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UNRESTRICTED

THE SPATIAL DEVELOPMENT OF THE CITY OF LONDON

IN THE LATER MIDDLE AGES

by

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Thesis submitted for the degree of Doctor of Philosophy
in Design Discipline, Faculty of Technology,
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ABSTRACT

The thesis is concerned with a particular spatial morphology - that of the City of London in the later Middle Ages - and the way that it evolved. It addresses itself to the organisation of space at the meso-scale, i.e. the way buildings were aggregated or arranged on the ground, and the external spaces that were formed. The work has two main aims: firstly, to discover the principles which governed the arrangement of buildings; and, secondly, to develop a model which will simulate the actual development of building patterns in late mediaeval London.

The work is divided into three main parts. Part I provides a general introduction. The overall form and development of the City are described, and the social and economic context considered by reference to secondary sources. An outline is given of some of the main social and economic forces operative in the late mediaeval period - c.1400 - c.1600 - and in the seventeenth century - the period from which most of the cartographic evidence is drawn. The principal sources - cartographic and documentary - are listed and discussed. Graph theory, the mathematical language used in this study, is briefly discussed, and some basic definitions given.

Part II comprises the morphological analysis, the results of which are in all cases presented in verbal rather than in mathematical form. Firstly, the gross geometrical and topological properties of the urban pattern are described, and the connectivity between buildings analysed by reference to a graph-theoretic representation of a limited area of the City. Attention is then turned to the organisation of space within the house. A substantial body of plans, drawn from seventeenth-century property surveys, is analysed, using graph notation to describe the access patterns within the house. A typology of house plans is proposed on the basis of the access graphs, and a possible functional and social interpretation of the

evidence is considered.

Returning to the meso-scale, the urban structure is decomposed into its constituent elements. At the highest level is the block - a region surrounded by streets ; at the lowest level is the individual building or unit. The block is divided into two zones - the perimeter zone and the interior zone - and each zone is subdivided into segments. It is argued that the segments correspond to historical property divisions which exercised a decisive effect on the evolution of the building pattern. From a state description of the morphology, the analysis proceeds to a process description, based on historical evidence. The historical continuity of the property divisions is supported, and the historical process of segment development reconstructed, by reference to cartographic and documentary sources. From this analysis, the basic rules of building development are identified, and a concise description of the process of development is given for perimeter and interior segments.

Finally, the process description is applied to various hypothetical block configurations. A computer simulation was used to examine two main properties : the access structure through the blocks, i.e. the way access is maintained (or not) from one segment to another; and the overall density of building development. The results obtained from the computer model are compared with the empirical evidence derived from plan analysis, and the similarities/differences discussed. The inference is drawn that the building pattern of late mediaeval London may be seen to result in large measure from the formal logic of the system, and can be accounted for on a probabilistic basis..

Part III summarises the results. The process description is seen as a form of shape grammar, and the relationship of this with other shape grammars is discussed. A programme of further work is outlined, in which it is hoped that the approach may be applied successfully to the analysis of other historical morphologies.

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Apart from the assistance referred to above, I declare, for the purpose of University Ordinances, that this dissertation is the result of my own work, and contains nothing which is the outcome of work done in collaboration.

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INTRODUCTION

This thesis is concerned with a particular spatial morphology - that of the City of London in the later Middle Ages - and the way that it evolved. It addresses itself to the organisation of space at the local level, i.e. the way buildings were aggregated or arranged on the ground and the external spaces that were formed. The work has two main aims: firstly, to discover the principles which governed the arrangement of buildings; and, secondly, to develop a model which will simulate the actual development of building patterns in late mediaeval London.

The study has been carried out at the Centre for Configurational Studies, and forms part of the programme of the Centre. More generally, it lies within that field of research known as morphological studies, which embraces work at the Martin Centre, University of Cambridge, and the Bartlett School of Architecture and Planning, University College London. Fundamental to morphological studies is the belief that in order to understand human artefacts or objects of design, one should study the objects themselves, rather than the methods of design or the predispositions of the designers. In the sphere of architecture, this means studying the buildings themselves. Underlying this view is a certain theory of the relationship between man and environment which requires explanation.

Much of the research into human artefacts, in architecture and the social sciences, has been based on a dualistic philosophy, which draws a sharp distinction between the organism - man - on the one hand, and the physical environment on the other. This has led to what Hillier and Leaman have called the 'man-environment paradigm' (1). The general effect of this paradigm is to stress the 'subjectivity, of human artefacts : since they are the product of human action, they are necessarily seen to spring from mental

states or behavioural predispositions, which they 'express' or 'communicate'. Conversely, if they are detached from human thought and action, the objects are unconsciously treated as part of the natural world and are endowed with a spurious air of 'necessity'. In either case, the result is to empty the artefacts of objective social content. The task of research, within this framework, becomes that of seeking causal relations between environment and behaviour.

Karl Popper has proposed an alternative theory, in which the universe is composed, not of two, but of three ontologically distinct worlds : "the first is the physical world or the world of physical states ; the second is the mental world or world of mental states; and the third is the world of intelligibles, or of ideas in the objective sense ; it is the world of possible objects of thought: the world of theories in themselves and their logical relations; of arguments in themselves; and of problem situations in themselves" (2). The crucial characteristic of Popper's philosophy is that the third world is accepted as having reality or autonomy, while at the same time originating as a product of man's activity. Seen in these terms, the built environment, along with other human artefacts, belongs to the third world of 'intelligibilia'. It follows that the relation of man to artificial environment is in large measure a cognitive relation, and that in order to understand the environment, the paramount task is to analyse the objects of which it is composed. The significant aspects of human thought and action are preserved or embedded in the attributes of the objects.

Herbert Simon has also addressed himself to the study of artefacts (3). His primary concern has been to differentiate artificial or man-made objects from those of the natural world. The former, he argues, should constitute a distinct branch of knowledge : 'the science of the artificial'. As natural science studies the world of natural objects and phenomena, so 'artificial science' studies the world of artificial objects and phenomena (4).

In Simon's thesis, however, artificial phenomena are characterised

by being purposeful and goal-directed ; design tends thus to be equated with rational behaviour, involving evaluation, decision-making, and choice. The argument draws largely on the experience of organisation theory, management science, and psychology. Simon's emphasis on the rational or intellectual aspect of artificiality has the effect of leading him away from the study of the objects as such to the investigation of the design process : to the way in which means are adapted to ends within the frame of an outer environment. He has not attempted for any particular phenomena to define the field of possible or actual objects of design ; nor does he extend his theory to consider man-made objects as embodiments of tacit knowledge.

The programme of the Centre for Configurational Studies focusses on design as the 'science of the artificial', but places emphasis on the representation of designs and of designed objects. It is this theoretical objective, rather than the specific subject-matter, which links the present project to others pursued at the Centre. A further common objective is the use of quantitative methods. A formal approach has been adopted in order to achieve a precise and unambiguous description of the properties under study. This is a precondition of analysis and modelling. Nevertheless, much of the work has been formalised through ordinary language rather than mathematics, and mathematical notation is kept to a minimum in the study. The findings will be presented in all cases by means of a verbal description.

The study has concentrated on the spatial aspect of buildings rather than their material form, as this is considered to be of fundamental importance in architectural and urban structure. The study of space has also been generally neglected in architectural research, which has dealt to a large extent with methods of construction and questions of style (5). At the architectural level, a programme which begins with a morphology of architectural form, and then proceeds to examine the relationship between form and performance, has the attraction, noted by Hawke's, of "offering a more structured basis for the application of traditional analytical research" (6).

We shall be concerned here principally with the arrangement of buildings in space, as opposed to the arrangement of space within the building. But, while at a higher level than the individual building - what may be called the local or meso-level - the study is seen to fall within the scope of architectural or building science, as outlined by Steadman : that is, a science which "should encompass not just the study of building materials, structures and buildings as environmental enclosures, but ... include, and indeed be founded on, the study of the forms and arrangements of buildings - their geometry and their topology" (7).

It will be evident that although we are dealing with buildings and their history, our study is very different from what is conventionally understood as architectural history. History of architecture, in the narrow sense, has confined itself almost exclusively to the aesthetic aspects of building, and has concentrated on the outstanding individual work of art. It has largely passed over the great mass of ordinary building, and has given little attention to plan form and arrangement. Our concern with buildings as artefacts draws us closer in many respects to archaeology. The formal approach owes much to the modern school of analytical archaeology, pioneered by David Clarke.

Inspired by the powerful new quantitative techniques of analysis developed in the social sciences in the 1950's and 1960's, this school sought to restructure archaeology in order to gain full advantage of the mathematical and statistical methods. Clarke attempted to develop a conceptual apparatus appropriate to the analysis of artefacts, which he identified as the central and distinctive concern of archaeology : "The archaeologist is ...studying the concealed and obscure facets of hominid behaviour through the peculiar medium of the fossilized and congealed results of this behaviour, imprisoned in the attributes of ancient artefacts. Archaeology is a discipline in its own right because it alone provides the conceptual apparatus for analysing this peculiar data ; a different discipline and different conceptual apparatus

from that required for the study of history in its limited sense" (8).

Spatial studies, in particular, received great impetus from this work. Clarke claimed a special place for spatial analysis in archaeology : "the retrieval of archaeological information from various kinds of spatial relationship is a central aspect of the international discipline of archaeology, and a major part of the theory of that discipline wherever it is practised" (9).

But, while cognate in its philosophy, analytical archaeology does, of course, concern itself only in very small part with settlement analysis; studies at the urban level are very few. Yet within the environmental disciplines themselves (architecture, planning), the study of settlement form has remained relatively undeveloped, owing to a divergence of interests and approaches : the study of building form and arrangement, having grown up in the field of architecture, has stayed overwhelmingly at the micro-scale (i.e. within-building); urban studies have steadily advanced within the field of planning, but, having been developed mostly by academic specialists from the social sciences, have tended to stress an approach oriented towards the socio-economic aspects of the urban structure, rather than spatial morphology.

One study which has attempted to close this gap is that of Krüger (10). In his analysis of modern Reading, Krüger set out specifically to examine the relationship between two sets of data : the connectivity properties of buildings, on the one hand, and socio-economic data on activity allocation and distribution, on the other. The urban spatial structure was decomposed into a hierarchy of levels, and the connectivity within and between these levels described by means of graph-theoretic representation. A large number of measures were used in the analysis, and were evaluated according to their explanatory power. From these, Krüger was able to conclude that "the connectivity properties are neither random nor deterministic but probabilistic in relationship with the urban spatial structure" (11). By virtue of its cautious, inductive

approach, the study has produced a body of empirical material which opens the way for further, and more theoretical, work. The approach does, however, have a number of limitations, which make it largely inappropriate for the present enquiry. In the first instance, the analysis is static. That is to say, it considers the patterns of connectivity at a single point in time, and makes no attempt to trace the growth and change of those patterns. This does not, however, preclude the introduction of a time component into the analysis. Indeed, Krüger envisages just such a possibility. More seriously, the description of the urban spatial structure embodies certain values and presuppositions which, while valid for most contemporary towns, cannot be applied unquestioningly to an earlier morphology. The hierarchical structure of the street system, and the direct access to the front of each house, are among the most prominent of these socially-specific premisses. The method of representation highlights the inherent difficulty of objectively comparing historic and modern morphologies.

Various attempts to characterise urban development have been made in the field of geography, although morphological work has in general lagged behind that on the functional nature of towns. We may note in particular the work of Conzen (12). His method of evolutionary plan analysis, developed initially for a market town (Alnwick), and later applied to a major city centre (Newcastle-upon-Tyne), provides a means of characterising some of the recurrent morphological phenomena found in historic British towns. It covers a very long time-period, from the Middle Ages to the present day, and therefore encompasses both the continuous, piecemeal growth ('repletion') characteristic of earlier centuries, and the accelerated growth and transformation ('commercial redevelopment') which followed the industrial revolution. It is clearly a method with wide application.

Like Conzen, we shall be concerned with the process of morphological development. But our aims are somewhat more limited, in that we shall be dealing only with piecemeal or incremental growth, and will not attempt to give an account of the transformative developments of

later centuries. Moreover, while working within the context of the town plan, the emphasis will be on the physical aspect of the developmental process, and the way this operated at the local level. The unique importance of London in the Middle Ages - it was the only city of major international standing in England - also created peculiar conditions which warrant special attention.

Within the fields of London history and archaeology, a number of recent studies have focussed on questions of urban topography and building development. Power has examined the growth of building in the eastern suburbs during the late sixteenth and seventeenth centuries (13). Working from a variety of documentary sources, he has traced the development of land beyond the walls, owned originally by the lord of the manor or by ecclesiastical authorities, and provides much useful information on the kinds of buildings erected, their size, construction and occupancy.

Keene's current study of mediaeval London (14) aims to build up a picture of the early evolution of the City from a detailed topographical study of the sample area - five parishes at the eastern end of Cheapside - for the period from the thirteenth to the seventeenth century. The changing pattern of property boundaries and the histories of individual buildings are being reconstructed by reference to all records of property holding in the City up to 1666.

Schofield's study (15), also concurrent with this one, focusses on secular building in the City of London from c.1300 to c.1550, the object being to compile a substantial body of information on buildings throughout the City by reference to approximately 200 plans and documentary sources. The work draws to a considerable extent on source material also used in this study - most notably the early seventeenth-century surveys of London houses drawn by Ralph Treswell (see chapters 3 and 6) - but has concentrated on a detailed reconstruction of the form and the histories of individual properties.

Each of the foregoing studies considers the spatial aspect of buildings, to a greater or lesser extent, as well as their material form. However, there has so far been little attempt at spatial analysis, save in a fairly informal and intuitive fashion. By applying a more formal approach to analysis, and by generalising, a posteriori' from the historical evidence, it is hoped to gain a deeper insight into the 'laws' of spatial arrangement. In so far as the spatial relations with which we are dealing are a social product, an embodiment of collective patterns of human thought and action, it is further hoped that some light might also be cast on social attitudes and values - the taken-for-granted ideas on spatial propinquity and privacy, which are so elusive in any historical research.

Since we are concerned with an historical process, reconstruction of context forms an integral part of the study. For this we have drawn mainly on documentary sources. The specific function of the documentary study has been to augment the information on buildings provided by the maps and drawn surveys, and to discover something of the landowners, on the one hand, and the builders and their methods of work, on the other. More generally, it has been used to reconstruct, albeit in a simplified or idealised form, the social and demographic background - the conditions which generated the demand for building. The latter is based mainly on secondary sources. This contextual study can be identified with what Popper has called the 'problem situation' (16). That is to say, it is the meta-problem within which the problem of building design and arrangement will be addressed.

In pursuing the research, advantage has been taken of the exceptional computer facilities available at the Design Department. A computerised model, constructed specifically for this project, has been used to simulate the patterns of building development under study. The computer simulation has been helpful in two related ways: as a check to intuitive judgements, both conscious and unconscious; and as a means of exploring fully the spatial consequences of various combinations of rules and constraints. In

the dialogue between empirical evidence and critical theory, externalisation of assumptions is of vital importance; the discipline imposed by the computer program was found to be a particular aid to the explicit formulation of organisational properties, and thus to their critical testing. The experience of this study suggests that the problem lies much less in the possibility of the posited rules being totally inaccurate, than in their being partly inaccurate, distortion being introduced through selectivity or additional (hidden) assumptions. Through successive cycles of hypothesis and test, the aim has been to correct the initial theories and assumptions, and then to refine of 'tune' the model to achieve a close approximation to the 'real world'.

It is necessary to say, finally, that while the present study was motivated by an interest in the historical development of London 'per se', it has also been used to explore an empirical approach which, it is hoped, can be applied to other historical morphologies. In view of the present dearth of spatial information, at both the architectural and the settlement level, it would seem that to widen and deepen the range of empirical studies is of the first importance. It is hoped by the following to take a step in that direction.

PART I

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**HISTORICAL BACKGROUND -
GENERAL DESCRIPTION**

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1. The City of London

The subject of this study is the City of London : not the vast metropolis, over 600 square miles in area, which today constitutes the Greater London Area, but its historic core, an area of little more than a square mile on the north bank of the Thames. London was founded by the Romans, and was designed from the first as a seat of government and administration. It was thus unique. Unlike other towns in Roman Britain, it served no local purpose ; it was neither a fortress nor a garrison town. Its role was the government and administration of newly-conquered lands. Morris has written : "the site was chosen because it was the most apt for the needs of government, the most convenient centre for the natural communications of Britain ; and for that reason it also became the main centre of commerce. But from the beginning, its prime purpose was political rather than commercial ; and so it has ever after remained" (1).

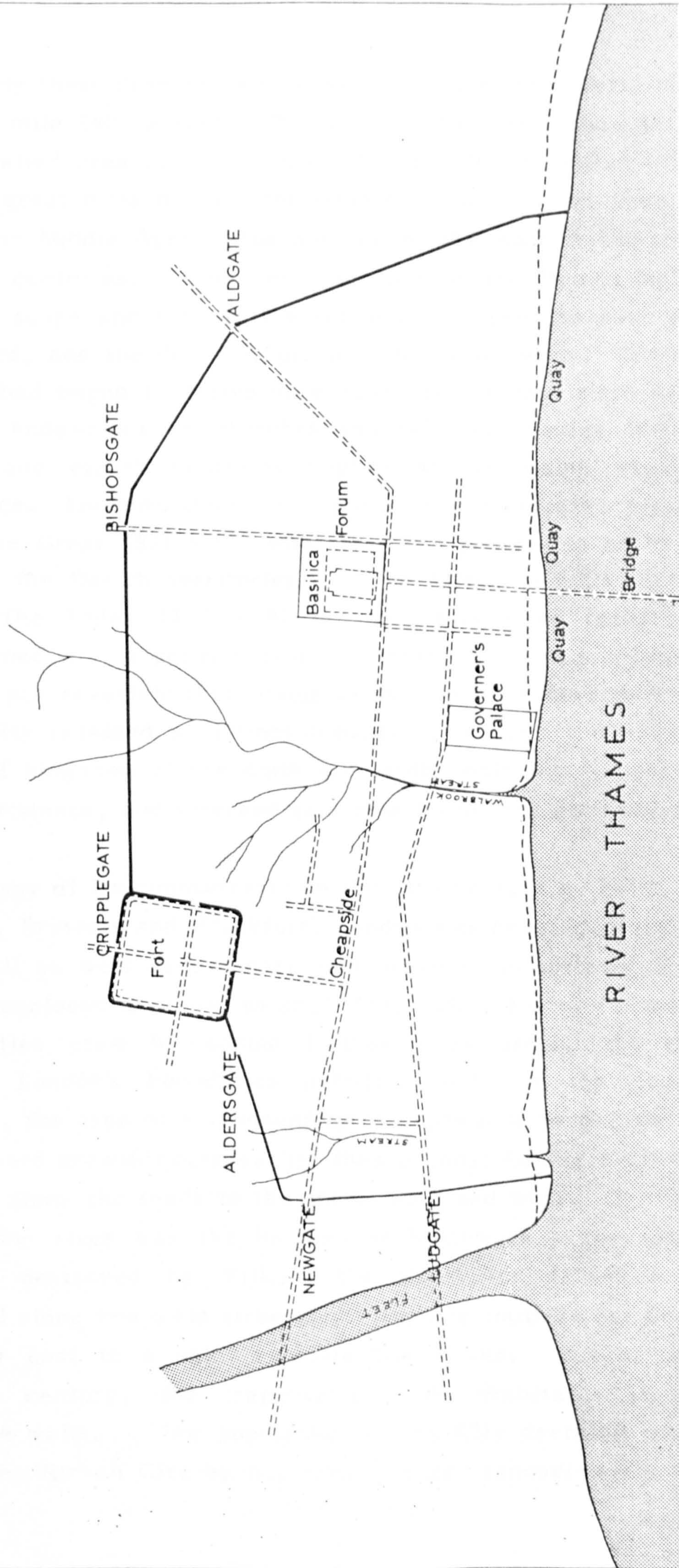
The City was placed at the lowest crossing place of the Thames, the original bridgehead being perhaps some way downstream from the present London Bridge. It would appear that the bridge came first, and the City grew up as a consequence of this. Although various authors have argued for the existence of a pre-Roman, British London, around which the Roman town was formed, there is little reason to believe that such a settlement existed. While the earlier colonists, the Belgae from Gaul, undoubtedly created roads and opened up the London region to the movement of men and goods, there is no evidence to suggest settlement on any scale (2). Both archaeological excavation and documentary evidence indicate that the Romans were the first to populate the region. Moreover, the Roman town did not grow in a gradual and piecemeal fashion, but was laid out in accordance with a definite plan within a few years of the building of the bridge (3). The formal foundation took place perhaps in the year 48 AD.

London was built around two low hills : Cornhill and Ludgate Hill.

area north of the City, later known as Moorfields, to the Thames at Dowgate (see figure 1). Its course was short, broad and shallow, spreading a thick deposit of alluvial mud: the ground in the upper reaches was so boggy that it remained largely uninhabitable until late mediaeval times. Further west ran the Fleet, a longer and stronger river, which entered the Thames at Blackfriars.

The principal roads were laid out in the first century. There were two main roads, running parallel in an east-west direction, one leading from the southern edge of the Roman citizen area westwards across the Walbrook to the Fleet at Ludgate Circus; the other, to the north, leading from the north-west corner of the settled area, on the Walbrook by Bucklersbury, westwards towards Oxford Street. When the City was later walled, gates were placed at the points where the wall crossed these roads, and, taking the names of the gates, the routes may be referred to respectively as the Ludgate and Newgate alignments (4). These were the 'base-lines' of the Roman town; they determined the orientation of the majority of Roman buildings and roads, and both left their imprint on the later street pattern. The Ludgate alignment is preserved in the modern Cannon Street. The Newgate alignment survives in Newgate Street and the western end of Cheapside (5). At its Cheapside end the course of the Newgate route deviated slightly to accommodate a road running south from Cripplegate fort, which it met at right angles. The northern section of this north-south Roman road is preserved in Wood Street.

The City was eventually walled in by the Romans as a defence against attacks from the north. The exact date of building of the walls is uncertain, and views have changed dramatically in recent years in the light of new archaeological evidence. Present evidence argues for a date of construction early in the third century (6). The City wall forms roughly a semi-circle, about two miles in length, from Blackfriars on the west to the Tower on the east. It is now known that the City was also closed off on its south side by a riverside wall, built possibly in the late fourth century (7). The riverside wall had been destroyed by erosion by the twelfth century. The area



— Town wall c. 200 A.D.

--- Roman road

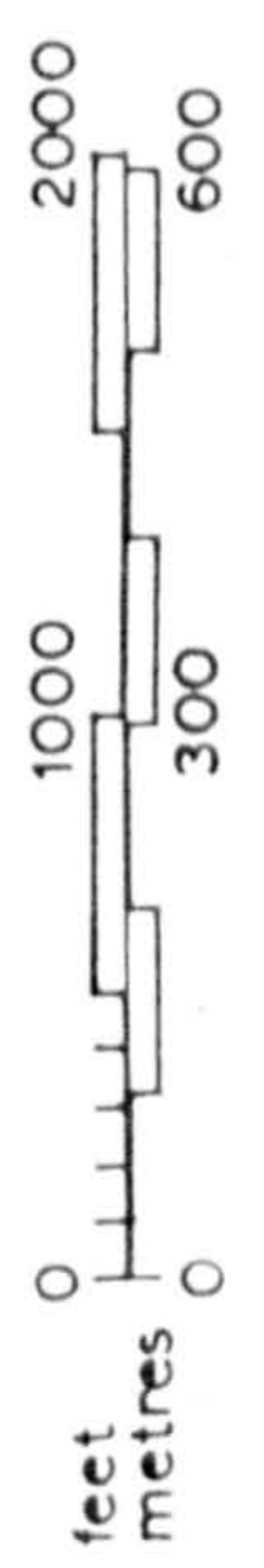


Fig.1.1. Roman London

bounded by these defences was small : approximately five-eighths of a square mile (400 acres). This was a little larger than one-tenth of the walled area of third-century Rome. It was within this area that the great mass of the population continued to live down to the end of the Middle Ages. The position of the walls barely changed over the centuries. After the departure of the Roman legions in 410, the scope and size of the settlement appear to have greatly contracted, and the defences probably fell into decay. But market activity had begun to thrive once again by the late sixth century, and the endowment of churches and religious houses during the seventh and eighth centuries implies an increasing wealth and importance. London's strategic importance was certainly grasped by Alfred the Great (871-899), who fixed the boundaries between the City and the Danish territories. Under Alfred and his successor, Edward the Elder (899 - 924), the walls were repaired and strengthened and a regular grid of streets laid out. Although it had not yet re-established itself as the seat of government, the walled City retained a distinct identity. Through the waxing and waning of kingdoms of the ninth and tenth centuries, it maintained its independence, and emerged as a clearly-defined political unit.

Unlike many of its counterparts on the continent, e.g. Paris, Aix-la-Chapelle, Brussels and Frankfurt, London was never confined by an outer wall as well as an inner fortification, in spite of the fact that the enclosed area was so small (8). While Paris, Cologne, and other cities grew by adding further rings around the original nucleus, London's boundaries petrified and, as the population expanded, the area of settlement spread outwards beyond the walls. This outward growth began earlier than in most European cities, and extended along the roads to the north, east and west. On the south side of the river was the Borough of Southwark - the suburb of 'Sudvirki' destroyed by William the Conqueror (1066) - which developed along two main streets, one running south to St. George's, the other east to a point opposite the Tower. But in the late sixteenth century, the majority of the inhabitants still lived within the walls. The population of the City certainly exceeded that of the Roman City by this time ; it was approximately 150,000

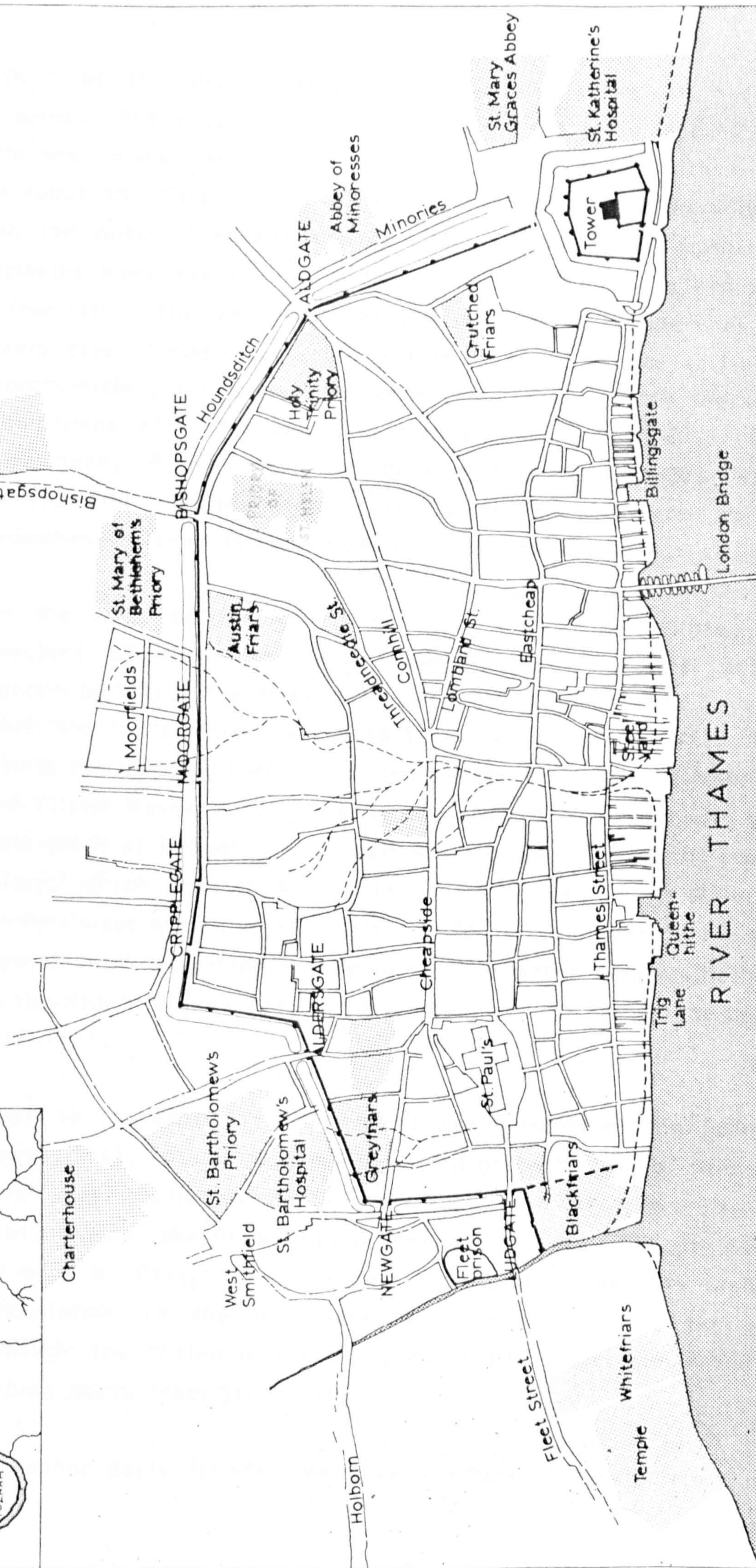
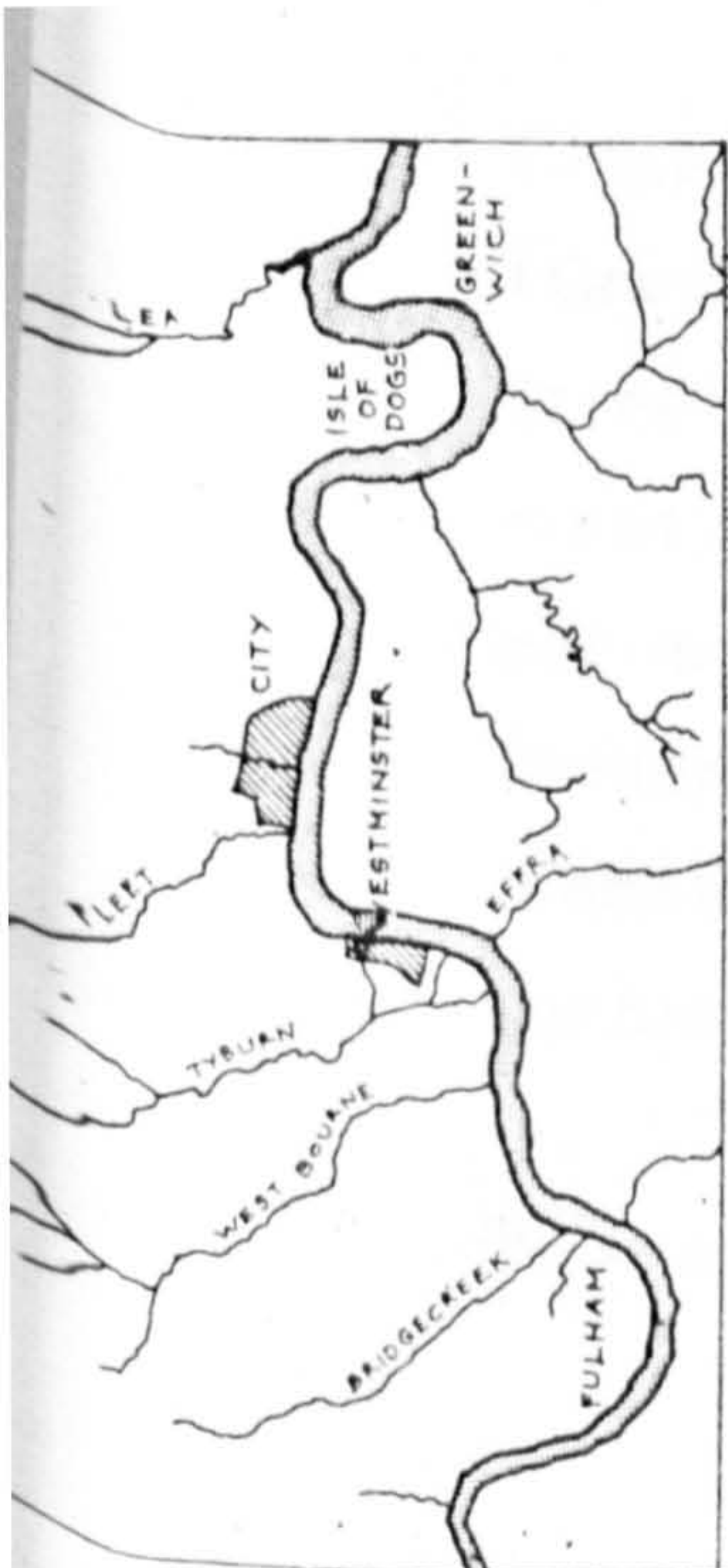
in 1590. The third-century population had been perhaps 100,000 (9).

From the Middle Ages to the present day, London has had two poles : the City and Westminster. Westminster became the political capital of the kingdom, while the City emerged as the centre of commerce and finance. Westminster was founded upstream from the City, on the stretch of gravel known as Thorney Island, where the Tyburn joined the Thames (see inset to figure 1.2). Its name - western monastery - was taken from the church of St. Peter, founded at some time in the dark centuries between the departure of the Roman legions and the Norman Conquest, perhaps in the seventh century, and later incorporated in Westminster Abbey. The church of St. Pauls in the City is said to have been founded in 604 by Aethelbert of Kent. King Canute was reputedly the first king to reside at Westminster (10). But it was Edward the Confessor (1042-1066), who first built a palace there, next to his abbey (completed 1066). William the Conqueror was crowned in Westminster, and the primacy of the king's court there was finally established when the Exchequer was transferred from Winchester in the reign of Henry II (11). Westminster thus had a peculiar character, evolving from a court suburb into a seat of government. Because of this, and its relatively late development, it will be largely excluded from the present study. The Borough of Southwark, a predominantly poor suburb, noted in Elizabeth's time mainly for its theatres and bear gardens, will similarly feature only marginally in the analysis.

The layout of the mediaeval City is shown in figure 1.2. The wall was punctuated by seven main gates, nearly all of which were on the site of Roman predecessors. From west to east these were : Ludgate, Newgate, Aldersgate, Cripplegate, Moorgate, Bishopsgate, and Aldgate. Outside the wall ran a ditch or moat, and inside there was a rampart. As both the ditch and the rampart were common land, they were progressively encroached upon by buildings towards the end of the Middle Ages. It is important to emphasise that the mediaeval City, the centre of trade and commodity exchange, was the place where people lived as well as worked. Shopkeepers and tradesmen



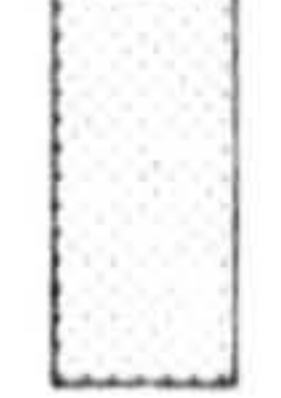
normally worked in their own house ; the separation of home - the place for eating, sleeping, and bringing up children - from workplace or shop did not come about until very much later (beginning in the eighteenth century).

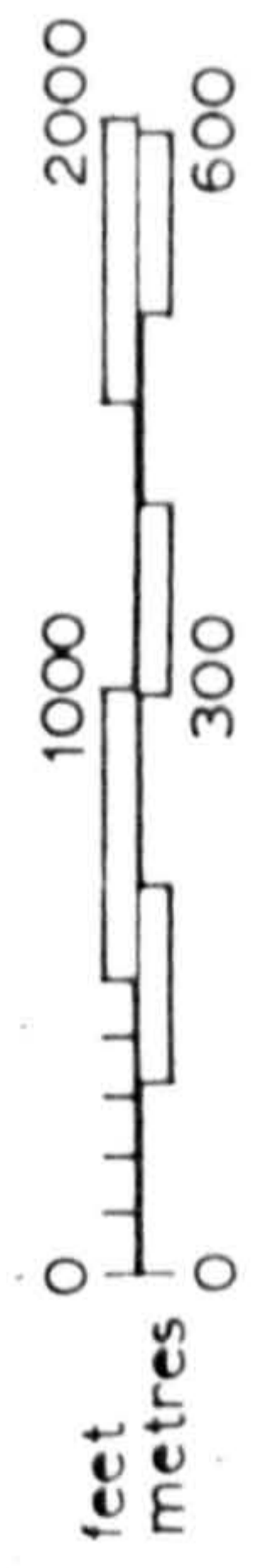
Fig.1.2. Mediaeval London



RIVER THAMES



-  City wall
-  Line of waterfront c.1300
-  Religious Precincts



Much of the space within the walls was therefore occupied by houses. But around the main inhabited area lay a ring of Religious Houses, whose precincts covered extensive areas both within and without the City walls. This 'suburban' ring acted as a constraint on the outward growth of the City. Monasteries, hospitals, and friaries were established in large numbers during the two centuries after 1100. The lands they occupied were private franchises, exempt from civic jurisdiction. They formed more or less self-contained communities, surrounded by walls which enclosed the precincts and sometimes also the adjoining streets and lanes (12). As noted elsewhere, "They possessed their own water supply, legislative centre (the chapter-house), bakehouse and infirmary, as well as churches as large as contemporary cathedrals" . (13).

To the west of the City, immediately beyond Ludgate, lay the precinct of the Dominicans (Blackfriars), who first settled in London in 1221. The friars removed from Holborn to the Ludgate site when the lands were granted to them by Edward I (1278). Included within the precincts were two strongholds, the Tower of Mountfitchet and Castle Baynard, which were demolished, together with the City wall south of Ludgate. The wall was subsequently rebuilt around the friary, which took in all the land as far west as the River Fleet. Further west were the Whitefriars, who occupied land to the south of Fleet Street, adjoining the Temple. The latter was originally owned by the Knight's Templars, but later became "the homestead of English Law" (14).

Close to Newgate lay the chapel and grounds of the Franciscans (Greyfriars), whose property extended on both sides of King Edward Street, originally called Stinking Lane from its proximity to the meat market, the Shambles, in Newgate Street. The site was later occupied by Christ Church (Christ's Hospital), the City orphanage. Immediately to the east was St. Martin-le-Grand, the earliest monastic foundation in the City, whose name survives in the street running north from St. Pauls.

Two other early foundations were St. Bartholomew's Priory in West

Smithfield, and Holy Trinity Priory, Aldgate. Adjoining the former, to the north-west of the City, was the twin foundation of St. Bartholomew's Hospital. The Augustinian priory of Holy Trinity, Aldgate, located within the walls on the eastern side of the City, was the wealthiest of London's monasteries. It was founded by Queen Maud or Matilda, wife to Henry I, in 1108. In 1115 the Cnihtengild, possessors of the ward of Portsoken, the eastern 'ward without', presented to the priory all their rights, and the prior became 'ex officio' an alderman of London. It may be noted incidentally that the Cnihtengild, in spite of what its name might suggest, was not a body of knights. The old English word 'cniht' meant a servant or retainer, and it seems likely that the original gild members were responsible servants of magnates owning property in London. By the twelfth century, however, the gild had become an association of independent traders (15). Although the priory has now almost completely vanished, a piecemeal archaeological reconstruction is in progress and promises to yield much new information on the layout of buildings (16).

Situated to the east of Holy Trinity, outside the City wall, was the Abbey of the Nuns of the Order of St. Clare, who gave their name of Minoreesses to the street running south from Aldgate to the Tower. To the south lay St. Mary Graces, the Cistercian abbey, on the site now occupied by the Mint, and next to the Tower, by Thames-side, was St. Katherine's Hospital. The latter differed from most hospitals in being a community of master of brethren; this was true also of St. Thomas of Acon, north of Cheapside, and St. Anthony's, in Threadneedle Street (17). Altogether, there were twenty-three major Religious Houses in and around the City. They retained their lands until the 1530's, when the Crown confiscated all the revenues of the monasteries and chantries. In the ensuing period the great mass of the property was thrown on to the land market, and was rapidly developed for residential use.

Much of the land within the City walls was held by ecclesiastical institutions of one sort or another. The monasteries had large property holdings in the City besides the precincts of the

conventual houses themselves. And the Church was omnipresent in mediaeval London: there were 126 parishes, each with its own church. A considerable proportion of the population gained their livelihood, either directly or indirectly, from the religious institutions.

On its south side the City is bounded by the river from the Custom House to Blackfriars. Morris has remarked that waterways were all important in the economy of antiquity (18). This was scarcely less true in the Middle Ages, overland travel being slow, difficult and often costly. The Thames was thus the focal point of London life. Its principal role was mercantile; London had grown by the later Middle Ages into a port of international standing, the hub of commerce and trade in England. Goods came both upriver from the Continent, and downriver from the Upper Thames. The waterfront was in consequence densely developed, with wharves and quays at which the goods were unloaded and stored. Among the most important quays were Billingsgate, Steelyard, Dowgate, Vintry, Queenhithe, Trig Lane and Baynard's Castle, all of which lay between the Tower and the Fleet. Trading activities are known to have existed before the Conquest, the earliest documented reference relating to Queenhithe in 899. Billingsgate is recorded as a haven from about 1000, and undoubtedly existed before that time. Foreign merchants operated from Dowgate in the time of Edward the Confessor. These three were the earliest centres, and development seems to have radiated outwards from these nodes (19).

By the early fourteenth century the waterfront was extremely prosperous and contained the wealthiest areas of the City. The riverside south of Thames Street was 'zoned', i.e. divided along its length into several and distinct areas, each devoted to a particular type of commodity. The Billingsgate and Bridge wards were the centre for fish and for wool. Dowgate was an international landing place, the headquarters of the Hanseatic merchants, Queenhithe, the Ethelredeshithe of early records, was the corn market. Vintry was the axis of the Anglo-Norman wine trade. It seems that most merchandise came through a small number of accredited hithes (the

'legal quays' appointed in the Act of Parliament, 1559). Thames Street, which originally coincided with the edge of the riverside, was lined with shops which were places of sale as well as storage. The Stockfishmongers (purveyors of dried fish), among others, held property there. But much of the produce was sold away from the waterfront, in the numerous market streets of the City, some of whose names record the commodities sold, e.g., Old Fish Street.

Two main types of trades were located along the waterfront: those such as the fishmongers and shipbuilders, whose work was bound up with river; and those, such as brewers and dyers, which produced noise or stench, and were thus found increasingly unacceptable elsewhere. It appears that the latter trades had largely supplanted the former group by the end of the sixteenth century (20). Recent archaeological excavations along the riverfront, at Trig Lane and elsewhere, have revealed timber and stone revetments, indicating that there was a steady reclamation of land from the river during the later Middle Ages. It now appears that the Thames reached its furthest point by the end of the late Saxon period, and that thereafter, from the eleventh to the sixteenth century, piecemeal land reclamation advanced the north bank from 50 to 100 metres southward (21).

In addition to its commercial function, the Thames played a vitally important part in local transport. The general condition of roads was so poor that the river was used for everyday travel in a way that is not easy to imagine today. According to Brett-James, the river was a normal way of approach for all foreigners, "who left the roads at Gravesend or Greenwich and proceeded to Westminster by water" (22). Within the City itself it was often easier to travel by boat, even over short distances, than to make the journey by road. Many of the lanes were too narrow to accommodate wheeled traffic, and even major streets were liable to be blocked by market stalls and other obstacles. Pigs still roamed the streets in the thirteenth century (23). The usual practice was to take a ferry from one of the jetties or 'stairs'. There were about 2000 rowing boats or 'river taxis' in Elizabethan London, plying regularly up

and down river. This aspect of London life is well illustrated on 'Agas' and other contemporary map-views (see chapter 3 below). (24). The tributaries of the Thames - the Fleet and the Walbrook - also served for commerce and transport, but both became choked with rubbish and sewage. The Fleet was covered over in 1539, and although it was dredged and made navigable again after the Great Fire (1666), attempts to revive commerce were unsuccessful. The Walbrook was entirely bridged over or covered with buildings by 1600.

Some of the principal streets of the City should be noted. Cheapside, on the Newgate alignment, was the main shopping street of the City (Anglo-Saxon 'cheap' = market), and was apparently of international repute even in the early Middle Ages. Many commodities were sold, but western Cheapside was especially noted for exotic articles, spices, and textiles. Trade was carried on in shops, stalls, and in large warehouses called selds. The street was also the scene of jousting tournaments, festivities and parades. One tournament, held in 1331 in the reign of Edward III, had calamitous results. In order to provide the spectators with a better view, a wooden scaffolding had been specially erected, "across the street like unto a tower wherein Queen Philippa and many other ladies richly attired and assembled from all parts of the realm did stand to behold the jousts; but the higher frames on which the ladies were placed, brake in sunder, whereby these were with some shame forced to fall down, by reason whereof the knights and such as were underneath were grievously hurt" (25). Various prints, paintings and engravings survive which show processions along Cheapside, e.g. the coronation procession of Edward VI, 1547, and that held on the occasion of Marie de Medici's visit to London in the time of Charles I (1638).

At its western end, Cheapside led off to the north of the enclosed precinct of St. Paul's. Towards the east the line was continued by Poultry as far as the Walbrook, where it separated into three main streets: Threadneedle Street, Cornhill, and Leadenhall Street. The first led north to Bishopsgate, the last two eastwards to

Aldgate. The Roman Ludgate alignment was represented by a series of roads: Watling Street, Budge Row, Candlewick (Cannon) Street, and Eastcheap (the eastern market place).

To the north of Cheapside, between Aldermanbury and Bassishaw Street, was the Guildhall, the seat of government of the City. This was the meeting-place of the City Council, whose members were elected by the wards. In order to provide a more impressive approach to the Guildhall from the river, a new street was created after the Great Fire, running north-south across Cheapside. The northern section was called King Street, the southern part Queen Street.

London had many markets. Apart from Cheapside, Eastcheap, and the Shambles (Newgate Street) already mentioned, the most important were the Stocks and Leadenhall. The Stocks, erected after the Great Fire, occupied a part of the site on which the Mansion House now stands, and was frequented by poulterers, butchers, and fishmongers. Leadenhall market, further to the east, sold butchers' meat and leather. To the north-west of the City was West Smithfield, the great livestock mart. By the seventeenth century, the demand for meat had led to the creation of a national network, whereby cattle were driven 'on the hoof' to grazing pastures in Gloucestershire, the South Midlands, Norfolk, Hertfordshire, and Essex, and subsequently sold to the City butchers at Smithfield.

Outside the City wall roads radiated from the gateways, e.g. Bishopsgate from Bishopsgate, Whitechapel from Aldgate. The only exception to this was Cripplegate, where there was no road leading north, but a suburb or small settlement centring on St. Giles, Church. As a result, a Fore Street grew up, running east-west outside the wall. To the north was Chiswell Street and, linking this to Fore Street, White Cross Street and Grub Street (later renamed Milton Street). St. Giles' Church now lies at the heart of the Barbican development. Extramural streets such as Houndsditch and Old Bailey, running parallel to the City wall, appear to have originated as tracks along the outer edge of the City moat (26).

Although the mediaeval population was concentrated within the walls, the City had already overflowed its boundaries before the sixteenth century. Ribbon development along the main approach roads and extramural clusters or groupings of houses expanded and coalesced to form suburbs to the north, west and east of the City. A similar development took place to the south of the river in Southwark. The suburbs bordering on the City were finally incorporated as 'liberties', and their limits were marked by bars. Thus, outside Ludgate was Temple bar, outside Newgate, Holborn bars, outside Aldersgate, Aldersgate and Smithfield bars, outside Bishopsgate, Bishopsgate bars and, outside Aldgate, Aldgate bars. Once absorbed, the liberties were no longer suburbs, but came within the jurisdiction of the City.

The palace of Westminster acted as a powerful attraction westwards, and from the twelfth or thirteenth century, a continuous and busy suburb extended two miles west of London (27). The Strand was especially favoured by nobles and members of court. The present 'Savoy' hotel takes its name from the palace built along the Strand by Peter of Savoy in the thirteenth century. A series of stately buildings was erected with fine gardens stretching down to the river: the Strand became "the faubourg of the aristocracy" (28). From the sixteenth century, the well-to-do increasingly left the City to settle in the more fashionable and salubrious areas to the west. Since the prevailing winds blew from the west, the move enabled them to escape "the fumes, steams, and stinks of the whole Easterly Pyle ..." (29). To the east of the City, the opportunities for work afforded by the naval and mercantile development of Stepney drew the manual and labouring classes to this district. Thus, there grew up that social division between the west and the east ends of London which has persisted to the present day. The north of London had no comparable centre of activity to pull the inhabitants in this direction. Growth was therefore slow, but accelerated after the abolition of the monasteries in the 1530's. During the seventeenth century, suburban development stretched northward as far as Old Street and beyond.

The seizure of monastic lands removed the final obstacle to the outward expansion of the City. Thereafter it could extend freely: suburban settlements grew and crystallised into boroughs and, as the middle ranks of society followed the wealthiest citizens in moving westward, a steady westward slide of London's rich took place. But there was no formal extension of the City limits beyond the bars. Hence, the mediaeval boundaries remain to this day.

The street pattern of mediaeval London has also remained largely intact over the centuries; the modern streets, though straighter and wider, generally preserve both the names and the alignment of their predecessors. The main road improvement schemes of central London were all completed in the years between 1830 and 1870 (30). Only two impinged on the area within the City walls: Queen Victoria Street and Cannon Street. The former, which represented an eastward extension of the new Thames Embankment, took a diagonal course between Blackfriars and the Mansion House, cutting through the densely built-up areas to the south of Little Knight-riding Street and Old Fish Street. The Cannon Street scheme involved the enlargement and westward extension of the mediaeval street of that name, to provide a direct route from King William Street to St. Paul's. To the west of the City, the major north-south route of Farringdon Street was built over the Fleet Canal.

The continuity of the street pattern is surprising in view of the dramatic architectural transformation of the City in the post-war period, following the introduction of daylighting and other building controls which sought to promote 'vertical planning' and the creation of open space at ground level. The persistence of the old layout is clearly due to the high commercial value of frontage at street level which, as Hawkes has observed, "has encouraged developers to cover the whole of their site area with one or two storey podia upon which the tower or slab block stands. The effect of this on the city form has been to consolidate existing street patterns and the possibility of changing this, which was implicit in the thinking behind the design of the control techniques, has seldom

been realised" (31).

Under the London Government Act of 1963, the areas of Middlesex, Essex, Surrey, and Kent which had been absorbed in London's growth, were subsumed under the County of Greater London. The new Boroughs of outer London combined with those of Inner London to form a single local authority. Within the County, the City of London remains a distinct entity, defined by its mediaeval boundaries.

2. Historical Background

Since our principal concern is with the morphological or spatial development of the City rather than its social or economic development, we shall not adhere rigidly to the time-periods established by historical scholarship. Many of the spatial characteristics of the City clearly persisted well beyond the Middle Ages. The study will, however, address itself chiefly to London in the late mediaeval period. This may be defined for present purposes as the period from the end of the fourteenth century to the end of the sixteenth century. In order to proceed, it is necessary to have a clearer picture of the social and economic background to London's development in these centuries. In the first section, some of the main developments of the later Middle Ages will be outlined. The second section will describe some of the social changes that took place during the seventeenth century. It is from this later period that much of our source material will be drawn.

2.1. Mediaeval London

London's uniquely independent status has already been pointed out. This status is bound up historically with the power of the merchant class, and is founded on wealth. The City was already a thriving centre of trade by the eighth century, when it was described by Bede as a market ('emporium') of many nations coming to it by land and sea (1). The citizens were a privileged group, and evolved a distinctive and fairly centralised form of organisation. They had a general assembly, the Folkmoot, under the bishop and the portreeve, and a weekly court, the Husting. The twenty-four administrative wards were governed by aldermen, a traditional and select group of law-men (2).

When William invaded England in 1066, he found two cities of especial importance : the royal city of Winchester and the commercial City of London. Winchester surrendered without resistance, but London, with a sizeable population (perhaps 20,000

people), the river, and the defensive walls, presented a more formidable prospect, and William withdrew after burning Southwark, making his way westward to Berkhamstead. There he received a deputation of Londoners, who informed him that London had recognised him as their king. He was subsequently crowned at Westminster. Thus the City was not conquered; it had acknowledged and approved of the king. The right to elect the king was later exercised by the Londoners (the election of King Stephen in 1135) and, to a certain extent, it has continued to obtain.

The Domesday Book, drawn up in 1086, was the first complete survey of England, and specified the acreage of land, persons, cattle, and everything that was of account in the collecting of revenue. But, significantly, London and Winchester were both excluded from this record. In London, instead of imposing a new feudal authority on the townspeople, William granted them privileges in a charter, which expressly confirmed their established rights and customs. But while appeasing the merchant population, he also began building a series of strongholds on the edge of the City: the enclosure that was later to become the Tower of London on the east, Baynard's Castle and Montfitchet Tower on the west.

This carefully measured relationship with the City remained a feature of royal policy under the Angevin (Norman) kings. The special favours that were granted must have stemmed in part from a desire to avoid conflict with the community. But they were also a means of obtaining money, a matter of great importance in the Middle Ages. In the absence of an over-arching state authority, the responsibility for undertaking and financing large-scale projects devolved largely on individuals, and above all on the Crown. At the same time, the want of banking institutions made the acquisition of large sums of money extremely difficult. As a result, the mediaeval kings looked to all places where money accumulated. The towns provided a ready source of revenue, and the granting of charters was a convenient means of obtaining this. William and his successors granted a series of charters confirming the existing rights of citizens of London, or conferring new ones, and for each of these

they levied large sums.

Another way of procuring money was through the Jews. The Jewish population was a race apart, existing within society but effectively separate from it (3). Their principal calling in this period was moneylending, which they pursued under the protection of the king. They were, in fact, considered as part of the personal property or 'chattels' of the king, to be carried by him wherever he went, and even pawned 'en bloc' if he so desired. The Jews had freedom in their investments because they stood outside the authority of the Church and could not, therefore, be brought before an ecclesiastical court for usury. They became, as a consequence, the principal moneylenders in society, and accumulated great wealth. Aaron of Lincoln is thought to have been the richest man of his day in terms of liquid assets. He was one of the developers of contemporary London (4). Gathered together in special quarters, the Jews were an important source of income for the king, and in times of dire need he might confiscate a large part of all their property (5). William I brought his own Jewish community with him from Normandy, and settled them in the northern part of Cheap. The area can be identified from the names of certain streets and churches to the south of Guildhall, e.g. Old Jewry, St. Lawrence Jewry. The Great Synagogue appears to have been in Ironmonger Lane.

The various attempts by successive kings to obtain money from the London citizens were seen by them as a despotic encroachment on their rights. The granting of royal charters appeared as an arbitrary act of authority, since the king was free to decide the sums he levied and the use he made of the money. The growing centralisation and strengthening of state power, particularly marked under Henry II, were finally countered by the people. In the turbulent years of the late twelfth century, they seized on the opportunity to take control of their own affairs: they formed a Commune (6). As Gwyn Williams has remarked, the logical end of their endeavour was a 'seigneurie collective populaire' in the French manner, a sworn urban community with its own judicial personality, existing in feudal relationship with the monarch (7).

Full independence was not achieved, but London established itself as a corporate body in 1191.

The thirteenth century saw two decisive events : the signing of the Magna Carta in 1215, and the commencement of the British Constitution in 1265. When the barons, indignant at King John's usurpation of power, began their attack in 1215, they found willing allies among the Londoners. The Magna Carta obtained from King John decided the Commune's place in the national community. Although it lacked the full fiscal and seigneurial independence of some of the European communes, its citizens were a sworn association with a communal seal, and had the right to elect their own mayor as representative of the City (8). Henry Fitz-Ailwyn was the first Mayor of London. He held the office for approximately twenty-five years, and the first building regulations of consequence appeared during his time of office (1189).

But the conflict between the citizens and the king was fully resolved only with the emergence of a new form of government, the Parliamentary system, in 1265. This was precipitated by King Henry III's abuse of the privileges of the City. The people rose up and took arms behind Simon de Montfort, a powerful noble and brother-in-law to the King. Henry was defeated at the battle of Lewes and taken as a prisoner to St. Paul's. The first Parliament was formed in which Commons were officially represented. Although this was soon to collapse, the system was revived under successive kings, and the Commons were henceforth regularly convened to Parliament. The thirteenth century was thus crucial to the shaping of the social and political structure of the City : it was mediaeval London's "age of iron" (9). "Parliament and the merchant class took shape within the framework of strong monarchical control, and it was a nation approaching maturity which, in the mid-fourteenth century, launched on a career of political and commercial aggrandizement" (10)..

Of central importance in the mediaeval City were the guilds : communities of traders and artisans drawn together by common interest. Under the Plantagenets, each of the trades - goldsmiths,

merciers, skimmers, drapers, ironmongers, etc., - found a separate and distinct place (or places) in the City. This localisation of trades, which is a striking feature of mediaeval London, was characteristic also of many other cities, e.g. Paris, Bruges. Guild organisation was thus not peculiar to London or even to England : "Throughout Western Europe till the close of the 18th century the control of trade and industry was largely, in some countries mainly, in the hands of the guilds"(11). The English guilds achieved a much greater degree of wealth and social importance than continental guilds, but their trading monopolies fell much earlier into desuetude. Unwin, the noted historian of the guilds, considered them to have laid the foundations of the social and political system of Western Europe : "the western guild in its various forms and in its subsequent developments, has been one of the main instruments of what we call progress, the progress which distinguishes the West from the East" .(12).

The earliest guilds, which date back to the ninth century, were religious and social organisations, providing succour in old age and sickness. But the connections between these and the later 'craft' guilds are wanting. The craft or trade guilds which emerge in the late twelfth century had many facets, but were clearly driven forward principally by economic motives. Each craft sought to impose monopolistic limitations on its particular branch of trade - at a local level at least - and to formalise its control by elaborate rules and regulations limiting the commercial activities of rural residents or citizens from other towns. At the same time, strict and detailed regulations were laid down concerning the admission and behaviour of members. A typical example is provided by the Hatters, whose ordinances of 1348 laid down "that six lawful men should be sworn to govern the trade, that none but freemen should be allowed to make or sell hats, that apprentices should serve for a period of at least seven years, and, finally, that the governors of the Company should be empowered to search for and punish vendors of defective wares" (13). Nearly all trade regulations followed the same pattern. For legal recognition the sanction of the Crown was necessary, but courts were set up and

ordinances made long before charters of incorporation were granted. There also arose during the twelfth century a great many unlicensed or adulterine guilds, which were disowned by the Crown (14). Their organisation was in all essential features the same as that of the crafts.

The growth of the craft guilds was intimately connected with the crucial changes in London's social and political structure, for it was the guilds that represented the rising middle class. The word 'craft' which was widely used in contemporary documents in reference to the guilds, may in this sense be somewhat misleading, since it did not necessarily denote manual work. A craft was a trade or calling generally. As Unwin has noted the "typical member of a craft was a well-to-do shopkeeper, a tradesman", and the full master of a craft "was from the first always a trader" (15). Some of the crafts, e.g. the mercers, grocers, goldsmiths, fishmongers, and vintners, were predominantly mercantile ; in general, it was the mercantile guilds that formed the upper level of the craft community. The strength of the merchant class increased as commercial expansion reached a peak, and this brought it into conflict with the established elite.

Although in principle a free community, the City had traditionally been governed in an autocratic fashion by the aldermen, whose position resembled that of the barons in the rest of the kingdom. The aldermen were not merchants but landowners, and many of them held remunerative offices under the Crown as chamberlains, collectors of revenue, privileged vintners, and officials. The merchant class sought increasingly to challenge the landed proprietors, and the guilds, as the means of organisation for the trades, were at the forefront of the struggle. By the fourteenth century, the guilds were distinctly powerful. They obtained control over citizenship in a charter of 1319. The aldermen of the City became elected representatives and, from 1346, the City had an advisory council consisting of men elected by the wards. By 1375, the members of the City Council were no longer elected by the wards, but by the trading guilds : they had the right to decide who were to

be 'freemen' of the City.

The trades were finally reconciled with the civic and national authorities by the grant of incorporation, which conferred on the Companies powers of trade regulation which were both extensive and effectual, but which were exercised under the authority of the Mayor (16). The important feature of the charters is that they conferred on the companies the immortal collective personality of a corporation. The Grocers' Charter, which may be taken as representative, declared that they should be "in fact and in name one body and one perpetual commonalty". Both the wardens and the commonalty were to have perpetual succession, and they and their descendants were for ever legally capable of receiving and possessing lands, tenements, rents, and other property (17). Charters were granted to the Goldsmiths in 1390, the Mercers in 1394, and the Saddlers in 1395. Under Henry VI (1423-1461) incorporation became the norm. The livery companies, which grew out of the guilds, were at the height of their power in the fifteenth and sixteenth centuries.

It was in the late mediaeval period that the companies acquired their own halls, where they could hold court, manage their business, and conduct their social activities. Unwin has written: "In the middle of the reign of Richard II (1377-1485)¹³⁹⁹, the halls numbered twenty-eight, and others were in the course of being built" (18). Many of the wealthier livery companies took over the mansion of a feudal magnate or the buildings of a religious community. Thus, the Merchant Taylors succeeded Oliver de Ingham, once Seneschal of Gascony, and the Grocers took over the mansion belonging to one of the Fitzwalter family who, in earlier days, had held Baynard Castle. The Mercers acquired the Hospital of St. Thomas of Acon; the Leathersellers, St. Helen's Priory (19). The Merchant Taylors' Hall, in Threadneedle Street, has changed little since the fifteenth century. In London, unlike Paris, the great majority of the company halls were located off lanes and side streets, rather than the main thoroughfares. This remains a feature of the City today.

In the heyday of their power and prosperity, the companies acquired extensive property in and around the City, apart from their own halls. It is in their capacity as landowners that we shall meet with them in this study. The drawn surveys of London property which they commissioned are among the earliest and richest sources of building plans for the City, and will constitute one of our primary sources.

The Reformation, i.e. the sixteenth-century reform of the doctrines and practices of the Roman Church, begun under Henry VIII, marks a branching point in the history of the guilds, since it brought to an end the religious aspect of gild organisation. But, by this time, the organisation for religious objects, which had once been the primary condition of voluntary association, had ceased to be essential to their existence, and their social and economic life continued without any serious break.

The sixteenth century does, however, represent a turning point in other, and much more important, ways. The Tudor period witnessed an unprecedented growth in London's population and, contemporaneously, a transformation of the physical aspect of the City. Discussion of population growth is hampered by the lack of reliable data: there are no exact figures for the London population before 1801, when the first census was drawn up. All the figures for earlier centuries are therefore estimates only, and cannot be taken as absolutely accurate. The overall trend is nevertheless quite clear. The population curve appears to have taken an upward trend from the end of the fifteenth century. Dr. Creighton, one of the most reliable of modern authorities, estimated the population of London in Henry VIII's reign at 50,000, two-thirds of them being in the walled City and the remainder in the liberties between the gates and the bars (20). By 1563, it had risen to about 93,000; by 1580, 120,000; and by 1593, 152,000. There were probably 200,000 persons living in the City and suburbs before the end of the century. The population continued to increase in the seventeenth century, and reached 500,000 before 1700. The rate of growth was very much more rapid than any other town in the country. London comprised perhaps 2% of

the population of England and Wales in 1500, 5% in 1600, and 10% in 1700 (21). This dramatic increase was in spite of a very high urban death rate, and a fall in the birth rate during a part of the period. Plague was in London five times between 1593 and 1664-5, and is said to have claimed 156,463 victims.

On the basis of these figures, it might appear that London was breaking free of what Braudel has called the biological 'ancien regime': the balance between births and deaths, very high infant mortality, famine, chronic undernourishment and virulent epidemics, which had hitherto been the norm (22). But it is clear that the cause was mainly economic and not demographic: there was no great upward press of numbers in England as a whole. London's was an exceptional, an asymmetrical growth within what remained a pre-industrial society (23). Transformation at the national scale did not take place until the Industrial Revolution, that momentous period of rapid change which commenced in the third quarter of the eighteenth century. The expansion of London at the end of the Middle Ages was evidently powered and sustained by the influx of people from the countryside. Preliminary work, by Wrigley et al., on the analysis of parish register material has suggested that there might have been a substantial surplus of births during the seventeenth century in the home counties and in the Midlands, the areas from which access to London was easiest, and that this surplus could have been siphoned off into London "to counterbalance the burial surplus there, and to enable it to continue to grow quickly at a time when the rest of the country was barely holding its own" (24).

People were drawn to the capital by the great increase in commerce. Until the sixteenth century, London had been on the outer edge of the large network of European trade; it now became the focus of a still larger one which spread over the continents (25). One reason for London's success was the close alliance between the City and Westminster, between the trading city and the seat of government, which was such a characteristic of Tudor sovereignty. The two cities were interdependent. The congregation of the aristocracy

around the Court led to a high level of consumption in the areas to the west of the City, which greatly increased the possibilities for trade and, therefore, the wealth of the merchants. At the same time, the City provided vital services to the country : it could call up trained bands of men to arms when necessary ; its merchant ships served to supplement the navy founded by Henry VIII ; and, above all, it was the place where wealth accumulated. It was to the City alone that the Crown could turn when large amounts of ready money were required. London was "a mighty arm and instrument to bring any great desire to effect, if it may be won to a man's devotion" (26). The trading centre therefore had much influence, and Tudor policies were conducted in the main in accordance with the exigencies of commerce.

London's supremacy was founded on her trade in cloth. The City was the centre of all the English cloth trade and, by virtue of this, secured a position unique in international commerce (27). England had been a major wool producer from the thirteenth century, but initially made only coarse cloth. Fine stuffs were manufactured principally in Flanders, to which the bulk of the English wool was sent. But the English cloth industry steadily built up and, through a monopoly on wool, was able to secure the market and eventually to supplant the Netherlands. The early sixteenth century completed the transition from export of raw material to export of the finished product ; it was the great age of English broadcloth. The period was also one of great maritime activity, of exploration and discovery, which helped to open up new sea-routes and create new centres of overseas trade. But more important for the cloth trade, it would seem was increasing demand in Europe itself. Although the boom was checked by a collapse of the export market around 1550, new markets were subsequently found, in Russia and elsewhere. By the end of the century, a new line of lighter cloths - the New Draperies - were being produced, and markets were opened up in the Mediterranean and in Africa. In Henry VIII's reign, the export of cloth amounted to about 70% of the entire exports of the country, while the export of raw wool was only about 8%. At the end of the century, the export of raw wool had practically ceased (28).

Whereas, in the early Middle Ages, wool export had been monopolised by the great landlords, including monasteries, who made bulk sales to foreign merchants, the sixteenth-century trade was based on the production of numerous small clothiers and passed largely through the hands of merchant-middlemen. The English merchants and the cloth companies were concentrated overwhelmingly in London. Under Henry VII, London had contributed about 50% of the entire revenues for the Customs, in Henry VIII's time it had risen to about 66%, but by 1581-1582 it was over 86% (29). Thus the increased commercial activity did not simply influence London, it originated there. It was founded on and reinforced London's dominion over the rest of the country.

Tudor rule (often referred to as despotism) brought about a prolonged period of internal peace and national unity. But the commercial expansion of this era was paralleled by a price revolution, a development well documented in the historical literature (30). The two cannot be seen in terms of a simple relation of cause and effect ; both formed part of a nexus of interrelated factors. The price revolution had no single cause, but it is plain that the expanding population was an important factor. In England the general price level rose five times between 1530 and 1640, wheat prices six times. One effect of this increase was "a savage depression of the living standards of the lower half of the population", since food and fuel prices rose more sharply than those of other commodities (31). An attempt by Elizabeth to restrict wage levels (1562) was of little help, and aggravated the conditions of the labouring classes. Whole occupational groups rose or fell during the period. In the building industry real wages in the later sixteenth century were less than two-thirds of what they had been in 1510, and in the fifty years before the Civil War they were less than half (32).

Those without land were the most seriously affected. The century after 1530 saw a social divide: a redistribution of wealth as well as a rise in total national wealth. "Some of the rich and many of

the middling sort grew richer; the poorer (and the improvident or unlucky among their betters) grew poorer" (33). In the City there was a great increase in the number of unemployed. There was also an unprecedented invasion of beggars and vagabonds. The great influx of people into London may have been promoted in part by eviction from the land, for the clothing boom encouraged the enclosure of farming land for pasture. A move to sheep-farming made it advantageous to manage large portions of estates as an aggregate, and many copyholds-lands 'held by the villeins' successors - were enclosed. Less labour was required for pasture than for cultivation of the land. The increased interest in estate management manifested in this period also reflects a change in attitude. The holding of land rested traditionally on custom, and the object of agriculture was to provide the inhabitants of the land with their needs. Now the aim was to obtain the greatest financial return, and landowners came to reduce hospitality, to rack rents, and to watch markets. Increased efficiency led to a steady rural depopulation.

London's population was swelled also by foreign immigrants. 'Returns of Aliens', made at intervals during the sixteenth and seventeenth centuries by the Lord Mayor or the Justices, show that many of the foreigners settled in the wards 'without'. The returns for 1583 reported 4,141 foreigners, of whom 1,604 lived outside the City (34). It would appear that the largest number of immigrants were weavers, tailors, silk throwsters and dyers - all "occupations which were subject to the economic vagaries and depressions of the cloth trade" (35). The districts on the edge of the City seem to have held a special attraction for the foreigners. The later returns show that Bishopsgate, merging into Spitalfields, alone had about one-third of all the aliens in the City. The weavers, i.e. wool weavers, of London were almost all of foreign extraction. Silk-weaving was introduced in the sixteenth century by a wave of immigrants who settled in the villages of Shoreditch and Spitalfields. A colony of french hatters settled in Southwark, together with the Flemings, who introduced the brewing of beer from hops. Printers from the Netherlands settled in Westminster, in Clerkenwell, and elsewhere.

The movement to the suburbs was in part a consequence of popular xenophobia. There was considerable ill-feeling towards aliens in the City of London, and several persecutions took place before the mid-sixteenth century. But it was also a means of escaping the powers and penalties of the livery companies, from whose membership the foreign craftsmen were excluded. The City companies fought to maintain their monopoly by widening the sphere over which they could exercise their jurisdiction. The Broderers, who were incorporated by Elizabeth, obtained rights of regulation in the City of Westminster, the Borough of Southwark, and St. Katherine's. The Blacksmiths' Charter of 1571 granted them a four-mile circuit, in addition to the City and suburbs. In subsequent charters the radius was sometimes extended to seven miles.

In addition to the influx from abroad, there was considerable emigration to the suburbs from the City itself. This was precipitated largely by economic changes. Industry, like agriculture, was beginning to be run increasingly on capitalistic lines (37). Whereas in former times the producer - the artisan or craftsman - had sold directly to the consumer, the relation was now frequently mediated by dealers or traders, who bought and sold the goods but took no part in the production. In general, little change was effected in the methods of production themselves, but the producers became increasingly dependent on the merchant middlemen, who 'put out' work for them to do. The establishment of a relationship of dependence enabled the trader to reduce wage levels. Many small craftsmen lost their position and sank to the level of labourers. Landless labourers were at the mercy of employers, and there was mass pauper apprenticeship in London and other towns. The impoverished craftsmen, who ceased selling to the consumer, neither needed nor could afford to live in the City, and so moved out to the suburbs. The larger merchants at the head of such companies as the Haberdashers, Drapers, Clothworkers, and Leathersellers began to encourage this movement (38). In cloth manufacture an appreciable change was wrought in the process of production itself. Greater organisation and a more balanced process

was achieved by extending the division of labour between successive stages of production : some workers carded and spun the wool, some wove it, others dyed it, and still others fulled it. They were all dependent on the merchant-employer, who financed the enterprise, and handled the finished product.

The combined effect of these developments - the price revolution, the influx of foreign immigrants and men from other parts of the country, the loss of status by inferior craftsmen - was a dramatic increase in the numbers of poor on the streets of London. The situation was exacerbated by the Dissolution of the Monasteries by Henry VIII, as the friars who had once provided alms for the poor now swelled their ranks. The large urban proletariat had to find accommodation as best it could, and this led to multiple occupation and the sub-division of existing houses into smaller units - a practice referred to as 'pestering'. The immediate effect of the Dissolution was to relieve pressure for space within the City, since it liberated the extensive lands of the monastic precincts for development. To the north alone were the attractive sites of St. Bartholomew's Priory and Hospital, Charterhouse, St. John's Priory, and Clerkenwell Priory. But the sites appear to have been built up very rapidly (39). Poverty and overcrowding became alarming in the 1570's. The propertied classes were fearful lest the plague should "enter amongst these multitudes" and endanger the whole population, including themselves.

Finally, Elizabeth issued a Proclamation in 1580. It declared that :

"her Majestie, by good and deliberate advice of her council, and being also thereto moved by the considerate opinions of the lord mayor, aldermen, and other the grave wise men in and about the citie, doth charge and strictly command all manner of Persons, of what qualitie soever they be, to desist and forbear from any new buildings of any house of tenement within three miles from any of the gates of the said citie of London, to serve for Habitation or Lodging for any person, where no former House hath bene known to

have bene in the memorie of such as are now living ; and also to forbear from letting or setting or suffering any more families than are only to be placed or to inhabit from henceforth in any one House that heretofore hath bene inhabited" (40).

The Proclamation was transformed into an Act of Parliament in 1592. The Act was clearly directed at the lower classes, as exempting clauses were included for the rich. A rich person could put up a house within or outside the City, but would normally be allowed to do so only after dispensation, for which it was necessary to pay a subsidy to the Crown. Subsidies were also demanded for the enlargement of existing houses. The restrictions were therefore used as a practical means of obtaining revenue. The statute did not appear to operate against rebuilding on old foundations, or on sites occupied in living memory.

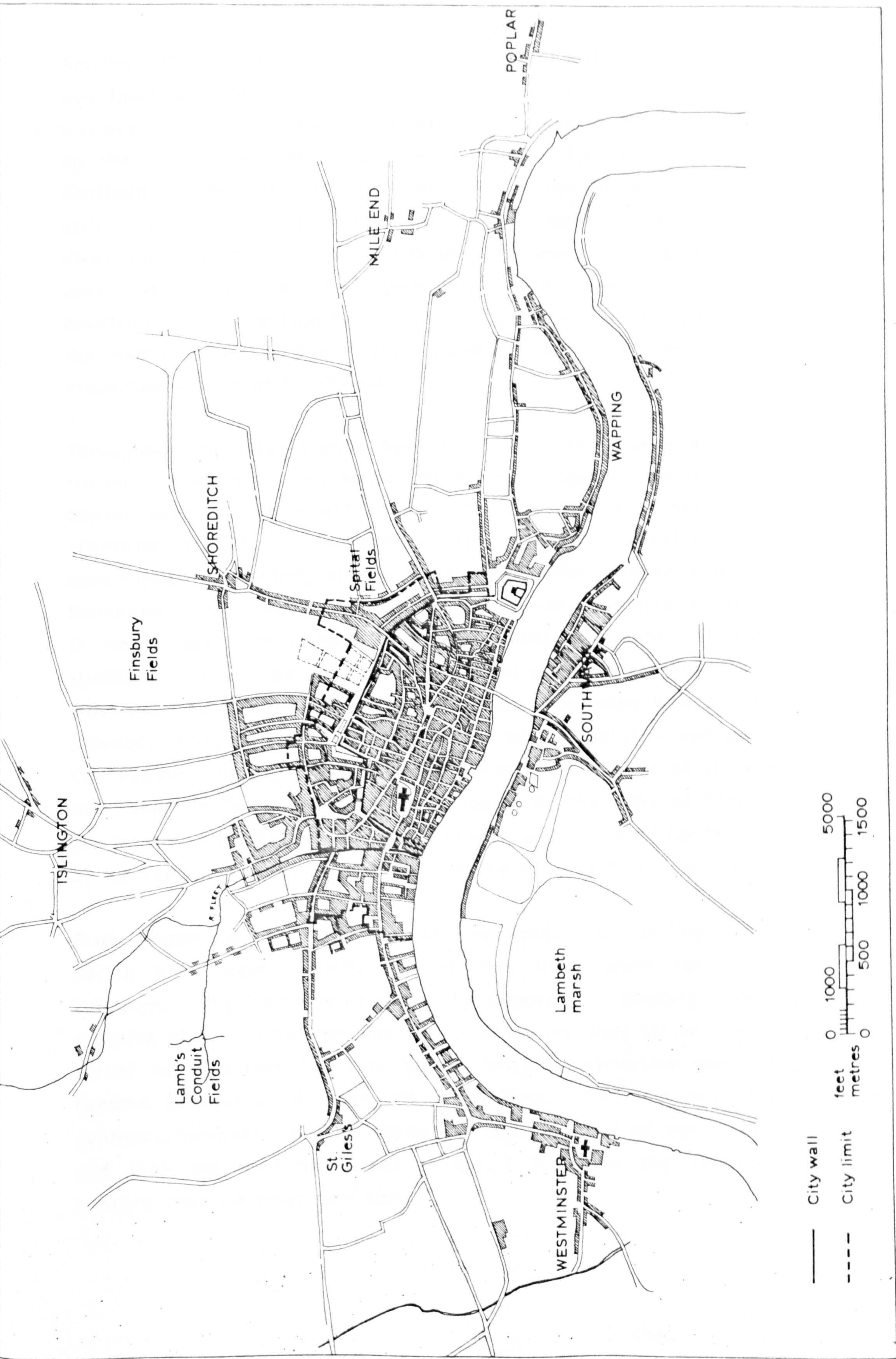
The Proclamation of 1580 has been seen as the first step towards town planning, and even as a precocious attempt to create an agricultural belt around the town (41). In its move to introduce a global form of control which would regulate the growth of the City, it may certainly be considered as an early piece of town planning legislation. But it is clearly a mistake to regard the Proclamation as anything more than a blunt attempt to stem the invasion of the poor. There was no real grasp - nor could there be any - of the social and economic forces that lay behind the problem. The aim was evidently to stop the inflow of people, to send the poor back to where they came from, and thus to prevent the "pestering of houses".

It was a vain attempt: the rising tide of population could not be curbed in this way. Inadequate enforcement meant that the regulations were flagrantly and consistently flouted by speculative builders and others. The Privy Council had occasion to remind the City authorities of the Proclamation, and to direct that immediate action be taken against persons refusing to obey the restrictions (42). Although there were later to be notable successes at Covent Garden, Great Queen Street, and Lincoln's Inn Fields, these were the

exception rather than the rule, and seem largely to have been the result of the involvement of Inigo Jones, who was the King's Surveyor General at that time (43). Elizabeth issued further Proclamations with similar contents in 1602 and 1603, and they were continually renewed by the Stuart kings during the seventeenth century. But London's growth was unabated, and the City continued to spread outwards beyond the walls.

The approximate extent of the suburbs in 1600 is shown in figure 2.1. The main expansion had been into the monastic lands, and outward along the main roads. To the west, development extended to Charing Cross and along Holborn to a point just beyond Staple Inn. Gray's Inn Lane was furnished with buildings on both sides, leading to the fields of Highgate and Hampstead. The line of buildings also continued westward to St. Giles', still then a hamlet, but in later centuries to become one of the worst slums or 'rookeries' in the capital. To the north-west, the lands belonging to Charterhouse, St. John of Jerusalem, and the Priory of Clerkenwell had all been built upon. To the north of the City wall, Moorfields and the

Fig. 2.1. Approximate extent of London, c. 1600, based on the reconstruction by Brett-James (1935).



Artillery Ground remained relatively undeveloped, but Bishopsgate was lined with buildings as far as Shoreditch and beyond. Hoxton was beginning to have houses on both sides of the road. Development on the north-east had spread beyond the walls, but was largely confined to the City limits. The colonisation of Spitalfields was still in its early stages. But buildings ran outward in an easterly direction along Whitechapel and Rosemary Lane. Close to the rivers edge, St. Katherine's had been built over, and a long ribbon development ran eastwards to Shadwell, and was soon to link up with the hamlets of Limehouse and Poplar. Over the river was the expanding suburb of Southwark.

Throughout the later Middle Ages the normal building material was timber. That is to say, houses were timber-framed and spanned by timber beams. It would appear that external wall panels were generally infilled with lath and plaster. Roofs were pitched, their ends hipped or gabled, and in most cases were covered with tiles. Internally, brick was used for fireplaces and adjoining areas, but it would seem that partitions were most commonly of timber studding. Stone was not a local material and was reserved for the most important buildings - churches, livery company halls, bishops' palaces, inns, and the mansion houses of the nobility and gentry. One example of a great house which was clearly built of stone was the 'Erber' in Dowgate, once the property of the Duke of Clarence, but later owned by the Drapers' Company and occupied for five years by Sir Francis Drake, who was a member of that Company (44).

Brick began to replace stone as the preferred building material during the Tudor period, but it was little used for ordinary buildings. This remained true in the seventeenth century. Despite a series of Proclamations and Edicts enjoining that all new building should be in either brick or stone, brick construction was not to become general until after the Great Fire. With the seventeenth century, however, we are stepping decisively out of the mediaeval and into the post-mediaeval period. It is to the seventeenth century that we must now turn.

2.2 Seventeenth-century London

The seventeenth century was a time of transformation. The economic and social changes which had begun in the Tudor period continued and gathered momentum under the Stuarts, breaking down social practices and habits of mind that had persisted for centuries. With the close of the sixteenth century, one may truly be said to have entered the post-mediaeval or modern period. Lawrence Stone has written : "Granted that change is a continuous process, that every shift has both earlier antecedents and later developments, it is nevertheless between 1560 and 1640, and more precisely between 1580 and 1620, that the real watershed between mediaeval and modern England must be placed". (1). It is no accident then that our cartographic record of London should also begin in these years.

One of the most powerful forces of change, as far as London was concerned, was the growth in population. As already noted, the dramatic expansion of the Tudor period continued throughout the seventeenth century. From approximately 200,000 in 1600, the population appears to have risen to almost 400,000 in 1650, and reached 575,000 by the end of the century. Both London and Paris were very much larger than any other rival in the same country, but whereas Paris ceased to expand in the latter part of the century, London's growth was unabated. Towards the end of the seventeenth century, it became the largest city in Europe (2).

Clearly, this massive and sustained growth had profound consequences, both for the physical form of the City and for its social composition. The rise in population was founded on horizontal mobility, i.e. the movement from rural to urban areas. As men poured into the capital from other parts of the country and from abroad, the suburbs expanded and new industries were established. Foreign immigrants played a particularly important part in improving English industries. In the course of time, more and more work escaped the control of the City companies, who were on the defensive for their privileges. Although they fought against

the independent producers by extending the area of their jurisdiction, and increasing the thoroughness of their 'searches', they steadily lost ground, unable to cope with the extension of industry or with the increasingly complicated methods of production and distribution. The techniques of production and the methods of organisation were still far removed from those of the Industrial Revolution : domestic industry was more common in London than manufacture in the workshop or factory, and producers still worked essentially with handicraft instruments. But the extension of the division of labour to the different stages of production allowed certain industries to be more closely organised as a unity. The example of clothworking has already received notice. As Dobb has pointed out, these early steps in the division of labour "prepared the ground from which mechanical invention could eventually spring" (3).

London trades were numerous and diverse, but in her study of the capital in the eighteenth century, Dorothy George has divided them into three main classes. First, there were the trades dependent on London's position as the chief port of the country. These included shipbuilding, brewing, distilling, and sugar-refining. Secondly, London produced high-class goods reputed to be brought to a greater degree of perfection than elsewhere in England, e.g. clocks and watches, cutlery. The third group, closely related to the second, comprised those trades that supplied the wants of a large, luxury-loving population, e.g. tailors, milliners (4). Each of these groups may be discerned in the seventeenth century.

The last category is of interest as it highlights a second aspect of London's growth. Not only were the City and suburbs a centre of production ; they were also a centre of consumption (5). The existence of the Court at Westminster and the centralisation of government created a powerful source of attraction for the aristocracy, and for that junior branch of the nobility, the country gentry. The gentleman come to town was given to much greater expenditure than was usual in the country : he required fine clothes, transport, and entertainment. Thus, a series of demands

was created "which it became an important function of the metropolis to fulfil", and from the fruits of this conspicuous consumption the luxury trades waxed strong (6).

The period was, in fact, marked not only by a high degree of horizontal mobility, but also by an increase in vertical mobility, both upward and downward. The salient feature of the period 1540-1640 was the rise of the gentry, a development of major social and political importance (7). Peers, baronets and knights, esquires, and armigerous gentry all grew in wealth and numbers. Altogether, the landed classes trebled in numbers at a time when the population scarcely doubled (8). This expansion was due in part to the buying out of copyholders and leaseholders, who were squeezed by inflated prices and economic rents. But it was made possible chiefly by the extensive activity of the land market in the century after the Dissolution of the Monasteries. Property transactions multiplied, facilitated by the relaxation of legal restrictions on alienation. The massive transfer of land seems to have reached a peak in the 1610's, and much of the property passed into the hands of the gentry. Stone has noted that "although the aristocracy gained a good deal of Church property by purchase or gift immediately after the dissolution of the monasteries, a lot of it was resold to the gentry in the late sixteenth century" (9). Thus, land came to them from both ends of the social scale. And this made for increased social mobility.

This is not to say that the rise in wealth and status was uniform; many of the more humble gentry, i.e. the parish gentry, as opposed to the county squirearchy, stagnated or declined during the period. But it is clear that, taken as a whole, the gentry class greatly improved in wealth and social standing between 1540 and 1640 (10). And, as their revenues rose, so their social contacts with the capital increased. Some went to school in London. Many more enrolled at the Inns of Court. And, once established in his country seat, the squire was liable to return frequently to the capital on business, if for no other reason (11). By the early seventeenth century, there had emerged a clearly defined London season, from

autumn to June, which was a regular and growing attraction for provincial landowners. This townward migration of the gentry met with official disapproval, and increasing efforts were made to discourage the practice and return the gentry to their country estates. All attempts were ultimately without success.

Besides the gentry, other social groups also enhanced their position in these years. Stone has distinguished four semi-independent occupational groups which rose to prominence: the merchants, the lawyers, the clergy, and the administrators. All of these categories were 'anomalous', in that they cut across the traditional sharp division of society into gentlemen and non-gentlemen. Their emergence transformed the profile of society (12). The development of the lay professions in this period is clearly of great importance, although it has not yet been the subject of detailed study. Most striking was the rise in lawyers. Their numbers multiplied in the late sixteenth and early seventeenth centuries, and in 1688 Gregory King estimated that the entire legal profession amounted to 10,000 persons (13). Some barristers and officials accumulated great fortunes. More than three-quarters of those trained at the Inns of Court, i.e. barristers and above, were of gentry or clergy stock (14). The medical professions underwent a similar growth, and there was a significant development of architects, scriveners, and journalists. The scriveners, although they began as legal copy-clerks, plainly extended their role during this period. In 1624, an Act of Parliament described them as those who "received other men's monies or estates into their trust or custody" (15). The fact that the development of these classes was concentrated in London and Westminster reflects the high level of demand for professional services in the capital. As one might expect, a not inconsiderable part of this demand came from the gentry (16).

The merchants too increased in wealth and prestige. The private relationship of dependence between craftsman and merchant-employer, which had made its appearance in the sixteenth century, was now firmly established. As the freedom of the producer was restricted,

and his indebtedness increased, the position of the merchants was strengthened. The merchant elites at the head of the City companies also enhanced their political strength by providing loans to the government. This financial role is already in evidence in the late sixteenth century. In 1570, Sir Thomas Gresham, the great merchant-financier, opened the Bourse, which was significantly christened the Royal Exchange by Elizabeth. Hill has observed that "by the seventeenth century some merchants were as rich as peers, though their fortunes were usually made in one lifetime" (17).

The upgrading of the status of trade and the professions relative to the landed classes understandably resulted in friction between the two groups. Such mobility was by its very nature in conflict with the mediaeval view of the world. According to social theory in the Middle Ages, all men had an acknowledged place in the hierarchical ladder: into whatever status you were born you remained, upon conditions older than you, and over which you had no control (18). The rise of new groups upset this structure, blurring the customary divisions in society. Moreover, every social rank was previously deemed to have its obligations as well as its rights; each man was responsible for those beneath him in the social scale. The possession of property depended on the discharge of these duties. The 'nouveaux riches', whose income was derived from entrepreneurial activities or professional services, severed the link between status and duty, and thus undermined the traditional structure of authority.

As time went on, social ideals were adjusted to accommodate changing political circumstances. Increased wealth did not necessarily bring social acceptance, but it is apparent that by the late seventeenth century, merchants, lawyers, clergymen and officials were held in much less contempt than they had been a century earlier. The business and professional man could by this time acquire the title of 'Gent.', and on occasion even 'Esquire' without having to buy an estate and cut himself off from his economic roots (19). More and more wealth was being reinvested in long-term mortgages, commerce and banking. Parliament helped to spread London's influence into

the counties ; it also helped to bind together the merchants and a section of the gentry into a single capitalist interest (20). There was an increasing association of merchants and gentlemen in commercial affairs and, *pari passu*, the gentry lost their earlier reluctance to put their sons into trade.

An important bridge between the gentry and the professions was formed by those members of the landowning class who were downwardly, rather than upwardly mobile. Downward movement was a fate which not uncommonly befell the younger sons of the gentry owing to the rigorous system of primogeniture (the rule in all the upper ranks of society), by which they were excluded from the inheritance of an estate. Obligated to make their own way in the world, they were drawn towards the City, where they formed part of a numerous class which Everitt has called the 'pseudo-gentry', i.e. "that class of leisured and predominantly urban families who, by their manner of life, were commonly regarded as gentry, although they were not supported by a landed estate" (21). They migrated easily from London to provincial towns such as Northampton, Bath or Tunbridge Wells, but, as has been pointed out, it was London that provided them with their patterns of behaviour and secured their status: it was their 'normative reference group' (22). The 'pseudo-gentry' fertilised both commerce and the professions, and their efforts contributed to a merging of old and new social groups (23).

What the seventeenth century saw then was a great change in the social and economic balance. There was a shift of wealth away from the traditional powers - the Church and the Crown - and equally away from the very poor, towards the upper middle and middle classes. The gap between rich and poor grew ever wider. At the same time, there was increasing equality between gentlemen and members of the trades and the professions. These diverse elements tended increasingly to be tied together by common interests (24).

Profound social and economic changes are always accompanied by changes in ideas and values, and an inherent part of the seventeenth-century metamorphosis was a change in the attitude to land itself.

Whereas in the mediaeval period land was something permanent, 'objective', unchanging, it now came to be looked upon as an exploitable asset, a means of increasing income. This shift in outlook, foreshadowed in the sixteenth century, was intimately related to the rise of commerce. To the mediaeval scholar, the question of commerce or trade constituted a difficult point of conscience, since it involved selling at a profit, a practice close to usury, which was forbidden in the Scriptures. This dilemma was invariably resolved by distinguishing between trade at a profit and trade for a profit. Thus, intention was all-important (25). Land was not considered as a source of profit, since it was held in conditional, never in absolute ownership. The rent that was paid was never competitive, and was never arranged according to the value of the land, but according to the value of the services that went with it (26). As a competitive outlook took hold, and wealth began to replace land as a symbol of power, absolute ownership was substituted for conditional ownership: the landholder could now do with it what he would. That land was seen as a good investment is evident from contemporary documents. Henry Phillipps, a seventeenth-century writer on the subject, observed: "A farm that formerly was worth but £30 a year is now worth £50 or more. So that the old rents of land may, in a short time be much improved, whereby the landlord may, in a short time mend his bargain, if it be in good pennyworth when he bought it" (27).

The changing attitude to land and wealth were fundamental to London's physical development in the seventeenth century since, as Booth has pointed out, they underlay both speculation in land and the growth of housing (28). Speculation in the housing market seems to have been an established fact by the early part of the century, though the interests involved in land development were various, and some were far from commercially minded. Institutional landlords, who probably regarded their holdings as being in perpetuity, in some cases showed little interest in securing a large increase in revenue or in capital value improvements. Thus, the Dean and Chapter of Westminster let most of its land on long leases (40 years), and undertook to renew the leases on surrender. Similarly, the City of

London leased Conduit Mead, the area of land between Oxford Street and Piccadilly, in 1666 for a period of ninety-nine years, and, on expiry, granted a reversion of part of the lease for a further hundred years. The ground rent was fixed. In both cases, the landowners seem to have regarded the capital value of the land as of more importance than increased return on capital (29).

But aristocratic landlords such as the Earl of Bridgewater took more positive steps to develop their land to advantage. And alongside these established landowners there were the parvenu speculators, men who had access to capital and whose overriding interest was to make money. The names of many have come down to us in the streets and squares that they laid out between the City and Westminster. Motivated primarily by the desire to maximise their return, they cast land into streets and divided up the frontage in such a way as to multiply the number of dwellings on a site. Thomas Neale, a "born gambler", speculated in the development of Seven Dials, east of Shaftesbury Avenue and south of St. Giles'. Though celebrated at the time, it rapidly decayed into an area of poor lodgings, known for its "drunkenness, profanity (and) Sunday trading" (30). Dr. Nicholas Barbon was the best-known speculator of the age, and was erroneously considered by some the originator of the new type of development. He is said to have laid out over £200,000 in building (31). The Conduit Mead development furnishes many other names: Richard Frith, Cadogan Thomas, John Hinde, Huntley Rigg, and Terry Sturgeon. The last two were both scriveners (32). It was in the post-Restoration period (the period after 1660) that the speculators became a major force in London's development. Almost all of London's housing from 1660 onwards was put up as a speculative enterprise. And it is in this period that the first true plan of the City appears.

Sociologists have drawn attention to the power of cities to transform modes of thought and action, and so dissolve the customs and prejudices of traditional rural society. Emphasis has been placed on the encouragement which urban life gives to 'rational', as opposed to 'traditional' patterns of action, and the tendency for

contract to replace custom (33). It is reasonable to infer that these trends were present in seventeenth-century London. Moreover, the level of rural immigration into the capital was in this period so great that the potential for transforming attitudes and values in the country as a whole far exceeded that in most other countries. Wrigley has estimated that at least one adult in six in England in the period 1650-1750 had had direct experience of London life. There were proportionately four or five times fewer Frenchmen caught up in Parisian life than Englishmen in London life (34).

It is a mark of the seventeenth-century transformation that as traditional hierarchy gave way to a more competitive, atomistic society, reason and utility played an increasing part in individual and social actions. A growing scepticism is evident in both secular and religious affairs, stimulated, in Hill's view, by the Reformation (35). Magic and animism suffered a general decline. There was a rational critique of the miracle of holy water and exorcism, a rejection of mediating saints and the Virgin, and an emphasis on the study of God's works in nature. An illustration of the waning of traditional beliefs is provided by the example of witchcraft. Trevelyan observed that while, in the post-Restoration era, the common people still firmly believed in the presence of witchcraft, the witch-hunt no longer found leaders among either the dominant clergy or the governing class: "without controversy and almost without notice, the persecution of witches died out of England - and its death was the first triumph of the humanising spirit of Rationalism" (36).

At the heart of the intellectual developments of these years was the growth of science. It has been said that the foundations of the modern world-view were laid during the seventeenth century. That complex of scientific achievements known collectively as the Scientific Revolution are a conspicuous feature of the period. The growth of experimental science received a great fillip during the English Revolution, with the formation of societies in Oxford, Cambridge and London, and culminated in the establishment of the Royal Society after the Restoration (1660). Among the eminent

Fellows of the Society were Hooke, Boyle, Ray, and Newton, all responsible for striking advances in the natural sciences. The Newtonian synthesis and the Mechanical philosophy were the ultimate legacy of the period.

Situating these intellectual developments against their social and religious backcloth, various historians, most notably Christopher Hill, have argued that the emergence of science was bound up with puritanism and the puritan social ethic. This question has given rise to considerable debate in historical circles (37). Hill has pointed to the strong puritan presence at Gresham College, an institute founded and controlled by merchants, and a major centre of scientific activity during the first half of the seventeenth century. In the years before the Civil War, Gresham College became a meeting place of a group of scientists terming themselves the 'Philosophical College', an organisation which was the immediate precursor of the Royal Society. The 'College' included among its members John Wilkins, John Wallis, and Jonathan Goddard, who were all closely linked with puritanism or the Parliamentary cause (38). It has been shown that the Royal Society was composed mainly of those who later came to be known as 'Latitudinarians', a word used to describe ex-Puritans who conformed to the restored episcopal church in 1660, or other conformists who had accepted the Cromwellian state church (39).

The association of scientific innovation with religious radicalism - be it puritanism or protestantism - is not at all clear-cut, however, and the thesis has been forcefully opposed by Kearney and Rabb (40). The question is inevitably too involved to be explored in any depth here, but one may note that Kearney, while denying any simple connection between puritanism and science, does suggest the possibility that "a more critical attitude to religious authority created a climate of opinion which predisposed some men to be equally critical of dogma in science" (41). In the light of present evidence, the view that certain religious attitudes should have given rise to a mood or ambience of doubt and questioning, and that this in turn was favourable to experimental science, seems the most

plausible hypothesis.

More pertinent to the present enquiry is the influence that the mathematical and scientific advances had on practical fields such as surveying. Land surveying was one of the two main ways open to mathematical practitioners to earn their living at this time (the other was the field of navigation). Patronage came overwhelmingly from the landed classes (42). When John Ogilby was granted the protection of the City Fathers in carrying out a complete survey of the City in the years after the Great Fire, the man he appointed to take charge of the work was William Leybourn (1626-1716), a celebrated writer on mathematics and on the theory and practice of surveying (43). His work 'Planometrica : or, the whole Art of Surveying of Land', was published under the anagrammatic pseudonym of Oliver Wallinby in 1650. In 1653, he published an improved version of the work under the title 'The Compleat Surveyor', a book which, as Hyde notes, was so successful that it passed through four editions in his life time and one after (44).

'The Compleat Surveyor' is divided into four parts, the second of which describes the necessary instruments used in surveying : the theodolite, the circumferentor, the peractor, and the plain table. The plain table is the instrument Leybourn recommends above all others, and he proposes various improvements which will make it "the most exact, absolute and universal Instrument for a Surveyour that was ever yet invented". These are: marking out the degrees of a circle, the inclusion of two sights, and the addition of a tangent line for taking heights. Although he notes incidentally how lines and altitudes might be calculated "only by Vulgar Arithmetick", the intention was that the instrument should be used in conjunction with logarithmic and trigonometrical tables, which are given in full in part 3 of the book. He further points out the advantage of having "upon the Index of your Table the lines of Artificial Numbers, Sines, and Tangents, by which you may work any proportion required very speedily and exactly, so that if you be destitute of your Tables, those lines will sufficiently help you".

The impact of the seventeenth-century mathematical discoveries is clearly evident in Leybourn's writings. It was such improved methods that made possible Ogilby's remarkable survey of the City in 1676.

3. Source Material

London is extremely rich in source material relating to building and to landholding. The extant record is such that most sites in the City are documented at some stage before 1600. The cartographic record, however, does not begin until relatively late : there is no true plan of the City before Ogilby's post-Fire survey, and plans of individual buildings are also rare before the seventeenth century. For our purposes, the cartographic material is of pre-eminent importance : only maps and plans convey clearly and explicitly the way buildings were arranged on the ground. Verbal descriptions of property boundaries, abuttals, and alignments, such as were characteristic of mediaeval estate surveys, are generally too imprecise and ambiguous to serve as a basis for spatial analysis. Furthermore, without the comprehensive picture provided by a large-scale map of the City, it is difficult to place this earlier fragmentary record in context.

The morphology of the mediaeval City will therefore be approached by the retrogressive method - by reading history backwards (1). Map- and plan- analysis will form the groundwork of the study. From this seventeenth-century evidence, we shall attempt to work our way back to the antecedent spatial organisation of the City with the aid of some of the earlier sources. Since our use of the early archival material is inevitably limited and selective, the historical reconstruction does not aim to give a full and detailed picture of development and change over the centuries. Its purpose is rather to sketch the general lines of development. Various sample areas will be used to elucidate the spatial process and to test hypotheses derived from the later evidence.

Maps . Our primary source will be Ogilby and Morgan's post-Fire survey. The Great Fire of 1666 devastated the City : more than two-thirds of the area within the walls was laid waste. In 1672, with reconstruction well-advanced, the Lord Mayor and Court of

Aldermen appointed two sworn viewers - John Ogilby and his wife's grandson, William Morgan - to draw up a plan of the City. The survey was completed in 1676, and the map was published by them in the same year. Ogilby and Morgan's map was the first ground plot (i.e. two-dimensional plan) of the City, and very nearly the first of any British town. It is also the first reliable map of London. Drawn at a scale of 1" to 100' (1:1200), it distinguishes all buildings, together with yards, gardens, courts, and alleys. Gardens are indicated by stippling; yards, alleys, etc., are left white. Eminent buildings, such as churches and mansion houses, are distinguished by the use of cross-hatching in both directions. Parish and ward boundaries are shown. These administrative divisions are identified, as are the courts, alleys, etc., by a system of lettered and numbered references, the index to which appears in a small accompanying volume.

Ogilby's map is clearly not comparable in accuracy with a modern Ordnance Survey map. It was, nevertheless, one of the most advanced products of its day. It would appear to be most dependable for areas close to the streets. Comparison of sample areas with contemporary large-scale surveys has indicated that "the number of buildings shown in main streets is likely to be correct", and that "the ground plans of these buildings may also be correctly depicted". The information given in courts and alleys, however, appears to be less reliable and "in some cases is diagrammatic" (2). The detailed studies undertaken here support these conclusions.

Printed maps of London date back to the Elizabethan period, but these early examples all show buildings pictorially rather than on plan. They are generally termed 'map-views' (3). The two consulted most frequently in this study were Braun and Hogenberg, and 'Agas', the best-known and most important of the early map-views. The former was published in volume I of the German atlas of European cities, 'Civitates Orbis Terrarum', under the title 'Londinum Feracissimi Angliae Metropolis', and is attributed to

Frans Hogenberg. It is an engraved map and, though small in scale, is very detailed. The map is set out as a plan or bird's-eye view, with the buildings drawn in three dimensions. The horizontal scale is fairly consistent, but the buildings are represented, as was customary, in a formal and conventionalised manner.

The latter - the so-called 'Agas' map - is a woodcut map, entitled 'Civitas Londinum', mistakenly ascribed to Ralph Agas. Though much coarser in execution than Braun and Hogenberg, the two have many points of similarity, and it is now generally agreed that both were derived from the same original, an Elizabethan copper-engraved map, of which only two plates survive (4). The two plates cover an area bounded by Finsbury Fields on the north, Houndsditch on the east, Bow Church on the west, and the Thames on the south. The 'copper plate map' has been dated to the late 1550's.

Plans. Plans of houses and other buildings in the City first appear at the end of the sixteenth century (5). But extensive surveys of London property are not found before the seventeenth century. They become most abundant towards the end of the century, especially in the period between 1675 and 1695, when many of the livery companies and other institutions employed professional surveyors to draw up a complete record of their property. Various post-Fire collections have been consulted, the largest population of plans being drawn from the manuscript survey of the City Lands and Bridge House Properties (see chapter 6).

Two plan books survive from the pre-Fire period : one a survey of the Clothworkers' property, the other of the lands of Christ's Hospital. Both surveys were executed by Ralph Treswell the elder, and both were compiled c. 1612. Their early date makes them of exceptional interest and importance. In addition to providing direct evidence of the mediaeval City, Treswell's plans possess the advantage of being very detailed and precise. Both sets furnish ample material for analysis. In this study, the bulk of the early plans are derived from the Christ's Hospital Evidence Book, which has been transcribed and analysed in full (see chapter 6 and

appendix). Since this invaluable early source has not yet been published, copies of the plans are included in the appendix.

Documentary sources While Stow's 'Survey of London' (6), the standard textual reference for the period, contains valuable topographic material of a descriptive nature, this is largely unsuitable for analysis, for the reasons given above. Stow and other documentary sources have therefore been employed chiefly as background and supplementary evidence. Schedules of buildings erected contrary to the Proclamations (State Papers Domestic), compiled at various times during the seventeenth century, though very incomplete, furnish background information and statistics relating to London's growth. Since disputes concerning building not infrequently led to legal proceedings, reference has also been made to the Acts of the Privy Council, the Mayor's Court Interrogatories, and to other court records.

Of the written surveys of buildings and property, the principal source for the early mediaeval period is the measured survey of the London lands of St. Paul's contained in Liber L, c.1128. A facsimile reproduction and transcript are included in the appendix. For the post-mediaeval period, the St. Paul's Parliamentary Survey of Houses (1649-57) gives the overall dimensions at ground floor level of a large number of messuages or tenements, and provides a complete inventory of rooms on each floor. It has been used here, among other things, to establish the heights of a sample of London buildings.

Details of primary sources will be given as necessary during the course of the work. The notes to each chapter, which refer both to primary and to secondary material, are assembled at the end of the thesis.

It is the maps and plans, then, that will constitute our main source material. Spatial analysis will rest to some extent on visual inspection and measurement of the plans. But we shall also use a formal system of representation in order to clarify the spatial

characteristics of the City, and of the buildings of which it is composed. This calls for a brief preliminary discussion.

4. Method of representation

The study will be concerned to identify and describe various kinds of spatial relations. In order to do this rigorously, in a way which will permit analysis and comparison, it is essential to resort to a formal and precise language. Graph theory was chosen for this purpose, and will be used throughout the study.

The advantage of graph theory in the present context is that it deals with entities or objects and the relations between them. It lends itself, therefore, to architectural and urban problems where one is concerned to represent relations between elements rather than properties of the elements themselves. It can be used successfully to represent, for example, the relation of adjacency between pairs of rooms in an architectural plan (1) or the adjacency ('physical connectivity') between buildings (2), but is less suitable for application to multi-dimensional questions, such as the metric dimensions of walls or the shape of buildings. Being combinatorial in nature, graph theorem takes no account of magnitude or position.

It is customary to represent a graph by means of a diagram, and to refer to the diagram itself as the graph. It is immaterial from the point of view of the theory how the diagram is drawn - whether the lines are straight or curved, whether they cross or not, or where the points are placed in the plane. What is important is the number of points, and which lines join which pairs of points (3). It is helpful, however, to adopt consistent methods of representation in order to permit easy visual identification of the properties under study. Different drawing conventions will be used according to the particular application ; each of these will be explained in the appropriate place.

For the fundamentals of graph theory, the reader is referred to Ore, Berge and Harary (4). No attempt will be made to cover all the definitions needed in the theory of graphs, as this would be both lengthy and superfluous. We shall confine ourselves here to some basic concepts and the terminology which bears directly on the

present application of the language.

1.

A graph may be defined as consisting of a finite set V of p points, together with a prescribed set X of q unordered pairs of distinct points of V . Each pair $x=(u,v)$ of points in X is a line of G , and x is said to join u and v .

2.

A graph is labelled when the p points are distinguished from one another by symbols, e.g.

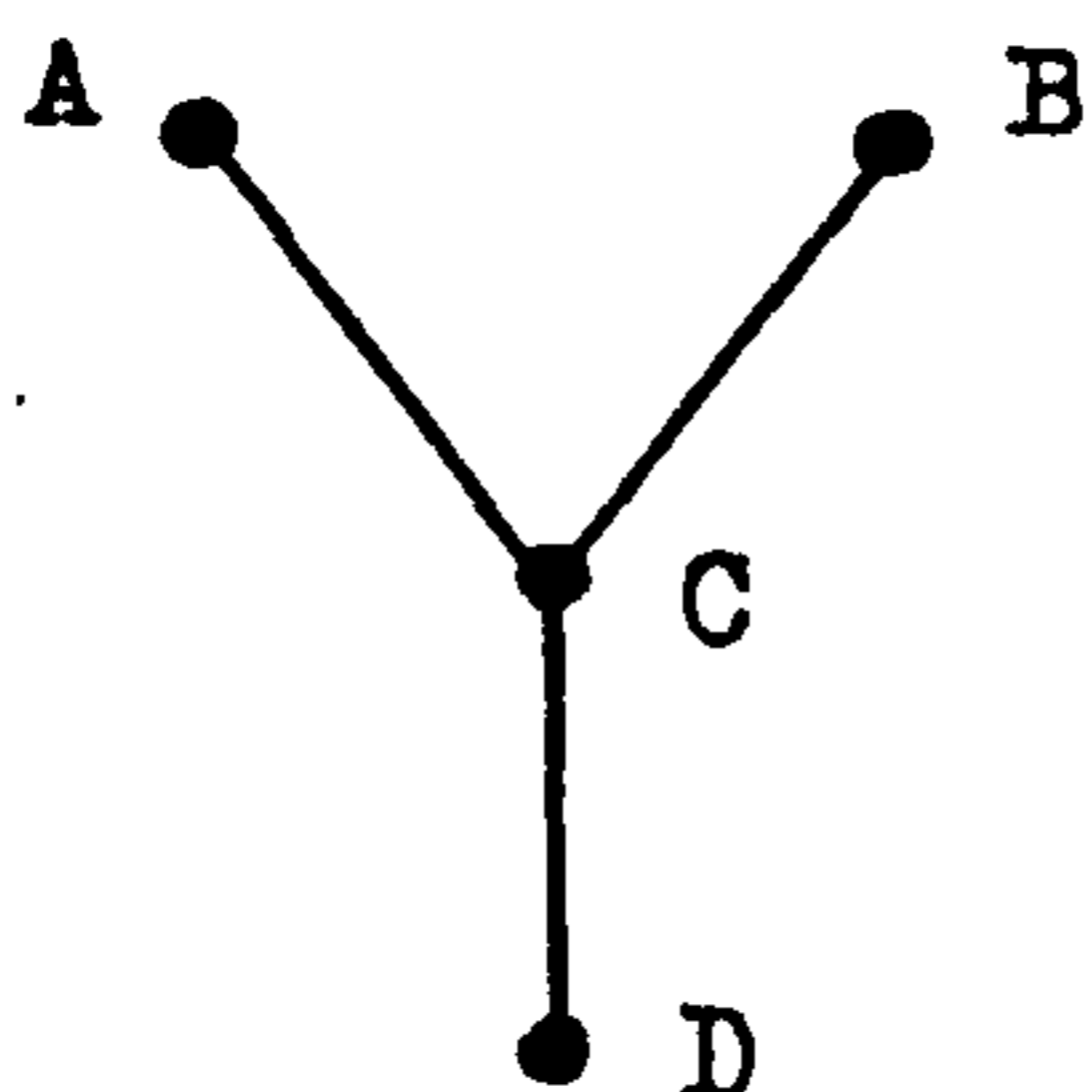
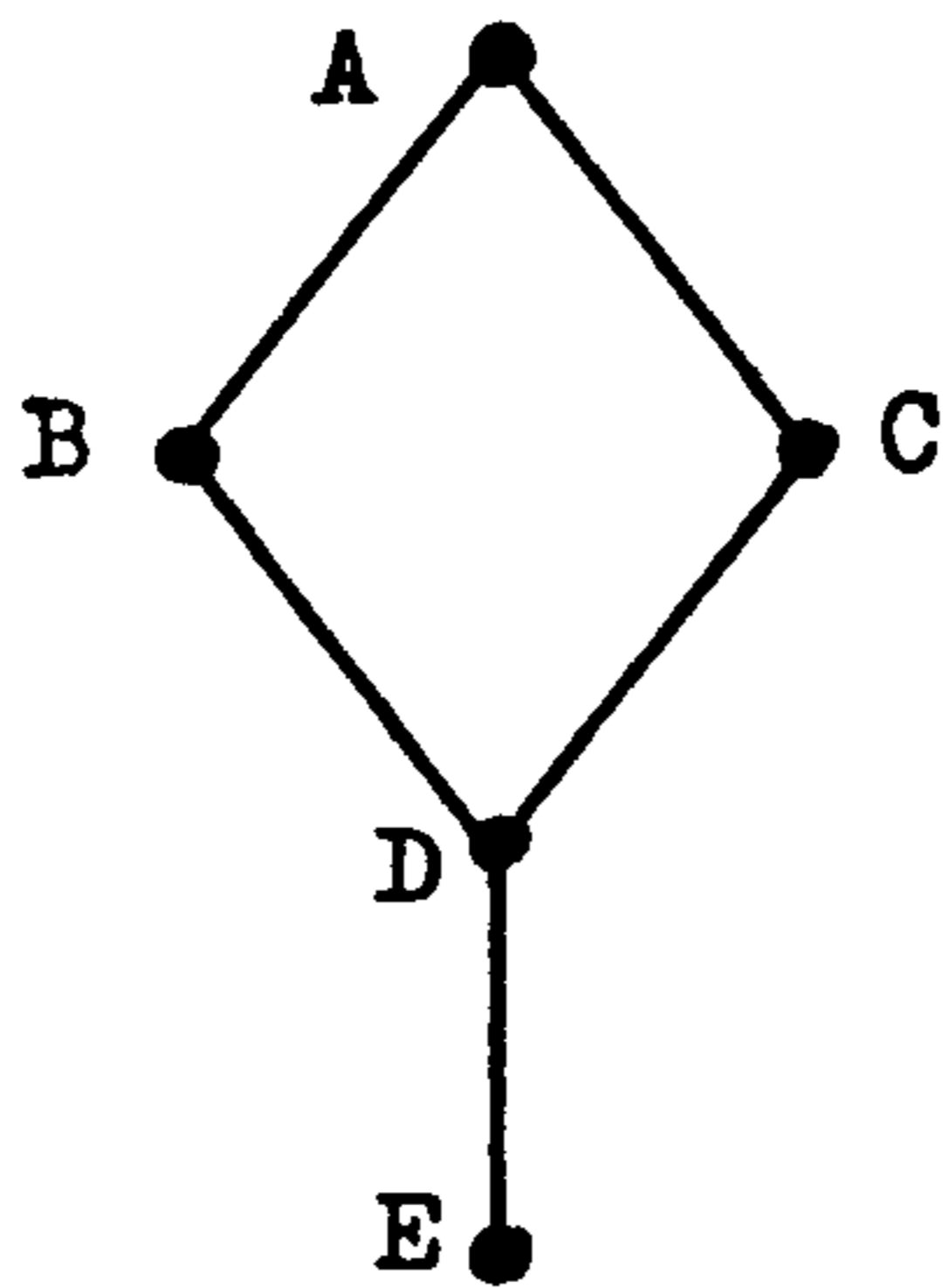


Fig.4.1

When the relations of adjacency or access between rooms in a house plan are represented by a graph, then the room names automatically impose a system of labelling on the graph (see chapter 6).

3.

A path of graph G is an alternating sequence of points and lines, beginning and ending with points, in which each line is incident with two points immediately preceding and following it and all the points (and thus necessarily all the lines) are distinct. A path is closed if it begins and ends with the same point. A closed path is a cycle provided its n points are distinct and $n \geq 3$. Thus, in



E D C A B is a path, while
D C A B D is a cycle.

Fig.4.2

4.

The valency or degree of a point is the number of lines in G which are incident with that point. A graph point is isolated if it has degree zero. It is an endpoint if it has degree 1.

The points and lines of a graph are referred to by various authors as nodes or vertices , and edges , respectively. Since in architecture we use the terms 'point' and 'line' in connection with building plans, i.e. plan drawings, it would seem less confusing to adopt a distinctive terminology with respect to the graphs. Thus the terms 'node' or 'vertex' and 'edge' will be used consistently throughout the study wherever graph representation is employed.

PART II

SPATIAL ANALYSIS

5. Spatial Organisation At the Local Level

5.1 General Characteristics

The streets and lanes which thread the old City divide the urban fabric into [†]disinct, bounded areas which we shall call blocks. Blocks vary in shape and size but, in the City centre, south of Cheapside, they are approximately rectangular and fairly small. In area, they range from 0.5 to 3 acres (0.2 - 1.1 hA); the ratio of width to length varies from 1:1.2 to 1:3.5. Both the smallest blocks and the most convex occur in the southern portion of the area, i.e. towards the riverside (fig. 5.1).

The general impression of the old City that may be gained by a casual examination of Ogilby and Morgan is of an extremely irregular morphology, composed chiefly of small buildings, haphazardly arranged across the length and width of the blocks. The dense packing of buildings is punctuated by yards and gardens, producing an urban surfae characterised by an alternating sequence of building and open space. Close inspection, however, reveals that buildings may differ considerably in size and shape within a given block. Moreover, the distribution of buildings is seldom uniform within the block.

The vast majority of buildings, regardless of location, have plans which are based on an orthogonal geometry. That is to say, each building is enveloped by a series of lines which intersect at right angles. The geometrical characteristics of the built forms are not, therefore, substantially different from those of a modern town. According to Krüger, "approximately 98% of the buildings in the town of Reading show geometric configurations made up by rectangular parallelepipeds put together" (1).

In the case of early London, however, it is perhaps more precise to speak of distortions of rectangles, since the contour lines of buildings sometimes show considerable deviation from the right-angled geometry. Buildings may also assume very intricate shapes, consisting of an assemblage of rectangular elements. From Ogilby



Fig. 5:1

and Morgan, it appears that the smaller buildings, both along the street edge and within the blocks, were usually a single rectangle in plan. Among larger buildings, irregular profiles were more common. The largest structures were generally situated away from the street edge. One may also observe that buildings along the perimeter of the blocks (i.e. those with one wall contiguous with the street edge) tend to be relatively long and narrow by comparison with those on the interior (within the blocks). This disparity is something one would expect where the street edge is of high commercial value, and the competition for building space correspondingly intense, as we know to have been the case in mediaeval London. The distinction is sharpest where a block faces on to a market place or a major commercial thoroughfare, but it is generally present to some extent even in blocks which are remote from the main streets. The diagrams in figure 5.2 show the width/length ratio of buildings in the block between the Old Change and Friday Street, facing Cheapside (block no.1). While the ratio ranges overall from 1:1 (45 deg.angle) to 1:4 (75 degrees), it will be seen that the perimeter buildings cluster in the upper part of the range, and the interior buildings in the lower part. The majority of the perimeter buildings fall between the angles of 65 degrees and 70 degrees, indicating a ratio of approximately 1:2.5. A large proportion of the interior buildings lie close to the 45 degree line, and are therefore roughly square in shape. Very few have a proportion greater than 1:1.5.

The number of interior buildings per block relates broadly to the size of the block: the smallest example (no.20) has no interior buildings; the largest (no.1) has the greatest number (see table 5.1).⁸⁵⁵ As local factors intervene, e.g. variation in the size of buildings and in the proportion of empty sites, the association is far from consistent. But the results for a sample of blocks in the City centre, when plotted in the form of a scatter diagram, suggest an upward curve (fig.5.3). The more intensive the development of the land, the closer one would expect the results to approach a logarithmic curve, i.e. the relationship of block area to perimeter length.

5.2 Building Connectivity

Turning to the topological characteristics of the building pattern (i.e. the physical location of buildings in relation to one another), the most striking feature is the high level of connectivity between buildings. Close packing appears to be the norm both at the street face and within the blocks. This property can be clarified with the help of graph representation. Each node of the graph will in this case represent a building, and each edge a common side wall between buildings.

To aid visual identification and comparison, the graphs will be drawn consistently with the nodes placed at the centre of the buildings, and the edges passing through the common walls. Edges are drawn for every distinct wall, or part of a wall, that buildings have in common. In a building of irregular profile, each line in the external envelope is considered a distinct wall where it forms an angle of 90 degrees with adjoining lines. Thus, an arrangement such as

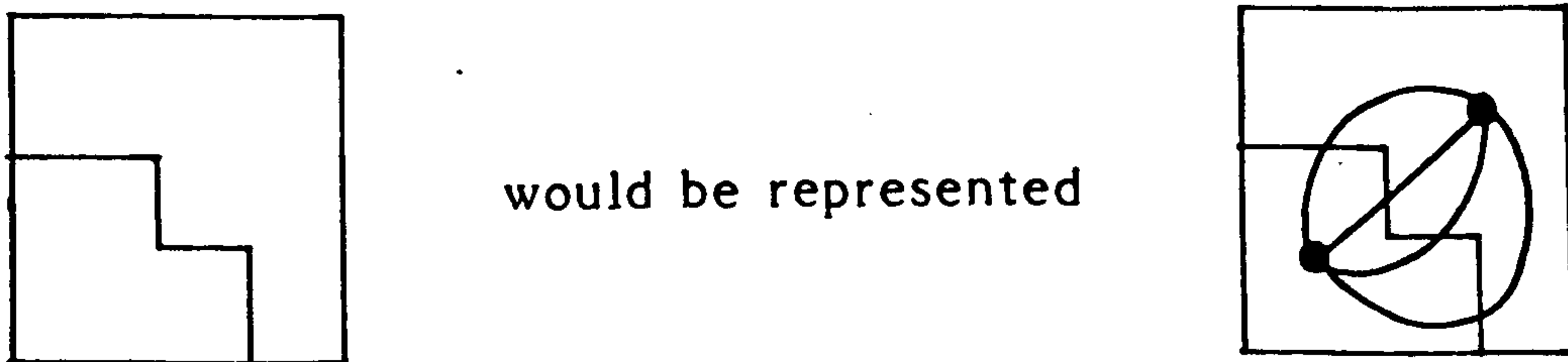


Fig. 5.4.

But edges do not represent corner junctions. Thus,

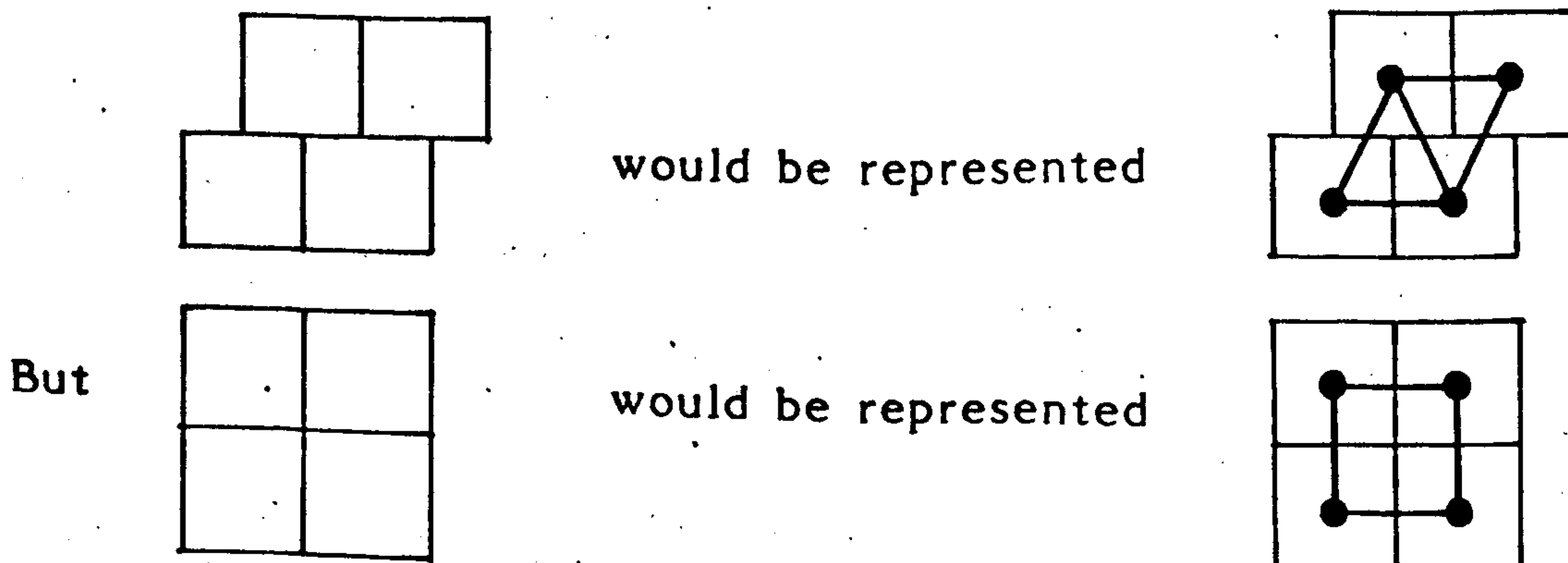


Fig. 5.5.

CHEAPSIDE - OLD CHANGE

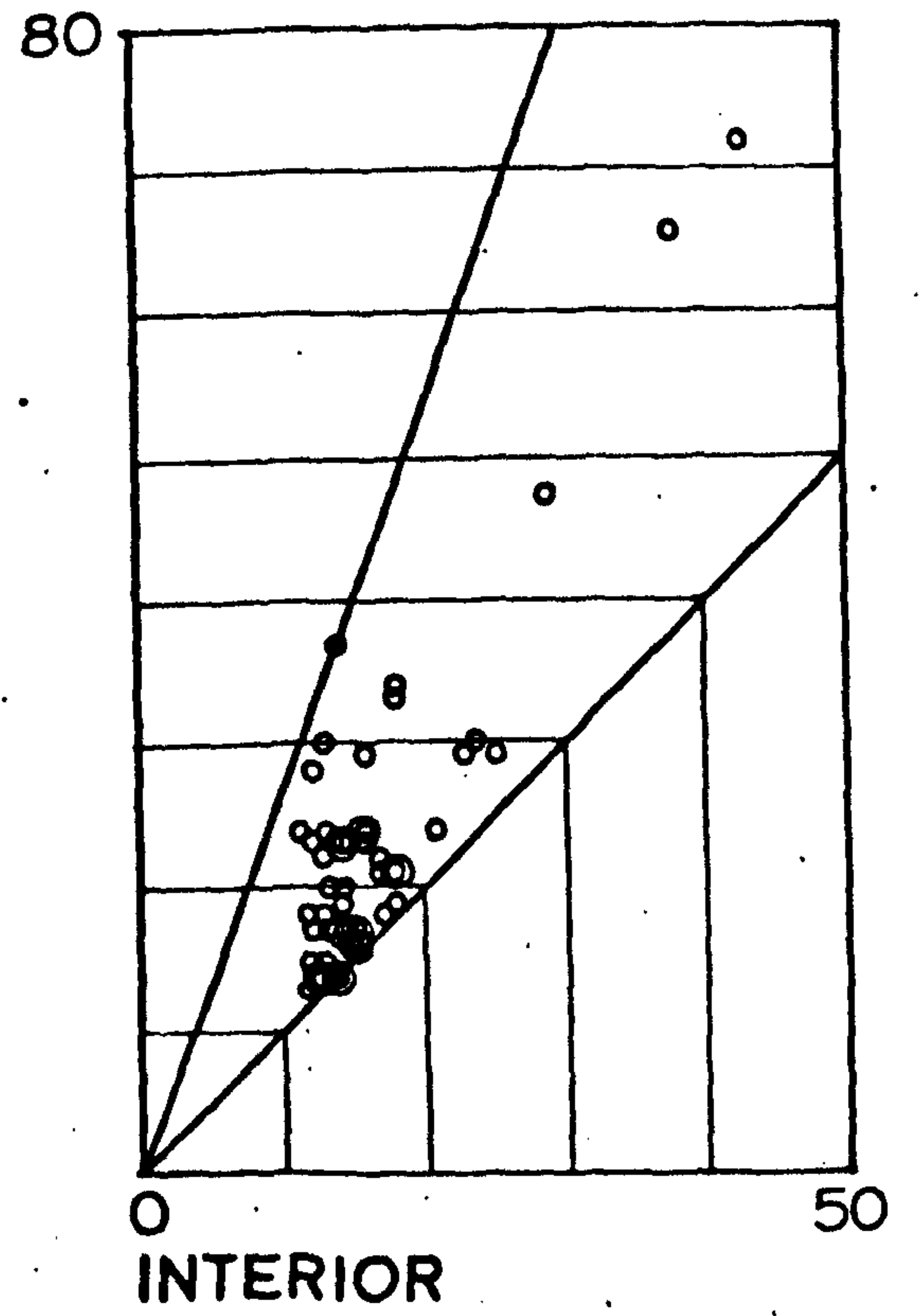
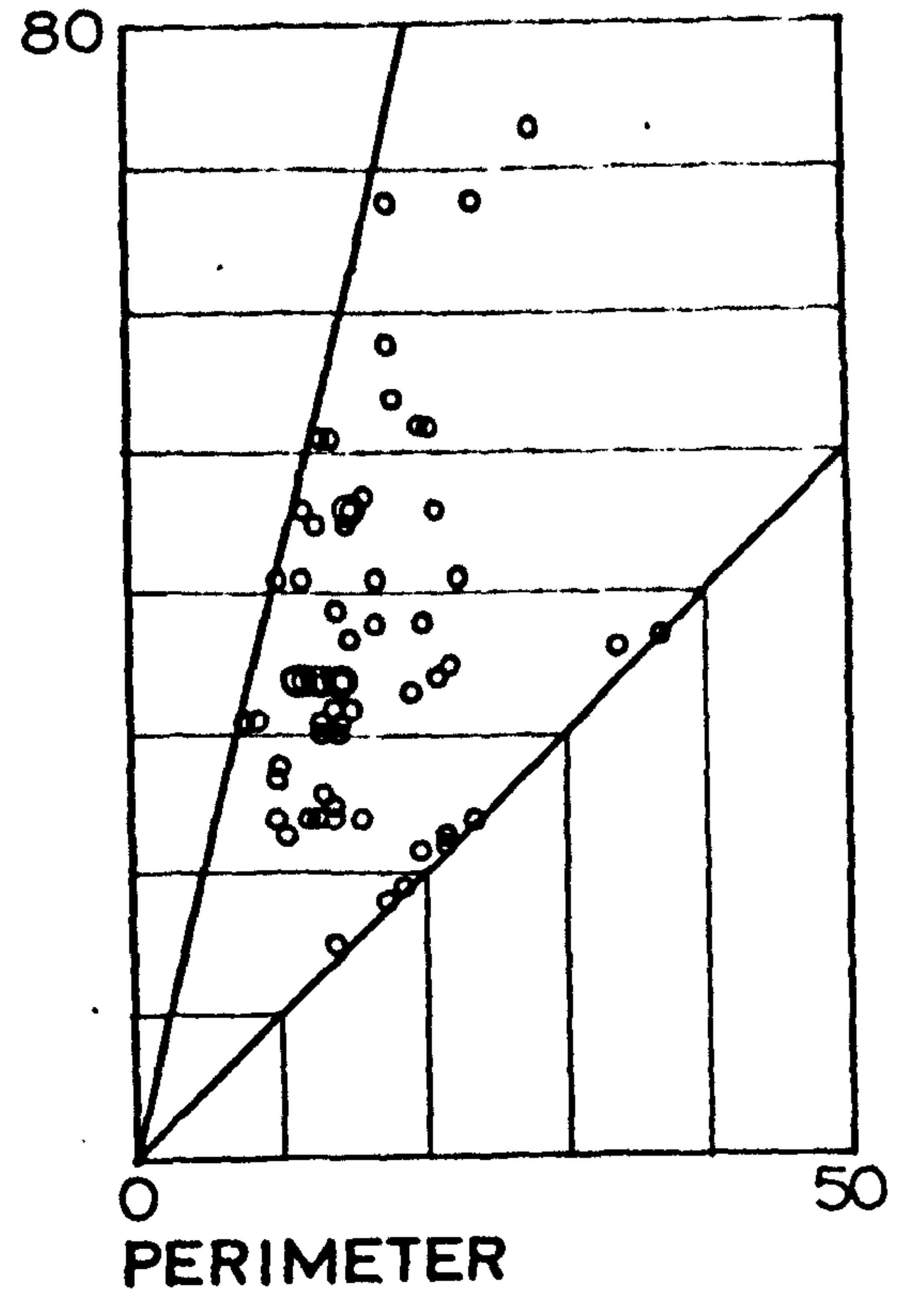
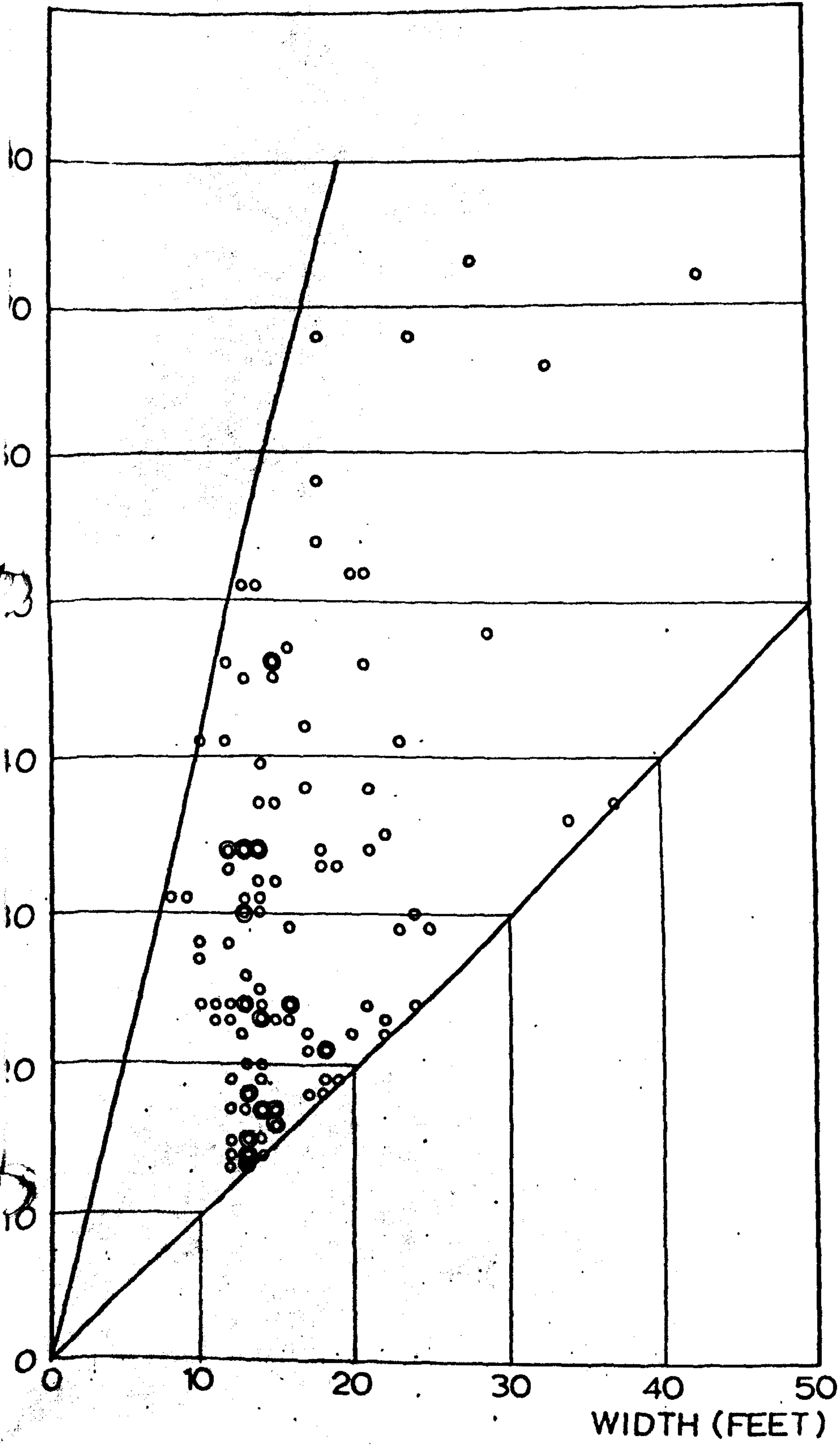


Fig.5.2. Length plotted against width for all buildings in block 1.

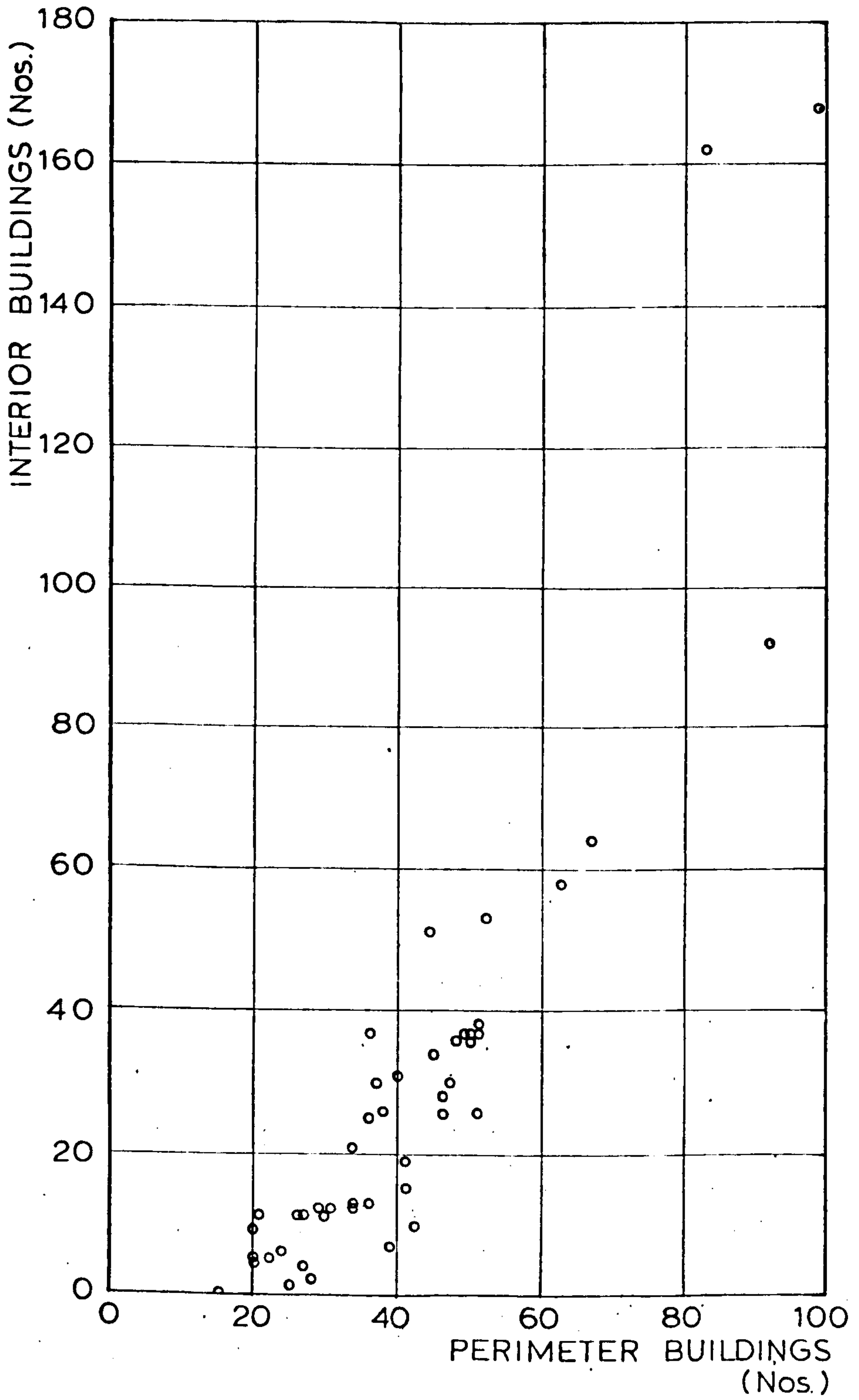


Fig.5.3. Number of perimeter buildings plotted against number of interior buildings for a sample of blocks in the City centre.

Figure 5.6 shows the area south of Cheapside transcribed in this way. Looking firstly at that portion of the map north of Upper Thames Street (i.e. excluding the riverside zone), one can make out twenty blocks, six of which appear in the representation as connected graphs. The remaining examples -the disconnected graphs- consist chiefly of independent connected components. The block between Old Change and Little Distaff Lane (no.14) resolves, when transcribed, into four components. The blocks contain from 15 to 121 buildings, the median figure being 60. The whole sample area contains almost 1200 buildings (see table 5.1).

BUILDING CONNECTIVITY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Perimeter	63	42	51	51	34	27	36	36	41	34	25	49	27	38	36	39	30	44	40	15	758
Interior	58	10	38	37	13	4	25	13	15	12	1	37	11	26	37	7	11	51	31	-	437
Total	121	52	89	88	47	31	61	49	56	46	26	86	38	64	73	46	41	95	71	15	1195

Table 5.1: Total number of buildings in the blocks south of Cheapside. The blocks are numbered consecutively from west to east, and from north to south, beginning with Cheapside-Old Change (no.1) and ending with Queen Street - Maiden lane (no.20).

A general feature of the graphs is that the vertices which represent the perimeter buildings tend to be linked one with another, forming long connected sequences or strings. These strings correspond to rows of contiguous buildings along the street edge. Breaks between strings generally denote the presence either of empty sites - many churches were not yet rebuilt - or, more commonly, of courts and alleys. Alleys, etc., run approximately at right angles to the street, and lead to the inner parts of the blocks. Not all of these secondary routes, however, form a complete break in the street frontage : it was common practice at this time, and earlier, to oversail alleys along the street face, so that building was continuous at first floor level and above. On Ogilby's map, the

portions of alleys bridged over in this fashion are indicated by horizontal cross-hatching. In the graphs, we have represented these upper-storey connections by broken edges. When the broken edges are taken into account, the perimeter strings become fewer and longer. The longest perimeter string consists of 45 nodes. In some cases, a block graph has all the perimeter nodes linked in an unbroken sequence, i.e. they form a cycle. The graph of block 2 has a cycle passing through all its perimeter vertices. Hence, the perimeter buildings were effectively a continuous row.

These general observations are pointed up by the valency measures presented in table 5.2. Over half (427 no) of all the perimeter nodes are found to have degree 2 (i.e. the buildings have two common walls), while only 9% (70 no.) are endpoints (i.e. the buildings have one common wall). Only a tiny proportion - less than 1% (4 no.) - of the total are isolated vertices, and 3 of the 4 correspond to buildings adjoining churchyards or similar empty sites. One of these is the Lutheran Church in Trinity Lane. It should be noted, however, that although parish churches might be detached, this was by no means the rule. In most cases, the secular buildings - houses and shops - were built directly against their outer walls. Churches were invariably located on the perimeter edge - in the area south of Cheapside, they are mostly to be found on the corners of blocks - and, through contiguous building, became integrated into the street frontage. St. Mary le Bow, next to Cheapside, provides an example of this pattern

Of the remaining perimeter vertices in the graph, the majority (28%) have degree 3. None has a degree higher than 5. These higher valencies signify either additional perimeter connections (not uncommon at the corners of blocks) or abutment on to interior buildings. Inward connection is most likely to occur where the frontage is broken by an alley, and development turns at right angles, following the line of the access route. Where development is associated with an alley or court, this frequently gives rise to further strings of vertices, which run into the heart of the blocks (e.g. block 3, i 51, and block 9, k 87 and k 88).



Fig.5.6. Connectivity graph for the area south of Cheapside.

Many interior nodes, however, are three- or four-way, rather than two-way connected. This reflects the prevalence of back-to-back development away from the street. Blocks 18 and 19, to the west and north of St. James Garlick, illustrate this kind of development. Interior strings are frequently connected to the perimeter at more than one point. Hence, the strings of perimeter vertices may lie on many cycles passing through the interior of the block.

A different connectivity pattern appears where a single building occupies the whole or a large part of the interior of a block, as occurs with many inns and mansion houses. Such a building may abut on to a considerable number of smaller structures, giving a high valency in the block graph. Bell Inn in block 1 (B80 on Ogilby and Morgan) has a valency of 8.

The connectivity of interior buildings for each of the blocks is recorded in table 5.3. Once again, two-way connections predominate, but these are markedly less frequent than on the perimeter: only 34% (149 no.) of all interior vertices have degree 2. The proportion of endpoints is approximately the same as on the perimeter, as too is the frequency of vertices with degree 3. But degree 4 is now more common (16% of the total) and 7% of the total is made up by nodes with a degree from 5 to 9. This shift towards a higher valency reflects the greater incidence of back-to-back buildings on the interior, and the presence of large inns and houses, as noted above. In the case of blocks 18 and 19, where rows of back-to-back buildings are well represented, vertices with valency 3 or higher make up 57% and 68% of the total respectively. The incidence of isolated vertices is again negligible.

If we now turn to the riverside zone, south of Thames Street, we are presented with a very different block pattern. The area is threaded by a whole series of secondary routes (lanes, alleys, passages), running north-south between Thames Street and the waterfront. The close spacing of these routes results in very narrow blocks, elongated in the north-south direction. A width of 30-50' is characteristic, while the overall depth of the riverside

development shown on Ogilby and Morgan is approximately 300' 0". Some of the blocks extend the full depth of the zone giving, in some places, a width/length ratio of 1:10.

BUILDING CONNECTIVITY

Block No.	Vertex degree (Perimeter)							Total
	0	1	2	3	4	5	6+	
1	-	3	31	26	3	-	-	63
2	-	-	23	16	-	3	-	42
3	-	9	22	17	2	1	-	51
4	-	6	33	9	3	-	-	51
5	-	1	18	13	2	-	-	34
6	-	-	19	7	1	-	-	27
7	1	3	16	13	3	-	-	36
8	-	5	21	8	2	-	-	36
9	-	5	27	8	1	-	-	41
10	1	10	14	7	2	-	-	34
11	-	4	15	4	1	1	-	25
12	-	4	21	19	5	-	-	49
13	-	2	15	5	5	-	-	27
14	1	2	24	9	2	-	-	38
15	-	6	14	13	3	-	-	36
16	-	2	25	11	1	-	-	39
17	-	2	26	2	-	-	-	30
18	1	3	22	12	6	-	-	44
19	-	-	31	9	-	-	-	40
20	-	3	10	2	-	-	-	15
Total	4	70	427	210	42	5	-	758

Table 5.2: Vertex degree of perimeter buildings in the blocks south of Cheapside.

BUILDING CONNECTIVITY

Block No.	Vertex degree (Interior)										Total
	0	1	2	3	4	5	6	7	8	9+	
1	-	6	23	12	11	4	1	1	-	-	58
2	-	-	-	5	2	1	-	1	-	1	10
3	1	6	15	7	7	1	-	-	-	1	38
4	4	2	15	12	3	1	-	-	-	-	37
5	-	2	4	2	3	1	-	1	-	-	13
6	-	-	1	1	1	1	-	-	-	-	4
7	1	1	12	5	6	-	-	-	-	-	25
8	-	-	4	3	4	2	-	-	-	-	13
9	-	4	6	5	-	-	-	-	-	-	15
10	-	2	2	6	1	-	-	1	-	-	12
11	-	-	-	-	-	1	-	-	-	-	1
12	1	6	10	11	4	2	1	1	1	-	37
13	-	1	-	6	4	-	-	-	-	-	11
14	-	4	8	11	1	1	-	1	-	-	26
15	1	3	17	9	4	1	1	1	-	-	37
16	-	1	3	2	1	-	-	-	-	-	7
17	-	2	5	4	-	-	-	-	-	-	11
18	-	6	16	17	12	-	-	-	-	-	51
19	-	2	8	15	4	2	-	-	-	-	31
20	-	-	-	-	-	-	-	-	-	-	-
Total	8	48	149	133	68	18	3	7	1	2	437

Table 5.3: Vertex degree of interior buildings in the blocks south of Cheapside.

That the waterfront development should assume this peculiar form is not surprising in view of the importance of the river in London's economy. The area shown is Queenhithe, the mediaeval corn market and the earliest documented trading centre along the river's edge. Competition for space in this prosperous riverside zone, together with demand for access to and from the wharves, would seem to have led to a subdivision of sites comparable with that along the main market streets. But here it is not only the individual plots that have become attenuated, but also the blocks themselves: the Thames was London's commercial thoroughfare 'par excellence'.

The effect of this north-south alignment, in spatial terms, is to make all buildings contiguous with an access route. In other words, all buildings now lie on the perimeter. In some cases, the blocks or strips have become so narrow that the buildings occupy the whole width, facing on to lanes or alleys at each side. In other instances, they accommodate two rows of building in a double-pile or back-to-back arrangement. Very few strips are greater than two buildings in width; where the width is sufficient for extra buildings to be inserted, external access is maintained by running additional alleys into the centre of the strip (e.g. Queenhithe - Towns End Lane).

The strip between Thames Street and High Timber Street differs from the majority in having an east-west alignment. But here again, the development is restricted in depth to two rows of buildings, bordering the streets (though separated, in this case, by gardens, rather than back-to-back). In some of the north-south blocks, the alleys are flanked, not by rows of small buildings, but by long, narrow structures, extending from the riverside almost to Thames Street. These were plainly warehouses or similar places of storage for merchandise (e.g. the building adjoining m.52). The heads of the strips were presumably occupied, then and earlier, by shops or houses facing Thames Street, as in the examples recently uncovered by archaeological investigations (2).

In the graph representation, two kinds of pattern are apparent: the

string of two-way connections ; and the cluster of three- and four-way connected vertices. The former clearly corresponds to the single-pile development, the small buildings being set out side-by-side in continuous rows. In the purest examples, the graph, or graph component, is a minimal connected sequence, i.e. it has no additional edges or connections (e.g. Dunghill Lane. In most cases, however, additional edges are found at the end of the string, marking the point where buildings turn at right angles to face the street. The graph for Thames Street - High Timber Street is a cycle, i.e. the two rows are connected in a continuous development. The more richly-connected graphs correspond to double-pile arrangements. Where the party walls of the two rows are in alignment, the graph vertices have degree 3 ; degree 4 arises where back-to-back buildings are staggered (e.g. to the east of Towns End Lane). The highest valency is produced by the warehouses, as these, like the inns of the City centre, often abut on to a sequence of smaller buildings. The very elongated structure adjoining Anchor Lane (m.52) yields a valency of 9.

BUILDING CONNECTIVITY

Riverside Zone	Vertex degree										Total
	0	1	2	3	4	5	6	7	8	9+	
	5	34	140	88	28	6	-	1	1	1	304

Table 5.4. Vertex degree of buildings in the area between Thames Street and the river.

The valency of all graph vertices in the riverside zone is recorded in table 5.4. 46% (140 no.) of the vertices have degree 2, 29% (88) have degree 3, and a further 12% have degree 4 and above. Thus, the connectivity properties fall somewhere between those of the perimeter buildings and those of the interior buildings for the larger blocks. Although the great majority of the riverfront buildings face on to access routes, two-way connections are rather less frequent than on the perimeter of the City blocks, while four-way connections and above are rather more frequent. The

increased connectivity is due principally to the higher incidence of double-pile development in the riverside strips. Back-to-back building, however, remains less common than on the interior of the City blocks. The frequency of end points and isolated nodes is extremely uniform in all the graphs.

Viewed as a whole, the area between Cheapside and the Thames may be taken to exemplify the topological characteristics of the City. The morphology is characterised, above all, by contiguity. Within an area of approximately 14hA (34.5 acres), there are nearly 1500 buildings, of which 1328 - 89% - have two or more contiguities. Detached buildings make up only 1% of the total. The isolated building then was clearly an exception in the local spatial structure of the City. For the purposes of simulation, the isolated entity may reasonably be discounted.

In subsequent chapters, we shall look more closely at some of the more characteristic blocks in this and other parts of the City. Because of its peculiar block pattern, the riverside zone will not be examined further in the present work.

6. Spatial Organisation Within The House

6.1 Introduction

In the previous chapter, we outlined some of the gross morphological characteristics of the urban structure of the City. No account was taken of the internal organisation of the buildings themselves. Yet, clearly, the two levels of spatial organisation are inter-locked: the packing of buildings on the ground, and the patterns of space so formed, cannot be fully understood without reference to the arrangement of space within the building envelope. It is proper at this point, therefore, to examine the plans of buildings in the City. To do this, we shall turn to the early manuscript surveys of property.

6.2 The Source Material

Ground plans of individual buildings, like maps of the City as a whole, begin effectively for London in the seventeenth century. Hence, the study has focussed on building plans during this period. Those surveys carried out in the years after the Great Fire - the most numerous - can be readily compared with the Ogilby and Morgan map, while, from the pre-Fire plans, some attempt can be made to project the analysis and conclusions back into the mediaeval period.

The City of London is, by comparison with other English towns, extremely rich in drawn plans of buildings. However, very little of this material has yet been published (1). The starting point for this section of the work was, therefore, to carry out a survey of the plan books belonging to the livery companies and to other bodies in the City (2). Since it was impossible to cover all the evidence, a small number of especially rich collections was chosen for detailed study. This has been supported by selected samples from other plan books, together with documentary evidence.

The analysis which follows is based on two important manuscript surveys.

1. Christ's Hospital Properties . Evidence Book, c.1612 (MS.12,805, Guildhall Library), 22 no. sheets, 97 plans, all recorded.
2. Survey of City Lands and Bridge House Properties . 2 vols. Late 17th century to early 18th century (Corporation of London Record Office). Total in sample = 258 plans.

Supplementary material has been drawn from :

3. Clothworkers' Plan Book , 1612 (Company Hall). Total no. of plans = 160.

4. St. Paul's Parliamentary Survey of Houses , 1649-57.
(MS.11,816A, G.L.). Total in sample = 99no.
5. Goldsmiths' Plans (loose), 1692 (C.H.).
6. Drapers' Plan Book , 1698 (C.H.).) Outline of
) buildings and
7. Merchant Taylors' Plan Book ,1680 (C.H.).) plots only.

No attempt has been made to follow in detail the alterations and additions made to individual buildings. While such an exercise can clearly be of interest and value in certain instances, it also takes a great deal of time to complete; for this reason, it was considered to be impracticable as part of the present project. More importantly, our principal concern here is with historical process of a different kind : that relating to the genotype rather than the phenotype (3). That is to say, we are concerned with the common code or set of instructions which underlies a whole class of buildings. This invariant structure can only reveal itself by reference to successive examples of buildings of the same spatial form. The priority has, therefore, been to suppress, rather than to delineate local characteristics, through the exhaustive analysis of a large body of empirical data.

Two of the manuscript books - Christ's Hospital and the Clothworkers' - date from the early seventeenth century. Both of these surveys were drawn by Ralph Treswell the elder (4). These are especially valuable sources for two reasons. Firstly, owing to their early date, the books provide a unique record of pre-Fire buildings. Many of these buildings were erected originally in the sixteenth century, and were thus truly mediaeval. Secondly, the majority of the plans in both books are carefully drawn and very detailed. Indeed, they are far more informative and convincing than many of the surveys executed in the latter part of the century (5). Rooms are labelled and dimensioned, doorways (but rarely windows) are shown, yards and gardens are included, and the names and owners of adjoining property given. Colour tints are used to distinguish

buildings under separate ownership or lease, and to differentiate internal spaces and yards from gardens. Fireplaces and masonry walls are also indicated. Furthermore, a considerable number of the plans contain a written description of the upper rooms, from which it is possible to deduce the number of storeys (where this is not also given) and to reconstruct the arrangement of spaces on the upper floors. The Christ's Hospital Evidence Book remains a comparatively neglected source since none of the plans have yet been published.(6). It seemed appropriate, therefore to transcribe and analyse this set of plans in full.

The two volumes covering the estates of the Corporation of London contain a very large number of plans, all carefully drawn to scale. The surveys were carried out at different times during the late seventeenth and early eighteenth centuries. The plans in the latter part of Volume II are dated from 1719 to 1723. The properties are nearly all located in the City liberties, i.e. those historic areas surrounding the City, which originally lay outside its jurisdiction (7). Especially prominent are Houndsditch, the Minories, Duke's Place, Camomile Street, and Fore Street. Unlike the Treswell plans, the City plans give no information on the upper floors of the buildings represented, and generally do not give the ownership of adjoining properties. They do, however, distinguish building materials clearly and consistently by means of a colour code.

Each of the main collections - Christ's Hospital and City plans - provided a large sample for analysis. And, separated by a century or more, and spanning the Great Fire, they offered a sound basis from which to examine the evolution of plan-types.

The great efflorescence of measured building plans that occurred during the seventeenth century is in itself an interesting and highly significant development, and one that should not be passed over without some discussion. In the latter part of the century, one finds a sudden upsurge of interest in property surveying: livery companies, and post-Reformation hospitals and schools decided, many for the first time, to have their lands and tenements systematically

recorded, and for this purpose employed professional estate surveyors. In the surveys that were produced, the buildings are almost invariably depicted on plan, i.e. in the modern manner. The fact that the majority of the surveys were executed in the period between fifteen and thirty years after the Great Fire strongly suggests that this burst of activity was closely tied up with the experience of that cataclysm. It certainly made necessary the production of detailed and accurate plans of the City as a prelude to rebuilding. But the technique of depicting buildings on plan, as opposed to the three-dimensional representation, had a longer history : it would be quite wrong to see the birth, or rather the rebirth, of the ground plan itself as a product of the Great Fire.

Apart from the theoretical objection that an event cannot be isolated from surrounding circumstances - it is not a self-sufficient cause - the historical evidence refutes this assumption. Especially illuminating are the surveys made in connection with encroachments. Philip Jones has illustrated the history of encroachment along the City wall by reference to the various property records which survive (8). The sources begin with the Iter rolls of the thirteenth century and extend to a survey by William Leybourn in 1676, and beyond. But Leybourn's plan was not the first to be made : a plan of the wall and ditches had been voted for as early as 1602 (9). It was in the early years of the century, too, that Treswell was engaged in producing the extensive surveys of the property of Christ's Hospital and the Clothworkers' Company, described above. The earliest surviving plans of individual buildings in the City (those of John Symons and John Thorpe) date from the 1590's; and, although only isolated examples, these early surveys clearly indicate that the technical means already existed to enable surveyors to produce plans of high quality. If, in fact, there is a turning point, which marks the accession of the measured building plan, we are entitled to see this, not in 1666, but in the closing years of the sixteenth century.

The drawing of plans had been well-understood and widely practised by the Romans. The 'gromatici, (county and borough surveyors), instructed from manuals of surveying, made accurate drawings which showed how streets, walls, and buildings were sited on the ground (10). But this knowledge had later fallen into decay, and the plan drawing effectively vanished during the Middle Ages. The method was not revived until the sixteenth century. In the middle decades of the sixteenth century, 'scenographic' prospects, i.e. panoramic and pictorial representations, were increasingly joined by 'ichnographic' plans, i.e. vertical or near-vertical 'views'. Town plans might be drawn employing either of these methods. Braun and Hogenberg's city-atlas, 'Civitates Orbis Terrarum', exemplifies the two approaches ; the map of London was one of those delineated 'ichnographically'. The rebirth of the vertical plan or map was made possible by technical developments in the methods of mensuration, and reflected a concomitant change of perception. The superiority of this form of delineation was quickly recognised, and the true ground plan began to come into its own, as the means of representing both cities and individual buildings, in the latter part of the sixteenth century.

In London, the emergence and general adoption of the building plan appears to parallel closely the rapid growth in population from Elizabethan times to the seventeenth century. The pressure to occupy common land and land of dubious ownership grew in tandem with the rising tide of population, and was clearly stimulated by the Elizabethan Proclamations and subsequent legislation prohibiting new building (11). The maximum pressure of population in the City seems to have been reached soon after 1600; and it was at this time that the pleasure gardens disappeared from the City wall (12). Plans were drawn up to check encroachments and to enable rents to be charged for them. As Skelton has observed, the unique advantage of a survey which describes buildings and towns from a vertical viewpoint is that it permits the accurate representation of spatial relations (13). With the ground plan, therefore, it became possible for authorities and property owners to monitor growth and change. It appears reasonable to infer that the effect of the

sudden and terrible devastation caused by the Great Fire was to bring into focus the value of the ground plot as an aid to planning and as a legal safeguard. In this context, the proliferation of surveys by the livery companies in the latter part of the century can easily be understood.

A synoptic history of topographical surveys would therefore suggest that the great concern with recording property by means of measured plans in the seventeenth century was neither ephemeral nor adventitious, but sprang from a real need - the need to record and to regulate change. This, in turn, was a product of urban growth, just as much as the separation of home and workplace which was to occur a century or so later. Hence, an intimate relationship emerges between the spatial arrangement of people (the density and distribution of the population, the frequency of encounters) and the mode of spatial representation of buildings. In order to test this hypothesis, it would be necessary to undertake a comparative study of different cultures at a similar stage of evolution.

To pursue this in detail would take us far beyond the scope of the present inquiry. Here we shall be concerned, not with the social context of the plans, but with analysis of the information that they yield ; not the source of the artefacts, but the artefacts themselves.

6.3 Description

The analysis will be concerned chiefly with two morphological properties of building plans : adjacency, and access or permeability . Rooms are adjacent when they have a wall, or part of a wall, in common. Rooms are permeable when there is at least one doorway, or other means of passage between them. The properties of adjacency and access are of particular interest in building layout because they indicate the functional relations between rooms.

It is possible to consider these properties by inspection and direct comparison of the plans themselves. But this is not the easiest nor the most rigorous way to proceed ; certain apparent similarities are found, on close examination, to be merely specious, while plans which are superficially very different may have identical patterns of access. In order to introduce greater precision into the description and analysis, we shall use graph-theoretic notation. The nature and applications of graph theory have been discussed in part I. The principal application here will be the access graph .

In the access graph each node will represent a room or other space within the house, and each edge will represent a connection (a doorway or other opening) between spaces. The access graphs will in all cases be drawn according to the 'justified' format of Hillier and Hanson (14). That is, each graph will be arranged vertically with the vertex representing the exterior region -in this case the street- at the base of the diagram. The vertices representing internal spaces (and yards, gardens) are placed on the appropriate levels above this according to their distance - in terms of edges - from the exterior ; those spaces which can be reached directly from the exterior are placed at level one ; those requiring two steps (edges) from the exterior, at level two ; and so on. This form of representation thus expresses the 'depth' of a space, not in any metrical sense, but in terms of the minimum number of spaces through

which it is necessary to pass in order to reach the one concerned.
 Thus, the three-room plan.

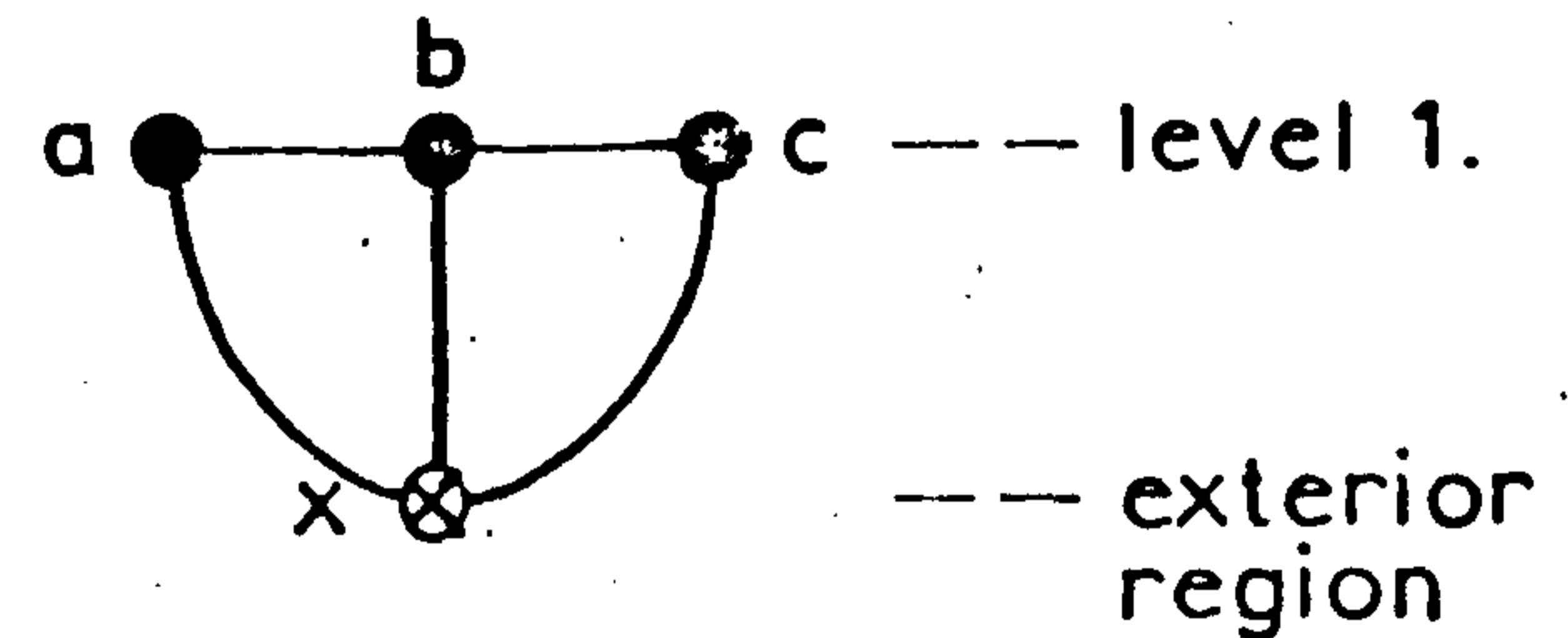
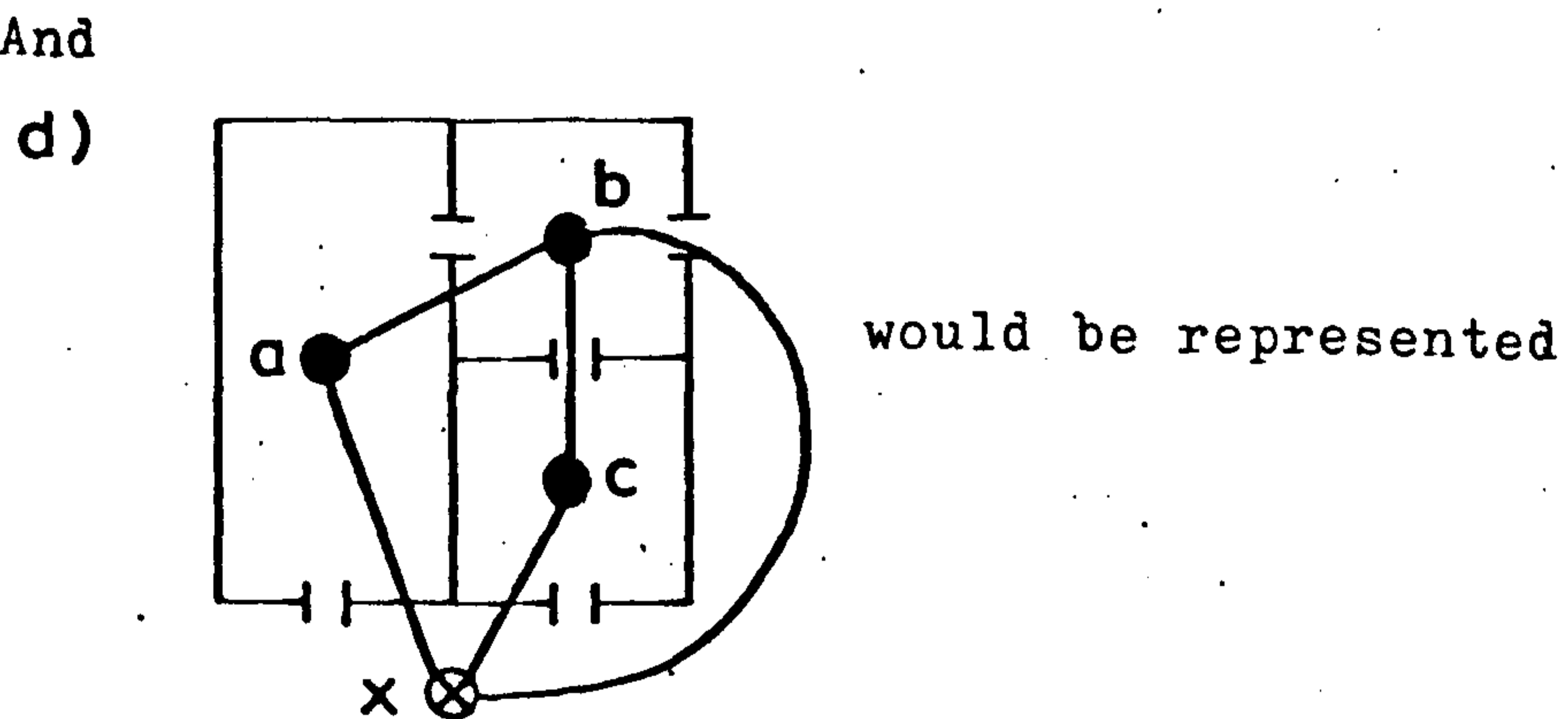
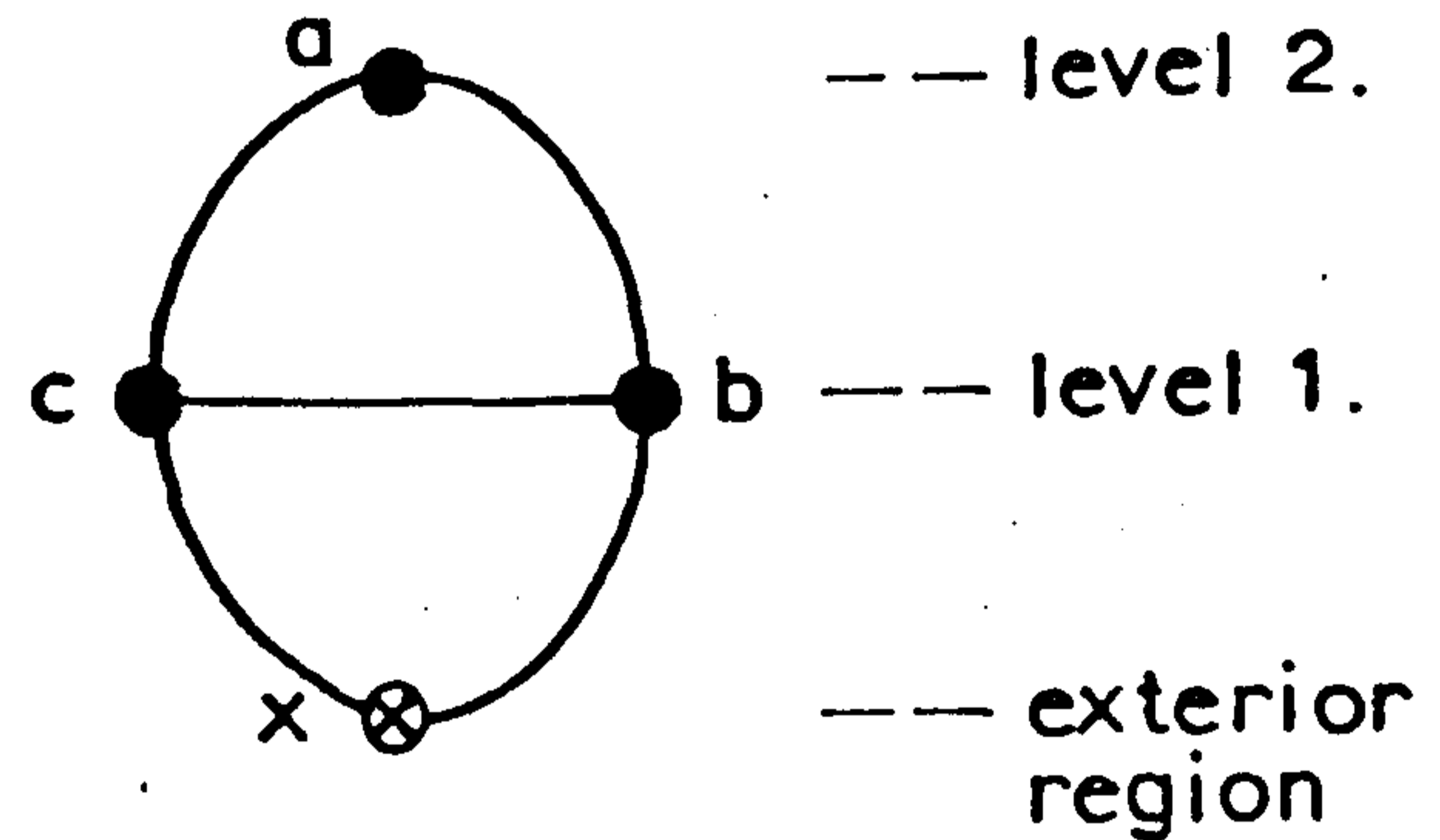
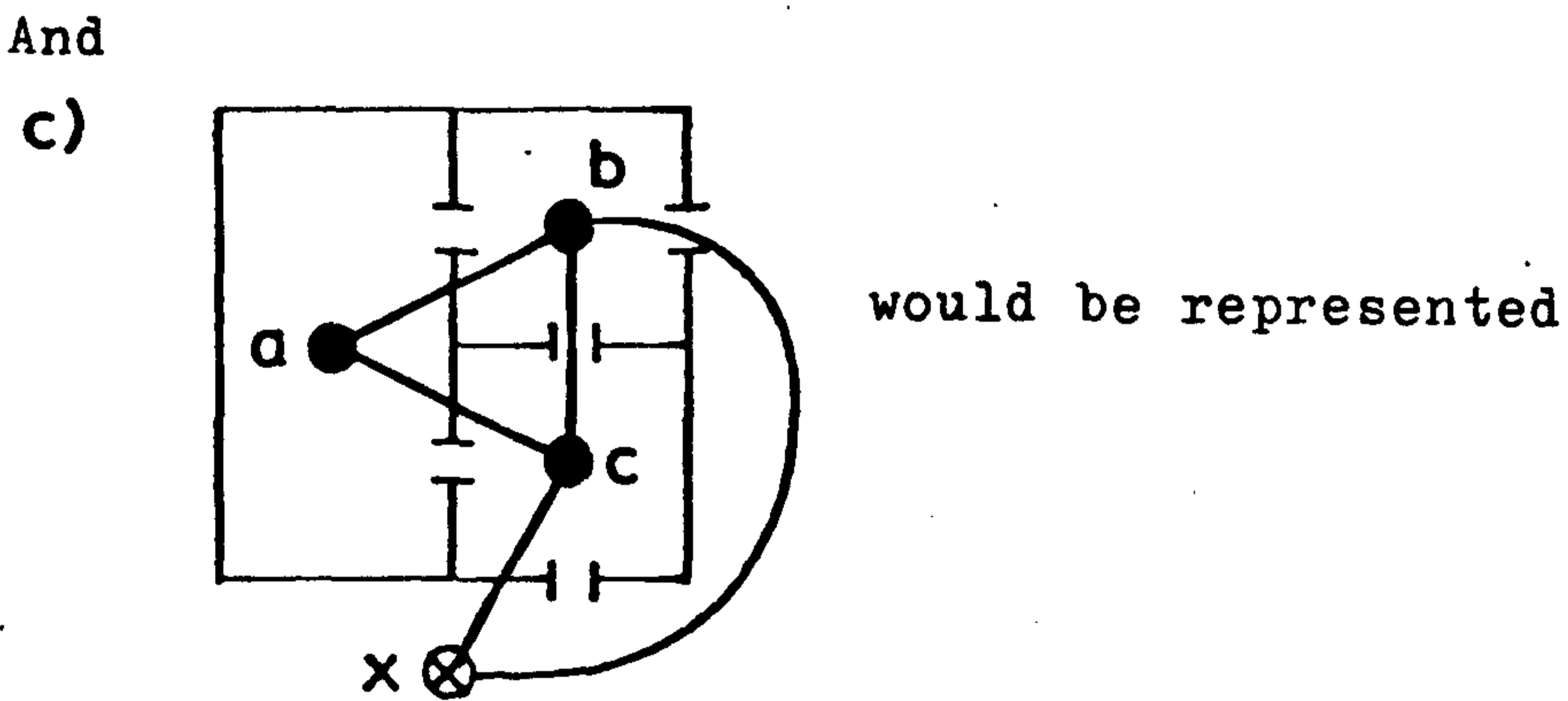
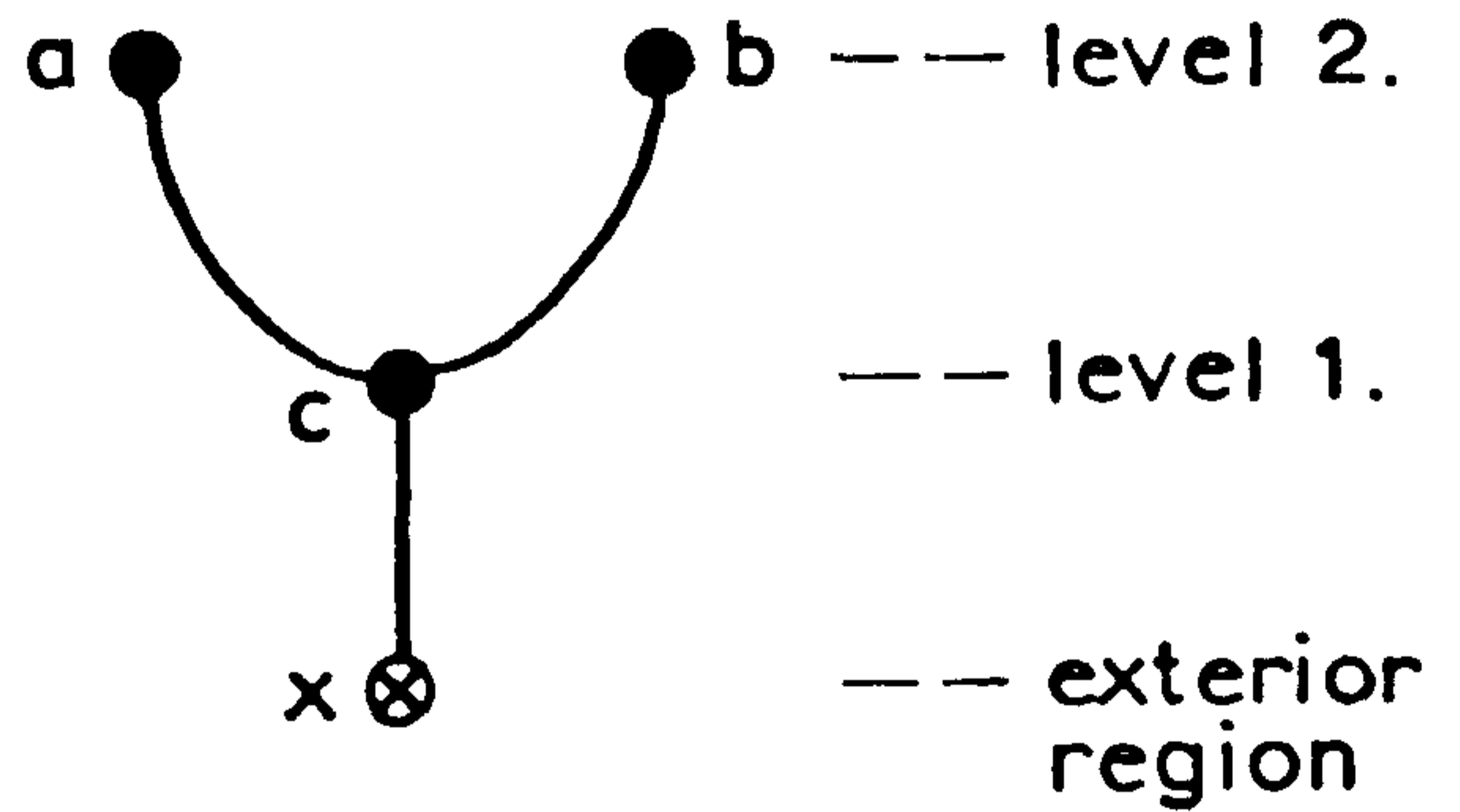
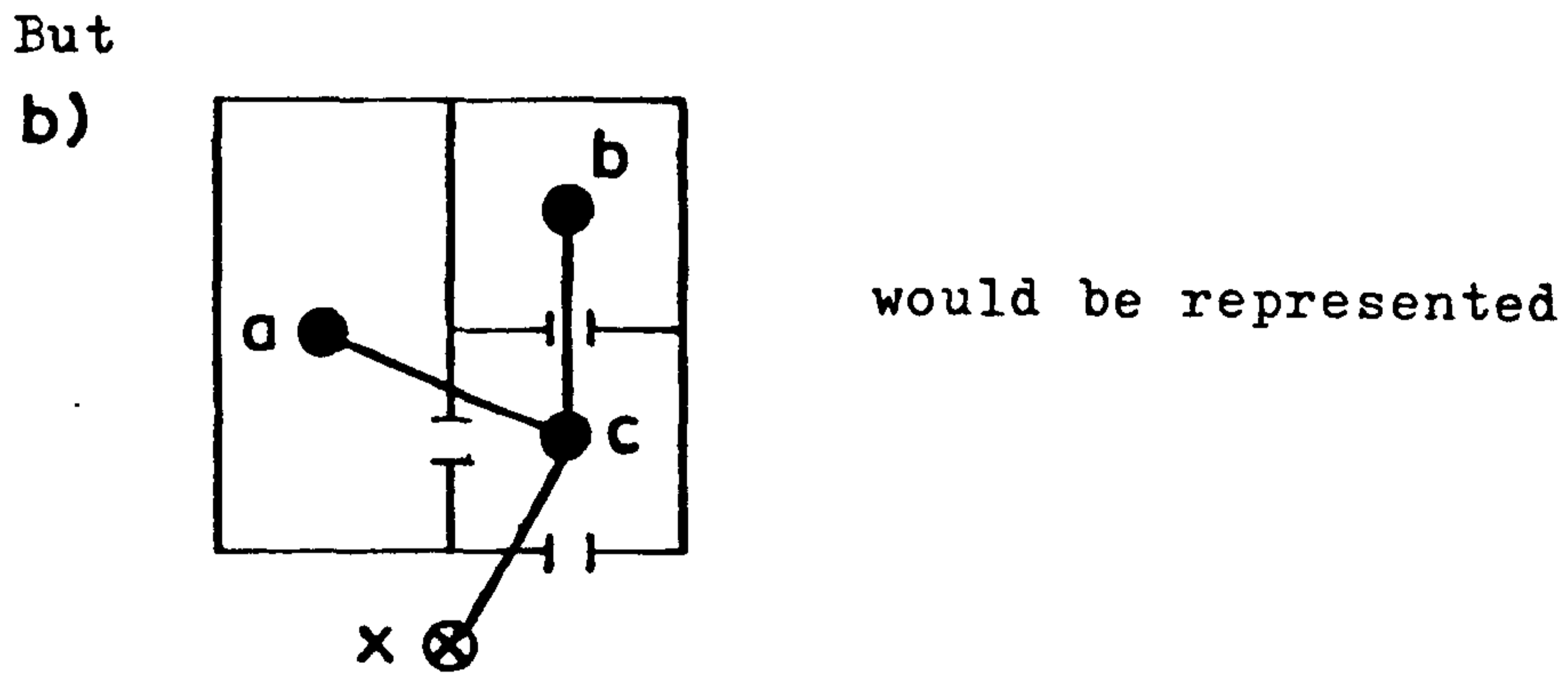
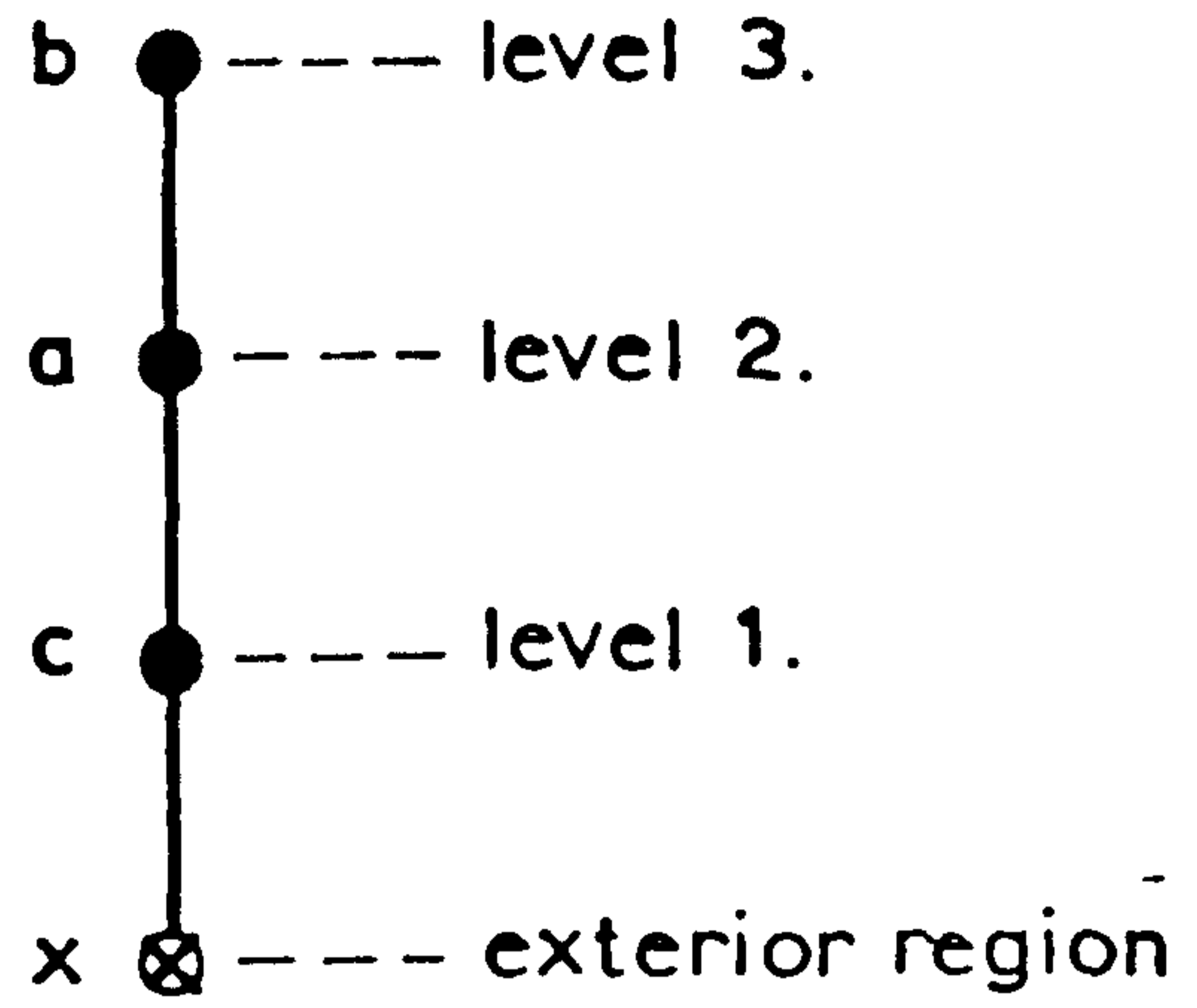
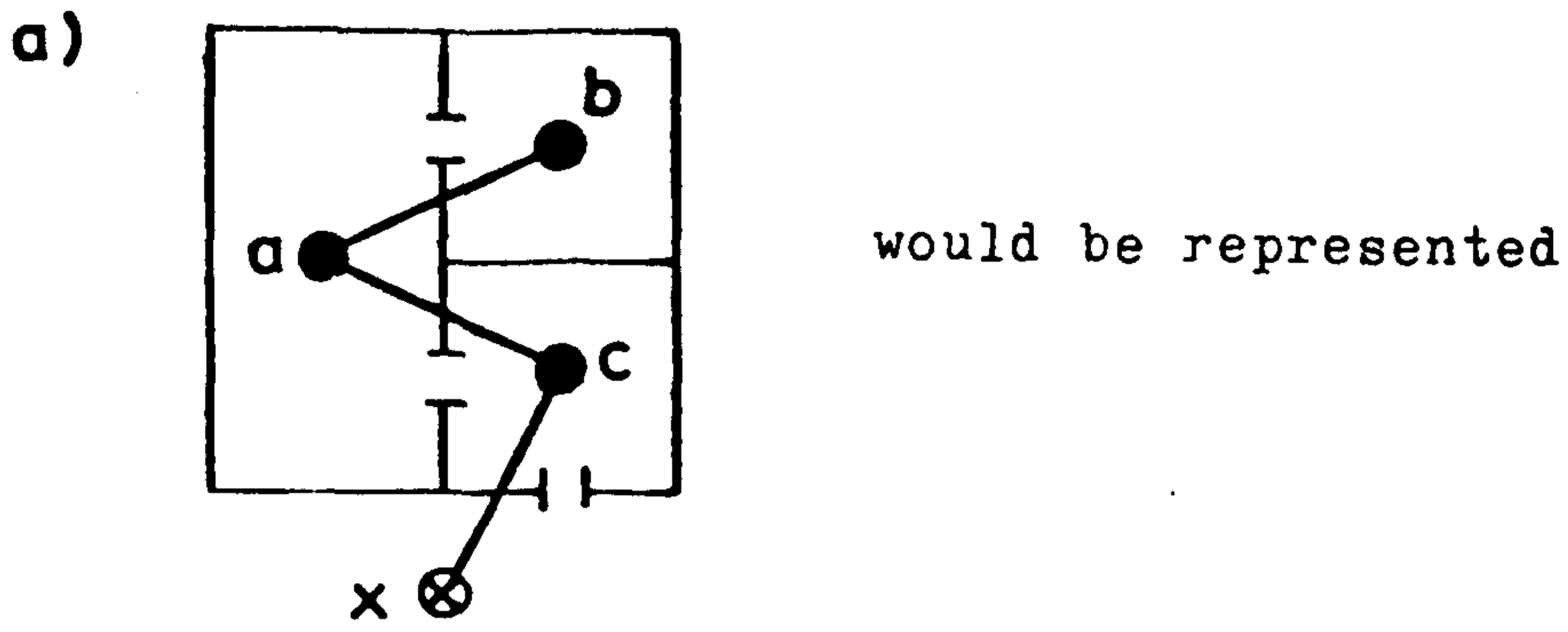
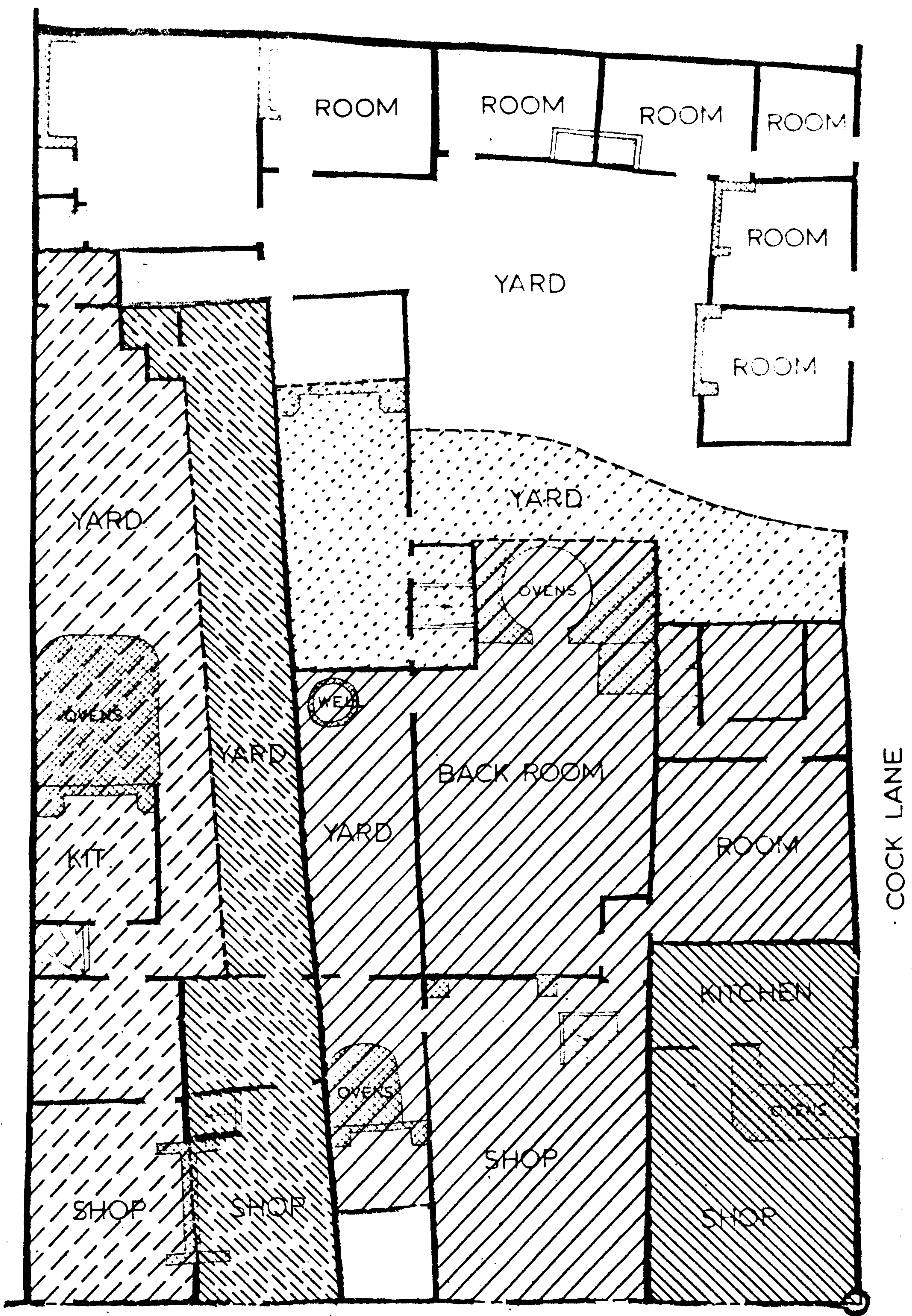


Fig. 6.1. Four possible access patterns for a three-room plan.

As can be seen from these examples, the advantage of the 'justified' format is that it points up the characteristic features of a graph: both the overall access pattern and the 'depth' of individual spaces are more easily identified when the graph is drawn in this way. The examples also illustrate the diversity of access patterns that can be achieved within the same plan form. Nevertheless, these represent only a small proportion of the total number of possible access graphs for the given arrangement of rooms. For a complete enumeration of the possible access graphs for the three-room plan, the reader is referred to Steadman (15).

The access graph has been found to be singularly the most useful and suggestive of the graph structures drawn. Previous work by Hillier and Hanson has demonstrated its value in providing insight into the social aspects of historic and modern building plans (16). In this study, we have drawn the 'justified' access graphs of all the plans in the samples (17). The morphological properties to be discussed are derived in most cases from the access graphs alone. In some instances (e.g. connections/insulations between spaces) the conclusions will be based on a comparison of the access and adjacency properties of the spaces in question. The symbol \otimes will be used to refer to the street, while internal rooms, yards, and gardens will be represented by a solid circle (\bullet). Transitional spaces - entries, passages, etc. - will be represented by an open circle (o). A zigzag line will be used to indicate a staircase to the upper (or lower) floors. Where the plans include an inventory of the upper rooms, conjectural access graphs have been drawn for these floors. When the 'depth' of a space is given, however, this will refer in all cases to the ground floor plan only.

The geometrical characteristics of buildings in the City have already been discussed. In most cases, we shall be dealing with buildings which approximate to a rectangle on plan. The processes of amalgamation and subdivision of properties, however, resulted in an ownership or occupation pattern which frequently cut across the physical contours of the buildings. Hence, when tenancies are plotted, irregular, interlocking shapes are found to be very common. An example is given in fig.6.2 shown overleaf, which shows a row of cookshops at Pie Corner. A similar consideration applies to the arrangement of buildings in the third dimension ; it was not uncommon for the upper floors to be subdivided differently from the ground floor, and for rooms to extend over a neighbouring tenancy. To avoid ambiguity, graph notation has in all cases been applied to those rooms grouped under a single lease or tenancy.



HOUSES AT PIE CORNER, SMITHFIELD
 based on the plan in Christ's Hospital Evidence Book, c.1612

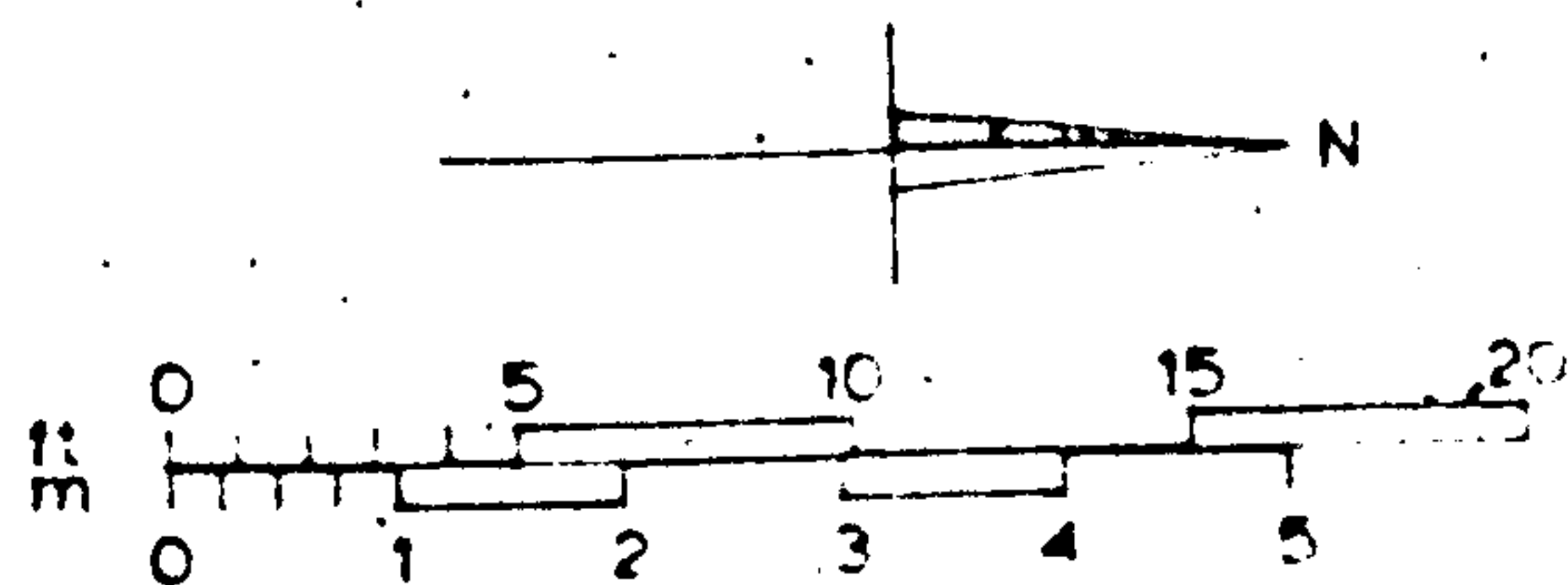


Fig.6.2. Pattern of tenancies in an area of London, c. 1612.

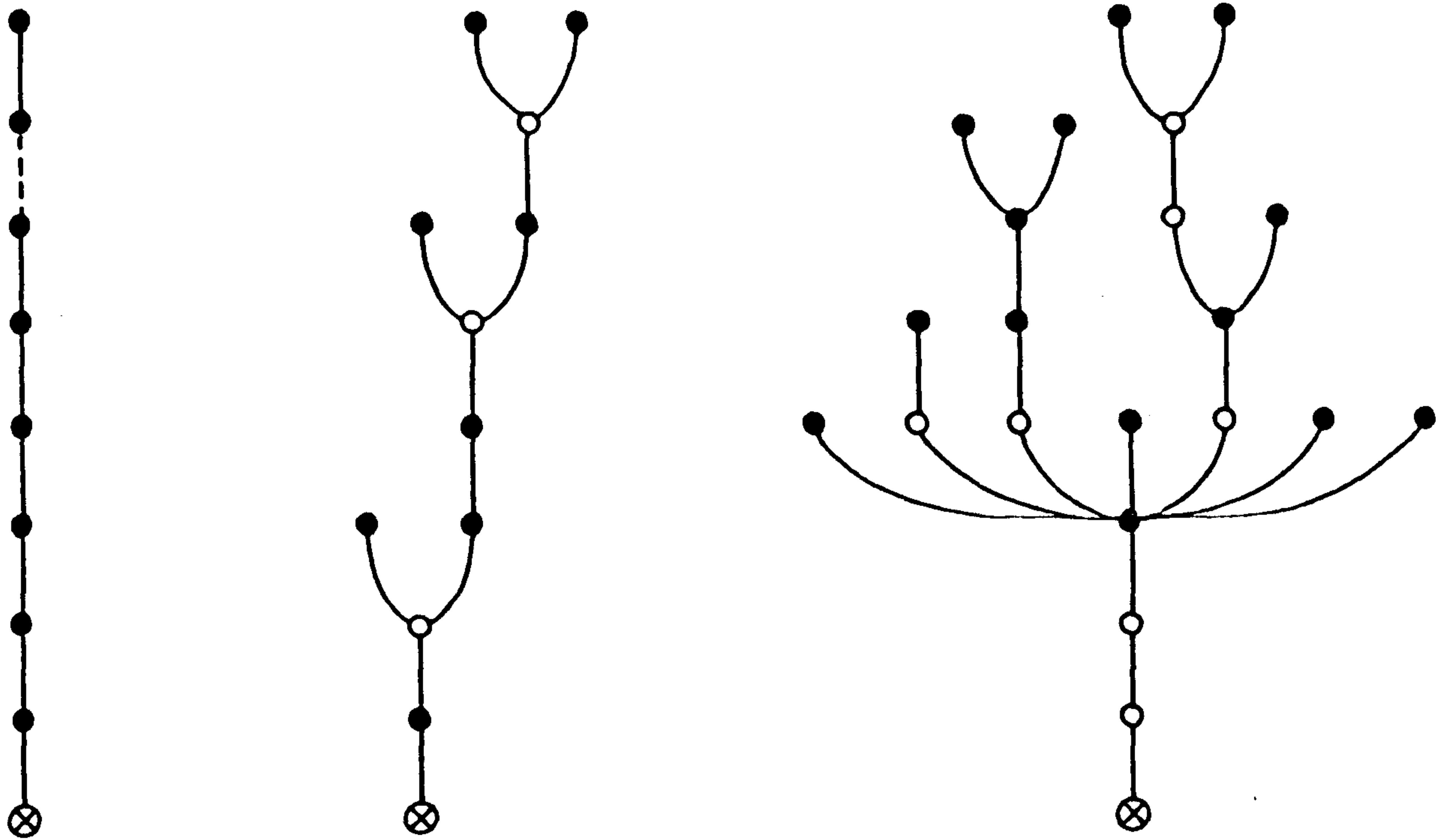
6.4.1 Once the justified access graphs are drawn for the plans, a number of features become apparent. These are purely morphological or syntactic properties, and take no account of the labelling of spaces.

Firstly, the majority of the plans in both the Christ's Hospital and the City land manuscripts have only one direct connection to the street system. Hillier and Hanson use the terms 'distributed' and 'non-distributed' to designate respectively those graphs which have cycles or 'rings' passing through the exterior region, and those which do not. (18). In the examples given above, c) and d) are distributed graphs, while a) and b) are non-distributed. If the two sets of plans are classified on this basis, the results are as shown in table 6.1.

Approximately three quarters of the plans, in each case, have graphs which are non-distributed. It should, however, be noted that the symbol for the external region here represents the street system, and not all open space. If the base vertex is used to denote all space external to the building, a very different result is obtained. For the Ch.H plans, 61% (59 no.) of the total, as opposed to 23%, now have 'distributed, graphs. This disparity is explained by the high incidence of gardens and yards which are connected to the house, but remain apparently unconnected to the street system.

The second feature is the relative absence of internal 'ringiness'. This is also shown in Table 6.1.^{*} The vast majority of the non-distributed graphs are trees. At their simplest, these take the form of a linear sequence of rooms. Examples occur in both plan books. The sequence may contain up to 8 levels, but is more commonly 4-5 levels deep. Other graphs are much more elaborate in form, with multiple branches and a deep asymmetric structure. Examples of various trees are given in fig. 6.3.

* Tables 6.1-21 at end of chapter 6: pp. 162A-1.



Houndsditch
(City, Vol. I, p. 80)

Westminster Market
place (Ch. H., p. 19)

Needlers Lane
(Ch. H., p. 4)

Fig. 6.3. Examples of 'non-distributed' access graphs from the Christ's Hospital and City lands surveys.

Thirdly, although the total number of levels ranges widely - from 1 to 8 - the majority of buildings have no more than 4 steps to their deepest space. This property is true for both sets of plans, but is particularly marked in the City sample, where 82% of plans have 4 levels and under, and 94% have 5 levels and under (see table 6.2).

The total number of rooms (excluding ancillary spaces) ranges from 1 to 10 for Ch. H., and from 1 to 6 for the City plans. But, in both instances, the majority of buildings are found to have 1 or 2 rooms only. The full breakdown in terms of numbers of rooms is given in table 6.3.

6.4.2. We can now consider the graphs from the point of view of their labelling as well as their spatial configuration. It is found that among the sequences and trees - the characteristic graph-types - the deepest space is generally either the garden, yard or back ground or, alternatively, a workshop, shed or house of office (privy) reached through this space. Different sorts of workshop abound in the City plans : a casting house (19), a cooper's workshop (20), a brewhouse (21), a founder's shop, a currier's workshop and a bakehouse (22) are merely a few of the names mentioned. Aside from their power to evoke local character, they give an indication of the great variety of trades practised at the time. The majority of these plans, it will be remembered, relate to buildings in the vicinity of London Wall, and it was against the wall, or close by, that many of the workshops were built.

A large number of plans in both sets - over 40% in each case - have no attached open space. The type and distribution of open space in the samples can be considered by reference to tables 6.4 and 6.5.

It will be seen that the buildings without open space are predominantly those of small ground plan. The majority have one room only. Gardens and yards are for the most part associated with buildings having two or more rooms on the ground floor. Of the one-room plans, 87.5% of the Ch.H. sample and 64% of the City sample are without attached open space. Of the two-room plans, 62% of Ch.H. and 70% of the City have a yard, garden or both.

The incidence of yards and gardens increases approximately in parallel with increase in the size of the building, and the largest houses (though not all large buildings) usually have both yards and gardens. Where this occurs, the yard is normally at an intermediate point in the access graph, while the garden is located at the deepest levels. The position of the yard is, in this case, plainly connected with the need to provide daylighting to internal spaces within the confines of a narrow plot, flanked by contiguous buildings. In a typical arrangement, the yard occurs after a suite

of two or three rooms, and is followed by a second grouping or sequence, leading finally to the back space.

The frequency of room names in the two samples is given in tables 6.6 and 6.7. Among the Ch.H.plans, a small group of room names is found to recur throughout the sample : shop, kitchen, chamber and garret are the most common ; hall, parlour, and buttery occur with rather less frequency. In the City plans, a century or more later, the pattern has changed little. Shop and kitchen remain at the top of the list, and parlour appears with similar frequency to the earlier set. The hall however, is much less common. Warehouses and workshops appear in greater numbers, and names such as 'counting house', 'back shop', and 'back warehouse' now occur with greater frequency. In the absence of upper floor plans or descriptions for the later buildings, no firm statement can be made concerning rooms above ground floor level. But, from the notes attached to a small number of plans, it would appear that 'chamber', 'room', and 'garret' were the most common names on the upper storeys, (23). A garret, as in the earlier plans, was clearly a room in the roof space. 'Chamber' and 'room' seem to have been used as generic terms for upper floor rooms and may have been equivalent. The label 'house' which is now widespread, is generally attached to the ground floor room in single-room plans, and would seem to have referred to the whole dwelling.

In both sets of plans, the shop is by far the most usual space at level 1 in the access graphs. This reflects the importance of the street as a commercial thoroughfare in the seventeenth and eighteenth centuries. The street frontage may be considered as a 'privileged edge' within the urban structure, in that it was this boundary that afforded maximum opportunity for direct contact with the community at large. The advantages of the street edge for buying and selling had long been recognised, and the mediaeval tradesmen congregated along the main thoroughfares in the City centre (24). By the seventeenth century, commercial use had clearly displaced all other land-uses in the great majority of the streets, and the houses of the rich - the mansion houses- are to be found

within the blocks, where they were presumably also protected by the ranges of shops from the noise, dirt, and hazards of the street (25).

The deeper levels in the perimeter buildings - levels 2,3 and perhaps deeper - are normally occupied by the living quarters - the kitchen and/or the parlour. The chamber is overwhelmingly, although not exclusively, an upper floor room. An analysis of room depths was made for both sets of plans, and the results are presented in Tables 6.12 to 6.14. The implications of the topological characteristics of the different rooms will be discussed more fully below. But, before proceeding to a detailed analysis, it is important to establish a typology of spatial configurations. This will provide the basis for an economical representation of building plans, and serve as a frame of reference for questions of internal layout.

6.5 Typology

The analysis will confine itself initially to the Ch.H plans. These may be divided into 3 classes or sub-sets according to size, i.e. the number of rooms in the ground floor plan, viz.

- 1) The single-room plan,
- 2) The two-room plan,
- 3) The plan with three or more rooms.

For (1) and (2) type-graphs may be drawn which represent the most frequent access patterns (the modes) in each sub-set, viz.

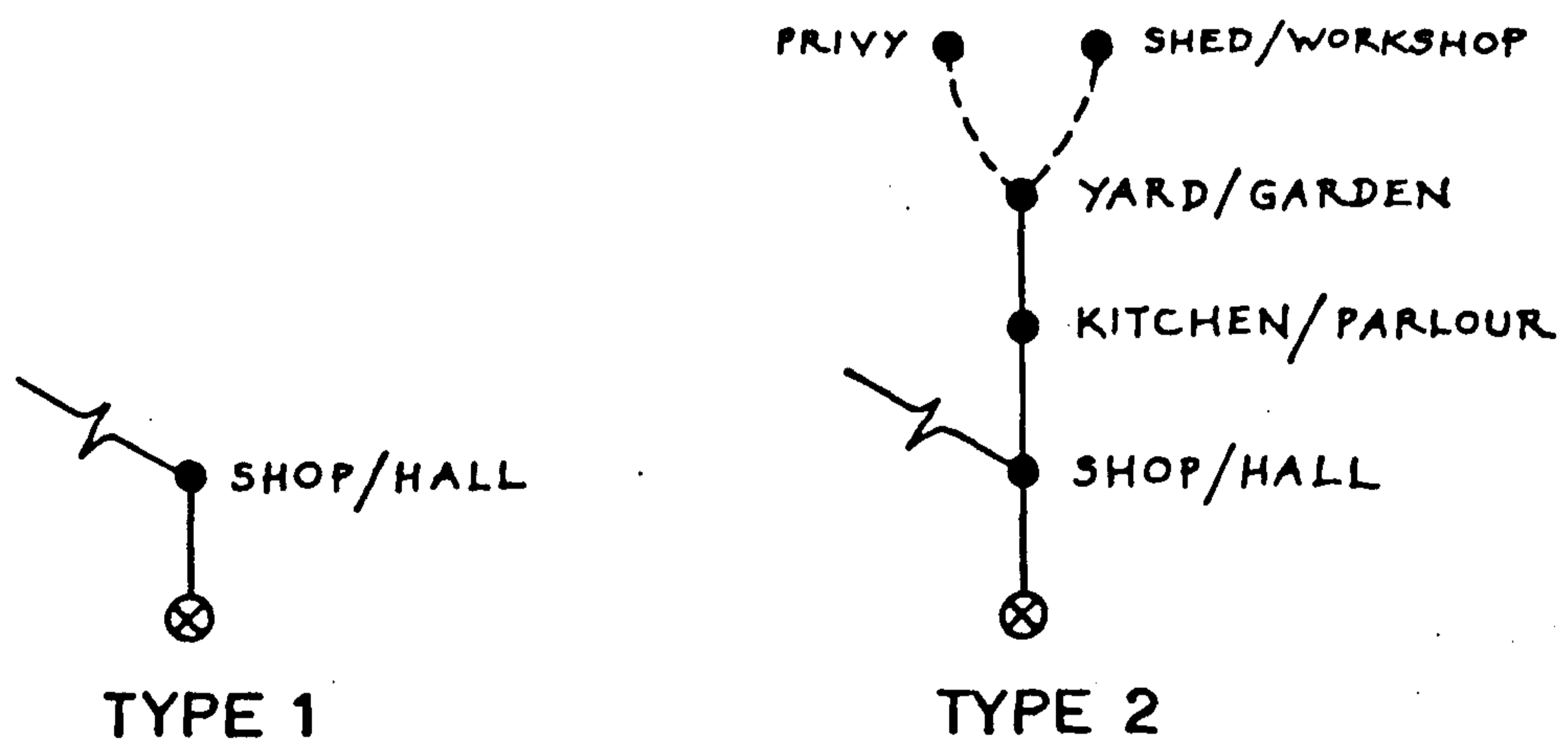


Fig.6.4. Access graph types 1 and 2.

Type 1 is the most elementary access graph. The single ground floor space is generally a shop or a hall, although it may also be a chamber or room. Access is direct from the street or external space, and vertical circulation to the upper floor(s) is usually by means of stairs located within the room. There is no garden or

yard. 35% (34.no) of the Ch.H. plans fall into this category, all of which conform exactly to the access graph shown.

Type 2 is essentially a linear sequence, with the shop or hall reached directly from the street.. This is followed by the kitchen or parlour, which in turn leads to a back yard or garden. Various circulation spaces - entry, passages - may be introduced. The stairs to the upper floor(s) may be in either of the main rooms or in an intervening circulation space. The number of buildings falling within this category can vary according to the classification of rooms and the character of the graph. Taking the maximum possible number, 42% (41 no.) of the Ch.H plans can be included in this type, of which 12% (12 no) are pure examples, i.e. conform exactly to the type-graph. The remaining 30% are variants of the access graph. Although the variants thus represent a substantial proportion of the total number, the majority of these differ only marginally from the type-graph. The differences arise principally from the addition of circulation spaces within the plan, and the absence of, or the addition of further external space. Also included in the category are those larger plans in which suites of chambers are built around the type 2 core.

Type 3 is a more amorphous category than the previous two. As a catch-all for the larger buildings, which represent approximately a quarter of the Ch.H sample, it embraces plans which differ widely in size and in access structure. Since the number of theoretically possible room arrangements increases rapidly for plans above two rooms, especially when circulation spaces, yards, and gardens are taken into account, it was not unexpected that the analysis of this sub-set would reveal a considerable variety of access graphs (26). In fact, little regularity is to be observed when the access patterns for each complex are compared : each configuration tends to be unique.

An initial attempt to capture the common access properties in a single graph is shown in figure 6.5.

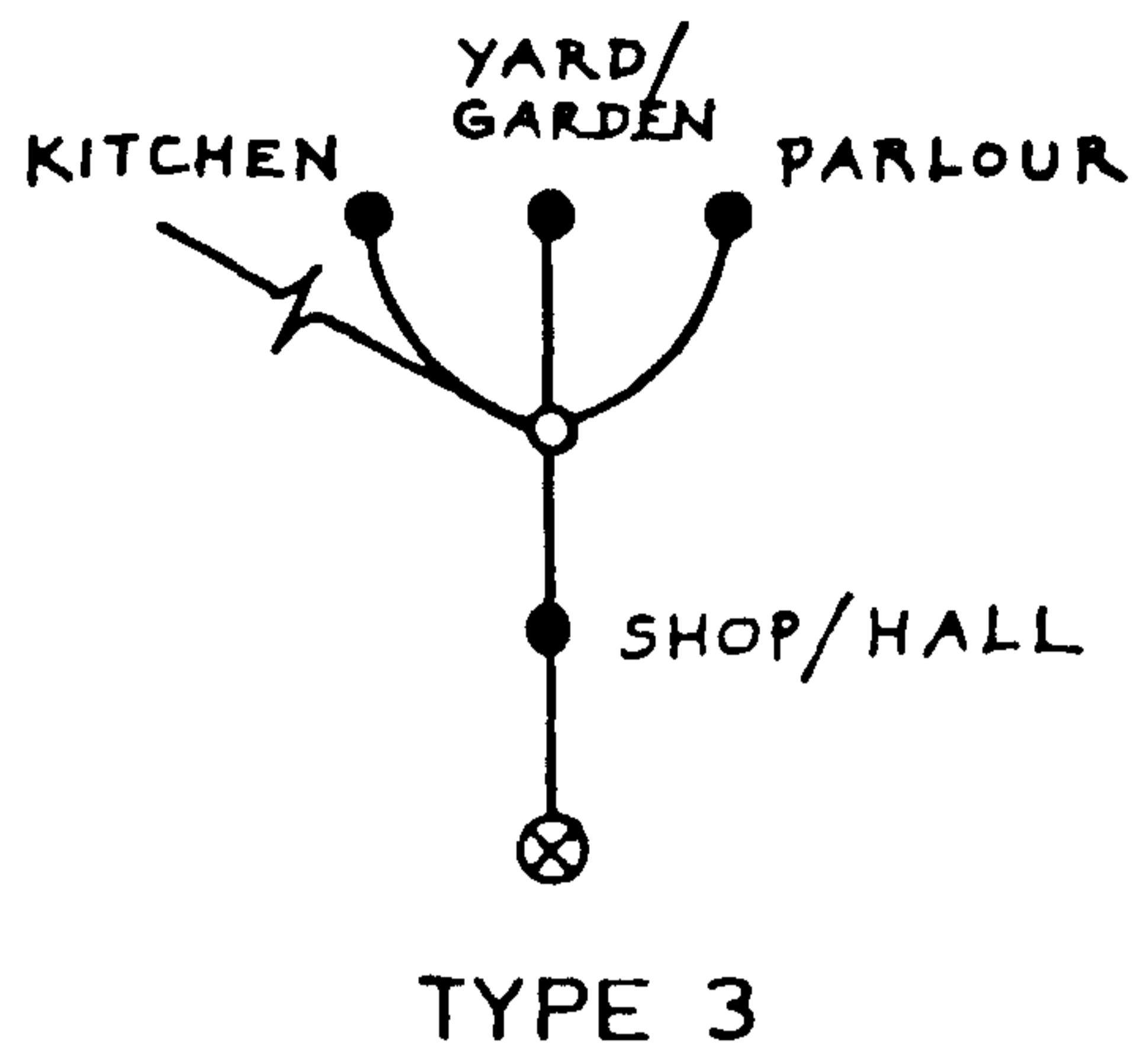
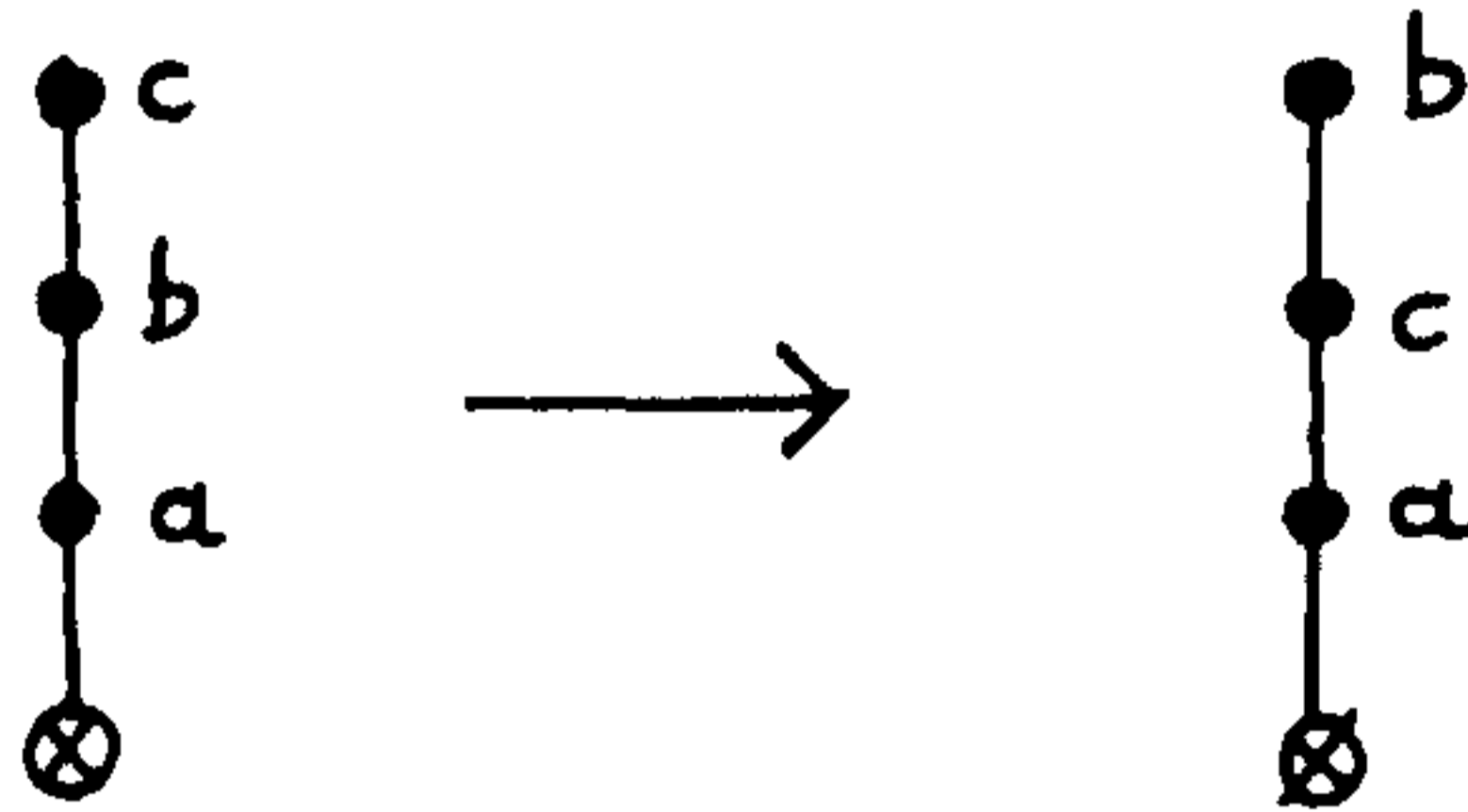


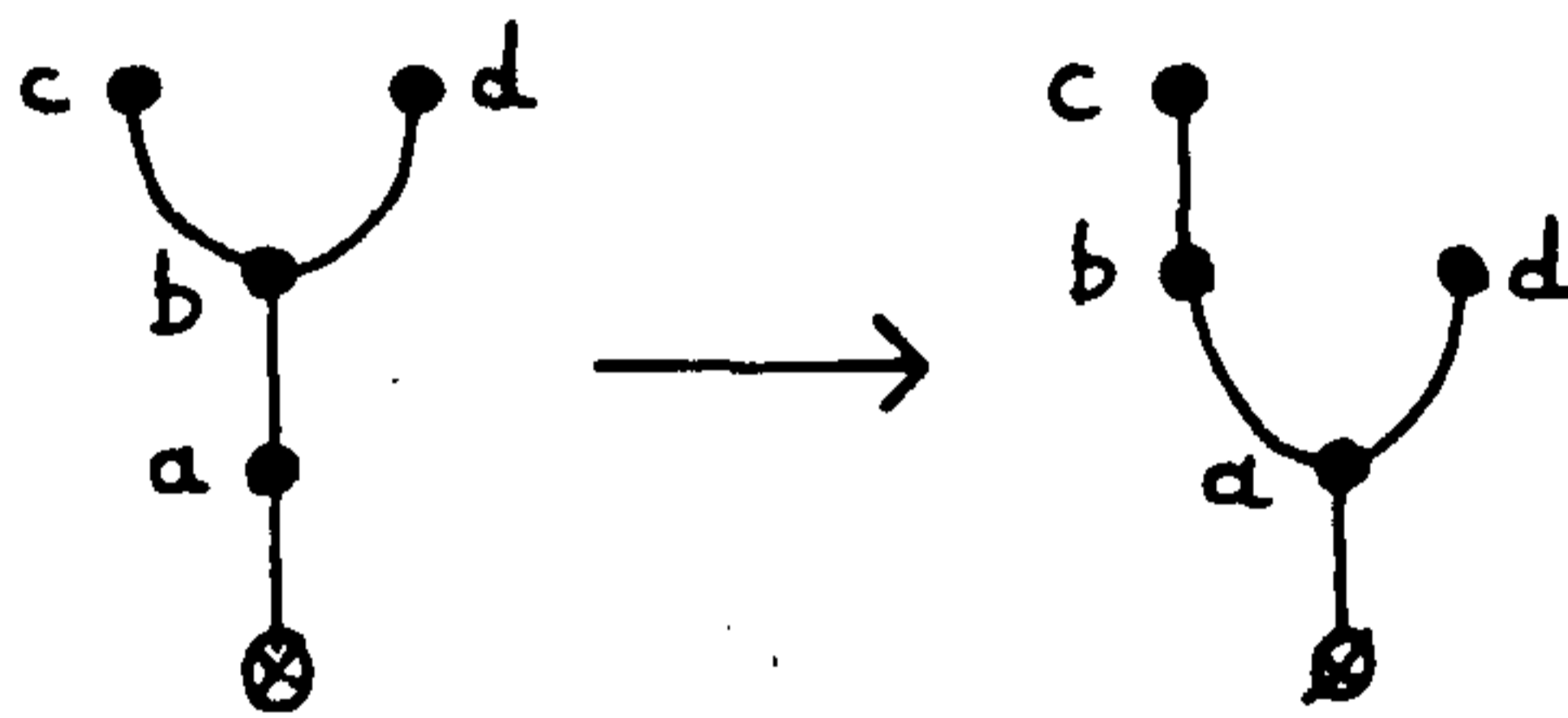
Fig 6.5. Access graph type 3 : the ideal type

The graph represents a synthesis of properties - number of rooms, labelling and room depth - derived from a large group of plans in the sample. While offering a yardstick against which the different graphs may be measured, it nevertheless correlates poorly with individual examples. Deviation from a given type-graph was measured in terms of the number of adjustments or operations required to bring each example into conformity with the graph. Four operations were counted :

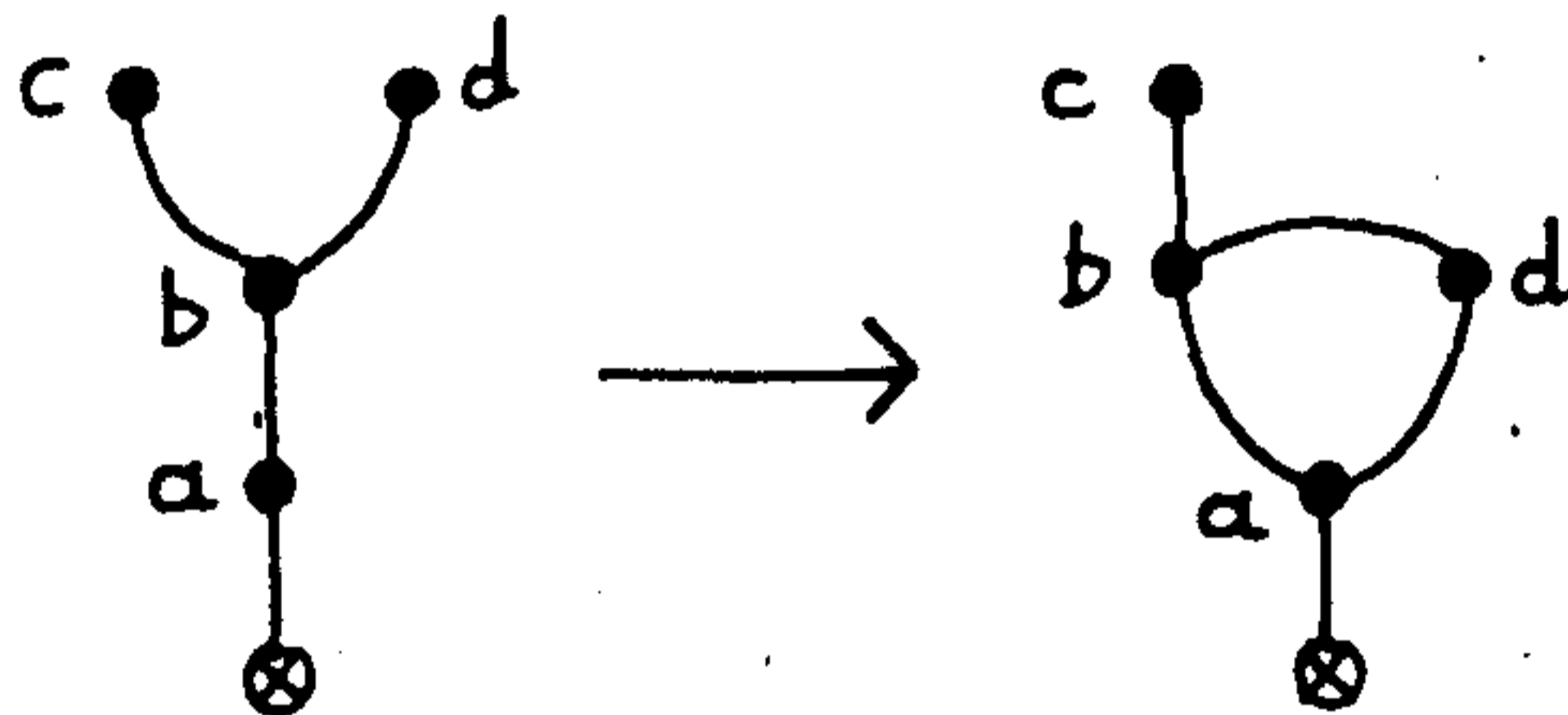
- 1) Swap labels



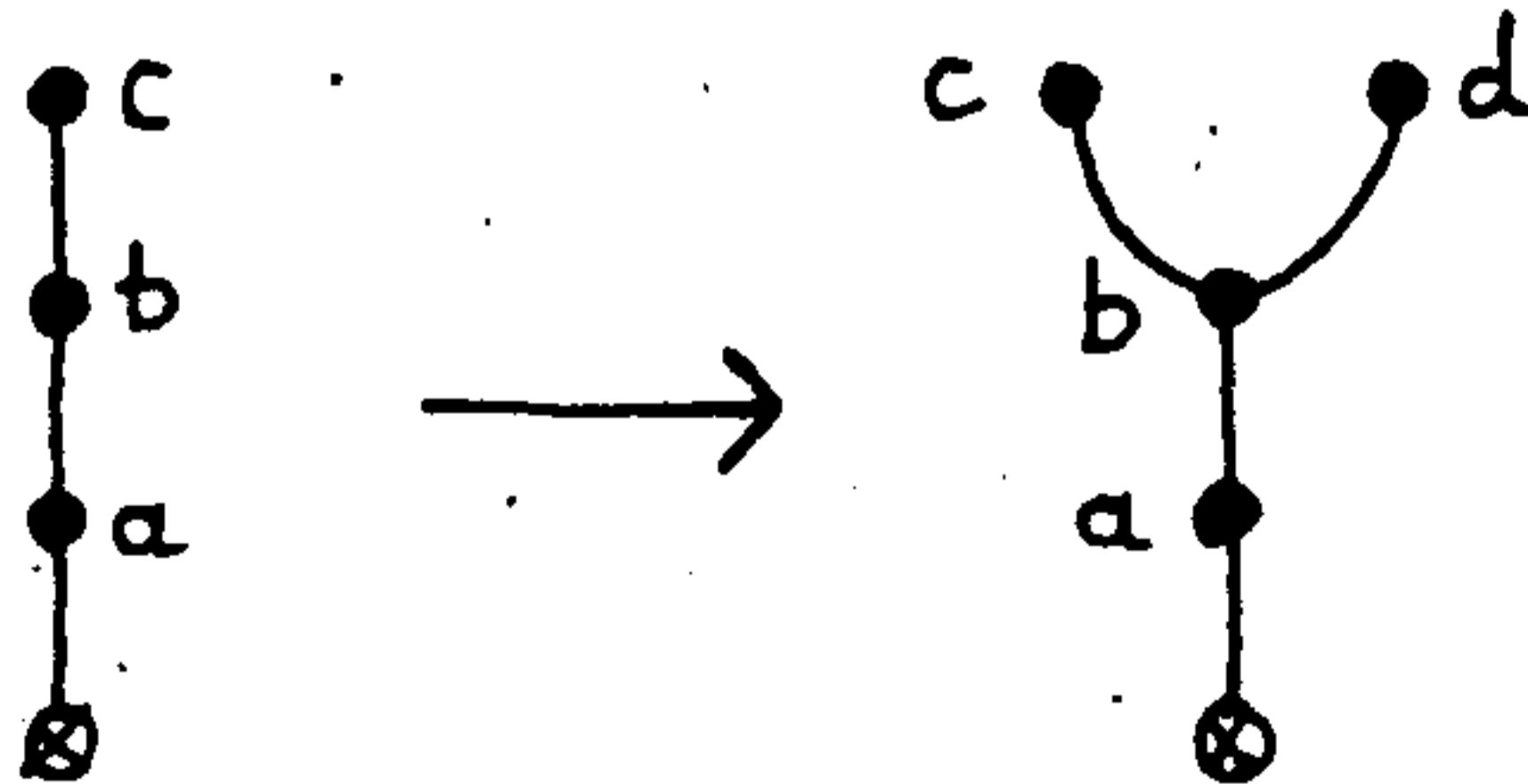
- 2) Move edge, i.e. detach from one vertex and connect to another, e.g.



- 3) Add (or subtract) an edge e.g.



- 4) Add (or subtract) a vertex, i.e. add (or subtract) a vertex together with an edge connecting this with another vertex, e.g.



The results of this test, when applied to graph type 3 are given in Table 6.8. All the examples appear as variants, and more than half the total require 4 or more operations in order to match the type-graph.

The 'ideal type' is also somewhat misleading with regard to the connectivity and permeability characteristics of individual rooms. A more accurate picture is gained of the morphology of larger buildings by dividing group 3 into several distinct types. The structural similarities between groups of plans are further clarified if we focus on the access characteristics of portions of the buildings - sub-complexes - rather than transcribing the whole complex. The Ch.H. plans suggest the typology shown in fig. 6.6.

Type 3a) is characterised by a deep kitchen and by a relatively shallow parlour, which is linked to the shop or hall, and to the yard in various ways (i,ii,iii). This configuration occurs chiefly in narrow plots, and takes the form of a sequence, or of elaborations on a sequence.

Type 3b) is distinguished by having the kitchen at a shallow point in the graph, directly or indirectly accessed from the shop or hall, with the parlour beyond. This arrangement is found in plots of both one-room and two-room width, and is usually a branching tree.

These are the principal forms, and appear in equal numbers in the Ch.H.set. Using the method given above to measure the divergence from type (see table 6.9), it is found that the great majority of examples can be assimilated to these two arrangements, and the number of operations required is considerably reduced : 18 no.(82%) need 4 moves or less to bring them into line with either a) or b); over half (12 no.) require 2 moves or less.

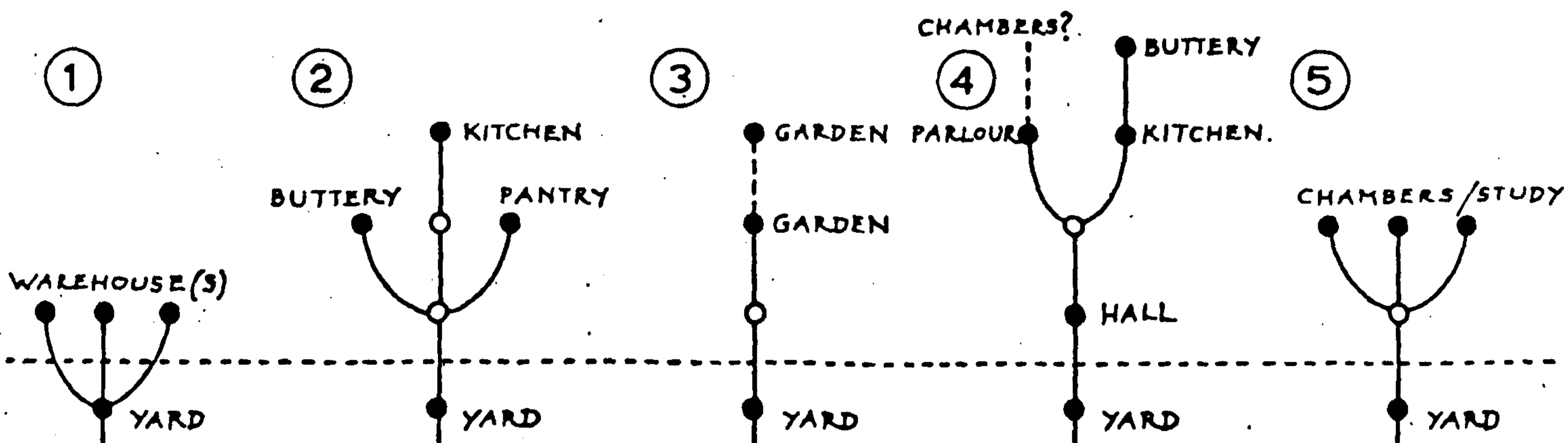
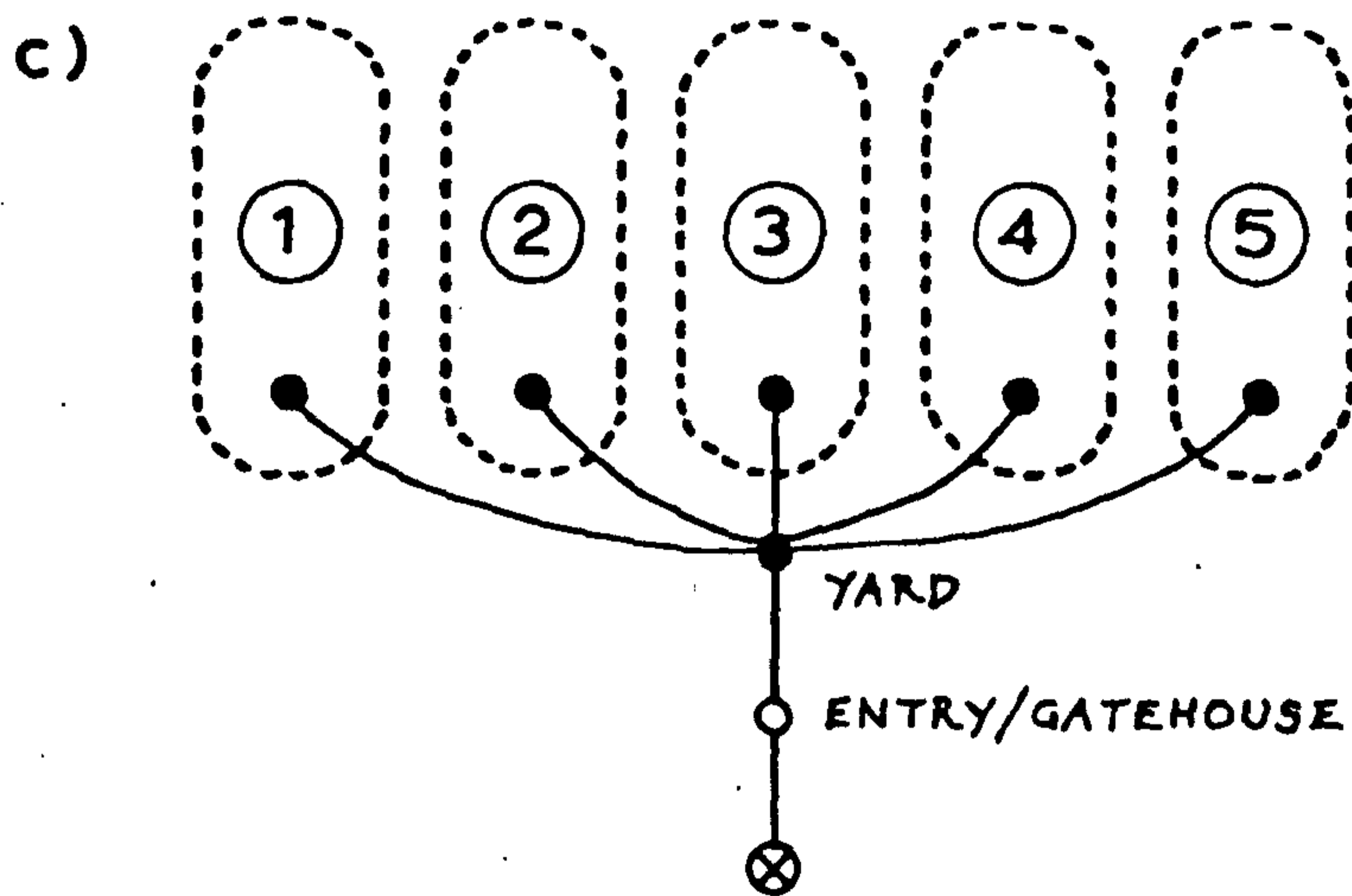
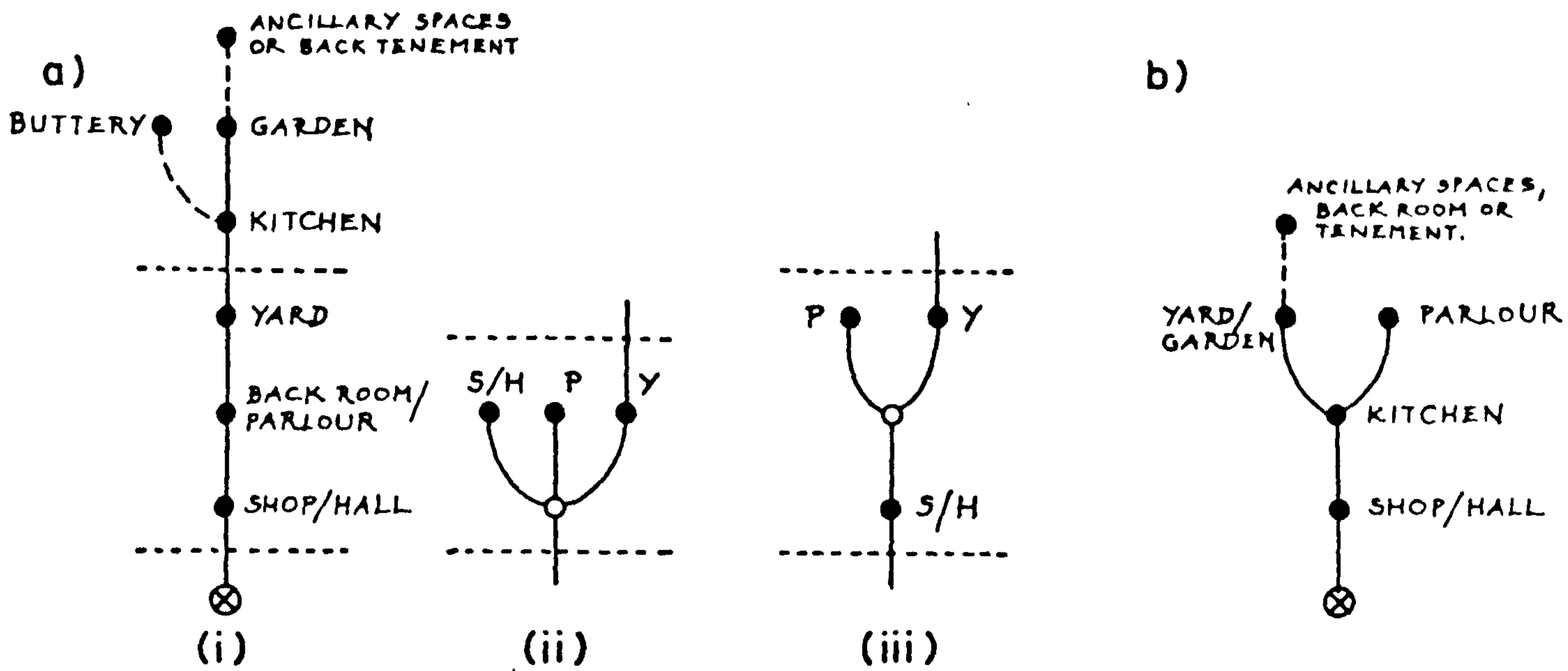


Fig. 6.6. Access graph types 3a), 3b), 3c).

The correlation for 3a) is rather better than for 3b). It should, however, be noted that most of the buildings contained in this group are located in one area (Westminster market-place) where, it would appear, they formed part of a single development. The plans subsumed under 3b), by contrast, occur on disparate sites in both the City and the suburbs. The configurations in both groups which require the greatest amount of adjustment are those with a very 'ringy' structure and hence a large number of faces: the typology is still 'stretched' to encompass these plans.

The third type, 3c), represents a numerically small but significant group of plans, consisting chiefly of mansion houses built within the blocks, but including also inns, halls, and various other large buildings, usually occupying a similar position away from the street edge. The principal feature of the plan is a central courtyard, which is entered from the street by way of a passage or gatehouse, and which gives on to suites of rooms on two, three, or four sides. The courtyard may lead to further yards or, what is more usual, to gardens. The arrangement expresses itself in the access graph as a branching tree, in which each main branch constitutes a distinctive suite or grouping of rooms, and is tied at its base to the courtyard. In the typology, we have decomposed the graph into a series of possible branches; a particular building may be constituted out of some or all of these.

Only 2 of the Ch.H plans fall properly within this category - Mr. Barber's house in Needler's Lane (plan 4) and the Crown Inn, Aldgate (plan 14) - and each differs considerably in detail from the pure type proposed. The type is, however, well represented in the coeval plan book of the Clothworkers' Company, a good illustration being provided by Sir Edward Darcy's house in Billiter Lane (Cl.pp.10-11).

If the typology is now set against the City plans, it is found that the great majority of the later buildings are also conformable to the proposed classification. The results are presented in table

6.10. Furthermore, the frequency of occurrence of the different types is strikingly similar to that for the Ch.H. plans : type 2 is the most common, with 44% (as against 42%) of the total ; types 1 and 2 together constitute about 80% (as against approximately 77%) of the total. Type 3 is the least common, now forming about 11% (cf. 23%) of the sample. 10% of the total have been classed as atypical.

As in the Ch.H. set, the incidence of variations increases with the size of the house-type. But, in the case of the City plans, the proportion of variants is very much larger throughout. On examination, the access graphs reveal that the irregularities lie in a restricted number of clearly identifiable and recurring features. In the type 1 group, where over half of the total are now variants, the principal causes of variation are, firstly, the insertion of transitional space(s) between the street and the house, and secondly, the inclusion of external space (a yard or a garden) within the plot. The transitional space may be in the form of a passageway or an entrance lobby. An example of type 1. buildings with yards attached is provided by a row of brick houses in London Street (C.L., Vol. II, p. 52).

In the type 2 group, the variants predominate, forming 87% of all the examples. Once again, a relatively small number of features may be discerned. Firstly, many of the houses now include a side passage, which in some instances is used to provide access to the shop and/or the kitchen. Secondly, there has been a change in labelling ; certain names, such as back shop, back warehouse and compting house, now appear with greater frequency. The latter examples have been included within type 2, where not more than one of the labels is changed, and where the size of the building and the access graph conform to the model. In those instances where the appellation of both the main spaces has changed (e.g. drinking rooms, Vol. I, p. 56, room and coffee room, Vol. I, p. 62, the examples have been classed as atypical.

The type 3 group is composed almost entirely of variants. In spite of this, the typology provides a close fit to the actual examples found. As table 6.11 shows, the great majority of graphs (86%) require 4 operations or less to agree with either 3a) or 3b) ; exactly half require 2 operations and under. An important difference from the Ch.H. plans is the fact that most of the sub-set (78%) falls within type 3b) (the shallow kitchen configuration), while type 3a) (the deep kitchen configuration) is much reduced.

Type 3c) has disappeared altogether: the explanation for this is to be found in the atypical category to which the largest houses have been assigned. These substantial dwellings have been detached from the typology, not because of their access structure, which can be assimilated to the branching tree model, 3c), but because of their system of labelling. The various sub-complexes now include such names as 'dining room', and 'withdrawing room', and each of the branches is tied, not to a courtyard as before, but to an entrance hall. This change in nomenclature marks a fundamental shift in the underlying principles of design, a morphological change which clearly corresponds to the adoption of 'Palladian' rules. The spatial analysis would thus confirm the more intuitive observations made by various authors on the characteristic features of the new plan inaugurated by Inigo Jones (27). It also shows clearly that the rise of the new form was concomitant with the decline of the mediaeval courtyard plan. Of far greater general interest, however, is the extremely limited influence that 'Palladian' design appears to have had in society as a whole : whilst fashionable amongst a social elite, it would seem from the City plans that this had little, if any, impact on the principles and practice of the great mass of builders and developers of the time.

So far, the typology has considered only the ground floor plans of buildings. Turning now to the upper floors, it is found that the majority of buildings (Ch.H.plans) are at least 2 storeys in height, and commonly have rooms in the roof space, making them 2 and a half, or 3 and a half storeys high overall. It would appear that in the case of the larger buildings -those classified as type 3

- the living quarters were confined to the ground floor level; the upper floors were given over predominantly to chambers, which were positioned over the main ground floor rooms. It is possible, however, that 'chamber' was sometimes used by Treswell as a blanket term for an upper floor room, especially where he was unable to make out the exact function of a space. It cannot be taken for granted, therefore, that the name refers definitively to a sleeping chamber. Judging from examples at ground floor level, it would seem that chambers might in some cases be bipermeable (i.e. have more than one means of access). The roof space of the house usually contained one or more garret chambers.

The majority of type 2 plans resemble those in type 3 in having only chambers and garrets listed for the upper floors. In certain cases, however, a hall, kitchen or buttery is specified on the first floor or above. It is clear, therefore, that in some buildings at least, the living/working functions were split between the upper and lower floors.

Among the smallest class of buildings - type 1 - one may distinguish 2 kinds of arrangement. The first consists of two, or perhaps three rooms in all, placed one above the other. The ground floor room can be a shop or a hall, but may also be referred to simply as a chamber, or room. Above this is a chamber, and perhaps a garret. This plan-type is characteristic of the almshouses, built by the City companies to house their poorer members and their widows. The dwellings are frequently arranged around a courtyard, which contains a privy, pump and other common facilities.(28). In some instances, the ground floor and upper floor rooms are each in separate occupancy, as for example in the Clothworkers' almshouses at Whitefriars, where five buildings, each on two storeys, housed ten persons (nine widows and a porter). But this does not occur in any of the Ch.H examples. One suspects that single-room occupancy might have been widespread away from the streets, where numerous tiny buildings were run up in courts and gardens, contrary to the Proclamations, and used to house the poorest families.

The second kind of house is larger, and clearly has the living functions on several floors. It may have five or more rooms in all. The typical room arrangement which emerges is one with a hall at first floor level, over the shop. Attached to the hall is the kitchen and/or the buttery. Above are chambers on one, two or three floors, and garrets in the roof void. Houses of this type are found only within the City walls, and were probably confined chiefly to the most important commercial thoroughfares, where land values were highest, e.g. Cheapside, Bread Street, Friday Street, and Cornhill. The houses could reach a considerable height ; an example in New Fish Street rises to 5 and a half storeys (29); another in Friday Street is 4 and a half storeys high (30); while 2 tenements lying between Cornhill and Threadneedle Street are also 4 and a half and 5 and a half storeys in height (31).

It is instructive in this case to compare the type-graph obtained with 3a) presented earlier. With the exclusion of the yard, which has no place in a high-rise building, the two plans can be seen to achieve a similar sequence of spaces. Types 1b) and 3a) may thus be considered as polar types, or alternative spatial unfoldings of a single model according to the constraints of different sites : vertical sequence/small urban plot -- horizontal sequence/long, narrow plot.(32).

The final typology is presented in figure 6.7.

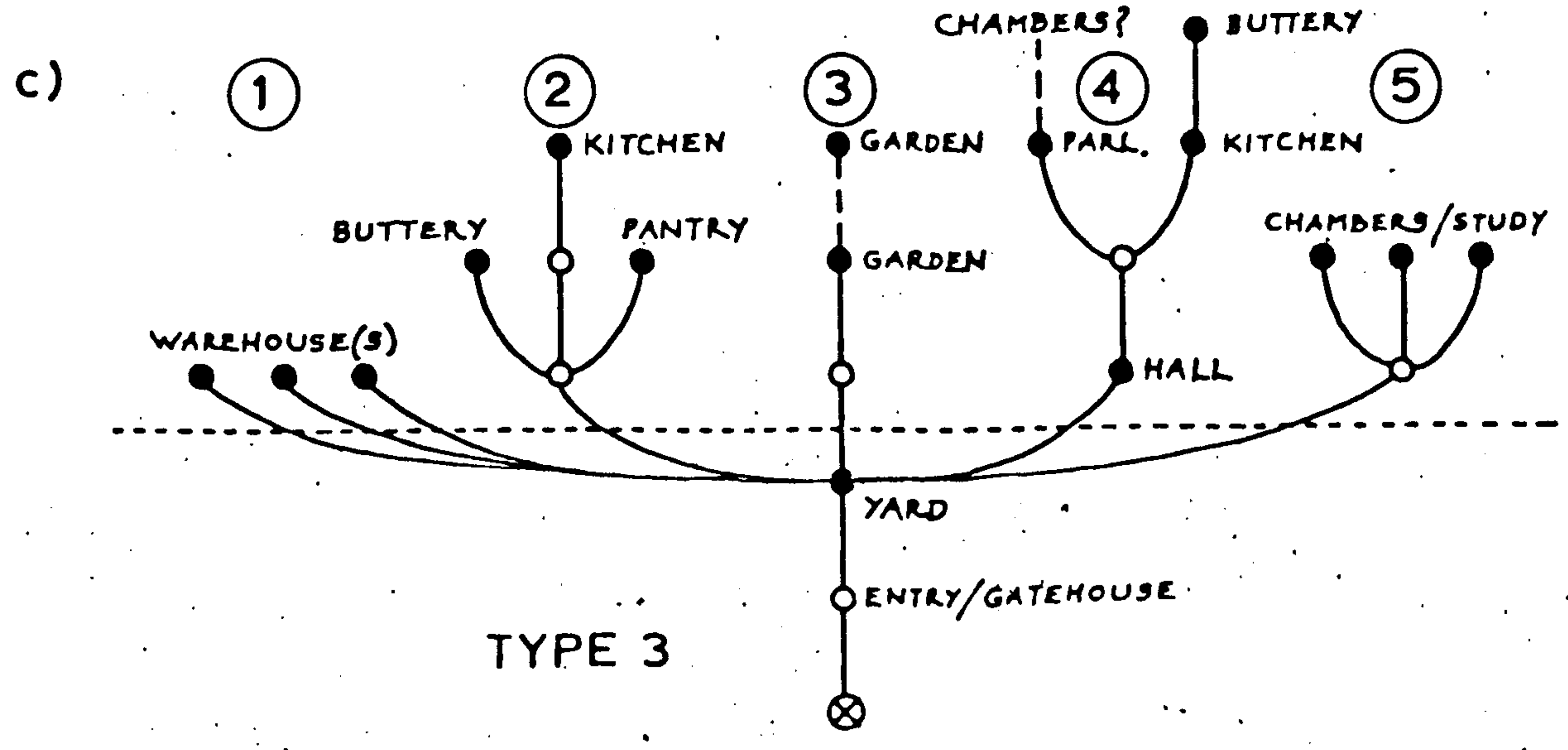
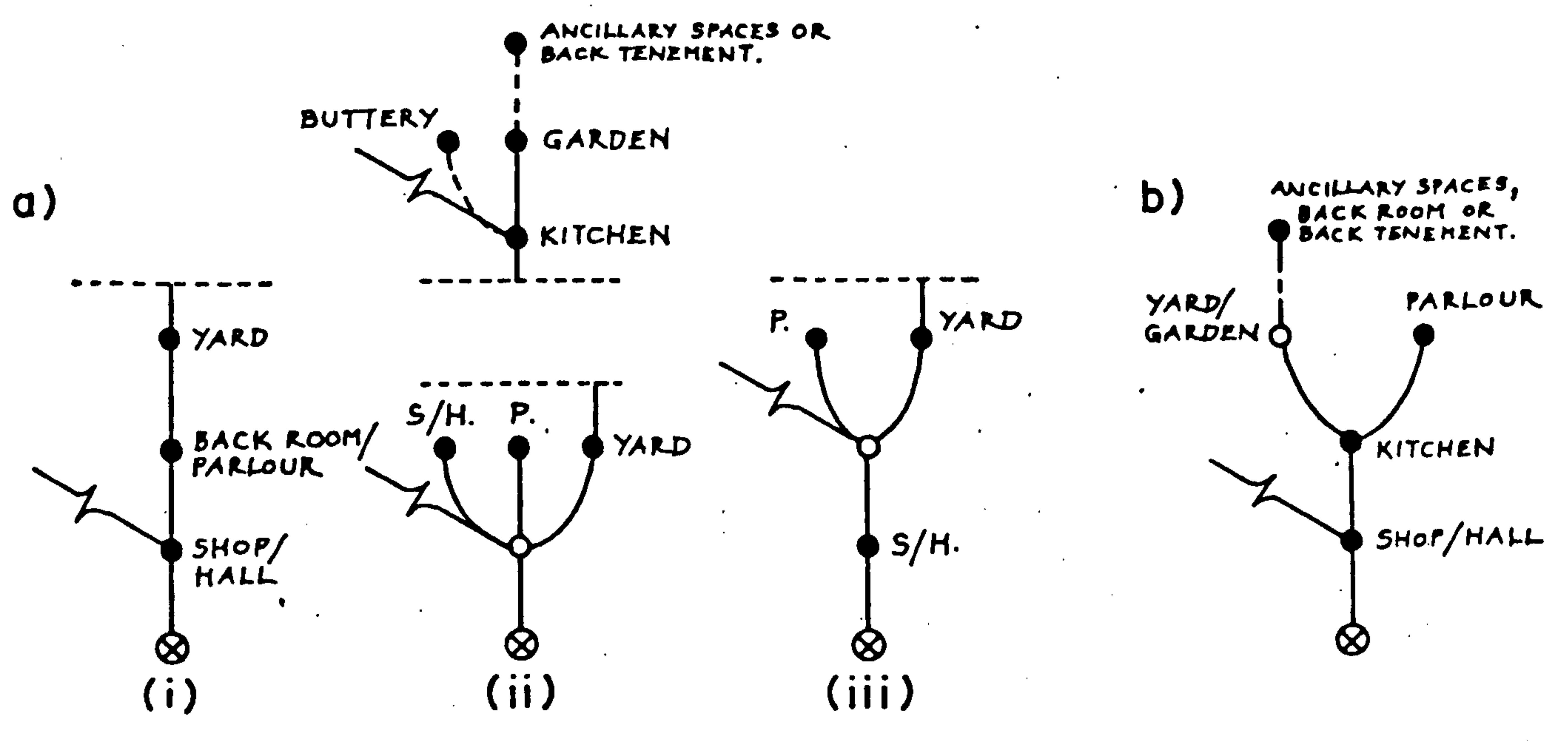
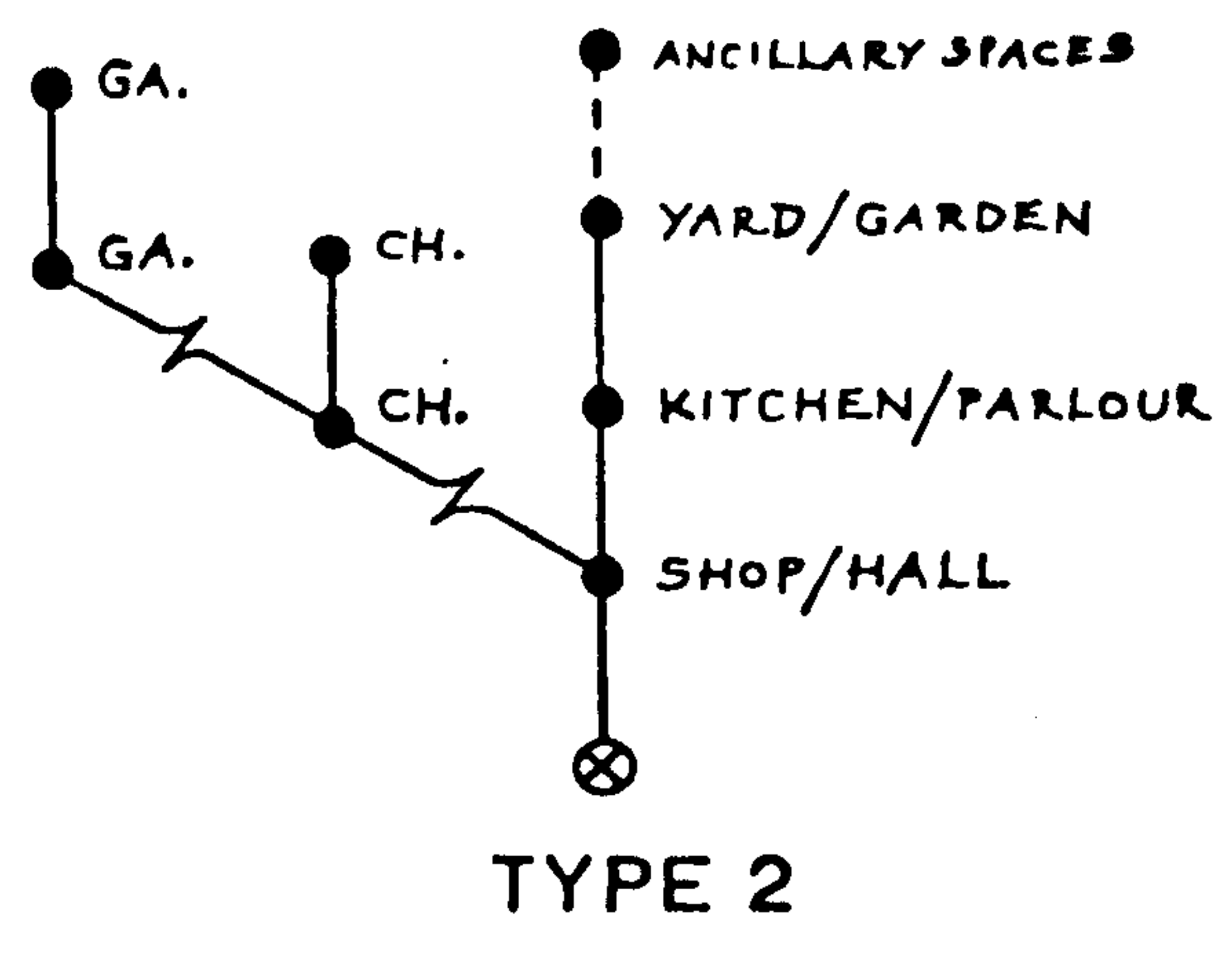
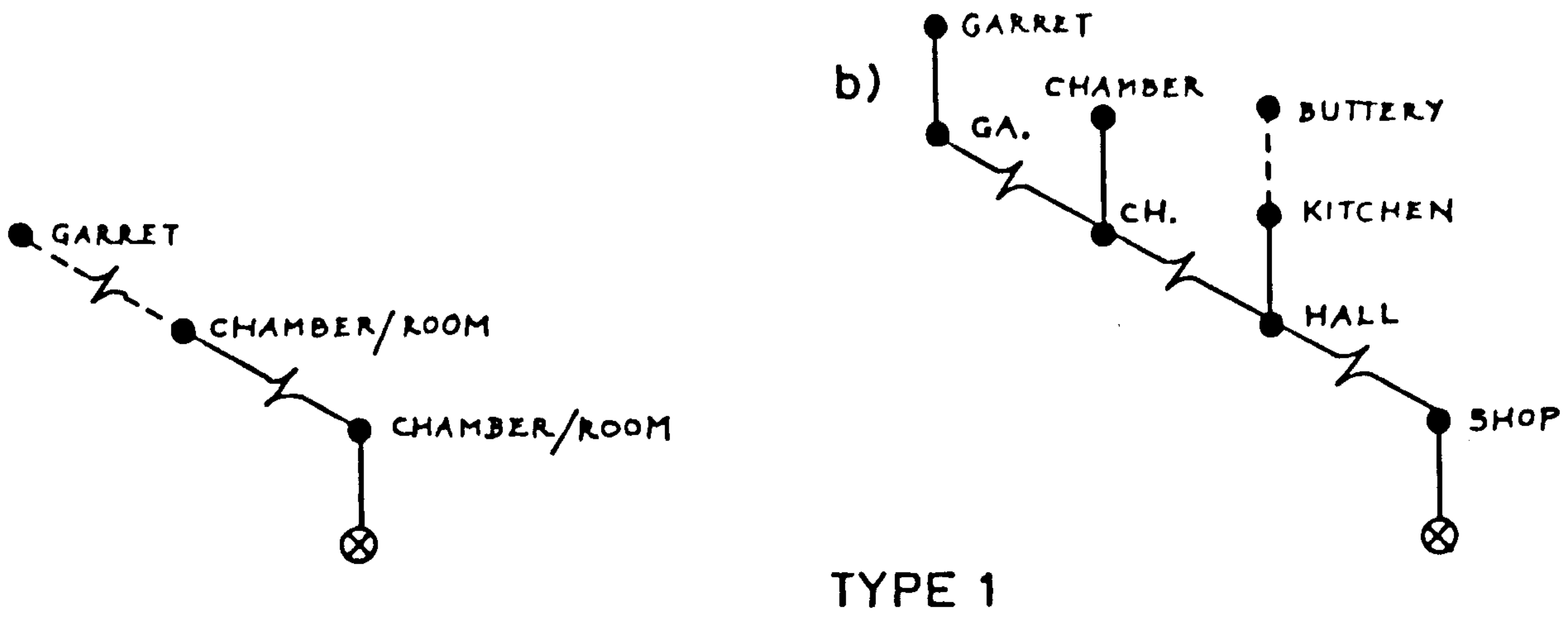
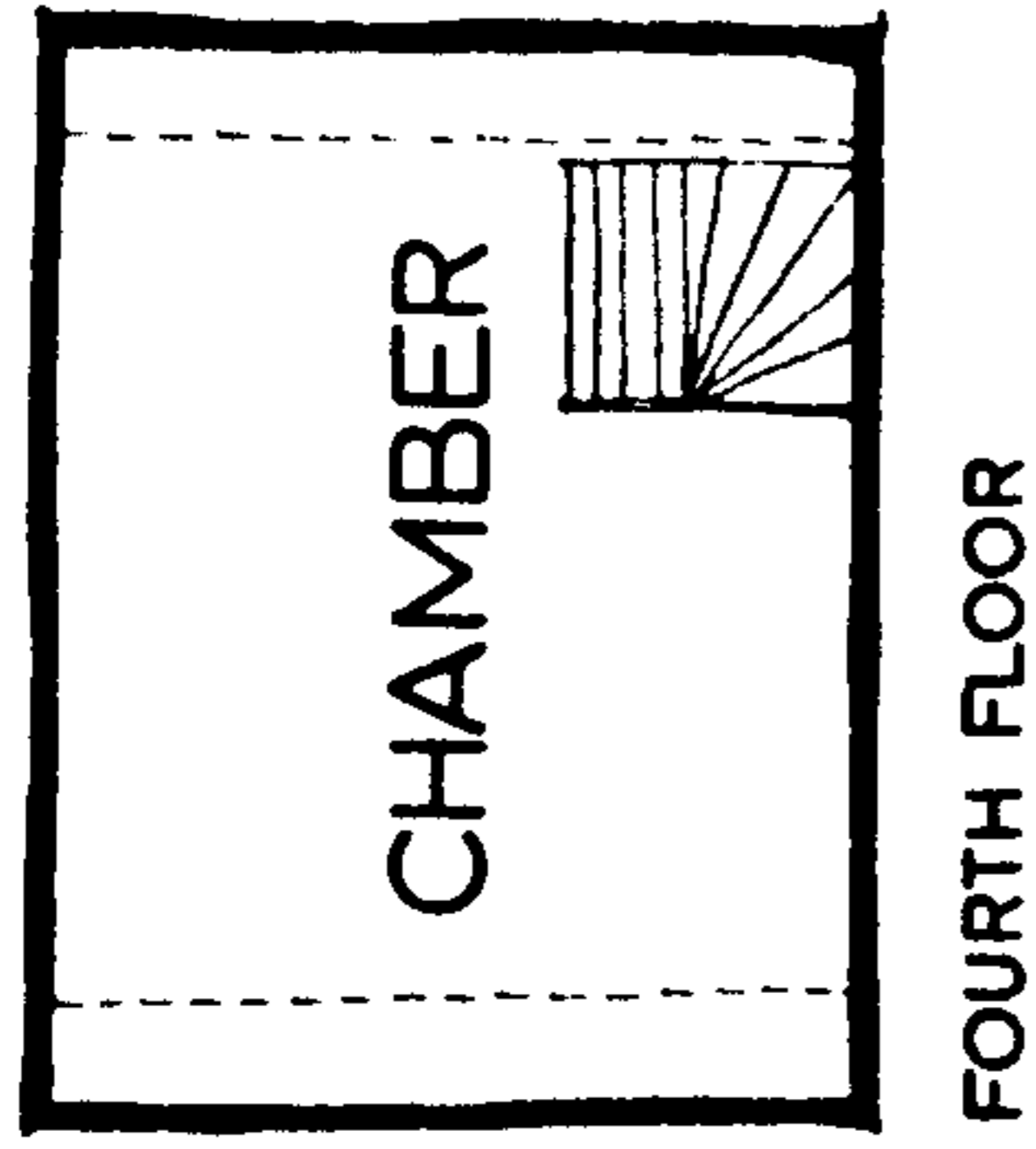
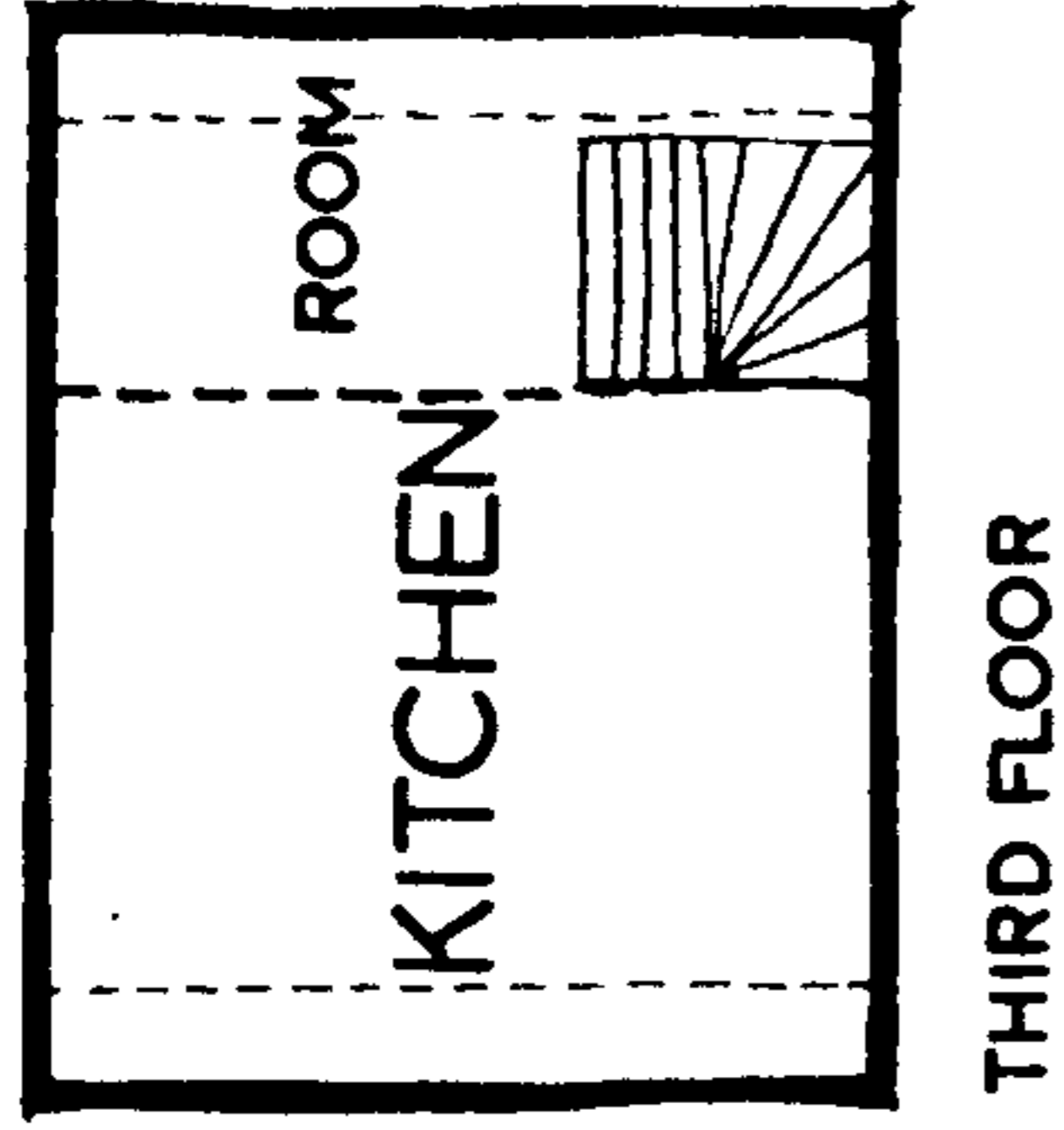
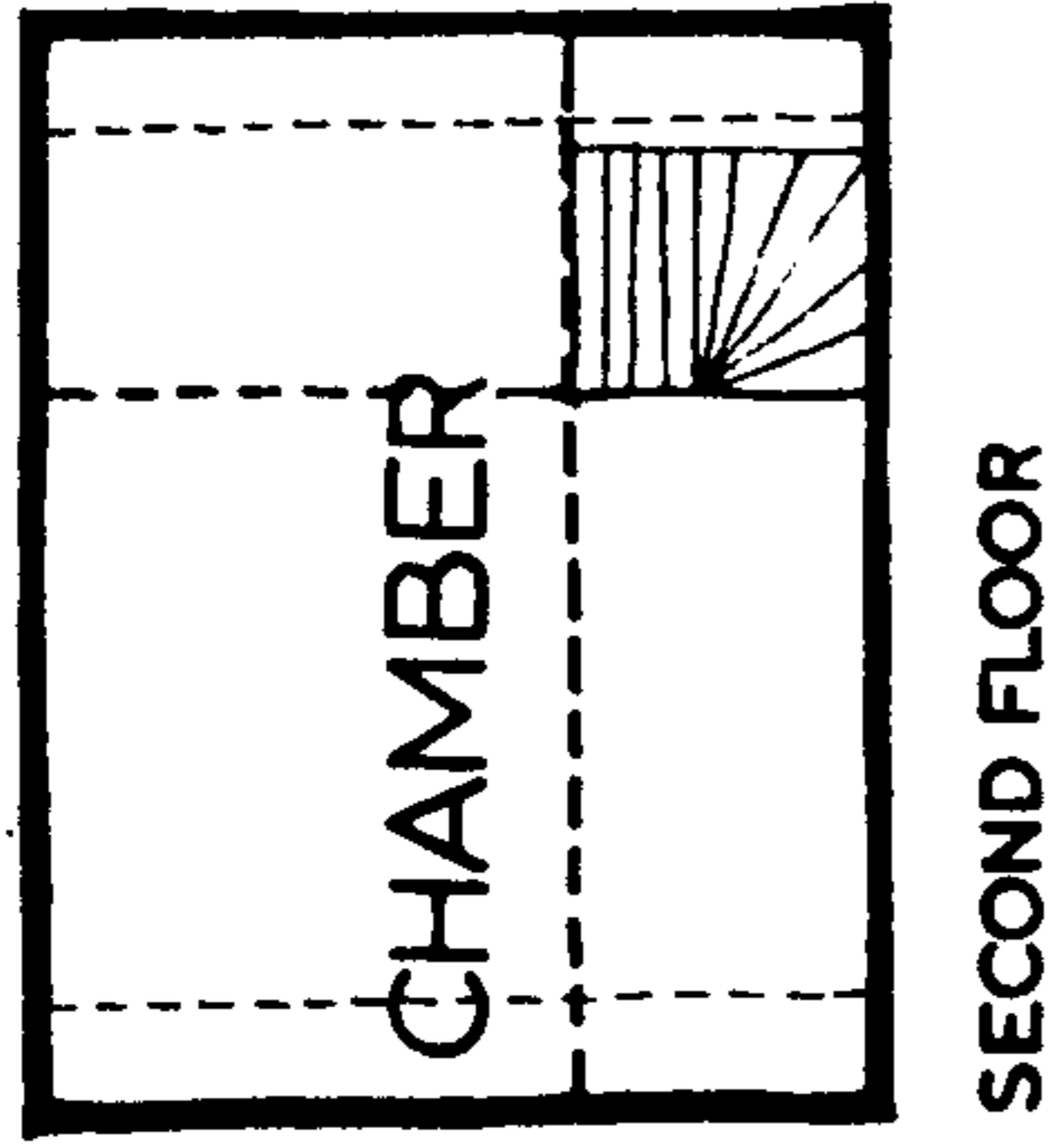
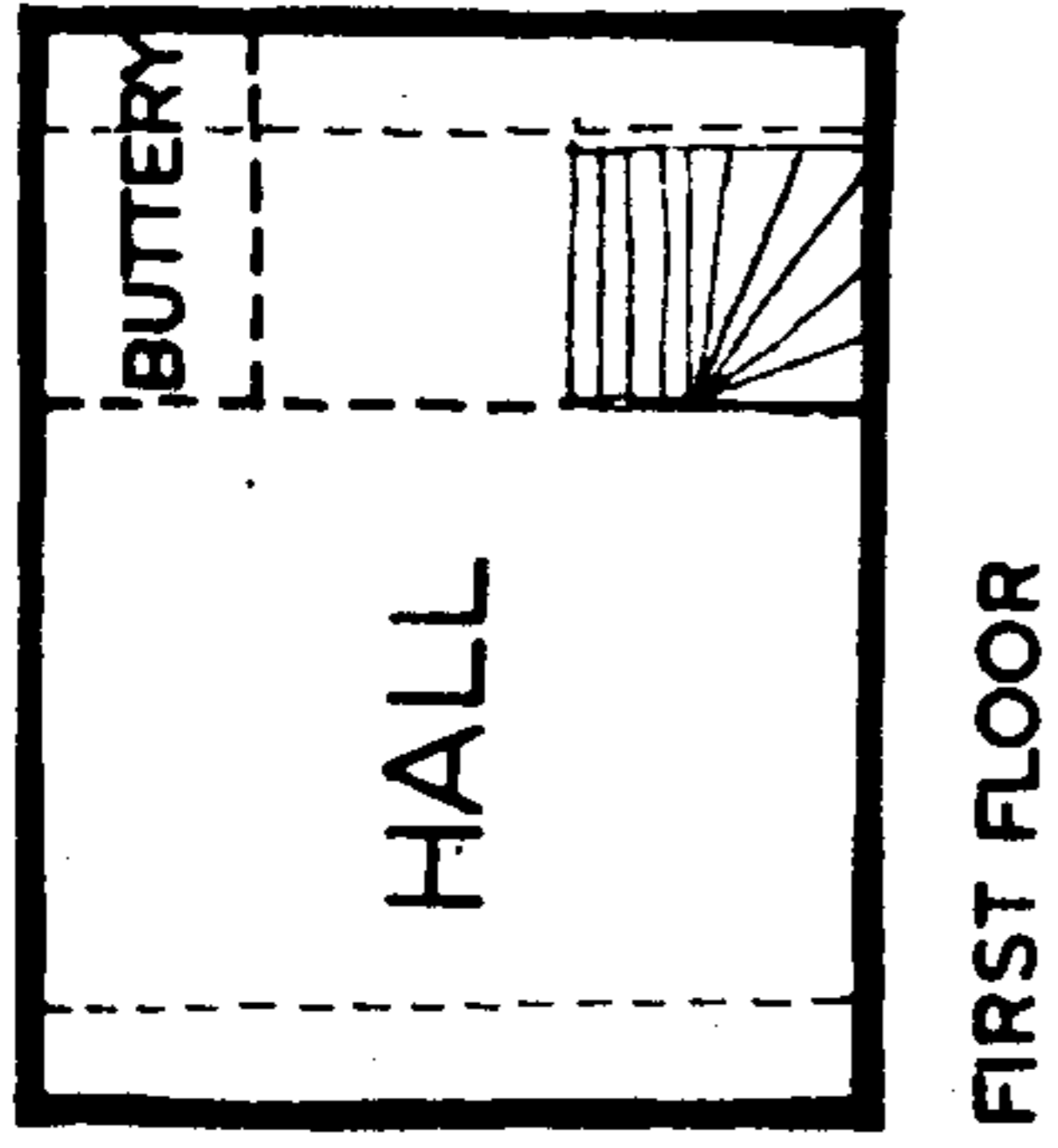
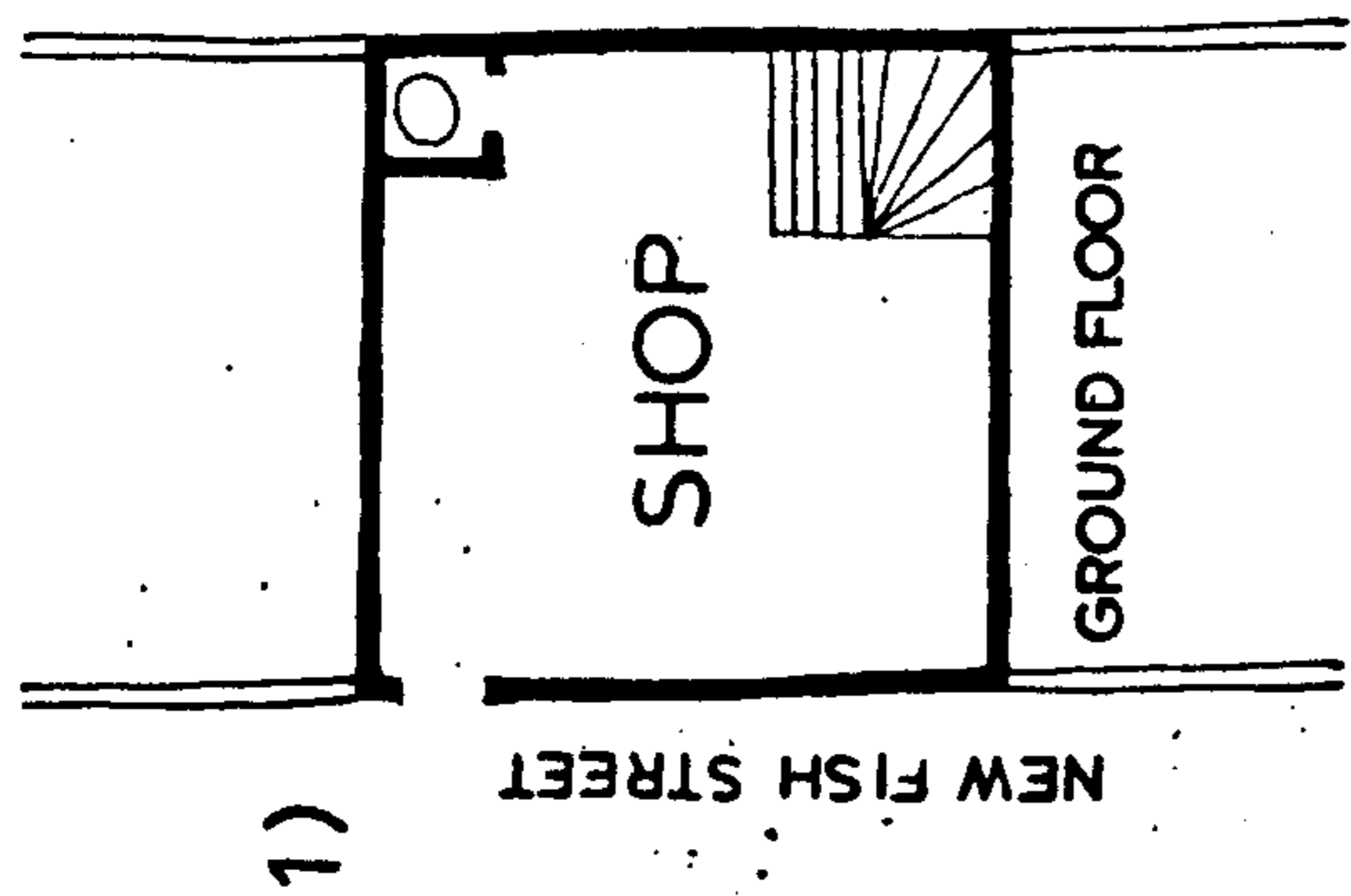


Fig. 6.7. Access graphs : full typology.



ALL UPPER FLOOR PLANS ARE CONJECTURAL

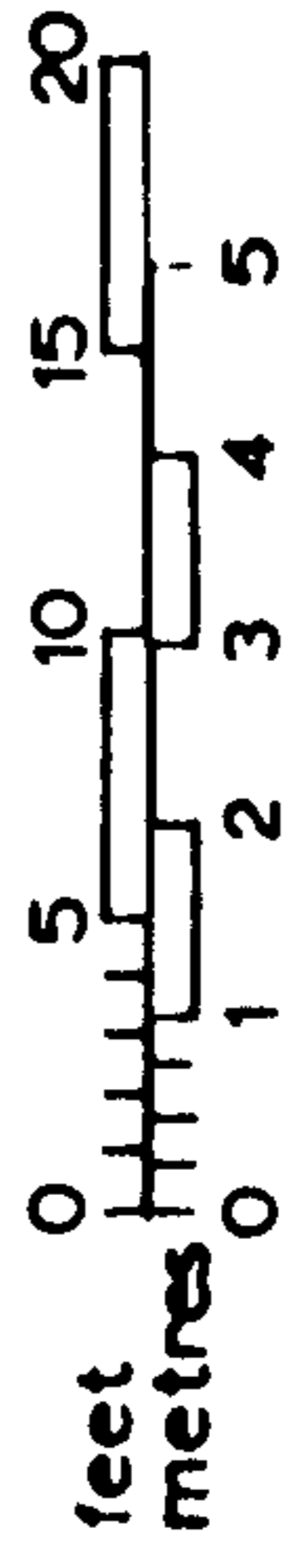
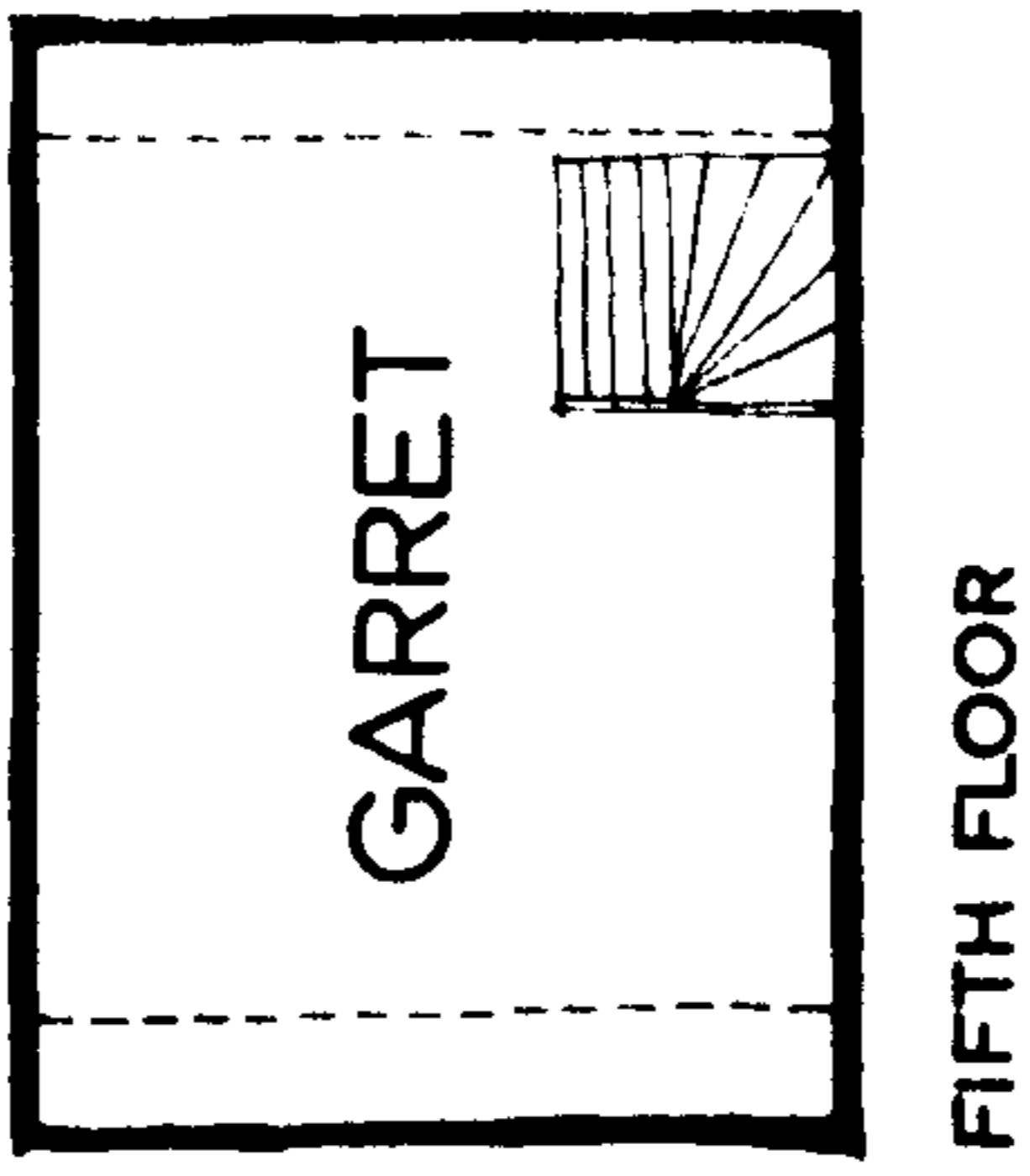
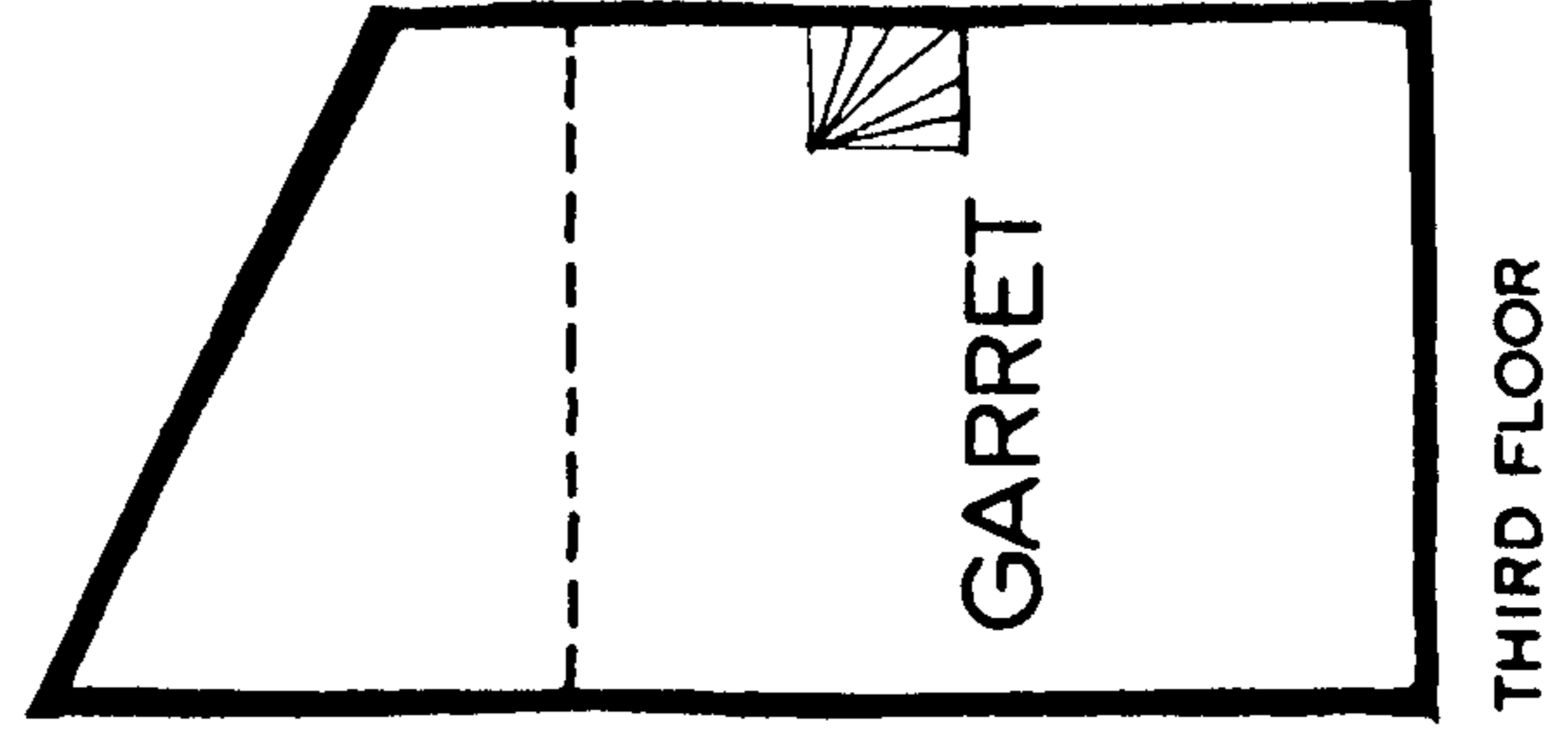
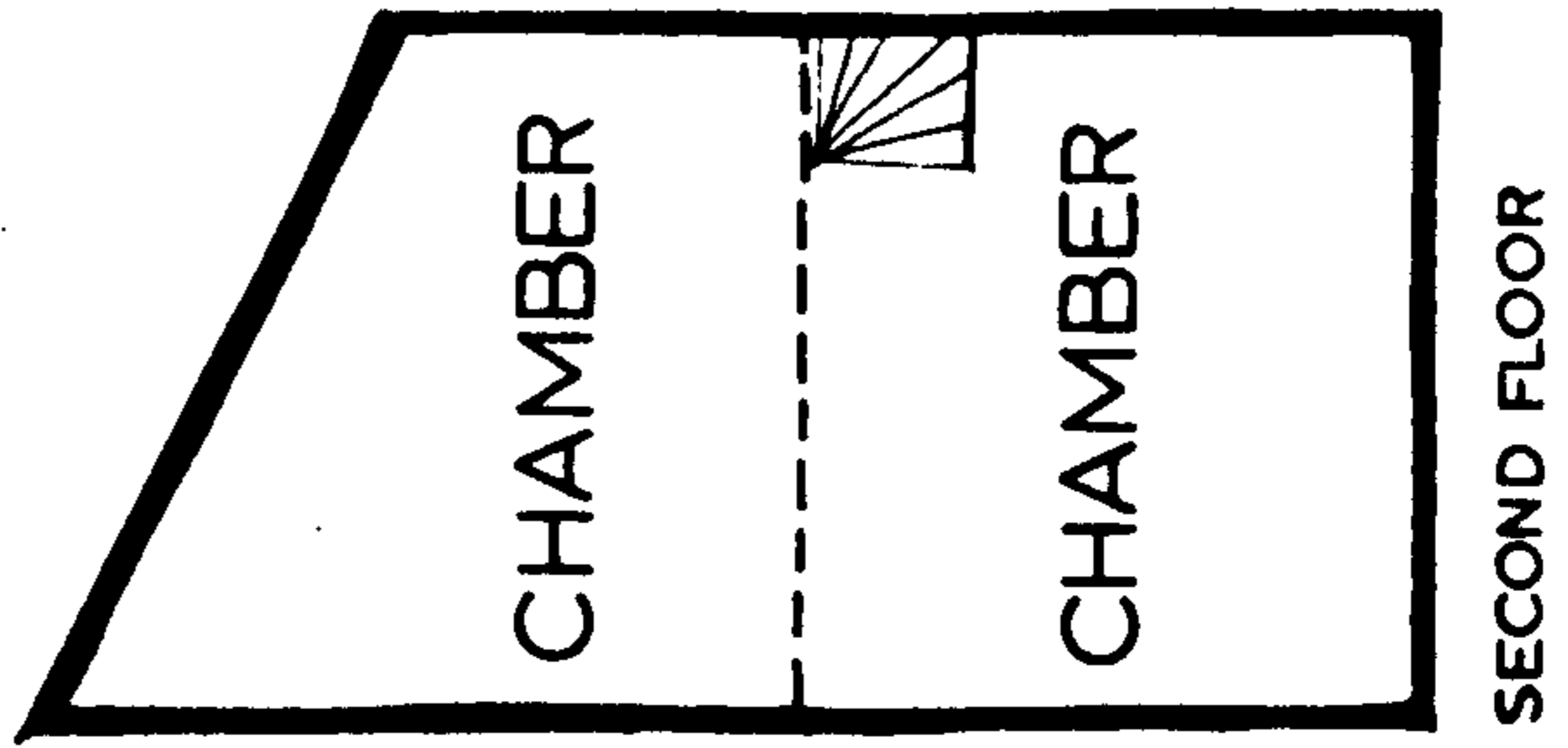
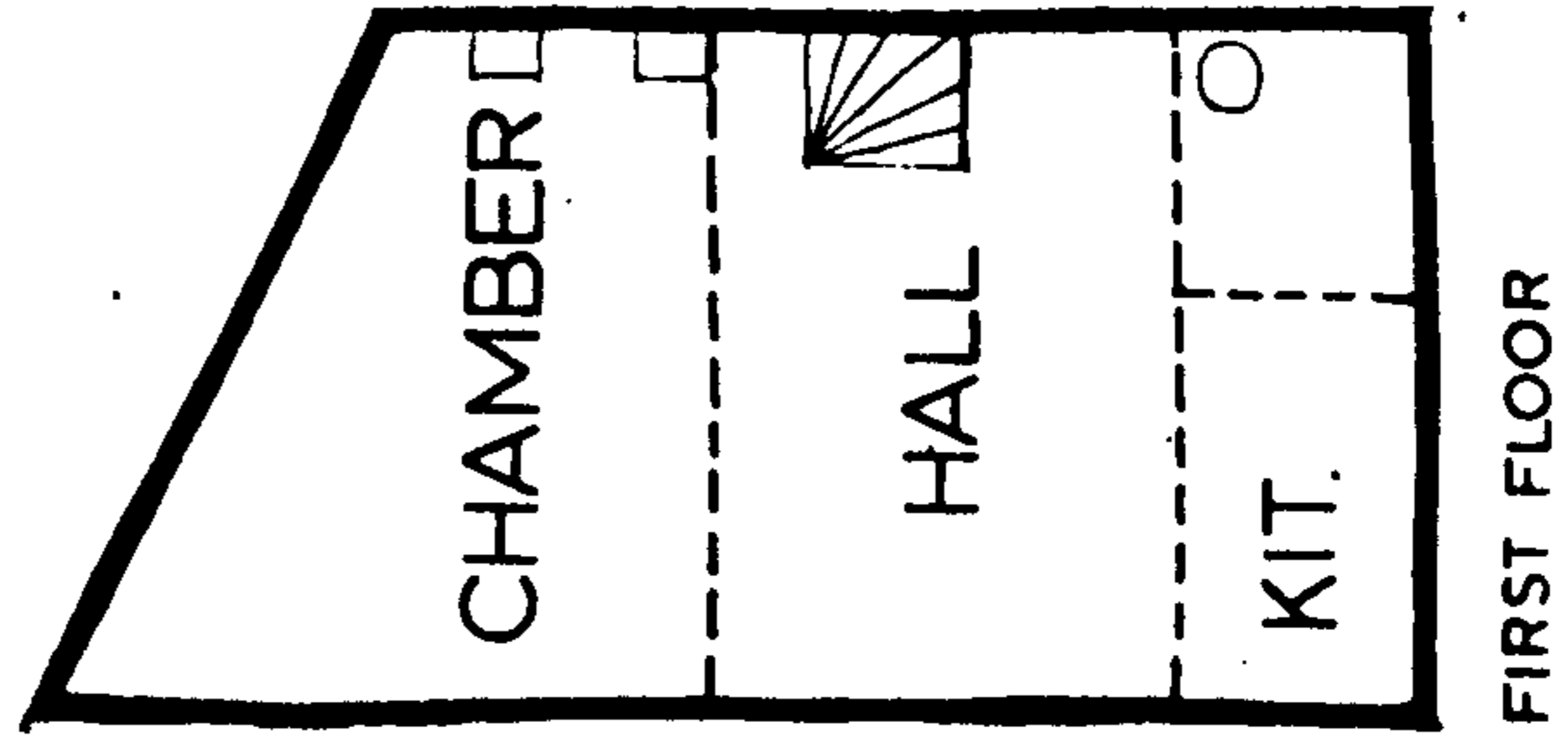
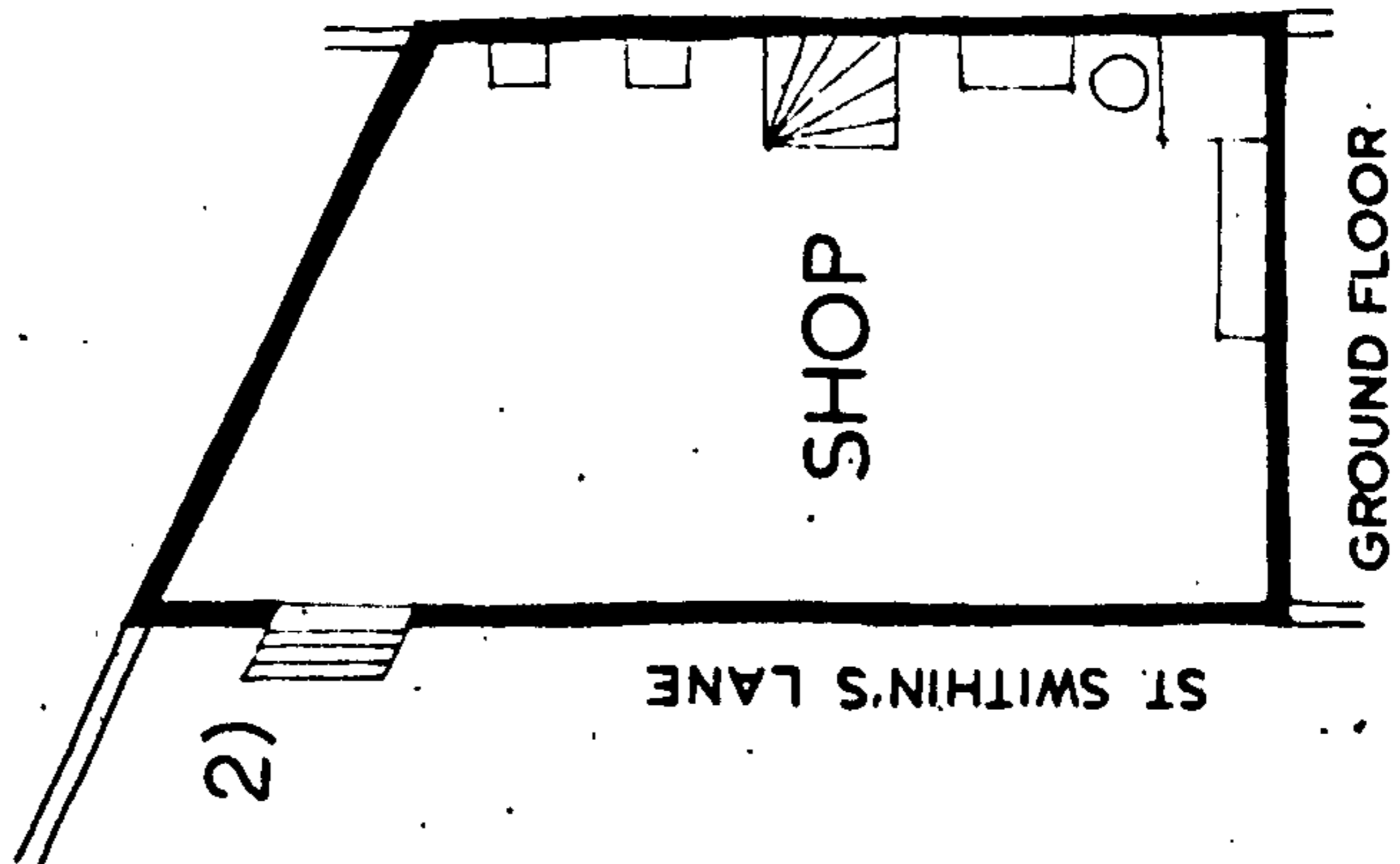
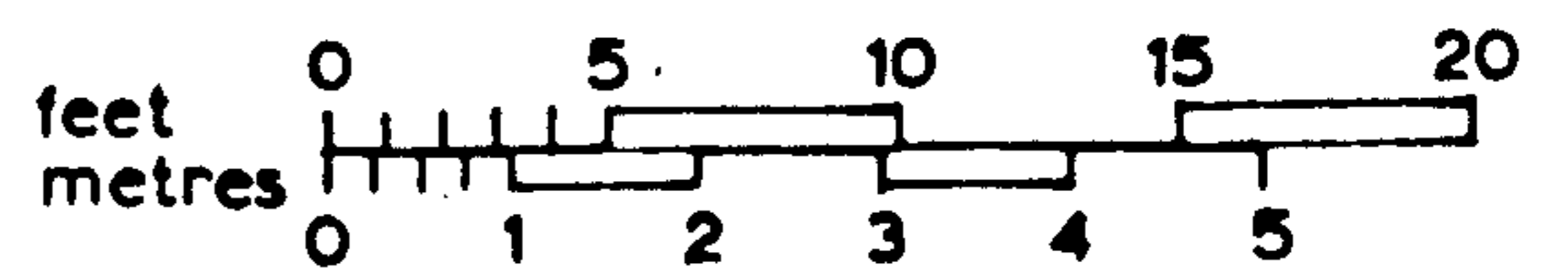
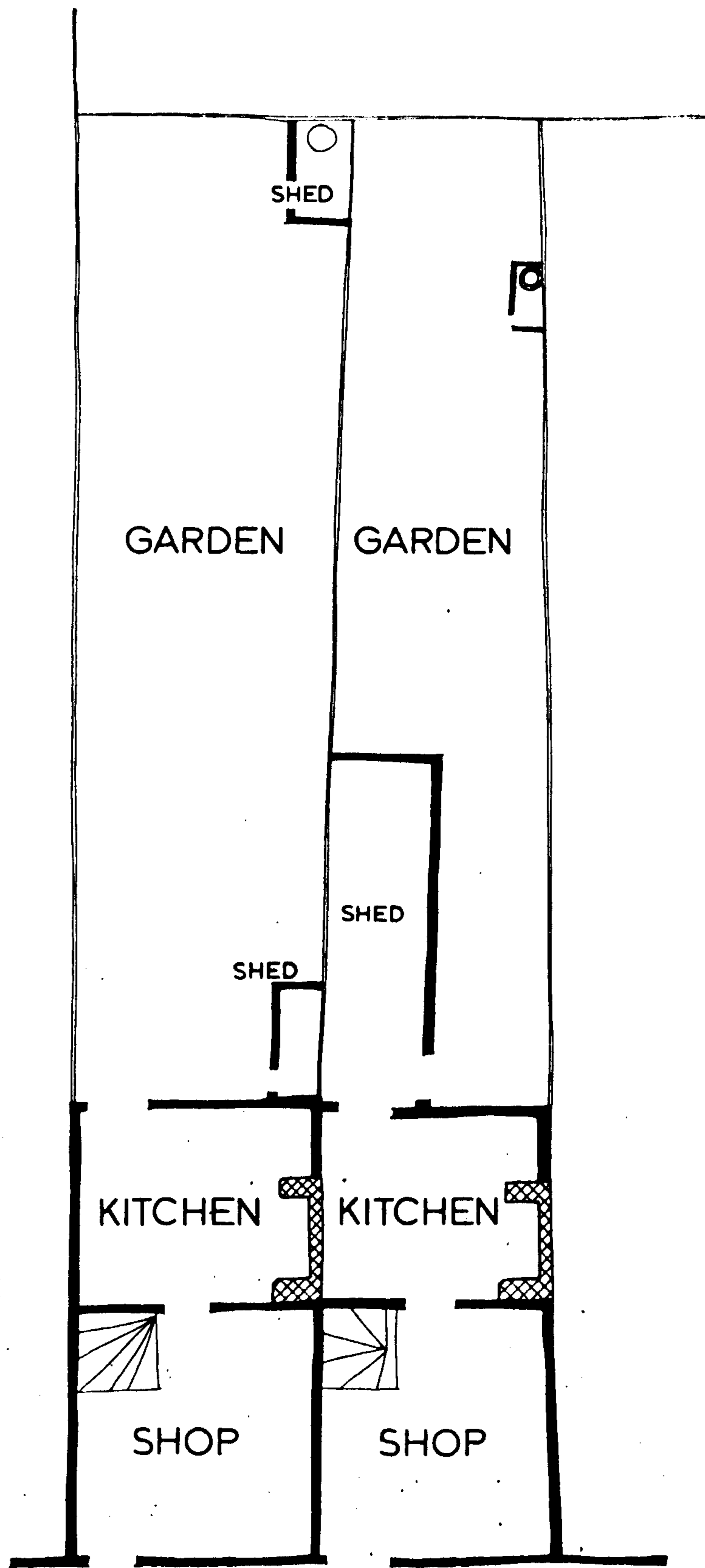
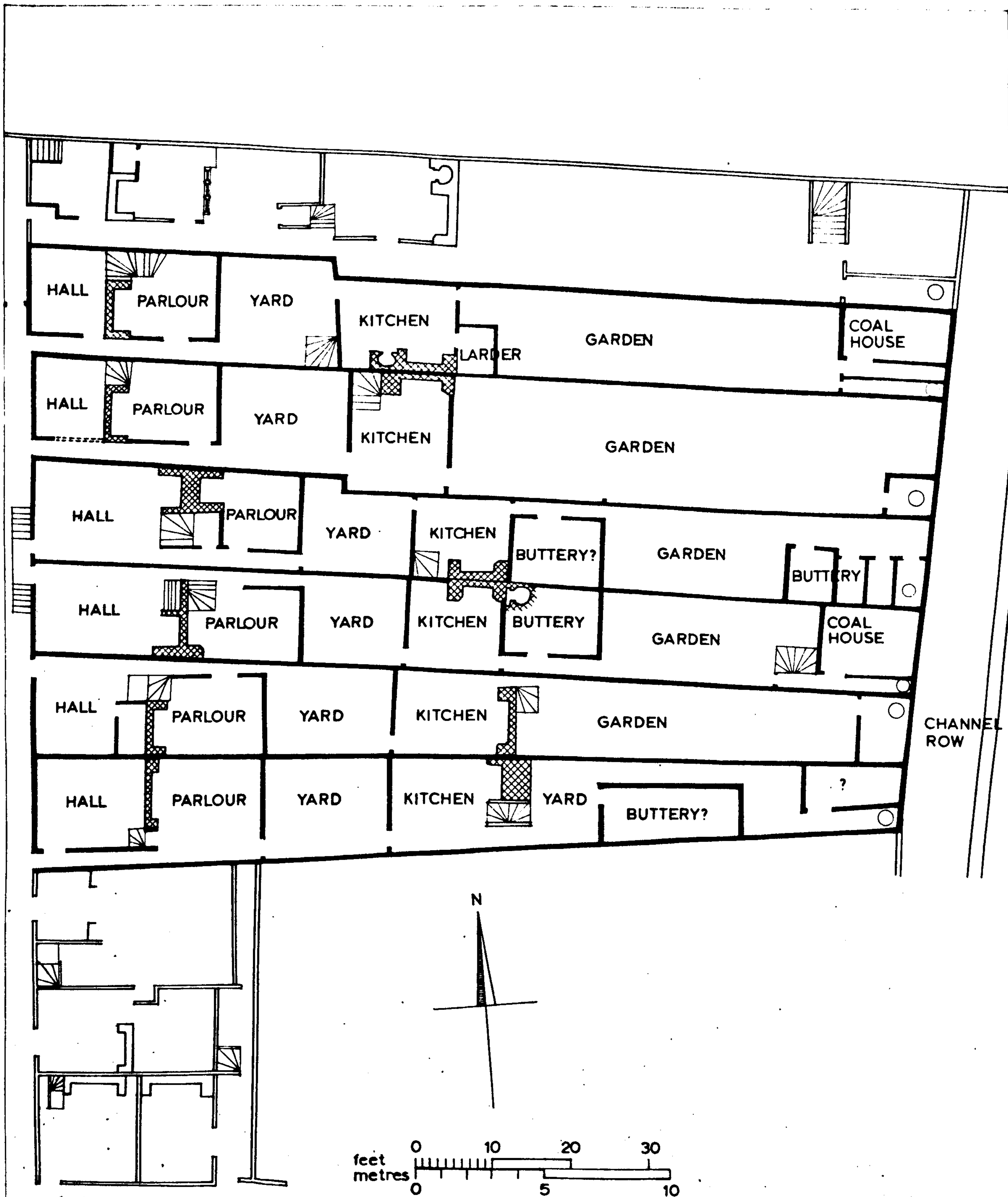


Fig. 6.8.

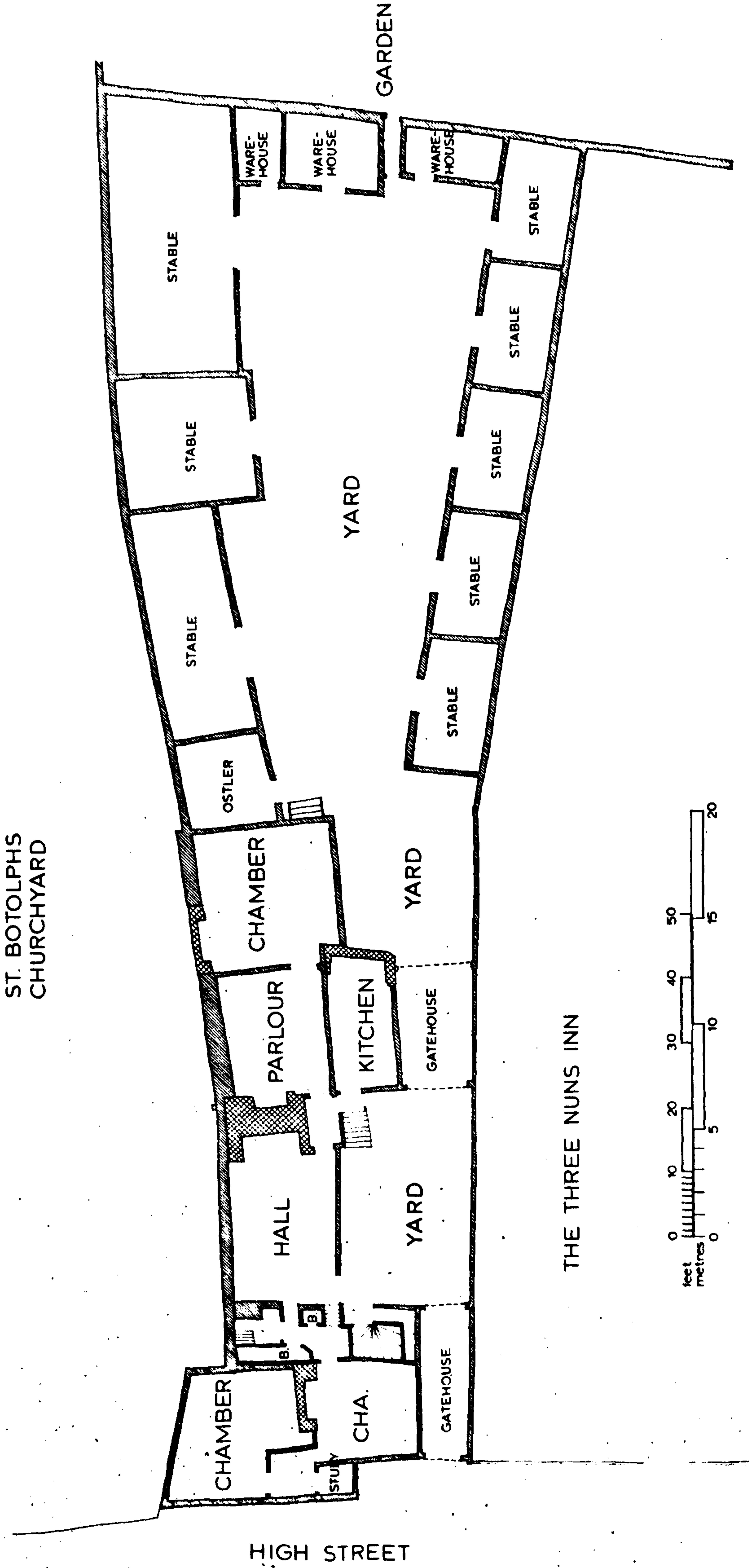
PLAN TYPE 1b): HOUSES IN NEW FISH STREET AND ST. SWITHIN'S LANE
 based on the plan in Christ's Hospital Evidence Book, c.1612



PLAN TYPE 2): TWO HOUSES IN HOUNDSDITCH
 based on the plan in Christ's Hospital Evidence Book, c.1612



PLAN TYPE 3a): HOUSES AT WESTMINSTER MARKET PLACE
 based on the plan in Christ's Hospital Evidence Book, c.1612.



ST. BOTOLPHS
CHURCHYARD

THE THREE NUNS INN

HIGH STREET

THE CROWN INN, ALDGATE WITHOUT
based on the plan in Christ's Hospital Evidence Book, c.1612

Fig. 6.11.

6.6. Analysis : Access to Rooms

Having drawn up a typology of access or permeability graphs for buildings of different sizes, we are now in a position to turn to more detailed questions of plan morphology. A number of characteristics can be easily 'read off' the access structure of a building : the property of 'depth' has already been noted. Two other topological characteristics may now be considered: permeability and, related to this, the connection/insulation between pairs of rooms. Permeability refers to the number of ways into, and out of, a room : it is given by the vertex degree of the space concerned. Connection/insulation between rooms is measured in terms of the frequency of access between those rooms across a range of examples of similar buildings.

In any configuration, access from one space to another is clearly not equally desirable for every pair of rooms. In certain cases, where the functions are closely related, a direct connection will be a high priority in order to avoid long and circuitous journeys between these spaces. This, in turn, will place a premium on adjacency. In other cases, direct access will be undesirable ; this might lead to the rooms being separated wherever possible. By calculating the frequency of direct access between rooms, and by comparing this figure with the number of adjacencies between rooms, we can obtain from a large sample an index of the preferred relations between spaces.

From these formal or structural properties, it is possible to draw some general inferences concerning the functions of the various rooms, and their status within the house. One can, arguably, take the analysis and conclusions further. Hillier and Hanson have focussed in their studies on the relationship between social morphology and spatial morphology. In their view, the spatial structure of buildings and settlements does more than merely express or reflect the properties and relations which define the social 'world': it constitutes or embodies these properties and

relations (33). Social information may be transmitted in various ways, and at various levels of organisation. It may in some measure be embodied in the overall spatial configuration of the house. But far more significant, in the opinion of the authors, is the part played by individual spaces within the complex. Certain spaces within a building may be highly impregnated with social meaning. An example of such a space is the front parlour of the nineteenth-century terrace house, built originally for the 'petit bourgeoisie' in central London and elsewhere. The distinctive feature of the front parlour is that it does not form part of the everyday living accommodation. On the whole, it is reserved for special occasions of a formal or ceremonial nature. "The vicar coming to tea' is the paradigm encounter in this type of space" (34). The front parlour thus has high categoric importance, and this is reflected in, or rather constituted by, its position in the spatial configuration of the house.

If the building plans under examination are viewed in this light, any structural invariance across the sample - controls on room location, systematic separation of rooms - could reasonably be taken to indicate that some special categoric importance was attached to the space in question. In the discussion which follows, the implications of the results will be considered with respect both to the functional affinity between spaces, and to the possible social or cultural 'lode' carried by those spaces.

It seemed that the findings would be most conveniently discussed if presented in the form of a glossary. In the first part, the properties of depth and permeability will be discussed for each of the principal rooms. In the second part, the connections and insulations between pairs of rooms will be examined. The results of the analysis are summarised in tables 6.12-6.16.

The analysis is clearly subject to limitations imposed by the source material. This creates some serious difficulties, two of which should be noted. In the first place, we cannot be certain how far the labelling of spaces corresponds to the actual use of those spaces. Where houses were in multiple occupancy, it would be

reasonable to infer that rooms were used to a large extent as all-purpose spaces, rather than being assigned a particular function (35); the appellation of the spaces could, therefore, be misleading. The likelihood of such discrepancies is perhaps increased by the fact that one is probably seeing the houses through the eyes of the surveyor, rather than those of the owner or tenant. In the absence of supporting evidence, we have thought it justifiable to work from the names given on the plans, the assumption being that the labelling of spaces by the surveyors was both meaningful and consistent, even if it did not always reflect the actual usage by the owner or tenant.

The second problem is that houses were not necessarily, nor even usually, built at one time. Where a building was extended or subdivided, it is clear that the local constraints on spatial arrangement could greatly increase: this might lead to unwanted adjacencies or, conversely, to the separation of rooms where adjacency was desirable. At the same time, there is evidence of thorough adaptation of houses. Moreover, one would expect an owner or tenant, at any phase of development, to attempt to overcome any irregularities, and to realise a certain pattern of access within the given constraints. On these grounds, we would maintain that the relations between rooms were, on the whole, rule-governed. The process of piecemeal development does not preclude structural regularity: it does, however, increase the potential amount of 'noise' in a morphological set.

In interpreting the results of the analysis, we shall attempt, as far as possible, to suspend our prior knowledge and judgements concerning the use of spaces within the house. Inferences will be drawn from the morphological properties alone. In the final section, documentary evidence will be used to complement this material and to test the conclusions.

6.7 Depth and Permeability

1. Shop.

The shop is a conspicuously 'shallow' space : 89% of examples in the Ch.H.plans, and 87% of those in the City plans, are to be found at level 1 in the access graphs. The remainder are all located at level 2, where they are reached by way of an intervening circulation space.

A feature of the City plans is the prevalence of the house with a side passage running from the front to the back of the plot. This arrangement provides an opportunity for side access to the shop (as well as to other rooms) and for back access to the house. It is interesting to note, however, that the shop with side access is much less common than might at first appear to be the case. As spatial analysis shows, the depth of the shop is almost identical in the two sets of plans. The proportion of 'non-distributed' to 'distributed' graphs is similarly found to be almost identical for the two samples (see table 6.1).

All of this points to a space where direct contact between 'inhabitants' (the residents or occupants of the building) and 'strangers' (the general public) is of the greatest importance (36). The access characteristics would clearly be consistent, therefore, with the traditional role of the shop as a place primarily for the retail sale of commodities.

2. Hall.

The hall is much less common than the shop. The total sample is, in consequence, rather small. Since the name 'hall' appears only rarely in the City survey, the tabulated results for the later plans cover also those ground floor spaces labelled 'room' and those included

under the general label 'house'. Like the shop, the hall is a 'shallow' space. In the Ch.H plans, 50% of the examples are at level 1 ; none is deeper than level 3. In the City sample 65% of the total are at level 1 ; none is deeper than level 4.

It is notable that a shop and a hall are rarely found together on the ground floor. It was, on the other hand, quite usual in buildings of small floor area, for the hall to be placed on the first floor, immediately above the shop, (see type 1b)). This practice began in the early mediaeval period, and seems to have persisted until the early seventeenth century, at least. From the access graphs, the hall appears as a space which, like the shop, was both very accessible to strangers and well-connected to the rest of the house. 81% of the Ch.H. examples and 56% of the City are bipermeable. The high degree of permeability and the apparent flexibility of its location indicate that the hall formed part of the everyday living or working accommodation, and was not reserved for any special function. At the same time, it clearly had an identity which was quite distinct from that of the shop. A general living/entertaining space would seem to be suggested by the evidence.

3. Back Shop/Back Warehouse

The term 'back shop' is found only in a small proportion (8%) of the City plans. In the Ch.H. plans, the equivalent space appears to be the back room, which is found in 5% of the total. Both the back shop and the back room are characteristically located at level 2 in the access graph, having direct access from the shop at level 1. This position in the access graph is sometimes also associated - in the Treswell plans and later - with the label 'warehouse'. The Clothworkers' Plan Book of 1612 contains a survey of a row of tenements backing on to Foxe's Court, each of which has the ground floor room sequence, shop-warehouse-yard-kitchen. (37). On the grounds of depth and permeability, one would infer that 'back shop', 'back room' and 'warehouse' were more or less inter-

changeable names, each referring to a space given over to the storage of materials for use or sale in the shop.

4. Parlour

The parlour appears in a relatively small number of plans : 18% of Ch.H., and 14% of the City sample. It is confined chiefly to the larger dwellings, inns, etc., where it occurs in addition to the principal spaces - the shop or hall, and the kitchen. It sometimes figures also as the second room in a 2-room plan (see type 2).

In the Ch.H set, the parlour is exclusively a ground floor room.(38). Its depth ranges from level 2 to level 7, the peak being at level 3. The most striking feature, however, is that the label is never found at level 1. Moreover, a large proportion of examples are unipermeable: 9 no. (47%) are wholly unipermeable : a further 3 (16%) are horizontally unipermeable but contain stairs leading to the upper floors. These two characteristics mark the parlour off clearly from the hall. The picture is complicated, however, by the fact that in one instance Treswell has referred to the main chamber of a house as 'A parlor or hall' (39). This could be taken to indicate that the two rooms were not easily distinguishable at this time by either their size or their furnishing.

The access graphs drawn from the City plans point to some important changes. The range of depths is still large, but there is a conspicuous shift to a shallower position in the complex : over half of the examples (58%) now occur at level 2, and 2 no. are found at level 1. At the same time, the restrictions on permeability remain and appear to have strengthened, with 21 no. (58%) of the total accessible from one point only.

The change in the location of the parlour within the complex - the move from a uniformly deep space in the Treswell plans to a relatively shallow one in the later set - appears highly significant. There clearly exists, by the early 18th century, a well-defined plan-type, in which the parlour is adjacent to the

street and accessible, either directly or by way of a side passage, from this.(40).The parlour thus occupies the position formerly reserved for the shop or hall. One possible explanation for the shift is that the label 'parlour' is now used to denote the general living space, i.e. what was formerly the hall. This is consistent with the decline of the hall in its traditional sense, a process which is known to have taken place in the post-mediaeval period, and which is evident from the plan books examined here. Where the name 'hall' does occur in the later set of plans, it is in the context of the large house or mansion and plainly denotes an entrance hall.

An alternative explanation is that the opposite process has been at work. The parlour has shifted in role from an intra- to an inter-household space. That is to say, instead of becoming more of a focus for everyday life, it has, conversely, become an increasingly social space, directed towards relations with the larger community. This would make it comparable in function, as well as position, to the front parlour of the 19th century terrace house, discussed by Hillier (41).

5. Kitchen

This is the most frequent label to appear at ground floor level in both sets of plans ; it occurs in 49% (48 no.) of Ch.H. and 52% (134 no.) of the City plans. In 2 - room plans it is usually the kitchen that forms the second space, located to the rear of the shop or hall.

The depth of the kitchen can be seen from table 6.12 to range between levels 1 and 5 for Ch.H. 89% of the total, however, fall between levels 2 and 4 inclusive. The City plans (table 6.14) exhibit the same overall range, taking in levels 1 to 5. But, in terms of frequency of occurrence, the range is even more restricted than for Ch.H., with 87% of the total at levels 2 or 3. In both cases, a kitchen at level 1 is relatively uncommon, but not impossible (5% in the City sample are 1 step in). Among the smaller

plans in the Ch.H.set (types 1 and 2), the kitchen is sometimes to be found on the upper floors. Whether this arrangement occurred in the later buildings is not evident from the City plans.

Unlike the parlour, the kitchen is generally bipermeable. This is true for both the Ch.H. and the City plans, the proportion of bipermeable examples being almost identical for the 2 sets (approx. 75%). Despite this greater measure of access, the results show that it is relatively unusual to find the kitchen on a cycle or ring (11-18% of examples). This feature is clarified by turning to table 6.13, which gives the depth and permeability of the Ch.H plans in relation to all external space (i.e. including back yards and gardens). With the access patterns represented in this way, the majority of kitchens move to a position at level 1. Moreover, 63% of the total now lie on a cycle. It is clear, then, that the high permeability of the kitchen results not from multiple interior connections, but from a strong link with the outside space - the yard or garden. In less than 10% of cases is the kitchen further than 2 steps from the external space.

The access characteristics of the kitchen, taken alone, would indicate a space which had a utilitarian function, and was a scene of everyday activity. Plainly it was not reserved for special occasions. The fact that the kitchen was the characteristic adjunct to a shop or hall in smaller plans also suggests that it had a complementary function within the house. From this, one is led to infer that the name was used in its modern sense, and that the space was given over predominantly, if not exclusively, to cooking.

6. Buttery

The buttery is much less common than the kitchen, a point which is of interest in view of the importance of the space in the rural house (42). It occurs in 17% (16 no.) of the Ch.H plans, and in only 7% (18 no.) of the City plans. Like the parlour, it is found most often in the larger houses (i.e. type 3). Some of the more substantial houses and the inns have several butteries (43), which

may be grouped together. The buttry is also grouped variously with the kitchen, the washhouse and, in the rare instances when these appear, with the pantry and the scullery.

The position of the buttry in the complex can vary widely, but it is characteristically a deep space. The range of depths obtained extended from level 2 to level 7 for the Ch.H plans and from 2 to 6 for the City. In each case, however, the majority (approximately 95%) are at level 3 or deeper. More strikingly, the buttry never occurs at level 1 in either set. When the Ch.H graphs are transcribed according to the second method (see table 6.13), the overall depth range is, as one would expect, reduced. But the mean depth of the buttry (2.75) is greater than that of any other space, including the chamber. Moreover, unlike any other space it is still never to be found at level 1. Hence, the buttry is deep with respect not only to the street, but also to all external space.

The results also show that the buttry is overwhelmingly unipermeable : 87% of Ch.H. and 100% of the City examples have one path of access only.

The close association of the buttry with the service spaces makes it clear that the room had a related role as a utility space. At the same time, its unipermeability distinguishes it from the kitchen. The one-way access, together with the deep position within the complex, at a remove from the main rooms of the house and from the outside space, point to a storage space of some sort ; the storage of cooking utensils for use in the kitchen suggests itself as the most likely function.

7. Chamber

Chambers, usually more than one, are listed for all the Ch.H. plans which describe the upper floors. They were not confined to the upper storeys of houses, although examples of ground floor chambers are relatively few : 15 no.(7% of total) in the Ch.H plans ; 0 in

the City plans.

When on the ground floor, the chamber is generally a deep space (levels 2 to 7), and where it occurs in juxtaposition with the living quarters of the house, it is usually reached by way of a lobby or other transitional space. It would appear in most cases to have been unipermeable; 9 no. (64%) of the ground floor chambers have only one means of access.

Two observations may be made concerning the function of the space. Firstly, there is nothing in the syntactic properties of the room to suggest the complexity or variety of usage noted by Barley.(44). The prevalence of the room above ground floor level points to a fully-fledged sleeping space. Should this be the case, it was undoubtedly not a recent innovation. Since the density of population within the City walls promoted high building at an early date, it would seem reasonable to infer that the emergence of the specialised sleeping chamber accompanied, or was a corollary of, this development.

The second point is that, given the use as a sleeping space, the bipermeability which clearly obtained in some, at least, of the examples sharply contradicts our modern notions of what constitutes acceptable access for a bedroom. Dorothy George has drawn attention to the part played by social custom and tradition in determining the crowded manner of living in London (45) The demand for privacy within the house would appear to have been relatively undeveloped even in the eighteenth century. The fact that chambers were designed to permit through-access underlines this point and suggests that social values or norms were still in the seventeenth century very much closer to those of the Middle Ages than to those of the twentieth century.

6.8. Connections and Insulations

A number of significant connections emerge from tables 6.15 and

1. Shop -- Kitchen

In about three-quarters (22 no.) of the Ch.H. plans which contain both a shop and a kitchen, the two spaces are adjacent ; in over half (55%-12 no.) of the adjacent examples, they are directly permeable. Among the City plans the permeability is more marked : 71% (51 no.) of all adjacent examples (which here include those configurations with a hall or room on the ground floor in place of a shop) have direct access.

The shop/kitchen connection reflects the close tie between these rooms in the living and working centre of the house. It is not possible to say to what extent their functions overlapped. However, the fact that a transitional space is placed between the two rooms in 41% (9 no.) of the adjacent examples (Ch.H plans) would suggest a desire to keep the functions separate. This is consistent with the working space/cooking space distinction proposed above. The circulation space perhaps also represents an attempt to form a break between the domain of strangers and that of inhabitants.

2. Kitchen - Yard

The kitchen/yard connection is especially marked in the Ch.H collection, where 89% (24 no.) of adjacent examples are directly permeable. In the City plans 68% (53 no.) of adjacent examples have direct access. The high degree of permeability between the kitchen and the yard suggests that their adjacency was more than a function of daylighting requirements. One possibility is that their uses were closely related; the yard may have been used for outside storage of household vessels and, perhaps also, foodstuffs. Alternatively, or additionally, the yard would have provided a place to discharge waste, smoke, etc., which were more likely to accumulate in a cooking space than elsewhere in the house.

3. Kitchen - Buttery

In the Ch.H set, over half of the adjacent examples (5 out of 8) are permeable. It should, however, be noted that in a further 6 cases, the two spaces were not adjacent. Connection between kitchen and buttery is stronger in the later plans, with 9 of the 10 adjacent examples being directly permeable. A strong connection would be expected for practical reasons, given that the latter was used for storage of food, drink or cooking implements. The greater permeability exhibited by the City plans accompanies a more obvious attempt at grouping the buttery with other service spaces, especially the wash-house and stores, at the back of the plot, with access from a common yard.(46).

The strongest aversions to appear from the tables all relate to either the parlour or the chamber.

1. Parlour - Kitchen

Of the Ch.H. plans which include these two spaces, only a quarter (4 out of 16) have them as adjacent rooms. And in only 1 of the 4 adjacent examples is there direct permeability. The most revealing test of aversion between spaces is the extent to which, when they are contiguous, circulation is routed through other rooms within the complex. In this instance, 2 of the 4 adjacent examples have such an indirect access.

The insulation between kitchen and parlour appears to be rather less rigorous in the City plans : 41% (7 out of 17) of the adjacent examples are also permeable.

2. Parlour - Buttery

The tabulated results for the hall/parlour -- buttery connection in the Ch.H plans show that the majority of examples (64%) are non-

adjacent. Of the 8 adjacent examples, it will be seen that only 2 are directly permeable and 2 have the circulation directed through other spaces.

In the City plans, the parlour and the buttery are never adjacent. This striking result suggests that by this time the two rooms were systematically separated in the design of buildings. The uniform separation of these spaces stands in sharp contrast to Barley's findings on the position of the buttery in rural houses of the 16th and 17th centuries. Barley has observed that the buttery is next to the parlour "much more often in the seventeenth century" than next to the hall, and he goes on to list examples in Somerset, Devon, Cornwall, Derbyshire, and Staffordshire, where the buttery was either adjacent to or placed within the parlour (47). The results of this study indicate that, in London of the 17th and early 18th centuries, the parlour was one of the rooms to which the buttery was least likely to be connected.

The sample of chambers at ground floor level is too meagre to permit firm conclusions. But the few instances that exist are insulated from the service spaces in the way one would expect, assuming the separation of the sleeping areas from food storage and preparation.

3. Chamber -- Kitchen

2 adjacent examples, neither of which is permeable. City plans: no examples.

4. Chamber -- Buttery

1 adjacency : impermeable. City plans : no examples.

Two further cases are of interest. The first is the hall parlour connection. The results (Ch.H. plans) point to a high incidence of adjacency for these two rooms, 82% (9 out of 11) of the sample having a wall in common. Moreover, in none of these cases of

adjacency is the circulation diverted through other rooms. It will nevertheless be noted that in most instances (78% of adjacencies) the access is not direct but is made by way of a transitional space. This implies that, whatever the functional and physical similarities between the two rooms, there was a commonly held distinction of sufficient importance to warrant forming a break in the passage from one to the other.

The second case is the parlour - yard relation. In contrast to the kitchen - yard relation given above, this appears as a consistently weak connection. The frequency of permeability is almost identical for the two samples : 18% of adjacent examples (2 out of 11) in the Ch.H set and 17% of those (2 out of 12) in the City plans have direct access. Clearly, therefore, the adjacency between parlour and yard did not arise from the demand for access. More important, it would appear, was the opportunity that this afforded for a view out, an amenity that was especially sought after where there was a garden rather than a yard. The insulation is well illustrated by a plan of a house in Holborn, drawn by Ricus Ryder on behalf of the Clothworkers' Company in 1640 (48). The parlour is shown with windows looking on to the garden at the back of the plot, but it is possible to reach the garden only by first passing through the kitchen and a yard which juts out at the side of the plot. The kitchen - yard connection figures plainly as a stronger link than either parlour - yard or parlour - garden.

6.9. Interpretation

The access graphs and the tabulated data reveal definite regularities in the access or permeability structures of buildings, at the level both of the whole complex and of the individual rooms of which it is composed. Only in the case of very small plans can these regularities be explained by the operation of a random process of selection. This suggests that, in spite of the vagaries of historic growth and the peculiarities of plan shape, the rooms

within the house were at any given stage arranged in accordance with accepted, and therefore probably implicit, notions concerning sequence, position, connection and insulation.

The results obtained from this topological analysis indicate that the organisation of domestic space in London differed in important ways from that in rural areas and in provincial towns. One may note in particular the position of the kitchen on the ground floor. Archaeological and historical studies have shown that the kitchen began as a detached building. This may have been through the danger of fire (49). The practice of putting up a separate structure continued through the 15th and 16th centuries in rural areas, and it was apparently normal to treat the kitchen as a secondary building, an addition to the main house, even in a provincial town such as Leicester in Elizabethan times. Hoskins notes: "A kitchen certainly involved the extension of the house in some way" (50).

In London houses, it might therefore be expected that the practice would persist, albeit within the constraints of the narrow-frontage site. The kitchen would then be placed at a point deep within the plot and beyond the yard. While such an arrangement does occur, it is by no means the most common, even in the earliest plans. It is found in less than half the Ch.H plans, and in a much smaller number of the City plans. Perhaps the clearest example of the type is offered by the series of buildings with analogous ground plans at Westminster market place (51). In the majority of cases the kitchen forms part of the body of the house, and is related to other rooms in a variety of ways: it may be the second room in a 2-room plan or part of a suite of 3 or more contiguous rooms (52); it may be adjacent to hall, shop, or parlour; and it may be placed on one of the upper storeys (53).

The London buildings were clearly not a simple translation of the mediaeval house plan into the restricted urban site. The 'through-passage' plan, which is often taken as the archetypal arrangement for the rural house (54), is nowhere to be found in the domestic architecture of 17th-century London. This is scarcely surprising,

as the layout presupposes a long-frontage building, which was a rarity along the densely built-up streets of the City. But, more important and more interesting, is the fact that the organising principle which the cross-passage embodies or entails - the division of the house into two parts, the house and byre, or the hall and service rooms, separated by the entrance - has also largely disappeared.

If the form of the London house is inadequately explained by reference to rural house types, it is equally clear that the geometric constraints of the urban site, though sometimes considerable, are insufficient to account for the variety of spatial configurations and access patterns that have been encountered in the examples.

The exact relationship between geometry and topology, the alternative ways in which it is possible to realise a particular access graph within a plan of given size and shape, can only be elucidated properly by the enumeration of all theoretically possible arrangements for different parameters. It is hoped that a theoretical analysis of this kind will follow from the present study.

A number of preliminary conclusions may, however, be drawn from the foregoing analysis. In the first place, the structural regularities among sets of plans would appear to be predominantly at the level of the individual space or small group of spaces. While there is also consistency at the higher level - that of the whole complex - this is confined chiefly to the smaller plans. Secondly, the regularities observed refer to a majority of examples, but seldom to all examples, in a set. They therefore yield rules or propositions which are probabilistic in nature rather than universal.

The absence of a strong invariant genotype among large and complex buildings, and the comparative flexibility of rules within sets would suggest that house plans were determined in large measure, not by encoded social information, but by the experience and demands of

everyday activity. The type 2 plan would seem almost certainly to have emerged in this way. The simple 2-room arrangement, consisting of a shop or hall in the front, a kitchen or parlour behind, and a back yard or a garden, recurs with only slight variations over a long period of time, from the sixteenth to the eighteenth century. One would conclude from its success that this offered a convenient and workable solution, adapted to the needs of a certain section of the population and, at the same time, economical for builders to erect, using available scantlings to span the width of the building. Once established, it was presumably repeated or copied wherever similar conditions prevailed.

Practical and functional considerations were plainly decisive in determining the access characteristics of most rooms. The importance of the shop-to-street connection has already been noted. It is equally not difficult to understand the desire of householders to have their bed-chambers insulated from both the street and the living quarters of the house. Allowing for the fact that the attitudes towards privacy were very different from those of today, it is to be expected that the majority of tenants would not wish for direct access from the most social areas of the dwelling. Again, the deep position of a service space such as the buttery would be predicted, given that it was reserved exclusively for household use, and that street frontage was on the whole too valuable to be occupied by unprofitable functions.

In the case of the parlour, however, we are presented with a more complex and more interesting space. The access properties have already been pointed out : it is consistently deeper than level 1 in the complex (Ch.H plans); it is generally unipermeable ; and it is highly insulated from both the living and the service rooms within the house. These features point to the existence of strong external controls over position and permeability, and mark the parlour off as a separate, perhaps even a 'sacred' space, in the dwelling. Of all the rooms that have been identified, the parlour bears the strongest imprint of social relations ; it accordingly suggests itself as the principal interface between inhabitants and strangers. Documentary

evidence relating to furniture and fittings supports this interpretation, and will be discussed in the final section.

A further point which demands note is the apparent continuity of house plans throughout the period examined. The typology of access graphs derived from the Ch.H. plans has been found to apply with very few exceptions to the houses of the City liberties and elsewhere, over a century later. The close affinity between the post-Fire and the pre-Fire buildings, both in their room arrangement and their access patterns, should be stressed, since it is customary to emphasise the changes to built form which resulted from the Rebuilding Act of 1667. Brett-James, for example, has observed "the King's regulations, which scheduled four styles of rebuilding, led to a complete transformation of the City, and streets were widened even if they followed the same general lines" (55). Ralph Hyde, following Reddaway, has similarly remarked on the condition of London in 1676: "In place of rickety houses with overcrowded basements, the streets were now lined with rows of regulation houses. The streets, as reconstructed, were straighter and wider". (56).

The question of morphological development has, in fact, been obscured and confused by a conflation of the material aspect of buildings with their spatial form. The post-Fire legislation clearly had far-reaching effects on building construction. The provisions of the 1667 Act were drastic and wholesale. Wood was banned from the exteriors of houses, which were now to be constructed either of brick or stone. Jerry-building was also outlawed by the imposition of standard house designs. "The heights, storeys, thickness of walls and depth of cellars were all prescribed, and scantlings laid down for the woodwork" (57). These requirements do not, however, presuppose a change in the spatial organisation of the house.

It is a feature of architectural history that traditional spatial forms tend to persist in spite of changes in construction and detailing. Steadman has drawn attention to the importance of

precedent and recourse to tried solutions even in the modern 'self-conscious' process of design. He writes: "This can result in a continuity at the level of spatial organisation and underlying geometric form, while surface features and stylistic treatment are more rapidly transformed".(58).

The results of this study would suggest that the rebuilding of the City of London is an example of exactly this process. The dramatic change manifest by the phenotypes (the outward form of the buildings) conceals and belies the perpetuation of the genotypes.

6.10 Room Dimensions

For any building plan, topological properties have to be considered in relation to properties of shape and size. Dimensional and geometric constraints operate not only at the level of the building envelope but also at that of the component spaces. It is inaccurate, therefore, to picture a spatial configuration as merely a two-sided equation, in which an access pattern is set against a particular geometry. While these constitute the basic parameters, an arrangement of rooms is also determined or limited to some extent by what are held to be the acceptable dimensional limits of rooms of a certain function. The more restricted the range, the more rigid the dimensional parameters, the more these impinge on the ways in which rooms can be arranged within a given shell.

The evolution of domestic spatial organisation since the Middle Ages has been marked by a progressive differentiation of functions within the house. This has been accompanied by an increasingly precise 'tailoring' of spaces according to the activities they are to contain. These developments have greatly accelerated in recent years under the impact of the functionalist 'programme' in architectural design. Local authority housing, in particular, has become highly standardised, following a series of official reports and design guides, including the influential Parker Morris Report (1961), which set down recommended areas for houses of different

type and occupation.

In the mediaeval house, by contrast, the principal rooms were designed to accommodate a wide range of activities - sometimes all the activities of the household. The hall was a true multi-functional space (59). The concept of close fit of activity to space was not one which recommended itself to the mediaeval mind. As a consequence, dimensional tolerances were very large indeed, and room size clearly had a low criticality as a determinant of spatial form (60). This weak functional differentiation evidently carried over into the post-mediaeval period. One would, therefore, expect a wide latitude of room sizes in the two samples. The results, which are presented in tables 6.17 and 6.18, confirm this expectation.

Measurements were taken for the main rooms in all the Ch.H. plans, and in 248 no. of the City plans. As can readily be seen, the dimensional range in the Ch.H. set is large, and sometimes vast. Considering all plan types together, the room areas vary by a factor of 10 for the kitchen, and by a factor of greater than 20 for the shop/hall (here tabulated together). The parlour gives the rather more modest figure of +/- 7. The range for the shop/hall and for the kitchen is reduced when the sample is subdivided according to plan size, but generally remains large : a factor of +/- 10 is still common, and the shop/hall in plan type 1 varies by a factor of +/- 16.

A much more drastic reduction is possible, however, if one looks at the results from the point of view of relative frequency. In all cases, the great majority of examples (75-90%) are found to lie within a relatively small part of the total range, varying by a factor of 1.5 to 5. (See table 6.17)). This distinct bias within each group makes it clear that the selection of room sizes did not operate according to chance; social constraints - the general preferences of residents - and the constraints of built form would account for the 'peaking' in each sub-set. For the purposes of plan generation, it would appear that dimensional constraints could reasonably be incorporated within a model, provided the data

restricts itself to the modal sizes. A further reduction in the number of possibilities is achieved when the ratio W:L is taken into account since, as table 6.17c) shows, this is never greater than 1:3.

Turning to the City plans, a similar set of results is obtained. Once again, the overall range of room areas is very large: both the shop/hall and the kitchen vary by a factor of ± 10 , although, in each case, the lower and the upper limits have risen. A smaller range is found to hold for the parlour and for the back shop, both of which give a factor of ± 7 . These are, however, based on a very small number of examples.

Table 6.18b) shows the effect of pruning the upper and lower figures in each group. Again, this would seem to make the results tractable for plan analysis and enumeration.

It is interesting to observe among the City plans the prevalence of a fairly standardised house type : single-room, approximately square in shape, and built of brick. The staircase is internal and is normally placed in one corner, frequently adjoining the fireplace, which extends along the back or one of the side walls. Access is usually direct from the street, alley, or court, but is occasionally baffled by a small entry or lobby formed within the building shell. Many examples of such houses are found in the Minories, and in Houndsditch. The internal layout can be considered a rationalisation rather than a transformation of earlier buildings. A sample of 99 no. was selected from different locations and measured. The results are given in table 6.18c).

It will be seen that 70% of the sample have an area of between 150 and 300 ft., the dimension on side lying chiefly between 12 and 17 feet. If these figures are compared with those obtained for the type 1 shop/hall in the Ch.H plans, a close correspondence is found to exist between the two sets of results. The dimensions and floor area of the later houses cluster around the mean for the pre-Fire

dwellings.

Kelsall has stated that, irrespective of any new building made necessary in the suburbs by the Great Fire in the City in 1666, "later 17th-century London was faced with speculative building on a new scale to meet the demands of an increased and increasing population" (61). Booth has focussed on the part played by speculative builders in the physical transformation of London after the Restoration (62). He has drawn attention to the fact that "almost all London's housing from 1660 onwards was put up as a speculative enterprise in which builders and property developers were involved in the hopes of a sound financial killing" (63). And he has stressed the need of the developer, then as now, to supply a marketable product if he were to realise the hoped-for return on capital (64). The speculative builder was thus innately conservative in his approach. This inherent conservatism, this risk-counting, which was fundamental to the workings of the land market, would explain not only the regularity of the particular plan form described, but also the continuity in space standards. The brick construction would clearly have reassured the potential resident with "an appearance of solidity" (65); the adoption of a plan which conformed in size and arrangement to the general standard, the necessary 'fit' to social requirements. One would assume that the single-room dwelling was built principally for the less wealthy members of society.

6.11 Building Heights

A number of the plan books and written surveys give a full inventory of rooms within each house. From this information, it is possible to derive or infer the overall height (i.e. no. of storeys) of a considerable number of dwellings in the City and the suburbs in the early 17th century. These statistics can, in turn, be used to test general statements and hypotheses made elsewhere (66).

The height of buildings has been calculated for samples from three of the surveys, viz.

- 1) Christ's Hospital Properties
Evidence Book, c. 1612.
Total number in sample = 63 no.

- 2) Clothworkers' Plan Book
1612.
Total number in sample = 160 no.

- 3) St. Paul's Parliamentary Survey of Houses
1649-1657.
Total in sample = 99 no.

The results are presented in table 6.19. A half-storey denotes the existence of rooms in the roof space.

The overwhelming majority of buildings in each sample (90%) are between 2 and 3 and-a-half storeys in height. It is clear that, unlike its counterpart in the provincial towns (67), the typical London house had long since been built on several floors. The incidence of single-storey dwellings would appear to be negligible ; no examples are to be found in the first two surveys and 1 no. only in the St. Paul's sample. The figures for Ch.H. and St. Paul's suggest that 3 to 3 and-a-half storeys was a more common height than

2 to 2 and-a-half storeys, although the breakdown for Cl. gives the opposite indication. This difference appears to be accounted for by the fact that the Cl. plans contain a correspondingly larger proportion of houses located in courts and alleys. These areas, shielded from the street, were widely used for ancillary buildings and for housing the poor. The accommodation provided was accordingly very basic in general no more than one room per floor - and the buildings appear to have been predominantly 2 to 2 and-a-half storeys in height. If the analysis is restricted to those buildings along the street edge, the balance is redressed in favour of the 3 to 3 and-a-half storey building.

Thus, one would conclude : firstly, the majority of perimeter buildings were 3 - 3 and-a-half storeys in height: secondly, the great majority of all buildings were 2 - 3 and-a-half storeys in height. It is impossible to establish the exact balance between 2 - 2 and-a-half storey and 3-3 and-a-half storey buildings in the total building stock, but the results suggest that the two occurred in approximately equal numbers, each forming at least 40% of the total.

All three surveys confirm that buildings on the street rose at times to 4 storeys and above. Ch.H. and Cl. both contain buildings of 5 and 5 and-a-half storeys. The results indicate that high buildings (4 - 5 and-a-half storeys) constituted somewhere between 1 and 10% of the housing stock. They occur only in the central areas of the City where they front principally on to the main streets and market places. They would all appear to belong to type 1b) in the morphological classification given above. Records from the end of the century - the 1694 Act - show that the parts of the City in which the tall buildings feature most strongly were also those which contained a large proportion of 'substantial households'. i.e. "the upper part of society in respect of income and status" (68). The primary area of these high status households covers five contiguous parishes in the neighbourhood of Cheapside, including St. Matthew, Friday Street. It has also been noted that the areas with the highest proportion of 'substantial households' appear to have had a

very slightly higher population per house (69). Although the analysis of household size is fraught with difficulties - not the least of which is the definition of who or what constitutes a household - it would seem justifiable to associate the high-rise building with the upper social stratum, the 'surtax households', which were most likely to require space for a large number of servants and apprentices.(70).

The tables below (6.20 and 6.21) give the breakdown of building height in relation to house size (no. of rooms) for two of the sources.

It will be seen that there is a clear tendency for building height to increase as plan size decreases, a trend which is more marked in the St.Paul's sample than in Ch.H. This does not, however, take the form of a linear relation, but rather an abrupt upward curve at the bottom end of the scale. It represents, in particular, the shift among the smallest category, the single-room plans, towards a height of 3 storeys and above. Plans with 3 or more rooms in ground plan show no corresponding tendency to decrease in height with increase in size ; it is exceptional for a building to be without upper chambers, and the range of 2 - 3 and-a-half storeys remains the norm among the largest and most complex examples.

Since two of the surveys examined date from the beginning of the 17th century, it is not unreasonable to take the results presented here as a guide to the height of buildings in Elizabethan London. It has been suggested elsewhere that the majority of buildings shown in the Elizabethan copper plate map, and in those maps derived from it - the so-called Agas map, and Braun and Hogenberg - were probably at least one storey higher than the 2 storeys generally indicated (71). The results of this analysis would confirm that view.

6.12 The Functions of Rooms

In sections 6.7 - 6.9 above, a number of conclusions were reached on the function and status of rooms within the house from examination of their topological properties. Finally, this information may be augmented and the hypotheses tested by turning to documentary sources. The information given here is derived from inventories of fixtures and fittings for houses in London. It has been possible to examine only a small number of these within the time available ; the study cannot, therefore, claim to be systematic or exhaustive. Three main sources have been consulted : probate inventories ; the Orphans' Court inventories ; and lists of fixtures annexed to leases (Husting Rolls). 30 inventories have been examined in all. Most of the material dates from the 17th century.

One of the problems inherent in working from evidence of this kind is that it presents a distorted picture of society by dealing only with its wealthier members. Christopher Hill has warned of such 'optical illusions' created by the accidental survival of evidence. He uses the example of wills to illustrate the point: "the bottom fifty per cent or so of the population left no wills because they had no property worth leaving.." (72). The omissions are all the more serious as it appears that "this stratum of the population was getting poorer, not richer, in the century after 1530". This social imbalance has to be borne in mind at all times when generalising on the use of rooms. The problem is not restricted to documentary sources. Similar considerations apply to the maps and plans: it is the houses of the very poor which go unrecorded. Thus, the exclusion tends to be all the more effective by its universality. Over half of the inventories examined here relate to citizens who were also members of one of the twelve great Livery Companies ; these were clearly in the main rich merchants or very well-to-do shopkeepers. But the lists also include some less wealthy

citizens, conspicuous by the shorter length and more modest contents of their inventories. These were perhaps small shopkeepers, craftsmen or artisans. Hence, the evidence gives some cross-section of livery company members, but by no means a cross-section of society as a whole.

The results will be listed, as before, under room names.

1. Shop

The shop appears primarily as a place of work and business. Reference to counters, scales, and weights makes it clear that the space was used for the sale of goods, and for reckoning prices or accounts. The shop belonging to Daniel Waldo, Clothworker, in Honey Lane (d.1661), contained a beam and scales, and weights of lead and brass. The furniture included counters, chests, presses, and shelves (73). In Robert Manne's inventory (Grocer, d.1622/3), the contents of the shop and warehouse are listed together, and include a great quantity and variety of cloths (74). This stresses the close link between shop and warehouse, and the use of both for storage of merchandise. Occasionally, a bed is also recorded. Robert Manne's warehouse contained a flockbed and bolster, pillow, old rug and coverlet. Waldo's house contained one half-headed bedstead in the "little room by the shop".

2. Hall

The hall would appear, at least in the first half of the 17th century, to retain its original function as the living room of a dwelling (75). The room is typically furnished with one or more tables, together with benches and chairs, and may contain a chest. It frequently also contains a considerable quantity of fabrics in the form of curtains, carpets, upholstery and cushions. A hearth or fireplace is indicated in the majority of examples by the presence of andirons, brasses, tongs, creepers, etc.

Robert Manne's hall contained a "Drawing table, court cupboard, 7 joyned stooles and a chest ...; 2 Chaires, 3 lowe stooles and a paire of virginalls....; 8 Old Cushions, old stript carpett, 2 old window curtens and Rodde ...; paire of brass Andirons, paire of Creepers, firehovell and tongs tipt with brass..."

It is interesting in this case to find a pair of virginals among the list of goods, especially as the house also contained a parlour. One would infer that the hall, rather than the parlour, was considered to be the appropriate place to keep (or display) such an instrument. Virginals are recorded in two other examples, including the much earlier inventory of Thomas Deane, citizen and Fletcher (d.1571) (76). Richard Langley (Fishmonger, d.1659) (77) had a "paire of harpsicalls" in his hall, while that of Henry Crone (Barbersurgeon, d.1661),(78), contained a pair of organs. The practice is consistent with a relatively formal space : a withdrawing or retiring room. But this role is contradicted, in the case of Thomas Deane at least, by other furniture and portables listed for the hall. These include one pair of playing tables, a tin laver to wash hands, 5 drinking glasses, a cane and a girdle, two shooting bows with a quiver and 24 shafts and the bow cases.

This assortment of items, at first sight somewhat curious, reinforces the picture of the hall as a multi-functional space. Plainly the fletcher was happy to have the products of his craft there. It was apparently adapted equally to a certain measure of formality, to sitting, talking, and the entertainment of guests ; and to everyday activity, eating and drinking, gaming, and all the paraphernalia of the home. The fact that Deane's inventory also specifies two women's chairs and one stool for a woman is positive evidence that the room was used by both sexes. Henry Crone's hall contained a child's chair and a couch for children.

3. Back Shop,/Warehouse

This is relatively uncommon among the selected inventories, but the four examples found confirm one's expectations, its general use being as a repository for merchandise. Robert Manne's warehouse has been noted above. Others were similarly used for storage, both of raw materials and finished products. The back warehouse might also contain a counter and/or a beam and scales. It would also seem that it was not uncommon to have a bedstead in this back space. Daniel Waldo had a back warehouse in his house in Honey Lane, which contained a table, a flour chest, an old trunk, and a cupboard with presses and shelves. This was evidently a general storage space.

4. Parlour

Like the hall, the parlour is invariably furnished with tables and chairs. It generally contains a fireplace, and may be richly appointed with fabrics. Matthias Prosser, citizen and brewer, (d.1658/9) had a parlour next to the street, which contained a drawing table and a round table, two joined stools, five high chairs, and two low chairs of leather, a leather carpet and two striped carpets with two window cushions (79).

The house belonging to John Williams (Draper, d.1637) had two parlours. In the great parlour were six chairs and six stools of Turkey work, two tables, a form, two court cupboards, and a pair of playing tables. The little parlour contained eight high-back chairs of Muscovy leather, four lower ones, a great elbow chair and seven high leather stools ; a wainscot chair, two tables, two carpets, six cushions, window curtains and wooden windows (80).

The inventories thus point to a close resemblance between the parlour and the hall, the principal difference residing in the fact that, for the parlour, there is very much less evidence of everyday activity. There is no record of cooking utensils, glasses or cutlery ; nor is there any intrusion of the trade or craft into this space. The results would, therefore, support the earlier conclusion

that the parlour stood apart from the ordinary living accommodation of the house. The existence of a superordinate function of a formal or ceremonial nature, such as the entertainment of special guests, would be compatible with the documentary evidence summarised here.

A Bible is included among the inventories of Robert Manne and of Thomas Deane. Whether or not these citizens used their parlour for Bible-reading or for conducting household catechism (81) can only be guessed at, but it does seem that the Bible was more appropriate to this space than to any other in the house. A further point is that, while the inventories often indicate a superabundance of furniture in the parlour, neither women's nor children's chairs appear among the lists. Hence, there is no direct evidence that the parlour, like the hall, was used by all the family.

5. Kitchen

The inventories for the kitchen consist, in all cases, predominantly of cooking utensils. Daniel Waldo's kitchen is representative. The list gives a jack with line, pulleys and iron weight, pot-hangers, iron racks, a pair of fire irons and bar, and a pair of creepers, fire shovel and tongs; frying pans, warming pans, a dripping pan, kettles, skillets, a ladle, a scummer, a mortar and pestle, and a chopping block ; and a large quantity of pewter. The furniture consisted of a table, a form, and six old stools.

All of this points unquestionably to a cooking room. Hence the use and status of the kitchen in the seventeenth century would appear to differ little from that of today. Since tables, chairs and/or stools usually figure in the lists, it is possible that food was eaten as well as prepared in the kitchen. It seems more likely, however, that the general practice was to eat in the hall, where there was one, and to keep the kitchen solely for preparation (82).

The kitchen in John Wedge's house (Saddler, d.1650/51) contained - in addition to the full range of utensils, "a flockbed, fetherbed,

boulster, 2 pillowes, rug and blankett" (83). Strange as it may seem to modern eyes to have a bed in the kitchen, this was undoubtedly not a unique case. It was probably connected with the practice, noted by Dorothy George, of accommodating servants and apprentices under the one roof.

6. Buttery, Pantry, Yard.

The buttery, though originally a cool storage place for drink, appears by the seventeenth century to be more commonly employed for general storage. Henry Crone's buttery contained a very miscellaneous collection of objects : 2 muskets and bandoleers, a "birding peece", a pair of pistols, 2 swords, 2 bird cages, lumber, and a rat trap. Daniel Waldo's home at Harrow-on-the-Hill had no buttery, but included a pantry, together with a kitchen and larders. The pantry contained a table, 2 forms, 2 old cupboards, a pair of tables, 2 stands and 2 hogsheads together with about 20 loads of firewood, a bridle and saddle, a mortar and pestle, a parcel of ribbons, 4 old curtains and a vallance.

Where a yard is recorded, this always contained a cistern. But the inventories frequently also list a great quantity of other lumber, similar to that found in the buttery and pantry. Thus, in the outer yard and walk of Constans Wallis's house (widow of William Wallis, Mercer, d.1661) were 2 tables, 4 chairs, 3 cushions, a stool, 2 bird cages, a clock, a wooden cistern, a lantern and wooden ladder; a musket and bandoleers, 2 picks, a halberd, 2 headpieces, and a sword (84). In one case, a flockbed and bolster are recorded. The hypothesis offered above - that the yard was used as an outdoor storage space - would thus appear to be borne out. Aside from its special role in storing water, a yard is almost indistinguishable by its contents from the buttery or pantry.

7. Chamber

The chamber differs from the previous spaces in being principally an

upper floor room. From the inventories it was plainly a room for sleeping. Waldo's house in Honey Lane lists eight chambers, all of which contained at least one bed (two have a second bed). The main beds are all described as having mat, cord, tester, curtains, and val^lance, and all have feather mattresses. The second bed is in each case a trundle bed, i.e., one on castors. The bed chambers generally have fireplaces.

Other furnishings include tables, chairs, stools, couches, trunks, chests of drawers, a looking glass, a stone basin and a ewer, along with curtains, cloth hangings, rugs, and blankets. The great variety as well as quantity of fabrics which are catalogued - serge, buckram, 'Dornex', say, kersey, velvet, damask, Turkey- and tapestry-work - can be ascribed in this instance to the owner's wealth and his profession as clothworker, and are probably not to be considered typical. Judging from the number of beds, the household was very large - perhaps ten persons. If this were the case, it is unlikely that they were all members of the same family or kin. A more plausible explanation is that the household consisted, in large part, of servants, apprentices, or 'lodgers'. This would agree with Glass's findings in his analysis of the London parish listings, and would place Waldo among the ranks of the 'substantial' householders(85). The inventory of David Wiffin (Skinner, d. 1626/7) specifies a servants' chamber which contained 4 bedsteads and 4 flockbeds(86).

Samuel Ward's inventory (Stationer, d. 1639) lists the contents of what was apparently a ground floor chamber. These comprise a "standing bedsted, matt and cord, vallens and curtens of green sey, fetherbed and boulster, flockbed and boulster, pillow, 2 blanketts and rug..; 2 flockbeds and boulsters, a little rug and a blankett..; little trunke and 3 boxes."(87). Hence, there would appear to be no essential difference in function between chambers at ground floor level and those in the upper storeys.

8. Garret

The garret was a room in the roof space. In some cases this was used purely for storage. Waldo's garret in Honey Lane contained one small iron grate, a "portmantell and some other lumber".

In other instances, it was definitely a sleeping chamber: probably for servants and apprentices, but perhaps also for members of the family. Robert Manne's garret contained a "Halfe headed bedstead, matt and cord, straw bed, flockbed and bolster, fether bolster, 2 old blanketts and an old Rugge...; 3 Chests, Cradle, 2 basketts and a pillion...."; also listed is a great quantity of cloths, cushions and coverlets. Much of the latter must have been for use in other parts of the house.

For the most part, then, the evidence of the inventories corroborates the conclusions drawn from examination of the topological properties of the house plans.

The hall, whether on the ground floor or the first floor, remained, during the early 17th century, a general living space. At the same time, many of the activities which the mediaeval hall would have accommodated now have special provision: cooking is usually carried out in the kitchen, the upper floors are used for sleeping, and various ancillary spaces - the buttery, the pantry, the yard - contain food and drink, equipment, and general lumber.

Where a house was large enough to have one or more parlours, these were withdrawing rooms. From the furnishing, one would infer that greater formality of behaviour was demanded in the parlour than elsewhere in the house. It was noted in the graph analysis that none of the spaces has an absolutely fixed position within the house. Nevertheless, the parlour, by virtue of its relatively 'deep' position in the sequence of ground floor rooms, its frequent unipermeability, and its insulation from the working part of the house, does appear to be charged with a social significance which transcends utilitarian considerations. This was possibly the decisive difference between the parlour and the hall.

An important characteristic to emerge from the inventories is a negative one : the parlour never appears to have been used for sleeping. This is all the more striking as beds are recorded in such large numbers and are listed for so many different rooms : they are to be found even in the shop and the kitchen. The lack of any reference to a bed in the parlour stands in sharp contrast to the evidence of contemporary rural inventories. Not only was it usual, in the rural house, for the parlour to contain a bed ; the space was widely understood as the principal sleeping-room of the house (88). The London records, if representative, signal a great change in the character and purpose of the room, and underline its 'separateness' in domestic spatial arrangement.

In the later plans - those of the late 17th and early 18th century - the consistently 'deep' position of the parlour is disrupted by the appearance of a new configuration, in which the room has shifted to the front of the house, facing the street. The rise of the 'shallow' parlour configuration coincides with the decline of the hall as a general living space (89). By the early 18th century, the label 'hall' is rarely used, except in the very different sense of an entry in certain houses of the social elite. The change in the position of the parlour is susceptible of different interpretations ; it can be taken to indicate a growth in, or the shedding of, practical functions. It is tempting, however, to see it as an increase in the categoric importance of the space, a further step in the process of separation, which marks the drawing apart of social groups, the permeation of capitalist relations throughout society, that was taking place in our period.

A final point of a general nature concerns the quantity of furniture described in the inventories. Far from there being a shortage, the general impression gained from the lists and schedules is that of an over-supply of furniture. Very few spaces were unused. The majority of halls and parlours contained an abundance of tables and chairs of different types, along with carpets, draperies, and cushions. Most beds had feather mattresses, and the records indicate a plentiful

supply of feather bolsters, pillows, blankets and coverlets. Chairs appear to have been more common than benches even in the 16th century (90). It is interesting to note that houses in the eastern suburbs also seem to have been over-, rather than under- furnished (91). To a certain extent, the results reflect the bias of the inventories towards the more prosperous households. They clearly tell us nothing of the poorer classes. One may, however, conclude that considerable standards of comfort were enjoyed by a certain section of the population in the 17th century ; that this took in some part of the lower middle class as well as the upper stratum ; and that improvements in furnishing were neither new nor sudden, but date back to at least the late sixteenth century.

6.13 Conclusions

This analysis of London house plans has revealed definite regularities both in the overall access structure of houses, and in the access and adjacency characteristics of particular rooms within the complex. The regularities appear to derive principally from two factors :

- 1) the limited range of possible configurations for small house plans, which form the great majority (over 75%) of those examined ;
- 2) the practical and functional demands of everyday life.

It would appear that small houses were built according to traditional patterns or models ; certain configurations, most notably the 2-room sequence, were repeated with only minor variations over a very long period. These models clearly entailed an intimate relation between spatial arrangement and building technique. The 'vocabulary' and methods of timber-framed constructions were sufficiently well understood for builders to be able to erect houses without recourse to explicit instructions. It would appear, however, that the standardisation of the frontage dimensions of houses, which is so much in evidence in the City plans, was a function of economic, rather than structural, considerations : the commercially valuable street frontage would be divided up into that number of plots which, when developed, would yield the highest total rent, and thus the greatest return on capital investment. The physical constraints imposed by timber-framed construction would seem to have been very low. While the lengths of beams must have set an absolute upper limit on the spacing of cross-walls, it is unlikely that these actually determined the frontage dimensions of houses. And the fact that neither the size nor the spatial arrangement of small dwellings was appreciably affected by the transition from timber to brick construction in the years following the Great Fire suggests that the material adopted for the outer shell of the building had little, if

any, influence on spatial form.

The building plans transcribed from the manuscript surveys in this study were divided into three main sets according to size, and for each of those sets, 'genotypes' or 'type-designs' have been proposed on the basis of recurring patterns of access in a large number of examples. One further study which suggests itself is a more systematic examination of the relationship between the access patterns and the geometry (i.e. the overall plan form) of the house. Providing the range of access patterns and house forms is restricted, it should be possible to 'map' the access graphs into the constraints imposed by narrow-frontage plots and a rectangular geometry to obtain a complete enumeration of the possible room arrangements for given parameters. Comparison of the actual configurations with those which are theoretically possible holds the advantage that it yields a numerically precise, rather than intuitive, measure of probability. Statistical analysis might, in turn, lead to a more rigorous classification of plan types. Where there is a great disparity between the actual and the possible, it follows that certain processes or controls are at work, restricting the possible range. One's attention is, therefore, directed back to the empirical evidence, and to the factors - social, economic, and technological - which could explain the restrictions of choice.

In this case, the main advantage would be to clarify the relationship between urban and rural house plans ; the extent to which the differences can be accounted for by physical constraints alone. But such a study is neither practicable nor necessary here. For our present purposes, the graph analysis has put us in a position where we are much better equipped to address the central question of the thesis : the way buildings were aggregated in space. It is to this that we shall now turn.

ACCESS PATTERNS

	'Non-distributed'		'Distributed'	Total
	'Trees'	Internal cycles		
Christ's Hospital	68	5	22	95
City Lands	186	9	56	251

Table 6.1.
Access graphs of building plans from Christ's Hospital Evidence Book, 1612, and the Survey of City Lands and Bridge House Properties.

'DEPTH'

	Number of Levels										Total
	1	2	3	4	5	6	7	8	9	10	
Christ's Hospital	26	15	14	19	11	4	4	2	-	-	95
City Lands	46	51	56	47	28	8	3	3	-	-	242

Table 6.2. Total number of levels in the access graphs of building plans. The figures have been calculated for ground floor plans only. The street system (base vertex) is not included in the number of levels.

BUILDING SIZE

	Number of Rooms										Total
	1	2	3	4	5	6	7	8	9	10	
Christ's Hospital	34	28	13	8	7	3	1	-	1	1	96
City Lands	101	120	31	8	3	1	-	-	-	-	264

Table 6.3. Number of rooms at ground floor level. Ancillary spaces (e.g. closets), circulation spaces, workshops, and outhouses are not included in these figures.

EXTERNAL SPACE

No. of rooms at g.f. level	Buildings with yard(s) but no garden	Buildings with garden(s) only	Buildings with yard(s) and garden(s)	Buildings with <u>no</u> private external space	Total
1	1	1	2	28	32
2	9	9	-	11	29
3	4	2	4	2	12
4	5	1	3	-	9
5	4	-	2	-	6
6+	2	-	3	2	7

Total no. of rooms					
1	-	-	-	-	-
2	-	-	-	-	4
3	-	-	-	-	10
4	-	-	-	-	5
5	1	2	-	-	2
6	-	2	-	-	1
7	2	-	-	-	7
8	3	-	1	-	4
9	2	-	1	-	-
10-20	5	-	5	-	-
21+	1	-	-	-	-
Unknown	11	9	7	10	

Table 6.4. External space for different house sizes. Christ's Hospital Properties.

EXTERNAL SPACE

No. of rooms at g.f. level	Buildings with yard(s) but no garden	Buildings with garden(s) only	Buildings with yards) and garden(s)	Buildings with <u>no</u> private external space	Total
1	28	8	-	65	101
2	73	11	2	36	122
3	17	1	3	10	31
4	3	2	1	2	8
5	2	-	1	-	3
6	-	-	1	-	1
Total	123	22	8	113	266

Table 6.5. External space for different house sizes. City Lands and Bridge House Properties.

ROOM NAMES

	Total No. recorded	No. of buildings.
Shop	46	44
Hall	23	23
Parlour	19	17
Kitchen	48	48
Buttery	18	16
Pantry	1	1
Larder	2	2
Wash-house	4	4
Chamber	208	65
Garret	62	44
Room	42	27
Drinking Room	2	1
Study	3	3

Table 6.6
Frequency of occurrence of room names in the sample : Christ's Hospital Properties. The figures include rooms above ground floor level. Upper floor rooms are listed in 63 no.(65%) of the building plans.

ROOM NAMES

	Total Number Recorded
Shop	122
Hall	6
Parlour	36
Kitchen	121
Buttery	18
Scullery	1
House	84
Back Shop/Back Warehouse	10
Counting House	11
Room	37
Drinking Room	7
Warehouse	16
Workshop/Workhouse	19

Table 6.7. Frequency of occurrence of room names in the sample : City Lands and Bridge House Properties. The figures refer to ground floor rooms only.

TYPE 3: VARIANTS

	Number of Operations									Total
	0	1	2	3	4	5	6	7	8+	
No.	-	1	2	5	3	3	2	4	2	22

Table 6.8. Extent of deviation of actual examples from type-graph 3. Christ's Hospital Properties.

TYPE 3 : VARIANTS

	Number of Operations									Total
	0	1	2	3	4	5	6	7	8+	
a)	2	2	4	-	1	-	-	1	-	10
b)	-	2	2	-	5	1	-	-	-	10
c)	-	-	-	-	-	1	1	-	-	2
Total:	2	4	6	-	6	2	1	1	-	22

Table 6.9. Extent of deviation from type-graphs 3a), 3b), 3c). Christ's Hospital Properties.

CITY PLANS :TYPOLOGY

	Pure Type	Variant	Atypical	Total
Type 1	40	55	10	105
Type 2	15	102	9	126
Type 3	1	28	7	36
Total:	56	185	26	267

Table 6.10. Correlation of building plans with type-graphs. City Lands and Bridge House Properties.

TYPE 3 :VARIANTS

	Number of Operations									Total
	0	1	2	3	4	5	6	7	8+	
a)	1	-	3	2	1	1	-	-	-	8
b)	-	5	9	7	3	2	1	-	1	28
c)	-	-	-	-	-	-	-	-	-	-
Total:	1	5	12	9	4	3	1	-	1	36

Table 6.11. Extent of deviation from type-graphs 3a), 3b), 3c). City Lands and Bridge House Properties.

DEPTH AND PERMEABILITY OF ROOMS

Rms recorded	Total No.	No. of bldgs.	Permeability			'Depth' (level)							
			uniperm.	horiz. uniperm.	on cycle	1	2	3	4	5	6	7+	
Shop	46	44	5	8	9	41	5	-	-	-	-	-	-
Hall	16	16	5	-	3	8	5	3	-	-	-	-	-
Parlour	19	17	9	3	2	-	5	8	4	1	-	-	1
Kitchen	45	45	10	2	5	2	16	11	13	3	-	-	-
Buttery	18	16	15	1	2	-	1	6	2	4	2	-	3
Chamber	14	7	9	-	3	-	1	4	3	5	-	-	1

Table 6.12. 'Depth' and permeability of ground floor rooms in the Christ's Hospital Plans. Access graphs drawn in relation to the street system only. 'Uniperm.' designates rooms which are unipermeable both horizontally and vertically. 'Horiz. uniperm' signifies rooms which are horizontally unipermeable, but which contain stairs to the upper floors.

DEPTH AND PERMEABILITY OF ROOMS

Rms recorded	Total No.	No. of bldgs.	Permeability			'Depth' (level)							
			uniperm.	horiz. uniperm.	on cycle	1	2	3	4	5	6	7+	
Shop	46	44	4	4	28	41	5	-	-	-	-	-	-
Hall	14	13	5	-	7	7	7	-	-	-	-	-	-
Parlour	18	16	9	3	6	2	12	4	-	-	-	-	-
Kitchen	48	48	11	1	30	25	19	3	-	1	-	-	-
Buttery	18	16	15	1	2	-	8	8	2	-	-	-	-
Chamber	14	7	9	-	5	7	3	3	-	1	-	-	-

Table 6.13. 'Depth' and Permeability of ground floor rooms in the Christ's Hospital Plans. Access graphs drawn in relation to all external space.

DEPTH AND PERMEABILITY OF ROOMS

Rms	Total No. Recorded	No. of Bldgs.	No. of uniperm. on uniperm. cycle	Permeability		'Depth' (level)							
				horiz.	on uniperm. cycle	1	2	3	4	5	6	7+	
Shop	128	124	23	6	27	111	17	-	-	-	-	-	-
Hall/Room/'House'	89	87	18	21	14	58	28	2	1	-	-	-	-
Back-shop/Warehouse	22	22	10	-	5	3	10	4	4	1	-	-	-
Parlour	36	36	21	1	6	2	21	6	5	2	-	-	-
Kitchen	138	134	33	7	25	7	79	41	9	2	-	-	-
Buttery	18	18	18	-	-	-	1	6	6	4	1	-	-

Table 6.14. 'Depth' and permeability of ground floor rooms in the City Plans. Access graphs drawn in relation to the street system only.

CONNECTIONS/INSULATIONS

	ADJACENT			NOT ADJACENT	
	Permeable	Imperm.- circ.int.	Imperm.- room(s) or yard(s) int.	circ.int.	room(s) or yard(s) int.
Shop--Kitchen	12	9	1	3	4
Hall--Kitchen	2	1	-	3	8
Shop--Hall	-	1	-	-	-
Shop-Parlour	1	1	-	-	2
Hall--Parlour	2	7	-	1	1
Shop--Buttery	1	-	1	1	3
Hall or Parlour -- Buttery	2	4	2	2	12
Kitchen--Parlour	1	1	2	1	11
Kitchen--Buttery	5	1	2	1	5
Kitchen--Chamber	-	-	2	-	3
Parlour-Chamber	1	-	-	-	2

Table 6.15. Connection/Insulation between pairs of rooms in the Christ's Hospital Plans. Abbreviations : 'circ.int.' = circulation space intervening between rooms; 'room(s) or yard(s) int.' = access by way of other rooms only.

CONNECTIONS/INSULATIONS

	ADJACENT	PERMEABLE
Shop/Hall/'House'		
-- Kitchen	72	51
-- Back Shop	15	14
-- Parlour	9	3
-- Buttery	1	1
-- Yard/Shed	46	36
-- Chamber	-	-
Back Shop -- Kitchen	5	2
Parlour	2	1
Buttery	-	-
Yard/Shed	10	5
Chamber	-	-
Kitchen -- Parlour	17	7
Buttery	10	9
Yard/Shed	78	53
Chamber	-	-
Parlour -- Buttery	-	-
Yard/Shed	12	2
Chamber	-	-
Yard -- Yard/Shed	37	36
Chamber	-	-
Chamber -- Chamber	-	-
Buttery -- Yard/Shed	4	1
Chamber	-	-

Table 6.16. Connection/Insulation between pairs of rooms in the City Plans.

ROOM DIMENSIONS

Plan Type	Shop or Hall		Kitchen			Parlour			
	Length	Width	Area	L.	W.	Area	L.	W.	Area.
Type 1									
Min.	3 3		26.0		5 0	42.5	-	-	-
Max.	34 9		426.0	19 0		209.25	-	-	-
Type 2.									
Min.	4 0		46.0		4 6	51.0	-	11 0	121.0
Max.	34 9		457.5	28 0		434.0	18 6		314.5
Type 3									
Min	10 9		77.0		4 6	38.25		8 6	76.0
Max	36 0		558.0	21 6		365.5	36 0		558.0

Table 6.17a. Dimensional limits of rooms according to plan type : Christ's Hospital Properties. Dimensions in feet and inches. Areas in square feet.

Type	Shop or Hall	Kitchen	Parlour
Type 1			
	26.0--426.0 (100%)	42.5--209.25 (100%)	-
	150.0 400.0 (91%)	124.0 209.25 (85%)	-
	150.0 350.0 (82%)		
Type 2			
	46.0--457.5 (100%)	51.0--434.0 (100%)	-
	46.0 400.0 (94%)	75.0 300.0 (79%)	-
	46.0 300.0 (83%)	75.0 240.0 (75%)	-
	120.0 400.0 (72%)		
	120.0 300.0 (61%)		
Type 3			
	77.0--558.0 (100%)	38.25--365.5 (100%)	76.0-- 558.0 (100%)
	77.0--316.0 (83%)	70.0 365.5 (90%)	110.0 558.0 (89%)
		70.0 250.0 (81%)	110.0 360.0 (78%)

Table 6.17b. Relative frequency of room sizes according to plan type.

Type 1	1.0 -- 2.84 (100%)	1.15 -- 2.58 (100%)	-
Type 2	1.03 2.84 (100%)	1.08 2.51 (100%)	-
Type 3	1.0 2.8 (100%)	1.03 2.47 (100%)	1.04 2.6 (100%)

Table 6.17c. Ratio W : L

Type 1	22	7	0
Type 2	36	24	2
Type 3	18	21	18

Table 6.17d.
Total number in sample.

ROOM DIMENSIONS

Rms.	Shop/Hall/'House'			Back Shop			Kitchen			Parlour		
	L.	W.	Area.	L.	W.	Area.	L.	W.	Area	L.	W.	Area
Min .	3 0		69.375	5 6		57.75	5 0		52.0	6 0		54.0
Max	42 0		832.5	26 0		379.5	41 0		656.0	22 0		360.75
Total No.	215			13			112			28		

Table 6.18a. Dimensional limits of rooms : City Lands. Dimensions in feet and inches. Areas in square feet

Shop/Hall/'House'		Back Shop	
69.375-832.5	(100%)	57.75-379.5	(100%)
100.0 --450.0	(85%)	100.0--300.0	(69%)
100.0 300.0	(70%)		
150.0 300.0	(53%)		
Kitchen		Parlour	
52.0 - 656.0	(100%)	54.0 --360.75	(100%)
100.0 --300.0	(92%)	100.0 --300.0	(61%)
150.0 - 250.0	(50%)		

Table 6.18b. Relative frequency of room sizes.

	L	W	Area
Min.		8 6	99.75
Max.	39 6		632.0
Total No.		99	
	150 -- 300.0		(70%)
	150 -- 250.0		(59%)

Table 6.18c. Dimensional limits of ground floor room for a sample of single-room brick dwellings.

BUILDING HEIGHTS

No. of storeys	Christ's Hospital	Clothworkers'	St. Paul's
1 - 1.5	-	-	1
2 - 2.5	25	85	26
3 - 3.5	36	59	64
4 - 4.5	1	15	8
5 - 5.5	1	1	-
Total:	63	160	99

Table 6.19. Height of buildings in samples from three 17th-century building surveys.

BUILDING HEIGHTS

No. of rooms at g.f.level.	No. of storeys					Unknown	Total
	1-1.5	2-2.5	3-3.5	4-4.5	5-5.5		
1	-	10	14	-	1	9	34
2	-	9	7	-	-	13	29
3	-	4	5	-	-	4	13
4	-	1	6	1	-	-	8
5	-	1	3	-	-	3	7
6	-	-	-	-	-	3	3
7	-	-	-	-	-	1	1
8	-	-	-	-	-	-	-
9	-	-	1	-	-	-	1
10	-	-	-	-	-	1	1
Total:	-	25	36	1	1	34	97

Table 6.20. Height of buildings in relation to house size : Christ's Hospital Plans.

BUILDING HEIGHTS

No. of rooms at g.f.level.	No. of storeys					Unknown	Total
	1-1.5	2-2.5	3-3.5	4-4.5	5-5.5		
1	1	7	21	5	-	-	34
2	-	7	37	2	-	-	46
3	-	4	1	-	-	-	5
4	-	3	2	1	-	-	6
5	-	3	1	-	-	-	4
6	-	-	-	-	-	-	-
7	-	2	1	-	-	-	3
8	-	-	-	-	-	-	-
9	-	-	1	-	-	-	1
Total:	1	26	64	8	-	-	99

Table 6.21. Height of buildings in relation to house size : St. Paul's Parliamentary Survey.

7. Urban Structure and Urban Evolution

7.1 Introduction.

We are now able to return to the central theme of the research : the way buildings were arranged in space. In this chapter, our object will be to identify the principal levels of organisation within the urban fabric, and to extract the underlying rules and constraints which gave rise to the characteristic urban morphology.

In his book "The Sciences of the Artificial", Herbert Simon suggests two distinct ways of describing phenomena (1). The first of these he calls a 'state description'. This essentially specifies an object or arrangement at a point in time; it is a blueprint or a picture, and has no historical dimension. The second method is a 'process description'. This takes the form of a recipe; it is a "means for producing or generating objects having the desired characteristics".

This study has proceeded broadly from a state description to a process description. The seventeenth-century maps and plans which form the bulk of our raw material present, of necessity, a static picture of the urban morphology. They are a horizontal cut, a cross-section, through the evolutionary process. In the case of Ogilby and Morgan, and of the majority of building surveys, this cross-section is in the years following the Great Fire. From a close examination of the surveys, and in particular of Ogilby and Morgan, recurring geometric and topological features have been identified and listed. This information has been used to build up a picture of what we consider to be the main elements that constitute the urban structure. This is the state description. Subsequent to this, we have postulated rules which would generate the configurations discovered. This is the process description.

The chapter will be divided into two parts. The first part will be concerned with the state description of the urban morphology. The second part will deal with the process description. In each case the arguments will be supported by documentary evidence, which has been used to supplement the cartographic sources, and to test the hypotheses.

But, before turning to the main thesis, it is necessary to define with greater precision certain important terms.

Rules The term will refer to the principles which govern the arrangement of buildings in space. Rules are not necessarily explicit: more often than not in historical morphologies, they were taken-for-granted ideas about the way things should be done. But all rules are capable of articulation. They can be expressed as : given condition (A), perform operation (B). It is the rules which generate forms and produce states.

Constraints The term will refer to the various factors which go to limit the range of possibilities of development. They are the 'givens' of any situation. Constraints can be of many different kinds - physical, technological, social, political. We shall be concerned here principally with the limitations on form imposed by topographic features within the town. The term will be used chiefly in this narrower sense.

It follows from these definitions that the first part of the chapter - the state description - will be concerned principally with constraints, while the second part - the process description - will go on to identify rules.

It should be emphasised at this point that the selection of rules has not been an arbitrary one. Nor has the aim been to achieve mathematically the most economical description of the urban morphology. Our prime objective has been to capture the principles which underlay actual historical growth. That is to say, we have sought to achieve a generative procedure which plausibly corresponds to that which obtained in the period under survey. As in the case

of house plans, the analysis will be concerned, not with ontogenesis - the way individual examples grew up - but with phylogenesis - the broad evolutionary sequence of development. It does not, therefore, attempt to reconstruct the incremental growth of particular areas, save to elucidate the general principles of development. In specifying a process description, we shall be seeking to reduce the number of rules to a minimum, and thus to produce the most elegant model; but this will be related in all cases to historical and social criteria rather than purely formal ones.

7.2 Urban Structure

The urban structure of post-Fire London may be divided up firstly into regions or blocks. As in Chapter 5, the term 'block' will be used to describe a built-up area surrounded by streets. A street in this context is a major thoroughfare which forms part of a cyclical network. The term will be applied not only to thoroughfares bearing that name on the Ogilby and Morgan map, but also to lanes, etc., which form part of the main transport network. In this analysis, the block stands at the highest level in the urban scale. At the lowest level is the individual building or unit. A block may be subdivided by secondary routes, which will be called alleys. An alley is a thoroughfare connecting two streets; hence, it also forms part of the cyclical network.

Classification of the transport network is somewhat intuitive owing to the frequent absence of continuity in the main routes through the City centre, and the fact that street width does not relate consistently to the type or volume of traffic. It is not possible to establish a strict hierarchy of transport routes such as Rickaby has observed for part of modern Cambridgeshire.(2). Greater precision will not, therefore, be attempted.

Certain general characteristics of the urban structure have already become clear. Firstly, the great majority of buildings have a rectangular geometry. Secondly, these dwellings along the street edge tend to be more elongated than those deeper within the block. The shape of the perimeter units may now be correlated with plan-form: the most convex units are chiefly of plan-types 2, 3a) and 3b).

Another recurrent feature of the urban pattern is that the street edge is broken by passages, which provide access to the backs of the buildings and to the inner parts of the block. The term passage will be used consistently to refer to any secondary route (other than an alley) which extends into a block, regardless of its appellation on the map. Passages may sometimes link to form part of the cyclical network.

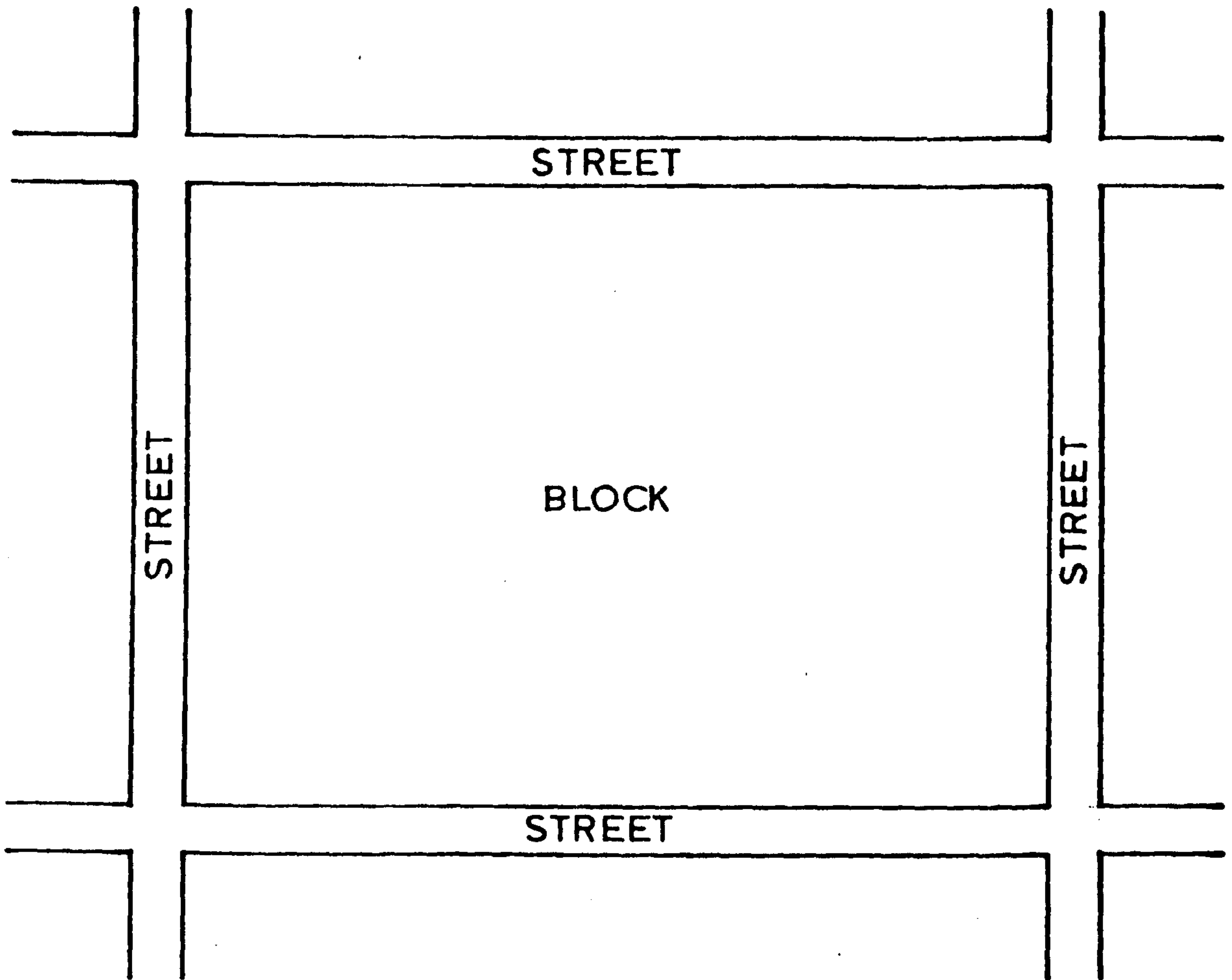


Fig.7.1: Levels of organisation for the urban structure : the block.

In the great majority of blocks the passages are predominantly cul-de-sacs. Moreover, a disproportionate number are found to terminate at a relatively shallow point within the blocks (≤ 125 ft). The pattern of access within blocks is clarified when the map is redrawn with the buildings omitted. Figure 7.2 shows the area to the north

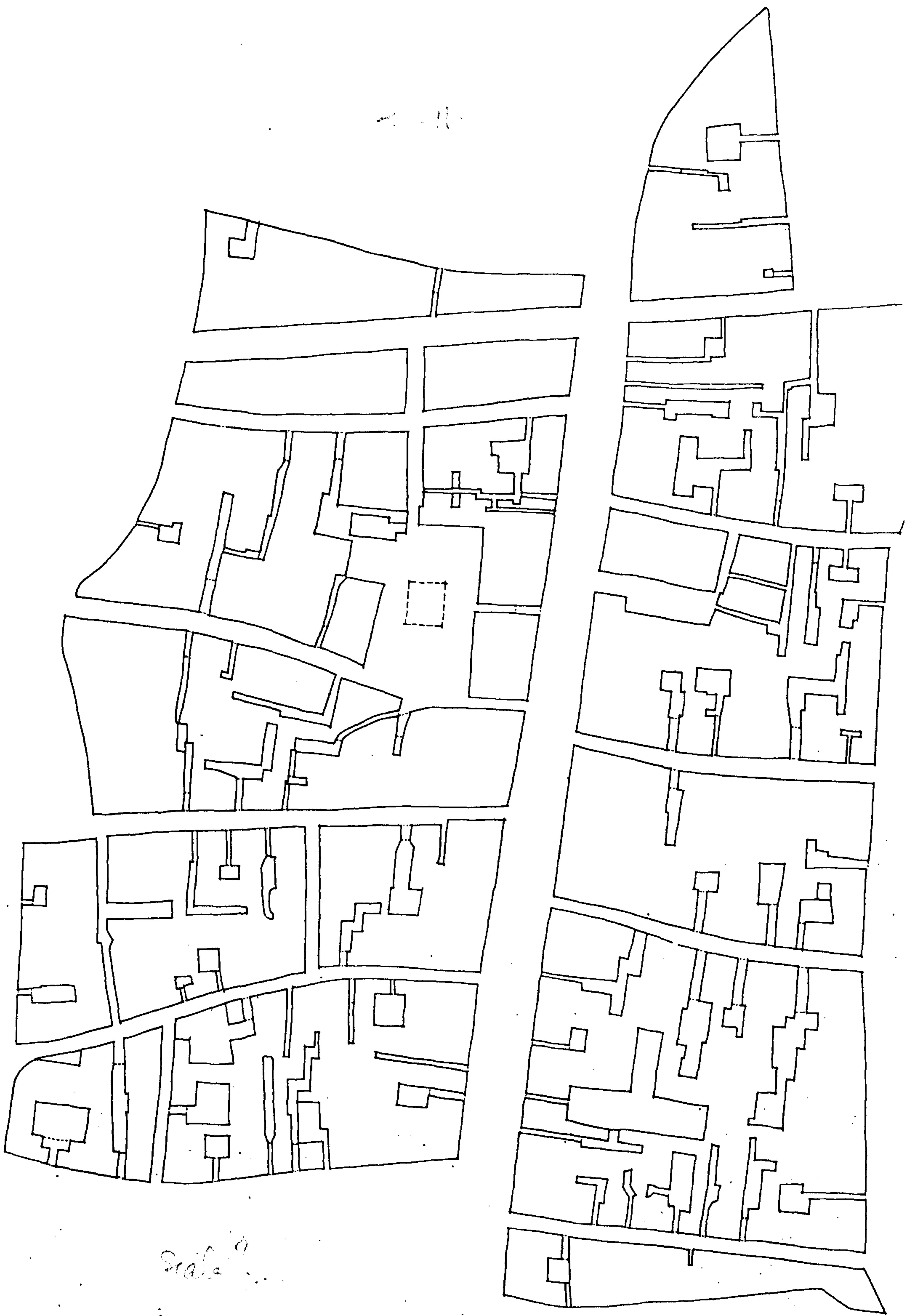


Fig.7.2 : Blocks to the east of St. Paul's redrawn from Ogilby and Morgan with the buildings omitted.

and south of Cheapside drawn in this way. It will be seen that many of the passages fail to break through to their neighbours or to connect up with those coming from the opposite direction even though they are separated by only a very short distance (<20 ft).

The terminal point of the cul-de-sacs is often clearly distinguishable on Ogilby and Morgan by a continuous line running at right angles to the passages, i.e. parallel to the street. The line, which may represent a boundary between rows of buildings or between buildings and open space, can mark the inner limit of a series of passages. The historical reality of these inner boundaries and their influence on building development are illuminated by examination of the relationship between the passages and the ward and parish boundaries.

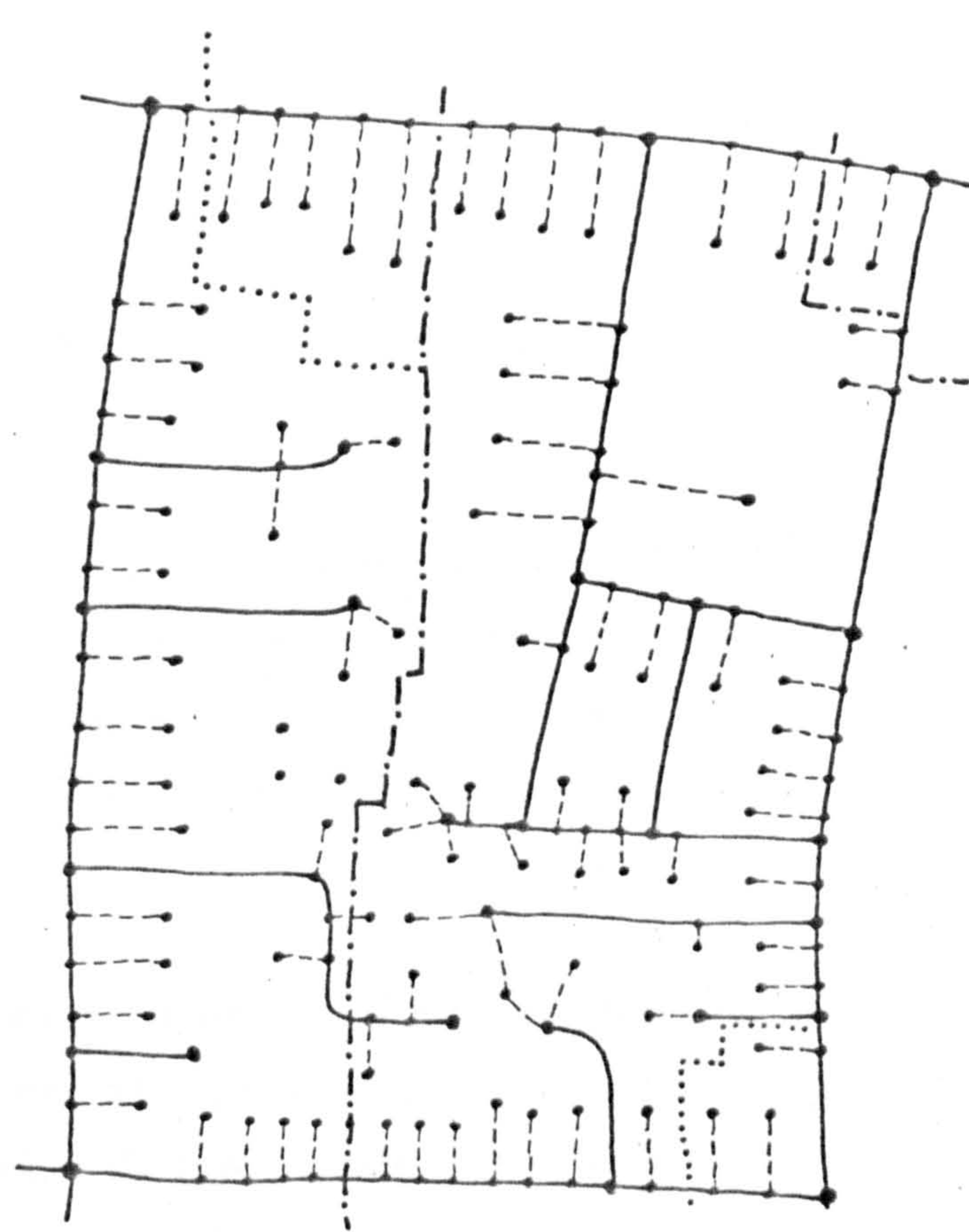
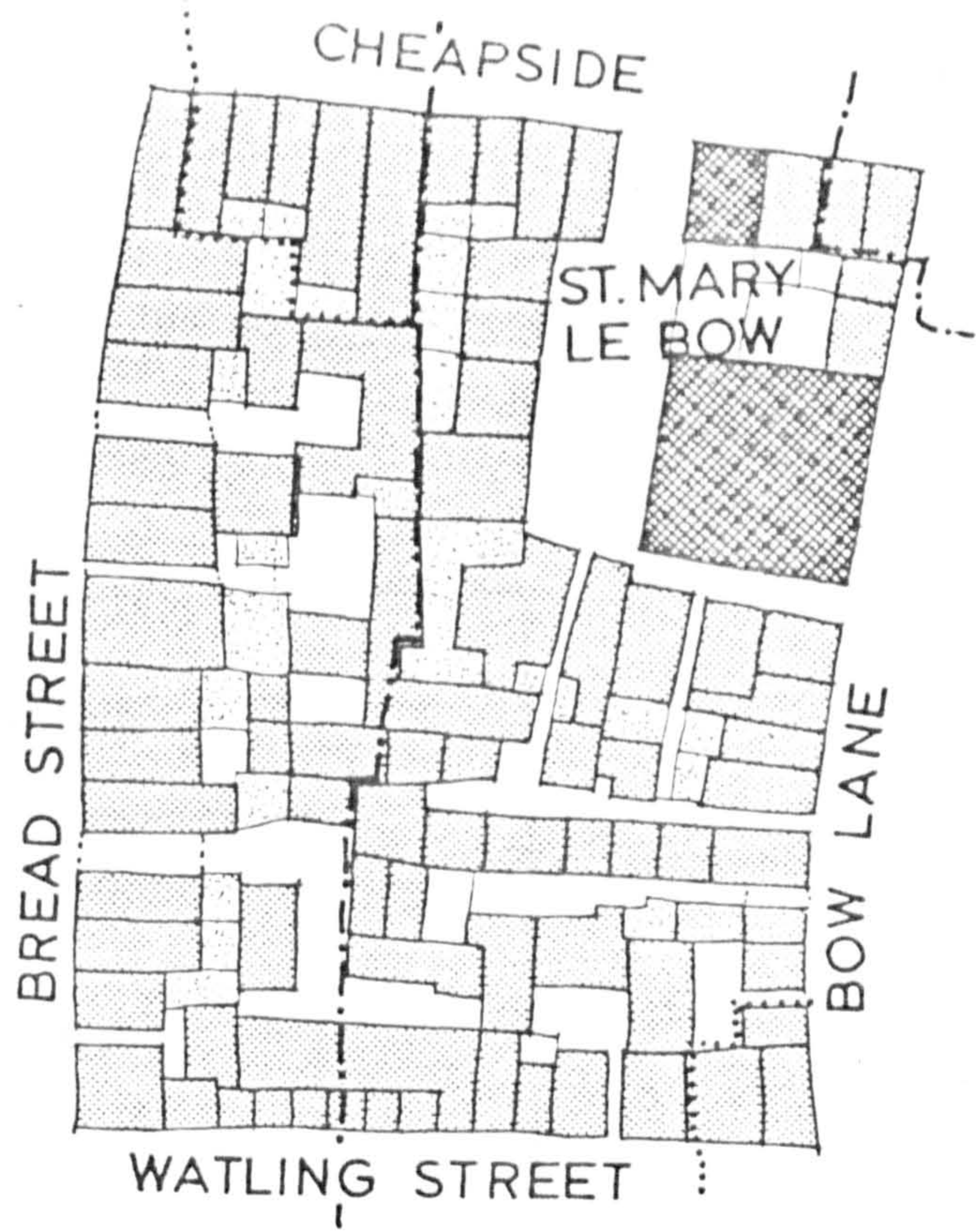
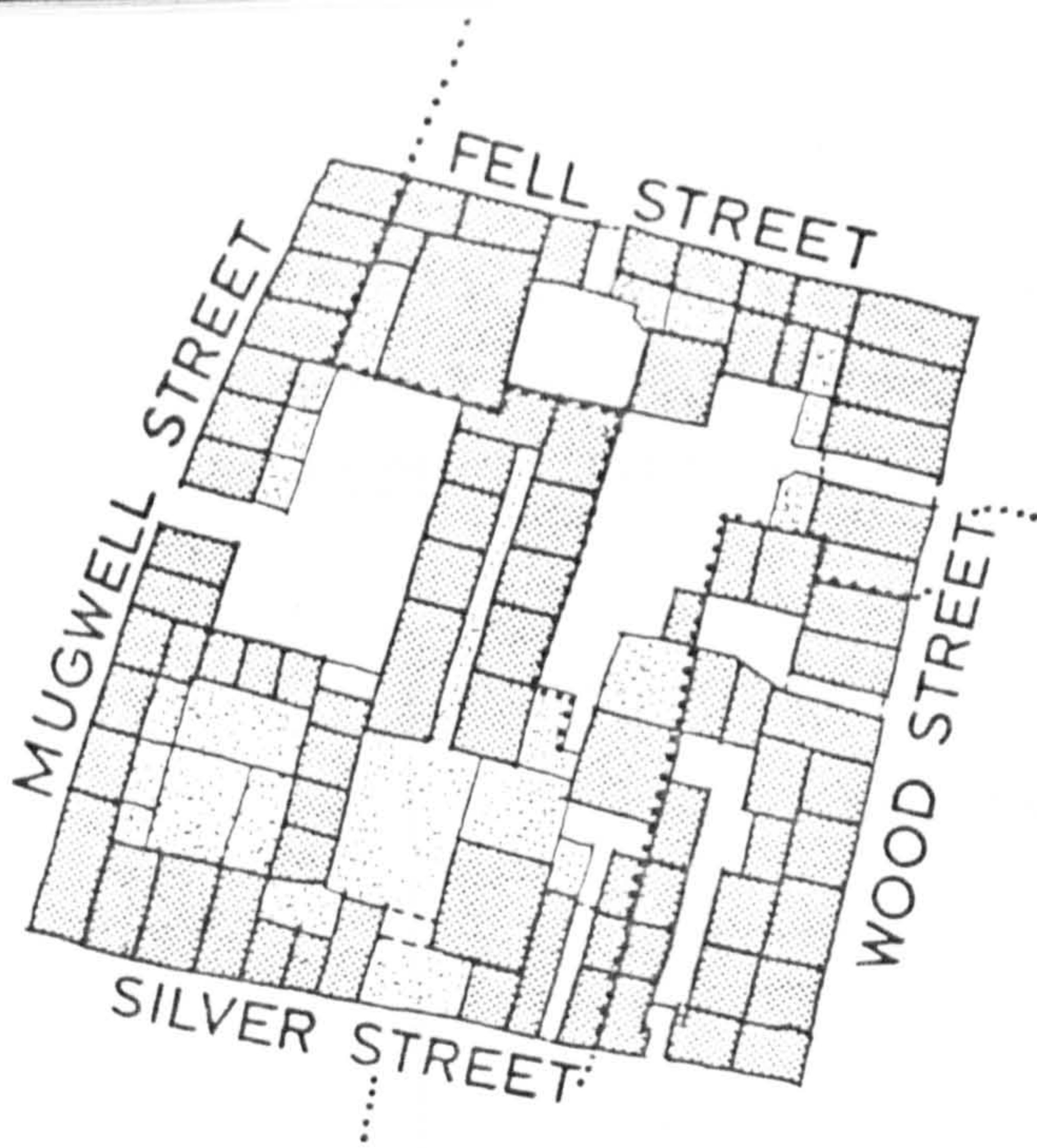
It is now generally accepted by historians that the boundaries of most of the wards were determined originally by the lines of the main streets, some of which in turn were related to the principal gateways of the City. The observation that the four principal cross-streets formed backbones to a series of wards appears first to have been made by W.R.Lethaby, who went on to suggest that "these wards were formed by aggregations of dwellings upon either side of the roads which passed through them, exactly as a high road threads a village" (3). Later authorities have supported the view that the wards generally grew along the line of a main street or centre of trade (4), and were formed from the land on either side that was subservient to it (5). The parishes grew up at a later date. They are smaller in extent than the wards, and the parochial boundaries are independent of the municipal boundaries (6).

This is not the place to enter into the long and complicated history of the topographic divisions of the City. Suffice it to say that a considerable number of the wards have been identified with former divisions, the sokes of the pre-Conquest period (7). One may conclude from this that some of the wards were very ancient. Looking at the boundaries purely from the map evidence, it is found

that the ward and the parish divisions pass to a large extent through the blocks, following an irregular course which generally (though not exclusively) coincides with boundary divisions (building to building or building to open space) within the blocks. If the passages are examined, it will be seen, furthermore, that only a small number of these cross the administrative boundaries. In a sample area extending from London Wall on the north to Thames Street on the south, and from St. Pauls on the west to King Street on the east, 86% of passages (227 out of 273) were found to terminate at the administrative boundaries or at a point within them. This containment of passages by the ward and parish boundaries is particularly evident to the east and west of Wood Street, and on the north side of Cornhill and Leadenhall Street. The relation is illustrated in figure 7.3 by two blocks from the City centre, for each of which a conjectural access pattern has been drawn

The very unequal depth of what are clearly separate edge developments within the same block also points to the existence of some external constraints (i.e. physical limits) on the freedom of growth, as, for example, in the Old Change block, where the western portion is occupied by a cluster of small units, while on the eastern side the Saracen's Head Inn and the Bell Inn extend to a depth of approximately 200 feet.

It is clear, then, that the administrative boundaries (municipal, parochial) were inextricably connected with the development of passages and the groups of buildings associated with these. We would suggest that they were not in themselves deterministic but that they coincided with property boundaries, and it was the latter which acted as an inner limit to the extension of passages.



PLANS

- WARD BOUNDARIES
- PARISH BOUNDARIES

GRAPHS

- ACCESS ROUTES
- - -●- - - ACCESS TO BUILDINGS (CONJECTURAL).

Fig. 7.3: Relation between passages and administrative boundaries for two blocks in the City

On the basis of this topographic analysis, we would therefore propose a two-fold division of the block into a perimeter zone and an interior zone, viz.

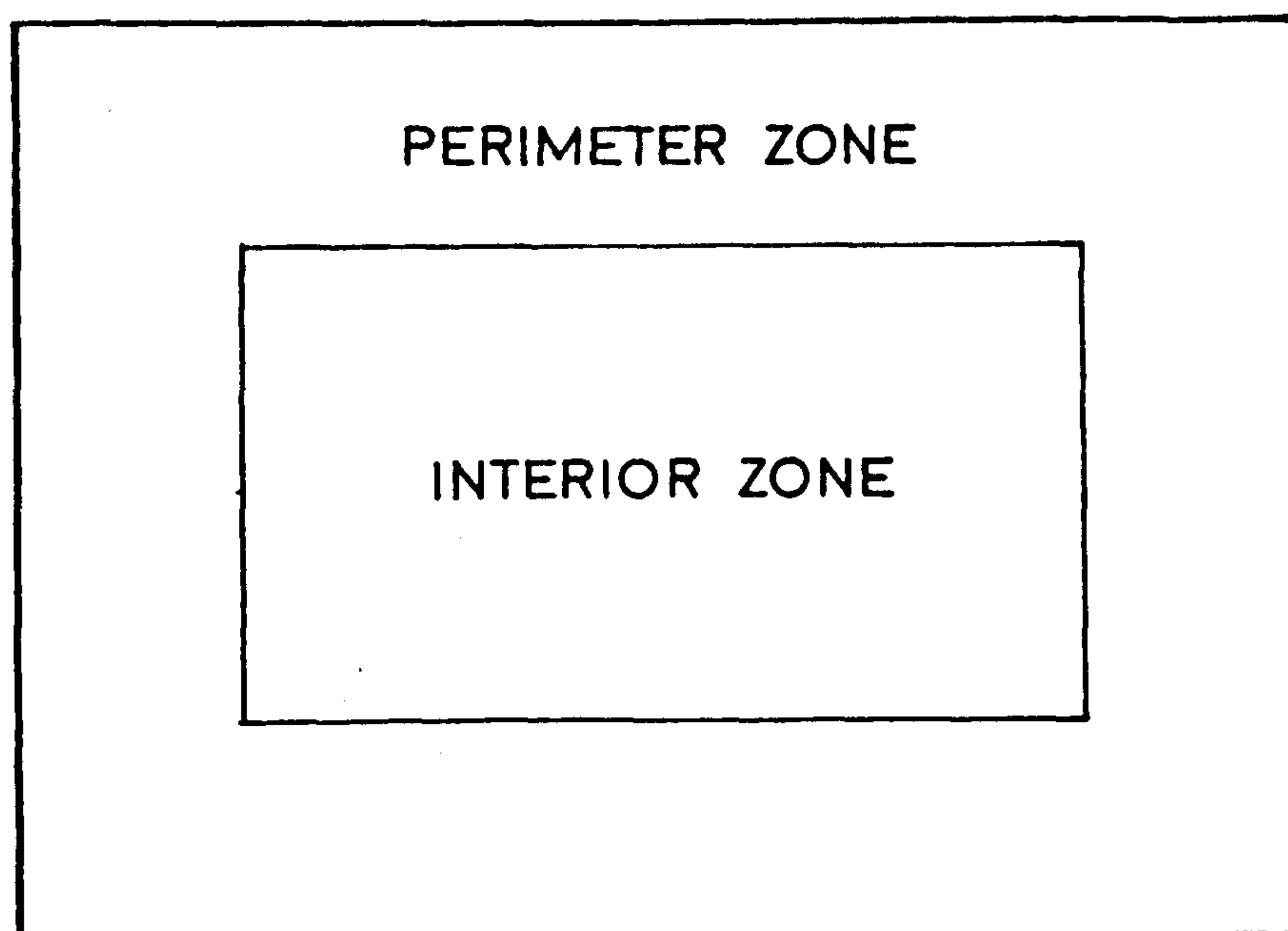


Fig. 7.4: Levels of organisation for the urban structure : the zones.

The division does not apply to all blocks. Many of those in the City centre are too small to have an interior and consist only of perimeter zones. But among larger blocks (>350 feet) such a division would appear to be normal. The largest blocks are all to be found outside the City walls.

Perimeter zones appear to range widely in depth, from perhaps 20 feet to 200 feet and above. However, the great majority would seem to lie in the narrower range of 50 to 150 feet. Measurements taken from a sample area in the City centre (Ogilby and Morgan) would suggest that the majority of these lay between 50 and 100 feet (see figure 7.5).

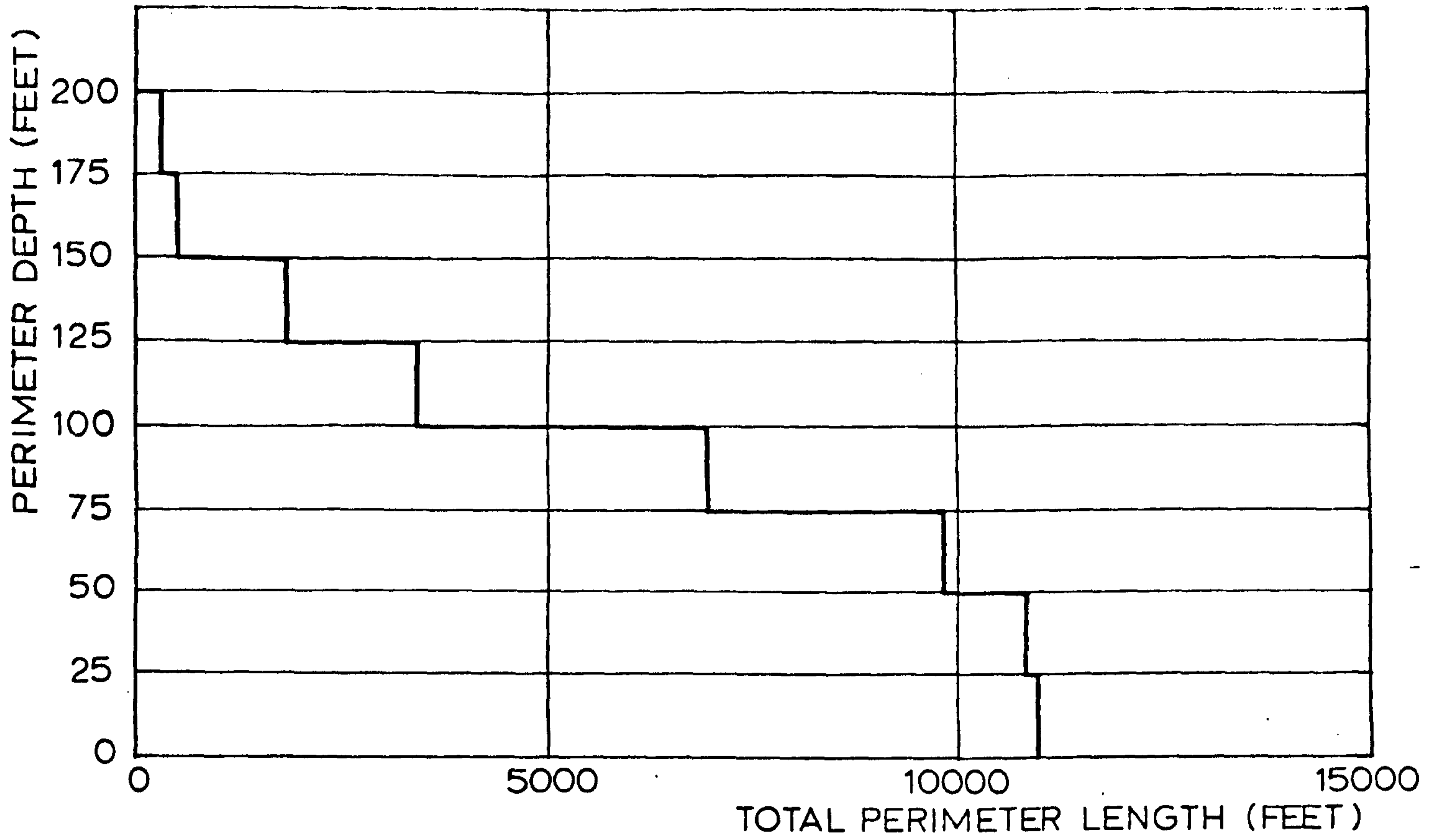


Fig. 7.5 : Depth of Perimeter Zone. Figures based on a conjectural reconstruction of property boundaries for a sample of blocks in the City Centre. Corner regions omitted.

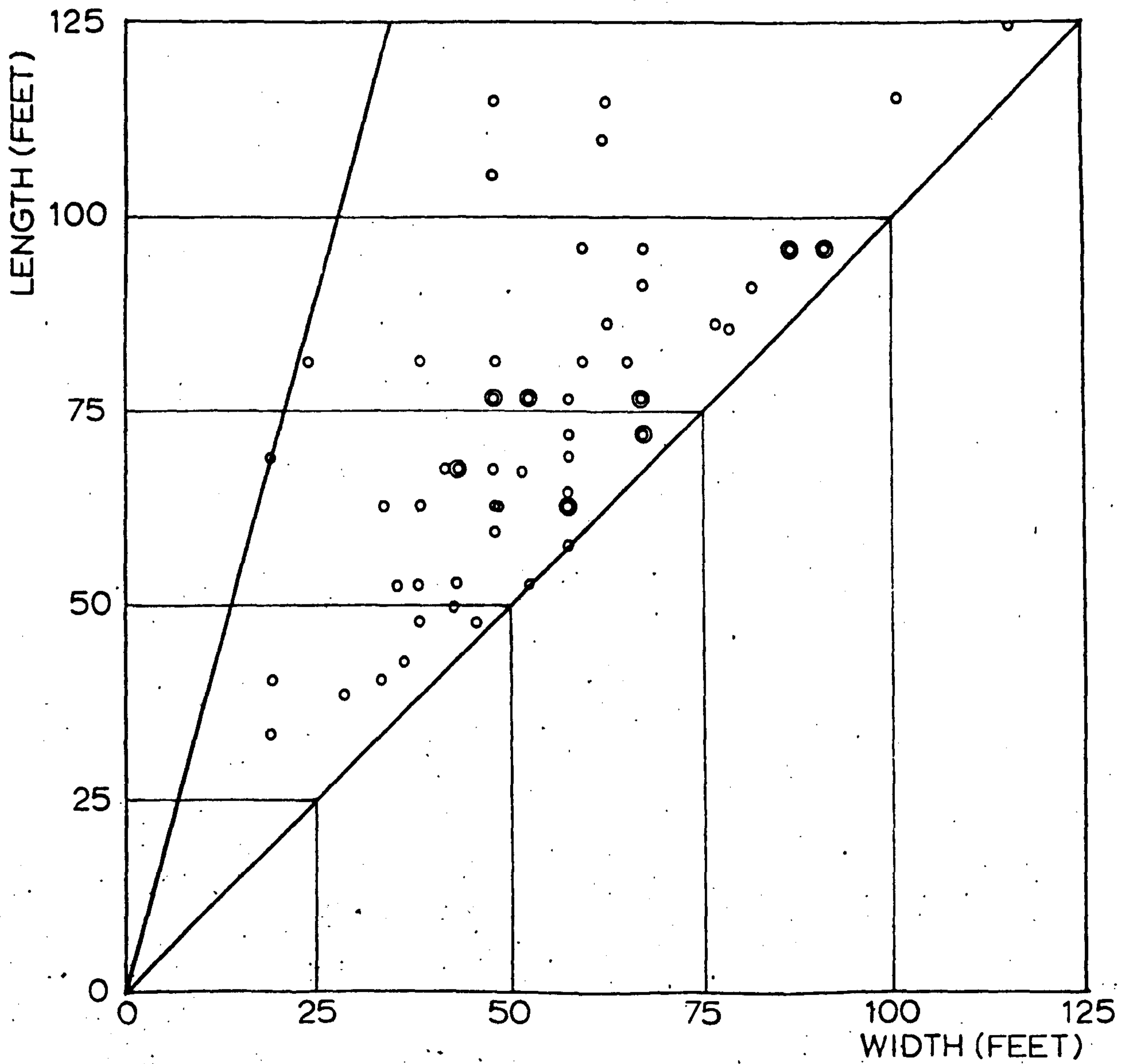


Fig.7.6: Corner Regions : length plotted against width (173)

7.2.1 The Perimeter Zone

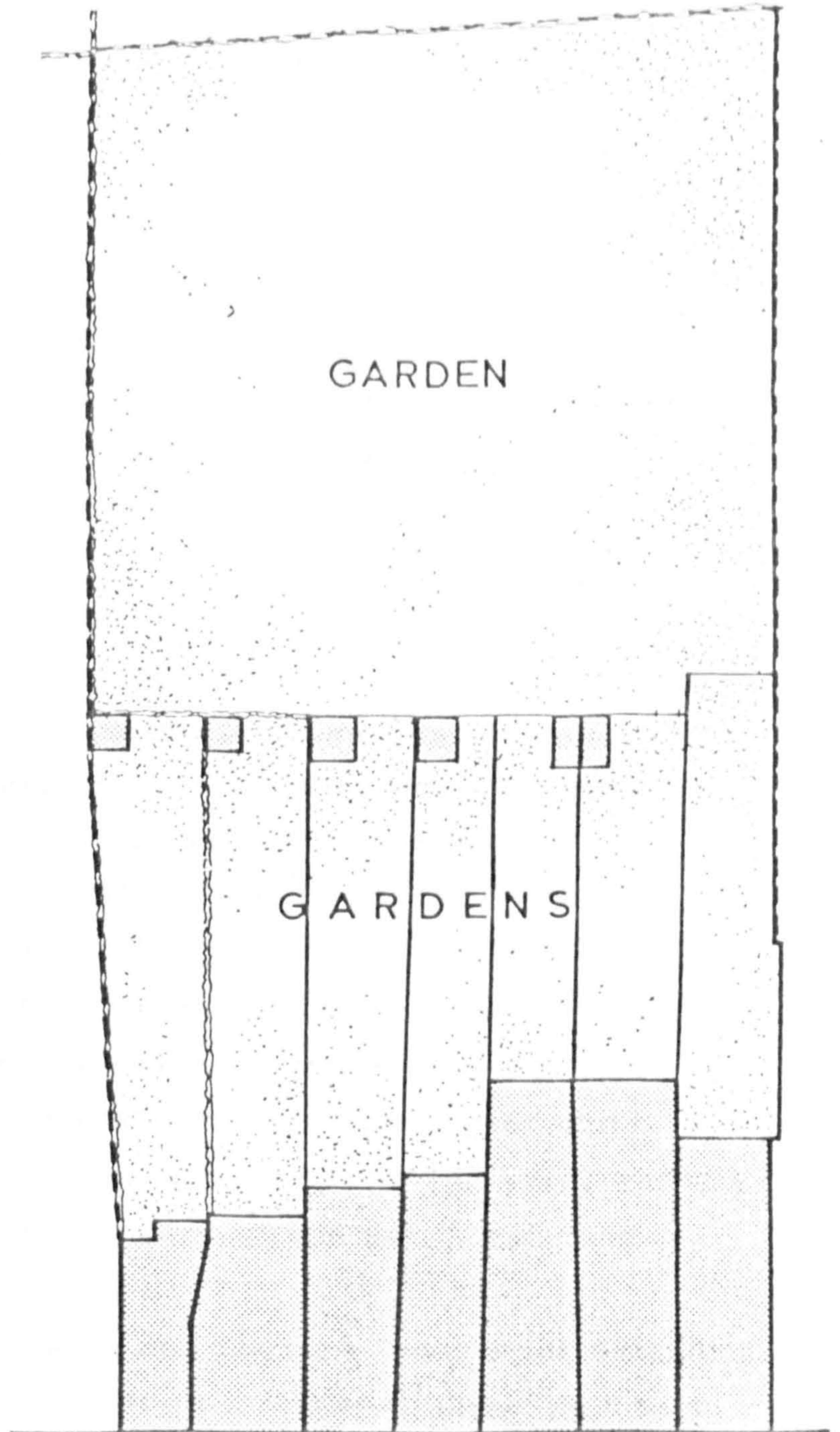
In some cases the perimeter zone represents the depth of the perimeter plots. That is to say, the zone is divided up into contiguous plots, each of which runs from the street face to the inner boundary. The narrow street frontage of each plot is in general wholly occupied by building, while the back part forms a yard or a garden. The yards and gardens may be built up to a varying extent with workshops, warehouses and outbuildings. The ratio of plot width to length can be very high : 1:17 is the maximum recorded (8). In most cases, however, the ratio is \leq 1:6. Examples of such arrays of contiguous plots are illustrated in figure 7.7.

This arrangement conforms to the characteristic picture of mediaeval towns. The long strip-shaped plots were a feature of most sizeable towns in this country, as indeed in western Europe as a whole, and were known as burgages. These represented originally the holdings of the enfranchised members of a mediaeval borough, the burgesses. Ownership of land was fundamental to citizenship in the mediaeval town ; burgesses were deemed to be personally free, and the holding of land by 'burgage tenure' was "a fully-free title which approached very closely the concept of full untrammelled ownership represented by the Roman 'proprietas'" (9). Land and status, together with fiscal autonomy, were extra-feudal privileges, which were in most cases "defined and assembled in charters of liberties granted to (the towns) by the Kings or the great barons on whose land they happened to be situated". "The charter and its liberties embodied the essential pre-conditions of urban development" (10).



0 50 100 150
feet

Redrawn from
Ogilby and Morgan, 1676



0 10 20 30 40 50
feet

Houses in Blackman Street, Southwark
from Christ's Hospital Evidence Book
(p.5), c.1612.

Fig. 7.7. Contiguous strip developments in seventeenth-century London.

The amount of land that was required of any householder was measured originally according to the custom of the borough (11). But with the growth of industry and commerce, and the pressures of population which resulted from the influx of rural immigrants, burgages became progressively sub-divided. It was this process, well-documented in the historical literature, which led to the extremely narrow proportions of some holdings by the late Middle Ages.(12). Conzen, in his study of Newcastle-upon-Tyne, has given considerable attention to the effect of the mediaeval 'burgage series' on the subsequent morphological development of the city centre (13).

But while rows of strip holdings are in evidence in the City of London in the late seventeenth century, they form only a small part of the total development. They are by no means the characteristic feature of the perimeter zones. It is much more usual for perimeter buildings to have only a short yard or garden at the back or, alternatively, to be without any attached open space. In these cases the passages, which occur at frequent but irregular intervals, normally open out behind the perimeter units to form yards or courts of varying width. Around these yards are grouped clusters of units, generally smaller and squarer in shape than the perimeter units. The units may be arranged on one or more sides of the yard, and are bounded internally by the inner boundary of the perimeter zone.

The comparative width of the yards and courts - sometimes extending across a whole series of perimeter plots - makes it clear that back development was not constrained by a pattern of burgage strips. It suggests, rather, that the back buildings were laid out with reference to subdivisions which were greater in width than the individual plot. On Ogilby and Morgan the left-hand and right-hand boundaries of the yard are frequently adumbrated, in the same way as the back boundaries, by continuous lines. The lines in this case run from the front to the back of the perimeter zone. They may represent an inward extension of a party wall between perimeter buildings, but do not necessarily coincide with these divisions. And, as with the back of the perimeter zone, the lines may represent

boundaries between rows of buildings or between buildings and open space.

On the basis of the evidence, it is therefore possible to subdivide, albeit tentatively, considerable lengths of the perimeter zone into sub-blocks, each of which represents a bounded area served by a common yard or back space. These sub-blocks we shall call perimeter segments. One can conceive the perimeter zone as constituted, in whole or in part, of contiguous perimeter segments.

The above hypothesis is supported by the large-scale plans executed for the livery companies and other institutional landowners, which show consolidated blocks of property under single ownership. These large holdings generally have a passage from the street, running between perimeter units, and leading to a yard and associated buildings at the back. They are thus precisely of the form described. The large-scale plans give a much more reliable and exact measure of the extent of property holdings than can be obtained from inspection of the Ogilby and Morgan map. The sites recorded are, however, too few and too scattered to permit reconstruction of adjoining properties of the perimeter zones, save in a small number of cases (14). The information derived from these sources has been used, therefore, mostly for corroboration rather than analysis. A number of examples of perimeter property holdings are illustrated in figure 7.10.

Given that perimeter segments were an integral part of the post-Fire plan of the City, the question which immediately arises is whether these had any significance in London's historical development before the Great Fire. Clearly, neither Ogilby and Morgan nor the post-Fire surveys give us any reason to assume that the divisions existed in the City of 1666. The historical aspect of the perimeter segments will be taken up below. For the present, we shall confine ourselves to the morphological characteristics manifested in the post-Fire sources.

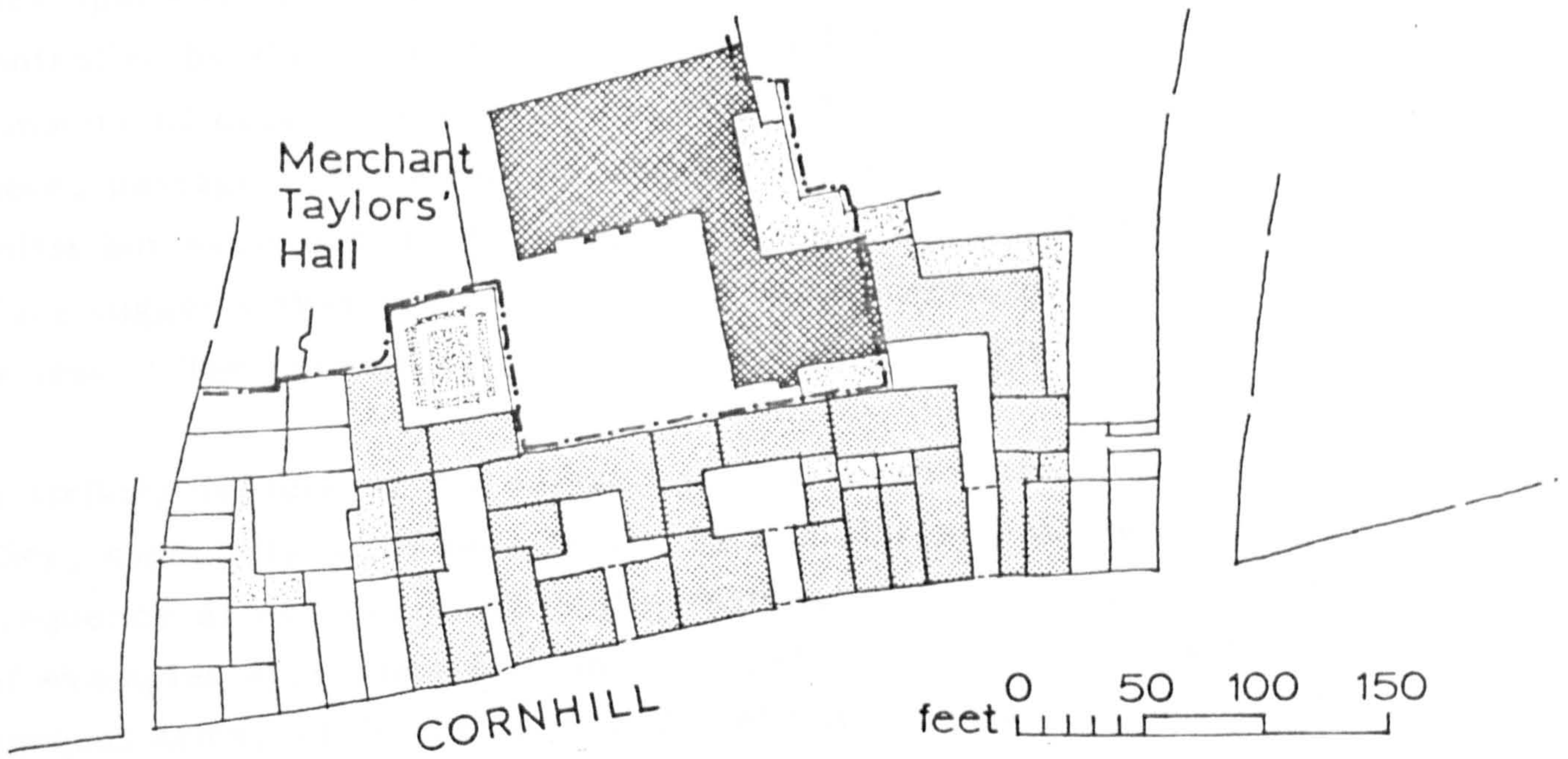


Fig.7.8: Perimeter development on the north side of Cornhill (redrawn from Ogilby and Morgan).

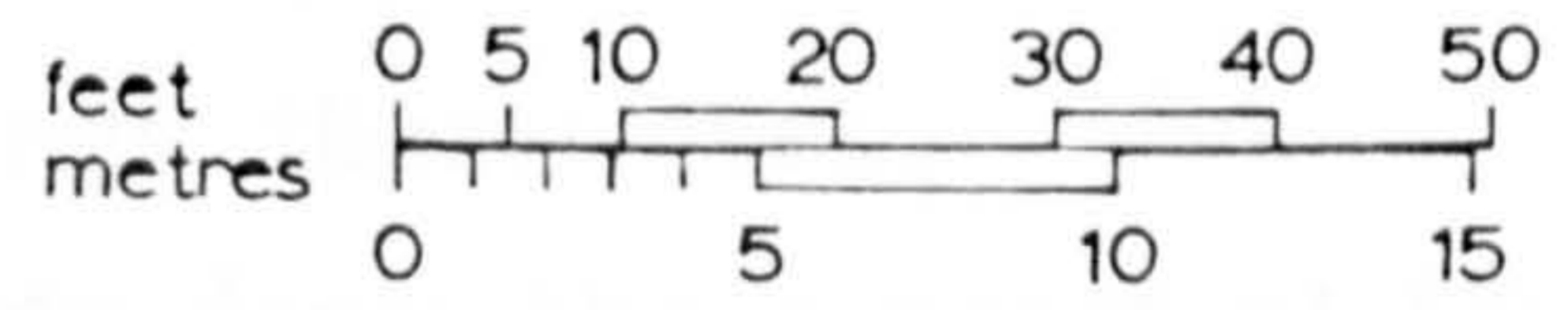
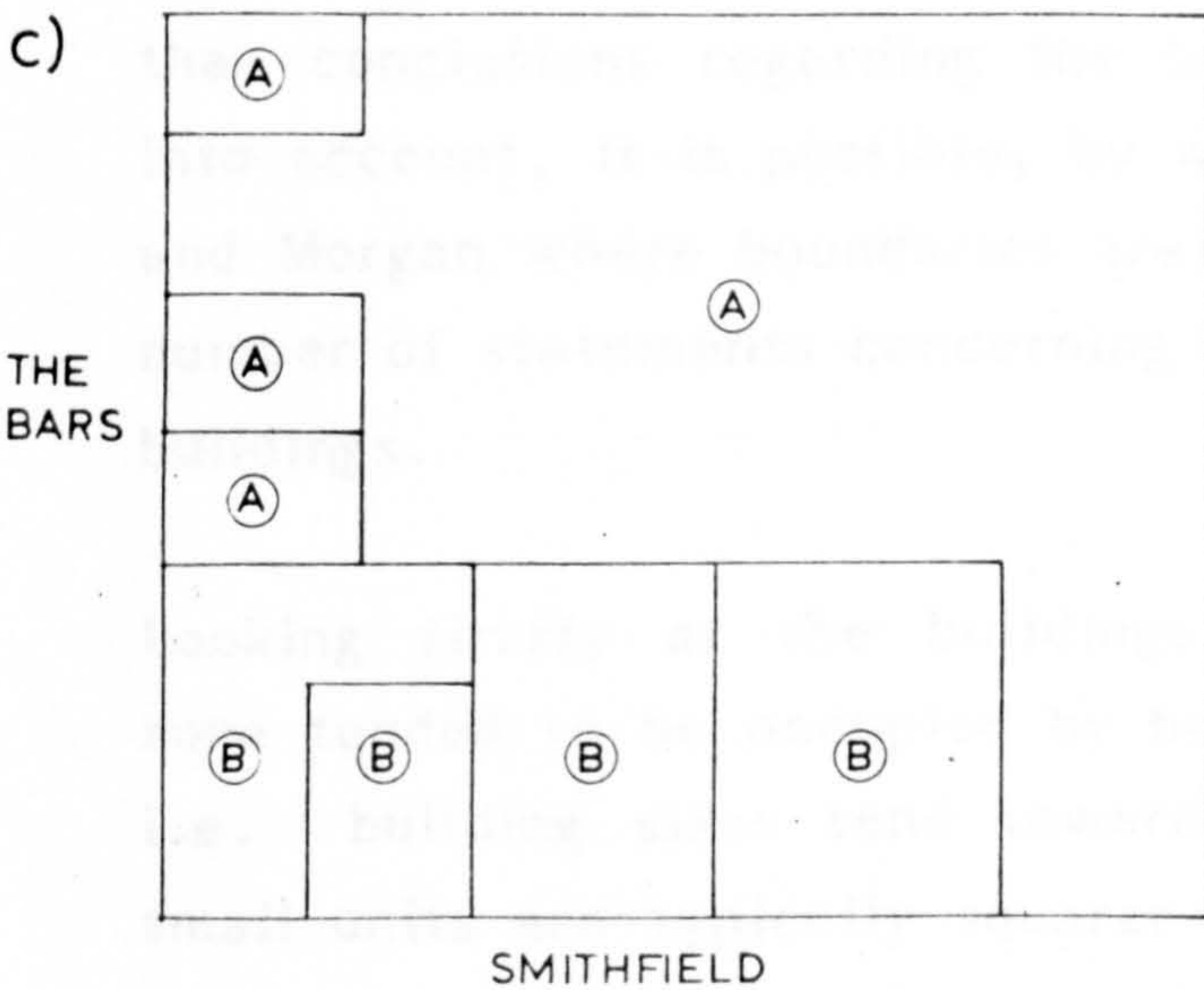
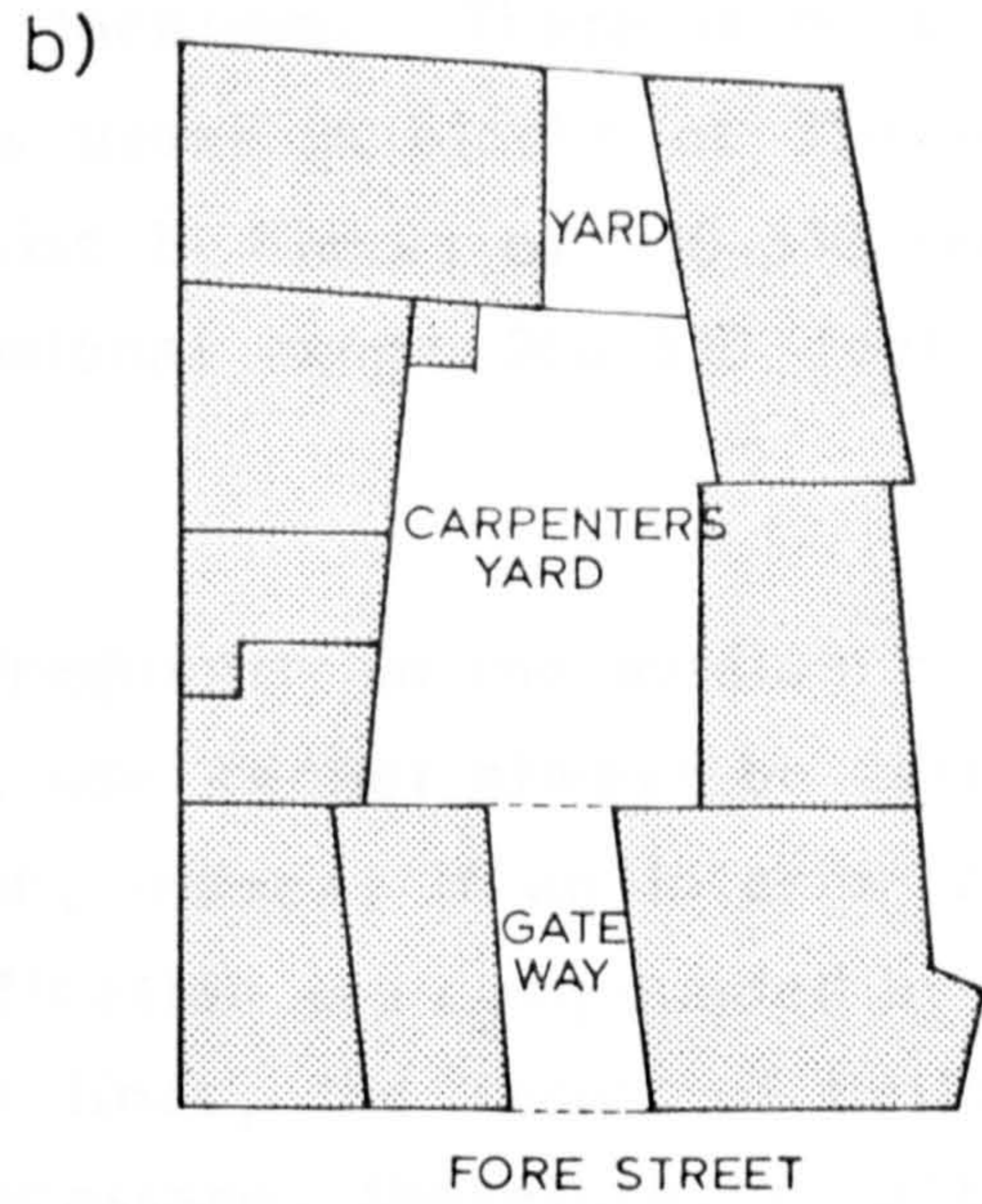
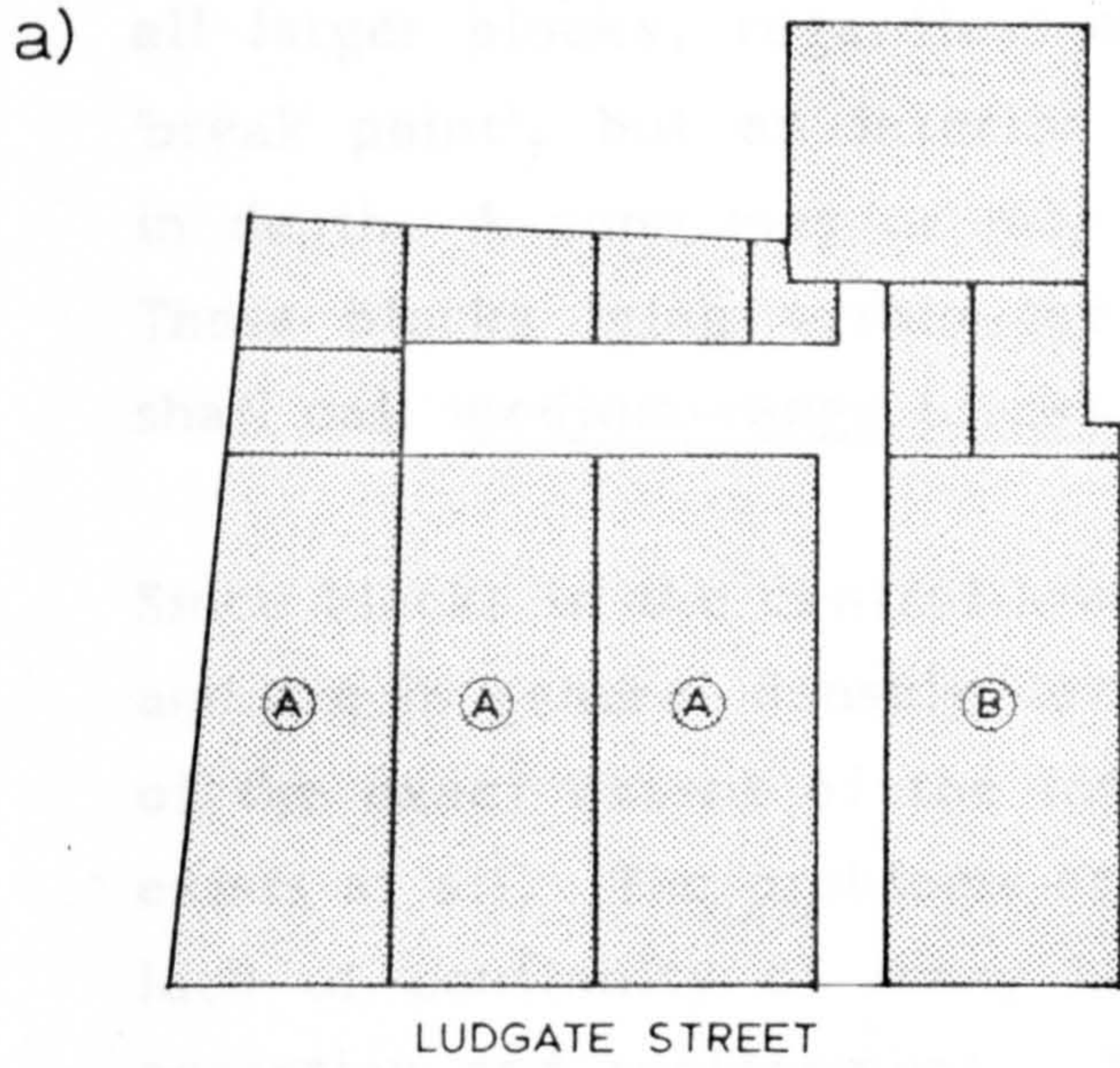
PERIMETER SEGMENTS					

Fig.7.9 : Levels of organisation for the urban structure : perimeter segments.

In width the segments appear to range from 15 feet to 100 feet or more, the majority lying between 20 feet and 75 feet. Access to the back space is normally by way of a single passage, held in common or controlled by the owner/tenant of the back tenancy. In a small minority of cases, however, a segment may contain two, or perhaps more, passages. The street frontage has anything from 1 to 12 units; but examination of Ogilby and Morgan and the large-scale plans suggests that the vast majority of segments contained 5 units or less. The passage can occur in various positions.

A striking feature of the passage-yard arrangements throughout the City, especially when seen on Ogilby and Morgan, is the relative frequency of asymmetrical configurations. A disproportionate number of examples approximate to an 'L-shape' or to a 'T-shape' with unequal arms, while the true 'T-shape' with the yard symmetrical about the passage, is relatively uncommon. The nature of the geometry would appear to offer sufficient explanation for this. A passage must always run between perimeter units. Hence, in a segment with x no. perimeter buildings, there are $x+1$ possible positions for the passage. *Ceteris paribus*, a centrally placed passage is much less probable than one to either side. In a segment with 2 perimeter units, for example, there is a 2:1 probability that an 'L-shape' would result. In a segment with an odd number of perimeter units, there is nil probability of a symmetrical arrangement. While historical factors may have influenced the choice of access position, the general frequency of yard configurations would appear to correspond closely to their statistical probability. This will be examined in more detail in Chapter 8.

A further point of note is that a segment is not necessarily completely insulated from the adjoining areas. The back space may be connected by way of additional passages to the interior zone or to the neighbouring perimeter segments. The passage network can thus be continuous through successive segments.



- a) From the Merchant Taylors' Plan Book, 1680
b) From the City Lands and Bridge House Properties (II.11), Early 18th C.
c) From the Drapers' Plan Book, 1698

Ⓐ, Ⓑ, etc. - separate tenancies

Fig.7.10 : Examples of perimeter property holdings in the City.

7.2.2. The Interior Zone

It has already been observed that a great many blocks within the City walls do not have a true interior zone, owing to their small size. Nevertheless, such a zone would appear to be a normal part of all larger blocks, regardless of their location. There is no sharp 'break point', but an interior zone is usual in blocks of 350 feet in depth. A zone may or may not exist in blocks of 200-350 feet. Those blocks lying within the dimensional range 200-350 feet we shall call medium-range blocks .

Since blocks in the central area fall frequently in the medium range and are in general densely developed, one cannot always be certain of the exact extent of the interior or, indeed, if an interior zone exists at all. The problems of identification are compounded by the lack of continuity of many boundary lines, the result of building accretion and replacement. It is necessary, therefore, to attach reservations to all of the observations which relate to interior divisions, where these are based on visual inspection alone. The inferences will necessarily be much more open to doubt and revision than conclusions regarding the buildings themselves. Taking this into account, it is possible, by working from those parts of Ogilby and Morgan where boundaries are most clearly expressed, to make a number of statements concerning both the interior divisions and the buildings.

Looking firstly at the buildings, one observes that the interior zone tended to be occupied by both the largest and smallest units, i.e. building sizes tend towards the extremes. Both large and small units are typically squarer than those on the perimeter. This characteristic has already been noted by reference to the Old Change block, the graphs for which (figure ^{p. 23} 5.2) showed the interior units clustering around the 45 degree line (1:1 ratio), while those on the perimeter are grouped between 65 degrees and 70 degrees (approx. 1:2.5 ratio). In that case, however, all the internal units belong, properly speaking, to the perimeter zone, since the block has no interior zone. The shape property appears, therefore, to be common

to those units located away from the street ; it is not restricted to the interior zone.

At the top end of the scale in size are the company halls and the houses of wealthy citizens. These are reached by passages from the street, and frequently have extensive gardens within the interior zone. Examples are the Grocers' Hall (O & M., B.53, 7.12) and the Leathersellers' Hall (6.16). Halls and gardens are normally adjacent but may occasionally be separate. Thus, the Drapers' Hall was located along the perimeter of the Coleman Street-Broad Street block, facing Throgmorton Street, while the large Company Garden (approx. 225 ft. sq.), with its maze, its bowling alley and dicing house, was in the interior zone (15). The largest units are between 100 and 200 feet on side.

The smallest units, by contrast, lie chiefly in the range 10-20 feet on side. This is a very large class of buildings, and the examples are remarkably uniform. Units smaller than 10 feet are rare. Those over 20 feet are more common, but are generally in the minority. These tiny units were plainly dwellings, with one room per floor, probably no more than two storeys in height. They occur mostly in rows rather than singly, and are usually without either yard or garden. It is clear that the polarity of size reflects a social polarity, the interior providing not only a home for the wealthy, but also a refuge for the poorest social classes.

From examination of the boundaries of both the great halls and houses, and the groups of small units, it is apparent that the interior zone was developed with reference to subdivisions comparable with those on the perimeter. For many of the blocks in the City centre, it is unfortunately impossible to reconstruct these subdivisions adequately, for the reasons given above. But an appreciation of the original (or earlier) state of the interior zones can be gained by looking at those blocks, in the suburbs and elsewhere, which were still only partially developed in post-Fire London.

One instructive example is the very large block extending between Coleman Street and Broad Street. Although this lies in the heart of the City, it appears to have remained sparsely developed until relatively late in the mediaeval period, perhaps because of the low-lying and marshy nature of the ground (16). Its central location makes it especially pertinent. It may be considered unrepresentative in respect of its physical size, and perhaps also its social composition. When eventually developed, the block became the residence of some of the most distinguished members of society : wealthy merchants, and gentlemen of town and country (17). Many substantial houses were erected, as well as company halls, and the interior zone used for the ample gardens which were the normal accompaniment of these buildings. Since garden size was approximately related to social status, it is possible that the average size of the original subdivisions was larger than usual.

The Elizabethan copperplate map, which dates probably from the late 1550's, shows building development still confined largely to the perimeter of the block, particularly in the western half, and the interior subdivided into a small number of very large gardens (perhaps 200 to 300 feet long), separated from one another by hedges and walls. The Drapers' Garden is easily recognised among these. By the time of Ogilby and Morgan, building had clearly spread throughout most of the block. Many internal gardens had been preserved, however, and are clearly delineated on the plan. These range in size from 40 x 20 to 250 x 225 feet. But those at the upper end of the scale are exceptional cases. The majority now lie in the range 40 - 125 feet in length, a figure which suggests that some fragmentation had taken place.

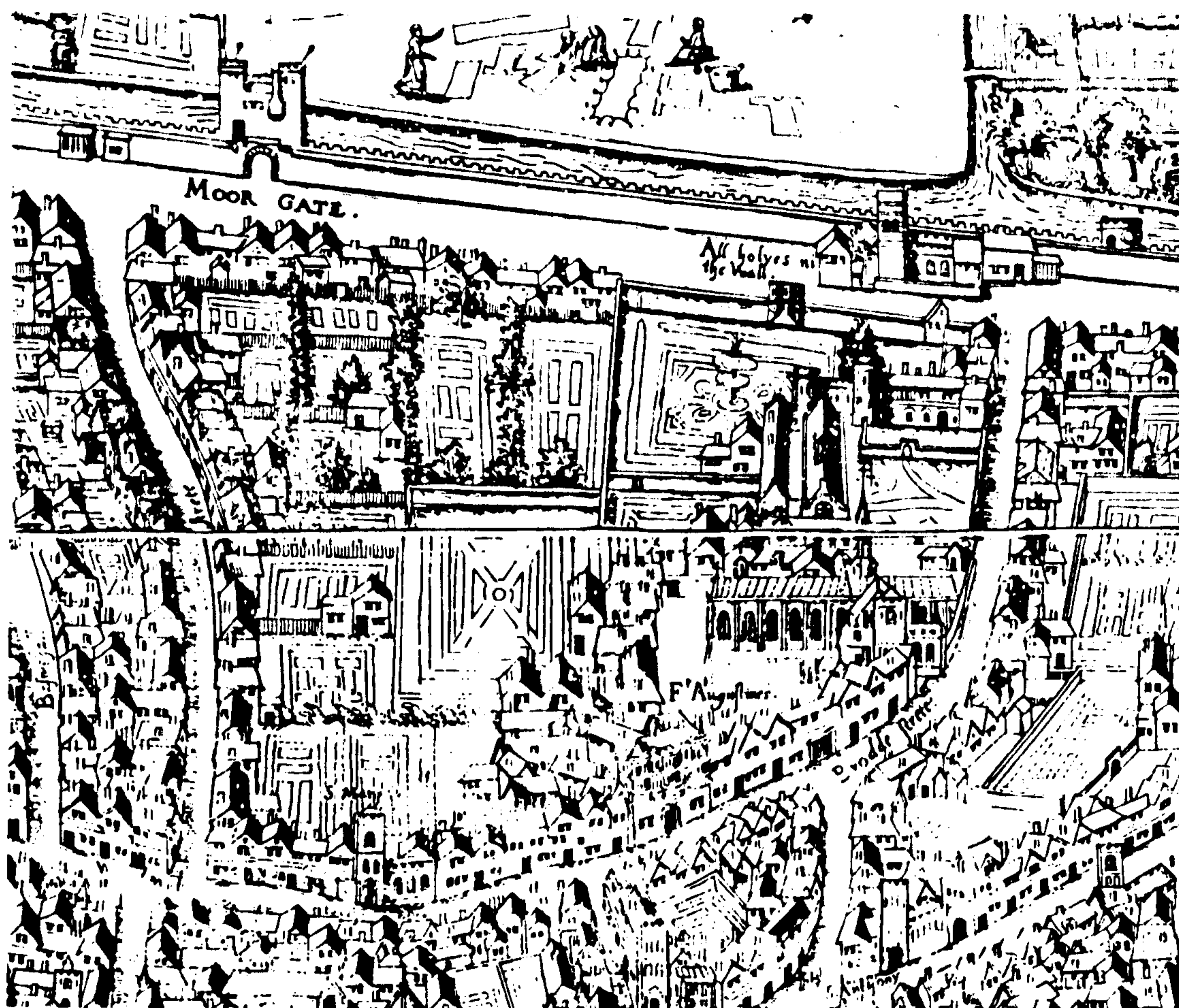


Fig.7.11: The block between Coleman Street and Broad Street as depicted on the 'copperplate' map.

Much more evidence is available if we turn to the areas outside the City walls. But caution needs to be exercised in generalising from this for several reasons. In the first place, the great majority of blocks are very much larger than those in the City centre (some of these exceeding 1000 feet in length). Secondly, the inhabitants of the suburbs were to an overwhelming extent people at the opposite end of the social scale from the residents of Coleman Street : the labouring poor and 'foreigners' who, excluded from the privileged membership of the guilds and City companies, put up houses and practised their trades where they were immune from the jurisdiction of the City authorities . Large houses were therefore few, and small ones numerous. More importantly, the land-use and mode of development in these areas may have differed considerably from those within the City walls. The eastern part of Spitalfields, for

example, was open pasture land, and remained so until the latter part of the seventeenth century, when the streets were laid out and developed by speculative builders (18). In other places, the land was divided into very large fields (e.g. Goodman's fields), and the new streets followed the line of the field's perimeter (19). It is unlikely that the intramural areas were ever given over to pasture in this way, or that the land was parcelled on such a large scale.

More valuable for comparative purposes than the eastern suburbs are those immediately to the north of the City wall. The blocks to the west of Moorfields had a much longer history than those of east London : they were already well-developed at the turn of the century and, lying outside the area of the Great Fire, their development during the seventeenth century was a continuous one (20). Examination of the block between Grub Street and White Cross Street (3.11,4.11,) reveals a partly developed interior zone, composed of subdivisions which may be either yards or gardens. While the gardens may be completely bounded, the yards are always shown with passage access. Building development is mostly in the form of small units, arranged in rows around the edges of both yards and gardens. It is clear from this that the interior gardens were progressively colonised or encroached upon, that development was intimately associated with passage access, and that the gardens were transformed into yards as the development progressed.

This mode of development was obviously not peculiar to London. Early map-views of other cities in Britain show a similar pattern : the blocks are comprehensively parcelled into gardens, and buildings, where they exist, are located along the garden boundaries. Fig. 7.12 shows a part of Edinburgh as it is depicted in the 'Civitates Orbis Terrarum'.

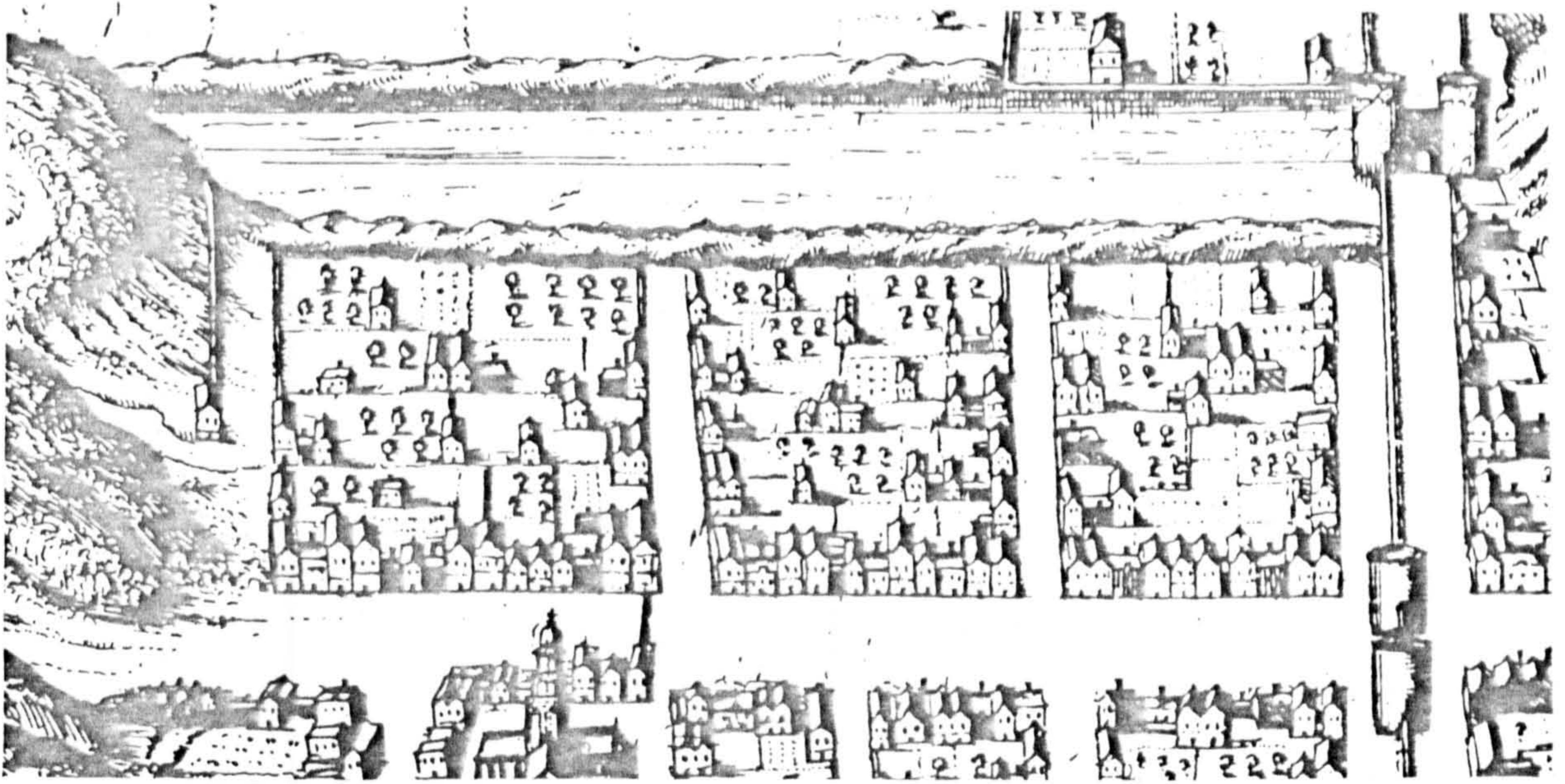


Fig. 7.12. Subdivision of blocks in a part of Edinburgh as shown in 'Civitates Orbis Terrarum'. After a woodcut view in Raphael Holinshed's 'Chronicle', 1574.

Measurements were taken of a random sample of interior gardens (either undeveloped or partly developed) in the northern suburbs, and the results are summarised in figure 7.13. It will be seen that the great majority are between 50 and 100 feet in length, and between 30 and 70 feet in width. Areas range approximately from 1500 to 7000 ft². It is not clear whether this range, which is considerably smaller than that for the Coleman Street block, results from fragmentation of formerly large holdings, or whether it represents the original state of the gardens. One suspects that both were true, i.e. that interior gardens in these areas were predominantly smaller and more uniform than those in Coleman Street, but that larger gardens also existed and were broken down to a more convenient size. In either case, these figures would seem to give a

more realistic indication of the effective constraints on building development than the overall dimensions of the larger gardens.

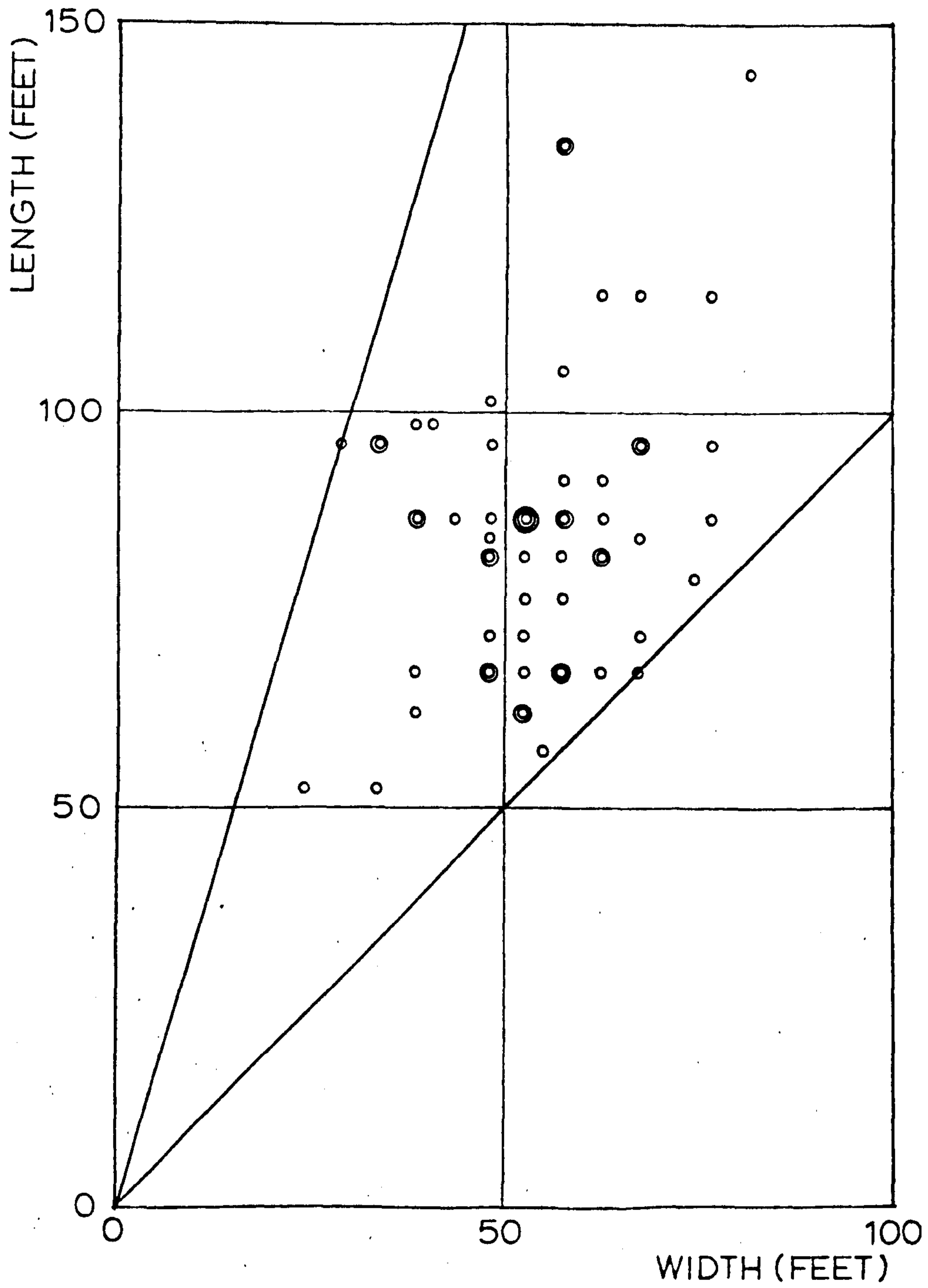


Fig.7.13 : Length plotted against width for a sample of interior gardens in the northern suburbs.

It is not necessary for our present purposes to attempt a detailed reconstruction of any of the interior zones. The main points seem clear : buildings within the interior zones were set out in relation to land divisions at a lower level of organisation than the zone as a whole ; these divisions resemble the segments of the perimeter zone. We shall henceforth refer to the divisions as interior segments . Our model of a City block might thus appear finally as follows :

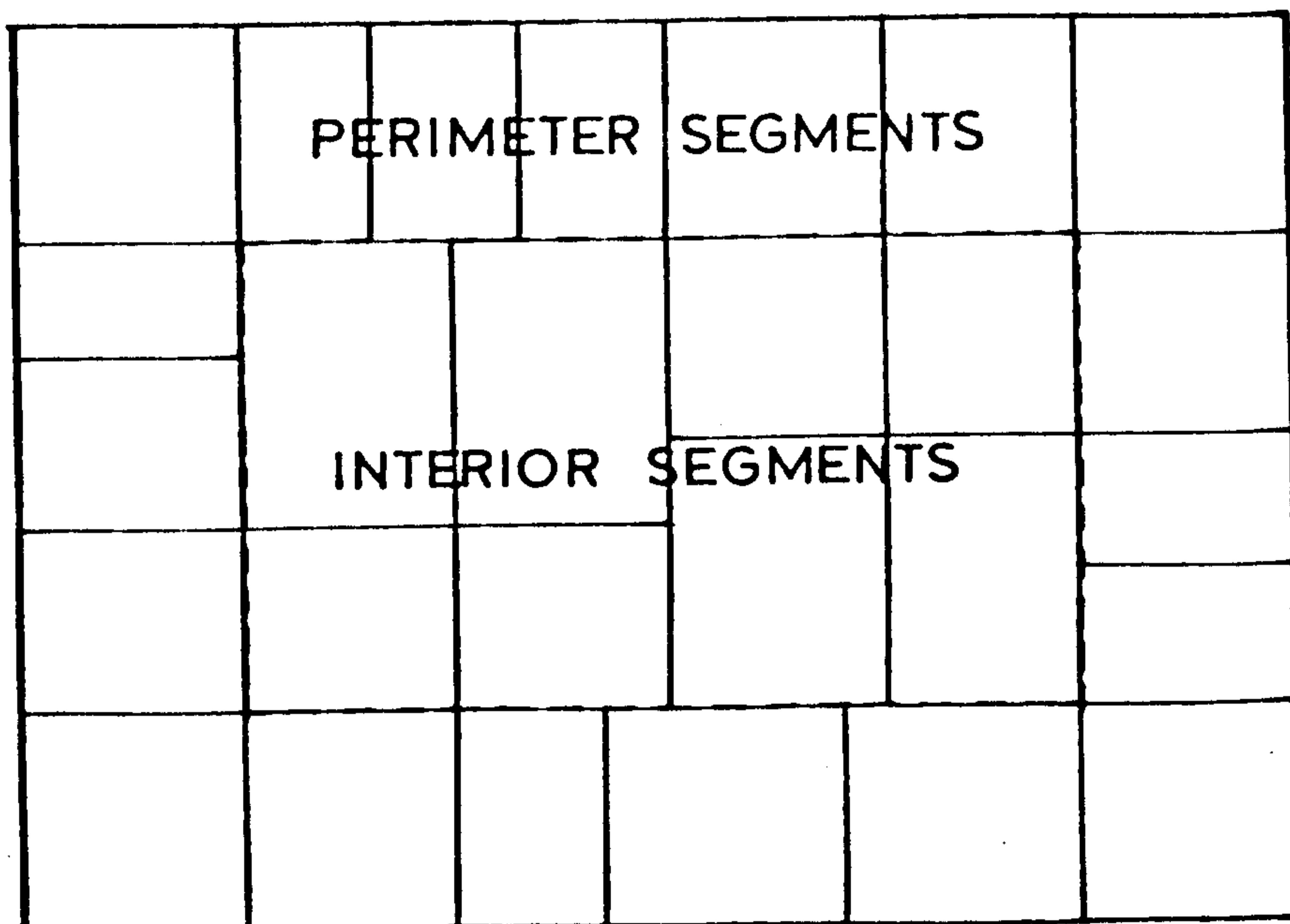


Fig.7.14: Levels of organisation for the urban structure : perimeter and interior segments.

7.3. Urban Evolution

In the case of both the perimeter and internal segments, the first requirement of a process description is to establish the historical continuity of the segments themselves. We need, therefore, to work our way back in time from the map sources, to "unwind the spool", as Marc Bloch has put it (21), and in this backward journey we must depend to an increasing extent on documentary sources. The first, and most serious obstacle to be confronted is the Great Fire, which swept away more than two-thirds of the mediaeval City. The extent of the burnt area is shown on maps by Hollar and by Leake; 13,200 houses were in all destroyed (22).

Despite various ambitious proposals to replan the City on new lines (23), it was decided to rebuild according to the old street plan, improvements being limited to the widening of "eminent and notorious" streets, and to a small number of grander projects, most notably the dredging of the Fleet Canal and the creation of an embankment along the river front (24). Rebuilding proceeded at a considerable pace, and it appears that by the end of 1671 the City was substantially rebuilt (25). Ogilby and Morgan's map of 1676 therefore represents the City as it was reconstructed. The decision to follow the old street layout meant that the block pattern survived virtually intact. At this level, therefore, one can be certain of historical continuity. But the buildings themselves were all new. Moreover, they were required, officially at least, to conform to the provisions of the Rebuilding Act of 1667, which regulated both the height of buildings and their form of construction (26). Hence, at the lower levels of organisation, the measure of change was potentially much greater and is relatively indeterminate.

7.3.1 The Perimeter Zone

Turning firstly to the perimeter zone, a limited attempt at reconstruction has been made by reference to Oliver's Survey (27). In the period following the Fire, Robert Hooke, Peter Mills and John Oliver were appointed as surveyors, whose responsibility alone it was to measure and mark out the sites as the owners decided to rebuild. The need for foundations to be set out by the surveyors and the fee required were authorised retrospectively in the second Rebuilding Act of 1670. Altogether the foundations surveyed by Mills and Oliver covered a substantial part - approximately two-thirds - of the burnt area, and by piecing together adjoining plots, it would seem possible to reconstruct a part, or in some cases the whole, of the perimeter zone for many blocks within the central area. The advantage of Oliver's survey for the present enquiry is that it provides a pre-Fire record of sites. As noted elsewhere: "In many cases Oliver and Mills's surveys can be substituted for Ogilby and Morgan's map as the earliest reference, a pre-Fire instead of a post-Fire reference" (28). By comparing these two sources, we can therefore obtain an indication of the degree of change.

We have focussed on one block - the Old Change block, examined above, which was extensively surveyed by Oliver. Piecing together adjacent sites from the surveys, an overall plan of the block as it existed in 1666 has been drawn, and this is superimposed on the plan from Ogilby and Morgan (figure 7.15). A further reconstruction of a small part of the west side was carried out by reference to the written descriptions of property in St. Paul's Parliamentary Survey (1649 - 1657). It has not been possible to reconstruct all parts of the block from Oliver's Survey, and in some cases what are clearly adjacent sites do not fit together as they should. The greatest difficulty was experienced in the eastern and southern sections of the block and on the interior. Very large sites extending into the block would be expected to present the chief problem (in the absence of diagonal measurements), and the exact relationship of the

Saracen's Head Inn, Angel Court, and the very irregular site of the Bell Inn, both to one another and to their western neighbours, is not easy to determine. Nevertheless, the greater part of the perimeter zone has been laid out, and the results are particularly informative on the western side, facing Old Change.

The first important result is that nearly all the passages shown on Ogilby and Morgan (13 out of 14) are found to exist on the pre-Fire plan. Moreover, all of those which can be accurately plotted are found to occupy the same positions in the pre-Fire block as in the post-Fire rebuilding. In the second place, the site surveys make it clear that courts and yards were seen as a gestalt, as unitary blocks of land on which buildings were erected: Purse Court was laid out as a whole; the building sites of Lamb Alley and Crane Court, though surveyed separately, were set out in relation to the boundaries of the larger block or unit of land. The results lend support to the proposed division of the perimeter zone into segments.

Examination of the site boundaries reveals in some instances a close correspondence between the boundaries of the courts and yards and the continuous lines shown on Ogilby and Morgan. Among the clearest examples are the boundary between the south side of Purse Court and Lamb Alley, and that between Lamb Alley and Crane Court. Star Court, off Cheapside, which appears as a clearly defined entity on Ogilby and Morgan, similarly corresponds almost exactly to the site of the Star Tavern set out by Oliver. In other places, however, the post-Fire buildings straddle the pre-Fire boundaries (eg. the north side of Purse Court, and the south side of Crane Court), suggesting that some rearrangement of plots had taken place. In these latter cases, it becomes much more difficult to infer the court boundaries from the later plan since the lines are now discontinuous. This does not invalidate our earlier attempts to generalise on segment dimensions; it does, however, make detailed reconstruction very hazardous. It can be seen from Oliver's Survey that the passages associated with the courts and yards are variously positioned in



CHEAPSIDE

OLD CHANGE

FRIDAY STREET

WATLING STREET



OGILBY & MORGAN, 1676 (REDRAWN).



OLIVER'S SURVEY
1667-1672

Fig. 7.15: Reconstruction of pre-Fire building plots for Cheapside - Old Change.

relation to the perimeter units; they may be placed centrally or to one side of the yard. This would seem to corroborate our previous hypothesis regarding the yard-passage configurations, i.e. that these were the probabilistic outcome of passage location.

To generalise from the evidence presented here, it would appear that post-Fire development within the perimeter zones closely followed the pre-Fire boundaries; and the observed perimeter segments originated as unitary blocks of land in the pre-Fire period. The site surveys also confirm that pre-Fire as well as post-Fire boundaries can in some cases be accurately identified by visual inspection of the Ogilby and Morgan map.

Much of the property within the perimeter zones belonged to the livery companies and to other institutional landowners, and documentary evidence indicates that a large number of the holdings were acquired during the late sixteenth and early seventeenth century (29). Property was acquired by purchase, donation or bequest. Crane Court, in the Old Change block, which appears among the property of the Merchant Taylors' Company, is recorded in their plan book of 1694-5 as "given by Mr. John Harrison by Will - bearing date the 15th of May 1618". The houses in the court were charged with regular yearly payments towards the upkeep of the school of Great Crosby in Lancaster. The remainder of the rents and profits were "to be yearly given to so many poore men free of the said Company of merchant Taylors as it will amount to pay each £iiii every year by quarterly payment" (30).

It seems likely that many of the property holdings were originally held by ecclesiastical landowners, and that these came on to the property market following the Dissolution of the Monasteries. Brett-James has observed: "the Dissolution of the Monasteries set free a large additional area for building, which was hardly filled until about 1570" (31). In his recent research into the history of the

Christ's Hospital properties, Schofield has shown that the majority of the holdings depicted in Treswell's survey belonged to ecclesiastical landowners - monasteries, parish fraternities, and chantries - before the Dissolution and the Reformation. He notes : "only nine of the twenty-one blocks of property are not associated with former ecclesiastical owners, and in some cases this may only be because of lack of documentation before the 1540's" (32). It is clear, however, that holdings were sometimes accumulated over a much longer period. The Saracen's Head Inn, owned, like Crane Court, by the Merchant Taylors' Company, was given together with the house adjoining to it "by Deed -bearing date the 29th of march in the second year of King Henry the 4th - Thomas (Sibsey?)" (i.e. 1401) (33).

For the purposes of a morphological history it would be ideal if we could trace a number of selected sites back through time to their mediaeval origins. This is unfortunately impossible. Not only is the historical record rarely continuous for any particular site, the sources vanish in their entirety long before we reach those vital years when the lines of the property divisions were established (34). London was already an important centre of commerce at the time of the Norman conquest, and when the first records appear in the twelfth century, urban development was clearly well-advanced. Land values in the City centre exceeded by far those of comparable sites in the provincial towns (35), and sites were already being subdivided into smaller 'mansurae' (36). A small number of early sources are, however, of exceptional value in the information they provide on land holdings in the City. The document examined here is a survey of the London lands of St. Paul's (c.1128) contained in Liber L (Fo.47-50b). This survey, first reproduced in facsimile by J.E.Price in 1886, gives a list of holdings within the City walls, arranged geographically by wards and sokes. For most properties, the overall dimensions -length and breadth - are given. Using these measurements to calculate the area of each holding, we obtain an aggregate land area of almost 8 acres (3.2hA). If the area within the City walls is taken as 365 acres (148hA), and 15% of this space is deducted for streets and lanes (i.e. the main routes around the blocks), it is found that the St. Paul's lands amounted

to approximately one-fortieth of the total developable area within the walls.

Altogether, the survey provides information on more than 80 sites in 24 intra-mural wards. Most of the wards have now been identified (37), but the exact location of the individual properties is, in most cases, impossible to ascertain. We have plotted length against width for all those holdings where both dimensions are given, and the results are tabulated below (Table 7.1). It will be seen that, in spite of the vast range overall, the great majority of sites lie at the lower end of the scale. 87% of the total are ≤ 150 feet deep, and 90% of the total are ≤ 70 feet wide. The figures clearly peak between 51 and 100 feet in depth (52% of the total) and between 31 and 50 feet in width (45% of the total). 28% of all sites are in the range (51-100) x (31-50).

Length (feet)	Width (feet)					Total
	0-30	31-50	51-70	71-90	91+	
0- 50	11	6	-	1	-	18
51-100	10	24	8	2	-	44
101-150	-	4	5	2	-	11
151-200	2	4	-	-	2	8
201-250	-	-	2	1	-	3
Total	23	38	15	6	2	84

Table 7.1: Length and frontage width of St. Paul's lands within the walled City, c. 1130.

This relatively narrow range represents, nevertheless, a plot size which is considerably larger than the typical perimeter plots of seventeenth-century London. In particular the plot width is very much greater than the normal frontage dimensions of buildings in later centuries (cf. fig.5.2). The median width is 42 feet and the

modal range 30-40 feet. While there is insufficient evidence to permit direct comparison of individual sites with later site surveys, the average widths do agree rather strikingly with those obtained for the perimeter segments. There would seem to be good reason to draw a connection between the two. We would suggest that the segments had their origin in these very early property divisions. That is to say, they were originally blocks of land under single ownership.

The perimeter buildings on the early properties were perhaps arranged with their long dimension facing the street. As the holdings were progressively broken up, plots became narrower and buildings turned at right angles to the street. The holdings may have been divided up in width only, or in width and length. It is noticeable in the table that decrease in width tends to be accompanied by decrease in length. While there may have been considerable inequality of holding size from the outset, it seems most likely that the figures reflect the progressive fragmentation of large holdings. If this were the case, the smallest holdings - the 'mansurae' - would represent subdivisions in both length and width. The evidence of other contemporary surveys supports this conclusion (38).

Whatever the exact process of subdivision, it appears that the boundaries of the early property holdings continued to re-assert themselves and to act as a constraint on subsequent development. It was these boundaries that were to contain the courts and yards that developed at the back of the perimeter plots. The passages which served these yards were not laid down all at one time. Mediaeval building contracts indicate that a passage or gateway might be specified as part of the perimeter development (39). Passages, once established, were not easy to erase. Evidence suggests that, like the property boundaries, they tended to survive for a very long time. During the late mediaeval period, the back spaces which were accessed by passages came increasingly under separate ownership or tenancy.

Having considered the historical basis of the perimeter segments, we can now look at the process by which the building configurations emerged within these segments. Tracing the social and demographic history of London in the later mediaeval period, it is clear that population growth began to accelerate in the sixteenth century ; it was in this century also that building development within the blocks began to 'take off'. Until the end of the fifteenth century, it would appear that the land area within the City walls was sufficient to contain the growing population. There was little suburban expansion, and development within the City, though in some places very dense, seems to have been concentrated along the perimeter of the blocks. But, entering the Tudor period, there are signs of congestion. The pressures appear to have been relieved temporarily by the Dissolution of the Monasteries, which, as already noted, liberated a great amount of additional land for building. The population continued to rise, however, and according to contemporary observers, the monastic lands were largely filled up by the 1570's (40).

The demographic increase has been discussed elsewhere. The exact population at any time before the first census is debatable, but the most reliable estimates suggest that it rose from about 50,000 people in the 1530's to perhaps 200,000 by 1600. Clearly, the growth was unstemmed by the recurrent outbreaks of plague or a fall in the birth rate. The situation became serious in the 1570's, once the monastic sites had been built up. The Royal Court and City authorities became alarmed at the invasion of the poor, and fearful of plague, famine, plots and disorder. As a result, Elizabeth I issued a Proclamation in 1580, which prohibited all new building. This became an Act of Parliament in 1592.

The Proclamation was quite ineffectual. Far from stemming the tide of population, which it was powerless to do, it plainly led people to seek more covert means of putting up houses and adding to existing structures. There seems little doubt that it was the Elizabethan Proclamation that provided the real impetus to building

development away from the streets. Brett-James has remarked that "the various restrictions on building tended to produce the very evils they were presumably intended to prevent or cure. Only the cheapest houses were erected as long as there was a risk of their being pulled down for a breach of the building rules, and these were put as far as possible out of the way, in narrow squalid alleys and courts" (41). Dorothy George, in her study of eighteenth-century London, has similarly observed : "Buildings of a sort were put up in yards behind thoroughfares and in the courts of existing houses and by encroachment on waste land. The object must have been to escape notice and build in such a way that demolition would be no great loss. Overcrowding and poverty continued the process long after the restrictions had been given up " (42). Further Proclamations followed under the Stuarts 1605, 1607, 1608, 1618, 1619, 1620, 1625 - and under Cromwell - 1656/7. They were equally unsuccessful in achieving their aims, and interior development became firmly established in these years.

One way of attaching some figures to these very general statements is through the schedules of buildings erected contrary to the Proclamations, the most comprehensive of which was prepared in 1637. This lists 450 culprits, and 1361 houses, erected possibly within the previous thirty-four years, i.e. since the accession of James I (43). The majority of the buildings were in the western and northern suburbs. The schedules are, as Power has noted, an imperfect source (44). Of one thing we can be certain : the buildings that are listed represent only a proportion, probably a very small proportion, of those that were put up. But this, in itself, indicates the scale of the problem.

The later maps and large-scale property surveys show clearly that in the case of perimeter segments, the normal practice was to build up to the boundaries of each segment. Each building was set out with its back wall against the segment boundary, and was contiguous with its neighbours. Development proceeded along the sides and/or the back of the plot (i.e. the segment) and in some cases continued

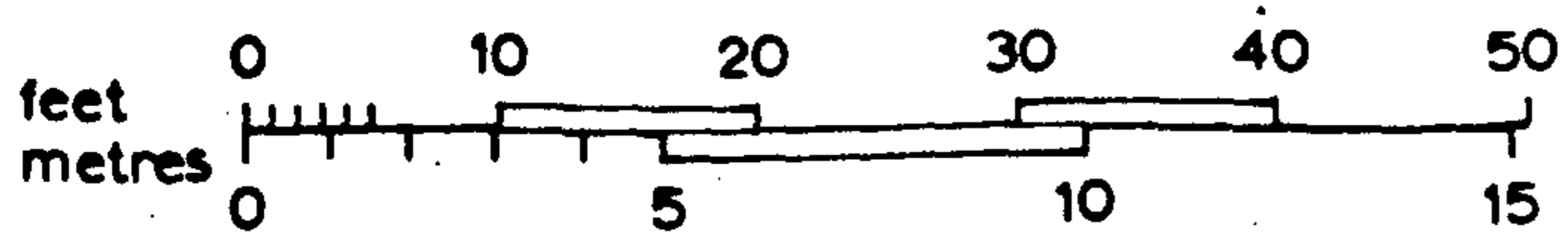
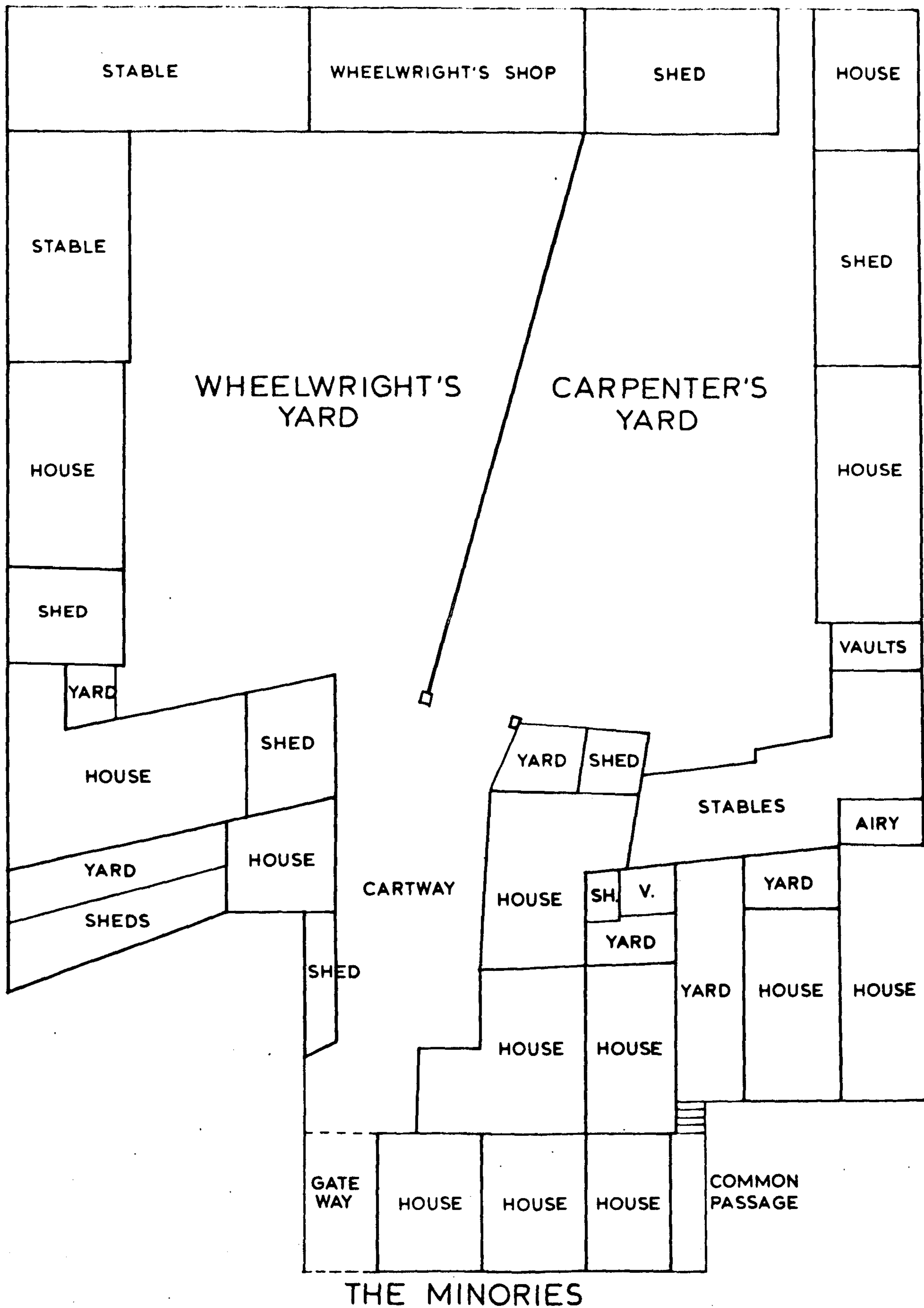
along the back of the perimeter houses. Where the same process was followed on adjoining segments, this could result in back-to-back rows. Back-to-back development is very widespread on the maps, and would indeed appear to have arisen principally in this way, i.e. through independent development in contiguous segments. Thus, it was rather the 'natural' outcome of the system than a globally-conceived model. In this respect it may be contrasted with the building patterns which were later to become characteristic of working-class housing in many of the industrial cities. While the two types of development were congruent in form, the latter were invariably planned as a whole. An early example of high-density industrial housing is that in the East End of Leeds, discussed by Beresford (45). The developments of the White Cross Area and Marsh Lane, both carried out by Richard Paley towards the end of the eighteenth century, are typified by long terraces of back-to-backs. The usual practice, it appears, was to build parallel to the street, but where there was enough space left on the interior, additional rows of back-to-backs were built facing into interior courts, and reached from the street by a tunnel or series of tunnels. Not only was the overall form of the courtyard developments similar to that in parts of London, the individual units also were almost identical: in Marsh Lane they were virtually standard, 15' x 15' square, two storeys high, with one room on each floor. As Beresford has pointed out, the significance of the East End development is that it set a pattern for speculative development in Leeds which contemporaries accepted and which later generations followed (46). But one may argue that it was the earlier uncontrolled and piecemeal development - segment development rather than burgage development - such as that in the City of London, which paved the way for, and legitimated, these building patterns.

The perimeter segment developments in London did not necessarily consist entirely of houses. They frequently included a series of buildings of related or ancillary functions : stables, workshops, sheds, coalhouses. This can be seen in the City properties illustrated in fig. 7.16. But whatever the functions, the

principles of organisation remained the same. The fundamental characteristic of the building pattern is that the groupings were inward-looking, receiving both light and access from within the segment. Modes of access and positions of windows cannot, of course, be determined from the maps, but they can be established by reference to large-scale plans and to documentary sources.

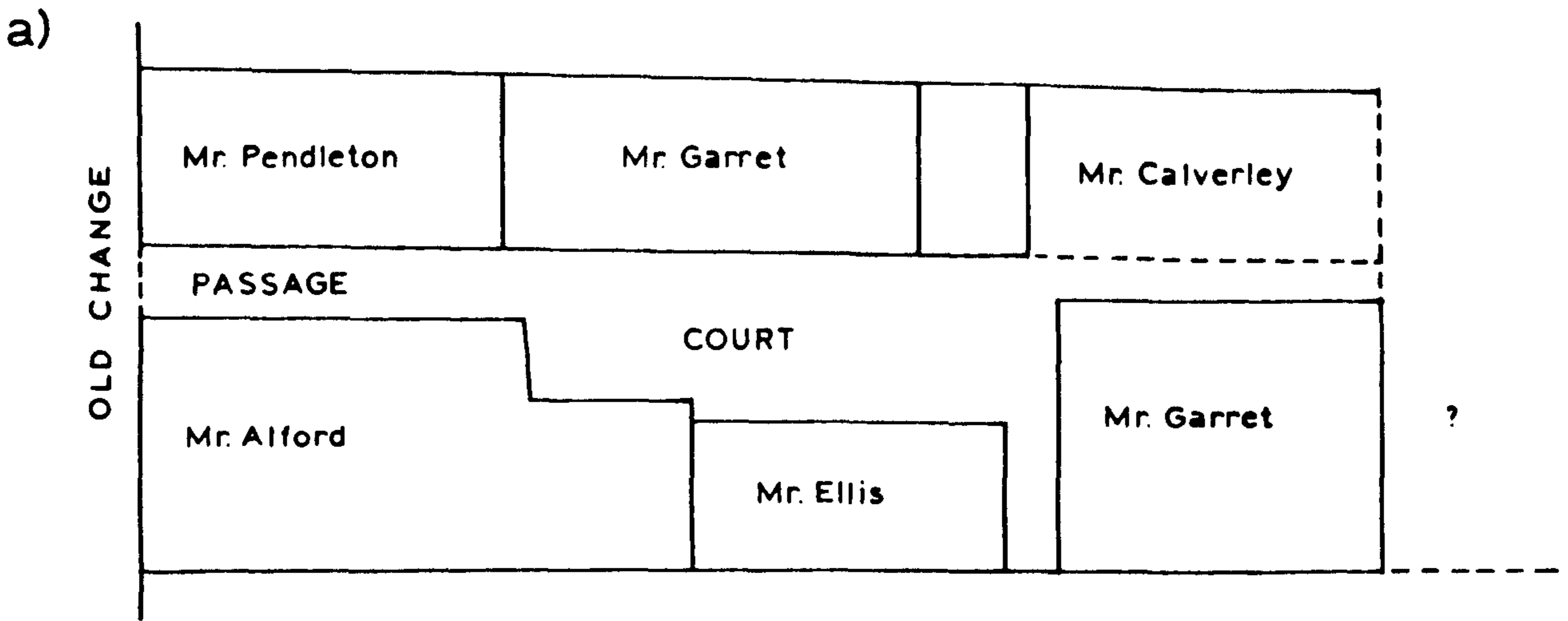
For building access we may return to the example of Crane Court, Old Change, which is depicted in the Merchant Taylors' plan book of 1680 (see fig. 7.17). Although the buildings within the court are shown in outline only, the position of the doorways is rudely indicated in all cases except one. It will be seen that each building has one means of access only and this from the court. All units appear to have had an independent means of access, even where they are part of a single tenancy (e.g. Mr. Ellis). The perimeter units also have only one means of access, but this is from the street. They are not connected with either the entrance passage or the court. Since the layout of buildings within the court closely recapitulates the pre-Fire arrangement, we can safely conclude that the access structure also matches that of the earlier development. The opportunity for alternative access is in this case highly restricted, as many of the buildings back on to those in the neighbouring segments (e.g. Lamb Alley to the north). But since the same access pattern is found in single-pile strips, it is clearly not a function of the double-pile, or back-to-back arrangement. The one-way access to buildings also agrees with the results of the building plan analysis, the graphs for which, it will be remembered, fell overwhelmingly into the 'non-distributed' class.

The surveys are much less informative on the position of windows. They are rarely shown on plans, and then only for the perimeter buildings (47). But here we are fortunate in that the rules we are seeking were not, as is so often the case, merely tacit; they were explicitly formulated and actively enforced by the City authorities. Hence, they can readily be extracted from documentary sources. According to City tradition, regulations for the settlement of disputes between neighbours concerning boundaries and

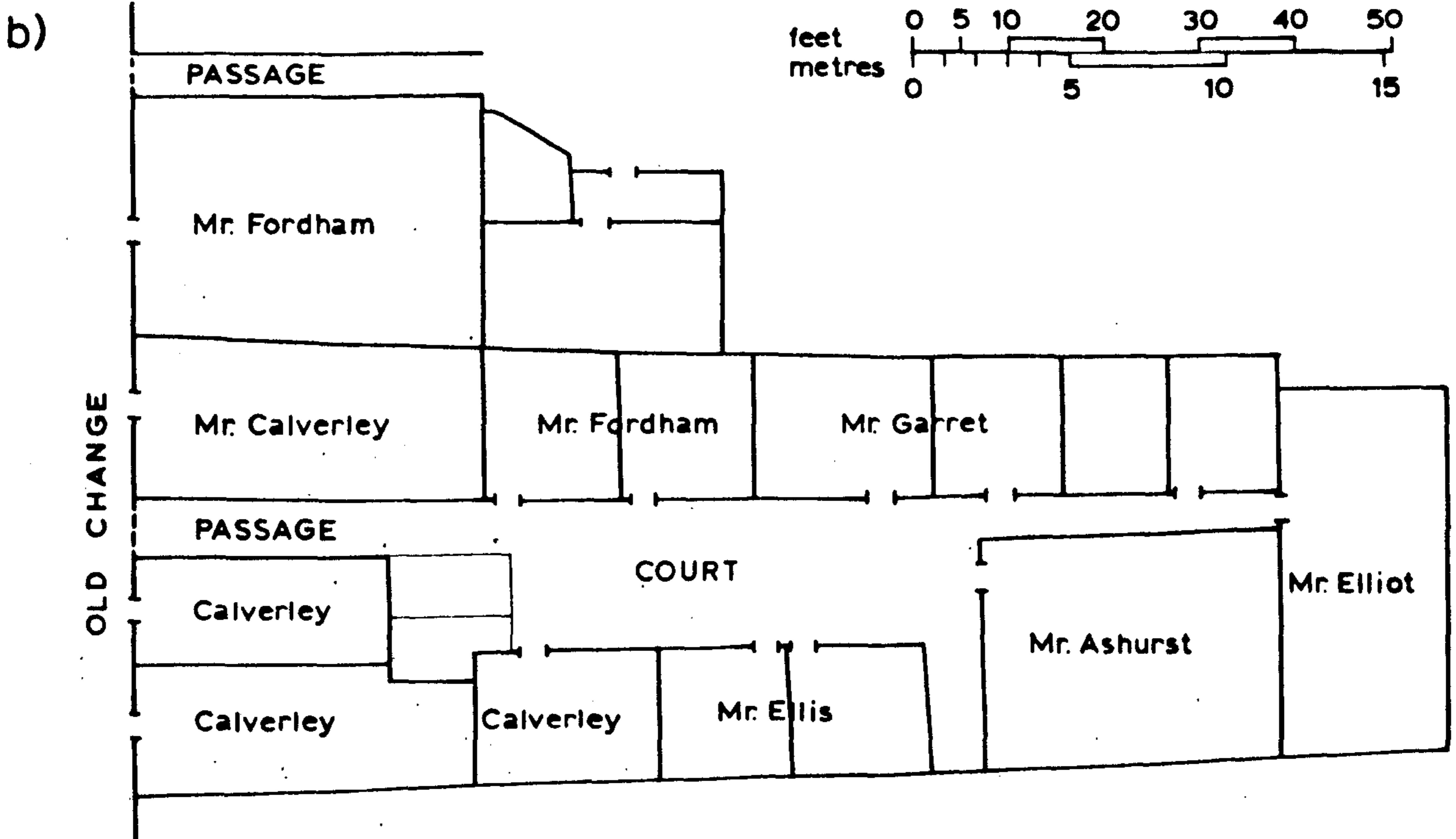


Based on the plan in the City Lands Plan Book (1.65)
Early 18th C.

Fig. 7.16: Yard Development in the Minories



CRANE COURT, OLD CHANGE: PRE-FIRE PLAN
reconstructed from Oliver's Survey, 1670-71



CRANE COURT, OLD CHANGE: POST-FIRE PLAN
based on the drawing in the Merchant Taylors' Plan Book, 1680

Fig.7.17 : Building access in a perimeter segment.

other matters were first laid down under the mayoralty of Henry Fitz Ailwyn at the end of the twelfth century. Extant records begin in 1301 with the regulations contained in the 'Assisa de Edificiis' and continue down to 1431 (48). From the first, the regulations were extremely elaborate : windows were governed by rules of 'nuisance', which also covered walls, gutters, privies, and paving.

The Assize ordained that "a view from a window, despite long possession, could be fully obstructed by a neighbour who built opposite to it on his land, unless it were protected by a deed" (49). But, as Chew and Kellaway have observed, the plaint most frequently found was made by plaintiffs whose neighbours had windows or other apertures, or doors, overlooking their land. The most common complaints were that the private business of the plaintiff and his household could be seen by the defendant and his household, and that filth and rubbish were thrown out on to the plaintiff's land (the windows at this time being largely unglazed openings). On the 29th Feb., 1348, for example, "Simon de Worthstede complains that Robert Bisshop and Roger Madow have six windows and two apertures in their tenement adjoining his in the par. of St. Alban de Wodestrete through which they can see his private business: and his tenants throw sewage and other refuse through the apertures on to his land . The defs. are summoned by Robert de Sutton, 'lorimer', and John de Totenham, 'chaundeler'. Robert makes default. Roger comes but says nothing to delay the assize. The site is viewed but the parties are given a day at Guildhall on Wed. 5 Mar. for lack of aldermen. On that day, there being assembled (cōgregati sunt) Thomas Leggy, mayor, Andrew Aubrey, Richard Lacer, Geoffrey de Wychingham, Roger de Depham, William de Causton, John de Causton, Walter Turk, John Syward, Adam Brabazon and Richard de Basyngstoke, aldermen, Simon and Roger come, and the record and process of the plea having been read, it is adjudged that the nuisance be removed within 40 days etc." (50).

In those cases where the defendant had a window at a height of less than 16 feet above the ground, it was normally adjudged that he or she should block up the window in question. Where an owner, whose

view had been blocked by a new building, sought to prohibit the building, it seems that he was unlikely to be successful - in the long term - unless he could produce a deed granting light and view to him or his predecessor. It seems clear that the regulations in respect of windows were implemented fairly rigorously and consistently, and that these placed a burden on the owner to dispose his windows in such a way that they did not overlook, or in any other way interfere with the neighbouring properties. One can easily see that this would encourage an arrangement in which windows, as well as doors, faced on to one's own land. By this arrangement, one would be secure both from allegations of 'nuisance' and from the threat of later building or encroachment. The inward-looking configuration of the perimeter segment developments clearly offered the greatest safeguard for light and view from each house.

Buildings within a segment might be added one by one or built in rows. The alignment of building frontages in many segments, though not a reliable index, does suggest that a substantial proportion of interior buildings were put up in groups rather than singly. The smaller buildings, occupied for the most part by the poor, were not erected by them, but mainly by builders who saw a chance of making a profit. When one considers the mounting pressures of population in the sixteenth century, the feeble enforcement of the Proclamations, and the profits that were open to an owner or tenant who decided to turn his back yard or garden over to buildings, it is easy to understand why so many took the risk. The documentary records of the sixteenth and seventeenth centuries - schedules of buildings, court proceedings - add little in the way of firm data on building layout. They do, however, show us the kind of people who were behind the developments, and the way in which they worked. Court actions concerning building development were numerous, and referred to a large extent to property in the suburbs. In 1641, Thomas Stilgoe, carpenter, appeared in a dispute over property in Angel Alley in the parish of St. Botolph without Bishopsgate. Stilgoe sought a reduction in rent from Edmond Eyres of Chelsham, Surrey, the owner. In reply, the defendants claimed that "Stilgoe has built

hovels against the building regulations on the land, and filled them with poor people likely to become a charge on the parish". The defendants had a bond with the parish to indemnify it for any of their tenants who might become chargeable (51).

Providing they could escape notice, builders could amass a considerable amount of property by developing land which they owned or held in lease. In their introduction to Oliver's Survey, Jones and Reddaway have briefly discussed the activities of Peter Mills, one of the surveyors responsible for setting out building sites after the Great Fire. Mills was a not untypical figure in that "he was primarily a builder, putting up a house when opportunity offered, rather than what would now be called a developer" (52). He seems, nevertheless, to have acquired considerable property in the right of Elizabeth, his wife. Thus, in 1658, Elizabeth Heydon, widow, Peter Mills and his wife (Elizabeth Heydon and his wife were probably one and the same) leased a house at the entrance to Moore's Yard, Old Fish Street, formerly two messuages, with a privy in common with the house next door. The next transaction is in 1669, when Mills and his wife leased the property to Nicholas Dunscombe, citizen and mercer, and Richard Cleare, citizen and joiner. In the deed, the pre-Fire property is described as "a messuage on the east side of the gate leading to Moores Yard in the occupation of Edward Hall, two messuages on the other side of the gate in the occupation of Edward Chipp and Edward Abthorpe, eleven small messuages in the courtyard and three warehouses nearby, together with two messuages in Middle Row, afterwards required for enlarging the street, and a stable in Five Foot alias Finimore Lane, which property had been rebuilt by Peter Mills after the Fire as three messuages next the street and four in the yard at a cost of £1,600" (53). There appears to be no record of the foundations in Moores Yard having been set out.

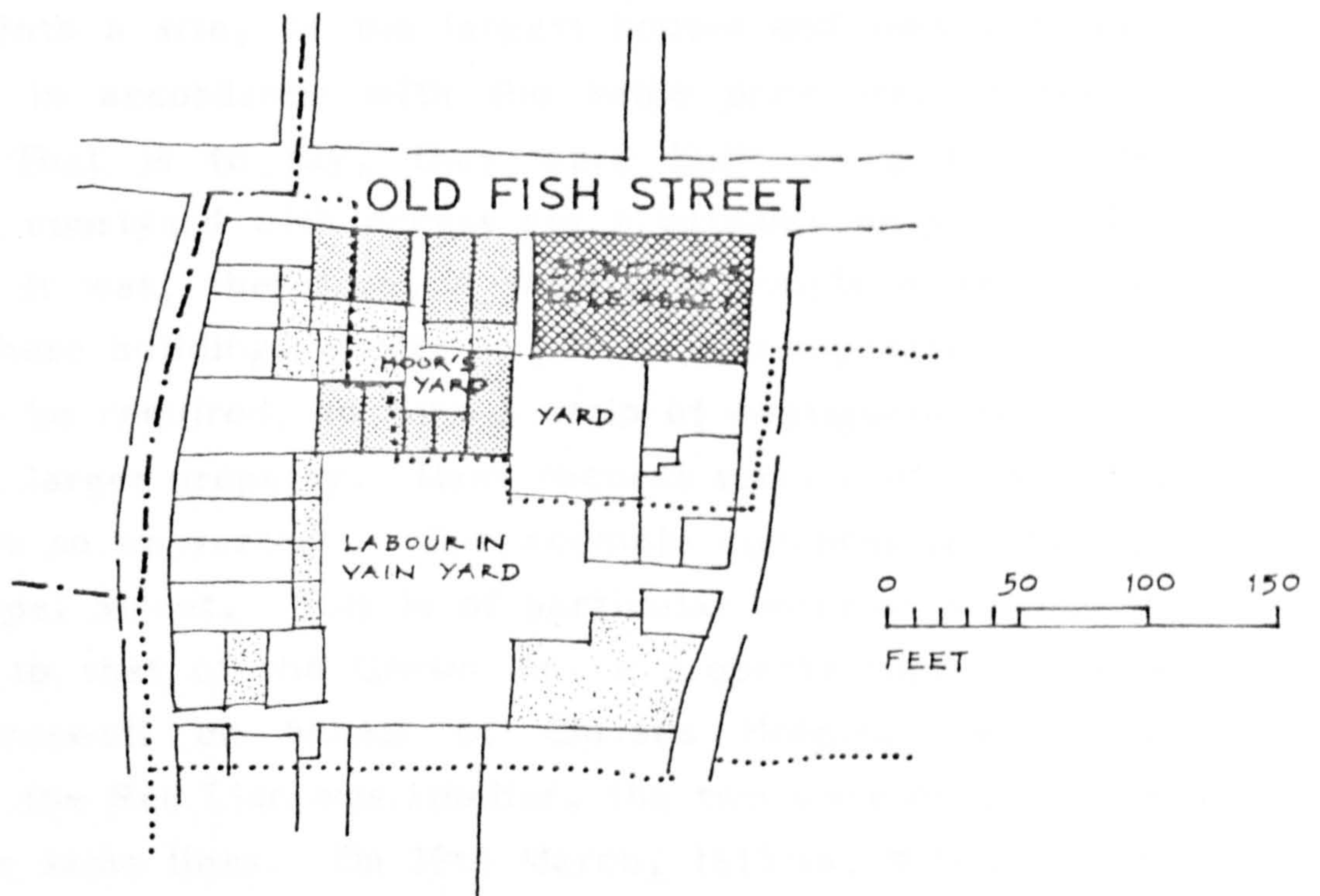


Fig.7.18 : Moor's Yard as it appears on Ogilby and Morgan (redrawn).

One method of development which recommended itself to many was to demolish an old mansion house or other large building, and to put up small houses on the same site. In January 1668, Darnet Forth and John Forth were brought before the Mayor's Court by Henry Greene for having built 18 tenements on the site of the old brewhouse called the "Flower de Luce" in Golden Lane, which was old and ruinous. It was adjudged that this was not against the custom of the City, "which does not forbid a change of use when property is rebuilt", and was not to the disadvantage of William Cole, the inheritor of the property (54).

The redevelopment of large sites with tenements was already a cause for concern in Elizabeth's reign. A 'Device' prepared by the Recorder recommended provisions "against converting great houses to alleys, or multitude of habitations" (55). But it is important to note that in many cases it was unnecessary to run an alley or passage into a site, as the largest houses and inns were generally arranged in accordance with the same principles as the smaller units. That is to say, they were built as a single-pile strip around a courtyard with access via a gateway or passage from the street. It was, therefore, a relatively simple matter to convert one of these buildings wholly or partly into separate tenements or, should it be required, to turn a strip of contiguous tenements into a single, larger property. Many records survive of inns and taverns that were so converted. One example concerns the 'Red Lion' in Whitechapel Street. This is of particular interest because the site is close to that of the Crown Inn, a property surveyed in 1610 by Ralph Treswell on behalf of Christ's Hospital (see fig.6.11). Although the Red Lion was smaller, the two were obviously designed along the same lines. On 19th March, 1615/16, William Hearne, of the parish of Whitechapel, was charged with building "divers tenements of an auntary stable in a common Inn called the Red Lion in Whitechapel Street, directly contrary to his Majesty's proclamation, and to the great annoyance and charge of the rest of the parishioners by bringing in poore people there to inhabite, who dying leave their children to be maynteyned by the parish". The complaint arose because of a petition from the inhabitants, and Hearne was ordered by the Privy Council to pull down the new chimneys and put back the tenements into their original form of a stable (56).

To the east of the Crown Inn lay the Broad Axe Inn, property of St. Paul's. By the 1650's, this also had been converted into "severall messuages or tenements" (57). In this instance, the transformation seems to have been a permanent one, as the site appears on Ogilby and Morgan under the name Hatchet Alley.

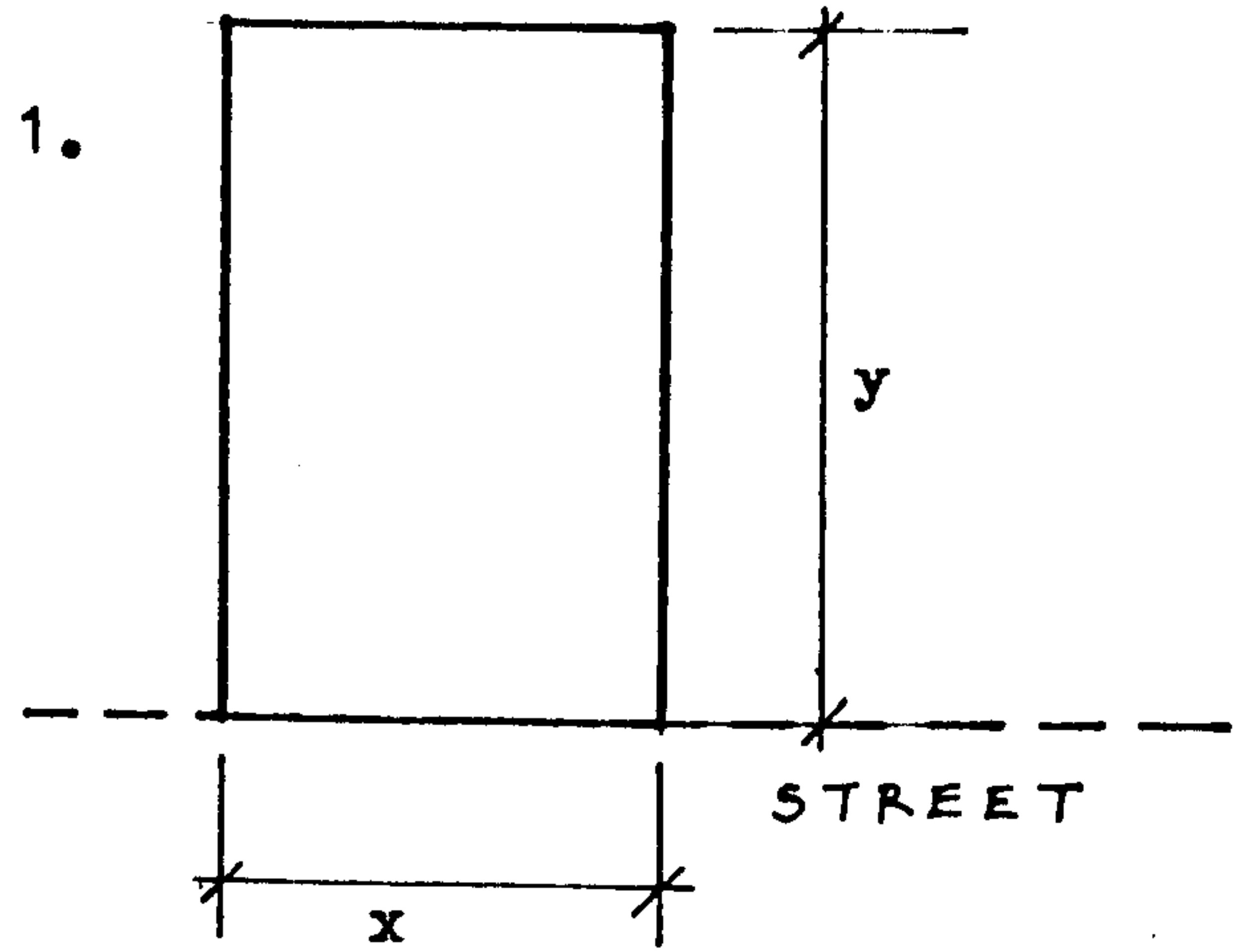
From the analysis of building surveys and consideration of the more general, descriptive material provided by the documentary sources, it is now possible to set down the rules of perimeter development in a condensed form. We would propose the following set of instructions :

1.

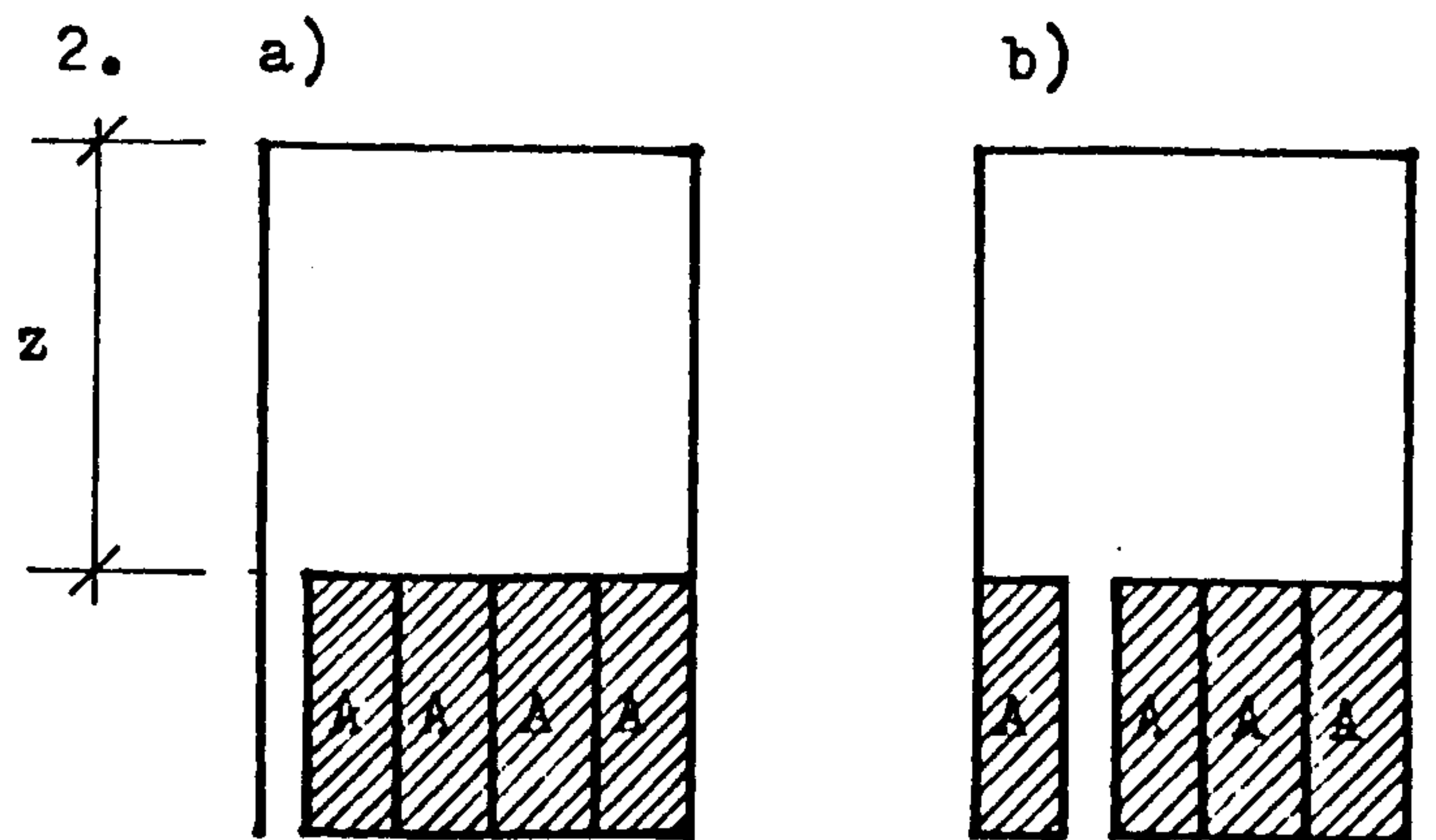
Take any perimeter segment
 $x \times y$. $20' 0'' \leq x \leq 75' 0''$
 $50' 0'' \leq y \leq 150' 0''$

2.

Develop the street frontage with perimeter units A. Each perimeter unit to be 10'-15' wide and 15'-50' deep. All perimeter units to be congruent. A passage 5'-10' wide is to run from the street edge to the back of the perimeter buildings. The passage may run between any two perimeter units, or between a perimeter unit and the side boundary. All perimeter units to have their front wall coincident with the street edge and to be contiguous, save when a passage runs between them. Each end unit is to have its side wall coincident with the side boundary of the segment, save when a passage occurs at this point.



2.



3.

Develop the back space

Where $z \geq 25' 0''$

Where a) the passage adjoins the side boundary of the segment, begin development along the opposite side boundary,

Where b) the passage occurs between perimeter units, begin development along the nearest side boundary.

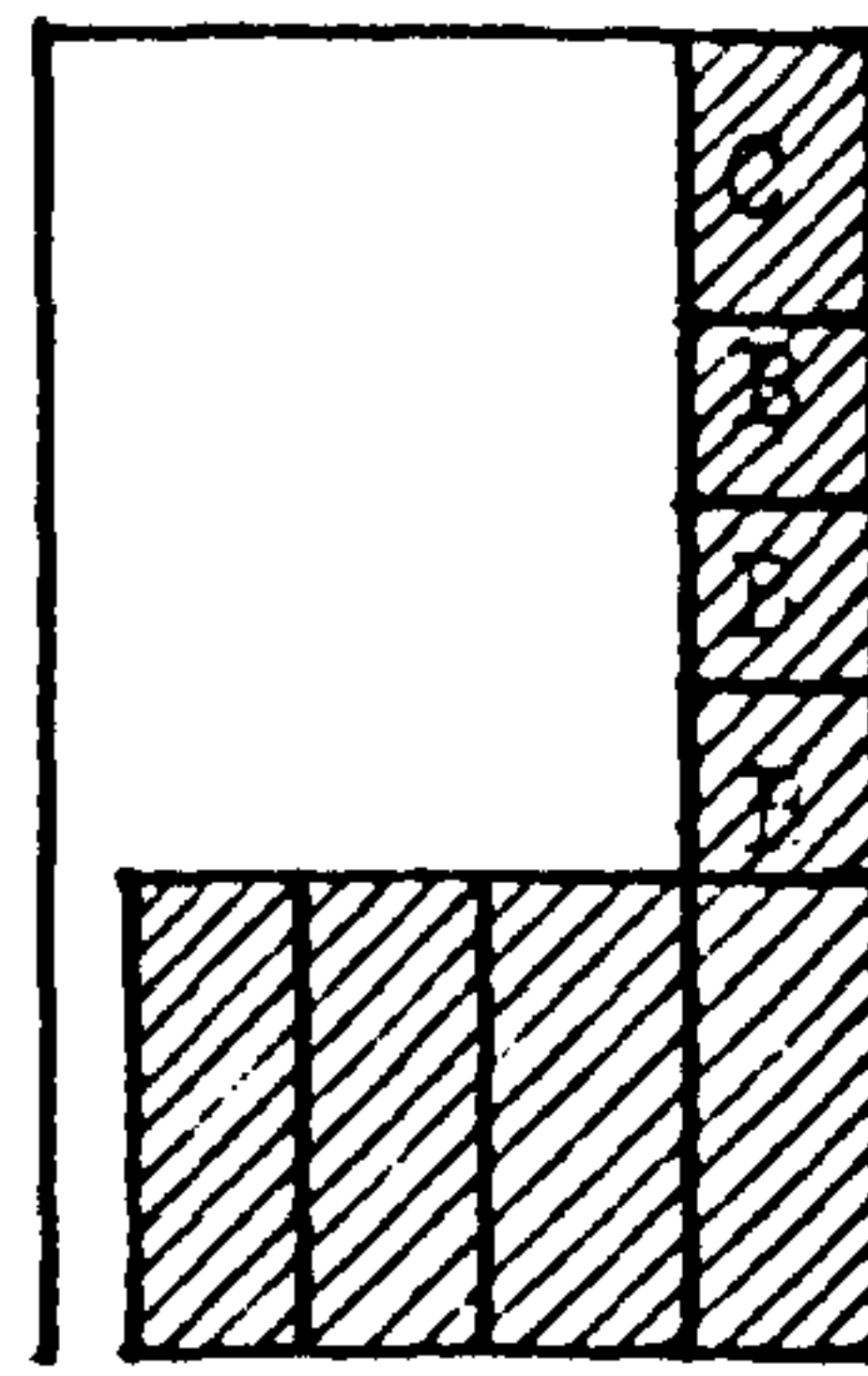
Develop with units B. Each unit to be square. All units to be congruent. Depth of units to be equal to the width of perimeter units. Place first unit with side wall coincident with the back wall of perimeter unit, and back wall coincident with side boundary of the segment. Add further units along the side boundary. All units to be contiguous and to have their back wall coincident with the side boundary. Where the row meets the back boundary of the segment, it is to be completed with special unit C.

4.

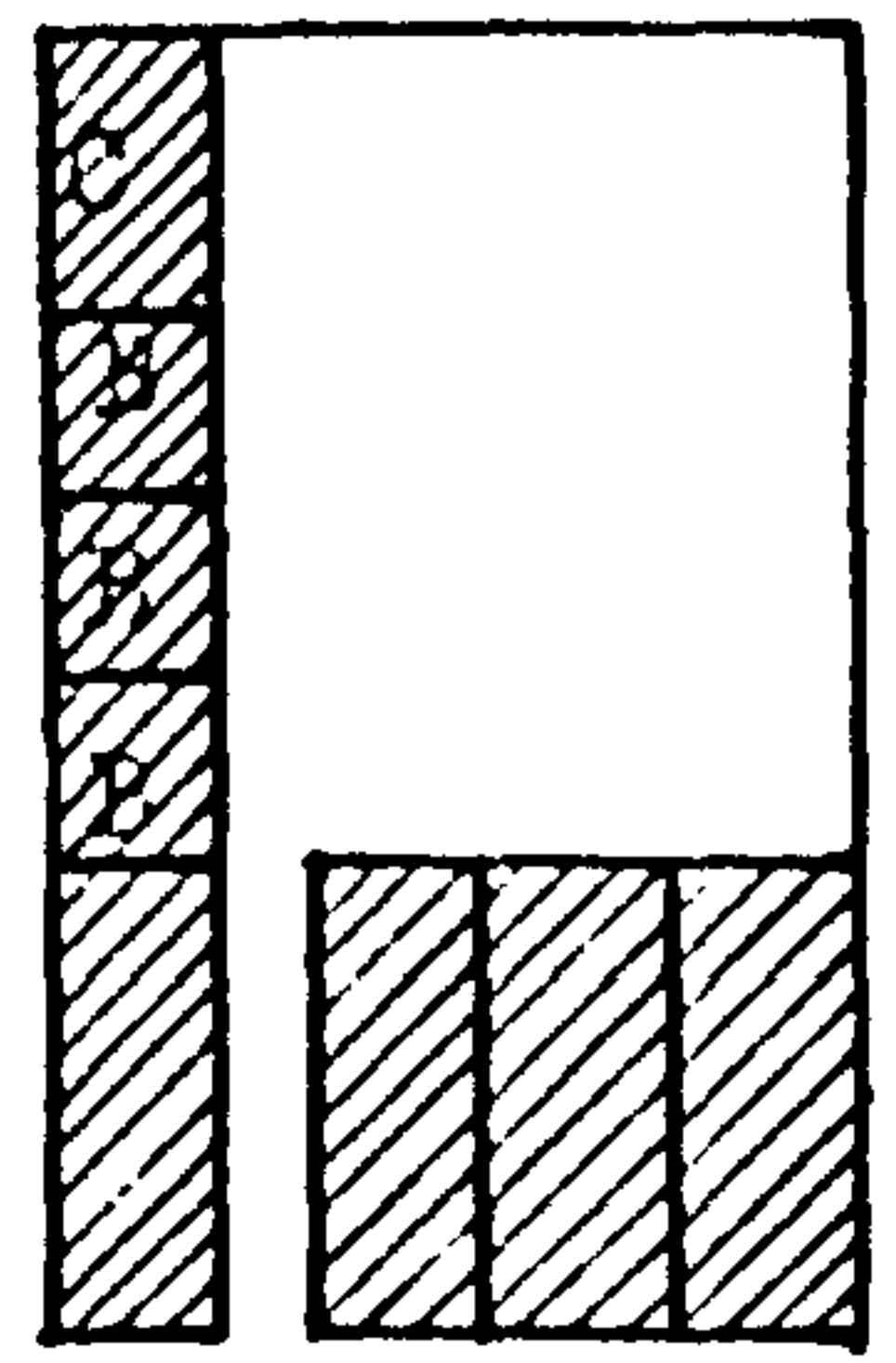
Continue development at right angles along the back boundary of the segment. Place first unit (type B) with side wall against unit C and back wall

3.

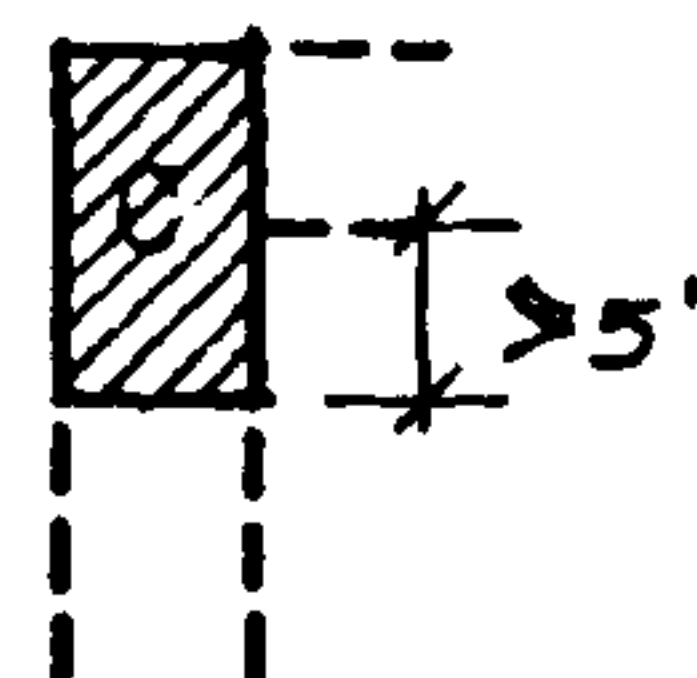
a)



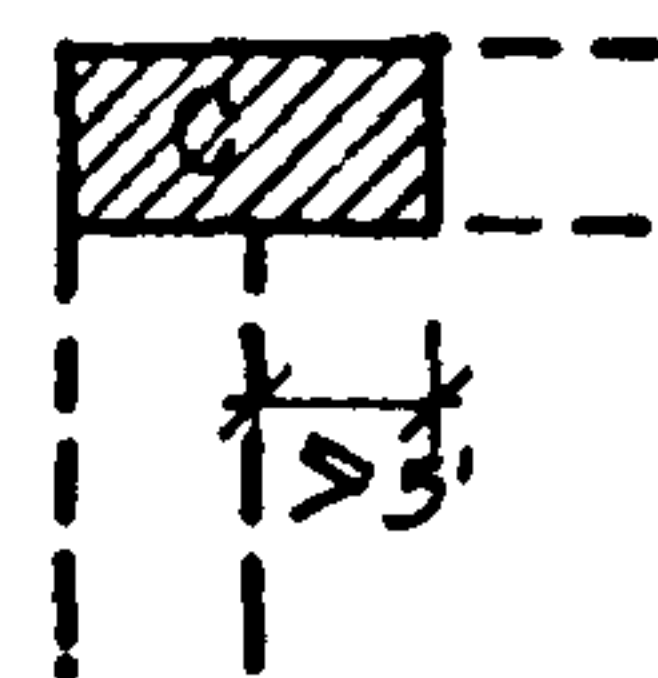
b)



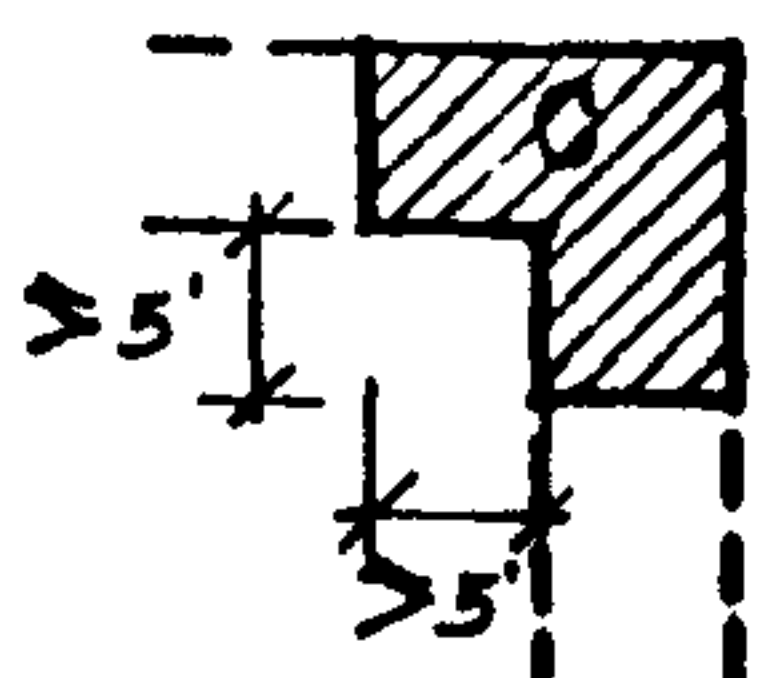
i



ii

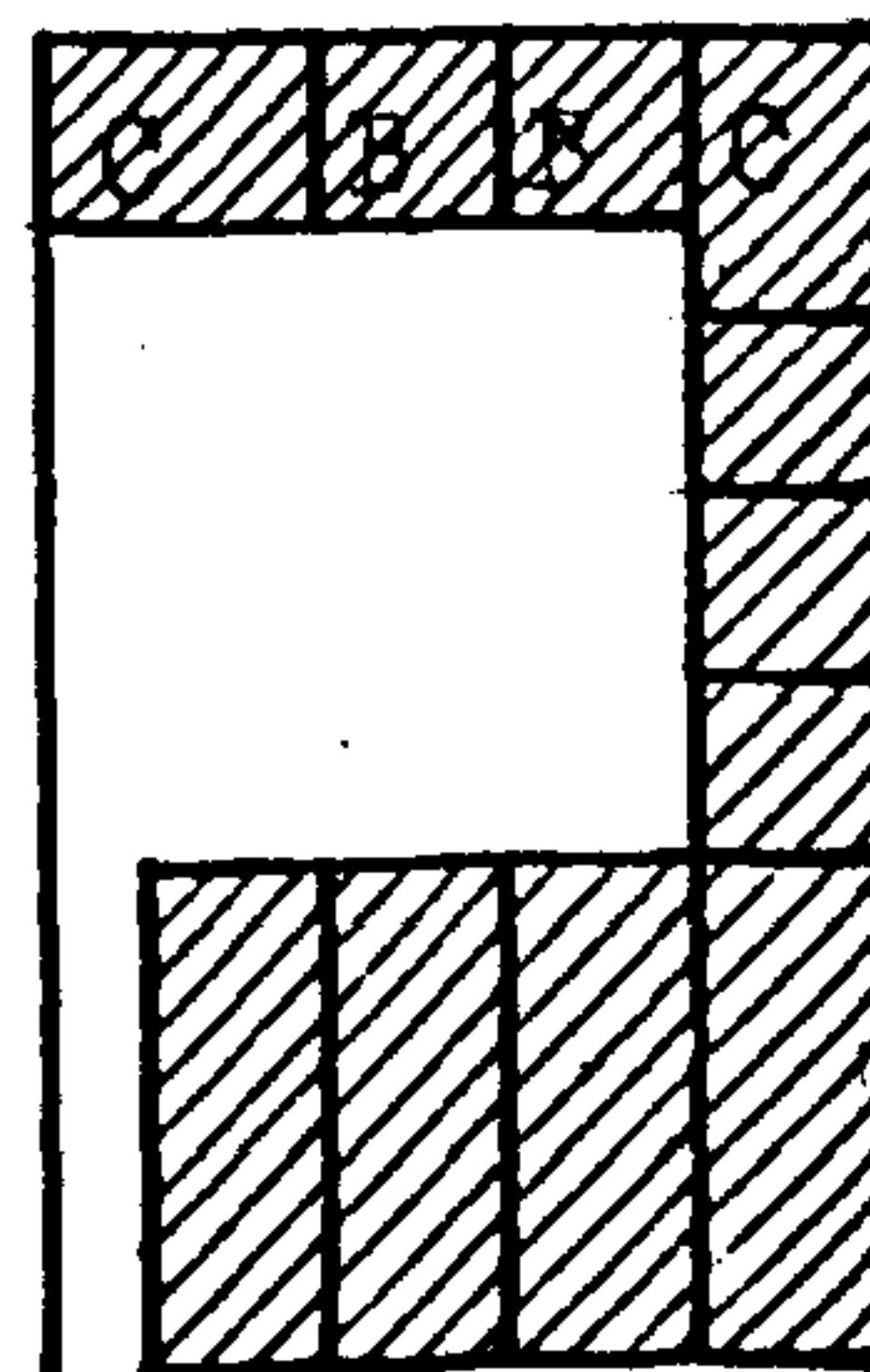


iii

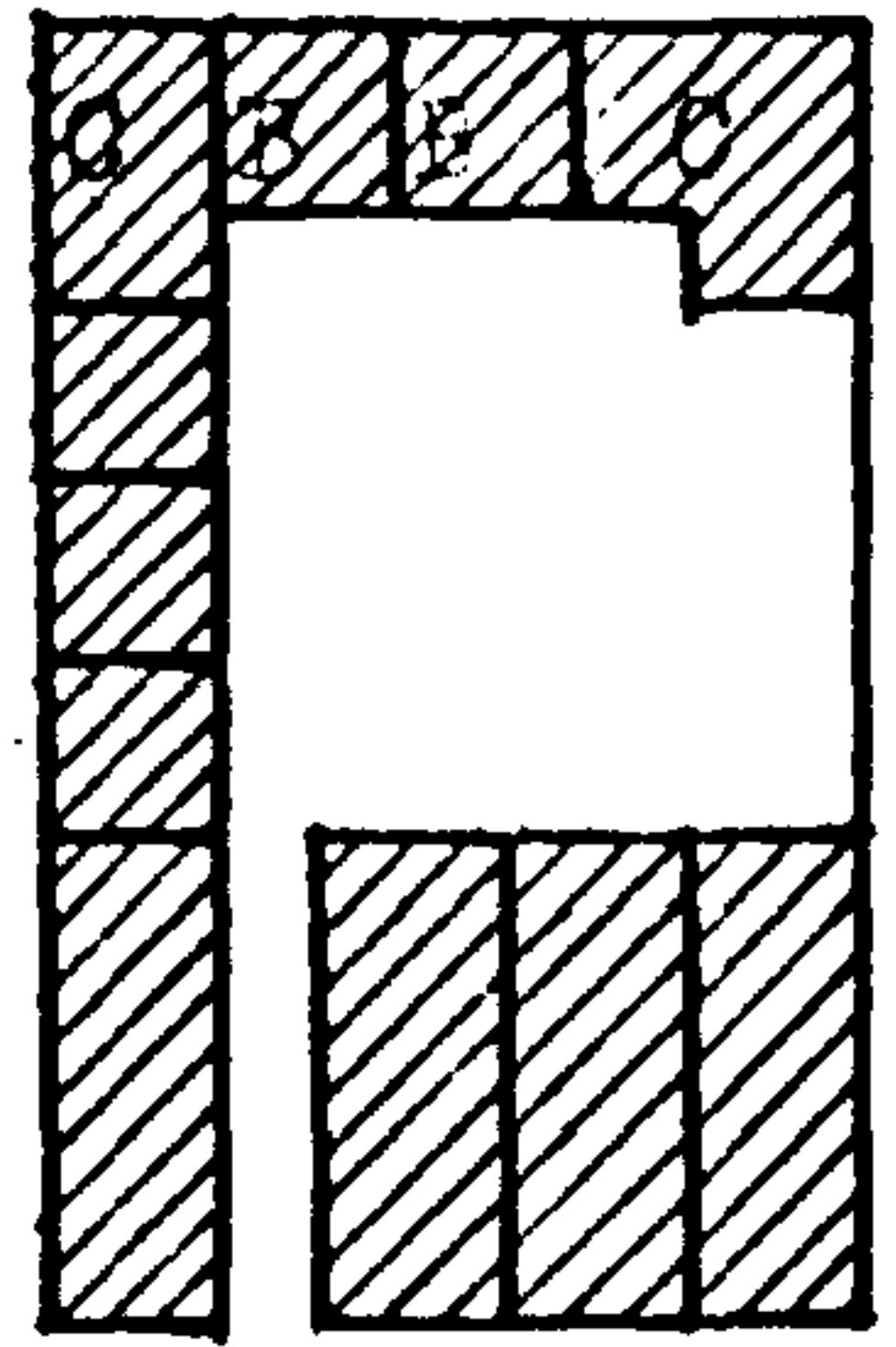


4.

a)



b)



against the boundary. Add further units. All units to be contiguous.

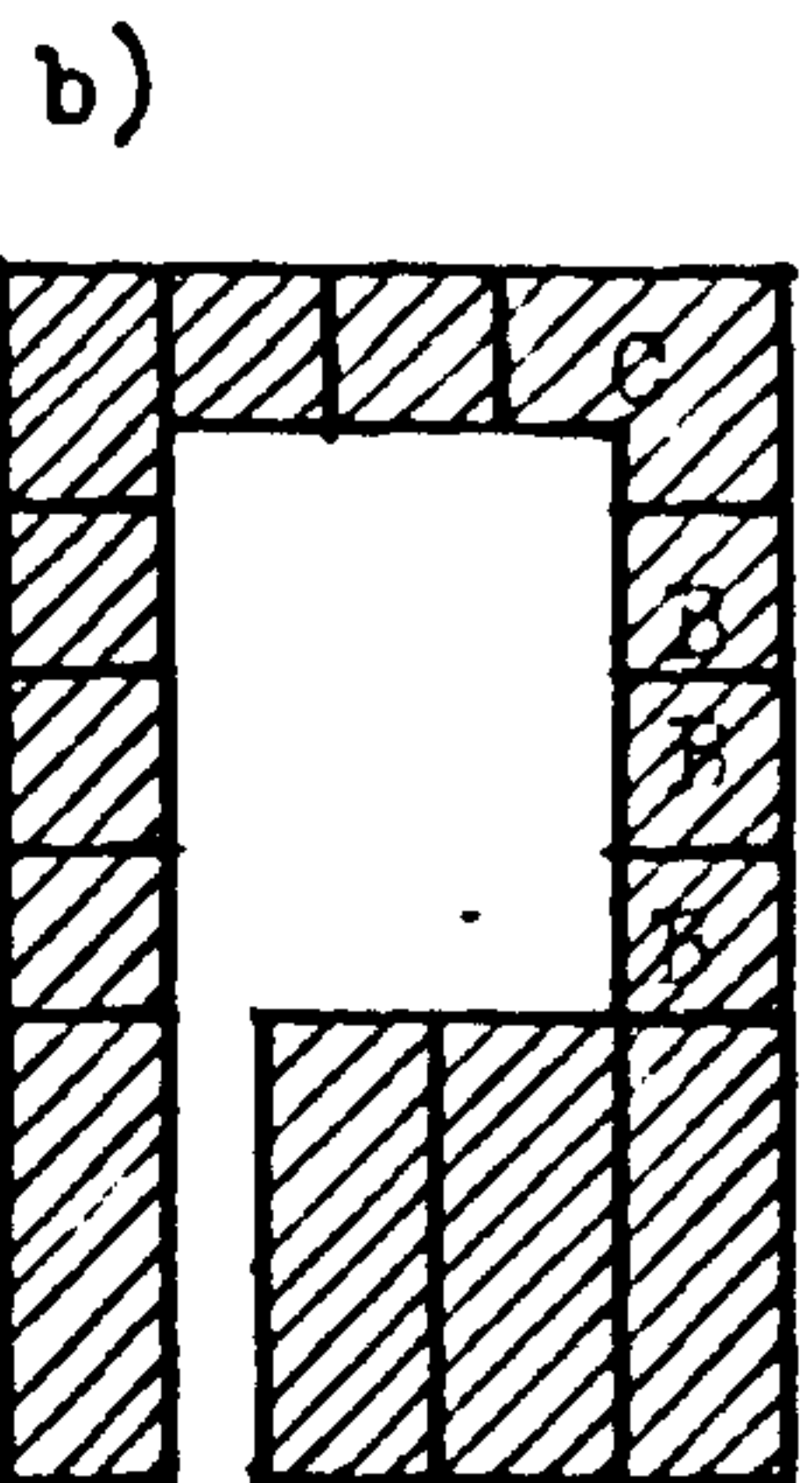
If case a) continue until the side boundary is reached and terminate development with B or Cii unit.

If case b) complete the row with special unit C.

5.

Case b) only. Continue development at right angles along the side boundary as before. Final B unit to be contiguous with the end perimeter unit A.

5.



The building patterns generated here represent the maximum development of a perimeter segment. A segment need not be maximally developed, and the continuity of building along any one side may be interrupted by passages which break through the segment boundaries, providing access to the interior or to adjoining perimeter segments. The question of access between segments will be taken up in the next chapter. It should also be noted that the process description never applies to all perimeter segments in a block. Other perimeter segments will be developed with contiguous burgage strips, as described above.

7.3.2 The Interior Zone

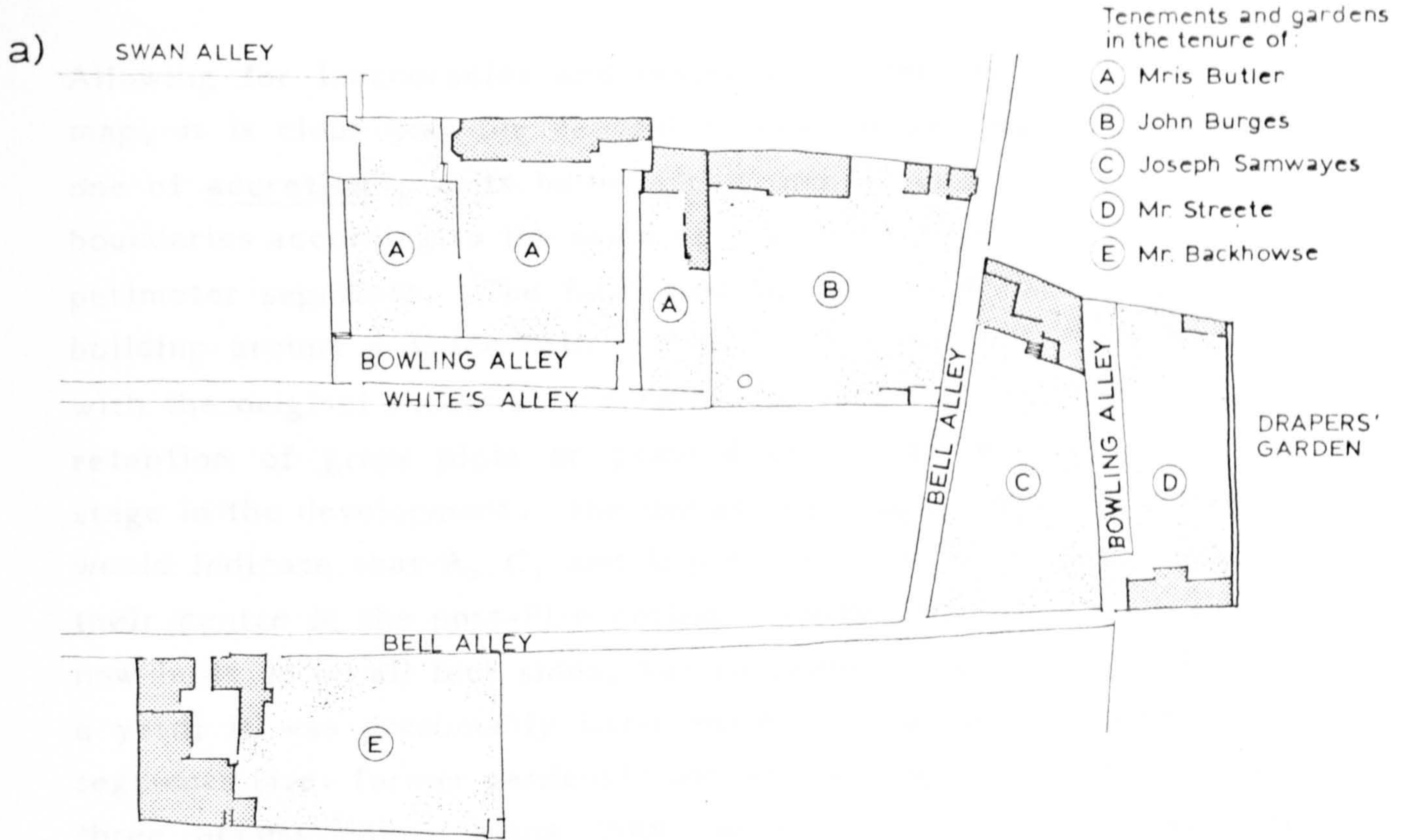
The filling up of the interior zone was the final stage in the sequence of land development in the City. If the 1580's and 1590's represent the 'take-off' point for back development in the perimeter zones, this is true 'a fortiori' for development within the interior proper. Although the medium-range blocks of the City centre already exhibit a dense development in the earliest maps (Braun and Hogenberg, Agas) and panoramic views, it seems certain that the larger blocks, both within and without the City walls, remained relatively undeveloped in their interior zones until the late sixteenth century. The zones are in general rendered as gardens, bounded by walls, hedges or fences, with few or no buildings.

Reconstruction of the process of building development is much more problematic for the internal than for the perimeter segments. This is due to the fact that the historical record - both cartographic and documentary - is poorest for these areas. The Elizabethan maps are clearly not dependable as a source of information : the interior zones undoubtedly contained many more buildings than are indicated. But even the later plans are very deficient for areas away from the street edge: Ogilby and Morgan, which delineates buildings and gardens with some care, has been shown to be least reliable on the interior of blocks (58). Documentary information is exiguous since the internal spaces - especially in the suburbs which lay outside the jurisdiction of the City - were often built upon illegally. The gardens and courts of the suburban blocks were the places least likely to be visited by viewers and surveyors. The great mass of building development went unseen or unrecorded.

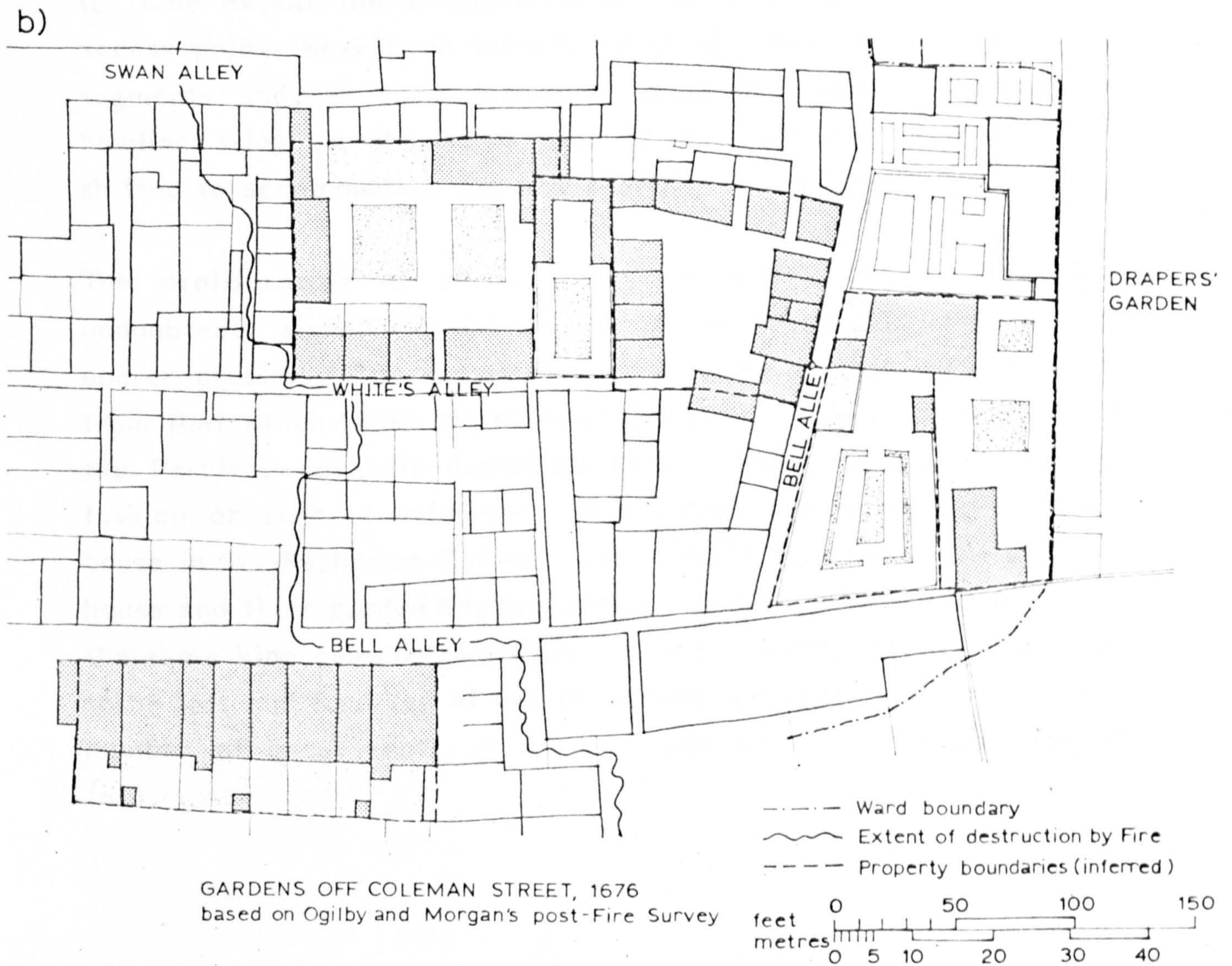
We are obliged therefore to generalise from one or two instances. A valuable early source to which we may turn is a survey of the Clothworkers' property in Bell Alley and White's Alley off Coleman Street, executed by Ralph Treswell, c.1612 (59). A simplified drawing of the plan is given in fig. 7.19. The property depicted consists of a series of gardens and tenements lying to the west of the Drapers' Garden. Each garden is either a single tenancy or part of

a tenancy, and building is in the main restricted to one side of the garden. The developed portion may be along the long side or the short side of the garden. Considering A, B, C, and D, the development is in each case along the north or south side of the garden, and consists of a single house, with three or more rooms on the ground floor, arranged with its long side against the boundary. The houses are reached by means of the alleyways, but access, in the case of A, B, and D, is from the inner face of the building. One assumes that the windows also were concentrated on this side in order to overlook the garden. Each house had a second floor, given over principally to chambers, and over this most had garret chambers. Both Mrs. Butler's and Mr. Streete's gardens contain a bowling alley. Mr. Backhouse's tenement (E) is, like the others, built against one side of the garden, but comprises three separate tenancies arranged around a courtyard, entered from Bell Alley.

If the same area is examined on Ogilby and Morgan (7.19b)), the gardens can still be made out without difficulty. Property boundaries would therefore appear to have moved very little in the intervening period. But within the confines of each plot, the number of buildings has multiplied dramatically. Mrs. Butler's garden (A) has acquired some narrow buildings along its west side, and a row of buildings, some with their own small gardens, has been erected on the bowling alley. The adjacent tenement seems to have gained an additional wing, so that the plan now forms a 'U' rather than an 'L-shape'. John Burges's garden (B) has a series of buildings in place of the original house, and a row of contiguous buildings against the western boundary. Further buildings have been put up on the eastern boundary, backing on to the alley, and the development extends at right angles along part of the southern boundary. Gardens C and D. are comparatively untouched, although both of the main buildings are now larger, and the bowling alley would seem to have disappeared.



GARDENS OFF COLEMAN STREET, c.1612
based on Ralph Treswell's Survey for the Clothworkers' Company



GARDENS OFF COLEMAN STREET, 1676
based on Ogilby and Morgan's post-Fire Survey

Fig. 7.19: Building development within interior segments

Allowing for inaccuracies and omissions in the Ogilby and Morgan map, it is clear that the general process of development has been one of accretion , units being added successively along the garden boundaries according to the same principles we have observed for the perimeter segments. The fundamental feature of the system, i.e. building around a space rather than into it, was clearly consonant with the original access structure of the gardens, and permitted the retention of grass plots or planted beds until a fairly advanced stage in the development. The use of stippling on Ogilby and Morgan would indicate that A, C, and D preserved enclaves of this sort at their centre in the post-Fire period. Garden B, however, which is now built up on all four sides, has apparently been transformed into a yard; it was presumably little more than an access space. The segments (i.e. former gardens) have at least one, but not more than three access points along their perimeter. In most cases the original access positions would seem to have survived and dictated to some extent the arrangement of the buildings. But additional access points have been introduced in the most densely developed segments and, in some instances (e.g. the passage through the bowling alley on the south side of A), the access points have shifted to accommodate the new building development.

The proliferation of small tenements within the garden plots undoubtedly signals an increasing occupation of the land by the poorer classes. The social decline was perhaps not very different from that which befell Northumberland House, the City residence of the Percies, on their departure (60). When, through pursuit of fashion or fear of infection, the Percies moved westward, their house in St. Katherine Coleman and Aldgate Ward became a gaming-house and their garden bowling alleys. But the many other places of the same kind caused "this their ancient and only patron of misrule to be left and forsaken of her gamesters and therefore turned into a number of great rents, small cottages for strangers and others" (61).

Each of the dwellings shown in gardens A to D on the Treswell plan appears to have survived until Ogilby and Morgan's time, or to have been replaced by another in the same position. Whatever the exact history of the individual houses, they clearly remained the reference point for all later development within the segments. This was possible because the buildings escaped the wholesale destruction of the Great Fire. As can be seen from Ogilby and Morgan, the Fire died out just ^{to} the west of garden A, arrested probably by the open space of the garden. But the fifth tenancy, E, lay within the burnt area. It is interesting, therefore, to compare the development of this garden with the others. While the early layout was similar to that in the rest of the Clothworkers' property, the tenements being located at one end of the plot, the post-Fire development is organised in a completely different way. The segment is now occupied wholly by a row of dwellings, all of which face on to Bell Alley and have their own private gardens at the back. Access is evidently direct from the alley. The process here is one of replacement rather than accretion, and the new development has taken a form comparable with that along the street edge. This change may be attributed to the importance of the alley as a thoroughfare. It appears to have functioned much like a street or lane, providing both a through-route within the block and a means of access to houses on either side.

The dominant process to emerge from the Clothworkers' property is, nevertheless, incremental or accretive development, and the rules followed in this development were identical to those which applied in the perimeter segments.

Documentary evidence, as already pointed out, is scant. It is valuable more for the insights it provides into contemporary attitudes to the spread of building than for specific information on garden development. The 'Device' prepared in the reign of Elizabeth to be offered to the Lords of the Privy Council, recommended among other measures "A remedy for new buildings in gardens, where now are habitations, and many times incontinent acts, and the sale of men children by private contracts, etc. as Bridewell Knoweth". There

was concern also to prevent encroachment on common land, and the formation of new gardens: "The City of London hath ever had, and now most meet it should have, their free and open walks in the fields about the City, and namely in Moorfields, and some other fields, where groundes have been enclosed for gardens, and new dwellings there builded" (62). The latter is of interest since it supports the hypothesis that the processes of enclosure and building were intimately related. Buildings were not put up in undifferentiated space but were, as accepted practice, set out in relation to bounded and defined plots.

A passage in one of John Chamberlain's letters of 1602 reads: "The Council have lately spied a great inconvenience of the increase of building within and without London, by building over stables, in gardens and other odd corners ; whereupon they have taken order to have them pulled down ; and this week they have begun almost in every parish to light on the unluckiest one here and there which, God knows, is far from removing the mischief" (63)

The fear is echoed again in a tract published in James I's reign. Remarking on the houses built by great and rich citizens, the author writes : "These sortes of Buyldinges were erected for private and necessarie uses by the parties that fyrst buylte them ; but when as by deathe or otherwise they parted from them, and that they came to the hands of such who either for necessitie or covetousness divided them and rented then out, then presently after these doth enter and dwell in them, either those sorte of lewde people wch are before mentioned, or a worse sorte than they wch are Papistes, who in thes places of covert doe shrowde themselves in such sorte, as when they cannot hyde themselves in any parte of the lande else where but they shall be espied, yet here they can shrowde themselves in some divided place or garden-house , and doe them both use their superstitious services (drawinge many of the weaker sorte of his Matie's subjects unto their false worship of the true God;) also doe these plotte all their treacheries and wycked attempts whatsoever, bothe against the King's Majestie, the State and their own Countrie" (64).

More sober accounts are to be found in the schedules of newly erected buildings. Illegal building is recorded in Swan Alley, (not, unfortunately, the Swan Alley off Coleman Street, but another near the Wardrobe), in Houndsditch and the Minories. In one case in Cursitor's Alley, Chancery Lane, the Commissioners for Building managed to stay the clandestine activities of George Peck, who "was pretending to build walls of brick around a field in which to keep tame coneys, but it was really a blind to conceal tenements" (65).

The general trend is clear. But the process description towards which we have been working must remain somewhat speculative in the absence of more comprehensive and detailed historical information. Two main rules emerge, both of which have already been identified as underlying the perimeter segment developments: 1) units are built against the segment boundaries; 2) units are contiguous.

The frequent alignment of the front walls of contiguous buildings suggests that buildings were often put up in groups or rows, rather than singly. It also suggests that the internal segments were viewed as a gestalt, and not as a mere accumulation of entities (buildings, spaces). In both respects, the interior segments correspond to those on the perimeter. It is nevertheless difficult to establish a unique sequence of development for internal segments, since individual examples clearly developed in different ways. While it was common - not surprisingly - for the first building or row of buildings to be placed along the access side of the segment, the next row might be built against either of the side boundaries or against the back boundary.

Close examination of the yards and building configurations within the suburban blocks to the north of the City wall also suggests that in certain instances additional rows of buildings were put up within a segment. Thus, a segment might be developed

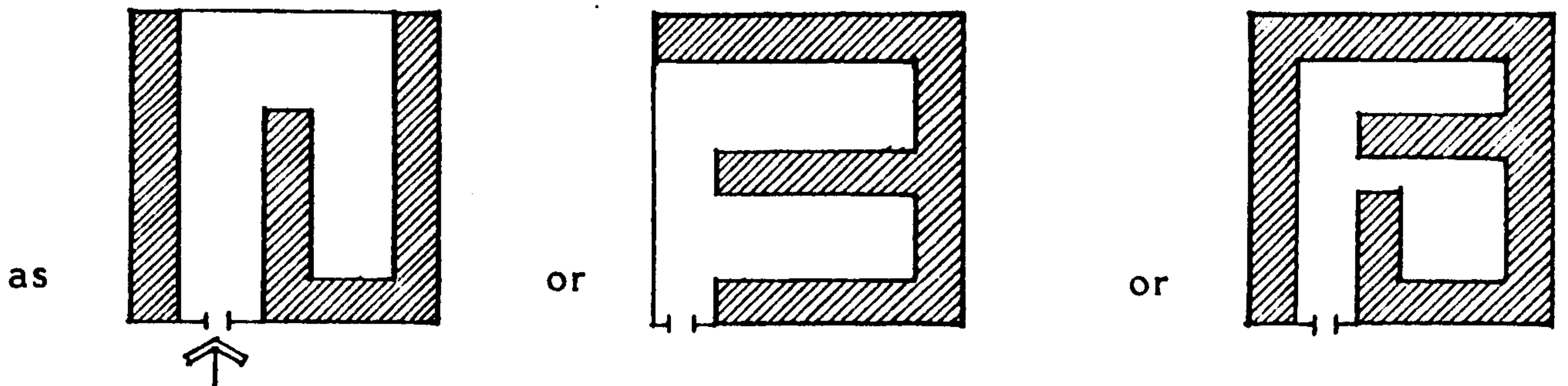


Fig.7.20: Three types of within-segment development.

It would nevertheless appear that the various types of within-segment development were relatively infrequent. Although the proportion must have varied from block to block, we would estimate that, in general, configurations of this kind formed not more than 20%, and in most cases less than 10% of the interior segments of a large block. It would seem justifiable, therefore, to omit this type of development from our general picture. Should the reader wish to include these configurations in the model, we would suggest that this might be achieved by regarding the interior segment as divided into four equal parts. The 'within-segment' strips might then be generated with reference to the boundaries of these subdivisions, applying the rules already given, i.e. build against boundary, add units contiguously. A full taxonomy of configurations is included in the appendix.

Boundary development thus remains unquestionably the fundamental process. Moreover, if it is not possible to arrive at a single sequence of development, empirical evidence does indicate that certain lines of development were much more probable than others. A number of areas were selected for analysis from the northern and eastern suburbs, as depicted on Ogilby and Morgan. The main criteria governing the choice were : 1) that the blocks were large enough to contain a substantial number (20 or more) interior segments, and 2) that the blocks had been at least partly developed before 1600. The latter condition was designed to ensure some

measure of continuity in segment boundaries, and to avoid any peculiarities that might arise from the planning and building practices of seventeenth-century speculative developers. In each case, the interior zone was marked out and subdivided into what were considered to be the main property divisions, i.e. the segments. It needs to be underlined that the reconstruction of segment boundaries is highly suppositional, since it is based entirely on visual inspection of the map. Even if the possible errors and omissions of the survey are discounted, a large allowance has to be made for errors of interpretation. Identification of boundaries is most hazardous for single -, as opposed to double-pile development, as the map provides few clues as to which is the front face, and which the back face, of a row of dwellings. In the case of double-pile or back-to-back development, the boundary between segments may generally be assumed to coincide with the line (back wall) between the two rows ; in the case of single-pile development, where both front and rear walls are aligned, the boundary might lie along either face. Given these considerable reservations, however, it is possible to identify and record the building configurations and access points for each interior segment, and thus to establish the frequency of the different types of configuration. This has been done for three blocks : Grub Street - White Cross Street, to the north of Cripplegate; Cow Cross - St. John's Lane, to the north-west of the City wall, the former site of St. John's Priory ; and Houndsditch -Petticoat Lane, outside Aldgate. The results of the analysis are summarised in tables 7.2 - 7.7.

The configurations are classified in the tables according to the number of sides of the segment which are developed - one-sided, two-sided, etc., - taking into account the various combinations or arrangements of each, and the orientation of the segment. The segments listed under any type are not necessarily fully-developed along the sides in question, but have some building along each of those sides. Two forms of orientation have been used: in tables 7.2 - 7.4, all configurations are oriented in relation to the main access point (from the perimeter zone), which is placed along the bottom edge of the segment; in tables 7.5 - 7.7, the configurations

are shown in relation to the geometry of the segment, the vertical dimension representing the length, and the horizontal dimension the width.

From the results presented in these tables, it is clear that interior segments are much less likely to be maximally developed than those on the perimeter. In two of the three blocks (St. John's and Houndsditch), over 75% of all interior segments have buildings on two sides or less. The third block - Grub Street - is comparatively densely-developed, but, even here, only about 40% of all the interior segments have three or more sides developed. Four-sided development is uncommon; segments with this configuration seldom constitute more than 5% of the total and, in some blocks, none is developed to this extent. The St. John's site is a slight exception, with 7.5% (5 no.) of interior segments developed on four sides. Considering the lower end of the scale (configurations 1-8 in tables 7.2 - 7.4), the balance or mix of configurations would seem to vary from block to block, presumably reflecting the stage reached in the process of accretion. Two-sided configurations preponderate over one-sided forms in both Grub Street and Houndsditch, this being most marked in the former, where about 50% of all the interior segments are developed on two sides, and only 7.5% (2 no.) have one-sided development. The corresponding figures for Houndsditch are 38% as against 25%. A balance of 30-50%/10-30% would seem to be prevalent among suburban blocks. In the case of St. John's, however, this balance is reversed, with one-sided configurations making up 41% of the total, and two-sided arrangements, 20%.

With regard to the sequence of development, it appears from tables 7.2 - 7.4 that the first strip of building could occur on any of the four sides, but that it was most frequently placed on either the access side or one of the two adjoining sides. At stage 2 (two-sided development) the 'L-shaped' configuration is by far the most common, comprising at least 70% of two-sided configurations in both Houndsditch and St. John's. A high frequency of the 'L-shape' would be predicted on the grounds of statistical probability. Hence,

there seems to be a close agreement between the random and observed patterns here. Development on opposite sides of the segment could take place in either direction in relation to the access point. But tables 7.5 - 7.7 indicate a preference for the long, rather than the short sides of the segment. This is an intuitively plausible result, as one would assume that the builder/owner would, *ceteris paribus*, want to maximise his use of the site boundary and, at the same time, minimise the walking distance between the two separate blocks.

At stage 3 (three-sided development), the configuration may also be oriented N-S or E-W in relation to the access point. But, once again, a preference for the two long sides of the segment is evident. The lengthwise configuration - two long sides plus one short side - predominates in all three blocks. This result reinforces the bias already noted for the stage 2 configurations. Few segments reach stage 4, and at this point there is, of course, only one option available.

It would appear, therefore, that the pathway or sequence of development within a segment was neither predetermined nor random but, rather, probabilistically dependent upon the geometry and the access characteristics of the segment. Accordingly, it would seem to be possible to assimilate the majority of actual examples to a limited number of prescribed pathways of development. It is appropriate to conclude this discussion, and the chapter, with a concise process description of the most probable modes of growth. If the access and dimensional characteristics of the segments are brought together, two orientations need to be considered. For each of these, two main sequences may be observed, the instructions for which are as follows :

(A)

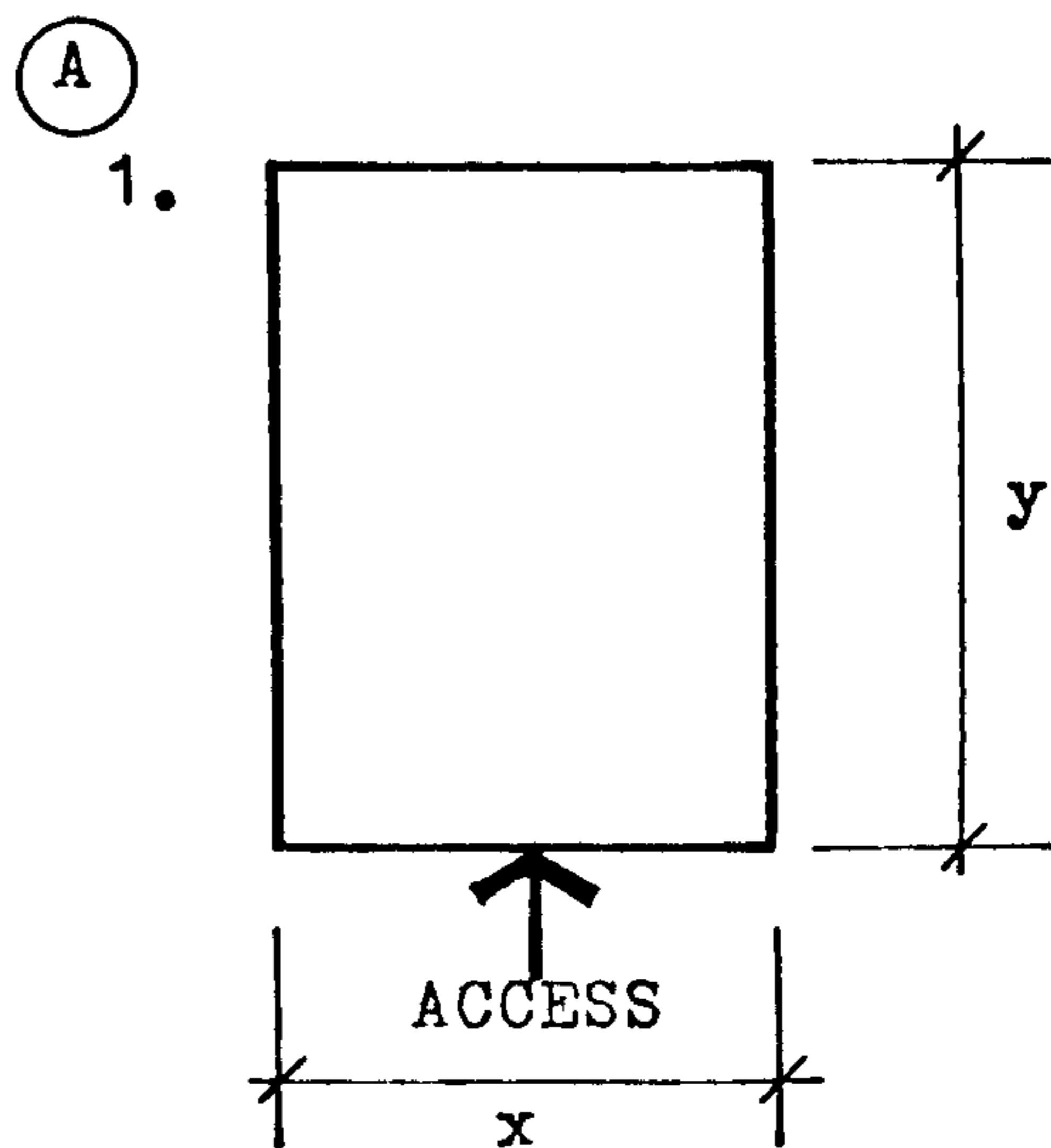
1. Take any interior segment $x \times y$, in which x = width and y = length, and the main access lies along one of the two shorter sides.

$$30'0'' \leq x \leq 70'0''$$

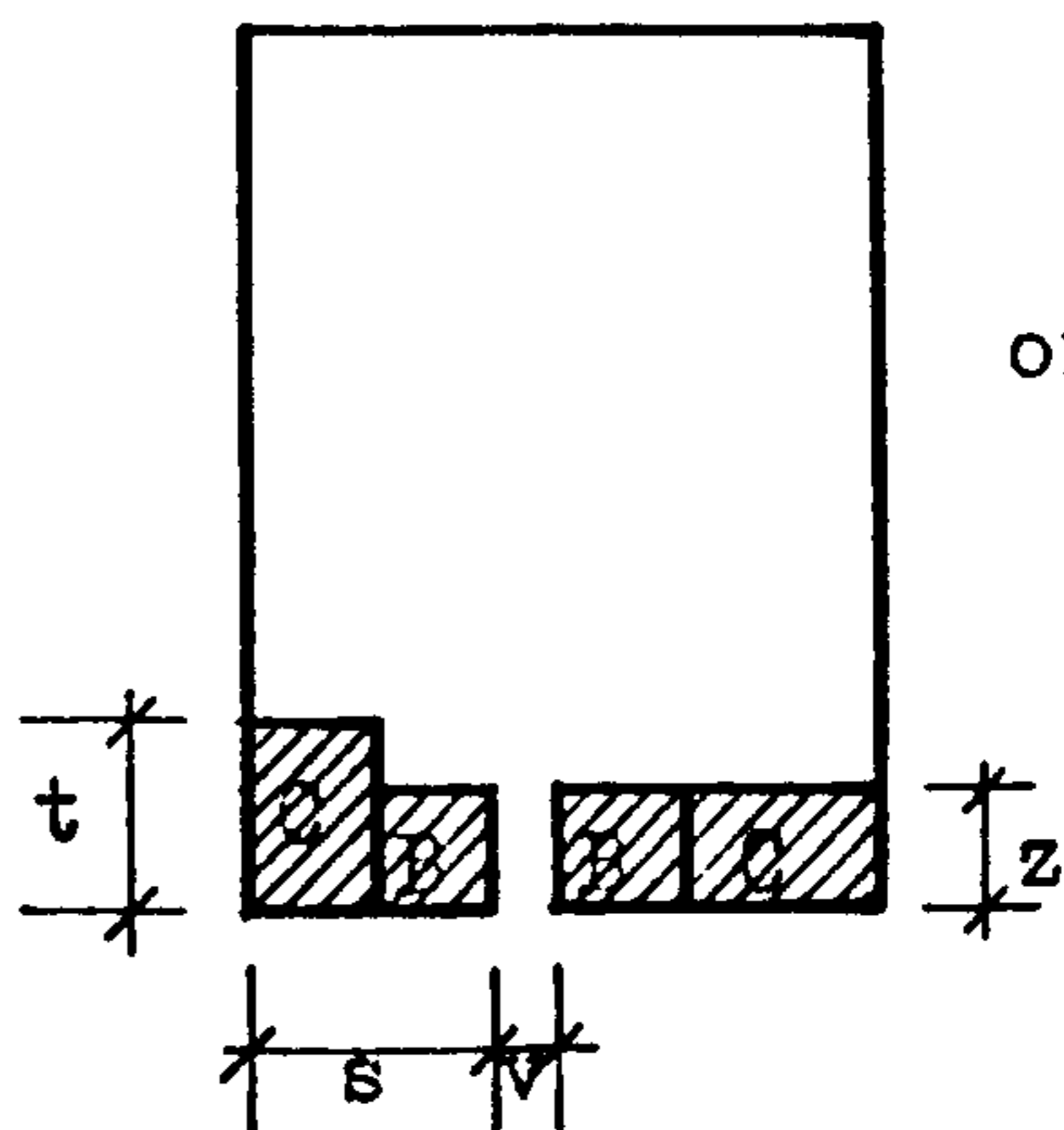
$$50'0'' \leq y \leq 100'0''$$

2. Build the first row of units along the access side (a) or along one of the two long sides (b). Row to be composed of units B, except at corners, which are to be completed with special units C (see perimeter development). All B units to be square and congruent. Depth $z = 10'0'' \rightarrow 25'0''$.

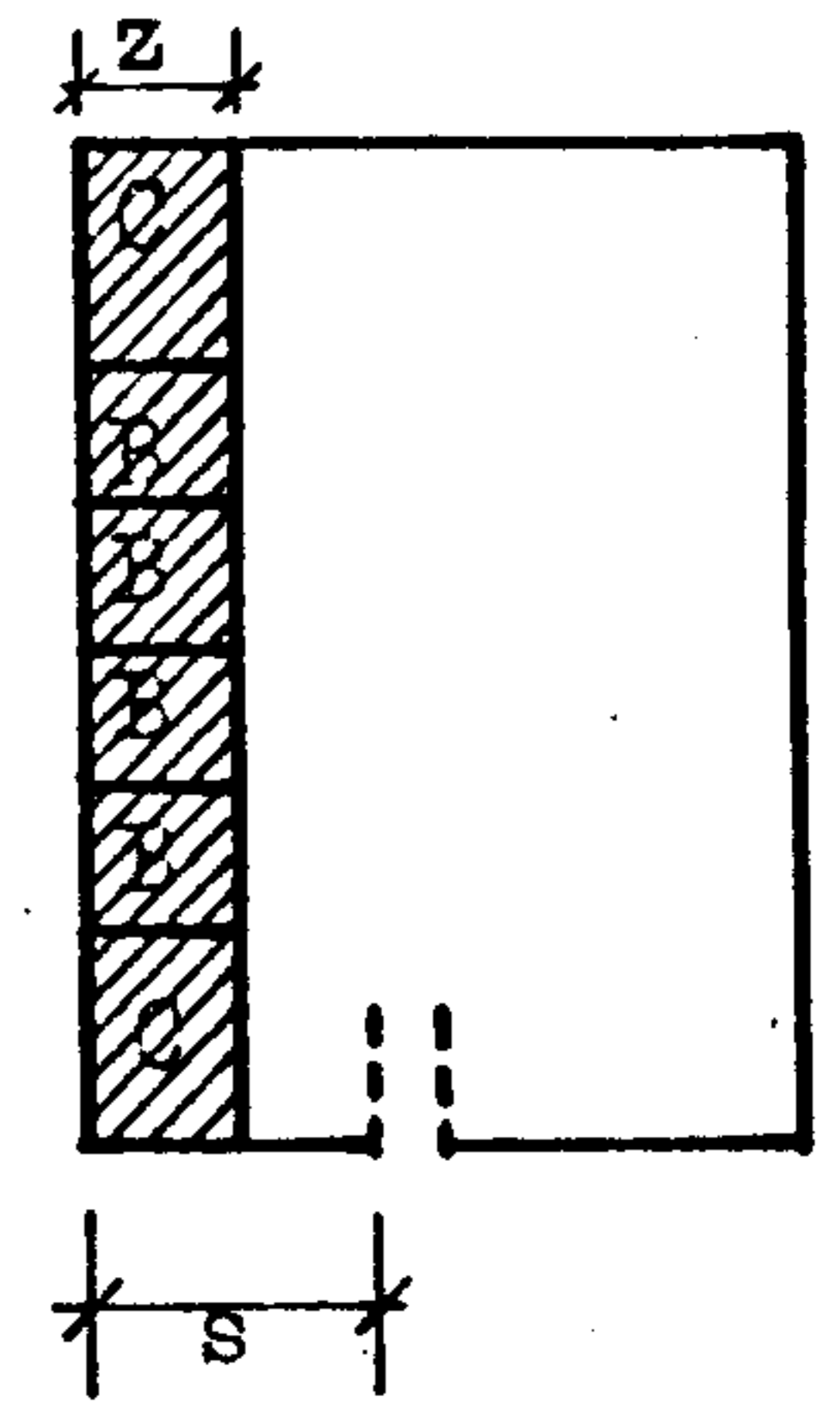
In case a), where $s \geq 10'0''$, develop firstly towards L.H. boundary. Access passage to be not less than 5' and not more than 10' in width (v) and to run the full depth of the units. Develop towards R.H. boundary: place first unit to R.H. side of passage, with back wall coincident with access boundary of segment; add units contiguously, completing the



2. a)



b)



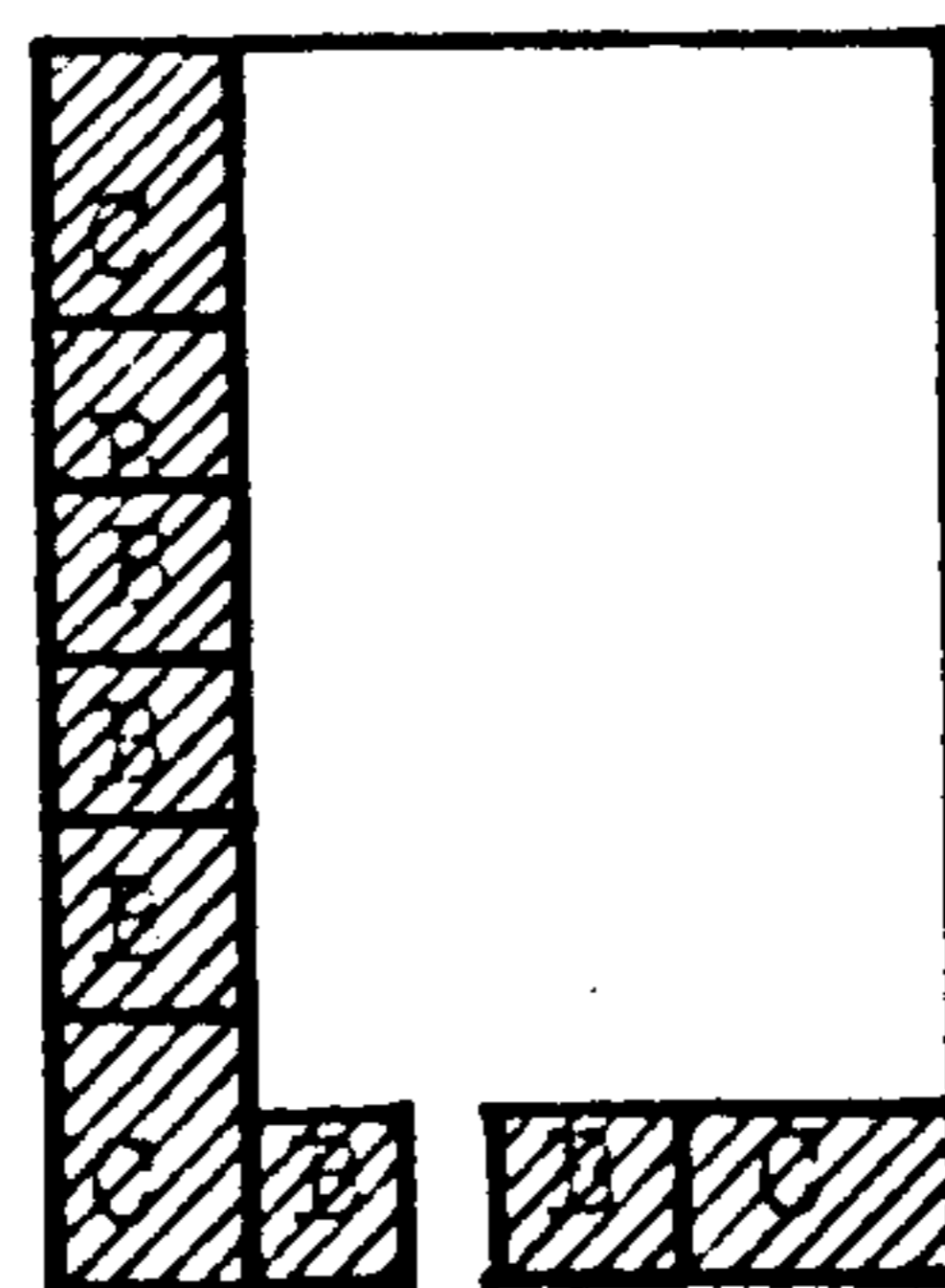
OR

row with corner unit C.
 Where $s < 10'0''$, leave L.H. space empty and build only towards R.H. boundary.
 In case b), where $s > 10'0''$ begin development along L.H. boundary with corner unit C.
 $z \leq s, t \geq z + 5'0''$. Where $s > 10'0''$ leave empty space $s \times t$ and begin development with B unit. Complete development as on access side.

3. Build row 2 as 3a) or 3b).
 Place first unit (type B) along segment boundary adjacent to that already developed, with side wall of unit against front wall of corner unit C and back wall against boundary. Complete row as before.

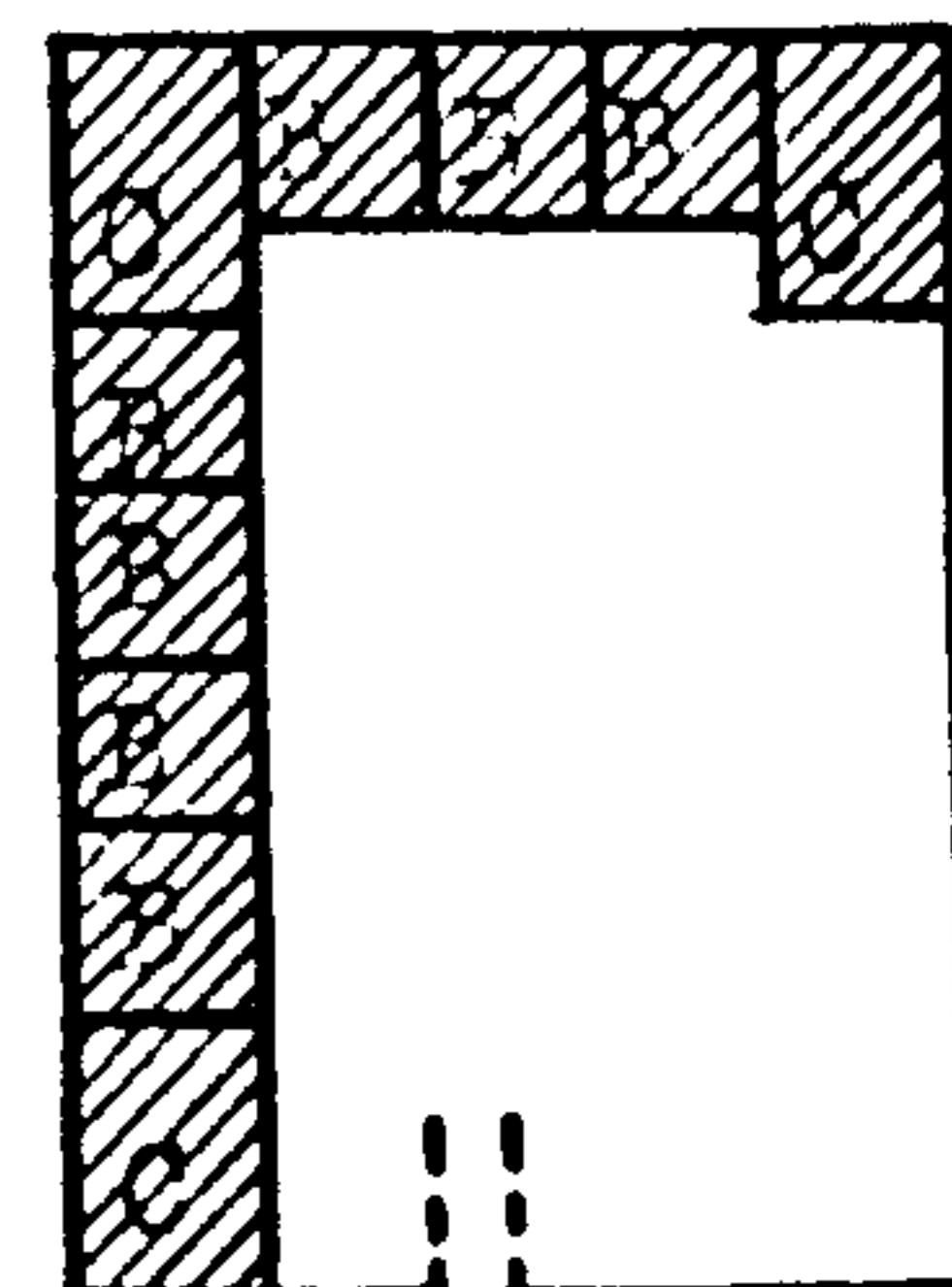
4. Build row 3 at right angles to row 1 or 2. If 3a) develop as 4a). If 3b) develop as 4b). Begin with type B unit and end with type C unit as before.

3. a)

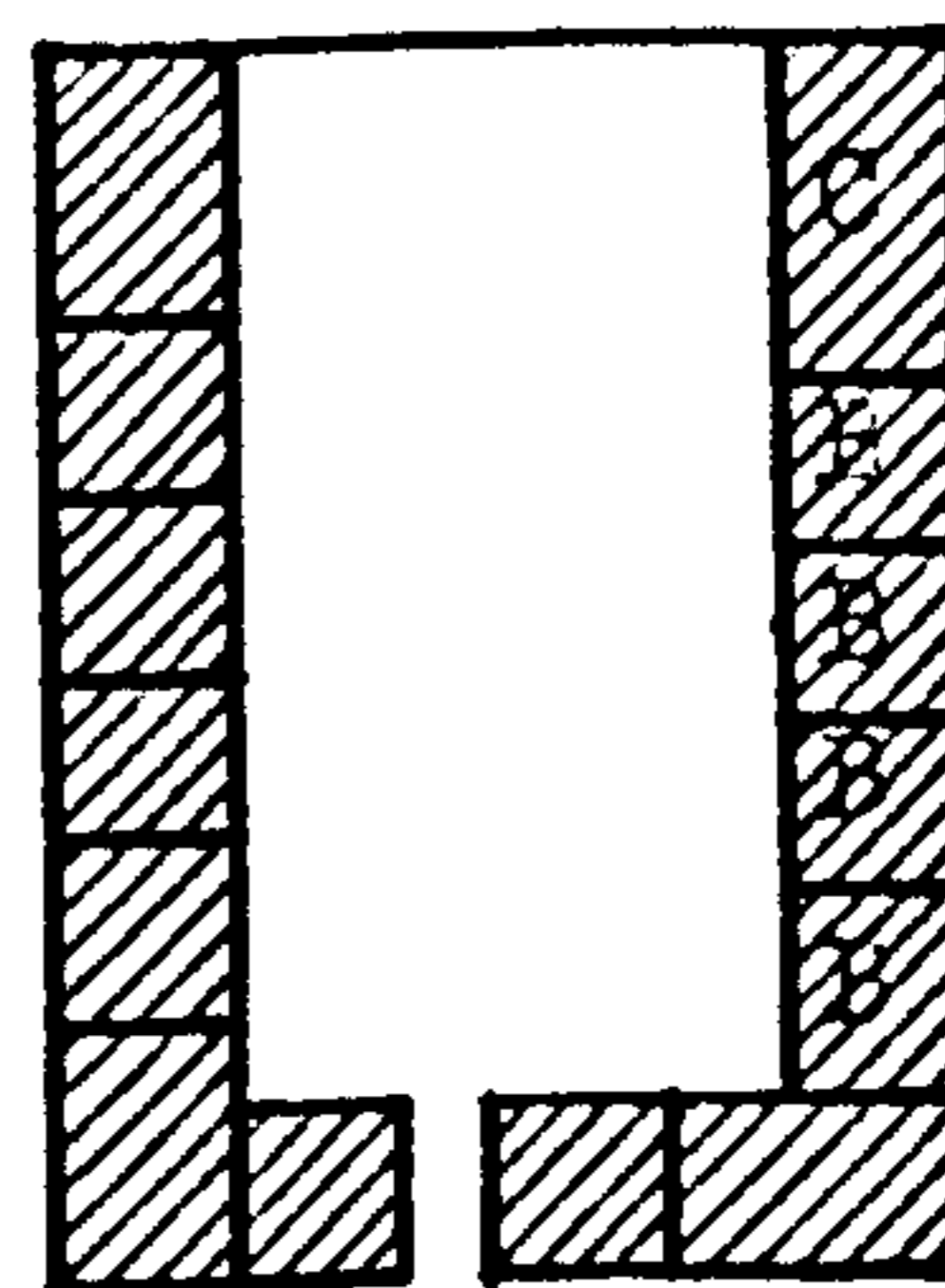


b)

or

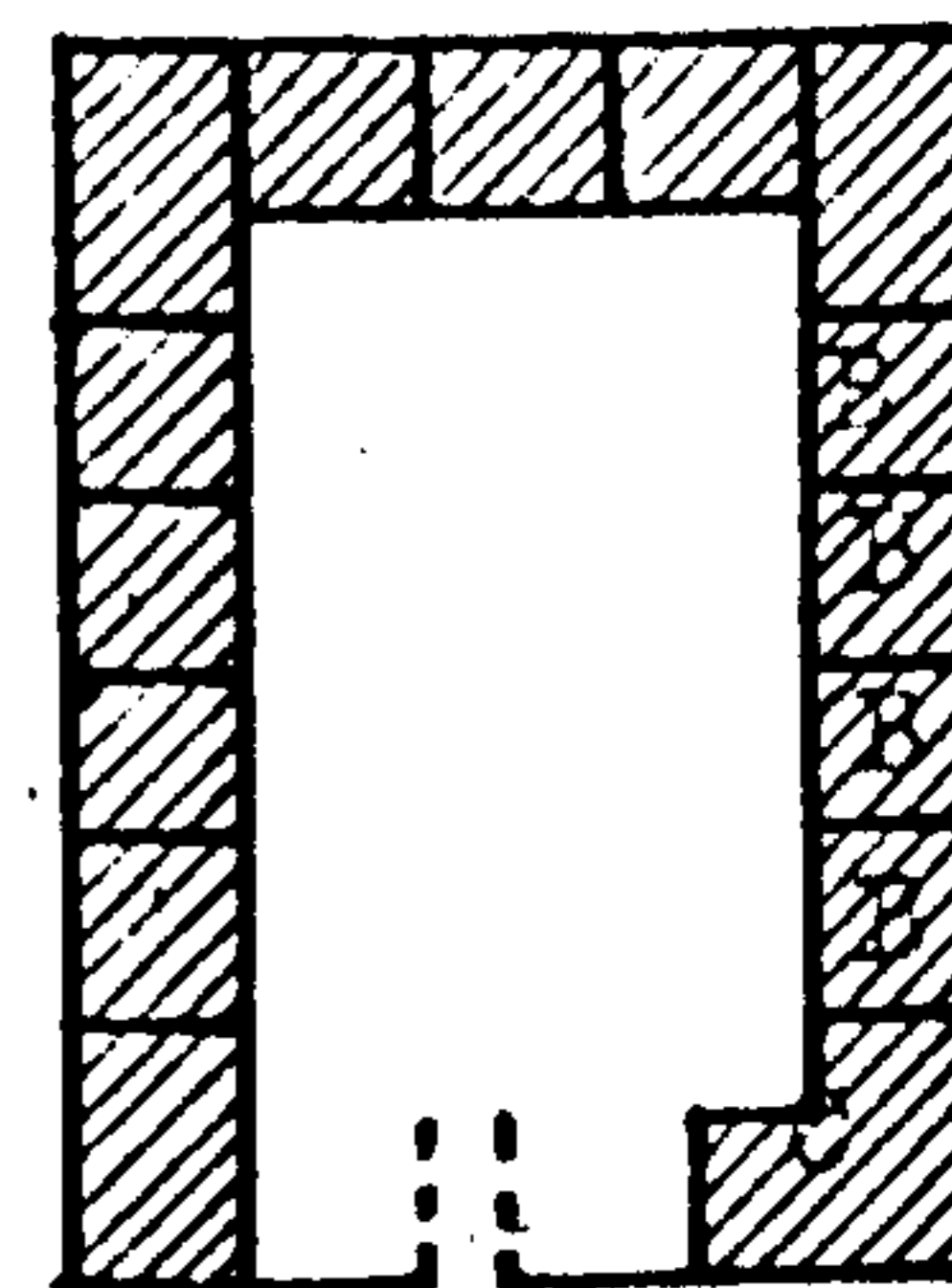


4. a)



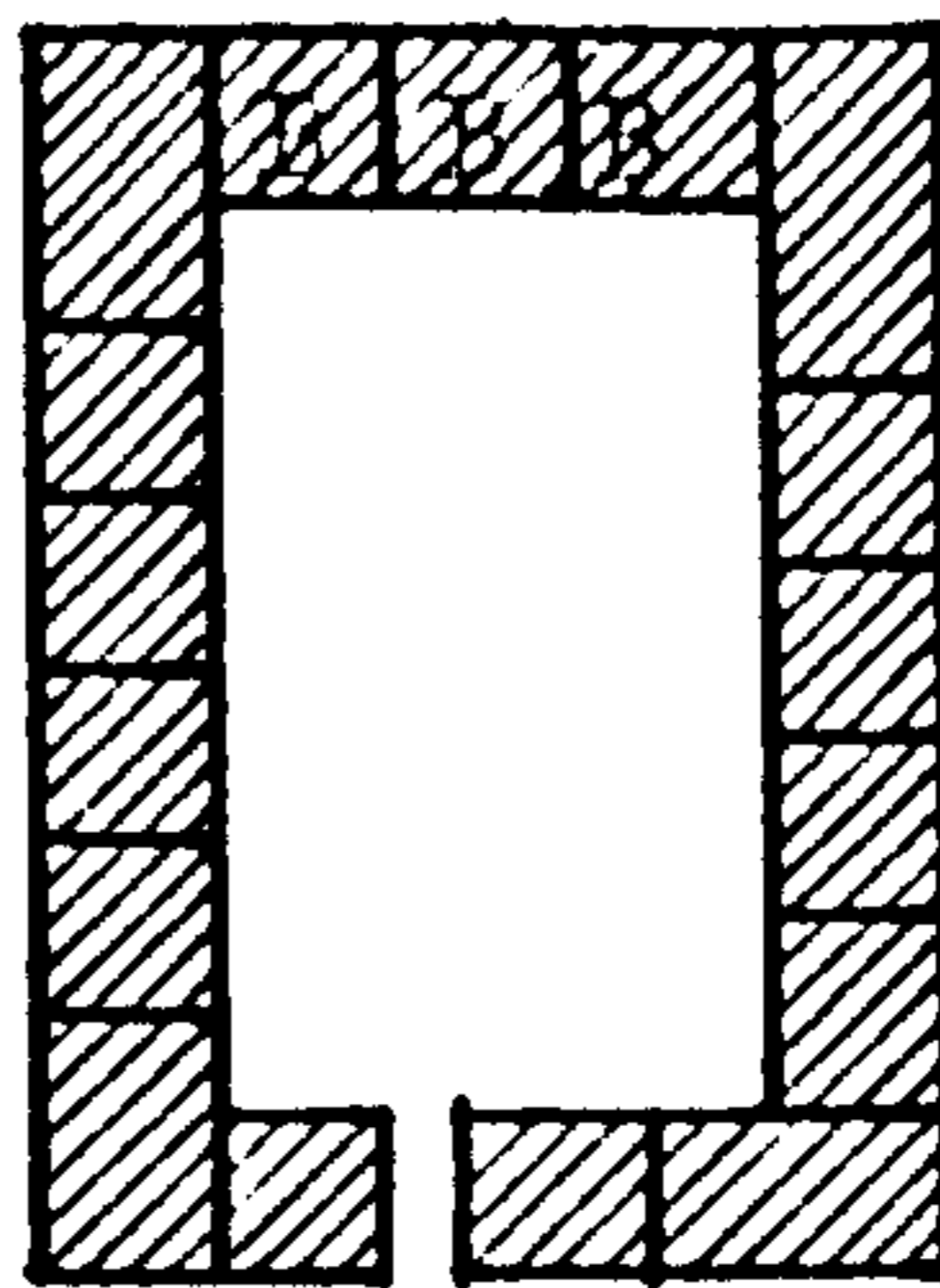
b)

or



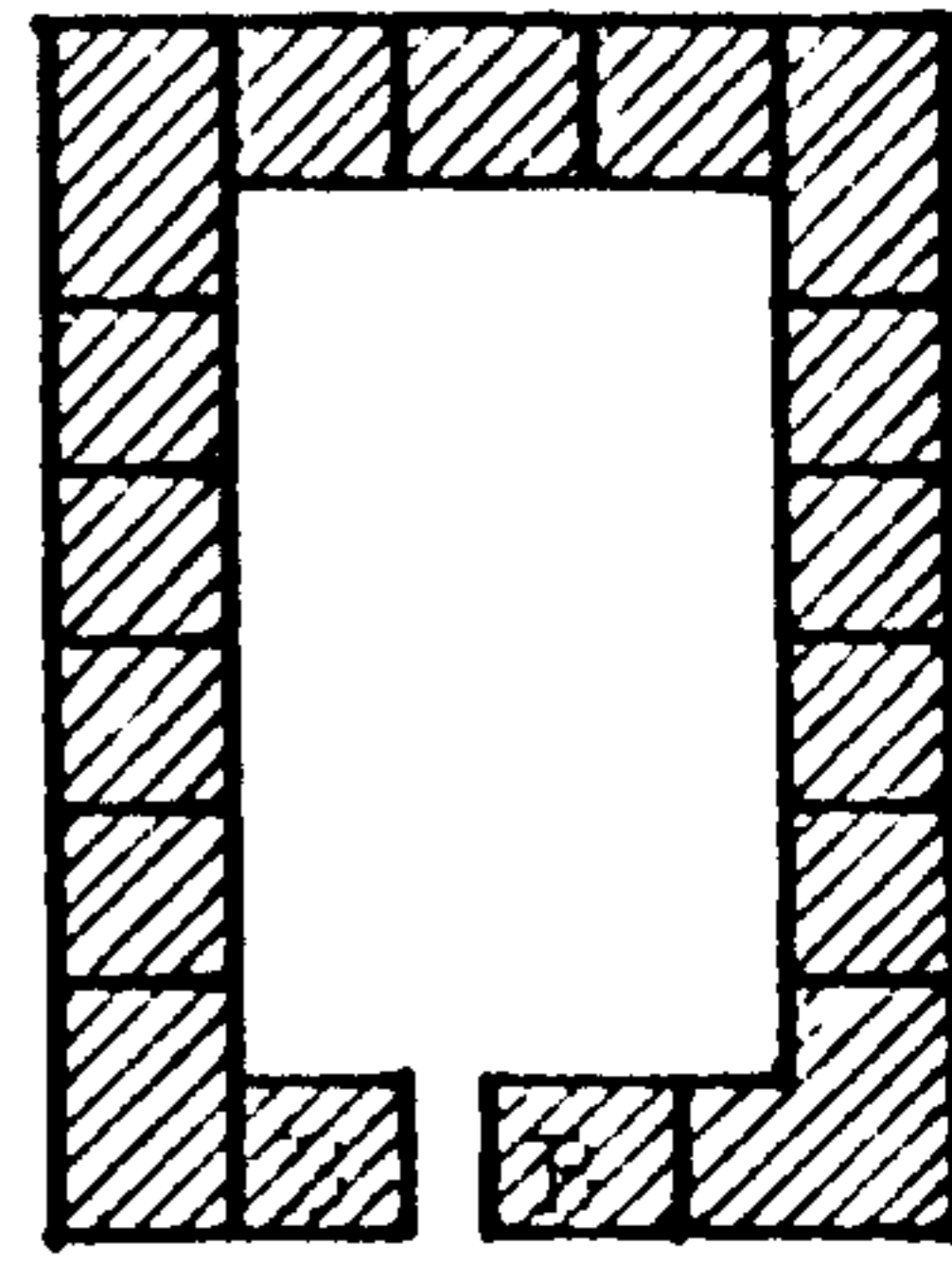
5. Build row 4 at right angles to row 3. Where development began along the access boundary (2a)), and row 1 extended to both L.H. and R.H. boundaries, final unit B is to be contiguous with corner unit C. If L.H. portion of access boundary was left undeveloped, and row 4 is along L.H. boundary, terminate development at distance t from access boundary. Where development began along the L.H. boundary (2b)), and extended the full length of the boundary, final unit B is to be contiguous with corner unit C, unless this is contiguous with the access passage, in which case the final unit should terminate at distance v from the corner unit. If the space between the L.H. boundary and access passage was left undeveloped, and row 4 is along the access boundary, terminate development at distance $s + v$ from L.H. boundary..

5. a)



or

b)



(B)

1. Take any interior segment $x \times y$, in which x = width and y = length, and the main access lies along one of the two longer sides.

$$\begin{aligned} 30'0'' &\leq x \leq 70'0'' \\ 50'0'' &\leq y \leq 100'0'' \end{aligned}$$

2. Build first row of units along access side (a) or one of the two short sides (b). Rules of development as (A).

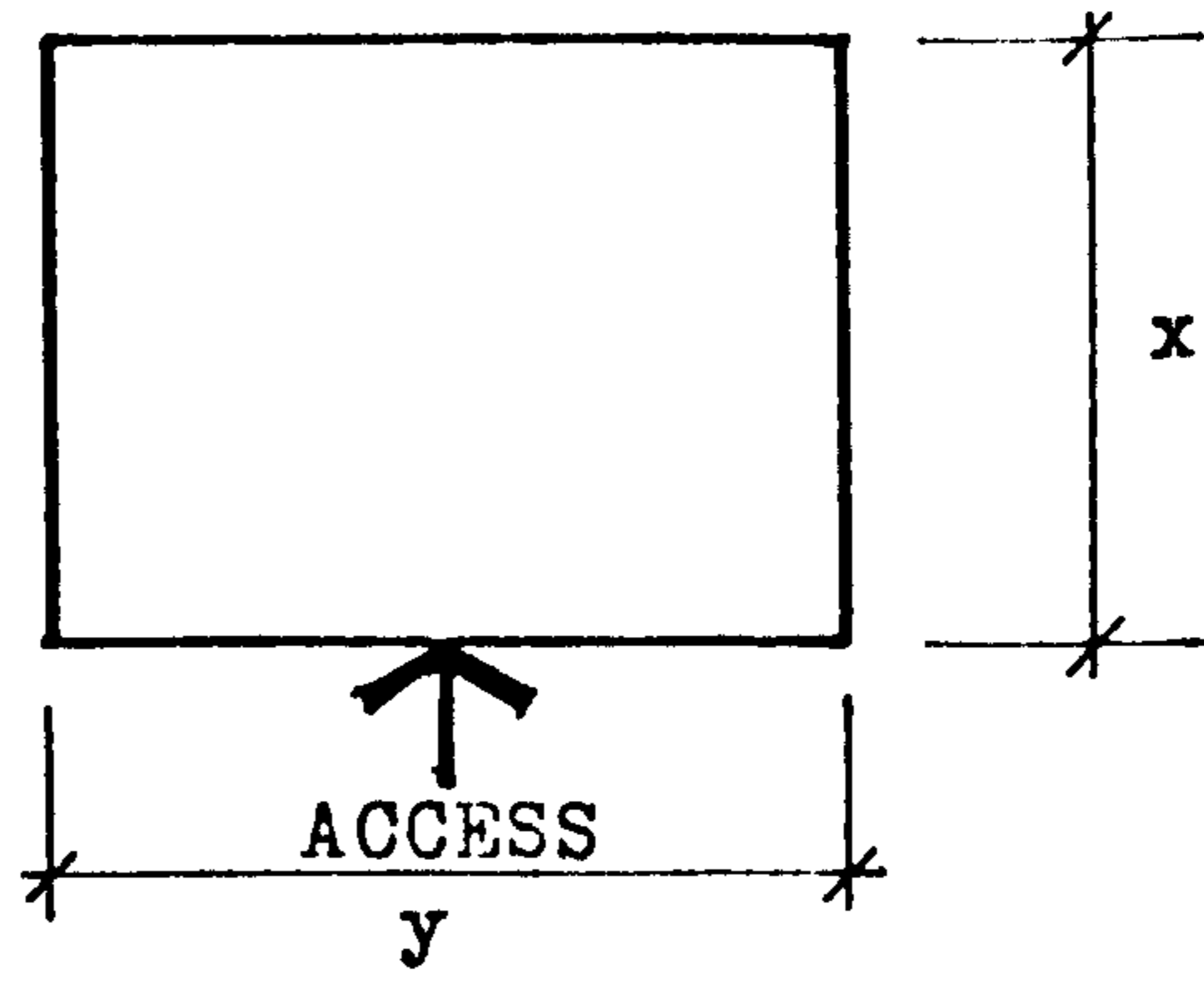
3. Build row 2 along one of the sides adjacent to that already developed. Rules of development as (A).

4. Build row 3 along the long side of the segment opposite to that already developed. Rules of development as (A).

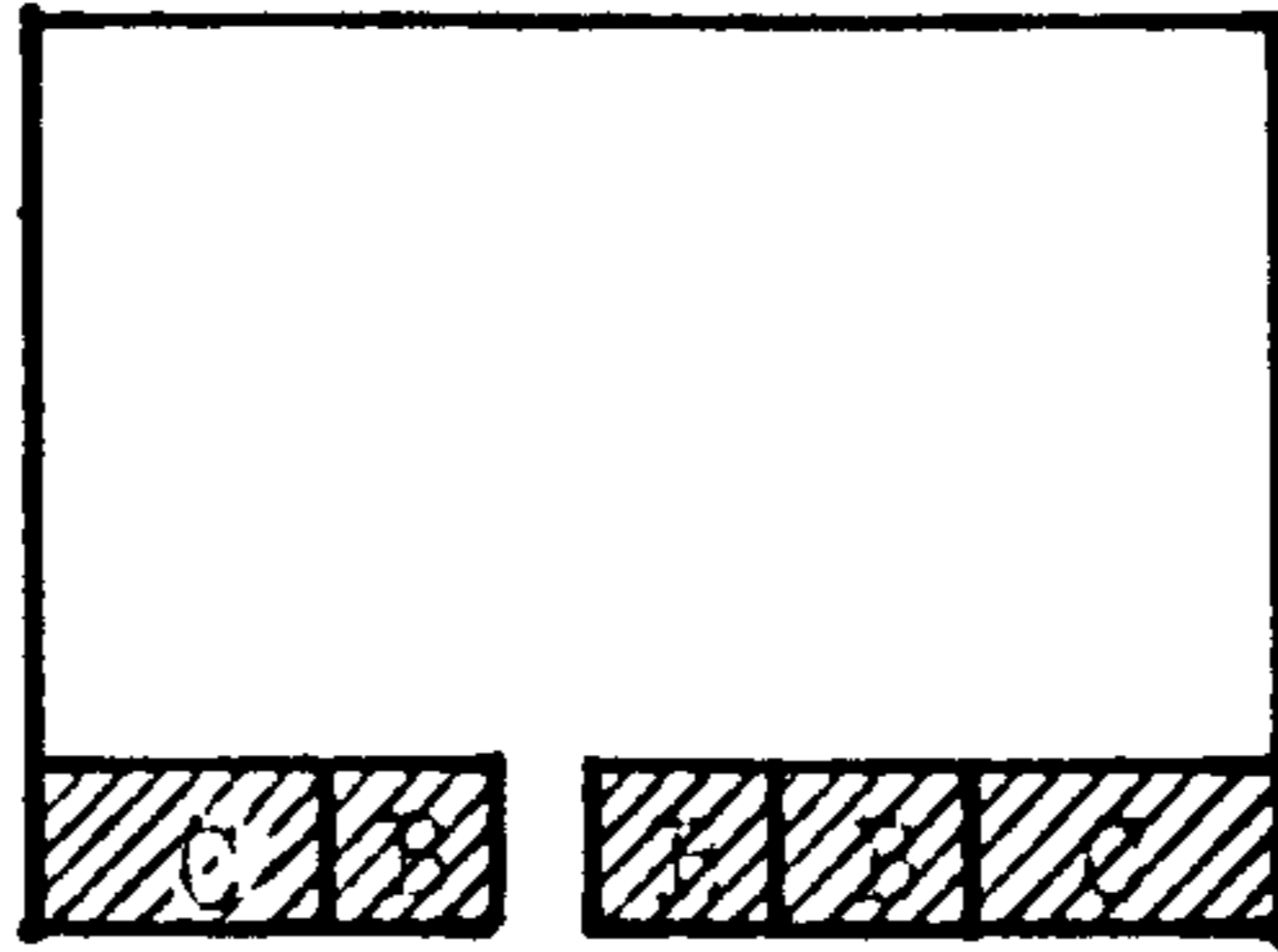
5. Build row 4 along the remaining undeveloped side of the segment. Rules of development as (A).

(B)

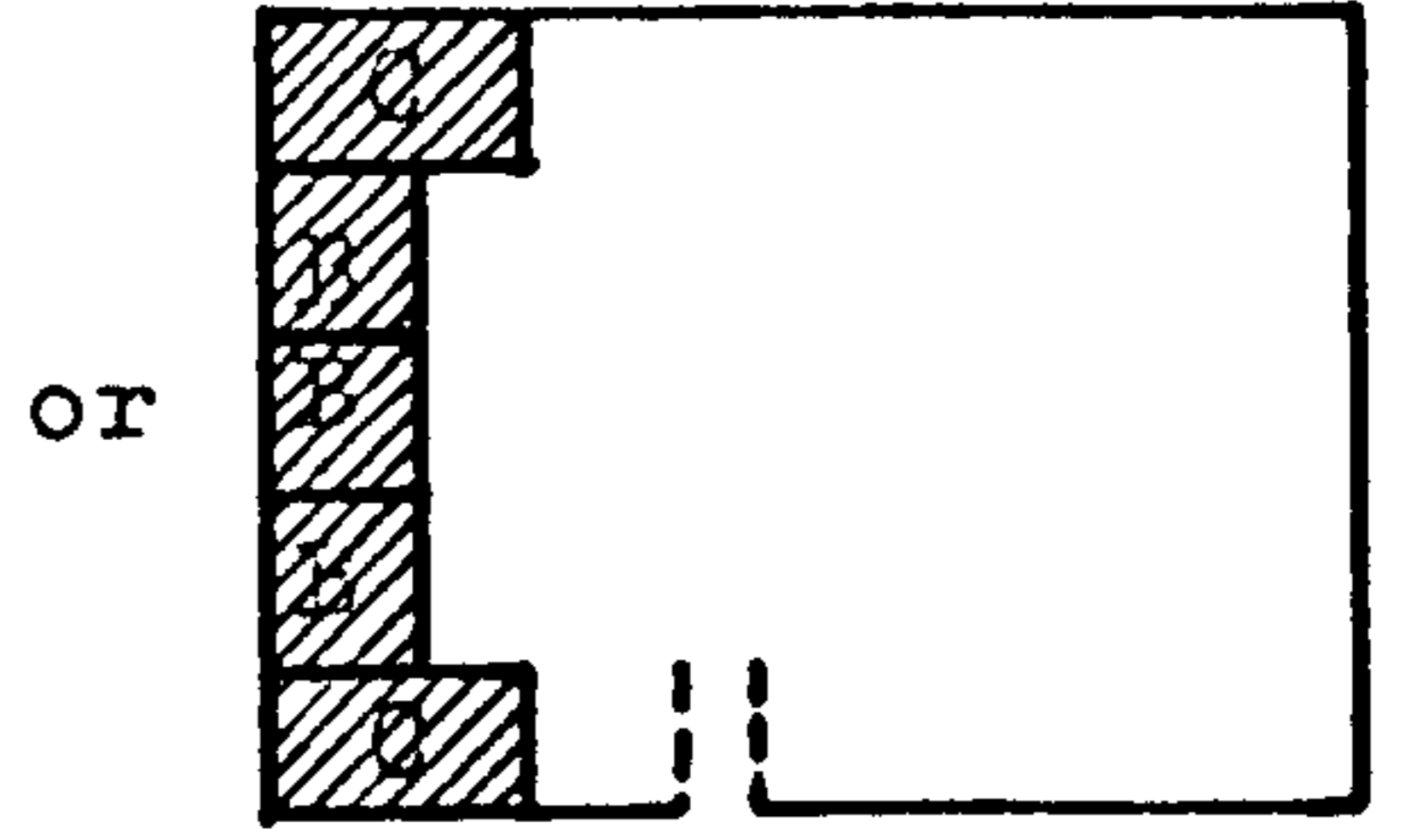
1.



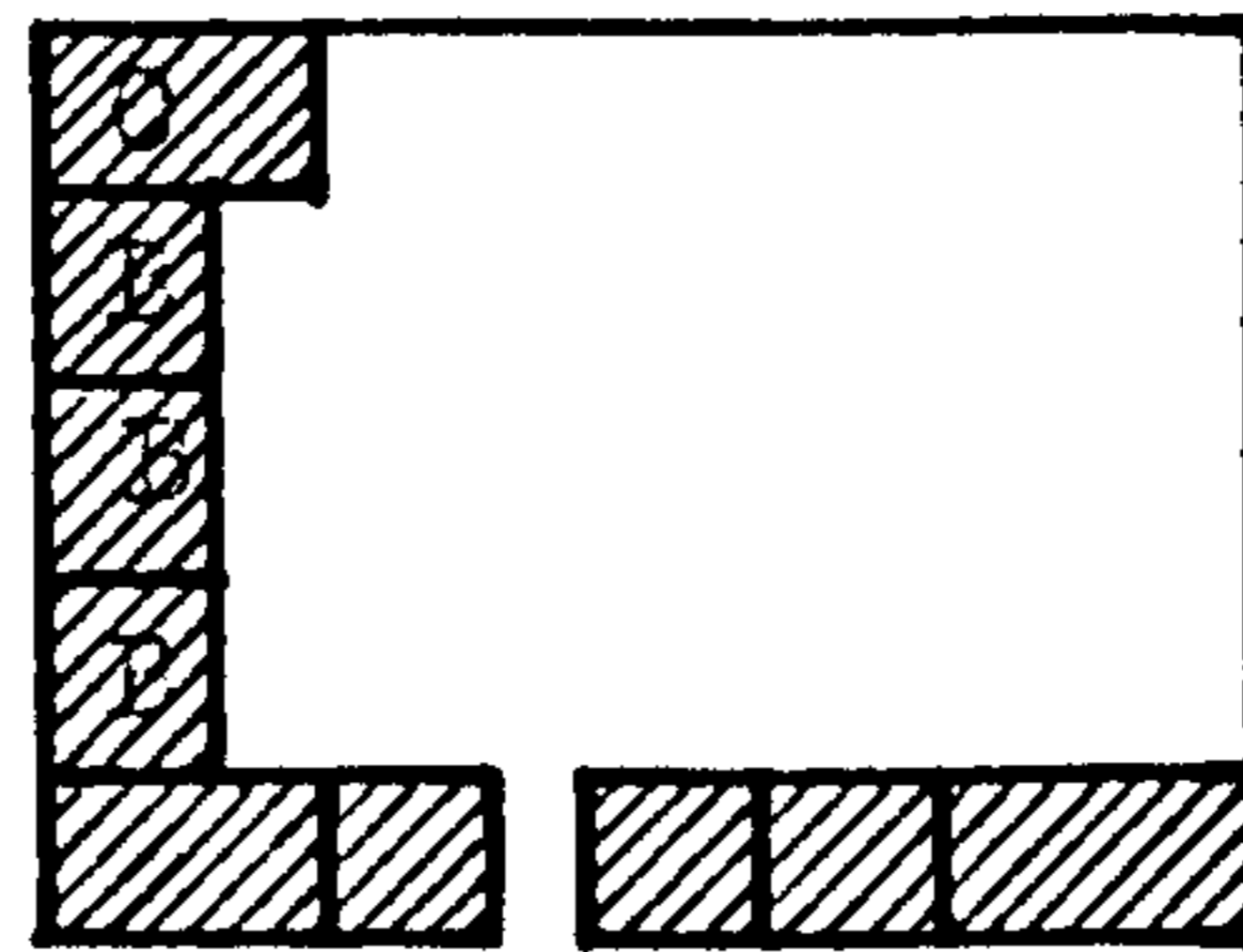
2. a)



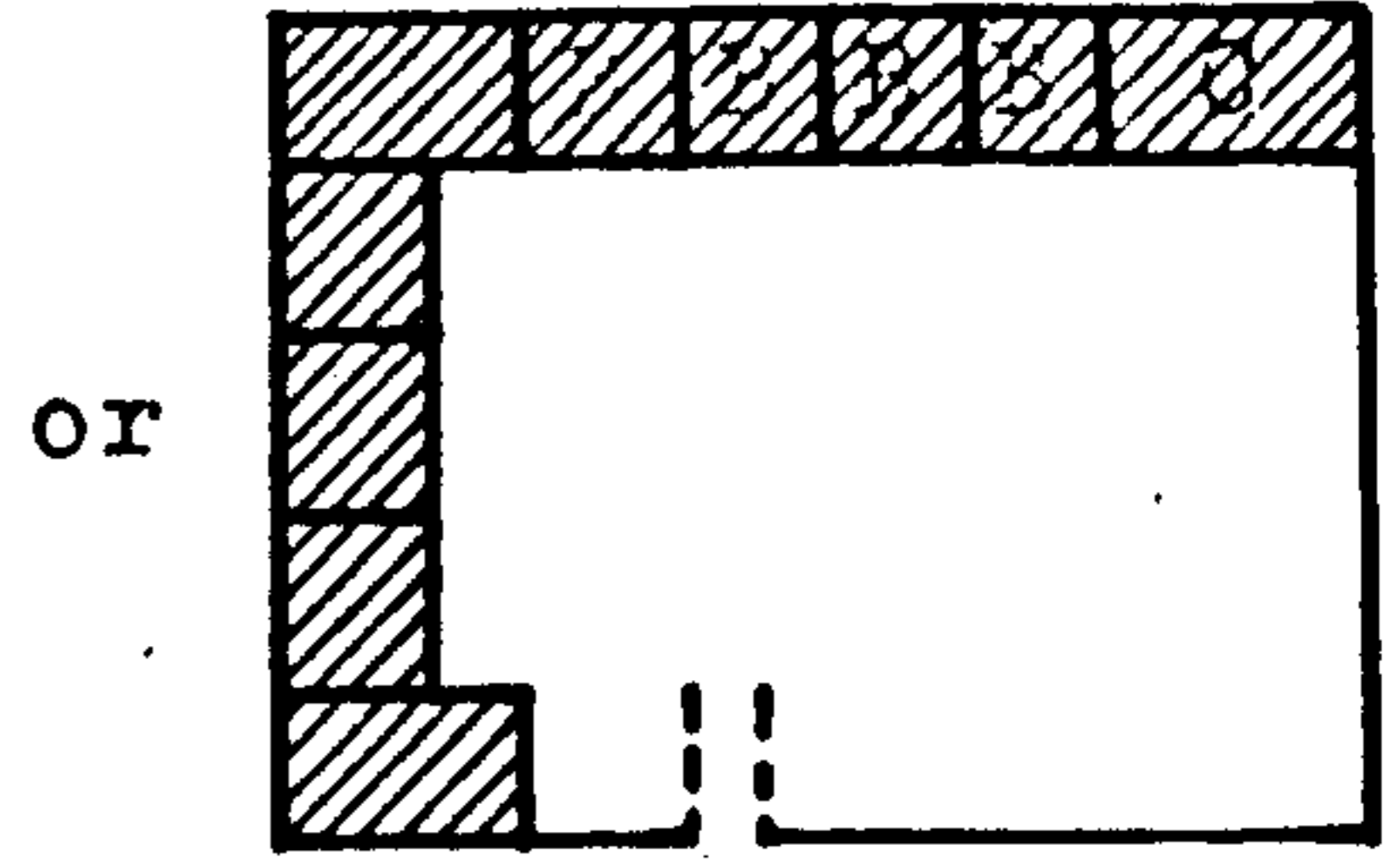
b)



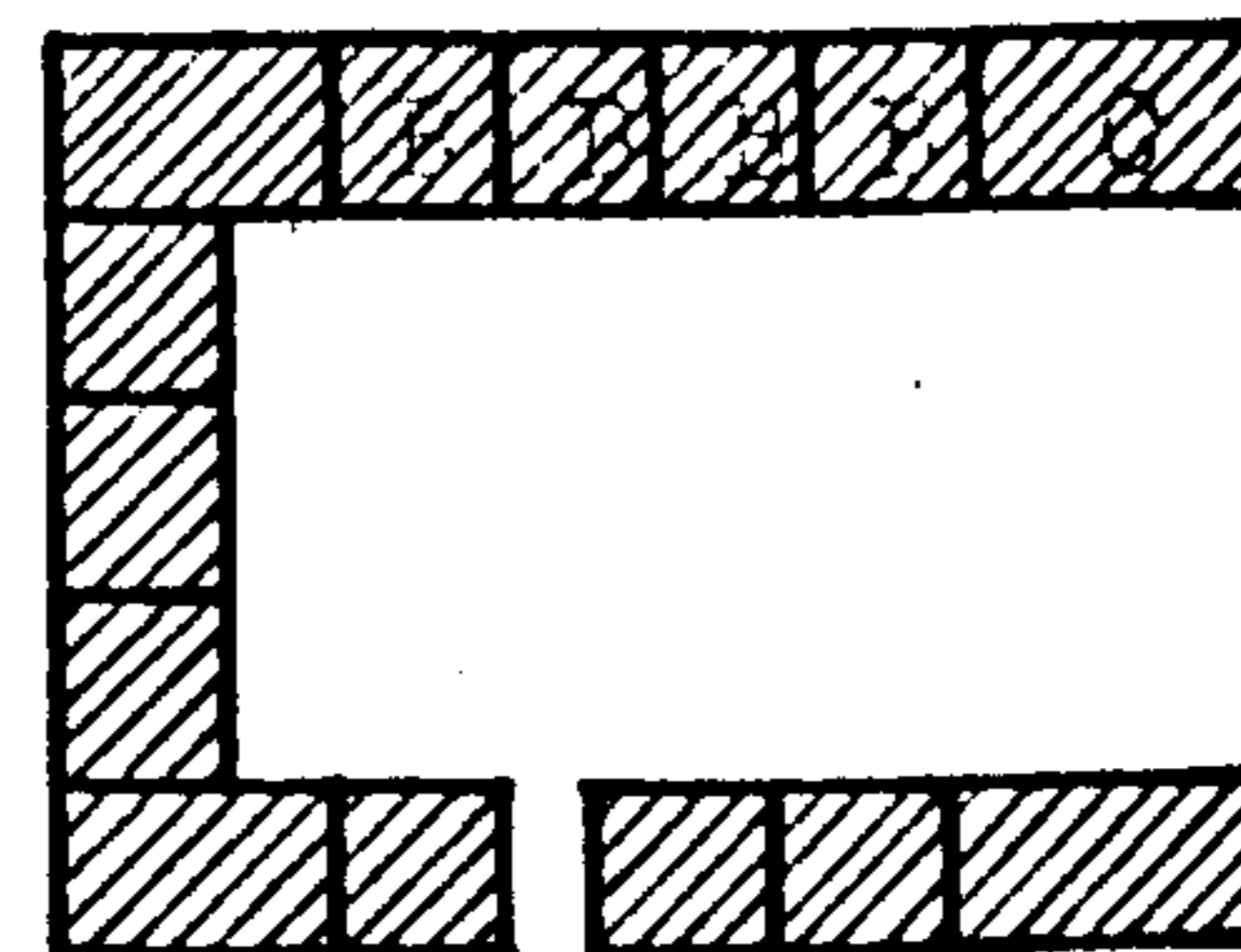
3. a)



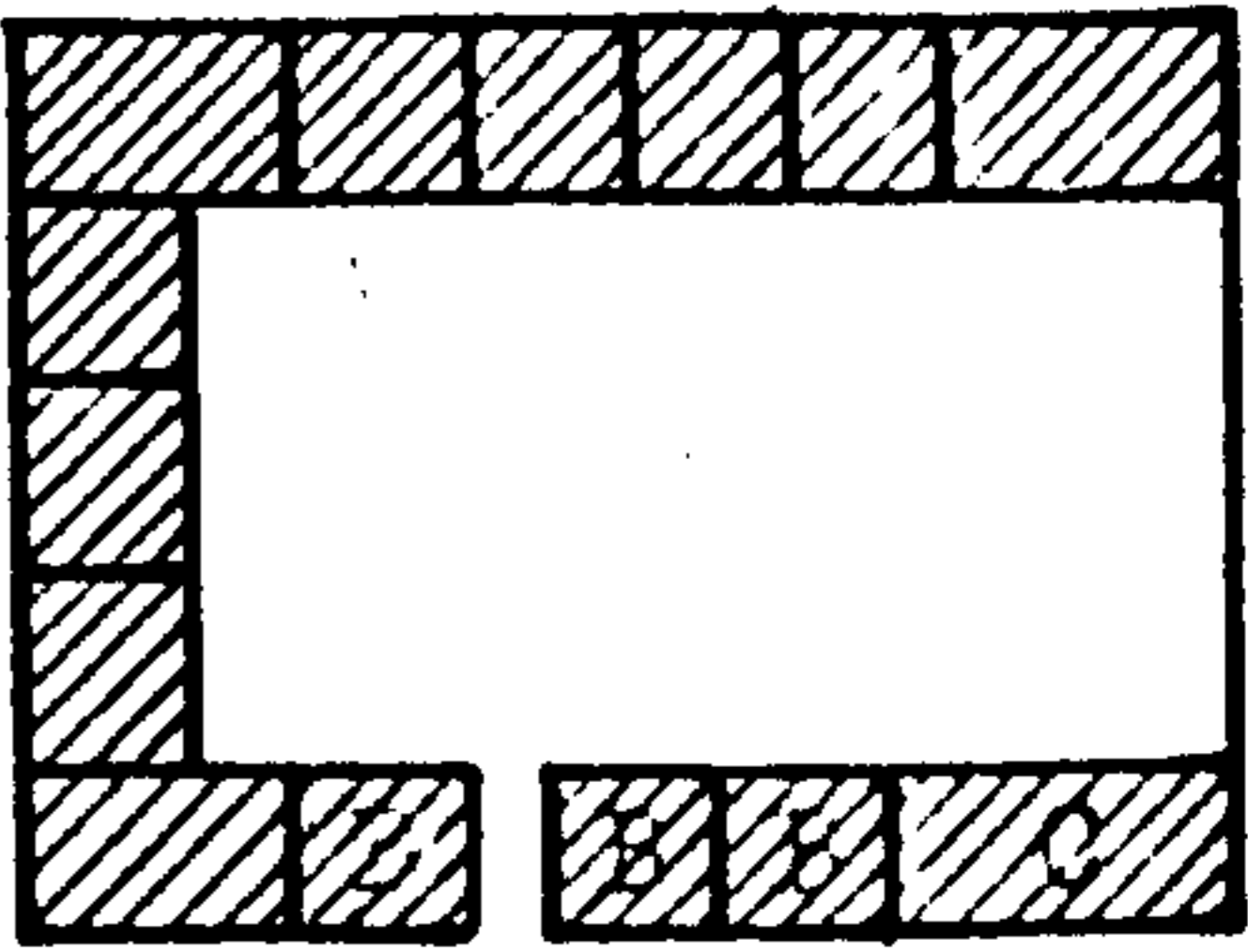
b)



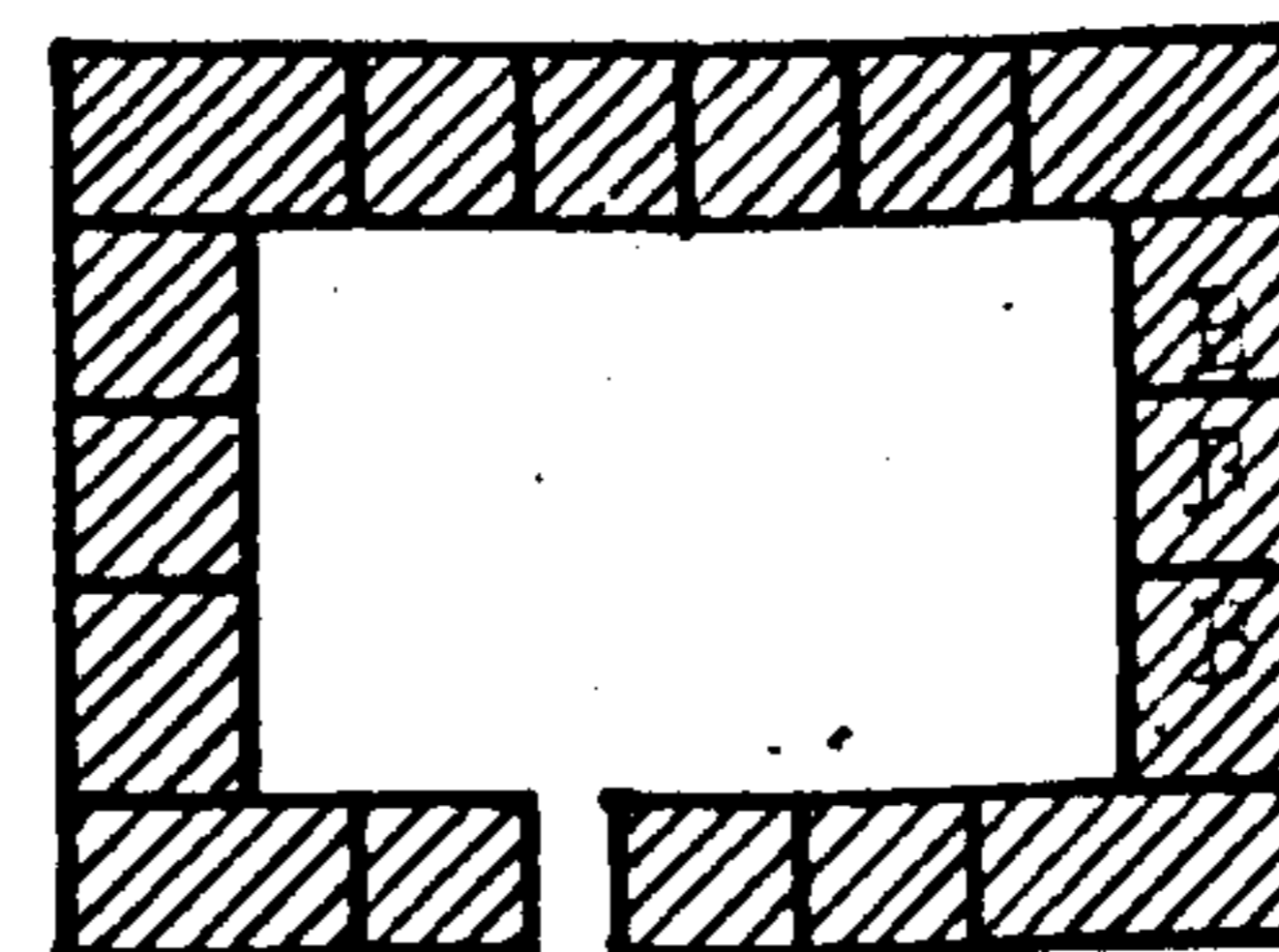
4. a)



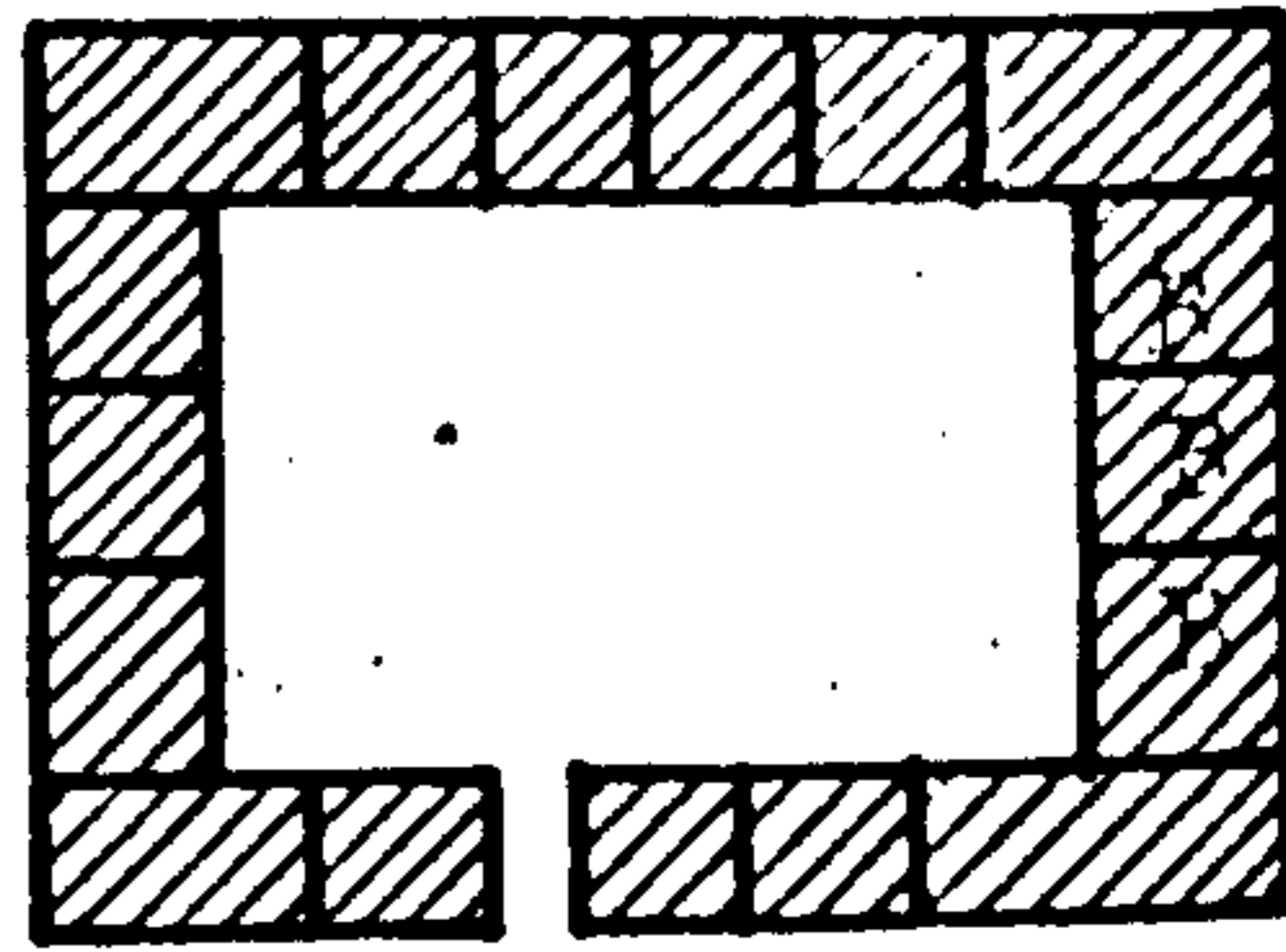
b)



5. a)



b)



INTERIOR SEGMENT CONFIGURATIONS






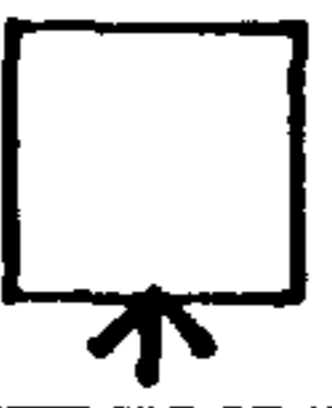










Configurations	Access Points					Total
	1. 	2. 	3. 	4. 	5. 	
1. 	1	-	-	-	-	1
2. 	2	-	-	-	-	2
4. 	-	-	-	-	-	-
5. 	4	-	-	-	-	4
6. 	-	1	-	-	-	1
7. 	-	-	1	1	-	2
8. 	2	2	-	-	-	4
9. 	1	1	-	-	-	2
10. 	2	-	-	-	-	2
11. 	-	-	1	1	-	2
12. 	-	1	-	-	-	1
Others						5
Total	12	5	2	2	-	26

Table 7.2 Grub Street - White Cross Street : building configurations and external access points for interior segments.

INTERIOR SEGMENT CONFIGURATIONS

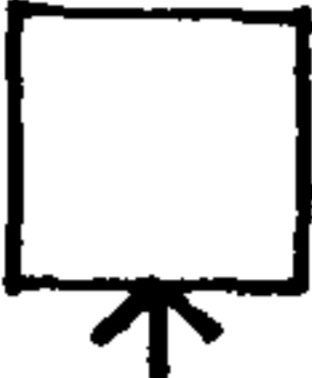











Configurations	Access Points					Total
	1.	2.	3.	4.	5.	
1. 	7	3	-	-	-	10
2. 	3	2	3	1	-	9
3. 	3	1	1	-	-	5
4. 	7	1	2	-	-	10
5. 	3	-	2	-	-	5
6. 	2	-	4	-	-	6
7. 	1	-	-	-	-	1
8. 	-	-	-	-	-	-
9. 	2	-	1	1	-	4
10. 	1	1	-	-	-	2
11. 	2	-	-	-	-	2
12. 	4	-	-	1	-	5
Others						7
Total	35	8	13	3	-	66

Table 7.3 Cow Cross - St. John's Lane : building configurations and external access points for interior segments.

INTERIOR SEGMENT CONFIGURATIONS







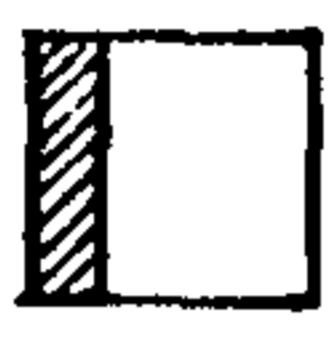





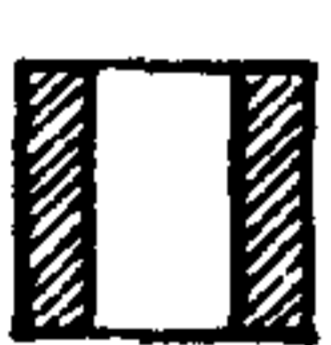
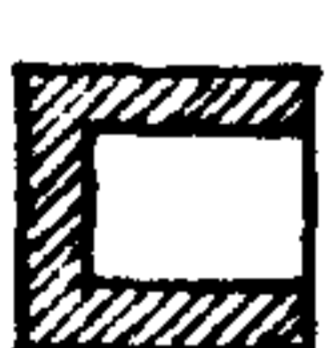



Configurations	Access Points					Total
	1. 	2. 	3. 	4. 	5. 	
1. 	6	-	-	-	-	6
2. 	5	-	-	-	-	5
3. 	1	-	-	-	-	1
4. 	2	-	2	-	-	4
5. 	6	-	-	-	-	6
6. 	6	-	-	-	-	6
7. 	-	-	-	-	-	-
8. 	3	-	-	-	-	3
9. 	3	1	-	-	-	4
10. 	1	-	-	-	-	1
11. 	1	-	1	-	-	2
12. 	1	1	-	-	-	2
Others						9
Total	35	2	3	-	-	49

Table 7.4 Houndsditch - Petticoat Lane : building configurations and external access points for interior segments.

INTERIOR SEGMENT CONFIGURATIONS

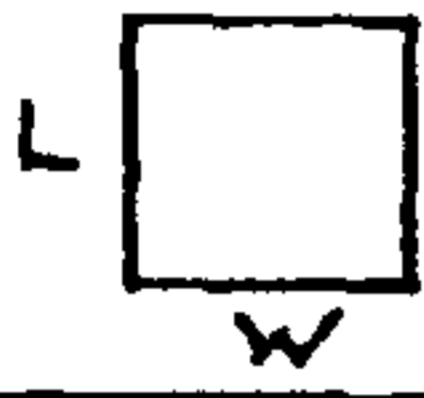








Configurations	Length						Total
	0-50'	51-75'	76-100'	101-125'	126-150'	151'+	
1. 	-	-	1	-	-	-	1
2. 	-	-	2	-	-	-	2
3. 	-	-	-	-	-	-	-
4. 	-	2	1	2	-	-	5
5. 	-	1	1	-	-	-	2
6. 	-	1	5	-	-	-	6
7. 	-	2	-	-	-	-	2
8. 	-	3	2	2	-	-	7
9. 	-	-	1	-	-	-	1
Others							
Total	-	9	13	4	-	-	26

Table 7.5 Grub Street - White Cross Street : building configurations in the interior segments, for different overall lengths of segment.

INTERIOR SEGMENT CONFIGURATIONS

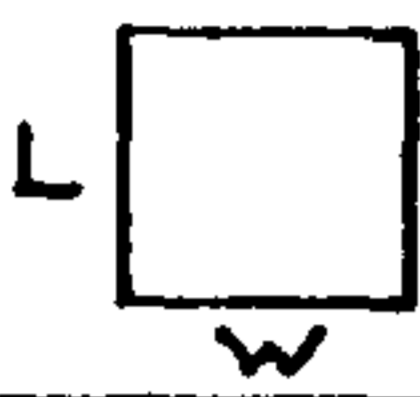




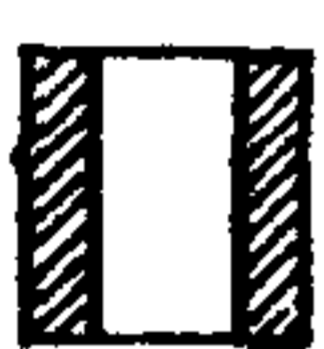
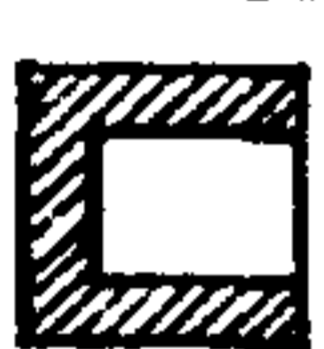
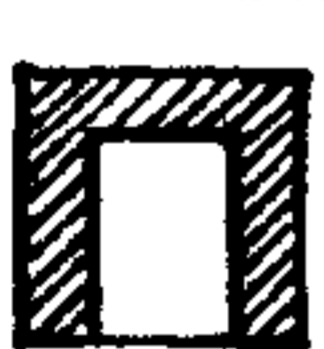

Configurations	Length						Total
	0-50'	51-75'	76-100'	101-125'	126-150'	151'+	
1. 	1	5	2	1	1	-	10
2. 	5	3	4	1	-	-	13
3. 	-	6	1	1	-	3	11
4. 	1	6	2	2	-	-	11
5. 	-	1	-	-	-	-	1
6. 	-	-	-	-	-	-	-
7. 	-	3	-	-	-	-	3
8. 	-	3	2	-	-	-	5
9. 	-	2	2	1	-	-	5
Others							7
Total	7	29	13	6	1	3	66

Table 7.6 Cow Cross - St. John's Lane : building configurations in the interior segments, for different overall lengths of segment.

INTERIOR SEGMENT CONFIGURATIONS

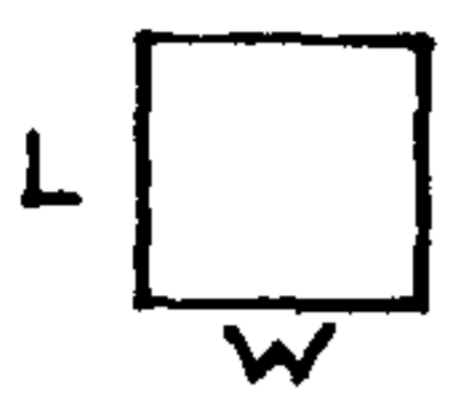








Configurations	Length						Total
	0-50'	51-75'	76-100'	101-125'	126-150'	151'+	
1. 	-	2	1	-	1	-	4
2. 	1	1	2	-	1	-	5
3. 	-	3	3	2	-	-	8
4. 	-	1	6	5	-	-	12
5. 	-	-	-	-	-	-	-
6. 	-	-	4	-	1	-	5
7. 	-	2	-	1	-	-	3
8. 	-	1	3	1	2	-	7
9. 	-	1	-	-	-	-	1
Others							
Total	1	11	19	9	5	-	45

Table 7.7 Houndsditch - Petticoat Lane : building configurations in the interior segments, for different overall lengths of segment.

8. A Model of Urban Growth

8.1 Introduction

The process descriptions advanced in the last chapter provide a means of generating building patterns within perimeter and interior segments. They therefore furnish the basis for a simulation of land development within the block as a whole. For such a simulation to be 'life-like', it is clearly necessary to achieve a realistic distribution of segment sizes and types (perimeter, interior). In the case of the interior zone, it is also necessary to ensure an appropriate mix of building configurations. But, in aggregating the component parts into a whole, a further dimension has to be considered, namely, the interdependence of the segments.

No segment was developed 'in vacuo'; the form and extent of the development were tied up with the access network of the block. Incidental reference has already been made to the passage connections between segments. It was by such connections that access to the interior was maintained. Thus, for medium-range and large blocks, it is essential to determine the continuity of access through the segments. p.171

Our first task then will be to describe the access structure of blocks in the City. Following this, the density of development (i.e. ground coverage) will be considered; the building/open space ratio will be examined with respect to the segments, the zones, and the block as a whole. This will bring us, finally, to a point where we are able to simulate the growth process within the blocks. The results obtained from the computerised model will be compared with the empirical evidence, and the formal and social implications of the results will be considered.

8.2 The Access Structure

All access derives ultimately from the perimeter edge. In the great majority of cases, access to the interior zone takes the form of passages linking one segment to another. The inner part of a block may also be reached by alleys, as noted in the previous chapter. However, alleys occur in only a small proportion of blocks - chiefly, though not exclusively, the larger ones. Moreover, since alleys run by definition from one side of the block to the other, they effectively break it into two or more smaller blocks, each of which may be treated as an independent entity, with its own passage structure. We shall confine our attention, therefore, to the passages. Where a passage provides access from a perimeter segment to an interior segment, or from one interior segment to another, this will be termed a break-through .

In the mediaeval City, the access structure, like the building pattern, was essentially 'unplanned'. It was not laid down at any one time, but was the cumulative result of numerous decisions and actions - individual and collective - over the centuries. The opportunities for access in any part of a block were constrained by the layout of existing buildings. Demolition of a building might provide a breakthrough where it had hitherto been impossible to achieve one. Conversely, an existing passage might conceivably become blocked by building encroachment, and a new, and perhaps more circuitous route would have to be found. Such actions were not subject to global control. But nor were they entirely arbitrary. As one might expect, the preservation of passageways was tied up with legal rights, the rights that come of property ownership.

Those individuals or institutions who owned an extensive part of the interior of a block frequently also held adjoining perimeter segments, by which they were assured of access to their property. In such circumstances, further perimeter connections would often be unnecessary or undesirable, and the interior gardens might be completely bounded by a wall or by buildings. Extension of the property holding might afford additional opportunities for interior

access, but these were not necessarily exploited; access might still be 'controlled' from one or two points only, and the remainder of the perimeter developed independently, forming a buffer between the street and the internal spaces. This arrangement seems to have been characteristic of the Company Halls. One may take as an example the Merchant Taylors' Hall between Threadneedle Street and Cornhill, partly shown in a previous sketch (7.8).

The nucleus of the Merchant Taylors' property was purchased in the sixth year of Edward III (1332), and the holding augmented by the acquisition of adjoining properties, either through gift or purchase, during the course of the sixteenth and seventeenth centuries. The Company's lands extended along the perimeter of Threadneedle Street, and took in part of the frontage to Bishopsgate Street and to Finch Lane. But the main entrance remained in its original position along Threadneedle Street (the north side of the block). On the south side, the Hall and gardens backed on to the perimeter properties of Cornhill, the majority of which were in the hands of other landowners (the Grocers, among others). Hence, the passages in the southern portion of the perimeter zone served in the main for local access, not for access to the interior. This segmentation of the block expresses itself on Ogilby and Morgan by the series of cul-de-sacs facing Cornhill, each with its encircling segment development, the feature that initially attracted our attention. A similar demarcation of access routes is found between Lothbury and Poultry, where the Grocers had their Hall. The Hall is approached from the south by a wide passage leading off Poultry. On the north side (Lothbury), a series of cul-de-sacs mark a self-contained perimeter development: the northern edge was partly the property of the Drapers' Company (1). Thus, penetration into the block was, once again, restricted.

Against this kind of access pattern - the segregated pattern - one must set the other very widespread arrangement, in which passages to the interior gave on to several lots of property. Both the 'Assize of Nuisance' and 'Oliver's Survey' provide evidence of common rights being exercised over passages leading to internal spaces (although

in most instances the spaces concerned were at the back of the perimeter zone). Treswell's survey for the Clothworkers' Company includes a deep perimeter plot on the north side of Throgmorton Street, in the tenancy of Mr. Fishburne. In addition to an entry, leading directly into Mr. Fishburne's court, the plot contains a side passage - Copthall Alley - which furnished a separate access to the back of Mr. Fishburne's premises, and a right of way to the interior gardens under the ownership of Lord Rich. Lord Rich's land could also be reached by way of Bell Alley off Coleman Street, an alley that served a sequence of interior segments, including more of the Clothworkers' property (see fig. 7.19). Where access was dependent upon a common passage or upon right of way through another's property, one would imagine that there was every encouragement to seek alternative routes, in order to avoid becoming closed off. This, in turn, might lead to a multiplication of ways into the interior zone, a very different arrangement from that associated with the company halls, and one well attested by the map evidence.

The above examples have been used to illustrate some general trends. No attempt will be made in the following analysis to trace the diverse social actions that went into the creation of the access patterns. Our concern is with the spatial consequences of these actions. We shall therefore work through a state description of the phenomena - the access patterns as they appear on Ogilby and Morgan - and attempt to draw some conclusions from the configurations alone.

Certain features of the passage network are of particular importance in an analysis of the block structure. These are : 1) the frequency of passages along the perimeter of the block; 2) the 'depth' to which they penetrate; and 3) the number of breakthroughs into and out of each segment. Each of these can be established, more or less accurately, from Ogilby and Morgan.

The first characteristic - the frequency along the street edge - is the easiest to ascertain, and also the most dependable.

Measurements were taken from the map for a number of middle-range

and large blocks, the distances recorded being the length of the street frontage between adjacent passages, except at the ends of each side, when the measurements were taken to the corner. The results for five blocks-two of them medium-range and three large - are summarised as bar graphs in figure 8.1. In the case of the middle-size blocks, the total number of passages per block is clearly too small for a reliable curve to emerge. The range is nevertheless extremely consistent, the majority of passages being spaced at between 20' and 100' intervals. A similar range is found in most of the large blocks, although in a few instances, most notably the Grub Street block, a closer spacing of passages is evident. In the latter case, the results cluster in the range 0-50', rising to a single peak around 20'. In blocks of both sizes, however, the general tendency is for two peaks to emerge : one below 50' (usually between 30 and 40'), and another above 50' (generally between 60 and 80'). In terms of building numbers, this means that in the majority of instances, there are from two to ten units between passages along the street edge. A sample of thirteen medium-range blocks in the City centre gave a total range of one to thirteen units, and a median figure of 4.6. 71% of the total sample lay between two and six units inclusive.

For the other two properties - the 'depth' of the passages, and the number of breakthroughs per segment - we have to rely upon a conjectural reconstruction of perimeter and interior segments for a limited number of blocks. One such reconstruction, for Grub Street - White Cross Street, is illustrated in figure 8.2. The segments were defined by visual inspection, and the breakthrough positions determined by superimposing the inferred segment divisions on to the passage network.

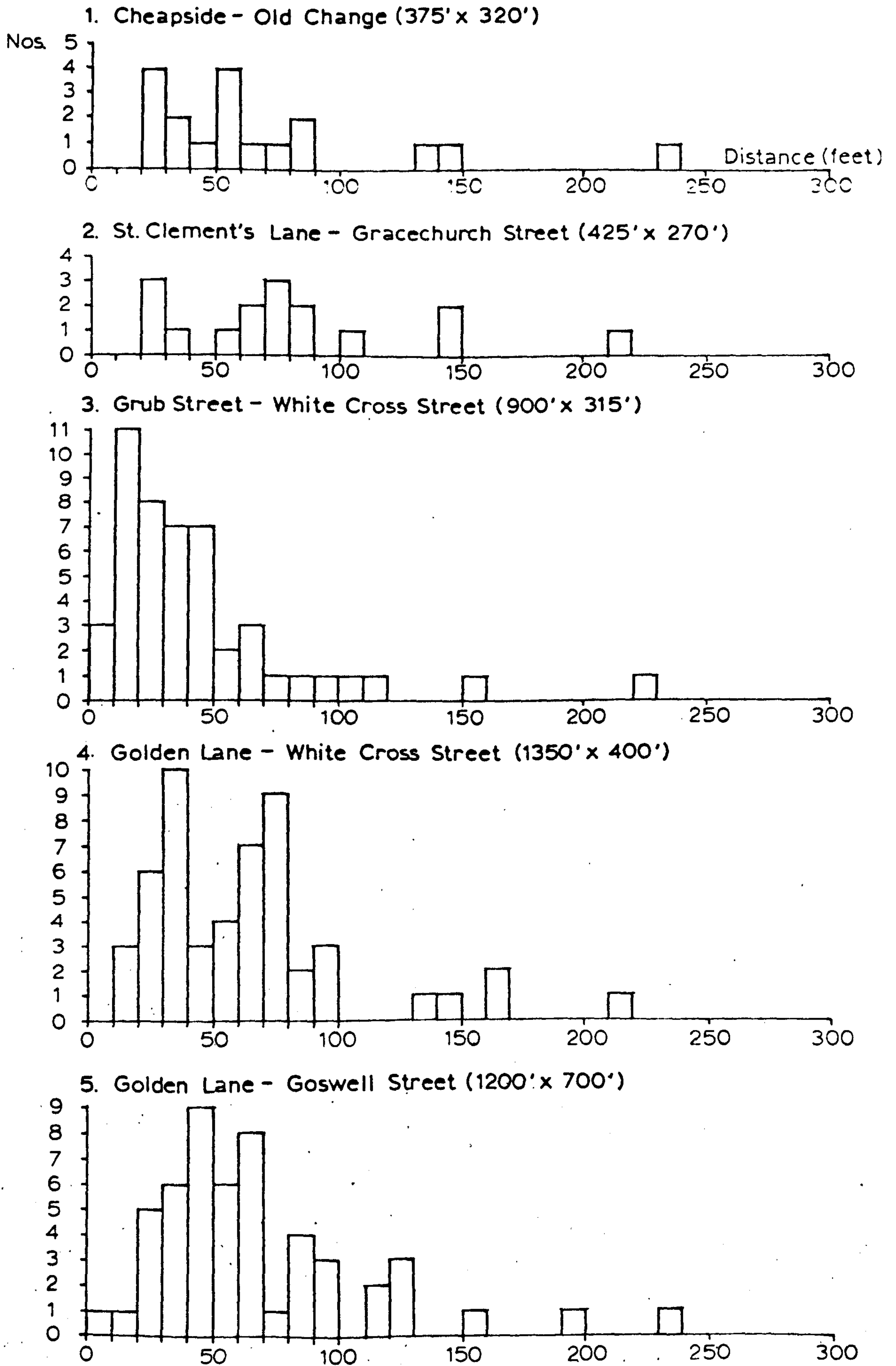


Fig. 8.1 : Distance between passages along the street edge, for various blocks.



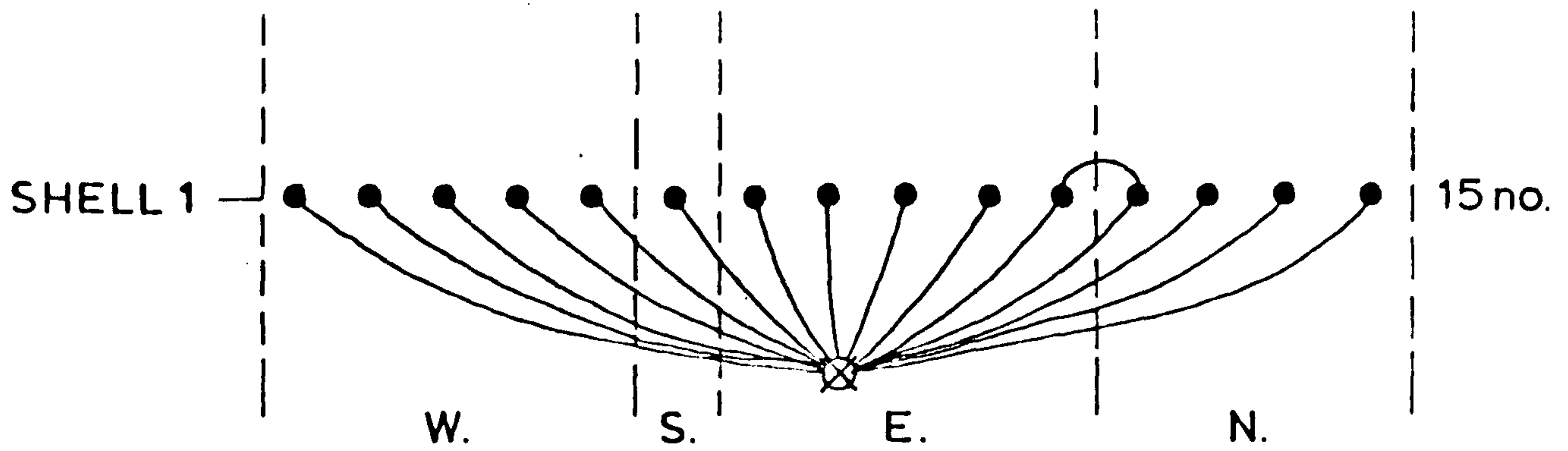
Fig. 8.2: A conjectural reconstruction of segment boundaries and access breakthroughs : Grub Street - White Cross Street.

The access pattern of a block may be conveniently represented by means of a graph, in much the same way as the permeability relations between rooms in a house. But, in this case, the nodes will represent, not rooms or spaces, but segments (perimeter, interior) and the edges will represent, not doorways, but breakthroughs. All of the graphs will be justified in the vertical direction, (i.e. in the same way as the access graphs of house plans), and the different levels will be referred to as shells. Figures 8.3 and 8.4 show the access graphs obtained for a selection of medium-range and large blocks in the City.

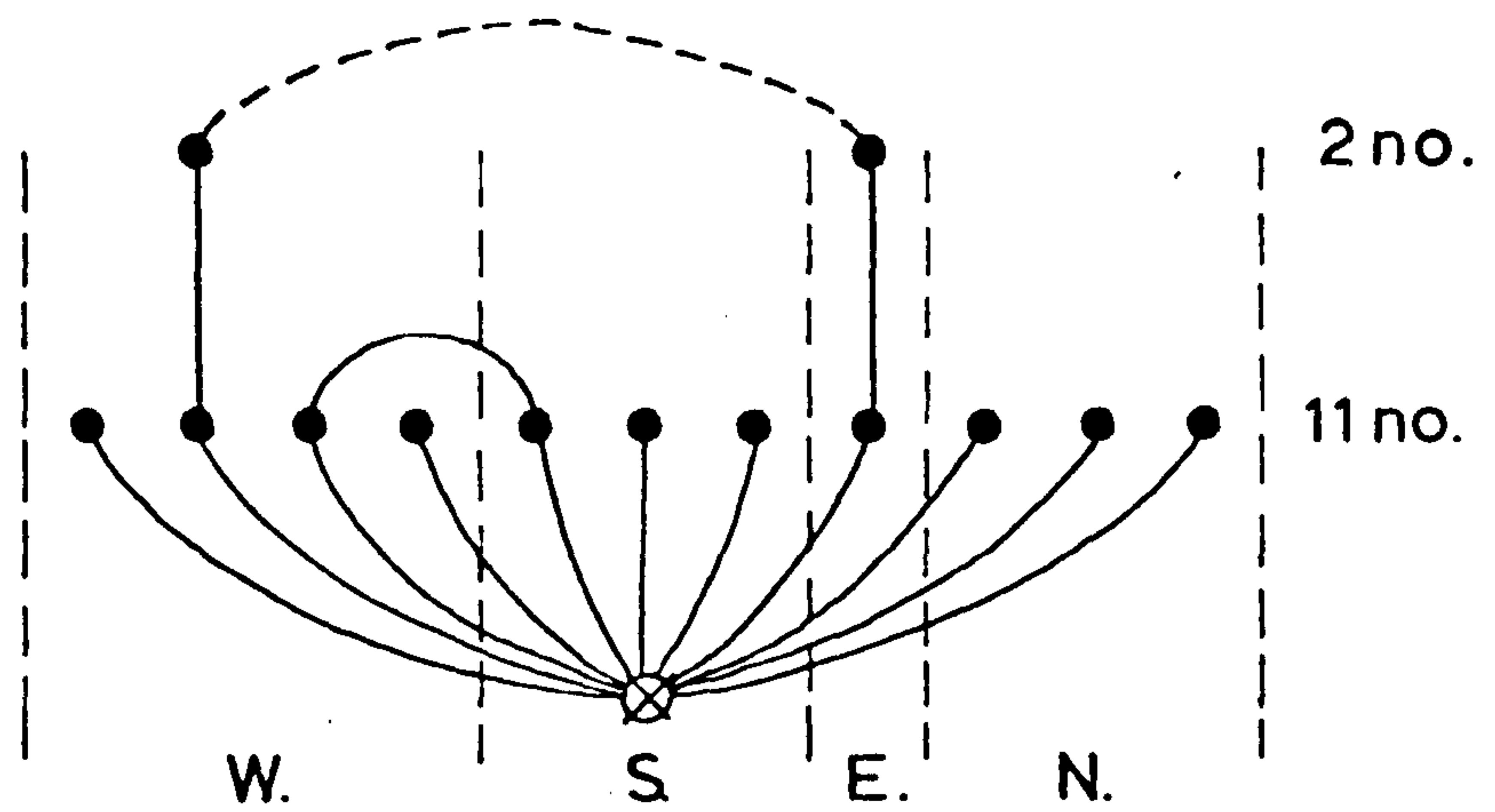
It should be noted that only those perimeter segments which have passages appear in the graphs. Intervening segments, composed wholly of contiguous burgage strips, each receiving direct access from the street, do not figure in the graphs unless these too are penetrated by the passage network. Were the remaining burgage segments included, they would have to be represented as discrete nodes. That is to say, we would have an disconnected graph.

All interior segments are included in the graphs, since, by virtue of their position away from the street front, all require passage access. Interior segments lie in shell 2 or deeper. Perimeter segments lie predominantly (though not necessarily) in shell 1. The vertices in shell 1 are ordered from left to right, following the actual sequence of the perimeter segments around the block. A vertical broken line between vertices indicates the corner of the block. The letters N., E., S., and W. designate the north-, east-, south-, and west-facing sides of the block respectively.

CHEAPSIDE - OLD CHANGE



GRACECHURCH STREET - PHILPOT LANE



TOWER STREET - MARK LANE

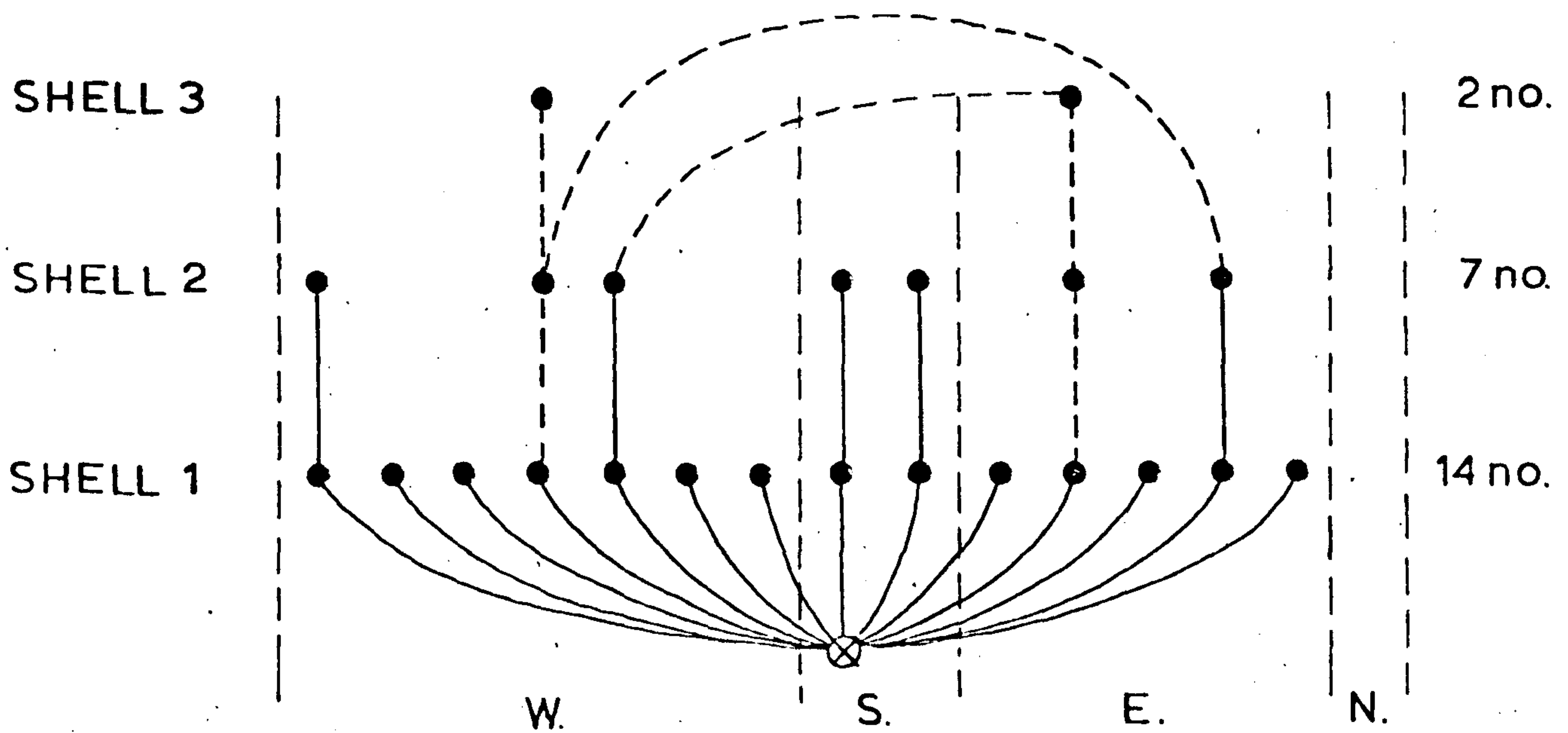
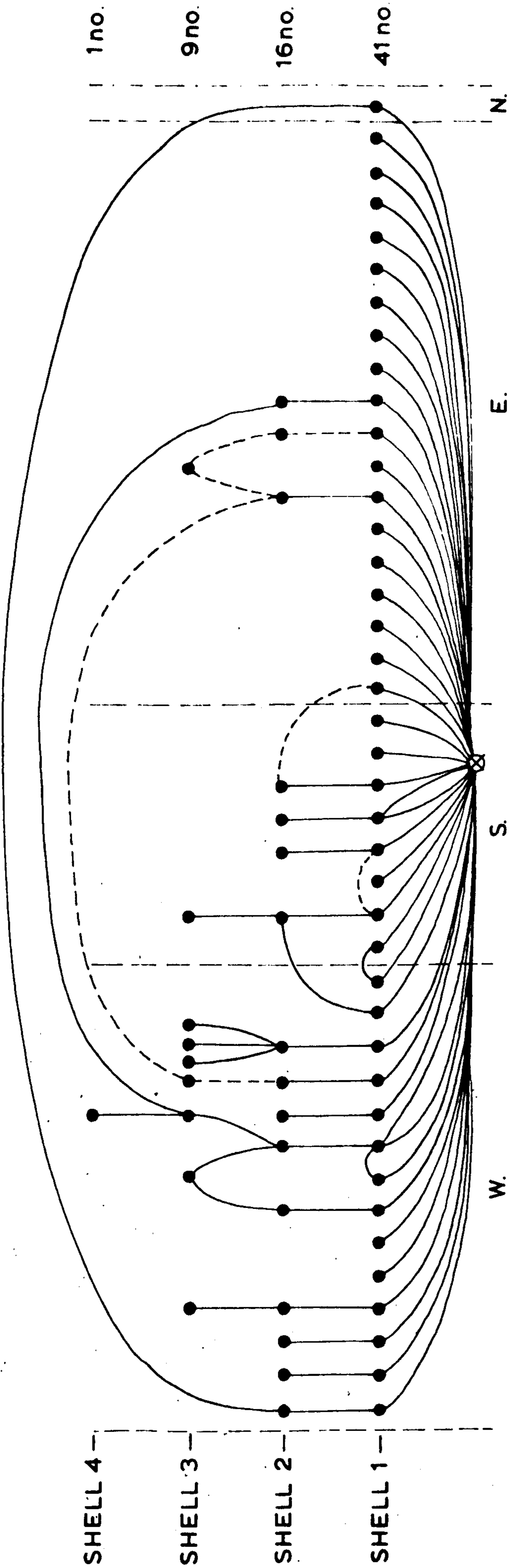


Fig.8.3 : Access graphs of three medium-range blocks. Lines (edges) denote actual breakthroughs into and out of segments. Broken lines indicate possible further breakthroughs.

GRUB STREET - WHITE CROSS STREET



GOLDEN LANE - WHITE CROSS STREET

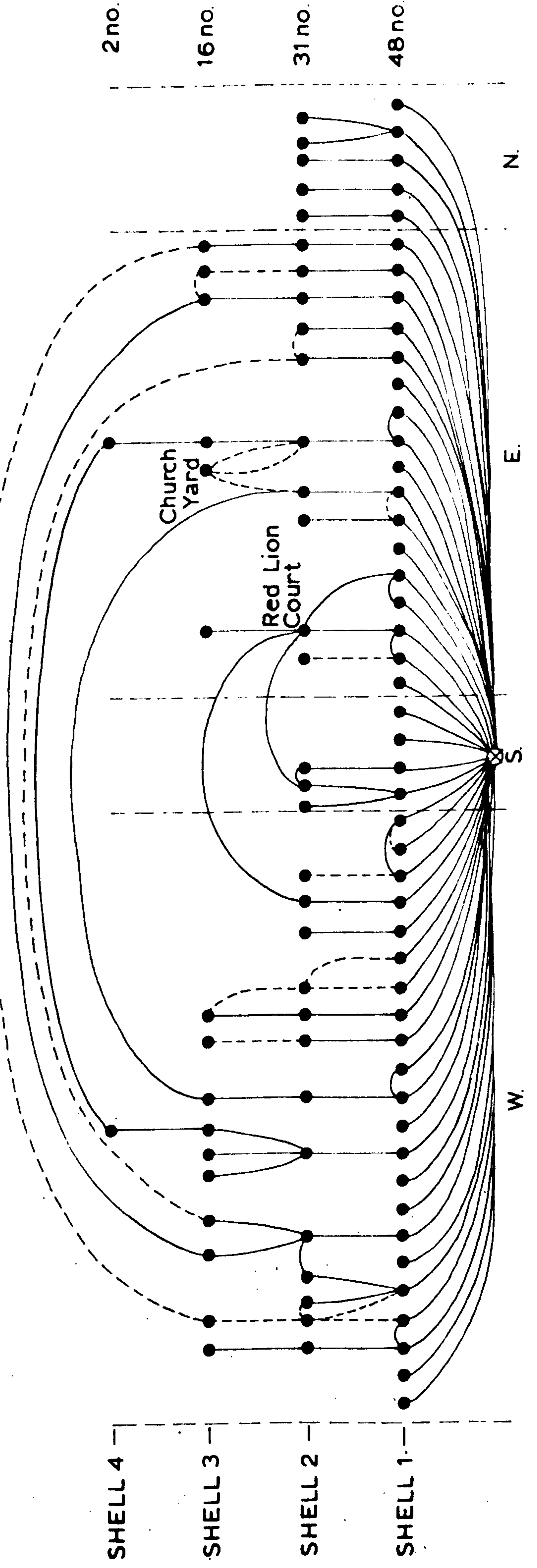


Fig.8.4 : Access graphs of two large blocks. Lines (edges) denote actual breakthroughs into and out of segments. Broken lines indicate possible further breakthroughs.

The most striking feature in all the examples is the comparative 'shallowness' of the access graphs. In the case of the medium-range blocks, this is not too surprising, as there are so few interior segments that difficulties of access were not likely to arise. The gardens on the interior could normally be reached directly from one side of the block or the other. Hence, they are mostly to be found in shell 2. The Cheapside-Old Change block represents an extreme case, in which all the segments lie on the perimeter; there are no interior segments. All the vertices therefore fall within shell 1. This kind of graph, which has been termed a 'bush' (2), is the shallowest possible arrangement for any spatial configuration. At the opposite pole is the unipermeable sequence, which achieves the maximum possible depth. More representative of medium-range blocks in the City is the access graph obtained from the Gracechurch Street - Philpot Lane block. Here there would appear to be only two interior segments, both of which lie in shell 2. The third example, the Tower Street - Mark Lane block, contains a larger number of interior segments: 10 no., two of which apparently lie in shell 3.

The access characteristics become more conspicuous in the larger blocks. In the case of Grub Street, 26 no. interior segments were identified, of which 16 (62%) lie in shell 2, and 9 (35%) in shell 3. Golden Lane - White Cross Street, a block of considerably larger overall dimensions, exhibits a strikingly similar distribution of segments. Of the 49 interior segments, 31 no. (63%) are in shell 2, and 16 no. (33%) are in shell 3. Thus, there is a distinct tendency for an increase in block size to be accompanied by an increase in the depth of the access graph - a predictable result, given the almost geometrical increase in the number of interior segments. But, more interesting and significant is the fact that the vertical extension of the access graphs is relatively slight - far short of what is theoretically possible. The vertices beyond shell 1 are never strung out in a continuous sequence. The access graphs of the City blocks may thus be said to tend towards the 'bush' form (the norm in the smallest blocks). The greatest depth occurs in the largest blocks, but the majority of the segments still lie in shells 1 to 3, and the graphs rarely seem to exceed 4 shells in depth. This property will be examined further when we come to the computer

simulation.

Remaining with the empirical evidence, we may now examine the breakthrough characteristics of the blocks. As already pointed out, only a proportion - never all - of the perimeter segments in a block contain passages. Moreover, only a proportion of the perimeter passage segments break through into contiguous segments. The latter holds true for the deeper levels : there is generally a certain number of cul-de-sacs in every shell, as the graphs clearly show. The proportion of breakthroughs from one shell to another varies, but the range may be determined approximately by reference to the graphs of the reconstructed blocks. Looking firstly at the perimeter segments, the proportion of segments with passage access from the street appears, in the case of medium-range blocks, to be remarkably uniform. In six medium-range blocks in the City centre, with from 24 to 33 no. perimeter segments, it was found that not less than 40%, and not more than 50% of the segments had passage access. In the larger blocks, outside the City wall, the proportion seems to be rather higher. In the case of Grub Street, 41 of the 57 perimeter segments (72%) had passages (it will be remembered that there was an exceptionally close spacing of passages along the street front in this block). For Golden Lane - White Cross Street, the figure obtained was 48/88 (55%) -considerably lower, but still comprising over half the perimeter segments.

The proportion or ratio of breakthroughs to successive shells is in general only significant in the larger blocks, where interior segments exist in reasonable numbers. In Grub Street, 17 of the 41 perimeter segments (i.e. passage segments) (41%) break through to shell 2. The Golden Lane block was in this instance examined in two halves: the portions north and south of the alley called Playhouse Yard. In the former, 15 out of 29 (52%) shell 1 segments break through to shell 2 ; in the latter, 13 out of 23 (56%). It is worthy of note that in the case of Tower Street- Mark Lane, a medium-range block with a considerable number of interior segments, a similar breakthrough ratio, 13 out of 23 (56%), was found. For the proportion of shell 2 segments giving on to shell 3, the following figures were obtained : Grub Street, 7/16 (44%); Golden lane, 8/18,

(44%) and 5/12 (42%).

Thus, generalising from this analysis, we should expect a typical medium-range block to have passage access into 40-50% of its perimeter segments, and interior breakthroughs from 0-60% of these segments. For a large block, we should expect to find passage access into 50-75% of perimeter segments, a 40-60% breakthrough proportion from shell 1 to shell 2, and a 35-50% breakthrough proportion from shell 2 to shell 3.

It will be evident from the access graphs that the valency of the vertices is in general fairly low. If the valency of all the nodes in the Grub Street graph is counted, it is found that 34 no. (51%) of the total are endpoints, and 27 no. (40%) have degree 2. Thus, the vast majority of segments have only one or two access points. The relatively low level of connectedness of interior segments became apparent in the last chapter, when the process of development within the segments was examined. The results presented in tables 7.2 - 7.4 (building configurations against access points) show that one-way connections (cul-de-sacs) were, without exception, the most common, and two-way connections the second most frequent. Three-way connections were relatively uncommon, and four-way connections non-existent in all three blocks. The present results confirm that these characteristics apply, not only to the interior segments, but to all segments within a block.

The implication of the low vertex degree is that blocks tend on the whole to be relatively impermeable : they have rather few cycles or 'rings'. We may express this property more precisely by taking the 'cyclomatic number' (given by $e - v + 1$) of a sample of the blocks. This measure counts the interior faces in a planar graph (3). Hence, it provides an index of the number of alternative routes that exist between points (in this case, segments) in a complex. A tree, a graph in which there is a unique path from any vertex to any other, has no interior faces. The cyclomatic number of a tree is always zero.

The access graph for Grub Street has 76 edges and 67 vertices. The

cyclomatic number is therefore 10. The Golden Lane graph yields a figure of $(111 - 97 + 1) = 15$. Since the maximum possible number of edges for any plane graph is $(2v - 5)$, a measure of 'relative ringiness' is obtained by dividing these figures by $(2v - 5)$ (4). The ratio can take values from 0 to 1. The result for Grub Street is $10/129 = 0.08$; for Golden lane, it is $15/189 = 0.08$. Thus, the 'relative ringiness' of the two blocks is identical, and low.

It is clear from visual inspection of the maps that the permeability of blocks does, in fact, vary considerably from one part of the City to another. Some medium-range blocks are threaded through with interconnecting passageways. The degree of 'ringiness' was undoubtedly related to local conditions, such as the social composition of the population. Thus, the area to the west of the King's Wardrobe, south of St. Paul's, a part of the City notorious for its unruly population, and one whose pre-Fire layout survived largely intact, exhibits an exceptionally 'ringy' structure. A similar multiplication of routeways is found in the block to the north of Blow Bladder Street (north of St. Paul's). These blocks are the most difficult to reconstruct, precisely because of their highly fragmented nature, but an approximate reconstruction of the Blow Bladder Street block was attempted, and the access graph is included to indicate the level of permeability sometimes attained (fig. 8.5).

In general, however, the 'ringiness' of both medium-range and large blocks is comparatively low. It is interesting to note that even in the case of Blow Bladder Street, the 'relative ringiness' of the graph, given by the above expression, is only 0.19. While considerably higher than the figure obtained for the large blocks, it is still low on the scale of possible 'ringiness'. Thus, the block is less richly interconnected than might intuitively appear to be the case. It seems reasonable, therefore, in our simulation of the City blocks, to take the tree as the characteristic form of access graph. Should it become necessary to simulate those blocks with a 'ringy' structure, this can be done very simply by adding edges to the type-graphs.

BLOW BLADDER STREET

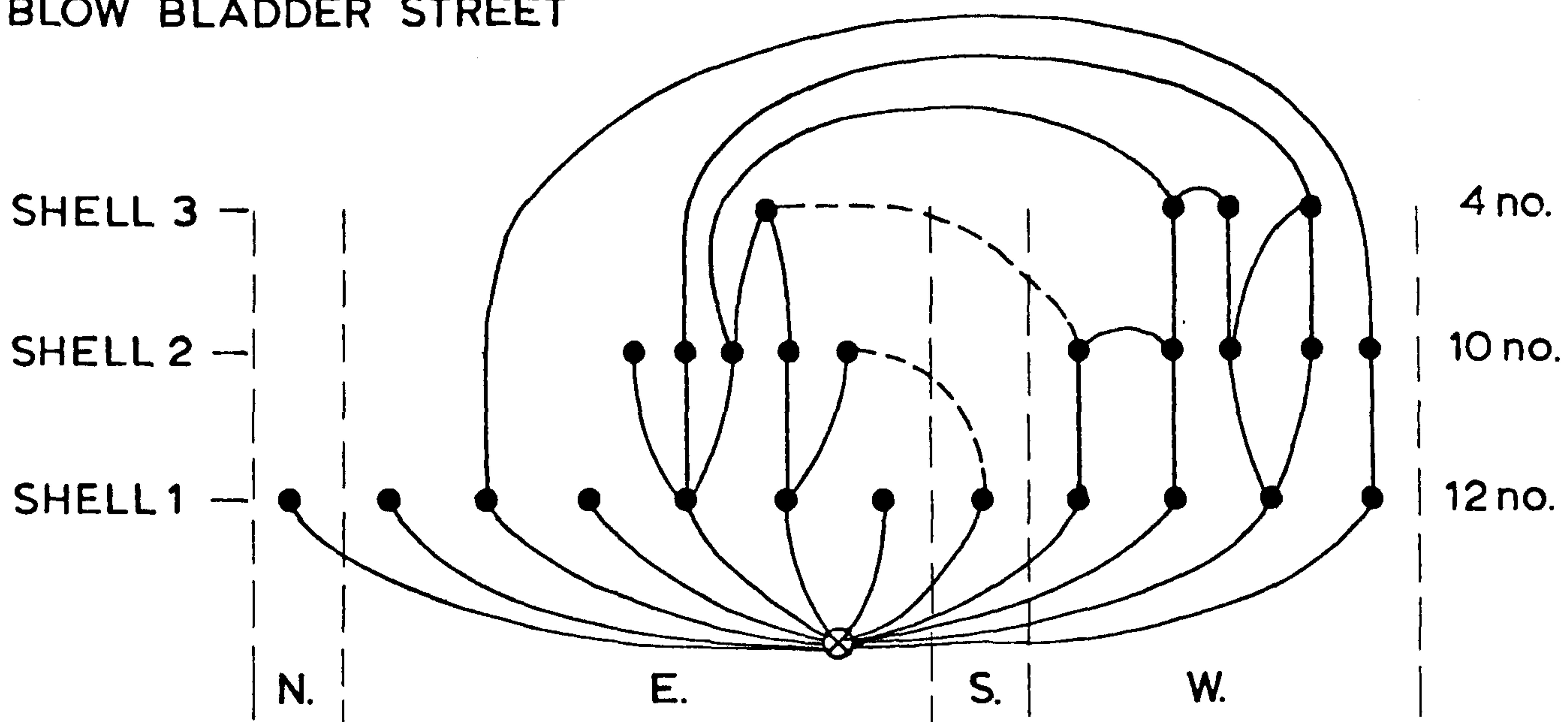


Fig. 8.5: Access graph of block north of Blow Bladder Street, (Ogilby and Morgan, 7.9).

8.3. Building Density

We shall now turn to the question of building density within the blocks. The term 'density' will be used consistently to refer to the fraction of land covered by buildings. Ground coverage is, in the first instance, a function of the organising principles of development. These have been encapsulated in the process descriptions. The courtyard or boundary form of development, which has been identified as characteristic of all areas away from the street edge, is an arrangement which maximises density for any plot of land (5). It is plain, nonetheless, that given a consistent application of the rules of development, the ground coverage may vary considerably according to 1) the size of the segment, and 2) the depth (in the metrical sense) of the rows of building within the segment. The density of building per segment will decrease, *ceteris paribus*, with an increase in the dimensions of the segment. Variations in the depth of the rows may magnify the discrepancy still further, thus increasing the overall range of density values. Map analysis does, however, suggest some correlation between segment dimensions and building dimensions.

Measurements were taken of the depth of buildings in all the interior segments of two blocks : Grub Street and Petticoat Lane. These were then plotted against the width of the segment, i.e. the overall dimension at right angles to the row of buildings measured. The results are presented in tables 8.1 and 8.2. Taking segments of all sizes, the buildings cluster heavily in the depth-range 11-25': 77% (47 no.) of those in the Grub Street block and 80% (65 no.) of those in Petticoat Lane fall into this range. But, as the breakdown shows, there is a certain tendency for depth to vary in proportion to the size of the segment. In both blocks, the rows of buildings within segments of 0-50' width peak in the depth-range 11-15', while those within segments of 51-75' width are spread more evenly across the depth-range 11-25'. In segments above 75' in width, the smallest depth-range, 5-10', disappears altogether, but there is little increase in the modal depth of the buildings. It would seem, therefore, that below 50', the segments began to exercise a significant physical constraint on the size of buildings : houses

of 15-25' depth or greater were possible but in the minority. Above 50', the builders could be rather more generous in their space standards, and deeper rows become more common. But 25' would appear to be a threshold dimension, an accepted upper limit for the dwellings, so that further increases in segment width are not accompanied by any marked increase in building depth. Using these parameters, the density range is somewhat reduced, a fact that will facilitate comparison of hypothetical and observed configurations.

In matching the density of real against possible blocks, the interaction between access structure and density must also be taken into account. The access pattern of a block influences building density in two main ways. First, and more important, is the probabilistic relation that has been observed between 'depth' (in terms of access) and the development of the segment. Segments in the interior zone are much less likely to be maximally developed than those on the perimeter. As a result, the mean density of the interior (effectively shell 2 and deeper) is usually considerably lower than that of the perimeter. This disparity is already provided for in the process descriptions for the two zones. Measurements taken from the map do imply, however, that there was not simply a broad division between the perimeter and the interior, but a progressive diminution in the amount of building as one passed into a block. Thus, shell 1 is denser than shell 2, which is denser than shell 3, and so on. This result is perhaps not too surprising if we proceed on the premise that development within the blocks was primarily a response to population pressure, and that it succeeded perimeter development. For any sequence of segments, 1, 2, 3, it is improbable (though evidently not impossible) that segment 3 would become filled up with tenements while segment 2 remained entirely undeveloped, for the simple reason that the pressures of illegal building and encroachment, and the opportunities for financial gain, which led to the development of 3 would be correspondingly greater for a segment closer to the street edge. Some attempt has been made to reproduce this characteristic in the computer model, by varying the mix of configurations for each shell. This will be discussed below.

BUILDING DEPTH

Depth of row (feet)	Segment width (feet)					Total
	0-50'	51-75'	76-100'	101-125'	126-150'	
5 - 10	2	4	-	-	-	6
11 - 15	9	9	3	1	-	22
16 - 20	5	5	2	1	-	13
21 - 25	1	7	2	2	-	12
26 - 30	2	3	1	-	-	6
31 +	1	-	1	-	-	2
Total	20	28	9	4	-	61

Table 8.1. Building depth against segment width for interior segments :
Grub Street - White Cross Street.

BUILDING DEPTH

Depth of row (feet)	Segment width (feet)					Total
	0-50'	51-75'	76-100'	101-125'	126-150'	
5 - 10	4	4	-	-	-	8
11 - 15	10	13	3	4	-	30
16 - 20	3	10	10	1	-	24
21 - 25	1	5	3	2	-	11
26 - 30	1	2	2	-	-	5
31 +	-	-	3	-	1	4
Total	19	34	21	7	1	82

Table 8.2. Building depth against segment width for interior segments :
Houndsditch - Petticoat Lane

The second way in which the access structure affected building density was by placing physical constraints on the disposition of buildings within a segment. Since a continuous passage had to be

maintained from an access point (breakthrough) to the area within the segment, building could never extend along the entire length of the access boundary. The minimum width of a passage was approximately 5' 0". This factor is on the whole much less significant than the shell/density relation, but it can result in an appreciable reduction in local density where there are several breakthroughs into a segment. The space required for passages is also allowed for in the model.

To furnish comparative data, density measures were taken for a selection of blocks on Ogilby and Morgan. The sample included blocks of all sizes, and measurements were taken by means of a fine graticule (10' X 10'). Land-use was classified under three headings : buildings, passages (including yards, courts, etc.,) and gardens (including any open space which was not part of the access system). The figures obtained are tabulated below (table 8.3).

BUILDINGS/OPEN SPACE

Block	Type	Area (hA)	Ground Coverage (%)		
			Buildings	Passages	Gardens
Bread Street-Bow Lane					
- Trinity Lane	Small	0.6	71	17.5	11.5
Little Trinity Lane -					
Garlick Hill	Small	0.5	62	14	24
Cheapside - Old Change					
	Medium Range	1.1	66	24	10
Grub Street - White					
Cross Street	Large	2.8	60	22	18
Golden Lane - White					
Cross Street, (n. section)	Large	2.45	53	17	30
(s. section)	Large	2.1	51	23	26

Table 8.3: Actual ratio of buildings to open space for a sample of blocks.

The building density is uniformly high, over 50% of the land being developed in each case. But the results show a clear decrease with increase in size of the block. This inverse relation is exactly what we would expect, given the sparser ground coverage characteristic of the interior zones. The largest and 'deepest' blocks are the ones with the greatest amount of interior space, and hence the lowest density ; the smallest blocks have no interior zone, and thus approach more closely the maximum possible ground coverage.

This evidence is, nevertheless, still rather difficult to use in its 'raw' form, since local features tend to introduce distortions and irregularities into the land-use figures. The street frontage in Ogilby and Morgan's City was still punctuated by empty plots. These were not numerous, but could be of considerable area, since they frequently represented the sites of former churches. The Cheapside - Old Change block contained the vacant sites of St. Austin's and St. Matthew's, while the Nag's Head Inn, adjoining Star Court, also awaited rebuilding. These gaps in the block development diminish the overall density. Where churches and public buildings were rebuilt, on the other hand, they tend to tip the balance in the opposite direction : their large ground area exaggerates the weight of building to open space. In the large blocks, the position is further complicated by the differing mix of interior building configurations from block to block.

In order to correct for these anomalies, all large entities (churches, etc.) and all empty sites within the perimeter zones were replaced by a hypothetical boundary development according to the type 1 process description. A maximal development was generated in each case. All other sites, already densely developed, were left untouched. On the interior, large entities were similarly removed, and replaced by rows of building according to the type 2 process description. Open space was dealt with, not locally, but at the level of the whole interior zone, by varying the overall mix of interior configurations. Where the actual balance of configurations diverged markedly from the norm, a hypothetical mix was substituted and the density calculated accordingly. By further varying the mix

from zero to maximal development, it was possible to predict the density of past and future states, and to examine the effect of these changes on the density of the whole block.

Looking firstly at the shallow blocks (those with perimeter zones only), it will be seen from table 8.4 that, once the adjustments are made, the building density is remarkably uniform - between 70 and 75% in all cases. Access routes occupy approximately 20% of the land area, and private gardens account for 5 - 10%. From these figures, we should expect our model to generate a maximal density for the perimeter zone close to 75%, i.e. a 3:1 building/open space ratio.

MAXIMUM BUILDING DENSITY

Block	Type	Ground Coverage (%)		
		Buildings	Passages	Gardens
Bread St. - Bow Lane - Trinity Lane	Small	74	19	7
Little Trinity Lane - Garlick Hill	Small	72	18	10
Cheapside - Old Change	Medium- Range	73	21	6

Table 8.4. Hypothetical ratio of buildings to open space for a sample of blocks: all segments maximally developed.

For the large blocks, the extrapolation of density measures demands an accurate breakdown of land-use for the perimeter and interior zones. This is given in tables 8.5 and 8.6. It will be noted that the building density in the perimeter zone, though somewhat less than the maximal figure obtained for the smaller blocks (approx. 65%), is well above that for the interior zone, for which 30-50% ground coverage would appear to be normal. Few alterations were required to the perimeter zone in either case, there being few churches or other institutional buildings in these extramural blocks. Both perimeter zones are extremely homogeneous. The main

'adjustments', therefore, apply to the interior zones. Taking the most common segment size, 75' x 50', a modal density range was established for the different types of configuration by applying the building depth/segment width relation given above. Four configurations were considered - those which the earlier analyses revealed to be most common. The results are recorded in fig. 8.6.

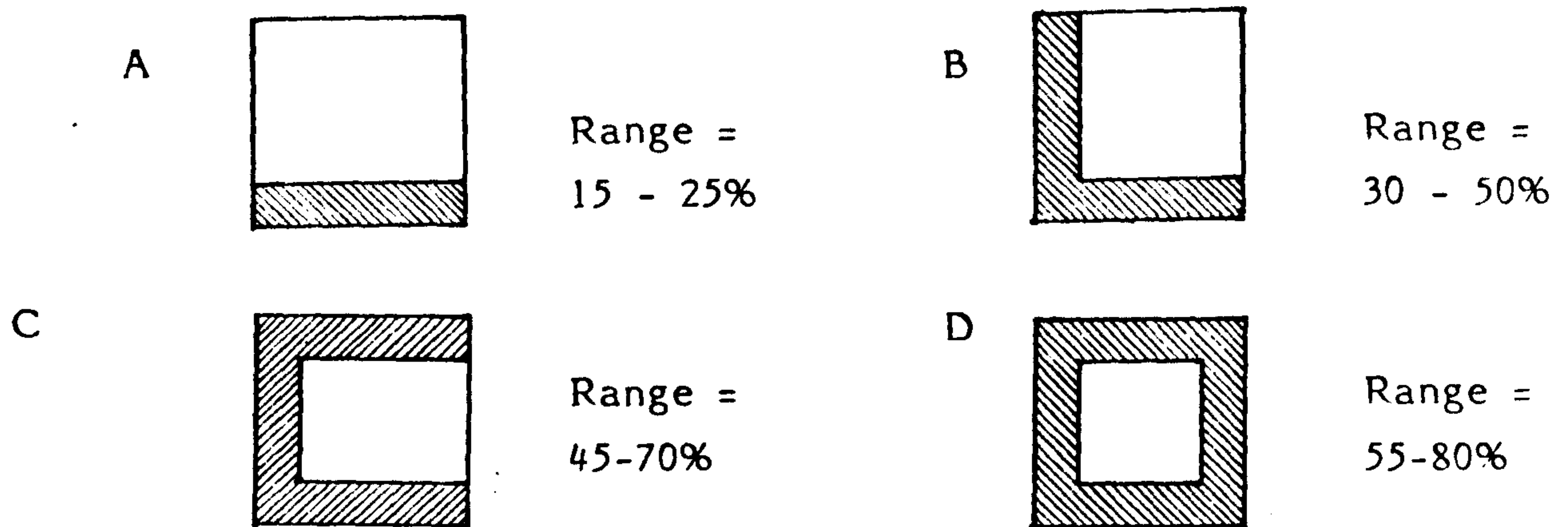


Fig.8.6. Modal density range for different building configurations (interior segments).

BUILDINGS/OPEN SPACE

Land-use	Ground Coverage (ft ²)		Total
	Perimeter Zone	Interior Zone	
Buildings	122, 550 (65%)	56, 600 (51%)	179, 150 (60%)
Passages	41, 300 (22%)	23, 500 (21%)	64, 800 (22%)
Gardens	24, 500 (13%)	30, 650 (28%)	55, 150 (18%)
Total	188, 350	110, 750	299, 100 (2.78hA)

Table 8.5. Actual ratio of buildings to open space for perimeter and interior zones : Grub Street - White Cross Street.

BUILDINGS/OPEN SPACE

Land-use	Ground Coverage (ft. ²)		Total
	Perimeter Zone	Interior Zone	
Buildings	88, 050 (64%)	51, 050 (40.5%)	139, 100 (53%)
Passages	27, 050 (19.5%)	19, 050 (15%)	46, 100 (17%)
Gardens	22, 900 (16.5%)	56, 100 (44.5%)	79, 000 (30%)
Total	138, 000	126, 200	264, 200 (2.45hA)

Table 8.6. Actual ratio of buildings to open space for perimeter and interior zones : Golden lane - White Cross Street (n.section).

The mean values for A, B, C, and D will be taken as 20%, 40%, 57.5%, and 67.5% respectively. If we consider a hypothetical mix of segment configurations, 50% type B, 30% type A, 15% type C, and 5% type D - a mix which is fairly representative of the interior zones of large blocks on Ogilby and Morgan - the overall density obtained is 38%. If this proportion is substituted for the actual proportions of building/ open space in the interior zones of the two blocks (tables 8.5, 8.6), the overall building density for the blocks becomes: Grub Street, 55%; Golden Lane, 51%. The overall ratio of building/open

space is thus very similar for the two examples. Let us now consider the theoretical maximum density for the two blocks. If every interior segment were developed on all four sides, i.e. as type D, then the density of the interior zone would be 67.5%. Substituting this proportion in the two blocks, the overall density becomes : Grub Street, 66%; Golden Lane, 66%. This figure, identical for the two examples, is some way below the density produced by the small blocks.

This results from the relatively light development of the perimeter, as well as the interior zones. Were the private gardens on the perimeter more extensively built upon, a density approaching 75% would be expected for the perimeter zone. It is unlikely, however, that the interior development would achieve a density greatly in excess of 65-70%, unless it was composed entirely of small segments. The gross density of a large block would therefore seem to tend towards a maximum of about 70%, rather than 75%. A realistic breakdown of buildings/passages/gardens for a maximally developed large block might then be 70/25/5.

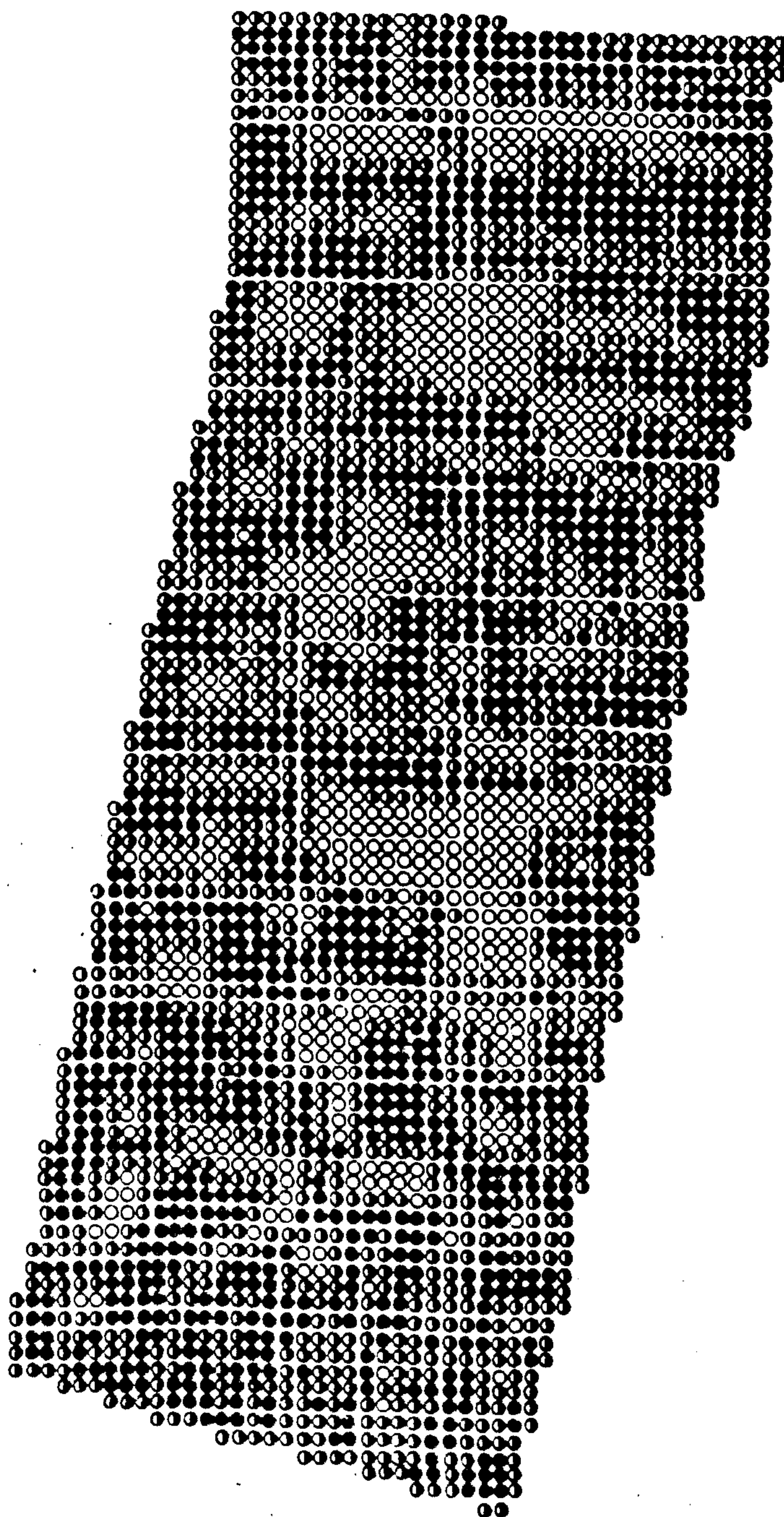


FIGURE 8.7: Density map for Grub Street - White Cross Street. Measurements taken on a 10' x 10' graticule.

8.4 The Model

To explore further the development of the City blocks, the model was implemented in the form of a computer program. Two blocks were considered, one medium-range (A), and the other large (B) (see fig.8.8). Both are hypothetical blocks, designed to simulate the physical characteristics of actual blocks in the City centre and in the suburbs, respectively. Thus, the overall dimensions of the blocks and the mix of segment sizes were based on the data extracted from Ogilby and Morgan. The orientation and alignment of segments were based more on an intuition of what seemed 'life-like' in each case. Block A is 400' X 300', and has 8 no. interior segments. Block B is 650' x 500', and has 21 no. interior segments. The former would seem, in retrospect, to contain rather more interior segments than was usual for a block of that size, but since this enhances the access characteristics, it makes the block more, rather than less valuable as a formal experiment. The set of boundaries shown in each block was treated as an inherited framework, within which the building patterns were to be generated; it was the 'given' structure. The block structure, and its progressive infill, are reproduced as visual images on the computer graphics terminal. But before going on to discuss the results of the exercise, it is necessary to say something of the workings of the program itself. This will help to clarify the role of the computer, and the status of the objects produced.

8.4.1 The Computer Program

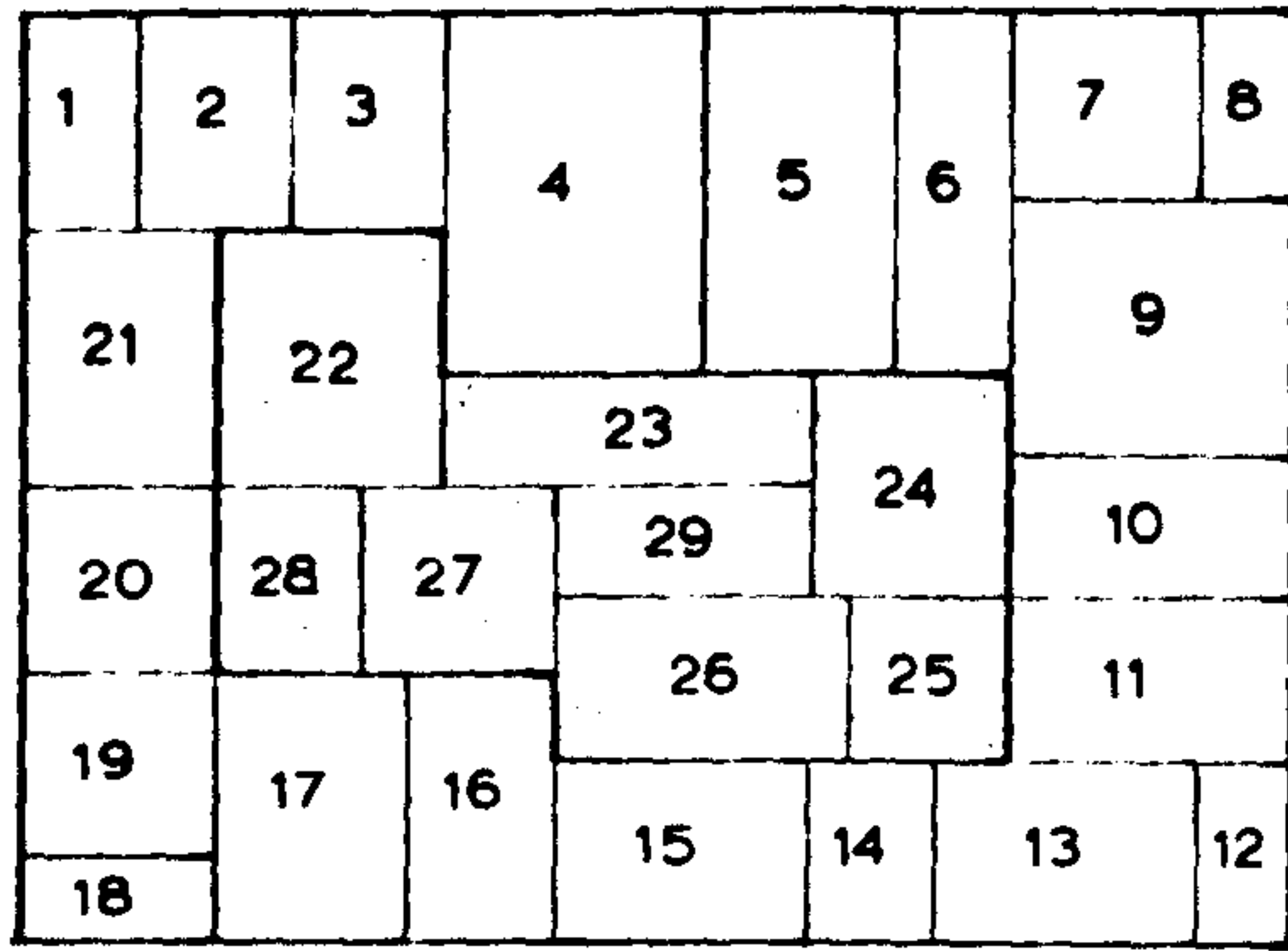
Because they represent a set of inherited boundaries and constraints, the blocks were entered into the computer as fixed data; they are not generated. Also fixed are the initial access points, i.e. those from the street. Accesses are introduced into specified perimeter segments along the street edge; they remain unchanged until new data are assigned. The blocks (and accesses, buildings) are set out on a 5' x 5' grid. Since the morphology is characterised by its geometric and dimensional irregularity - a

feature that we wished to some extent to recapture - consideration was given initially to the possibility of parameterisation, i.e. to the use of an algorithm which would permit all dimensions to be infinitely variable. However, difficulties of programming made it impracticable to implement the model in this way, and the grid method, based on the lowest common denominator of all dimensions, was adopted as a more workable alternative. The 5'0" graticule, though not exactly the lowest denominator of all entities within the blocks, was found to come close enough to the typical (i.e. modal) building and passage dimensions to give a very authentic rendering of the building/open space configurations. 15' 0" was adopted as the most common frontage for perimeter units; interior units were variously 10', 15', 20' and 25' on side ; passages were made 5' wide.

The desire to simulate the 'higgledy-piggledy' quality of the morphology led us to adopt a step-by-step approach to the generation of building patterns, rather than a state description. Segments and parts of segments are developed separately and sequentially, according to the process descriptions we have set down. While it was possible, in principle, to set out large parts of an array as a single state description (a more economical approach), this would have been in conflict with our primary objective, which was to reconstruct the mode of growth of the building patterns, not merely their final form.

Development commences along the street edge, this being a 'privileged edge' in the arrangement. The access point is defined in each chosen segment as a 5' x 5' square in the central portion of the perimeter edge. The segments with direct access from the street constitute the first level of penetration or, as we have called it, the first shell. All segments in the first shell are developed according to process description 1, i.e. as yards. Those perimeter segments which do not form part of the first shell are developed as burgages.

BLOCK (A)



BLOCK (B)

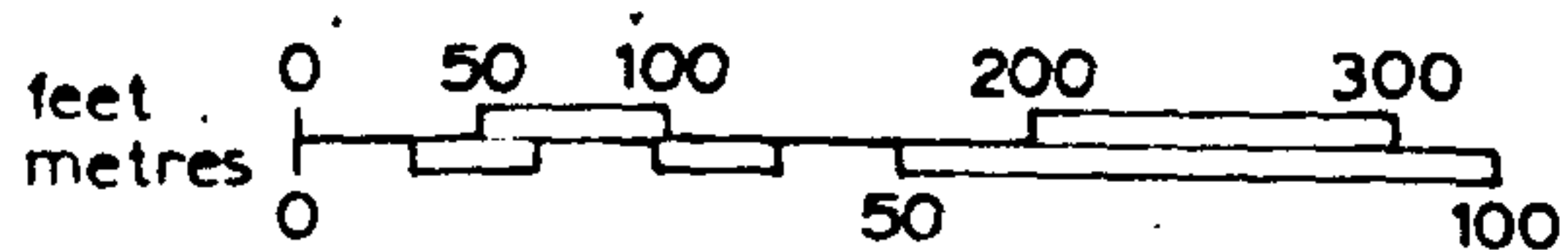
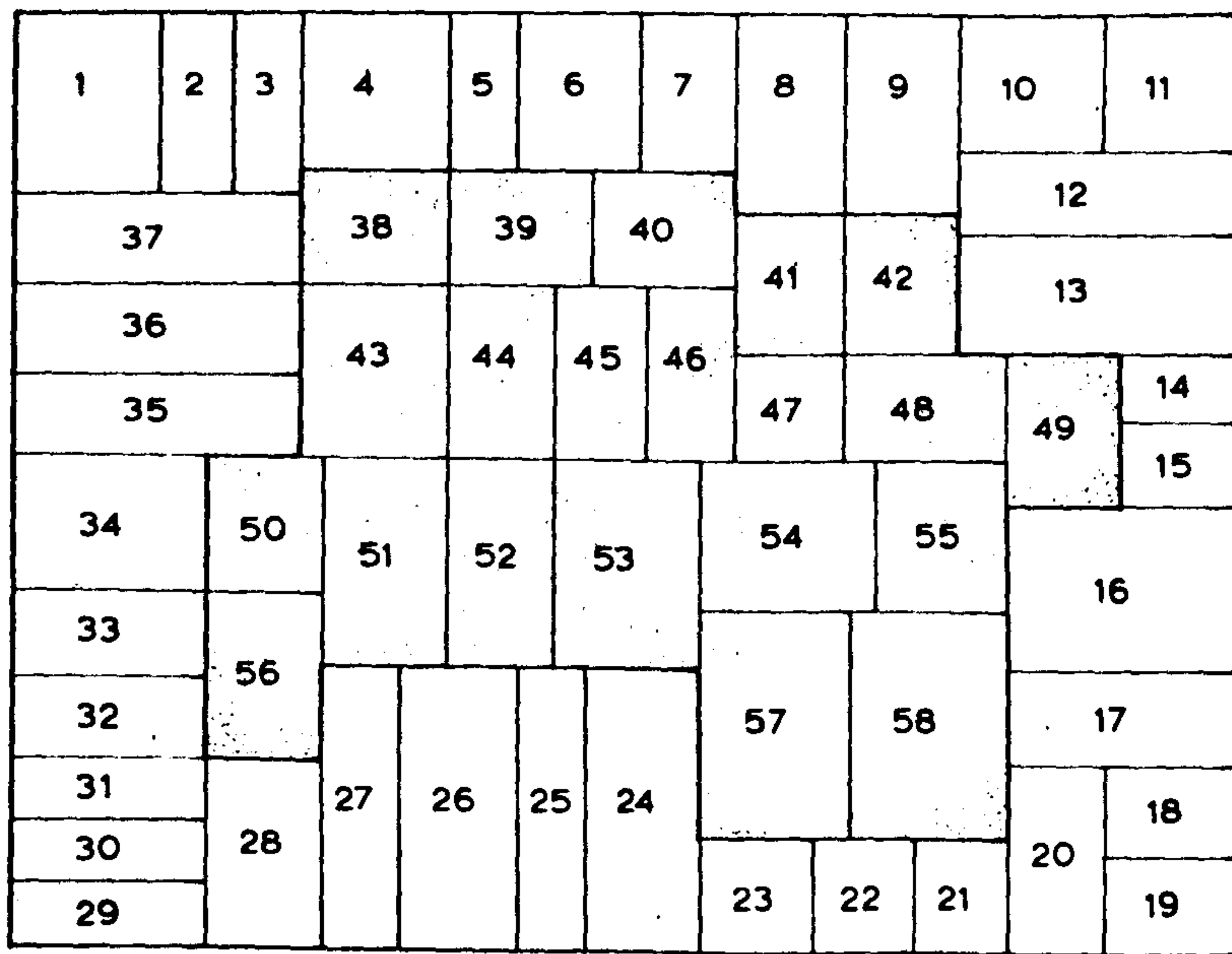
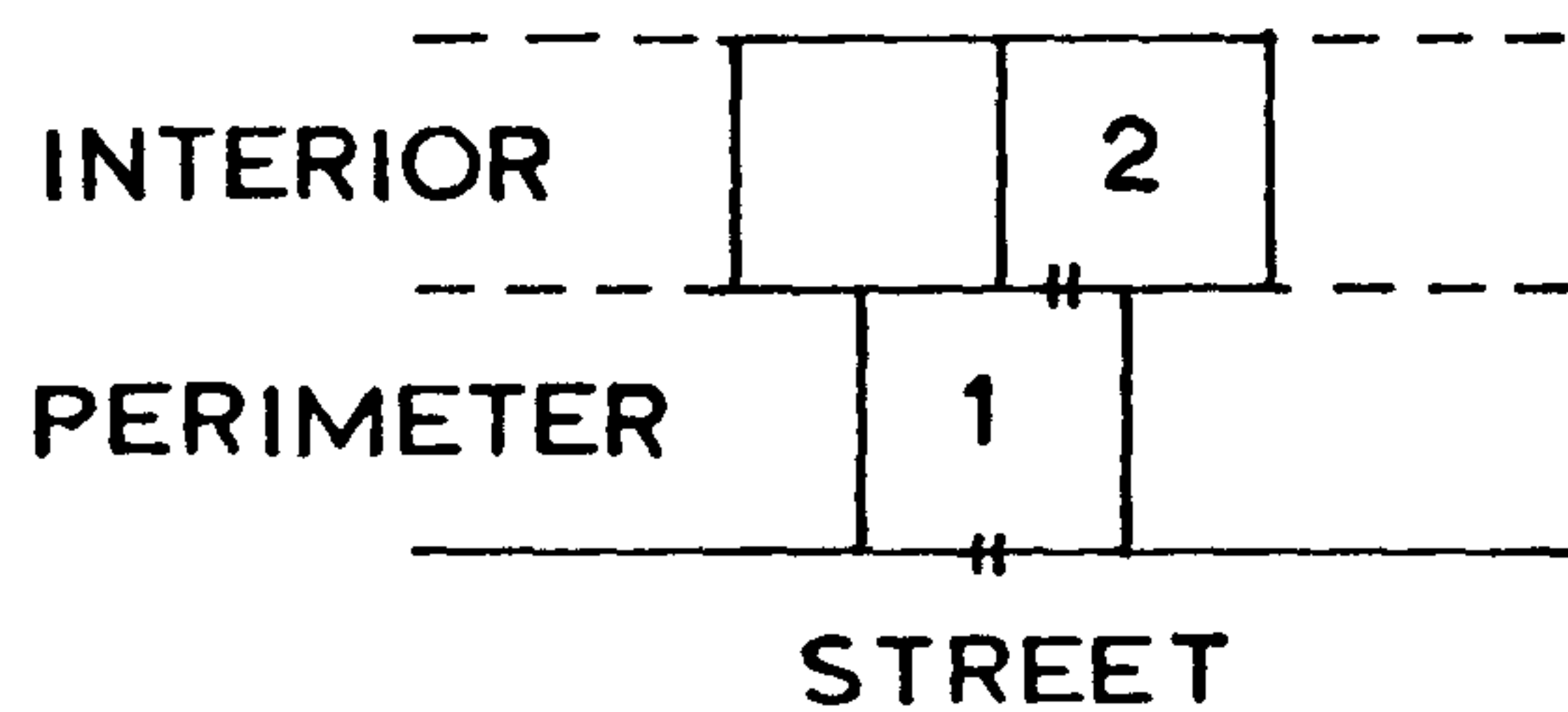


Fig.8.8. Hypothetical blocks used in the computer simulation

A start area is selected from the segments in shell 1, say segment no. 16. Given this information, the computer shuffles the segments into an array, beginning with segment no. 16, and proceeding in numerical order around the perimeter. It then counts the number of segments contiguous with each segment in shell 1. From these, it

sorts out the perimeter segments : these, the burgage plots, are not broken into or out of. All breakthroughs from shell 1 are, therefore, into the interior zone. The number of breakthroughs is specified as a proportion of the contiguities, e.g. 1 in 2, 1 in 6, etc. The computer will then break through into every second, or every sixth, contiguous interior segment. Each breakthrough is defined, as on the street edge, as a 5' x 5' square in the central portion of the common boundary, viz.



This breakthrough ratio 'rolls on' through the array. That is to say, if perimeter segment A adjoins two interior segments, and a breakthrough ratio of 1 in 6 is specified, no breakthrough will occur from this segment, and the computer will count the first contiguity for the next perimeter segment, B, as number 3. Hence, the breakthrough might be made from segment B or further on in the array.

Those interior segments which are penetrated in this way comprise shell 2. The process is then repeated : the computer counts the number of contiguities and, when a ratio is specified, breaks through accordingly. These breakthroughs define shell 3, and so on. The important point about the program is that the breakthroughs are not chronological, but spatial. The levels of penetration do not, therefore, represent a time sequence. A breakthrough from the perimeter zone in one section of the block might occur much later than that in another section, but both will be labelled as break-

throughs from shell 1 to shell 2. This is consistent with the evolutionary approach taken throughout the study.

Building development occurs as each segment is broken into, and the perimeter (shell 1) and the interior (shell 2 and deeper) are developed on different principles, following the rules already elaborated. In the case of the perimeter segments (i.e. the access segments), the street edge is developed with a row of units, 20' to 50' deep, on each side of the access point. From the access position, a passage, 5' wide, is formed perpendicular to the street, leading to the yard at the back. The remaining three sides of the segment are developed with rows, the depth of which is related to the width of the segment. The program maintains a minimum distance of 15' between opposite rows. In order to simplify the process of simulation, the developments were set out as whole rows, rather than building by building. Hence, individual buildings are not distinguished. Although this involves some loss of detail, it does not significantly affect the gross morphological characteristics, and indeed conforms closely to actual building practice.

Development of the interior was based upon process description 2 but, because of the difficulty of dealing with alternative sequences of development, the buildings were set out instead according to a taxonomy of configurations. The interior segments were oriented in all cases in relation to the main access point, not to the geometry of the segment. Thus the taxonomy comprises the twelve configurations given in tables 7.2 to 7.7.

Allocation of the various configurations was made by means of a matrix, which was designed to achieve a mix of patterns comparable with that found in actual examples. Thus, of the 24 entries for shell 2, 1 no. (4%) is a one-sided (type A) configuration, 12 no. (50%) are two-sided (type B) configurations, 7 no. (29%) are three-sided (type C) configurations, and 4 no. (17%) are four-sided (type D) configurations. The computer selects the configuration type by proceeding serially through the matrix. It was observed above that the building density tends to decrease the further one penetrates the block. In other words, the higher the shell number, the greater

is the preponderance of type A and type B configurations. In order to simulate this grading effect, the mix of numbers (configurations) in the matrix was altered for each successive shell. Shell 3 consists of 29% type A, 50% type B, 17% type C, and 4% type D configurations. From shell 4, types C and D are excluded from the mix ; from shell 5, the mix is made up of type A configurations only.

Once again, the program sets out whole rows, rather than individual buildings, and the depth of the rows is related to the width of the segment. Where building development occurs on the access side of the segment, the access square is extended at right angles to the boundary to form a clear passage, 5' wide, through the row.

Given the parameters described, the computer will generate any or all of the possible access and building configurations. Indeed, its advantage lay principally in showing the sorts of things that could and should occur. We may now consider the results obtained from the program.

8.4.2. Results

Access points were defined at first in about 50% of perimeter segments, a frequency which is common in actual examples. Access patterns were then generated, employing a wide variety of breakthrough ratios, from 1:50 to 1:1. In its early stages, the breakthrough routine made no distinction between perimeter and interior segments ; adjoining perimeter segments were therefore counted as contiguities, and broken into, in the same way as interior segments. This resulted in an excessive amount of activity around the access segments : breakthroughs were too many and too frequent, and few cul-de-sacs were formed in shell 1, even with a 1:50 ratio. The program also produced some very circuitous routes, since it might break into a neighbouring perimeter segment only by way of a whole series of interior segments, i.e. it would break back into the perimeter zone.

These results were manifestly at variance with the empirical evidence. Nor had these very 'branching' patterns been produced when the blocks had been generated by hand. Clearly, these had been corrected by an implicit assumption, namely, that all those perimeter segments without street access are developed with burgage plots, and are neither broken into or out of. This rule is, in fact, not universally true : sideways access did sometimes lead to back development of burgage strips. But it is generally true. And once the program was modified to 'recognise' and sort out the perimeter segments, the access patterns were found to conform closely to the 'real' graphs. A further modification, made in the light of the generated patterns, was to restrict access into the corner segments : these, like the burgage plots, were developed as self-contained parcels. A sample of access graphs obtained for block A is given in fig. 8.9.

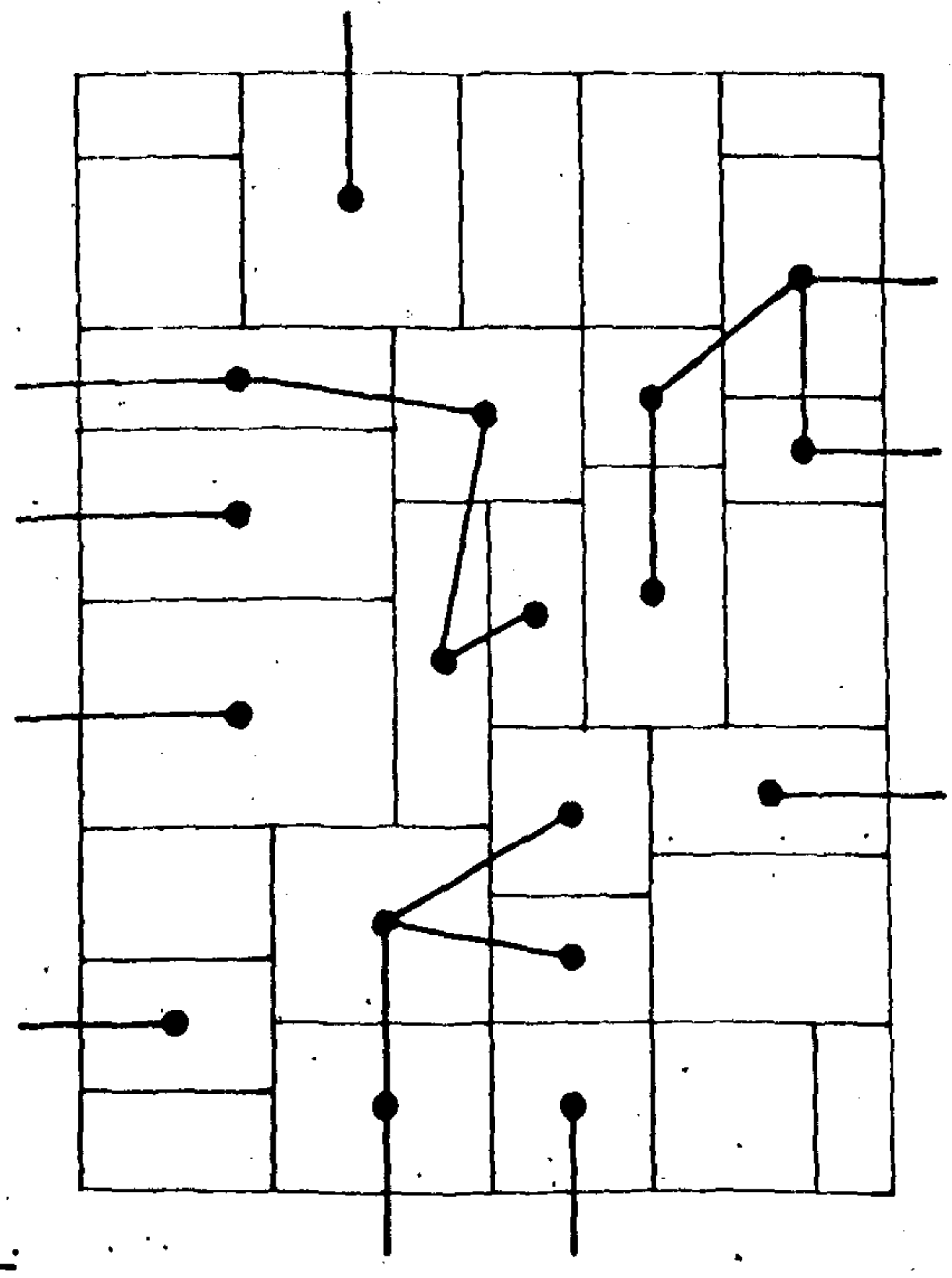
It will be noted that the 'depth' of the graph increases as the breakthrough proportion is reduced. Thus, in examples 1 and 2, only 3 no. (30%) of shell 1 segments give on to shell 2, and the graph extends in all to four shells. In number 3, there are breakthroughs from 6 of the 10 access segments, and all interior segments are reached within three shells ; while in number 4, 7 no. of the access segments break into shell 2, with the result that the majority of interior segments now fall within shell 2. Of these graphs, no. 3 is closest to the patterns derived from the map evidence. Reduction of the breakthrough ratio produces access graphs which, while possible in terms of the given geometry, do not seem to occur in practice. Thus, the 'real' access structures are plainly at the shallow end of the spectrum. However, the shallowest graph-type, no.4, is rarely, if ever, achieved.

The fact that the real access graphs fall consistently within such a narrow band of the possible seems highly significant, and central to an understanding of the processes by which the blocks were developed. It is especially interesting that the proportion of perimeter segments broached from the street should be so uniform

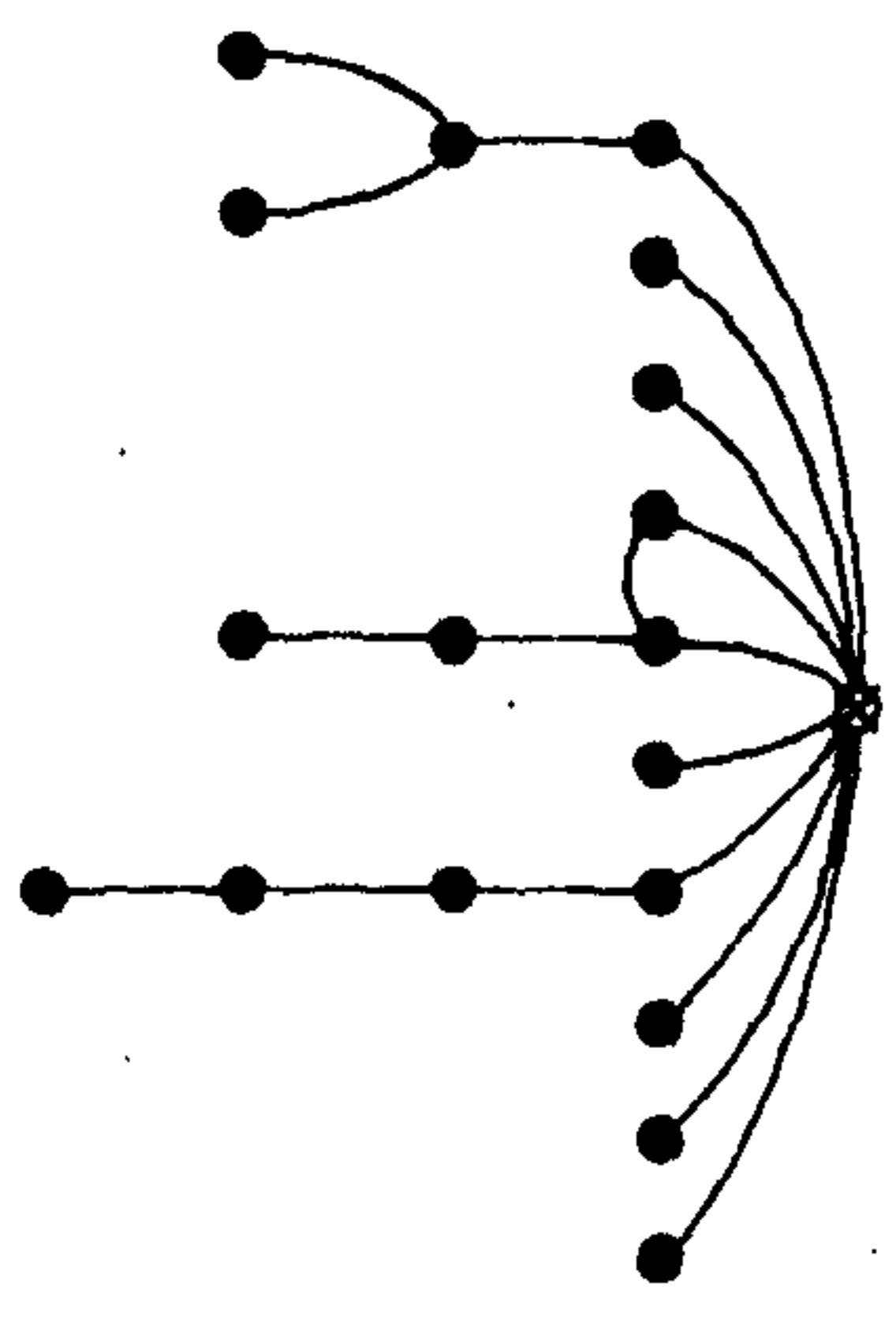
Fig.8.9. A sample of access patterns generated for block A.

across examples of a particular size. In medium-range blocks, it seldom falls below 40%, and apparently never below 30%. In the case of large blocks, the threshold would appear to be somewhat higher: a 40% access proportion is uncommon. In order to elucidate this relation, a simple experiment was conducted, in which the breakthrough ratios were held constant, while the number of initial access points was reduced. This was done for both blocks. In block

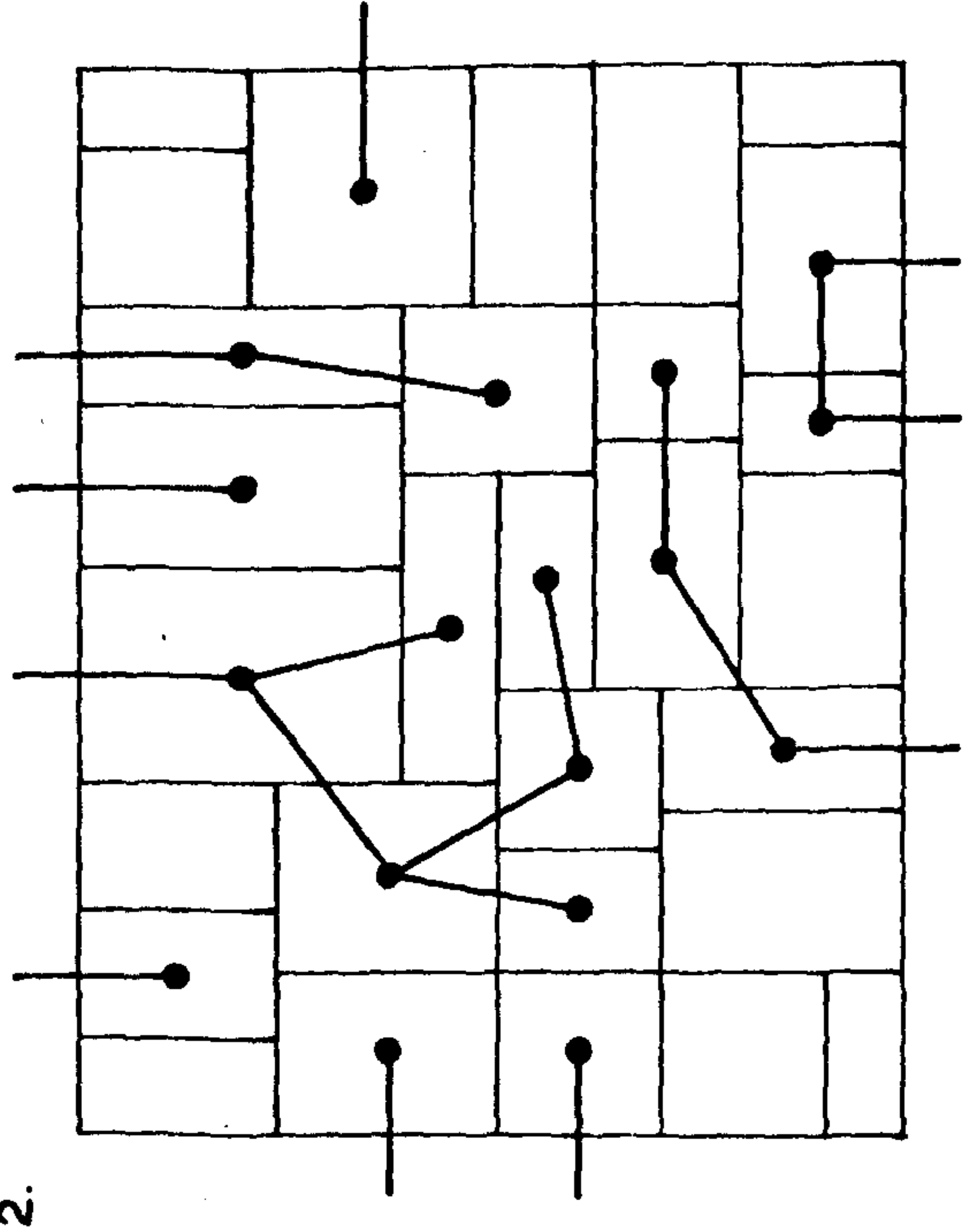
1.



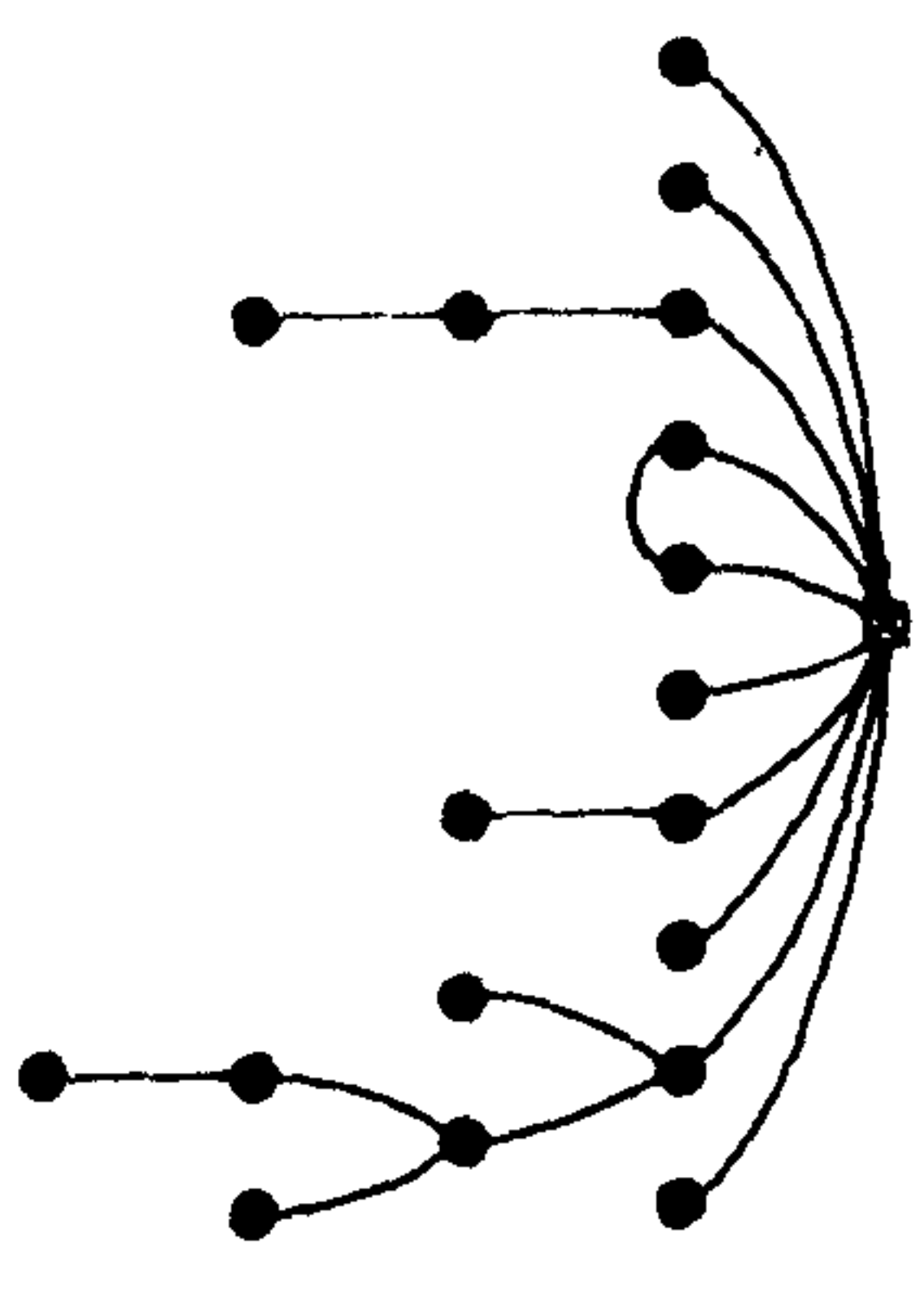
Initial access points: 10 no.
 (50% of perimeter segments)
 Breakthrough sequence
 Intra-shell: 1 in 10
 Inter-shell: 1 in 10, 1 in 10,
 1 in 10.



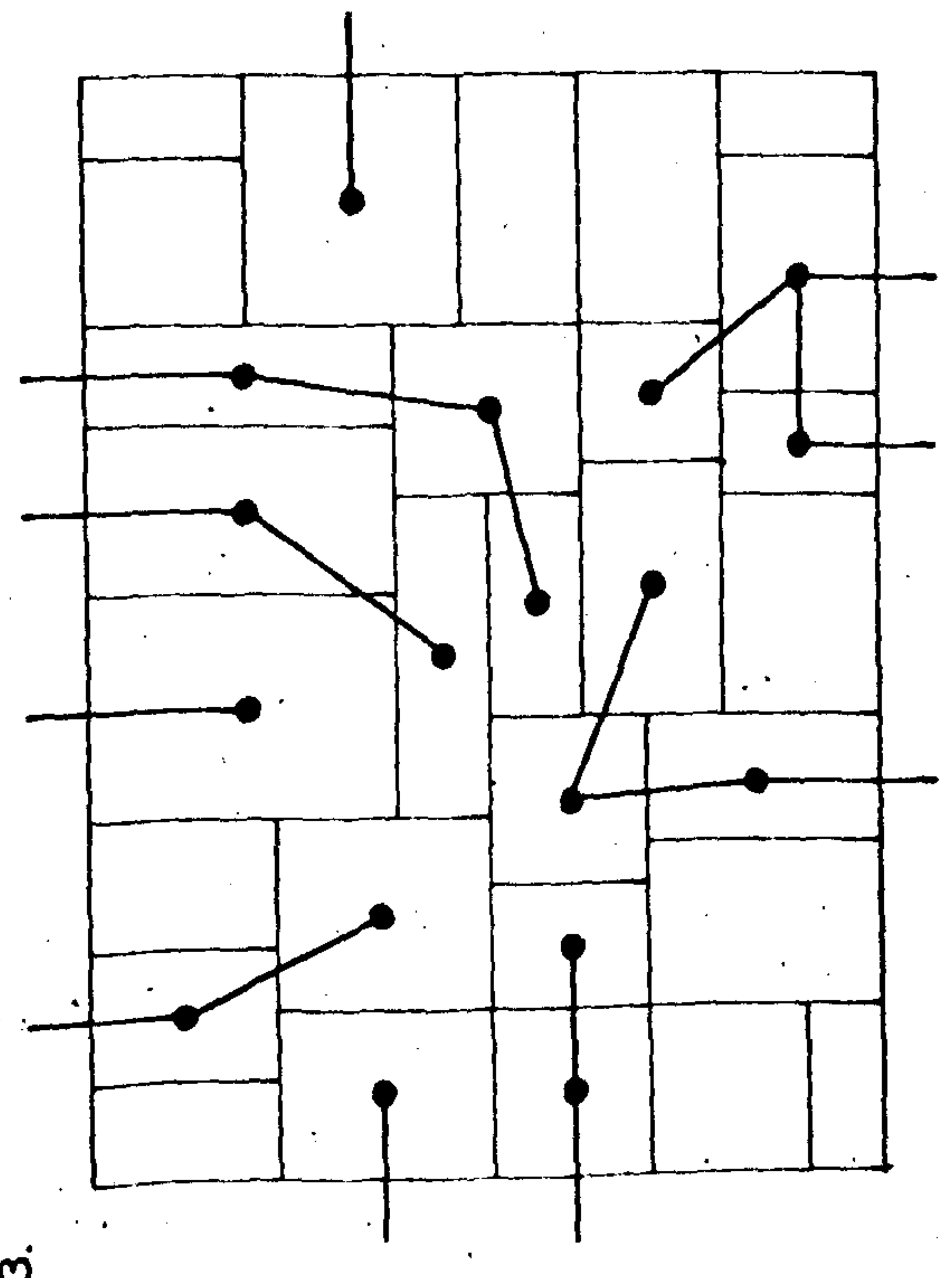
2.



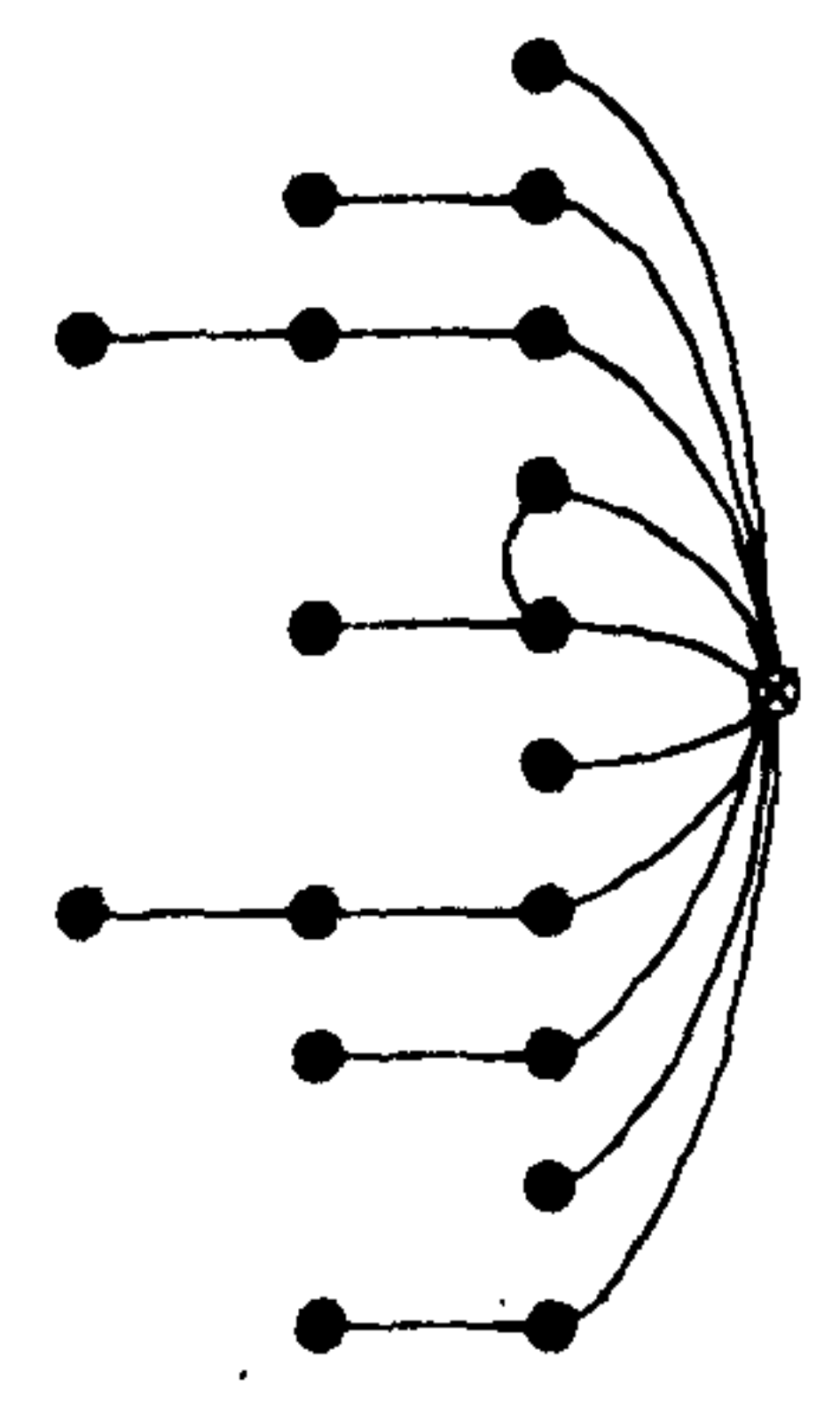
Breakthrough sequence
 Intra-shell: 1 in 10
 Inter-shell: 1 in 5, 1 in 5,
 1 in 5.



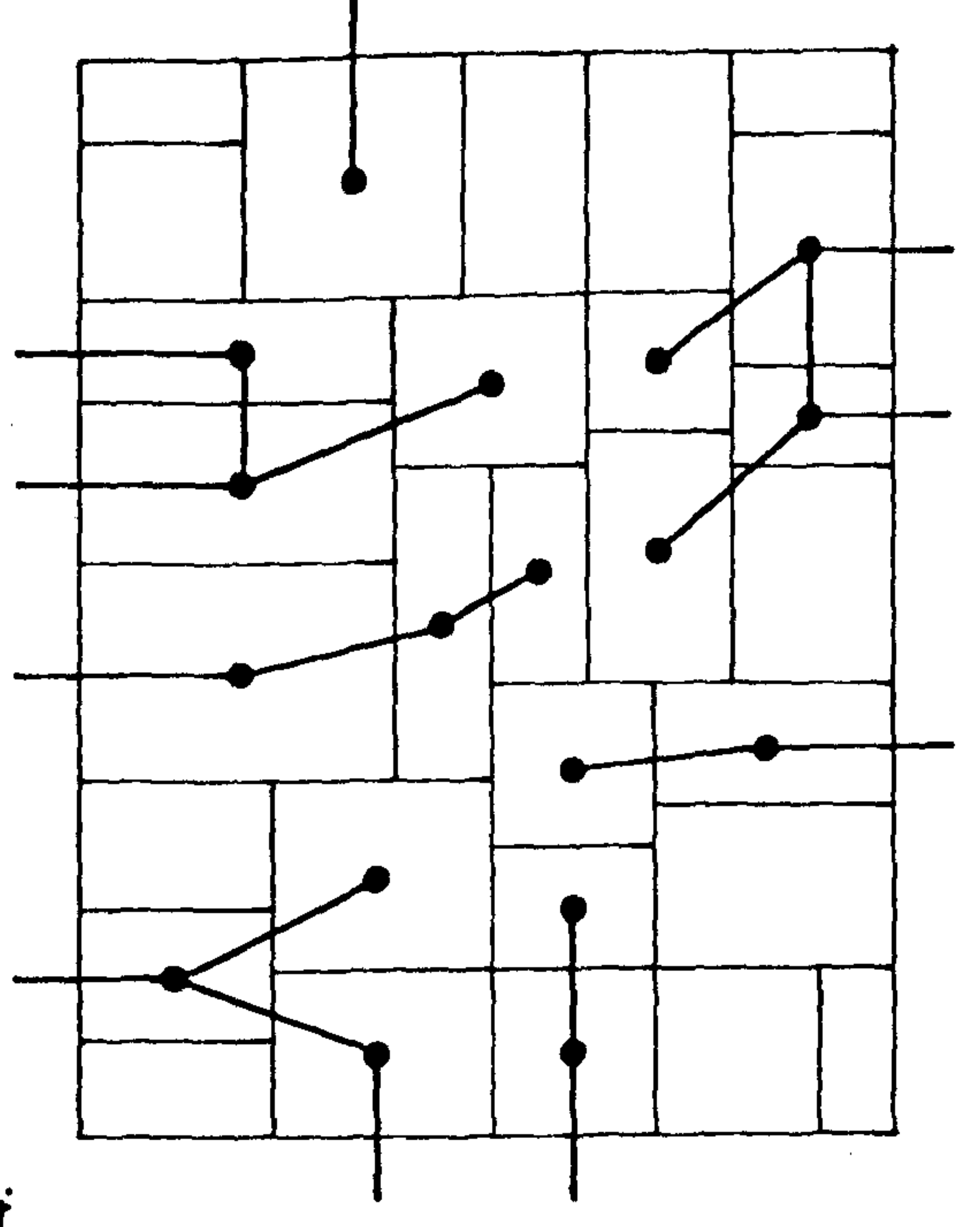
3.



Breakthrough sequence
 Intra-shell: 1 in 8
 Inter-shell: 1 in 7, 1 in 4,
 1 in 2.



4.



Breakthrough sequence
 Intra-shell: 1 in 2
 Inter-shell: 1 in 1, 1 in 1.

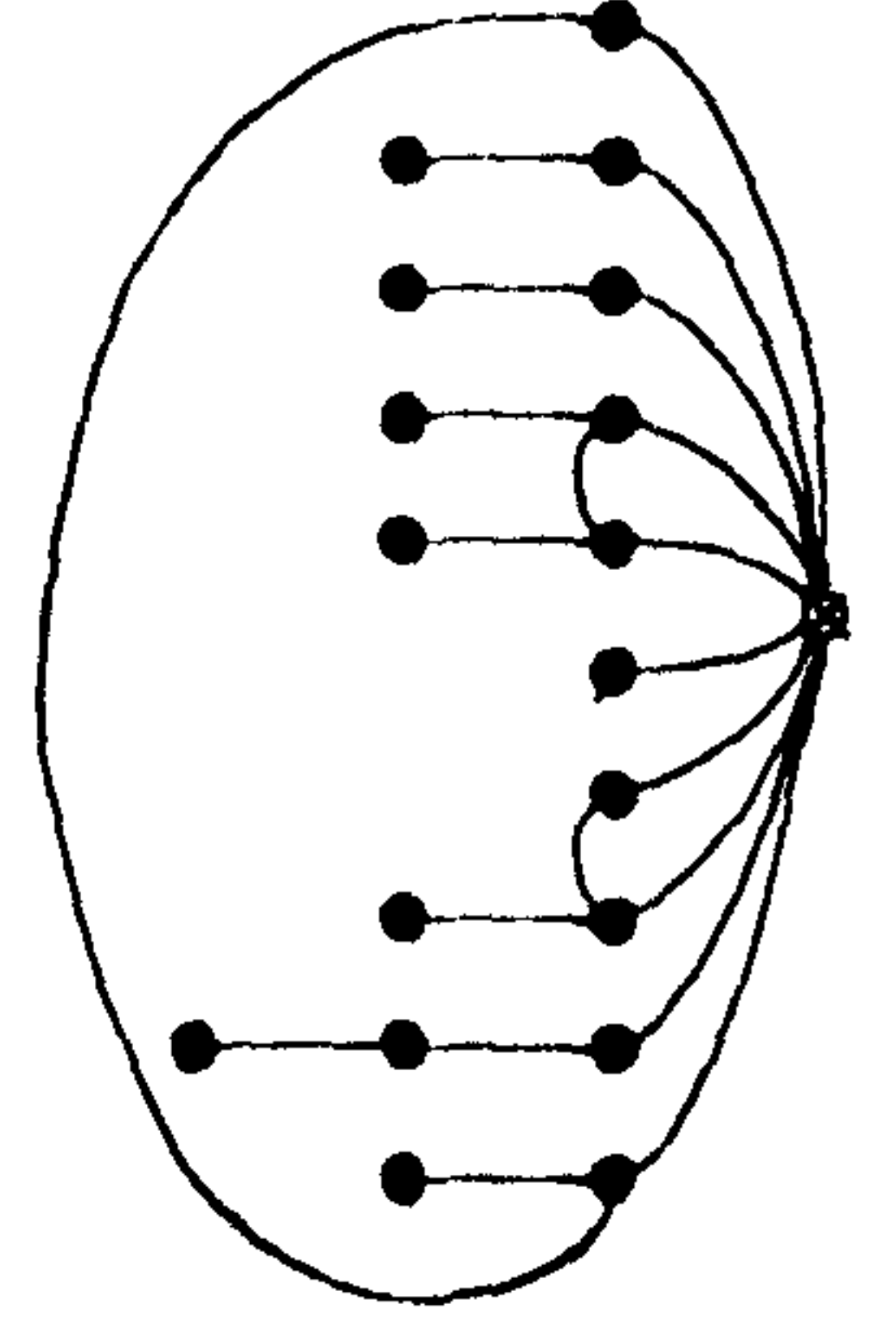


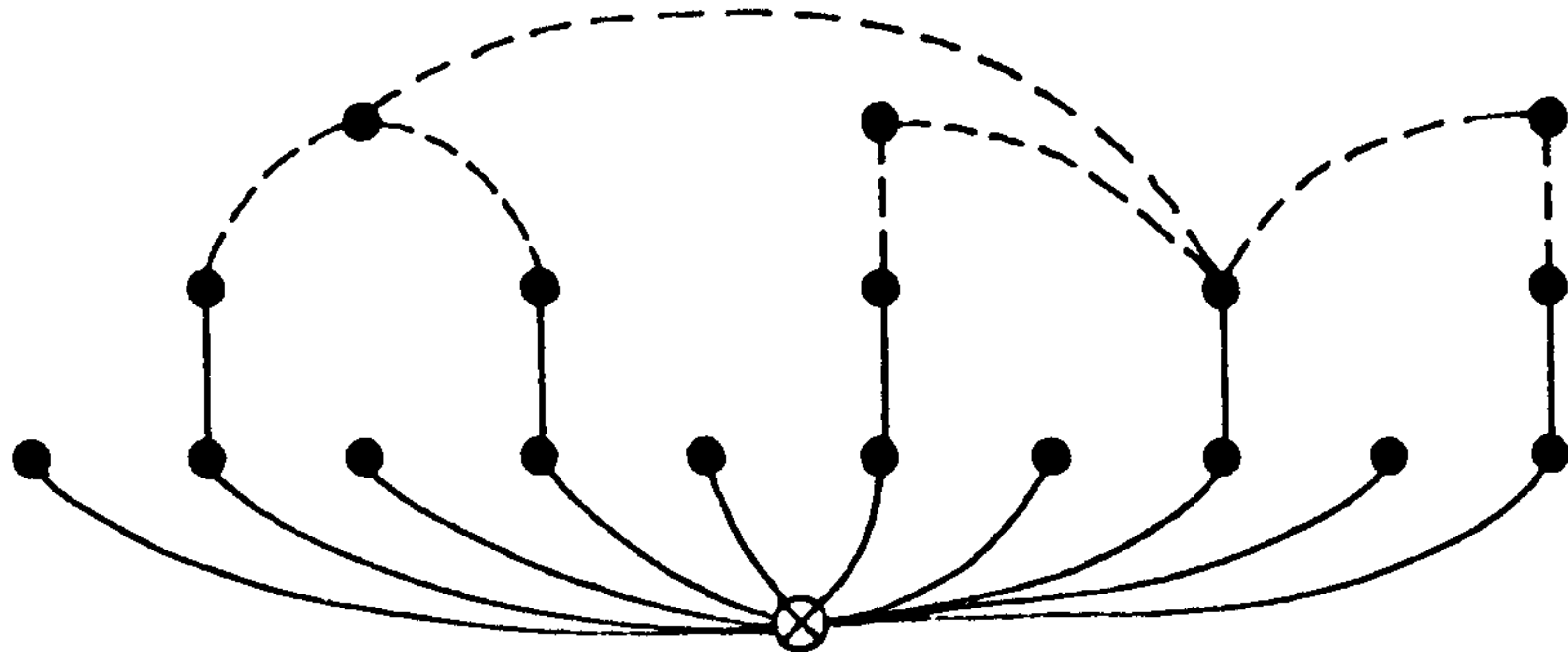
Fig. 2.9

A, the proportion of perimeter segments with access from the street was reduced from 10 (48%) to 8 (38%) and then to 5 (24%). In block B, the proportion was reduced from 18 (49%) to 14 (38%) and then to 11 (30%). The resultant access graphs are reproduced in figs. 8.10 and 8.11.

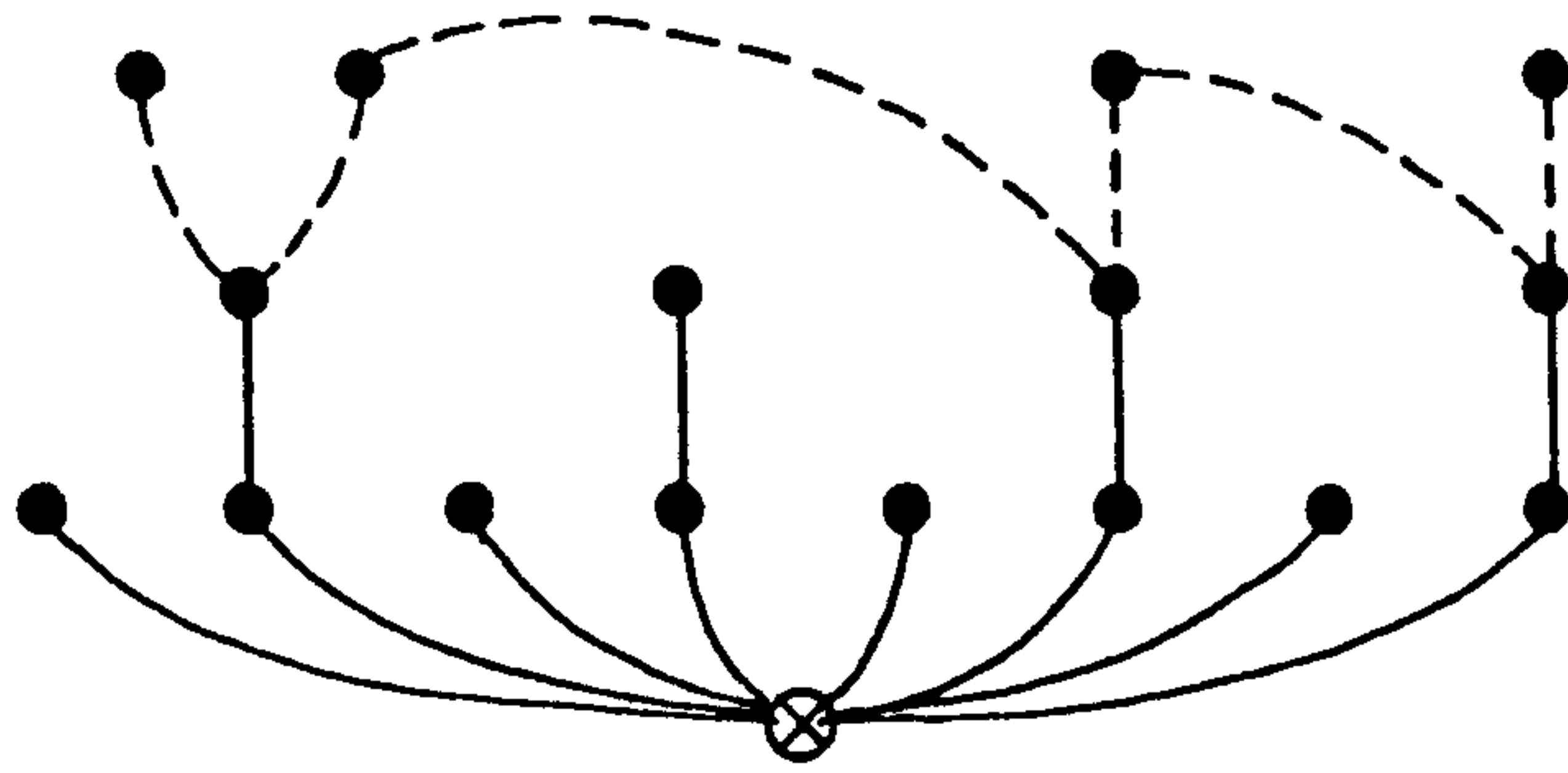
In the case of block A, when 50% (5 no.) of shell 1 segments have breakthroughs to shell 2, the overall graph does not exceed three shells, and the segments in shell 3 remain relatively accessible to the perimeter. The broken lines indicate the adjacency and hence potential access, between shell 2 and shell 3 segments. It will be seen that each of the shell 3 segments has at least two possible routes to the perimeter (this excludes the possibility of further direct connections to shell 1). When the proportion of initial access segments is reduced to 40%, the number of shell 3 segments is increased to four, and the theoretically possible routes to the perimeter are correspondingly fewer. Two of the four segments now have, of necessity, a unique route to the street edge. At stage 3 (a 24% access proportion), five of the interior segments fall within shell 3. Access now becomes more critical as several of the segments are dependent on a single shell 2 segment for their right of way (the graph assumes the form of a branching tree). The deeper segments are thus more highly 'controlled' by those in shell 2 than are their counterparts at stages 1 and 2.

Fig.8.10. Relationship between 'depth' and initial access. Access patterns generated for different initial access conditions in block A.

1)



2)



3)

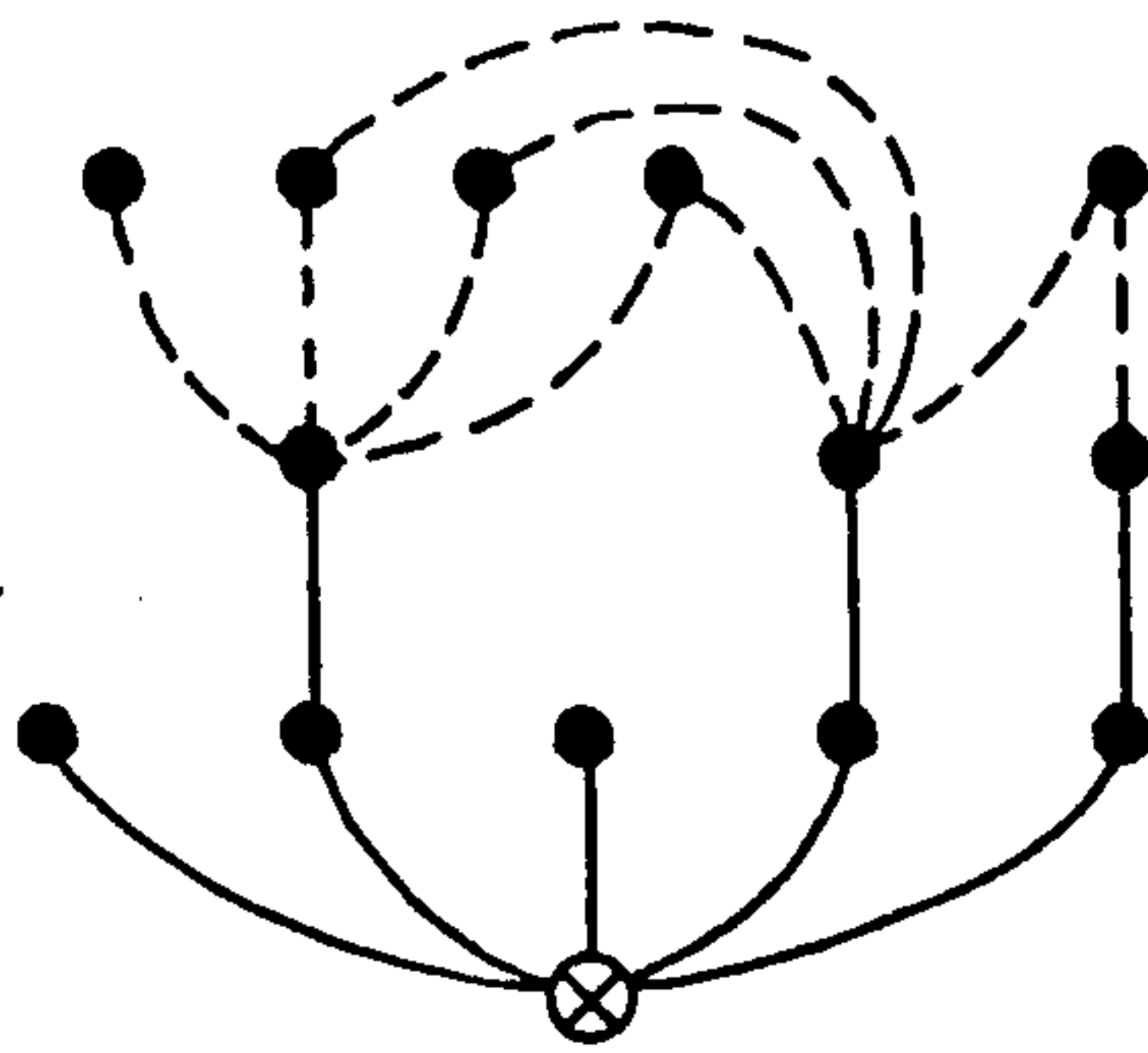
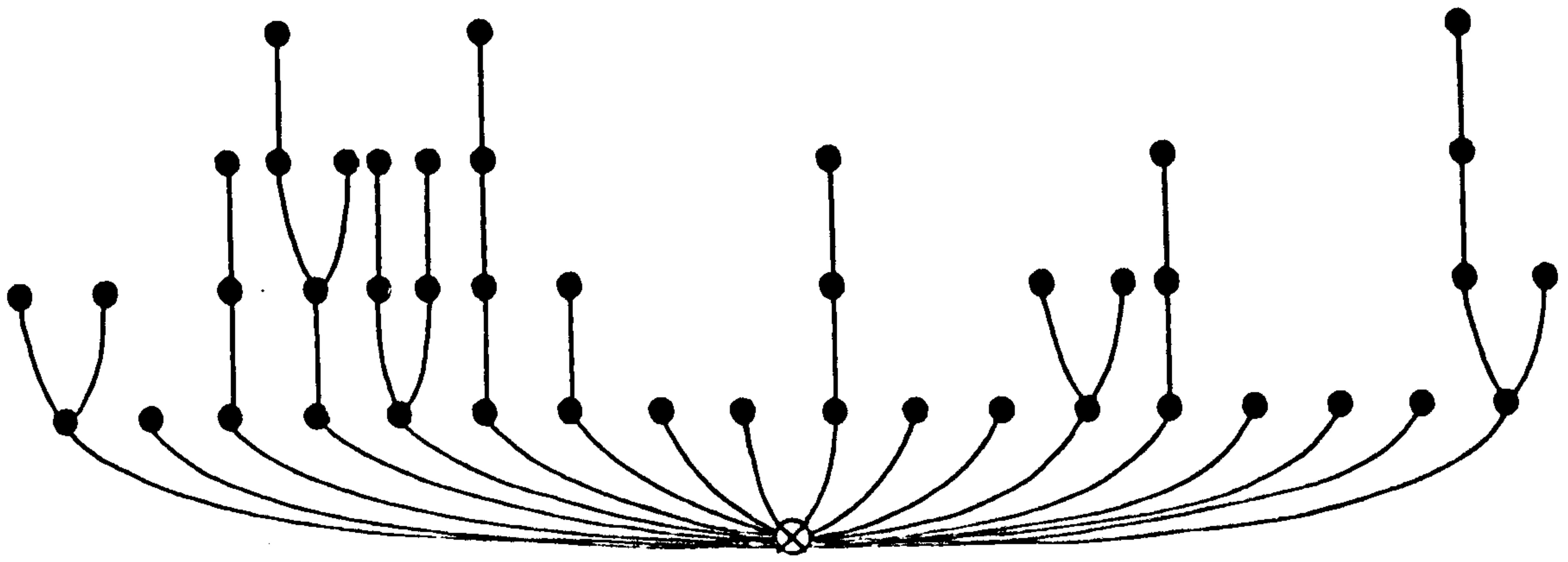


Fig. 8.10

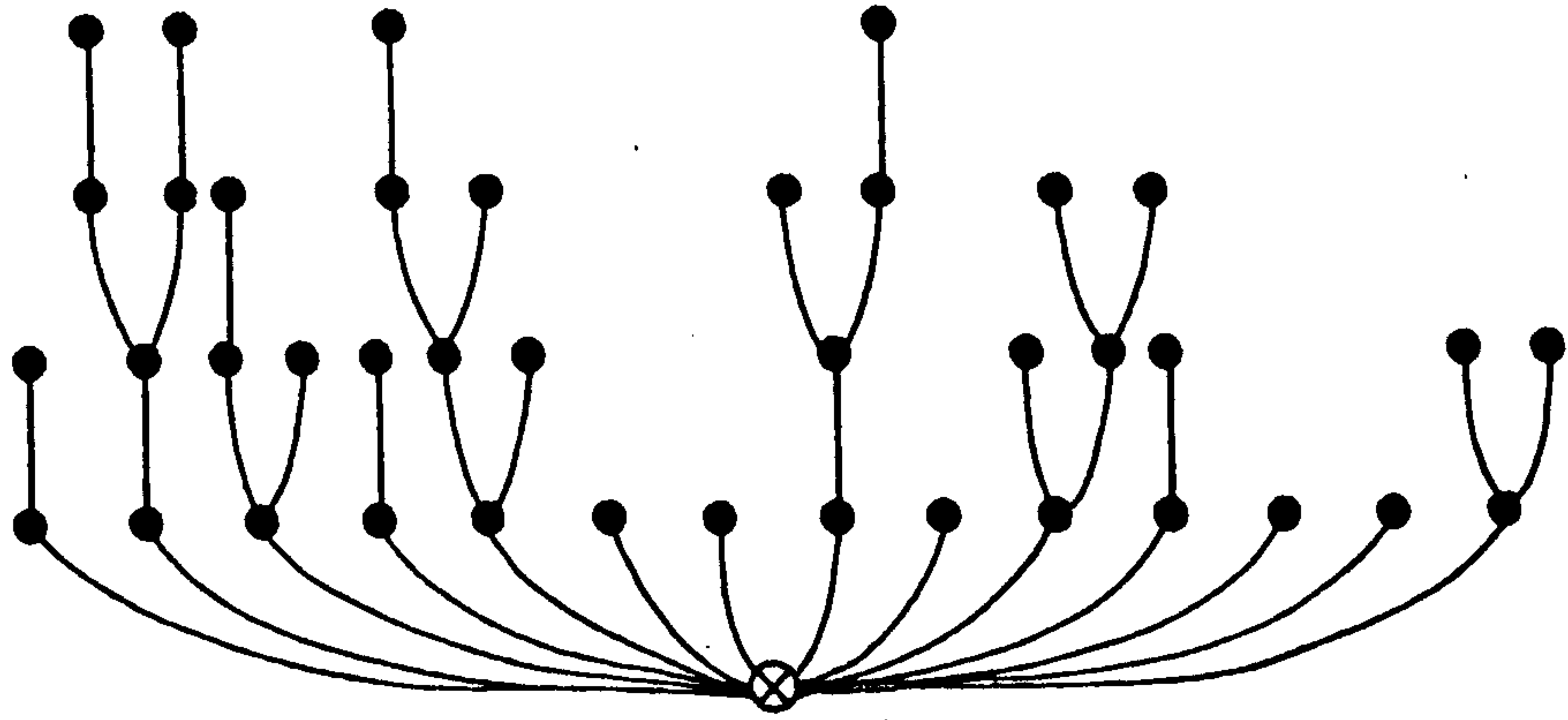
Fig.8.11. Relationship between 'depth' and initial access. Access patterns generated for different initial access conditions in block B.

These characteristics are underlined by the graphs for block B. Access graph 1, arrived at after some experiment with breakthrough ratios, is a very 'life-like' simulation of actual access patterns (cf. Grub Street, fig.8.4). 10 out of 18 (56%) shell 1 segments break through to the interior, and the majority of interior segments (23 out of 26) lie in shells 1 and 2. The valency of the vertices - 23 no. (52%) have degree 1, 16 no. (36%) have degree 2 - is also very close to the results obtained for Grub Street. When four of the initial access points are eliminated (stage 2), the number of segments in shell 4 rises from three to four, and the graph becomes markedly more 'branchy'. Each of the deep segments is controlled by a shell 2 segment which is three-way connected. At stage 3, the same breakthrough ratios produce a graph which extends to shell 5. Four of the shell 2 vertices give on to two or more in shell 3; the segments in shells 4 and 5 are accessible only by way of a very

1)



2)



3)

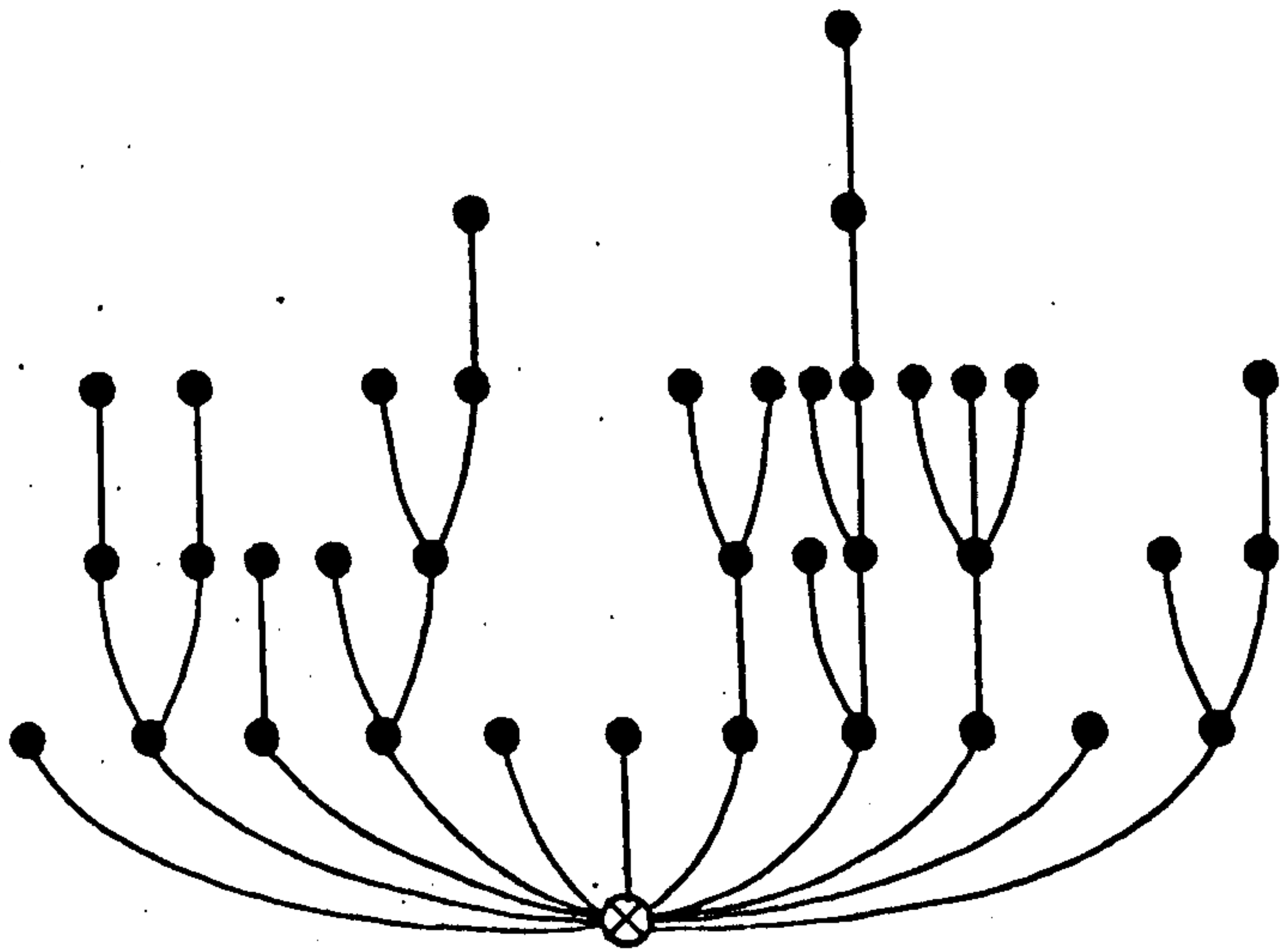


Fig. 2.11

dendritic, or branching system.

It is clear from these examples that the number of access points along the perimeter of a block has a direct influence on the types of access or permeability pattern that may be realised. Assuming a fairly consistent parcelling of land into segments, a reduction of the initial access ratio below 1 in 3 was likely to produce access routes of such 'depth' that they would be unacceptable, either by virtue of their length and circuitousness or because of their dependence on rights of way through another's property. Should access be closed off at a point near the perimeter, a whole succession of deeper segments might be left without any feasible means of reaching the street edge. Plainly, the owners or occupants of the deep plots would seek alternative access long before such a dire situation was reached: they would attempt to bring themselves closer to the perimeter, i.e. to make the segments 'shallower'. This would explain why access patterns such as those generated at stage 3 are seldom to be found in the map analysis. An initial penetration of about 30% may be seen in these terms to constitute a physical, or spatial threshold. In the case of large blocks, a greater number (i.e. frequency) of passages was necessary to achieve a comparable reduction in depth, and the threshold is somewhat higher - approximately 40%. A frequency above these levels was necessary to sustain the working of the block as a whole. This is at root a formal property of the spatial structure. But, translated into social terms, it would seem to imply considerable collective pressure to secure and maintain access to the perimeter zone.

Turning now to the question of density, the relation between building configurations and ground coverage was examined for block B, whose larger interior zone made it more valuable as a test-case. The segments were developed for access pattern 1 above. Hence, provided that the process descriptions were correctly formulated, there was every reason to expect the gross density to match that derived from the map evidence. In fact, it was slightly low. The mix of configurations for each shell of the interior zone was generated from the matrix described above. Applying this mix to the interior zone of the Grub Street block, we obtain, for the whole

zone, 3 no. type A, 13 no. type B, 7 no. type C, and 3 no. type D configurations. Using the median density for each of these types, the overall building density in the interior zone of the block is 50%, fractionally below the actual figure. This gives a gross building density of 59%. From this result, a range of 55-60% may be predicted for the gross density of block B. The results fell instead between 50 and 55%.

It was easy to appreciate from the graphics display that this slight discrepancy was due, not to an imbalance in the interior configurations, but to inadequate ground coverage in the perimeter zone. This was caused by under-development of the burgage segments. In reality, the burgage tails, i.e. the gardens, were usually covered over to some extent with outbuildings, sheds, workshops, etc., - a process that paralleled the development of the perimeter yards (see the City plans). Since it would have required a substantial, and disproportionate, enlargement of the computer program to generate this burgage repletion, we confined ourselves to some adjustments within the context of the program. In order to simulate the tail development, the rear portions of the burgage segments were defined separately, as interior segments. This allowed them to be broken into, in the same way as other interior segments, and developed on one or more sides. The resulting development approximates the coverage, if not the form, of the desired infill. In addition, the ratio of access segments/burgage segments was increased. By increasing the proportion of the former from 50% to 66%, the balance of perimeter segment types was made to conform more closely to the Grub Street block, and the effect of the open burgage space was further diminished.

With these adjustments, the gross density was raised to within the predicted limits. The generated patterns have been found to produce a ground coverage varying from 58 to 62%. It is of interest to note that the configurational properties of the block are not significantly affected by the start area selected. Development has been commenced at each of the 24 access segments ; with the breakthrough ratios held constant, there is little variation in either the access structure or the density. This serves to

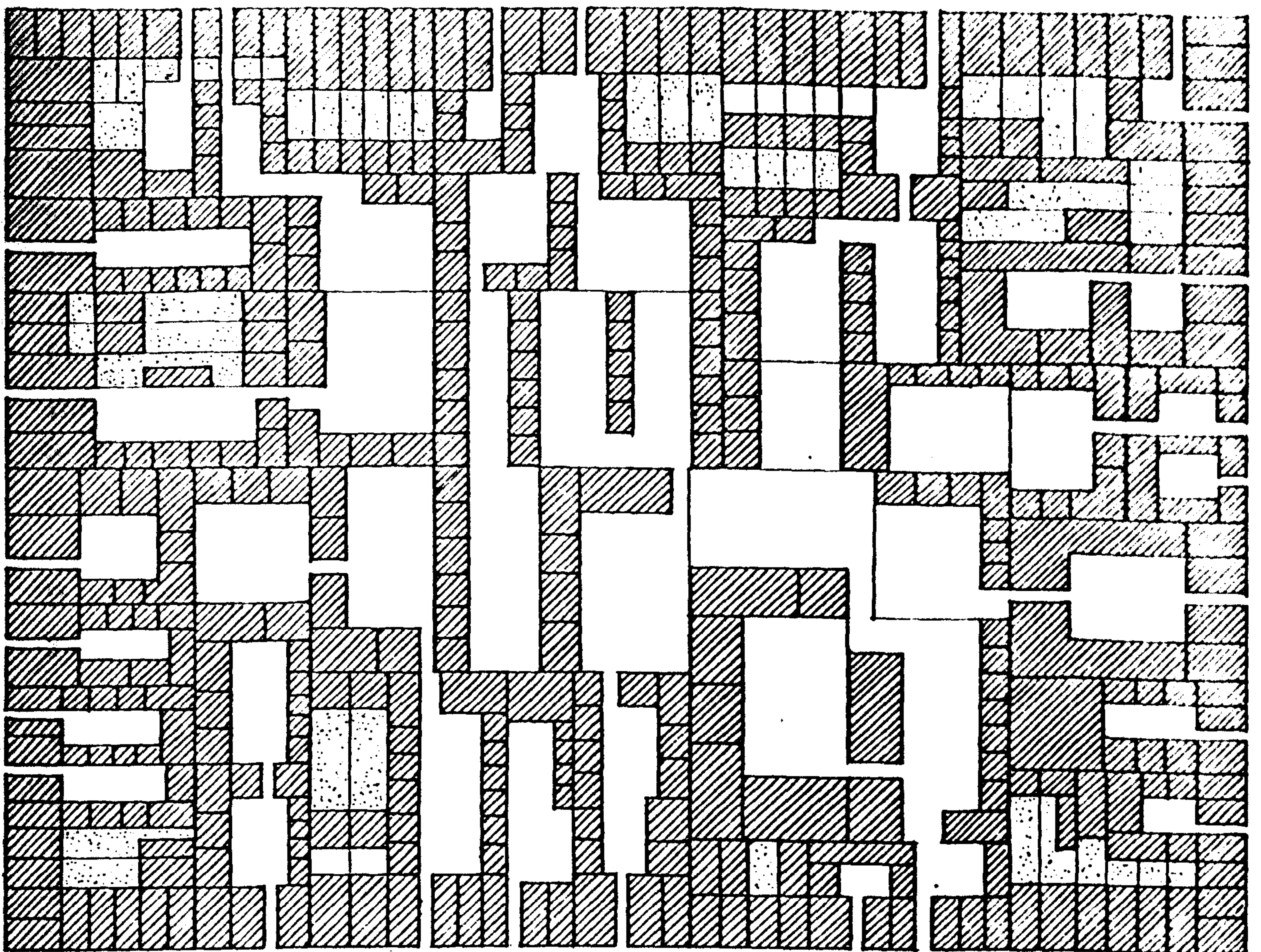
underline the fact that the morphological characteristics are a function of the global organisation of the block, and not of a particular historical sequence of development. One may also note that the space required for breakthrough passages on the perimeter and the interior only marginally reduces the total fraction of land developed. Access through rows of buildings is provided by a 5' 0" passage in all cases. Although, in reality, the space occupied by passages might be rather larger, this should not appreciably affect the overall density.

The close correspondence between the gross properties of the real and the hypothetical blocks, and the 'life-like' appearance of the latter, both corroborate the process descriptions advanced here. While the computer simulation has highlighted the presence of various tacit assumptions in the original model, and has thus demanded the specification of additional rules, these may be considered as auxiliary rules - as labels rather than principles. The basic principles of growth - the boundary rule and the contiguity rule - have held good for all experiments. They represent the model in its simplest, its most stripped-down form. In its final elaborated version, however, the generative procedure helps us to define much more precisely what spatial forms were possible. That is to say, it helps us to describe the limits of what could actually have occurred within the social and economic context of late mediaeval London. Figure 8.12 shows an example of a hypothetical large block generated by computer. The buildings have been indicated in order to make the configurations more life-like. The 24 perimeter passages are spaced at realistic intervals along the street edge. The breakthrough ratios, regulated to maintain a 40-50% proportion of cul-de-sacs in shell 1, yield an access graph four shells in depth, and a total building density of 58%. We would consider this a possible block.

8.5 Conclusions

The above findings suggest that many of London's morphological characteristics at the meso-scale were a product of the formal logic of the system, i.e. the grammar of relations between spaces. The visually complex, but nevertheless very ordered, spatial patterns of the mediaeval City arose from the consistent application of rather few local rules within the context of a rather narrow and consistent set of constraints. Thus, while far from deterministic, the patterns of building and open space may be seen as probabilistically dependent on the system of relations within the block.

With respect to segment access, it has been shown that the number (frequency) of passages along the perimeter of a block closely circumscribes the possibilities for reaching all parts of the interior zone. More specifically, it places a lower, but not an upper limit, on the number of shells by which the access graph may be constituted. Thus, the restriction of perimeter accesses to 30% of perimeter segments creates the situation, already demonstrated, in which increasing numbers of interior segments are likely to be located 'deep' in the access structure. This increase in depth can be counteracted only by increasing the frequency of breakthroughs from the perimeter zone (shell 1), so that few or none of the perimeter segments remain as cul-de-sacs, or by increasing the connectivity of the shallow segments, so that each segment controls a series of deeper ones. At the other end of the scale, a proportion of initial accesses above 75% makes for a considerable redundancy of routes to the interior, an unnecessary and perhaps undesirable 'ringiness'. A frequency of 30-75%, and more usually 40-60% (varying with the size of the block) may be seen to arise through a process of homeostasis: it ensured that most or all of the interior segments were reached at one step in from the perimeter zone.

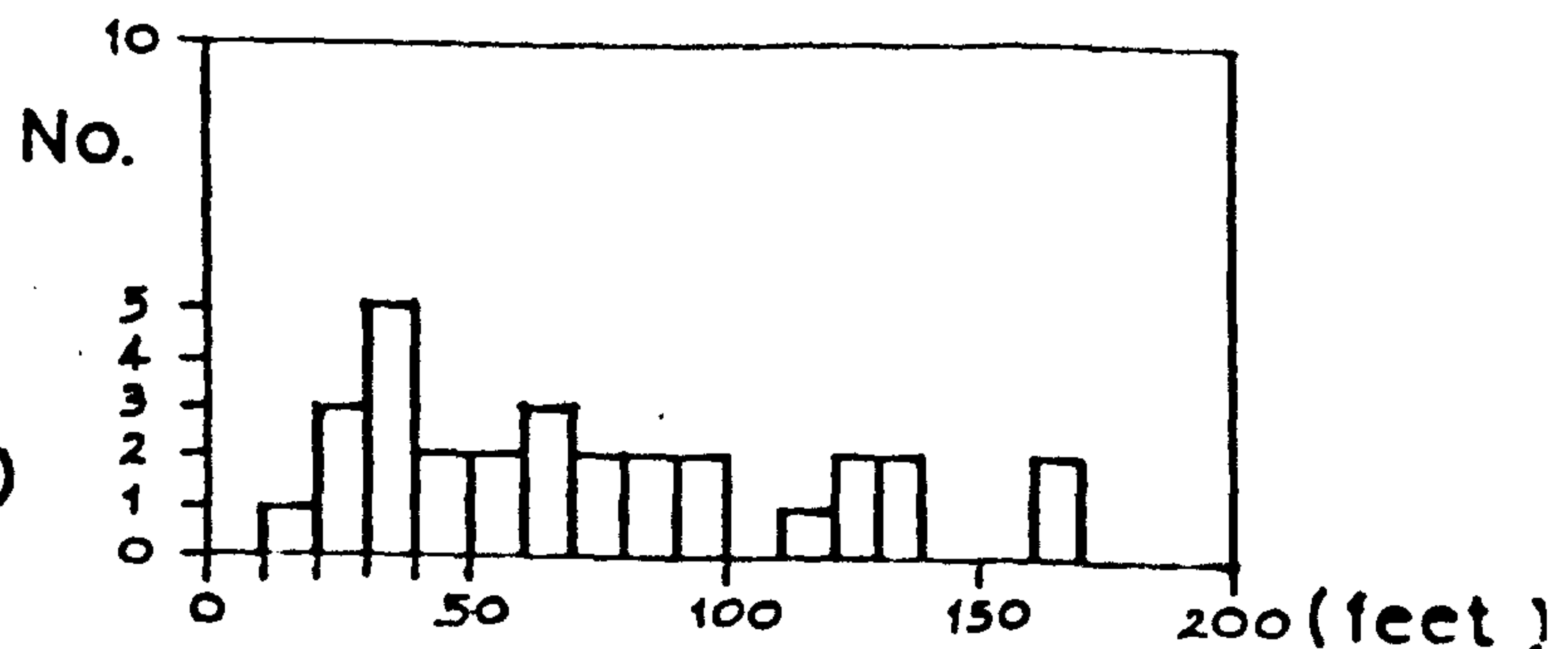


Area of block = 325,000 ft.²
 = 7.5 acres (3 hA.)

Spacing of passages
 along perimeter

Fraction of land developed
 = 58%

Median spacing of passages
 along perimeter
 = 71 ft. (4.2 units)



Breakthrough ratios:
 1 in 3, 1 in 2, 1 in 1.

Access graph

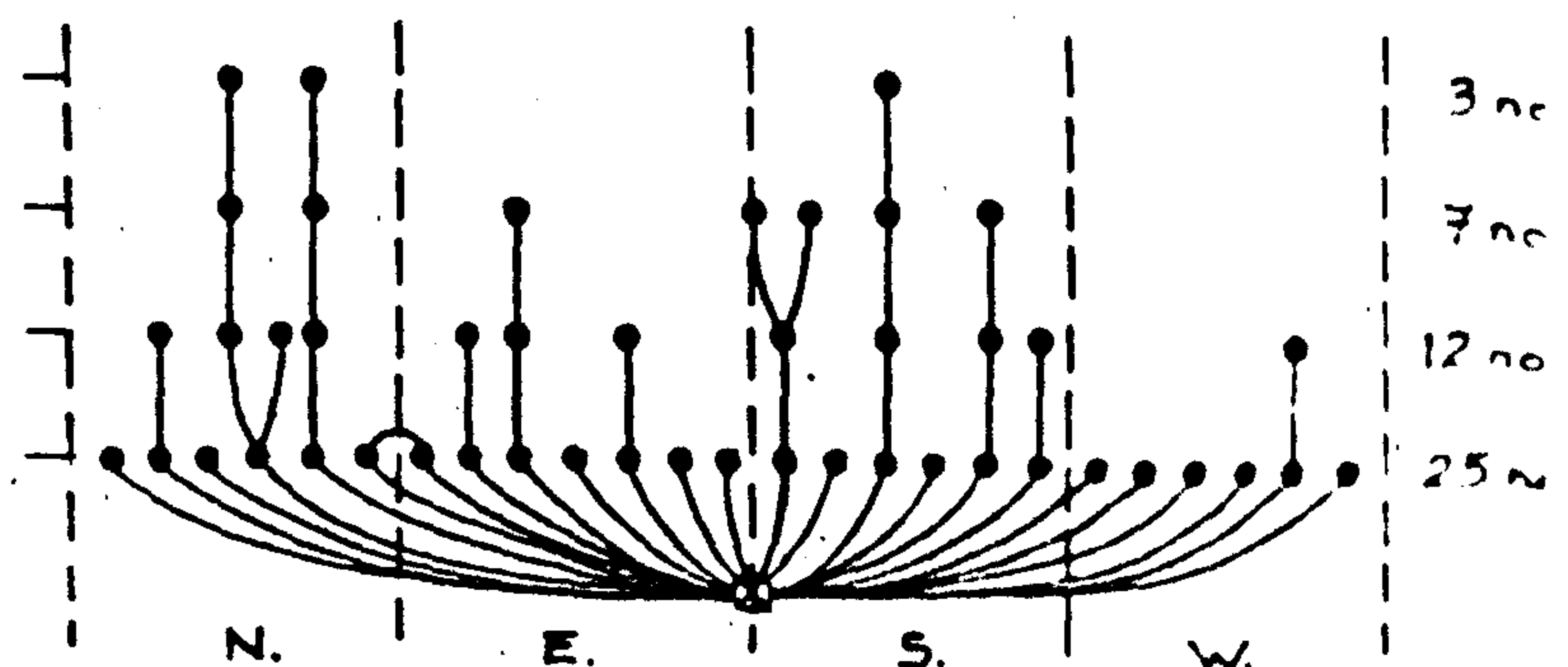


Fig.8.12. A hypothetical development generated by computer for block B. Building walls and burgage infill have been added

Another characteristic, directly related to accessibility, is the circuitousness of the access routes. The tendency for passages, especially the longer ones, to take an indirect course to the perimeter is a salient feature of the maps. On close examination, however, it becomes clear that there was a limit to how tortuous a route could become - turns through 90 degrees are relatively commonplace, but passageways never wind round in spiral fashion to the perimeter. This threshold - very palpable on close study, but difficult to quantify - would seem to be accounted for by the topological properties of the system.

If we return to the four hypothetical access patterns shown in fig. 8.9, it is easy to see that the most circuitous routes occur in nos. 1 and 2, i.e. the blocks with the 'deepest' access graphs, and the most direct routes in no.4, i.e. the block with the 'shallowest' graph. Both 1 and 2 contain routes (those extending to shell 4) which make two or more right-angled turns in order to reach the perimeter; the routes in no.4, predominantly shell 2 to shell 1 connections, require no right-angled turns. Each of these access patterns, it will be remembered, was judged improbable. In the most realistic example, no.3, two of the six routes extend to shell 3, and each of these is required to make a single right-angled turn to reach the perimeter. The remaining (shorter) routes are all more or less direct. This is exactly the degree of indirectness we should expect in a block of this size. The precise course of any passage will depend on the disposition of buildings within the segments - hence the variety in the alignment of routes. But the parameters are set by the access graph: the 'deeper' the access graph to be embedded in the geometry, the greater the probability of circuitous routes. No further hypothesis would seem to be necessary.

At the level of the individual segment, we may go back to an earlier observation concerning the prevalence of asymmetrical yard shapes in the perimeter zone. It was noted that the symmetrical yard, i.e. one which is symmetrically arranged about a central perimeter passage, is relatively infrequent on the map, a fact that may be accounted for on the grounds of statistical probability. Having measured the frequency of passages along the street edge for a

sample of blocks (fig. 8.1), we may now look to see how these results correlate with the position of passages within the segments. The relationship is not easy to determine empirically, as we are dependent upon a conjectural reconstruction of segment boundaries. But the situation is clarified by means of some hypothetical examples.

Let each perimeter segment be 30-40' wide (the modal range obtained from the St. Paul's survey); and let us consider the case (i) where passages occur in adjacent segments, and (ii) where they occur in alternate segments. Now, if the passages are centrally placed, the spacing for (i) will be 30-35'; for (ii) it will be 60-75'. If, on the other hand, the passages are run against the side boundary of the segment, three results are possible in each case. For (i) the spacing might be 0 (the passages are adjacent), 30-35', or 60-70'; for (ii) the spacing might be 30-40', 60-75', or 90-100'. Taken together, these figures give two peak frequencies (each with 40% probability) - 30-40' and 60-75' - precisely as we found in the bar graphs.

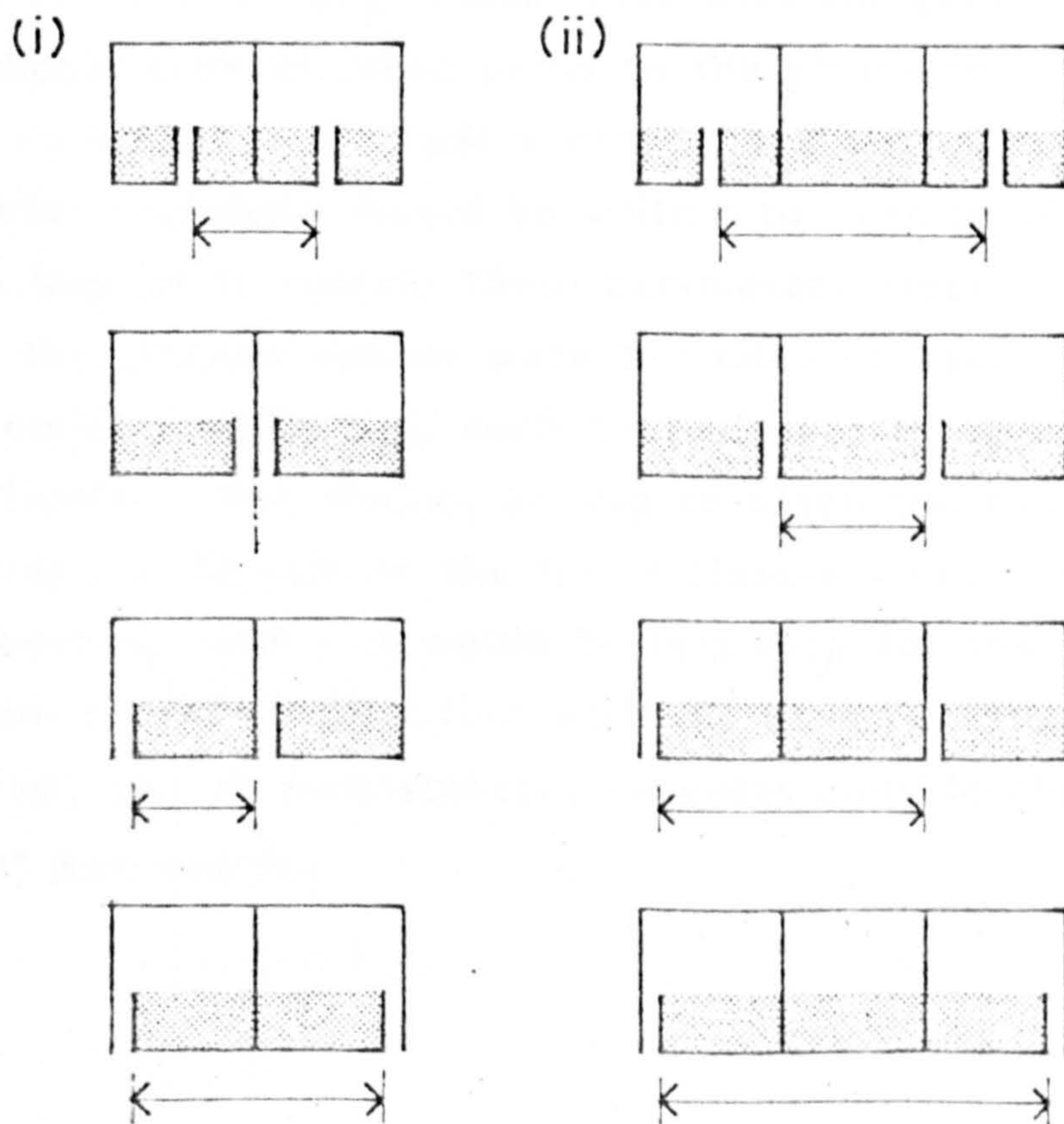


FIGURE 8.13

This does not, of course, take account of those cases where the passages are off-centre, or of the possible combinations of the different arrangements. But it does indicate that a close correspondence exists between the observed and the random frequencies. In table 8.7, empirical data from a variety of blocks have been assembled for reference. It has to be stressed that the size and location of segments are mostly conjectural. It will be noted, however, that the typical segment would appear to be 30-40' in width, and to have two units along the street edge. Segments with more than one passage were uncommon. The results on passage position are markedly skewed towards the side boundary, but this closely reflects the random distribution. It would seem, then, that the placement of passages may reasonably be predicted by a stochastic process of development.

Finally, it is important to point out that if the set of spatial relations within the City blocks enable us to define the range of possible developments, these relations are themselves predicated on certain social assumptions: that the inhabitants of the interior should be able to forge close links with the perimeter zone; that they should seek discrete paths to the perimeter rather than ones which converge on a single segment; and that the owners of the perimeter segments should be willing to develop their properties in such a way as to sustain these perimeter-interior connections. Where the interior spaces were the sites of livery company halls and other eminent buildings, such control over the perimeter would not be difficult. But where, as was so often the case, the interior zone was the domain of the lower classes - craftsmen, artisans, and the labouring poor - it would be less easy for the inhabitants to maintain a close interaction with the street. That this was achieved, and so consistently, suggests considerable collective thought and action.

PERIMETER PASSAGES

Perimeter Segments.	Block Cheapside-Old Change	St. Clement's Lane	Gracechurch Street	Grub Street
Frontage dimension of segment (feet)				
0 - 10	-	-	-	-
11 - 20	4	1	-	4
21 - 30	9	5	3	13
31 - 40	10	3	9	16
41 - 50	5	3	4	9
51 - 60	4	3	2	7
61 - 70	1	5	2	4
71 - 80	-	1	3	2
80+	-	3	1	2
Passages				
None	19	12	15	16
1 no.	13	12	9	38
2 no.	1	-	1	3
Position of passage				
Against boundary	9	6	7	17
Central	3	-	3	13
Off-centre	3	6	1	14
No. of units along street edge				
0	-	-	-	-
1	12	6	5	7
2	13	5	14	23
3	7	6	5	16
4	-	5	-	5
5	1	2	-	3
6	-	-	-	3
7+	-	-	-	-

Table 8.7. Number and position of passages within the perimeter segments for a sample of blocks. Figures based on a conjectural reconstruction of segment boundaries.

PART III

CONCLUSIONS

9. Conclusions, Conjectures and Further Work

The findings of the study may now be summarised :

1)

The spatial morphology of late mediaeval London was characterised by dense aggregations of buildings, punctuated by yards, courts, etc. (i.e. passages) and gardens. This alternating sequence of building and open space, while visually complex, and apparently haphazard, was in fact highly ordered in terms of local rules and constraints .

2)

Development took place within urban regions bounded by an inherited network of streets. These regions we have called blocks . All blocks were subdivided by property boundaries into smaller regions, which defined and limited the spread of building. These property boundaries constitute the constraints. Between the block and the individual building, or unit , several levels of organisation have been observed. A block is divided into two zones : the perimeter zone , and the interior zone . The former represents all those bounded areas which are contiguous with the street edge. The latter comprises all those areas located away from the street edge. Each of these zones is subdivided into the areas themselves, which we have called segments . The perimeter segments are normally greater in width than the individual building plot; it has been argued that these represent early property divisions, i.e. blocks of land originally under unitary ownership. The interior segments represent gardens or subdivided fields.

3)

The buildings along the perimeter were arranged contiguously, with their narrow dimension parallel to the street. Perimeter buildings

were normally more elongated than those on the interior. The great majority of these buildings were, however, of small ground plan : they had no more than two rooms on each floor. The smallest houses were without yard or garden. Houses were normally entered directly from the street : this constituted their main, and usually their only access. The street frontage at ground floor level was in most cases occupied by the shop; the upper floors contained the living spaces and/or the sleeping chambers. Perimeter houses were typically three-and-a-half storeys high but could be considerably higher.

The interior zone was occupied by both the largest buildings - mansion houses, livery company halls - and the smallest - the houses of the poor. The largest houses were of the courtyard plan, and both these and the company halls often had extensive interior gardens attached. The smallest units had one room on each floor and were probably no more than two and a half storeys high. They were normally built in rows, with access from within the segment.

4)

Perimeter segments were developed in two ways : (i) as yards; (ii) as burgages. In the former, the back space was built up with small units, arranged contiguously along the back and side boundaries of the segment, and facing into a yard. The yard was entered by a passage from the street. In the latter, the whole of the segment was occupied by contiguous burgage strips. The segment was without passage access, but the back spaces - the gardens - were built upon independently.

Interior segments were developed as (i), i.e. as yards : small units were arranged contiguously in rows along one, two, three, or four sides of the segment, facing into the yard, which was entered by a passage. It has been shown that it was the yard development, generated by a process of accretion, which imparted to London its distinctive morphological character.

5)

Two rules underlay the yard development : (i) units were built against the segment boundary; (ii) units were contiguous. These were the basic rules, or principles, by which London was generated. The arrangement was intrinsically inward-looking, each unit receiving daylight and access from the yard. Thus, any row of buildings may be seen implicitly to define a zone along its front face, on which new buildings were not to be erected, viz.

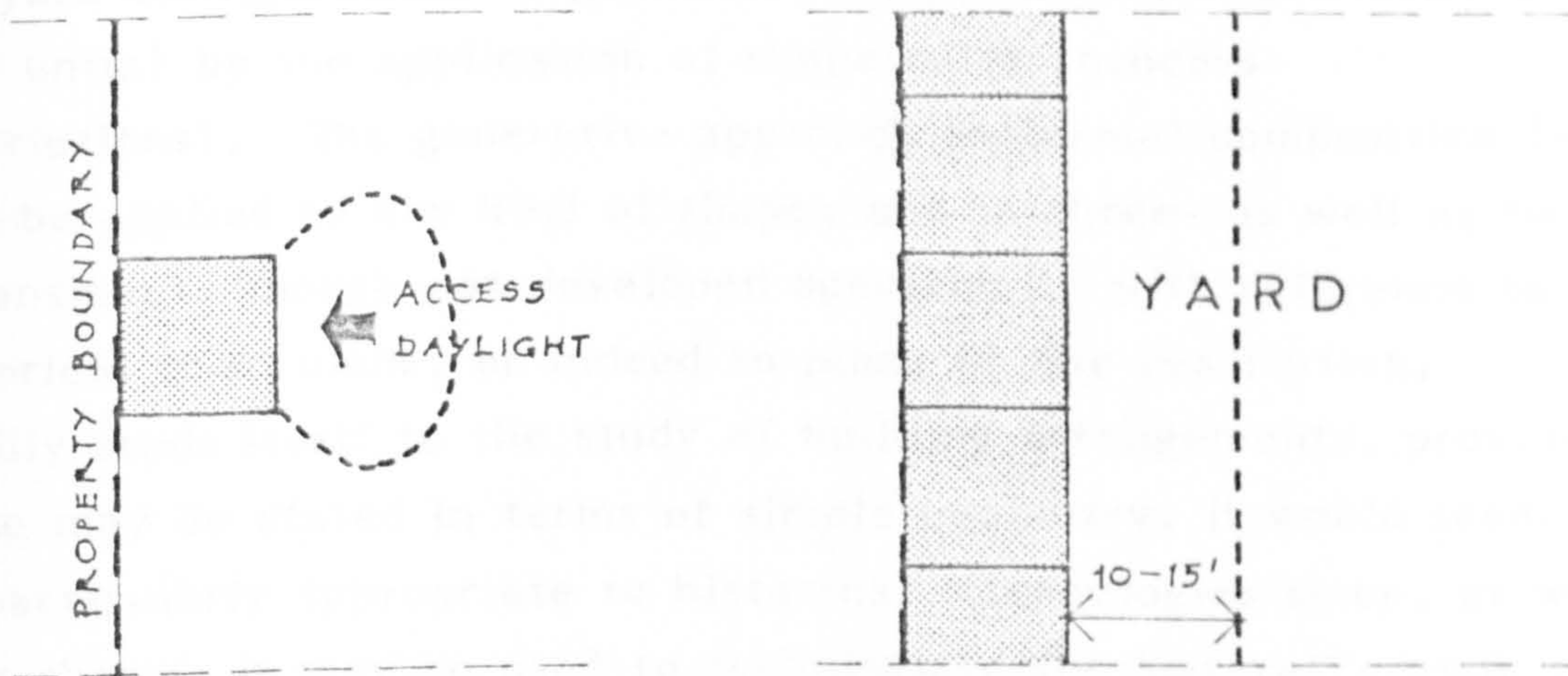


Fig. 9.1. Minimum daylighting and access requirements in a yard development.

6)

The interior zone is penetrated by means of passages from the perimeter, which 'break through' the boundaries between segments. When the access graphs of the blocks are drawn, it is found that the interior segments are comparatively 'shallow': penetration is seldom beyond shell 3 in medium-range blocks, or beyond shell 4 in large blocks. This implicit restriction on 'depth' highlights the importance of proximity to the street; it would seem to offer a necessary and sufficient account of the frequency of passages along the street edge.

The foregoing rules of growth have been elaborated as process descriptions for perimeter and interior segments. These descriptions, when applied to an appropriate set of constraints (segment boundaries), enable one to generate possible building/open space configurations. The generative system does, in fact, represent a form of shape grammar (1).

Shape grammars, as developed by Stiny, are a system of formal composition, in which shapes are recursively defined in terms of spatial relations. Thus, a given two-dimensional shape (in our case the yard configuration) is generated from basic spatial elements (the units) by the application of shape rules (process descriptions). The generative approach to formal composition (which may be applied to any kind of shape, and in three- as well as two-dimensions), though not developed specifically with reference to historical town plans, or indeed to plans of any description, readily lends itself to the study of building arrangements, provided these may be stated in terms of simple geometry. It would seem to be particularly appropriate to historical morphologies since, as we have shown, it may be used to recapitulate the 'natural' growth of the whole.

At the architectural level, Stiny has himself specified a parametric shape grammar which will generate the ground plans of Palladian villas (2). This grammar was used to characterise the plan as an aspect of the Palladian style and, as an extension to this work, Stiny and Mitchell have produced a complete catalogue of possible room layouts for Palladian villas of certain types (3).

While undoubtedly affording insight into the formal organisation of Palladian plans, the use of the shape grammar to generate non-existent villas does, however, raise some important questions concerning the status of these additional plans. In the first place, it is necessary to point out that, in principle, the same morphology or set of plans may be generated by different grammars. The question therefore arises: how is one to choose between these grammars? One solution is to choose the

most parsimonious (i.e. the most 'elegant') grammar. The alternative - and the approach advocated here - is to seek to aim at a series of rules which, while perhaps more cumbersome and less economical, is capable of interpretation in terms of social and technical process. Now, clearly, this is not true of the 'Palladian' grammar. Stiny has noted that the grammar is arbitrary to the extent that it rests primarily on Palladio's explicit canons of design. It does not take into account the executed villa projects, and considers only a sample of those extant in his drawings. The corpus of evidence is, therefore, partial. But of greater significance is the fact that the generative rules take no account of the way the buildings were actually planned and built. The grammar corresponds neither to Palladio's known methods of composition, nor to any kind of plausible sequence of building operations. The buildings are thus effectively isolated from their social and historical context.

In contrast to this approach, we would stress the need for a reconstruction of historical context : a recreation of economic and technical constraints, of the social milieu in which the buildings were commissioned, designed, and constructed and, above all, of the community of ideas and concepts upon which the actual designs were grounded. This may appear merely a methodological point. In fact, it is rather more. It is always theoretically possible to devise a grammar which will generate the particular set of designs under study. A grammar which is slightly 'looser' will generate some additional objects. One which is looser still, will generate yet more. On purely formal grounds, therefore, it is somewhat arbitrary at which point one decides to stop. The additional objects generated by the 'Palladian' grammar represent possible villa plans only in the context of the sequence of rule applications specified in the grammar. Should the rules be modified, the body of possible plans would similarly be altered. In this sense, the hypothetical plans are of dubious ontological status : they may or may not have been possible in the context of Palladio's 'problem situation'. If, however, the rules have a hypothesised historical significance in relation to actual methods of working or design, then the

hypothetical plans have a less ambiguous status. They are 'possible' within the specific historical 'problem situation'.

Norms or stereotypes in design are based partly, and often largely, on tacit rules and assumptions - a kind of congruent consciousness which emerges from a particular social relation. In the case of Palladian villas, the canonical designs were the product of a dialogue between architect and wealthy patron ; in seventeenth-century London, the speculative builder held the field, and the standardised house-plan arose rather from "a generalised appraisal of society's needs" (4). Our task then is less one of generating languages of shapes than of breathing life into languages which are dead. It would seem that the articulation and formalisation of the implicit rules is of the first importance. Only by this means can one hope to 'build into' configurational studies the kinds of constraints, the restrictions on form, that actually go to define those entities we call buildings. The precise definition of these restrictions is in our view central to the development of architectural science.

In anticipation of further work at the meso-scale, one may observe that the two basic rules of development identified in this study appear to have very wide application ; they would seem to have been the cornerstone of spatial organisation, not only in other European cities (e.g. Paris, Bruges), but in the settlements of many pre-industrial societies. Should this be the case, it would follow that the apparent diversity of building patterns is primarily due to variations, not in rules, but in external constraints.

It is also of more than passing interest that the model or stereotype of modern housing development should embody principles which are the opposite of those of the traditional morphology : buildings are detached, built away from the boundary, and face outward from the site. Thus, a spatial inversion appears to have taken place. If there were a necessary relation between the social structure and spatial structure of mediaeval society, we should expect to find very similar patterns of local spatial arrangement in

other societies to which feudal or mediaeval characteristics have been ascribed. Were the settlements of feudal Japan or of Chou-dynasty China arranged on the same spatial principles? And if not, why not?

These questions take us far beyond the scope of the present work. Comparative studies cannot be contemplated until other historical morphologies have been studied in depth. Given the paucity of spatial information at present available, there seems no doubt that a broadening and deepening of the range of studies must be our first priority. It is hoped that the method of analysis used here will lend itself to application in other situations.

As a final note, we would wish to emphasise the need for a cautious empirical approach in further morphological work. Popper has stressed that the customary distinction between observational terms and theoretical terms is mistaken since all terms are theoretical to some degree (5). However, certain hypotheses are much closer to observation than others. In 'Principia Mathematica', Bertrand Russell pointed out that

"...the chief reason in favour of any theory on the principles of mathematics must always be inductive, i.e. it must lie in the fact that the theory in question enables us to deduce ordinary mathematics. In mathematics, the greatest degree of self-evidence is usually not to be found quite at the beginning, but at some later point; hence the early deductions, until they reach this point, give reasons rather for believing the premises because true consequences follow from them, than for believing the consequences because they follow from the premises."(6).

Mutatis mutandis, the statement is still valid.

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37. See the papers reprinted in Webster C (ed.): 'The Intellectual Revolution of the Seventeenth Century' , Past and Present Series ; London, Routledge & Kegan Paul; 1974.
38. Mason S.F: 'Science and Religion in Seventeenth-Century England' , in Webster C: op.cit., p.199.
39. By J. R. Jacob ; ref. Hill C. (1980), p.62., Cf. Shapiro B.J: 'Latitudinarianism and Science in Seventeenth-Century England' in Webster C: op.cit., pp.286-316.

40. Kearney H.F: 'Puritanism, Capitalism and the Scientific Revolution' , op.cit., pp.218-242; Rabb.T.K: 'Religion and the Rise of Modern Science' , op.cit., pp.262-285.
41. Kearney H.F: op.cit., p.240.
42. Ibid., p.230.
43. Hyde R: Introductory Notes to Ogilby J. and Morgan W : 'A Large and Accurate Map of the City of London' , 1676; facsimile reprint by Harry Margary, Lympne Castle, Kent, in association with the Guildhall Library, London ; 1976.
44. Ibid.

3. Source Material

1. This was the method advocated by the great mediaeval historian, Marc Bloch. See Baker A.R.H. and Butlin R.A: 'Studies of field systems in the British Isles' , pp.39-40; Cambridge; 1973.
2. Hyde R.: Introductory Notes to Ogilby and Morgan, op.cit.
3. For a full catalogue of the early map-views, the reader is referred to Howgego J: 'Printed Maps of London circa 1553-1850' , p.8ff.; London; 1978 (2nd ed.). In addition to these three-dimensional plans, there are many panoramic views of the City - pictorial representations, usually at a lower point of vision, and without a consistent scale. A list of panoramic views is given in Scouloudi I : 'Panoramic Views of London 1600-1666' ; Corporation of London, multilith.; 1953.
4. Howgego J : op.cit., pp.8-9.
5. The earliest known to me is a plan of Holy Trinity Priory made by John Symons in 1592. See Lethaby W.R: 'The Priory of Holy Trinity, or Christ Church, Aldgate' , The Home Counties Magazine, Vol.II, 1900, pp.45-53. I owe this reference to John Schofield.
6. Stow J: 'A Survey of London' , 1603, ed. C.L.Kingsford; Oxford; 1908.

4. Method of Representation

1. Steadman J.P: 'Graph-theoretic representation of architectural arrangement' , Architectural Research and Teaching, 2/3 June 1973.
2. Krüger M.J.T: 'An Approach to Built Form Connectivity at an Urban Scale' , Ph.D. diss., University of Cambridge, August 1977.
3. Steadman J.P: op.cit.
4. Ore O : 'Graphs and their uses' ; New York, Random House; 1963; Berge C: 'The theory of graphs and its applications' ; London, Methuen; 1962 ; Harary F: 'Graph theory' ; Reading, Mass., Addison-Wesley; 1969.

5. Spatial Organisation at the Local Level

1. Krüger M.J.T: op.cit.
2. Schofield J: 'Medieval Waterfront Buildings in the City of London' (forthcoming).

6. Spatial Organisation within the House

1. A selection of plans from the Clothworkers' Plan Book, 1612, has been published by the London Topographical Society, pubs. LXXII-LXXV, 1938. There is a brief discussion of the Christ's Hospital Plans, c.1612, in Glanville P : 'London in Maps' ; The Connoisseur, London ; 1972. A forthcoming publication by Schofield will include copies of most of Christ's Hospital plans, together with a history of the individual properties : Schofield J: 'An early seventeenth century collection of London house plans' .

2. The majority of the livery company plan books are to be found at the company halls. A complete list of the early plan books has been compiled by Derek Keene as part of a current project investigating the historical development of a small sample area in the City. This list, which he has kindly made available to me, is reproduced in the appendix.
3. Hillier W., Stansall P., and Hanson J : 'Compressed Descriptions of Spatial Arrangements in Human Settlements and Buildings' , mimeo., Unit for Architectural Studies, the Bartlett School of Architecture and Planning, University College London ; March, 1978. See also Hanson J., and Hillier W : 'Tradition and Change in the English House' , p.26; UAS, UCL; August, 1979.
4. Schofield. J: op.cit., and 'Ralph Treswell's surveys of London houses, c. 1612' (forthcoming).
5. E.g. the Goldsmiths' plans, drawn in 1692 by John Ward. Although many of the plans indicate the internal layout of the houses, the drawing is, as Glanville has observed, extremely unconvincing. In many other cases, e.g. the Merchant Taylors' Plan Book (1680) by John Oliver and William Leybourn, and the Drapers' Plan Book (1698) by Hugh (Kandy?), only the outline of buildings and plots is recorded.
6. This excludes the single unrepresentative sheet reproduced in Glanville P. (1972), which shows a group of buildings viewed from the outside. For a more detailed account of the form and contents of the plan book, see the forthcoming pubs. by Schofield.
7. Brett-James N.G: "The Growth of Stuart London" , p.42; London, George Allen & Unwin; 1935.
8. Jones. P.E. 'The Estates of the Corporation of London : Property Records as a Source for Historical, Topographical and Economic Research' ; Guildhall Miscellany, no.7, August 1956, pp.3-16.
9. Ibid., p.3.

10. Hibbert A: Introduction to 'Old European Cities' , p.9; London, Thames and Hudson; 1955.
11. Brett-James N.G: op.cit.,p.94ff.; and Wilson F.P: 'The Plague in Shakespeare's London' , p.25; Oxford; 1927.
12. Jones P.E: op.cit., p.4; Brett-James N.G: op.cit.,p.499.
13. Skelton R.A: Introduction to facsimile reprint of Braun and Hogenberg: 'Civitates Orbis Terrarum' (1572-1618), p.xiv; World Publishing Co., Cleveland and New York ; 1966. Ref. Hibbert A: op.cit., p.9.
14. Hillier W., Stansall P., and Hanson J: 'The Analysis of Complex Buildings' , mimeo., Unit for Architectural Studies, the Bartlett School of Architecture and Planning, University College London; March 1978.
15. Steadman J.P: 'Architectural Morphology : an Introduction to the Geometry of Building Plans' , ch.10; Pion (forthcoming).
16. See, for example, Hillier W., and Hanson J: 'Tradition and Change in the English House' .
17. The access graphs of the Ch.H. and City plans are reproduced in the appendix.
18. Hillier W., and Hanson J: 'Compressed Descriptions of Spatial Arrangements' .
19. Survey of (C)ity (L)ands and (B)ridge (H)ouse (P)roperties, Corporation of London Record Office, Vol.I, p.4 (plan ref. 7).
20. Ibid., I.125 (156).
21. Ibid., I.131 (164).
22. Ibid., I.81 (112-114).
23. Ibid. Upper floor rooms are noted, for example, in plans (ref. no.) 233, 238, 239; upper floor chambers in plans 259,283,286.
24. The names of streets and lanes sometimes recorded the trades or commodities sold, e.g. Bread, Fish and Lime Streets ; Honey, Ironmonger, Seacoal Lanes. See Unwin G : 'The Gilds and Companies of London' , p.33ff; Frank Cass & Co. Ltd., London; 1908; and Schofield J. and Dyson A: 'Archaeology of the City of London' , p.49; City of London Archaeological Trust; 1980.

25. The arrangement was also described by contemporary observers. Fynes Morrison (1617) states that in London "the richer citizens' houses are built all inward, that the whole room towards the streets may be reserved for shops of tradesmen..."; qu. in Hoskins W.G: 'Provincial England : Essays in Social and Economic History' , p.103; London, Macmillan; 1964.
26. The immense combinatorial possibilities for room arrangements in the larger plans have been demonstrated by Steadman, who calculated the number of topologically distinct packings of rectangles within a larger rectangle. For six rooms, there are 24 adjacency graphs, and 117 topologically distinct packings of rectangles. Seven rooms were estimated to give about 120 graphs, and perhaps 700 packings. Steadman J.P: 'Graph-theoretic representation of architectural arrangement' , Architectural Research and Teaching, 2/3 June, 1973. A complete enumeration of rectangular dissections for seven rooms is given in Bloch C.J: 'Catalogue of small rectangular plans' , Environment and Planning B, 1979, vol.6, pp.155-190.
27. See, for example, Godfrey W.H: 'A History of Architecture in London' , pp.234-35; 1911. Qu. in Brett-James, N.G: op.cit.,p.183.
28. An example of this arrangement is provided by the almshouses at St. Peter's Hill, Ch.H., p.16.
29. Ch.H., p.8; see fig.6.8.
30. (C)lothworkers' Plan Book, 1612, pp.21-22.
31. Ibid.
32. It is clear from the documentary record that the vertical arrangement was not a recent innovation. In 1410, a carpenter and a timber-merchant undertook to build three houses in Friday Street, each of which was to have, on the ground floor, a shop with a sale-room and office; on the first floor, a hall, larder, and kitchen ; on the second floor, a principal chamber, a retiring-room, and a privy. Salzman L.F.: 'Building in England down to 1540' , Oxford (2nd ed.), Appendix B, Contract No. 51.

33. Hillier W. and Hanson J: 'The social logic of space' ,
(forthcoming).
34. Ibid.
35. Historical studies have shown that it was common practice in the eighteenth century for the housekeeper to live in only a part of the house, usually one or two rooms, and to let the remainder to other families or individuals. See George M. Dorothy : 'London Life in the Eighteenth Century' ; p.103, Penguin Books; first pub.1925, reprinted 1966. In the later Middle Ages, the garret was frequently used to accommodate elderly widows: Schofield J. (private communication).
36. For a full explanation of these terms, see Hillier W. and Hanson J: ' The social logic of space' .
37. Cl.,p.15.
38. This agrees with Barley's findings for rural houses, see Barley M.W: ' A Glossary of Names for Rooms in Houses of the Sixteenth and Seventeenth Centuries ' in Foster I.LI. and Alcock L.(eds.): ' Culture and Environment ', Essays in honour of Sir Cyril Fox, p.496 ; Routledge.
39. Ch.H.,p.4, no.12.
40. This configuration is more than a local phenomenon. Examples are found both within and without the City walls, e.g. Fore Street (Vol. II, p.29), Chiswell St., (p.48), Ratcliff Narrow St.,(p.50), and Aldermanbury (p.54).
41. Hillier and Hanson : ' The social logic of space '.
42. The buttery appears to have taken precedence over the kitchen in Elizabethan Leicester. Hoskins notes : "where a third room was added (i.e. after the hall and the parlour), it was usually a buttery"; op.cit.,p.106. A number of the Leicester houses contained a buttery but no kitchen.
43. E.g. Mr. Barber's house, Needlers Lane (Ch.H. p.4), and the Crown Inn (ibid.p.14).
44. Barley states : "this name is the most complex of all those used of parts of house, in local variations in its meaning, in the uses made of rooms so-called, and in the distribution pattern of these variations". Op.cit.,p.484.

45. George M. Dorothy : op.cit., p.103.
46. E.g. the house in Houndsditch, CLBHP, Vol.I, p.80.
47. Barley M.W: op.cit., p.483.
48. Cl.,p.56. Plan dated 1640.
49. Wood M: 'The English Mediaeval House ', p.247; Ferndale, London; 1965.
50. Hoskins: op.cit., p.106.
51. Ch.H., p.19, nos.81-87; see fig.6.10.
52. Examples of 3 rooms 'en suite'; CLBHP. nos. 128, 165, 202.
53. Eg. Ch.H.,p.8., nos. 28, 29, 30.
54. Hillier and Hanson's analysis of 17th-century houses in the Banbury region does, however, suggest that the 'through-passage' plan may have been much less frequent among rural houses than many authors have claimed : 'Tradition and Change in the English House ', pp.5-9.
55. Brett-James : op.cit., p.22.
56. Hyde R: Introductory Notes to Ogilby and Morgan.
57. Reddaway T.F.: 'The Rebuilding of London after the Great Fire ', p.80; London; 1940.
58. Steadman J.P: 'Architectural Morphology : an Introduction to the Geometry of Building Plans ', ch.11.
59. Wood M: op.cit., p.49.
60. For the concept of criticality, see Rapoport A: 'House form and culture ', pp.58-59; Prentice-Hall; 1969.
61. Kelsall A.F: 'The London House Plan in the Later 17th Century ' in Post-Medieval Archaeology, vol.8, 1974, p.88.
62. Booth P : 'Speculative Housing in Post-Restoration London ', M.A.diss., University of Sheffield, August 1974; and 'Speculative Housing and the Land Market in London, 1660-1730 ', Town Planning Review, vol.51, no.4, Oct.1980.
63. Booth (1974), p.3.
64. Booth (1980), p.396.
65. Ibid. p.396.

66. Various authors have argued, on the basis of particular examples, that, in the late 16th century, buildings consisted generally of three or more storeys: e.g. 'A to Z of Elizabethan London', Introductory Notes by J. Fisher, p.xi, n.4.
67. According to Hoskins, the "majority of Leicester houses (in the Elizabethan period) were on one level only". Op.cit., p.103.
68. Glass D.V: Introduction to 'London inhabitants within the walls, 1695'; London Record Society Publication ii, p.xx; London; 1966.
69. Ibid., p.xxi.
70. Ibid., p.xxv.
71. 'A to Z', p.viii.
72. Hill C: 'Reformation to Industrial Revolution', p.87; Pelican; 1969.
73. Public Record Office Inventories: E.154.4.34.
74. Orphans' Inventories, Miscellaneous Transcripts 29c, no.2, Corporation of London Record Office.
75. Barley: op.cit., pp.490-491.
76. Orphans' Inventories, no.1.
77. Ibid. 14.
78. Ibid. 21.
79. Ibid. 13.
80. Ibid. 7.
81. This is not the place to enter into the question of the growth of Puritanism in the early 17th century. But Stone, while noting that the merchant oligarchies of London and other towns were some of the most self-interested supporters of the Crown, also lays great stress on the diffusion of Puritanism and Puritan sentiment throughout large sectors of society in the century preceding the English revolution. Behind the urban patriciates stood the large numbers of "yeomen and artisans, the respectable, industrious, literate, bible-reading, God-fearing lower middle class", (1972, pp.114-115). London society appears to have been highly literate (Wrigley, 1978, pp.222-223).

82. Daniel Waldo's house in Honey Lane contained a dining room, but this was obviously exceptional outside the class of wealthy property owners.
83. Orphans' Inventories, no.9.
84. Ibid., 16.
85. Glass D.V: op.cit., p.xx.
86. Orphans' Inventories, 4.
87. Ibid. 8.
88. Barley : op.cit., p.497.
89. Houses with a shallow parlour are occasionally found in the pre-Fire surveys, e.g. Cl. p.17, tenements in Hart Street, Crutched Friars. But in these cases, the arrangement appears to be the product of sub-division of tenancies. Thus, Mr. Osborne's two tenements, one of which had a parlour at the front, were "sometimes but one".
90. See inventory of Thomas Deane, n.76.
91. Power M.J: 'The urban development of East London, 1550 to 1700', Ph.D.thesis, University of London, 1971, p.167.

7. Urban Structure and Urban Evolution

1. Simon H: 'The Sciences of the Artificial', pp.111-113.
2. Rickaby P: 'The Configuration of a Region', p.17ff., Working Paper 2. re. 'A theoretical comparison of accessibility and energy use in regional settlement patterns'; Centre for Configurational Studies, The Open University ; June 1980.
3. Lethaby W.R: 'London before the Conquest', p.132; London, Macmillan; 1902.
4. Harben H.A: 'A Dictionary of London', p.610; London ; 1918.
5. Page W : 'London : its Origin and Early Development', p.174 ; London ; 1923.
6. Harben H.A: op.cit., p:612.
7. Page W : op. cit., p.173.

8. This figure refers to the plots at the north-western end of Grub Street. These properties were acquired by the City and are recorded in its Plan Book : see C.L.B.H.P. Vol.I, pp.63, 77, 109, 110; Vol.II, pp.12a), 12b), 47.
9. Postan M.M: 'The Medieval Economy and Society' , p.240 ; Pelican ; 1975.
10. Ibid.
11. A citizen of Preston was obliged to show a frontage of twelve feet to the street ; in Manchester or Salford he had to own at least an acre of land. See Green J.R: 'Town Life in the Fifteenth Century' , Vol. I, note to p.170 ;London, Macmillan; 1894.
12. See, for example, Green J.R: loc.cit. "In Liverpool the burgages originally established by John were already in the fourteenth century divided into small fractions one-eighth or even one forty-eighth part of their original size ; and the amount of land held by owners of property in Nottingham in the fifteenth century varied so much that the taxes levied on them were in some cases as high as £3. 14s, 7.1/2d., in other cases as low as a farthing".
13. Conzen M.R.G: 'The Plan Analysis of an English City Centre' , in Norborg K (ed.): 'Proceedings of the I.G.U. Symposium in Urban Geography'; Lund Studies in Geography, no.24 (1960), p.387ff.
14. A notable exception is afforded by the City properties in Houndsditch, The Minories, and elsewhere in the liberties, which may be pieced together to give considerable lengths of street frontage.
15. See plan in Drapers' Co. archives. The area of the garden is given as 1 acre, 1 rood, 7 perches and 53 feet, (i.e. approx. 1.3 acres).
16. Price noted the unsubstantial character of the soil in the vicinity of the Guildhall. Price J.E: 'A Descriptive Account of the Guildhall of the City of London' , p.23 ; London; 1886.
17. Brett-James. N.G: 'The Growth of Stuart London' , p.37.

18. Power M.J: 'The urban development of East London, 1550 to 1700' , p.143.
19. Ibid.
20. Brett-James N.G: op.cit., pp.59-60.
21. Bloch M: 'Les caracteres originaux de l'Histoire Rurale Francaise' , Vol.I, pp.x-xiv; Paris, Librairie Armand Colin; 6e tirage, 1976; and 'The Historian's Craft' , pp.45-6; 1954.
22. Hyde R: Introductory Notes to Ogilby and Morgan.
23. See Rasmussen S.E: 'London : The Unique City' , ch.6; Pelican edition; 1961.
24. Hyde R : op.cit.
25. Introduction to Mills P., and Oliver J: 'The Survey of Building Sites in the City of London after the Great Fire of 1666' ; facsimile reprint from Guildhall Library MS.84, London Topographical Society (1962-67), Vol.I, pp.xxvi-xxvii.
26. Reddaway. T.F: 'The Rebuilding of London after the Great Fire' , p.80ff.; London; 1940.
27. Mills P. and Oliver J : op.cit., 5 vols.
28. Ibid., Introduction, p.xxiv.
29. For the histories of the Ch.H. properties, see Schofield J : 'An early seventeenth century collection of London houseplans' , (forthcoming).
30. Merchant Taylors' Co. Plan Book , 1694-5, MS.25, Company Hall.
31. Brett-James N.G: op.cit., p.67.
32. Schofield J: op.cit.
33. Merchant Taylors' Co. Plan Book , 1694-5.
34. Keene has shown, however, that changing property boundaries may be reconstructed for central areas of the City by use of the full range of source material for the early mediaeval period.
35. Urry notes that the monks of Canterbury derived greater income from rents in London than from Canterbury, although their holdings in London were smaller in number: "...the monks possessed twenty-five holdings (in London) as opposed to four hundred holdings in Canterbury, while rents from the London dwellings amount (c.1180) to £44.3s.9d. One London house

- alone, in the busy commercial quarter of 'Westcheape' (Cheapside) furnishes an enormous (by Canterbury standards) rent of £9.12s.". Urry W.G: 'Canterbury under the Angevin Kings' , p.35; University of London, the Athlone Press; 1967.
36. 'Mansura': a building lot, or place on which a house might be erected, 'Measurements of the Lands of St. Paul's within the City of London' , (c.1128), Liber L, Fo.47-50b, Dean and Chapter of St. Paul's. A facsimile and a transcript of the text are included in the appendix.
 37. Loftie W.J: 'A History of London' , vol.I, p.158ff; London; 1884. Summarised in Harben H.A: op.cit., p.612.
 38. Hassall W.O.(ed.): 'The Cartulary of St. Mary Clerkenwell' , Camden 2nd Series, Vol.LXXI, London, 1949.
 39. Eg. contract no. 21 (1369) in Salzman L.F: 'Building in England down to 1540' , Appendix B, pp.441-3; Oxford; 2nd ed.,1967.
 40. Brett-James N.G: op.cit., note 2, p.100; and Jeffries Davis, E: 'The Transformation of London' .
 41. Brett-James, p.94.
 42. George. M. Dorothy : 'London Life in the Eighteenth Century' , p.82.
 43. Brett-James, p.116.
 44. Power M.J: op.cit., p.130ff.
 45. Beresford M: 'The making of a townscape : Richard Paley in the east end of Leeds, 1771-1803' , in 'Rural Change and Urban Growth 1500-1800: Essays in English Regional History in Honour of W.G. Hoskins' ; Longman; 1974.
 46. Ibid., p.310.
 47. Windows are indicated in a small number of Treswell's plans (apparently when they were exceptionally fine examples). E.g. Mr. Barber's house, Ch.H. (see appendix. plan no.1). For a more modest house in Holborn, see the plan by Ricus Ryder (1640) Cl.p.56.
 48. Chew, Helena M. and Kellaway W: 'London Assize of Nuisance, 1301-1431' , A Calendar; London Record Society ; 1973.
 49. Ibid., Introduction, pp.xxv-xxvi.

50. Ibid., no. 407, p.100.
51. Mayor's Court Interrogatories , 1641-1710, p.2; C.L.R.O.
52. Introduction to Oliver's Survey, p.xxvii.
53. Ibid., p.xxviii.
54. Mayor's Court Int., 1641-1710, p.215.
55. Qu. in Brett-James, p.71.
56. Acts of the Privy Council , P.R.O. PC2/28, p.205; qu. in Brett-James, p.92.
57. St.Paul's Parliamentary Survey of Houses , 1649-57, G.L. MS. 11816A, pp,308-9.
58. Hyde R: op.cit.
59. Cl. p. 21.
60. Brett-James, p.36.
61. Ibid.
62. Qu. in Brett-James, p.73.
63. Ibid., p.79.
64. Ibid., pp.98-9.
65. Ibid., p.98.

8. A model of urban growth

1. See the Drapers' Co. Plan Book (1698).
2. Hillier W. and Hanson J: 'Discovering Housing Genotypes' ; paper given to the Conference on Material Culture, Dept. of Archaeology and Anthropology, University of Cambridge, March 13th, 1982.
3. Steadman J.P: 'Architectural Morphology : an Introduction to the Geometry of Building Plans' , ch.10, Pion (forthcoming).
4. Ibid., ch.11.
5. The efficiency of the courtyard form, in terms of land use, when compared with the tower (pavilion) form is clearly demonstrated in Martin J.L. and March L: 'Land use and built forms' , Cambridge Research, 1966. See also, by the same authors, 'Urban Space and Structures' , pp.89-96; Cambridge University Press ; 1972.

9. Conclusions, Conjectures, Further Work

1. Stiny G: 'Pictorial and Formal Aspects of Shape and Shape Grammars' ; Basel, Birkhauser Verlag; 1975.
2. Stiny G. and Mitchell W.J: 'The Palladian grammar' ; Environment & Planning B, vol.5, 1978, pp.5-18.
3. Stiny G. and Mitchell W.J: 'Counting Palladian plans' ; Environment & Planning B, vol.5, 1978, pp.189-198.
4. Booth P. (1974), p.3.
5. Popper K: 'The Logic of Scientific Discovery' , pp.75-77; London, Hutchinson; 1959 (1st ed., Vienna, 1934).
6. Preface to 'Principia Mathematica' , 1910. Qu. in Simon H: 'The Sciences of the Artificial', p.17.