HOSPITAL TRAFFIC & SUPPLY PROBLEMS

King Edward's Hospital Fund for London

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Hospital Traffic and Supply Problems

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A report of studies undertaken by members of the Hospital Design Unit of the Ministry of Health within the context of the Greenwich District Hospital development project

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Preface

A one-day conference was held under the auspices of the King's Fund at the Hospital Centre in April 1967, at which papers were given by members of the Ministry of Health's Hospital Design Unit* on the traffic and supply studies carried out during the design of the new Greenwich District Hospital. The speakers at the conference were Howard Goodman, J R B Green, Ceri Davies and C F Jackson of the Architects Branch, and H J Chappell of the NHS Central Organisation and Methods Unit.

This volume has originated from the suggestion that the material presented at the conference might be of general interest to many concerned in the hospital planning process. The papers presented, and the notebook illustrations which were drawn during the course of the Studies, have therefore been recast in this form, and whilst the content has been updated and additional material included, the primary purpose of the volume remains the same as the purpose of the conference – to report on studies of issues and options in the field of hospital traffic and supply which were carried out within the context of the Greenwich District Hospital development project.

The publication of the conference material in this way should not be taken to imply that a comprehensive survey of the many problems involved in the planning of traffic and supply systems was in fact undertaken. Still less is it intended to suggest that the solutions to the problems which were subject to investigation are now ready for general application in all other new district general hospitals. The Greenwich hospital development project was in fact seen as a laboratory situation in which new ideas could be tested and assessed. Some of those ideas are referred to in this volume, but since at the time of writing only the first phase of the new building is under construction, the design-in-use assessment period is still some time away. Indeed even before this time arrives further research may expose the inadequacy of solutions which, because of the pressure for design decisions and the limitations of research resources, may have been too readily adopted.

* Since the text of this volume was handed to the printer the Ministry of Health has been amalgamated with the Ministry of Social Security to form the new Department of Health and Social Security.

Even the best solutions in one situation may not be applicable elsewhere. On many occasions during the Greenwich hospital design process it has been evident that where solutions to particular problems have been arrived at within the context of a hospital project, with its individual main operational policies and design concept, it is dangerous to transfer those solutions to another project without first evaluating them in the light of the main operational policies and the design concept which are relevant to the new situation.

Nevertheless it is hoped that this volume will be of benefit to others in so far as it highlights some of the problems and options in the traffic and supply field which have not, in recent years, received as much attention as they merit. In so far as the method of approach adopted placed an emphasis on the assessment of each issue within a wider context of interrelationships it broke new ground, whilst on particular issues where information was lacking research exercises were able to give new guidance to the designers. Some of the 'facts of life' which became evident as the investigations progressed may also be of interest to others. It is possible, finally, that some of the solutions themselves as described in this volume may be of wider relevance than solely to the Greenwich hospital for which they were conceived.

The members of the Hospital Design Unit would not have been able to carry through these studies without the help of many other people, so numerous that they cannot all be named individually. We are indebted to colleagues within the Ministry of Health – doctors, nurses, administrators, engineers, statisticians and other specialist advisers – for their information and advice; to the officers of the South East Metropolitan Regional Hospital Board, and to the officers of the Greenwich and Deptford Hospital Management Committee for their contribution as well as their cooperation and acceptance of endless interruptions to their day-to-day commitments.

We are also indebted for guidance on particular studies to Miss Flora Black of the Building Research Station and to Dr A Barr of the Oxford Regional Hospital Board Operational Research Unit. Not only was their instruction in the early days invaluable but also their continuing advice and their kindness in commenting on the appropriate sections of this volume when in draft.

We would also wish to express our thanks to the King's Fund for staging the conference, and without whose sponsorship this volume would not have been published.

Finally it must be stated that the views expressed in this volume are those of the contributors and should not necessarily be regarded as Ministry of Health policy.

W A H Holroyd October 1968

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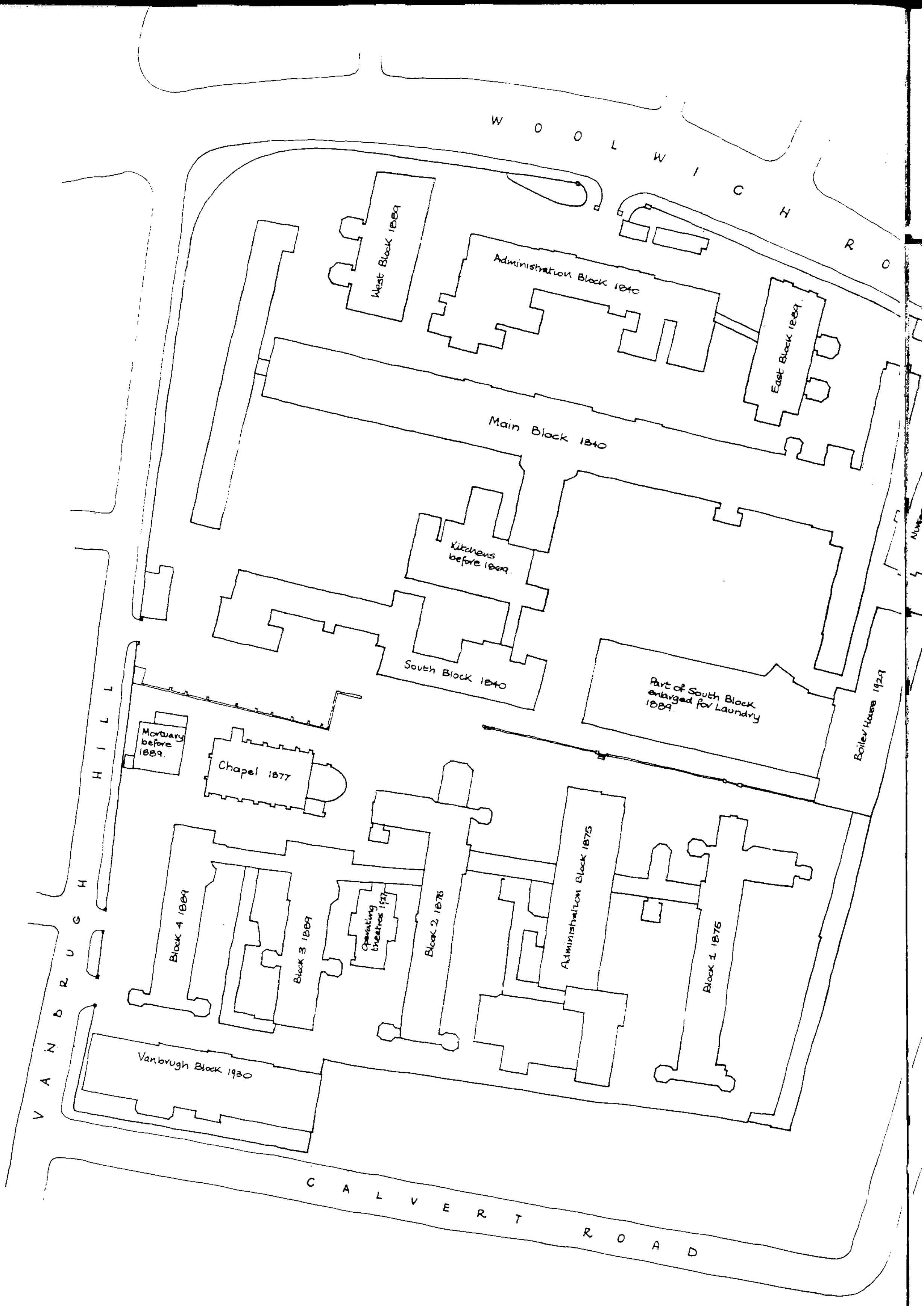
1 Introduction to the Greenwich Project

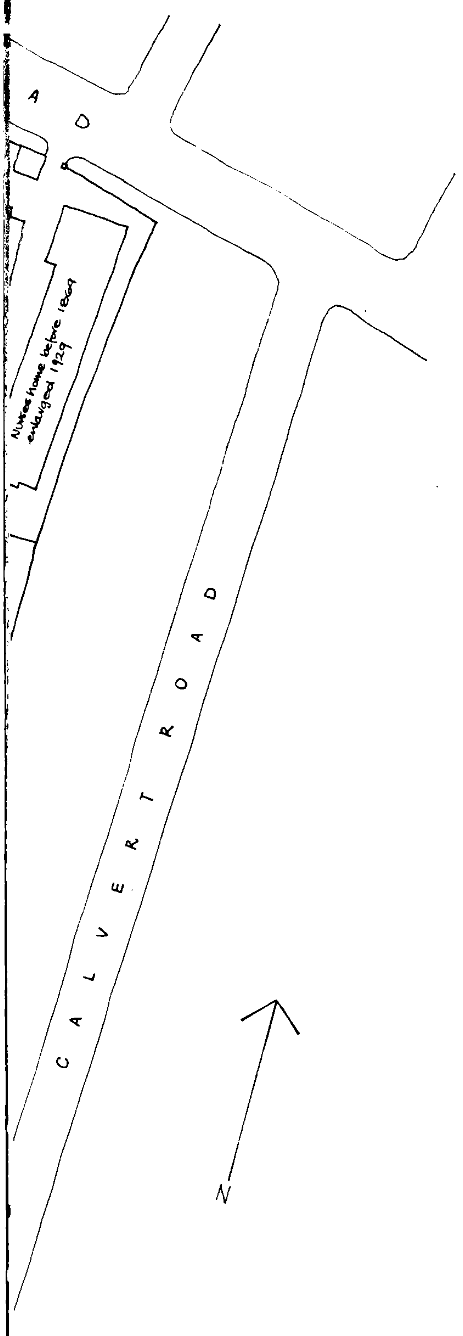
based on a paper given by Howard Goodman DipArch ARIBA

During recent years the Ministry of Health has undertaken a series of selected development projects in order to explore the validity of conventional solutions to the problems of hospital design, and to test new solutions where these appeared to offer advantages. The Greenwich hospital project has been the third in this series and the first to involve the design of an entire hospital. It has been conducted as a joint exercise between the Ministry and the South East Metropolitan Regional Hospital Board in whose area Greenwich is situated. The method employed in carrying out the functional surveys which formed the basis of the project is described in *Hospital Building Bulletin No 3.*[1] The professional team within the Ministry has consisted of architects of the Hospital Design Unit together with quantity surveyors, mechanical and electrical engineers, and has had the assistance of a private firm of consulting structural engineers. Assistance has also been given by the medical, nursing and statistical sections of the Ministry of Health.

This scheme must be seen as a real project within the existing system of the National Health Service. It is possible to criticise it in that it is not correctly related to the community or that it should be on a larger site. However, it is a solution to a particular problem which exists at this moment. Discussion on whether a district hospital is a valid concept or not was beyond this particular brief. Not only was the brief to design a hospital within the framework of the existing health services, but also to design a hospital comparable in cost to those being built under the national cost limits currently applicable. The problem was further complicated by the fact that the existing buildings on the site housed a working general hospital which had to continue to function in all its aspects whilst development was taking place. Any scheme therefore which involved closing or emptying the hospital would obviously have been impracticable.

This problem is one of the foremost facing the National Health Service, which has many hospitals correctly related geographically to the community they serve but unacceptable by modern hospital standards. For this reason the redevelopment of an existing site was deliberately chosen in preference to a virgin site where the difficulties of phasing and decanting would not be experienced in this form.


W O O L W I C H R O
West Block 1889
Administration Block 1840
East Block 1889
Main Block 1840
Kitchens before 1889
South Block 1840
Part of South Block enlarged for Laundry 1889
Boiler House 1929
Mortuary before 1889
Chapel 1877
Block 4 1889
Block 3 1889
Operating theatres 1927
Block 2 1876
Administration Block 1875
Block 1 1876
Vanbrugh Block 1930
V A N B R U G H H I L L
C A L V E R T R O A D



1.1 The site for the new Greenwich District Hospital, showing the original buildings and their dates of erection.

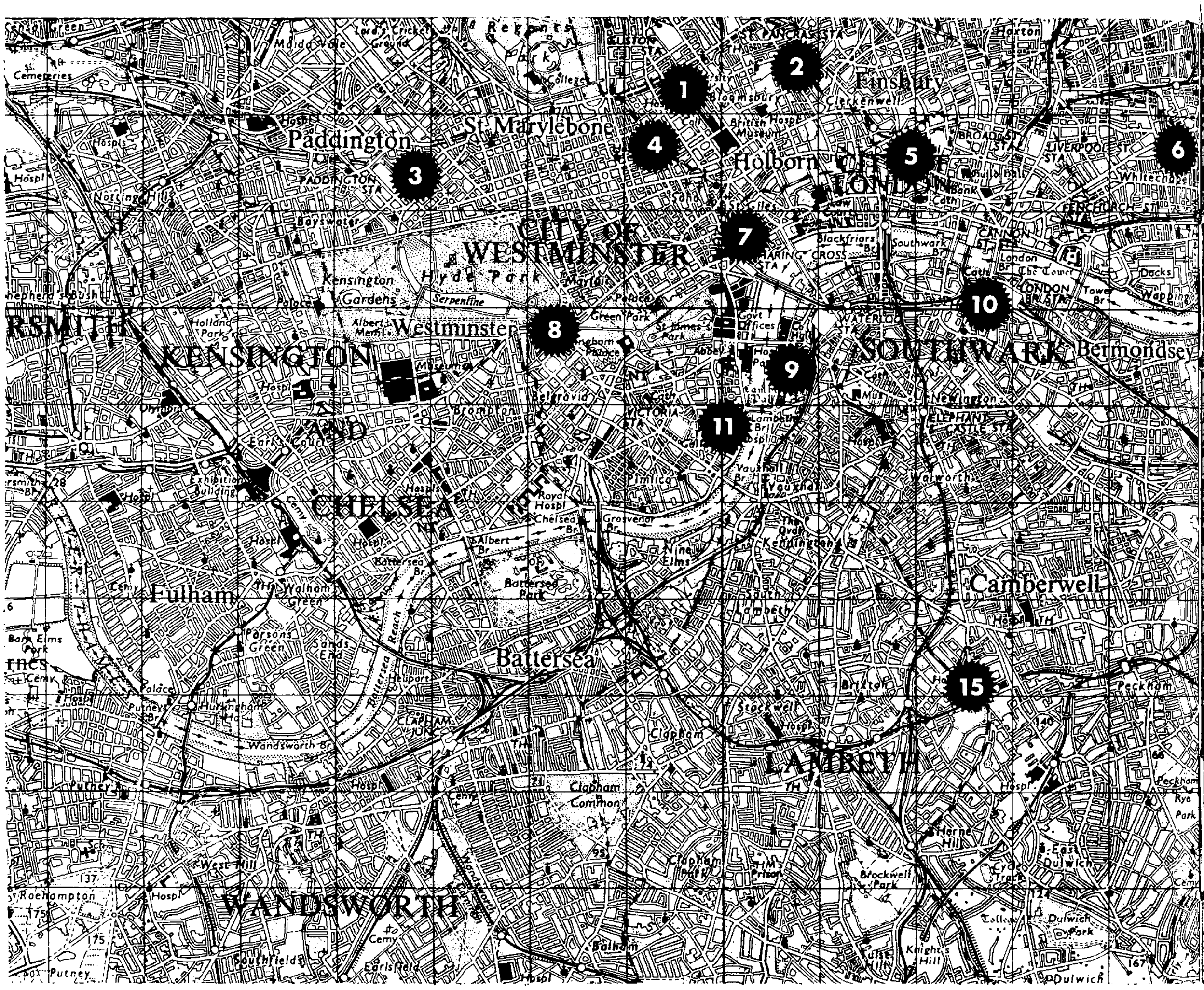
Planning started at the end of 1962. The first part of the project was to meet the anticipated need for additional residential accommodation for staff. Three 10-storey blocks, including in total 213 units of accommodation, were erected in the grounds of the existing nurses' home, near to although separate from the main hospital site. In November 1966 construction work began on Phase 1 of the main hospital, and the final phase should be completed and occupied in 1972.

History

Greenwich and Deptford Union Workhouse was built in 1840 and for the first 90 years of its life administered by the Greenwich and Deptford Board of Guardians.[2] Its original purpose under the Poor Law Act of 1834 was to meet the needs of the destitute section of the local population, or perhaps more accurately to make destitution unattractive for those at least who were able to work. Under the 1834 Act admission to the workhouse was an essential prerequisite to the receipt of alms, which created the demand for the construction of new and larger workhouses, and despite the unwelcoming nature of their facilities helped to fill them once they were built. Main Block – see diagram 1.1 – which was part of the original building at Greenwich and only demolished in 1968, accommodated up to 700 inmates in crowded conditions which at times allowed only 1ft between beds. A smaller building, known as South Block, housed about 200 ill patients, but its sole purpose was to look after the sick who were within the workhouse. The sick of the parish were cared for by a number of dispensaries, including the Miller Hospital and Royal Kent Dispensary, founded in 1783. The Miller Hospital is now known as the Miller Wing of the Greenwich District Hospital and is sited about a mile away from the former workhouse, now known as St. Alfege's Wing.

The size and purpose of the workhouse was extended in 1875 when work started on the construction of a new infirmary block to the south of the existing buildings. The new block provided facilities for about 400 patients and also included administrative and staff accommodation. At about the same time the chapel was erected with a seating capacity of 400, for the exclusive use of those workhouse inmates who were members of the Church of England.

Two further blocks were erected on the workhouse part of the site, known as East Block and West Block, between 1886 and 1889. Their purpose was to house 300 of the chronic sick. The Board of Guardians at this time also determined to increase its accommodation for the treatment of acute illnesses, and in the next few years two further units, adding 250 beds in total, were erected on the infirmary block side of the site. Admission to the infirmary block was not restricted to inmates of the workhouse, but for a long time the new infirmary beds were under-used, perhaps because of the stigma attached to the infirmary block which could only be approached through the workhouse, perhaps



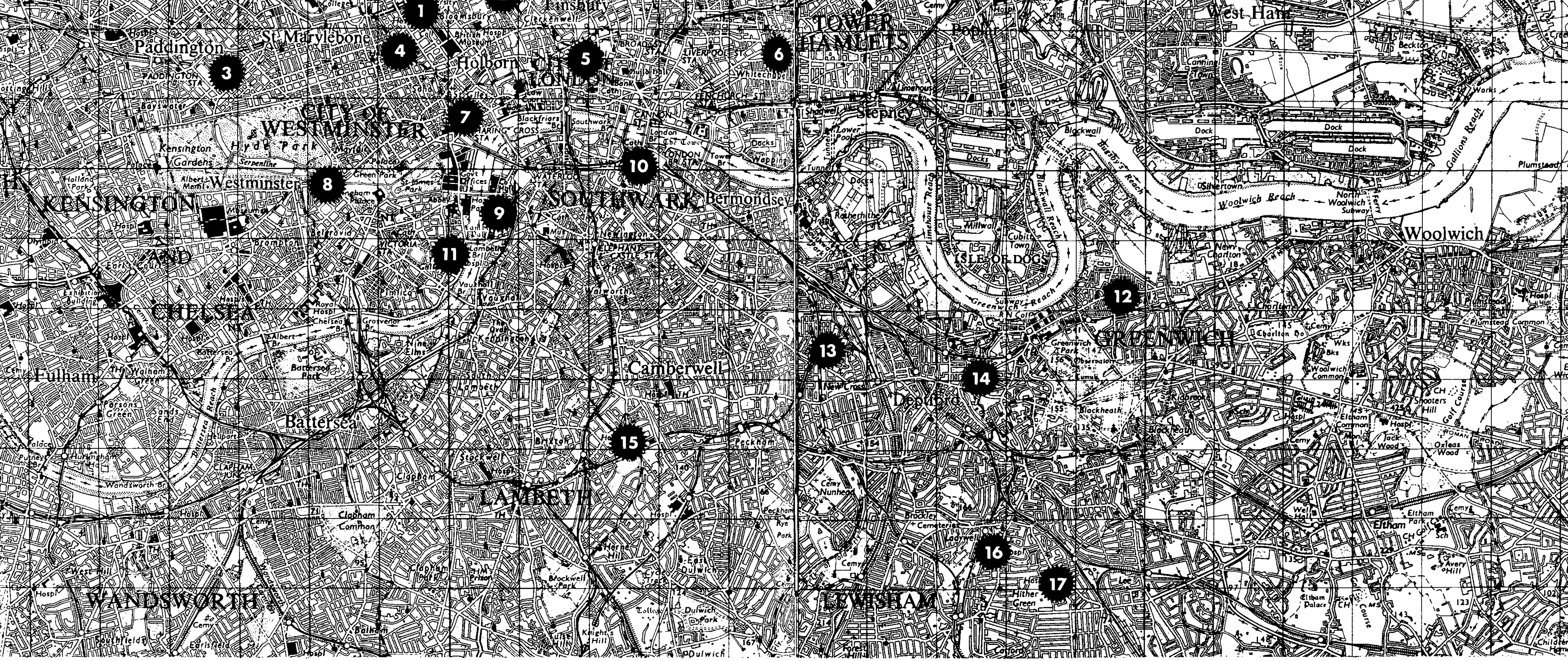
1.2 Map of Central and South-East London, showing the principal hospitals in and around the Greenwich area and the undergraduate teaching hospitals. (Reproduced from the Ordnance Survey Map with the sanction of the Controller of Her Majesty's Stationery Office. Crown copyright reserved.)

1 University College 2 Royal Free 3 St Mary's 4 Middlesex 5 St Bartholomew's 6 London

because of a natural fear of surgery which was still very crude in its methods, perhaps because in the absence of any sick benefit schemes the working poor could not easily afford the loss of pay and to risk the loss of a job in order to be admitted to hospital.

At the end of the 19th century the workhouse section had an average daily occupancy of 1,200 inmates, whilst the infirmary block had accommodation for 538 beds. Site limitations prevented any further extensions except for the construction of a new out-patient unit (known as Vanbrugh Block) in 1930, which also included a pharmacy, antenatal clinic and nurses' sick bay. The Local Government Act of 1929 transferred responsibility for the whole hospital to the London County Council. Its workhouse function had ceased by this time and it now performed the duties of a general municipal hospital. One of the first acts of the London County Council was to give the hospital the name of St. Alfege's, in honour of St. Alfege, an 11th-century saint who was said to have been killed at Greenwich by seamen from invading Danish ships.

A small section of the hospital was damaged during the Second World War, but when the development project began in 1962 the hospital still had a total capacity of 670 beds. The *Hospital Plan for England and Wales* (1962)[3] proposed that St. Alfege's Hospital should be redeveloped to form a district general hospital of some 800 beds.



Central and South-East London, showing the principal
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Office. Crown copyright reserved.)

1 University College 2 Royal Free 3 St Mary's 4 Middlesex
5 St Bartholomew's 6 London

7 Charing Cross 8 St George's 9 St Thomas' 10 Guy's
11 Westminster 12 St Alfege's

13 New Cross 14 Miller 15 King's College 16 Lev
17 Hither Green

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Location

St. Alfege's Wing of the Greenwich District Hospital is situated at the east end of the borough, about seven miles south-east of the centre of London – see diagram **1.2.** It fronts onto the Woolwich Road to Blackwall Tunnel. Vanbrugh Hill runs up the west side of the site and leads to Blackheath. It is on the north side of the Greenwich and Woolwich railway line and the nearest station is Maze Hill, which is about five minutes walk away. It is about three-quarters of a mile east of the Naval College and the Dreadnought Seamen's Hospital.

The main site is about 7½ acres in area and is roughly square with a small projection at the south-east corner. It slopes down to its northern boundary, the difference

in levels between extreme south-west and no
being about 12ft. The site has been divided in
by a retaining wall 3ft to 4ft high. South of th
the acute part of the hospital and to the north
former workhouse accommodation, the geriatr

An area in the north-west corner of the site ha
been partially cleared of buildings subsequent
damage, and it was preferable that this portion
site be developed first with possible extension
demolition to the south and east.

Outline Functional Content

The catchment area to be served by the new h
has a population of approximately 150,000.

Administration

Medical, nursing and lay administration	offices and committee rooms
Medical records	department providing full service
Religion	chapel

In-patients

General acute	378 beds
Intensive therapy	12 beds
Paediatric	49 beds
Maternity	81 beds
Special care baby	20 beds
Geriatric	180 beds
Psychiatric	59 beds

Day patients

General acute	13 beds
Geriatric	50 places
Psychiatric	50 places

Diagnosis and Treatment

Operating department (with theatre sterile supply unit)	6 theatres
Day surgery	1 theatre
Labour suite	10 delivery rooms
Accident and emergency	2 minor operating areas 13 examination/ treatment spaces
Observation ward	8 beds
Diagnostic x-ray	7 diagnostic rooms
Department of physical medicine	department providing full service (including occupational therapy)
Pathology	department providing full service
Mortuary	30 body places
Medical photography	department

Consultation and Examination

General out-patient clinics	34 consulting/ examination rooms
Dental clinic	3 surgeries
Ophthalmic clinic	2 consulting rooms
Antenatal clinic	12 consulting/ examination rooms
Orthopaedic/fracture clinic	3 consulting bays 4 examination rooms
Medical social workers	5 consulting rooms

Education

Centre to accommodate all training – nursing, midwifery, post-graduate medical and other	4 lecture rooms

Staff Facilities

Sick bay	clinic rooms 8 beds
Changing accommodation	
Staff duty rooms	15 rooms
Children's nursery	

Service Departments

Pharmacy	dispensing and manufacturing sections
Catering	1 food preparation kitchen 3 floor kitchens 3 staff dining rooms 2 patients' dining rooms 1 cafeteria
Supplies	1 main store 3 distribution centres
Engineering and maintenance	1 boiler house workshops plant rooms

Notes

1 *Staff residential accommodation. Three 10-storey blocks have been erected on a nearby site to provide 213 units of accommodation, including 2-room, 3-room, 4-room flats, bed-sitting rooms and study bedrooms.*

2 *Clean linen and sterile supply items are to be supplied from an off-site area industrial zone.*

1.3

although for maternity and out-patient purposes it may well be somewhat greater.

Diagram 1.3 gives an outline statement of the functional content of the new building, which in fact reflects the original statement of content prepared at the beginning of the project, modified as a result of research investigations.

1 *Hospital Building Bulletin No 3: A traffic and organisation survey for hospital redevelopment.* Ministry of Health. HMSO 1964.

2 For further information on this subject refer to *St Alfege's Hospital: Greenwich and Deptford Union Workhouse and Infirmary.* Raymond Moss DipArch ARIBA and Hugh Thomas MA DipArch. British Medical Journal 24 December 1966 p1587.

3 *Hospital Plan for England and Wales* (Cmnd 1604). HMSO 1962.

2 The Design Concept

based on papers given by Howard Goodman and J R B Green AADip ARIBA

The Purpose of a Hospital Building

Before looking briefly at the main types of hospital layouts which were being considered for new hospital designs at the time when the Greenwich project started, it may be valuable first to consider the purpose for which any hospital building is erected and the organisation which it houses, since the latter will always be influenced by the building's design.

A hospital should act as a centre for the main medical care facilities for the community it serves. This is not a static purpose since the size of the community may change as may its age structure, whilst independently of such population factors the demands on the medical care facilities made by the community may change for epidemiological, sociological or other reasons.

A hospital which attempts to meet this demand should be defined not as a building but as an organisation which employs two people for every in-patient, is multi-professional to an extreme, and is both complex and ill-defined in its management structure. Yet despite the diversity of components it is this organisation which the hospital designer must attempt to house in a way which is conducive to its efficient operation.

In the early years of the National Health Service much hospital planning was based solely on departmental units, since in most cases new departments were being erected to be added to an existing hospital complex. In consequence, the traditional departmental division of the hospital's function was very largely accepted. In a situation where a whole hospital is being designed, however, a consideration of the hospital's operation department by department misses the opportunity of looking afresh at the traditional allocation of hospital duties. In the interest of future operational efficiency there is considerable value at the design stage in looking at functions rather than departments, in considering for instance in-patient care rather than wards, total supply needs rather than simply the laundry or the stores department. The studies which form the main part of this volume were carried out within such a functional framework.

There are certain general criteria affecting the whole hospital against which the efficacy of the hospital design concept can be judged. In terms of its circulation it should provide for all its occupants quick and obvious routes between the main sections of the hospital. This is particularly important for those sections which are visited by the public. Many people, because of the purpose of their visit, may be both unwell and apprehensive, and in consequence able to follow only the simplest guidance. Patients' visitors may know nothing of the building's geography and may quickly lose themselves if the building design has even a remote affinity to the Maze at Hampton Court. The design must also provide a quick and easy route between all sections, especially those which have strong operational links with each other. It must also satisfy the needs of the supply and distribution system which is one of the most significant sources of movement within a hospital. The aim must be to achieve speed, economy and unobtrusiveness in the distribution of all goods to user points and in the collection from disposal rooms of all returns and items of waste.

In terms of comfort to its occupants the building should at all times provide a pleasant atmosphere and in certain areas at least an environment which is fully controllable. It should be easy to keep clean, whilst at the same time it should avoid being ostentatiously clinical in appearance or inhuman in scale. Whilst meeting the needs of particular functions within the hospital it should encourage staff to recognise that they are all there for the same purpose – the care of the patient – by fostering an integrated community which can overrule the fragmenting influences of professional and departmental loyalties.

In terms of structure the design concept must usually be capable of being erected in phases, especially where it is to be erected on small sites already occupied by existing hospitals which must continue to function during the course of the new development. Its building finishes and engineering services must be robust and easy to maintain. It should be possible to carry out repair work without disrupting the life of the hospital.

In terms of flexibility the building during the course of its lifetime must be capable of adaptation in order to meet changes in demand for whatever reason. This may involve an extension of the building at one particular point in order to meet an increased demand. It may involve simply the re-allocation of space between one section and another as the need for space changes. It may arise from changes not in demand but in the methods of meeting that demand, whether they be new clinical techniques, operational procedures or the consequence of changes in the management structure.

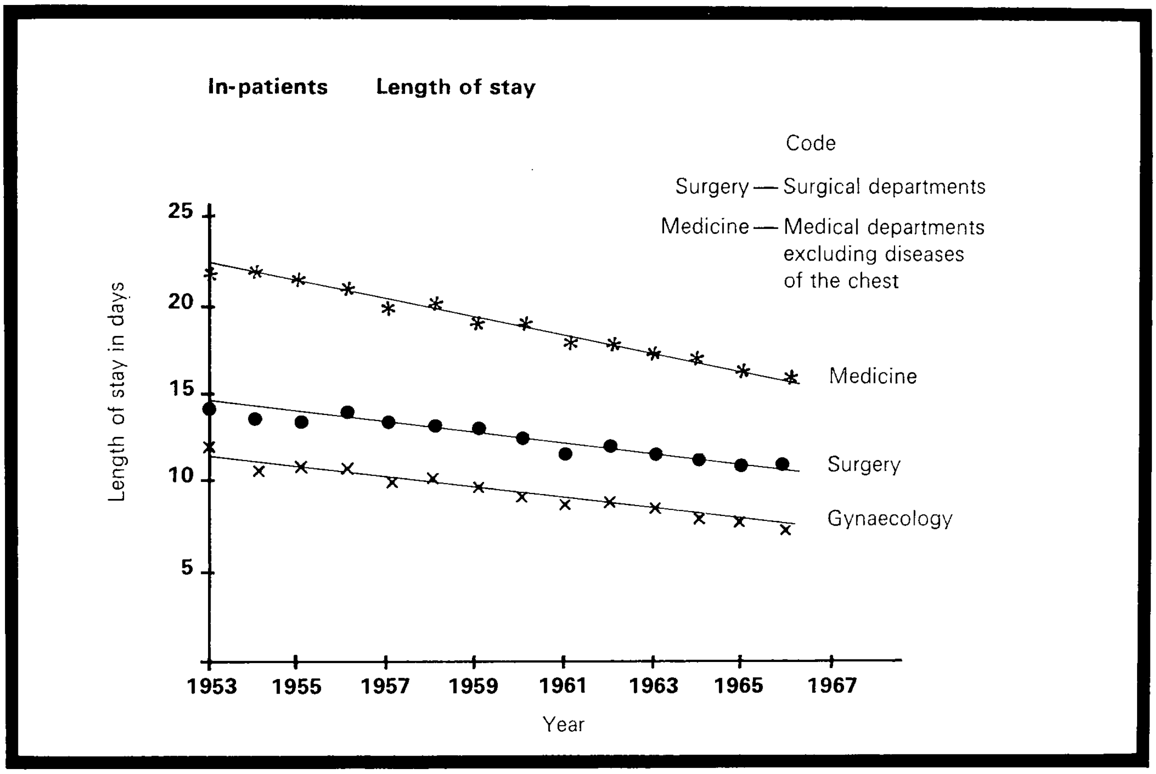
Phasing

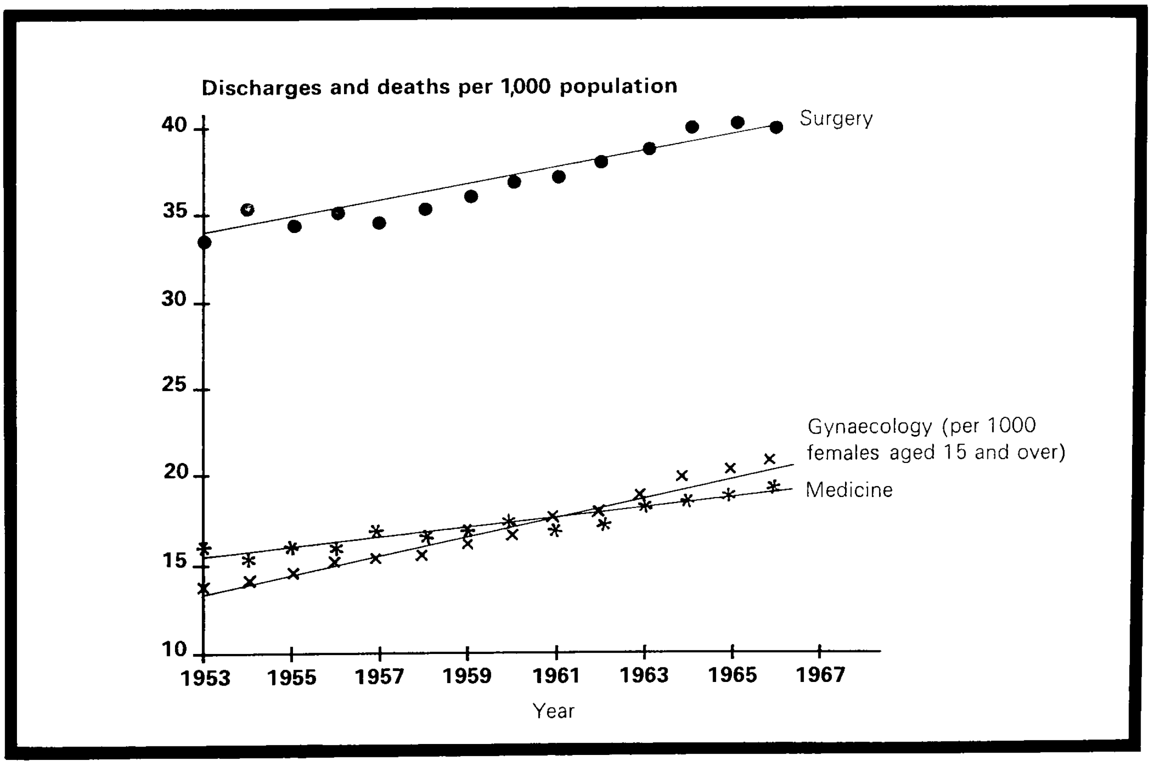
It may be of value to expand a little further on two aspects already mentioned, those of phasing and flexibility. The phasing of a project almost invariably incurs additional building costs and can create major operational problems for the users. Nevertheless the need for phasing a large hospital development has often been necessary because of limitations of finance. There are many hospitals at present which are subject to redevelopment by independent phases over a long period of time for this reason. Even if adequate finance were available at one time a phased development is essential on sites where existing hospitals are already meeting an essential community need which cannot be truncated for the period of the redevelopment. The cost of purchasing alternative sites naturally encourages the use of existing hospital property, and indeed many old hospitals are still correctly situated geographically to meet the needs of the community which they serve.

There is a third reason why phasing is often seen as an acceptable method of programming a hospital's construction. The time required first to plan and then to build a hospital is such that it is frequently said that a new hospital is out of date before it opens. By phasing a development the building work can to some extent overlap the planning work, and the latter can more easily be undertaken as a continuing process by a small but integrated design team, since the need to determine every detail before the building contract can begin is in this way removed.

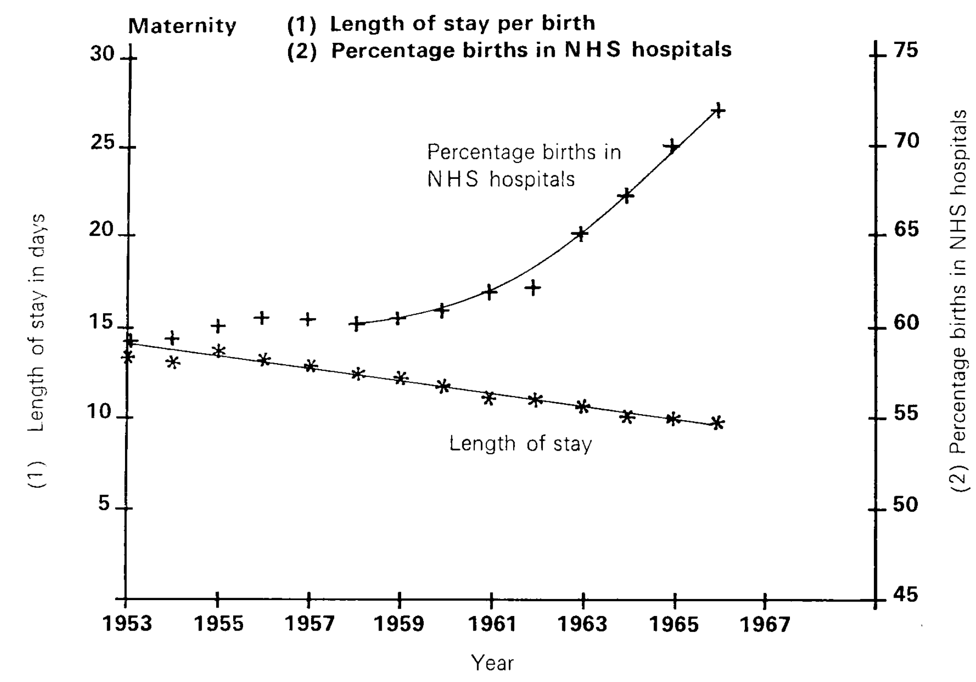
Flexibility

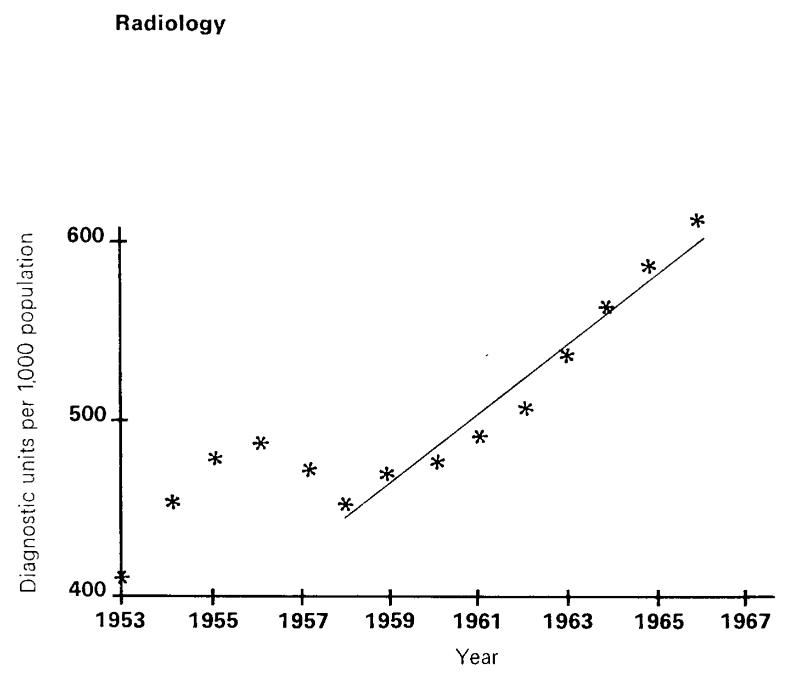
There are several current trends both in clinical practice and in the organisation of community health services which emphasise the need for a hospital building to be flexible and adaptable to change. A study of the workloads in several hospital departments during the 14-year period 1953–66 – see diagram **2.1** – shows that the average length of stay for in-patients in surgical, gynaecological, medical and maternity departments has steadily decreased, whilst at the same time there has been a substantial increase in the number of patients admitted, both in absolute terms and in proportion to the size of population. The number of people attending out-patient clinics and the accident and emergency department has also risen both proportionately and in absolute terms. There has been a particularly striking rise (nearly 50 per cent in 14 years) in the number of new attendances at accident and emergency departments, although a comparison with the total number of accident and emergency attendances suggests that there has been some decline in the number of patients attending on a second or subsequent occasion. Over the same period there has been a 50 per cent rise per 1,000 population in the workload of the x-ray department, whilst in the other main diagnostic department, pathology, and calculated on the same basis, the number of individual requests handled has more than trebled. The number of attendances by in-patients at the physiotherapy department has increased substantially but the number of out-patient attendances has declined at an equivalent rate, suggesting a change in emphasis in the work of the department. An expansion in the



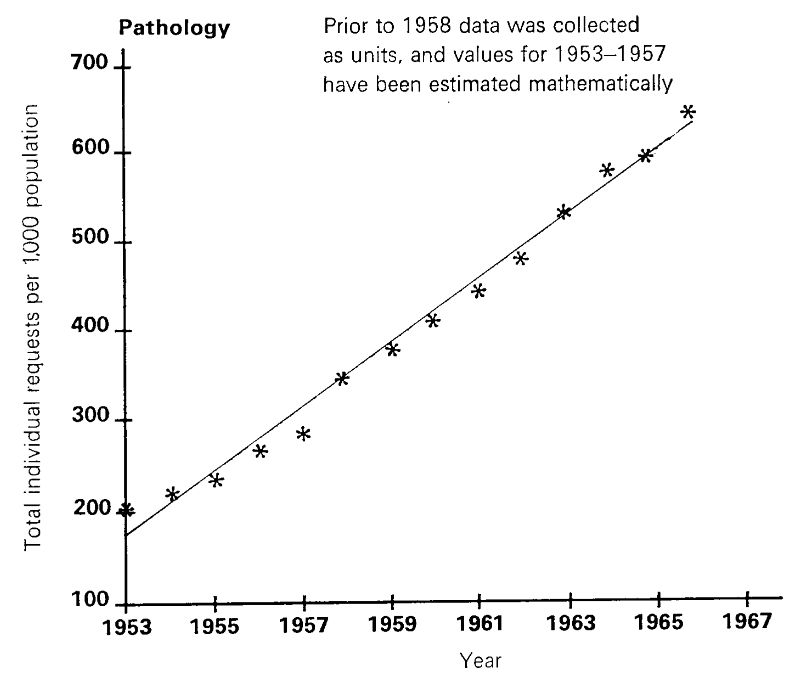


2.1 Examples of trends in the hospital treatment of patients 1953–1966. The statistics used have been collected from all National Health Service hospitals in England and Wales.

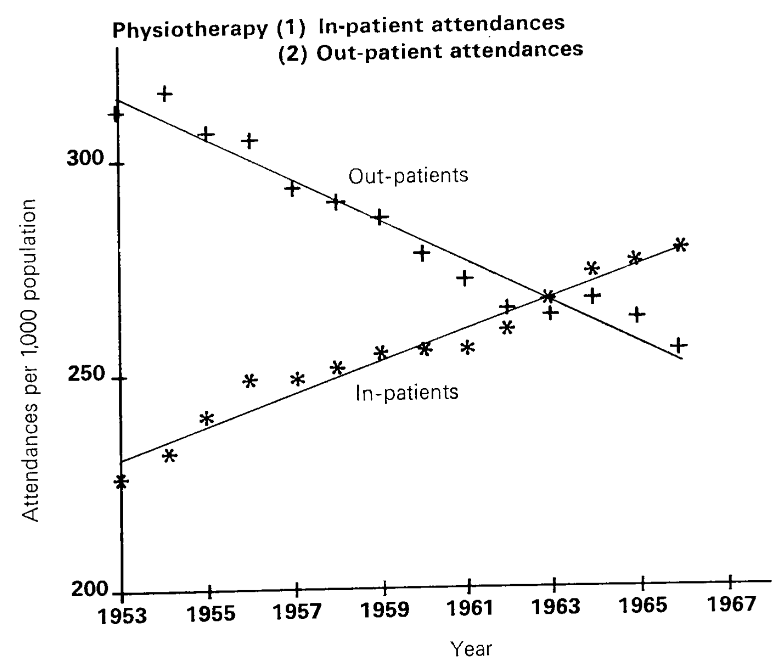




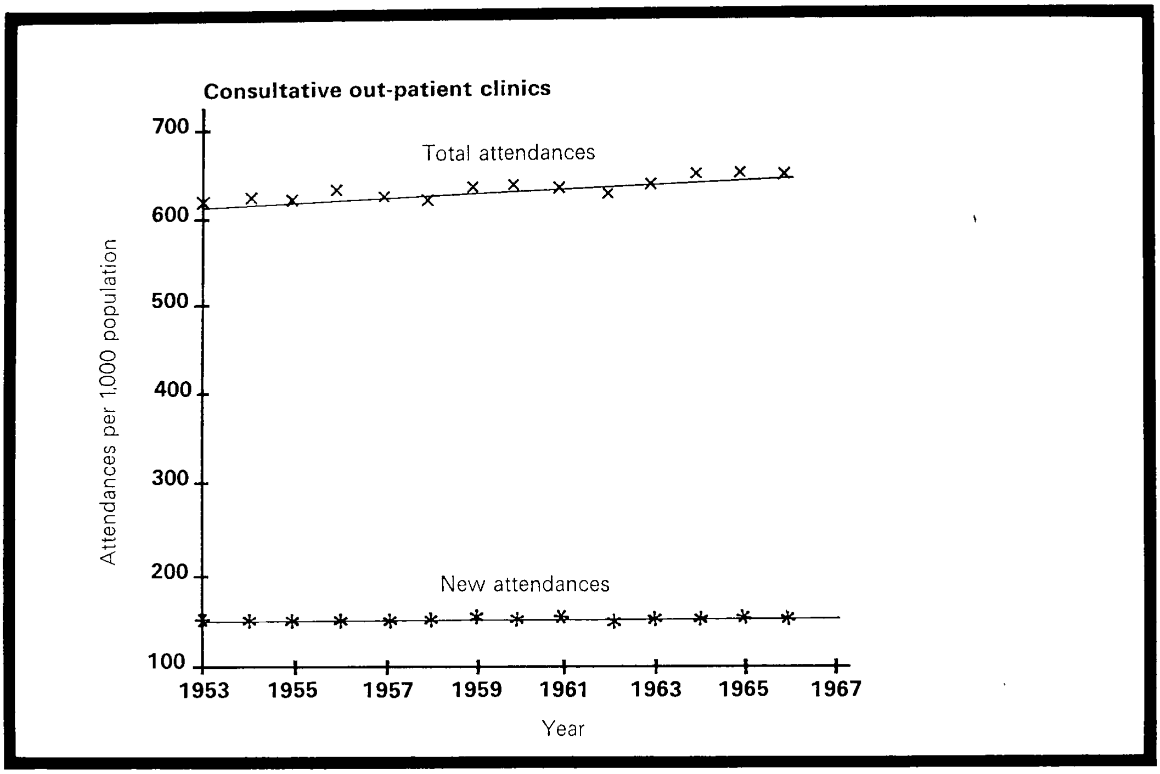
2.1 continued **Examples of trends in the hospital treatment of patients 1953–1966. The statistics used have been collected from all National Health Service hospitals in England and Wales.**

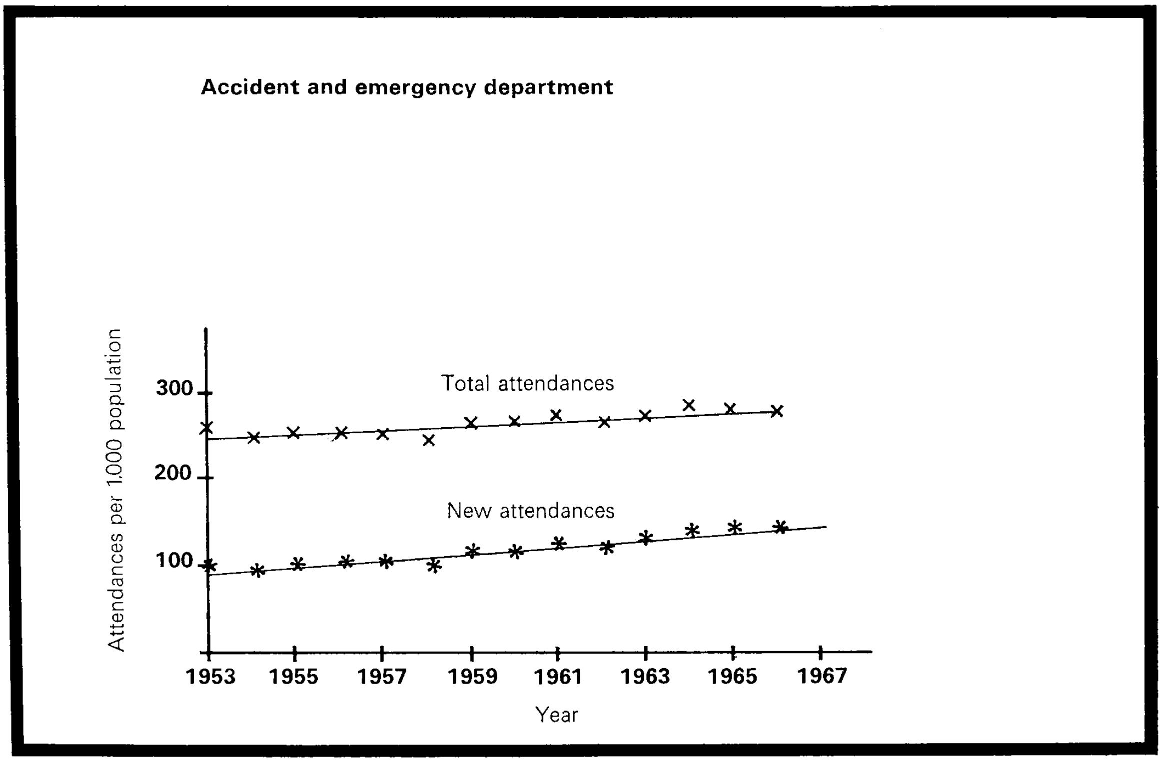


Pathology
Prior to 1958 data was collected
as units, and values for 1953–1957
have been estimated mathematically
Total individual requests per 1,000 population
700
600
500
400
300
200
100
1953
1955
1957
1959
1961
1963
1965
1967
Year



Physiotherapy (1) In-patient attendances
(2) Out-patient attendances
Out-patients
In-patients
Attendances per 1,000 population
300
250
200
1953
1955
1957
1959
1961
1963
1965
1967
Year





2.1 continued Examples of trends in the hospital treatment of patients 1953–1966. The statistics used have been collected from all National Health Service hospitals in England and Wales.

domicilary health services may mean that hospital in-patients of the future will be almost exclusively in the high dependency category. Indeed there may eventually be a decline in the number of beds required, whilst the demand for diagnostic and treatment facilities may continue to expand.

Changes in the methods of carrying out continuing hospital functions also have their effect on the use of the building. The mechanisation of many pathology laboratory procedures encourages the prospect of area laboratories, with a consequential reduction in the number of laboratories on hospital sites. Similarly the concentration of laundry, sterile supply and other manufacturing functions will tend to vacate premises at present occupied on hospital sites, in this way precipitating an alteration in room usage. It is such situations as these which hospitals built today must be able to meet during the course of their lifetime.

Basic Types of Hospital Layout

Hospitals in use, currently being built or at the design stage at the time when the planning of the Greenwich project began may be grouped into any one of five main types. These are briefly as follows.

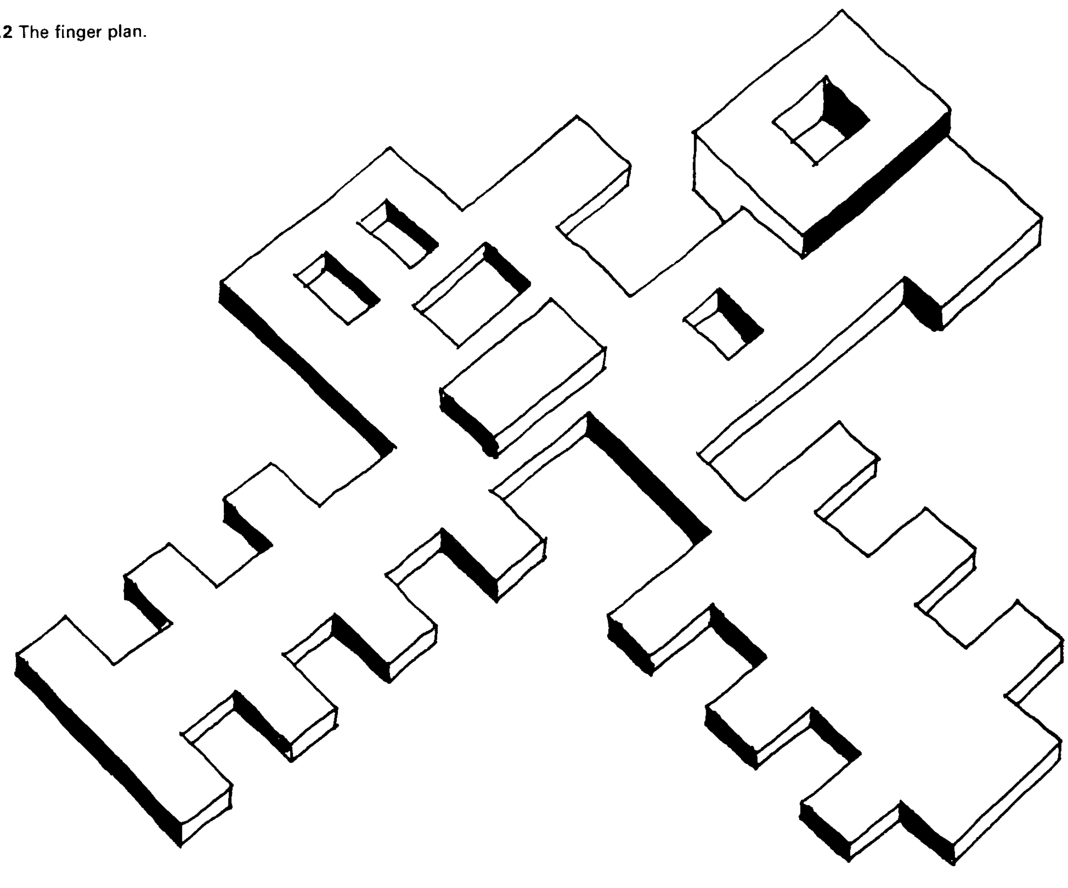
Finger Plan – see diagram **2.2**. The layout is usually based on a spine corridor linking the various fingers or wings. The fingers are usually fairly narrow, permitting good natural ventilation and lighting even in tall blocks. In the case of multi-storey layouts lifts and hoists are often located at the base of the fingers, but there are also many single-storey hospitals of this type.

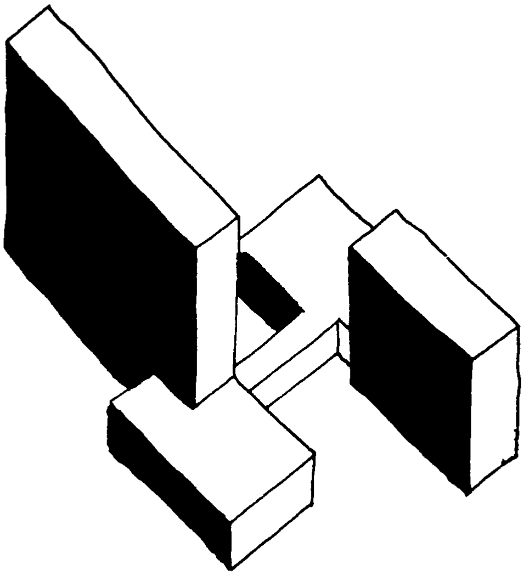
The fingers usually contain the wards but the lower floors in multi-storey versions often contain out-patient and diagnostic departments. Where the spine is not simply a corridor it is generally composed of administrative, supply and diagnostic departments.

A recent example of the finger plan layout is Wexham Park Hospital, Slough, which consists entirely of single-storey buildings, with the exception of a central tower containing administrative offices and medical staff quarters. One consequence of this layout is an extended circulation pattern, but with most departments on one level it is possible to solve some of its traffic problems by mechanical means.

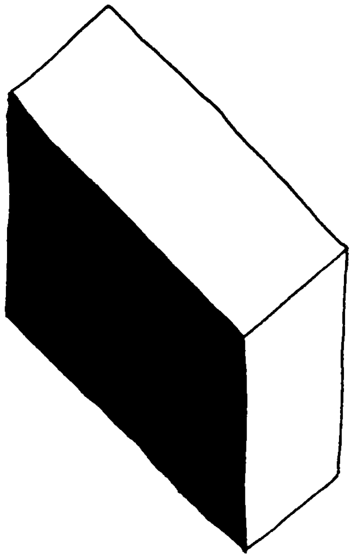
Independent High and Low Blocks – see diagram **2.3**. The blocks are often scattered over the site, being only loosely linked to each other and perhaps having been built at different times. The blocks are usually devoted to different functions, being designed to suit the individual needs of each. Communication routes tend to be fairly long, and lifts and hoists where used are

2.2 The finger plan.





2.3 Independent high and low blocks.



2.4 The slab block.

frequently dispersed. A recent example of this building type is Princess Margaret Hospital, Swindon.

Slab Block – see diagram 2.4. In this type of layout, which may be more complex on plan than just a simple rectangle, departments of all kinds are housed in the one vertical slab. The length of the block sometimes means that there may have to be two or more vertical shafts to reduce horizontal travel in the upper floors to a minimum, although a scheme prepared for the Bellevue Hospital, New York, is square on plan and has only one vertical shaft for all lifts and hoists. This is a type of hospital layout which in recent years has frequently been used in the building of American hospitals.

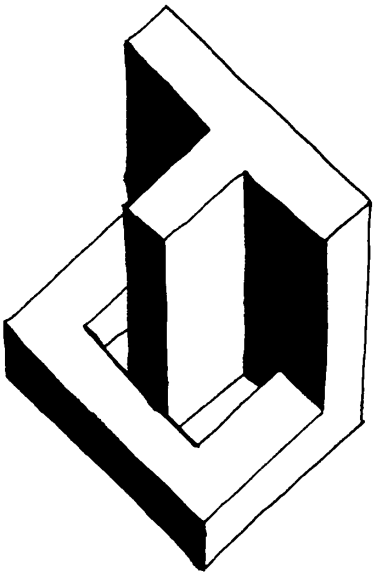
Tower or Slab with Low Block – see diagram 2.5. Almost all the accommodation is housed in a single building which may be composed of several wings. Wards and some diagnostic and treatment departments are usually housed in the tower block, the main out-patient departments often being sited at or near ground level. Supply departments are usually at low level but are sometimes in entirely separate blocks away from the main hospital. Lifts and hoists are usually concentrated at the centre of the tower block. Examples of this layout in use are to be found at Altnagelvin Hospital, Londonderry; Queen Elizabeth II Hospital, Welwyn Garden City; and the new Hull Royal Infirmary.

Tower on a Podium – see diagram 2.6. This is at first sight the most striking expression of whole hospital planning, which has developed round the concept of a central core serving the stacked wards in the tower, and a podium consisting of the main out-patient, diagnostic and treatment departments. Supply departments in the lower ground floor serve the wards above by means of lifts and hoists in the core. To reduce horizontal travel in the upper floors the double corridor plan is frequently employed for the wards. Some mechanical ventilation is often necessary for internal rooms in both the tower and the podium. The new general hospital at High Wycombe is a good example of this concept (although its later phases for both site and phasing reasons are likely to complicate the pattern so far created).

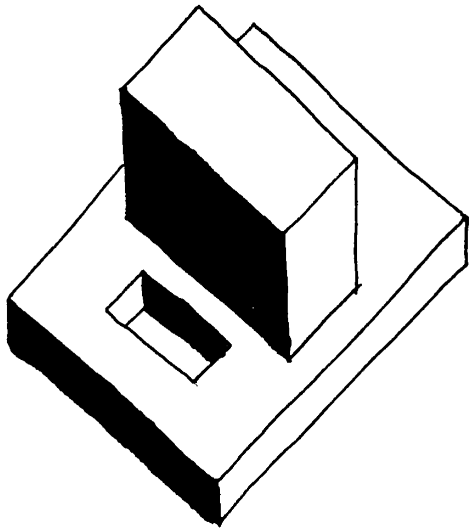
It will be seen immediately that there is considerable overlapping of characteristics between these hospital types as outlined. Furthermore, there are many hospitals old and new which do not fall clearly into any one of the above types, although usually they have certain essential features which are similar to one or other. Nevertheless, an analysis of hospital building types in this way was of value at the start of the Greenwich project in assessing the suitability for the Greenwich situation of hospital layouts which had been or were currently being used in hospital building.

Assessment of Layouts for Greenwich

The choice of hospital layout for any development inevitably reflects a compromise between, on the one hand, the client's ambition that the hospital should be suitable for both present needs and future demands, and, on the other hand, the many restrictions imposed by the peculiarities of site and the limitations of finance. Indeed even the client's intentions concerning the functioning of the building may not always be mutually compatible. A building type which most successfully meets today's workload and operational methods may



2.5 The tower or slab with a low block.



2.6 The tower on a podium.

be unable to respond to changes in the quantity and nature of future hospital treatment. On the other hand it is conceivable that the price of flexibility for the future may be an element, albeit marginal, of operational inefficiency for the present.

Among the members of the project team responsible for planning the new hospital at Greenwich there was a strong desire to optimise the building's flexibility. This was based on the suspicion that too many hospital buildings, both new and old, were acting like strait-jackets in inhibiting the proper development of the hospital's performance, whether it be the efficient execution of current practices (the maximum use of beds, for example), a desirable change in current practice (alterations in the method of meal preparation, for example), or much needed changes in the use of accommodation arising from changes in workload. It was also thought that even where the need for change was recognised, if it involved building alteration the necessary work could often only be carried out with difficulty, sometimes inadequately, and often at considerable cost.

The available building layout types had to be assessed in the first instance, however, in relation to the Greenwich site restrictions, which were considerable. As has already been mentioned the site is in total about 7½ acres in area, and is roughly square with a small projection at one corner. There is a reasonably even slope across the site, the difference in levels from one extreme to the other being approximately 12ft. With the exception of one corner, which had been cleared after war damage, the site before the redevelopment started was densely covered with buildings which provided a capacity of 670 beds. Furthermore the target of the development project was to house a total of 800 beds on the same site.

The finger plan, whether single, two or multi-storey can clearly be built easily in phases, and in its single or two-storey form can be erected in such a way that it is susceptible to structural alteration or expansion. In its low form, however, the finger plan requires a large site of 25 acres or more in order to accommodate a district general hospital, whilst even in its multi-storey form the finger plan cannot readily be squeezed onto an area the size and shape of the Greenwich site.

The second type of hospital layout, that using independent high and low blocks, also fits best on a fairly large site. The number of blocks is roughly equivalent to the number of main traffic foci, so that the main interdepartmental communication routes are horizontal. Where the number of independent blocks is reduced in order to fit a restricted site there arises an unfortunate combination of horizontal and vertical journeys along the main traffic routes. Again for site reasons, therefore, this solution was not acceptable at Greenwich.

A single slab block on the other hand requires only a small ground acreage, but in the Greenwich situation it had other disadvantages. A phased development would have been difficult, although not impossible, but in order to meet the site limitations imposed by the existing buildings it would have been necessary to build a vertical section of the block which when completed would present operational problems, as well as being subject to disturbances at every level during the construction of the later phases. In addition, the slab block type imposes some limitation on the alteration of its function because of the great number of separated floor areas, but more significantly because of the fact that such a large proportion of its floor space is above ground floor level that it is impossible to expand most areas of the building except by adding a multi-storey appendage.

The tower or slab with low block has many similarities with the fifth basic type referred to, that of the tower on a podium. Its main difference from the latter tends to be that the low block is a uniform structure of two or three storeys with no floor being very large in area, so that there are some difficulties in meeting the varied needs of diagnostic, treatment or service departments which may have to be housed there. The podium by contrast tends to be single or at most two-storey in height and often of varying structure in order to meet the particular needs of different departments. It was the tower on a podium layout which of all the five basic layouts considered above appeared to be possible for the Greenwich situation. Yet after a detailed consideration of this solution certain limitations became evident.

There were, firstly, problems of phasing. It is difficult to phase accommodation within a tower block other than by extending vertically, or by adding a complete wing, or by building another tower block alongside. The first method is expensive in tall buildings, the second is restrictive because of the small units of floor space in each wing, and the third is uneconomic in use of both space and transport systems. The first two methods are also likely to cause disturbance to patients in the first phase of the tower block during building operations. If on the other hand the tower is built as one phase it needs to be sited away from the perimeter of the site so that the podium can surround it on all sides, reducing to a minimum the distances from any point in the podium to the base of the vertical communication shaft. On a site as small as that at Greenwich this would severely disrupt the functioning of the existing hospital.

Secondly, the degree of flexibility in the tower section of the building was also thought to be less than adequate. The small fixed area of each floor in the tower limits its use both for ward accommodation and for other departments, whilst the small number of beds on each floor level (up to 90 beds, say) and the probable further division of each ward floor into ward units would tend to restrict flexibility in the use of ward accommodation and hinder the maximum use of beds. Furthermore, the separation of accommodation and circulation in the tower from the podium restricts the ability of the building to respond to any changing emphasis in the demands for accommodation from different departments.

Thirdly, there were several problems relating to internal traffic routes. Distribution of supplies to departments in the tower would necessarily be on a different system from that used for departments in the podium, the tower relying very heavily on lifts and hoists whilst in the podium some form of horizontal conveyance would be required. This design constraint would tend to encourage the existence of two distinct distribution procedures in a situation in which a single universally adaptable system would always seem to be preferable. Furthermore, the traffic system for the tower block would be inflexible and could not easily be extended or altered.

There were other factors which appeared to be limitations. The need for two types of structure, one for the tower block and another for the podium, limits the possibility of achieving financial economies and saving time in construction by the use of a standard structural system. It also imposes uneven stresses on the ground and involves two different types of foundation for the high and low blocks.

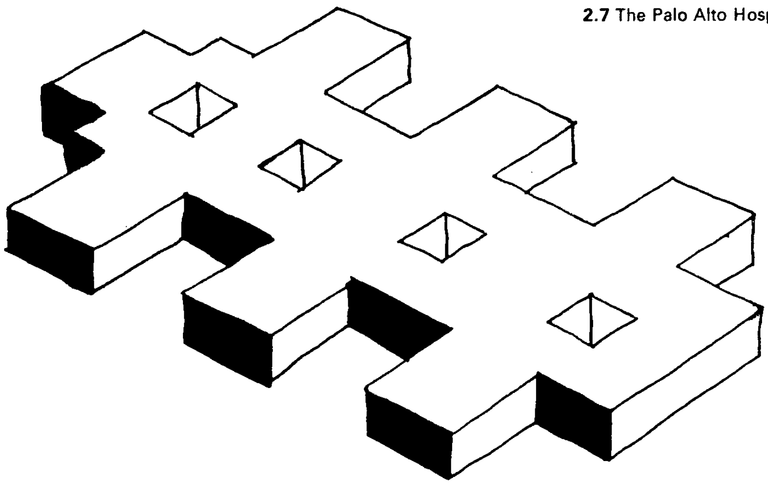
Finally, on a point concerning engineering installations, the podium could economically employ a system of service sub-floors, but it would be uneconomic to use them in the tower block due to the greater height and perimeter of the building. Access to services in the tower block would therefore have to be through the ceiling from rooms below or into vertical service shafts through removable wall panels, preventing easy access to the services and creating a cause of disturbance to the occupants whenever repair or alteration was necessary.

The Greenwich Solution

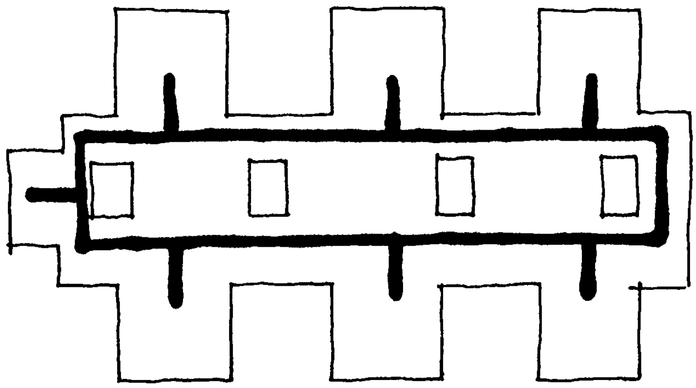
Origins

The Greenwich design concept resulted initially from a conviction that a solution to the problem posed at Greenwich could not be found from among those hospital layout types which were immediately available. The design concept which ultimately emerged drew upon experience gained in fields beyond the hospital service, in particular in schools, offices and factory buildings. Yet the germ of the design concept was found in at least one hospital, the Palo Alto Hospital project then being designed in the United States by Isadore and Zachary Rosenfield – see diagram **2.7**. Here was a three-storey hospital consisting of a main oblong block with several subsidiary wings attached at right angles on both of the longer sides. There were several interesting features. It was an extremely compact layout requiring a small ground acreage, yet it could easily be expanded by extending either of the short sides of the oblong and adding more wings. The inside of the main oblong would require artificial ventilation but the wings were sufficiently narrow for natural ventilation to be possible. The most interesting feature, however, and particularly in relation to the main subject of this volume, was the principle of the ring main corridor, where the main internal traffic route consisted of a continuous corridor running close to the perimeter on all four sides of the central oblong and linking with each wing – see diagram **2.8**.

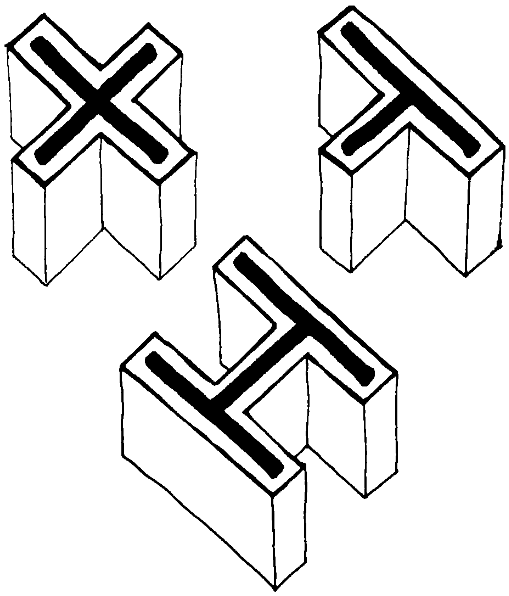
The corridor system in almost every hospital so far built has approximated to an X, a T or an H – see diagram **2.9**.



2.7 The Palo Alto Hospital, California, U.S.A.



2.8 The ring main corridor system.



2 9 X, T, and H corridor systems.

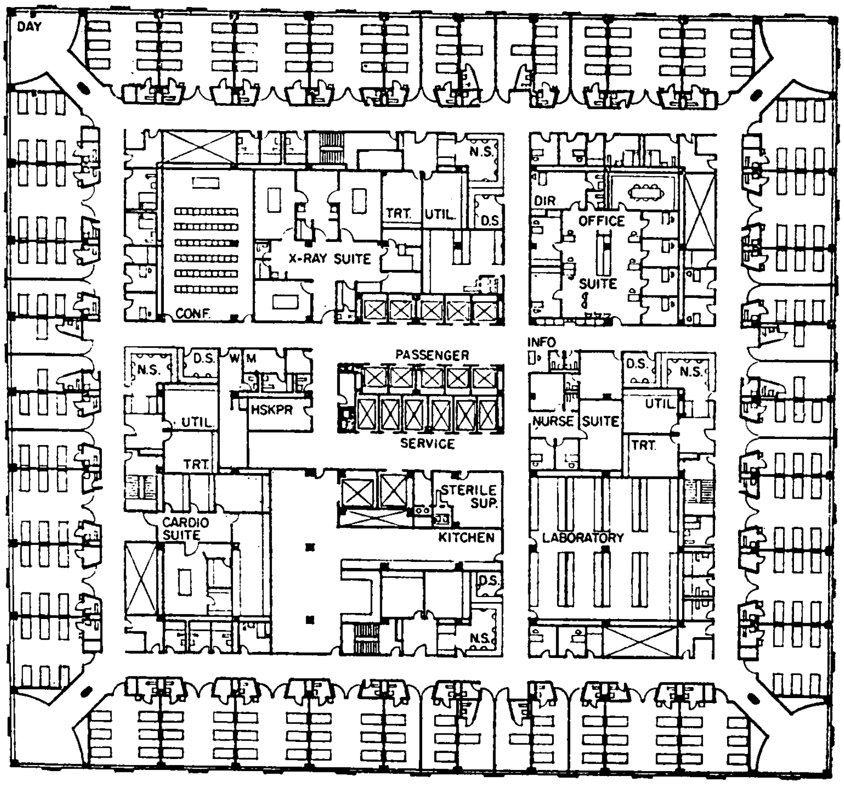
Each corridor therefore either leads to an exit or is in effect a cul-de-sac, so that a substantial part of internal hospital traffic has to travel across the corridor junction and along at least two of the corridors. Such a corridor system can easily handle all traffic from the main entrance to one point or from one point to the exit. Perhaps slightly less efficiently it can also cope with traffic moving from point A to point B within the hospital. On those occasions when there are several points on the journey, such as a linen distribution round or refuse collection round, a corridor system which includes extended cul-de-sacs can lengthen considerably the distance which has to be travelled, as well as causing a risk of congestion at the point where the corridors meet. The ring main corridor system, especially when bisected twice by link corridors, seemed to provide the opportunity of minimising the distance between departments and so improve the efficiency not only of the distribution services but also of particular departments which rely heavily on each other.

Another new hospital design in the United States which highlighted this point of close association of related departments was that of the Bellevue Hospital, New York – see diagram **2.10**. In this case each ward floor is approximately a square, containing 180 beds in rooms along the four perimeter walls, whilst a wide range of supporting facilities are sited in the internal areas, including x-ray diagnostic rooms, a pathology laboratory and floor kitchen. Each floor can thus be seen as substantially a self-contained unit. Whilst a division of departments between several floors such as x-ray and pathology would not be considered acceptable in this country it is nevertheless possible to site certain departments in close association with those beds which provide them with the greater part of their work – operating theatres with surgical beds for instance, the pathology laboratory with medical beds.

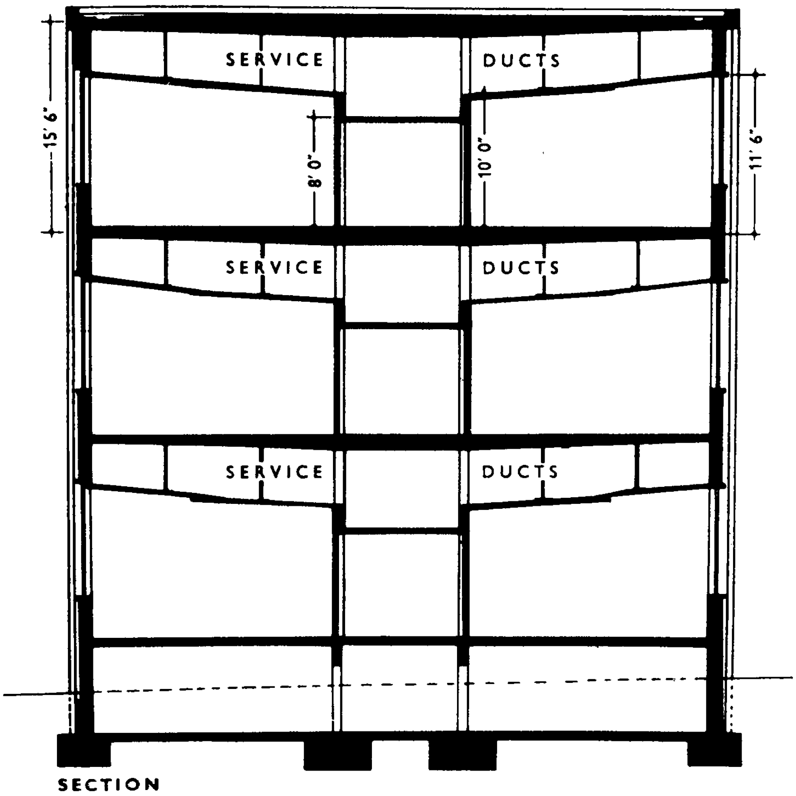
From outside the hospital field came the idea of using long-span construction methods, combined with the concentration of all vertical communications and service connections into a small number of shafts, in this way creating a floor space which could be subdivided almost at will by lightweight partitions but which was otherwise unobstructed. This principle has for some time been employed in factory buildings and has recently been developed in Germany in the construction of office blocks, where the open-plan floor space is subdivided by nothing more substantial than the arrangement of desks and the positioning of flowers, shrubs and screens.

When this principle is adopted for hospital purposes the large amount of engineering services required in almost every section might well limit the possibility of changing the allocation of space by the removal and re-erection of lightweight partitions, especially if the engineering services are installed in a limited number of ducts above the ceiling or below the floor. Similar problems concerned with the adaptability of engineering services are especially acute in laboratories, and one of the best current solutions to this problem is found in the Wellcome Research Laboratory buildings at Beckenham – see diagram **2.11**. Each has a horizontal service sub-floor over the whole of the block, although giving full headroom only over the spine corridors, the remaining space varying between 4ft and 3ft in height. The vertical connections occur at either end of the block on the line of the main access corridors.

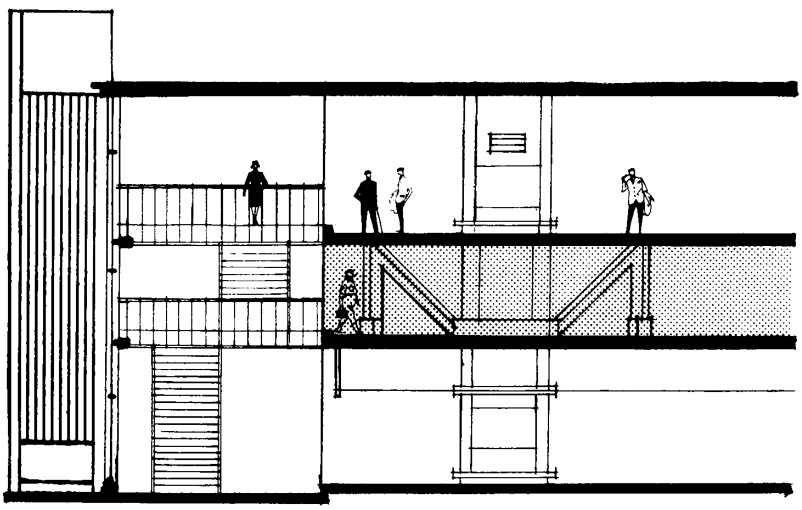
Probably the most complex development of the service sub-floor is that of the Texas Instruments Inc. electronics factory in Dallas which has an 8ft space between production floors – see diagram **2.12**. By the provision of a service sub-floor access for maintenance purposes is made easy so long as the use of the space is well planned, whilst even alteration work can be



2.10 15th floor (medical and surgical), Bellevue Hospital Center, New York. Designed by Joseph Blumenkranz and Associates. (Reprinted from Architectural Record, April 1964.)



2.11 Typical section, Wellcome Research Laboratories, Beckenham. The design concept for these buildings was evolved by the late R L Kennedy, chief engineer of The Wellcome Foundation 1947–1959. (Reprinted by permission of The Wellcome Foundation Limited.)

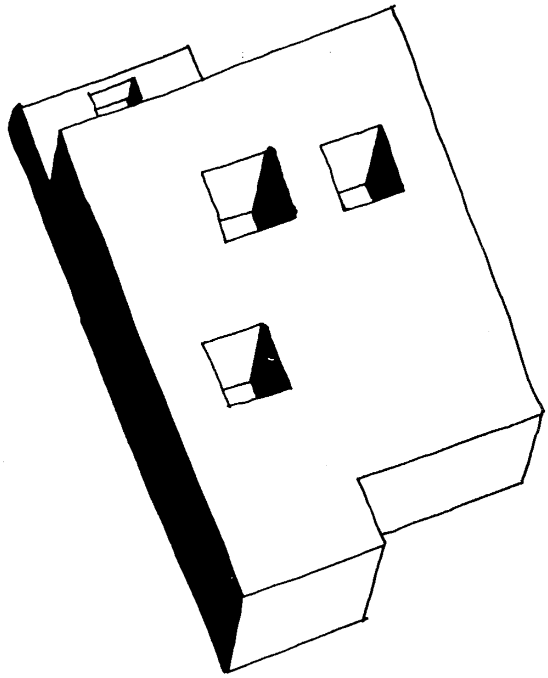


2.12 Typical section, Texas Instruments Inc. factory, Dallas, U.S.A. (Reprinted from Engineering News-Record, July 16, 1964. Copyright McGraw-Hill Inc. All rights reserved.)

carried out to a great extent without disturbing the floor above and certainly without the need to face the problem of creating new ducts.

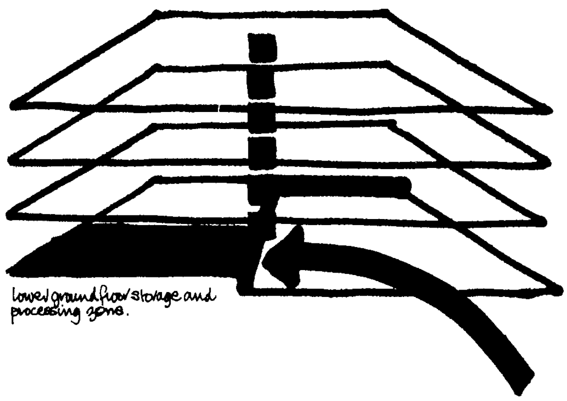
Description of the Design Concept

The building layout as ultimately adopted at Greenwich consists of a four-storey square block, each side measuring approximately 400ft. When compared with the Palo Alto Hospital the wings have been combined within the central block, creating the simplest and shortest of perimeters. Within the square, however, there are three internal courts which by allowing natural lighting to much of the internal area reduce considerably the number of rooms which will rely solely on artificial lighting – see diagram **2.13**. At the same time the structure of the building enables wings of almost any size to be added where functional convenience dictates. Thus a two-storey wing is being added to provide an extended layout for the out-patient clinics, and the gymnasium will be housed in a single-storey building attached to the main department of physical medicine. Only the boiler house, which is situated in one corner of the site, is structurally distinct from, although connected to, the main block.



2.13 Greenwich Hospital. Internal courts and wings.

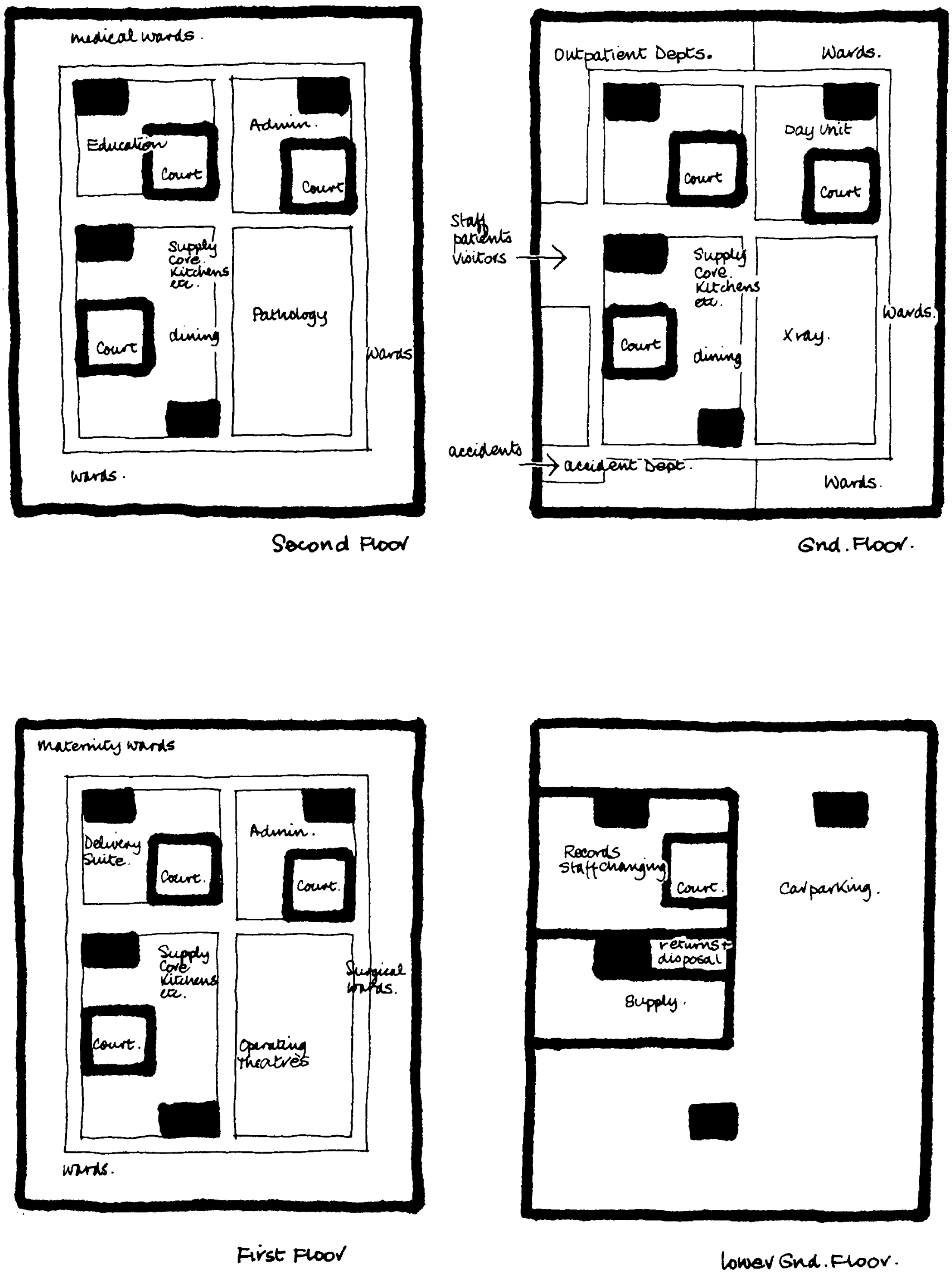
Content. Of the four floors the lowest contains the main vehicular access and service areas for the upper three floors, and also a considerable amount of car parking space, which must be provided within the building on such a small site in a densely populated area – see diagrams **2.14**, **2.15**. The ground floor immediately above contains the main entrance for patients and the public, and therefore includes those departments which have a reception function or give an immediate service to out-patients. There are only 170 beds on this floor. Each of the upper two floors contains 300 beds as well as several other departments.



2.14 Greenwich Hospital. Relationship of the floors.

The size and shape of the floor areas at each level, along with the use of a long-span beam construction, has given considerable freedom in the location of departments within the building. For amenity reasons all ward units have been placed on the perimeter of the building, but this has also the advantage of linking wards together in continuous strips, thus creating 'swing' areas between wards where single bed or multi-bed rooms can varyingly be used by one ward or the other – see diagram **2.16**. It is thought that this will offer new opportunities for efficiency in the field of bed management.

Other departments have been sited within the area bounded by the wards. Where departments serve the whole hospital yet have a special affinity with a particular section they have been sited on the same floor and in close proximity to each other. Thus the pathology laboratory is on the same floor as the medical wards, the operating theatre suite is on the same floor as the surgical wards, and the x-ray department on the same floor as the out-patient clinics and the accident and emergency department.

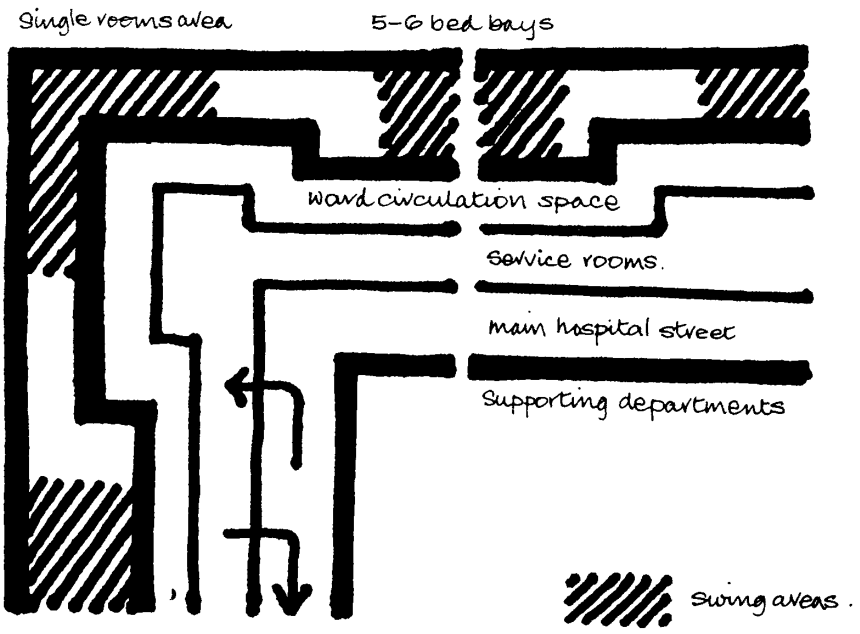


2.15 Greenwich Hospital. The four floor zoning plans.

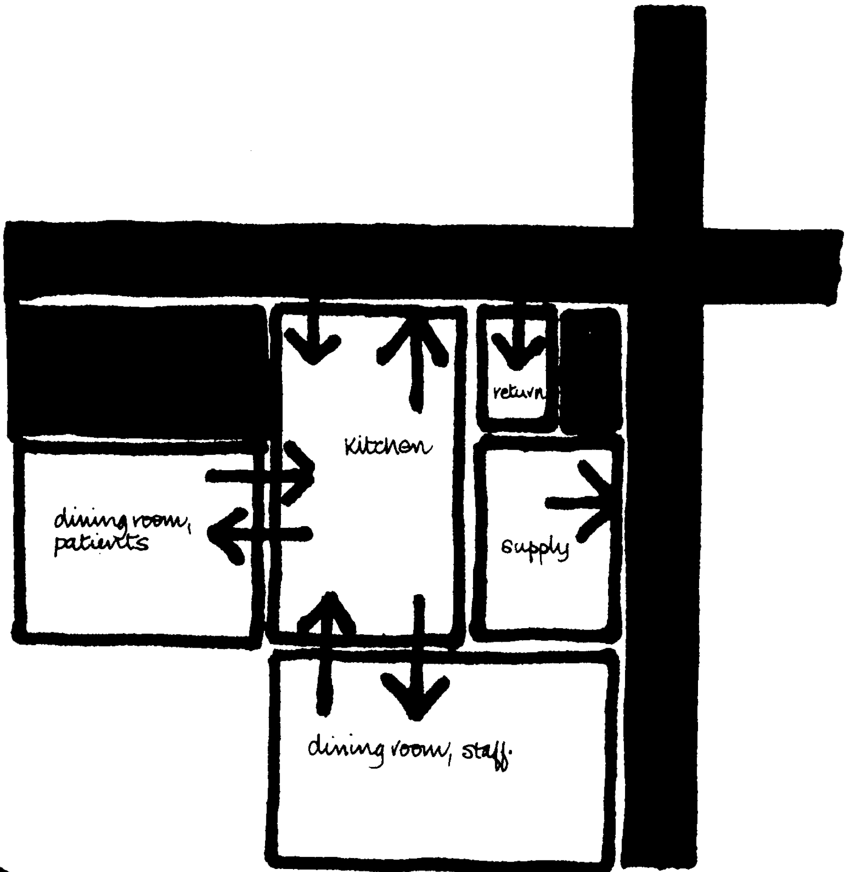
The compact nature of the planning on each floor meant that horizontal movement would clearly be eminently efficient. It was an asset which could be further exploited, and the amount of vertical movement correspondingly reduced, if some of the supply departments were split into three and sited on each of the upper three floors. This has in fact been done with the distribution aspect of the supply process, the catering department, and both the staff and patients' dining rooms – see diagram **2.17**. The fact of these subdivisions was of crucial significance in the planning of these sections, each of which is considered during the course of this volume.

One result of this arrangement has been to create three floors each of which is functionally self-contained for many purposes. It is hoped that the subdivision of the whole hospital in this way will help to reduce some of the less desirable consequences of a building and organisation of this size, whether they be concerned with staff supervision, the direction of patients, or simply the atmosphere created by the scale of such a building.

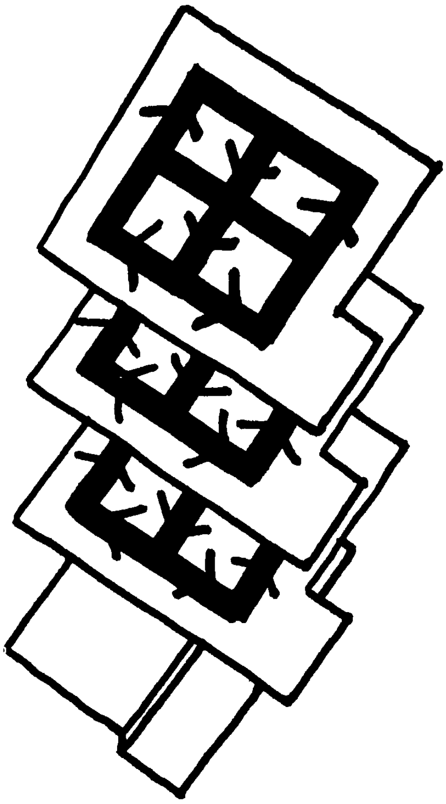
Each of the upper three floors relies for its main horizontal movement on a ring main corridor which runs along the internal boundary of the ward units – see diagram **2.18**. Each of the four sides of the ring main corridor is connected by a link corridor to the centre of the floor, at which are situated the primary vertical traffic routes. Another consequence of the emphasis placed on horizontal movement has been the isolation of those functions which demand vertical movement, and thus the opportunity to consider what is the best solution for each of these particular functions. The solutions to these problems are described later. It is sufficient to mention now that at the centre of each floor and linking all floors are a six-section escalator for the movement of all people who are ambulant, a paternoster for the movement of goods, and disposal chutes for the removal of soiled linen and refuse. Because of the provision of these purpose-selected forms of vertical movement it is considered that



2.16 Greenwich Hospital. Examples of the ward 'swing' areas.



2.17 Greenwich Hospital. Grouping of the supply departments at the centre of each floor.


2.18 Greenwich Hospital. The ring main corridor system.

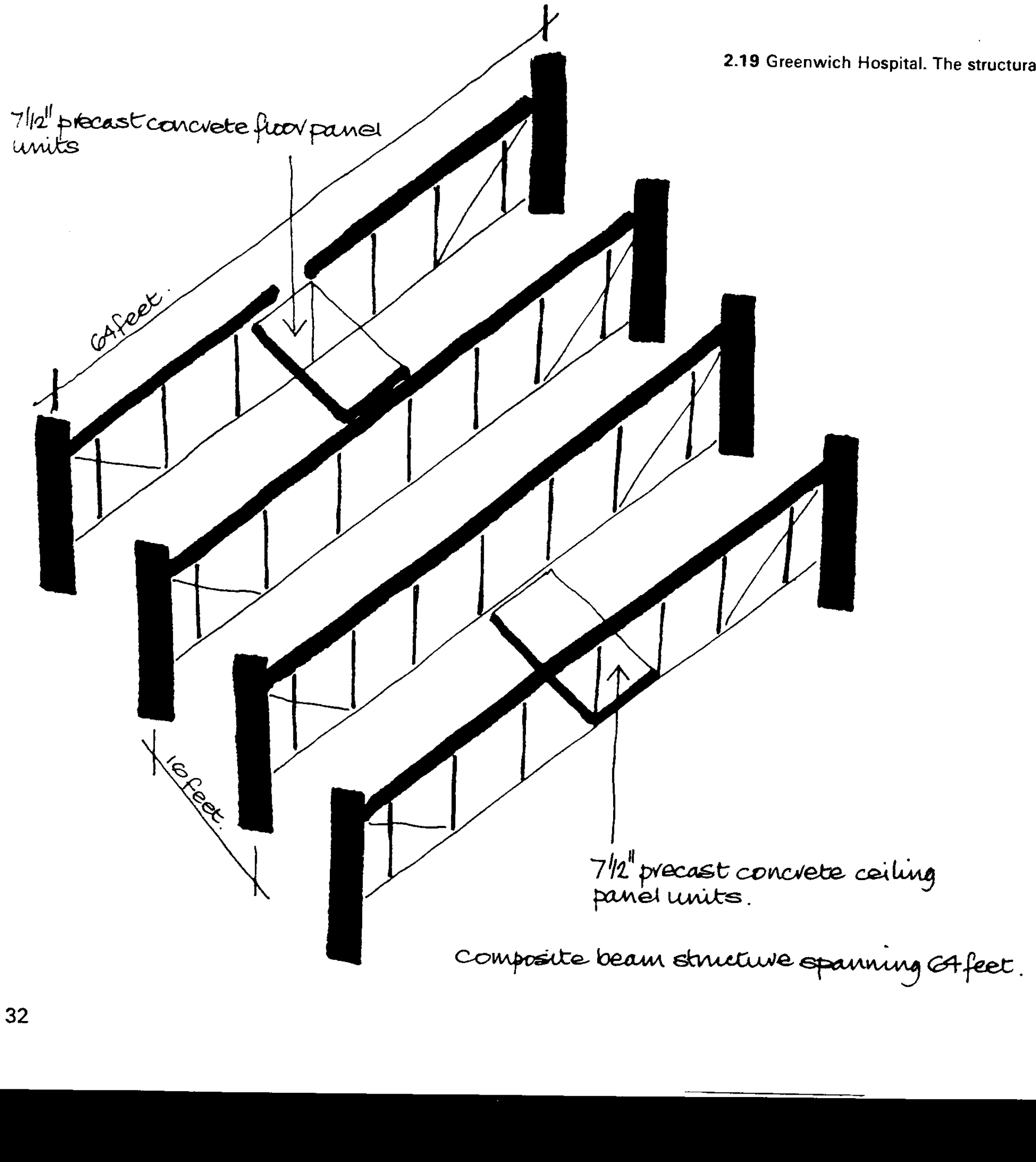
only three general purpose bed/passenger lifts will be necessary for the whole hospital.

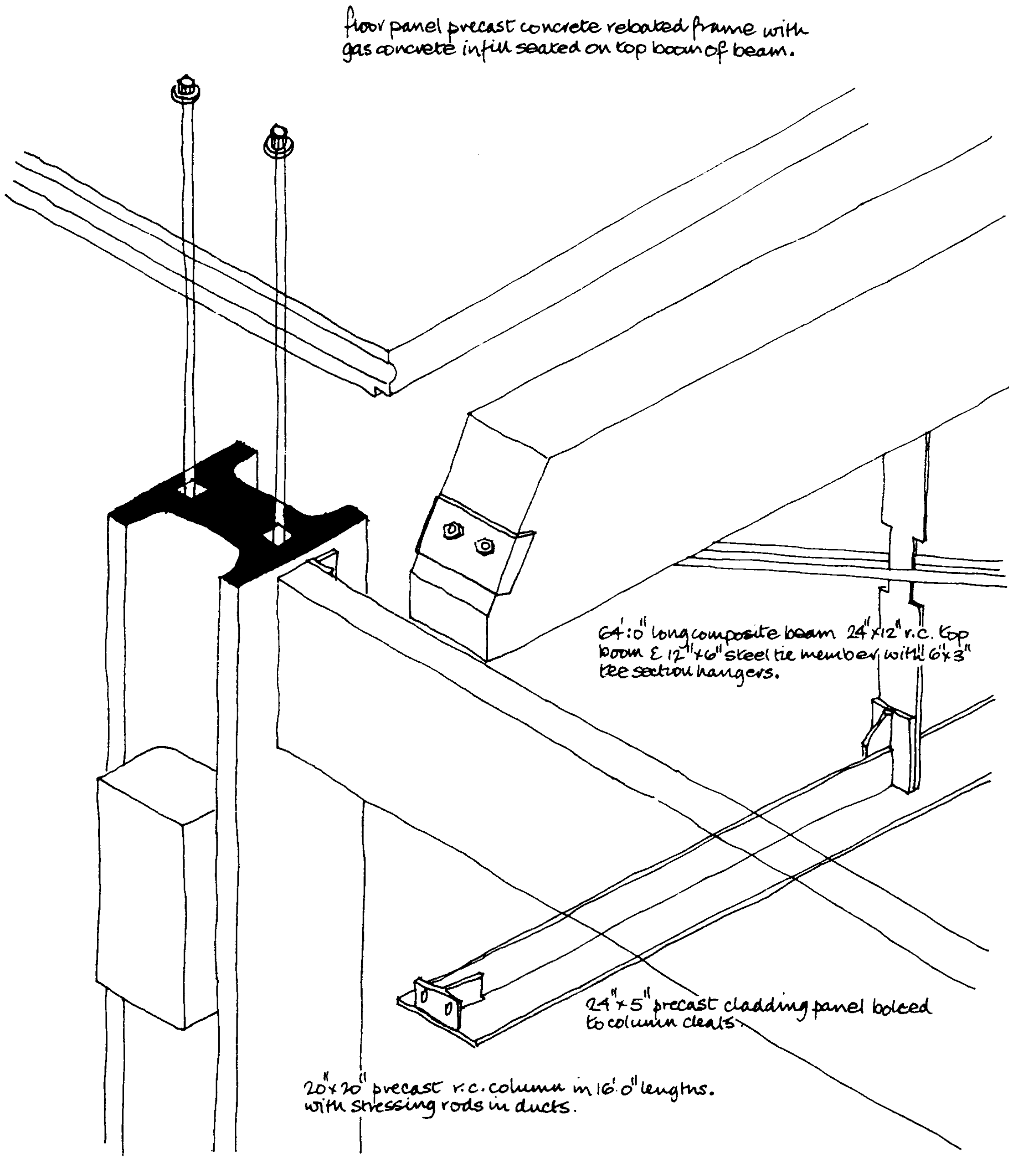
Structure. The main structure has a span of 64ft, giving a clear span of 62ft 8in of floor space uninterrupted by columns – see diagram **2.19**. Spans of 16ft (giving a clear span of 14ft 8in) at right angles to the main beams are consistent with structural efficiency and enable corners to be turned conveniently. Apart from the columns required to support the beams the floor space is perforated only by four vertical engineering shafts, one of which at the centre of the building also contains all the main vertical traffic routes. In order to avoid further perforations of the floor area most of the minor internal staircases have been associated with one or other of the engineering shafts. All partitioning of the floor area is in prefabricated lightweight panels which can be easily erected on site, and almost as easily dismantled.

The long-span beam is a composite structure with a 2ft deep concrete top member, steel ties, struts and hangers, giving a space of nearly 6ft between the floor above and ceiling below – see diagram **2.20**. It is this void which is being used as the engineering services sub-floor, linking together the vertical engineering shafts and housing all the horizontally running sections of the engineering services – see diagram **2.21**. Floors and ceilings above and below the engineering sub-floors consist of precast panels composed of modularly spaced concrete ribs with gas concrete infilling, enabling all services, light fittings and ducts to penetrate the panels at a variety of points without cutting into the dense concrete of the panel ribs. Thus not only is the initial siting of partition walls basically unrestricted by the availability of engineering services supply points; there is also similar freedom of action in any subsequent alterations to the partitioning of the floor area.

Ability to Expand. The ability of the hospital building to be expanded is limited ultimately by site restrictions. As a hospital layout the Greenwich design is very susceptible to extensions, since in the event of a major addition the ring main corridor could itself be enlarged, whilst in the event of a minor extension its internal traffic route could be linked to the existing ring main

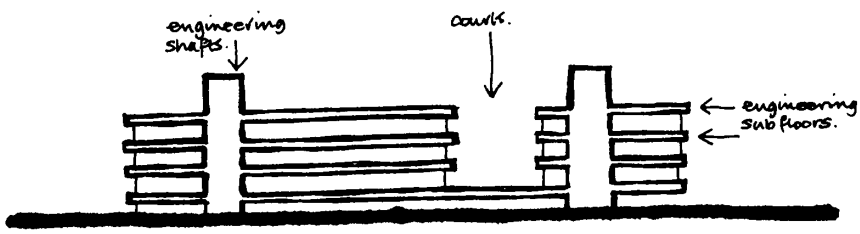
2.19 Greenwich Hospital. The structural system





2.20 Greenwich Hospital. Connection of the composite beam to the column.

2.21 Greenwich Hospital. The engineering sub-floors and shafts.



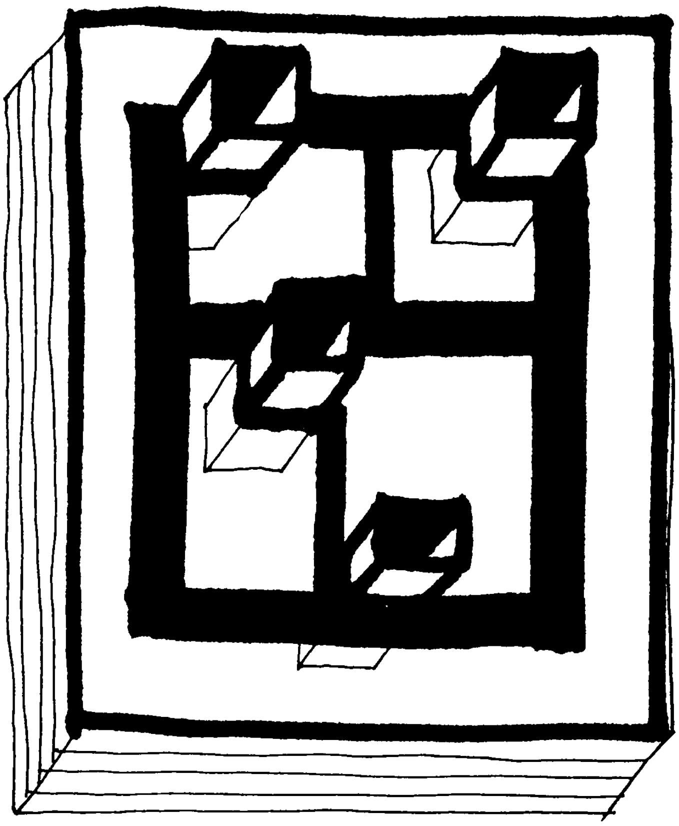
corridor without creating an extended form of cul-de-sac. The Greenwich site may permit expansion on two sides of the square. In addition, the loadbearing structure of the building has been designed to carry an additional floor should this be necessary. If both these methods of expansion were used the total floor area of the hospital could be increased by nearly 50 per cent without violating the essential compactness of the plan or its principles of internal traffic movement.

Phasing. For phasing purposes this type of hospital layout can be divided into vertical segments so long as these segments equate with the main engineering shafts. Since the Greenwich concept included a central engineering shaft with associated floor servicing departments it was found necessary to attach the central core to the first phase. The initial intention was to complete the construction in four phases, working in a clockwise direction round the site. It is now intended to build the last two phases together, and it has been found to be possible to serve both of them from a single peripheral engineering shaft – see diagram **2.22**.

It would be wrong to imply that the project is being carried out without any disruption of the work of the existing hospital. Nevertheless the number of beds in use on the site – 670 in total before the redevelopment began – will not drop below 400 during the construction period. In addition the out-patient clinics and other diagnostic departments will maintain a full service throughout, although for a short period it will be necessary to refer all accident and emergency patients to the main area centre at the Miller Wing, one mile away.

There are aspects of the structural method which assist a phased development. An early decision on the approximate size of the building, coupled with a standardisation of all structural components, means that the designers of the later phases can concentrate on the detailed layouts of individual departments, whilst at the end of the project a simplicity and consistency of form has been achieved. Furthermore the use of prefabricated building components transforms the work of *in situ* erection into a quiet process which can be carried out comfortably in close proximity to occupied sections of the old or new building.

Mechanical Ventilation. There is one essential element of this type of hospital layout which has so far not been mentioned – mechanical ventilation. There are certain sections of a hospital which for clinical reasons alone demand some form of mechanical ventilation, perhaps 10 per cent of the total floor area. Any form of deep ward planning on a multi-storey basis demands that at least the central core areas have some form of



2.22 Greenwich Hospital. The positions of the four engineering shafts. The shaft shown at the foot of the diagram will serve the last two phases.

mechanical air extraction. In the Greenwich layout, with a building depth of approximately 400ft each way, perforated only by three 64ft square internal courts, it was initially thought that some 70 per cent of the total floor area would need to be served by mechanical ventilation, since the rooms in the perimeter zones could be naturally ventilated through opening windows. However, a study of those factors which bring about natural ventilation – the wind differential pressure across the building, the stack effect inside the building, and the temperature differential inside/outside the building – showed that only the third factor, the temperature differential inside/outside the building, would have any effect on a building as deeply planned as the Greenwich layout. Moreover its effect would be greatest in winter when it would cause draughts, whilst in the summer when ventilation was most necessary the effect of the temperature differential would be minimal. It was ultimately decided therefore that the whole of the building should be served by mechanical ventilation.

This decision of course has several advantages. All windows can be fixed, so preventing the influx of atmospheric dirt and airborne noise. The internal atmosphere can be controlled in terms of its temperature, humidity and, to some extent, its cleanliness. By the use of differential pressure devices distasteful odours can be extracted quickly, whilst air movement can be prevented from areas which are potentially sources of infection into other areas of the hospital.

There are certain financial savings to be obtained by using 100 per cent mechanical ventilation. The prevention of external dirt being blown into the building should reduce the amount of cleaning and eventually the amount of redecoration required. The hospital's heating system can be integrated almost completely with the ventilation system, so avoiding the extensive provision of pipework and radiator panels. Indirectly there are savings to be gained through the compactness of planning which a deep plan permits, and also, as has been shown in this type of layout, a reduction in the amount of vertical transport required. The capital cost per square foot may be higher than in other hospital designs, but it is possible to house the same functional content in fewer square feet.

It has to be recognised nevertheless that a hospital which is fully served by a system of mechanical ventilation is more expensive to build and to run than a hospital which largely relies on natural ventilation. At the same time, whilst on a large site the use of mechanical ventilation can be avoided, except in the minimum number of clinical areas, on a restricted site a greater amount of mechanical ventilation is essential for any district general hospital layout. Furthermore where a multi-storey block is included in the design there is an additional construction cost involved by building high. On a restricted site therefore the extra capital cost of installing a full mechanical ventilation system in a low compact design is substantially less.

As for running costs it has yet to be established whether the benefits gained – from flexibility of use, compactness of plan, and control of environment – can be said to give 'good value for money'.

The remainder of this volume is concerned with a consideration of some of the traffic and supply problems which were faced during the planning of the Greenwich hospital development project. Although this is referred to elsewhere it is perhaps important to emphasise at this point that each of these problems was considered within the framework of the design concept as outlined above. In no case therefore was it possible to choose from the whole range of options which would have been open if the problem had been considered on its own. The task was rather to find the best solution which was consistent with the whole hospital design concept. By the same token the success in this situation of the particular options chosen depends ultimately on the success of the whole hospital design concept itself.

Area Services

One further aspect of the design concept should be mentioned because of its relevance to what follows. The decision that certain supply services to the hospital should be provided from an off-site area industrial zone was taken at an early stage in the development of the design concept, and preceded therefore the detailed planning of individual functions. It was imagined that in a densely populated area such as South-east London an industrial zone would be able to serve several groups of hospitals, and gain the benefits of a large-scale operation, which were considered to be:

- an improved utilisation of capital, and economies in overheads;
- the possibility of improvement in product quality arising from variety reduction;
- opportunities for large-scale contracting and purchasing of raw materials;
- the breaking down of complex tasks into simple stages, made possible by the scale of production and facilitating the use of less skilled labour;
- economies arising from the adoption of flow-line in place of batch methods of production;
- capital economies in building construction and the supply of specialised engineering services.

At the time when the decision was taken (1963) there was no information available which offered any guidance on the range of supply services which could with advantage be provided by an off-site area industrial zone. It is possible that in due course hospital supply services being organised on an area basis may include food preparation, pathology investigations, pharmaceutical manufacturing, certain elements of building and equipment maintenance as well as

2.23 The route between Greenwich Hospital and the Industrial Zone, Hither Green. (Reproduced from the Ordnance Survey Map with the sanction of the Controller of Her Majesty's Stationery Office. Crown copyright reserved.)

the bulk purchase and storage of general stock items. The range of services being provided on an area basis to the Greenwich hospital, however, at least in the first instance, will be limited to the laundering and repair of linen and staff uniforms and the sterilising of surgical instruments and dressings, both of which will be carried out at the Hither Green Industrial Zone, some four miles away from the hospital – see diagram **2.23**.
A standard linen inventory has been worked out by the senior nursing officers of the participating hospitals, and all issues of clean linen will be made from a common stock, controlled by the laundry manager.
It should be added that the concept of an industrial zone is not subject to detailed discussion in this volume.

3 Movement of People

based on a paper given by
C F Jackson AADip ARIBA

Vertical Movement

The design finally adopted for the Greenwich hospital was based on the proposition that the simplest and most flexible way of moving people is horizontally. People or goods can either walk, be pushed or carried horizontally more easily than in other directions. Some of the architects involved in the early design period had also worked on the design of Wexham Park Hospital, Slough (almost entirely a single-storey hospital), and were aware of the case made by Isadore and Zachary Rosenfield for a horizontal emphasis in planning.[4] At the same time it was felt that whilst horizontal layouts could be efficient they became uneconomic in terms of travel time beyond a certain distance. Therefore in addition to being horizontal the layout ought to be compact.

A simple direct layout was adopted in order to ease the circulation of people and vehicles. Each floor can be regarded almost as a hospital in itself, sharing a central supply, catering, storage and vertical circulation core. The departments which have the heaviest or most important traffic links are situated next to each other on the same level. In this way the need for many inter-floor trips is eliminated completely. At the same time it becomes easier to identify the needs of the inter-floor trips which remain, as a prelude to seeking the most appropriate solution.

Traffic Predictions

A report entitled *Studies in the Functions and Design of Hospitals,* published in 1955,[5] suggested that when planning a hospital some predictions can be made on the quantity and nature of internal traffic, whether it be the number of out-patients, visitors, or supply/disposal trips. Since then the Building Research Station and the Ministry of Health Central O and M Unit have published data on traffic surveys.[6]

There are several variables to be taken into account, including the time of day, the day of the week and the season of the year. Changes in hospital policy and visiting times can substantially alter traffic patterns, and this is why a traffic and organisation survey of an existing hospital is useful for the insight it gives into the interaction of layout and operational policies.

The Building Research Station survey of hospital traffic suggested that some of the traffic could be predicted with a high degree of accuracy, given some knowledge of the hospital and departmental layout, staffing and organisation. Traffic which is precisely predictable includes trips on and off duty, to and from meals, and routine delivery and collection rounds. In addition the traffic of in-patients and out-patients for treatment and diagnosis can be predicted if the anticipated workload is known. On the other hand there will be a proportion of traffic which is unpredictable, or which arises for unseen administrative or social reasons. 'On average for every 100 trips that might have been fairly precisely predicted in advance, additional trips amount to about 25 in physiotherapy departments, to about 50 in individual wards, operating theatres and x-ray departments, and to about 400 at main records or medical secretaries' offices and pharmacy departments.'[7]

In the early stages of design work it is unlikely that much detailed information will be available on the proposed organisation of departments, either in a new hospital or in a hospital to be redeveloped; but approximate estimates may be made of the number of beds, staff and the workload of the main departments. Estimates from data collected in comparable situations can also be made. At a later stage, when the brief is developed and the design solution clarified, it will be possible to make specific estimates of the number and type of journeys, together with the origins, destinations and times of trips. In a hospital redevelopment situation in-patient traffic data can usually be obtained from records of admissions, discharges, deaths, and the workload of operating theatres, the x-ray department and the physiotherapy department. Traffic to and from the out-patient department may be estimated if the timetable of clinics and pattern of referrals to other departments for diagnosis or treatment is known. Staff traffic when going on and off duty or to and from meals is relatively straightforward. Reliable estimates can also be made of visitor traffic although the daily variation will depend on local transport facilities, working hours and policies on visiting. It should be emphasised that there will be daily, weekly and seasonal variations in the traffic pattern together with long-term changes which have to be accommodated but which may not be predictable. Changes in operational policies during briefing could also modify the traffic pattern.

The Building Research Station survey of hospital traffic showed that wheeled traffic comprises only a small proportion (less than 10 per cent) of the total traffic observed in hospitals; although of the people (excluding visitors) going in and out of wards, operating theatres and some other clinical departments the proportion pushing wheeled equipment is higher (up to 15 per cent). In a tall multi-storey building all traffic, wheeled or ambulant, depends largely on the lift system, and here traffic from in-patient wards to diagnostic departments is more likely to suffer from delays which can occur in a tall building. Single-storey layouts such as Wexham Park Hospital, Slough, on the other hand, avoid the use of lifts altogether. Layouts with two to three storeys can reduce the dependence on the lift system by grouping those departments with heavy traffic links on the same level.

Use of Predictions

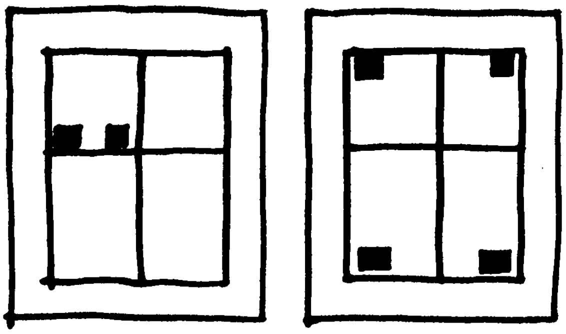
If some prediction of the quantity of traffic can be made, how can this information be used at the design stage? Ideally, comprehensive and reliable information on inter-floor traffic is required in order to select traffic peaks and decide the type, size and number of lifts or alternative systems. Too often the number of lifts provided in a building is determined by the money available rather than the standard of service anticipated. The design of lift systems in hospitals is more complex than in other buildings because of the several types of traffic with different degrees of urgency or importance. There may also be practical or aesthetic reasons for separating the types of traffic and the lifts serving them. Patients being moved to and from operating theatres, for example, should not be held up by visitors or supply traffic. More traffic is likely between intermediate floors in both directions than in the typical office block or housing situation where the simple flow from ground upwards or from higher floors downwards prevails.

Conventional methods of calculating the number of lifts required are too crude for the hospital situation. Their performance criteria are based on the concept of a 'round trip time', and the performance is measured in terms of 'flow rate' or the 'waiting interval'. These methods are based on only superficial information regarding traffic demand and are more relevant to the simple office block situation. They assume continuous arrivals and standard door opening and closing times. The probable number of stops is based on the distribution of the population between floors. It is doubtful if such calculations are ever accurate or indicate the performance of the lift system in terms of the users' satisfaction.

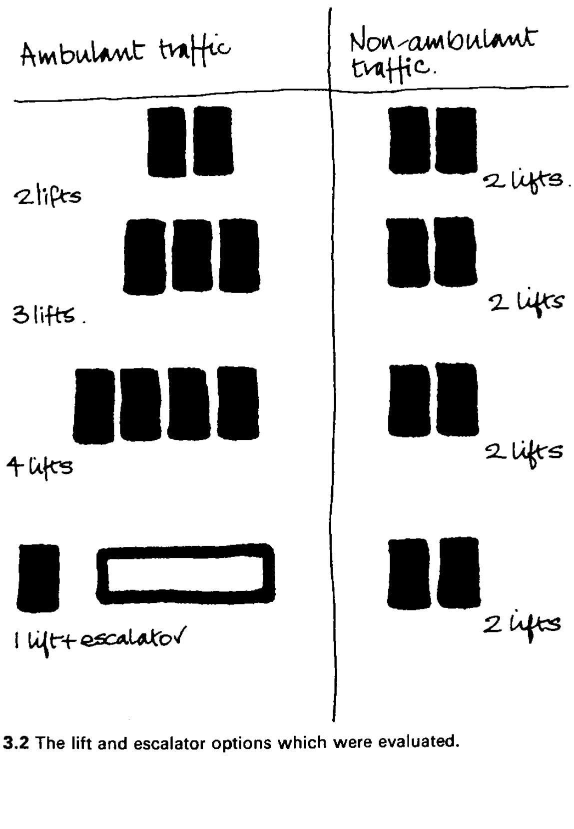
Assessment of Options

In order to limit the terms of reference for a traffic evaluation exercise it is probably of value to make a prior decision on the siting of the vertical circulation systems. Both centralised and decentralised locations were considered for the Greenwich design – see diagram **3.1** – although it was always assumed that there would be escape stairs in each corner of the building. Because of the compactness of the layout it was eventually decided to centralise the vertical circulation systems in order to provide an efficient standard of service at least cost, a reasoning which was based on the principle that by grouping lifts both physically and operationally a higher standard of service can be provided, along with a more convenient method of cover at times of breakdown and maintenance.

It was also decided that there would be two separate vertical circulation cores at the centre of the building for the movement of people – one for the movement



3.1 Greenwich Hospital. Centralised and decentralised lift bank options.



3.2 The lift and escalator options which were evaluated.

of those who were ambulant (including staff, patients and visitors) ; the other for the movement of non-ambulant patients, whether in a wheelchair, on a trolley or in a bed. By segregating people in this way, it was considered, a person who was ambulant would only very rarely find that a lift was full and would not run the risk of being upset by certain types of non-ambulant traffic ; and, thirdly, the lift system would not be subject to delays caused by the loading and unloading of non-ambulant traffic. At the same time, by using the second vertical core non-ambulant traffic would not have to compete with the rather more frequent demands made by the ambulant.

On the basis of these two decisions a range of alternatives of provision were considered and made the subject of an evaluation exercise – see diagram **3.2**. A full description of the method used to evaluate the alternatives is included in a later section of this chapter. What follows here is a brief summary of the method and of the choice of solutions which was based on the findings of the exercise.

Method of Evaluation

Primary information was obtained from traffic surveys in the existing building, surveys in other situations and from the Building Research Station and the Ministry's Central O and M Unit. This information was assessed and to some extent modified in the light of the operational policies to be adopted in the new building. The traffic estimate was then built up by the type of trip (ambulant, wheelchair, bed or trolley), the purpose of the trip, floor of origin, floor of destination, the likely route to be taken and the time of the trip. Allowances were made for unpredictable traffic and for a proportion of ambulant traffic using the stairs. Histograms were drawn to show the traffic peaks and from these the periods where traffic movement was at its most complex were selected. The operation of the lift logic was then simulated, and from these calculations it was possible to work out waiting times and travel times for each trip. Several situations were simulated with different numbers of lifts in the two lift banks and with variations in traffic density. Indeed, the value of simulating the operation of a lift system based on a detailed traffic estimate is that the performance of several possible solutions can be considered at the design stage.

Choice of Solution

As a yardstick against which to assess the suitability of any lift system it was decided that a system which could serve 90 per cent of the potential users within 30 seconds at any time of day would provide an acceptable standard of service.[8] This performance requirement is one which is in current use in the design of vertical communication systems for commercial buildings and after a few, albeit subjective, tests was adopted as an acceptable standard for Greenwich.

The simulations undertaken suggested, however, that a large number of lifts would be needed to achieve this standard. There were several reasons for this:

the need to separate the lifts into two banks in order to segregate non-ambulant from ambulant traffic;

the probability that large numbers of people would enter the building at two levels (the ground floor and the lower ground floor) and that simultaneously there would be inter-floor movement of staff coming off duty or going to the dining room;

the continuous nature of inter-floor traffic would be such that a lift would usually stop at each floor, possibly with long emptying and filling periods, and very rarely reach its design speed between floors.

Accordingly it was decided that an escalator would be a better means of dealing with ambulant inter-floor traffic in a low compact building such as Greenwich. It would also provide a transporting capacity large enough to deal with daily fluctuations, and provide the flexibility to cope with long-term increases in traffic. As a result of doubts which were expressed about the suitability of escalators for infirm or elderly users, it was agreed to provide in addition a single large capacity lift as an alternative. The needs of non-ambulant traffic would be met by the provision of a group of two bed/passenger lifts. The simulations had indeed confirmed the suspicion that it would be better to separate trolley traffic from ambulant traffic since trolleys or beds reduce the free space in the lifts to such an extent that the standard of service for all users starts to deteriorate.

The results of the simulation exercises for Greenwich are only the first step. One of the real needs in hospital buildings, or, for example, universities where the traffic pattern consists of simultaneous flows in both directions, is to develop a computer programme to simulate the likely performance of proposed lift systems. The results of such a programme would provide the designer with the performance of several alternatives. Different numbers, speeds and groups of lifts need to be considered as well as the use of different control systems and parking arrangements. Until this is done it will be difficult to make rational decisions on the number, type and location of lifts appropriate for a hospital building.

An Evaluation Method for Lift and Escalator Systems

The method adopted to evaluate the proposed lift system at Greenwich was developed at the Building Research Station as part of a study of traffic between departments in hospitals. The method provides a clear indication of the standard of service which a proposed system will provide for a given traffic demand.

Simulation demands a number of repeated runs to ensure accuracy, since hospital traffic patterns are dynamic rather than static and the implications of alternative policies need to be explored. Some studies have been and are being carried out on the computer simulation of lift systems. [9, 10] Regrettably a computer programme was not available for the evaluation of the lift systems at Greenwich and, in consequence, it was possible to carry out only a very limited number of calculations.

Traffic Estimates

Before the exercise can begin an estimate of the traffic demand on the system must be made. The data for each trip must be stated as follows:

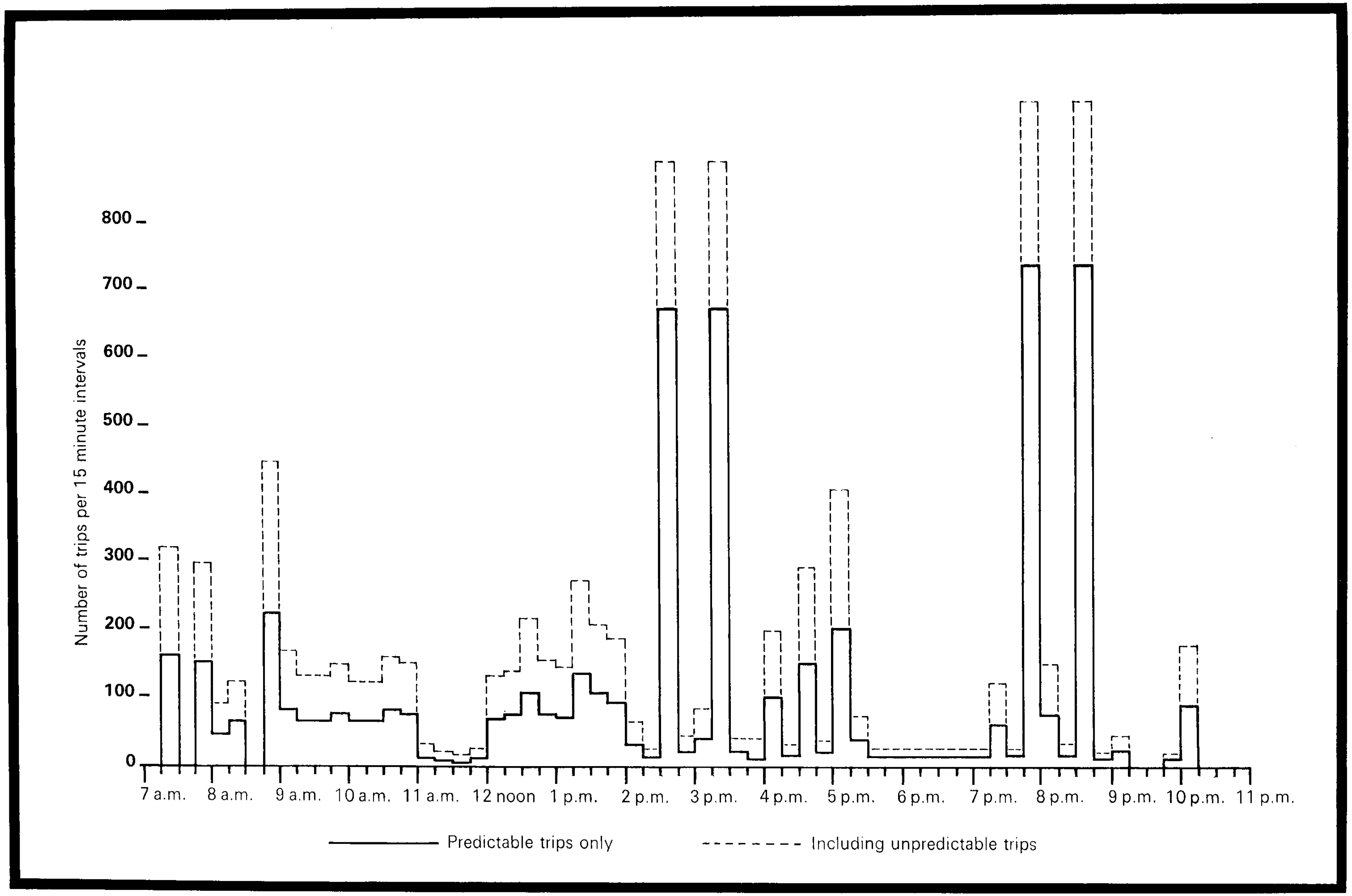
Type of traffic (ambulant/wheelchair/bed/trolley)
Floor of origin
Floor of destination
Probable time of trip (related to staff's working hours, programming of departments, messenger and supply rounds)

For example, the information might be that a pharmacist would begin work at about 9 am, that he would arrive at the main entrance and go to the pharmacy department on the lower ground floor. This trip might be one of 200–300 occurring within the same 15-minute interval. In order to construct the estimate a series of assumptions have to be made on, for instance, the time of arrival of the person at the hospital and the mode of arrival (for example, if by car he will enter from the lower ground floor car park, or if on foot through the ground floor entrance). Similar assumptions on the route of the person from origin to destination in the building have also to be made in the light of operational policy decisions. The data for the pharmacist would be as follows:

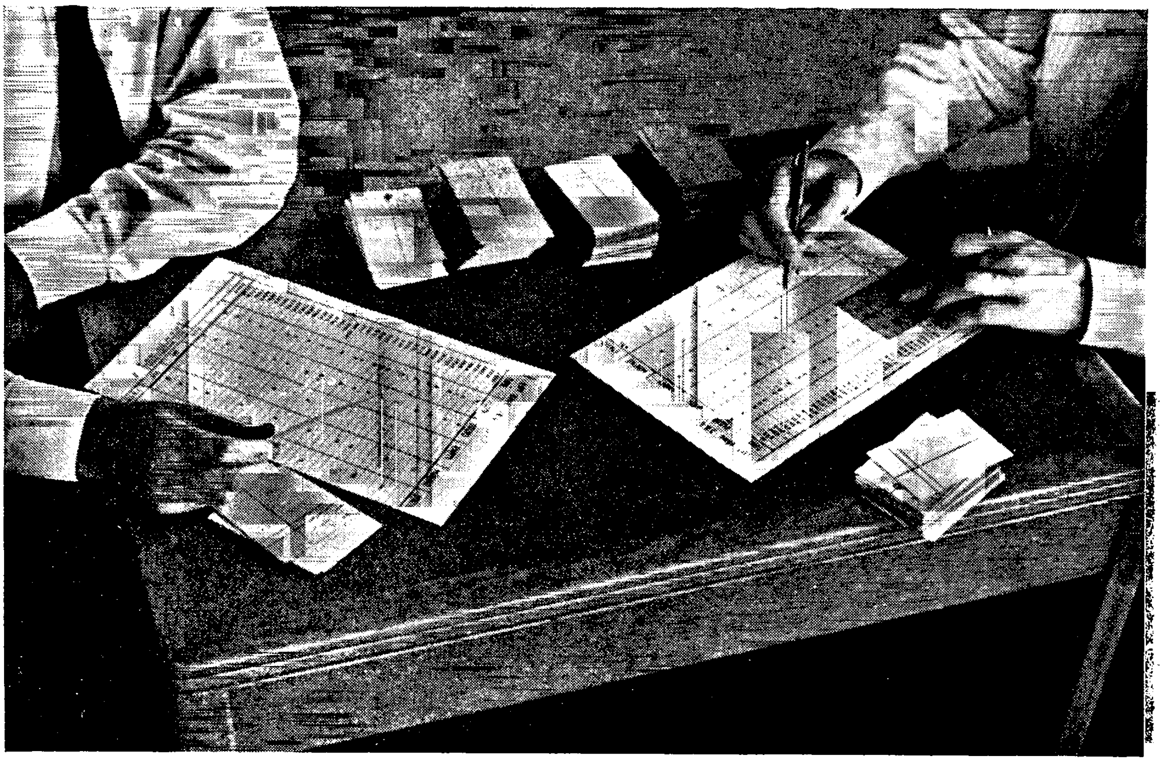
Type of traffic: ambulant
Origin: ground floor
Destination: lower ground floor
Time of trip: 8.45 am–9.05 am

When the total estimate of traffic has been completed, histograms may be drawn from which the peaks can be deduced. The peaks which are most relevant to the investigation are then selected for study. Diagram **3.3** shows the histogram, representing trips of one or more floors, which was drawn from the results of the estimate for Greenwich. The two enormous peaks at 2.30 pm–3.30 pm and 7.45 pm–8.45 pm were ignored for the purpose of the further study of alternative lift systems, since either the de-restriction of visiting times or the use of porters to operate lifts during restricted visiting times would make the exercise irrelevant. It is hoped that the implications of various methods of coping with the visitor peaks will be the subject of a later investigation.

Apart from the two visitor peaks the main peaks of



3.3 The total number of inter-floor trips assumed to be taken by lift (shown in intervals of 15 minutes).



PHA	LG
900	2100

3.4 A lift simulation exercise in progress, and the content of a typical trip card.

traffic were found to be:

7 am–9 am
12 noon–2 pm
4 pm–5.15 pm

It would have been desirable to study all three periods but due to lack of research time only the most complex period – 12 noon to 2 pm – was studied. Yet even within this period each simulation carried out involved from 220 to 980 trips.

Information on each trip which occurs during the selected period is next transferred to a card, one card for each trip. (A typical card is shown in diagram **3.4** representing the example of the pharmacist already referred to.)

A differently coloured card is used for each floor of origin. The colours used in the Greenwich exercise were:

Pink card = lower ground floor
Blue card = ground floor
Green card = first floor
Buff card = second floor

The colour of the card illustrated in diagram **3.4** therefore will be blue, since the trip originated at the ground floor. The letters 'PHA' denote that the trip is made by a member of the pharmacy staff and therefore that it is by an ambulant person. The letters 'LG' denote that the destination is the lower ground floor.

All the times used in a simulation exercise of this kind are in seconds, so that the limits of the time of trips are also expressed in seconds. If the period to be investigated in this particular exercise is 8.30 am–9.30 am the limits of the period are 0–3600. The limits of the trip by the pharmacist are 8.45 am and 9.05 am, that is 900 and 2100. Once the limits of the time of trip have been written on each card all the data have been transferred, but the exact time of arrival at the lift bank of each item of traffic is not known. A specific time is therefore taken at random between the limits of the time of the trip. The random times of arrival would ideally be provided by a random number generator such as *Ernie* which picks the winning numbers of Premium Bonds for the GPO. Random times may, however, be extracted from any suitable volume of random number tables.[11] Once established, the random time of arrival is written on the first line of the left-hand column of the card. The other lines in the column may be used in subsequent simulations of the same situation but with different random times.

When completed the cards are sorted into four groups by colour, that is, by floor of origin, and each group is then sorted into chronological order. At this stage the simulation is ready to begin.

Lift Simulation

Data sheets are used to record the progress of the lifts, separate data sheets being used for each lift, and at any time reference to the data sheets will reveal exactly what the lifts are doing. The 'operation' of the lifts on the data sheets relies upon the use of certain predetermined times for each stage of the lift's activity. The activity times used in this exercise were:

One-floor trip = 8 seconds
Two-floor trip = 13 seconds
Three-floor trip = 18 seconds
Doors open/unload/load/doors close:
 person/wheelchair = 6 seconds
 trolley/bed = 10 seconds

It was assumed that traffic arriving at the lift bank 5 or 6 seconds after the lift doors began to open would cause the doors to open and close again. It was also assumed that if both lifts were available to answer a call, then the one which could get there first would do so.

Typical data sheets from the Greenwich exercise are shown overleaf in diagram **3.5**. They consist of six columns:

T – time in seconds from start of period of exercise
F – floor on which lift stands
D – time for doors open/unload/load/doors close
E – time taken for lift to travel empty between floors
M – time taken for lift to travel loaded between floors
S – time lift spends static with doors closed

This is represented on the data sheets illustrated in diagram **3.5** as follows.

Starting at time 1600 both lifts are on the second floor when a person arrives at the lift bank on the lower ground floor. Lift 1 sets off immediately to answer the call, taking 18 seconds to make the three-floor trip, and arrives at time 1618, by which time two more people have arrived at that floor.

During this time somebody arrives at the lift bank on the second floor and gets into lift 2. The lift sets off at time 1608, arriving after the two-floor (13 seconds) trip at the ground floor at time 1621. The person gets out of the lift, and the person who arrived at time 1614 gets in and travels upwards from time 1627, when the doors close, until time 1635 when the lift arrives at the first floor; the doors open, the person gets out and two more people get in. The doors close by time 1641 when the lift carries the two people to the second floor by time 1649; the doors open, the people get out and the doors close.

When lift 1 arrives at the lower ground floor at time 1618 three people are waiting. As the doors open someone else arrives at the lift bank and at time 1624, when the doors close, there are four people in the lift. The lift arrives at the ground floor at time 1632; the doors open and two people get out, the other two wishing to travel up to the first floor. As the doors close someone else arrives and causes the doors to open and close again. It is not therefore until time 1644 that the lift starts off for the first floor, arriving at time 1652. There is no need for the lift to continue up to the second floor, so the one person waiting to go down from the first floor gets into the lift.

Lift 2 leaves the second floor at time 1655, arriving at the lower ground floor at time 1673. The doors open, two people get in and the doors close by time 1679 when the lift travels up to the ground floor. The lift arrives at time 1687, the doors open, the two people get out and another person gets in. As the doors start to close someone else arrives at the lift bank and causes the door to open and close again as he gets in. The lift leaves the ground floor by time 1699, and arrives at the first floor at time 1707 when the doors open and the two people get out of the lift.

Lift 1 carries one person from the first floor to the ground floor from time 1658 to time 1666, when the doors open, the passenger gets out and another gets in. The doors close at time 1672, and the lift makes a two-floor trip arriving at the second floor at time 1685. When the passenger gets out and the doors close, the lift remains static for 21 seconds until time 1712, when it goes to answer a call registered on the ground floor.

Once the simulation has been completed the columns of the data sheets are added up to give the total time during which the lift is:

i Moving with a load
ii Moving empty to answer a call
iii With doors opening/unloading/loading/door closing
iv Static

The grand total of these four columns should be equal to the total period of the investigation. The trip cards are then sorted by their waiting times and the numbers of trips with each waiting time are tabulated.

If the sum of the above totals **i**, **ii** and **iii** is expressed as a percentage of the total period under investigation then the result represents the 'percentage usage'. There are indications to suggest that when the percentage usage reaches 50–60 per cent the standard of service provided begins to deteriorate.

From the table of waiting times it is easy to calculate:

The average waiting times including zeros
The average waiting time excluding zeros
The percentage of traffic with zero waiting time

In addition, the table of waiting times will show the time within which 90 per cent of the traffic is served, that is, 'the waiting time of the 90 percentile'.

It is this 90 percentile which indicates whether or not the expected standard of service is acceptable; on the Greenwich exercise it was decided that the serving of the 90 percentile within 30 seconds would indicate an acceptable standard of service. The other values give a basis for comparison with other lift systems, but are not significant in themselves when assessing a particular system.

Evaluation of Options

It had initially been proposed there there should be two banks, each of two bed/passenger lifts, in the Greenwich hospital. The inner pair of lifts (lifts 3 and 4) would be used primarily by non-ambulant traffic, a large portion of which would be bed, trolley or wheelchair traffic. The pair of lifts near the main entrance (lifts 1 and 2) would be used by all ambulant traffic, including staff, patients and visitors.

The first part of the study involved five simulation exercises on lifts 1 and 2, which included two from 12 noon until 2 pm (A, B), and three from 1 pm until 2 pm (C, D, E). The shorter period in the latter three simulations was adopted when it was found that one simulation exercise carried out manually was consuming 6–8 man days. The period 1 pm–2 pm contains more traffic than 12 noon–1 pm, and so it was selected for further study with the expectation that if the operation of the lifts were to become critical then it would do so within this period. The results from the second of the longer period exercises were later broken down to give results which could be compared with those for the shorter period exercises.

The Building Research Station survey of hospital traffic already referred to indicated that unpredictable or unscheduled traffic can account for 50–100 per cent of the total number of trips. A figure of 50 per cent unpredictable trips was therefore incorporated, and a further 50 per cent to allow for trips which would be made on the stairs, on the assumption that a quarter of the total number of journeys would be made by the stairs.

The details of these simulation exercises are as follows.

Simulation A. Trips of two and three floors for predictable trips only, assuming one-floor person trips to be made by stairs; during the period 12 noon–2 pm there were 224 trips.

Simulation B. Trips as A plus trips of one floor; during the period 12 noon–2 pm there were 742 trips.

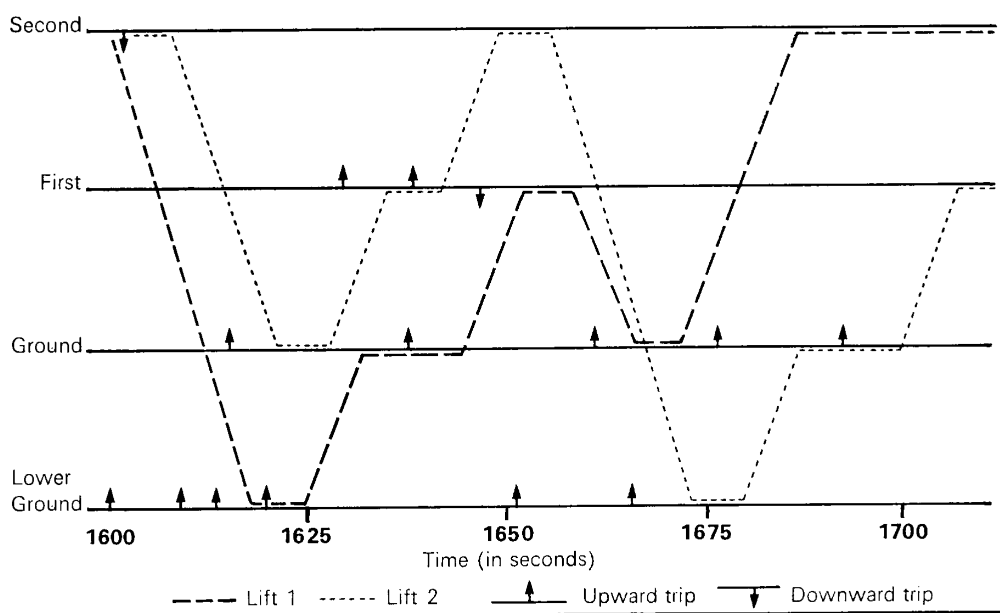
Simulation C. Trips as B but only during the period 1 pm–2 pm; there were 431 trips.

Simulation D. Trips as B, but including unpredictable trips; period 1 pm–2 pm; 980 trips.

Simulation E. Trips and period as D, but with extra lift.

Lift 1					
T	F	D	E	M	S
1600			18		
1618	L	6			
1624				8	
1632	G	6			
1638	G	6			
1644				8	
1652	1	6			
1658				8	
1666	G	6			
1672				13	
1685	2	6			
1691					21
1712					

Lift 2					
T	F	D	E	M	S
1600	2				2
1602	2	6			
1608				13	
1621	G	6			
1627				8	
1635	1	6			
1641				8	
1649	2	6			
1655			18		
1673	L	6			
1679				8	
1687	G	6			
1693	G	6			
1699				8	
1707					



3.5 Extracts from two data sheets, and a graphical representation of the journeys described.

Simulation	A	B	C	D	E	F	
Percentage usage	37.7	79	86.4	98.8	94	21.1	per cent
Average waiting time (including zeros)	7.8	10.8	12.2	16.6	9.4	5.4	seconds
Average waiting time (excluding zeros)	12	14.6	15.9	20.2	13.2	10	seconds
Percentage with zero	34.8	26.2	23	17.9	28.7	46.5	per cent
90 percentile within	18	26	29	38	27	13	seconds

3.6 Results of simulations A–F.

One simulation exercise was done on lifts 3 and 4:

Simulation F. Since the majority of trips fell between very wide limits, traffic was simulated over the period 8.30 am–5.30 pm; there were 856 trips.

As can be seen from the table in diagram **3.6** the result for simulation F shows that lifts 3 and 4 cope quite well with the non-ambulant traffic, and that they would probably be able to absorb more traffic without substantial detriment to the standard of service. The critical situation on this lift bank occurs when more than two trolleys or beds arrive at the lift bank at the same time. With so low a percentage usage the use of different random times could also cause relatively large fluctuations in results.

The result of simulation D on lifts 1 and 2 indicates that even with 25 per cent of trips being made by stairs the standard of service with the two lifts would certainly not be acceptable, whilst simulation E shows that with three lifts the standard would be only just acceptable (even with the very high percentage usage in these exercises the 90 percentile value could vary by 5 seconds if different random times of arrival were used).

In the light of this information it was decided that six further exercises should be carried out, including three in which escalators would replace lifts 1 and 2 in handling ambulant traffic. Since it was obvious that the continuous flow of inter-floor traffic would present no problems to the escalator, it was decided to assess its capacity at peak visiting times, instead of at the 1 pm–2 pm period as in the earlier exercises.

The first three simulations in this series assumed the use of lifts for the movement of ambulant traffic.

Simulation G. Visitor arrival peak 7.40 pm–8 pm; 758 trips of one, two and three floors; 75 per cent used bank of two lifts and the remainder used the stairs; result=90 percentile served within 64 seconds.

Simulation H. As simulation G but with 4 lifts; result=90 percentile served within 18 seconds.

Simulation I. Staff on duty peak 8.45 am–9 am; 233 trips of one, two and three floors; 75 per cent used bank of four lifts and the remainder used the stairs; result = 90 percentile served within 20 seconds.

From these simulations it was established that four lifts would probably provide a good standard of service during all but the periods of most intense traffic, such as before and after restricted visiting times. Although the waiting times even during these periods were low, the overall trip times were relatively high (up to 90 seconds) owing to the doors being open for long periods at each floor for loading and unloading.

The other three simulations in this series assumed the

Escalator type (overall width in inches)	**'32'**	**'40'**	**'48'**
Tread width	**2**ft	**2**ft **8**in	**3**ft **4**in
Nominal capacity	**6,000** persons per hour	**7,000** persons per hour	**8,000** persons per hour
Normal peak capacity	**4,800** persons per hour	**5,600** persons per hour	**6,500** persons per hour
Width in terms of persons passing each other	**1½** persons width, person with child or suitcase, passing usually impossible	**1¾** persons width, passing usually difficult	**2** persons width, passing usually easy

3.7 Brief dimensions of the escalator types used in the simulations.

use of an escalator for handling ambulant traffic. Since each simulation assumed the use of a different size of escalator, brief details of the three escalator sizes which are currently in common use are given in the table in diagram **3.7**.

Each of these exercises looked at what appeared to be the most critical situation for an escalator – from the first floor to the ground floor in the period following visiting times (which it was assumed all ended at the same time, with the exception of the maternity wards). The greatest possible load was expected to be 70 per cent of all visitors arriving at the escalator within 5 minutes.

Simulation J. 5 minute period after visiting session; 376 trips from first floor to ground floor using escalator type '32';
result=maximum queue length 7 persons, average queue length 3.1 persons.

Simulation K. As simulation J but with escalator type '40'; result=maximum queue length 4 persons, average queue length 0.63 persons.

Simulation L. As simulation J but with escalator type '48';
result=maximum queue length 3 persons, average queue length 0.38 persons.

Choice of Solution

In a situation such as that at Greenwich escalators would appear to have several advantages for dealing with ambulant traffic:

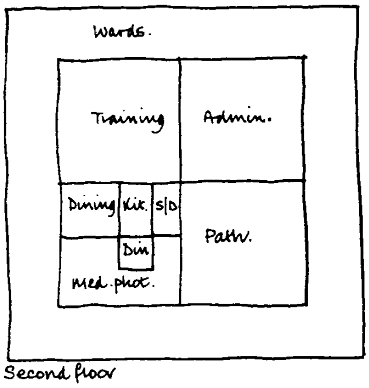
escalators provide flexibility in that they have a large traffic-handling capacity to deal with long-term increases in demand or changes in the traffic pattern;

there is no waiting time except in 'crush' conditions;

for a journey length of three floors trips by escalator are not likely to be shorter in time than trips by lifts, but in the Greenwich situation the great majority of trips will be of one or two floors, and in these cases travel times by escalator will be noticeably shorter than by lift.

It was therefore decided to instal a type '32' escalator, along with a single lift for use by the infirm or elderly who might not wish to use the escalator. These simulation exercises had in fact shown that even the smallest escalator could deal with the most intense traffic, although there is little practical knowledge on the actual carrying capacities of escalators in a hospital situation. It is of course possible that the stated capacities are somewhat optimistic. Nevertheless if visiting sessions were staggered there would be absolutely no danger of the traffic on escalators approaching maximum capacity, and the choice of their size would then be governed only by the size and agility of the people who were expected to use them.

3.8 Estimated number of trips per hour on each floor.



Wards	250
Administrative Offices	75
Training Centre	150
Pathology Laboratory	120
Medical Photography Department	30
Supply Centre and Kitchen	75
Dining rooms	550
Total	1,250 trips per hour

Conclusions on the Evaluation Method

If the accurate design tool, which is a computer programme on lift simulations, is to be used to its best value, the traffic estimates which it requires must also be improved. The traffic estimate for Greenwich gave the limits within which a trip occurred but not the distribution pattern of arrivals within these limits. In the case of the pharmacist who should begin work at 9 am, the estimate shows that he will arrive between 8.45 am and 9.05 am, but not that on four days out of five he will in actual fact arrive between 8.55 am and 9 am. This is an unfortunate limitation in the present technique, and it should be noted that until traffic estimates become more sophisticated a lift system will be shown to provide a better standard of service in theory than in practice. Despite its shortcomings, however, the method used in the Greenwich evaluation provides a far higher standard of information than conventional methods employed to reach decisions on vertical traffic systems.

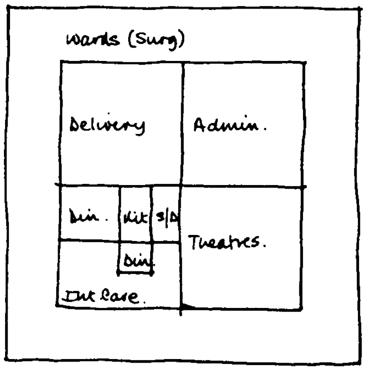
Horizontal Movement and Corridor Widths

At a fairly advanced stage in the Greenwich design process the compactness of its layout gave rise to the suspicion that the width of the internal corridors – already determined at 9ft 8in clearance – might not be sufficient to prevent congestion occurring rather more than just occasionally. The work described here was undertaken in an attempt to test the validity of this suspicion, but some of the conclusions reached may well be of more general interest.

Volume of People

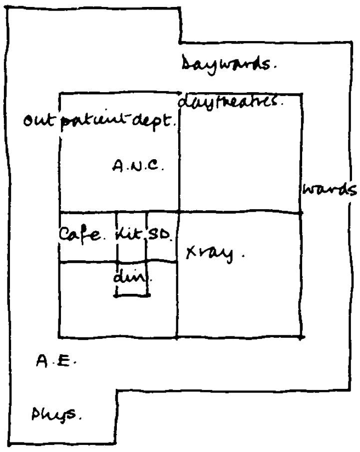
Again the Building Research Station's survey of hospital traffic provided the basis for the exercise. It had shown that hospital corridors are seldom crowded with people. The dimension of beds, trolleys and equipment, and the space required to move these round corners and into doorways are the critical factors in determining both corridor and door widths. In order to test this claim in the Greenwich situation predicted flow rates of people were compared with flow rates in other situations, using in particular the optimum flow rate suggested by the London Transport Board for corridors of varying widths in the new Victoria underground line. This comparison indicated that the peak period traffic flows of people were likely to be small. Any difficulties encountered were likely to be caused by localised queues, stationary vehicles, or by local short-term peaks such as a large number of students leaving lecture rooms simultaneously.

Diagram **3.8** is based partly on information from the Building Research Station survey. It shows for a selected hour the typical number of trips from departments and what the total number of trips per hour might be on each floor. By inspection it would appear that the peak rates of flow in any section of the hospital street will be in the range of 1,000–2,000 per hour. For example, 100 people may leave lectures in the training centre



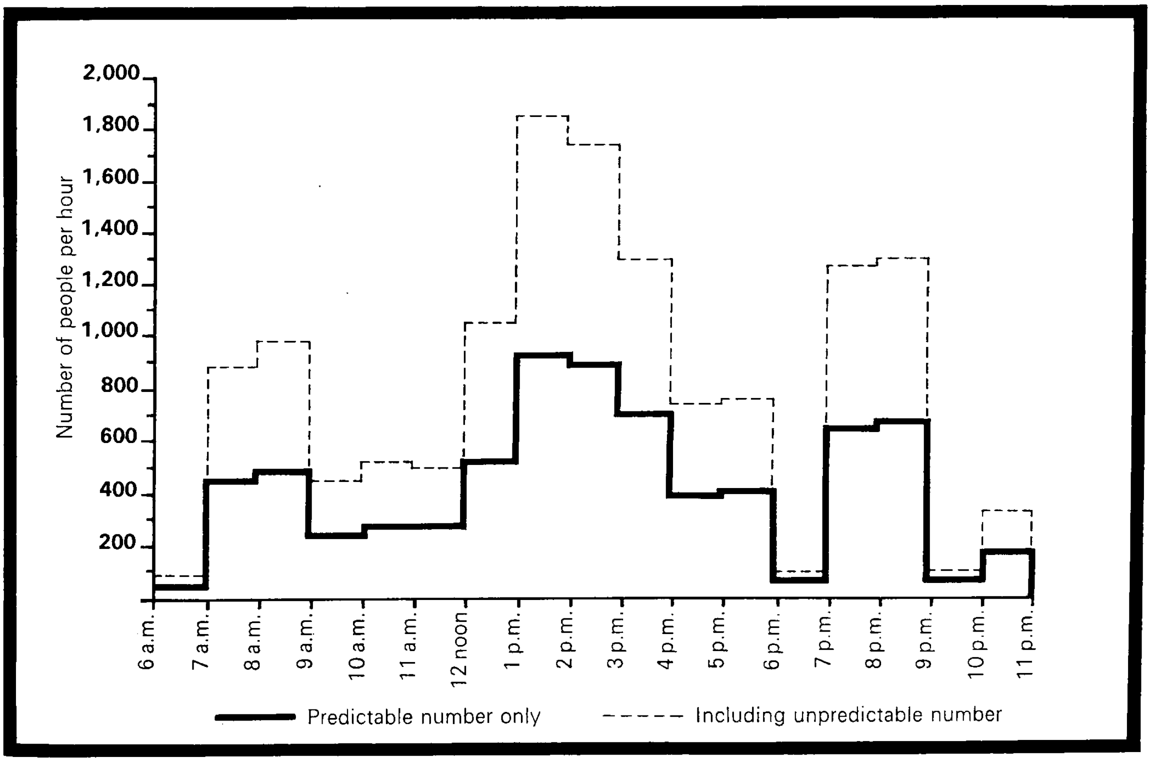
First floor.

Wards	250
Special Care Baby Unit	30
Administrative Offices	75
Delivery Suite	100
Operating Theatres	100
Intensive Care Unit	30
Supply Centre and Kitchen	75
Dining rooms	550
Total	1,210 trips per hour

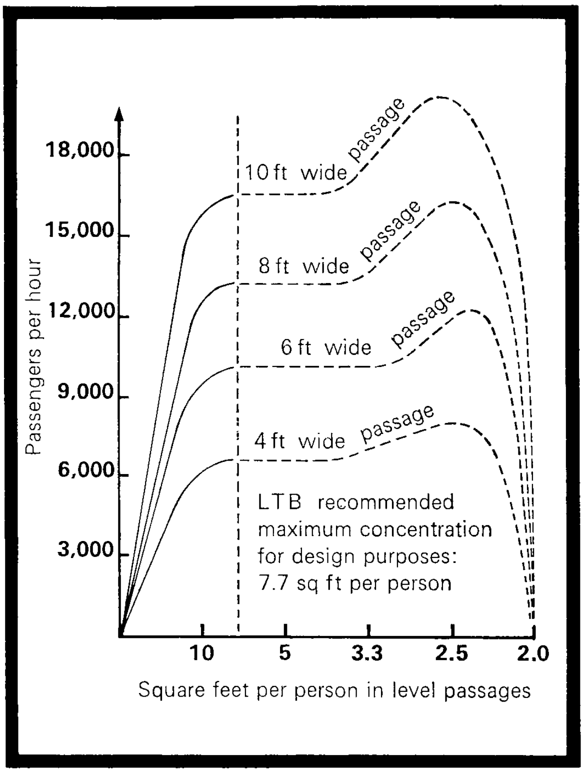


Ground floor.

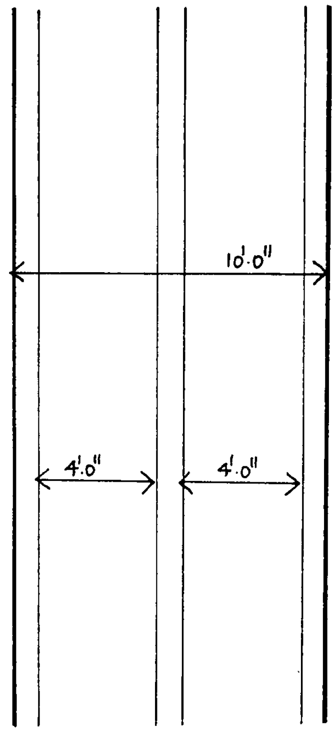
Wards	160
Day Wards	60
Day Theatre	100
Out-patient Clinics	300
Antenatal Clinic	100
X-ray Department	100
Accident & Emergency Department	200
Department of Physical Medicine	80
Pharmacy (Dispensary)	100
Supply Centre and Kitchen	75
Dining rooms	550
Total	1,825 trips per hour



3.9 Estimated number of people passing through the main entrance hall on a Wednesday (shown in intervals of 1 hour).



3.10 London Transport Board: passenger flow rates in one direction in level passages.
The speed of flow varies, that is, the speed reduces as concentration increases and congestion occurs. The maximum recommended concentration in level passages is 0.13 persons per sq ft (7.7sq ft per person) at a speed of 2.3mph. The free flow speed in corridors is 3.6mph. The space allowance for people moving at the free flow speed (or good walking pace) in circulation spaces would be about 40sq ft per person. (Reproduced by permission of the London Transport Board.)



3.11 Notional traffic lanes in a 10ft wide corridor.

within a period of say 5 minutes in the worst case. This represents a rate of flow of 1,200 people per hour.

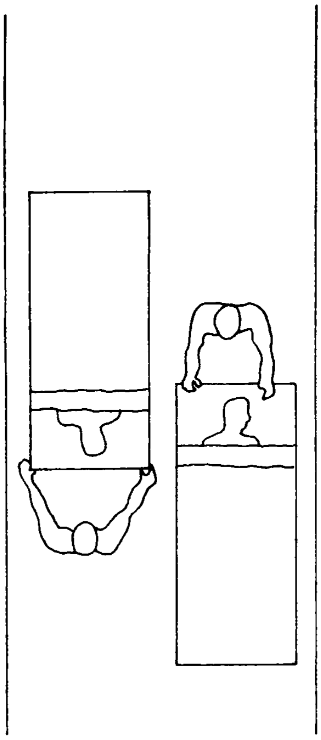
Diagram **3.9** shows the estimated number of people passing through the main entrance hall. The peak is in the range of 1,000 to 2,000 people per hour. If a restricted visiting policy is maintained the peak rate of flow in one direction, that is at the beginning and end of the visiting period, could reach 3,000 per hour through the main entrance and 1,000–1,500 through the lobbies on the upper floors.

Diagram **3.10** was produced by the London Transport Board and is based on the research work undertaken for the new Victoria Line.[12] Obviously any conclusions based on this data should be treated with discretion, but at least it indicates the relative scale of the circulation problems in a hospital such as that at Greenwich. The diagram shows that the maximum flow capacity of a 10ft wide corridor is about 16,000 people an hour in one direction. If by gross simplification we separate the two-way traffic into two 4ft wide lanes, one in each direction, the flow capacity of a 10ft wide corridor for traffic in both directions is twice 6,000, or 12,000 people an hour – see diagram **3.11**. Obviously it will be less perfect than this in practice and we have not taken into account vehicle traffic.

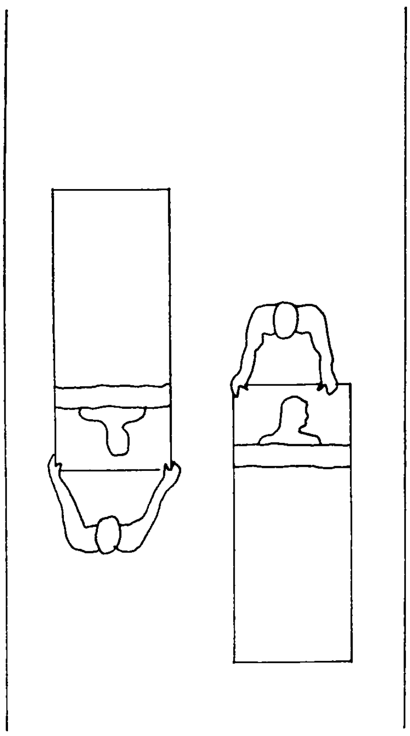
A free flow speed of 2.7 miles an hour in corridors has in fact been observed,[13] but if we apply the London Transport Board's optimum standards, assuming a free flow speed of 3.6 miles an hour, and allow 40sq ft per person (2ft × 20ft), the flow capacity of a 10ft wide corridor in one direction will be about 4,750 people an hour. On the same basis, and assuming two 4ft wide lanes, the flow capacity of a 10ft wide corridor for two-way traffic will be about 4,000 people an hour, including journeys in both directions. If a free flow speed of 2.7 miles an hour is assumed the capacity of the corridor in one direction will be 3,500 people an hour, or 3,000 an hour with journeys in both directions.

Wheeled Traffic

In addition to the traffic of people moving along a hospital corridor there will also be vehicular traffic of beds,



3.12 7ft 8in corridor – straight run (scale ¼in to 1ft). Two 7ft × 3ft beds can pass easily.
The following were also tested in this situation:
two 8ft 9in × 3ft 6in shapes can pass only with a great deal of care;
two 8ft 9in × 3ft shapes can pass easily.



3.13 9ft 8in corridor – straight run (scale ¼in to 1ft). Two 7ft × 3ft beds can pass easily. Two 8ft 9in × 3ft 6in shapes can also pass easily.

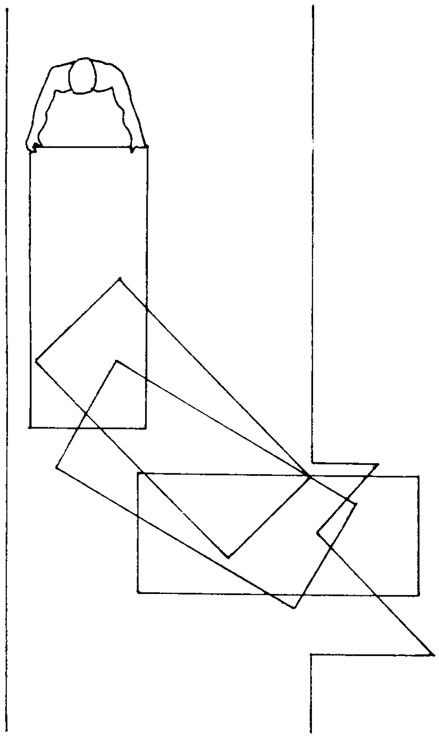
stretcher trolleys, wheel chairs and supply vehicles. The total number of such journeys may range between 20 and 60 an hour on each floor. This leads to the conclusion that the intensity of vehicular traffic does not appear to be critical, but we should examine other factors relating to vehicles, a) the manoeuvrability of vehicles at junctions, lobbies and doors, and b) the accommodation of stationary vehicles.

There are also other possible causes of congestion and delay to moving traffic. The provision of an escalator will eliminate the likely causes of the greatest congestion, which are queues of people at the main entrance and other levels; but there will be other places where there will be queues of people or stationary vehicles, and special design provision may be necessary at these points.

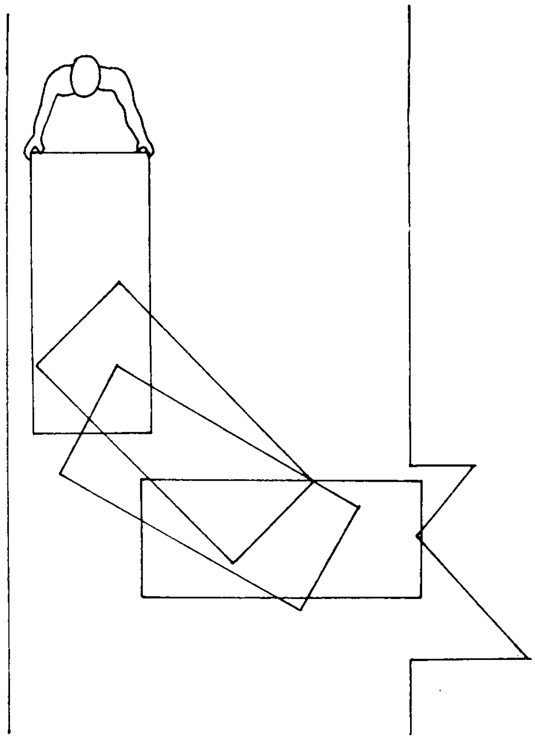
Mock-up Trials

In order to establish the ease or difficulty with which various sizes of beds or trolley could be moved in several directions various mock-up situations were created. Two corridor widths were tested – 7ft 8in and 9ft 8in – both being tested in straight runs, straight runs with doors, and at corner junctions. The vehicles used were trolleys, general beds and three shapes of orthopaedic bed. The dimensions of the three latter beds (8ft 9in × 3ft 6in, 8ft 9in × 3ft, 8ft × 4ft) were influenced by the possible sizes of orthopaedic bed which can fit into a standard 4,000lb bed lift. It is realised that in practice the shape of equipment will be more complex than this, but nevertheless the trials served to indicate some of the critical points.

Corridor – Straight Run – see diagrams 3.12, 3.13.
In the 7ft 8in wide corridor two 3ft 6in wide orthopaedic beds can pass each other if a great deal of care is exercised. Clearly two 4ft wide beds cannot pass in this width of corridor. Nevertheless it may be an adequate width on stretches of corridor which are likely to carry only a limited amount of vehicular traffic, especially if a local widening is given at the entrances to departments.



3.14 7ft 8in corridor – straight run with doors (scale ¼in to 1ft).
A 7ft × 3ft bed can be pushed into a 3ft 4in wide opening with a great deal of care.
The following were also tested in this situation:
- a 6ft 6in × 2ft 6in stretcher trolley can be pushed into a 3ft wide opening;
- an 8ft 9in × 3ft shape can just be pushed into a 3ft 8in wide opening, but care is needed to avoid damaging the door jambs;
- an 8ft 9in × 3ft 6in shape can just be pushed into a 4ft wide opening but scrapes the wall opposite the door;
- an 8ft × 4ft shape can just be pushed into a 4ft 4in wide opening.



3.15 9ft 8in corridor – straight run with doors (scale ¼in to 1ft).
A 7ft × 3ft bed can be pushed into a 3ft 4in wide opening with care.
The following were also tested in this situation:
- an 8ft 9in × 3ft shape can easily be pushed into a 3ft 8in opening;
- an 8ft 9in × 3ft 6in shape can be pushed into a 4ft opening;
- an 8ft × 4ft shape can just be pushed into a 4ft 4in wide opening.

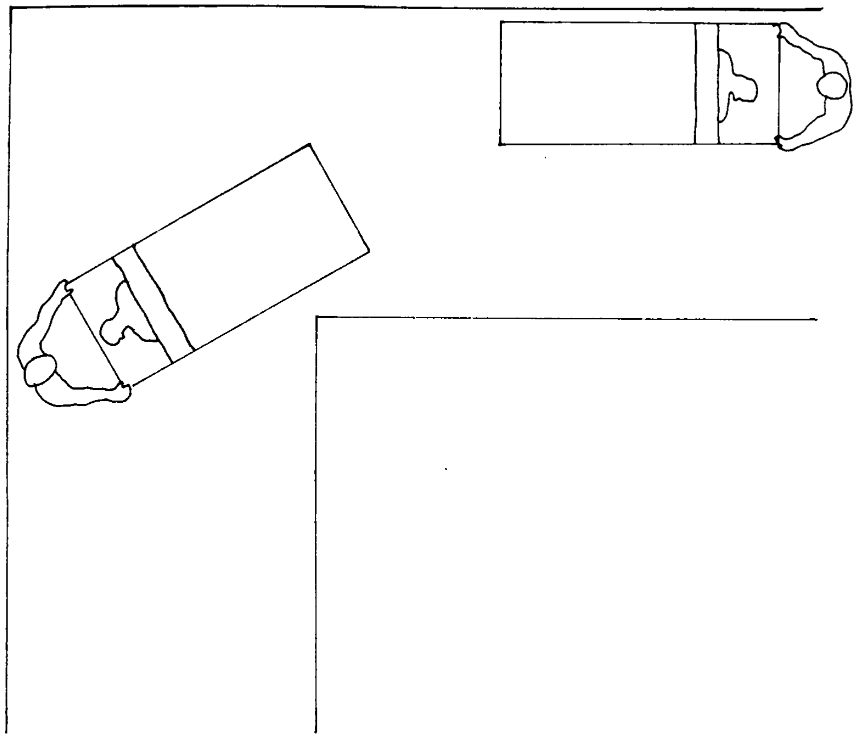
All items can pass in the 9ft 8in wide corridor. Difficult situations will only arise when furniture is being moved or stationary equipment occupies the corridor for activities such as cleaning or maintenance.

Corridor – Straight Run with Doors – see diagrams **3.14**, **3.15**. The ease with which a bed can be pushed through a door opening is related to the size of the bed, the width of the corridor and the clear door opening. When the bed length exceeds the corridor width it is very difficult to push the bed through the door without fouling the jambs or damaging the wall opposite the door. To push a bed through an opening without reducing speed seems to require a clearance of 3in to 4in on either side of the bed, although this can be modified to some extent by the length of the bed and the corridor width.

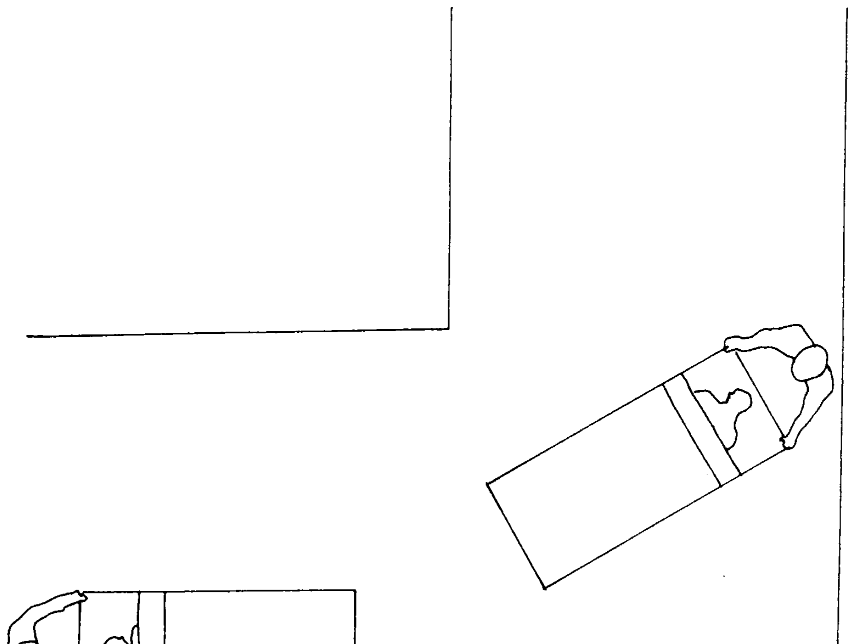
Corner Junctions – see diagrams **3.16**, **3.17**.
The worst case arises when two beds or trolleys reach the corner at approximately the same time. In a 7ft 8in corridor two vehicles cannot pass each other at the corner unless one stops at say half to one bed length from the corner to allow the other to swing round and pass. In a 9ft 8in corridor two 7ft × 3ft beds could possibly get round the corner simultaneously although with difficulty. With the larger beds, however, one would have to stop in order to allow the other to pass.

The main difficulty in the corner situation is that the people pushing the beds or other vehicles cannot see each other. There will thus be some uncertainty on who gives way. A suitably sited mirror could be useful in overcoming this particular problem. It is also evident that visibility is best on approaching the corner if both beds are in the outside lane. Lane discipline therefore would not be an answer to the problem unless the corridors were considerably wider. In both corridor widths tested a large radius cut-off on the corner is necessary before large beds can pass on the corner without stopping. Even for movement of people a small cut-off is probably of value in helping to avoid collisions when people are close to the inside wall of the corner.

In conclusion, the mock-up trials established that the



3.16 7ft 8in corridor – corner junction (scale $\frac{1}{4}$in to 1ft). Two 7ft × 3ft beds cannot pass each other on the corner.



3.17 9ft 8in corridor – corner junction (scale $\frac{1}{4}$in to 1ft). Two 7ft × 3ft beds can pass each other with difficulty, as long as the persons pushing are aware of each other's presence. No larger shapes can pass each other in this situation.

main factors affecting the manoeuvrability of wheeled traffic are the design of the vehicle, corridor widths, door widths and locations, and corner and junction design.

The number of vehicles circulating on a typical Greenwich floor at any time is small, so that the occasions when vehicles will need to negotiate corners or junctions simultaneously will be few. Junction design can be improved by splaying corners and by the use of mirrors. These improvements would clearly be vital if the corridors were required to accommodate trolley trains.

4 *It is Better to Build Out than Up.* Isadore and Zachary Rosenfield. The Modern Hospital Vol 86 No 1 January 1956.

5 *Studies in the Functions and Design of Hospitals.* Sponsored by the Nuffield Provincial Hospitals Trust and the University of Bristol. Oxford University Press 1955.

6 *Hospital Building Bulletin No 5: Traffic Movements and the Inter-relation of Departments.* Ministry of Health. HMSO 1966.

7 *Inter-departmental Traffic in Non-teaching Acute General Hospitals.* Flora W Black BSc AInstP. Architects Journal 16 March 1966 and 6 April 1966.

8 *An Evaluation of New Guy's House* (section 34 p82). King Edward's Hospital Fund for London 1963.

9 *Lift Operation and Computers: Simulation of Performance.* Helen Parlow. Architects Journal 23 March 1966.

10 *Study of Vertical Circulation in Tall University Buildings* (unpublished). Part of a research project to be completed in 1970 by P R Tregenza MBdgSc BArch, University of Nottingham.

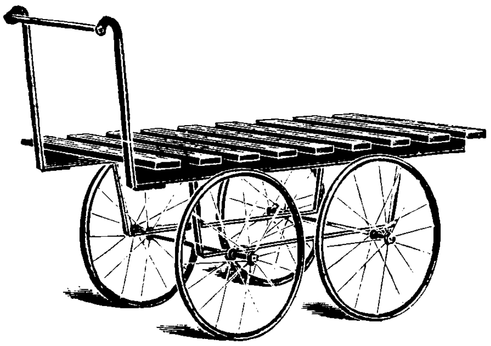
11 The exercise under discussion made use of *Statistical Tables for Biological, Agricultural and Medical Research.* R A Fisher and F Yates. Oliver and Boyd 6th Edition 1963.

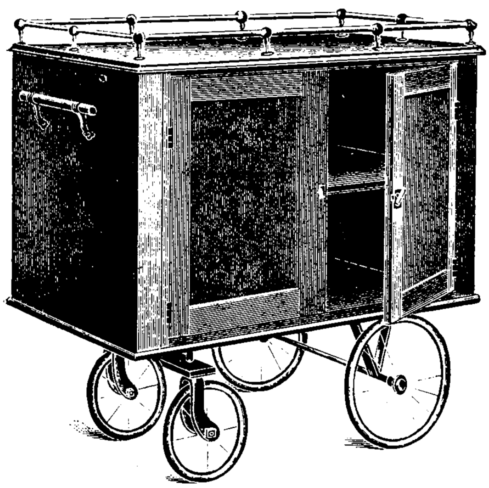
12 *Information sheet No 1194.* Architects Journal Information Library 20 March 1963.

13 *Planning for Hospitals. A Systems Approach Using Computer–aided Techniques.* James Souder. American Hospital Association Chicago 1964.

4 Movement of Goods

based on a paper given by Ceri Davies





4.1 These illustrations of a 'laundry delivery truck' and a 'dinner wagon (hospital type)' are reproduced from an early catalogue of H H Stark Ltd, London E1. Both vehicles were being manufactured in the 1920s.

The supply of goods and the collection of items for disposal or reprocessing are of crucial importance to the overall efficiency of the whole hospital organisation. Their significance becomes strikingly evident as soon as there is a breakdown in service. It might even be said that if within a particular hospital their importance is underestimated this could be a measure of the efficiency with which the service is being provided. Both services are required by every section of a hospital, and because they involve physical movement their method of operation must be dictated to some extent by the overall layout of the hospital. It is because of this relationship that the supply and disposal systems need to be considered at an early stage in the design process. Yet even before this can be done, the nature and the size of the problem has first to be recognised.

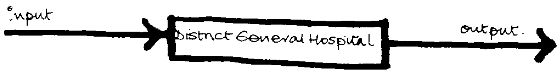
In recent years there has been a tendency to concentrate design research mainly into clinical areas, and in consequence the storing, processing and distribution functions have received little attention. In particular, their relationship with each other and with the rest of the hospital has all too frequently been largely unnoticed during the planning process, and solutions to these problems, which nevertheless exist, have been reached on an *ad hoc* basis during the commissioning period or even later.

Hospital supply systems have remained virtually unchanged since the end of the 19th century – see diagram 4.1. The substitution of a new plastic container for a wicker linen basket or the replacement of a distribution trolley (which was probably designed for an entirely different purpose anyway) by a mechanically propelled vehicle may give a superficial impression of modernisation. Most systems, however, still rely on the signature of a ward sister or department head to be given at the time of receipt for each item, and depend on manual handling methods which assume a plentiful supply of suitable male labour. Yet within the context of the need for a ward sister to concentrate her energies on nursing duties here is one non-nursing function which should not require her attention; whilst in the light of the current and likely future labour market conditions a supply system should aim at being labour saving wherever possible, and capable of being operated by part-time married women, the only remaining source of labour which still includes a permanent element of spare capacity.

The Greenwich hospital project presented its designers with the opportunity first to identify the problems of goods supply and disposal, and then to study them in some depth, questioning the assumptions upon which previous organisational solutions both within the United Kingdom and abroad have been based. In this process extensive use was made of experience gained from commercial and industrial organisations, where the problems of goods supply are not entirely different from those found within a hospital. It is only honest to add that at the end of the study the Greenwich designers probably feel more confident in the range of problems raised than in the depth to which they were investigated or in the particular solutions which were selected for Greenwich. Resources were inevitably limited and the design and construction timetable acted as a guillotine on the investigating process. There is a vast range of problems relating to the supply and disposal system – the extent and influence of area services, for instance, the method of handling and transporting, the control of issuing quantities – each of which demands a full scale study in its own right. What follows in this chapter and the next is a consideration of a few of the problems as they were faced in the Greenwich project, a glance at some of the options and a brief description of some of the solutions. The next chapter considers the supply of meals as part of the main supply function. This chapter is concerned essentially with the supply and disposal aspect of general stock items, linen and sterile supply items.

Steps in the Method of Investigation

Quantity Assessment



4.2

In terms of its supply needs, a hospital can be seen as an input/output machine – see diagram **4.2** – of which the input may consist of some or all of the following groups:

Medical and surgical supplies
Provisions
Pharmaceutical items
Linen
Sterile supplies
General items including, for example, stationery, cleaning materials, crockery, hardware
Equipment, including items which have been repaired

The output consists of:

Items for re-processing, for example, linen, sterile supplies
Items for incineration
Items for disposal by Local Authority collection
Items for disposal by sale
Items to be returned to suppliers, for example, containers

The volume of both input and output will depend to a very large extent on the operational policies adopted in a particular hospital. Consumption levels and the range of items in use can vary considerably from one hospital to another, and this variation will be reflected in the total input/output volume. The operational policies for Greenwich include, for example, the use of disposable bedpans and urinals, as well as several other disposable items. Their storage demands are discussed in Chapter 6.

With the exception of the information on refuse, which was obtained from a British Standard report,[14] the table in diagram **4.3** was prepared for Greenwich in the light of operational policy decisions as far as they were known at the time. On the input side the table relates only to clean linen, food, sterile supply and disposable items, since these groups account for the greater part of the input volume. Each estimate is expressed in terms of an average daily requirement per patient in a ward.

The information as given in this table represents the net volume for each group of items, that is, without any packaging or allowance for division into handling units. When converted into handling units it can then be said to represent the gross volume. It is in the latter form that the information is of value to the designer in assessing storage capacities and transport systems, both internal and external. The table in diagram **4.4** expresses the same basic information in terms of a handling unit with a maximum weight of 25lb and a volume of 2cu ft (the reasons for adopting this handling unit at Greenwich are discussed later). The details in this table relate to the whole hospital of 800 beds.

In this form the information can be used to give some indication of the total load to be transported daily round each floor of the hospital, or to measure the scale of the transporting problem between the hospital and the off-site industrial zone providing a laundry and sterile supply service.

Some form of quantity assessment along these lines at an early stage in the design process gives a measure of the scale of the problem when the procedural, handling and space aspects of the supply system are considered.

Objectives

Before assessing the relative merits of alternative solutions, it is of value to define the objectives against which the validity of any alternatives should be measured. What follows is a suggested summary of the probable objectives.

Economical. The system must be economical in the use of space, the installation and maintenance of equipment and in the amount of labour required to operate it.

Category of patient (wards only)	Linen	Food	Sterile supply items	General disposable items	Refuse for incineration
Maternity	**1.5**cu ft	**4/5**lb	**22**cu in	**0.4**cu ft	**0.35**cu ft
Geriatric	**1.4**cu ft	**3/4**lb	**16**cu in	**0.8**cu ft	**0.5**cu ft
Psychiatric	**0.7**cu ft	**4/5**lb	**3**cu in	**0.2**cu ft	**0.12**cu ft
Medical	**0.8**cu ft	**4/5**lb	**26**cu in	**0.5**cu ft	**0.5**cu ft
Surgical	**0.8**cu ft	**4/5**lb	**32**cu in	**0.6**cu ft	**0.5**cu ft

4.3 Greenwich Hospital. Estimated volume of four groups of supply items and refuse generated daily by different categories of patient, expressed in terms of quantity per patient.

Clean linen	**420** units
Food (to the floor kitchens)	**200** units
Sterile supply items	**60** units
General disposable items	**180** units

4.4 Greenwich Hospital. Estimated daily volume of four groups of supply items for the whole hospital, expressed in terms of the preferred handling unit.

Integrated. Separate and uncoordinated services will result in obtrusive traffic, over-manning and under-use of equipment and space. The integration of all supply systems wherever possible is a desirable aim, even though this may involve operating at slightly less than optimum level for particular items.

Localised. The system should be suitable for the particular hospital and area in which it is to operate. In particular, it should be geared to the type of labour likely to be available to operate it during its lifetime.

Flexible. It must allow for change and growth in the demands made upon it and be able to take full advantage of unforeseen improvements in method and equipment.

Safe. The handling aspects of the system should be absolutely safe, involving no risk of injury to the staff operating them and minimising the risk of damage either to the goods being handled or to the building fabric.

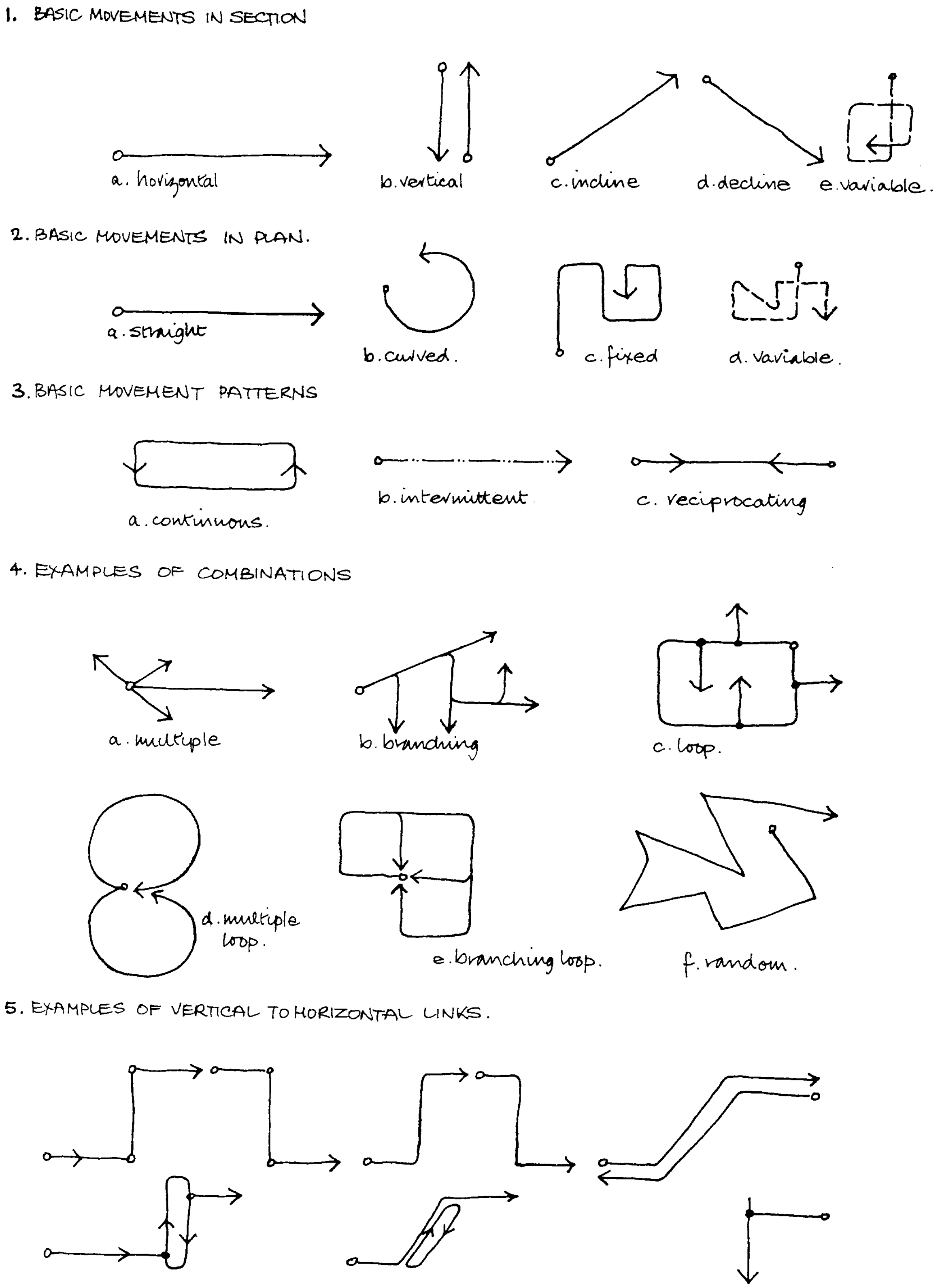
Secure. Security precautions should be incorporated with the aim of discouraging the casual pilferer (no system is likely to be proof against the determined thief).

Hygienic. The operation of the system should not involve any risk of spreading infection.

Reliable. The essential commodity needs to be in the right place at the right time. Unreliability of service will inevitably encourage uneconomical hoarding.

Simple. The system should be easy to understand and simple to operate by the supplies distribution staff. The allocation of responsibility for its operation should be clearly expressed both for the benefit of its staff and for other staff in the hospital who are served by the system. The procedural, handling and space aspects of the system should be in harmony with each other.

There is no simple order in which decisions on a goods supply system can or should be taken. The three main aspects involved in distribution have already been referred to. The procedural aspect includes the formal method by which issues are made, whether it be based on requisitions, topping up levels, a one-for-one trolley exchange system, or standard issues; and also includes the allocation of responsibility for operating the system and the link between the supply staff and the consumers. The handling aspect is simply the method by which goods are transported from the main store or processing unit to the point of consumption. The space aspect has two distinct elements, one of which is linked to the overall shape of the building and its main traffic routes, the other of which is more or less limited to the detailed requirements for loading and off-loading, storage and



4.5 Movement patterns.

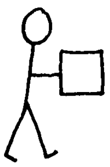
administration. In an ideal situation decisions on the procedural aspects should precede decisions on the other two aspects. Frequently, however, decisions on the space aspect taken at the design concept stage pre-determine to some extent decisions on procedure. Other pressures might also help to upset this sequence, particularly since some elements contained in or associated with the goods supply system (for example, catering) require an internal assessment of their own, the results of which may exert a determining influence on the main distribution system. Some form of compromise therefore may in practice be inevitable. It is important, however, in the first instance to be aware of the options.

Options – Handling

Reduced to its simplest, movement can be analysed as movement in section, movement in plan, and basic movement – see diagram **4.5**. In the context of a multi-storey building horizontal and vertical movement are necessarily interrelated, and the points at which they join are critical in any method of goods handling. Many combinations of the basic horizontal/vertical circuits are possible, the primary variables being the horizontal circulation pattern, the form of vertical movement and the siting of the junction between the two.

The choice of horizontal/vertical circulation pattern will influence, and indeed, should be influenced by the range of goods-handling methods which it is intended to use. The number of handling options currently available is enormous. What follows here, by way of illustration, is little more than a random selection of examples.

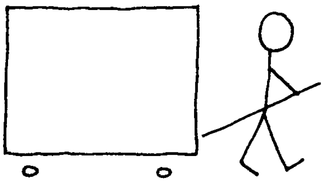
Horizontal Movement



4.6

Carrying by Hand. A porter carrying a container or pushing a trolley on a horizontal plane at normal walking speed would travel at two to three miles an hour, assuming a carrying load of not more than 30lb or a pushing load of not more than 300lb – see diagram **4.6**. The primary limiting factor on this the simplest form of goods distribution is the distance involved, in terms of the time taken to complete a journey. In the case of most supply items (with the exception of a few which are defined as emergency items) time is not critical where the distribution process is programmed efficiently. Food distribution systems on the other hand may be limited by the problems of heat retention, or more significantly by a loss in the nutritional value of cooked food if it is not eaten promptly.

Mechanical Float. A device which combines the advantages of horizontal pedestrian traffic with mechanical drawing power is the manually controlled mechanical float, enabling the quantity of goods per journey to be increased without undue risk to other users of a corridor system, even if it includes junctions and corners – see diagram **4.7**.



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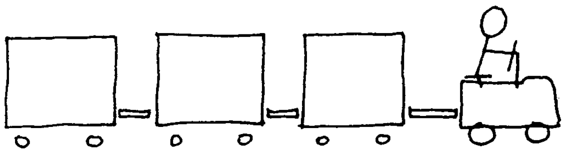
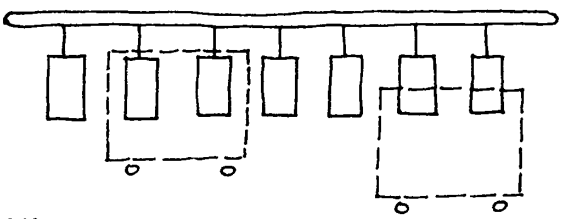


4.8

Trolley Train. The trolley train has obvious advantages where the number of trolleys to be moved is large and where the distances involved demand that a journey is undertaken at something greater than walking speed – see diagram **4.8**. A separate corridor system or a very wide straight corridor may be necessary if the trolley train is not to become a source of danger or obstruction within a hospital.

4.9

Conveyor Belt. A conveyor belt is able to move goods automatically, although installation costs will tend to restrict its range – see diagram **4.9**. Manual loading and off-loading is possible at several points, and both can in some circumstances be mechanised.

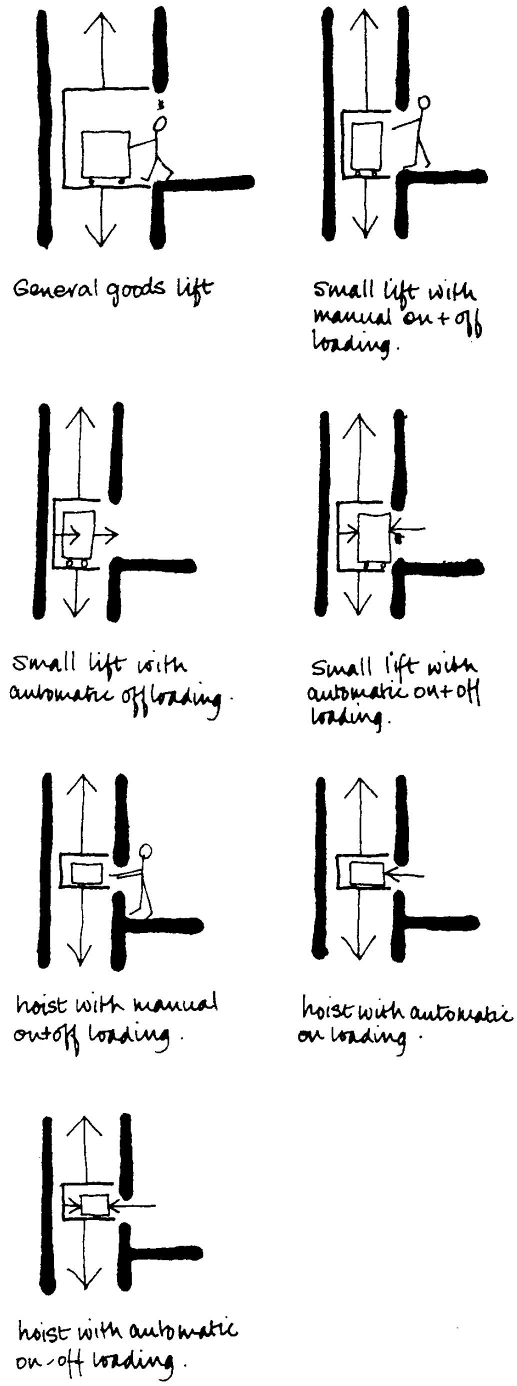


4.10

Chain Conveyor. The overhead chain conveyor is a variation of the conveyor belt, and whilst the variety of items it can carry is smaller, it is more appropriate for the handling of bagged items – see diagram **4.10**. Like the conveyor belt it can also carry items on an incline.

Vertical Movement

As a guide to an assessment of the suitability of the many vertical handling options now available the user's



4.11

requirement can be considered under the following heads:

Whether movement upwards, downwards or in both directions needs to be intermittent or continuous

The distance and speed of movement between levels

Space available for equipment and its related structure (including floor space for loading and off-loading)

The relationship with horizontal movement at each level

The nature, size and weight of units to be handled

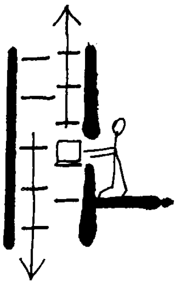
Capital and running costs

Personnel safety

Degree of security required

From the range of lifting devices available for consideration the following are probably representative.

Goods Lifts – see diagram **4.11**	give complete flexibility throughout their lifetime; the largest conventional models are able to carry a maximum load of 12 tons.
Continuous Lifting Devices	
Simple manually loaded paternoster, with automatic off-loading by tipping – see diagram **4.12**	suitable only for items which are unaffected by tipping.
Automatically loading paternoster and off-loading by tipping – see diagram **4.13**	as above, suitable only for items unaffected by tipping, this can carry items of various sizes, shapes and weights.
Automatically loading and off-loading paternoster – see diagram **4.14**	this system involves a restriction on the size and shape of load; it will carry items each weighing at least 56lb, with a capacity of about 400 items per hour, and can be linked automatically to horizontal conveyor belts to make one integrated system.
Heavy-duty paternoster – see diagram **4.15**	this system is normally limited to traffic between two floors only.
Gravity Systems	
Chutes – see diagram **4.16**	limits on both the nature and size of items handled.



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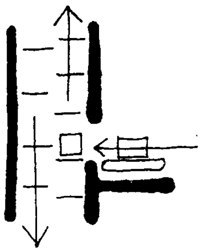

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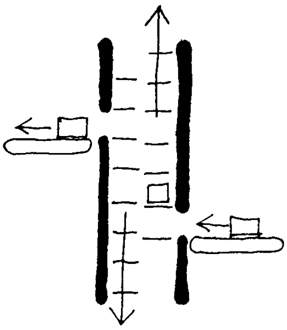

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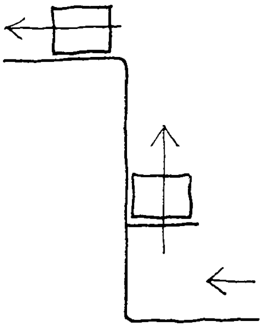

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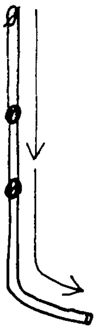

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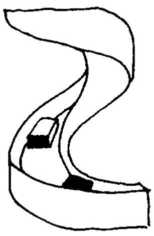

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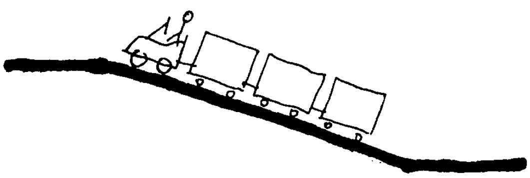


4.18

Open chutes – see diagram **4.17**	limits on shape and size not so severe, but as above items must be robust or well packed.

Incline Systems

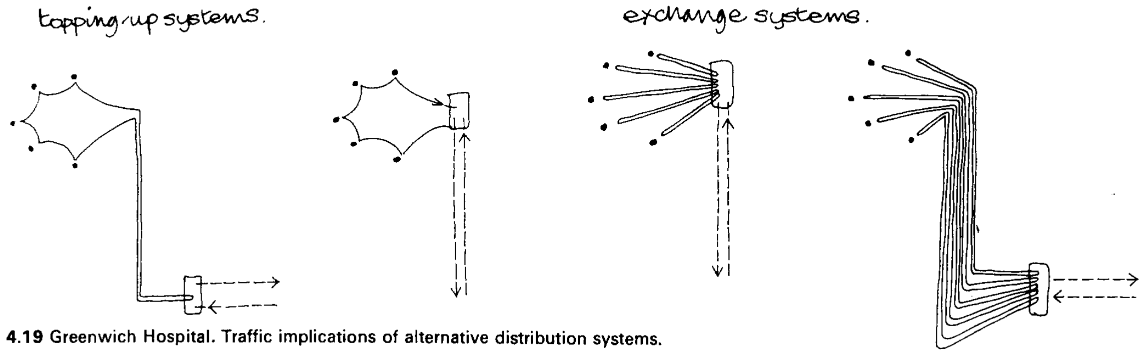
Ramps – see diagram **4.18**	floor levels can be linked in this way to provide a continuous travelling surface; mechanical assistance may be necessary for most loads, and even then the slope of the ramp should not be more than 1 in 20; it may well therefore not be suitable for more than say three floors; self-righting trolleys are available for items which cannot be tilted.

The assessment of the vertical and horizontal handling options in the context of the Greenwich hospital are described in a later section of this chapter and in the chapter on the supply of meals which follows.

Options – Procedural

Requisition. The issue of goods in response to a requisition has for many years been the traditional method of distribution for a wide range of items. The ward sister is responsible for checking her stock levels, specifying the items in need of replenishment and submitting the details on a requisition, usually on a designated day. Once approved the order is made up in the store and delivered to the ward either by one of the storemen or by the general portering staff. The ward sister is usually responsible for the transfer of the delivered goods to her shelves. The requisitioning system has the merit of limiting the number of distribution staff required, and on the face of it should keep at a minimum the total quantity of goods being moved. In practice, however, stock level control is difficult and hoarding by ward sisters is a constant temptation. In consequence the total quantity of goods in the distribution pipe line may well be substantially higher than necessary.

Topping up. In recent years topping up methods have been introduced with increasing frequency into hospitals, especially for the distribution of clean linen where the linen items have not been permanently marked for an individual ward. Under this system regular topping up rounds replenish consumer stocks to predetermined stock levels, which represent the consumer's maximum likely requirements during the interval between topping up rounds. Local principles of financial control may demand that the ward sister still signifies receipt of the goods by her signature, although within the system its value is questionable; but with this possible exception the ward sister is absolved from all



4.19 Greenwich Hospital. Traffic implications of alternative distribution systems.

responsibility for stock replenishment. Topping up in its simplest form is not suitable for all items, however. Where the range of items is large and their consumption level small and uneven it may become uneconomic to carry a large quantity of stock round the hospital in order to meet limited and unpredictable demands. A preliminary stock assessment round by the distribution staff is one method used to overcome this difficulty.

Trolley Exchange. This system is essentially a variation on the topping up system, where the mobile ward store is brought to a central issuing point and in its absence replaced by another trolley on the ward. In this way savings can be achieved in issuing time, but on the other hand there is a considerable increase in the amount of trolley traffic and also in the total quantity of goods on the move, since the trolley carries the maximum ward stock rather than simply the amount consumed since the last replenishment time. Furthermore, unless there are separate trolleys for high and low consumption items the frequency of trolley exchange must be determined by the needs of the high consumption item, and in this event the low consumption item may be moved several times between the issuing point and the ward before it is actually used.

Standard Issue. The use of standard issuing packs is suitable only for a limited range of items, where the consumption is regular and predictable, but it has the advantages of simplifying financial control, removing the need to measure consumption before replenishing, and enabling the preparation of issuing packs to be undertaken more on the lines of an industrial process not necessarily related exactly to the moment of issue.

In terms of space consequences the trolley exchange system creates more traffic in the main corridors than the other three systems and requires a larger space at the central issuing point for the parking of trolleys. In an exercise for the Greenwich hospital it was calculated that the trolley exchange system involved 2½ times the length of journeys required by either the topping up or requisition systems where the central issuing point was on the same floor as the wards and departments being served – see diagram **4.19**. In the Greenwich situation the difference would have been even greater if vertical as well as horizontal movement had been involved. Both the topping up and the trolley exchange systems can be operated with little more than a 24-hour storage capacity being available at ward level so long as a service is provided seven days a week. If, however, a five-day supply is required at ward level, to cover bank holiday weekends for instance, the storage space must be increased, and in the case of the trolley exchange system the number of trolleys must also be greatly increased.

The Greenwich Solution

Procedural Method

In an assessment of the procedural options for Greenwich it was quickly decided that the ward sister should not be concerned with the problems of stock replenishment, and that improved methods of stock control were possible under the alternative systems. It was established that when compared with the topping up system the trolley exchange system achieved a time saving of some 25 per cent on the task of moving goods from the issuing point to the wards, since under this system the assessment of replenishment needs and the loading of the shelves at ward level was not necessary. These two functions would still have to be carried out at the central issuing point however, so that the saving on the issuing round of 25 per cent would be considerably reduced, although probably not entirely removed. Despite this possible disadvantage, however, the topping up system was ultimately selected for the majority of items, including linen, because of its comparative unobtrusiveness in terms of traffic, its suitability for a wider range of items, and the facility it allowed for the varying replenishment needs to be met at differing frequencies.

Floor Issuing Points

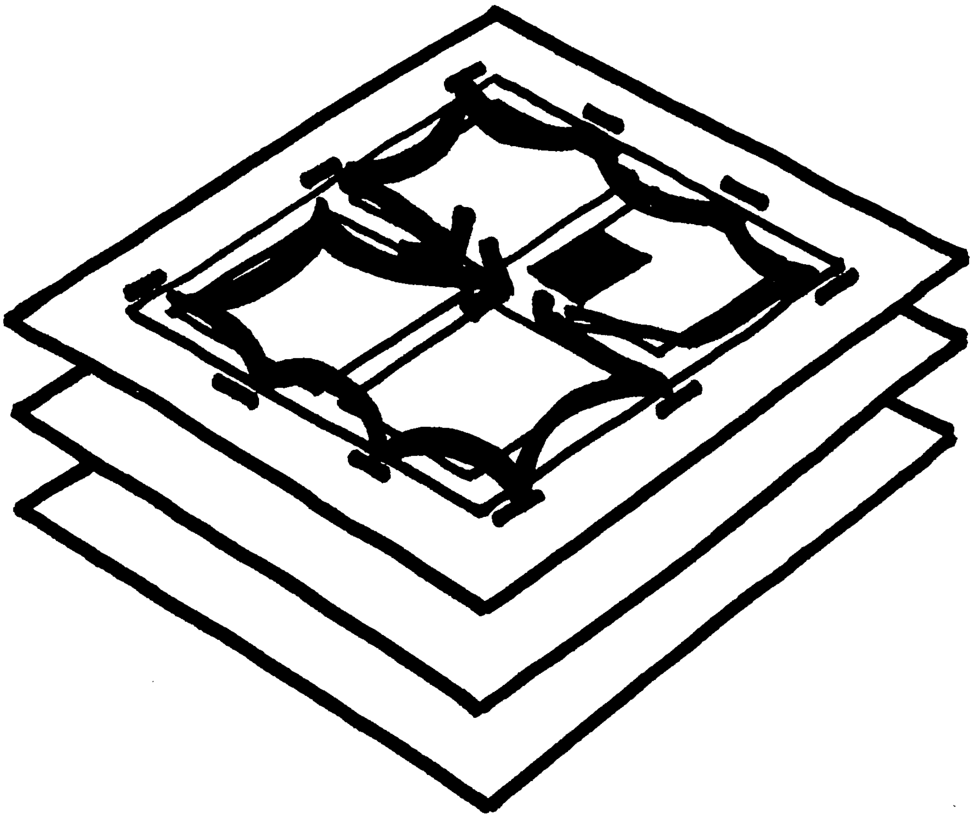
Under any of the procedural options described above there is always the alternative of having either one or several issuing points. The most obvious danger of having several issuing points is that double handling may be incurred where the issuing points are themselves served from a central store within the hospital. Where the processing unit is not on the hospital site of course (as in the case of area laundries, for instance) a measure of double handling is inevitable, and need not be greater in a situation where there are several issuing points than where there is only one. Again, where distribution from a single central unit involves vertical as well as horizontal movement an additional cost in both installations and staff time is incurred. Where distribution from any one of the several issuing units is only horizontal it may be possible to achieve economies in the method by which they are each served vertically from the main store.

The Greenwich design concept seemed to suggest a system of three floor issuing points, each served entirely vertically from a main store in the lower ground floor – see diagram **4.20**. The size of each of the upper three floors did much to justify a separate unit for each, whilst at the same time allowing the issuing unit to be responsible not only for the distribution of items from the main store but also of linen and sterile supply items from the off-site industrial zone. There was also the possibility of installation and staff economies by the use of mechanical handling methods between the main store and the floor issuing points, and also directly between a laundry vehicle in the off-loading bay and each of the floor issuing points. The latter facility assumed greater significance once it was established that the total quantity of clean linen to be distributed throughout the hospital was something in the order of 10 times the volume of items to be distributed from the main store.

The decision on three issuing points was directly related to the fact of three patient floors. The fundamental appeal of this subdivision, however, was its consistency with the philosophy behind the overall design concept of 'each floor a hospital'. Within the field of goods supply it is hoped that at least two of the disadvantages of a large hospital from the consumer's point of view – those of centralisation and specialisation – will be counterbalanced by the presence on each floor of a person who can satisfy the needs of the consumer over a wide range of items, including general stock items, clean linen and sterile supply items, as well as the collection of used linen and other items for reprocessing or destruction. When the new hospital is in full operation it is conceivable that the duties of this person will be further expanded so that he can become in some senses a floor manager.

Handling Method

Once it had been decided that there would be no requirement for the vertical movement of large trolleys (as in the trolley exchange system), and that there should be a central issuing point on each floor, all three sited vertically above the main store and off-loading bay, it was possible to look for methods of vertical transport which would be suitable for goods only but could achieve economies by not depending on staff accompaniment or manual operation. The first step in



4.20 Greenwich Hospital. The topping up system operated from a central issuing point on each floor.

this exercise was to establish the size and shape of the maximum load which, whilst being a standard to which the great majority of items could conform, would be easy to handle both mechanically and manually by the kind of staff most likely to operate the distribution system.

In many parts of Britain in recent years there has frequently been pressure on the available pool of male labour in the categories from which hospitals normally recruit ancillary staff, and to a large extent the same is also true for women who are willing to undertake full-time employment. Most hospital authorities have for a long time experienced difficulty in recruiting male labour for the portering services, and there is little evidence to suggest that their recruiting ability is likely to improve in the future. In view of this it is possible that before long the only way to provide many of the unskilled services within a hospital will be by adapting the duties involved in such a way that they can be undertaken by part-time married women, the most likely source of available labour in the future. For the Greenwich hospital it was decided therefore that the maximum load should be measured in relation to a woman's handling and lifting ability.

It was somewhat surprising to discover that little research work in this field had so far been undertaken. One useful piece of information, however, came from research by the Philips Ergonomic Group of Holland, where an exercise had been carried out in order to determine the optimum unit load for the flower bulb industry of Holland.[15] The conclusion reached by the group was that a unit weight of 17 SKG (about 30lb) for untrained female labour was somewhere near the optimum load. For the flower bulb industry the size and shape of the unit load was determined largely by the nature of the activities involved.

Standard Container

The Greenwich designers therefore undertook a series of tests to assess the validity of this conclusion in a hospital situation. Female staff at a hospital laundry were asked to lift several weights to a variety of heights and to show by their actions or their comments which was easy, possible, difficult or impossible – see diagram **4.21**. It was at length concluded that a fixed shape of approximately 2ft × 1ft × 1ft, weighing 25lb, was the maximum load which most women could lift up to a height of 4ft 6in above floor or platform level.

A second exercise was then necessary to establish the degree of suitability of a container with these dimensions and weighing when empty not more than 5lb, for the range of items which the vertical lifting system would be expected to handle. A detailed survey – see Appendices B, C and D – showed that 95 per cent of the range of items emanating from the main store, the food preparation kitchen, and the industrial zone laundry and sterile supply unit could be packed into such a container – see diagram **4.22**. It was thus possible to think in terms of a standard container for the transport of the great majority of items, and because it remained a unit which could be easily handled the container could conceivably be used not only for the vertical journey between the main store and the floor issuing points but also for the journey between the industrial zone and the floor issuing points, and to some extent on the topping up rounds themselves. In this way a substantial amount of wasteful packing and unpacking could be avoided.

When the performance specification for the standard container was prepared it read as follows.

Size. 2ft long × 1ft wide × 1ft deep.

Shape. When not in use the container should occupy as little space as possible; it should therefore be capable of nesting; it should also be able to pass freely over a roller conveyor and should therefore have a flat base.

Strength. The container should be strong enough to withstand rough handling, which might include being dragged along floors or thrown onto vehicles; it should be sufficiently strong and rigid to preserve its shape and appearance, giving a life of at least five years.

Weight. The container when empty should weigh no more than 5lb.

Material. The container should be able to carry all types of item which require carrying in a hospital; it should be capable of being cheaply and easily cleaned and of being processed through water temperatures of up to 180°F.

Security. No system can be effective against the determined thief but the container should deter the casual pilferer; the container should therefore be opaque, preferably strongly coloured, including a lid, and lockable by a simple device if necessary.

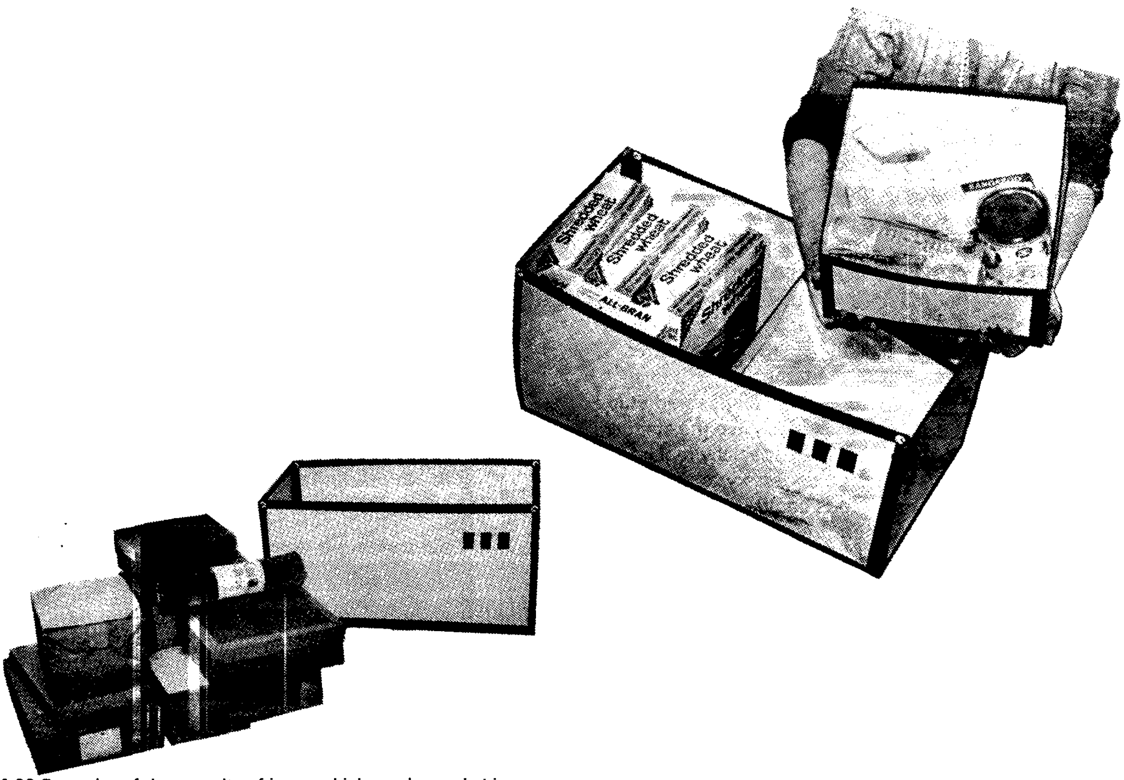
Identification. The container should be able to carry a removable card, which may identify its contents or signify its destination in such a way that it can be read by an electronic device.

Movement. The container should be capable of being stacked, and should be able to carry the weight of four full containers (a maximum of 100lb) stacked on top of it.

Mechanical Handling

A decision on the size and shape of loads to be carried is an essential prerequisite to a consideration of mechanical handling options. It is also important to know the total quantity of goods to be carried expressed in terms of the standard container (as shown for Greenwich in diagram **4.4**). It was calculated that in total the operational policies and layout of the Greenwich hospital would generate a daily vertical movement of 800–1,000 containers (including the movement of

4.21 Women lifting linen to a variety of heights, as part of an exercise to determine an optimum unit load.



4.22 Examples of the quantity of items which can be carried in a container measuring 2ft × 1ft × 1ft.

food from the food preparation kitchen to the floor kitchens).

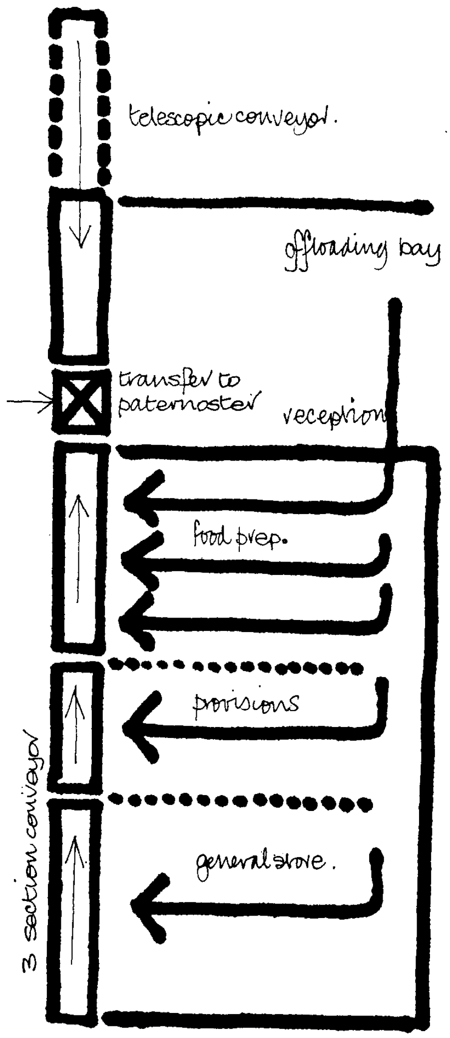
A further issue to determine is the point or points at which goods are to be loaded onto a mechanical handling system and the point at which they are to be discharged. Within the Greenwich design the discharge point was simple, the floor issuing point being in a sense the main user, which could be sited next to the floor kitchen. The loading points were several, however, since there were three main points (the main store, the food preparation kitchen and the industrial zone) at which goods would be packed into standard containers. It was clear that the best solution would be one which linked the main store, the food preparation kitchen and the off-loading bay in such a way that each had a direct mechanical link with the floor issuing points without the need for any manual horizontal movement.

Of the options for horizontal movement noted earlier only the conveyer belt can provide this facility in a single integrated system. The conveyor belt also has other advantages. In a sectionalised system the sections at the beginning of the belt can be operated independently from the sections at the latter end and can thus be used as live storage at times when the latter sections are operating – see diagram **4.23**. It is also possible by the use of a telescopic section to bring the beginning of a mechanical handling system into the rear of a lorry parked in the off-loading bay whilst linking it to the main system. Finally, it is possible to programme a conveyor system so that one or all of its sections will operate at an appointed time, delivering any goods which have been loaded on to it. In this way the delivery of goods need not be immediately related to the availability of staff to load goods on to the conveyor. It should also be pointed out that the conveyor occupies remarkably little space since both above and below it can be used for storage purposes – see diagram **4.24**.

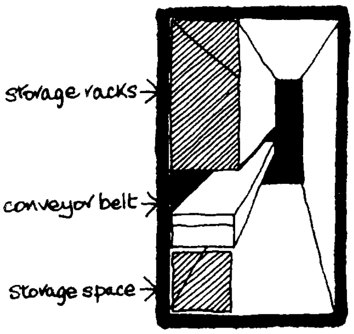
The choice of horizontal handling method is also bound up with the choice of vertical handling method. As has already been mentioned one of the targets in the Greenwich design was to save staff time by removing the need for goods to be accompanied on the vertical journey. A conventional type of lift did not fulfil this requirement. If hoists were to be used it appeared that several would be necessary in order to give the standard of service which the floor kitchens especially required. Furthermore it would always be necessary to load the hoists manually even if the loads could be automatically discharged at their destination.

It was because of these inadequacies in the performance of the more conventional solutions that the alternative of a paternoster was considered. Its most obvious disadvantage is that it imposes restrictions on the shape and size of the items which it can carry, in particular demanding a perfectly flat base, and requiring fixed sides either where there is any risk of items slipping or where a discharge instruction is to be carried. Nevertheless this limitation is counterbalanced by its ability to be linked automatically with horizontal methods of mechanical handling, its ability to discharge goods at one of several points, and its total handling capacity, which in the case of the Greenwich installation is said to be 360 containers an hour. Finally, by means of an automatic transfer mechanism at the base of the paternoster linking it to the horizontal conveyor system, it is possible to achieve the primary target in the Greenwich design of linking directly the main store, food preparation kitchen and off-loading bay with each of the floor issuing points whilst using only one vertical means of mechanical handling – see diagram **4.25**.

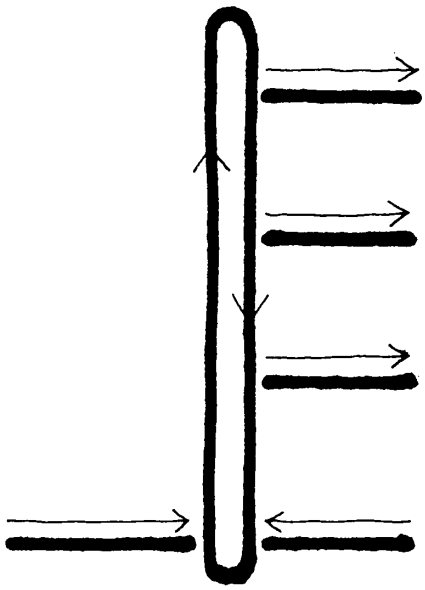
Each container carries an index card, displaying simply one, two or three dots, and just before the container is transferred from the horizontal conveyor to the paternoster – see diagram **4.26** – the information on the card is recorded by a photo-electric scanner. The instruction is thus registered and the container off-loaded automatically at the selected floor, being transferred on to a



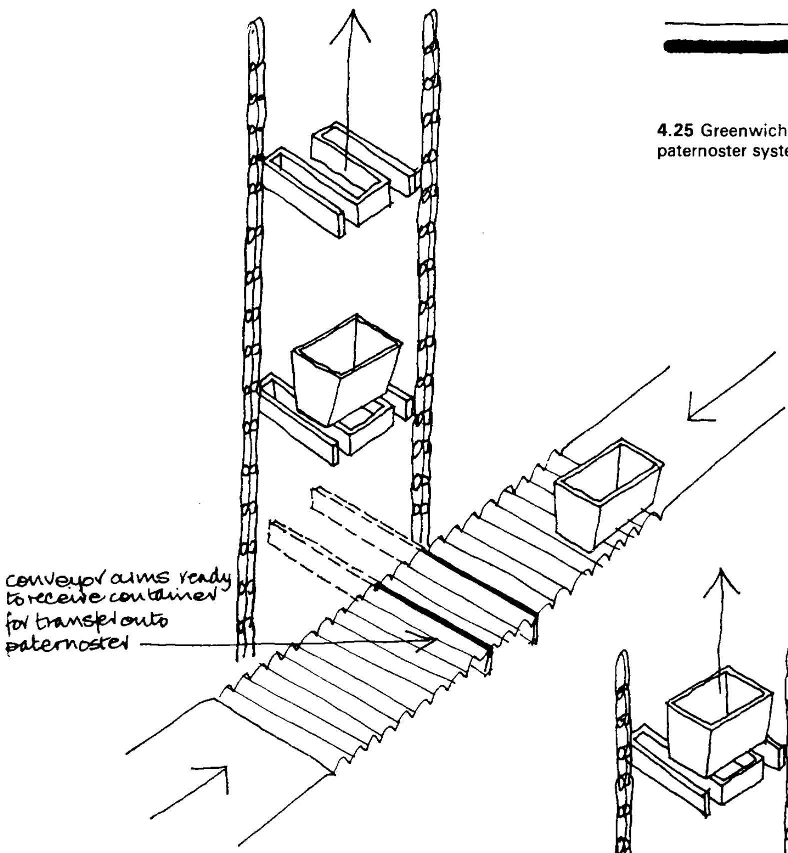
4.23 **Greenwich Hospital. The sectionalised conveyor.**

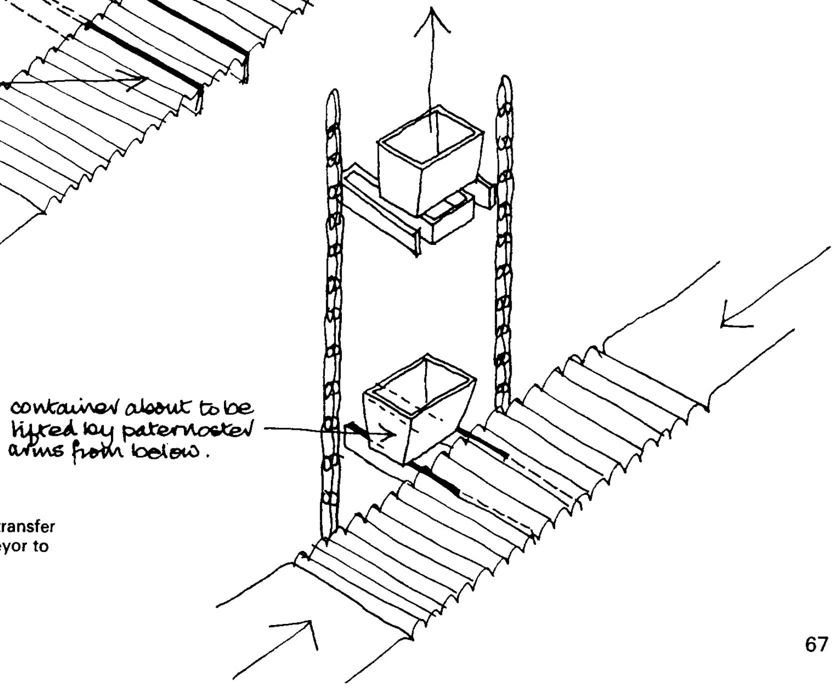


4.24 Greenwich Hospital. Storage space provided above and below the conveyor.

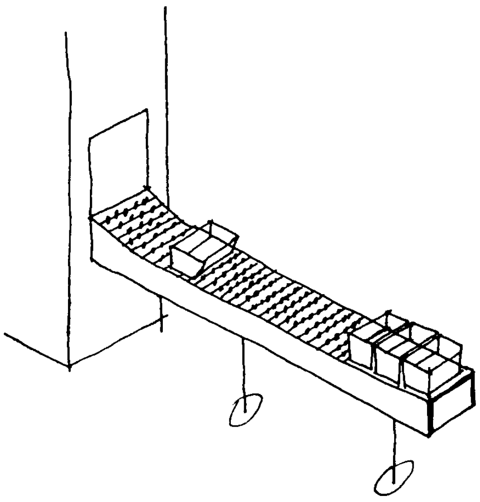


4.25 Greenwich Hospital. The conveyor and paternoster system in section.

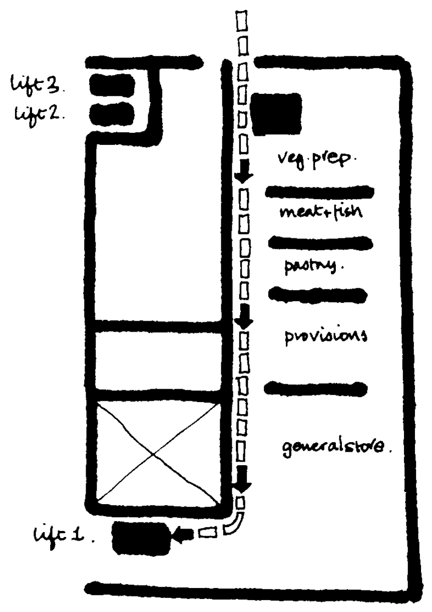




4.26 Greenwich Hospital. The transfer of the container from the conveyor to the paternoster.



4.27 Greenwich Hospital. The off-loading gravity conveyor.



4.28 Greenwich Hospital. In the event of the paternoster breaking down the conveyor can be reversed to link with one of the bed/passenger lifts.

skate-wheel gravity conveyor – see diagram 4.27. Should the off-loading points on a particular floor become full the containers for that floor will circulate in the paternoster until a free space is available. At the same time an indication will be given to the operators so that appropriate action can be taken. When running automatically the activities of the complete system are governed by a remote control panel, but at any time the control programme can be overriden if required, either by the staff on the lower ground floor or by those at any one of the floor issuing points. Because of the importance of transporting food to the floor kitchens the system has been so designed that containers from within the building will take precedence over those coming from the telescopic conveyor. In this way a container from the food preparation kitchen can be dispatched during the period when the clean linen is being off-loaded yet without noticeably interrupting its flow.

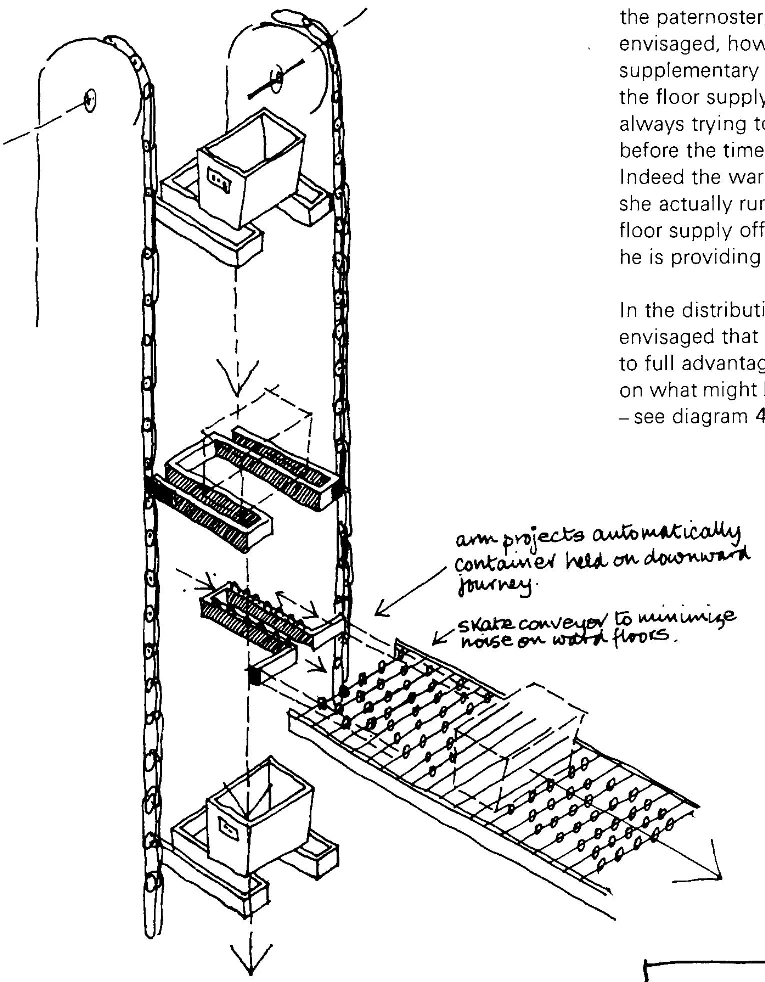
In the interests of reliability the conveyors have been designed so that they are reversible. Thus in the event of the paternoster breaking down containers can be carried by the bed/passenger lift which is sited close to the first section of the conveyor – see diagram 4.28. It is expected, however, that the capacity of the paternoster will be adequate both to give an efficient standard of service and to allow ample time for regular maintenance to be carried out on it.

In concluding this brief description of the paternoster's capabilities it should be mentioned that the particular paternoster being used at Greenwich is unable to return any goods from the floor issuing points to the lower ground floor, since the installation cannot load and off-load at the same point. The method of off-loading is mechanically simple – see diagram 4.29 – but once both loading and off-loading are required the mechanism becomes more complex, and the considerable additional cost did not seem to be justified by the scale of demand for this facility. The capital cost of the combined conveyor/paternoster system as installed was rather less than £16,000. The biggest consequence of this limitation is that empty containers must be returned by other means. Since the timing of their return is not critical, however, they can conveniently be returned via one of the bed/passenger lifts during off-peak periods in the lifts' activity.

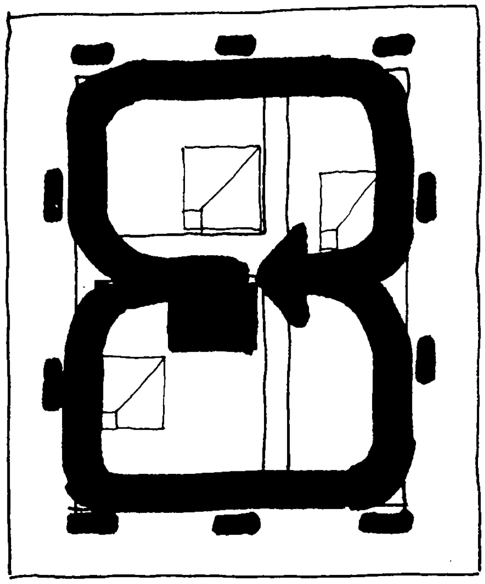
Distribution at Floor Level

The floor issuing point in the Greenwich design has gained the title of 'floor supply centre', but it is not intended that it should assume the role of a subsidiary store. As far as both clean linen and sterile supply items are concerned it is in effect the first off-loading point in the hospital. It will also receive bulk deliveries from the main store, but as with linen the quantities received will be in response to orders placed by the floor supply officer after an assessment of his own requirements, so that if the procedure is operating correctly he should be able to distribute immediately to the consumer points all that he receives. Clearly his sequence of ordering and replenishment must be programmed, but as has already been explained it is always possible for him to receive a supplementary delivery, by means of the paternoster, at least from the main store. It is envisaged, however, that on most occasions when a supplementary issue is necessary to a particular ward the floor supply officer will borrow from another ward, always trying to ensure that no ward stock runs out before the time of the next regular replenishing round. Indeed the ward sister should only be concerned when she actually runs out of an item, and so long as the floor supply officer prevents this situation from occurring he is providing to the consumer a satisfactory service.

In the distributing of goods throughout the floor it is envisaged that the main corridor pattern will be used to full advantage, with issuing rounds being undertaken on what might be described as a 'figure of eight' principle – see diagram 4.30. The size of the issuing trolley will



4.29 Greenwich Hospital. The paternoster's off-loading mechanism.



4.30 Greenwich Hospital. The intended pattern of issuing rounds on each floor.

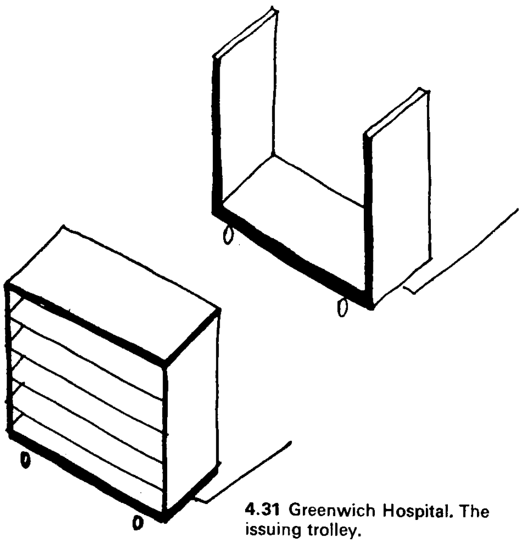
therefore be such that all consumer points on a loop can be served on one journey, in this way reducing the amount of wasted time when a trolley is travelling empty. The design of the trolley will be adjustable so that, for instance, all shelves can be removed if for a particular round it is economical to transport items still packed in their containers and stacked on top of each other – see diagram **4.31**. Because of the corners and junctions in the corridor system it is not intended that trolley trains should be used. It is envisaged, however, that by the use of a manually controlled mechanical tug the trolley dimensions can be as great as 6ft long × 3ft wide × 6ft high (approximately equivalent to the dimensions of a general purpose bed), giving a maximum carrying capacity of 100cu ft.

At ward level the clean supply room is entered directly from the main hospital corridor, thus preventing the need for any supply traffic to enter the ward corridors. The ward clean supply room holds most general stock items as well as linen and sterile supply items, and can hold sufficient stock to meet three days' demand. By the use of the internal ward supply trolleys and the main floor issuing trolleys it is estimated that a five-day supply can be held on each floor.

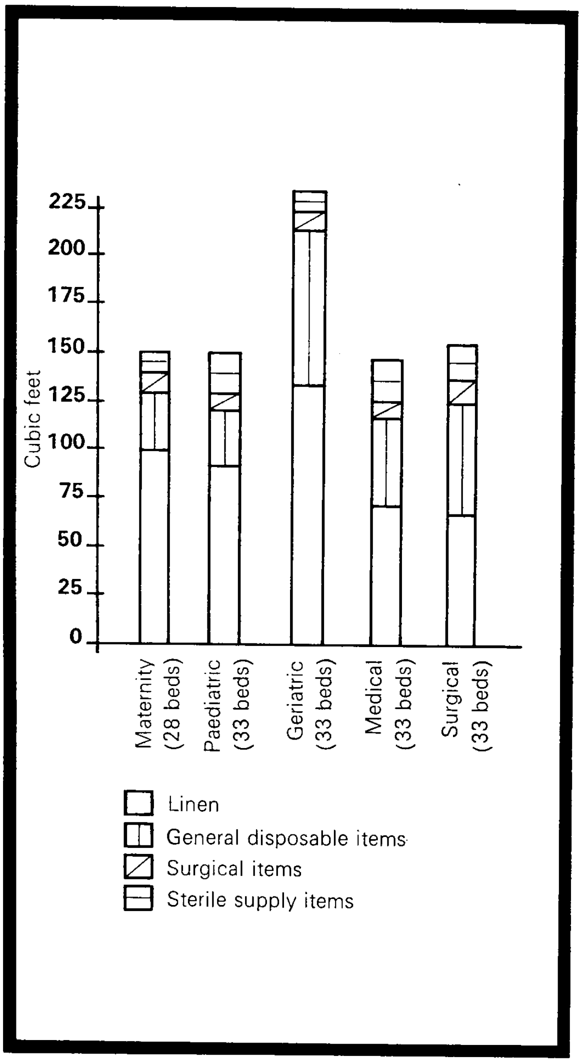
The topping-up system must of course be susceptible to variations in consumption levels between wards, and indeed between one season of the year and another. Diagram **4.32** illustrates some of the main variations which are expected in the Greenwich hospital.

Disposal

In this context the word 'disposal' is used to refer to all items which have to be removed from the consumer



4.31 Greenwich Hospital. The issuing trolley.



4.32 Greenwich Hospital. Estimated volume of four groups of supply items to be stored at ward level, based on a three-day demand.

unit. The range is considerable, including for example x-ray developing fluids, but the main categories are as follows:

Soiled, fouled and infected linen
Sterile supply items for reprocessing
Combustible refuse (that which can be disposed of by incineration)
Non-combustible refuse (for example, bottles and cans)
Empty issuing containers

A sixth category, food waste, might also be added, but where waste disposers are provided at the point of generation this ceases to have any transport implications. In terms of volume used linen and combustible refuse are the most significant. It may be noted in passing that used linen occupies some 25 per cent more space than does clean linen, and the return of empty containers to the laundry further adds to the total volume of items on the return journey. On the other hand only a small proportion of sterile supply items are returned for reprocessing since the great majority of items in this category are disposable.

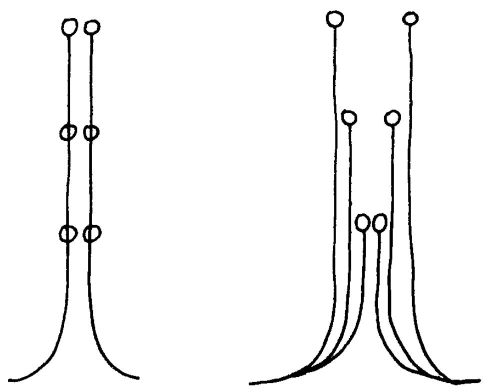
In the design of the disposal system for Greenwich the following objectives were set.

i All possible precautions should be taken to prevent the spread of infectious or communicable disease within or from the hospital. It is important therefore to keep to a minimum the handling and exposure of used materials, and to dispose of all waste products, especially those which are not enclosed in sealed containers, as close as is organisationally possible to their source.

ii Incineration should be the main form of refuse disposal, requiring that non-combustible waste should be separated from combustible waste at the user point. The collection of disposal items should follow the same principles as those governing the floor issuing round.

As with the ward clean supply room the ward disposal room opens direct on to the main hospital corridor, facilitating easy and unobtrusive collection. Consideration was given to the possibility of using the standard containers for disposal purposes, but several factors militated against the adoption of this idea. The use of the standard containers would have involved additional cleaning, and always held the risk of cross infection. Within the context of nursing procedures the nylon or paper bag was more convenient because of its extra capacity, whilst if the containers had been used it might have been necessary to instal a second paternoster in order to transport them to the lower ground floor.

On the other hand the use of a chute system in a hospital which had only four floors seemed to be the obvious answer, especially since it could easily handle the nylon and paper bags preferred at ward level. In examining existing chute installations it was discovered that the most significant part of the installation cost was in the electronic locking devices which permit only one door in a single chute system to be opened at a time. A comparison was made between a single chute system and one in which each of the three patient floors had its own chute directly linked to the lower ground floor – see diagram **4.33**. Even though the alternative scheme involved $2\frac{1}{2}$ times the amount of ducting it proved to be half the cost of the first system because of the elimination of any electronic locking devices. It also provided the advantage that there need be no waiting on one floor whilst the chute is open on another floor. As a result of this comparison a linen chute and a refuse chute are being provided on each floor, all three chutes in each category combining in the engineering sub-floor immediately above the lower ground floor so that there is a single flow of linen from one chute and refuse from the other chute into the main disposal room.



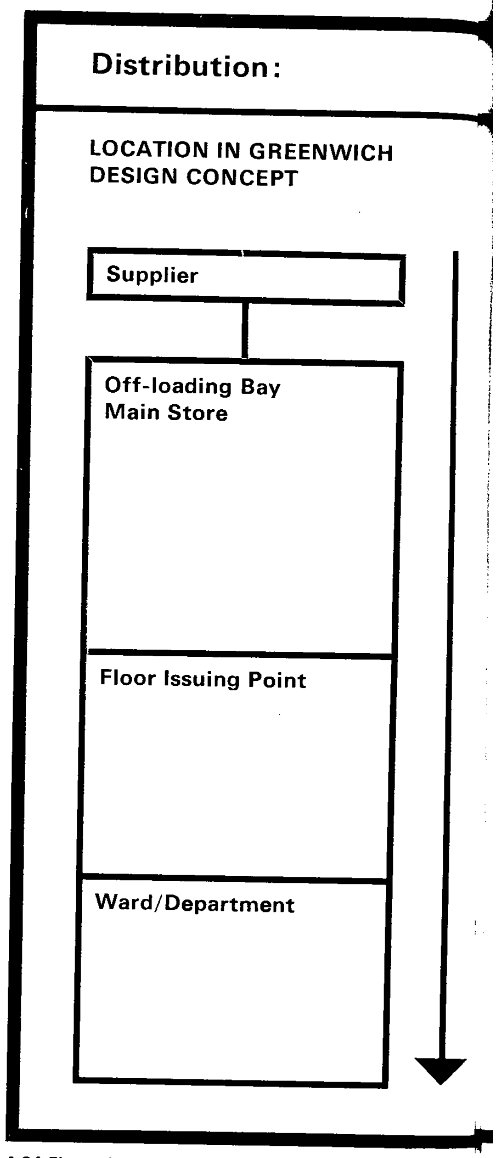
4.33 Greenwich Hospital. Alternative disposal chute systems.

The main disposal room in the lower ground floor is sited next to the off-loading bay so that used linen and non-combustible refuse can be easily collected. An overhead chain conveyor is provided in order to minimise the manual handling of the used linen bags. Two incinerators are installed within the main disposal room for the speedy incineration of all combustible refuse.

It is thought that by combining these several functions into one room a substantial improvement in the efficiency of these frequently forgotten services can be achieved, whilst at the same time reducing the amount of staff time required to perform them.

Flow Diagrams

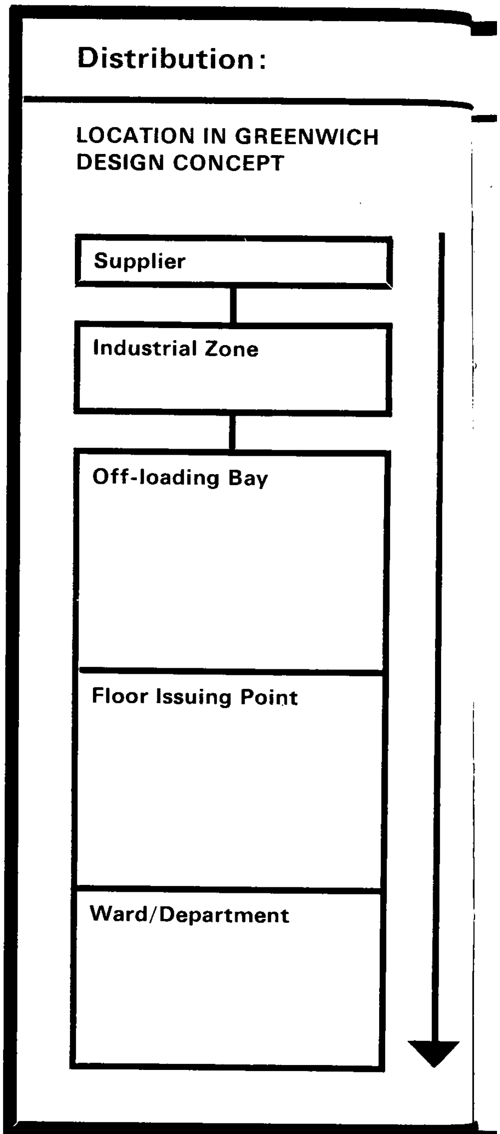
The flow diagrams which follow – see diagram **4.34** – may serve as a summary of the issues touched upon in this chapter. These flow diagrams were in fact prepared in the early days of the Greenwich investigation, and were used throughout as the basis on which to assess the many options, whether they related to the procedure, the method of handling, or the space requirement. During the course of the studies this discipline was felt to be of particular importance in assessing the merits of mechanical handling methods in the context of the total problem, since in this field there always seemed to be a danger that mechanisation would give the appearance of being an advantage in itself. In fact, of course, any element of mechanisation is only of value where it is consistent with the purpose and procedures of the organisation within which it is opertaing – see diagram **4.35**.



4.34 Flow Diagram A. Distribution: General Stock Items.

General Stock Items

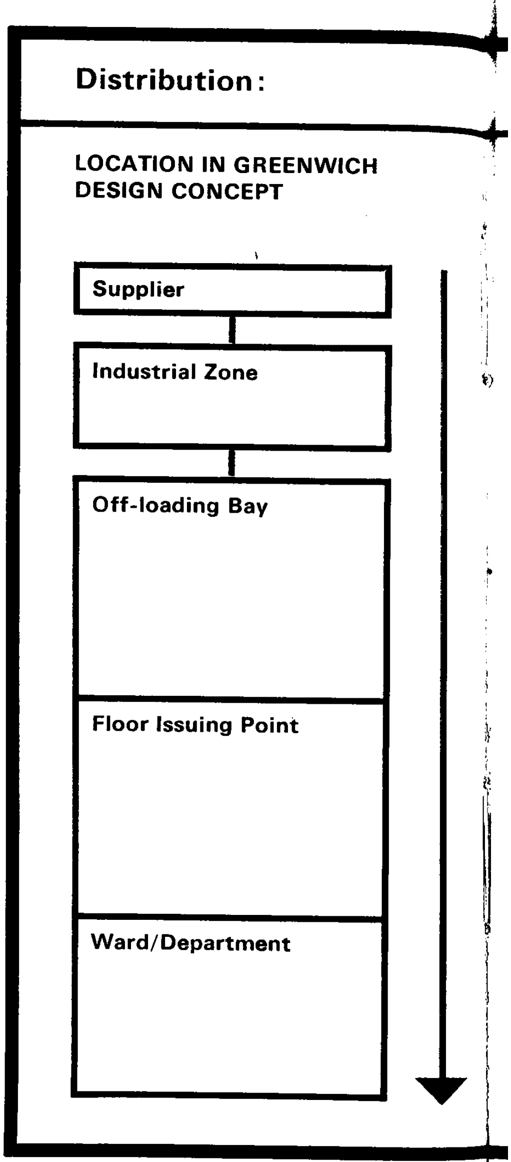
ACTIVITY	POINTS OF INFLUENCE ON DESIGN Items marked * may or may not be required, depending on operational policy decisions
Receive **Store** **Unpack** **Issue** – either a) to each floor or b) to each ward/department	**Means of** – transferring goods to store from off-loading bay – handling issues **Space for** – off-loading, with access for vehicles – storage – unpacking (and storing returnable empties) – assembling goods to be issued – office procedures – * parking distribution trolleys
Receive (dependent on above) **Issue** to wards/departments by either a) requisition or b) topping up or c) trolley exchange or d) standard issue	**Means of** – handling goods received – handling issues **Space for** – * receiving point – * sorting – * storage – * office procedures – * parking distribution trolleys
Receive (dependent on above) **Store** – either a) at single point or b) at main point with sub-points, e.g. supply trolleys	**Space for** – storage – * temporary parking of trolleys during off-loading
Use	



4.34 continued Flow Diagram B. Distribution: Linen.

Linen

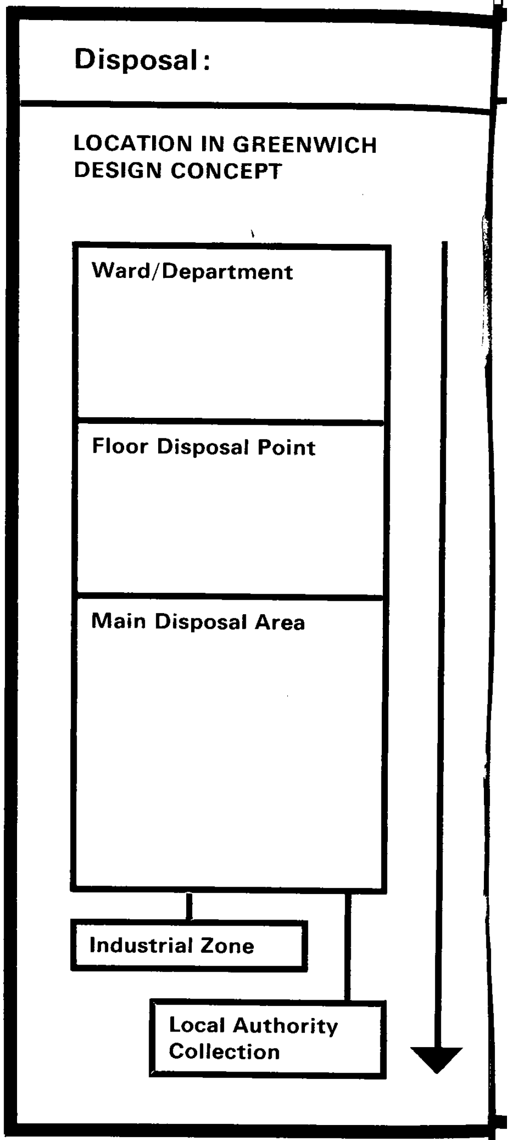
ACTIVITY	POINTS OF INFLUENCE ON DESIGN
	Items marked * may or may not be required, depending on operational policy decisions
Receive used linen **Launder** **Issue** clean linen **Order, receive, store** and **issue** new stock	
Receive from industrial zone either a) assigned to hospital only or b) assigned to each floor or c) assigned to each ward/department **Issue** either a) to each floor or b) to each ward/department	**Means of** – handling linen received – handling issues **Space for** – * receiving point – * sorting – * storage – * office procedures – * parking distribution trolleys
Receive (dependent on above) **Issue** to wards/departments by either a) ward marking of linen or b) topping up or c) trolley exchange or d) standard issue	**Means of** – handling linen received – handling issues **Space for** – * receiving point – * sorting – * storage – * office procedures – * parking distribution trolleys
Receive (dependent on above) **Store** – either a) at single point or b) at main point with sub-points, e.g. supply trolleys	**Space for** – storage – * temporary parking of trolleys during off-loading
Use	



4.34 continued Flow Diagram C. Distribution: Sterile Supply Items.

Sterile Supply Items

ACTIVITY	POINTS OF INFLUENCE ON DESIGN
	Items marked * may or may not be required, depending on operational policy decisions
Receive items for reprocessing **Process** **Issue** processed items **Order, receive, store** new stock	
Receive from industrial zone either a) assigned to hospital only or b) assigned to each floor or c) assigned to each ward/department **Issue** either a) to each floor or b) to each ward/department	**Means of** – handling goods received – handling issues **Space for** – * receiving point – * sorting – * storage – * office procedures – * parking distribution trolleys
Receive (dependent on above) **Issue** to wards/departments by either a) requisition or b) topping up or c) trolley exchange or d) standard issue	**Means of** – handling goods received – handling issues **Space for** – * receiving point – * sorting – * storage – * office procedures – * parking distribution trolleys
Receive (dependent on above) **Store** – either a) at single point or b) at main point with sub-points, e.g. supply trolleys	**Space for** – storage – temporary parking of trolleys during off-loading
Use	

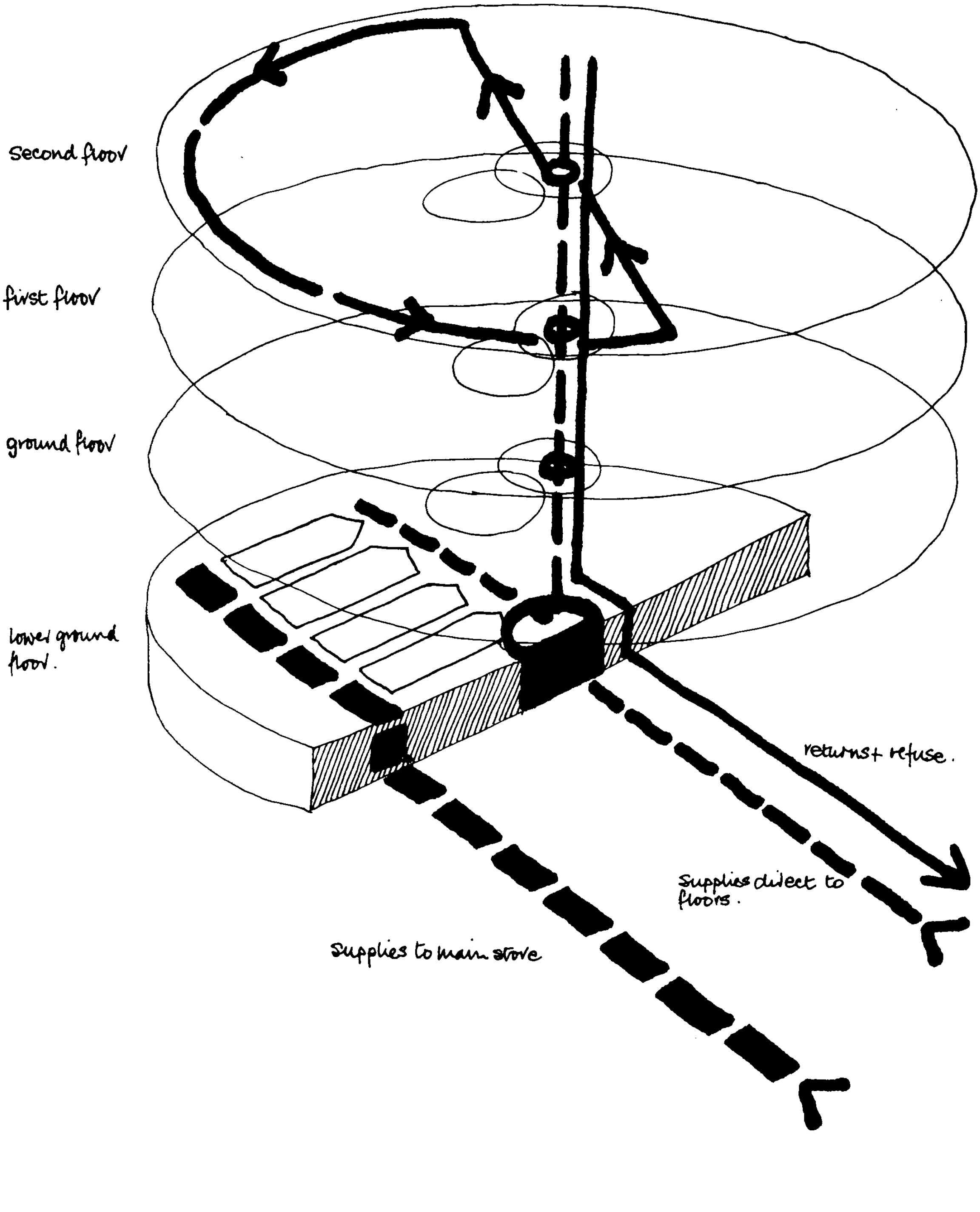


4.34 continued Flow Diagram D. Disposal: General Stock Items, Linen, Sterile Supply Items.

General Stock Items, Linen, Sterile Supply Items

ACTIVITY	POINTS OF INFLUENCE ON DESIGN
	Items marked * may or may not be required, depending on operational policy decisions
Deposit at user point segregating a) combustible from non-combustible refuse b) soiled from foul linen c) sterile supply items for reprocessing	**Means of** – holding items at user point, segregating categories as listed
Collect return items and refuse from user points **Deliver** to main disposal area **Collect** issuing containers and return to off-loading bay	**Means of** – collecting return items and refuse – delivering to main disposal area **Space for** – * parking collection trolleys – * holding issuing containers – * special staff facilities
Receive return items and refuse **Incinerate** combustible refuse **Despatch** – non-combustible refuse (Local Authority collection) – linen to industrial zone – sterile supply items for reprocessing to industrial zone – issuing containers to industrial zone	**Means of** – incinerating combustible refuse – * crushing non-combustible refuse – handling return items and refuse **Space for** – holding return items, refuse and issuing containers awaiting despatch – loading into vehicles – * parking collection trolleys – * special staff facilities

4.35 Greenwich Hospital. The distribution and disposal system in outline.



14 *Large Incinerators for Hospitals. BS 3316.* British Standards Institution.

15 *The Optimum Size and Shape of Containers for Use by the Flower Bulb Industry.* F T Kellermann and P A van Wely. Ergonomics July 1961.

5 Supply of Meals

based on a paper given by Ceri Davies

Within the field of institutional catering hospitals are distinguishable from other situations by the fact that they alone require as many service points as there are beds, in contrast to the single service point provided in a dining room. This requirement influences the way in which food is prepared and cooked, and also means that the service of meals is one of the most significant generators of trolley traffic within a hospital. It is essential therefore to consider any method of meal supply in relation to a hospital's overall design concept.

Quality of Meals

A study which was published in 1963 under the title *Food in Hospitals*[16] emphasised the point that food is an essential part of the medical care of a patient, whether or not he has been placed on what is popularly known as a 'special diet'. The study drew attention to the fact that there is a loss in nutritional value when cooked food is not served immediately to the patient. Further information can also be found in a Ministry of Agriculture publication:[17] 'Heat, especially prolonged heat . . . destroys vitamin C and a further loss occurs if vegetables are kept hot for any length of time. If cabbage is kept hot for 30 minutes after cooking it loses 40 per cent of its vitamin C, and after 60 minutes the loss may rise to 60 per cent. Similar losses have been found for potatoes which have been kept in a hot cabinet for the same length of time.' The problem of serving freshly cooked hot food to patients is to a large extent organisational, but equally it has considerable design implications.

An exercise which is also reported in *Food in Hospitals* points to the substantial amount of plate waste generated in many hospitals, in some cases as much as 50 per cent of cooked food leaving the kitchen. The results of the exercise suggest that to some extent the bigger the unit being served from a single central kitchen the greater the plate waste factor. Many observers when faced with evidence of deficiencies in the quality of hospital food have argued that the primary cause, at least in the larger hospitals, is the attempt to serve too many meals from a central kitchen. On the evidence reported in *Food in Hospitals* of the amount of plate waste and the time elapsing between cooking and the final service – two fairly crude indicators of food quality – the larger hospital tends to compare unfavourably with the smaller unit. If it is assumed that the operational efficiency of the staff working in a large hospital kitchen is not at fault, this evidence seems to highlight a problem which is properly part of overall hospital planning and design.

In an effort to achieve higher food quality at the point of service to the patient several experiments have been conducted in recent years to explore the benefits to be gained from decentralised finishing kitchens serving up to say 150 beds, which themselves rely on a central food preparation kitchen serving the whole hospital. A rather different approach to the problem has been the introduction of centralised meal-plating units attached to the main kitchen, one object of which is to cut down the time interval between cooking and final service by means of batch cooking. In addition this method of meal service is intended to provide a better standard of presentation, offer an effective menu choice to patients and facilitate a reduction in plate wastage by permitting individual portion control. It has to be recognised that one consequence in each of these experiments has been a net increase in the number of catering staff, although there are indications that this could to some extent be offset by corresponding savings elsewhere, particularly on the ward. Service by a centralised plating unit, however, does not eliminate the primary problems of the large central kitchen – the need to schedule a wide variety of operations to fit the deadlines of meal times, with significant peaks and troughs of activity, complex duty rotas and the staffing problems which flow from them.

In addition to the loss of nutritional value arising from delay in the service of cooked food at least four other defects in the quality of food were referred to in the study *Food in Hospitals:*

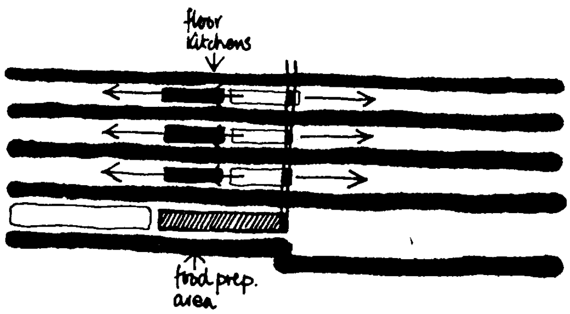
Unappetising appearance (due largely to lack of proper overall control from the kitchen)

Heat loss (due to long routes from the central kitchen to the wards and to delays in the service of meals at ward level)

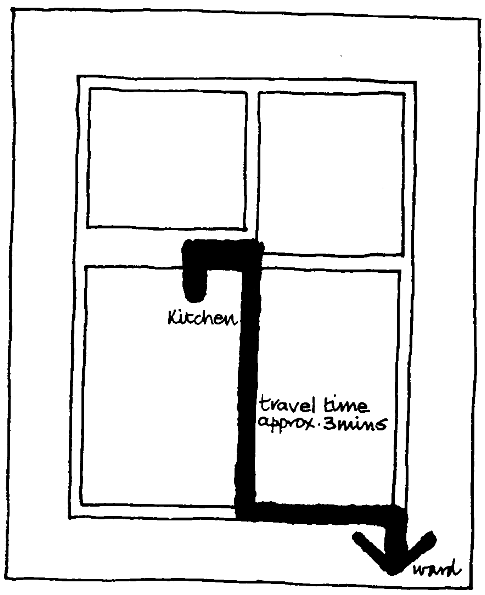
Absence of portion control systems

Limited amount of menu choice

Within the context of the Greenwich project the problem of providing a satisfactory level of meal service had to be considered in relation to the hospital's overall design concept of three patient floors over a service floor. The removal of both food preparation and cooking, which are essentially industrial processes, to the off-site industrial zone was looked at as a potential solution. The same unit could then serve a number of hospitals in the area, with a possible maximum daily capacity of 5,000 main meals. The success of this method depends on the use of quick freezing processes, but it has been argued[18] that this solution may be the only valid long-term answer to the problem of improving food quality at an acceptable price. Under this system only storing, reheating and meal service facilities will be required on



5.1 Greenwich Hospital. The positions of the kitchens.



5.2 Greenwich Hospital. The furthest distance between the floor kitchens and the wards they serve.

the hospital site, thus greatly simplifying the organisational and scheduling problems at hospital level. At the time when this solution was being considered for the Greenwich hospital, however (1963), the remaining unsolved technical problems involved were such that, whilst the system might well eventually be adopted even in this hospital, its premature introduction would bring with it several risks for the hospital, and as a system it would remain uneconomic until such time as it was found to be acceptable for several hospitals within the area. A frozen food trial, using commercial supplies of frozen food, was in fact undertaken at one wing of the existing Greenwich hospital, but primarily because of a lack of variety in the menu the service did not meet with the general approval of the patients who participated in the experiment.

Greenwich Kitchens

Attention was therefore concentrated on developing the more conventional methods of food preparation and service, and on the scale of the food processing units which the hospital required. To have followed the example of many existing hospitals of a similar size would have meant the provision of a single central kitchen to serve all 800 beds and staff meals (a further 800 main meals per day), possibly including within the kitchen a meal-plating unit for the service of meals to patients. In the light of the apparent disadvantages of a central kitchen already referred to, however, this solution was not very attractive, especially since the central plating of meals to all patients would in any event require the installation of more than one meal-plating unit. If an average speed of eight meals per minute were maintained on a single plating unit all ward meal times would have to be staggered over periods of nearly two hours, which would probably be unacceptable. Furthermore, to operate the unit without loss in efficiency for this length of time would require a rather higher calibre of staff than most hospitals are usually able to recruit.

On the other hand, if a series of smaller kitchens were to be considered as an alternative solution there was no conclusive evidence available which pointed to an optimum number of meals to be served from one kitchen. In the absence of such evidence the division of the hospital into three patient floors created a *prima facie* case for three cooking and service kitchens, each supplied from a single food preparation kitchen in the lower ground floor – see diagram **5.1**.

There were several factors which seemed to point to the adoption of this solution. The siting of a kitchen on each floor would permit a horizontal relationship between the kitchen and the points at which each meal was served. If the kitchen were to be placed centrally on the floor no ward would be more than three minutes away from the kitchen – the time taken by a person to push a loaded trolley the furthest distance separating a ward from its floor kitchen – see diagram **5.2**. Furthermore a single meal-plating unit in each floor kitchen would be able to serve 300 meals – the greatest number of patients on any floor – in less than 40 minutes, thus avoiding the need to stagger meal times over more than a short period.

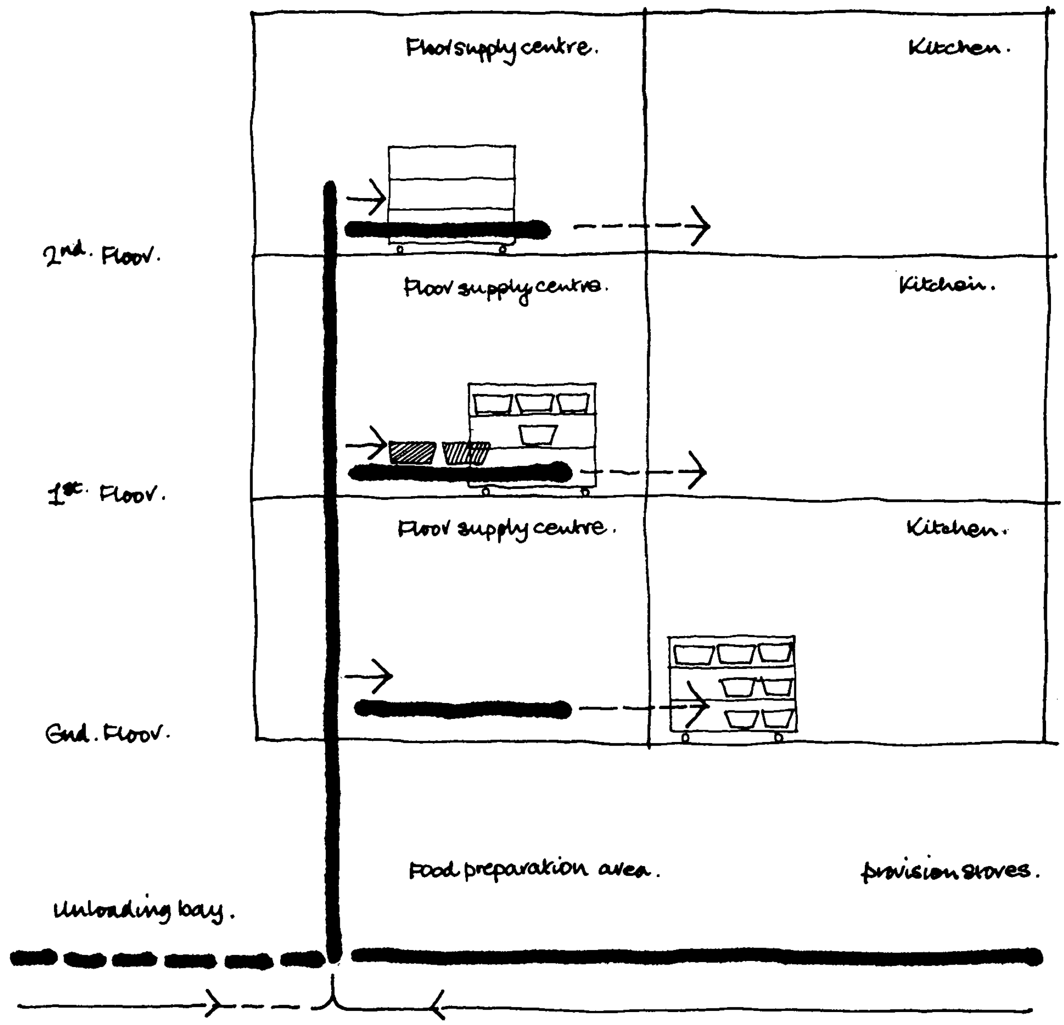
Further advantages were to be gained from the similarities between the proposed system for the supply of meals and the main goods distribution system – both consisting of a service unit centrally situated on each floor, being itself supplied from a single 'base' unit in the lower ground floor. By being sited adjacent to the main store the food preparation kitchen would be able to make use of the off-loading bay for the direct delivery of perishable items, would be close to the provisions store for the remainder of its supplies and, most significantly, could share with the main store the conveyor/paternoster installation for the distribution of prepared food to each of the floor kitchens immediately above – see diagram **5.3**. The siting of the floor kitchens next to the floor issuing points would give to each almost direct access to the paternoster, thus completing the link. As was mentioned in the last chapter, the decisions on the exact subdivision of the food processing unit and of the goods issuing point were inextricably linked, once the principle of an element of subdivision for each had been accepted.

Food Preparation Kitchen

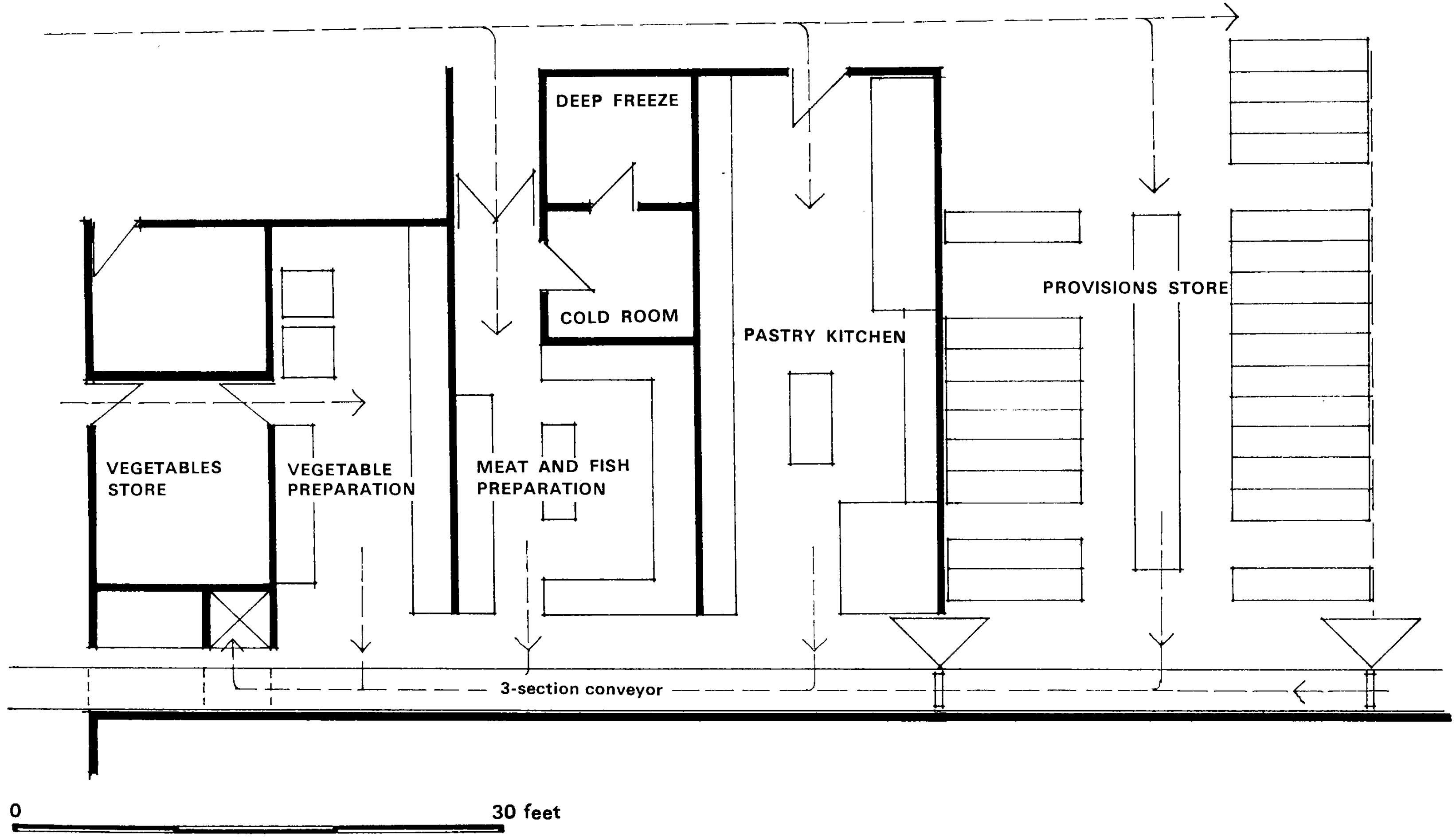
The detailed division of duties between the food preparation kitchen and the floor kitchens is clearly a matter for adjustment in the light of experience. Space and equipment have been provided on the assumption that the food preparation kitchen will prepare to the 'oven ready' stage all meat, fish and vegetables – see diagram **5.4**. Its pastry section will prepare all pastry items, and is also equipped with pastry ovens so that this comparatively specialised function can be centralised in one point if it proves to be convenient. During most of the week, no doubt, issues of prepared food will be made shortly before the time required by the floor kitchens for cooking. It may be possible to achieve staff economies during evenings and at weekends, however, by early preparation and dispatch to the floor kitchens.

Floor Kitchens

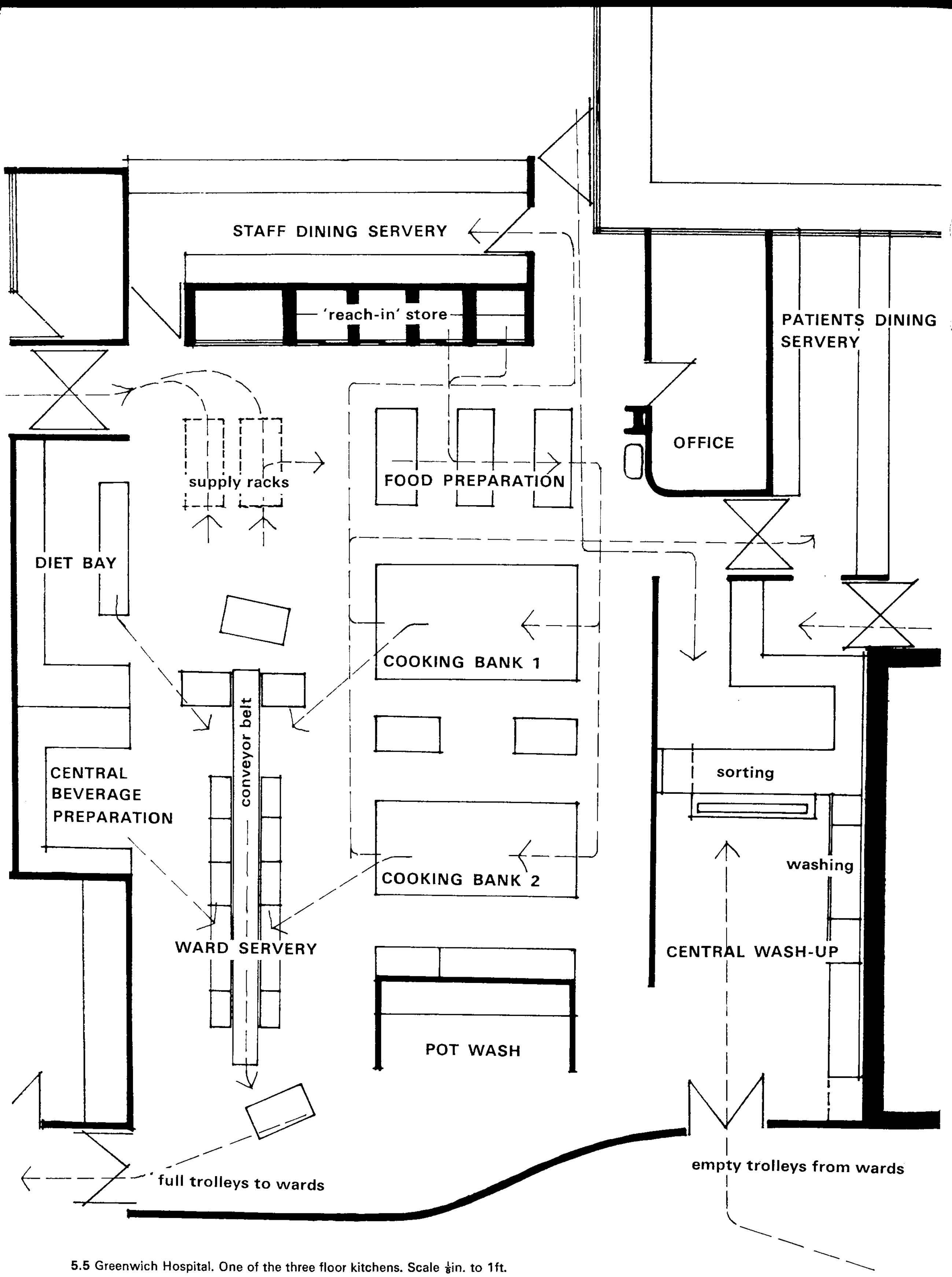
The choice of cooking equipment in the floor kitchens has been based on the assumption that most cooking will be undertaken in small batches, on the one hand to meet the needs of the meal-plating unit for patients over the 40-minute period of operation, and on the other hand to meet the needs over a longer period of the self-service counter in the staff dining room – see diagram **5.5**. The principle of 'each floor a hospital', which was part of the original design concept, when expressed terms of a kitchen for each floor resulted in the provision of a dining-room, one for each floor, intended primarily although not exclusively for use by the staff working on that floor. One further area which is related to each of the kitchens on the upper two floors is a patients' dining room, which is intended for use by all patients on the floor who are fit



5.3 Greenwich Hospital. The use of the conveyor/paternoster system for the delivery of food to the floor kitchens.



5.4 Greenwich Hospital. The food preparation kitchen.



5.5 Greenwich Hospital. One of the three floor kitchens. Scale ⅛in. to 1ft.

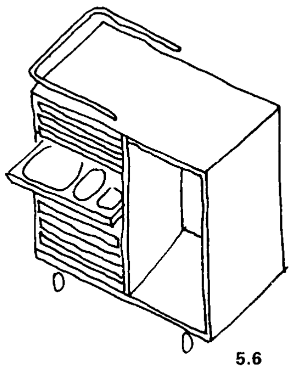
enough to leave the ward for their meals.

Meal Service to Patients

It is a truism to say that even the best cooked food will cease to be appetising if there are deficiencies in the method of service to the consumer. The existence of patients' dining rooms will bring some patients to a central point close to the floor kitchen. It is not anticipated, however, that more than a small minority of patients will be able to take advantage of this facility. The great majority of patients will receive their meals within the ward, necessitating the transport of food from the kitchen and distribution at ward level. The method of transporting cooked food from the kitchen to the ward and the method of food distribution on the ward have often been highlighted as potential points of weakness in a hospital's meal supply system. In many hospital situations the physical problems of maintaining the temperature of the food and of presenting the meal attractively on the plate are complicated by the split in responsibility for meal service between the catering staff and the ward staff. In recent years a few attempts have been made to overcome this organisational problem by introducing waitresses at ward level who can be supervised by the catering officer. Another approach, which may be more economical in the use of staff, has been to centralise, and to some extent mechanise, the meal-plating procedure, in this way simplifying the role of the ward staff in the distribution of meals. As has already been implied it was this latter approach which was adopted for Greenwich.

Centralised Meal Plating

Several methods of supplying a central meal-plating service have been developed in recent years. The simplest method, which involves no mechanisation, uses a tray trolley essentially as a drawer unit, each tray being pulled out in turn for each item on the menu – see diagram **5.6**. This method is only practicable, however,



5.6

where the number of beds being served is small (perhaps 30 beds or less). Where the kitchen is near to or part of the ward it serves it may be possible to distribute sufficiently quickly to avoid the need for any system of heat retention. All the other methods of central meal plating, however, make use of a conveyor belt, which takes the patient's tray and menu past as many as ten stations, each one of which is responsible for a particular item on the menu. All the other methods are also concerned with the problem of heat retention, for which there are at present four main solutions available.

Thermal Vacuum Containers. These containers use a vacuum and additional insulation to retain the meal temperature, on the same principle as the thermos flask – see diagram **5.7**. A cover is securely clamped over the

5.7

plate containing the main course, which is effective in maintaining the temperature for over one hour if necessary (although food held for so long in this vacuum begins to lose its quality as it steams). It has not so far been found to be economic to use this method for retaining the temperature of either the soup or the sweet course.

Heated Pellets. A flat metal pellet of, say, 3in diameter is heated to a very high temperature, and placed in a container below the plate holding the main course – see diagram **5.8**. A cover is placed

5.8

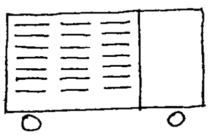
over the meal during transit. Again this method is not used for the soup or the sweet courses, which are instead usually placed in insulated bowls.

Heat Retaining Plates. The plate for the main course has a thickened base which is first heated to a temperature of about 230°F, and which will then maintain the temperature of the main course for approximately 20 minutes – see diagram **5.9**. One version of this method

5.9

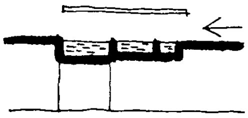
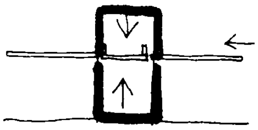
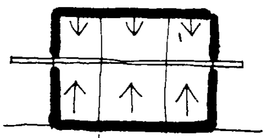
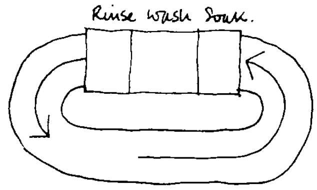
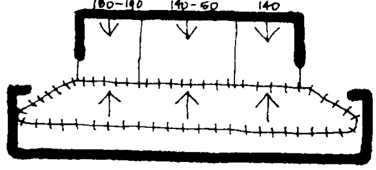
also makes use of an insulated and segmented tray which when covered by a lid helps to maintain the temperature of the soup and sweet courses as well as of the main course.

Heated and Refrigerated Food Trolleys. Unlike the other three methods which do not require a heated food trolley, this method involves the use of a two-part trolley, one half of which is heated and the other half refrigerated – see diagram **5.10**. The hot food when



5.10

plated is placed in the heated section of the trolley. The tray itself along with condiments, cutlery and any

	method.	hospital meals through put	operators	capital cost £	hot water per hour	area occupied.
1.	 sterilizing sink 180–190°F; wash sink	40/hr.	1			
2.	 sterilizing sink 180–190°F; wash sinks	60/hr.	1		30 ↓ 60 gls./hr.	
3.	 Soak wash rinse	100 ↓ 300/hr	1.	400 ↓ 500	100–115	approx. 2'0"x2'0"
4.	 180–190 Rinse; 140/50 wash; 110/20 soak	600 ↓ 1000/hr.	2.	800 ↓ 1500	120–130	approx. 5'0"x 2'6" ↓ 8'0"x 2'6"–3'0"
5.	Rinse wash Soak. 	600 ↓ 1000/hr.	2.	200 ↓ 3000	120–130	approx. 10'0"x 4'6" ↓ 15'0"x 4'6"
6.	Rinse 180–190; wash 140–50; Soak. 140 	600/hr. ↓ upwards	3 ↓ upwards	3000 ↓ upwards	130 ↓ upwards	approx 14'0"x 4'6"

5.11 Examples of some of the types of dishwashing machines which are currently available.

cold food is placed in the refrigerated section. The hot food is then added to the tray at the moment when it is issued to the patient.

The choice of system for any one situation can only be made after an assessment of comparative capital and running costs, the amount of space required by the plating units and related trolleys, the cost and availability of replacements, and the relative complexity of the procedures required to operate the system.

Central Dishwashing Service

The centralisation of dishwashing facilities has for some time been generally accepted as desirable because of the opportunities it offers for mechanising the dish-washing process and for reaching a higher standard of performance, whilst at the same time achieving economies in the use of staff. The main restriction on the degree of centralisation is the length and nature of the journey between the ward and the central dish-washing unit, which if unduly extended and including vertical as well as horizontal movement, may incur transporting costs which begin to offset the economies achieved. As can be seen in diagram **5.11** the capacity of some of the new dishwashing machines now available is equal to the demands of even the largest hospitals, and it should be further noticed that in general terms the larger the machine the fewer proportionately are the number of staff needed to operate it.

A central meal-plating unit, which necessitates the transfer of crockery to the kitchen, only serves to emphasise the advantages of a central dishwashing unit, since in this situation the only additional movement involved is of crockery and cutlery items which do not form part of the meal-plating service. Yet the savings gained in the reduced dishwashing facilities required at ward level, as well as in terms of staff time, would seem amply to justify this small increase in traffic.

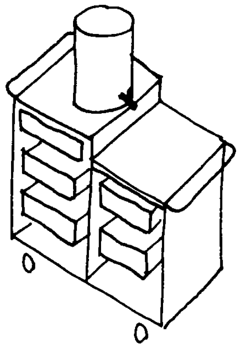
This relationship between the central meal-plating unit and the dishwashing unit probably does not demand, however, that the two should invariably be sited adjacent to each other and handle the same load. In view of the increased and still increasing capacity of recent dishwashing unit designs it is possible that the advantages of scale may now be greater than the inconvenience of the additional journey incurred in moving crockery from the central dishwashing unit to more than one meal-plating unit. The nature of the journeys, between the units and between both and the wards, is still significant in this calculation, however, especially when they involve vertical movement.

Diagram **5.11** gives an indication of some of the alternative methods by which dishwashing machines in current use operate. It is a field in which a substantial amount of design development work is in progress, both in devising new methods and in increasing the capacity and efficiency of existing methods.

Beverage Service to Patients

It had been decided as a matter of policy for the Greenwich hospital that mid-morning and mid-afternoon beverages for staff would be supplied from a central beverage making unit on each floor rather than by a multiplicity of informal arrangements. Staff would either go to the dining room, or be served from a trolley which operated from the beverage point. Since equipment was to be installed for this purpose it seemed sensible to increase its use by planning a central beverage service to patients, along the lines of the central meal service. The advantages of centralisation seem to be evident particularly in the case of milk drinks, which if prepared on the ward require the issue of considerable quantities of milk, the collection of empty bottles, and involve a potentially messy process in their preparation. At Greenwich a central wash-up service would in any event be available on each floor, and if the preparation of beverages were also centralised economies could be achieved in space and equipment provision at ward level.

It was therefore decided that a beverage point should be provided on each ward sufficient only to enable the ward staff to meet the *ad hoc* requests received at odd times during the day or night. For all regular beverage rounds the appropriate quantity of crockery, raw materials and where necessary hot milk, will be issued at the time from the floor kitchen – see diagram **5.12**. Only hot water will be added at the ward,



5.12 Greenwich Hospital. The beverage distribution trolley.

and even this will be unnecessary for afternoon tea, when a tray with an individual teapot for each patient will be prepared on the meal-plating unit in the floor kitchen.

Staffing Implications

The system of meal supply for the Greenwich hospital should in its operation show a marked reduction in the quantity of food waste, if only because it is possible to serve to both patients and staff the menu item and quantity which they choose. In a hospital catering organisation, however, labour costs are more than three times as high as food costs, so that the staffing implications of any system should receive at least as much attention.

During the course of the Greenwich study an exercise was undertaken in an attempt to measure the amount of time saved at ward level by floor centralisation, leaving at the ward little more than the distribution and collection of prepared trays. The exercise was based very largely on predictions, but on a 30-bed ward it was estimated that a total of eight hours a day would be saved on the three main meals of breakfast, lunch and supper.

The extent to which such a saving balances the additional staff time required on a central meal-plating unit and dishwashing unit will be determined, on the one hand, by the respective capacities of the two units, and on the other hand by the length and nature of the journey between the units and each ward. The decision at Greenwich to provide three floor kitchens supplied by a food preparation kitchen has minimised the length of the journeys involved, and the centralising in one place of the food preparation process should result in staff economies in this area. The eight hours a day, notionally saved from each of the ten to twelve wards on each floor, go some way towards balancing the additional staff required for the meal-plating and dishwashing units, although clearly in these aspects at least of the meal supply system further staff economies would have been possible if there had been fewer units to be manned.

Perhaps the most critical consequence, however, of three floor kitchens is the need they create for an additional number of supervisory and skilled cooking staff, since it is in the cooking process that an individual's productivity can most strikingly be increased by centralisation, and it is these posts which hospital authorities have particular difficulty in filling. It is for these reasons among others that the concept of food preparation and cooking being organised on an area basis, with the use of quick freezing processes, deserves further study.

16 *Food in Hospitals. A Study of Feeding Arrangements and the Nutritional Value of Meals in Hospitals.* B S Platt CMG MSc PhD MB ChB, T P Eddy CBE MA DPH, P L Pellett BSc PhD ARIC. Published for the Nuffield Provincial Hospitals Trust by Oxford University Press 1963.

17 *Manual of Nutrition* (p54). Ministry of Agriculture, Fisheries and Food. HMSO 6th Edition 1961.

18 *Food in Hospitals* pp106–108.

6 Storage

based on papers given by Ceri Davies and H J Chappell

Within a consumer organisation such as a hospital storage should be seen as an integral part of the supply system, a temporary halt in what is essentially a moving system. The efficiency of a main hospital store is usually, and rightly, expressed in terms of its ability to provide the consumer with the right goods in the right form at the right time. Its efficiency can also be expressed, however, in terms of the cost of storage.

Cost of Storing

Interest in the cost aspect of storage has grown in recent years within the commercial field, and a recent estimate[19] has put the cost of holding stock at between £20 and £30 per annum for every £100 of stock held. The factors which affect storage costs are briefly:

- Loss of interest on capital tied up in stock
- Cost of storage equipment and space
- Cost of lighting and heating storerooms
- Wages of storekeeping staff in looking after and issuing stock
- Cost of recording and accounting for issues
- Cost of audit and checking stock
- Cost arising from obsolescence and deterioration of stock

It has been suggested[20] that a 20 per cent reduction in the volume of stock holdings should be possible in most cases by using a rationally based stock control system rather than relying on sensible but informal methods. The value of stocks held by National Health Service authorities on 31 March 1965 was £16½ millions. A 20 per cent reduction would reduce the annual interest paid on the capital tied up by some £200,000 at a bank interest rate of around 7 per cent, whilst in addition there would be a reduction in storage space required and a probable reduction in the number of storemen employed.

The cost of storage should not be allowed to override the main purpose of a store, which is to provide a reliable service to its customers for items which cannot appropriately be obtained direct from the supplier; but it does justify a critical examination of the range and quantity of items to be held in stock. The design question thus ceases to be: what is the maximum amount of space which can be found? – and becomes instead: what is the optimum amount of space which is required? A study of methods and equipment for both storage and handling is also relevant in answering this question.

Design Decisions

The design problem for storage areas can broadly be broken down into four stages, each of which reduces the limits within which subsequent decisions can be taken. The decision stages can be itemised as follows:

The range of items and economic stock levels (including maximum and minimum quantities)

The movement/handling system appropriate for the amount and type of item and for the type of labour available to run the system

The location of the store within the total physical context of the building as a whole (that is, its relationships to other departments and to entrance and exit points)

The overall shape of the store to satisfy the need for:

- a variety of storage compartments (for example, adjustable racking, drawers, bins, floor standing space)
- the arrangement of items in relation to both receipt and issue points in accordance with their speed of turnover
- the grouping of items for issuing purposes
- accommodation of items with special characteristics (whether for instance they be smelly, perishable, or hazardous; or need to be stored in dust-free, sterile or refrigerated areas)
- adequate supervision of the store and adequate security at times when it is open as well as when it is closed
- ease of circulation
- office and cloakroom facilities

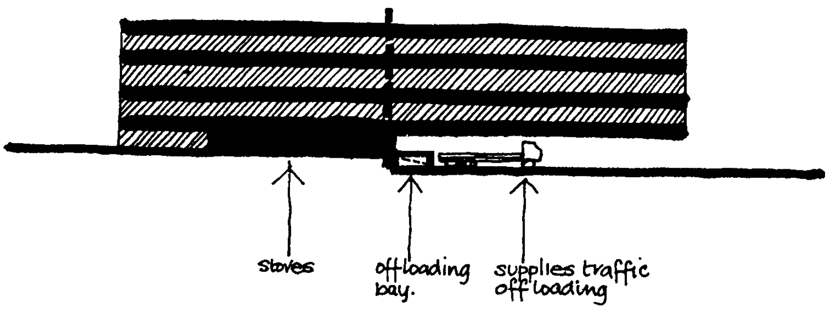
Planning procedures for the hospital as a whole may not permit the study of storage problems to be carried out in this sequence. The Greenwich design concept determined that the main storage area should be in the lower ground floor, centrally sited but with direct outside access – see diagram **6.1**. This decision was taken a long time before the optimum quantity of goods to be stored was known, although options on the size of the store were retained. The design concept also had a controlling influence, at least in a negative way, in the choice of handling equipment, and the standard ceiling height of 9ft determined the maximum possible height of storage compartments.

The main part of what follows in this chapter describes a survey of stock items and usage rates which was carried out in order to establish a storage space requirement appropriate for the new building, and which made recommendations both on the range of storage compartments to be used and on a possible method of stock level and re-ordering control. This section is preceded by a consideration of a few of the handling and circulation problems relating to storage space design.

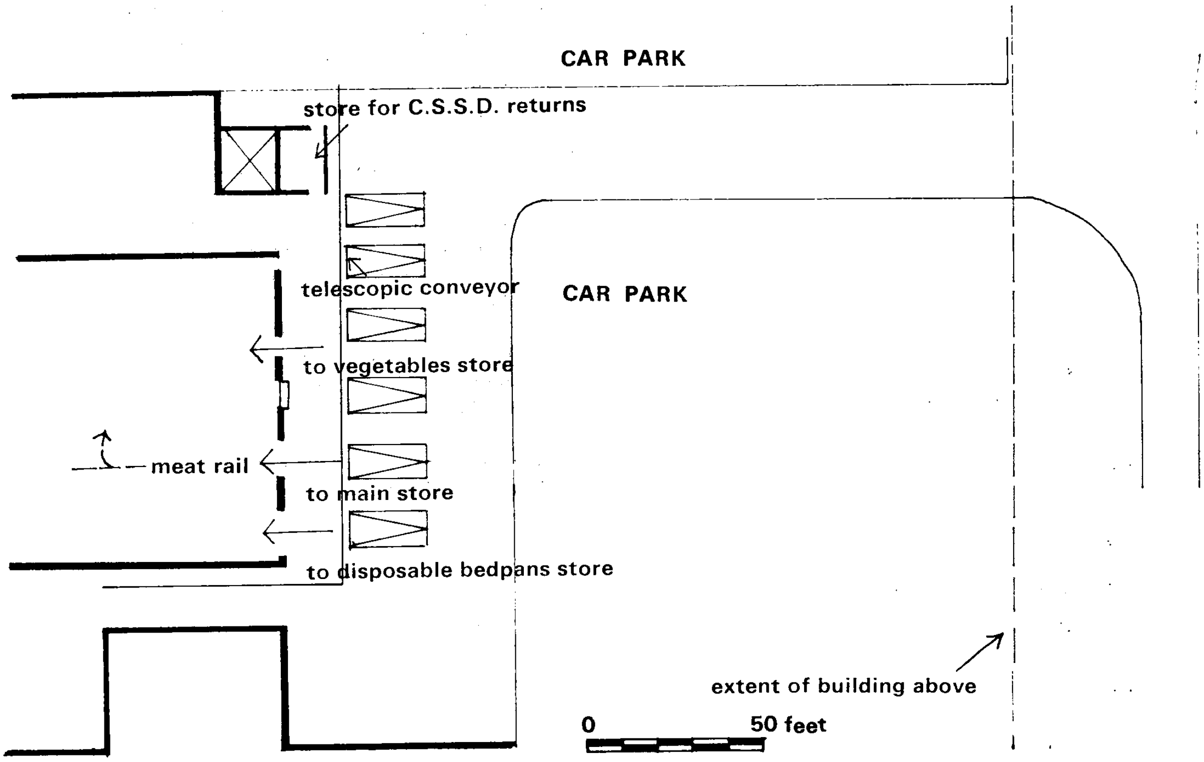
Handling and Circulation

Off-loading

Vehicles. Little information was available to the Greenwich designers on the most appropriate size of off-loading platforms to meet the collected needs not only of the main store but also of refuse collection, the delivery and collection of linen and sterile supply items, and of the pharmacy store. A survey was therefore carried out at the existing hospital over an eight-day period, recording the visits of all vehicles to the main store and the pharmacy store, noting the capacity of each vehicle and the commodities carried. The information collected was compared with that from a similar exercise carried out at the North Middlesex Hospital (834 beds), which had shown that 80 per cent of all goods deliveries were made before 1 pm, and that a maximum bunching of four to five vehicles might be expected on any day. At Greenwich a wider spread of arrival times was observed but nevertheless a peak was discernible around midday. The average daily bunching peaks as observed were of between three and four



6.1 Greenwich Hospital. The position of the main store.



6.2 Greenwich Hospital. The off-loading bay.

Type of vehicle	Length	Width	Height	Turning circle
15/17cwt van	13ft 10in	5ft 10in	6ft 3in	34ft
Van on 3 ton chassis, 670cu ft	20ft 8in	7ft 3in	10ft 3in	44ft
Box van on 7/8 ton chassis, 870cu ft	24ft 9in	7ft 3in	10ft 7in	55ft
Van on 3/4 ton chassis, 1200cu ft	23ft 7in	7ft 2in	11ft 10in	55ft 6in
Van on 7 ton chassis, 1600cu ft	22ft	7ft 6in	12ft 6in	58ft 6in
Articulated van, 1500cu ft	33ft	7ft 6in	13ft	75ft

6.3 Range of commercial vehicles observed delivering goods to the St Alfege's Wing of the Greenwich Hospital.

vehicles. It was recognised that the pattern and quantity of visits would change in the new hospital because of new operational policies, especially those which would lead to the increasing use of disposable items. The outcome of this exercise was a decision to provide six off-loading points, which it is considered should meet all eventualities – see diagram **6.2**.

The table in diagram **6.3** gives the sizes of commercial and other vehicles which were observed entering the hospital site during the course of the survey. The fact that many vehicles were found to be higher than 9ft – the ceiling height in the lower ground floor – led to the lowering of the access road by 3ft, giving a headroom of 12ft and the selected off-loading platform height of 3ft.

Handling. There are several options available for the off-loading of goods from vehicles in the off-loading bay. Some of the options are as follows.

The height of the off-loading platform is the same as the height of the tailboard, within a tolerance of, say, 16in, enabling goods to be transferred manually direct from the rear of the vehicles to the off-loading platform – see diagram **6.4**.

A telescopic conveyor is extended into the rear of the vehicle, enabling the transfer of goods to be carried out mechanically – see diagram **6.5**.

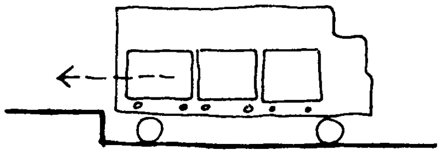
The use of vehicles with trailers which can be parked at the off-loading bay removes one pressure for the immediate and speedy off-loading of its goods – see diagram **6.6**. (There may of course be other factors, such as the number of vehicles in the bay or the work schedules of the storemen, which cancel this out.)

Racks or trolleys may be off-loaded either by a mechanically operated tailboard lift or by a forklift truck in situations where the tailboard height and the off-loading platform height do not coincide – see diagram **6.7**.

An overhead chain conveyor is a possibility where goods are packed in an appropriate form. Overhead conveyors are usually not adjustable in direction, so that a vehicle would have to back on to the conveyor's projection – see diagram **6.8**.

Where the manual off-loading of goods is adopted, the use of pallets on the off-loading platform may avoid an element of double handling – see diagram **6.9**.

It was felt that at Greenwich, as probably in most hospital situations, no single solution would be universally suitable for every category of delivery. The height of the off-loading platform (3ft) is intended to be suitable for a substantial number of vehicles, but at the same time a telescopic conveyor has been provided in order to handle the large loads of linen and sterile supply items from the industrial zone. An overhead conveyor is there to transfer meat carcasses from vehicles direct



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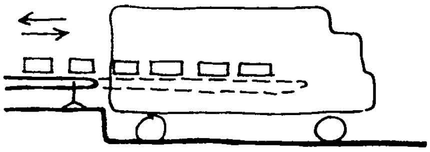

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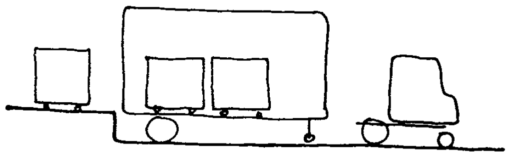

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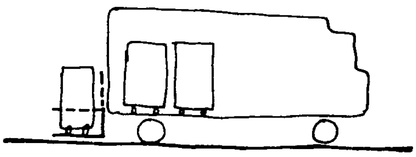

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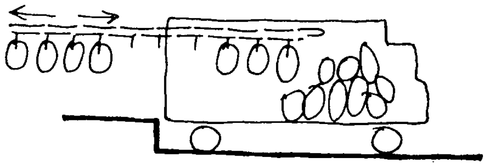

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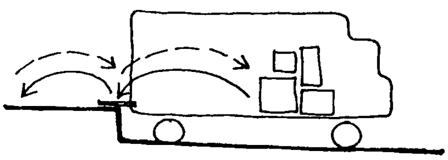


6.9

to the food preparation kitchen, and an overhead chain conveyor will move bagged dirty linen from the main disposal room to the off-loading platform.

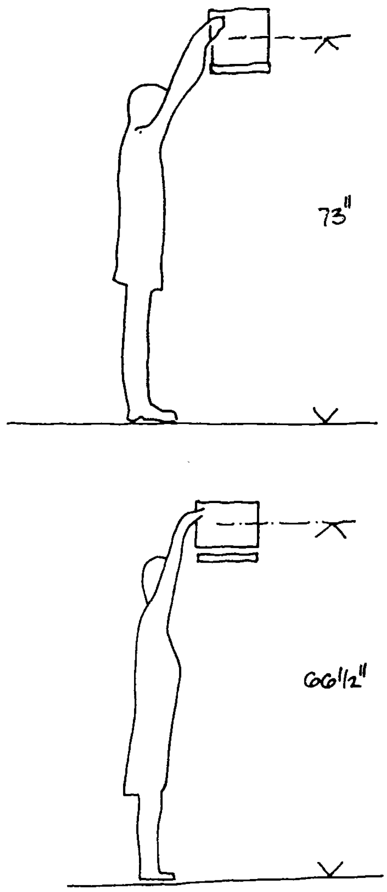
Movement within the Storage Area

The problem of movement both by goods and by people within a store is rather more complex than it might at first appear. Almost every storage compartment must be accessible for the receipt of goods, perhaps in bulk, as well as for the issue of goods, which will usually be in smaller quantities. The main receipt and issuing points should be so sited in relation to each other and to the storage compartments that traffic cross flows are avoided as far as possible. Yet at the same time compactness of planning is desirable in order to reduce walking and carrying distances.

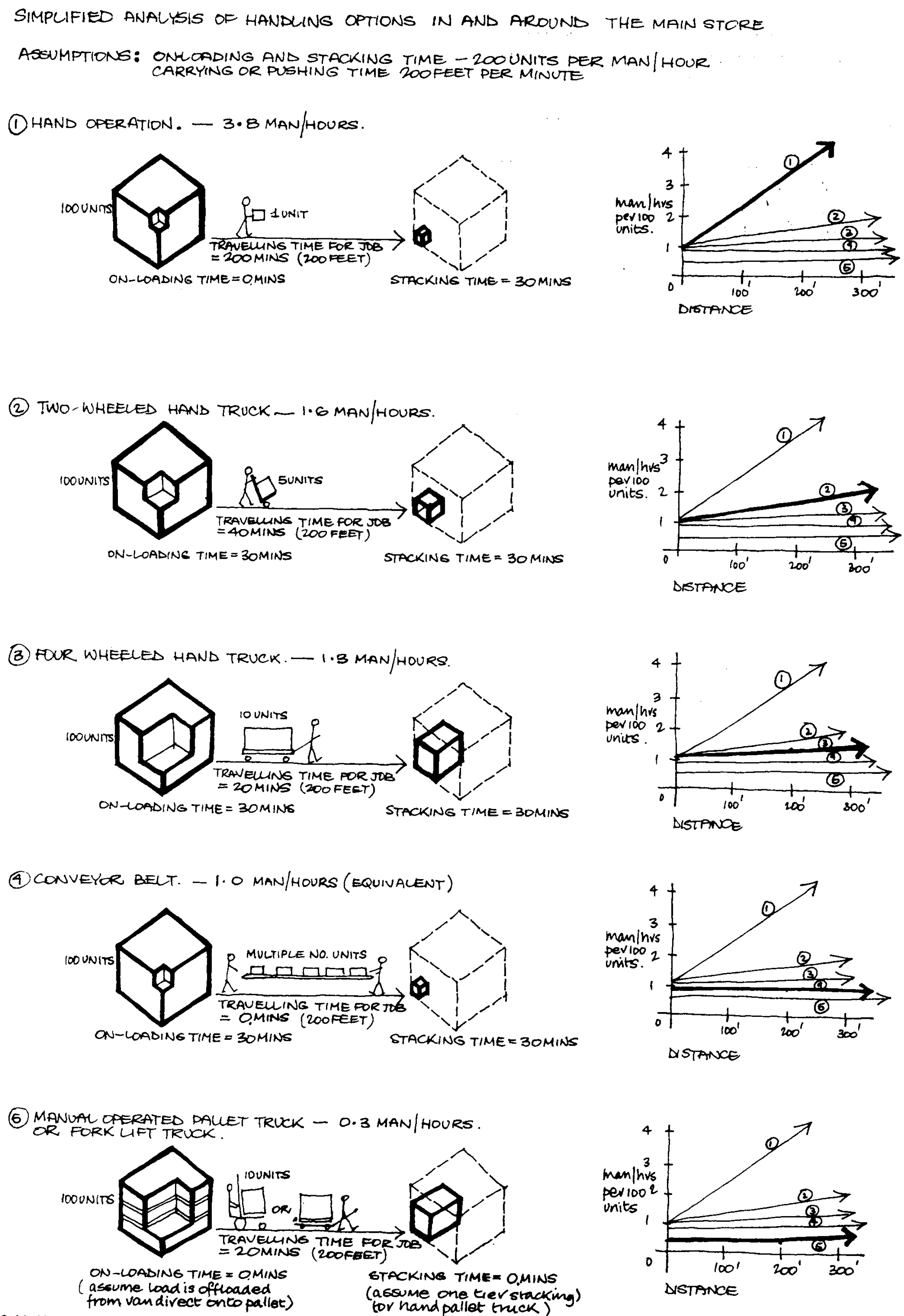
Decisions on storage compartments may be influenced by the extent to which it is intended that within a store the goods rather than the storemen should be mobile. The use of moving platforms, floor conveyors or the more sophisticated types of mobile racking will in varying degrees reduce the amount of walking demanded of the storemen. Where pallets are used (and they are especially suitable for bulky items) the storemen are involved in the movement of goods but by means of a forklift truck or mobile lifting jack. A simple exercise was undertaken during the Greenwich studies in order to compare the more conventional methods of goods movement in terms of the amount of labour required – see diagram **6.11**. Within the limits of the exercise the results demonstrated the labour-saving merits of storage on pallets combined with movement by means of a forklift truck or mobile lifting jack.

Gangways. Storage implies accessibility, whilst movement implies gangways. Various on-the-spot measurements were taken in an existing hospital store in an attempt to define acceptable limits of accessibility.[21] The height limit at which a person can remove an item from a shelf clearly varies considerably between individuals and between men and women, but for a shelf unit containing either six 12in high shelves or four 18in high shelves most people would need to use a step in order to reach at least the top shelf – see diagram **6.10**. Furthermore, to enable a person to lift an object clear of the shelf unit it appeared to be necessary that the width of the gangway in front of the shelf should be at least 2ft 4in – see diagram **6.12**. If a stock-picking trolley was being used in close association with the shelf unit it could usually be manoeuvred within this gangway width but of course would block the path of the storeman. A 2ft 4in gangway however would not allow most sizes of pallet to be brought close to the shelf unit.

The 2ft 4in gangway is being used in the Greenwich store between fixed shelf units since its potential disadvantages are very largely removed by the fact that the shelf units are never more than 9ft in length. Thus even where the units are accessible only from one



6.10 Shelf heights in relation to the reach of a man and a woman of average heights.



6.11 Alternative methods of handling deliveries to the main store.

6.12 A person stock picking in a 2ft 4in wide corridor.

end no item is more than a few strides away from a main gangway where the pallet or stock-picking trolley can temporarily be parked.

Movement within the store relies primarily on the main gangways, which are intended to provide direct access a) between the point of delivery and each storage unit, and b) between each storage unit and the point of issue. By permitting trolley and pallet access to within a few feet of any point in the store the main gangways should minimise the number of journeys which need to be taken by the storeman during the course of his duties – see diagram **6.13**.

Survey of Items to be Stored

The twin objectives for a main store of economy and reliability have already been referred to. At the beginning of a stock-surveying exercise reliability has itself to be defined. It is necessary to decide for each item whether it must be readily available because of its essential nature, and what the significance of any delay is in supply.

Alternative Methods

There are three possible methods of undertaking a stores survey.

i In a redevelopment situation existing stocks can be critically examined, the amount of space required then being adjusted by the increase in the number of beds and services being provided in the new building. A notional amount of extra space would also need to be provided for the storage of new items resulting from changes in techniques and operational policies.

ii An assessment can be made of the stock holdings in a number of new hospitals, applying operational research formulae to their known demands and known supply arrangements.

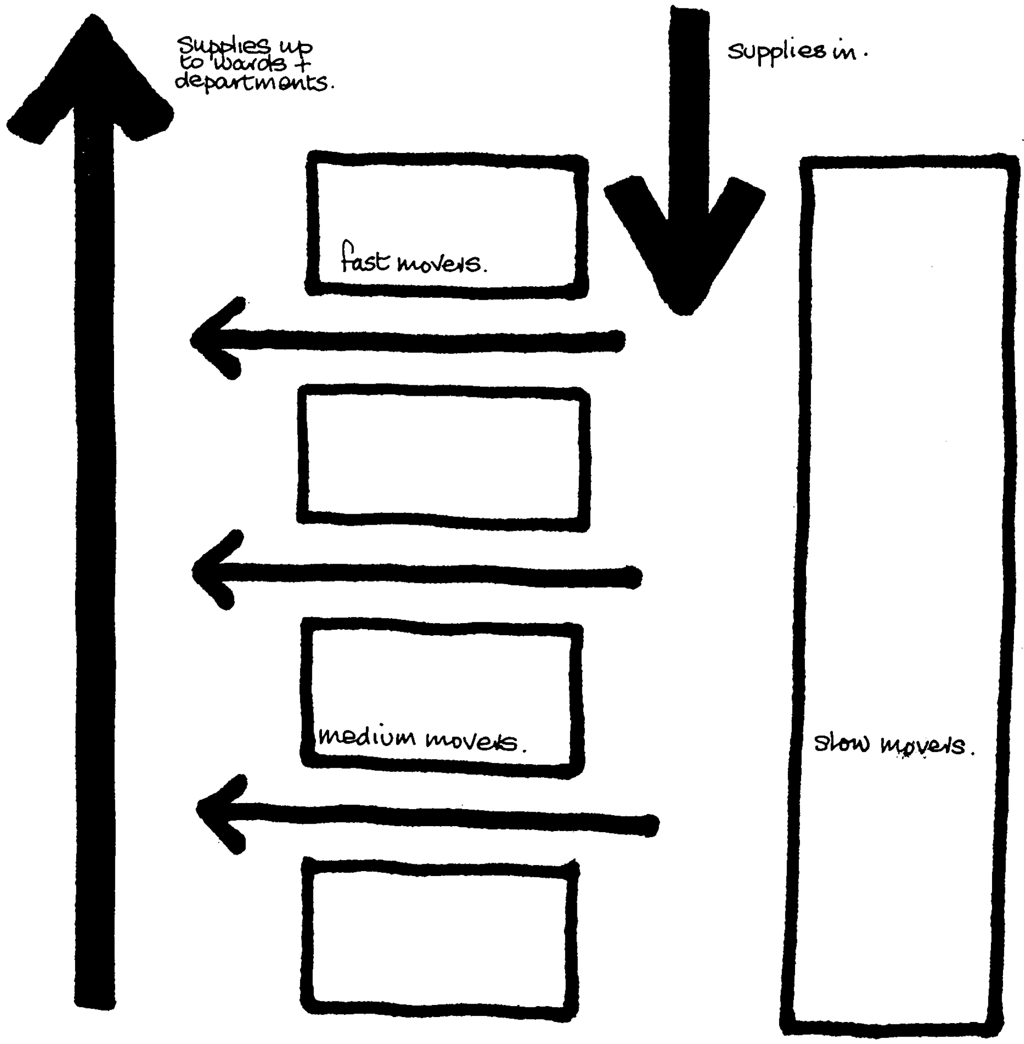
iii Attempts can be made to forecast consumption of the various items based on the proposed operational policies. This will involve the use of operational research techniques to determine re-order levels and quantities. From this information the amount of space required can then be calculated.

Method i will probably achieve the quickest results, but it suffers from the two disadvantages, a) that it takes account only superficially of the changes in the operational policies of the hospital, and b) that it assumes the continued use of existing methods of stock control. Method **ii** is far more attractive because it gets away from a survey of existing hospital stocks which may bear little relation to the range and quantity of demand in a new hospital, whilst also giving some idea of the items to be found in a hospital of recent design. The limitations of this method when used for a complete survey of items are the amount of work involved and the danger of drawing comparisons between situations which are not, in fact, identical.

The value of results achieved by method **iii** may be affected by the absence of proposed operational policies, and even where these exist the detailed consequences in terms of stock requirements may still be no more definite than a 'best estimate'. Detailed information on the consumption levels and supply of items which are not in use in the existing hospital may also be difficult to obtain. Nevertheless this method was finally adopted for the survey at Greenwich because, on the one hand, an existing hospital store was available for study and, on the other hand, several operational policies for the new hospital had already been determined. There were of course many gaps, but by the end of the survey it was felt that the nursing, cleaning and catering functions, for which operational policy statements were available, were of particular significance in producing the forecast of demand.

Range of Items. The work of forecasting the range and scale of the items to be used in the new hospital took several months to complete – see Appendix C. An indication of consumption rates for the various items which were in current use was obtained by extracting from the store records the consumption rates for the previous three or four years. This was relatively easily done for items subject to stock records, but was much more difficult for items which were not. In the case of printed forms and stationery it was necessary to analyse all orders placed over a period of three years and to record the range and quantity of current stock.

Once information had been collected on the level of existing consumption adjustments were then made to meet the new situation by discussions with the heads



6.13 Greenwich Hospital. The main gangways in the store.

of departments concerned, using working drawings where relevant and studying operational policy statements wherever available. For example, the amount of cleaning powder required to clean the carpet in the hospital was calculated as follows:

Carpets cover 12,250sq ft in phase 1
Carpets cover nil sq ft in subsequent phases
12,250sq ft *whole hospital*

Carpets will be cleaned twice a year with a cleaning powder used at the rate of one $2\frac{1}{2}$lb packet for 125sq ft

$$\frac{12{,}250}{125} \times 2 = 196$$ packets of cleaning powder used in a year

During the course of this exercise care was taken to keep the number of stock items to a minimum by standardising items wherever possible. Substantial variety reductions in the existing stocks were in fact recommended in the slow moving groups of items – stationery, printed forms, and hardware and crockery – when during the course of the exercise the overlapping performance of different items became apparent.

For each item to be held in store, the following information was sought:

Demand for the item

Lead time, that is, the period between placing an order and obtaining delivery

Acceptable risk of the item being out of stock

Holding cost

Cost of placing an order

Unit cost of the item

It was possible to apply operational research formulae in order to determine the two basic elements of any stock control method: a) *the re-order level,* that is, the quantity of existing stock which prompts the placing of a new order, and b) *the re-order quantity,* that is, the amount to be ordered. The re-order level may be somewhat higher than the minimum level to which it is considered safe to allow the stock level to fall at any one time, since the re-order level must take into account any issues in the period between the placing of the order and the receipt of the goods.

Method of Calculation. In 1962 the Operational Research Unit of the Oxford Regional Hospital Board published the booklet *Optimum Purchasing Policy,*[22] putting forward two formulae for the calculation of the re-order level and the re-order quantity for each stock item. These formulae were used throughout the Greenwich study, and the authors are indebted to the Operational Research Unit at the Oxford RHB for the help given not only at the outset but throughout the course of the study.

Re-order Level. The re-order level formula considered appropriate by the Oxford Operational Research Unit for the range of items to be found in a typical hospital store is:

$$LD + K\sqrt{LD}$$

L = lead time
D = demand in units
K = a constant number representing the probability level selected for stock run-out

In further explanation of K, if an item is to be immediately available on 95 per cent of occasions $K = 1{\cdot}64$; if this is increased to 99 per cent $K = 2{\cdot}33$.

It was not in fact necessary to make detailed calculations for every item since calculation tables had been prepared by the Oxford Operational Research Unit, and are published in *Optimum Purchasing Tables.*[23]

Re-order Quantity. The second formula provides a method of arriving at an economic re-order quantity, which in effect is a balance between the cost of holding goods in store and the cost of placing a new order. The formula is as follows:

$$\sqrt{\frac{24 \times \text{demand per month} \times \text{cost of placing an order}}{\text{price in shillings per unit} \times \text{holding cost}}}$$

The demand per month and the cost per item are usually readily available for most items (although this may not be so in a design study) but the cost of holding stock and the cost of placing an order are more difficult to obtain. These costs will be governed by the procedures adopted in a particular hospital. The order cost which ideally should have been used in this study was that which will apply in the new hospital when it is fully operational. It may be, for example, that by that time automatic data processing will be a possibility for some aspects of stock control and invoice payment, and if used might be significantly less expensive than the existing procedure.

Enquiries in search of ascertained ordering costs within the National Health Service were made, but with only two results – one of 5s 0d per item (now thought to be too low), and another of 3s 0d, both calculated some years ago. Ordering costs obtained from outside the National Health Service, but which related to the type of items which might be kept in a hospital store, varied from between 6s 0d and 10s 0d per item. Whilst the importance of an accurate calculation should not be underestimated it is also important, however, not to overestimate its value in this context. Provided that the cost is a reasonable approximation the accuracy of the total result, which usually needs to be adjusted for other reasons, will not be prejudiced. Pilot calculations for the Greenwich survey showed that the accuracy of the result would not be significantly affected even if the estimated ordering cost was 10 per cent inaccurate. A standard ordering cost of 8s 0d was therefore used throughout the study.

The holding cost was another issue on which it proved to be impracticable to reach an exact figure. In similar situations outside the National Health Service it was found that the annual holding cost usually amounted to between 15 per cent and 25 per cent. After taking into account some work done by the Local Government Operational Research Unit at Reading it was decided to adopt a standard holding cost of 20 per cent.

The formula for calculating the re-order quantity does not attempt to take into account all possible influencing factors, but produces a guide which needs to be assessed by the ordering officer in the light of those factors which vary in effect from item to item. It was decided in the Greenwich study, for instance, that on those items which are in very small demand but nevertheless need to be kept in stock an order limit of one year's supply should be imposed. This limit was primarily designed to reduce the possibility of loss by obsolescence and of deterioration whilst in stock. In an extreme case a period limit of only a few days might have to be imposed on perishable items, affecting especially those which are in small demand.

Discount Terms. An important factor affecting the re-order quantity may be the offer of a discount linked to the purchase of specific quantities. The problem to be solved is whether the saving obtained by buying larger quantities is greater than the cost of holding the additional stock. For this purpose a further formula was supplied to the officers on the Greenwich survey by the Oxford Operational Research Unit:

The savings will be worthwhile if

$$\frac{DA}{100} > \frac{NAH}{2400}$$

D = discount
N = extra months' stock
A = value of annual consumption
H = holding cost

The formula can also be shown as $24D > NH$

Thus the decision level will be at $N = \frac{24D}{H}$

Whilst it was not possible to negotiate with potential suppliers to establish what quantity discounts might exist in the future it seemed essential to take quantity discounts into account where these were currently known. In these instances order quantities were therefore calculated in accordance with the above formula.

Assessment of Space Requirement. The simple addition for each item of the re-order level and the re-order quantity would in theory give the maximum quantity of stock to be stored at any time. As has already been pointed out, however, the re-order level includes any issues made during the lead time. It was therefore decided for the purpose of calculating the maximum storage requirement that for all items, except those with an issue interval time greater than the lead time, the re-order level should be reduced by one third.

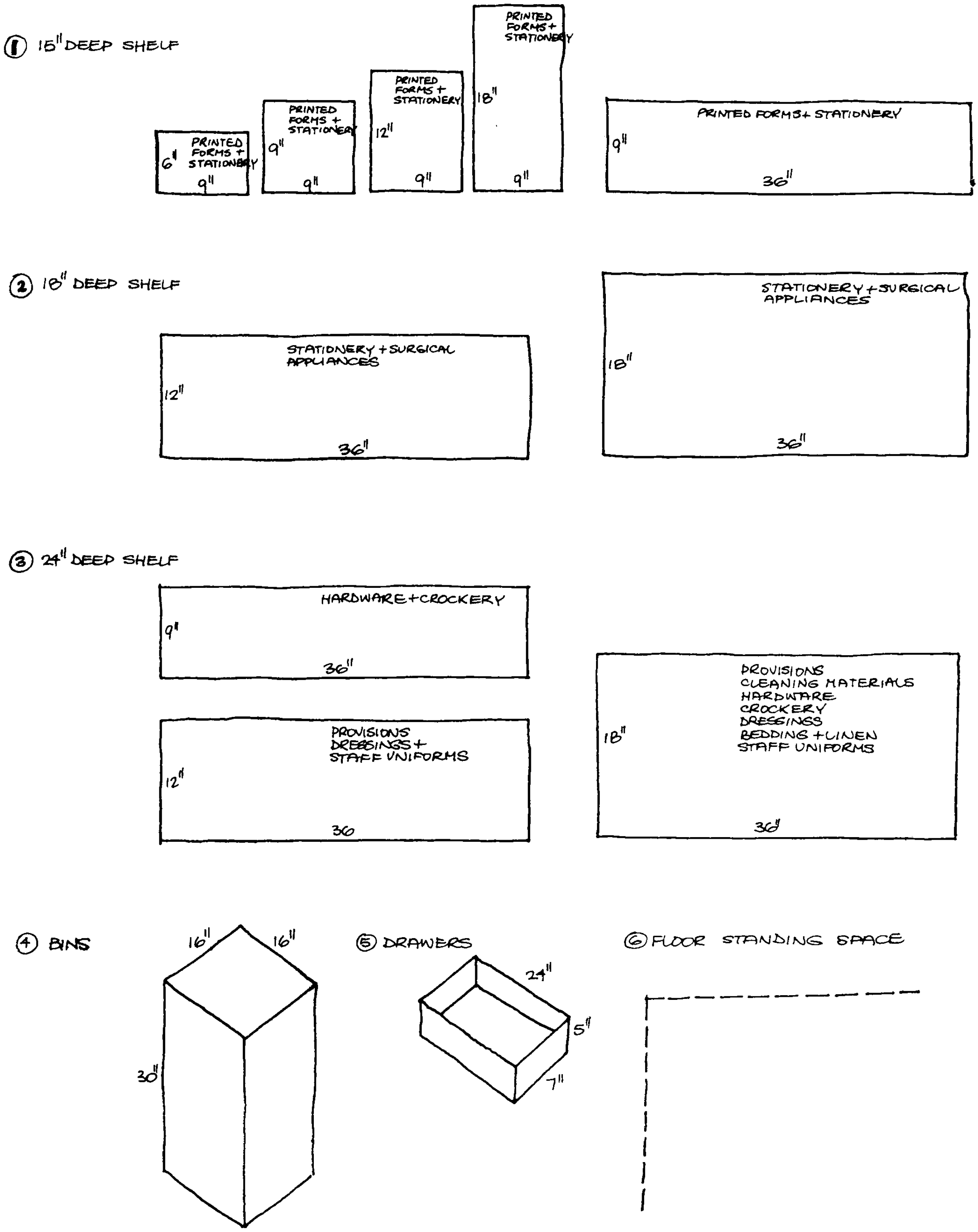
The calculations outlined above were necessary prerequisites to an assessment of the total storage space requirement. Once the maximum storage quantity for each item is known numerically, however, it still has to be translated into terms of space. This part of the exercise requires the dimensions of each item to be kept in stock, or rather of the most convenient unit in which an item or group of items can be handled for storage purposes. In the Greenwich study it was decided to do a pilot exercise in order to determine a preferred range of storage compartments so that the measurement of items could be assessed within this context. The range of compartments selected, along with the items considered suitable for these compartments, is shown in diagram **6.14**. In assessing the amount of storage space required by each item it is necessary to allow an element of free space to permit stock picking and stock checking – see Appendix C.

The final outcome of the survey therefore was not simply an expression of the total volume at its maximum of items to be stored, but of the total amount of storage space within a preferred range of storage compartments which was necessary to house the maximum volume of items in stock at any one time. Only in this way can the results of such a survey have any meaning for the designer. It is not intended, however, that the storage compartments should be inflexible in shape. Floor standing space is very obviously flexible, whilst the subdivisions of shelf units can and should be fully adjustable. The importance of determining a preferred range of storage compartments is in briefing the architect on the amount of space required and the main forms in which that space is to be provided. The operation of the store, and of the hospital which it serves, will in time demand changes in the shape and capacity of storage compartments. Every possible step should be taken during the course of design to allow for future change.

Results of the Study

As has been mentioned, the survey was conducted within the context of operational policy decisions in so far as these had been taken. Another volume would be required to describe all those policy decisions which influenced the survey, but it is necessary at this point to mention two decisions which influenced the range of items to be held in the main store.

Firstly, it was decided that the laundry at the industrial zone would hold all stocks of those items of bedding and linen, patients' clothing and staff uniforms which required laundering, and that the sterile supply unit would hold all stocks of those raw materials which it processed. Secondly, it was decided that specialist stocks which were only issued to one department



6.14 Greenwich Hospital. The preferred range of storage compartments adopted for the survey of items to be held in the store.

Financial category (as applied in NHS hospitals)	Storage compartment capacity (expressed in cubic feet)	
	shelves, bins, drawers	**floor standing space**
Bedding and linen	**135**	**1,203**
Cleaning materials	**759**	**2,102**
Crockery	**270**	
Hardware	**774**	**32**
Medical and surgical appliances	**209**	**3,796**
Patients' clothing	**51**	**606**
Printed forms	**244**	
Provisions	**3,179**	**995**
Staff uniforms	**67**	
Stationery	**647**	
Surgical dressings	**605**	**222**
Totals	**6,940**cu ft	**8,956**cu ft

6.15 Greenwich Hospital. **Summary of the required storage capacity for the new hospital, based on the survey of items to be stored.**

(laboratory glassware and chemicals, x-ray films and chemicals, occupational therapy materials) should be stored in the departments concerned. All these items are therefore excluded from the table in diagram **6.15** which summarises the estimates of storage space produced by the survey.

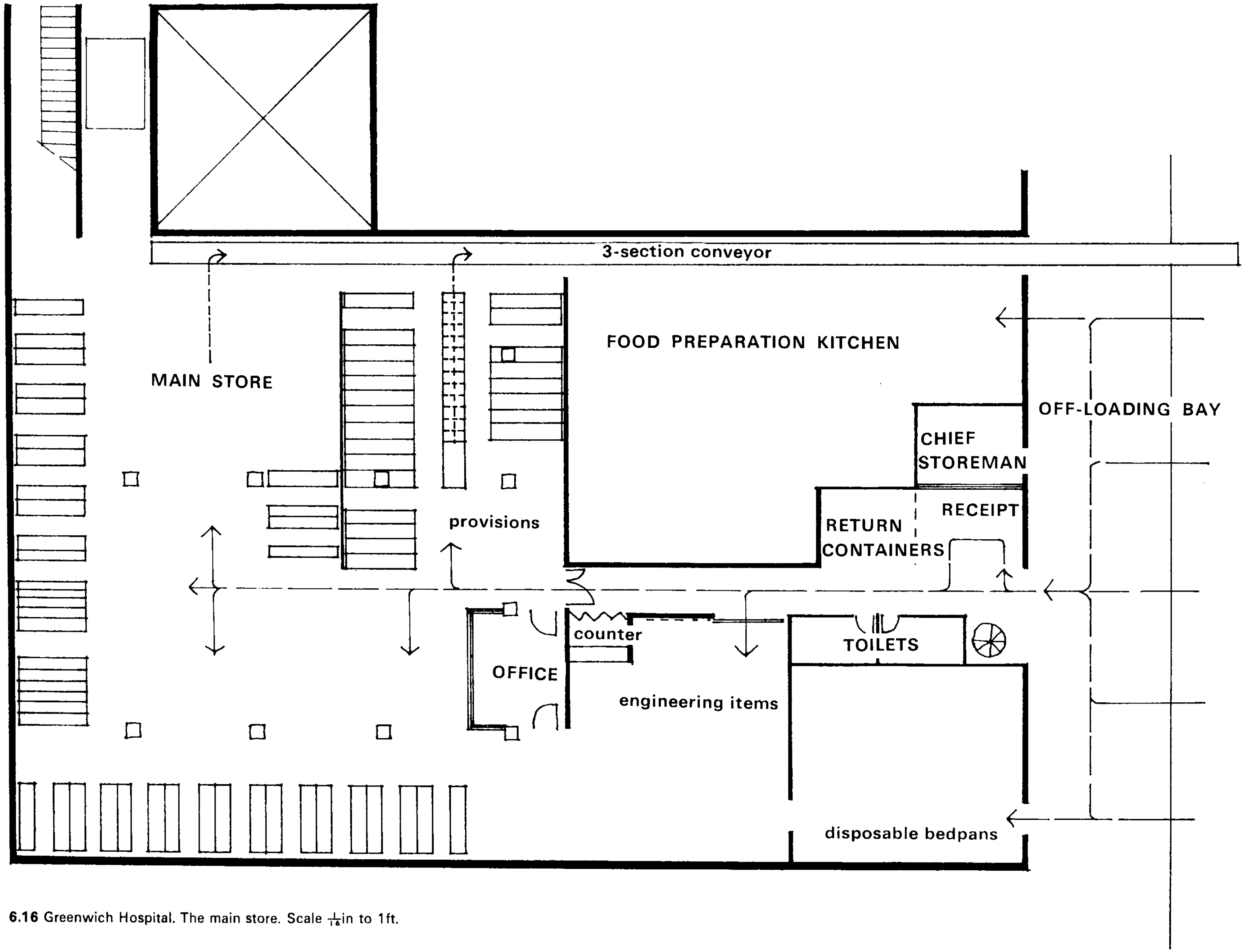
It is significant that well over half the storage space required is for floor standing items. Of these the following are among the largest space users, each requiring in excess of 200cu ft:

Bedding and Linen	
Incontinence pad (small)	216cu ft
Incontinence pad (large)	270cu ft
Paper hand-towel	432cu ft
Cleaning Materials	
Paper sack (large wet)	552cu ft
Paper sack (large dry)	672cu ft
Paper sack (large non-combustible)	432cu ft
Medical and Surgical Appliances	
Disposable urinal	1,692cu ft
Disposable bedpan (child)	288cu ft
Disposable bedpan (adult)	1,650cu ft
Patients' Clothing	
Disposable napkin	480cu ft
Total	6,684cu ft

These 10 items – less than 1 per cent of the range of items to be stocked in the main store – account for 42 per cent of the total storage space requirement. In any operational considerations on whether or not to use these or similar items, it is important to realise the demands they impose on storage space. It will be noted that all these items are in the disposable group even though they fall into several financial categories.

Arising from the survey it was proposed that the store should hold a total range of 1,082 items, but from an analysis of the individual space requirements it was found that 303 (30 per cent of the total range) accounted for 75 per cent of the total storage space requirement. Even within those financial categories which were not affected by the new range of disposable items (provisions and stationery, for example) it was found that a very small proportion of the total number of items accounted for a very large proportion of the total storage space required. Further research in time may show that it is possible to estimate the total quantity of storage space to be provided simply by identifying a small range of high space-consuming items and using a simple scale to determine the space required for all remaining items.

Another piece of evidence from the survey lends support to this view. 882 items out of the total of 1,082 require less than 12cu ft storage space – that is, a storage compartment of 3ft × 2ft × 2ft. Only 98 items require more than 24cu ft.



6.16 Greenwich Hospital. The main store. Scale $\frac{1}{16}$in to 1ft.

Diagram 6.16 indicates the size and intended layout of the Greenwich hospital main store. For calculation purposes an internal height limit of 6ft was imposed on all storage compartments (including floor standing space), so that the space requirement of 15,896cu ft was translated into a net floor area requirement of 2,649sq ft.

When the exercise of locating this amount of storage capacity within a storeroom, following the agreed principles of circulation, was completed, the gross floor area required (including offices and cloakrooms) was found to be 6,300sq ft. In other words the net storage area was only 42 per cent of the total floor area.

Also included within the same store is a space for the storage of engineering items, which did not form part of the survey, and a small area for the storage of equipment. The few partitions which are provided are demountable so that there can be flexibility in the allocation of space to meet changing demands.
The total area of the store is 7,200sq ft.

The continuing validity of such an assessment of storage space requirement depends of course on the continued acceptance of the assumptions on which the assessment was based. A change of policy, for instance, on the storage of specialist items within the user department would clearly have an effect on the total size of the main store. Rather less obviously an increase in the range of items to be stored, which inevitably will occur unless a rationalising process is carried out regularly, will also present a demand for more storage space. More critical, however, to the continuing adequacy of the storage space provided is the implementation of objectively calculated re-order levels and re-order quantities. Each will need to be recalculated for each item as and when any one factor in the formula changes, whether it be the consumption level, the lead time, the holding cost or perhaps the discount rate. Where items demand an increase in space this may already be apparent, either in a regular failure of supply, or by congestion within the store (although both symptoms may arise from other causes). Only by a regular review of all re-order levels and re-order quantities, however, will any decreases in space requirement be highlighted, which may be just as substantial as the more obvious increases in demand for space.

A survey of this kind can only give accurate information at the design stage if the methods of stock control then presumed are the same, or are at least as space consuming as the methods by which the store is in fact operated. Just as in any other area of the hospital a realistic space assessment can only be made when the way in which the activity to be performed has been determined.

19 *Storage and Control of Stock for Industry and Public Undertakings.* A Morrison. Pitman 2nd Edition 1967.

20 *How to Control Stock.* Ian McLellan and David Mace. Management Today March 1967.

21 Further information can be found in *Ergonomics for Industry No 11: Layout of Work Spaces.* Ministry of Technology. HMSO 1967.

22 *Optimum Purchasing Policy: a Supplies Officer's Guide to the Mathematics of Ordering and Maintenance of Stocks.*. Oxford Regional Hospital Board 1962.

23 *Optimum Purchasing Tables: Extended Tables for Ascertaining Re-order Quantity and Minimum Stock Level.* Oxford Regional Hospital Board 1962.

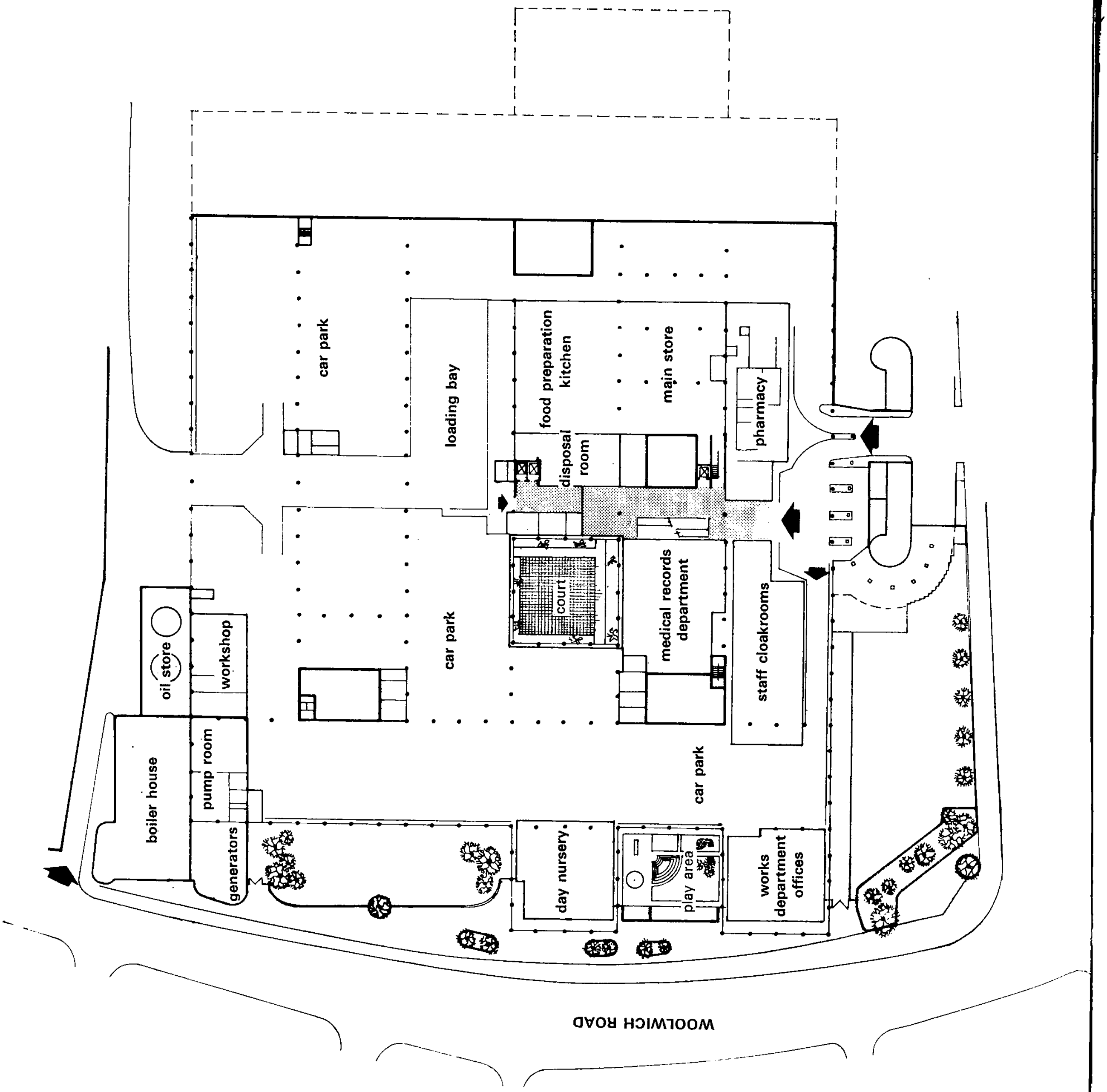
Appendices

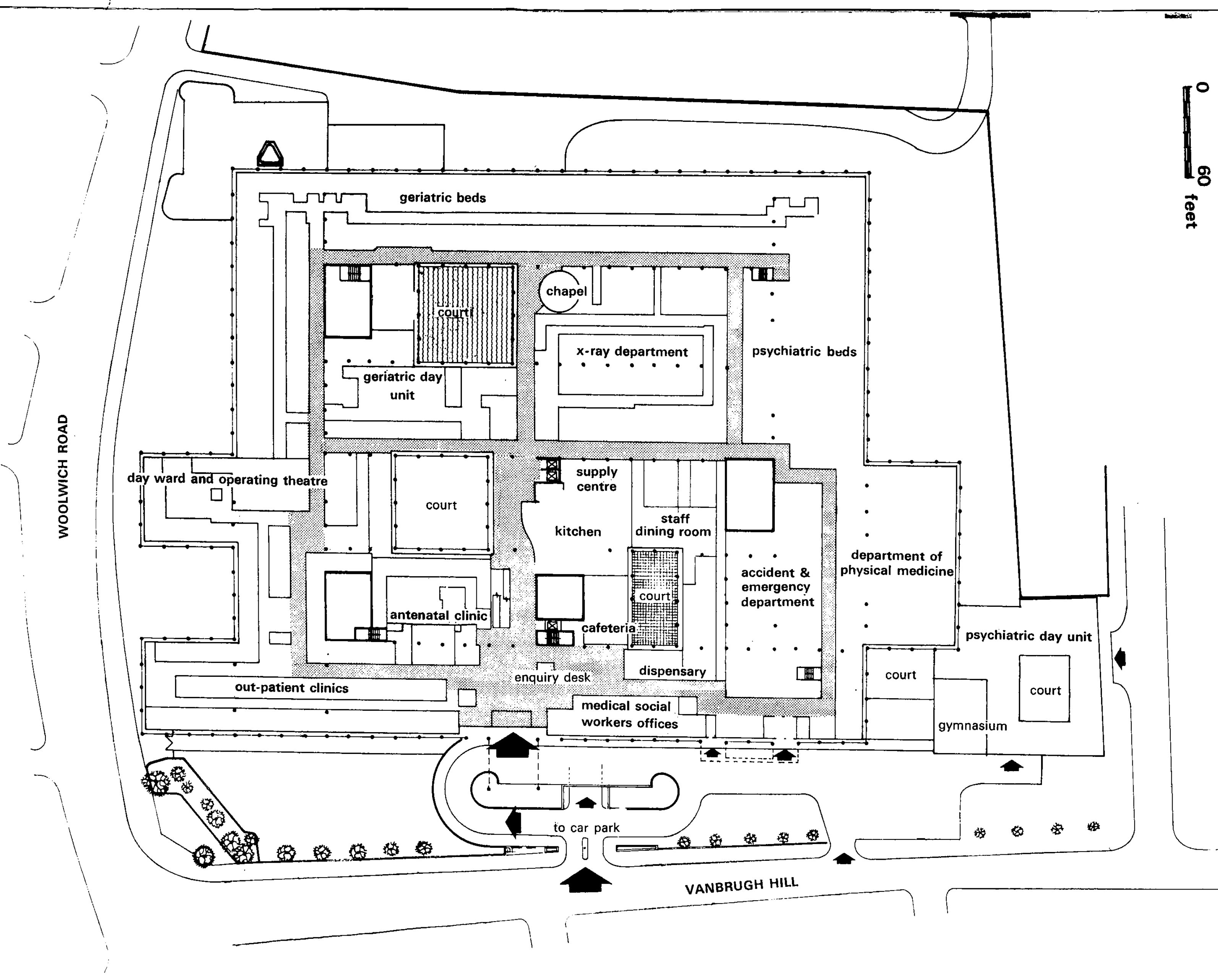
Appendix A

Greenwich Hospital. The Four Floor Plans.

Greenwich Hospital. Lower Ground Floor.

0 60 feet





Greenwich Hospital. Ground Floor.

Greenwich Hospital. First Floor.

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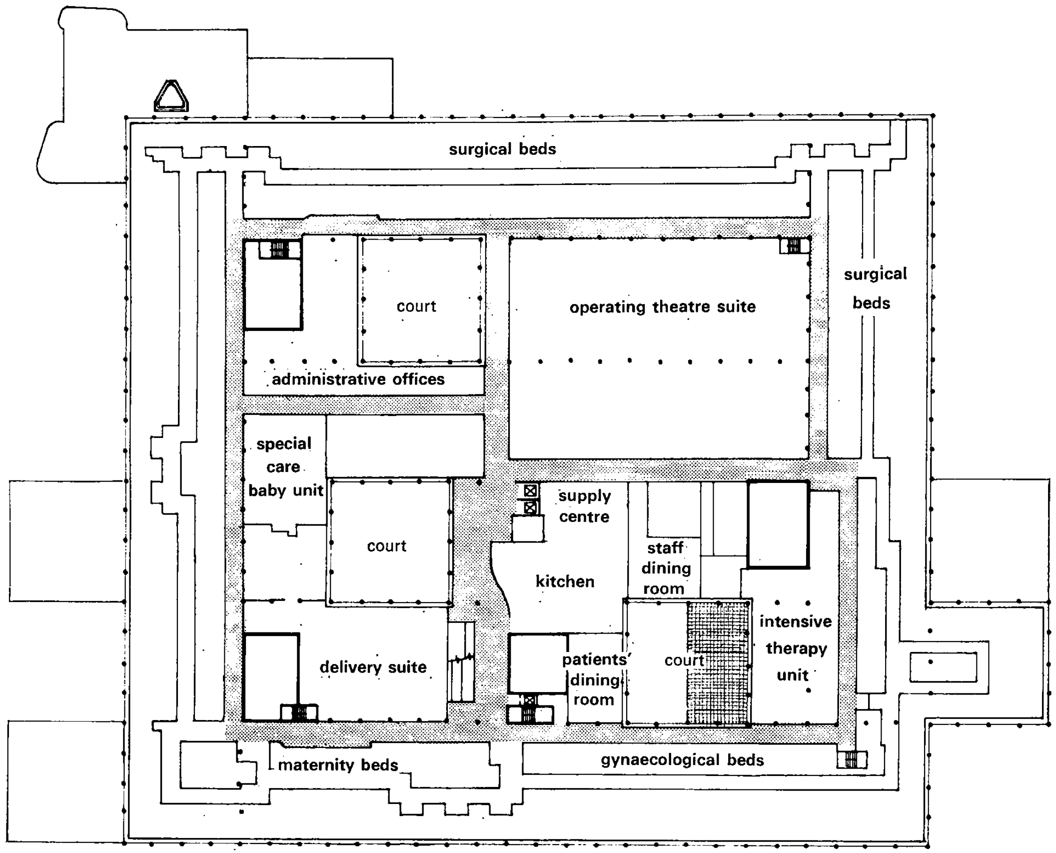

Greenwich Hospital. Second Floor.

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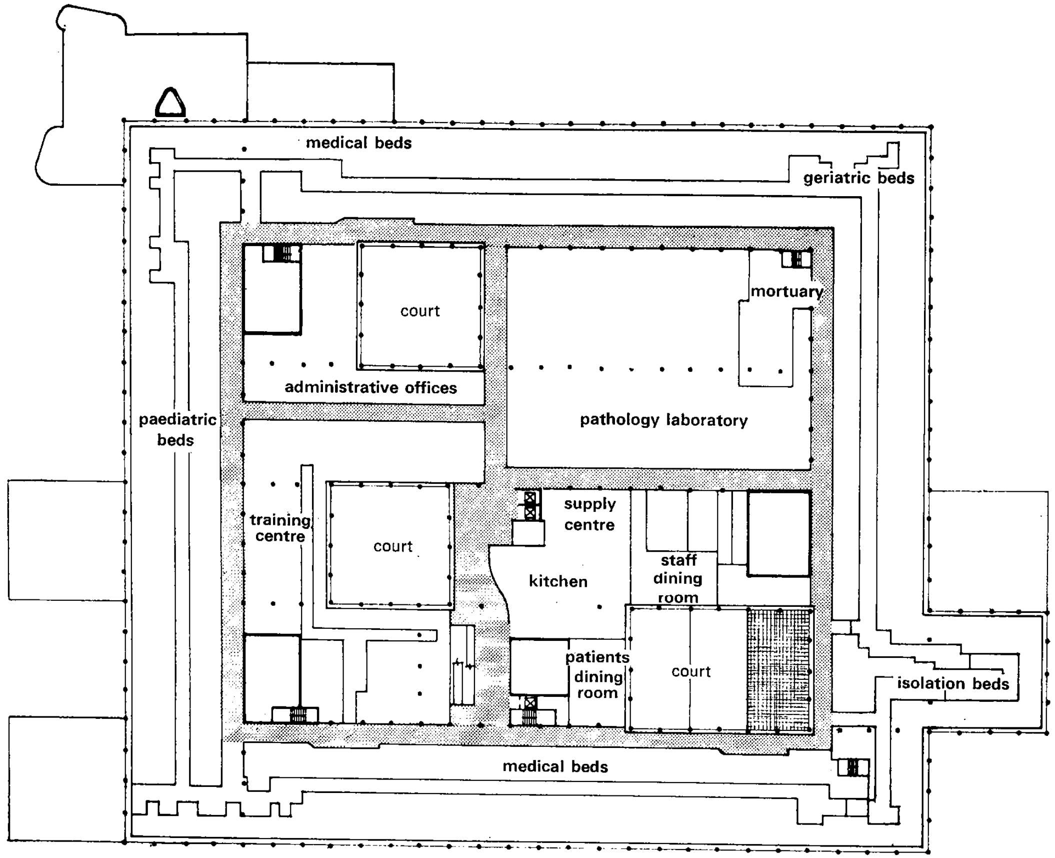


Appendix B

Greenwich Hospital. An Exercise to assess Unit Loads and the Throughput of Clean Linen.

Tests were conducted to determine the appropriate content of unit loads of clean linen, bearing in mind their ability to be handled by female staff. For this purpose a maximum weight limit of 25lb was imposed. When alternative unit loads had been prepared within this limitation it was found possible to select for each item a unit load which could be carried in a container measuring 2ft × 1ft × 1ft.

An attempt was also made to estimate the throughput of linen on each ward a) to gauge the total quantity of linen to be distributed and collected, and b) to determine the amount of storage space required for linen at ward level. The estimate made for a 28-bed maternity ward is shown here.

CLEAN LINEN REQUIREMENTS FOR WARD OF 28 MATERNITY BEDS, ASSUMING 2 DAYS SUPPLY.

ITEMS.	MAX. NO. HELD AT WARD LEVEL ASSUME TOPPING-UP.	CUBIC FEET.
COUNTERPANES.	10	3.2
CUBICLE CURTAINS.	4	2.0
BED SHEETS.	32	3.4
BATH TOWELS.	20	2.0
DRAW SHEETS.	60	5.0
PILLOW CASES.	60	2.0
HAND TOWELS.	20	0.4
DRESSING GOWNS.	2	2.0
NIGHT GOWNS.	40	2.8
OPERATION GOWNS.	2	0.1
BABY TOWELS.	56	3.0
BABY GOWNS.	168	2.7
MATERNITY TOWELS.	56	1.9
COT SHEETS.	150	2.9
SWING COT BLANKETS.	80	6.9
COT COUNTERPANES	40	0.4
COT FRILLS	12	1.2
BLANKETS.	16	8.0
NAPKINS.	560	21.6
NURSES GOWNS	24	1.4
LAUNDRY BAGS (NYLON)	16	1.3

ITEM.	DIMENSIONS OF PACK.	NO. OF ITEMS IN PACK.
1. SHEETS A. DRAW B. BED.	A: 23, 9, 9, 14 B: 20, 10, 12	A. 12. B. 14.
2. BLANKETS A. WOOL.	A: 21, 19, 14.	A. 5.
3. PILLOW CASES.	11, 8, 21	75.
4. DRESSING GOWNS. A. ADULTS B. CHILDREN.	A: 32, 18, 22 B: 21, 16, 39	A. 11. B. 25.
5. NAPKINS.	11, 9, 24	25.
6. TOWELS. A. LARGE BATH. B. PATIENTS. C. HUCKABACK.	A: 17, 15, 25 B: 12, 13, 45 C: 11, 7, 48	A. 12. B. 45. C. 120.
7. COUNTERPANES	20, 14, 14	15.
8. NIGHTGOWNS PYJAMAS.	17, 14, 10	18.
9. CUBICLE CURTAINS A. LIGHTWEIGHT. B. HEAVY WEIGHT.	A: 24, 14, 10 B: 24, 24, 17	A. 7. B. 4.
10. PILLOWS.	27, 17, 25	6.
11. NURSES GOWNS.	15, 20, 12	24.

Appendix C

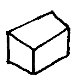
Greenwich Hospital. Examples of General Stock Items, showing Unit Dimensions, Stock Levels and Annual Consumption.

Included here are examples of the working sheets on which the assessment of space required in the main store was based. In the third column on each sheet shown the number of units to be held in store is the maximum number recommended after an analysis of each item by the techniques outlined in Chapter 6. In the final column R denotes racking (shelving), and F.S. denotes floor standing space.

The unit of issue was significant in evaluating the suitability of a container measuring 2ft × 1ft × 1ft for the distribution of supplies, whilst the annual consumption of all items taken together gave an indication of the load from this source on the distribution system.

CROCKERY.

COMMODITY	APPROPRIATE FORM & SIZE FOR STORAGE [MOST CROCKERY ITEMS ARRIVE FROM SUPPLIER IN CRATES*]	NUMBER OF UNITS HELD IN STORE.	UNIT OF ISSUE TO WARD OR DEPARTMENT.	THROUGH PUT [ANNUAL DEMAND BASED ON 800 BEDS]	TYPE OF STORAGE REQUIRED AT MAIN STORE.
BASIN, COLOURED	STACK OF 24 (6ø, 12)	79	EACH	72	R.
BASIN, PUDDING 7"	STACK OF 12. (7ø, 13)	39	EACH	24.	R
BASIN, PUDDING 9".	STACK OF 12 (9ø, 16)	15	EACH	24	R.
VINEGAR BOTTLE.	12 BOTTLES (12, 12, 5)	56	EACH	50	R.
BOWL, FRUIT PLASTIC 9½"	108 BOWLS 36×24×17	84.	EACH	150	R.
BOWL, MOUTHWASH. ST'NLESS STEEL.	STACK OF 6. (3ø, 7)	27	EACH	48.	R
BOWL, SWEET SOUP ETC.	44 BOWLS 7×7×12	81.	EACH.	100.	R.
BOWL, SUGAR.	120 BOWLS 18×24×9	90.	EACH.	120	R.
CASSEROLE. 6 OZS.	6 CASSEROLES (12, 8, 6)	35.	EACH.	50	R
CUP, PATIENTS	400 CUPS 36×24×17	564	EACH.	1,600.	R.
CUP, STAFF	400 CUPS. 36×24×17	737	EACH.	4,800.	R
DENTURE HOLDER.	STACK OF 6. (3ø, 6)	81	EACH	96.	R
DISH, BUTTER BASE.	144 BASES 36×24×16	40	EACH.	36.	R.
DISH BUTTER LID.	72 LIDS 36×24×16	40	EACH.	36.	R
DISH CHEESE BASE.	STACK OF 12 8×6×5	8	EACH	6.	R
DISH CHEESE LID.	EACH 6×5×4	8	EACH.	6	R
DISH GLASS SMALL	CARTON OF 72 (18, 17, 16)	270	EACH	450.	R
DISH GLASS LARGE.	STACK OF 5 (9ø, 8)	94	EACH	180	R
EGG, CUP STAFF.	432 STACK. 18×24×8	177	EACH	240.	R
JUG WITH LID 1½ PINTS.	30 JUGS. 18×24×12	46	EACH	120	R
JUG WITH LID ¼ PINT	32 JUGS 24×6×6	41	EACH	48	R
JUG WITH LID ½ PINT	28 JUGS 24×7×9	50	EACH	84.	R
JUG PYREX WITH LID 1PT.	6 JUGS 12×9×4	37.	EACH.	60	R
LEMON SQUEEZERS	12 SQUEEZERS 7×7×6	5	EACH	4.	R
MUG, CHILDS	18 MUGS 16×8×3	180	EACH	360	R
PLATE DINNER 9"	STACK OF 24. (9ø, 8)	150	EACH	480	R.

* SIZE OF CRATES RANGE FROM  TO 

CLEANING MATERIALS

COMMODITY	UNIT RECEIVED FROM SUPPLIER	NUMBER OF UNITS HELD IN MAIN STORE.	UNIT OF ISSUE TO WARD OR DEPARTMENT	THROUGHPUT [ANNUAL DEMAND BASED ON 800 BEDS]	TYPE OF STORAGE REQUIRED AT MAIN STORE.
BOOT POLISH, BLACK	BOX OF 36. 12 8 7	39.	EACH	48	R.
BOOT POLISH BROWN.	BOX OF 36. 12 8 7	78.	EACH	96	R.
CARPET, DRY SHAMPOO	PACK OF 2½ LBS. 7 10 3	50.	PACK	196	R.
CLEANING PASTE	PACK OF 36. 12 12 9	4496	EACH 1LB. TIN	38,140.	F.S.
COMB, DRESSING.	BOX OF 144 14 8 3	724	EACH	1,800	R.
COMB, SMALL TOOTH.	BOX OF 12. 6 3 1	14.	EACH	12.	R.
DETERGENT WITH BACT'CIDE	DRUM OF 25 LBS. 11⌀ 20	30	DRUM.	268	F.S.
DETERGENT DIVERSEY.	DRUM OF 50LBS 11⌀ 17	14.	DRUM.	120.	R.
DETERGENT NEUTRAL	DRUM OF 5 GALLS. 11⌀ 16	45	DRUM.	525.	R.
DISINFECTANT	DRUM OF 5GALLS. 12⌀ 17	93	DRUM.	1,896.	R.
DISH CLOTH	BUNDLE OF 864 16 13 8	314	EACH	725	R.
EMERY CLOTH.	PACK OF 60 SHEETS 12 9 2	382	EACH SHEET.	550	R.
EMULSION POLISH	DRUM OF 5GLS. 11⌀ 17	55	DRUM.	486	R.
FRESHAIR	CARTON OF 12 TINS 9 6 8	212	TIN	836	R
GREASE PROOF PAPER.	ROLL. 20 9⌀	14.	EACH	65.	R
MOPITCLENE	TIN OF 1GL. 7 4 12	30	EACH	180	R
OIL, 3IN1.	TIN OF 1GL. 7 4 12	90	PINT.	208	R
PAPER BAGS 1LB, 6"x7".	PACK OF 1000. 21 15 14	53	PACK	217.	R
PAPER BAG 2LBS, 7"x9".	PACK OF 1000 17 11 15	4	PACK.	3.	R
PAPER SACK COMB'ST. DRY 24"x11".	BALE OF 100. 24 11 15	156	BALE.	2,175.	R
PAPER SACK COMB'ST. WET. 36"x16".	BALE OF 100. 35 16 10	88	BALE.	1,280.	R
PAPER SACK DRY. 36x16	BALE OF 100. 35 16 10	136	BALE	2,200.	R
PAPER SACK NON COMB'ST. 36x16.	BALE OF 100. 35 15 10	58	BALE	686	R

HARDWARE.

COMMODITY	UNIT RECEIVED FROM SUPPLIER	NUMBER HELD IN STORE	UNIT OF ISSUE TO WARD OR DEPARTMENT.		
MEASURE 1/2 PINT.	EACH	7	EACH	6	R
MEASURE 1 PINT.	EACH	7	EACH	6	R
MEASURE 2 PINT.	EACH	7	EACH	6	R
MOP. ATO WITHOUT B'SH.	EACH	14	EACH	50	R
MOP. ATO SPONGE HEAD	EACH	47	EACH	208	R
MOP. IMPREG. FLOOR.	STACK OF 4 MOPS	400	EACH	4,576	R
MOP. IMPREG WALL.	STACK OF 4 MOP	500	EACH	5,500	R
MOP. MINIT SPONGE HEAD	BOX OF 12	14	EACH	12	R
PAIL POLYTHENE FOR MOP	STACK OF 6	34	EACH	96	R
PAIL POLYTHENE WITH LID.	EACH	7	EACH	6	R
PAN DUST.	EACH	28	EACH	30	R
PEELER POTATO	EACH	28	EACH	24	R
RACK BATH.	EACH	13	EACH	48	R
SAUCEPAN 1 PINT.	EACH	3	EACH	2	R
SAUCEPAN 2 PINT.	EACH	3	EACH	2	R
SAUCEPAN 4 PINT.	EACH	3	EACH	2	R
SAUCEPAN 8 PINT.	EACH	3	EACH	2	R
SAUCEBOAT	EACH	9	EACH	18	R
SIEVE, PUDDING 15"	EACH	22	EACH	60	R
SLICE, FISH + EGG.	EACH	7	EACH	6	R
SPOON, COOKS WOOD SMALL.	EACH	7	EACH	6	R
SPOON COOKS WOOD LARGE	EACH	14	EACH	12	R
SPOON DESSERT	EACH.	14	EACH	12	R

PROVISIONS

COMMODITY.	APPROPRIATE FORM & SIZE FOR STORAGE — USUAL FORM RECEIVED FROM SUPPLIER.	NUMBER OF UNITS HELD IN MAIN STORE	UNIT OF ISSUE TO WARD OR KITCHEN.	THROUGHPUT [ANNUAL DEMAND BASED ON 800 BEDS]	TYPE OF STORAGE REQUIRED AT MAINSTORE.
BISCUITS SWEET	CARTON OF 20 PKTS. 12 8 10	62	EACH.	696	R
BLOCK CHOCOLATE	14 LBS 14 6 6	150	EACH	336	R
BRANDY	CARTON OF 6 BOTTLES 10 7 13	290	EACH	1728	R
BREAD	TRAY OF 9–12 LOAVES 26 22 12	24	EACH		R
BUTTER	CARTON OF 56 PACKS 12 10 9	42	EACH	686	R
BUTTER BEANS	BIN 27 16 21	118		168	R
BUTTER PEANUT.	CARTON OF 12 JARS 8 6 14	235	EACH 5 3	864	R
CAPERS	CARTON OF 2 JARS 12 6 9	12	EACH 1/2 GAL.	24	R
CARAMEL MIX	CARTON OF 6 PACKS 10 7 6	144	EACH 1/2 GAL	720	R
CARROTS	CARTON OF 6 TINS 19 13 7	150	EACH A10 TIN	720	R
CHERRIES	CARTON OF 6 TINS 19 13 7	36	EACH A10 TIN	216	R
CHERRIES IN WATER	CARTON OF 36 TINS 19 10 9	40	EACH 16 OZ TIN	48	R
CHERRY PULP	5 KILO TIN 7ϕ 10	31	EACH 5 KILO TIN.	72	R
CHEESE	70–80 LB. ROUND 14ϕ 12	710	PER LB.	9240	R
CHEESE BLUE VEIN	BOX OF 1 1/2 LB. 9 7 6	19	PER LB.	24	R
CHEESE CAERPHILLY	40 LBS BOX 13 10 10	90	PER LB.	336	R
CHEESE CHESHIRE	40 LBS BOX 12 10 15	90	PER LB.	336	R
CHEESE DUTCH.	BOX OF 4–6 lb. CHEESES 14 12 8	130	PER LB	360	R
CHEESE PACKETS	CARTON OF 72 PACKS 14 10 7	395	EACH	1652	R
CHILLI SAUCE	CARTON OF 12 BOTTLES 11 9 8	146	EACH 3 7	288	R
CHOC DRINKING	CARTON OF 4/7 lb TINS 14 14 9	36	EACH.	144	R
CHOC SPREAD.	CARTON OF 12 JARS. 8 6 7	100	EACH 4 3	120	R

PROVISIONS.

COMMODITY.	APPROPRIATE FORM & SIZE FOR STORAGE — USUAL FORM RECEIVED FROM SUPPLIER.	NUMBER OF UNITS HELD IN MAIN STORE.	UNIT OF ISSUE TO WARD OR. KITCHEN.	THROUGH PUT [ANNUAL DEMAND BASED ON 800 BEDS]	TYPE OF STORAGE REQUIRED AT MAIN STORE.
RICE BROKEN	BIN OF 1 1/2 CWTS. (27 16 21)	752	PER LB.	4,032	F.S.
RICE GROUND	2 CWTS SACK. (27 21)	234	PER LB.	336	F.S.
RICE KRISPIES	CARTON OF 24 PACKS (23 15 13)	226	EACH.	864	F.S
RICE PATNA	1 1/2 CWT SACK. (27 20)	366	PER LB.	1344	F.S
RHUBARB.	CARTON OF 6 TINS (19 13 7)	103	EACH. A10 TIN	504	R
ROLLED OATS	PACK OF 70 LBS (36 25 10)	16	EACH.	60	F.S.
RYVITA.	CARTON OF 12 PACKS (11 8 9)	113	EACH. (5 3 3)	144	R
SACCHARINS	BOX OF 12 PACKS (7 5 3)	51	EACH. (2 1)	48	R
SAGO		481	PER LB.	1680	F.S
SALAD CREAM	CARTON OF 24 JARS (13 9 7)	340	EACH. (8 2)	1440	R
SALAD CREAM	CARTON OF 1 JAR. (7 13 7)	28	EACH (10 6)	120	R
SALMON	CARTON OF 48 X 8OZ TINS (14 11 8)	166	EACH (2 4)	1008	R
SALMON	CARTON OF 24, 16OZ TINS (14 10 8)	80	EACH (4 4)	288	R
SALT, COOKING	1CWT PACK. (18 32)	32	PER LB.	72	F.S
SALT, TABLE.	CARTON OF 36 PACKS (13 10 10)	28	EACH.	66	R
SANDWICH SPREAD.	CARTON OF 24 JARS (15 10 5)	280	EACH	1008	R
SARDINES.	BOX OF 100 TINS. (30 12 12)	222	EACH	1080	R
SAUCES	CARTON OF 12 BOTTLES (9 7 8)	62	EACH	320	R
SEEDED PRESERVES	CARTON OF 24 TINS (17 12 5)	134	EACH.	288	R
SEMOLINA	SACK OF 1 1/2 CWTS (34 27)	484	PER LB.	1680	F.S
SHERRY	CARTON OF 6 BOTTLES (10 7 13)	148	EACH	288	R
SHREDED WHEAT.	PKT. (8 3 9)	274	EACH.	864	F.S
SODA WATER.	CRATE OF 12 BOTTLES (17 13 14)	214	EACH (12 3)	433	R

SURGICAL DRESSINGS

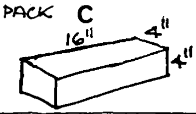
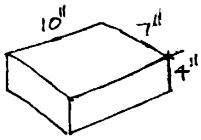
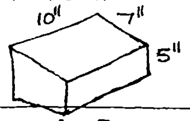
COMMODITY	UNIT RECEIVED FROM SUPPLIER	NUMBER OF UNITS HELD IN MAIN STORE	UNIT OF ISSUE TO WARD OR DEPARTMENT.	THROUGH PUT [ANNUAL DEMAND BASED ON 800 BEDS]	TYPE OF STORAGE REQUIRED AT MAIN STORE.
BAG, DISPOSABLE SMALL.	CARTON OF 2500 (20 12 12)	290	PACK OF 50	1000	R
BAG, DISPOSABLE LARGE.	CARTON OF 2600 (26 14 15)	232	PACK OF 50	850.	R
BAG DISPOSABLE EXTRA LARGE	CARTON OF 1000 (20 16 11)	92.	PACK OF 50	250	R
BANDAGE BISCARD.	½ YARD ROLL (10 3)	82.	YARD	100.	R.
BANDAGE CALICO 4"	PACK OF 12 (12 6 2)	22	PACK OF 12.	60	R.
BANDAGE CALICO 6"	PACK OF 12 (12 9 2)	19	PACK OF 12	60	R
BANDAGE CONFORMING 2"	PACK OF 12 (10 6 1)	44	PACK OF 12.	96	R
BANDAGE CONFORMING 3"	PACK OF 12 (7 6 3)	64	PACK OF 12	240.	R
BANDAGE CONFORMING 4"	PACK OF 12. (9 5 3)	30	PACK OF 12.	72.	R
BANDAGE CONFORMING 6"	PACK OF 12. (12 5 3)	22	PACK OF 12	48	R
BANDAGE B.P.C CREPE 2"	CARTON OF 144 (18 12 7)	25.	PACK OF 12.	42.	R
BANDAGE B.P.C CREPE 3"	CARTON OF 120 (18 12 7)	31	PACK OF 12	80	R
BANDAGE B.P.C CREPE 4"	CARTON OF 84 (18 12 7)	32.	PACK OF 12.	90	R
BANDAGE B.P.C CREPE 6"	CARTON OF 60 (18 12 7)	18	PACK OF 12.	48	R
BANDAGE HOSP. CREPE 2"	CARTON OF 144 (18 12 7)	44	PACK OF 12	100	R
BANDAGE HOSP. CREPE 3"	CARTON OF 120 (18 12 7)	90	PACK OF 12	860	R
BANDAGE HOSP CREPE 4"	CARTON OF 84 (18 12 7)	74	PACK OF 12.	250	R
BANDAGE HOSP CREPE 6"	CARTON OF 60 (18 12 7)	45	PACK OF 12	150	R.
BANDAGE DOMETTE 3"	PACK OF 12 (12 6 2)	18	PACK OF 12.	18	R
BANDAGE DOMETTE 4"	PACK OF 12 (13 9 2)	17	PACK OF 12	18	R
BANDAGE DOMETTE 6"	PACK OF 12. (12 6 4)	19	PACK OF 12	40	R
BANDAGE 2" ELAS. ADH'IVE	BOX OF 12 (9 6 3)	264	EACH	850	R
BANDAGE 3" ELAS. ADH'IVE	BOX OF 12 (10 8 3)	188	EACH	560	R
BANDAGE 4" ELAS. ADH'IVE	BOX OF 12. (10 7 5)	152	EACH	600	R.

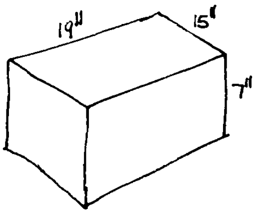
Appendix D

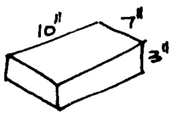
Greenwich Hospital. A proposed Range of Sterile Supply Packs, showing Content, Dimensions and the Purpose of each Pack.

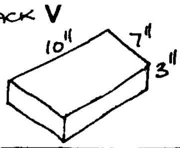
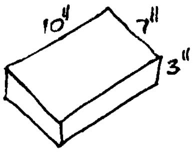
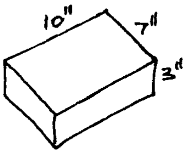
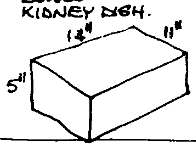
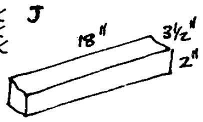
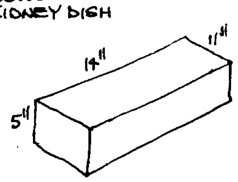
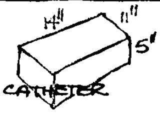
The beginning of the exercise to formulate a comprehensive range of sterile supply packs was to list those procedures which required the use of sterile equipment. Once the content of each pack was determined it was measured in order to confirm its ability to be carried in a container measuring 2ft × 1ft × 1ft.

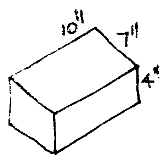
It should be added that since the time of this exercise the range has been supplemented by further packs, but so far without going outside the size range established in the exercise.

PROCEDURE	PROPOSED PACK	CONTENTS OF PACK	SUPPLEMENTARY ITEMS / EQUIPMENT.
1. MINOR DRESSING	PACK **A** (BASIC PACK.S.) DISSECTING FORCEPS 	5. COTTON WOOL BALLS 2. GAUZE SWABS, 3×3. 1 GALLIPOT, POLYPROPYLENE 1 PAPER DRESSING TOWEL	
2. MAJOR DRESSINGS	PACK **B** (BASIC PACK. L.) DISSECTING FORCEPS 	10 COTTON WOOL BALLS 6. GAUZE SWABS, 4×4 2 GALLIPOTS, POLYPROPYLENE 2 DRESSING PADS 1 PAPER DRESSING TOWEL	
3. LUMBAR PUNCTURE	PACK **C** 	6 GAUZE SWABS, 3×3 3 PAPER DRESSING TOWELS 2 GALLIPOTS, POLYPROPYLENE 1 GREENFIELD'S MANOMETER-WITH 4" SILICONE TUBING. 2 HOWARD JONES LUMBAR-PUNCTURE NEEDLES	SYRINGE, NEEDLES FOR LOCAL ANAESTH.
4. INTRAVENOUS CUT DOWN INFUSION	PACK **D** 	5 GAUZE SWABS, 3×3 1 PAPER DRESSING TOWEL 1 GALLIPOT, POLYPROPYLENE 1 DISSECTING FORCEPS PLAIN, FINE 1 DISSECTING FORCEPS TOOTHED, FINE 1 B.P. HANDLE No3 WITH BLADE 15 1 VEIN SCISSORS 1 MOSQUITO ARTERY FORCEPS CURVED 1 MOSQUITO ARTERY FORCEPS STRA'T. 1 ANEURYSM NEEDLE. 1 BRUCE CLARKE, NEEDLE HOLDER	INTRAVENOUS CAN'LE GIVING SET SUTURE MATERIAL SYRINGE, NEEDLES
5. CHEST ASPIRATION	PACK **E** MEASURE ADDITIONAL NEEDLES IF REQ. KIDNEY DISH. 	5 GAUZE SWABS 2 PAPER DRESSING TOWELS 1 GALLIPOT, POLYPROPYLENE. 1 SPONGE HOLDER 7" 1 DISSECTING FORCEPTS PLAIN 5" 1, 20ml. LUER-LOCK SYRINGE 1 TWO-WAY TAP LUER-LOCK. 3 ASPIRATING NEEDLES GU. 16, 18, 20 1 DUN'S SINKER WITH SILICONE TUBING.	SYRINGE, NEEDLES. FOR LOCAL ANAESTH.
6. SHORTENING DRAINAGE TUBE	PACK **A** or **B** DISSECTING FORCEPS STITCH SCISSORS SAFETY PIN	DITTO A+B	
7. REMOVAL DRAINAGE TUBE. REMOVAL SUTURES	PACK **A** DISSECTING FORCEPS SCISSORS	DITTO A.	
8. REMOVAL MICHEL CLIPS	PACK **A** DISSECTING FORCEPS MICHEL CLIP REMOVER	DITTO A.	
9. WOUND IRRIGATION	PACK **B** DISSECTING FORCEPS	DITTO B	BULB SYRINGE OR 50ml. WARDELL SYRINGE (STYLEX)
10. DRESSING WITH PROFUSE DRAINAGE	PACK **B** ABSORBENT DRESSING PAD OR— DISSECTING FORCEPS	DITTO B.	COLOSTOMY BAG.
11. CATHETERISATION	PACK **A** KIDNEY DISH 8" DISSECTING FORCEPS	DITTO A.	CATHETER
12. VULVAL TOILET.	PACK **F** MEASURE JUG (IF REQ) 	10 COTTON WOOL BALLS 1×4 BOWL, FOIL 1 GALLIPOT, FOIL 1 MATERNITY PAD 1 PAPER DRESSING TOWEL	
13. BLADDER WASHOUT.	PACK **A** MEASURE JUG KIDNEY DISH DISSECTING FORCEPS	DITTO A	STYLEX WARDELL SYRINGE.
14. VAGINAL EXAMINAT'N	PACK **F** VAGINAL SPECULUM.	DITTO F.	

PROCEDURE	PROPOSED PACK	CONTENTS OF PACK	SUPPLEMENTARY ITEMS / EQUIPMENT.
15. INJECTIONS Subcutaneous Intramuscular Intravenous	PACK A (or supplementary pack of wool balls depending on procedure used.)	DITTO A.	SYRINGE, NEEDLES
16 IRRIGATION OF EYE.	PACK A UNDINE KIDNEY DISH EYE PAD.	DITTO A.	
17. INSTALLATION OF EYE DROPS.	PACK A	DITTO A.	PIPETTE
18. SYRINGING OF EAR.	AURAL SYRINGE (NO PACK) KIDNEY DISH 10" MEASURE JUG.		
19. PARACENTESIS ABDOMINIS	PACK A DISSECTING FORCEPS TROCAR + CANNULAE WITH TUBING. OR. SOUTHEY'S TUBES WITH TUBING. B.P. HANDLE	DITTO A.	Nº 15 BLADE.
20. PERITONEAL DIALYSIS	PACK A DISSECTING FORCEPS B.P. HANDLE TROCAR + CANNULAE, 8 EG.	DITTO A.	Nº 15 BLADE. SYRINGE + NEEDLES PERITONEAL DIALYSIS CATHETER SUTURE MATERIAL.
21. ACUPUNCTURE.	PACK A B.P. HANDLE Nº3.	DITTO A.	BLADE 11.
22. BONE MARROW PUNCTURE.	PACK A DISSECTING FORCEPS BOWL 4" KIDNEY DISH WATERFIELD'S STERNAL PUNCTURE NEEDLE	DITTO A.	SYRINGE NEEDLES
23. LIVER BIOPSY	PACK A DISSECTING FORCEPS, SILVERMAN BIOPSY NEEDLE 50ml. SYRINGE. BP. HANDLE Nº3.	DITTO .A.	SYRINGE, NEEDLES BLADE No. 15.
24. LUNG BIOPSY	PACK E ABRAHAMS LUNG BIOPSY NEEDLE	DITTO E.	SYRINGE, NEEDLES
25. TRACHEOSTOMY	PACK. H 	ALUMINIUM TRAY CONTAINING- 10 RAYTEC SWABS, 3×3. 2 DRESSING TOWELS 36×36 1×4" BOWL, POLYPROPYLENE 1×8" KIDNEY DISH 1 SPONGEHOLDING FORCEPS, 7" 2 TOWEL CLIPS 1 B.P. HANDLE WITH Nº10. BLADE 1 McINDOE'S DISSECTING FORCEPS. 1 GILLIE'S DISSECTING FORCEPS 2 LANGENBECK'S RETRACTORS. 2 BLUNT HOOKS, DOUBLE 1 BLUNT HOOK, SINGLE 1 SHARP HOOK 1 MAYO SCISSORS, 5" 1 BLALOCK SCISSOR 2 MOSQUITO ARTERY FORCEPS (S) 2 MOSQUITO ARTERY FORCEPS (C) 1 TRACHEAL DILATOR 1 SUCTION CATHETER + CONNECT'N. 1 SELF-CLEANING SUCKER + TUBING 1 NEEDLE HOLDER	TRACHEOTOMY TUBES SUTURES. SUCTION MATERIALS.
26. INSERTION OF SUTURES.	PACK A SUTURE SET (instrument in aluminium tube)		SYRINGE, NEEDLES SUTURE MATERIALS
27. INCISION OF ABCESS.	PACK A DISSECTING FORCEPS B.P. HANDLE Nº3. DOUBLE ENDED SCOOP		

PROCEDURE	PROPOSED PACK	CONTENTS OF PACK	SUPPLEMENTARY ITEMS / EQUIPMENT.
28. MINOR OPERATION	PACK S BOWL KIDNEY DISH GALLIPOT.	ALUMINIUM TRAY CONTAIN'G 10 RAYTEC SWABS 4×4 4 DRESSINGS TOWELS 36×36 4 TOWEL CLIPS. 1 SPONGE HOLDING FORCEPS 7" 1 DISSECTING FORCEPS PLAIN 1 GILLIES DISSECTING FORCEPS 1 McINDOE'S DISSECTING FORCEPS 1 B.P. HANDLE No3 WITH BLADE 1 STRAIGHT MAYO SCISSORS 5" 2 CURVED MOSTQUITO ARTERY FORCEPS 2 STRAIGHT MOSQUITO ARTERY FORCEPS 1 WATSON CHEYNE'S DISSECTOR 2 ALLIS TISSUE FORCEPS. 1 NEEDLE HOLDER	SUTURES.
29. WOUND TOILET.	BOWL DRESSINGS BRUSH		
30. REMOVAL SPLINTER	SUPPLEMENTARY DRESSING PACK. SPLINTER FORCEPS		
31. REMOVAL OF FOREIGN BODY FROM EYE	PACK U EYE NEEDLES IN ALUMINIUM TUBES.  	TRAY CONTAINING:- 5 SWABS 2 EYE PADS 1 BANDAGE 2" FAST EDGE 2 PAPER DRESSING TOWELS 3 GALLIPOTS POLYPROPYLENE 1 SPUD 1 CONJUNCTIVAL FORCEP 1 FIXATION FORCEPS 2/3 TEETH 1 SPECULUM LARGE 1 SPECULUM SMALL 2 DESMARRE LID RETRACTORS 2 LANG LID RETRACTORS	
32. REMOVAL OF FOREIGN BODY FROM NOSE & EAR.	SUPPLEMENTARY DRESSING PACK. CERUMEN HOOK / NASAL FORCEPS		
33. TENDON SUTURE	PACK S SKIN HOOKS	DITTO S.	SYRINGE, NEEDLES TENDON SUTURES SKIN SUTURES
34. JOINT ASPIRATION OR INJECTION L.A. TO JOINT	PACK A DISSECTING FORCEPS	DITTO A.	SYRINGE, NEEDLES
35. PACKING OF NOSE	PACK A RIBBON GAUZE NASAL SPECULUM NASAL FORCEPS.	DITTO A.	
36. PACKING OF TOOTH SOCKET	PACK A RIBBON GAUZE DENTAL COLLEGE FORCEPS MOUTH GAG.	DITTO A.	
37. SKIN GRAFTING	PACK S SKIN GRAFTING BOARDS HUMBY KNIFE		SYRINGE, NEEDLES
38. ANTRUM WASHOUT.	SUPPLEMENTARY PACK GAUZE 3×3 ANTRUM TROCAR + CANNULAE HIGGINSON'S SYRINGE WITH LUER ADAPTOR. NASAL SPECULUM MEASURE JUG KIDNEY DISH, 10"		
39. REMOVAL OF NASAL POLYPS.	SUPPLEMENTARY PACK 3×3 NASAL SNARE NASAL SPECULUM.		
40. INJECTION OF HAEMORRHOIDS	PACK A PROCTOSCOPE HAEMORRHOID SYRINGE AND NEEDLES	DITTO A.	
41. URETHRAL DILATATION	PACK A 1 SET URETHRAL SOUNDS	DITTO A.	

PROCEDURE	PROPOSED PACK	CONTENTS OF PACK	SUPPLEMENTARY ITEMS / EQUIPMENT.
42. TAPPING OF HYDROCELE	PACK A DISSECTING FORCEPS HYDROCELE TROCAR AND CANNULAE. KIDNEY DISH.		
43. REMOVAL OF WARTS	SUPPLEMENTARY PACK GAUZE, 3X3. VOLKMANN'S SPOON.		SYRINGE, NEEDLES
44. SYRINGING OF LACHRYMAL DUCT	PACK V 	5 SWABS 1 GALLIPOT (P) 1 PAPER DRESSING TOWEL 1 EYE PAD 1 KIDNEY DISH 8" 1 DISSECTING FORCEPS PLAIN 1 LACHRYMAL CANNULA 1 NETTLESHIP DILATOR 1 SET BOWMANS PROBES	
45. EXCISION OF MEIBOMIAN CYST.	PACK W 	TRAY CONTAINING 10 SWABS 3 GALLIPOTS 2 PAPER DRESSING TOWELS 1 EYE PAD. 1 X 2" FAST EDGE BANDAGE 1 B.P. HANDLE No. 11 BLADE 1 IRIS FORCEPS 1 MOSQUITO ARTERY FORCEPS 1 FIXATION FORCEPS 1/2 TEETH 3 TARSAL CYST CLAMPS 1 EACH 1 IRIS SCISSORS 1 SET CURETTES	SYRINGE, NEEDLES.
46. CARBOLISATION OF CORNEAL ULCERS	PACK X 	TRAY CONTAINING 5 SWABS 1 EYE PAD 1 EYE BANDAGE, 2" FAST EDGE. 1 GALLIPOT. 2 POINTED ORANGE STICKS 2 MOUNTED ORANGE STICKS 3 SMALL PIECES BLOTTING PAPER. 1 SPECULUM, LARGE. 1 SPECULUM, SMALL 1 IRIS FORCEPS.	
47. NORMAL DELIVERY.	PACK I PACK AS REQD. BOWLS KIDNEY DISH. 	20 COTTON WOOL BALLS 5 GAUZE SWABS 4X4 3 MATERNITY PADS 2 RECTAL PADS 4X4 1 ACCOUCHEMENT SHEET 3 DRESSING TOWELS 1 GOWN 1 MAYO SCISSORS 6" STRAIGHT 1 CORD SCISSORS 2 SPENCER WELLS ARTERY-FORCEPS 7"	CORD LIGATURE CATHETER MUCUS EXTRACTOR.
48. FORCEPS DELIVERY	PACK J PACK PACK 	15 RAYTEC SWABS 4"x4" 1 TAMPON 1 LITHOTOMY SET 1 GOWN 2 GALLIPOTS 1 PUDENDAL BLOCK NEEDLE	
49. SUTURE PERINEAL	PACK M BOWL KIDNEY DISH 	10 COTTON WOOL BALLS 10 GAUZE SWABS 4X4 2 TAMPONS 1 MATERNITY PAD 1 LITHOTOMY SET 1 GOWN 1 SPONGE HOLDING FORCEPS 9" 1 SIMS SPECULUM, MEDIUM. 4 SPENCER WELLS ARTERY-FORCEPS, 7". 1 DISSECTING FORCEPS, PLAIN 6" 1 DISSECTING FORCEPS TOOTHED 5" 1 MAYO SCISSORS 5" STRAIGHT. 1 NEEDLE HOLDER, STRAIGHT.	SUTURES
50 ARTIFICIAL RUPTURE OF MEMBRANES	PACK. N BOWL JUG KIDNEY DISH DREW-SMYTHE CATHETER 	10 COTTON WOOL BALLS 1 MATERNITY PAD. 1 LITHOTOMY SET 1 GOWN 2 SPONGE HOLDING FORCEPS 9" 1 STRAIGHT KOCHER FORCEP 7" 1 CURVED KOCHER FORCEP 7" 1 SPENCER WELLS ARTERY FORC. 7" 1 SIMS SPECULUM. MEDIUM	

PROCEDURE	PROPOSED PACK	CONTENTS OF PACK	SUPPLEMENTARY ITEMS / EQUIPMENT.
51. INSERTION OF PESSARIES	PACK F (VULVAL TOILET PACK)	10 COTTON WOOL BALLS 1 x 4" BOWL, FOIL 1 GALLIPOT, FOIL 1 MATERNITY PAD 1 PAPER DRESSING TOWEL	PESSARIES
52. X-RAY EXAMINATION	PACK A DISSECTING FORCEPS SPECIALISED SYRINGES INSTRUMENTS BOWLS KIDNEY DISH	DITTO A.	SYRINGE NEEDLES CATHETERS
53. INSERTION INTERCOSTAL TUBE	PACK F UNDERWATER SEAL BOTTLE & TUBING	DITTO F.	
54. PNEUMO — THORAX ASPIRATION	PACK A DISSECTING FORCEPS MORLANDS NEEDLE.		SYRINGE, NEEDLES
55. CARDIAC MASSAGE	PACK G UNDERWATER SEAL BOTTLE + TUBES. 	4 TOWEL CLIPS 1 SPONGE HOLDER 9" 2 B.P. HANDLES No4. BLADE 22 1 DISSECTING FORCEPS, PLAIN 7" 1 DISSECTING FORCEPS, TOOTHED 7" 1 STRAIGHT MAYO SCISSORS 7" 1 NELSON LOBECTOMY SCISSORS 9" 1 NELSON DISSECTING FORCEPS 9" 2, 5" DUNHILL ARTERY FORCEPS 4 9" ROBERTS ARTERY FORCEPS 1 RIB SPREADER 4 PACKETS (5) SWABS 18x18 RAYTEC 4 DRESSING TOWELS 36x36 1 SUCKER + SUCTION TUBING PACKED WITHIN MAIN PACK FOR RESUTURE :- 1 DISSECTING FORCEPS, TOOTHED 7" 4 DUNHILL ARTERY FORCEPS. 1 NEEDLE HOLDER 1 PACKET (5) SWABS, 18x18 RAYTEC 2 DRESSING TOWELS 36x36	ARGYLL THORACIC-CATHETER UNDER WATER SEAL-BOTTLE. SUTURES.

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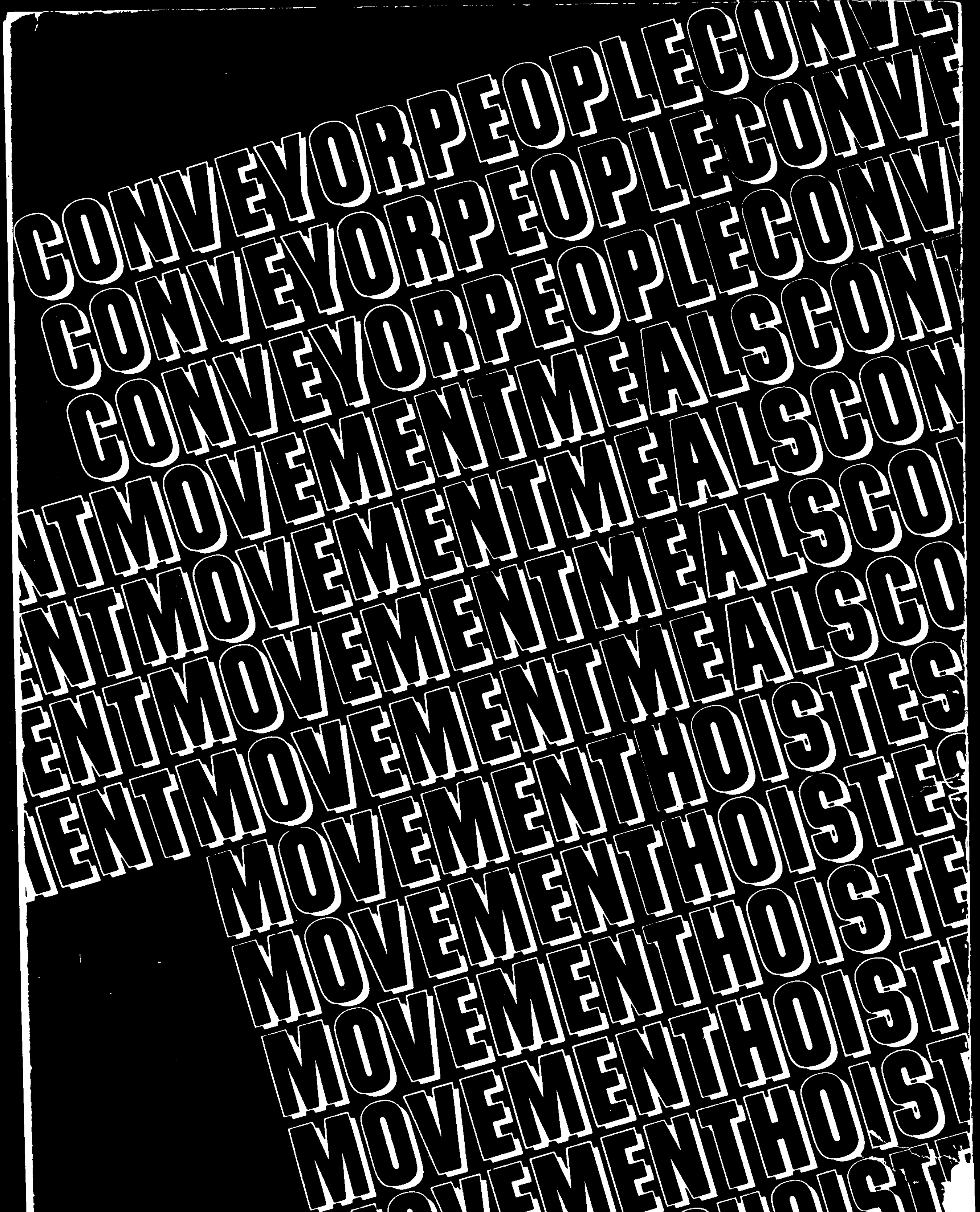

CONVEYORPEOPLECONVE
MOVEMENTMEALSCON
MOVEMENTHOISTES
HANDLINGHOIST