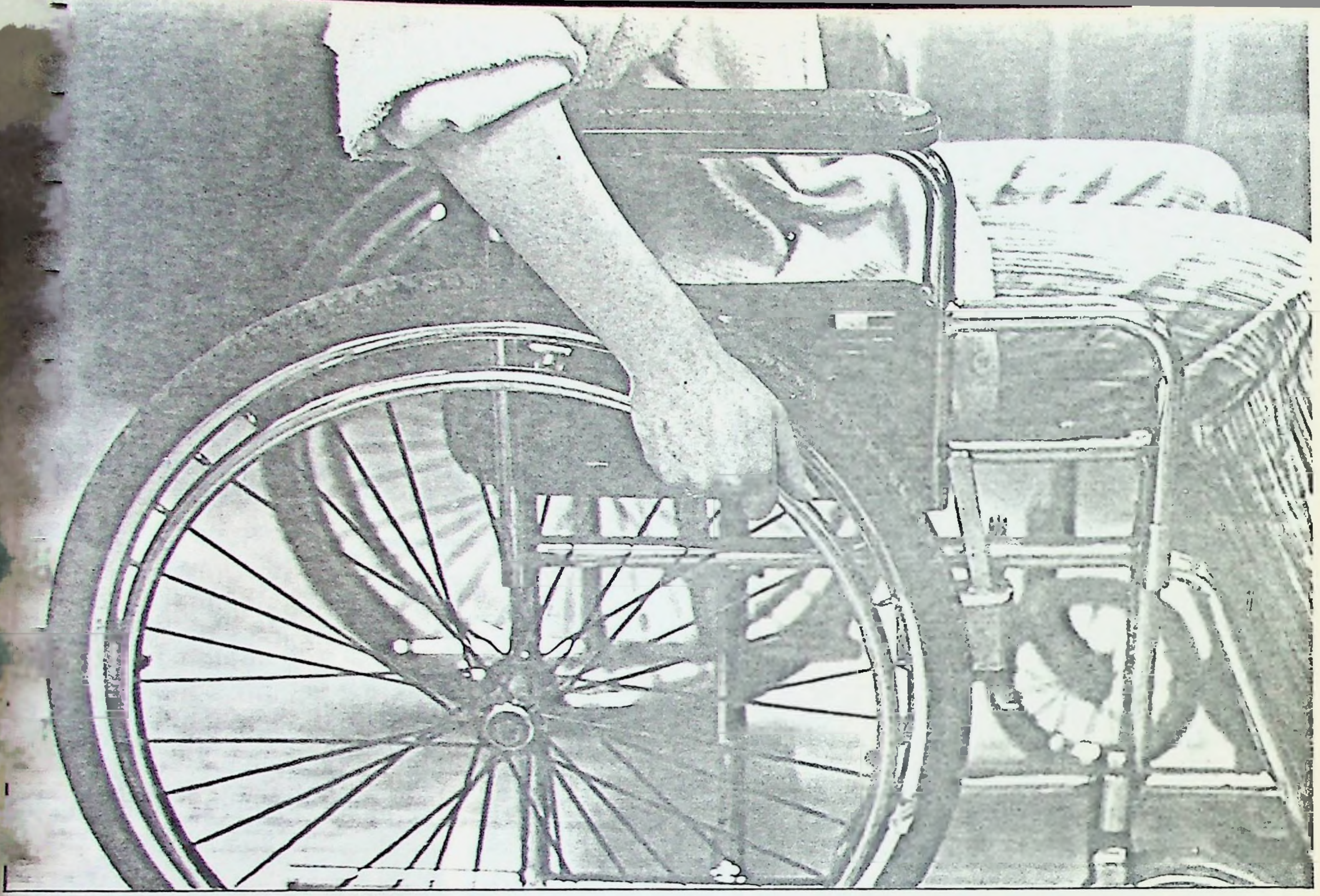
2. COMMON GRIP USING TYRE AND HANDRIM → GREATER CONTROL

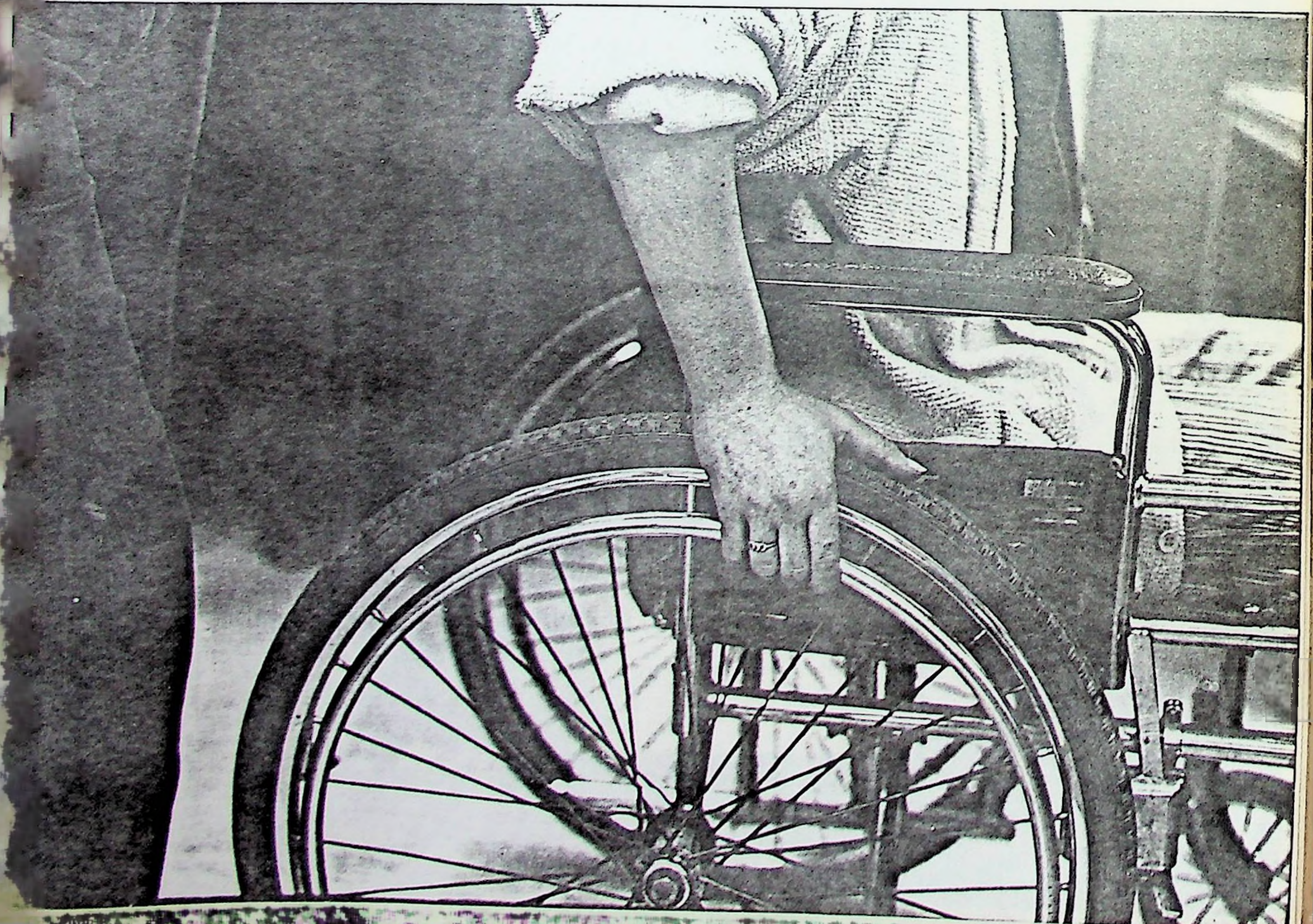


2A. MORE NARROWL WIDTH USING TYRE & RIM GRIP → BUT







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PLEASE
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DOG
OUTSIDE
SMEDLEYS
STRAWBERRIES
RICE
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STRAWBERRIES
45p
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PORK
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Jaffa
Jaffa
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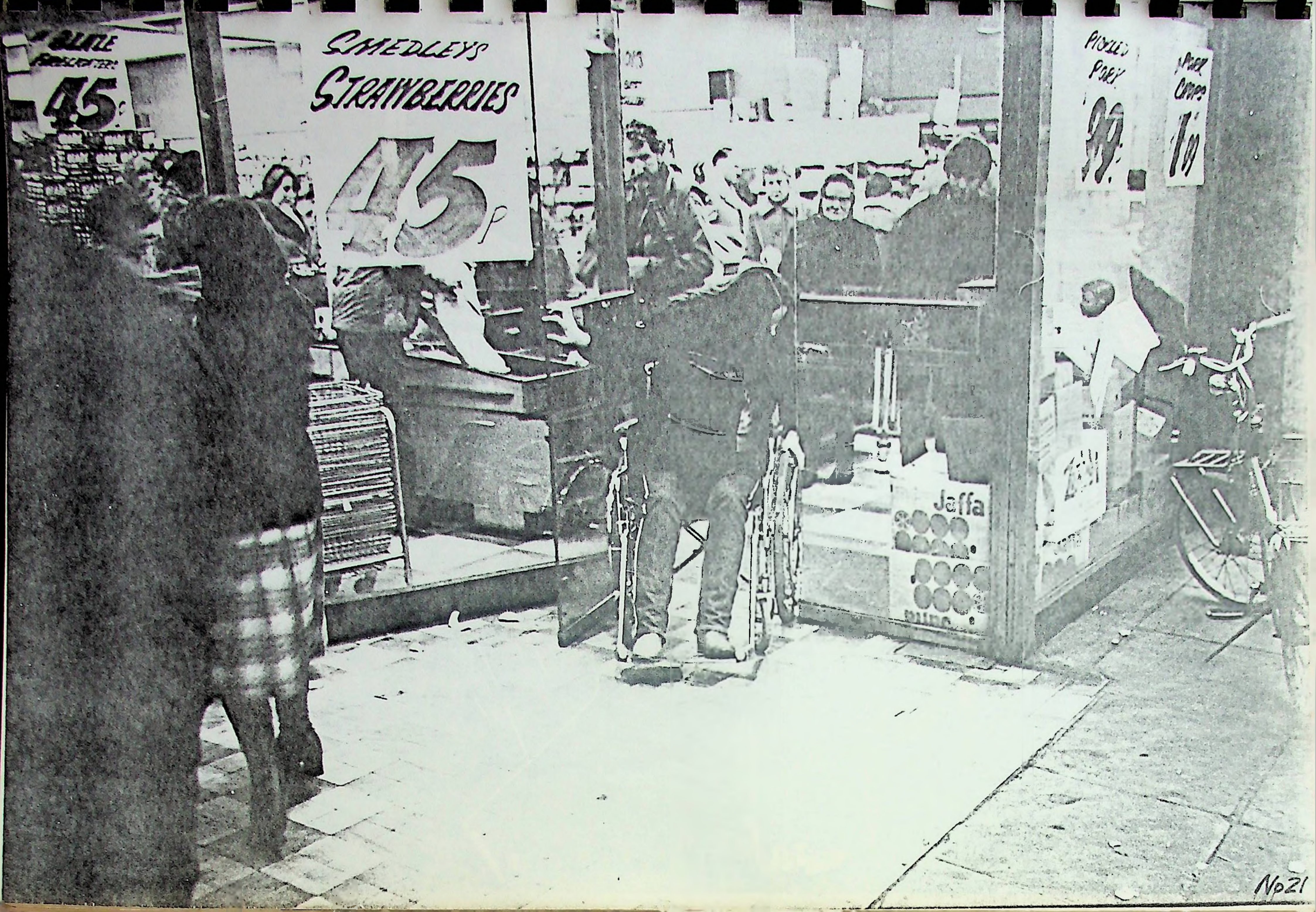
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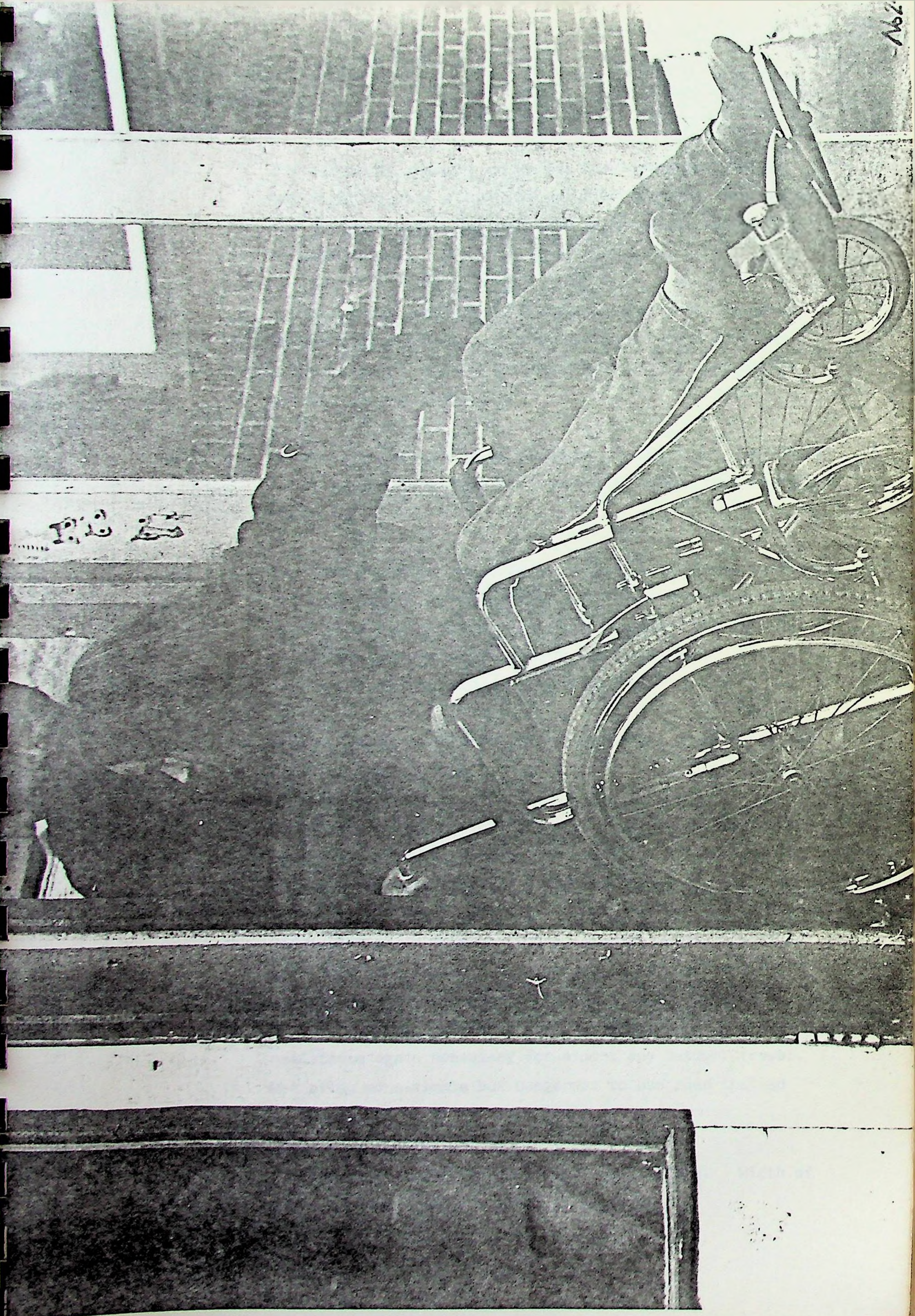

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NUMBER:

13. The method of carrying goods was considered too unstable but might provide a possible solution if clips attached to the standard basket were in turn attached to the arm rests or main frame.

14. It was always possible to ask for help in reaching goods on the higher shelves but this would be unnecessary with extra height. General attitude helpful but many people avoided any eye contact.

15. Considerable amount of manoeuvering at checkouts, necessary to have both hands free for control of normal self propelled chair.

17. Too deep a carrier was slow for unloading although convenient for packing and carrying goods. Hands and sleeves dirty from using tyre instead of handrim to propel chair. By using the tyre for propulsion it was possible to save a few mm. on either side. (See Fig. 1)

18. Grazed knuckles again! Quite tired having shopped for less than one hour.

19. Both hands necessary for doorways. With more experience in the chair it was possible to propel up to the door and remove hands when travelling through it.

20. & 21. Difficulty again in negotiating swinging doors this time, with load on a less durable surface, e.g. paintwork, Using bungs on end of footplate would cause damage.

22. Assistance again necessary for almost any outdoor travel. Was often more simple but dangerous to use road instead of pavements.

23. & 24. A phone call on the way home proved impossible. Width of doorway, step, height of mounted phone etc.

No.25

No26.

No27

No.28

No 29

No.30

Fig. 2

PHOTOGRAPH
NUMBER:

25. - 30. Series of photographs showing a range of movements and possible reach heights assuming reasonable balance. Summation of the movement range from photographs 25. - 30. (See Fig. *2*)

Summary of Findings

The exercise did prove helpful in increased understanding of some of the obstacles encountered every day by the wheelchair user. The interaction with other pedestrians and shoppers proved an unexpected dimension and an interesting part of the exercise. Of the many special features available for wheelchairs, e.g. curb climbers, width decreasers etc., it must be remembered that the greater the number used, the bulkier, heavier and less convenient the chair becomes for normal use. The design at all stages has operated within this realization.

2.2 PROJECT SPECIFICATION

The project specification was divided into two main areas considered for improvement, i.e. general areas and specific areas or components

2.2.1 General

1) To design a wheelchair specifically for children between the ages of 4 - 10 years, suitable for manufacture in Ireland.

2) To provide a greater range of accommodation for the user and attendant.

3) To design the frame construction for propulsion by occupant and with a minor adjustment to convert the chair to attendant-propelled.

4) To reduce and simplify the number of components on the existing chair.

5) To design a supportive and adjustable seating system that the 'growing' factor of the design remains as a part of the solution.

2.2.2 Specific Areas and Components

1) To design height adjustable push handles.

2) To design a supportive, adjustable and collapsible backrest.

3) To design height adjustable arm rests that remain an integral part of the chair and that will fold away to permit unobstructed side transfer of the occupant.

4) To design a stronger, safer and more suitable

skirt guard for the user.

5) To design a supportive, adjustable (depth and width) and collapsible seat.

6) To design a leg rest with a range of height and angular adjustments and with foot plates that pivot upward to facilitate folding.

7) To improve on the main frame/castor link.

8) To reduce the overall length for easier manoeuverability and storage.

9) To provide a more suitable foot tipping bar so that its function is more apparent to the occasional user.

10) As a result of work done on carriage of goods for wheelchair users, it was concluded that under chair storage was an area with vast potential and free space except for the 'X' cross frame. Hence it was decided to attempt to change this construction to eliminate the need for telescopes that currently exist for folding (See Figs. 3&4) and a solution that would permit storage.

11) To have the driving rim as an integral part of the wheel which would be injection moulded and would replace the conventional bicycle.

12) To investigate the possibility of changing the upholstery to a 'breathing' fabric.

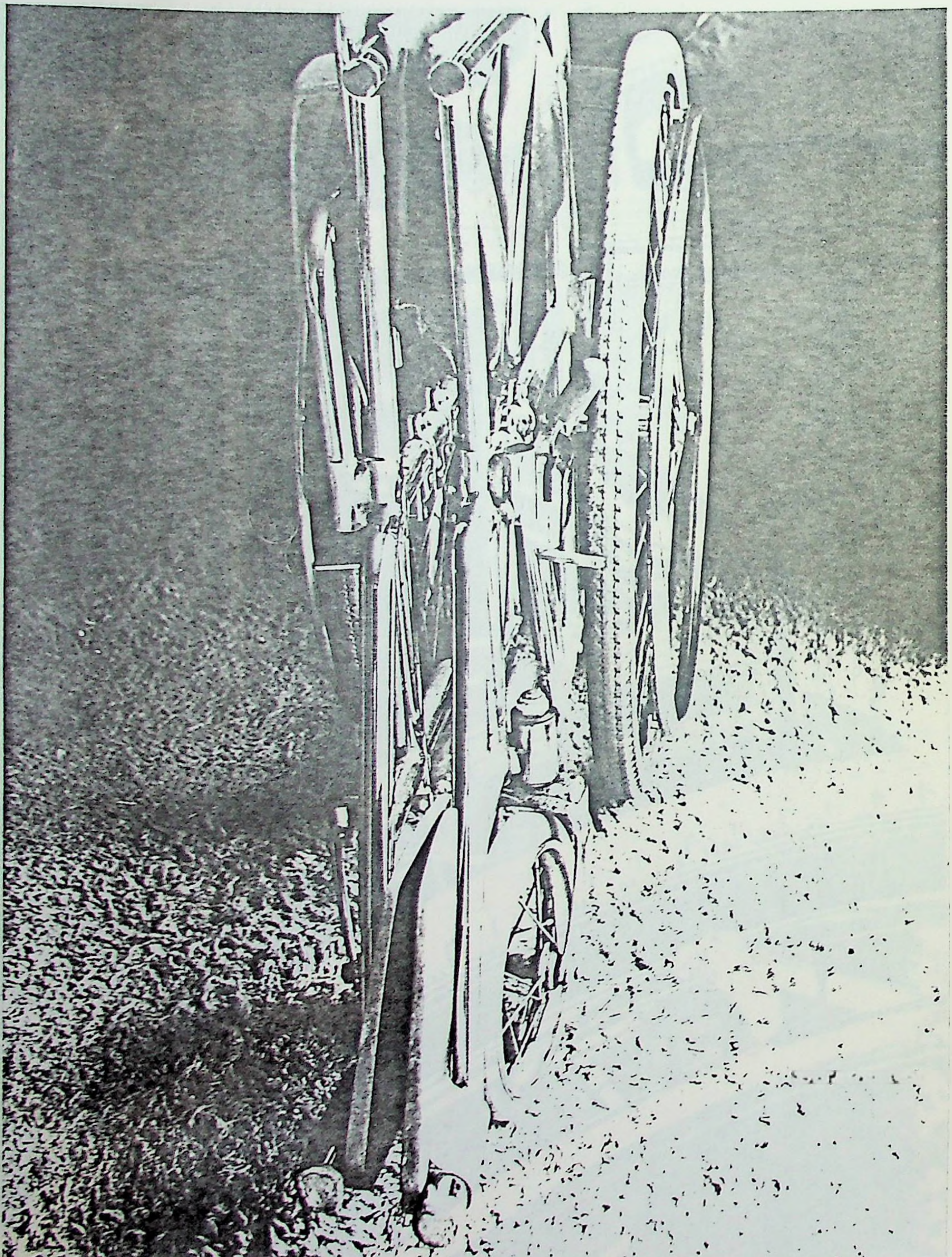


Fig. 3

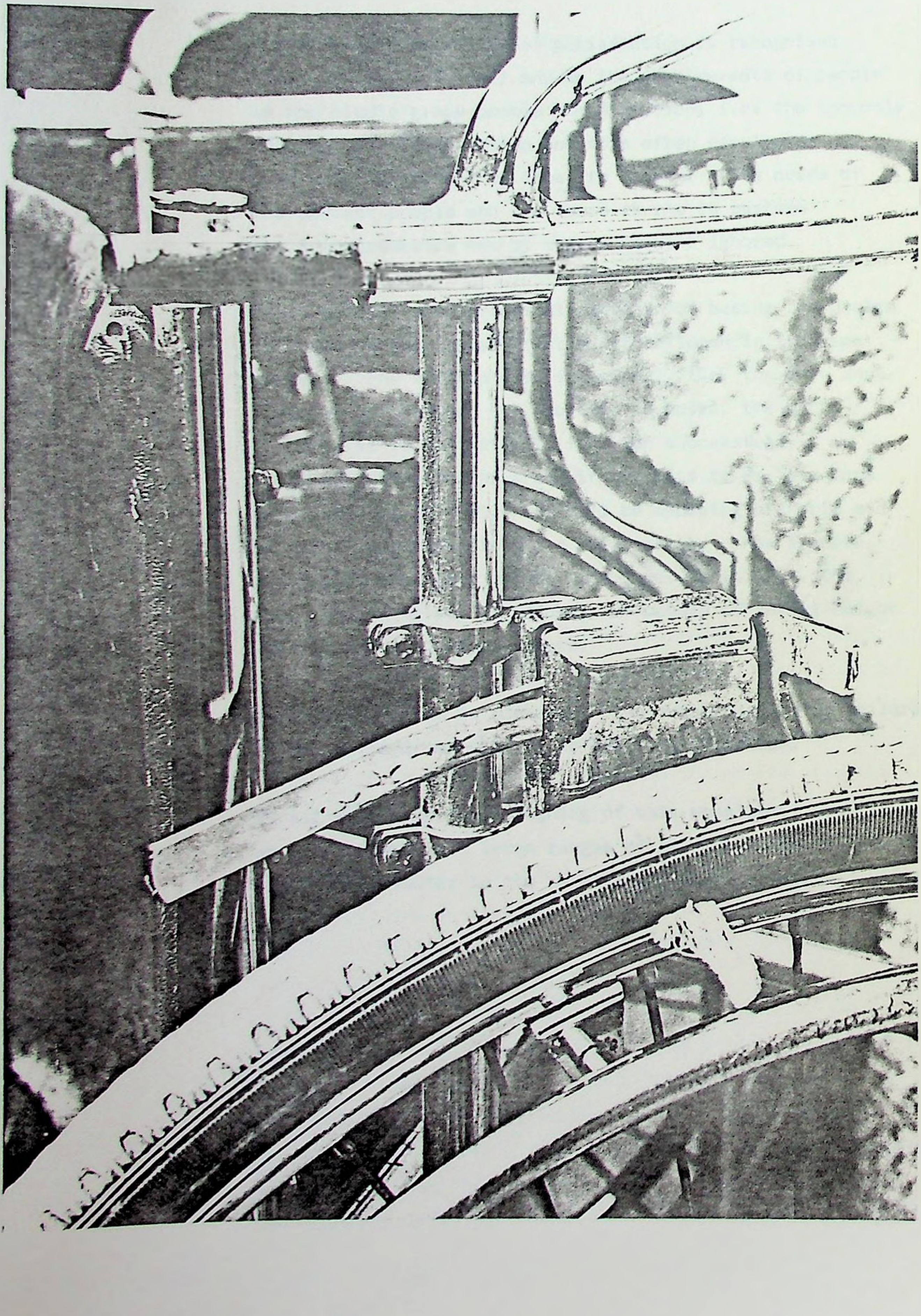


Fig.4

3. GENERAL ANTHROPOMETRIC CONSIDERATIONS

The provision of universal satisfaction is recognised as an unattainable goal and so the requirements of people in the middle group become the criterion, i.e. the commonly adopted 5 - 95 condition and this often results in a compromise solution not ideal to anyone. The needs of the deviant people who are found in the 5% sectors at the extremities are by common consent ignored.

There are two main practical reasons for basing the design criteria on the characteristics of children in the mean ranges. The first one is functional, i.e. the more any facility is designed for specific purposes, the more probable it is that it will function successfully. Likewise, the more universal it attempts to be, the more inevitable it is that there will be opposing criteria and hence a compromise situation will result. For example, the height of a wash basin: the lower it is made, the more unsatisfactory it becomes for people of normal height who are the majority of users.

The second reason is economic: the accommodation of children at the extremities will cause additional expense.

At all stages in the designing of this wheelchair, particularly as it included such large ranges of accommodation, this was a paramount factor in the resulting design decisions.

3.1 Wheelchairs

Although wheelchairs have many inherent limitations, they do greatly help those who cannot walk, by providing mobility. The fact that the world is not flat and that nearly all buildings have steps and stairs does not help, but if these and other limitations are recognised and properly considered in the design stages, the wheelchair user can be aided to participate as fully as possible in the busy world and to lead a fulfilled life. The wheelchair must be designed to not only fit but also to be comfortable since the confined individual may have to sit in the chair all day. This is important when it is considered that most people would have difficulty in sitting for one day in even the most comfortable of chairs! The wheelchair must be suitable for indoor and outdoor use and for propulsion by the user and by an attendant.

But as the object to design a 'growing' chair suitable to the 4 to 10 year old child, research and data collection included visits to institutions where there were considerable cross sections of the disabilities of users, many hours spent in the chair and an afternoon spent shopping and encountering the problems of general outdoor use. Several visits to the Wheelchair Association, where the chairs are repaired, was also helpful. As the chair was specifically designed for the 4 - 10 year old child, their needs and requirements had to be catered for. But despite the significant proportion of population that children in this group constitute, difficulty was had in attempting to compile conclusive anthropometric data.

The most accurate data applied to young males as large samplings were taken by the armed forces to make the man/machine relationship successful in a fighting environment. However, Human Scale, compiled by H. Dreyfuss, was extensively used in compiling the data necessary for this project. (See Figs. 5 , 6)

Dimensions shown below are relevant to 4-10 years respectively and are given in mm unless otherwise stated

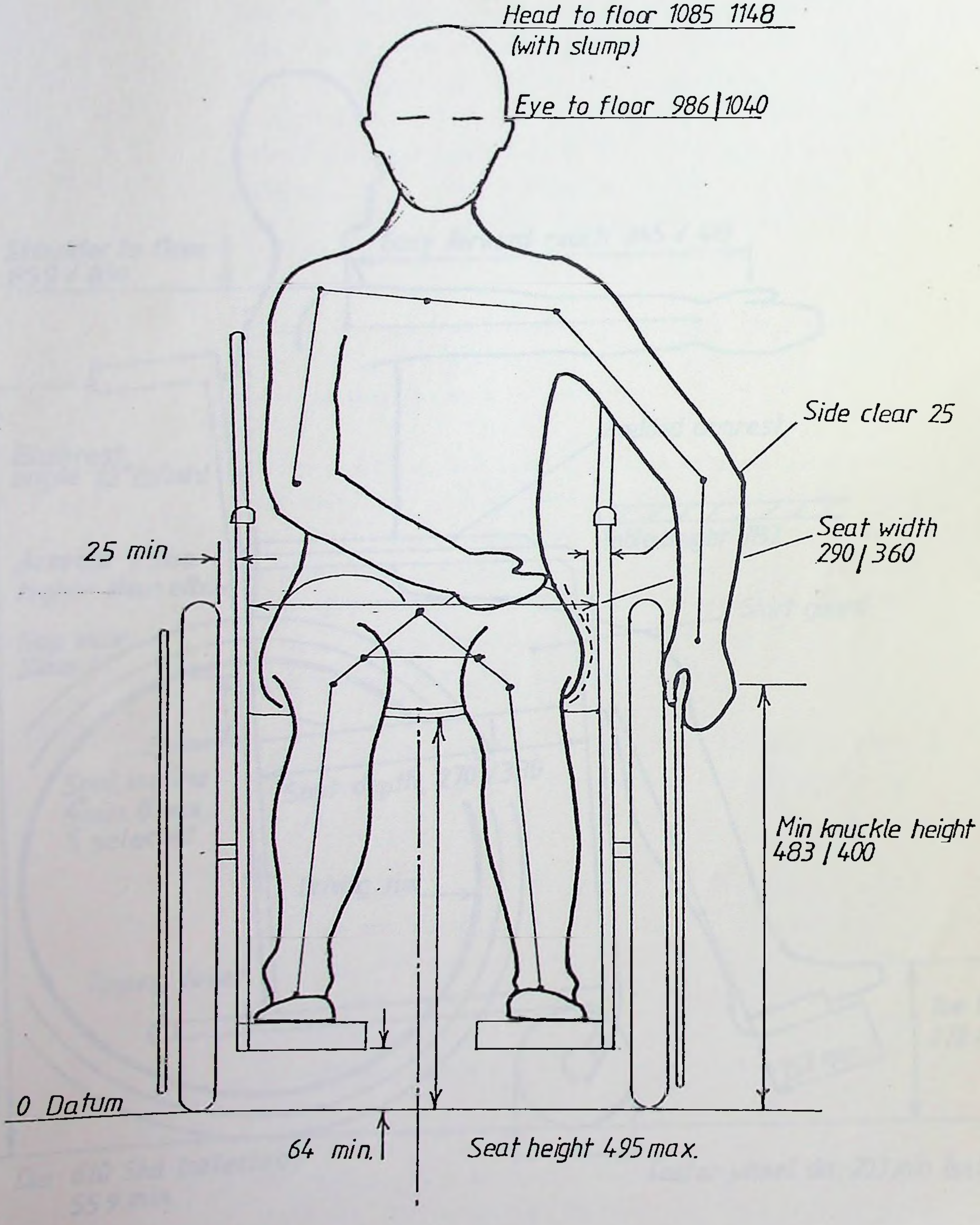


Fig. 5 HUMANSCALE WHEELCHAIR USERS – H. DREYFUSS

Dimensions shown below are relevant to 4-10 year old children and are given in mm unless otherwise stated.

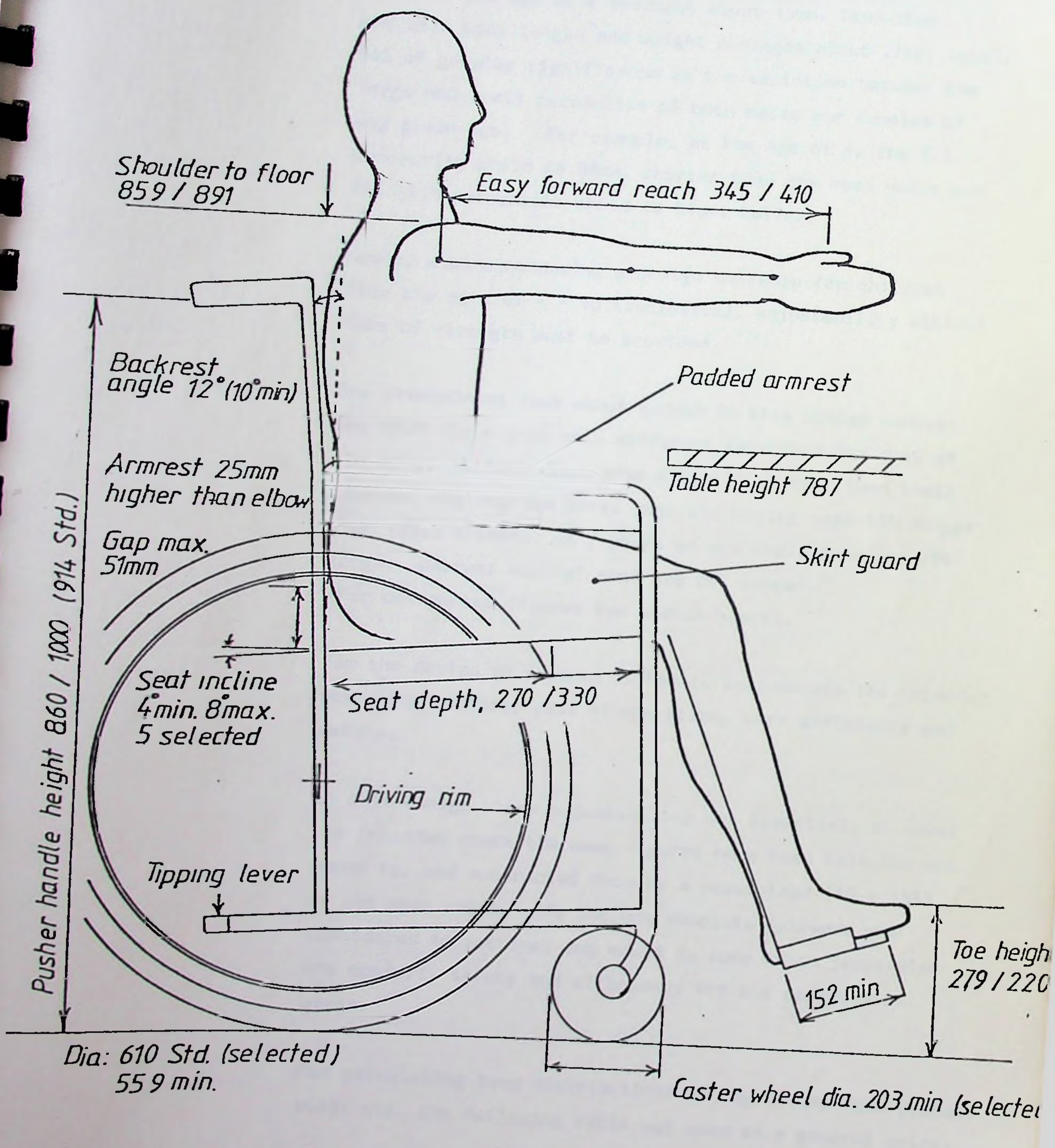


Fig. 6 HUMANSCALE, WHEELCHAIR USERS- H. DREYFUSS

The figures selected were for boys as designs based on these figures would not exclude girls since the variance is slight. (The female body length from birth to the age of 4 averages about 13mm. less than the male body length and weight averages about .7kg. less). But of greater significance is the variation between the large and small percentile of both males and females of any given age. For example, at the age of 4, the 2.5 percentile child is 94mm. shorter than the mean value and the 97.5 percentile child is 94mm. taller.

Hence, when considering a design suitable for children from the ages of 4 - 10 (inclusive), adjustability without loss of strength must be provided.

One predominant fact about growth in this design context was that limbs grow at a different rate from the rest of the body. Infants have arms slightly shorter than their trunks; the average three year old having arms 15% longer than their trunks; at 7 years of age their arms are 25% longer, whereas adults' arms are 28% longer.
(For documented figures see sketch block).

For the design to succeed it had to accommodate the intended users for comfort, ease of operation, work efficiency and safety.

In this design where adjustability was essential, to cover the intended users the mean figures have been selected and added to, and subtracted from by a percentage (10 - 15%) of the mean value. To include absolute extremes was considered impractical and would in some cases jeopardise the comfort, safety and efficiency for the majority of users.

For calculating load distributions on leg rests, foot plates, seats etc. the following table was used as a general guide:

Body Segment Weights

Percentage of Total Body Weight (approx. for Medium Build)

	Male	Female
Head	7.1	5.7
Neck	2.5	2.0
Trunk	45.8	46.3
Upper Arms	6.6	6.0
Forearms	3.8	3.1
Hands	1.3	1.0
Thighs	21.0	23.0
Legs	9.0	10.5
Feet	2.9	2.4
TOTAL	100%	100%

The environment in which the design must operate is also important. For example, physically and psychologically it was considered necessary that a child in a wheelchair should be able to converse and eat with others at a table of normal height and to be able to pass through a normal doorway.

The attendants also had to be considered and anthropometrically a large male, the average adult and a small female were the criterion. The experience of the attendant likewise was necessary in, for example, the design of the tipping lever of the chair. In such instances, the design attempted to immediately explain the function and as the foot pedal (see Presentation and Technical Drawings) replaced the conventional bunged pipe, a greater area, grip in wet weather conditions and lever action were accommodated.

4. ANALYSIS OF THE DESIGN PROBLEM AREAS

In order to facilitate easier reading and continuity of this report each area has been dealt with as a separate entity and the associated problems and significant specification of that component included.

An attempt was made not to duplicate information that is available on the presentation sheets in the sketch block.

A photograph of the existing wheelchair is included at this stage (See Fig. 7) to familiarise the reader with the existing solutions to the areas under analysis, and to serve as a comparison.

Note: Dimensional standards comply with B.S. 5568
See Fig. 8 , and accompanying tables

Fig.7

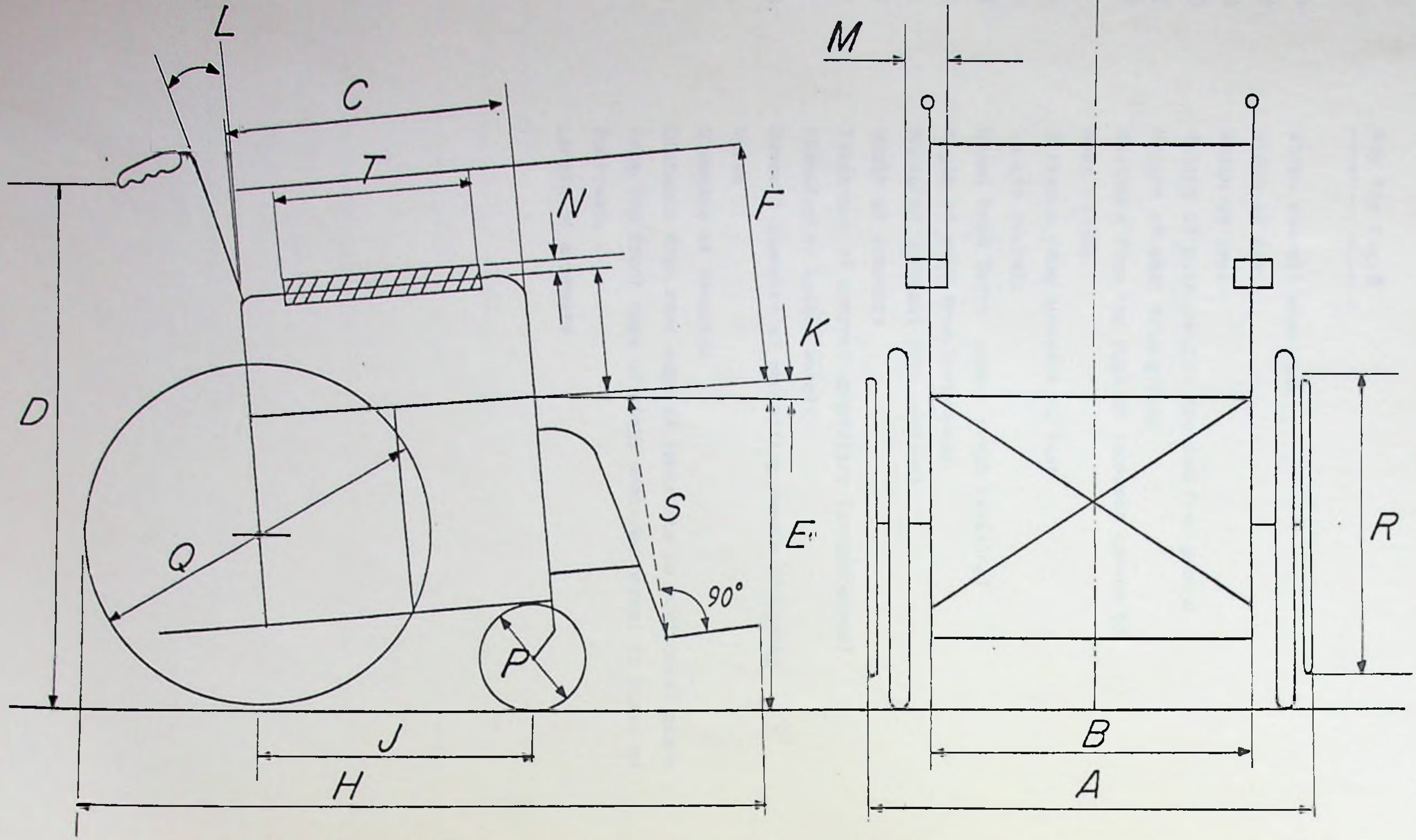


FIG.8. Line diagram of principal dimensions (key tabulated on following page)

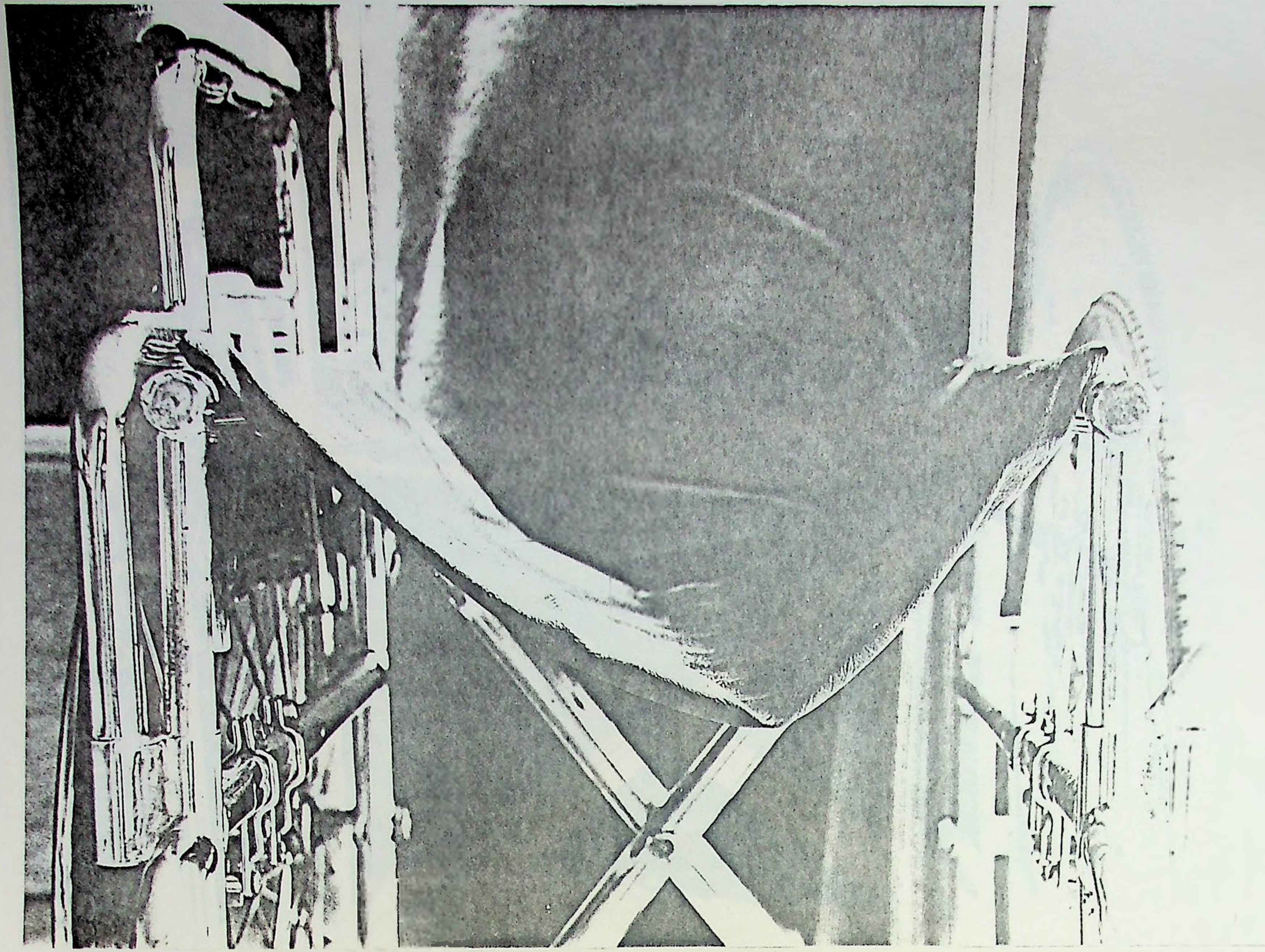
Key for Fig.8

A	Width overall when open
B	Width of seat
C	Depth of seat
D	Height of push handles (centre) from ground
E	Height of seat from ground
F	Distance from top edge of backrest canvas to seat canvas
G	Distance from armrests to seat
H	Length overall
J	Wheel base (with castor wheel trailing)
K	Angle of seat from horizontal
L	Angle of backrest from vertical
M	Width of armrests
N	Thickness of armrest upholstery (uncompressed)
P	Diameter of castor wheels
Q	Overall diameter of propelling wheels including tyres
R	Diameter of handrims
S	Distance from rear edge of footrests to horizontal plane from top front edge of seat, measured normal to place of footrest.
T	Length of armrests

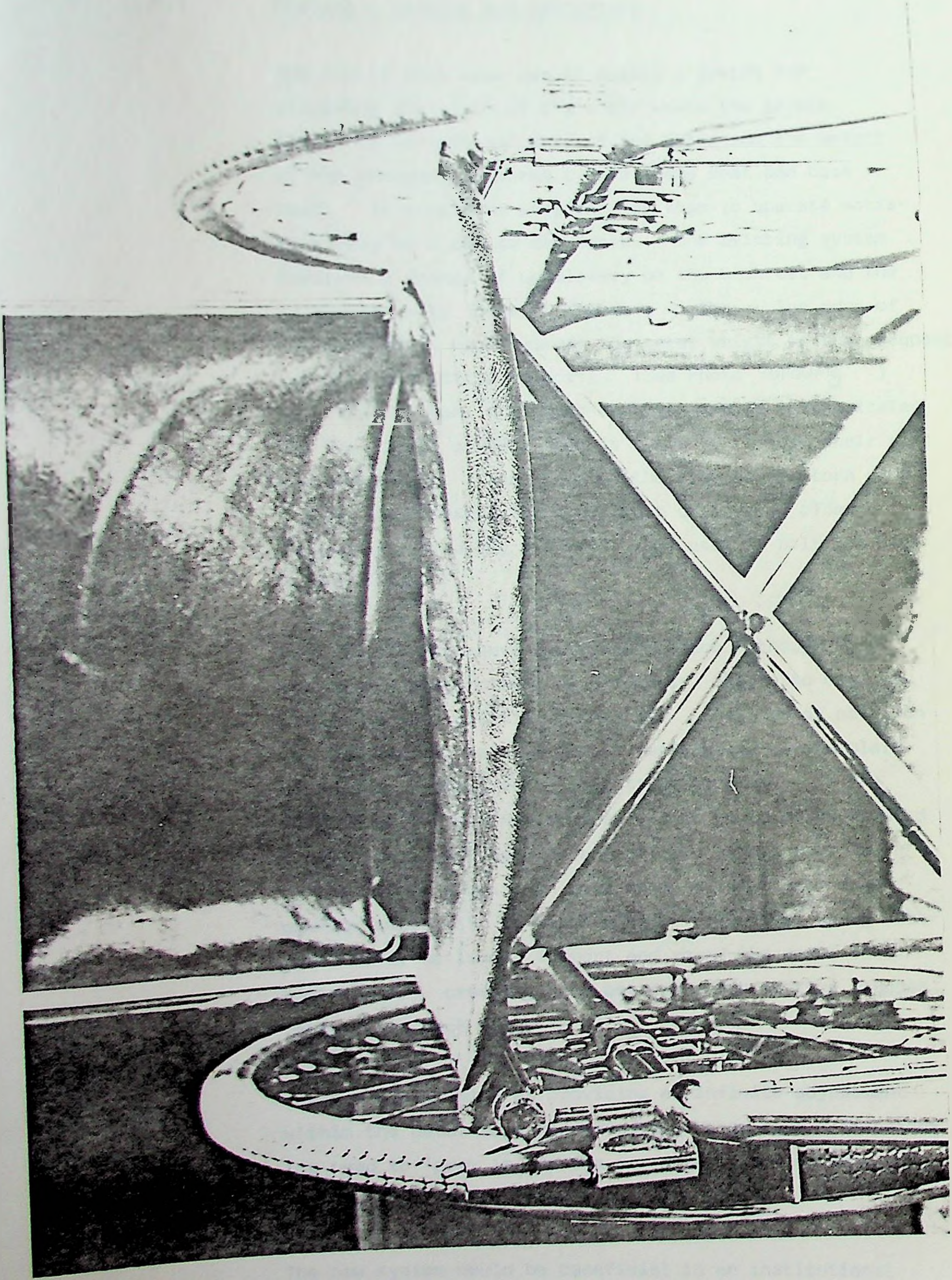
TABLE 1 DIMENSIONS

*Feature	Fig. Reference	Small Size mm.
Width overall when open (max)	A	600
Width overall when folded (max)		285
Width of seat (min)	B	370
Depth of seat	C	380 - 405
Height of push handles (centre)	D	890 - 940
Height of seat from ground	E	430 - 520
Distance from seat front to rear of footrests adjustable at least from:	S	330
to:		405
Distance from top edge of back rest to seat canvas (max)	F	405
Distance from armrests to seat	G	200 - 255
Length overall (max)	H	1040
Wheelbase (with castor wheels trailing) (min)	J	350
Angle of seat from horizontal (front raised)	K	up to 10° (5° preferred)
Angle of backrest from vertical	L	up to 15°
Width of armrests (min)	M	50
Length of armrests (min)	T	300
Thickness of armrest upholstery uncompressed (min)	N	12
Diameter of castor wheels (min)	P	125
Overall diameter of propelling wheels wheels including tyres (min)	Q	450
Diameter of handrims	R	75 - 150 less than dimension Q

* See Fig. 8 and accompanying key.



EXISTING SEATING



4.1 Seating - Padding and Upholstery

The aim in this area was to design a system for extending the width of the chair where the growth factor is an integral part of the chair and the weight of the occupant is borne by the frame seat and back rest. It should be possible for them to operate satisfactorily on a day to day basis. The existing system involves a change of upholstery on the backrest and the seat which only comes in standard widths. The edge of the upholstery bears almost the total weight of the occupant yet provides little support. (See Photo following) With this system the chair and the user is incapacitated for the length of time that it takes to fit the chair with new upholstery. The edges of the seat become torn very quickly thus making the chair look untidy and often dangerously exposing the metal rod, used to bolt the seat to the frame.

Most wheelchairs have slung seats which although they facilitate easy folding of the chair, they also make any change of body position difficult. A change of position is necessary to relieve muscle tension and to stimulate blood circulation over long-sitting periods. In the opinion of the medical profession, it would be considered a definite improvement to use a flat, padded seat and a rounded front edge. In some cases a gel air or foam cushion would also be recommended. Likewise, slung backrests offer no lumbar support and round the upper back horizontally, creating poor posture which in turn induces fatigue and back pain.

The new system aims at providing an infinite adjustment within the determined accommodation range thus eliminating the need to 'grow in' to the new size. Any extra width is a definite inconvenience.

The new system would be beneficial in an institutional context where children of various ages may need the chair and hence would be a more cost effective solution.

As the actual load bearing area of the seat was several millimetres from the edge, it was decided to utilize this area to accommodate the different ranges desired. This was done using an 'accordion' type system at the edges, giving a total adjustment range of 70mm. The seat is hinged in the centre and folds upwards with outside hinges revolving around the main framework. (See Technical Drawings, Sketch Block)

The back rest operates on a similar principle but incorporates a rigid section on either side of the back panel which a slider covers to fix the two halves in position. This was deemed necessary as direction of folding was the same as applied force of the seated occupant. As width adjustments were seen as more permanent than the everyday folding of the wheelchair, the system ensured that it could not easily be tampered with by other children.

Padding and Upholstery

In order to be supportive and comfortable a considerable amount of thought was necessary in the selection of the padding and upholstery. 'Humanscale' was used as a guide and eventual selection was done with the help of Dunlop, Technical Sales Division, and Blindcraft, Rathmines, (upholsterers for hospital and remedial equipment)

The following table provides the criteria for selection and the selected material:

Item	Density	Desired Effect	Suitable Foams	Depth mm.	Selected Materials	Retail Price 1'x1'x 1")
Seat	Medium	Supportive	D13,D133	50	D13	£0.25
Backrest	Light	Soft	D50,D263	35	D50	£0.19
Armrest	Heavy	Firm	D8,Repol.	25	Repol.	£0.21

All of the above are flame retardant materials and comply to British Standards.

Individually customised Postural Support systems using expanded foam were considered initially but disregarded as not being practical or commercially viable. The growth factor of the chair had to be a dominant feature: any individually moulded seat would have to be changed several times in the six-year growth period of a child's life. The result is a compromise solution of a general supportive growing system as it was decided that in particularly difficult cases this need would have to be catered for on an individual basis.

Considering the majority of the intended users (Cerebral Palsy and Spina Bifida children) a mean value of the anthropometric data was selected as being the most appropriate guide to ensure the greatest possible safety and comfort for the greatest number of users.

The selection of upholstery had to conform to B.S.5568. The selection caused considerable problems, as in order to satisfy certain criteria, it was necessary to neglect other aspects. The main dilemma was in the selecting of an upholstery that would 'breathe' but yet would provide adequate flexibility, resist abrasion, spilling and tearing. It also had to be non absorbent and allow for easy cleaning and stain removal, be non-odour retaining and should conform to the flammability requirements. (AMD 1999: 1976, and B.S. 2601: 1973).

Detailed information was difficult to find but in view of the recent Dublin fire disaster, specifications are currently under review. There appeared to be little or no regulations controlling the importation of materials from abroad and Irish specifications were not available.

The colour selected should enhance the design of the chair but should be dark enough so as not to show up dirt and stains.

One main disadvantage in using expanded vinyl on a knitted fabric, in spite of conforming to the standards (B.S.5790: 1979) and also being flame retardant to meet with requirements of D.O.E./P.S.A. FR3.1g5), being specifically designed for use in contract furniture, the material because of these, and previously listed properties, could not 'breathe' and would still provide an unsatisfactory solution to the problem of a child in the summer or in a warm room, sitting for long periods with his back against a non-'breathing' material. Further investigation on this issue would be necessary and research to date indicates that any material that would adequately satisfy all of the above requirements would have to be specially made up. Therefore, the heavy duty, brushed nylon car seat upholstery was seen as being the most promising solution but again detailed information on its properties was difficult to find in this country.

4.2 Wheels

Initial investigation for designing the wheel involved research into the possibility of alternative materials and manufacturing. Since the 1930's, initially in the United States but later in Europe, the traditional bicycle wheel with a more solid and longer axle has been considered the standard wheel for a wheelchair. However, if one considered the exciting potential of polymers and the large area necessarily occupied by the wheel, this was considered usually one of the most important areas of the chair. For existing solutions see Fig. 9.

There were several reasons for deliberately designing away from the traditional bicycle wheel, including the psychological aspect, i.e. spoked bicycle wheels have always constituted a serious and traditional adult chair and also the spokes were seen as hazardous for smaller children's fingers. For this reason and from general observation the idea of combining the wheel, hub and rim in a single moulding was investigated.

Research continued to see whether or not an engineering plastic with a per kilo price double that of metal could compete in a large volume application (considering the large number of possible applications of a wheel and the potential market: sixty million wheel/yr. in Western Europe, including bicycles, mopeds etc. this was an area of the project that assumed a longer production in order to establish realistic criteria for eventual selection of suitable materials and processes).

Bernardi Mozzi Motors, Zola Predora, Italy, it was discovered during the research, do make a complete wheel-rim, spokes and hub in nylon 6. (Company contacted). Another from Acnosa, Paris, also began making nylon wheels late in 1980 and these are now in full production.

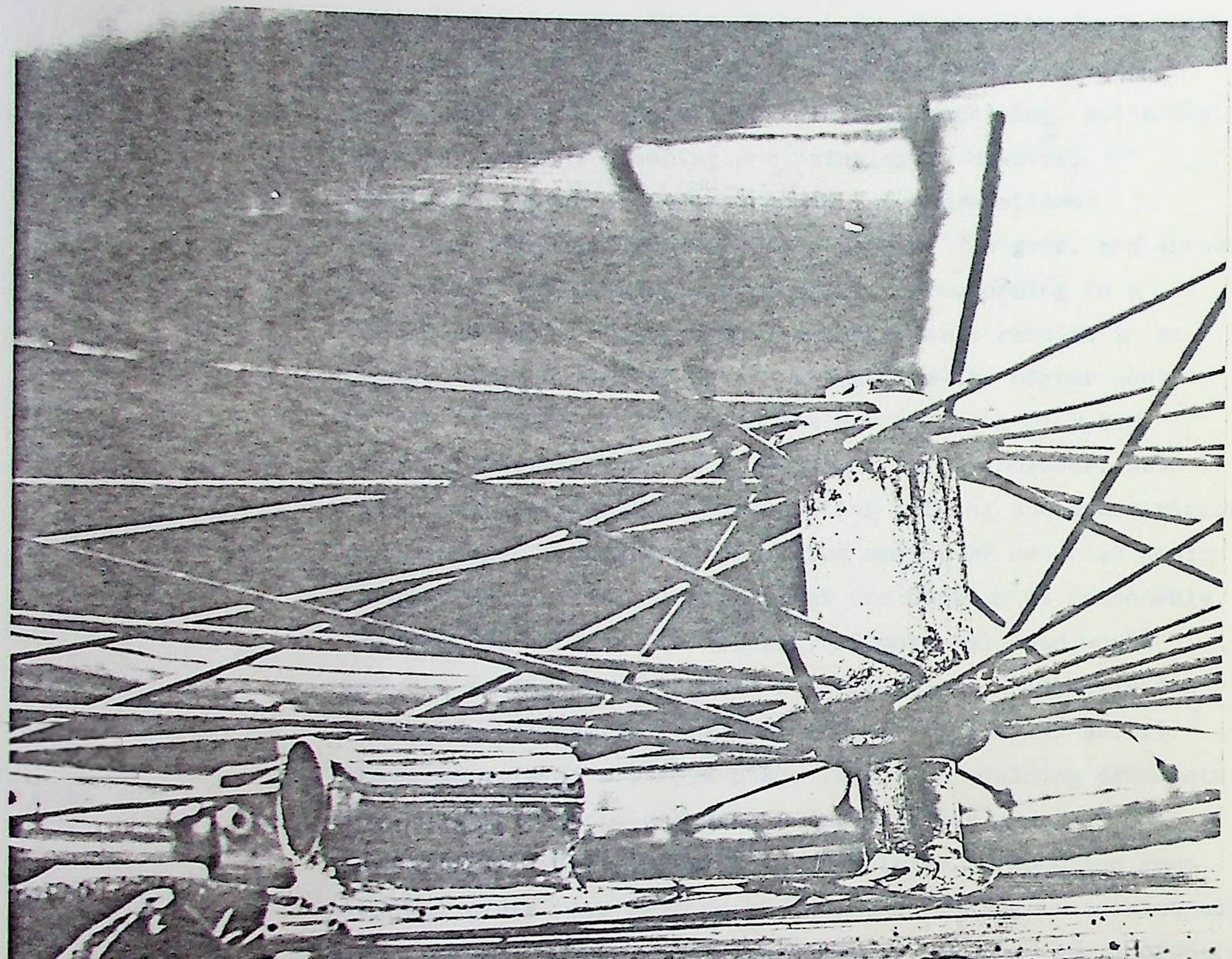


Fig. 9

The high initial cost of tooling and the material cost involved must be realistically compared with the production of the alternative. Production in aluminium requires seven operations: stamping, trimming, machining, polishing, sanding, solvent cleaning and painting. However, production in Nylon 6 requires only two operations: injection moulding from a single central fan gate, and sprue removal. The reduced production time (according to a report compiled recently by Technopolimeri) results in an overall cost saving of about 10% despite the higher cost of raw materials. Per kilo the current cost of Nylon is calculated at twice that of aluminium. However, with resourceful designing, incorporating ribbing and other rigidity and strength inducing methods, the amount of material could be minimised. Assuming too that the section is reasonably uniform the save in the quantity of material used would bring a subsequent reduction in cycle time. (An existing design for a bicycle wheel has a cycle time of 45 secs.) These aspects of a single piece injection moulding eliminate the cost difference and make it competitive and an economically viable product. With large production runs initial costs have been recovered, thus making it considerably less expensive than the existing one. Current and increasing labour costs now constitute an extremely important parameter for any form of product design.

The tooling would incorporate hot runners fed from a single injection point and several sliding cores.

Tensile strength, flexural modulus, impact strength, thermal and flammability consideration, scratch resistance, colourability etc. were some of the criteria used in the eventual selection of the following two materials considered for producing this item.

i) A 30% glass reinforced Nylon 6 Sniamid ASN 27/300 SR, and

ii) I.C.I. Marangle 50% glass reinforced Nylon - 6/6.

The Nylon 6/6 rims used for bicycle wheels are said also to offer better braking than the traditional rims and better riding comfort.

Another factor in favour of selecting one of these new materials, apart from the ease of processing, is that they do provide resiliency for shock absorption; corrosion resistance; integral colourability; a decrease in the maintenance required for a normal wheel; an altogether more aesthetic solution and, of particular relevance to this application, has been comprehensively tested, demonstrating an impact strength far superior to that of aluminium.

Dimensions for the driving rim selected were based on anthropometric data for Humanscale (H. Dreyfuss) and conform to B.S. 5568: 1978.

Various patterns for the wheels were experimented with and interesting and surprising results often emerged when a particular design was rotated causing the wheel to appear as though it were moving at a greater speed than another design with the same diameter and moving at the same speed. As car hubs were seen as a competitive market product, fulfilling basically the same function, designs were investigated.

Note: Initial Mozzi (Milan) production of the wheel has been for the Italian market but also in design and experimental stages, is a process for developing a complete moped frame in reinforced nylon. The possibility of manufacturing this design for the wheelchair, using a similar technique, could later be positive areas of investigation.

4.3 Leg and Footrests

The aim in this area was to design a footrest with a range of height and angular adjustments and with footplates that pivoted upwards to facilitate folding.

The growth rate and extent of the intended users' lower limbs, provide the parameters for this design area. (See existing solution Fig. 10)

The necessary adjustments were seen as three-fold:

1) Length
2) Angle of footplate relative to leg rest bar
3) The pivoting of the footrest to facilitate folding of the chair.

Having assessed the available anthropometric date, the resultant length range to be accommodated was estimated at 150mm. from the rear edge of the footplates to horizontal plane, from top front edge of seat, measured normal to the plane of footrest. The solution used telescopes so that no unnecessary bar was visible if the leg rest was accommodating the shortest leg length.

Further analysis of the anthropometric data demonstrates that a footrest, attached to, but travelling independently of the leg rest, would accommodate the angular requirements of the growth range. This effectively eliminates the problem of maintaining the required angle between the foot plates and the leg length adjustment bar. (See Fig. 11 for graphic representation of the problem and Fig. 12 for the adopted solution. The pivoting of the footrest to facilitate folding, was done by means of a simple hinge.

Lastly, a suitable slip resistant upper surface was provided on the footrests.

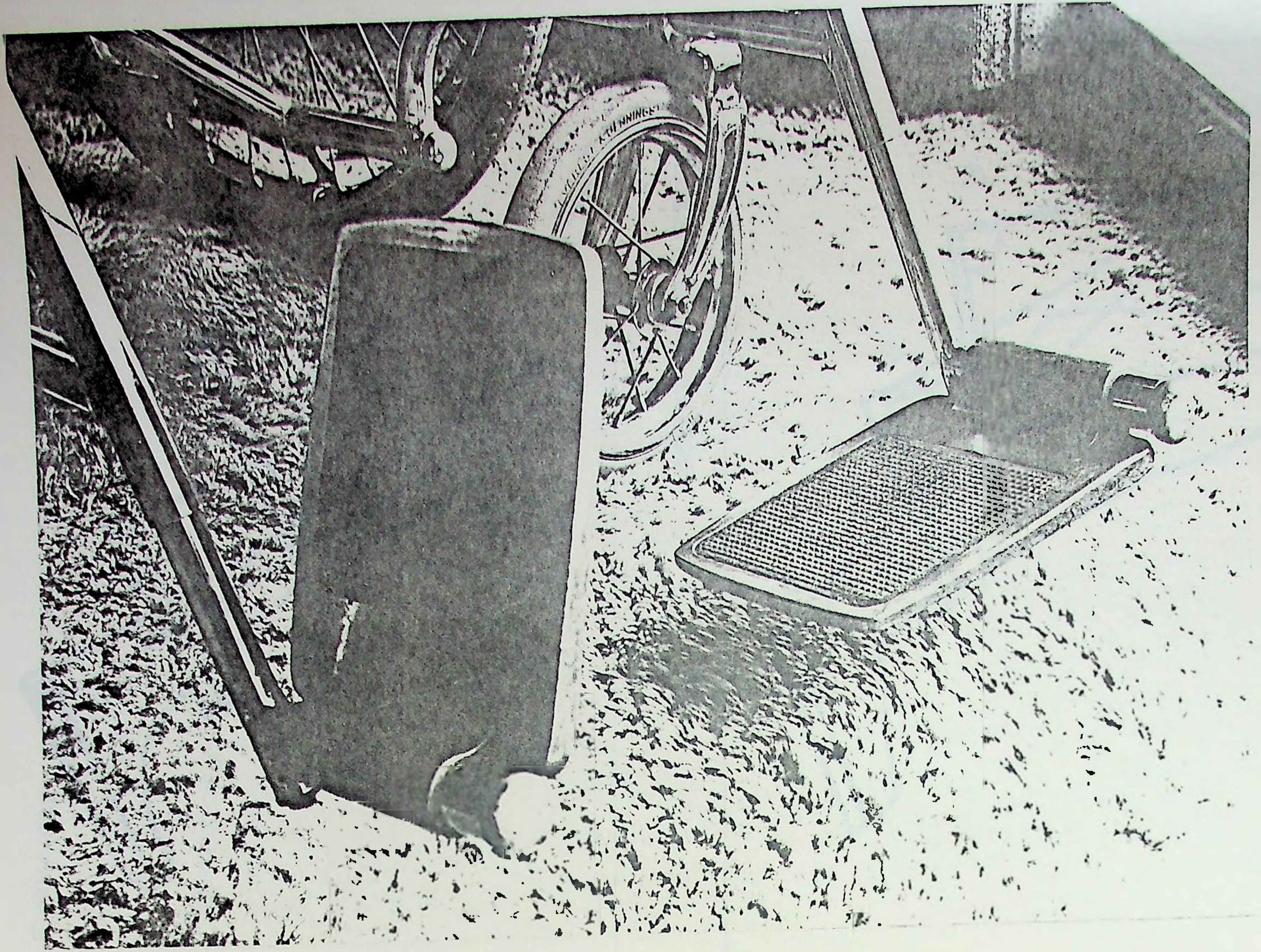


Fig. 10

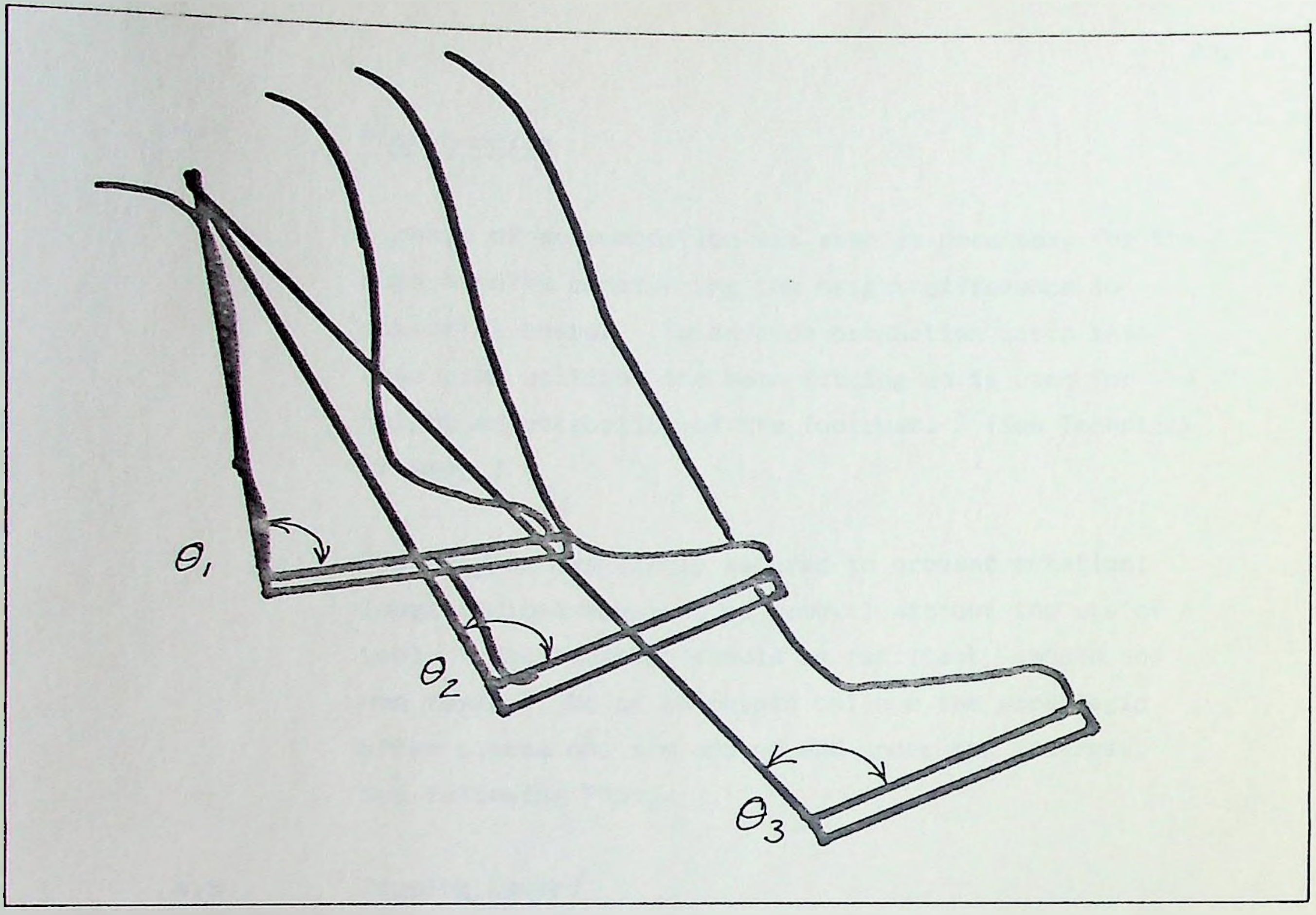


Fig. 11. PROBLEM IDENTIFICATION

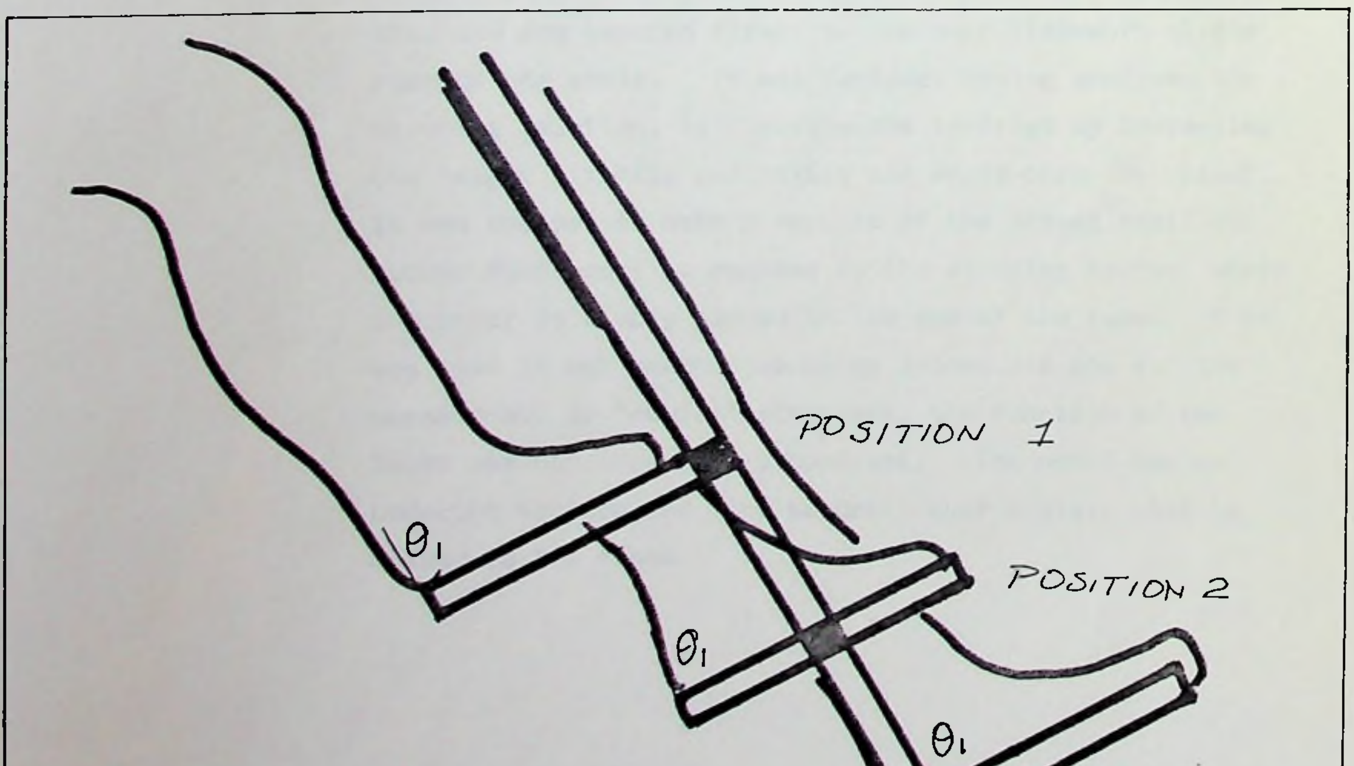


Fig. 12. ADOPTED SOLUTION

4.4 Push Handles

A range of accommodation was seen as necessary for the push handles considering the height difference in potential users. To save on production costs this area also utilizes the same fitting as is used for the height adjustability of the footrest. (See Technical Drawing)

The handles are firmly secured to provent rotation, longtitudinal movement or removal without the use of a tool. The material should be resilient, smooth and non toxic. So as to retain balance the paraplegic often places one arm around and under the backrest. See following Photo.

4.5 Tipping Levers

Foot tipping levers assist the attendant to tip the wheelchair backwards to descend steps, or mount pavements etc. and are secured firmly to the main framework at the rear of the chair. It was decided, having analysed the existing solution, to increase the leverage by increasing the height slightly and making the angle more convenient. It was decided to make a feature of the actual resilient rubber foot pedal as opposed to the existing system, where a stopper is simply placed in the end of the tube. This was seen in wet weather as being inadequate and for the occasional, or 'novice' attendant, the function of the lever was not immediately apparent. The pedal has an undercut section and fits securely over a plate that is welded to the frame.

4.6 Armrests

In order to give adequate support the length of the armrest should be sufficient to support the user's wrist and be no less than 50mm. wide. Padding should be firm and have recovery strength. The armrest height is gauged as being 25mm. above the elbow height of the seated person.

In this design area it was necessary that the component should be able to support the person's full weight and that each one should be able to be raised or lowered independently as this can be necessary in some cases of disability.

Hence the problem eventually lent itself to the solution, in that the greater the problem, i.e. the weight, the more effective the solution proved to be. A cam type system for the hinge was used that dug into a bushing around the tube. It was decided that it was more advantageous to keep the arm rest as an integral part of the chiar, as from visits to hospitals and various centres, it had been seen that removal ones were too easily damaged and lost. The solution still had to provide unobstructed entry to, and transfer from, the chair, hence, an arm rest that would pivot upwards would fill the above need and allow the chair to pull up closely to a table below or at standard height.

4.7 Length of the Chair

The length of the chair was effectively reduced by 20mm. when folded or when used by children younger than seven years of age.

5. CONCLUSION

Although there had been initial reservations in taking on a project of this magnitude in the second term, the area of study proved to be interesting and the challenges numerous and varied. Many contacts in hospitals and institutions had been made during the first project of designing a device for female urinary incontinence, and several of these people proved of invaluable help when contacted again in connection with the child's wheelchair project.

As the types of problems were so varied, many of the physiological ones needed a considerable amount of ergonomic and anatomical research. This aspect although very time consuming did lend itself, when the results were objectively analysed, to the solution as has been shown in the case of the leg rests.

A design philosophy or approach that developed through the project was, that the most difficult aspect of a problem could often prove to be the solution in itself. To illustrate the point, the challenge with the arm rest had been to support the user's full weight and hence using a 'cam system' the greater the problem, i.e. the weight, the ultimately more effective the solution could be.

The resulting design has, in the opinion of the designer, succeeded in tackling the main objectives established at the onset of the project. However, in terms of presentation the degree of finish is not as complete as had been initially intended as heavier emphasis had been allocated to amassing accurate research and data collection in a field that the designer, although interested, had to date little experience. In the designer's opinion, to design for almost any area of rehabilitation engineering, continuous medical backing is of utmost importance.

An enjoyable aspect of the project was the contacts the designer made through visiting various hospitals, centres and institutions. This project year has conformed the designer's intentions to work in the field of rehabilitation engineering.

BIBLIOGRAPHY

1. McCORMICK, Human Factors Engineering, 3rd ed.

2. GOLDSMITH Selwyn, Designing for the Disabled.

3. HALE Gloria, The Source Book for the Disabled.

4. International Conference on Rehabilitation Engineering Proceedings, 1980, Toronto, Canada.

5. Cunningham's Textbook of Anatomy, 11th ed., Edited by G.J. Pomanes

6. ROSS Janet & WILSON Kathleen J.W.., Foundation of Anatomy and Physiology, 4th ed.

7. SMITH M.J. and BELL Brian J., Theory of Structure

8. Access for the Disabled: (min. design criteria publication of National Medical Rehabilitation Board).

9. FAUGHMAN Pauline, The Dimensions of Need.

10. WOODSON Wesley E. & CONOVER Donal W., Human Engineering Guide for Equipment Designers.

11. McCANN Eleanor, Survey of the Irish Market for Rehabilitation Equipment, (16.8.77) I.D.A.

12. University of Virginia Rehabilitation Engineering Center, Annual Report 1980. (Rehabilitation Engineering centre specialising in wheelchair, mobility and research in the neural and structural aspects of the spine).

13. Rehabilitation Engineering, A plan for continued progress II, produced jointly by the Rehabilitation Services Administration Office of Human Development Services and Dept. of Health Education and Welfare. Published by Rehabilitation

Engineering Center at the University of Virginia.

14. Solving Problems for the Handicapped, Newcastle upon Tyne Polytechnic, The Handicapped Persons Research Unit.

15. DREYFUSS H., Humanscale: A Portfolio of Information.

16. KAMENETZ Herman, The Wheelchair Book: Mobility for the Disabled, Charles C. Thomas, Pub., Springfield, Illinois.

17. Reinforced Nylon Challenges Metal for Bicycle, Mo-ped Wheels, Modern Plastic International, February 1981.

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APPENDIX A

Costing

As the design solution was changed considerably so recently, a comprehensive costing was not possible. However a comparative costing is discussed and included.

Over a long production run the wheel would be similar in cost to the existing bicycle but would initially be the most expensive undertaking in tooling up for this design. The existing pneumatic castors and main propelling tyres would be replaced in the proposed design by foam-filled tyres providing comparative suspension but a decrease in the cost of the existing pneumatic tyres. Maintenance and replacement of tubes are also eliminated making the chair usable at all times. Testing with neoprene filled tubes did prove successful. Hence, in the area of wheel design a saving on the existing model would be estimated.

The bearings have been replaced in the castor/main frame with a bushing in Nylon 6, sufficiently long to cover the spriggot and provide adequate rigidity. The nylon could withstand considerable impact loadings and would be self lubricating, giving the spriggot a supportive housing. The bushing is prevented from being forced up the tube by crimping the tube and exit prevented by 2 self tapping recessed screws. This, if adequate testing could prove the solution viable, would be a considerable saving on the existing thrust bearings. See Technical Drawings.

The covers on the push handles would be estimated at the same cost as the existing handles and the modified foot plates seen as a little more expensive.

The seating would be initially more expensive but as the system remains the same for the expected life of the chair, costs would in the long run be comparative, and the inconvenience of upholstery changes would not be incurred.

The arm rests due to their construction should not require replacement as being an integral part of the chair, the chance of being damaged when removed from the chair, is eliminated.

The most significant saving is seen in terms of the basic construction of the frame. Initial material is seen as being mild steel where brazing rings would be placed in the joints and later heat applied resulting in a strong joint. The elbows in terms of large scale production would be cast using sliding cores or using lost wax casting technique. Soft tooling would be sufficient for shorter production runs.

When the jigs have been designed the main frame is a simple cutting and brazing operation with negligible labour costs. The joints would ideally be sprayed before assembly if sufficient heat to melt the brazing material was not enough to damage the stove enamelled tubes. If this was not feasible the job would involve spraying and subsequent masking. This was the main consideration for changing the design at such a late stage but the saving of the modular system was seen as being a superior and more elegant design solution.

Advantages were also seen in the areas of packaging, marketing and possible exporting of the chair. With further research it would be hoped to replace the main frame with a rigid polymer. Experimenting with tube lengths and joints filled with expanded polyurethane foam did produce very rigid structures and with further investigation with other foams may provide a satisfactory solution for production.

The main problem area was seen as the cantilevered connection for the self-propelled wheels. Using a solid axle (non folding chair) the design could be executed in a polymer or for the folding chair suffice with adequate reinforcing and ribbing.

The saving in the ever increasing labour costs should justify any initial tooling costs for the seat, wheel and foot plates, resulting in a cost effective solution for the design of a child's wheelchair.