Study of performance standards for space and site planning for residential development

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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/20386714
Internal Report (National Research Council of Canada. Division of Building Research), 1963-07-01

NATIONAL RESEARCH COUNCIL

CANADA

DIVISION OF BUILDING RESEARCH

A STUDY OF PERFORMANCE STANDARDS FOR SPACE AND SITE PLANNING FOR RESIDENTIAL DEVELOPMENT

A Joint Project of the School of Architecture
and the Graduate Program in Community and Regional Planning,
University of British Columbia
and the
Division of Building Research, National Research Council

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Internal Report No. 273

of the

Division of Building Research

OTTAWA

July 1963

FOREWORD

The appearance of this Report will remind all readers who knew the late Professor Fred Lasserre of his keen interest in research, and of his fertile and inquiring mind. His tragic death just a few weeks after he had written the preface that follows caused a real gap in Canadian architectural circles. That it resulted also in a great loss to the development of research in architecture in this country will be equally clear to all who read this first report upon work in which he had displayed such interest.

But this work, as with so many of his other activities, has continued and developed. His co-worker and fellow author, Professor Oberlander, has guided the project from its inception and since Professor Lasserre's death he has been joined in its direction by Professor W. Gerson. Professor H. M. Elder, who is now the Head of the School of Architecture at the University of British Columbia, has given the project his interest and support. This continued liaison, and cooperative work, between the UBC School and the Division of Building Research is highly valued by DBR/NRC.

The delay in the publication of this report (which the writer greatly regrets) is in itself a tribute to the interest which the project has generated. In the original draft there were some statements which led to useful discussions between the respective staffs in Vancouver and Ottawa. As a part of its contribution to the work, the Division arranged for Mr. Murdoch Galbreath (an architect in its Building Standards Section) to pay two special visits to Vancouver for detailed discussion of the work in progress and of some aspects of this report.

Mr. Galbreath has contributed two Appendices to the report, as has also Dr. T.D. Northwood, Head of the Division's Building Physics Section. Other members of the Division's staff, including Dr. N.B. Hutcheon, Mr. R.S. Ferguson and the writer, have had the opportunity of reviewing the work in progress at Vancouver, while Mr. Walter H. Ball, the DBR Officer-in-Charge of its Pacific Coast station in Vancouver, maintains continuing liaison with the work.

It will be clear that this report provides essentially an introduction to a research project that covers a rather wide field. Other more detailed reports, already drafted, will follow. This initial paper is published in this way as a prelude to more formal publication, in order that those responsible for the work may have the benefit of informed criticism of the approach that is herein outlined. Comments on this report will therefore be welcomed. They may be sent to Professor Oberlander at UBC in Vancouver or to the writer at Ottawa.

Ottawa
July 1963

R. F. Legget
Director, DBR/NRC

PREFACE

This study is an investigation into the factors that might have determined the spacing of residential buildings in the past and into the factors that should be operative today in this determination. Eventually these are the factors that become translated into zoning and building ordinances, and these in turn shape our cities.

Most present ordinances have frozen the development of our cities into rigid monotonous residential areas, as brought out in the Royal Architectural Institute of Canada's Investigation into Canada's Residential Environment. The rigidity of current regulations and the limitations they place on the production of variety in the layout of residential areas has been of much concern to planners, architects, and social scientists. This concern prompted the School of Architecture at the University of British Columbia to arrange with the Division of Building Research of the National Research Council to carry out an investigation into the criteria that might determine space standards, facilitating greater variety in the layout of residential buildings.

The project proved of great interest to those participating. It is hoped that the original thinking that has gone into it will offer some guidance to the direction of future zoning ordinances. Concern over the sprawling blight of expanding cities throughout the world has increased interest in a greater density of dwellings without loss of amenities. At the same time, through variety in the spaces between dwellings and attached groups of dwellings, the attractiveness of residential areas might also be improved. It is in these respects that this study might prove of greatest value, even though it is applicable to all levels of residential density.

As will be seen, this Report is really an introduction to a full study dealing with criteria for the spacing of all building types. There are also many details of implementation and of definition which require further investigation and which will form sequels to this first fundamental study. Particularly, it is hoped that this work will engender new directions in the preparation of zoning regulations, and that as a consequence the spacing of buildings will be less arbitrary and less rigidly fixed.

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Director, School of Architecture,
University of British Columbia.

January 1961

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INTRODUCTION

Between May 1 and August 31, 1960, a study of performance standards for space and site planning for residential development was undertaken by two graduate research workers under the supervision of Prof. Fred Lasserre and Dr. H. Peter Oberlander at the School of Architecture, University of British Columbia.

This study followed a survey of literature completed during the summer of 1959 from which an annotated bibliography was prepared. (1) In addition to the bibliography, which has been used extensively during this stage of the study, the literature review gave the initial direction to the work now reported. It was anticipated that this second stage of the study would conclude with:

(1) A comprehensive definition of the purposes to be achieved in controlling space relationships around and between buildings in typical residential areas in Canadian cities within the broad process of Community Planning.

(2) A full statement evaluating performance standards as an effective tool in establishing predetermined space relationships around and between buildings and codifying these for broad community-wide use and effective administration.

(3) The formulation of specific criteria for establishing performance space standards for residential development within the broad process of implementing community planning goals, e. g. :

(i) Optimum flexibility of municipal regulations within a framework of functional considerations of safety, health and amenity to encourage varied spatial results in residential areas.

(ii) Variety within unity as an objective for mixed residential development and its qualitative implementation providing economic, social, and aesthetic variations in residential areas.

(iii) Premium or bonus concepts in formulating space standards and regulations, rather than arbitrary prohibitions to attain flexible but practical spatial results in residential areas.

(4) A tentative range of specific performance space standards for typical residential developments in Western Canada in accordance with the considerations covered under 1, 2 and 3 above.

Each of these items was investigated as part of the second stage; however, the report was structured as follows to reflect clearly what appeared to be a more logical sequence of thought.

Part One	- Historical Development of Space and Site Regulations and Standards.
Part Two	- Clarification of the Objectives Basic to Site and Space Regulations.
Part Three	- Characteristics and Dimensions of Physical Space in Residential Development.
Part Four	- Relationship Between Community Objectives and Physical Space.
Part Five	- A Proposed Technique for Space and Site Planning in Residential Areas Based on a Performance Standards System. (This part has been omitted for further study and may be presented separately later on.)

Appendices A, B, C, and D.

Part One corresponds to item (1) (page 1). Parts Two, Three and Four cover items (2) and (3), and Part Five is the proposal suggested in item (4) above, but which is at present undergoing further investigation at the University of British Columbia.

While the second stage was under way, the Report of the Committee of Inquiry into the Design of the Residential Environment of the Royal Architectural Institute of Canada was published. This committee emphasized the adverse effects that existing site and space regulations are having upon residential development.

> "Where municipal codes governing physical development are demonstrably linked to such future contingencies, their clauses must be respected. But this sensible linkage is hard to discover in many of the by-law restraints put upon residential area design. For instance it is commonly laid down that an access road allowance must be 66 feet wide, with all buildings set back another 25 or 30 feet from that road line. These provisions sterilize 1000 square feet of land that some family should be allowed to enjoy. They also separate opposite house fronts by something like ten times their height, thus making illegal the grouping of houses for best effect at lowest cost. There are other examples of this unreason." (2)

Good residential development in Canada has occurred within the framework of existing site and space regulations based upon specific standards; however, the reverse is more often true. It is the general aim of this research project to focus on the existing standards upon which site and space regulations are based, uncover their weaknesses and suggest improved alternatives so that they no longer constitute a limiting factor to the enlightened development of the residential environment.

Although the subject of performance standards is one that would appear to lend itself to intensive investigation, it quickly broadens into the fields of municipal administration, law, physiology and, through its subjective implications, into sociology and psychology. This spectrum of subjects soon frustrates a single research effort, particularly when critical information appears to be limited. This second stage could not hope to be complete to the final detail nor accurate beyond dispute. Further work is obviously necessary. Despite the lack of certain critical data, however, sufficient information was available to make what is believed to be a fair assessment of the subject, sufficiently adequate to substantiate the adoption of flexible performance standards, clarify their purpose and examine the characteristics of the space media they employ.

On the basis of this limited evidence the research team felt justified in making a proposal which incorporates its experience to date. It is a proposed method which, after further study and refinement, might become a workable administrative device.

Although the second part of this study was substantially the work of the two research assistants, P. Batchelor and R. J. Mutter, others assisted periodically and contributed time and guidance to the research, which is gratefully acknowledged: Dr. Kaspar D. Naegele, Associate Professor of Sociology, University of British Columbia; Miss Melva Dwyer, Senior Librarian, University of British Columbia; and Mr. Harry Pickstone, Deputy Director of Planning, City of Vancouver, B. C.

UNIVERSITY OF BRITISH COLUMBIA H. Peter Oberlander
December 1960

PART ONE

THE HISTORICAL DEVELOPMENT OF SPACE AND SITE REGULATIONS AND STANDARDS

DEFINITION OF SPACE

For the purposes of this study, the urban residential environment is considered to consist of enclosed spaces - the structures containing one or more dwelling units, bounded on four sides with walls and covered by a roof - and open space which surrounds and separates the enclosed spaces. Figure 1 shows a hypothetical neighbourhood consisting of a variety of sizes and shapes of enclosed spaces embracing single-family dwellings, terrace houses and apartment buildings. Between these volumes is the open space utilized here for playground, gardens, roadways, landscaping and other outdoor residential functions. *

Site and space regulations affect the relationships between these two basic elements, but because these regulations are administrative measures intended to control the action of an individual developing these spaces, the regulations in Canada have been traditionally related to the smallest unit of land ownership - the residential lot (Fig. 2a).

THE SIGNIFICANCE OF PRIVATE PROPERTY

Private property has been defined as, "...a relationship among human beings such that the so-called owner can exclude others from certain activities or permit others to engage in those activities and in either case secure the assistance of the law in carrying out his decision." (3) Inherent in this definition is the acknowledged right an owner has to do with his property as he so wishes. Privately owned land is one form of private property.

Presumably, there was a period at some time in the past, prior to the existence of site and space regulations, when an individual

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* Since the accessory building or detached garage, illustrated in Fig. 1 across the street from the playground, does not contain a dwelling unit it is considered as a part of open rather than enclosed space.

land owner who was intent on developing his property was limited legally only by the definition of private property and spatially only by the boundaries defining his lot.

Figure 2b shows the space envelope within which the structure was to be contained. Figure 2c illustrates the sort of street elevation that would develop under these circumstances.

If the incentive existed, as it seems to have in the City of London, for example, before the Great Fire of 1666, for land owners to exploit their property to the maximum, then enclosed space was developed at the expense of open space. Unfortunately, this congestion, together with wooden construction and primitive sanitation current at the time compounded the hazards to safety and health from fire and pestilence. (4)

DISASTERS REQUIRE CONTROL

When disasters, like the Great Fire of London, or some lesser crisis, brought the adverse effects of uncontrolled development of urban land to the attention of the legislators, they were faced with the problem of preventing its recurrence without returning to rural standards or otherwise ignoring the trend towards urbanization. They sought to produce a "better" urban environment, one which was healthier and safer than that which had led to the disaster. This they did by regulating and controlling private development. Contemporary space and site controls appear to have evolved from these early efforts of communities to protect themselves against hazards to safety and health which might otherwise arise if development by the individual land owner was uncontrolled. Structural sufficiency, safety against fire and safety against health hazards still provide the basis for all laws in Canada dealing with the construction and use of buildings. (5)

METHODS OF CONTROL

Once a community considered it necessary to exercise control over the development of private property, two alternative methods were available. The first, exemplified by the regulations governing the materials of construction incorporated into the Redevelopment of London Act following the Great Fire of London, were intended to achieve the community value (the protection of the city from conflagration) by requiring minimum standards of materials and building construction. (5) The second achieved its purpose by imposing a dimension limitation on the enclosed space. For example, in Rome, during the reigns of Julius and Augustus Caesar, the height of buildings was limited to 60 feet to protect the community against the dangers of structural failure. (5) Both forms of control are exercised in modern building regulations, but it is the effect of the latter which is important in this study. It is the controls on the dimensions of space which are involved in site and space regulations.

THE SPATIAL EFFECTS OF CONTROL

Current space and site regulations define a restricted space envelope within which development is permitted to take place. Such an envelope (Figs. 3, 5 and 7), in comparison with the original conditions shown in Fig. 2b, illustrates in spatial terms the infringement by the community on the private property rights of an individual land developer to achieve community values. The product of these regulations is shown in Figs. 4, 6 and 8. These clearly show the employment of open space to achieve the objectives of the regulations.

THE INTENT OF CURRENT REGULATIONS

The purpose of site and space regulations is normally stated as a preamble to the document to give a basis for interpretation for building controls that follow. The National Building Code declares itself to be:

> "...essentially a set of minimum regulations respecting the safety of buildings with reference to public health, fire protection and structural sufficiency...(relating to) buildings and simple structures..." (6)

while the City of Vancouver Zoning and Development Bylaw defines its local objectives more thoroughly and goes on to declare its itention

> "...to regulate and limit the height, number of storeys, and the size of buildings and other structures to be erected hereafter or the alterations of existing buildings and structures; to regulate and determine the size of yards, courts and other open spaces; to prescribe building lines, to regulate and limit the density of population; to conserve and stabilize the value of property; to provide adequate open spaces for light and air; to protect and improve amenity; to lessen congestion on streets; to promote health, safety and general welfare..." (7)

Other regulations seem to be concerned with specific problems and give no hint as to the underlying purposes of the individual controls. The Corporation of the Township of Richmond intends that the

> "...natural growth of the municipality may proceed in a systematic and orderly way..." (8)

a fact which reflects on the problems of uncontrolled development contingent upon the growth of a contemporary Canadian suburb.

The majority of bylaws and codes deal only with standards that are easily applied. Specific set-backs, floor space ratios, lot coverages, height and width limits etc. are all quantities which can be measured by an inspector, and thus furnish convenient building controls. Abstract concepts such as aesthetics are not incorporated into building regulations owing to their seemingly arbitrary nature. West Vancouver, however, has written into its zoning bylaw a clause which acknowledges the preservation of the "character" of each district and the suitability of a building to its physical environment:

> "...it appears advisable and expedient to make regulations and divide the Municipality into districts as hereinafter provided...having due regard to...the character of each district, the character of the buildings already erected, and the peculiar suitability of the district for particular uses..." (9)

This statement is further reinforced by paragraph No. 118 of the Corporation of the District of West Vancouver Building Bylaw entitled "Architectural Design" in which it is stated that an inspector has the right to refuse the issuance of a building permit if he deems that the proposed building or structure would depreciate the value of the surrounding buildings. If this is the case, the application for a permit is referred to the council who deliberate on the suitability of the building.

These clauses clearly indicate a desire to maintain the visual attractiveness of West Vancouver which has developed over the years from a combination of natural (landscape) beauty in addition to the house-building activities of its population of medium- and high-income residents.

THE SIGNIFICANCE OF STANDARDS

It has become accepted practice to formulate site and space regulations with reference to a specification standard. The building height limitation of 60 feet in ancient Rome and current regulations which specify that the height of a building shall not exceed 35 feet or 2 1/2 storeys (7) are examples of specification standards. Such a standard gives quantitative meaning to the regulation and defines the extent to which a community can control the right of the land owner to develop his property. Providing a builder complies with the minimum standard specified in the regulation when erecting a structure on his property, it is assumed that the community interest has been satisfied insofar as the community value basic to the regulation is concerned. The specifications listed in Figs. 3, 5, and 7 are almost entirely specific dimensions. In Figs. 5 and 7, which describe multiple dwelling districts in Vancouver, some flexibility within the other dimensional limitations is permitted by the use of a floor space ratio for the control of building bulk.

SOME ADVERSE EFFECTS OF SPACE REGULATIONS

The community values generally accepted as underlying current site and space controls are related to safety, health and welfare. Urban areas and particularly urban residential areas are now safe and healthy places in which to live in comparison with those of the last century. This has not been entirely the result of site and space regulations; better traffic control, smoke abatement programs, regulations concerning domestic animals and other effects have been instrumental in achieving the present high levels of site and space regulations. Now that the standards of residential health and safety have been raised, a new problem is arising with which administrators must cope.

Regulations which control the dimensions of residential space for the purpose of safeguarding health and safety have contributed significantly toward the determination of the visual form of the residential environment. Indeed, there is a growing concern for the absence of satisfactory design in the spatial arrangement of housing. This is caused mainly by the repeated layout of structures of similar size and shape each conforming to specific standards of current site and space regulations, although other factors of a less tangible nature such as social conformity, for example, have also affected the form of urban residential areas.

Since it would appear to be impossible to ensure "good" residential design by regulation because of the multitude of variables and the subjective values involved, it would be unrealistic to propose site and space regulations which were intended specifically to achieve "good" design. A positive contribution toward better design in residential developments could be made, however, if the visually adverse effects of existing site and space controls were corrected.

The weakness of current residential design has been expressed in such terms as, "...rubber-stamp similarity...," "...the same (or very nearly identical) house is repeated over and over...," "the same plan used for every exposure...," "...monotonous rows of similar houses..." These comments are extracted from statements prepared by women's groups across Canada, representing the reaction of hundreds of housewives to the contemporary residential environment, for submission to the Committee of Inquiry into the Design of Residential Environment. (10) On the basis of such evidence and their own observations, the Committee adopted three general objectives for future housing, of which one stated:

> "That every possible measure should be taken to encourage diversity among these new dwellings in size and nature, and mixture of several types in each new urban area, matching the variety of households in the local scene." (11)

Dissatisfaction with the visual appearance of residential development is the current crisis confronting urban administrators, with "monotony" the keynote of this dissatisfaction. Although it is the visual result about which residents are most vocal in their complaints, this appears to be but a symptom of a much more important value that is being disregarded in current residential development in Canada. A city is a blend of all possible variations in family life. This complexity makes it stand in sharp contrast to its rural background. Yet today the compartmentalization of cities by zoning regulations into districts within cities, each entirely one type of activity inhabited by one type of person is probably one of the strongest single forces contributing to residential uniformity. Visual monotony is the outcome.

The visual monotony evident in Canadian residential development is to some extent a side effect of existing site and space regulations, based as they are on rigid specification standards. "Variety" and "diversity" are the qualities that will satisfy the changes of monotony in visual design. To enable these qualities to be incorporated into future residential developments, site and space regulations must be revised to include provision for adequate daylight, air circulation, privacy, view, outdoor space, and control of nuisances such as noise and traffic - in short, all those factors which influence the residential environment (see Part 4). The revision will not require a change in the basic community values underlying the regulations - these would still act as assurance of high standards of health and safety - but simply a change in technique; specifically, a change from regulations formulated with reference to specification standards to regulations based on flexible standards.

So far, spatial monotony has been identified as partly a function of rigid specification standards. The process by which this occurs requires clarification.

SOME OF THE CONDITIONS LEADING TO RESIDENTIAL MONOTONY

Where housing is being constructed for profit, either to be rented or sold on speculation, the economic return from a residential lot within the same neighbourhood is roughly proportional to the space enclosed by the structure. Under these circumstances, the building envelope defined by site and space regulations which establish the maximum permissible enclosed space, effectively shapes the structure. Where economy is secondary to design, the specific nature of the standards permits no substitution which might equally well achieve the purpose basic to the regulation, hence they exert a confining effect on imaginative layout design. Together with other factors, these effects contribute to the general dissatisfaction with the visual appearance of contemporary residential development.

Urban areas are inevitably composed of many and varied land use activities. The undesirable effects of indiscriminate mixing of these activities have been recognized and countered by land use zoning which aims at the physical segregation of incompatible activities. Broadly speaking, a distinction is made between industrial, commercial and residential activities, and zoning is carried out on that basis. Residential land use zones are further subdivided into zoning districts: single-family, two-family and multiple dwelling districts, within which the activity is identical - residential living - but with variations in the structure. The justification for the creation of these districts on this basis appears to have its origin in the desire to protect property values by preventing the invasion of multi-family dwellings into single-family residential areas either by the construction of apartment blocks or by the conversion of single-family houses to multiple-family dwellings. Multiple-family dwellings, particularly in the case of conversions, have been associated with poor quality housing. Their presence in a higher quality single-family area was considered to have an adverse effect upon it. Within recent years the social stigma associated with multiple-family dwellings has weakened. With the exception of open space, apartment dwelling units can provide a comparable, and in some cases a better, residential environment than the traditional single-family dwelling. As this trend progresses, the argument favouring segregation of residential development on the basis of residential types will diminish.

A hierarchy of residential types, if not intended, is implied in zoning regulations which exclude all but single-family dwellings in single-family dwelling districts, yet permit single-family dwellings in districts intended for two-family and multi-family residences. In theory, regulations of this type do not prevent combining a variety of types of residential development in districts zoned for two-family dwellings in which single-family dwellings could be erected, or in multi-family districts where either single- or two-family dwellings could be constructed in addition to multi-family structures. In practice, however, it is not possible to achieve this variety. In each of the three districts, minimum lot sizes are specified, for example, "The site area in this district shall not be less than 18,000 square feet..." (12) These minimum size restrictions for lots in multi-family dwelling districts, which apply regardless of the structure erected, make low density residential development in these areas uneconomical. With zoning regulations preventing high intensity residential development in single-family districts, and the cost of property preventing low intensity development in multi-family districts, the result has been almost complete segregation of residential types accompanied by the loss of diversity deemed desirable by the R.A.I.C. Committee of Inquiry.

The growing acceptance of apartment buildings and terraced houses as dwelling units indicates a movement toward a more urban society. In Eastern Canada the acceptance of such housing is greater than in the West where the tradition of the detached house on its lot as an urban residence dies more slowly. This acceptance of apartments and terrace housing suggests a return to residential neighbourhoods within which dwelling types are mixed. Flexible controls, related to the performance of residential activity rather than the type of dwelling structure, would permit the mixture of residential types to be achieved without losing any of the values at present ensured by site and space controls. In this manner, improved site and space regulations can contribute to the variety and diversity of dwelling types.

Visual variety in contemporary residential development further suffers from the combined effect of standard lot sizes, a site and space control device, and the large-scale developer, a post World War II technological phenomenon in Canada.

Because of the tradition of home ownership in Canada, sub-division of large parcels of land into individual lots has normally preceded the construction of housing units. The R.A.I.C. Committee of Inquiry noted the following practice common in current residential development:

> "The developer decides what plot dimensions he can sell to prospective dwelling owners. He shows the tract of land to technical advisers: salaried or consultant surveyors, site planners, utility engineers. About a third of his land will have to be dedicated for thoroughfares and public open spaces. The remainder of his tract he will ask to be divided for the optimum sale of plots of the chosen size. It is possible, and not uncommon, for a whole township to be reduced to little pieces of identical dimensions; on each plot only one sort and size of house can be built." (13)

To meet these conditions, regulations that were intended to control the spacing of structures in relation to one another were related to the legal lot lines to permit spatial controls to be exercised despite the absence of structures on the adjacent lots. Since the structures built on these individual lots were limited in type by the zoning district qualifications and shaped by space regulations which specified minimum building heights, front yard set-backs, and side yard clearances in relation to the lot lines, the over-all effect was one of continuous similarity. Neighbourhoods which developed under such conditions avoided being labeled monotonous, however, because of the variations present in the structures themselves. Houses were normally built by the land owner or by a small speculative contractor. These houses may have been individually designed by an architect or more likely, merely reflected a homeowner's preference for a particular style, yet this custom approach to residential development ensured a measure of variety in the street scene. Figure 9 shows a pre-war residential street developed by small builders.

After the Second World War, large-scale housing development began to have an increasing effect on the urban residential environment. The mass production methods of construction employed by these large-scale developers removed the main element of variety that had been present in pre-war housing - the appearance of the structure itself. With increasing frequency housing developments were being referred to as monotonous. Houses had been constructed in groups prior to World War II as Fig. 10 testifies, but not in whole neighbourhoods nor with so much interjected open space between structures.

The foregoing analysis attempts to account for some of the events that have led to the current dissatisfaction with contemporary residential development. It indicates the part that site and space regulations have played in contributing to this dissatisfaction and leads to a definition of the purposes to be achieved in controlling space relationships around and between buildings.

PART TWO

A CLARIFICATION OF THE OBJECTIVES BASIC TO SITE AND SPACE REGULATIONS

Broadly speaking, the purpose of site and space regulations is to foster a "better" residential environment. This has been their aim in the past and their reason for existence. When it became apparent that uncontrolled development of private residential property was leading to a negation of certain community values, regulations were enacted to counteract this trend. Standards of design and construction were adopted to which all development was required to conform. By such a process a "better" residential environment was achieved.

THE REQUIREMENTS OF "BETTER" RESIDENTIAL DEVELOPMENT

The qualities which describe a "better" residential environment today are more complex than those demanded in 1666 following the Great Fire of London. In those times the community had been threatened by fire out of which arose building regulations intended to remove that threat. Such regulations were specific and few in number, hence the relationship between the standards of construction incorporated in the regulations and the purpose they were to serve could be clearly understood. With time, further regulations have been added to the administrator's repertoire to make residential areas safer still, more livable, and in some instances more attractive. These, then, are the requirements of a "better" residential development today, which any proposal for new site and space regulations arising from this study must endeavour to achieve.

Although safety, livability and appearance are generally accepted as purposes of site and space regulations, they require clarification. Structural sufficiency, safety against fire and safety against health hazards are currently the basis for laws in Canada dealing with the construction and use of buildings. There is a growing body of opinion, however, suggesting that other values should be incorporated into space regulation, examples of which were given in Part One. Some communities, e. g. West Vancouver, in the preamble to their zoning ordinance state the purpose of the regulations. As is proposed in this report, the values they consider are more than simply safety against fire and health hazards. The consensus expressed in the writings annotated in Stage One (1) was that site and space regulations should be responsible for protecting the community against fire (14, 15), ensuring each dwelling unit adequate light (15, 16, 17, 18), and air (15, 16, 18) and guarding each dwelling unit from undue noise (14, 16 17). In addition, some authorities thought that privacy (18) was a value that regulations should ensure. Other hazards such as dust, odour, smoke and glare, which are important in regulating industrial developments, were not considered significant for the residential case. Finally, the ensurance of adequate open space (15, 16, 17, 18) for functions associated with residential development was judged a value worth regulating. The characteristics fire, light, air, noise, privacy, and outdoor space, and the values they involve, were accepted as suitable for control by site and space regulations. In addition, out of respect for the growing value placed upon a residential view, as evidenced by the outward orientation of houses, the evolution of the picture window, and the preference for residential lots with a clear vista towards the horizon, view was considered a value suitable for regulation. The growing importance of the automobile as an element in residential development and its adverse effects upon the safety, quietness and appearance of a neighbourhood were believed to warrant its inclusion as a separate characteristic in the list to be regulated.

It was intended to examine in some detail each of these characteristics to determine those qualities having a bearing upon its control by site and space regulation. Four of the eight reports covering this aspect of the study have been included as Appendices A to D. The following paragraphs summarize the completed reports and describe with more exactness the characteristic to be controlled.

FIRE AS A CHARACTERISTIC OF SPACE REGULATION

The protection of the community against the ravages of fire is probably the second oldest community value to be safeguarded by building regulations. Structural sufficiency may have predated it. Site and space regulations are not concerned with the prevention of the outbreak of fire. This is the responsibility of building regulations which set standards for fire-resistant construction and fire regulations intended to control fire activity. It is the specific function of site and space regulations to prevent conflagration by ensuring that once a fire has started, it is confined to the dwelling unit within which it originated. Fire, in common with the seven other characteristics, embraces a source, a receiver and a transmission path. In this study the source is the dwelling unit containing the fire, the receiver is the adjacent dwelling unit, and the transmission path, either an open space or a physical barrier, or a combination of the two. Radiative heat transfer is the critical mechanism by which fire spreads. Under conditions of radiative heat transfer, the variables of the source, receiver, and transmission path can be related in mathematical terms, since each of these components is an inanimate quantity which can be subject to reliable and consistent measurement. This does not hold true for the other characteristics. Appendix A describes in more detail the characteristic of fire.

LIGHT AS A CHARACTERISTIC OF SPACE REGULATION

Natural light is an environmental condition threatened by over-builing in urban areas. Daylight, or natural light, long recognized as beneficial to health, both physically and psychologically, has been subject to regulation from as early as Roman times. Natural light has its source in the sun but can be received as direct sunlight, daylight or reflected light depending upon its transmission path. The amount of light a resident of a dwelling unit will receive depends upon the time of day, the time of year, the latitude of the observation point, the climatic conditions, and the skyline. Of these, only the skyline can be subject to control. There are several techniques for measuring light, some in terms of direct sunlight based on the vertical angle the sun's arc makes with the horizon, and others in terms of daylight involving a measurement of sky area. In both cases, the skyline limits the light available. Although reasonably satisfactory techniques for measuring light have been devised, the problem still exists of defining what constitutes adequate light. It is generally agreed that natural light is beneficial for physiological and psychological reasons and site and space regulations controlling light must be based on generally accepted standards of adequacy.

Open space is employed to permit unobstructed penetration of natural light to the enclosed spaces. No other substitute appears to be available. Artificial light can provide satisfactory illumination but it lacks the psychological and anti-bacterial benefits of natural light. The quantity of natural light should be maximized, a fact that implies protecting its available transmission path from obstruction. The protection of daylight conflicts with other community values that result in a high ratio of enclosed to open space. This conflict must be rationalized by defining adequate light and protecting it by site and space regulation (see Appendix B).

AIR AS A CHARACTERISTIC OF SPACE REGULATION

This characteristic was not examined in any detail as part of this report but it would appear that site and space regulations should be responsible for ensuring that an adequate quantity of fresh air reaches every dwelling unit. Quality control of the air would be exercised by smoke abatement and air pollution legislation. Adequate fresh air aids ventilation of the dwelling units during hot weather and reduces contagion. As with light, the increasing ratio of enclosed space to open space tends to negate the values associated with adequate quantities of fresh air. Conflicting values would have to be rationalized and adequate air defined. The chances of arriving at a rational figure for adequate air appear better than for natural light since the physiological effects of thermal comfort are more universally understood. Satisfactory substitutes for normal fresh air are available in mechanical air conditioning and should be recognized in the regulations.

The quantity of fresh air available is a function of the air movement past the exterior wall of an enclosed space. Natural conditions such as prevailing wind direction and topographical features probably establish the upper limits to the amount of air an exterior wall will receive. Site and space regulations would attempt to control the size and placing of adjacent enclosed spaces so that the cooling effect of the moving air would not be reduced below an acceptable standard.

NOISE AS A CHARACTERISTIC OF SPACE REGULATION

Sound in the residential environment is increasing. Television, high fidelity sound reproduction systems, power lawn mowers and similar noise-making devices have been added to the scene. If these sounds intrude upon a listener they constitute noise. At the same time, modern trends toward the use of lightweight construction materials permit easier transmission of sound compared with the solid brick construction used in the past. Quiet is therefore a value that needs protection by community control.

Most noise problems can be analysed in terms of a source, a transmission path and a listener. Control can be exercised over some sources, such as noisy machinery, by demanding standards of construction that eliminate or reduce unnecessary sound generation. Sources such as radios and voices are not as readily controlled, however, since whether they are noise depends on the point of view of the listener. It is also impractical to suggest, except as a desperation measure, that the listener be fitted with ear protectors. Control must be effected on the transmission path, therefore, by the use of spatial separation, screens or barriers separating the source from the receiver.

In the multi-dwelling structure the sound insulation of party walls and floors separating dwellings is of major importance if such structures are to provide acceptable living conditions.

Planning of residential districts must take into account the high levels of traffic noise associated with main thoroughfares. Land abutting on such thoroughfares should preferably be used for non-residential functions, or for specially designed structures such as air-conditioned hotels, motels or apartment buildings.

Transmission of outdoor noise between adjacent residential properties can be controlled in limited fashion only. But consideration might be given to the shape and size of residential lots, and the siting of dwellings thereon, to increase the value of outdoor living areas from the viewpoint of noise.

A more detailed consideration of noise as a characteristic of space regulation is given in Appendix C.

PRIVACY AS A CHARACTERISTIC OF SPACE REGULATION

Privacy has also been judged as a residential characteristic that should be ensured. Current residential development with the exception of single-family dwellings has been criticized as lacking adequate privacy. This is probably a major reason for the preference of single-family over multi-family houses.

It is believed that privacy has more in common with aesthetics than the other qualities so far described; privacy differs from them in that there are more subjective values involved. For this reason it is doubtful if a definition of adequate privacy can be made. It appears to be more reasonable to improve privacy in residential development by correcting the adverse effects of current site and space regulations.

It is probable that the effects on visual privacy of variations in spatial elements could be determined. Knowing this, one could encourage more privacy in residential development through a bonus system without the necessity of defining adequate privacy.

(Note: The three remaining characteristics, view, traffic and outdoor space, have been reserved for investigation at a future stage of this research project.)

PART THREE

THE CHARACTERISTICS AND DIMENSIONS OF PHYSICAL SPACE IN RESIDENTIAL DEVELOPMENT

DEFINITION

For purposes of this study, urban residential environment is considered to consist of enclosed spaces - the structures containing one or more dwelling units - and open space which surrounds and separates the enclosed spaces. "Space" in this study has been considered in its three-dimensional rather than its two-dimensional sense. For the latter, the term "area" has been reserved.

THE FUNCTIONS OF SPACE

The function of enclosed space is to shelter the family by providing a controlled environment within which the activities associated with residential living can be performed. Open space has a two-fold function: first, it contains outdoor areas in which activities also related to residential living can take place, and second, it acts as a barrier or circulation space between enclosed spaces which insulates the activity in one dwelling unit from its neighbour or permits the penetration of air and sunlight into the enclosed spaces. It is the second function of open space that has been utilized in site and space regulations intended to protect community values (Fig. 12).

THE FORM OF SPACE

Because the dimensions of space and its form should reflect its function, space in residential areas should be shaped by the demands upon it to enclose the residential activities of families of various sizes and provide for their outdoor needs. Family composition varies, individuals vary, and the spatial needs of one individual vary through his lifetime. It would be expected that the disposition of open and enclosed space within a residential area would, in some way, reflect these human variations. Residential development seems to be tending in the opposite direction. A survey of residential neighbourhoods which included both recent and pre-war developments catering to a cross-section of income groups was made in the Vancouver area. It was obvious that some developments varied more than others.

Besides its physical meaning, space can be considered in terms of ownership; space which is both public and private is significant in this study.

AN ANALYSIS OF SPATIAL ELEMENTS

Residential space has physical meaning and can be described in physical terms. It is possible to describe residential space in geometric forms: the land surface could become a reference plane; the centre-line of a street could be a line of reference on the plane; and enclosed spaces, reference volumes based on the plane. This is a simplified description of spatial variety in residential development.

The situation with the least spatial variety in its composition would be that illustrated in Fig. 13. The plane is flat and level, the reference line is straight, and the volumes are of equal size and shape each occupying identical positions with reference to the line and to one another. Figure 14 shows streets of apartment buildings and semi-detached houses in Vancouver having just such spatial characteristics. Each of the succeeding illustrations, Figs. 15 to 20, shows the result of varying one spatial element while holding the others constant. These elements together in various combinations provide the spatial arrangement apparent in a street. Two examples are shown in Figs. 21 and 22. In the former the variation is in the shape and size of the volumes, while the other elements are unvaried. In the second example, the site is sloping, the roadway curved, the relationship between the houses and the street varies (a variation in set-back), and the shape of the volumes differ.

By focusing attention on two volumes or two enclosed spaces the variable elements can be examined in greater detail. Figure 23 illustrates two unit volumes "A" and "B" with the variable elements indicated. The roof shapes may suggest single-family dwellings but the unit volumes could represent any building type.

If the dimensions and positioning of "B" were considered fixed, volume "A" could be varied in its position and in its dimensions and with each variation describe a different relationship with "B." The two houses shown in Fig. 24 could be considered to represent "A" and "B" in the basic case. Although the two houses shown in Fig. 25 are identical houses they are on a sloping site, hence one is elevated with reference to the other. The houses in Fig. 26, in addition to the variation in elevation between them, are varied in orientation and volume. The height, roof shape, and set-back are generally the same, and hence are comparable to the other two cases.

A COMPREHENSIVE ANALYSIS OF SPACE FUNCTIONS

The functions of open and enclosed space in residential environment have been described in general terms, i. e., to contain the activities associated with residential living and, in outdoor space, to provide a buffer between enclosed spaces. In Fig. 28 the functions of both enclosed and open space are analyzed in greater detail.

The requirements of enclosed space are not considered in this study; open space is the critical element. The two-fold function of open space is represented by "residential outdoor space" and "insulation (separation) space." Figure 27 shows open space between semi-detached houses. This is clearly Insulation Space since its narrowness precludes it from any Residential Outdoor Space function aside from pedestrian access. By framing side yard set-back regulations so that the structure is toward one side of the lot rather than centred between the lot lines, the open space at one side can be utilized for a "residential outdoor space" function in addition to its insulating purpose.

"Residential outdoor space" is expanded in the lower half of Fig. 28. The quality of privacy is more essential to those functions listed under the heading "Living Space." All the activities related to these spaces depend upon natural outdoor conditions for their success. Those activities requiring "service space," however, can in almost all cases be contained within the "enclosed space" of the dwelling structure. These activities have traditionally taken place out of doors but technological advances have made substitute methods acceptable. Automatic dryers eliminate the need for clothes line space in apartments and single-family dwellings. In apartments particularly, vehicle storage space can be incorporated within the basement or lower floor of the structure. The development of the sink disposal unit and compact basement incinerators reduces the amount of space necessary for outdoor waste disposal.

Obviously, not every dwelling unit will have adequate open space for every function, and there will be frequent cases of multiple use of the same area. A patch of grass would be "cultivated usable landscape space." It could also double as a clothes drying space on washdays, and if it were sufficiently private the residents could utilize it as "non-active recreation space" for sunbathing.

Upper floor apartment dwellers may have adequate living space for sunbathing and dining in the open air if they have a balcony; it may be necessary, however, for them to go to the ground level to find adequate space for their children's active recreation needs. Such a play area might be communal for the apartment, or it might be a playground open to the general public.

A plan diagram illustrating the foregoing functions of "residential outdoor space" with reference to a single-family dwelling is given in Fig. 29.

PART FOUR

THE RELATIONSHIP BETWEEN COMMUNITY OBJECTIVES AND PHYSICAL SPACE

Part Two of this report presented a discussion of the community values considered to be worth ensuring by the regulation of space in the residential environment. Part Three contained an analysis of the characteristics of residential space with special emphasis on the dimensional elements which can be varied to achieve spatial variety. It is the purpose of this part to consider the relationship between the community values and the characteristics of space.

As a starting point, the community values were restated more specifically in spatial terms. For this purpose, the unit volumes "A" and "B," described in Part Three, were employed (Fig. 23). In each case "A" was considered the variable unit of enclosed space. Its performance in relation to volume "B" was to be controlled.

The objectives of site and space regulations are as follows:

	Characteristic	Objective
(I)	Fire	To minimize the possibilities of a fire having its origin in "A" spreading to "B."
(II)	Daylight	To maximize the amount of sunlight and daylight reaching the habitable living space of "B" by minimizing the obstruction to the passage of light caused by "A."
(III)	Air	To maximize the circulation of air between "A" and "B" for the purpose of promoting optimum thermal comfort at "B" for summer conditions by siting "A" so that the flow of air past "B" is least restricted.
(IV)	Noise	To maximize the opportunities to enjoy quietness in the habitable living space at "B" by minimizing the nuisance effect of noises originating at "A" and from adjacent public areas.

(V)	Privacy	To maximize the opportunities for residents of "B" to enjoy the physical privacy offered by their own habitable living space by minimizing the opportunities for infringement of this privacy by residents of "A" and by the general public passing "B."
(VI)	View	To maximize the opportunities for residents of "B" to enjoy the view offered by their dwelling site by minimizing the interfering effects of "A."
(VII)	Traffic	To minimize the hazard and the nuisance effects of vehicular traffic on public rights-of-way adjacent to "B."
(VIII)	Outdoor Space	To maximize the use of open space around "B" for activities related to outdoor residential living while minimizing the utilization of open space between "A" and "B" solely for insulation or barrier purposes.

The intent of each of the foregoing objectives is to minimize or maximize some characteristic so that the resulting residential area is either safer, healthier or in some way more livable. Each objective is directive rather than specific, and no demarcation is given in the statement of objective between adequate conditions of the characteristic and those that are unsatisfactory. In the past, the problem of quantifying values and translating them into units of space has been solved by an arbitrary decision. Frequently a single dimension giving a minimum separation between enclosed spaces or the minimum dimension of an enclosed space represented the limits of acceptable conditions. The adverse spatial effects of such specific dimensions have been described in Part One, and in addition the justification for the specific dimension chosen can usually be disputed.

Rather than become involved at this point in the problems of defining adequate spatial conditions to satisfy the objectives it was decided to consider the effect of each element of space upon the stated objectives.

The two unit volumes of enclosed space "A" and "B" are depicted in Fig. 30. Each represents a structure containing one or more dwelling units. Every spatial variation between them can be reduced to a variation in one or more of the dimensions indicated. For continuity, volume "B" was held constant and in turn each of the dimensions of volume "A" and the dimensions relating "A" to "B" were increased.

It was proposed to examine the effects of each increase in a single space dimension upon the eight objectives to be pursued. In addition to the dimensions of space, two space substitutes, structural baffles and shrubbery baffles, were included for consideration. The area of windows was included as a separate item. Windows represent an opening between the enclosed space and the surrounding open space and as such significantly affect each of the eight values.

The pro forma in Fig. 31 shows how it is proposed to relate each space dimension with the eight objectives. Values for the table have not yet been determined. This table is included only as illustrtive of the approach to be taken and as a succinct method of expressing the inter-relationships. Whatever difficulties are apparent in substituting numerical values for the blank spaces in the table, there is no question that the factors listed at the head of the table are the daily concern of town planners and the factors listed in the left-hand column each have a bearing on the town planner's appraisal of whether any given situation is acceptable or otherwise.

In this sense this table represents a pro forma by which the relationships between buildings can be analysed, and presuming that it is possible to establish useful numerical values, no matter how arbitrary, then this system might be used to ensure a minimum standard of performance with respect to building elements that define urban space.

At this stage in the work it is impossible to anticipate how the blank spaces might be filled. Each of the eight values will have to be considered separately before the possibilities of inter-relationships can even be entertained. In the meantime, and anticipating studies that may continue for some period, this table is a convenient reminder of the ultimate goal and of the futility of carrying on research with respect to any one of these factors in complete disregard of all the others.

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"OPEN SPACE" AND "ENCLOSED SPACE" ILLUSTRATED.

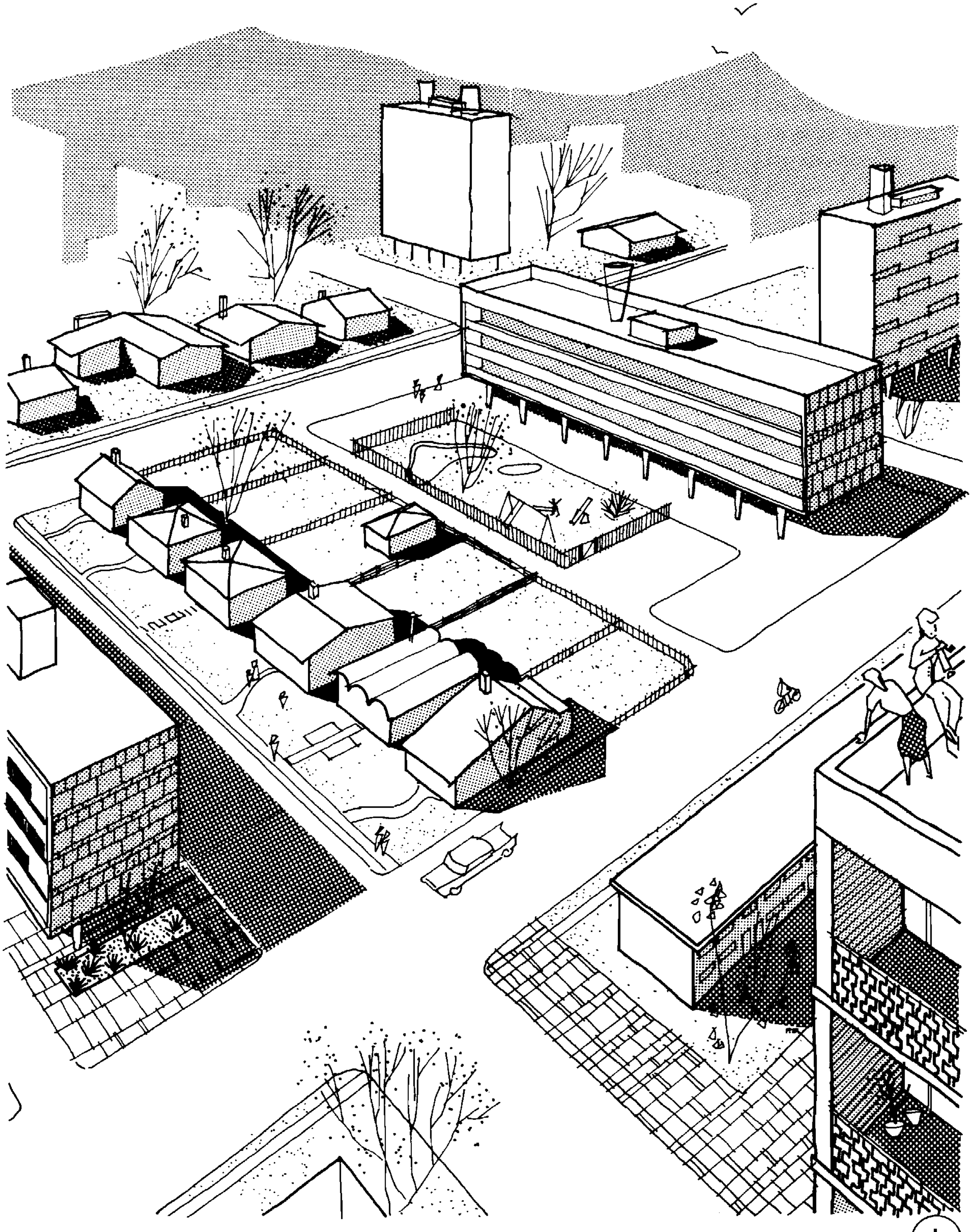
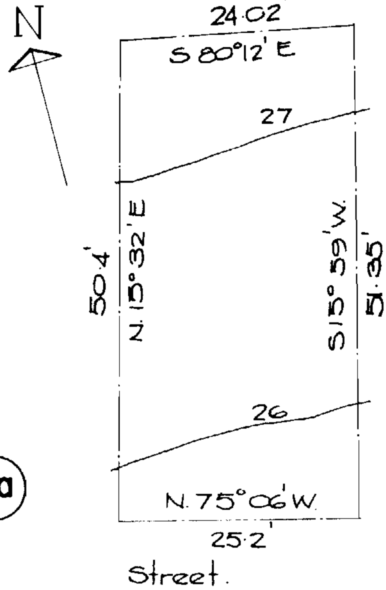


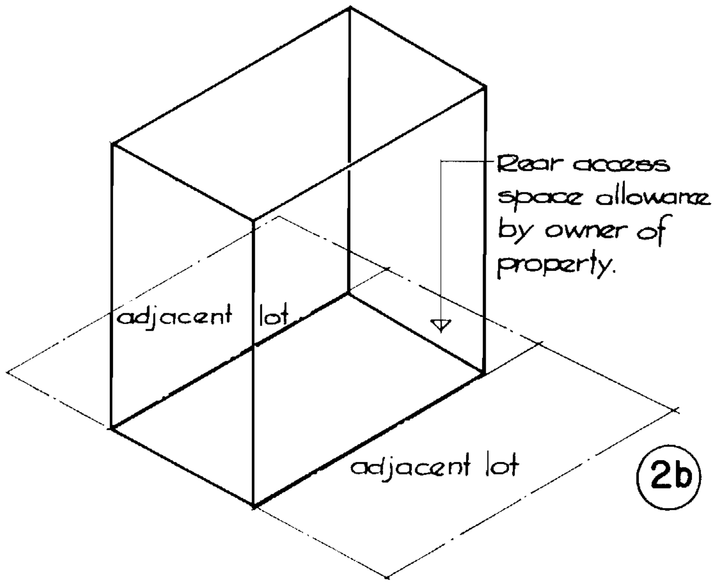
fig. 1

SPACE ENVELOPE DEFINED BY LOT LINES ONLY.

Note: Building ht. limited in the past only by structural, economic or minor regulatory considerations.



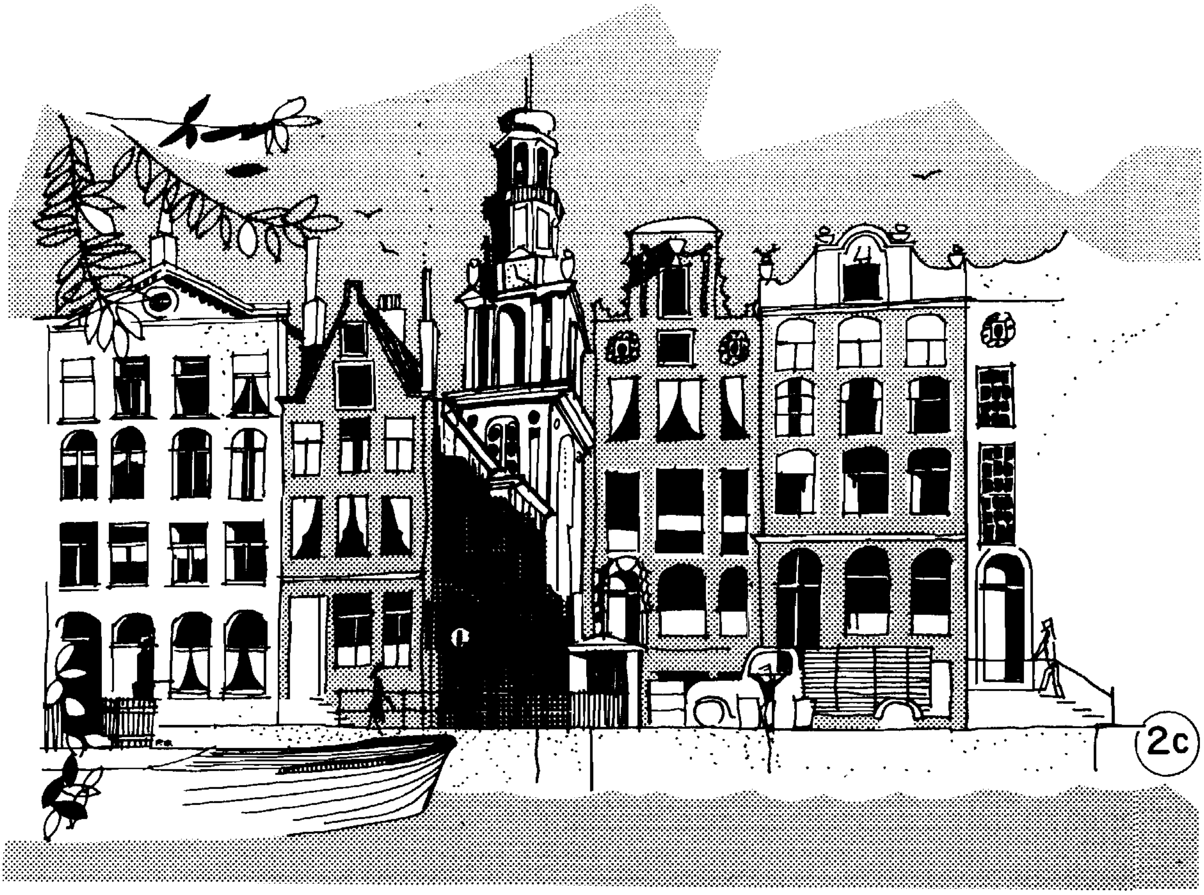
2a



2b

PLAN OF LEGAL LOT
Scale : 1" = 20'-0"

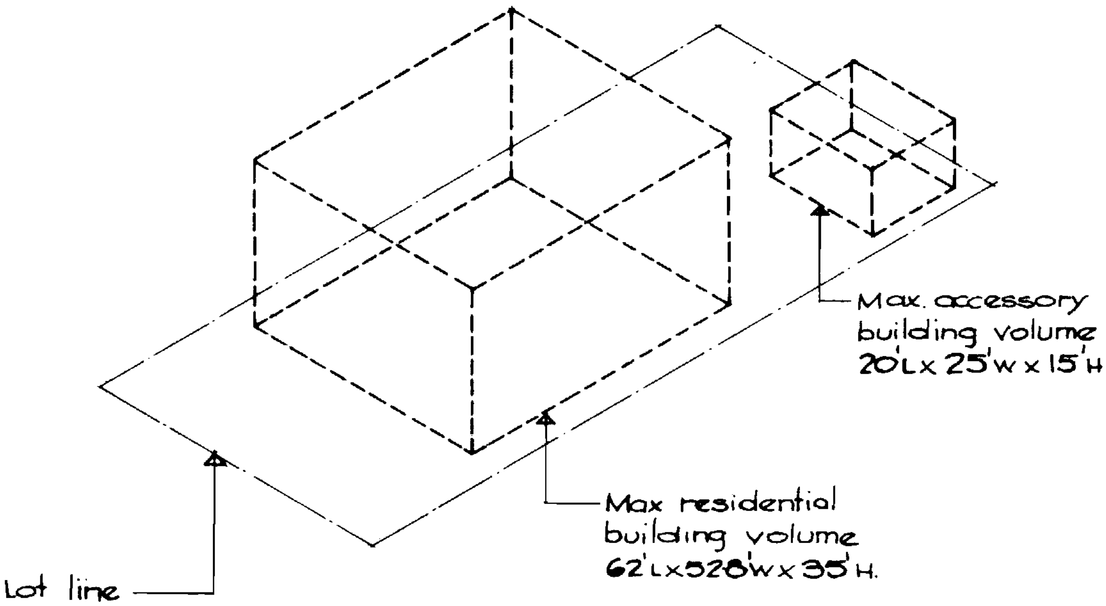
BUILDING ENVELOPE
Scale: 1" = 30'-0"



2c

Amsterdam: Canal street scene. From "The Urban Scene" by Gordon Logie, p.113 .

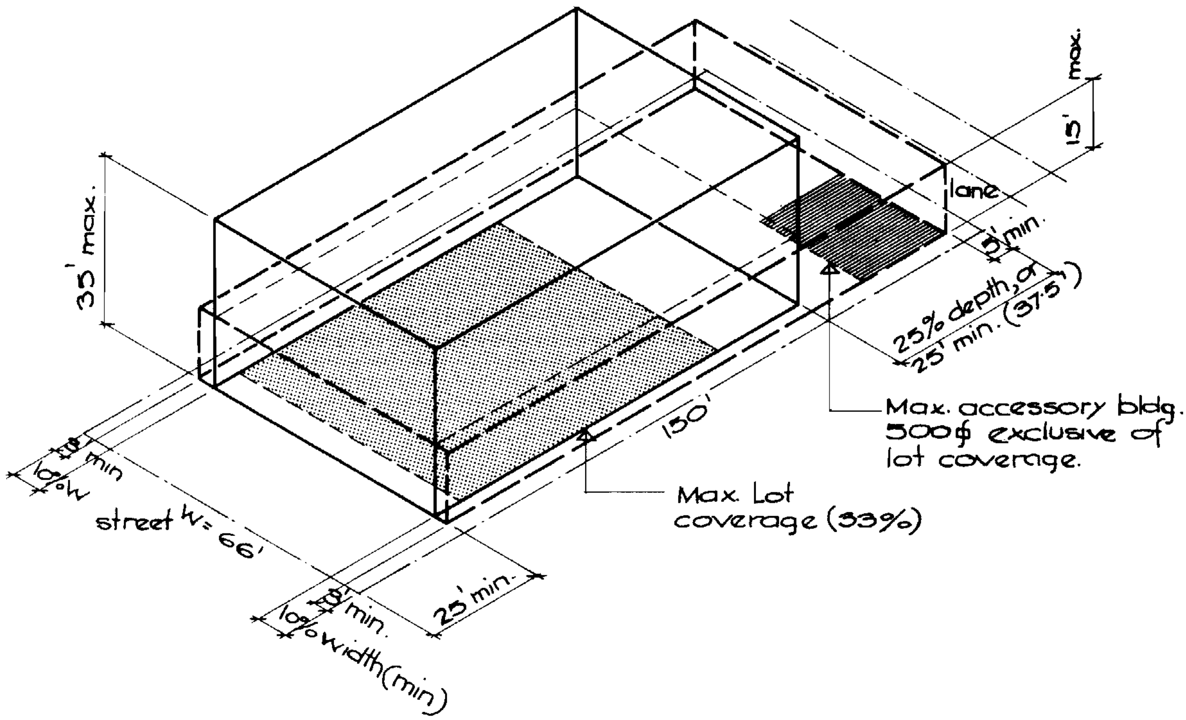
MAXIMUM BUILDING VOLUME OBTAINABLE ON A 66' X 150' INSIDE LOT IN A ONE-FAMILY DWELLING GENERAL RESIDENTIAL DISTRICT, RICHMOND B.C. (see overleaf)



Scale : 1" = 40'-0"

BUILDING ENVELOPE FOR AN INSIDE LOT 66'X150' IN A ONE-FAMILY DWELLING, GENERAL RESIDENTIAL DISTRICT, RICHMOND, B.C.

Scale: 1" = 40'-0"



SPECIFICATIONS: *

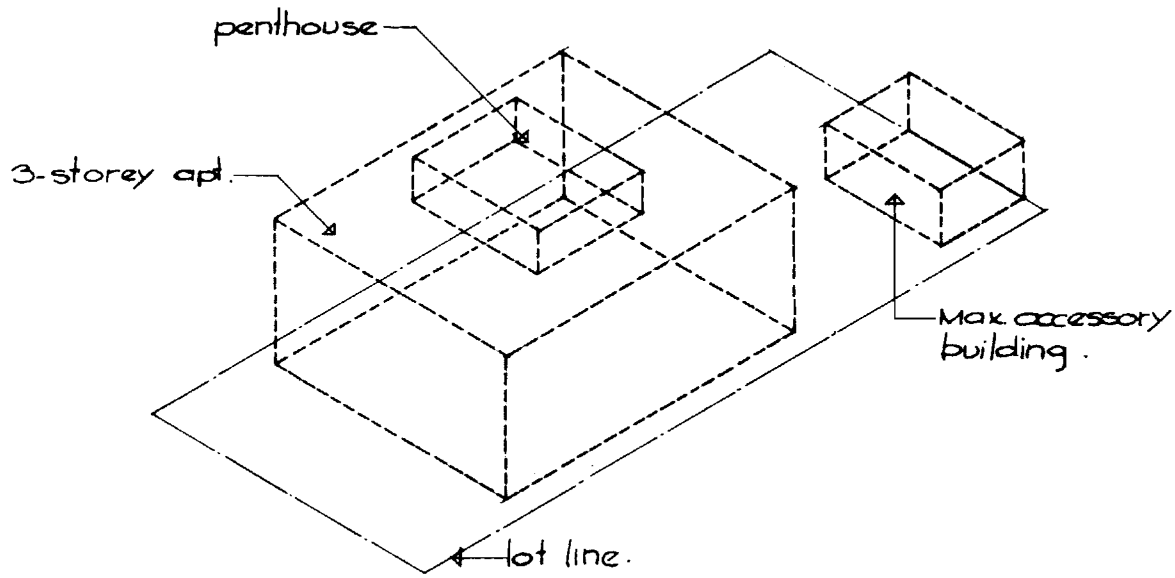
Front yard: 25 ft. min.
Side yard: 10% average lot width (10' max reqd.)
Rear yard: Min 25', or 25% lot length, whichever is the most.
Min lot width: 66' (60' for lots originally 120' wide prior to passing by-law)
Min lot area: 7920 ft² without sewer
Min lot area: 7000 ft² with sewer.
Maximum lot coverage: 33% of total area.
Minimum floor area of residence: 750 ft²
Main building height: 35' max.
Side yard on corner lot: 15' min on flanking street
Accessory buildings: Max. height = 15'. Min. set-back = same as residence. Min lot line clearance = 3'; 5' if lane abuts; 15' if next to side street. Max area = 500 ft² (exclusive of lot coverage). 10' clearance from main building (min.)

* Some of the less significant regulations are not listed here.

From: The Corporation of the township of Richmond (B.C) By-Law No 1430.

Illustration of figs. 3 and 3a: One-family dwellings in a Richmond subdivision (Lulu Island, B.C.).

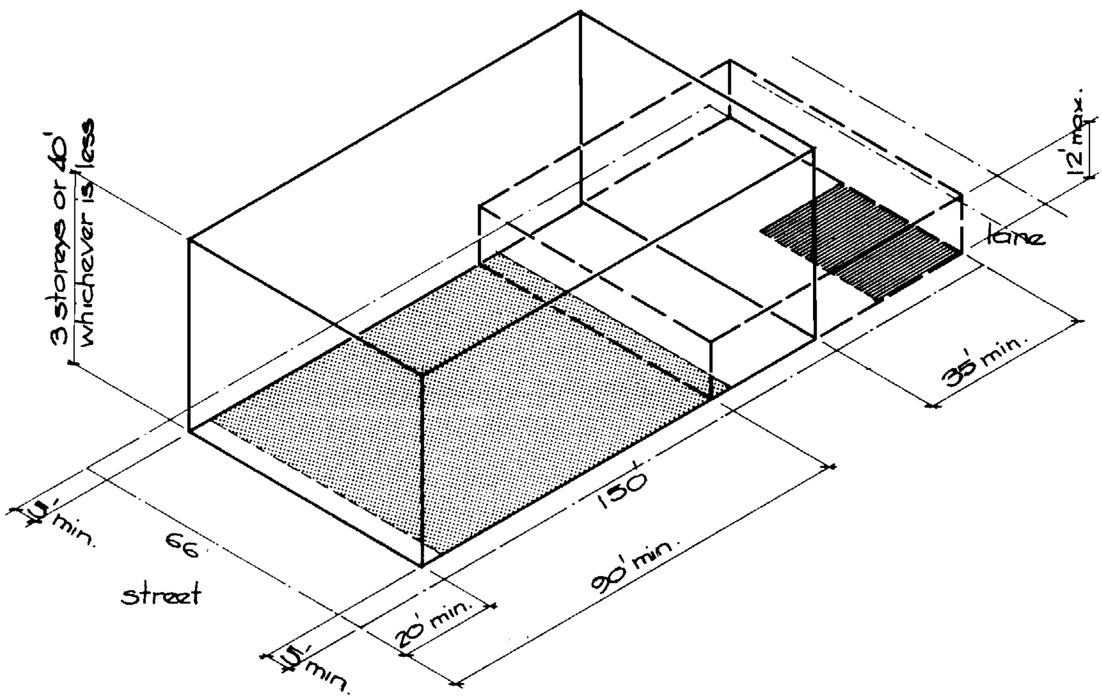
BUILDING DESIGNED FOR FULL FLOOR SPACE RATIO FOR AN INSIDE LOT IN RM-3 ZONE ON A 66' X 150' LOT (see overleaf).



Scale: 1" = 40'-0"

BUILDING ENVELOPE FOR AN INSIDE LOT 66' X 150' IN RM-3 ZONE (MULTIPLE DWELLING DISTRICT, MEDIUM DENSITY) IN VANCOUVER, B.C.

Scale: 1" = 40'-0"



SPECIFICATIONS:

Front yd: 20' min, 24' max. required.
Side yd: 5' min. (10' on flanking street side, corn. lot).
Rear yd: 35' min. with building width over 50'.
Floor space ratio: 1.3 (1.45 corner lot).
Min. site area: 6000 sf.
Main building height: 3 floors or 40'
Total penthouse area: 20% roof area, max.
Accessory building height: 12' max.
Max. accessory building area: 25% min rear yd.
Accessory building set-back: 90' min.

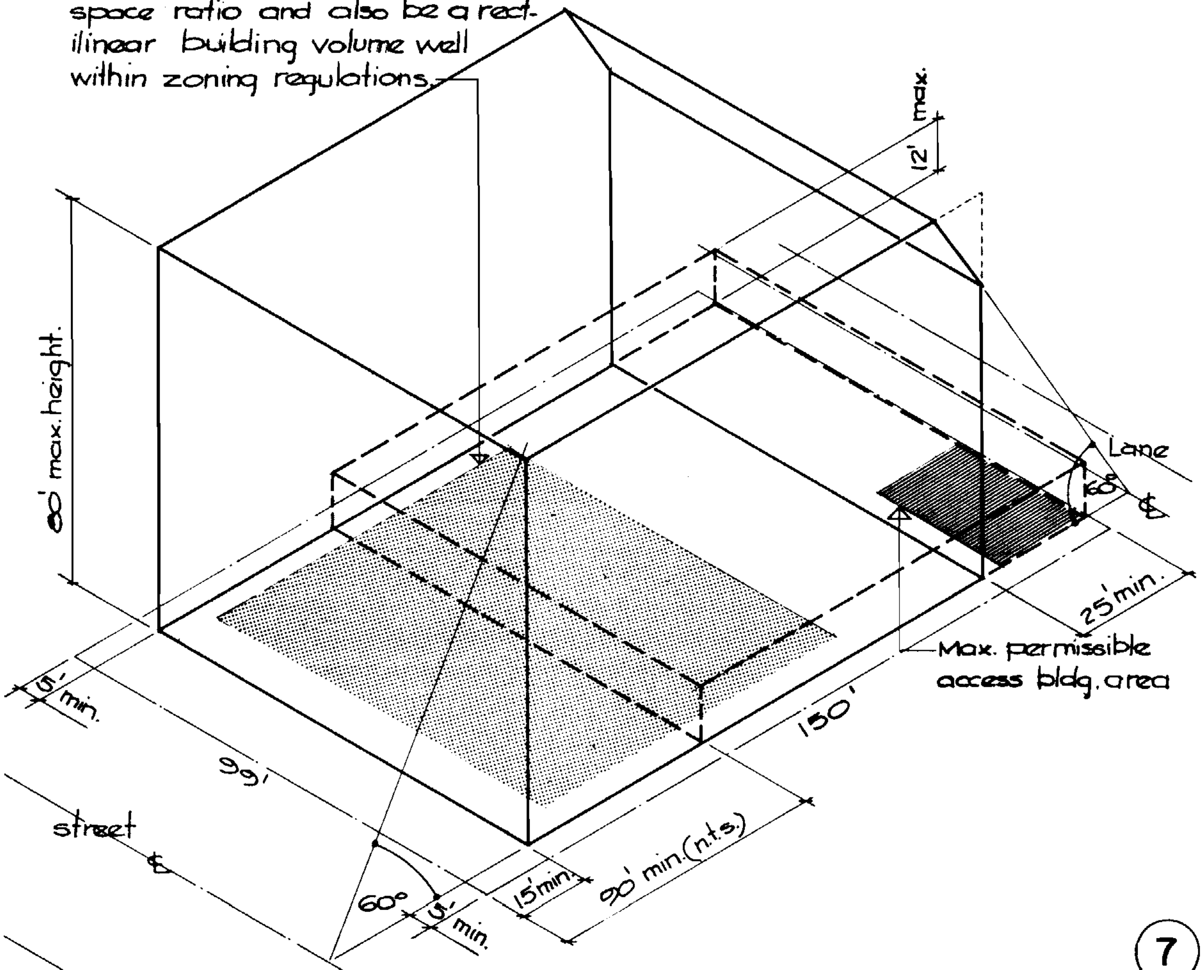
From: City of Vancouver Zoning and Development By-Law no. 3575, June 1956

Illustration of figs. 5 and 5a: Apartment in RM-3 zone in Shaughnessy area, Vancouver.

BUILDING ENVELOPE FOR AN INSIDE LOT 99'x 150' IN RM-4 ZONE (MULTIPLE DWELLING DISTRICT, HIGH DENSITY) IN VANCOUVER, B.C.

Scale : 1" = 40'-0"

Note: large shaded area below forms plan of volume, which, if projected to top of "envelope" would develop full floor space ratio and also be a rectilinear building volume well within zoning regulations.



* SPECIFICATIONS :

Front yd : 15' min.
Side yd : 5' min. (10' on flanking street side)
Rear yd : 25' min.
Floor space ratio : 3.0 (3.35 corner lot).
Site area : 6000 ф min.
Main bldg. height : 80' max.
Total penthouse area : 20% roof area max.
Accessory building height : 12' max.
Max. access building area : 25% min. rear yd.
Corner lot, access building side yd : 15' (flank. st)
Access bldg. set back : 90' min.
Vert. light angle : 60° from ℄ adjacent streets, lanes.

* Some variations are possible. This is only a typical case.

From : City of Vancouver Zoning and Development By-Law no. 3575, Jun. 1956.

Illustration of fig. 7: Apartment building in RM-4 zone in Vancouver at Barclay & Chilco (sts.

Inter-war housing showing variations in dwellings. Blanca st. and 9 th Avenue West. (Vancouver). 9

East side of Macdonald St. between 5 and 7th. Avenues, Vancouver. 10

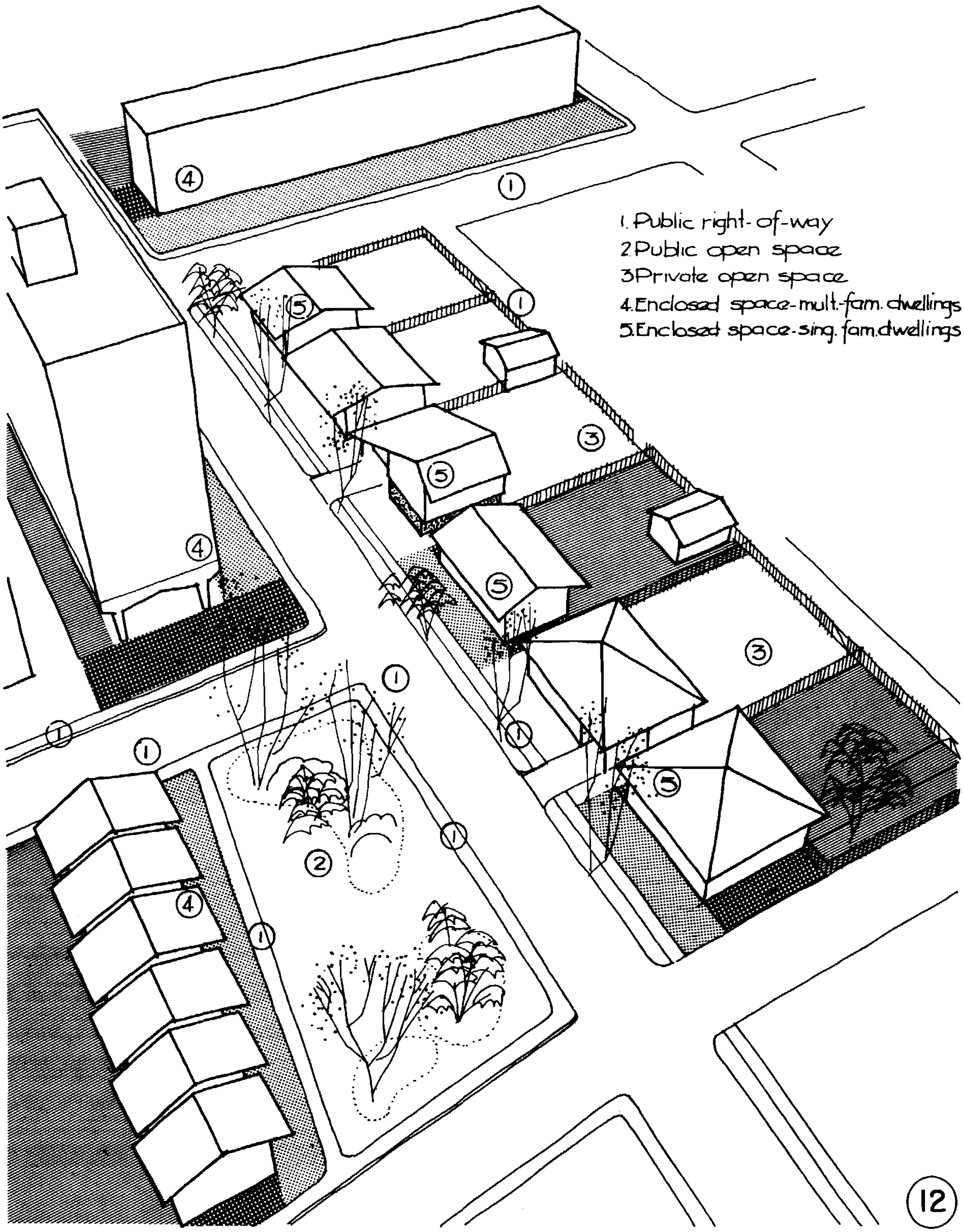
	Prior to existence of community regulations	Contemporary community regulations.	Proposed.
Basic objective of Space controls.		To foster "better" residential development.	To foster "better" residential development.
Interpretation of Objective.		(a) To raise the standards of health, safety and welfare.	(a). To raise the standards of health, safety and welfare. (b). To encourage visually attractive residential development.
Spatial Implications	Enclosed Space developed at the expense of Open Space.	Controls intended to inject Open Space into residential development to achieve objective. Main emphasis placed on regulation of enclosed space.	Controls recognise the distinction between Residential Outdoor Space and Insulation (separation) Space. They insure adequate amounts of the former and encourage substitution for the latter.
Effect.	Enclosed Space limited only by property ownership. High proportion of Enclosed Space had negative effects on health, safety and welfare.	Injection of Open Space into residential development promoted dispersed pattern of structures with loss of urban intimacy associated with earlier development. The form taken by the Open Space together with standard shapes of Enclosed Space contributed to spatial monotony.	A return to more compact urban development without sacrificing the advantages offered by functional Residential Outdoor Space and a chance to achieve spatial arrangements which reflect variety in the composition of residential areas.

GENERALIZED OBJECTIVES OF SPATIAL CONTROLS IN RESIDENTIAL DEVELOPMENT.

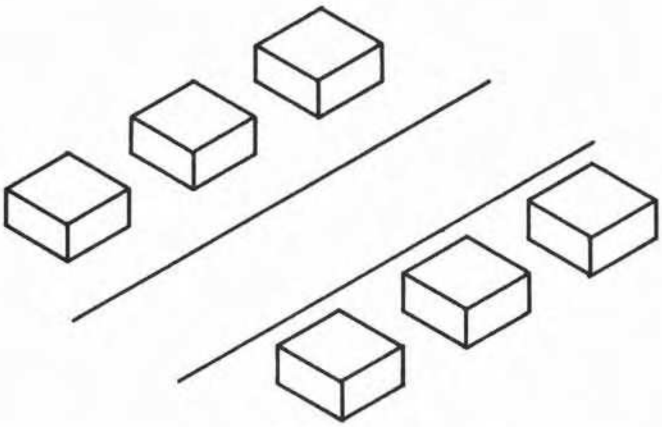
ELEMENTS OF "OPEN SPACE" WITH FUNCTIONS RELATED TO "ENCLOSED SPACE"

LEGEND:

Front yard   Side yard   Rear yard.



A STREET CONTAINING THE LEAST POSSIBLE SPATIAL VARIETY IN ITS COMPOSITION

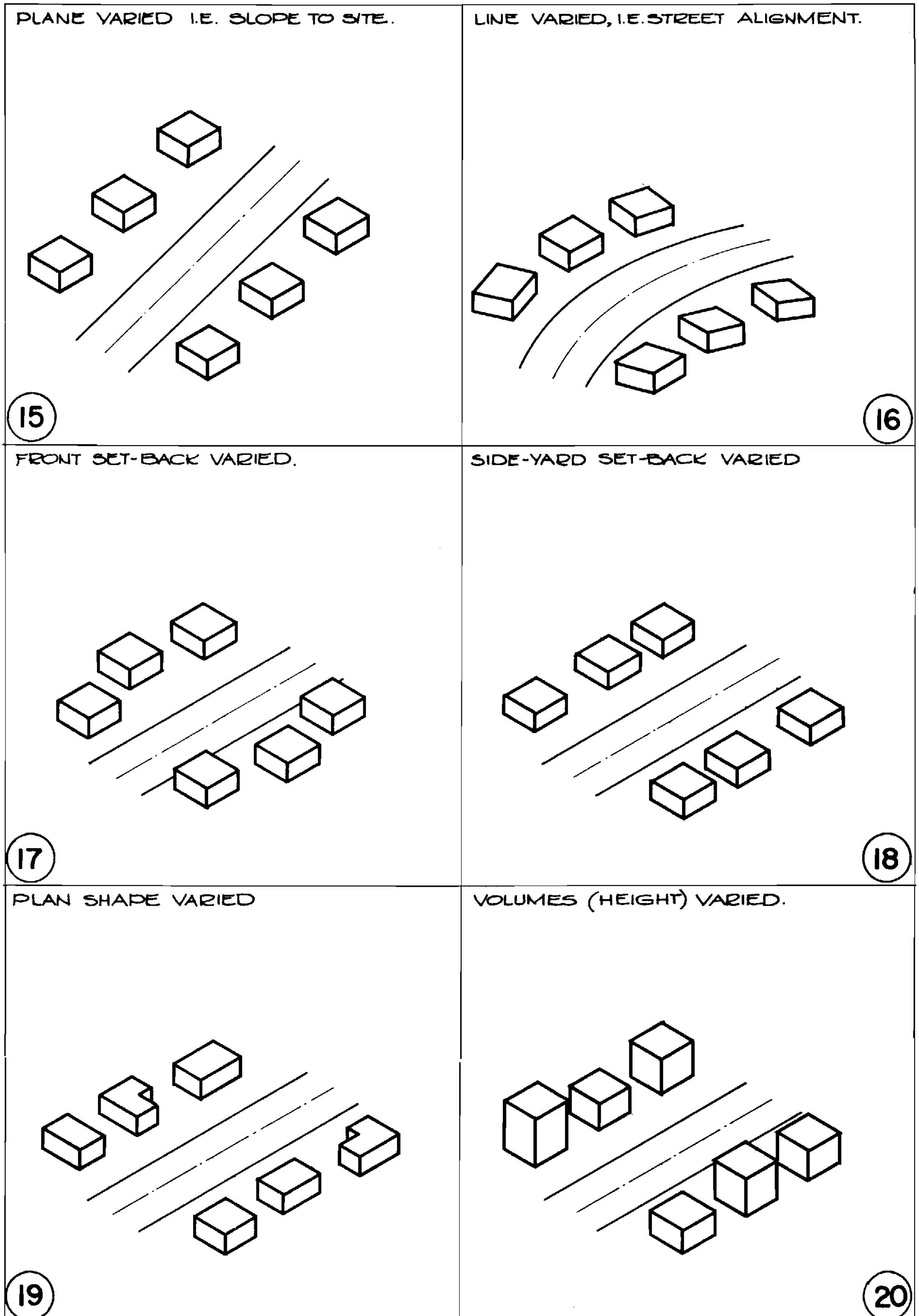


Level site; straight street; equal front yard set-back; eq. side-yard set-back; similar plan shape; same (approx.) height, or volume.

(13)

Two illustrations of fig. 13. Top: Semi-detached houses at 4th. Avenue and Wallace Street. Below: Apartments at Cambie Street and 24th. Avenue (Vancouver, B.C.).

(14)

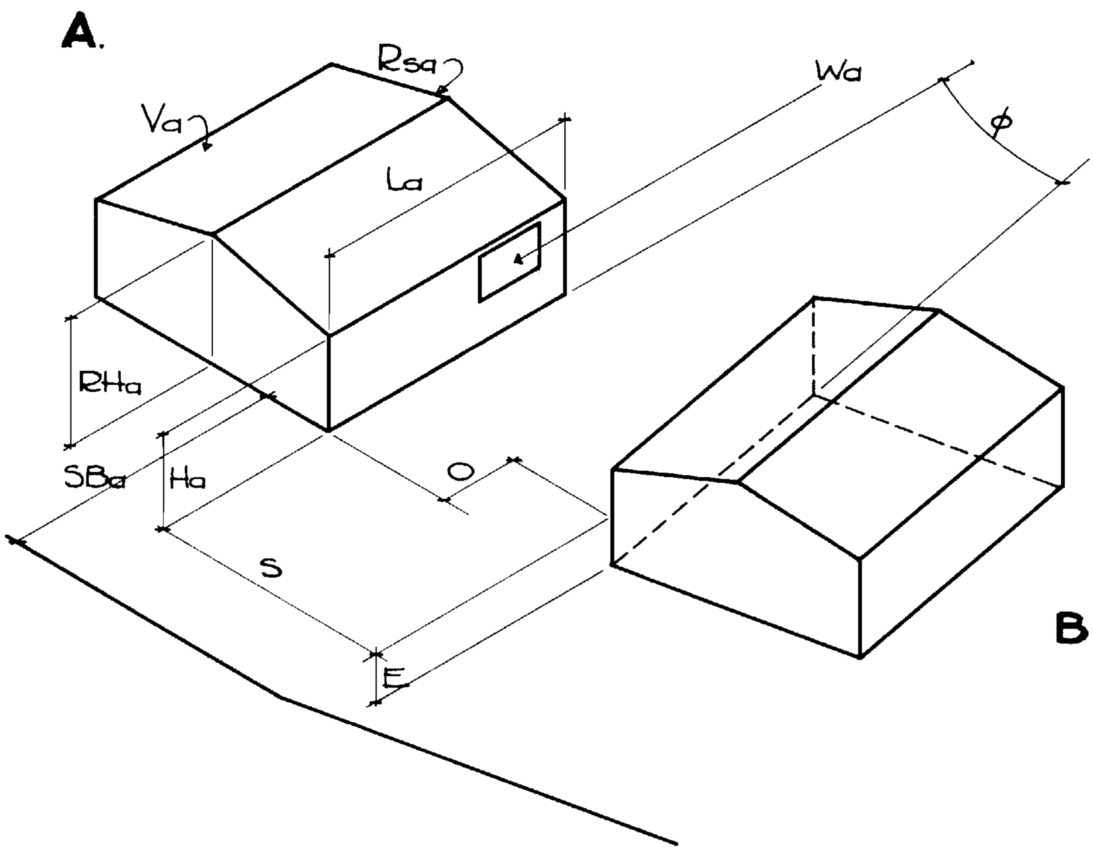


Six possible variations in the spatial composition of a street (see figure 13).

Variation in shape and size of volumes in a street (Whyte Avenue, Kitsilano, Vancouver) 21

Variations in site (slope), street (curve), set-back, and shape of volumes. Collingwood Place, Vancouver. 22

DIMENSIONAL BASIS FOR COMPARISON BETWEEN TWO BUILDING VOLUMES A&B TO ESTABLISH SPATIAL RELATIONSHIPS.



LEGEND.

1 — H Height of wall.
2 — L Length of wall.
3 — W Area of windows.
4 — RH Roof height.
5 — RS Roof shape.
6 — V Volume.
7 — S Spatial separation.
8 — SB Set-back
O Offset
9 — E Elevation, difference at grade.
10 — ϕ Angle of inclination for non-∥ walls
11 — Bst. Baffle, structural
12 — Bsh. Baffle, shrubbery 〉 note: not shown.
↑ — design factor nos.

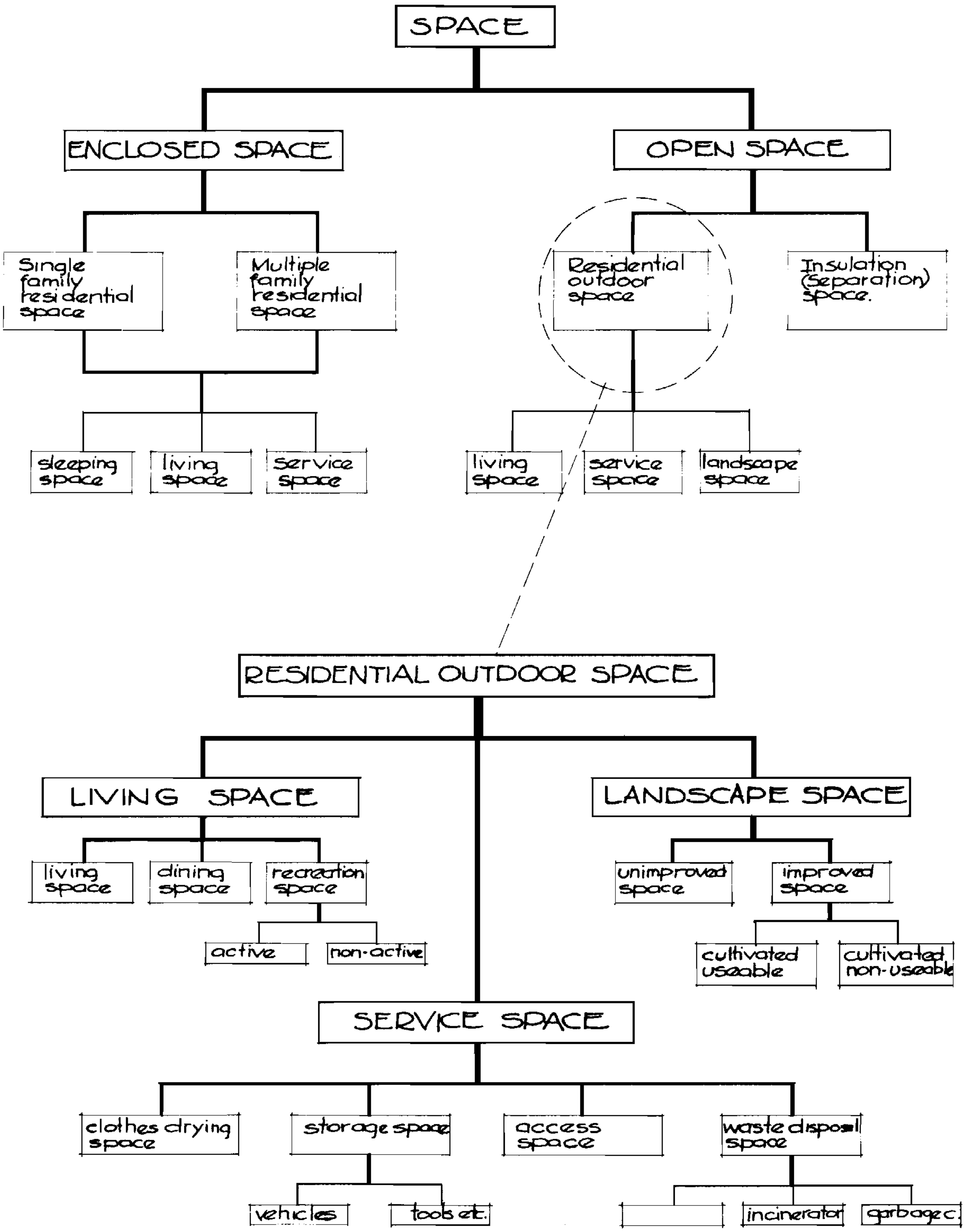
An illustration of basic volumes "A" and "B" (see fig. 23). Houses in a Richmond subdivision, Richmond B.C. 24

Houses otherwise identical except for an elevational difference. Houses in the "Bel-Aire" subdivision, Coquitlam B.C. 25

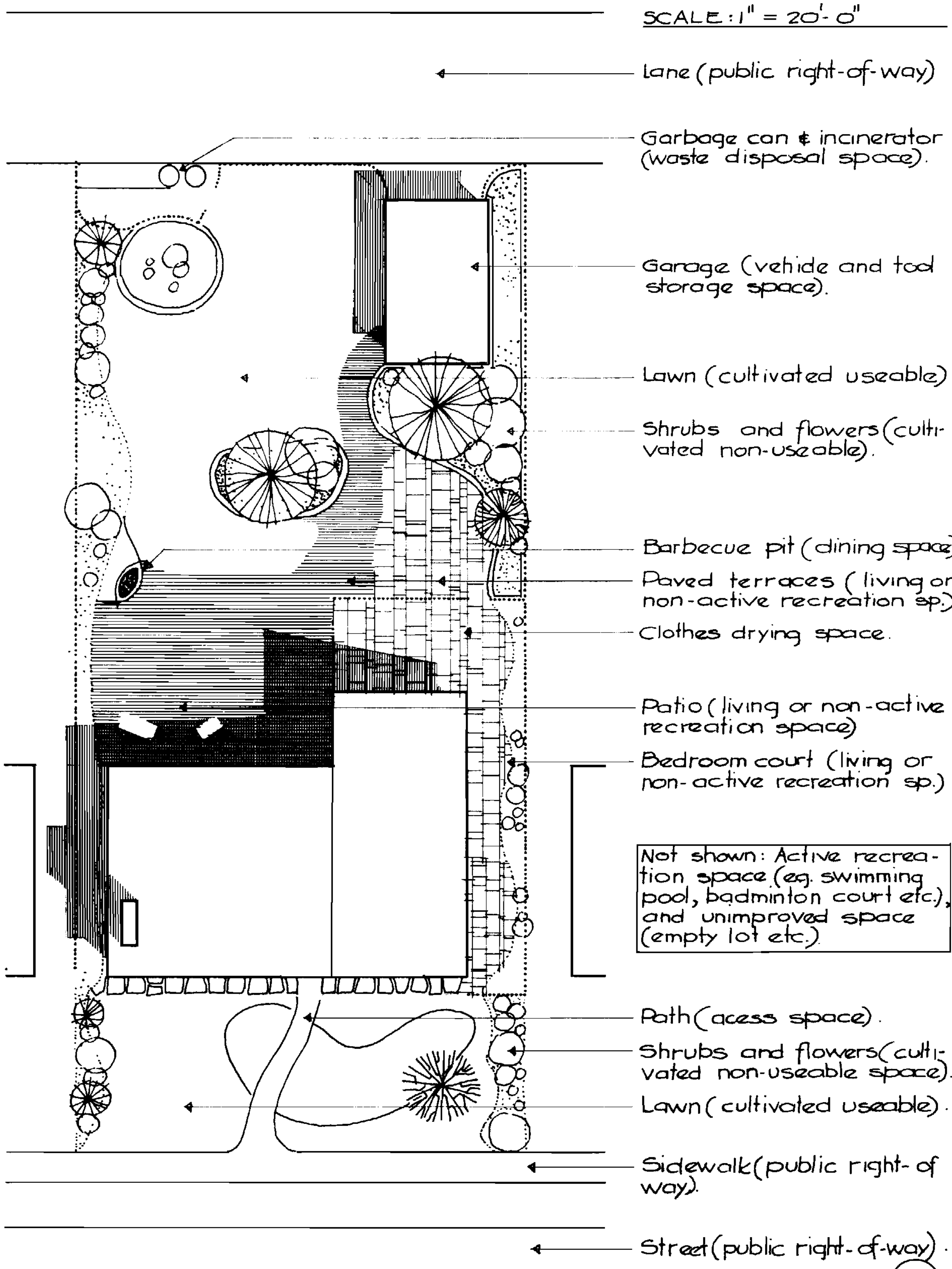
Variation in elevation, orientation and volume. Houses in Collingwood Place, Vancouver. 26

"Open Space" between semi-detached houses, Wallace Street and 4th. Avenue West, Vancouver. 27

THE COMPONENTS OF RESIDENTIAL SPACE
An analysis and general classification.

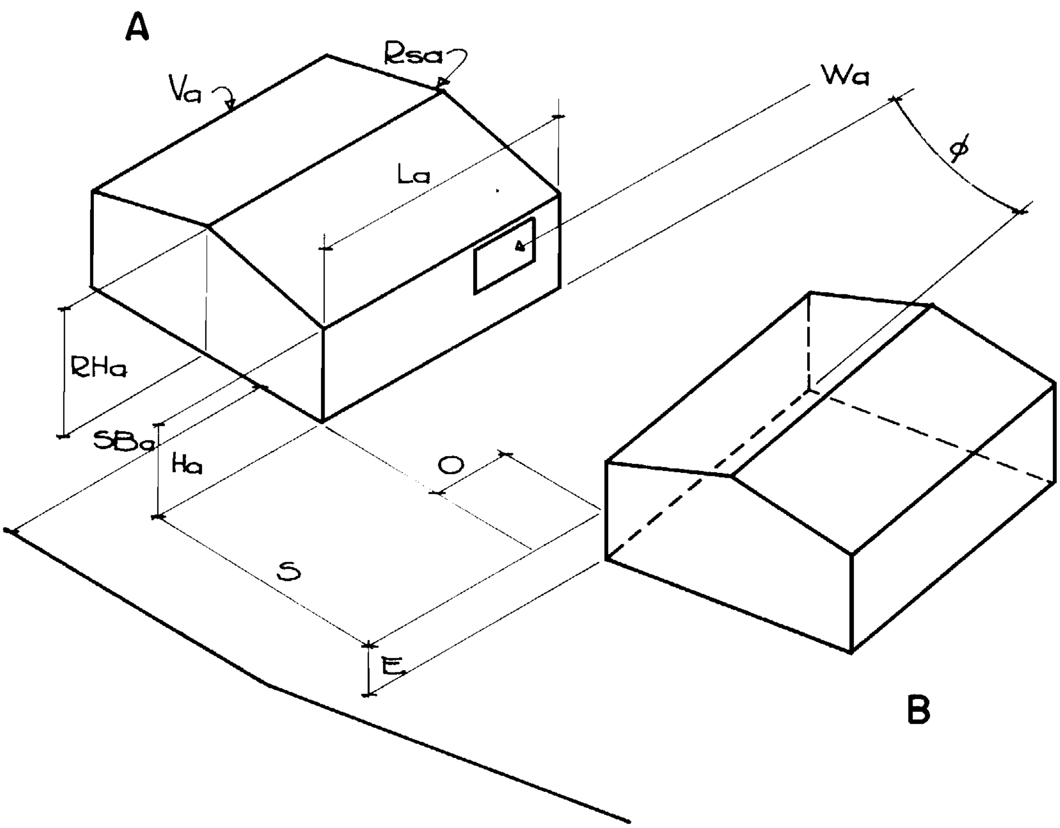


FUNCTIONS OF "OUTDOOR SPACE"



See fig. 28: "The Components of Residential Space".

DIMENSIONAL BASIS FOR COMPARISON BETWEEN TWO BUILDING VOLUMES A & B TO ESTABLISH SPATIAL RELATIONSHIPS.



LEGEND

(1)— H Height of wall.
(2)— L Length of wall.
(3)— W Area of windows
(4)— RH Roof height
(5)— Rs Roof shape
(6)— V Volume
(7)— S Spatial separation.
(8)— SB Set-back
— O Offset
(9)— E Elevation, difference at grade
(10)— ϕ Angle of inclination for non-∥ walls
(11)— Bst. Baffle, structural.
(12)— Bsh. Baffle, shrubbery. 〉 note: not shown.
↑— design factor nos.

PERFORMANCE TABLE SHOWING ALL THE POSSIBLE COMBINATIONS OF OBJECTIVES AND DESIGN FACTORS.

			A	B	C		D		E	F	G	H
							nuisances					
			FIRE	DAYLIGHT	AIR		NOISE		PRIVACY	VIEW	TRAFFIC	OUTDOOR SPACE
enclosed space	1	HEIGHT OF WALL										
	2	LENGTH OF WALL										
	3	AREA OF WINDOWS										
	4	HEIGHT OF ROOF										
	5	SHAPE OF ROOF										
open space	6	VOLUME OF STRUCTURE										
	7	SPATIAL SEPARATION										
orientation	8	SET-BACKS, OFFSETS										
	9	GROUND ELEVATION										
	10	ADJACENT WALL NOT ‖										
substitutes	11	STRUCTURAL BAFFLES										
	12	SHRUBBERY BAFFLES										

APPENDIX A

FIRE AS A CHARACTERISTIC OF SPACE CONTROL STANDARDS

by

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Building Standards Section, Division of Building Research

The possibility of unwanted fire occurring exists wherever there is a supply of combustible materials. Where large numbers of buildings are located close together as in a town or city, there is in addition the possibility that the initial outbreak will spread and develop into a conflagration; that is, a fire beyond the power of the fire service to control and involving many buildings. In the history of most large cities there is a record of one or more conflagrations. Some of the earliest regulations in building codes have been designed specifically to reduce this hazard.

Fire may spread from building to building by direct contact, by convection, by radiation, by flying brands or by combinations of these. Spread of fire between abutting buildings has long been recognized as a major hazard and fire walls are an accepted part of building construction. Spread of fire by radiation may be regarded as almost equally hazardous. Radiant heat may raise the temperature of combustible surfaces, over comparatively long distances, to a point at which ignition by sparks or flying brands will readily occur. Over shorter distances the temperature may be raised to a point at which spontaneous ignition will take place. The radiation hazard is related to the area and shape of the radiator and to the distance between radiator and receiver. If the exterior wall of a building is fire resistive it may be assumed that it will form a shield to fire within and the effective area of the radiator may be taken to be that of the windows. The radiation hazard can thus be related directly to the area and distribution of the windows and to the clear space between buildings.

Design methods available for controlling the spread of fire are (1) the provision of fire resistive barriers, floors or walls, between abutting buildings or compartments and

(11) provision of fire resistive exterior walls to buildings that are separated by open space and limitations on the window area depending on the clear space between buildings.

A fuller discussion of the problem of radiation between buildings and a suggested form of regulation are described in Spatial Separation of Buildings by J.H. McGuire. In this and in other recent forms of spatial separation regulations, the limiting distances are measured from building face to property boundary, the distance being half that desired between buildings. This is a compromise containing elements of error, made in order to simplify administration and to prevent the development of one site in such a way as to prejudice future development of neighbouring sites.

Spread of fire by flying brands may take place over long distances if assisted by wind. Protection against this hazard may take the form of limitations on materials likely to give rise to flying brands and restrictions on readily ignitable roof surfaces. Spread of fire by convection can take place only if the gas stream is at a very high temperature and is unlikely to occur except in locations very close to source.

The two forms of protection most suitable for building regulations are the provision of fire resistive construction as a barrier to fire and the relating of open space between buildings to the area of windows and to the non protected wall area. Both of these are effective in protecting the community from the danger of a fire originating in any one building.

APPENDIX B

LIGHT AS A CHARACTERISTIC OF SPACE CONTROL STANDARDS

by

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Until comparatively recently, natural light was the principal source of illumination of interiors and was therefore a major factor in the design of buildings. The development of electric power has, however, brought about a change in the situation. It is now both practicable and economical to provide adequate light by artificial means above. The design of interior space will have to be considered therefore, in terms of natural and artificial light both independently and in combination.

The desired level of illumination varies with the nature of the seeing task to be performed. More light is needed to distinguish a dark thread on a dark cloth than to read clear print on a white page. Excessive contrast within the field of view, however, produces glare that may be a source of discomfort or even temporary blindness. This is because the range of light values that can be comprehended by the eye at one time is limited. Guidance on the optimum conditions for seeing and recommended illumination levels for rooms can be obtained from publications such as the I. E. S. Lighting Handbook (1).

The contribution of natural light is dependent on latitude and/or local climate and must be determined on a local or regional basis (2). The two forms of natural light that are observed are: direct sunlight and daylight-diffuse radiation from the sky, direct sunlight being excluded.

Direct sunlight can be a cheerful amenity and has therapeutic and germicidal properties. Too much sunlight, however, causes excessive heat gain and glare and can be a source of acute discomfort. The degree of control that is necessary or desirable depends very much on local climate. The Sunlight Standard adopted in Britain recommends that the sun should penetrate each living room for at least one hour each day during the ten months from February to November. This is desirable in a cool and damp climate. Olgyay and Olgyay working in Princeton, New Jersey, have suggested that the direct rays of the sun should be excluded during that part of the year when the mean temperature exceeds 70°F (3). Some control of direct sunlight will always be required to avoid glare.

Daylight illumination is a continually changing quantity, being dependent on the solar elevation and/or cloud cover. Average values are, as might be expected, higher during summer months than in winter. From climatological data it is possible to determine the prevailing exterior illumination that may be expected throughout the year and by the design methods that have been developed to predict the natural light that will be available in the interior space.

The eye tends to judge the interior lighting by reference to the exterior illumination that is simultaneously visible. The relation that exists between the exterior and interior illumination is therefore perhaps of more significance in many cases than the absolute values of interior light in lumens per square foot. For this reason "daylight factor" has been the measure generally used to describe natural lighting of interiors. Daylight factor is defined by the International Commission (4) as "a measure of daylight illumination at a point on a given plane expressed as the ratio of the illumination on the given plane at that point and the simultaneous exterior illumination on a horizontal plane from the whole of an unobstructed sky of assumed or known lumenance distribution. Direct sunlight is excluded from both interior and exterior values of illumination."

The daylight factor is the sum of three components: Sky Component - a measure of the illumination received directly from the sky, the External Reflected Component and the Internal Reflected Component - measures of the light reflected from exterior and interior surfaces. The first is dependent on the geometry of the building and neighbouring obstruction and is readily measured. The other factors are influenced by the shape and colour of the surfaces involved and are subject to change either through accumulation of dirt or redecoration.

The natural lighting that is available indoors under conditions of minimum exterior illumination is dependent also on the lumenance distribution of the overcast sky. Surveys in many parts of the world have shown that this lumenance distribution may be expected to follow fairly closely the formula suggested by Moon and Spencer (5). This formula has been accepted by the International Commission on Illumination as the description of the Standard Overcast Sky.

In order to develop standards for residential environment acceptable conditions for human occupancy should be determined. This can be done by referring to recommended illumination levels or by obtaining the judgment of a large number of people as to the acceptability of the available daylight. Surveys of this nature formed the basis of the British Standard on Daylight (6).

The objectives may be assumed to be a desirable minimum level of daylight on any site and the possible presence of direct sunlight during some part of the year. The measurable criteria that are appropriate for this purpose are:

1. Sky Factor. A measure of the area of sky available to a building on the site. This can be obtained from diagrams such as the Waldrams diagram (7) or Daylight Tables.

2. The acceptable minimum average illumination of the sky for each region. A measure that has been adopted in a number of countries is the value of sky lumenance that is exceeded during 90 per cent of the daylight working hours.

3. Solar angles as they apply to the site. These can be obtained from astronomical tables or from the various charts prepared for the predetermination of solar shadows.

Techniques that have been used to control residential environment to ensure adequate daylight have been:

1. Right of light. In England, the law since 1832 protected any existing window and prevented any building that would appreciably decrease the light to the window. This right has been specifically rescinded in most provinces in Canada.

2. Light angles have been used to control development of a site in the interests of neighbouring property in Britain and the United States. These, in order to be effective, had to restrict building very severely.

3. Average light angles have been used to permit some variation in the skyline while protecting the light available to neighbouring buildings (8).

4. A system of alternate horizontal and vertical angles has been used in Britain since 1947 (9). This permits flexibility in the shape of buildings but ensures that an adequate patch of sky can be "seen" from each neighbouring site.

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APPENDIX C

NOISE AS A CHARACTERISTIC OF SPACE CONTROL STANDARDS

by

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Noise is usually defined as unwanted sound (1). This is a highly subjective matter: the same speech sounds, for example, may or may not be noise, depending on whether one is the listener or the talker. Nevertheless, following some preliminary discussion of the physical properties of sound it will be possible to consider the procedures available to prevent it from becoming noise.

Basic Properties

Sound originates as an elastic vibration of the source body, and in the simplest case this vibration is radiated into the air and propagated as a wave to the recipient. In unconfined space, as the sound spreads from the source, the sound pressure diminishes inversely as the distance from the source. In more complex situations there may be intervening barriers or enclosing surfaces through or around which the sound waves must be transmitted before reaching the recipient; in such cases the diminution of sound may depend largely on the properties of the intervening structure.

It is a useful scientific fiction to describe sounds as if they were composed of "pure tones" despite the fact that isolated pure tones rarely occur outside the acoustics laboratory. In a pure tone the sound pressure fluctuates sinusoidally, as shown in Figure C-1. It is characterized by its "amplitude," which is half the peak-to-peak fluctuation in pressure, and by the frequency of fluctuations, expressed as the number of cycles per second. Any complex sound may be completely described as the combination of a number of pure tones of various amplitudes, frequencies and phases relative to each other. Some musical tones, e.g., the flute, contain only a few components for which the frequencies and phases have definite, simple relationships. More complex sounds contain many components which may not be systematically related in frequency and phase. The ultimate complexity is "white noise," a randomly constituted disturbance in which all frequencies are equally probable. A simple sound may be described in terms of its pure-tone spectrum, i.e., in terms of its actual pure-tone components. A complex sound is usually described in terms of its "band spectrum," i.e., the distribution of sound pressures in a series of contiguous frequency bands (usually octaves, half-octaves, or one-third-octaves).

Absolute amplitudes or intensities of sound are rarely referred to in acoustics. Two sound pressures are compared by taking the logarithm of their ratio; more precisely, 20 log (P_1/P_2) is the level difference in "decibels." Two equal sound pressures differ in level by 0 db; a ratio of ten in sound pressures corresponds to a level difference of 20 db. The term "sound pressure level" (loosely, "sound level") denotes the ratio of a given sound pressure to a "standard reference level" (0.0002 microbars).

Because of its logarithmic basis the decibel scale compresses into manageable units the wide range of perceptible sound pressures. Moreover, the resulting decibel scale corresponds roughly to the subjective sensations associated with changes in sound; i.e., a given ratio of sound pressures produces the same sensation of change regardless of absolute levels.

Figure C-2 (2) shows the range of frequencies and sound levels perceived by humans. The threshold of audibility, represented by the lowest contour, varies considerably over the range of perceived frequencies. The standard reference level of sound pressure (0 db) is approximately the minimum perceptible sound pressure, in the frequency range 1000 to 2000 cycles per second. The highest curve, at about 130 db, is the threshold of pain.

Subjective Reactions to Sound

The subjective quantity corresponding to sound pressure level is "loudness level," measured in phons. The contours in Figure C-2 are contours of equal loudness level, for comparing pure tones of different frequency. For complex sounds the loudness is related in a very complex way to the band spectrum. The subjective sensation of pitch for pure tones is simply related to frequency, but for complex sounds it again becomes a complicated matter to decipher.

Because of the complexities associated with subjective impressions of sound it is usual to describe sounds in physical terms. A complex sound may be described simply, and imprecisely, by the (over-all) sound pressure level. This is approximately the quantity measured by a sound level meter (using the C weighting network, which provides a nearly flat frequency response).

Another simple measure, also obtainable with the sound level meter, is the A-scale weighted sound level, using the A weighting network, which emphasizes the middle frequency range where the ear has maximum sensitivity. This assesses complex sounds roughly as they would be perceived in a fairly quiet environment.

A third procedure is to determine the band spectrum or the pure-tone spectrum, or possibly a mixture of both. For example, jet engine noise comprises a mixture of "white" noise, best described by a band spectrum, plus a few discrete frequency components corresponding to turbine blade resonances.

This third procedure is the first step in determining several physically derived parameters that have some correlation with subjective reactions to noise. The simplest procedure is to compare a given spectrum with the spectra of a series of standard noises, for example the Noise Criteria (NC curves) (3) developed for assessing the effects of noise on speech communication. Figure C-3 shows the family of NC curves; Table C-1 shows the degree of communication possible for noises represented by various NC curves. Other procedures involve calculating a single-figure value of "loudness level" (4) or "perceived noise level" (5) from the band spectrum levels.

Basic Properties of Noise

Finally, it is necessary to come to grips with the distinctions between sound and noise. Any sound within the region of perception may in some circumstances be noise. The upper levels may be precisely assessed in terms of pain, impairment of hearing, or interference with speech communication. Fortunately residential noise problems rarely involve these criteria; but unfortunately they involve such variable and indefinable properties as "annoyance" and "disturbance."

Very few sounds are intrinsically unpleasant. They become so if they intrude sufficiently on a listener's consciousness to distract him from his own pursuits. The listener must first be able to hear the intruding noise, above the other "ambient" noises in his own quarters. In addition to being perceptible, it must attract his reluctant attention. This requires that the sound have some special character, usually connoting some specific activity. Speech sounds are particularly troublesome if they are intelligible or nearly so. Sudden impacts, startling or alarming sounds, and sounds with marked pitch or rhythm (even, for example, a dripping faucet) are particularly likely to distract and therefore annoy. Similarly a single identifiable source of noise is more troublesome than the same level produced by a random assortment of many noises from many sources.

Residential Noise Problems

In the residential environment most noises are made or controlled by humans. Hence the existence of a noise problem depends on human variability in the production as well as the perception of noise. It is not possible, in any practical sense, to eliminate noise entirely; the objective must be to reduce the probability of disturbance by sound to some sufficiently small fraction of people and time.

It appears from the current popularity of open planning in houses that noises originating within a detached dwelling do not constitute a serious problem to the occupants. Presumably one has adequate control over the noise sources in one's own household. At any rate it is the rare eccentric who insists on walls and doors between the various living areas in his house, and the rare designer who provides them. There remain three important categories of residential noise problems:

1. Noise originating in one dwelling and heard in adjacent dwellings (important only in multi-dwelling structures).

2. Noise originating outdoors and heard in nearby dwellings.

3. Noise originating outdoors and heard in nearby outdoor living areas.

Sound Insulation in Multi-Dwelling Structures

The reduction of noise passing from one unit to another in a multi-dwelling structure depends mainly on the nature of the intervening structure. If it is accepted that freedom from neighbours' noise, and freedom from constraint in one's own production of noise, are important qualities in a dwelling, then there must be regulations regarding the party walls and floors separating dwellings.

Unfortunately many building officials take the view that sound insulation has no place in a building code since it does not affect health or safety. The larger view regarding building codes is that they should ensure that buildings perform their designated functions. A dwelling does not perform its function if people cannot dwell comfortably therein.

Most regulations in this field are based largely on tradition. One of the earliest of party wall requirements, stemming from the great fire of London, specified a 9-inch brick wall as a minimum measure of fire protection. This provided, as a bonus, sufficient sound insulation to satisfy most residents. When the brick wall requirement was replaced by a performance requirement for fire resistance it became necessary to establish a sound insulation requirement as well. Most of the current requirements, (6, 7) are based on the performance of the brick wall, rather than on a rational consideration of what constitutes an objectionable noise. Recent analyses of the problem (8) have resulted in a rating system (9) that is reasonably well related to subjective requirements.

The basic measurement of the performance of a wall or floor as a sound barrier is its "sound transmission loss," defined as the difference between incident and transmitted sound power levels (in decibels) when the barrier separates a source room from a receiving room. In general the sound transmission loss varies with the frequency content of the sound; standard tests are conducted as a series of frequency bands from 125 to 4000 cycles/sec. Until recently it was usual to use the average of the transmission losses measured at a set of 9 frequencies; now most systems, including the ASTM Sound Transmission Class (STC) (9), involve a comparison with a standard transmission-loss curve.

Using the sound transmission class as a parameter, it is of interest to examine some existing requirements. Britain has two "recommended" grades of sound insulation (6): Grade I corresponding to the 9-inch brick wall (STC-50) and Grade II (STC-45). Surveys have indicated that Grade I would provide satisfaction most of the time for about 80 per cent of tenants, whereas Grade II would satisfy only about 65 per cent. Germany and the Scandinavian countries have 2 requirements (7), corresponding roughly to STC-55. Holland recently adopted one, based on middle-frequency sounds only, which is consistent with STC-53. In Canada a 9-frequency average transmission loss of 45 db (10), which corresponds approximately to STC-45, has been used for some years by Central Mortgage and Housing Corporation and is also recommended in the National Building Code of Canada.

The most reliable criterion of satisfactory sound insulation is whether intruding sound is perceptible over the ambient level of sound produced locally or from other sources. Thus an apartment in a quiet residential area will need more insulation from its neighbours than an apartment on a busy, noisy thoroughfare, since the high ambient level of external noise will mask a higher level of noise from the neighbours. Similarly a row dwelling, with but two easily identifiable neighbours, will need more protection than an apartment in a large building where randomly related noises from more distant neighbours will mask the more meaningful noise from adjacent dwellings.

Considering these factors, it appears that a suitable criterion for party walls separating row dwellings in quiet residential surroundings might be STC-50. For apartments or for noisy districts the requirement might be reduced to STC-45. These criteria would be acceptable to about 80 per cent of the occupants. Reducing them by about 5 units would probably satisfy 70 per cent of the occupants.

Factors Affecting the Sound Insulation of Wall and Floor Structures

The sound transmission loss of a wall or floor may be determined in the laboratory or in the field, according to prescribed procedures (9,11). The data so obtained on many constructions are available in various publications (12, 13, 14) and will not be reproduced extensively here. It will be salutary, however, to consider the basic factors.

The sound insulation provided by a single homogeneous wall depends on its surface density, stiffness, and to some extent on damping. A "limp" wall, with mass but no stiffness, has a transmission loss typified by curves A, Fig. C-4. Most practical walls have stiffness also, and this leads to the characteristic illustrated by Curve B. The position of the coincidence-frequency dip depends on the relation between mass and stiffness; for heavy masonry or concrete it may be below the frequency range of interest; for some lightweight materials it may fall in the middle frequency range, which is of major importance in sound insulation. The depth of the dip depends on the damping properties of the partition materials and its edge-mounting conditions.

To achieve high sound insulation with a single massive wall becomes impractical beyond, say, the 9-inch brick wall. To gain an additional 5 or 6 db, for example, would require an 18-inch brick wall. Thus, it is more usual to use a multiplicity of layers, with the minimum of rigid connection between them. This permits a substantial gain in sound transmission loss per pound of material except for certain frequencies at which the combination of masses and coupling elements (including the trapped air in a cavity wall) becomes a resonant system with low transmission loss. The successful multi-leaf wall must distribute these resonances as well as the coincidence dips for individual layers in such a way that good performance is maintained throughout the critical range of frequencies. The properties of a few illustrative structures are shown in Tables C-2 and C-3.

Impact Noise

In addition to the transmission of airborne sound, which is an important property of both walls and floors, the transmission of impact sounds such as footsteps is an important extra consideration for floors. No standard procedure for measuring impact has yet been established on this continent, but an international recommendation, based on the sound transmitted from a standard hammer machine, is available (11). No subjective criterion has been established, but requirements based on British and European experience are also tabulated in Table C-3. Note that the parameter used for impact is transmitted noise, rather than transmission loss as for airborne sound. An impact noise transmission less than the spectrum curve of Figure C-5 (from Ref. 6) is desirable.

Control of Outdoor Noise

The problem of sound insulation between apartment dwellings and the like may be solved simply by providing substantial party walls and floors between dwelling units. Protection from outdoor noises is not so straightforward, since ordinary doors and windows (especially when open) severely limit the protection provided by outside walls. It is possible, of course, to seal up the windows and depend on a special sound-attenuating system for ventilation or air conditioning. This is the only sensible procedure for apartments and hotels situated on noisy thoroughfares.

If, however, one envisages a residential area as a place where one can enjoy open windows and outdoor living, then other means must be used in the control of outdoor noises. The means available are: reduction at the source; use of spatial separation; and the use of obstacles between source and residential property.

It was noted earlier that unconfined sound (pressure) varies inversely as the distance from the source. In terms of sound pressure levels, doubling the distance from the source results in an attenuation of 6 db, a factor of ten in distance is equivalent to 20 db. The screening effect of an intervening wall may be estimated from Fig. C-6 (from Ref. 6, p. 111). It will be noted that such a wall is most effective when it is near either the source or the listening point. The barrier itself must, of course, have a transmission loss at least as high as the expected attenuation due to screening. Most walls will easily meet this requirement, but substitutes such as hedges and shrubbery are of negligible value.

Automobile Traffic

The principal component of automotive noise is the engine exhaust. This could readily be reduced substantially; the reasons why little has been done are threefold: it would cost a few dollars per vehicle, the roar has become a synonym for "power" in the automobile trade, and no organized pressure has ever been brought to bear on the manufacturers. Only one automobile manufacturer, unique in many other ways also, has ever boasted of silence. In parts of Europe and the U.S. there is now legislation governing noise emitted by vehicles. It affects primarily, of course, the large tractor-trailers that travel our main thoroughfares.

It is not likely that legislation will ever reduce vehicle noise to a level that is acceptable in residential areas. One measure is obvious: main thoroughfares should not be residential streets, except possibly for special occupancies such as air-conditioned hotels, motels and apartments. The structures built on main thoroughfares, offices, shops, etc., will act as screening walls between thoroughfares and nearby residences.

Aircraft Noise

Aircraft become obnoxious in the vicinity of airports. Again, control measures could be taken at the source, but there is strong resistance against doing so at the cost of reduced pay-load or speed of aircraft. It is safe to assume that there will be little reduction below present source levels. Failing this, the logical approach is the careful planning of land use for some miles adjacent to the principal airport runways. Such land generally has great commercial value, since airports are generally integrated with the main access roads in the vicinity and are thus desirable locations for manufacturing and distribution firms. There seems, in fact, no reason why such land should ever be used for new residential developments. Figure C-7 indicates approximately the area around a main runway that should not be used for residential development. Somewhat smaller restrictions might apply to secondary runways that are rarely used.

Resident-Produced Noises

Within the residential district one must finally contend with noise produced by the residents themselves. A few specific items, such as the power lawn-mower and the window air-conditioner, are controllable by proper manufacturing design. Others, such as radio and television sets, and perhaps children, are controllable by the residents. These two categories might lend themselves to legislation, perhaps specified in terms of an NC curve at the borders of adjacent residential property.

Another possible approach is to design residences and outdoor areas to minimize interference with each other. For example, houses built to look inward, on an enclosed or partly-enclosed court, may provide considerable shelter from surrounding sources of noise.

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TABLE C-1

APPLICATION OF NOISE CRITERIA TO OFFICE COMMUNICATION REQUIREMENTS

NC-30	Executive offices, conference rooms seating 50 people
NC-35	Small offices, semi-private offices, conference rooms seating 20 people
NC-40	General offices, in which speech and telephone communication are important
NC-45	Large general offices, drafting rooms. Normal communications at 3 to 6 ft.
NC-55	Business machine rooms, communication in raised voice at 3 to 6 ft.

TABLE C-2

AIRBORNE SOUND INSULATION OF TYPICAL WALLS

A. Sound transmission class 50 or more. (Recommended between critical areas of adjoining dwellings.)

1. Single masonry wall weighing at least 80 lb per sq ft including plaster if any.

2. Masonry cavity wall - 2 leaves of masonry spaced at least 2 in. apart, each leaf weighing at least 20 lb per sq ft*; leaves tied together with butterfly ties at 2-ft centres.

3. Composite wall - basic wall masonry weighing at least 22 lb per sq ft*; on one side of basic wall an additional leaf consisting of $\frac{1}{2}$-in. gypsum lath mounted with resilient clips, $\frac{3}{4}$-in. sanded gypsum plaster.

4. Stud wall - 2- by 4-in. studs; on each face $\frac{1}{2}$-in. gypsum lath mounted with resilient clips, $\frac{1}{2}$-in. sanded gypsum plaster; paper-wrapped mineral or glass wool batts between studs.

5. Staggered stud walls - 2- by 3-in. studs at 16-in. centres on common 2- by 6-in. plate; on each face $\frac{1}{2}$-in. gypsum lath, $\frac{1}{2}$-in. sanded gypsum plaster; paper-wrapped mineral or glass wool batts between one set of studs.

B. Sound transmission class 45 to 49. (Recommended between non-critical areas of adjacent dwellings.)

1. Single masonry wall weighing more than 36 lb per sq ft including plaster if any*.

2. Composite masonry - as in A-3 except gypsum lath supported on furring.

3. Staggered stud dry wall - 2 sets of 2- by 3-in. studs at 16-in. centres on common 2- by 4-in. plate; on each face 2 layers of 5/8-in. gypsum wallboard, the first layer nailed, the second cemented; joints staggered and both sets sealed; mineral or glass wool blanket or batts in the interspace.

C. Sound transmission class 40 to 44.

1. Single masonry wall weighing at least 22 lb per sq ft including plaster if any.

D. Sound transmission class 35 to 40.

1. Stud wall - 2- by 3-in. or 2- by 4-in. studs 3/8-in. gypsum lath and $\frac{1}{2}$-in. sanded gypsum plaster.

2. Stud wall - 2- by 3-in. or 2- by 4-in. studs, 2 layers of 3/8-in. plasterboard, the first layer nailed, the other cemented, joints staggered.

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* If porous blocks are used one face of each block section must be sealed with plaster or heavy paint.

TABLE C-3

AIRBORNE AND IMPACT SOUND INSULATION OF TYPICAL FLOORS

	Impact Rating * (db)
A. Sound transmission class 50 or more.	
1. 4-in. solid concrete or equivalent slab construction (precast or prestressed concrete, etc.) weighing 50 lb per sq ft; floor side strips of ½-in. soft fibreboard or cork supporting wood furring, rough and finish wood floors; ceiling side bare or plaster directly on concrete.	20
2. As in (1) except floor side 1-in. paper covered glass fibre blanket or foamed plastic, supporting 2-in. concrete, 1/8-in. linoleum, rubber or vinyl tile or ¼-in. cork.	20
3. As in (1) except floor side bare concrete or thin mastic or vinyl asbestos tile or wood parquet cemented to slab; ceiling side wood furring, ½-in. gypsum lath and ½-in. sanded gypsum plaster.	6
4. As in (3) except floor side ¼-in. sponge rubber underlay and 3/8-in. carpet.	25
5. As in (3) except ceiling side ½-in. gypsum lath supported on resilient clips, ½-in. gypsum plaster.	12
6. As in (3) except ceiling side ½-in. gypsum lath and ½-in. sanded gypsum plaster supported on separate joists from heavy walls.	18
7. Open web steel joists or similar; on floor side form work, 1-in. paper covered glass fibre blanket or foamed plastic, 2-in. concrete; ceiling side ½-in. gypsum lath on resilient clips, ½-in. sanded gypsum plaster.	20

* No standard rating system is yet available for impact sound. The impact rating given here is the average improvement in attenuation over a bare concrete slab. For residential application a rating of at least 15 db is desirable.

(see overleaf for balance of Table C-3)

TABLE C-3 (Cont'd)

		Impact Rating * (db)
B.	Sound transmission class 45 to 50.	
1.	4-in. solid concrete or equivalent slab construction (prestressed or precast concrete beams, etc.) weighing 50 lb per sq ft; floor side bare or thin mastic or vinyl asbestos floor tile or wood parquet cemented to slab; ceiling side bare or plastered direct to concrete.	0
2.	As in (1) except floor finished with 1/8-in. linoleum, rubber or soft vinyl or $\frac{1}{4}$-in. cork.	+5
3.	As in (1) except floor side finished with $\frac{1}{4}$-in. sponge rubber underlay and 3/8-in. carpet.	+25
4.	Wood joist structure; floor side plywood, asbestos building paper, finish wood floor or plywood and thin mastic, vinyl-asbestos or parquet; ceiling side $\frac{1}{2}$-in. gypsum lath supported on resilient clips, $\frac{1}{2}$-in. sanded gypsum plaster; 2-in. glass or mineral wool batts in joist spaces.	+10
5.	As in (4) except floor side finished in 1/8-in. linoleum, rubber or vinyl.	+13
6.	As in (4) except floor side finished in $\frac{1}{4}$-in. sponge rubber underlay and 3/8-in. carpet.	+25
7.	As in (4) except floor side plywood strips of $\frac{1}{2}$-in. soft fibreboard or cork supporting furring, plywood and finish floor. Furring laid crosswise to joists or parallel and between joists.	+25

* No standard rating system is yet available for impact sound. The impact rating given here is the average improvement in attenuation over a bare concrete slab. For residential application a rating of at least 15 db is desirable.

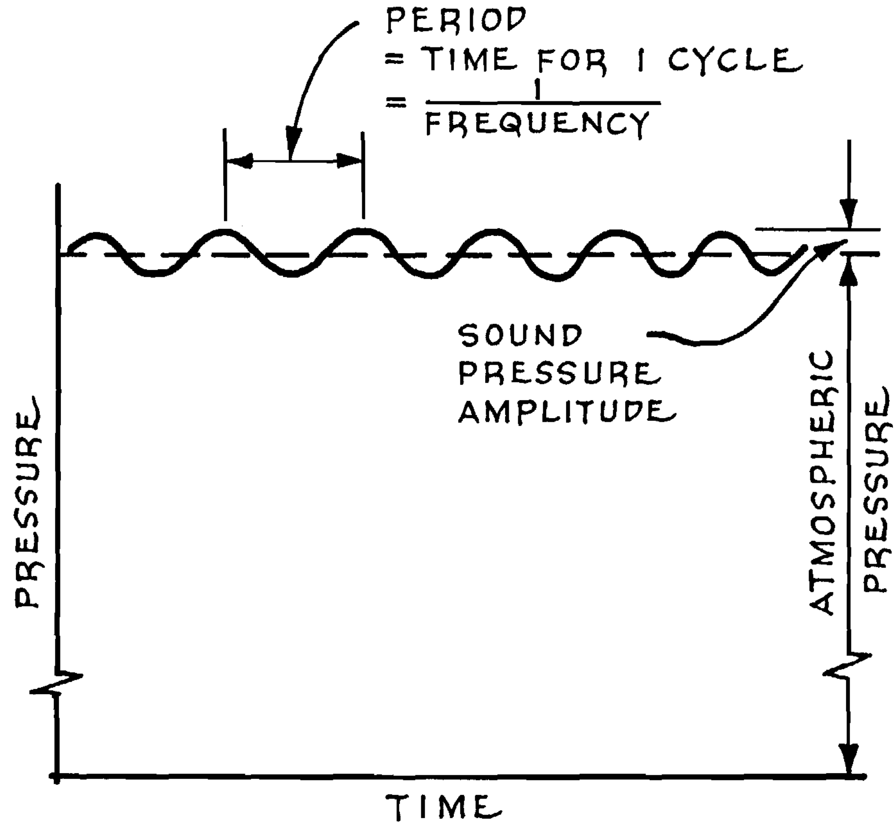

FIGURE C-1

PURE SINUSOIDAL WAVE IN AIR

BR 2872-1

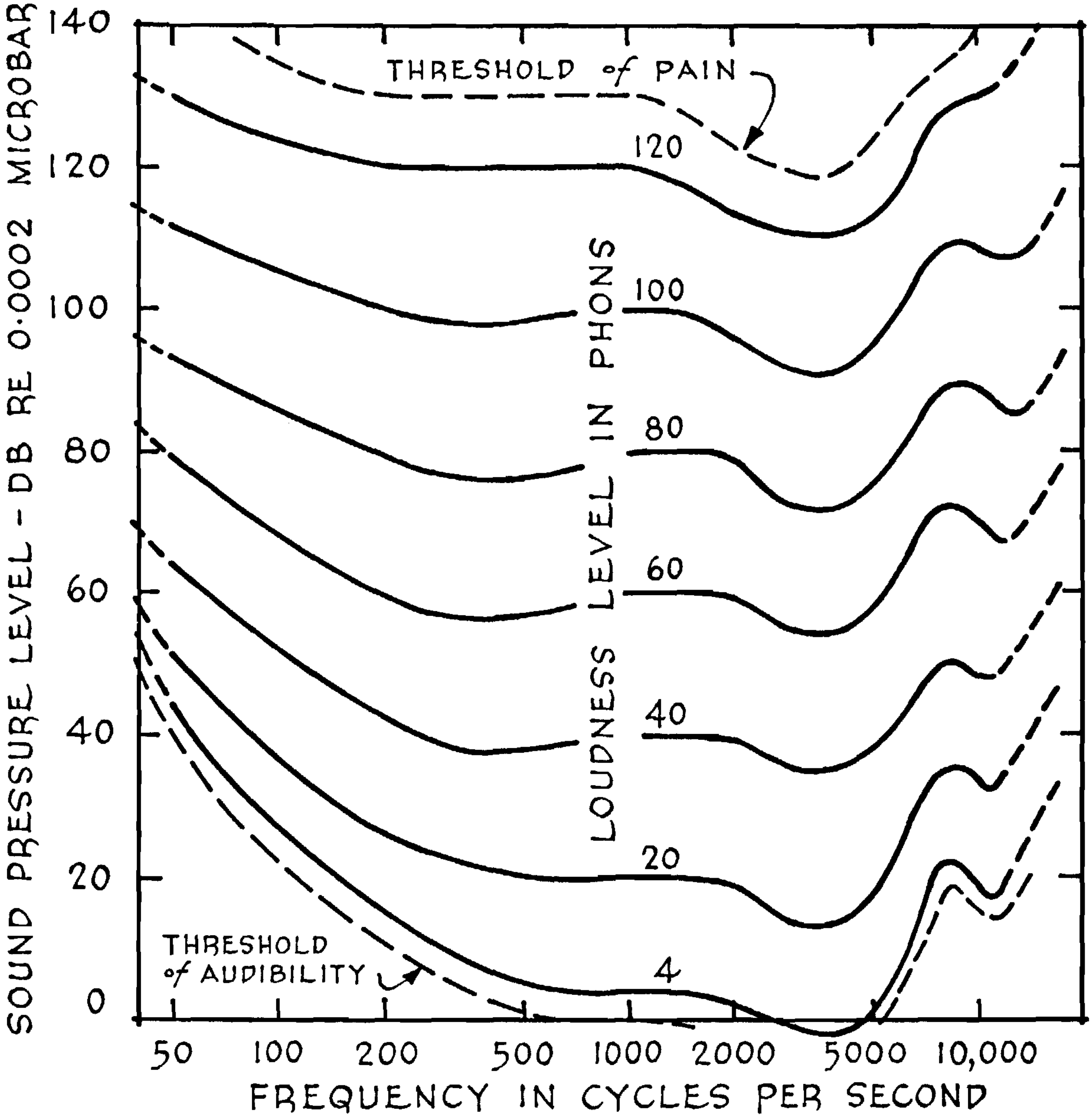

FIGURE C-2

BR 2872-2

RANGE of SOUND LEVELS AND FREQUENCIES PERCEIVED BY HUMANS. THE CURVES ARE EQUAL-LOUDNESS CONTOURS FOR PURE TONES

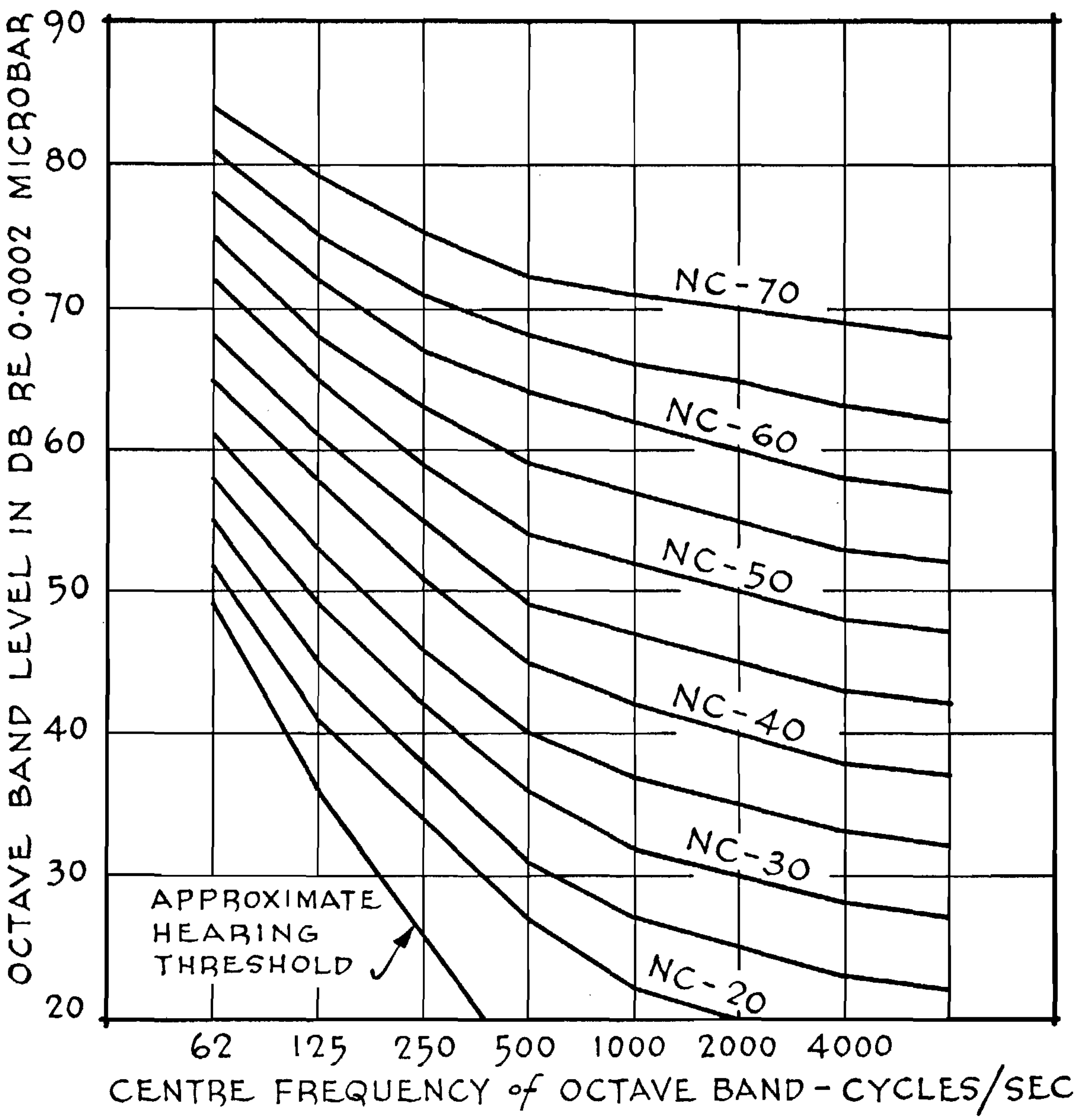

FIGURE C-3

BR 2872-3

NOISE CRITERIA AND OFFICE COMMUNICATION

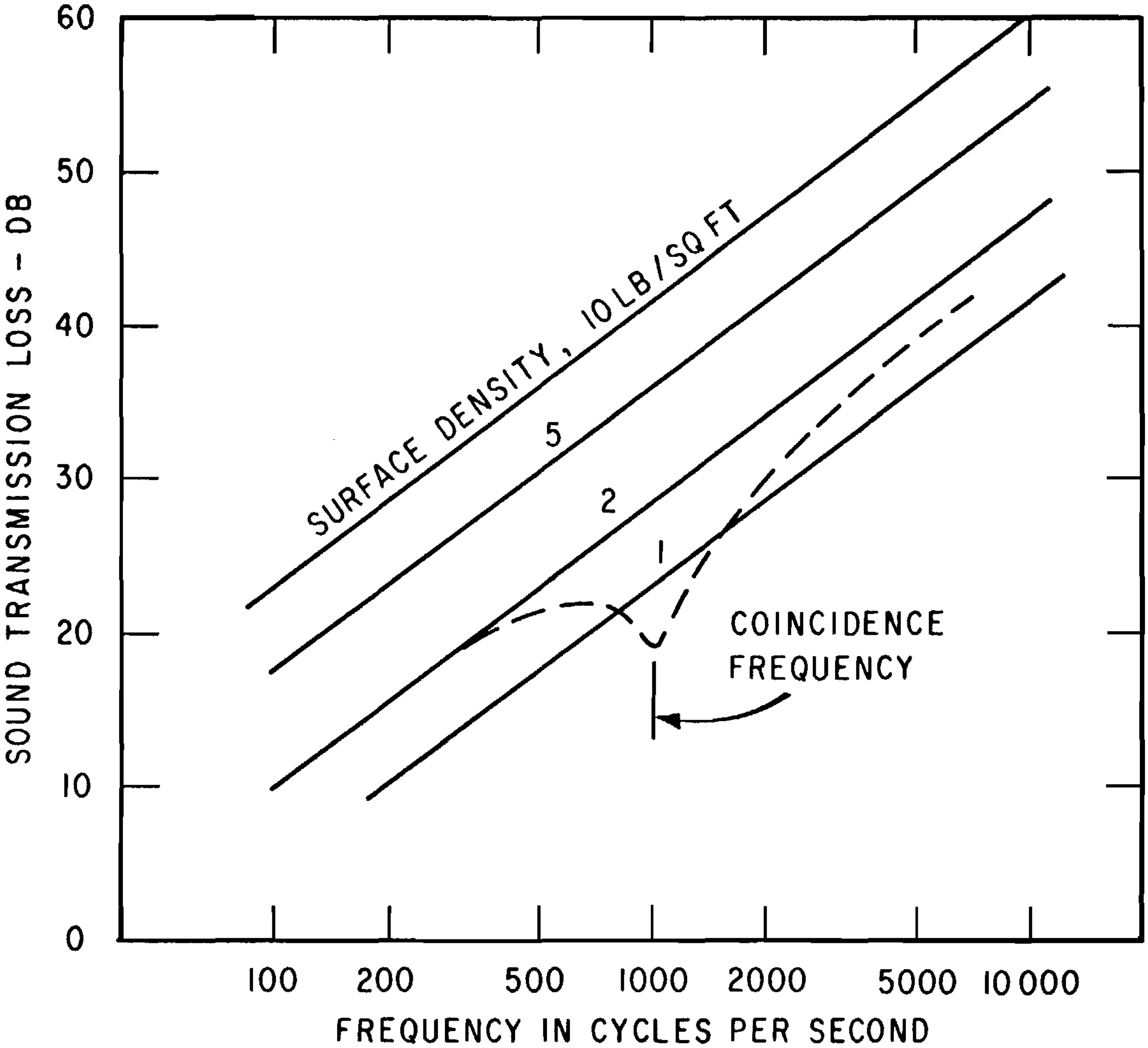

FIGURE C-4

SOUND TRANSMISSION LOSS OF "LIMP" WALLS (SOLID LINES) AND OF A "STIFF" WALL (BROKEN LINE)

BR 2883-1

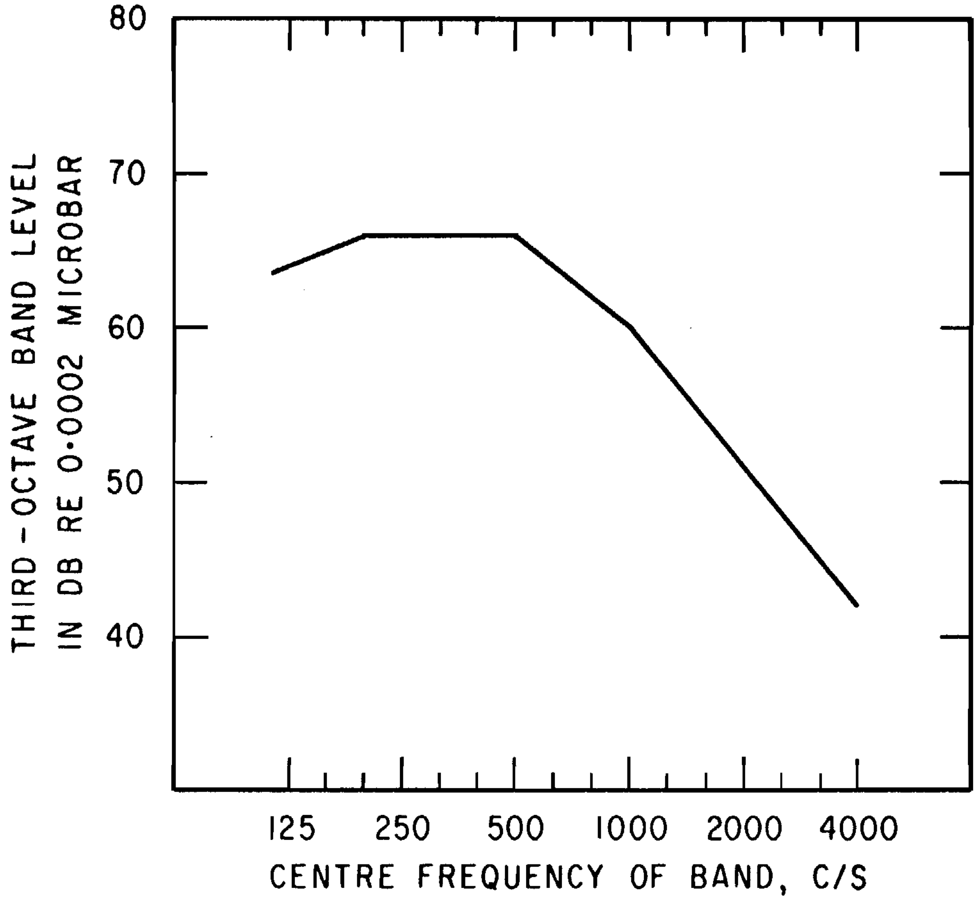

FIGURE C-5

ACCEPTABLE LEVEL (THIRD-OCTAVE BANDS) OF IMPACT NOISE FROM ISO STANDARD HAMMER MACHINE

BR 2883-2

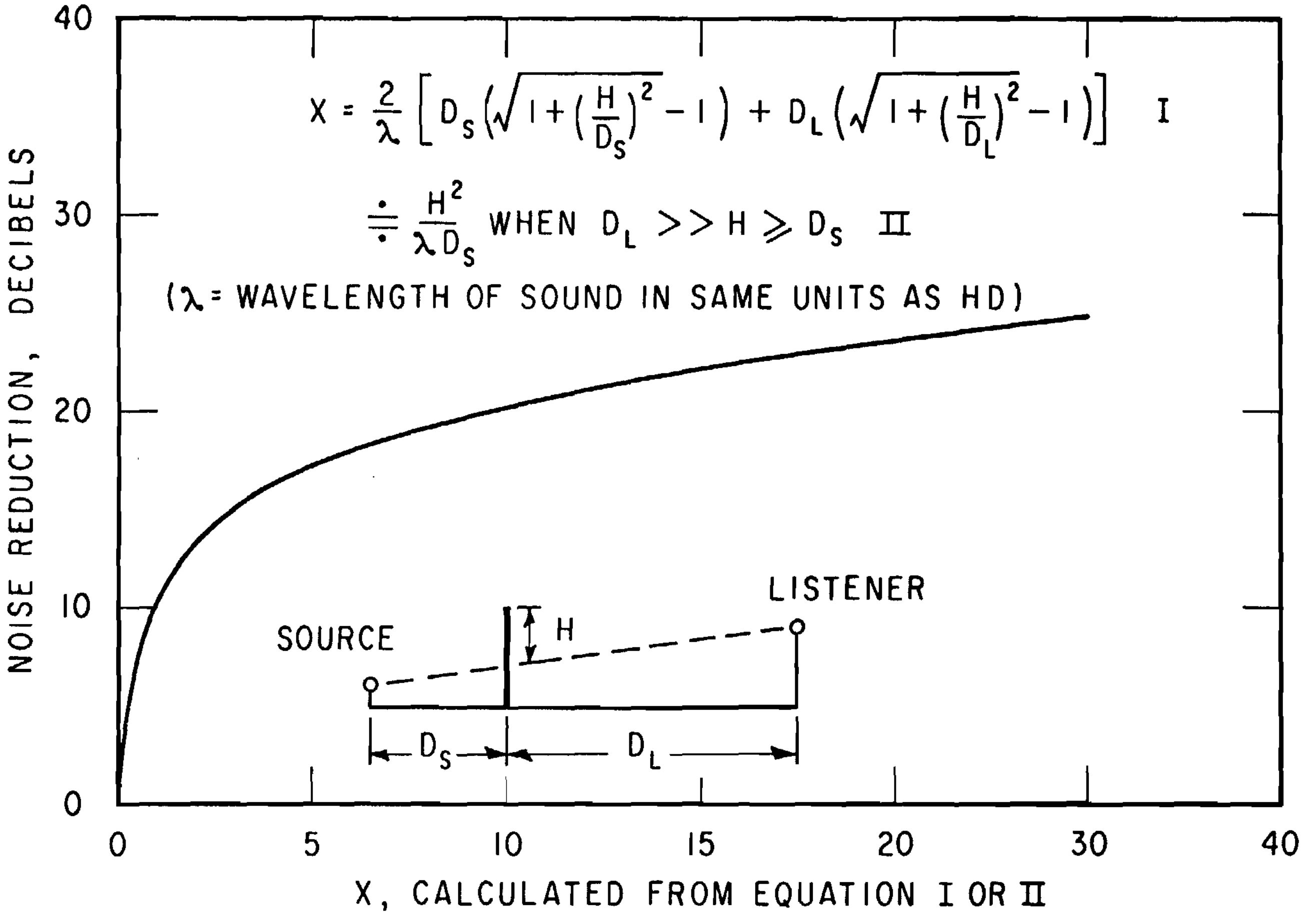

FIGURE C-6

SHIELDING EFFECT OF BARRIER BETWEEN SOURCE AND LISTENER (OUTDOORS) (FROM REF 6 p III)

BR 2883-3

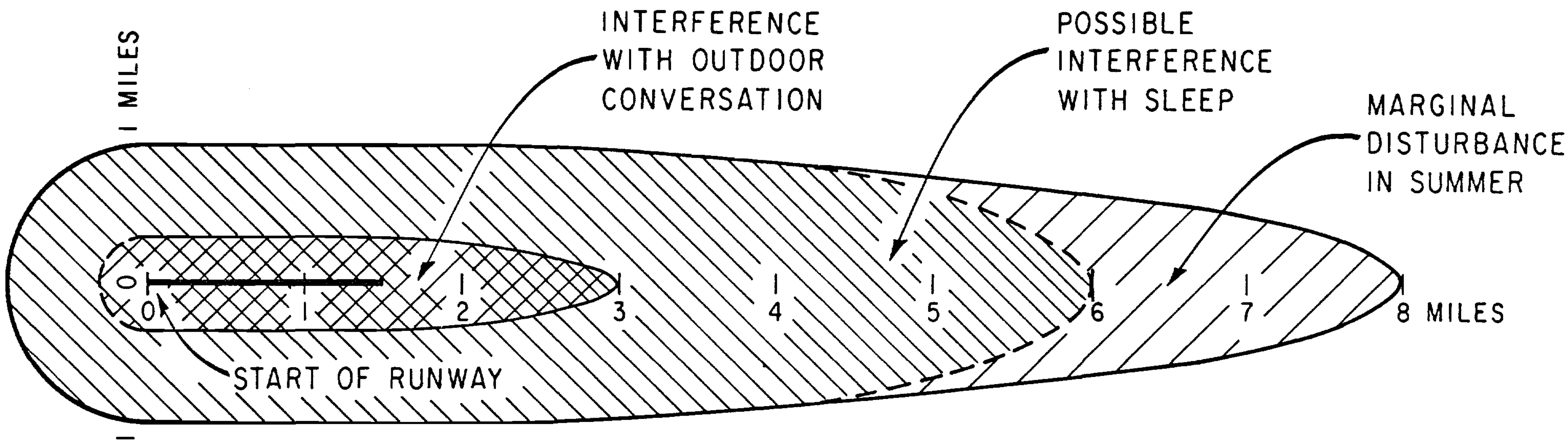

FIGURE C-7

REGION UNSUITABLE FOR RESIDENTIAL DEVELOPMENT IN VICINITY OF AIRPORT MAIN RUNWAY

BR 2883-4

APPENDIX D

PHYSICAL PRIVACY AS A CHARACTERISTIC OF SPACE CONTROL STANDARDS

(Since literary research failed to produce a satisfactory definition of physical privacy, the following argument was prepared to serve as a basis for a discussion of privacy in the residential environment.)

Individuals experience their environment and each other by means of their physical senses, i. e., their senses of sight, hearing, smell, touch and taste. These physical senses might be compared with the transmission path referred to in the case of fire, light and sound. The receiver is the individual himself and the source of his experience is his environment, including the people in it. In addition to these five main senses there appears to be, under certain conditions, a sixth by which an individual may be conscious of the presence of others without verification by any of his physical senses. In such a case the individual's "sense of awareness" could be said to be operative.

Morally, an individual has the right to exercise control over his relationship with other people. He can, if he so wishes, discourage their relationship by curtailing his own physical sense perceptions of others; although they may still observe him, he will no longer observe them. The interaction of sense perceptions which normally exist between two people is curtailed so that sense perceptions are only received by one person. A child closing his eyes rather than witnessing an undesirable scene is one example of this kind. Alternatively, the individual in question may seek seclusion so that his actions will go unperceived by others. Under these circumstances he may yet be able to observe others but they are no longer able to observe him. It is this latter case which describes physical privacy as it applies to the residential environment.

The degree of privacy required by an individual varies, first according to the activity he wishes to perform, second, according to his assessment of the activity in moral terms and third, according to his acceptance of the person liable to observe his activity. For the purposes of space control in the residential environment, the privacy between the individuals of the same family within the dwelling unit is of less concern than the privacy required by a family as a whole from either the public at large or neighbouring dwellings. Within this context, the privacy requirement of outdoor living space or what might be termed apparent outdoor living space, i. e., that enclosed space which is open to observation through windows or other openings, becomes significant.

Of the three elements which contribute to the degree of privacy, all the activities likely to require privacy performed within the outdoor living space can be identified and described in detail. These are summarized in the lower half of Figure 28 in Part Three. The person or persons liable to observe the outdoor activities can be generalized into two classes; adjacent neighbours, and the general public passing on adjacent rights-of-way. This distinction is based on the probability that neighbours will be more familiar and more liable to be accepted as observers of family activities than strangers passing on the street. It is the third element, the individuals, or in this case, the family's assessment of the activity in moral terms, which is difficult, if not impossible, to generalize.

An obvious difference in the assessment of an activity occurs between ourselves and the French over the matter of excretion. Their tolerance of the sounds, smells and even sight connected with this activity are in all cases greater than ours. Since there seems to be no rational basis for generalizing on the assessment of the activity in moral terms by a variety of individuals, it seems unlikely that privacy can be quantified and "adequate" privacy defined. Further development of this approach to privacy appears to be unwarranted.

For the foregoing reasons, privacy could be considered a quality having more in common with visual aesthetics than such characteristics as fire, light and air. Privacy, like aesthetics, is a quality in residential development worthy of support by space regulation, however, it may best be served implicitly rather than by making it a specific object of site and space regulations. Like aesthetics, adequate privacy can not be guaranteed by regulation for every case. However, a positive contribution towards residential privacy could be made if site and space regulations were so formulated that they no longer exerted an adverse effect on residential privacy. This recommendation is based on the assumption that the examples of residential development, particularly higher density development, which are criticised as lacking in privacy, are largely shaped by site and space regulations. The correction of this adverse side effect of site and space regulations, appears to be the most direct way in which privacy can be improved by regulation.

The still prevalent preference for a single-family dwelling is based largely on the privacy it offers. Such privacy is obtained simply by employing open space to separate two dwelling units. It would be consistent with other objectives of the proposal, if physical barriers or structure orientation could be employed as substitutes for open space.

Through the use of such devices multi-family dwellings, including terrace houses, could provide privacy equivalent to that enjoyed by the resident of the single-family dwelling, while conserving open space for more important functions and aiding the trend towards more urban residential development.