SPATIAL PATTERN OF MULTIPLE OCCUPANCY HOUSING IN HAMILTON

SOME ASPECTS OF THE SPATIAL

PATTERN OF MULTIPLE OCCUPANCY

RESIDENTIAL STRUCTURES IN

HAMILTON

by

JOHN MERCER, M.A.

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AUTHOR: John Mercer, M.A. (University of Glasgow).

SUPERVISOR: Mr. J.G.C. Potvin

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SCOPE AND CONTENTS:

This thesis describes the spatial pattern of multiple occupancy residential structures in Hamilton through time. Statistical, verbal, and cartographic description are employed to analyse the spatial patterns at four time periods and the changes from one time period to another. An attempt is also made to explain the spatial pattern of multiple occupancy residential structures within a multi-variate framework. A range of locator variables is identified from the literature and interviews. Four variables are then selected from this range and utilised in a multiple regression analysis in an effort to explain the occurrence of multiple occupancy residential structures in terms of their spatial relationships with the selected variables.

ACKNOWLEDGEMENTS

This thesis could not have been completed without the freely given help of a number of people. I should especially like to express my debt to my supervisor, Mr. Georges Potvin, for the initial stimulus for this study, useful criticism, advice and assistance. I gratefully acknowledge the interest, help and valuable criticism of Dr. Gerard Rushton. Thanks are also due to Mr. Mike Goodchild for his much appreciated help with statistical analyses and computer programs.

I am also indebted to numerous civic officials in Hamilton for their kind assistance and to those private developers and planners in various Southern Ontario communities who participated in the interviews. Finally, I appreciate greatly the time and effort of Mrs. Dorothy Brown who typed this thesis.

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a) Percentage of Land Use by major type - United Kingdom.[1]

	Housing	Industry	Open Space	Education	Residue (inc. Commercial & Transportation)
London	42.0	5.0	15.0	2.0	36.0
English County Boroughs	43.4	8.1	18.7	2.8	27.0
Large Sett. over 10,000	43.5	5.3	21.5	3.0	26.7

b) Percentage of Land Use by major type per one city dweller - Germany.[2]

Housing	Industry	Water	Railroads	Open Space	Cemeteries
32.0	15.0	8.0	15.0	11.0	2.0

Public Buildings	Sports/ Rec. Areas	Streets & Walks
4.0	4.0	8.0

c) Percentage of total developed area in Residential use - U.S.A.[3]

Population Group	Number of Cities	Percentage Area
50,000 or less	28	39.56
50,000 to 100,000	13	37.16
100,000 to 250,000	7	41.40
250,000 and over	5	39.97

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1. R. BEST and J.T. COPPOCK, The Changing Use of Land in Britain, (London: Faber and Faber, 1962)

2. J. GODERITZ, Stadtebau, in F. Schleicher's Taschenbuch fur Bauingenieuere, (Berlin: 1955), p.863.

3. H. BARTHOLOMEW, Land Uses in American Cities, (Cambridge, Mass.: Harvard University Press, 1955), p.46

FIG 1 LAND USE IN U.S. METROPOLITAN AREAS

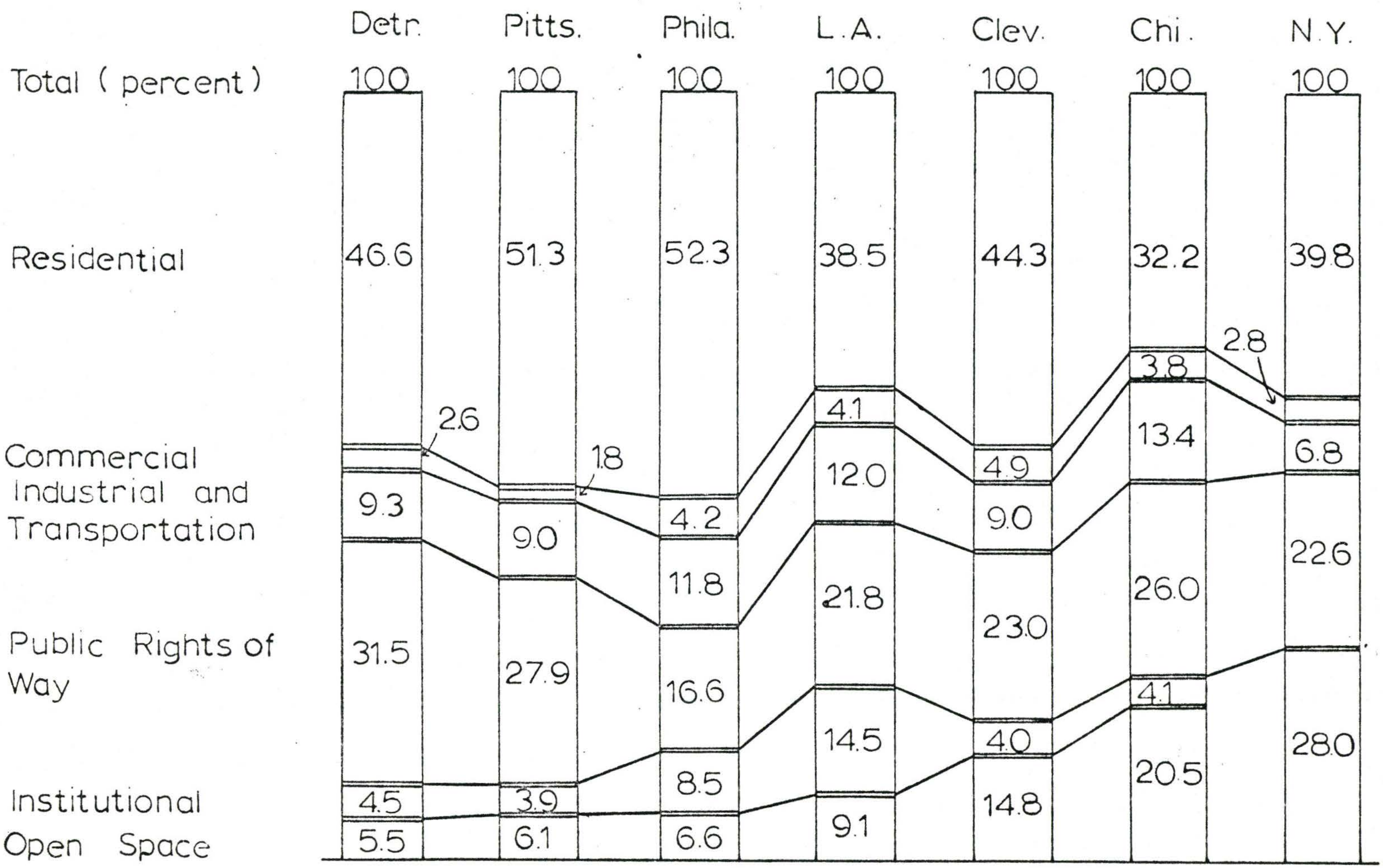
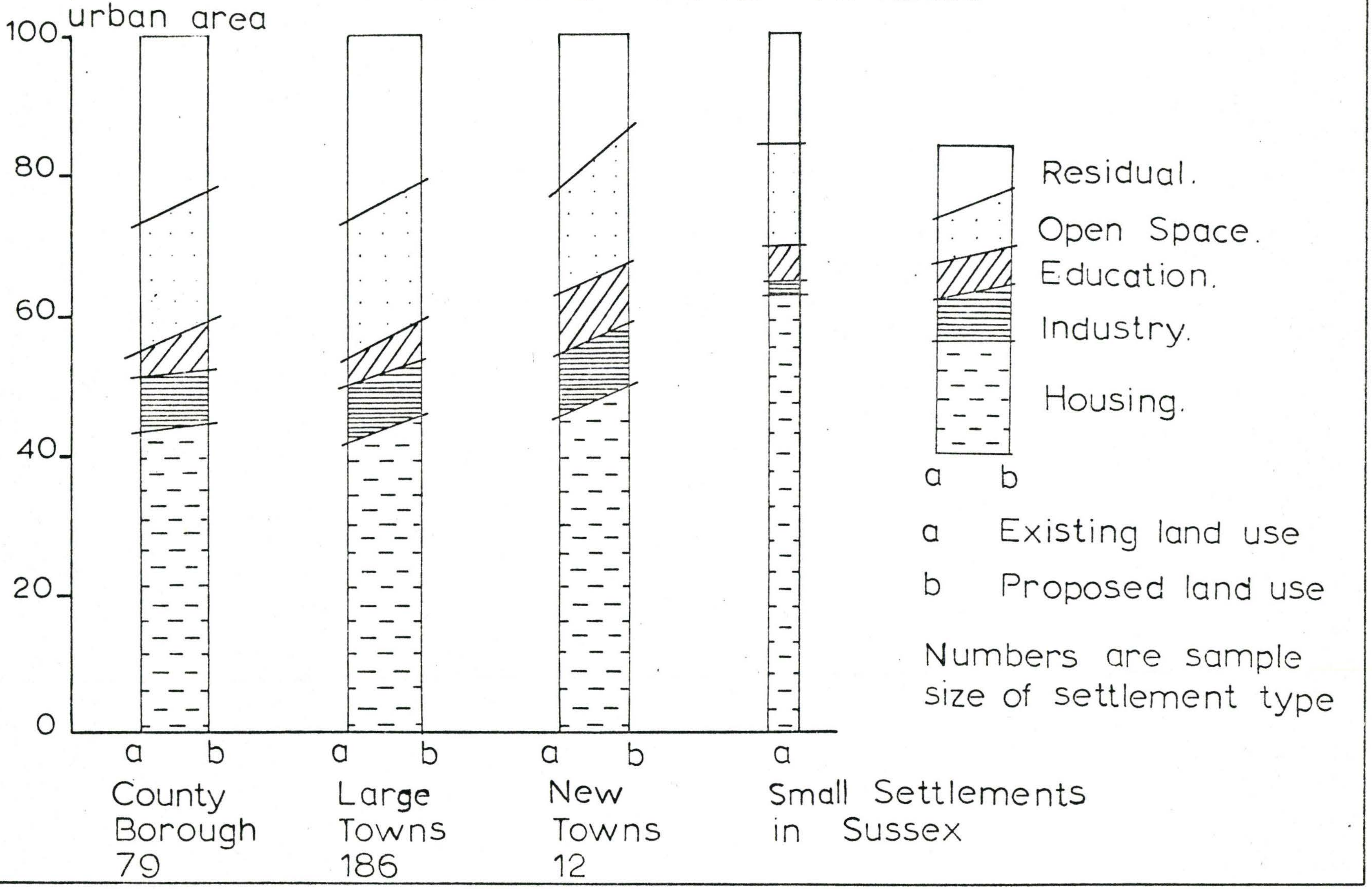


FIG 2 LAND USE IN URBAN AREAS: ENGLAND AND WALES



therefore, to focus some attention on this particular use of the earth's surface and it is hoped that this study goes some way toward remedying the neglect shown by geographers.

It is the writer's contention that a basic requirement in a geographic study, whether it concerns residential land use or any other phenomenon, is that the spatial element be fundamental - there can be no geographic research if the spatial element is ignored. The present study has increased depth and meaning with the added consideration of the element of time. Clark stated that

> "Dynamic studies of the changing city are needed if there is to be any real understanding of the future paths of city development .... too often studies of the city structure are undertaken for one point in time."[8]

While there is a great need for dynamic studies in geographic research, it is difficult to develop a truly dynamic study. For a study to be dynamic, time must be treated as a variable.[9] If time is not treated in this way then the study is 'static' in nature. If time is treated as two or more discrete points within the study then the study possesses a 'comparative static' nature.[10] With four time periods selected as representative of the total time span, the present study falls into the last category. In the terminology of the historical geographer this is a cross-sectional approach. Although such studies have been criticised for their lack of continuity, a cross-sectional approach was deemed adequate for the purpose of this research and for the convenience of obtaining manageable data. A certain amount of continuity does exist, however, since the spatial distribution at each time period is, in a sense, a summation of the net changes in each of the intervening years.

Following Bunge, it is argued that "any phenomenon of human significance on the surface of the earth constitutes relevant subject matter for the geographer."[11] The writer would wish to add a rider concerning the scale of analysis. At certain micro scales it is possible that geographers could contribute little and that micro specialists are more suited to research at such levels of scale. Since this study is concerned with the examination of a phenomenon that is spatially distributed and with the spatial relationships between multiple occupancy residential structures and other selected urban variables, it is argued that the research is geographic and that the characteristic of 'comparative static' strengthens the study.

As can be seen from the stated purpose this work is descriptive in nature. Too often social scientists and others have disparaged description - 'mere description' is a common phrase. It is quite possible that descriptions may themselves be explanatory; the 'how' may lead to a 'why' not just to a 'what'. Explanation is not intrinsically different from informing or describing but is an appropriate piece of informing or describing, the appropriateness being a matter of its relation to a particular context. Explanation can be regarded as obtaining the right description where the right description is defined as one which completes a particular gap in the understanding of a person or people to whom the explanation is directed.[12] The writer makes no apologies for a descriptive study, but believes that by striving for precision in the description, the likelihood of obtaining the right description and thus, insight or explanation, is the greater.

The present research is concerned with one particular aspect of residential land use, namely the multiple occupancy residential structure. For the purposes of this study a multiple occupancy residential structure is defined as any structure which contains six or more self-contained residential units. This does not exclude structures containing both residential and other uses so long as the structure contains at least six self-contained residential units. It is for this reason that the term 'apartment building' is not used as a general description since this phrase creates an image of a structure devoted entirely to residential purposes. This critical threshold of six self-contained units was chosen so that the study would focus on those structures that represent an intense use of the land for residential purposes. By choosing this level such structures as duplexes and triplexes are excluded, as are those buildings that are basically commercial in function but which may have five or less residential units available for occupance. Structures with less than six residential unites are common in many communities throughout Canada, but this level of differentiation results in the research being concerned with structures which have different economics of development and location. Such structures are a reflection of the demand and/or the scarcity of land that is characteristic of the large urban areas of Canada and elsewhere.

This research possesses both specific and general characteristics. As indicated, it focuses on one particular aspect of residential land use. It is concerned with the spatial location of multiple occupancy residential structures and deals only in a minor way with the aspect of vertical location. Furthermore, it examines the spatial distributions of these structures in the City of Hamilton, Ontario, and at four particular time periods - 1939, 1956, 1961, and 1964/5. In contrast to these specific features, the study has some general characteristics. For example, in the study of the spatial relationships of the multiple occupancy residential structures with other urban variables, these variables were chosen without any specific reference to Hamilton and are equally relevant in other North American urban areas. These selected urban variables are basic elements of any urban matrix and it is their spatial arrangement (together with other urban features) on a unique site that gives each urban area its character. These variables themselves are in no sense unique; nor are the multiple occupancy residential structures that are the concern of this study. These general characteristics allow some generalisations to be made on the relationships observed in the study. The degree of spatial association found in Hamilton could, therefore, be reasonably expected to occur elsewhere. Clearly, there will be a residue of explanation that can be attributed to the particular conditions obtaining in Hamilton.

The stimulus for concentrating on multiple occupancy residential structures as an aspect of residential land use was two-fold. Within the field of residential land use research, this particular aspect has been somewhat neglected compared to the single family dwellings in the amounts of research carried out. Secondly, the rapid increase in recent years of the construction of such structures has not only changed the appearance of the urban areas, but it has also posed problems for city planners, municipal governments, and the community in general.[13]

This research makes a contribution in a number of ways. It increases knowledge, firstly, of certain spatial patterns through time, in Hamilton, and, secondly, of the spatial relationships existing between multiple occupancy residential structures and other selected urban variables. A reservoir of experience is provided for other researchers with the bringing together and assessment of the contributions from a number of fields of research to this aspect of residential land use. By helping to overcome the lack of geographic research in this field, results are obtained and future avenues of research suggested which are of practical significance. Clark has pointed out that "urban redevelopment programs in all their forms are predicated upon a knowledge of residential conditions that is neither complete nor exact."[14] Unfortunately this is true of most facets of planning that are related to residential land use. There is need for basic research for, at present, the planning process operates on a basis of severely imperfect knowledge. It is to be hoped that this study will extend knowledge of the factors underlying the spatial pattern of multiple occupancy residential structures and of some of the spatial relationships that help shape the distribution of these structures in urban areas.

The research begins with an examination of the literature in order to provide information on the spatial pattern of multiple occupancy residential structures in urban areas and on the factors that are spatially related to this pattern. This forms the second chapter of the study. This is followed by the main body of the thesis containing the research design, the description of the distribution of multiple occupancy residential structures in Hamilton and the measurement of the spatial relationships between selected variables and the occurrences of such structures. A final chapter attempts to review and integrate the conclusions of the study.

FOOTNOTES - CHAPTER I

1. N. GINSBURG, Review of Man's struggle for shelter in an urbanising world, by C. Abrams, Economic Geography, Vol. 41, No. 3 (1965), p.275.

2. W.A.V. CLARK, "A Pattern of Residential Rents" (unpublished Ph.D. dissertation, Dept. of Geography, University of Illinois, 1964), p.10.

   Clark claims that, "scarcely any research has been accomplished on residential patterns" and after examining the literature relevant to his topic he comes to the conclusion that, "patterns of rental residential uses in the city have received but little attention."

   Clark's study is one of a few that consider housing as part of the spatial structure of urban areas. However, since his conclusions concern the pattern of residential rents, this study is not included in the review of literature. Clark's study was a stimulus to the present research and his methodology and approach have influenced this study.

3. W. ALONSO, Location and Land Use, (Cambridge, Mass.; Harvard University Press, 1964), p.1.

   Alonso observed that, "the theorists of urban land values and land uses have neglected residential land, and the economic theory of residential land uses must catch up with that of other uses."

4. H. MAYER, "Urban Geography", American Geography: Inventory and Prospect, eds. P. James and C.F. Jones, (Syracuse: Syracuse University Press, 1954), p.156.

   Mayer stated that, "residential land use has been investigated in considerable detail by a number of American Geographers". Mayer cited three papers in support of his statement - these were

   (i) W.D. JONES, "Field Mapping of Residential Areas in Metropolitan Chicago", Annals Assoc. Amer. Geog., Vol. 21 (1931), pp. 207-214.

   (ii) W. APPLEBAUM, "A Technique for Constructing a Population and Urban Land Use Map", Economic Geography, Vol. 28 (1952) pp. 240-243.

   (iii) H. MAYER, "Applications of Residential Data from the Chicago Land Use Survey", Land Economics, Vol. 19 (1943), pp. 85-87.

The earliest of these papers by Jones is a discussion of the usefulness and methods of field mapping in discovering, depicting and analysing the character of residential districts. Jones does suggest that the character of a residential district could be explained with reference to four factors - a) physical site factors, b) the character of neighbouring areas, c) distance to other sections of the city and type of transportation available and d) the character of the earlier occupance of the land. This important aspect of the research was never followed up. Applebaum discusses a method of constructing a population and urban land use map, while Mayer's paper is a comment on the utility and content of a residential data report presented by the Chicago Land Use Survey.

These three papers hardly represent "investigation in considerable detail", and furthermore, they are limited in nature, do not build on or link up with any previous research and, Jones apart, do not suggest any future research.

5. H. MAYER and C.F. KOHN (eds.), Readings in Urban Geography, (Chicago: University Press, 1959), p.497.

   In the introduction to a section on the Residential Structure of Cities, Mayer and Kohn were to write that "despite the fact that a large proportion of the land in our urban centers is used for residential purposes, geographers have not contributed substantially to generalizations regarding the location and character of urban residential areas. For many of the theories, as well as the empirical data related to the residential structure of American cities, geographers must depend on the work of sociologists, urban ecologists, and those interested in urban land economics."

6. What clearer evidence is needed to show that contemporary urban geography is an offspring of economic geography rather than of social geography?

7. For comment on this see JONES, op. cit., p.207.; ALONSO, op. cit., p.2; and MAYER and KOHN, Ibid, p.497.

8. CLARK, op. cit., p.2.

9. It would appear that for some historical geographers the consideration of the temporal element is sufficient to result in a study being described as 'dynamic'. For a discussion of how historical geographers treat time see 1) R. HARTSHORNE, Perspective on the Nature of Geography, (Chicago: Rand McNally & Co., 1959), especially Chapter 8. 2) H.C. DARBY, "On the Relations of Geography and History," Institute of British Geographers, Transactions and Papers, Vol. 19 (1953) pp. 1-11.

10. For a fuller discussion of this point see G. ACKLEY, Macroeconomic Theory, (New York: MacMillan, 1961), pp. 14-19.

11. W. BUNGE, Theoretical Geography, ("Lund Studies in Geography" Series C, No. 1; Lund, Sweden: C.W.K. Gleerup, Publishers, 1962), p.5.

12. M. SCRIVEN, "Explanations, Predictions and Laws," Minnesota Studies in the Philosophy of Science, Vol. 3., eds. H. Feigl and G. Maxwell (Minneapolis: University of Minnesota Press, 1962), pp. 170-230.

13. CLARK op. cit. Clark suggests some reasons for this increase. The age group of 20-24 is becoming more important in the population structure. Also, new households are being formed at a greater rate. At the opposite end of the population pyramid older age groups are increasing. All those groups are largely composed of one or two person households which various surveys have shown are major renting households (see footnores 13-17, Chapter II) Furthermore these trends are not expected to diminish. There has been an increase in the cost of suburban land and the costs of home ownership have risen considerably. The increasing mobility of the population, especially the younger elements, results in the increasing demand for a residence which is less binding than a home.

It should be noted that it is the demands of these groups that the developers seek to satisfy and by locating their developments in certain areas they attempt to satisfy the locational preferences of these consumers.

14. CLARK, op. cit., p.1.

CHAPTER II

REVIEW OF LITERATURE

Introduction

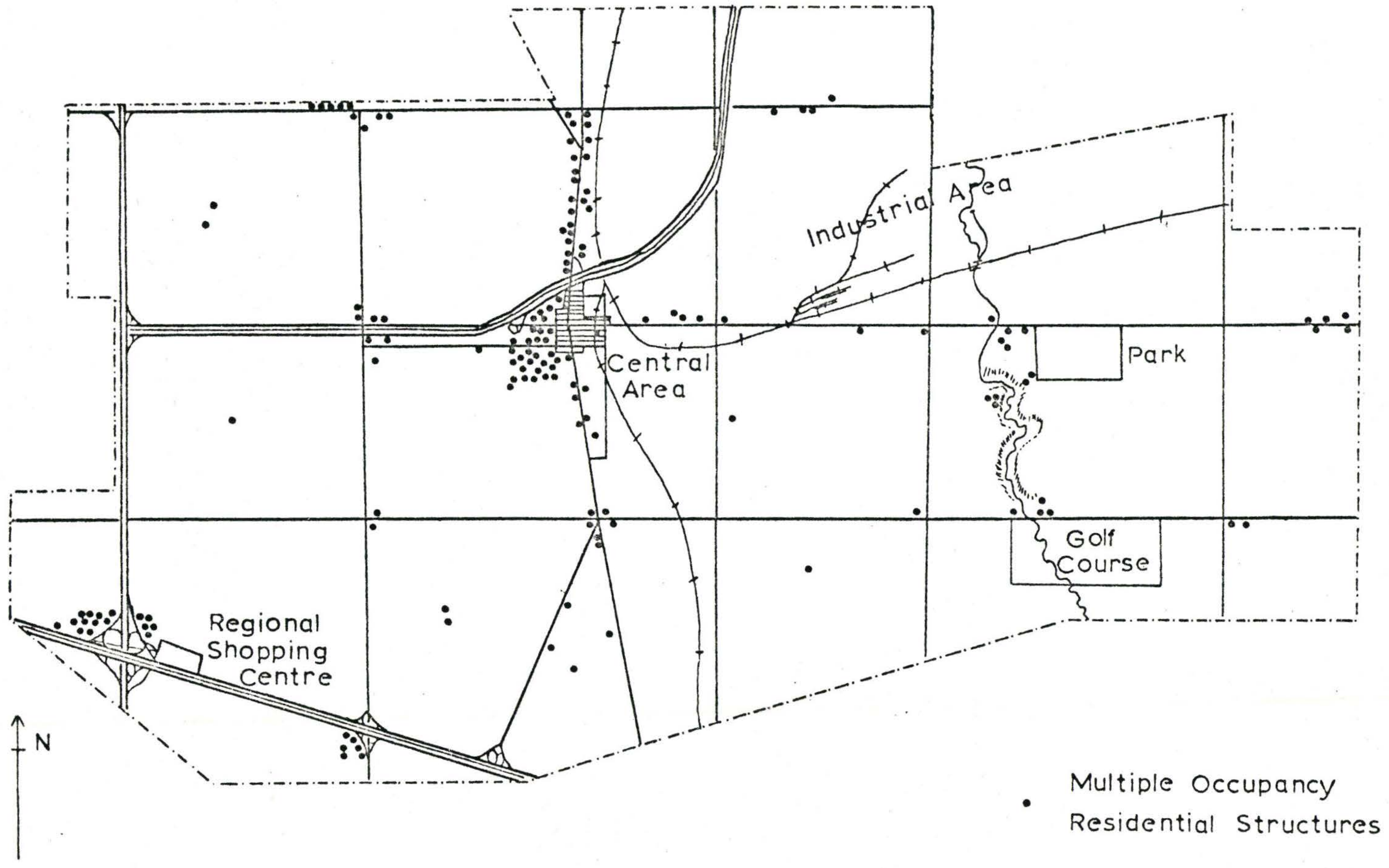
The review of literature was undertaken to obtain information on the recorded or hypothesised spatial pattern of multiple occupancy residential structures in urban areas; the literature was also examined to determine which other variables appeared to be related to the location of such structures in urban areas thus allowing their use in the analysis.[1] This review of literature allows an assessment to be made of the contribution of various disciplines to the study of the spatial pattern of residential land use. In particular, the contribution of the geographer will be considered and the relationship of the present study to previous geographic research noted.

The Pattern of multiple occupancy residential structures in urban areas.

A generalised description can be constructed of the characteristic pattern of multiple occupancy residential structures in urban areas. A characteristic spatial pattern is one which exhibits a high concentration around the central area or downtown section of an urban area. This is not a continuous belt of development but it is more likely to be concentrated in one or two sectors on the margin of the Central Business District. Away from this area, the pattern can be broken into two elements - a linear element and a clustering element. This is a somewhat artificial division since in reality the two elements can and do occur simultaneously in space. The linear developments of the structures are usually to be found along the major traffic arteries while the clustering is likely to occur at the principal intersections of the major traffic flows or at transit stops, e.g. subway stations. A more recent element to be included in this generalised description is the suburban clustering that is taking place on highways or at some attractive site or where both coincide. Fig. 3 is a hypothetical pattern as described above.

This generalised description was constructed on the basis of literature which noted existing spatial patterns of multiple occupancy residential structures in different urban areas or certain elements of the total pattern; hypothesised spatial patterns in urban areas were also considered. An early study that provided discussion of the spatial distribution of this type of residential land use and which synthesised some previous research was that of Homer Hoyt.[2] The purpose of this study was to develop tools of analysis and to seek general principles of urban structure and urban growth from an investigation of the residential neighbourhoods of American cities. One of Hoyt's conclusions was that multiple occupancy residential structures were clustered around the Central Business District and that they were also located along rapid transit lines leading to the C.B.D. He further noted that there were other small groups of structures scattered over a wide area of the city. These conclusions confirmed an earlier statement by Bartholomew that this type of residential structure tended to predominate in the 'zone of transition' adjacent to the downtown area, in the immediate vicinity of commercial sub-centers and along arterial thoroughfares.[3] Hoyt, however, refuted a statement that Burgess had made in the development of his concentric zone 'theory'.[4] Burgess had created an image

FIG 3 IDEALISED DISTRIBUTION OF MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES



of a high grade apartment cluster or area occurring in the outer residential area of his ideal concentric representation of the city.[5] Hoyt cited the examples of the apartment structures along the 'Gold Coast' on Lake Michigan, north of the Chicago 'loop' and on Park Avenue in Manhattan to reject this statement.

One of Hoyt's major contributions in this study was the establishment of the so-called 'sector theory'. For a number of North American cities the high rent neighbourhoods were established for different time periods. It was found that these areas exhibited a sectoral pattern of growth always toward the periphery of the urban area. Hoyt noted that the exception to the rule that high rent neighbourhoods do not reverse their trend of growth is the de-luxe apartment area which is composed of a 'colony' of wealthy households desiring to live close to downtown. Hoyt commented that in this case high land values of the downtown area had been overcome by the intensive use of the land and high rentals. This re-emphasised a point he had already made - "Because of the intensive use of land, such residential development can occupy land too expensive for single family houses".[6] This association between the high land value areas of cities and multiple occupancy residential development had been previously commented on by a number of other researchers.[7]

The rationale behind these statements on this association goes back to the fundamental work of Hurd[8] and Haig,[9] who believed that competition between activities was the chief mechanism operating in the distribution of land uses on sites throughout an urban area. If a site was deemed accessible, and from this characteristic derived high value, only uses which realised considerable sums of money could compete for that location.[10] Thus, if an entrepeneur wished to develop such a site for residential use, he could only hope to obtain the site if he had the future intention of developing multiple occupancy residential structures which would clearly produce more revenue than single family dwelling units. This would allow the developer to compete against other potential users who might intend commercial or institutional use. Under this framework, Joyt concluded that in a general way the interactions of this system would produce an axial pattern as well as central clustering while there would also be isolated nucleii on the urban periphery. Some indication on the intensity of this pattern had come from Bartholomew who noted that greater numbers of structures occurred close to the central area, and that they became fewer in number as one approached the city limits.[11]

More recent support for the central/marginal-central concentration observed in the generalised pattern established by Hoyt's basic research has come from a number of sources. In an analysis of the New York Metropolitan area, Vernon and Hoover concluded that the demand for luxury apartment structures would increase and broaden.[12] Since this type of structure is usually centrally located, this trend would strengthen the central area's reputation as an apartment district, although it is clear that the spread of the luxury structures throughout the urban area was also envisaged. These authors re-emphasised the intensity point of Burgess as they noted the decreasing numbers of apartment structures as one moves away from the central core of the Metropolitan area.

Vernon and Hoover also concluded that the replacement of old single family dwellings by multiple occupancy residential structures would continue. Since these older single family dwelling areas are usually close to the downtown section, this would further increase the central development of these structures. This concept of renewal in the central areas which results in the construction of multiple occupancy residential on cleared land has been studied and documented in a number of cases. Rapkin and Grigsby,[13] in estimating future demands for housing in central Philadelphia came to conclusions similar to those of Mowbray,[14] Hoffman,[15] the A.C.T.I.O.N. Study,[16] and the Downtown Idea Exchange group[17], that the downtown apartment dwellers are a distinct social group. In arriving at these conclusions, some understanding is gained as to why the central area is an attractive one for this form of residential development. The downtown apartment dwellers form small households, have a typical employment pattern, and tend to perform upper class occupations which consequently yield higher incomes; they are well educated and tend to be more mobile than the average population. The advantages for these households of living in these central or marginal-central apartment buildings are given as, proximity to employment, downtown shopping, amusement and cultural centres, and avoidance of lost hours in commuting. The disadvantages most noted are no daily change of environment, distance from certain recreational opportunities such as golf courses, lakes and the like, and problems associated with the raising of children.

The generalised pattern established so far needs to be expanded to include the more recent suburban development of multiple occupancy residential structures and the consequent locational patterns. Some of the reasons for this suburban development are given by Melamed.[18] He claims that with the ageing of the suburban population, the parents of the suburban household can be expected to move to suburban apartment structures: while the garden apartment structures might attract some young families. From the standpoint of the suburban municipal governments, such structures contribute to the tax base and can be serviced in a more economic fashion.[19] Melamed believed that apartment structures will increase especially in areas accessible to rapid transit (either mass transit or the urban expressways). While discussing the characteristics of suburban apartment dwellers vis-a-vis the central apartment dwellers, he pointed out that just as the location of the central area structures allows their occupants to draw on the downtown retail outlets, so is there a strong relationship between the suburban structures and retail facilities, often the latter being integrated shopping centres.

These integrated shopping centres, especially at the regional level, are often located on major urban highways. Thus as Hoyt points out, land adjacent to a major shopping centre with access to a major interurban highway is ideal for development of multiple occupancy residential structures.[20] Even without concomitant retail development, a site on such a highway is regarded as valuable since the travel time is reduced for the apartment dwellers, thus bringing other areas of the city such as sources of employment closer to the resident. Further confirmation of the relationship between the retail concentrations and multiple occupancy residential structures in the suburban areas comes from Babcock and Bossellman in an account of the legal aspects of the spread of apartment structures into the suburbs and the consequent zoning reactions to this spread.[21] This research showed that certain pre-conceived notions (often inadequately based) do have an effect on the resultant spatial distribution of apartment structures. The beliefs that multiple occupancy residential structures can be used as buffers between commercial areas and single family homes (but rigidly excluded from these selfsame single unit areas) and also as being suitable for 'buffering' along major urban streets are examples of such notions.

Most of the literature on which the generalised description has been based has been drawn from United States sources, but three Canadian sources confirm that this description is equally applicable to the Canadian scene. The central concentration, the decline in intensity as one moves away from the central concentration, the locational attraction of major urban arteries (both transit and expressways) and the spatial linkage between commercial development along these urban arteries and multiple occupancy residential structures are evident in studies from Montreal, Toronto and Vancouver.[22]

The spatial relationships of multiple occupancy residential structures.

One of the first studies of the spatial relationships between residential land use and other elements of the urban matrix was that of Marble.[23] Marble examined the residential site selection of the single family household and the impact on such selection of improvements in the road traffic network. Marble makes a major differentiation on types of residential land use based on the purpose of the operation of the residential units and the intensity of site utilization; on this basis, he distinguishes between the single family dwellings and apartment buildings since the latter have a higher density of use and

and a greater degree of commercial operation.

Marble provided some valuable insights into an understanding of the spatial pattern of multiple occupancy residential structures in urban areas. He noted that, for instance, the returns to a commercial operator operating a high density residential unit are not dissimilar to the returns obtained by the operators of retail businesses. This suggests that some of the factors pertinent to the location of retail establishments might also be relevant to the location of multiple occupancy residential structures.[24] He also reviewed the factors which influence the selection of a residential site by a household.

The site must be accessible to those activities in which a family or household engages, these activities being shopping, employment, education, religious activities and recreation of various forms. He also observed that the location of the site in relation to other land uses and socio-economic groupings is important.

This suggests that any site which has access or proximity to such areas as retail areas or employmemt areas or other areas where the above-mentioned activities are carried on would be an attractive site. The value of a central or downtown site and the value of a site in close proximity to a highway which can provide ready access to the location of these activities is clear. It is no surprise, therefore, to find that these are areas attractive to developers of multiple occupancy residential structures. Although Marble's work was focused on single family units and although the apartment dwellers are socially distinct from the occupants of single family homes,[25] their basic demands for the satisfaction of activities (albeit to differing degrees) are similar. Thus, the generalisations concerning areas attractive to multiple occupancy residential development can reasonably be made and Marble's work also allows the identification of some important urban variables whose spatial distribution could affect the distribution of these structures.

A body of work carried out at the Institute for Research in Social Science at Chapel Hill, N.C. is of value. This research takes the form of a section in "Urban Growth Dynamics"[26] and two research monographs.[27] The first of these two reports produced in 1962 analyses the factors of land development. It attempts to explain the mix of variables that influence the pattern of land development so that the future performance of these variables might be predicted. The second report incorporates these results in a probabilistic model which simulates residential development.

The rationale for the first monograph is provided in "Urban Growth Dynamics". The authors regard the land development pattern as one which results from many public and private decisions about such development. They distinguish 'priming actions', such as the location of an urban expressway and 'secondary actions' such as the development of a subdivision; such 'secondary actions' are envisaged as the consequence of and the follow-up to the 'priming actions'. It is argued by the authors that it is possible to identify the key factors involved in these decisions and actions. These can be measured so that their relative importance in creating the land development matrix can be assessed.

Briefly, thirteen factors are identified. These factors are, "widely held to be important".[28] In the research reported in the first monograph the number of factors is increased to fourteen and these fourteen variables are utilised in differing combinations in a multivariate regression analysis. One mix in particular showed a strong association with the pattern of residential development in the metropolitan test areas. This was as follows:

Marginal land not in urban use

Accessibility to work areas

Assessed value

Travel distance to the nearest major street

Distance to the nearest available elementary school

Residential amenity

Availability of sewerage.[29]

The second paper containing the probabilistic model is methodologically oriented and provides detailed discussion on the practical and conceptual difficulties of constructing the model and implementing the computer program.

The usefulness of this research comes in the statements concerning the process of development and the identification of factors that are believed to be significant in land development patterns. Since land development includes the kind of development that is the concern of this study, there is relevance in this respect. Also, these studies deal with particular urban areas and patterns by carrying out empirical tests of the models against a series of urban patterns. This spatial analysis is extended by examinations of land development through time. Since no distinctions are made within the broad field of residential or land development, it is not possible to directly relate some of the factors discussed in these studies with the spatial patterns of multiple occupancy residential housing. The factors discussed, however, were suggestive and warranted further consideration.

In a recent privately published work, Smolkin makes available both information on the distribution of multiple occupancy residential structures in urban areas and on the spatial relationships of such structures with other urban variables.[30] In this book, which sets out, step by step, how an apartment builder should carry out his development, the author lists a number of areas considered as prime areas for development.

1. the downtown business district or edge thereof

2. prestige established neighbourhoods, along streets where the apartment buildings of thirty years ago were built, where 'Society' used to live and where they may still do

3. key points of access such as along expressways, at major highway inter-sections, along commuter train or bus routes or at new bridge and tunnel exits

4. areas commanding scenic views of lakes, an ocean, a river or valley, a golf course, public parks or a country

5. areas next to regional or other shopping centres where multi-family residential zoning tends to be concentrated or is obtainable

6. in large residential subdivisions where land for apartment structures has been zoned as part of a planned unit development or similar such concept

7. areas close to universities, research centres or government offices, places that tend to attract large numbers of women, white-collar male workers, households subject to transfer and those beginning or approaching the end of their careers

8. areas accessible to industrial or office parks.

The author goes on to deal with many of these points in greater detail but it is clear that from further examination the central area is regarded as one of prime locational significance and for the reasons already outlined. Outside of the central area, the two main locational considerations are access (to work, services, etc.) and environment. In the discussion on access, the importance of proximity to limited access roads and the junctions of such roads is emphasised. Proximity to retail establishments emerges as a significant consideration with the domination of the downtown area being challenged by the regional shopping centres or plazas. The emphasis on environment, contrived or natural, is very important since this is regarded as a most marketable commodity and can often be critical to the success of a development. This is an aspect that is becoming increasingly important in a market which is fiercely competitive. Somewhat surprisingly, there is little emphasis on the role of land values in the development of these projects.

Conclusion.

The review of literature has achieved two objectives. It has allowed the construction of an idealised distribution which represents the spatial pattern of multiple occupancy residential structures in North American urban areas.[31] The distributions that obtain for Hamilton at the four particular time periods can be compared to this idealised distribution and points of similarity or departure noted. It has also allowed the identification of a number of factors which appear to be most important in the influencing of the spatial distribution of the multiple occupancy residential structures in urban areas. These factors are, proximity to the central area, the distribution of high land values, the proximity to major urban traffic arteries which allow access to all parts of the city and beyond, proximity to retail concentrations and the particular environment of the locale, especially the scenic value of the area. The distribution of land zoned for this type of high-density development and the location of municipal services are also important.

This review allows some consideration of the contribution of various disciplines to be made. The most significant contributions seem to have come from the land economists and the urban planners, and to a lesser extent from the developers themselves. In the field of Regional Science there has been some work on residential land use but the two reports available either tend to confirm existing work or follow an approach that has only made an indirect contribution.[32] The contributions of the geographers and sociologists or human ecologists have been more modest and less useful. The sociologist have, however, by sample survey and interview assisted in the understanding of why residents choose to live in certain apartment areas. Since it is these motives and demands that the developers seek to satisfy, one can gain from this insight into why, for example, the central area is attractive to apartment dwellers. Other insights may be gained from human ecologists such as Hawley,[33] who in their descriptions of urban areas throw some light on the patterns of multiple occupancy residential structures and offer some explanation of this spatial distribution; mostly these explananations follow the competition based notions of the land economists.

For the geographer pursuing studies in this field, contributions from his fellow geographers are rare. Apart from the work of Marble and

Clark, little geographic research on the spatial pattern of types of residential structures in urban areas has been carried out or made available to other researchers.[34] This is in contrast to the geographer's concern with house types; this concern of long standing and with a continuous development has yielded studies that range from Brunhes'[35] early studies where the house was recognised as an expression of the environment to the recent work of Kniffen[36] which uses folk housing as an index of cultural diffusion. Certainly, the present study breaks new ground and has a unique concern when contrasted to previous geographic research.

FOOTNOTES - CHAPTER II

1. The literature reviewed in this chapter was drawn from a number of disciplines, but chiefly land economics, planning geography and sociology.

2. H. HOYT, The Structure and Growth of Residential Neighbourhoods in American Cities, (Washington, D.C.: Federal Housing Administration, 1939).

3. H. BARTHOLOMEW, Urban Land Uses, (Harvard City Planning Studies, No. 4, Cambridge, Mass.: Harvard University Press, 1932). The following page references are from the revised version of this text - Land Uses in American Cities, (Cambridge, Mass.: Harvard University Press, 1955), p.40, p.45.

4. E.W. BURGESS, "The Growth of the City", The City, ed. R. Park (Chicago: University of Chicago Press, 1925), pp. 47-62.

5. BURGESS, op. cit., p.55, Chart 2.

6. HOYT, op. cit., p.26.

7. See 1. BARTHOLOMEW, op. cit. (1955), p.45.
   2. C. WOODBURY, "The trend of multi-family housing in cities in the U.S.", Land Economics, Vol. 6. (August and November, 1930) pp. 225-234 and pp. 399-408.
   3. J. GRIES, "Housing in the United States", Land Economics, Vol. 1 (1925), pp. 23-35

8. R.M. HURD, Principles of City Land Values, (New York: The Record and Guide, 1903).

9. R.M. HAIG, "Toward an Understanding of the Metropolis", Quarterly Journal of Economics, Vol. 40. (May 1926) pp. 402-434.

10. Locations that generally generate high land values are those that are in proximity to the Central Business District, near a lake or ocean front, have good access to urban arterial routes, especially where they intersect, and those that have a scenic value.

11. BARTHOLOMEW, op. cit., (1955) p.40

12. E.M. HOOVER and R. VERNON, Anatomy of a Metropolis: New York Metropolitan Region Study, (Cambridge, Mass.: Harvard University Press, 1959).

13. C. RAPKIN and W.G. GRIGSBY, "Residential Renewal in the Urban Core", (Philadelphia: University of Pennsylvania Press, 1960).

14. J. McC. MOWBRAY, "Apartments in central areas", Urban Land, Vol. 21, No. 1, (January 1962), pp. 1-4.

15. M. HOFFMAN, "Outlook for Downtown Housing", Journal of the American Institute of Planners, Vol. 37 (1961), pp. 43-55.

16. N. FOOTE and others, Housing Choices and Housing Constraints, (New York: McGraw Hill, Inc., 1962), Appendix, pp. 387-447.

17. "Bringing High Income Families Back Downtown", Downtown Idea Exchange, Vol. 3., No. 1 (1956).

18. A. MELAMED, "High-Rent Apartments in the Suburbs", Urban Land, Vol. 20 (October 1961), pp. 279-289.

19. In 1965, the town of Dundas, Ontario carried out a survey to ascertain the costs and returns to the municipality of multiple occupancy residential units vis-a-vis single family homes.

They found that apartment development is more favourable in terms of profitability for the municipality and that this type of development is balancing the town's lack of commercial and industrial assessment. Most of the town's service expenditures come in the areas of single family housing - education is probably the most significant cost and with few children or children of pre-school age, occupants of multiple occupancy residential development do not absorb any outlays in this respect.

The town compared 309 apartment units against 309 single family dwellings in Dundas (this was a fairly wide ranging choice but it tended to include above average quality single family homes). With an average assessment the apartments realised nearly 79,000 dollars while their charge on municipal services was estimated at 44,000 dollars. Thus the profit to the community was around 34,000 dollars. For the same number of single family units, with an average assessment there was realised 128,737 dollars, while the charge on services amounted to 135,007 dollars. Thus, the community had a deficit of around 6,000 dollars.

One example of the costs of education was quoted - A householder paying 600 dollars in taxes, living in a single family home, was sending three children to High School at a cost to the community of about 1,265 dollars.

The town of Dundas tried to make this an unbiased study and an accurate one since they wished to have some empirical knowledge of the situation. The study has been shown to one or two 'responsible people' who have commented favourably on the validity and utility of the survey.

20. H. HOYT, "Expressways and Apartment Sites", Traffic Quarterly, (April, 1958), pp. 103-106.

21. R.P. BABCOCK and F.P. BOSSELMAN, "Suburban Zoning and the Apartment Room", University of Pennsylvania Law Review, Vol. 3 (1963), pp. 1040-1091. For a further discussion of suburban prejudices with respect to apartment development see F.P. BOSSELMAN, "Apartments for Whom?", Planning - ASPO (1964) pp. 232-235.

22. For Montreal see P. CAMU, "Types de Maisons dans la Region Suburbaine de Montreal", Canadian Geographer, Vol. 1 (1957) pp. 21-29;

For Toronto see "Apartment Survey 1961", (Toronto: Metropolitan Toronto Planning Board, June, 1962). During 1965 research was being carried out in Toronto to update this survey and also to investigate the spatial relationships of multiple occupancy residential structures with other urban variables;

For Vancouver see "Apartment Zoning", (Vancouver: Vancouver Planning Board, 1958).

23. D. MARBLE, "Spatial Aspects of Residential Land Use", Studies of Highway Development and Geographic Change, W.L. Garrison et al. (Seattle: University of Washington Press, 1959), pp. 141-147.

24. This point will be discussed in Chapter 6.

25. See above references 13-17.

26. F.S. CHAPIN and S.F. WEISS (eds.), Urban Growth Dynamics in a Regional Cluster of Cities, (New York: John Wiley and Sons, Inc., 1962), pp. 425-458.

27. F.S. CHAPIN and S.F. WEISS, Factors Influencing Land Development, (An Urban Studies Research Monograph; Institute for Research in Social Science, University of North Carolina: University of North Carolina Press, 1962) and
T.G. DONNELLY, F.S. CHAPIN and S.F. WEISS, A Probabilistic Model for Residential Growth (An Urban Studies Research Monograph; Institute for Research in Social Science, University of North Carolina: University of North Carolina Press, 1964).

28. CHAPIN and WEISS, Urban Growth Dynamics in a Regional Cluster of Cities, op. cit., p.434.

29. CHAPIN and WEISS, Factors Influencing Land Development, op. cit., p.18.

30. W.R. SMOLKIN, A Marketing Plan for Apartment Builders, (privately published by the Barrett Division, Allied Chemical Inc., in conjunction with the Marketing Department of the National Association of Home Builders, 1964 - this publication is currently unobtainable from either of the original producers.

31. This description parallels the pattern of the urban area itself described in A.Z. GUTTENBERG, "Urban Structure and Urban Growth", American Institute of Planners Journal, Vol. 26, (1960), p.109

32. W.B. HANSEN, "An Approach to the Analysis of Metropolitan Residential Extension", Journal of Regional Science, Vol. 3, No. 1 (1961), pp. 38-55, and
J.D. HERBERT and B.J. STEVENS, "A Model for the Distribution of Residential Activity in Urban Areas", Journal of Regional Science, Vol. 2, No. 2., (1960), pp. 22-36.

The first of these articles is in the vein of the Chapel Hill research, but it employs a different technical approach. The second article identifies some factors influencing residential location much in the same fashion as the literature already cited, e.g. Marble, Smolkin.

33. A. HAWLEY, Human Ecology, (New York: Ronald Press, 1950)

34. The literature examined was that in existence as of 1965 with some updating in early 1966. Research observed since that time indicate an increasing concern by geographers for studies in residential land use.

35. J. BRUNHES, Human Geography, (trans. E.P. Row, London: G.G. Harrap, 1952) Chapter 3.

36. F. KNIFFEN, "Folk Housing: Key to Diffusion", Annals Assoc. Amer. Geog., Vol. 55, No. 4 (December, 1965), pp. 549-577.

CHAPTER III

RESEARCH DESIGN

The purpose of this chapter is to discuss the selection of the methods employed to achieve the purpose of the study as set out in Chapter I. There will also be a discussion of the source and nature of the data used in the research.

The first goal of the study is to describe the spatial pattern of multiple occupancy residential structures in Hamilton at different time periods. The initial step in the analysis was the selection of a number of years to represent the time span of the study. Data was collected from the annual Assessment Reports of the City of Hamilton and other sources on amounts of types of housing in Hamilton over the last forty-five years.[1] This data is presented graphically in Figs. 4-7. From these graphs, changes in the general trends of housing in Hamilton were observed. Four time periods, including the present day period of 1964/5 were then selected. Three years, 1939, 1956 and 1961, were selected at what appeared to be significant breaks in the general trends.

1939 was chosen as representative of the situation before World War II, while 1956 is representative of the growth that occurred during and after the Second World War. The considerable increase in apartment housing that took place after 1956 not only in Hamilton, but other Canadian urban areas can partly be explained in terms of the amendments to the National Housing Act in 1956. In an attempt to provide more

FIG 4 HOUSING TRENDS IN HAMILTON 1927 - 1964.

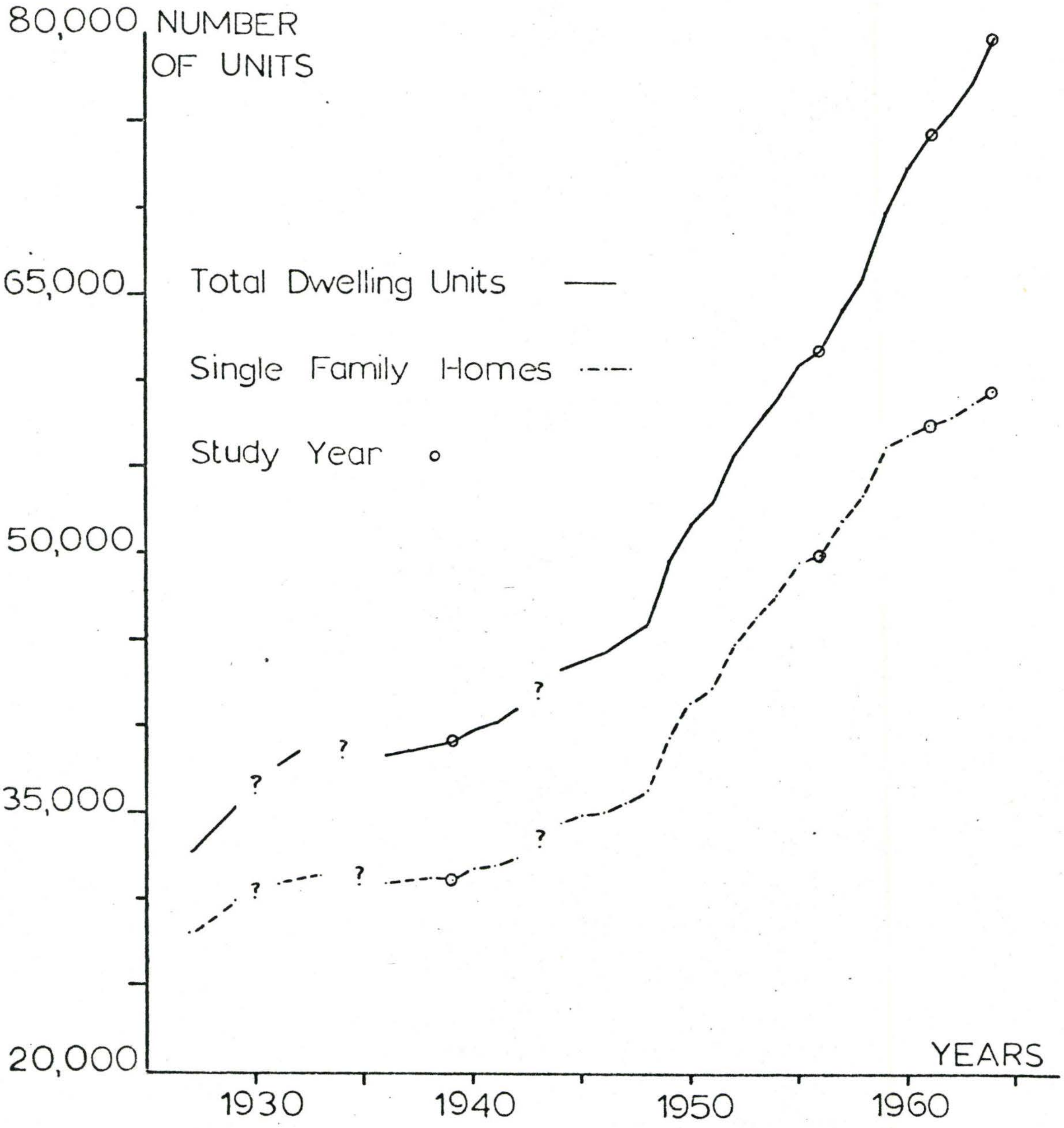
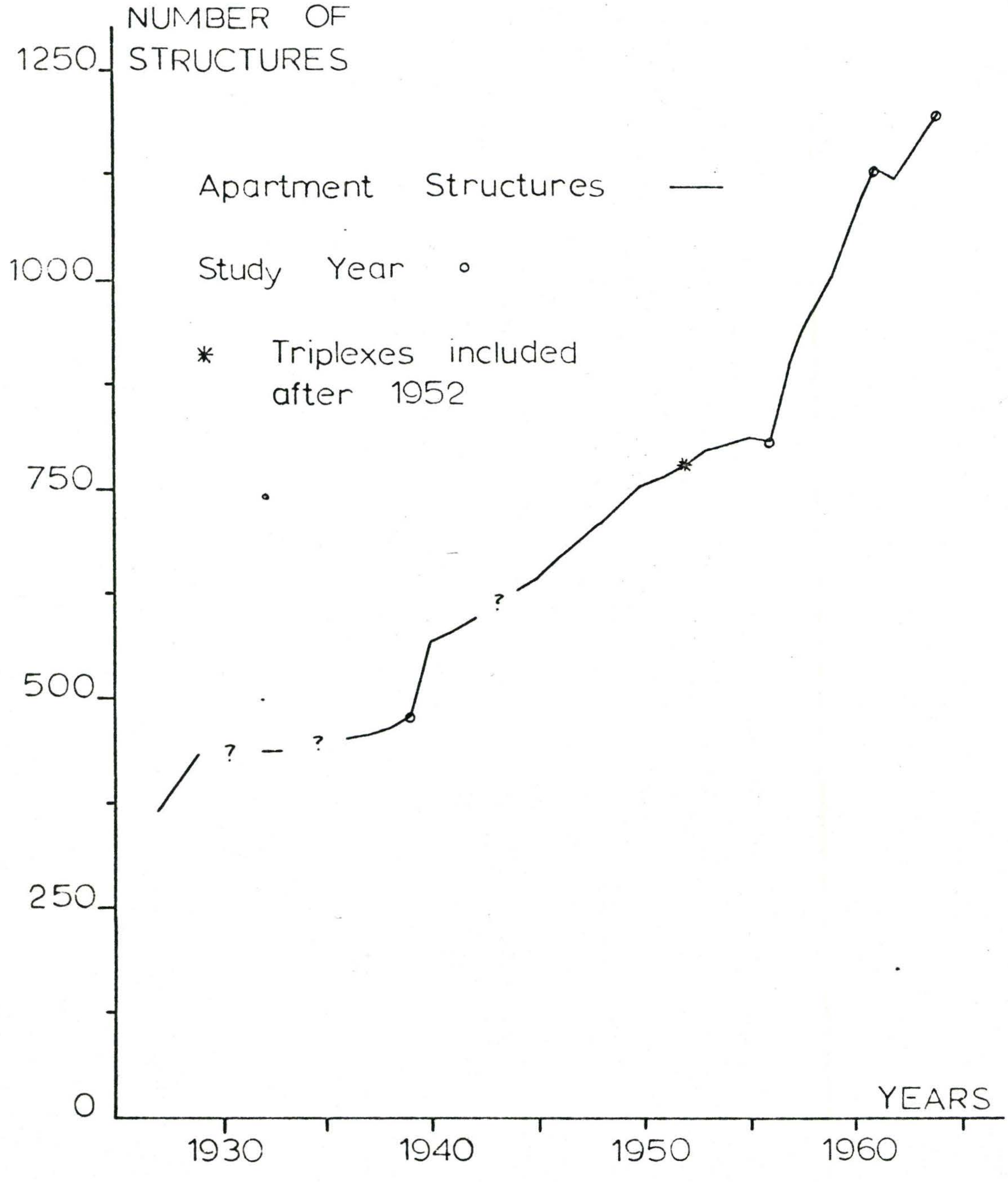


FIG 5 HOUSING TRENDS IN HAMILTON 1927 - 1964



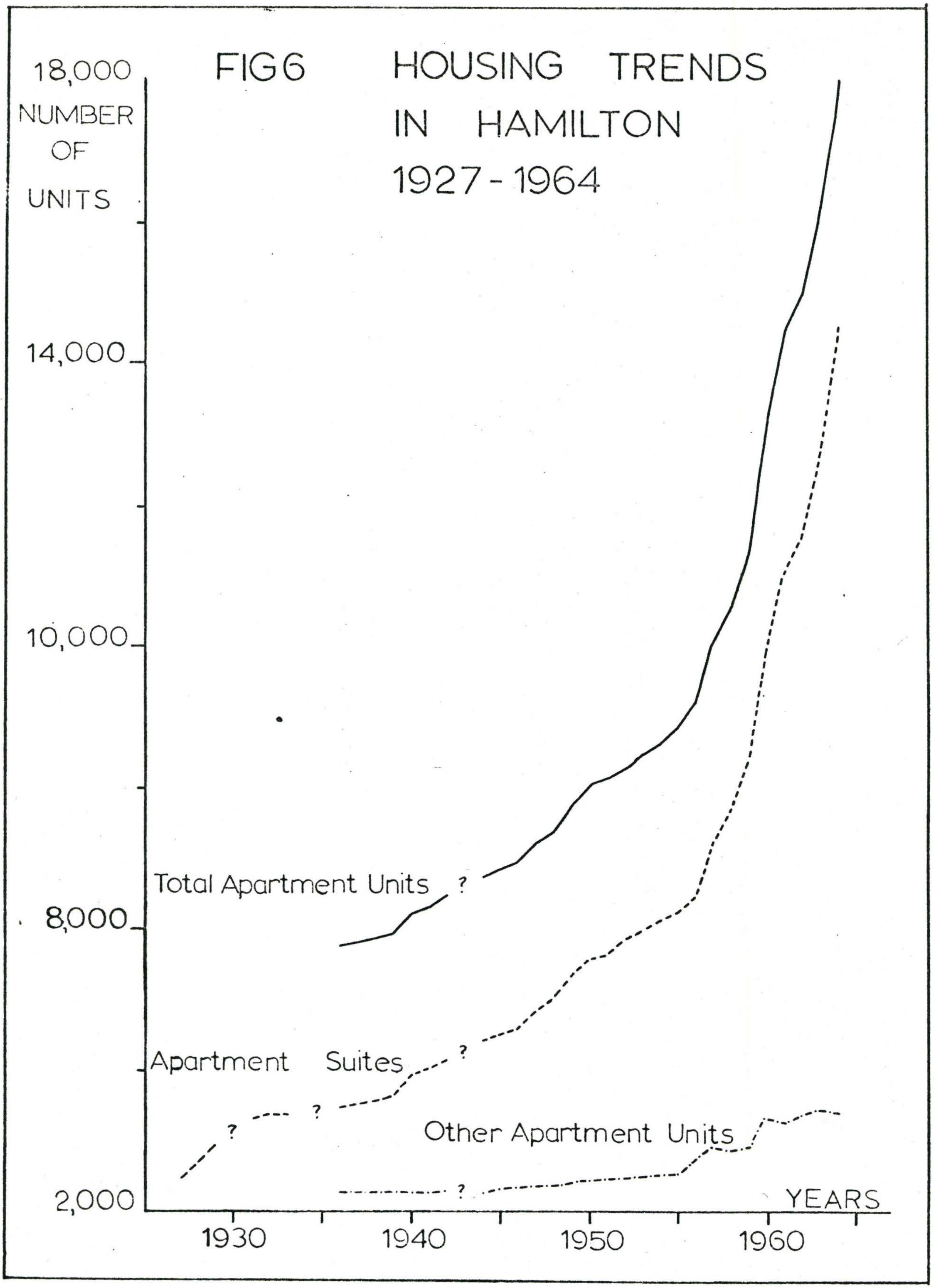
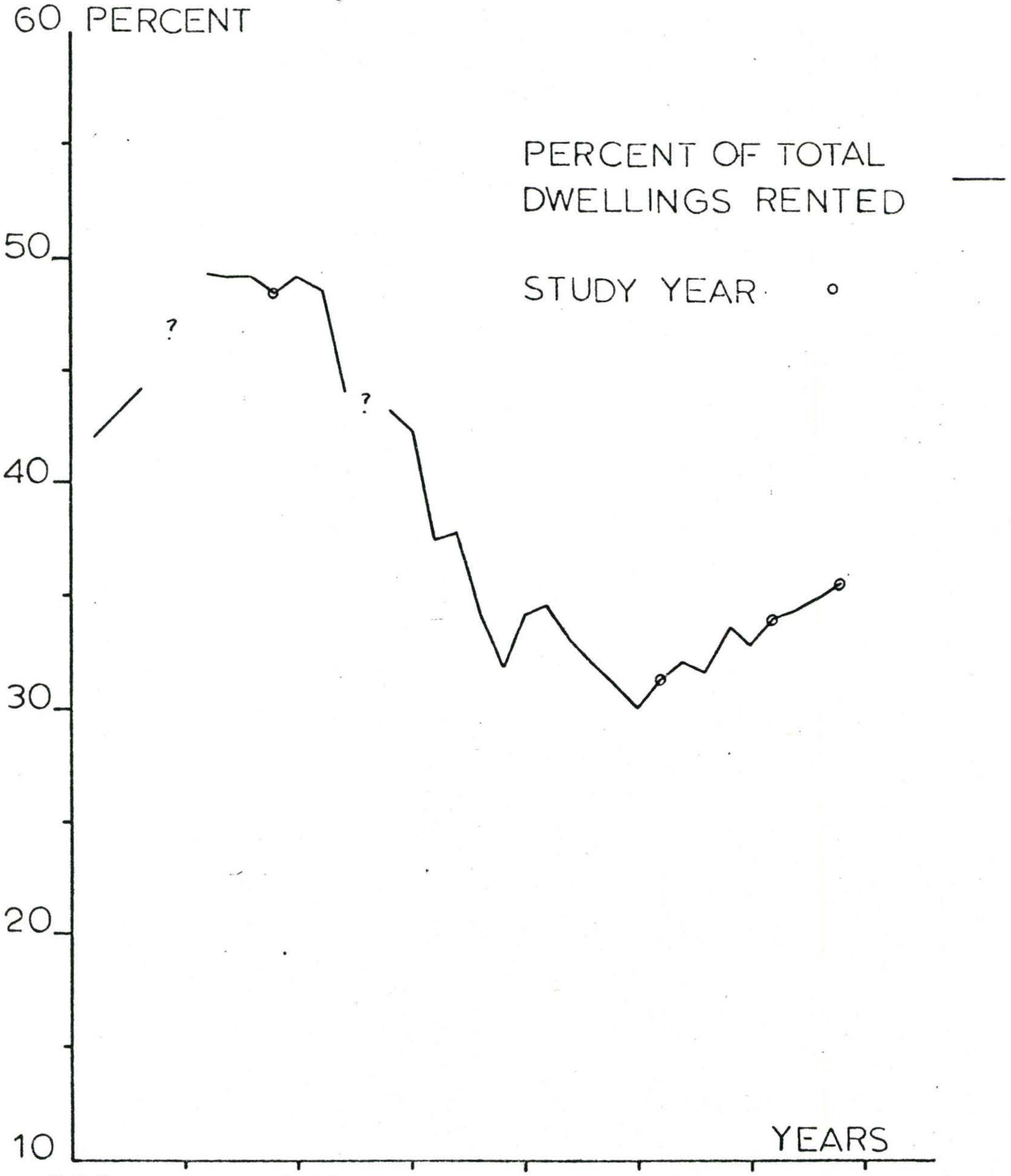


FIG 6 HOUSING TRENDS IN HAMILTON 1927 - 1964
18,000
NUMBER OF UNITS
14,000
10,000
8,000
2,000
Total Apartment Units
Apartment Suites
Other Apartment Units
?
YEARS
1930
1940
1950
1960

FIG 7 CHANGES IN RENTAL HOUSING IN HAMILTON 1931 - 1964



rental accommodation for Canadians, the Federal Government, through its agency the Central Mortgage and Housing Corporation, created a new financial framework which encouraged the development of multiple occupancy residential housing. 1961 is representative of this period of growth. Since 1961 the number of structures, while continuing to increase, did not increase at the rate of the previous period. The increase in the number of units, however, has kept pace with the pre-1961 development. This suggests that fewer but larger structures are being constructed. Much of this change in Hamilton can be attributed to the 1961 decision to allow developments of more than seven storeys, not previously allowable under the zoning by-laws. Certain economies of scale have encouraged the growth of large companies within the home construction industry and such firms tend to undertake large scale developments rather than spread their financial and technical resources on many small developments. The present day period of 1964/1965 represents this latest trend.

It was felt that these four time periods give an adequate picture of the distribution over the last twenty-five years; further this does not yield unmanageable amounts of data. Reasons were given in Chapter I for the choice of a cross-sectional approach.

After the data was collected on the location of multiple occupancy residential structures for each of the four time periods, the next step was the description of the four resulting distributions.[2] Description can take a number of forms. There is statistical description, verbal description and cartographic description. All three methods are employed in this study. The conventional map is a convenient and common method of portraying the absolute location of data and is one which is fundamental to geography, although its usefulness can be lessened by the problems of scale and projection. It was decided to map the location of the multiple occupancy residential structures at each of the four time periods, thus allowing an overall picture of the spatial pattern to be easily obtained. Projection was no problem because of the small areas involved, but scale did pose a problem. Large scale maps were required to ensure a degree of accuracy in the plotting of the individual structures. The reduction of these maps for presentation has resulted in a fine dot distribution. However, the pattern is distinguishable and can be readily grasped.

The description by map portrayal is supplemented by verbal description of the pattern. The spatial patterns are related to other elements of the urban matrix of Hamilton, such as the street pattern, functional areas such as the C.B.D. and the industrial area, and to physical characteristics. The spatial pattern noted in Hamilton is compared to the generalised pattern obtained from the review of the literature. The statistical description involves the summarising of a large body of data and the expression of this summary in a concise fashion. The method employed here is the mapping of the location of the arithmetic mean centre of the distribution at each of the four time periods.[3] This also gives an indication, in a general fashion, of the shifts in the distributions from one time period to another. A more detailed description of the changes is obtained from a map which shows the location of those structures that developed within the span of two time periods. This map is also discussed, areas of change identified, and these changes related to the urban matrix.

Another form of description is the division of Hamilton into a number of districts such as the Central district, the Mountain district and the West End districts.[4] The amounts of percentage and absolute change indicate those districts experiencing greatest change. These statistics also allow an assessment of the changing relative importance of districts within the city with respect to their contribution to the overall spatial pattern.

Subsets and their distributions.

The total population of multiple occupancy residential structures is subdivided into a number of subsets which are then described. Both cartographic and verbal description are employed and the maps allow visual tests of hypotheses to be made. As indicated in the Introduction, this study encompasses structures of mixed residential and commercial use as long as there are six or more residential units within the structure. This mixture of use is the criterion for defining one subset. The literature on retail location in urban areas suggests that the major areas of retailing are in the central area, along business or 'string' streets carrying large traffic flows, and at major intersection of such streets.[5] The development of the planned intergrated centre adds another element to the urban retail structure. With this pattern in mind, it seems reasonable to hypothesise that the structures exhibiting mixed use occur in the central area, along major city streets and at major intersections of these streets. The mapping and describing of this first subset will allow a visual test of this hypothesis.

A second subset is composed of what can be described as 'high-rise' structures. High-rise residential structures are defined as structures of more than seven storeys, i.e. is higher than the maximum number of storeys previously allowed under the pre-1961 zoning relations. Previous literature suggests multi-storied buildings are to be found in the central areas of cities.[6] The intensity of development allowed by multi-storey construction is regarded as a response to the high land values that are characteristic of this area. It is hypothesised here that 'high-rise' apartment structures are to be found in central areas in common with other multi-stories structures. A map of the location of these 'high-rise' structures in Hamilton is a test of this hypothesis.

Another subset that is of importance is composed of converted structures. In most cities these are structures which were formerly single family homes occupied by the wealthier groups of the urban society. Generally, these are large structures and represent some of the older properties in the urban housing supply. This type of home is very difficult to maintain under present economic conditions and it therefore lends itself to this type of subdivision or conversion which results in the division of the house into a number of residential units. The increasing demand for rental accommodation, especially of the less expensive type, is another factor which encourages this type of conversion. There is a greater amount of conversion of former single family homes than is indicated in this study since only converted structures which contain six or more distinct residential units were noted. One result of this conversion is a considerable increase in the intensity of use of the individual structure; amounts of conversion are also reflected in an increase in the population density of an area. It is hypothesised here that these converted structures are located in the older areas of the city and more particularly in well-to-do sections. Again, this hypothesis is tested by means of a map.

Scale Analysis.

One of the basic features of any spatial analysis is the level of scale of that analysis. Any given distribution, such as the spatial distribution of multiple occupancy residential structures, can be broken down into the regional and local components. This identification of regional and local components serves to describe distributions in a different fashion, but in an important fashion. Filter mapping is the technique employed to identify and analyse these components. This technique yields maps which show regional trends and the operation of local and regional factors as a pattern of positive and negative residuals. This analysis seeks to determine critical level of scale at which the local factors no longer have an effect on a distribution. An attempt is made to utilise filter mapping analysis in this study so that some statements can be made concerning this problem of scale.

Density Gradients.

The description of the distributions is continued by means of density gradients. Density gradients have previously been used in the examination of urban population densities; this method, however, can be applied to any spatial distribution. There is a brief discussion of the use of density gradients in geographical research and the usefulness of this type of analysis to the present study. A number of hypotheses are erected concerning the nature of the density gradients of multiple occupancy residential structures and units through time in Hamilton. The city is also divided into four sectors and the density gradients constructed for these four sectors in order to determine whether the forms that obtain for the whole city also obtain for the sectors.

The spatial pattern of multiple occupancy residential structures in Hamilton at each of the four time periods is thus described in Chapters IV and V. All types of description are employed - verbal, statistical and cartographic description. Two particular types of analysis, filter mapping and analysis by density gradients are employed to supplement the descriptions that were used. These were both precise methods of analysis and they strengthen the more conventional methods of description that have also been employed.

Measurement of Spatial Association.

The remainder of the study of the spatial pattern of the structures in Hamilton is a statistical analysis using the technique of multiple regression. This part of the study is an attempt to measure the spatial relationship between certain urban variables and the multiple occupancy residential structures. These variables represent the factors that enter into the considerations of the private developers and planners who are involved in the decision-making process, a process which produces the spatial pattern with which this study is concerned. This analysis, which is reported in Chapter VI of the thesis provides a discussion of the selection of the variables employed in the analysis; it shows how a few variables can be used to represent a larger number of variables, thus simplifying the statistical analysis. The operational definitions used in the multiple regression analysis are outlined and the results of the analysis presented.

The technique of multiple regression analysis is employed as the appropriate statistical measure to examine the relationship between the spatial pattern of multiple occupancy residential structures and the spatial pattern of selected urban variables which are believed to be related to the pattern of the residential structures. The regression equation essentially predicts the amount of multiple occupancy residential housing in an area, given information about the predictor variables in that area. It is clear that this is a deterministic approach as opposed to a probabilistic analysis using simulation techniques. Without attempting both kinds of analysis, it is not possible to say which approach is more appropriate to the explanation of the pattern of multiple occupancy residential structures. Either method is suited to the problem - one provides an equation which is a precise statement of the relationship between the variables employed in the regression analysis, while the other method yields a pattern which would be representative of a family of patterns, of which the real world pattern is but one.

Regression analysis, both simple and multiple, has been used increasingly in geographic research, but "it has not been an unmixed blessing".[8] In the development of the regression model, the problem discussed by Chorley concerning 'noise' was encountered.[9] There was a conscious effort to simplify the model, to "distil the problem down to its essence",[10] and yet simplification to the point where what was deemed to be relevant would be set aside was avoided. There is efficiency in the analysis in that there is an attempt to gain the maximum return from a minimum of input. A standard text on Correlation and Regression provides a rule of thumb concerning the number of variables that can be employed in this type of analysis, but this seems somewhat arbitrary.[11] However, there is merit in the attempt to reduce the number of variables in the analysis while not discarding relevant information.

The problem of the effect of areal units of different size on the values of the parameters of the regression analysis was also encountered. There has been considerable debate on this particular topic.[12] It would appear that weighting by area as suggested by Robinson is not the answer. Thomas and Anderson suggest an inferential approach. Given that one recognises three statistical levels of inquiry, the sample, the population, and the universe, data for a number of study areas can be treated as a random sample from some hypothetical universe of possible values. Having accepted this, the difference between parameters describing areal association can be evaluated by appropriate tests of statistical significance so that one may decide whether or not the parameters for different study areas have arisen from the same theoretical universe. If these statistical tests indicate that the differences in the parameters would have developed by chance, i.e. due to random 'shocks' within the same universe, "then for the purpose of geographic analysis, the various regression and correlation parameters for the several study areas may be treated as characterising areal associations within the same universe and the differences between them may be ignored."[13]

Curry finds it difficult to accept the notion of an infinite population.[14] He observes that "we still really do not know what we are doing in spatial regression".[15] This generalisation is perhaps less applicable to certain regression analyses, which may contain a spatial element and yet do not have an areal element, i.e. the variables are defined in distance terms. In the analysis reported in this study, the dependent variable is expressed as a density function, thus involving an areal element. Since the dependent variables cannot be defined at a scale lower than that of the dependent variable, the basic areal unit for the regression is that used in the definition of the dependent variable. The most that can be noted is that the choice of scale does effect the results in a regression analysis and this should be borne in mind in the interpretation of the results. In the light of present knowledge, however, no attempt was made to modify the results to compensate for the areal units chosen. The areal unit of measurement was increased for additional runs of the regression analysis, thus allowing the spatial relationships to be observed at different scales.

As has been noted, the assumptions involved in the use of regression analysis are often ignored.[16] However, the present study is not concerned with statistical inference, since it deals with the population of the multiple occupancy residential structures rather than with a sample. The importance of these assumptions is, therefore, greatly diminished. It was decided not to test the assumptions concerning normality and independence.

While the results of each particular stage of the study are set out at the close of each chapter, a concluding chapter provides an opportunity to review and integrate these conclusions. This final chapter also includes some discussion of the main problems encountered in the study and suggestions on how these might be faced in future work. An assessment of the contribution of the study is made and future avenues of research indicated.

The Data.

The data concerning the location of multiple occupancy residential structures for each of the four time periods was obtained from the Assessment Rolls of the City of Hamilton.[17] This involved the examination of these Rolls for any structure containing six or more separate residential units. When such a structure was identified, the number of units and the location of the structure were noted. The structures were mapped on City of Hamilton district maps[18] which allowed the locations to be determined in a precise manner since these maps show individual lots and street numbers. This detail was then transferred to a base map showing the whole city.[19] The accuracy of this data was checked by a field observation in the western part of the city.[20] While there was some variation in the number of units from one time period to another, this could largely be attributed to the varying occupancy of basement units. Generally, basement units were included in the total number of units in a structure. The locations were found to be accurate. The various sub-sets concerning retail establishments in a multiple housing structure, 'high-rise' structures, and subdivided structures were identified by field work. Such identification was relatively straightforward, although a somewhat subjective interpretation usually had to be made in the case of identifying converted structures.

The Identification of Variables.

The other data required in this research was for the multiple regression analysis. The review of literature provided some identification of those factors which students of the problem considered to be related to the spatial distribution of multiple occupancy residential structures. It was decided to supplement this information from the literature with information on the decision-making processes from people involved in those processes - namely, private developers and technical planners (representing the municipalities). Accordingly, interviews with private developers, technical planners and members of other authorities such as the Central Mortgage & Housing Corporation and the Hamilton Urban Renewal Committee were conducted.[21] In an effort to establish general factors which could be tested in Hamilton these interviews were held with developers and planners who operated or were employed in other Southern Ontario communities. It is felt that the identification of some general factors, followed by a test of their predictive ability in Hamilton, is more likely to result in a satisfactory explanation of the distribution in Hamilton than explaining this distribution without consideration of the information on how decisions were made with respect to similar situations in other urban areas.

These interviews were unstructured but focussed.[22] Most of the interviews had two general forms. The private developers were asked to describe what kind of factors they considered in the process of carrying out a development. The planners were asked the nature of the grounds for opposing certain developments and to describe the rationale behind the zoning of certain areas for multiple occupancy residential use. Where neither planners nor private developers touched on some topic or aspect that the interviewer wished to discuss, the respondents were questioned on these specific points and also on certain points that emerged from the main discussion. These topics or aspects were selected on the grounds of a priori reasoning or on the basis of information from the literature. One of the difficulties of this method is in the comparability of the interviews and the analysis of results.[23] This discussion of these interviews, the purpose of which was to identify some general factors involved in the decision making process, is set out in Chapter VI before the multiple regression analysis is reported.

Data for the Regression Analysis.

To implement the regression analysis after the selection of variables was made, certain other types of data were required. It was necessary to obtain information on major arterial streets, open space and the distribution of employment opportunities in Hamilton.

A major arterial street was defined as one which carried over three thousand vehicles in a twenty-four hour period. This figure was a class limit employed in the description of traffic volumes in the Hamilton Area Transportation Study.[24] City traffic officials agreed that this was a fair representation of the major city streets in 1961. They also provided information which allowed the up-dating of this 1961 data for 1965. There has been little change in this period since most of the traffic increase has been accommodated on streets that were already defined as major city streets in 1961. For 1956 the source allowing identification of major city streets was a survey and plan presented by Wilbur Smith and Associates.[25] Such exact information was apparently not available for 1939. However, in 1947, E.G. Faludi presented a Development Plan for the City to City Council.[26] This plan utilised data collected in 1945 in a survey of existing conditions. It would appear that for traffic conditions the data collected in 1945 was actually 1939 data. This allowed identification of the major city streets at that time.

A map showing open spaces in Hamilton in 1965 was obtained from the City Planning Department and, in consultation with City Parks officials and using the Park Director's Report,[27] the approximate dates of the creation of the parks were established.[28] Such natural features as the Mountain Brow and certain creeks in the East and West of the city were obviously pre-1939 in origin as areas of open space and scenic value. It also is clear from discussion with developers that some development does take place at the margins of built up areas so that, for some time at least, open vistas are available, especially in a multi-storey development. The margins of Hamilton's built up area were established at approximately the four time periods from a number of different sources.[29]

Data on the distribution of employment opportunities is not readily available, but fortunately, in the case of Hamilton, such data were available for fifty-eight traffic zones in the City of Hamilton for 1961.[30] These could be used as an estimate of the pattern of employment opportunities for 1956 and 1965, but a similar assumption for 1939 is less reasonable. Given these limitations, it was decided that this was still the best available measure.

Thus, the data sources and problems of data gathering have been identified and the research design of the study set out. The next stage is the description of the spatial pattern of the multiple occupancy residential structures in Hamilton at each of the four time periods.

FOOTNOTES - CHAPTER III

1. The other sources of information were the Census of Canada, 1921 and data for 1920 and 1916 obtained from a survey for the Social Services Council of Canada made by Dr. James Roberts, Medical Officer of Health, City of Hamilton. Data were not obtainable on a yearly basis prior to this period.

2. For a discussion of description in Human Geography see P. HAGGETT, "Locational Analysis in Human Geography", (London: Edward Arnold, 1965), Chapter 8.

3. There is a well developed body of geographic literature on two-dimensional statistical parameters; see HAGGETT, Ibid., pp. 229-230 and references.

4. See Fig. 16 for the location of these districts. The central district is defined as that area marginal to the central commercial core and frame as defined by J. FRIAR, "Hamilton's C.B.D.", (unpublished M.A. dissertation, Department of Geography, McMaster University, 1964). Both Mid Town West and Mid Town East are in the nature of residual districts, since the other districts are somewhat easier to define (in the sense that they are more meaningful in the perception of the city by its inhabitants).

5. B.J.L. BERRY "Commercial Structure and Commercial Blight", (Chicago: Dept. of Geography, Research Paper No. 85, University of Chicago, 1963). See also J. SIMMONS. Research Paper No. 92.

6. HAIG, op. cit.

7. HAGGETT, op. cit., p. 269-270.

8. E.N. THOMAS and D.L. ANDERSON, "Additional Comments on Weighting Values in Correlation Analysis of Areal Data", Annals Assoc. Amer. Geog., Vol. 55, No. 3 (September 1965), p. 92.

9. R.J. CHORLEY, "Geography and Analogue Theory", Annals Assoc. Amer. Geog., Vol. 54, No. 1 (March 1964), pp. 130-131.

Chorley provides a brief discussion of the problems involved in the process of abstraction from the real world or a segment of the real world.

10. CHORLEY, Ibid.

11. M. EZEKIEL and K.A. FOX, Methods of Correlation and Regression Analysis, (New York: John Wiley and Son, Inc., 3rd ed., 1959), p. 183.

"As a matter of practical procedure, it is seldom that a problem is so complicated or that enough observations are available so that significant results for each variable will be obtained using ten or more variables; and ordinarily, analyses involving not more than five variables are all that will yield stable results."

12. THOMAS and ANDERSON, op. cit., pp. 492-505
See especially their references.

13. L. CURRY, "A Note on Spatial Association", The Professional Geographer, Vol. 18, No. 2 (March 1966), p. 98.

14. THOMAS and ANDERSON, op. cit., p. 498.

15. CURRY, Ibid, p. 97.

16. See the comments of J.F. HART and N.E. SALISBURY, "Village Population Change", Annals Assoc. Amer. Geog., Vol. 55, No. 1 (March 1965), p. 151.

17. For the present day pattern, the 1964 Assessment Roll was utilised. This information was updated to May 1965 by the use of the monthly statistics prepared by the Building Department, City of Hamilton.

18. City of Hamilton District Maps, Zoning By-Law Number 6593 - the bound volume of these maps was obtained from the office of the City Clerk.

19. The base maps were obtained from the office of the City Engineer.

20. The area of the city included in this check was that part of the city West of Queen Street to the city boundary, but not including the area above the escarpment. See the street map (Fig. 13) for the location of Queen Street.

21. See Appendix A for the number of interviews and the names and positions of the respondents.

22. This means that, while the questions and responses permitted are not previously determined as in a structured interview, the interviewer has in mind a number of topics that he wishes to cover, but the actual nature of the questions and their timing are at his discretion.
See C. SELLTIZ et.al., Research Methods in Social Relations, (revised one vol. edition; New York: Holt, Rinehart and Winston, 1964), pp. 255-264.

23. SELLTIZ, et.al., Ibid, p. 264.

24. C.C. PARKER & PARSONS, BRINCKERHOFF, LTD., Hamilton Area Transportation Plan, May 1963, pp. 12-13.

25. WILBUR S. SMITH and ASSOC., Traffic and Transportation Plan for Hamilton, March, 1947.

26. E.G. FALUDI, A Master Plan for the Development of the City of Hamilton, March, 1947.

27. Director of Parks' Report, Board of Park Management for the Corporation of the City of Hamilton, 1965.

28. Open space is defined as including all areas of public recreation, areas of scenic value and undeveloped suburban land.

29. 1964-5 - from the map obtained from the City Engineer;
1961 - from 1:25,000 maps of the Hamilton area (compiled 1961-62);
1956 - from 1:50,000 maps of the Hamilton area (revised 1952);
1939 - from the extent of the built up area shown in the diagrams of E.G. FALUDI's Report - see Footnote 34.

30. C.C. PARKER et.al., op. cit., p.6, p.18.

CHAPTER IV

DESCRIPTION OF THE SPATIAL PATTERN

The task of this chapter is to describe the spatial pattern of the multiple occupancy residential structures in Hamilton through time. As indicated in the Research Design, this description is verbal, statistical and cartographic. The pattern of the structures for 1939, 1956, 1961 and 1965 is shown in Figs. 8-11.

The 1939 Pattern

In 1939, the total number of multiple occupancy residential structures was two hundred and seventy-six (Fig. 8). Two features that can be observed in this particular spatial pattern are characteristic of the generalised spatial pattern that was developed in Chapter II. These are (1) a general concentration around and within the central area of the city and (2) well developed linear elements along certain major city streets.[1] This linear element was most strongly developed along King Street East and Main Street East; it was also evident on Ottawa Street North and Barton Street East.[2] While there was a concentration of structures around the central commercial area, this was a discontinuous concentration. There was a cluster to the southwest of the core, in an area bounded by King Street West, Queen Street South, James Street South and Herkimer Street, and another equally well developed cluster on the eastern margin in Stinsondale, bounded by Stinson Street, King Street East, Wellington Street and Wentworth

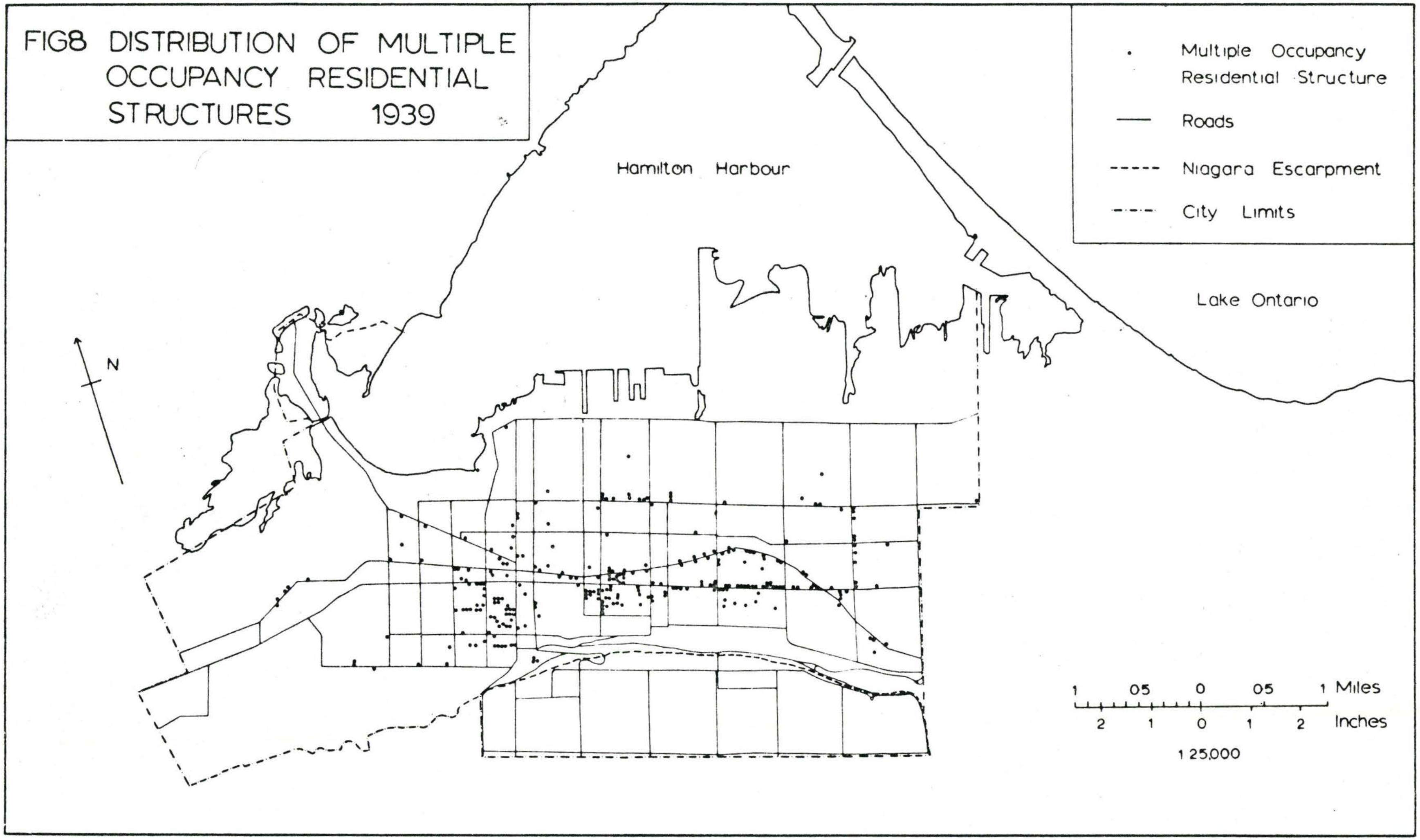


FIG8 DISTRIBUTION OF MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES 1939

Street. These clusters were separated by areas that show little development of multiple occupancy residential structures. At this time, there were no structures in that part of the city above the Niagara Escarpment,[3] and, apart from three isolated structures, there was no development north of Barton Street in the industrial sector of the city. Again, except for a small grouping in Westdale, the West End of the city was also devoid of structures.

The 1956 Pattern

Figure 9 shows the 1956 spatial pattern - the total number of structures was five hundred and eight. The central concentration and the linear developments of 1939 have been intensified as a result of continued development. The 1956 pattern is also more widespread. There was a development of multiple occupancy residential structures both eastward and westward along the axes of King Street and Main Street; north of Barton Street, there were some structures in the industrial area, while on the Mountain there was a marked concentration of structures in the area between the Mountain Brow and Concession Street. This initial development on the Mountain combined the value of a scenic site with that of accessibility to the central area as a result of the proximity of such Mountain access roads as the Jolley Cut and the Sherman Cut. The intensification of development is most evident in the cluster to the southwest of the central area, although there was also some development in Stinsondale, especially on Stinson Street itself. The location of those structures that came into existence over the period 1939-56 is shown in Fig. 14. One result of the developments over this period was that some sections of King Street and Main

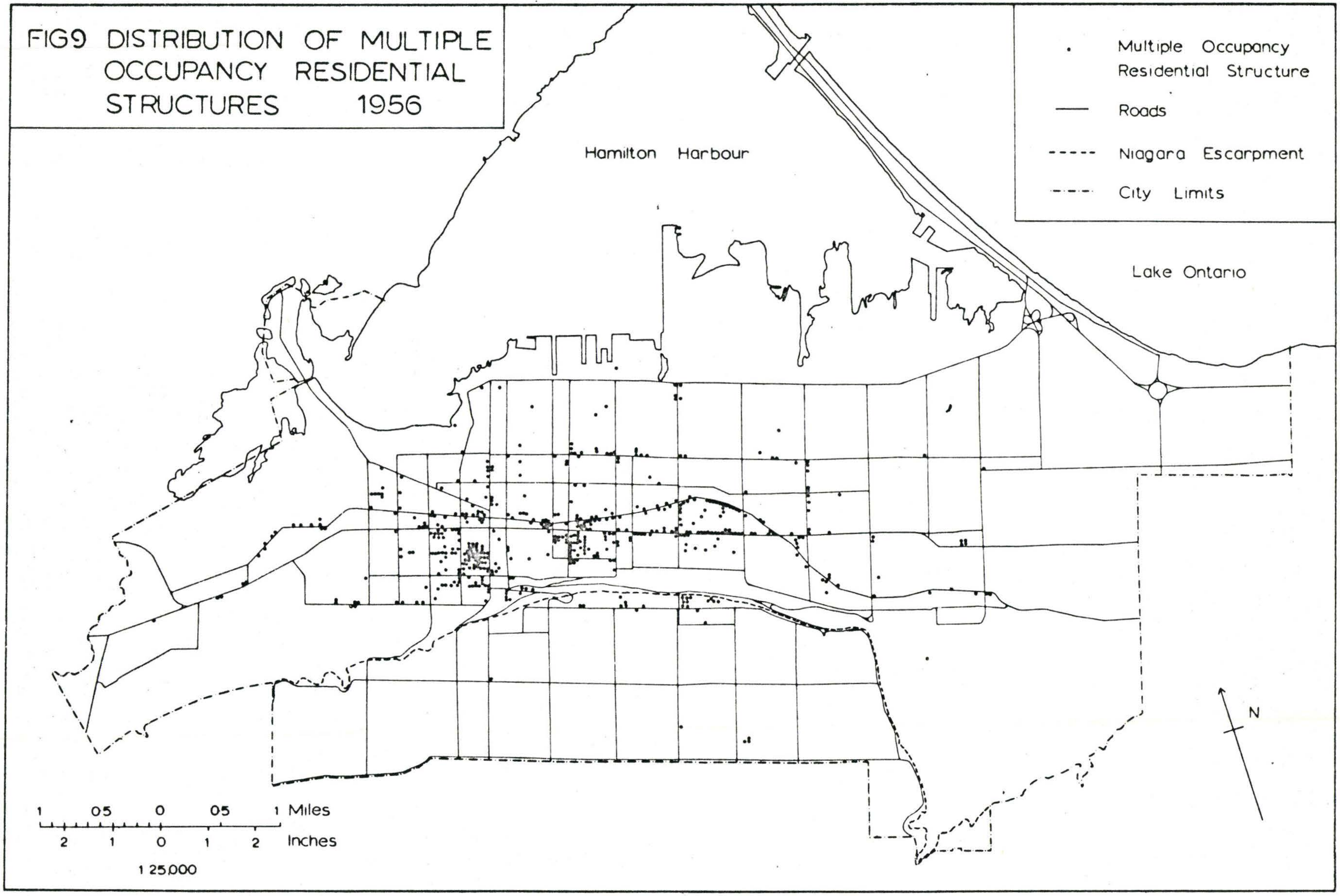


FIG 9 DISTRIBUTION OF MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES 1956
Multiple Occupancy Residential Structure
Roads
Niagara Escarpment
City Limits
Hamilton Harbour
Lake Ontario
N
1 05 0 05 1 Miles
2 1 0 1 2 Inches
1 25,000

Street were almost lined with apartment structures.[4]

The 1961 Pattern

By 1961, the total number of multiple occupancy residential structures had increased to six hundred and forty-two. Fig. 10 shows the location of the structures at this time, and Fig. 14 again allows the identification of the areas of increase over the period 1956-61. The grouping to the southwest of the central area had now emerged as the first ranking cluster with respect to density and amount of development in the city. In contrast, there was little development in this period in the cluster immediately to the east of the commercial core. Other marked clusters had also developed in the city, notably along Highway 2 in the west, along Concession Street and on Fennel Avenue East. The latter two groups are evidence of the increasing importance of the Mountain area for residential development in Hamilton.[5] Within the Mountain area, the location of structures on major city streets and at intersections is evident. The clusters on Highway 2 and Fennel Avenue developed very rapidly at this period. The linear characteristic is also clear in the newer developments on King Street and on Barton Street at its eastern end. These non-central clusterings are also characteristic of the generalised pattern of Chapter II - the location on major city streets, and at major intersections or at points of scenic attraction can be noted. In general, the older areas of the city exhibited little increase in the number of structures at this time.[6]

The 1965 Pattern

In 1965, multiple occupancy residential housing is widespread throughout the built up area of Hamilton - see Fig. 11. On the Mountain,

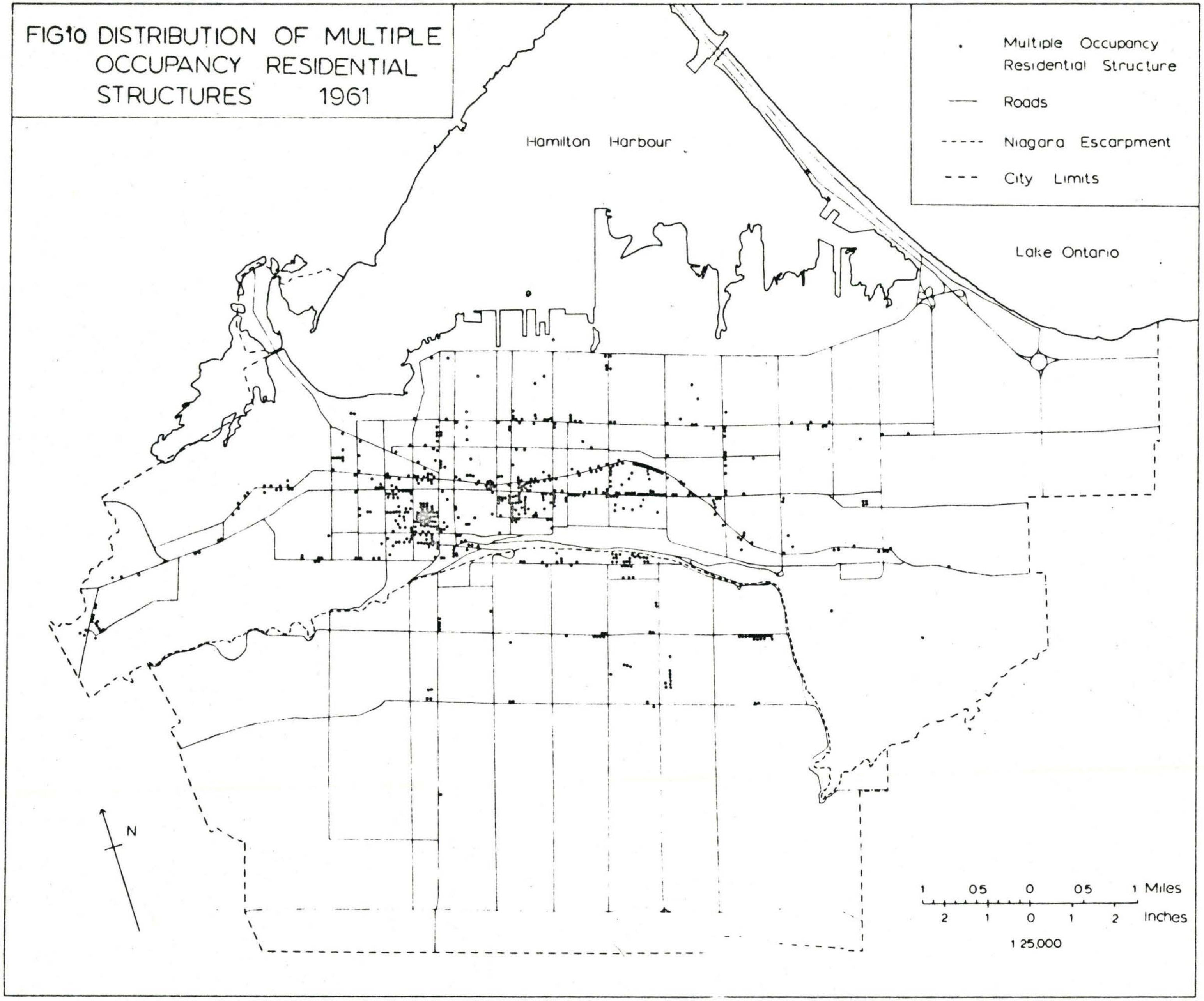


FIG10 DISTRIBUTION OF MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES 1961
Multiple Occupancy Residential Structure
Roads
Niagara Escarpment
City Limits
Hamilton Harbour
Lake Ontario
N
1 0.5 0 0.5 1 Miles
2 1 0 1 2 Inches
1:25,000

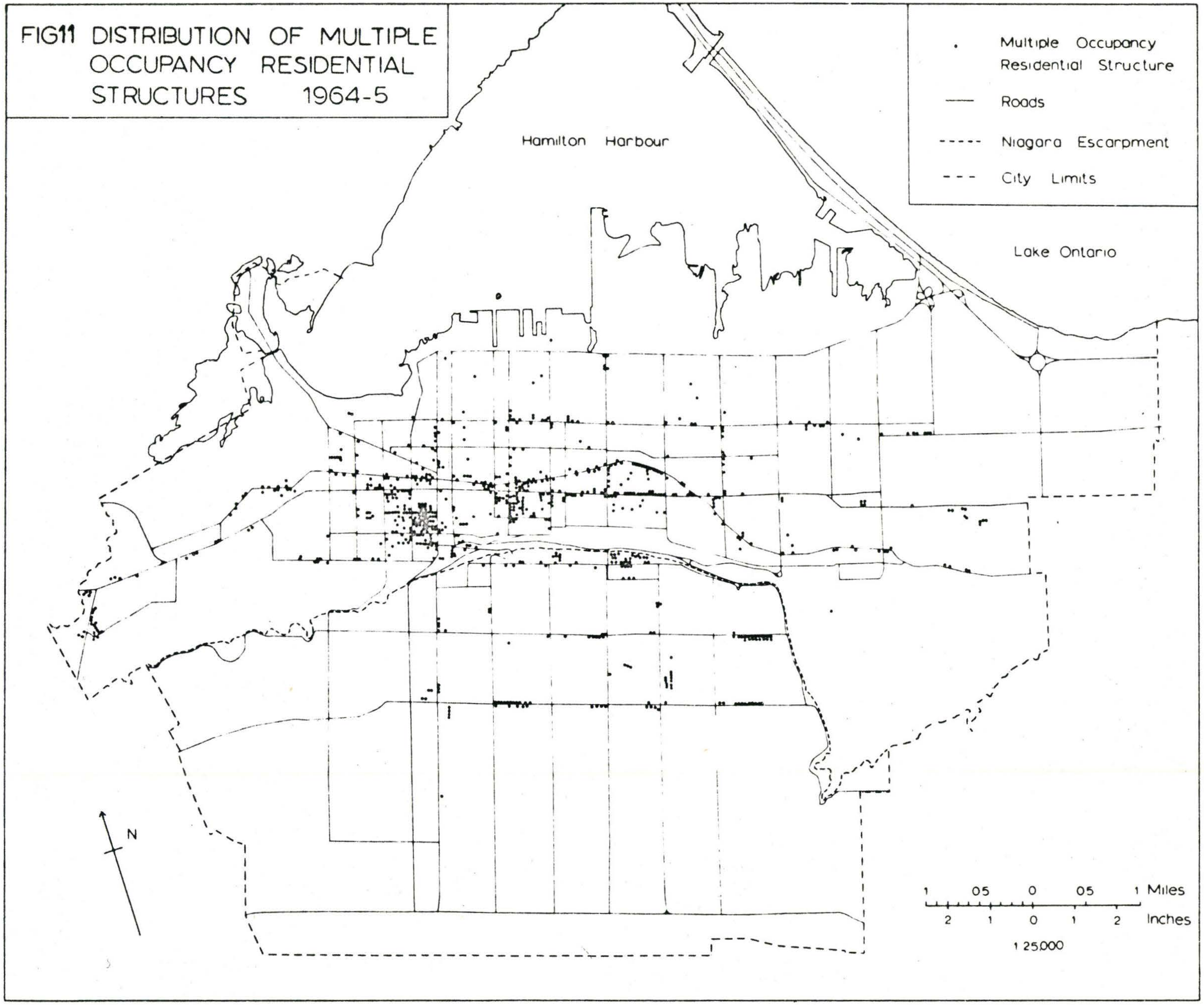
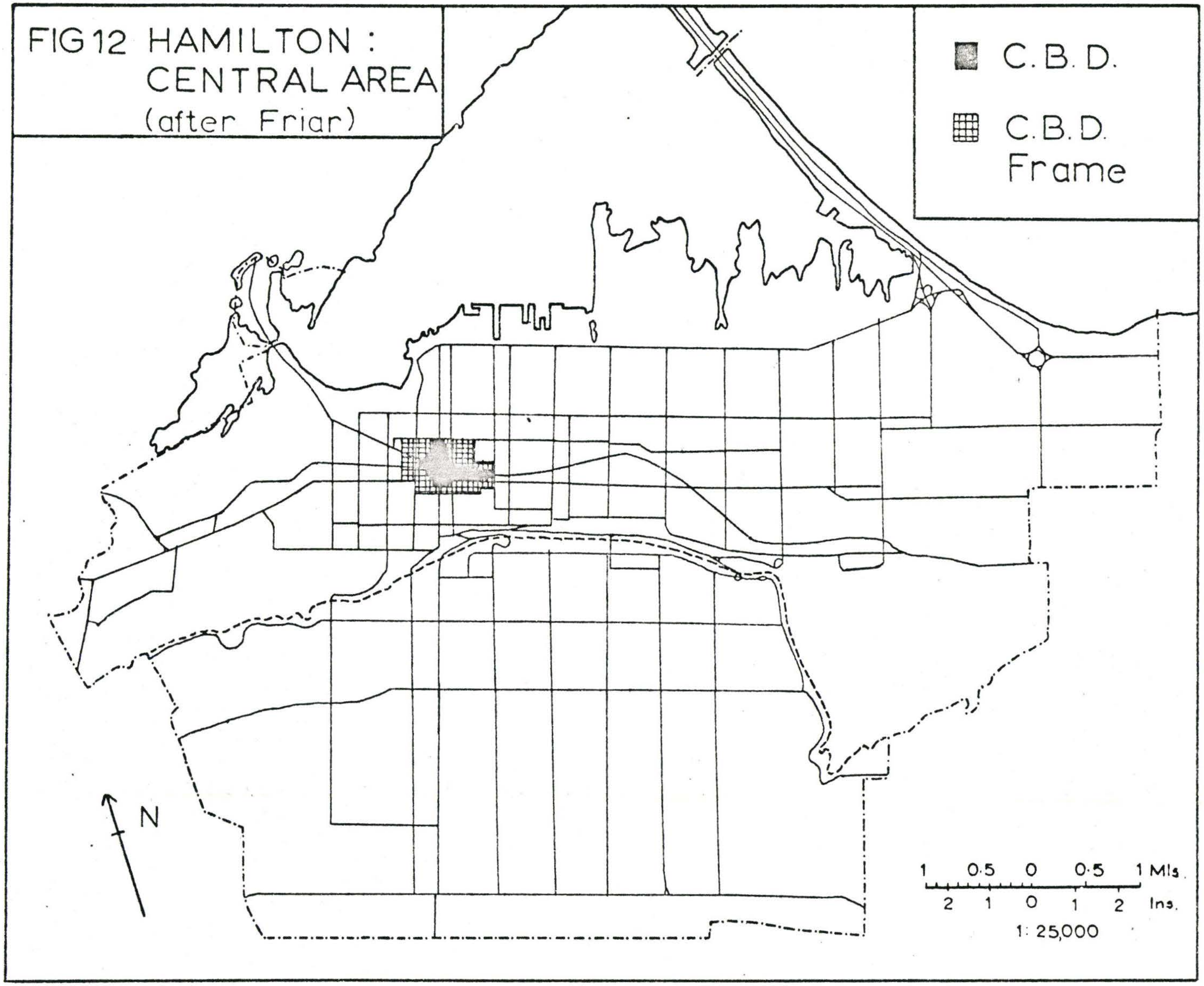


FIG11 DISTRIBUTION OF MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES 1964-5

FIG 12 HAMILTON : CENTRAL AREA (after Friar)



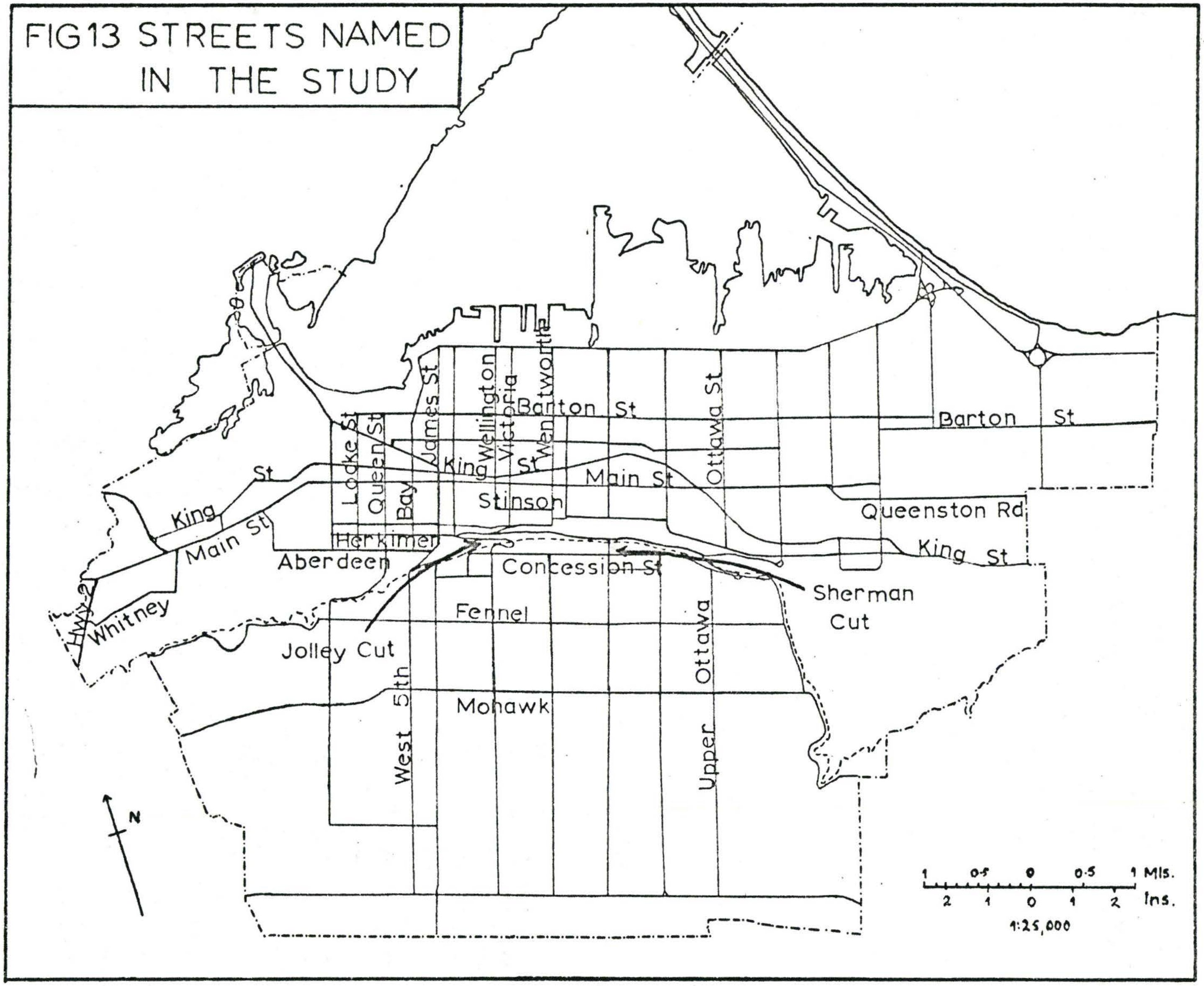
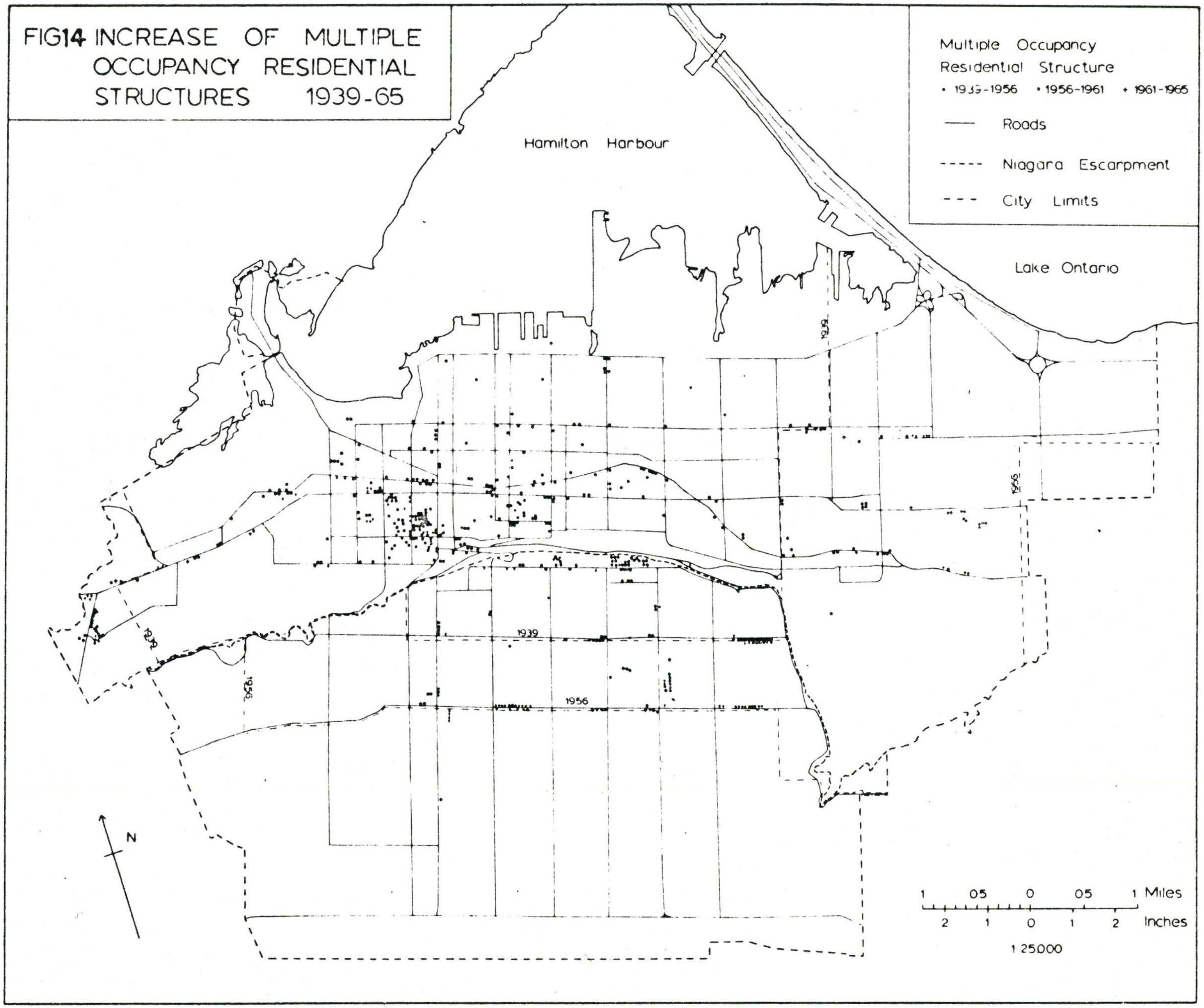


FIG 13 STREETS NAMED IN THE STUDY

FIG14 INCREASE OF MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES 1939-65



the development of multiple occupancy residential structures has been concentrated on the Mountain brow, on Fennel Avenue and Mohawk Avenue. On Mohawk Avenue in particular the structures are located at the intersection of Mohawk with major north-south streets.[7] Each of these three zones of development is separated by extensive areas of single family homes. Apart from the development along Mohawk Avenue, the other striking development has been in the East End, below the Escarpment. A major suburban cluster has developed at Queenston Road, while other developments have increased the importance of Barton Street as a strong linear element in the total city pattern. Fig. 14 shows that there has again been little development in the older parts of the city; the exception to this is in the cluster southwest of the central area which, as in 1961, contains a number of new structures, thus emphasising its importance in the total spatial pattern.

The present spatial pattern, with a total of 759 structures, is not dissimilar from that noted in other North American cities. It exhibits the characteristic central or marginal-central concentration; in Hamilton, this concentration is bi-polar with a cluster to the southwest of the commercial core and another cluster to the east. There are well developed linear elements along 'business' streets leading to the C.B.D., such as King Street and Main Street. Linear elements of the pattern occur elsewhere in the city, on Barton Street, Ottawa Street, Victoria, and Locke and also along Fennel Avenue and Mohawk Avenue. Then, in the East and West End and on the Mountain, clusters have developed, especially at major street intersections or at the periphery of the built up areas. Also, amongst these major locational elements, there is an uneven scatter of isolated developments, including single structures and small groups of structures. This completes the general spatial pattern in the city.

Although there has been a considerable areal spread of multiple occupancy residential structures in Hamilton over the period 1939-65, certain features have been evident at each of the four time periods. As well as development occurring in areas that previously had no multiple occupancy residential structures, there has also been an intensification of development in areas where these structures were in existence by 1939. As a measure of these movements in space, the arithmetic mean centre of the spatial pattern at the four time periods was calculated and mapped (Fig. 15). There has been little movement of the centre.[8] The movement southward of the centre reflects the developments of multiple occupancy residential structures that have occurred on the Mountain. The swing towards the east, evident since 1956, can be attributed in part to these eastern developments along Barton Street, Queenston Road and King Street; also, it is the eastern section of the Mountain that has experienced this type of residential development, there being no structures of this type west of West 5th Street. The continuing central location of the arithmetic mean centre illustrates the fairly even development that has occurred in both the East and West End together with continuing central development; only the Northern district of the city has generally proved to be unattractive to developers of this form of housing.

Statistical Summary

The broad spatial movements of the multiple occupancy residential structures through time and the relative importance of districts within

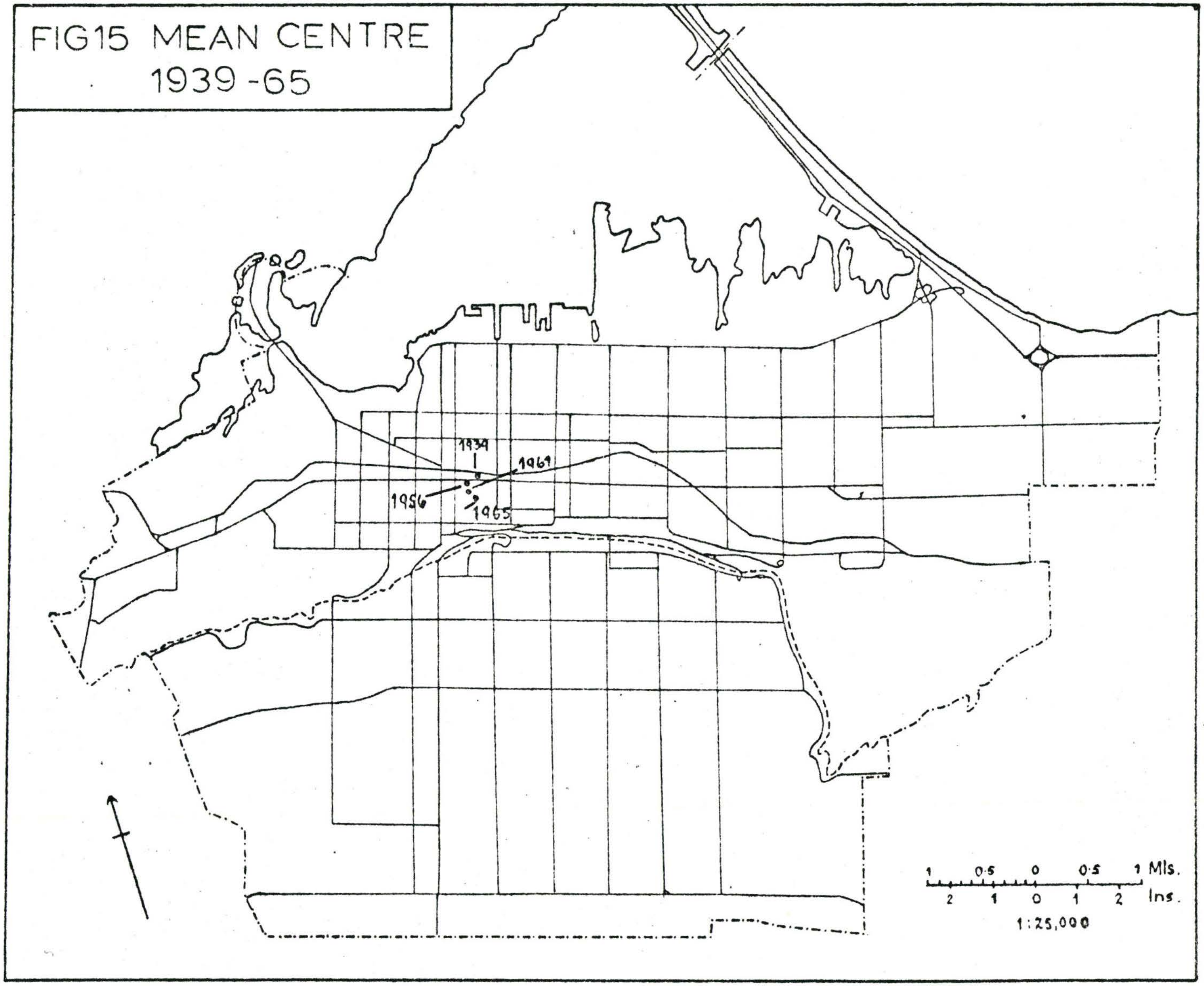


FIG15 MEAN CENTRE
1939 -65

the city to the total pattern can be summarised and expressed in a simple statistical manner. In the city as a whole, growth has been steady with an average increase of about 5% per annum over the study period (Table 2a). The city was divided into 7 districts (Fig. 16) and the rates of change and proportion of the total pattern by district were noted through time.[9] A clear difference emerges between the older districts of the city (that is, the Central, Northern, Mid-Town West and Mid-Town East districts) and those areas that are currently expanding at the margins of the built up area, or where development has been more recent (the West and East End and the Mountain) - (see Table 2b). These latter districts are the fastest growing in contrast to those parts of the city that are already built-over, where rates of increase are small and where a decline is evident in Northern district. In spite of having a growth rate below that of the city as a whole, Central district dominates the spatial pattern in terms of number of structures and proportion of citywide totals achieving first ranking at all four time periods. The Mountain district showed the most significant increase in this respect, moving from Rank 7 in 1939 to Rank 2 in 1965; other districts moved only slightly, but there was a marked downward displacement in ranking for Mid-Town West. Generally, the older sections of the city have more structures and a greater proportion of structures than the new districts, but this difference is now less pronounced than it was.

So far in this description, each structure has been treated as if it had a value or weight equal to that of any other structure. This is unrealistic. The number of units in a structure is an important factor that modifies the description. For the relevant range in Hamilton

FIG16 DISTRICTS USED IN THE STUDY

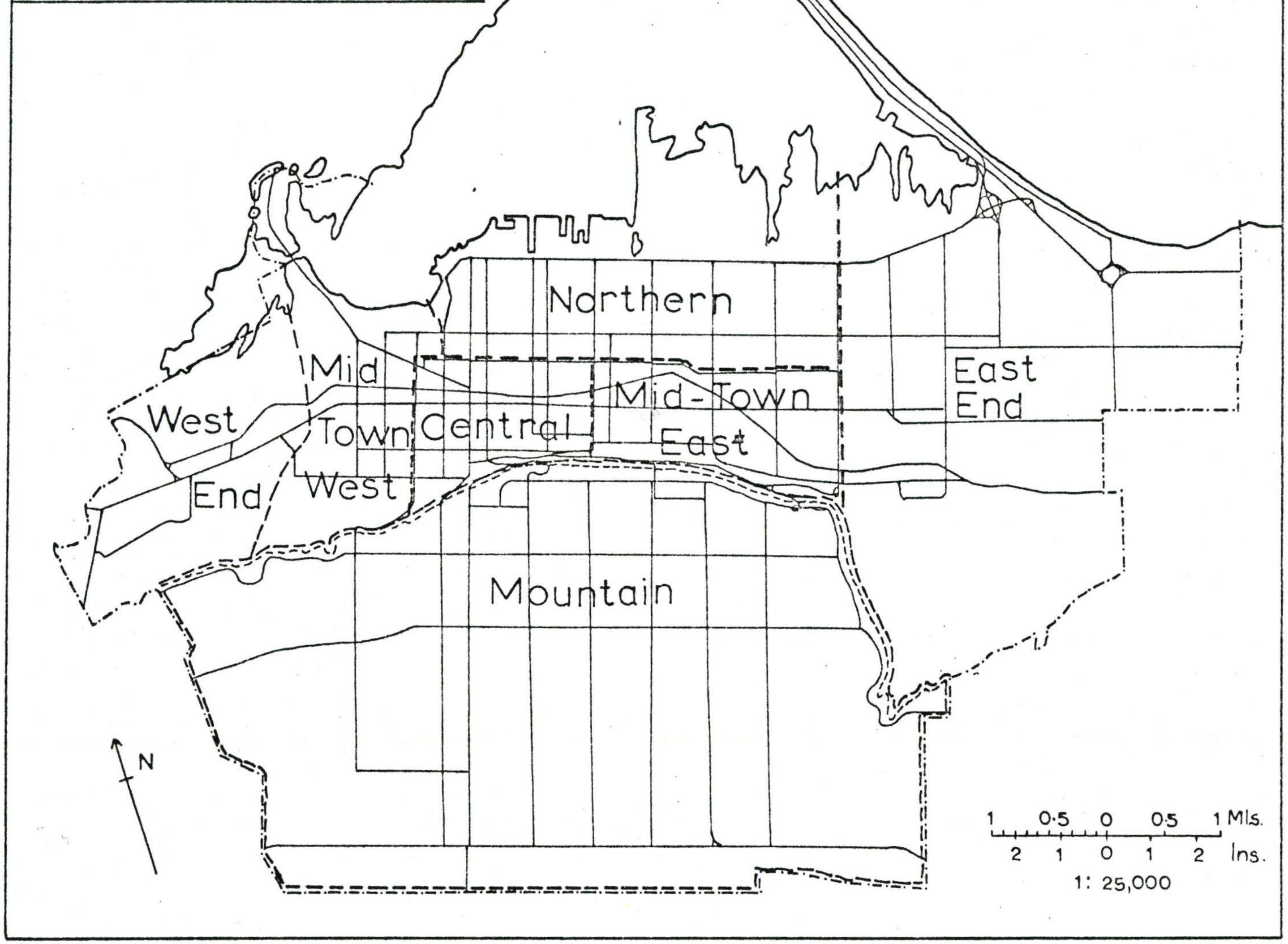


TABLE 2(a)

Rates of change in Total number of Multiple Occupancy

Residential Structures, Hamilton, 1939-65

Year	Number of Structures	% Change	Time span (in years)	Average % rate of change/yr.
1939	276			
		+84.05	17	+4.94
1956	508			
		+26.37	5	+5.27
1961	642			
		+18.07	4	+4.52
1965	759			

TABLE 2(b)

Average % rate of change per annum by districts

Hamilton, 1939-65

	(a) 1939 - 1956	(b) 1956 - 1961	(c) 1961 - 1964/5
Central	+4.82	+2.14	+1.30
Mid-Town West	+11.76	+1.11	+5.92
Mid-Town East	+0.15	+0.35	0
Northern	+3.75	+1.69	-0.78
West End	+14.11	+23.52	+9.46
East End	+88.23	+15.00	+20.53
Mountain	+152.94	+46.92	+15.86

TABLE 3

Distribution of Multiple Occupancy Residential

Structures by district, Hamilton, 1939-65

	1939	Rank	1956	Rank	1961	Rank	1964/5	Rank
Central	133	1	242	1	268	1	282	1
Mid-Town West	12	4	36	4	38	5	47	7
Mid-Town East	89	2	112	2	114	2	114	3
Northern	36	3	59	3	64	4	62	4
West End	5	5	17	6	37	6	51	5
East End	1	6	16	7	28	7	51	5
Mountain	0	7	26	5	93	3	152	2
	276		508		642		759	

see Fig. 17. By examining the rates of change and the proportional distribution of units by district, some of the preceeding statements on broad spatial trends can be qualified (see Tables 5a-7). For instance, the first rank position of the Central district is challenged more strongly by the Mountain district when their respective amounts of the city totals of units in multiple occupancy residential structures are compared. Further, the more recently developed and currently developing districts of the East and West End now show more appreciable increases in ranking from 1939 to 1965, both in absolute numbers of units and in the proportion of the total number of units in the city. The older districts show a decline in ranking on these two counts (excepting the Central district) compared with their equivalent rankings when structures were not distinguished on the basis of number of units.

These broad patterns are confirmed for 1965 by an examination of Fig. 18, which shows the location of multiple occupancy residential structures classified on the basis of number of residential units contained therein. The structures containing a small number of units occur more frequently in the older sections of the city - in the Central district, especially in Stinsondale, along King Street East, Main Street East and Ottawa Street North and also in the Northern district. Although small structures do exist in the newer areas, they do not represent such a large proportion of the total number of structures.[10] Large structures, with sixty or more units are found in the Central district, particularly in the large concentration south and west of the C.B.D., and also along major city streets in the more recently developed areas e.g. Mohawk Avenue, Highway 2 and Queenston Road. Interestingly, only two con-

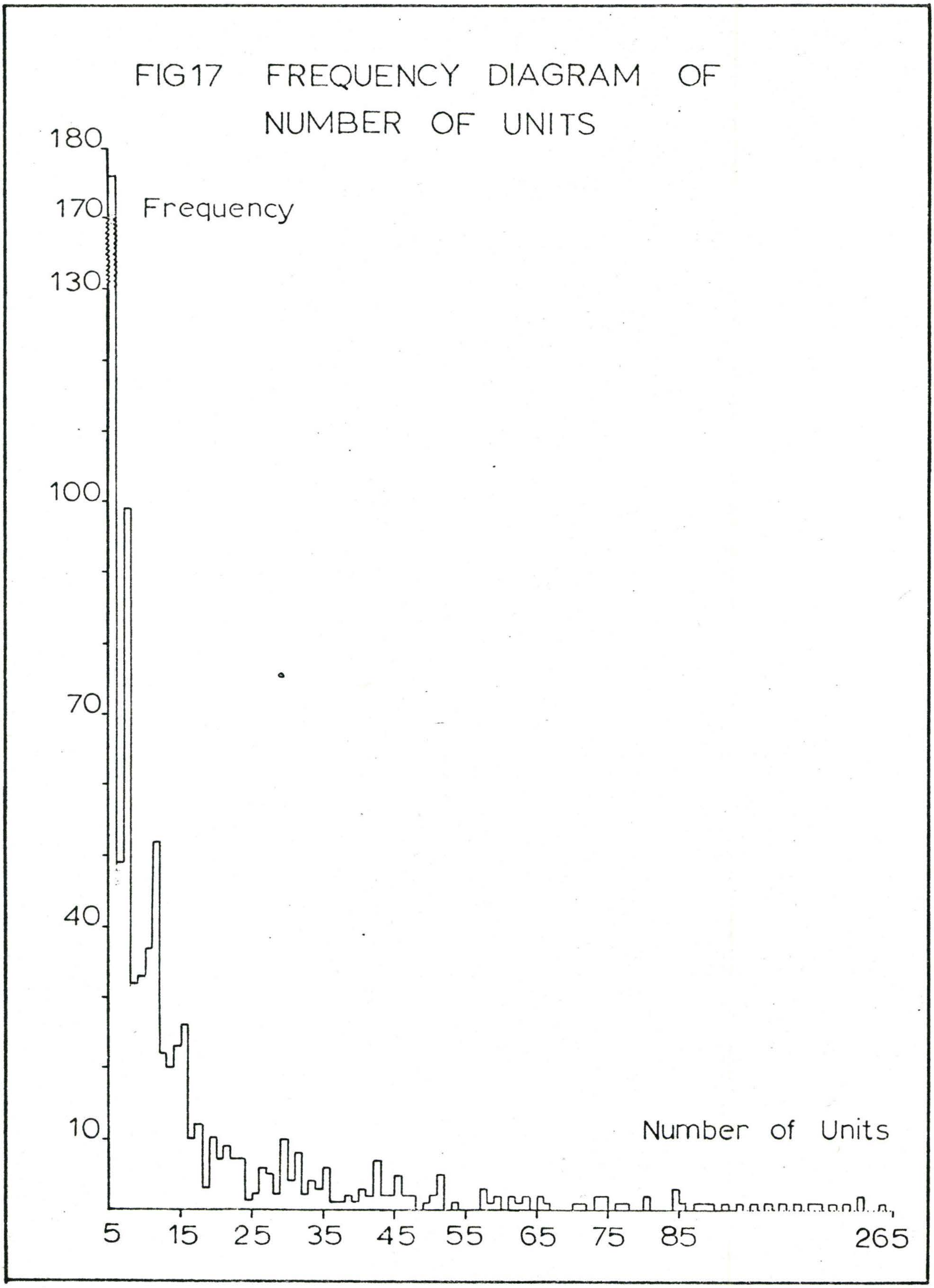


FIG 17 FREQUENCY DIAGRAM OF NUMBER OF UNITS
Frequency
180
170
130
100
70
40
10
Number of Units
5
15
25
35
45
55
65
75
85
265

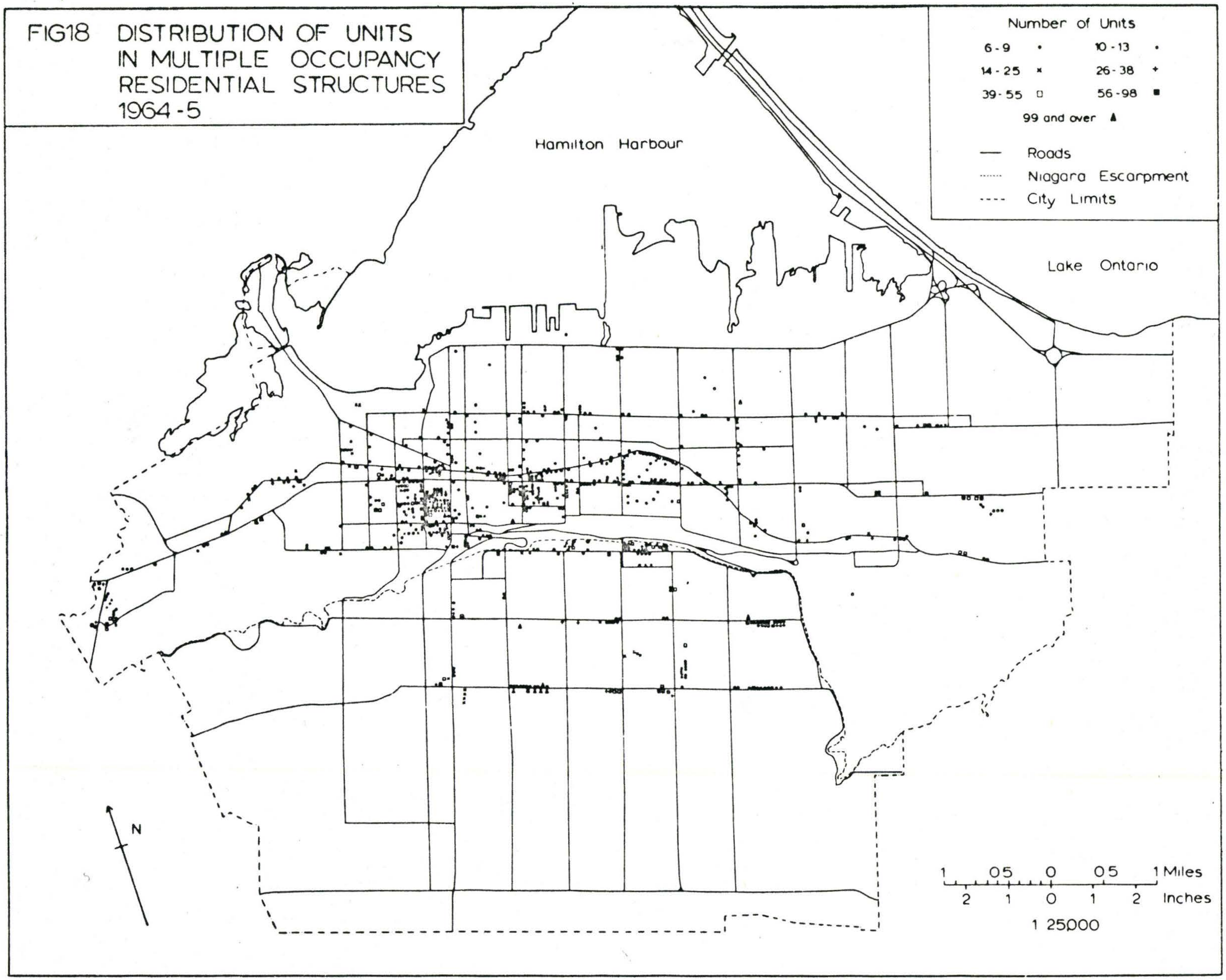


FIG18 DISTRIBUTION OF UNITS IN MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES 1964-5

TABLE 4

Proportion of total distribution by district,
Hamilton, 1939-1965

	1939	Rank	1956	Rank	1961	Rank	1964/5	Rank
Central	48.18	1	47.63	1	41.74	1	37.15	1
Mid-Town East	32.24	2	22.04	2	17.75	2	15.01	3
Northern	13.04	3	11.61	3	9.96	4	8.16	4
Mid-Town West	4.34	4	7.08	4	5.91	5	6.19	7
West End	1.81	5	5.11	6	5.76	6	6.71	5
East End	0.36	6	3.34	7	4.36	7	6.71	5
Mountain	0.00	7	3.14	5	14.48	3	20.02	2
	100.00		100.00		100.00		100.00	

TABLE 5(A)

Rates of change in total number of Units in
Multiple Occupancy Residential Structures,
Hamilton, 1939-1965

Year	Number of Units	% Change	Time span (in years)	Average % rate of change per year
1939	3,122			
		+97.21	17	+5.71
1956	6,157			
		+44.25	5	+8.85
1961	8,882			
		+62.93	4	+15.73
1965	14,472			

TABLE 5(B)

Average % rate of change per annum by district,
Hamilton, 1939-1965

	1939-1956	1956-1961	1961-1964/5
Central	5.70	3.64	7.20
Mid-Town West	15.76	2.42	19.58
Mid-Town East	1.23	0.69	0.91
Northern	3.03	9.25	0.63
West End	13.25	43.41	36.76
East End	66.17	11.63	62.17
Mountain	2,847.05	52.14	3.60

TABLE 6

Distribution of units in Multiple Occupancy Residential Structures by district, Hamilton, 1939-1965

	1939	Rank	1956	Rank	1961	Rank	1964/5	Rank
Central	1622	1	3195	1	3777	1	4865	1
Mid-Town East	983	2	1190	2	1231	3	1276	4
Northern	335	3	508	3	743	4	724	7
Mid-Town West	103	4	379	5	425	6	758	6
West End	63	5	205	6	650	5	1506	4
East End	16	6	196	7	310	7	1081	5
Mountain	0	7	484	4	1746	2	4262	2

TABLE 7

Proportion of total distribution of units in Multiple Occupancy Residential Structures by district, Hamilton, 1939-1965

	1939	Rank	1956	Rank	1961	Rank	1964/5	Rank
Central	51.95	1	51.89	1	42.52	1	33.61	1
Mid-Town East	31.48	2	19.32	2	13.85	3	8.81	4
Northern	10.73	3	8.25	3	8.36	4	5.00	7
Mid-Town West	3.29	4	6.15	5	4.78	6	5.23	6
West End	2.01	5	3.32	6	7.31	5	10.40	3
East End	0.51	6	3.18	7	3.49	7	7.46	5
Mountain	0.00	7	7.86	4	19.65	2	29.44	2
	100.00		100.00		100.00		100.00	

centrations in the city exhibit the complete range of size classes and these are (1) the central concentration southwest of the commercial core and (2) the linear development on Fennel Avenue east of Upper Ottawa Street.[11]

To summarise, a major distinction can be made between multiple occupancy residential structures in the older districts of the city and in districts that are currently expanding or have just undergone recent expansion. These older districts exhibit slower rates of increase and are characterised by large absolute numbers of structures which generally contain only a small to medium number of units. The newer districts are growing most rapidly and although they rank low in number of structures, these structures are generally larger than in the older districts and thus, these newer districts now provide nearly half of the units of this type in the city. This contrasts noticeably with the earlier time periods, when the older districts dominated the city wide picture.

The primacy of the Central district stands out clearly from these statistics and diagrams. The Central district is, however, less characteristic of the general description of the older districts that has been outlined. As mentioned earlier, the Central district structures are grouped in two main clusters and it is clear from an examination of the diagrams that these two clusters are very different in character. The maps of the different time periods (Fig. 8-11 and also Fig. 14) show that the development which has occurred in the Central district took place in the cluster to the south and west of the central commercial core, while, on the other hand, there has only been a small amount of growth in the Stinsondale cluster. An examination of Fig. 18 also shows that the structures in the Stinsondale cluster are in the small to medium range with respect to the number of units, while the other concentration exhibits a complete range with a number of very large modern structures. Therefore, although the Stinsondale cluster structures are marginal to the commercial core and frame (as defined), and are thus encompassed within the Central district, this cluster is more similar (in character) to the Mid-Town East district structures. This distinction between the two principal central clusters is less noticeable in the earlier time periods, but the scale and nature of the developments through 1961 and 1965 have served to emphasise the difference. Thus, this central cluster south and west of the commercial core is not characteristic of the general description of the older developed districts. However, the other groupings in the Central district are more similar to that description.

Tests of the Hypotheses on Subsets

Three hypotheses were erected concerning the location in 1965 of the subsets of the total multiple occupancy residential structure population that were identified in the Research Design. These hypotheses were

(1) that structures containing both commercial and residential units would be located along major city streets and at major street intersections;

(2) that 'high-rise' structures would be located in the central area or in a marginal position to it; and

(3) that structures containing six or more units formed by conversion

of a single family home would be located in the older sections of the city and particularly in the area of large, 'well-to-do' homes of the time.

A visual test of these hypotheses is provided by Figs. 19-21. Fig. 19 shows the location of those structures containing both commercial and residential units. The major city streets were identified on the same basis as that employed in the multiple regression analysis (see Chapter III). Out of 117 structures exhibiting this mixture of use, only five were not located on major city streets and of these, three were within one city block of a major city street. This provides substantial confirmation of the first hypothesis. As might be expected, there is a heavy concentration of this type of development in the commercial core area where residential use occurs on the upper storeys of structures which have the lower floors utilised by retail establishments. Generally, this subset is found in the older areas of the city and, as suggested previously, has not been evident in recent developments. Two anomalous examples can be found, however, on Whitney Avenue, where retail establishments occur on the ground floor of modern structures. The Mountain district is one where many of the retail establishments are grouped in integrated, planned shopping centres (except on Concession Street) and the effect this type of development has had on this particular subset is strikingly clear (see Fig. 19).

The 1965 location of 'high-rise' structures is shown in Fig. 20. Since 5 out of 13 'high-rise' buildings are not located in the central area, it is clear that this second hypothesis cannot be confirmed.[12]

FIG19 STRUCTURES WITH MIXED USES

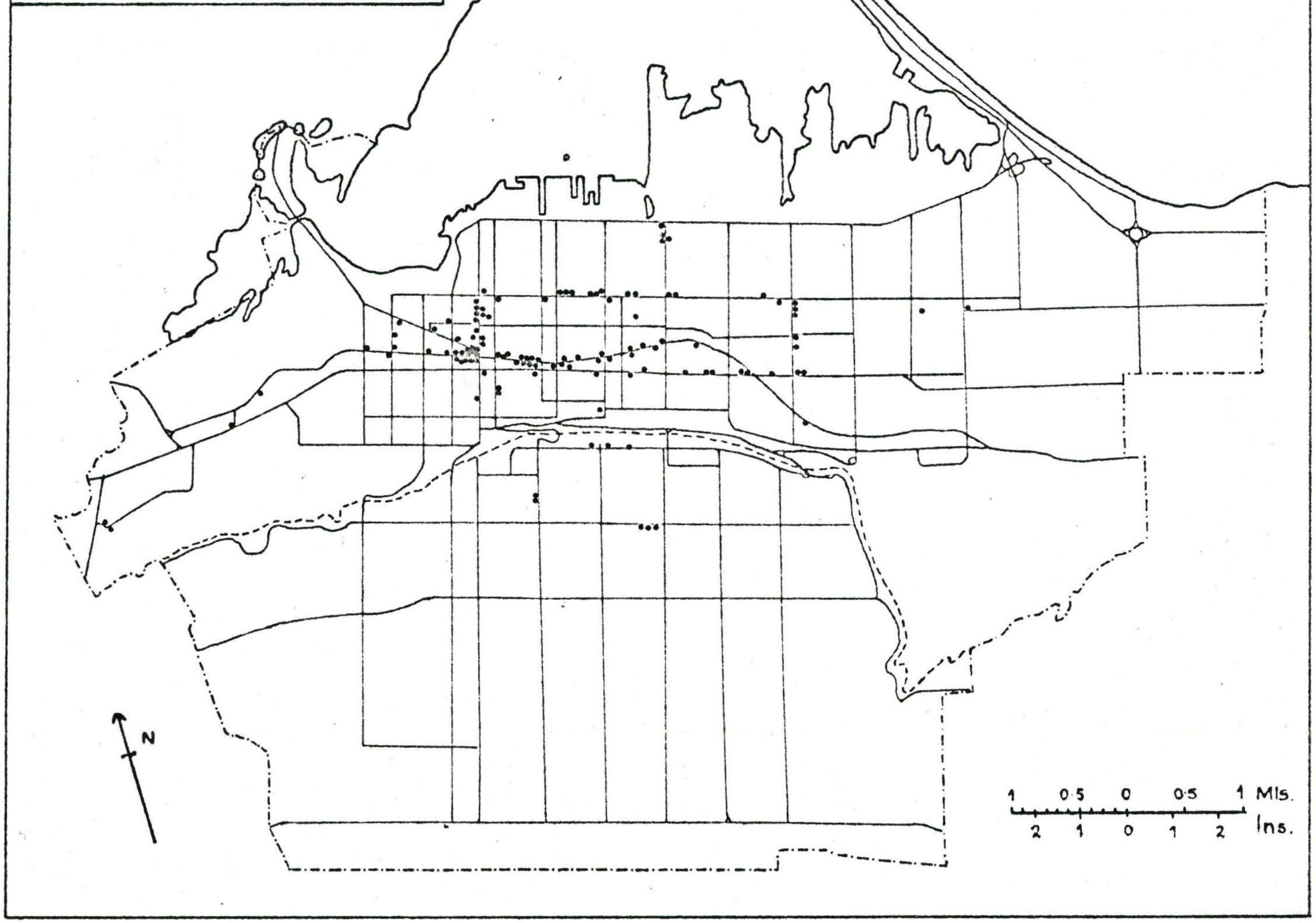
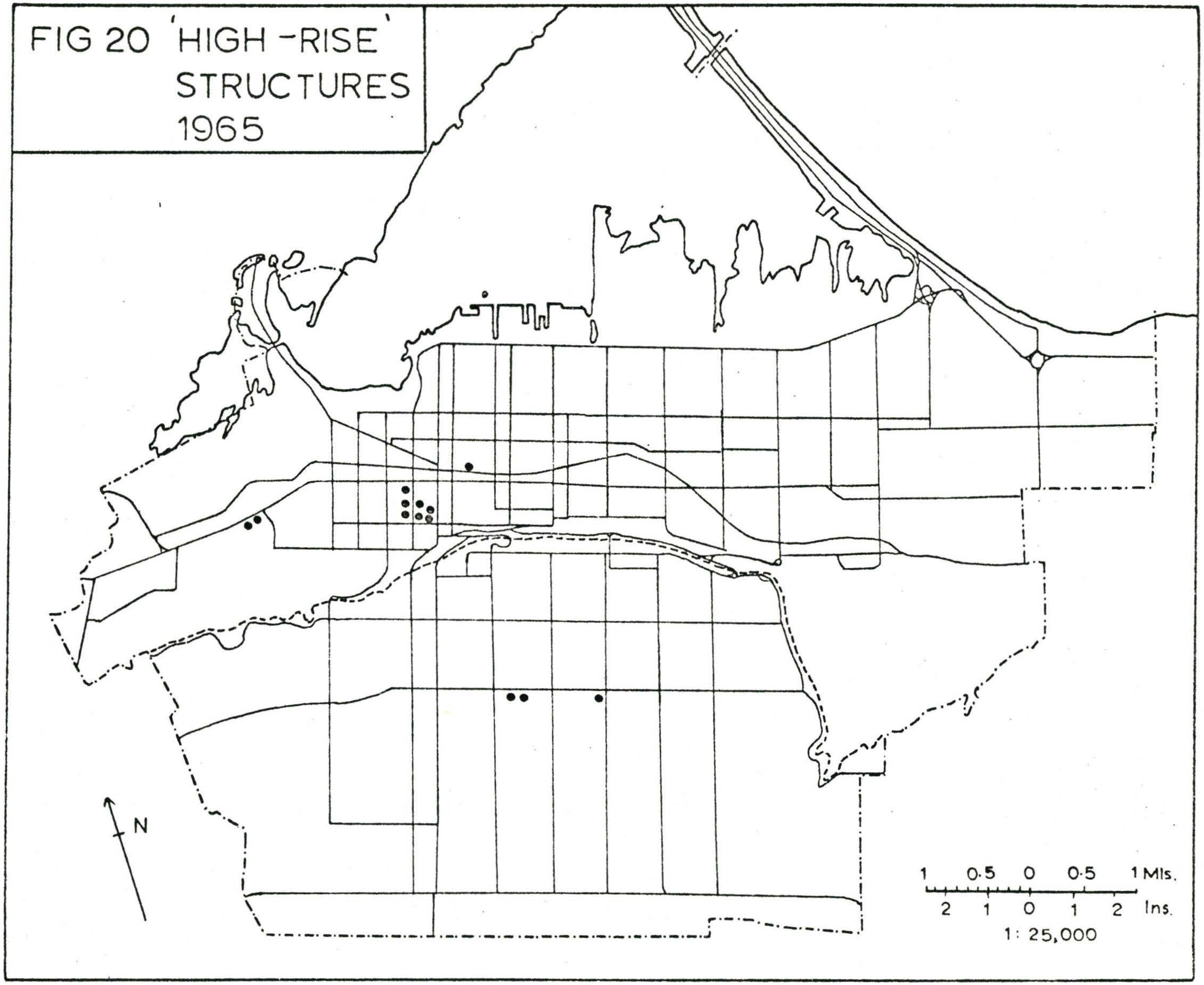


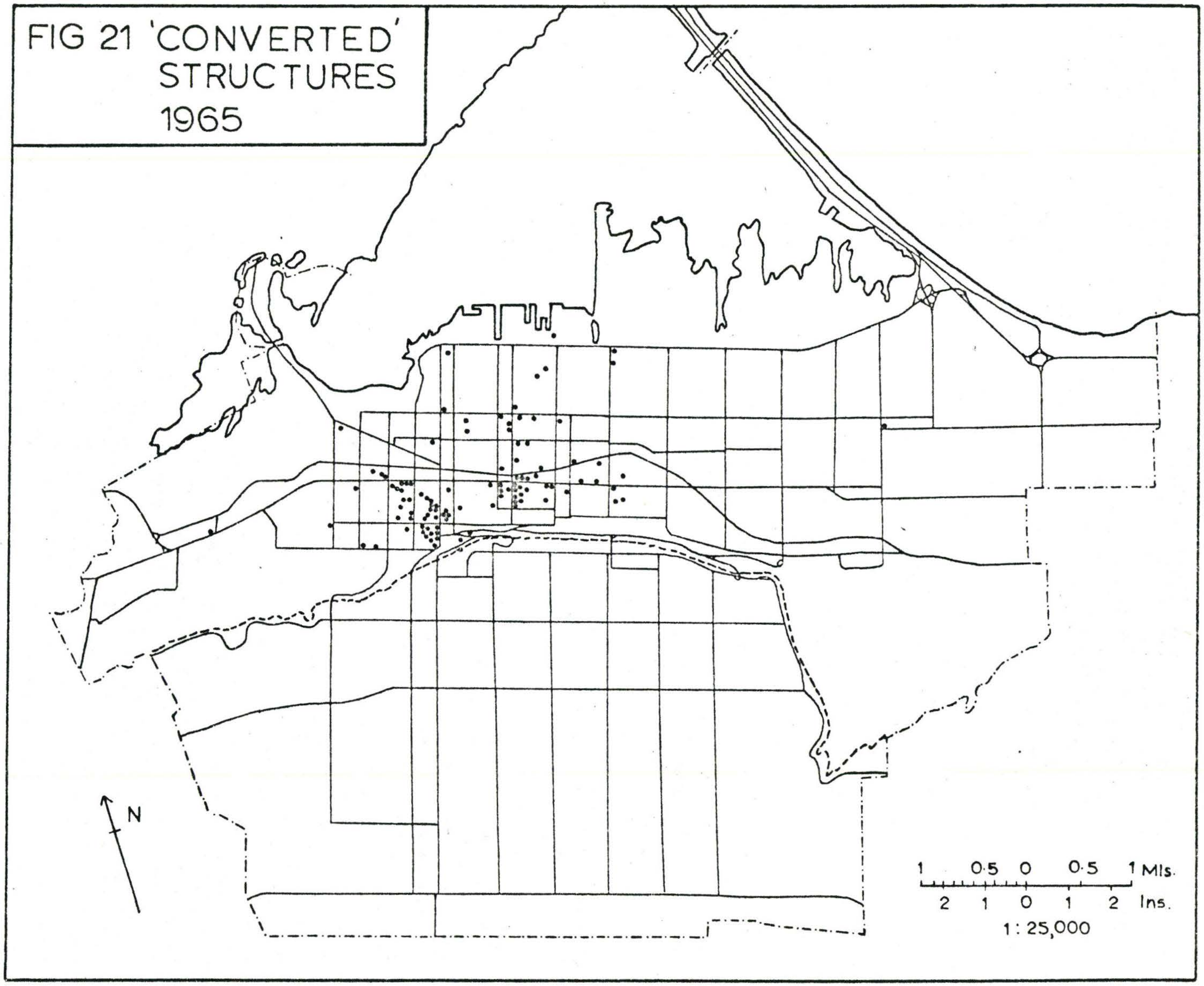
FIG 20 'HIGH-RISE' STRUCTURES 1965



This suggests that the argument that multi-storied development is a response to high central land values does not completely apply to residential use. It should be noted that the non-central 'high-rise' structures are located on major city streets and, further, the western development of Camelot Towers enjoys excellent access to a major inter-urban expressway and an attractive site. The developments on Mohawk Avenue also have spacious views of sparsely developed land to the south, but this will only be for a limited period due to proposed residential expansion in this area of the city.

Fig. 21 shows the location of the 'converted' structures. Apart from one isolated case on Main Street West, all the 'converted' structures are in that part of the city that was incorporated by 1910 and the bulk of the distribution is within the 1891 city boundary.[13] It is possible therefore, to accept that part of the third hypothesis concerning the relationship of such structures with the older nineteenth century part of an urban area. However, it is doubtful if that part of the hypothesis which suggests that this conversion occurs particularly in the wealthier area of that period can be accepted. While it is true that there are a large number of 'converted' structures in the area bounded by Aberdeen, Bay, Main and James in what was a fashionable area of the city, there are also a considerable number of converted structures in Stinsondale and a scatter of structures in the Northern section of the 1891 city. These are by no means fashionable areas, in comparison with the other area, (although some of the converted structures in Stinsondale are substantial mansion houses) and the amount of conversion in these areas suggests that the wealthier area

FIG 21 'CONVERTED' STRUCTURES 1965



with the larger homes is not the sole area liable to 'conversion'. What is likely, however, is that the resultant dwelling units in these less fashionable areas are of lower quality than those in the wealthier section.

These tests of the three hypotheses have resulted in further description which augments that achieved in the earlier section of this chapter. As set out in the Research Design, using the technique of filter mapping, an attempt was made to identify the critical level of scale at which local factors no longer have an effect on the spatial pattern of multiple occupancy residential structures. Filter mapping has been employed in geographic research by Haggett and this approach is followed here.[14] The analysis began with the construction of a square grid with a cell size of 0.5 miles square to cover the study area of the City of Hamilton. This grid which contained 408 cells was constructed with respect to the same reference points that had been used in a study carried out by the McMaster Department of Geography of the urban climate of Hamilton. This basic grid, which represents Matrix 1 of the analysis, together with the number of occurrences of multiple occupancy residential structures in a cell is shown in Fig. 22. 408 control points are created by assigning the values that occur in a cell for the number of structures in that cell to the centre of the cell:

5	0

5.	0.

These values range from 0 to 112 (see Fig. 22).

The technique of filter mapping involves the creation of a number of matrices of the same order as Matrix 1, but with different

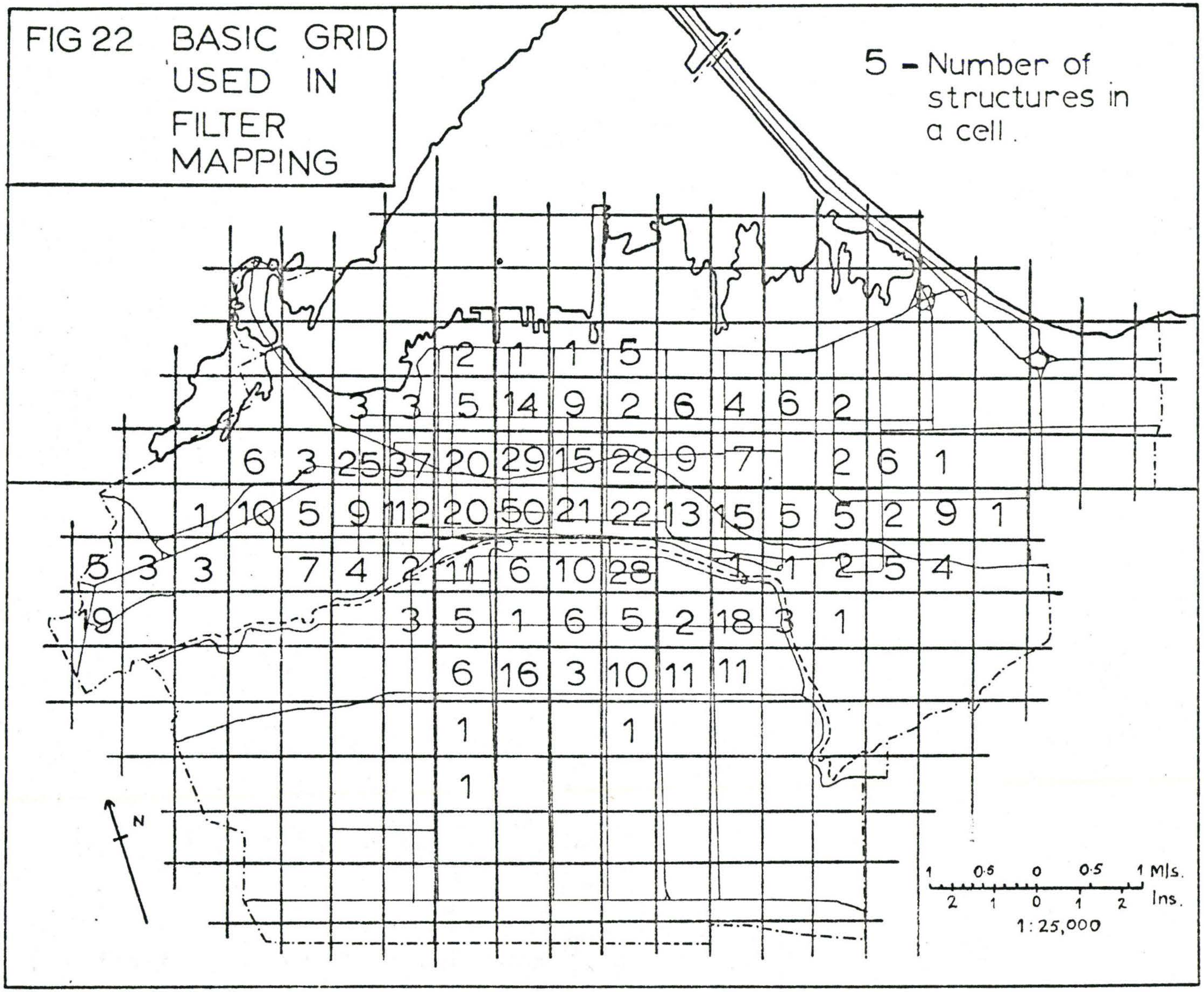


FIG 22 BASIC GRID USED IN FILTER MAPPING

scales. These other matrices are composed of overlapping cells centred on the control points, but these cells are of increased dimensions. Thus, Matrix 2 is made up of 408 cells, which are of a size 1.5 miles square (based on 9 cells in Matrix 1 - see Fig. 22a). The values assigned to the control points in Matrix 2 are the average values taken over the 9 cells that underlie the new cell. The difference between the value of the control points in Matrix 2 and their value in Matrix 1, that results when Matrix 1 is subtracted from Matrix 2, yields a pattern of positive and negative values (a trend surface). Positive values are the consequence of local values (Matrix 1) exceeding regional values (Matrix 2) and negative values are where regional values exceed local values:

1	4	6
0	18	0
2	1	0

Sum of cell values (Matrix 1) 32

Average value assigned to cell (Matrix 2) 3.5

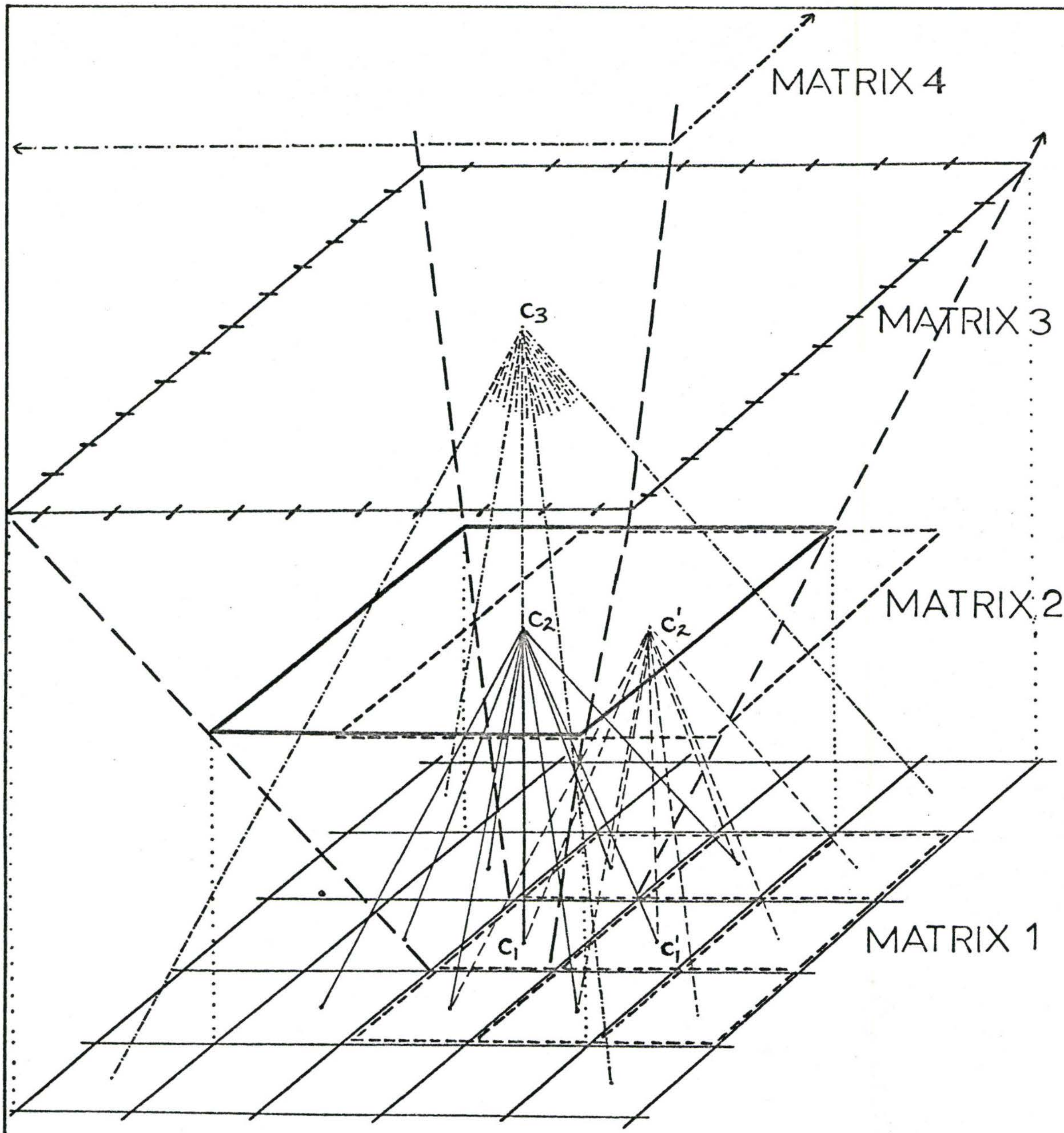
This value is assigned to the control point of the centre cell; therefore, 3.5 overlies 18 (C_2 and C_1 of Fig. 22a) giving a difference of 14.5. Since the local value exceeds the regional value, this is a positive residual.

4	3	1
6	3	4
8	9	10

Sum of cell values (Matrix 1) 48

Average value assigned to cell (Matrix 2) 5.3

Since this value is assigned to the control point of the centre cell, 5.3 overlies 3 giving a difference of 2.3. In this case there is a negative residual.



The composition of a cell in Matrix 2 is shown overlying 9 cells in Matrix 1. The linkage of the 9 cells to C_2 is shown since C_2 is the sum of the values in the linked cells divided by 9. $C_2 - C_1$ is the difference between Matrix 1 and Matrix 2. The overlapping nature of the cells is illustrated with reference to C_1' and C_2'. A cell in Matrix 3 overlies 25 cells in Matrix 1 and linkages and the value of C_3 can be established in a similar manner.

FIG22a CHANGE OF SCALE IN FILTER MAPPING.

This process of matrix building and creation of trend surfaces can continue until the cell size centred on a control point is the same size as the study area.

The present analysis was not carried out to that extent, partly because of computational problems and, more importantly, because it was felt that the use of cells removed an element of flexibility from the scale changes. The size of the cell in Matrix 1 determines the amount of change that is possible. An attempt was made, however, to measure the amount of variation in the distribution of structures that could be explained by using different levels of scale of analysis. This analysis was set in a framework of analysis of variance, using sums of squares. Four matrices of the order described were constructed (including the initial grid) and the amount of variation explained as a result of these scale changes calculated.

Y_{11}	Y_{12}	Y_{13}	Y_{14}	Y_{15}	. . . .	Y_{124}
Y_{21}	Y_{22}	Y_{23}	Y_{24}	Y_{25}		
Y_{31}	Y_{32}	Y_{33}	Y_{34}	Y_{35}		
Y_{41}	Y_{42}	Y_{43}	Y_{44}	Y_{45}		
Y_{51}	Y_{52}	Y_{53}	Y_{54}	Y_{55}		
.						
.						
.						
.						
Y_{171}						

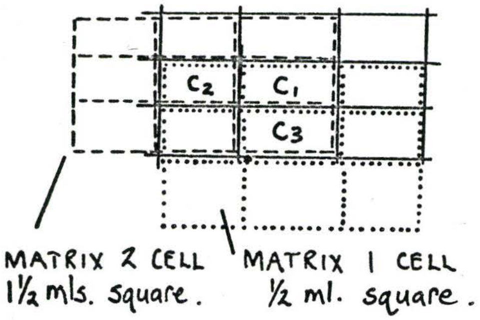
This is a section of Matrix 1, which has 24 columns and 17 rows. Y_{11}, Y_{12} ... etc represent the number of occurrences of multiple occupancy residential structures in a cell.

As is evident in Fig. 22a, Matrix 2 is composed of overlapping cells each of which is underlain by a set of 9 cells in Matrix 1. Taking the accentuated section in this case, it is clear that the cell Y_{34} is at the centre of a cell in Matrix 2 based on these 9 cells. Thus for this particular Matrix 2 cell the value to be assigned is

$(Y_{23} + Y_{24} + Y_{25} \cdot \cdot \cdot \cdot \cdot Y_{45})$ 9. This term will be called $\bar{Y}A_{34}$ and is C_2 of Fig. 22a.

$$\bar{Y}A_{34} = (Y_{23} + Y_{24} + Y_{25} \cdot \cdot \cdot \cdot \cdot Y_{45}) \quad 9 \qquad (1)$$

To obtain the difference between Matrix 1 and Matrix 2, we have $(\bar{Y}A_{34} - Y_{34})$. Similarily, there is a value $(\bar{Y}A_{23} - Y_{23})$ and so on. Since the control point in every cell in Matrix 1 underlies a control point in Matrix 2, there exists a value $(Yij - \bar{Y}Aij)$ for every control point.



The overlapping nature of the cells in Matrix 2 is shown here and this also illustrates how each cell in Matrix 1 is at the centre of a Matrix 2 cell.

The square of this difference $(Yij - \bar{Y}Aij)$ can be summed across the trend surface which is made up of these differences (the pattern of positive and negative residuals) to give the within sum of squares.

$$\text{Within sum of squares} = \Sigma(Yij - \bar{Y}Aij)^2 \qquad (2)$$

This is a measure of the deviations of the individual cells in Matrix 1 from the cell mean, which is the value assigned to the cell in Matrix 2.

Similarily, when Matrix 3 is considered, the same technique is followed, but in this case, the cells in Matrix 3 overlie 25 cells in Matrix 1 (see again Fig. 20a). Following the argument set out above, it is evident that there exists another value $(Yij - YBij)$ where $\bar{Y}Bij$ is the average value of the 25 cells underlying some cell in Matrix 3, centred on a control point in a cell Yij. Again if the square of this difference is summed across the trend surface, a value for the within sum of squares is obtained.

$$\text{Within sum of squares} = \Sigma(Yij - YBij)^2 \quad . \; . \; . \; . \; . \quad (3)$$

This process can be repeated for the fourth matrix.

The within sum of squares can be regarded as representing unexplained variation.[16] Therefore, the explained variation can be represented by 1 - the within sum of squares, (where 1 is equivalent to total explanation of variation). The percentage variation explained by change of scale can be calculated from the expression

$$1 - \frac{\text{within sum of squares (Scale 2)}}{\text{within sum of squares (Scale 1)}} \times 100 \qquad \text{or}$$

$$1 - \frac{\Sigma(Yij - YBij)^2}{\Sigma(Yij - YAij)^2} .100 \qquad \text{(see (2) and (3))}$$

Following this method, it was found that, with change of scale, the percentage of explained variation decreased from 59.62%, through 37.65%, to 34.57%. The decline from 59.62% to 37.65% suggests that many of the local factors causing variation from the regional trend were "filtered out" in the first scale change.

This particular analysis is very much exploratory in nature; certainly, the results confirm the importance of understanding the effects of scale in locational analysis. It is demonstrated here that the amount of variation detected in a distribution is a function of the level of scale of the analysis. One avenue of research might be the substitution of some form of grouping analysis to replace analysis by cell. If, in a spatial pattern, definite groups could be identified, then it would be possible to locate the mean centre of the group and express the difference in terms of distance from the "real" point to the mean centre of the group. This would serve to measure the variation at that level of scale. As with the cell analysis, this could be taken to a level of scale where only one mean centre would exist for the whole distribution and the 'real' points related to this one centre. It is possible that this approach may achieve some of the flexibility that is lacking in the analysis by cell.

The description of the spatial pattern in Hamilton is continued in Chapter V, where the use of density gradients provides a more precise description than some of the general methods used in this chapter. Particular attention is paid to the intensity of the spatial pattern as expressed in these gradients.

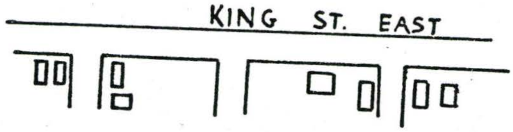
FOOTNOTES - CHAPTER IV

1. For the extent of the central commercial area and the Central Business District, as defined by J. FRIAR, op. cit. (see Fig. 12). This study by Friar provided an exact areal definition of the C.B.D. and the frame area. While other definitions would create different areas, it is doubtful if there would be considerable deviation from the areas defined by Friar.

2. See Fig. 13 for the location of all streets named in the study. James Street and King Street are the basic north-south, east-west streets in the city system and it is in relation to these two streets that a street is described as north, south, east or west, e.g. Queen Street South is that part of Queen Street south of King Street.

3. That part of the city above the Niagara Escarpment is known locally as 'the Mountain' and this term will be used in the text to identify this area.

4. The impression of continuous development of structures is largely due to the scale of the map on which these data are presented. The actual pattern is shown in this sketch.



5. The changes in the city limits indicate the direction of expansion (see Fig. 14).

6. The concentration to the southwest of the central commercial area is an exception to this generalisation.

7. The apartment structures on Mohawk Avenue have created considerable public reaction. The phrase, "apartment alley", has been used to describe Mohawk Avenue, chiefly by those in opposition to further multiple occupancy residential development on the Mountain. An interesting feature of these developments along Mohawk Avenue concerns lot sizes. As Fig. 9 shows, the city limits run south of Mohawk, parallel to the street, and this has resulted in the creation at some points of large lots between the street and the city boundary. These large lots were not suitable for single family development, but were suited to the development of multiple occupancy residential structures

since the existence of these lots reduces the task of land assembly for the developer, always a difficult part of the development process.

8. There is the possibility that this lack of movement may result from the use of those four particular years and that the use of data for some other four years might show greater amounts of movement.

9. The basis for the choice of these districts is set out in the Research Design (Chapter III).

10. For example in the Northern district, structures with 6-13 units represent 88% of the total number of units, but only 57% in the West End district.

11. A large scale development recently constructed (late 1965) has led to the creation of a third cluster, exhibiting a complete range as to size classes of units. This is the grouping on Highway 2.

12. Since the collection of the data for this study in June, 1965, eight "high-rise" structures have either been constructed or are presently under construction. Only two are centrally located; three are on Barton Street in the East End, two on Highway 2 and one on Fennel Avenue near its intersection with Upper James Street.

13. The source for these dates is the Annexation Map of the City of Hamilton provided by the City Engineer's Department.

14. HAGGETT, op. cit., pp. 269-270.

15. It was anticipated that the use of the same reference points for geographic studies concerning the City of Hamilton would facilitate comparison between such studies.

16. H.M. BLALOCK, Social Statistics, (New York: McGraw Hill, Inc., 1960), p. 247.

CHAPTER V

DENSITY GRADIENTS

Many of the distributions that the geographer has traditionally concerned himself with, such as population, economic phenomena and settlements have often been represented in a punctiform manner - the dot distribution map is a familiar example. It is possible to generalise this type of distribution into a continuous surface which can be represented as a three dimensional surface (c.f. terrain models).[1] The variations in these surfaces are brought about by the interaction of the forces which shape the distribution of the phenomena under consideration and tnese forces may be known or unknown. In examining these distributions represented in this somewhat unfamiliar fashion, the importance of slopes is immediately apparent. Since the slopes represent those parts of the surface where the effect of the interactions between the controlling factors is greatest, attention has been focussed on the slopes of density surfaces rather than on the more uniform parts of the surface where the effect of the interactions might well be represented by an approximation to a constant.[2]

Distributions in urban areas are clearly no different in their spatial nature from distributions of any phenomena over wider areas, and it is not surprising, therefore, that some geographers have chosen to investigate the density gradients or slopes of phenomena in urban areas. The stimulus from workers in fields other than Geography deserves recognition however. In a relatively little known paper, Burgess reported some results concerning the role of gradients in city growth. There, a gradient is defined as "the rate of change of a variable condition like poverty, or home ownership, or births or divorce, from the standpoint of its distribution over a given area."[3] This was only an exploratory paper, but avenues of research were suggested - "to derive mathematical formulae for these gradients in urban organisation and growth."[4]

The next researcher to employ density gradients was the economist Colin Clark.[5] Clark was surprised at the lack of quantitative investigation by geographers of urban population densities.[6] His paper has been described as, "a stimulating and fundamental contribution."[7] Clark set out two hypotheses which he claimed had general validity. These hypotheses postulated a decline in population density as distance from the central area increased and secondly, that, through time, the densities decline in the central areas and increase in the suburban areas, thus causing the density gradients to become less steep. From an analysis of thirty-six cities ranging from Los Angeles to Budapest over the period from 1801 to 1951, Clark found that urban population densities declined in a negative exponential fashion with increasing distance from the city centre. He expressed the relationship in the form of an equation

$$y = Ae^{-bx}$$

where y is the density of resident population in thousands per square mile

x is the distance in miles from the city centre

b is the density gradient,

and A is the central density (extrapolated).

The evidence presented also tended to support the hypothesis that the density gradients declined through time.

In spite of this fundamental contribution, urban geographers continued to neglect this method of analysis until recently.[8] A paper by Berry et. al. provides a comprehensive review of recent empirical research (including research by the junior authors) which has strengthened the regularity so clearly expressed by Clark. Berry and his co-authors also draw on recent work, in an attempt to provide a theoretical framework for the occurrence and form of the density gradient and also its behaviour through time.

Berry et. al. suggest that an explanation of the urban population density gradients can be found in the land use competition theories put forward by Alonso and Muth.[9, 10] Under these theories the most desirable locational property of urban sites is centrality, i.e. location at that area of the city which possesses maximum accessibility as a result of the convergence of transportation arteries. From each location in the urban area, there is derived to the user of the location a utility which can be represented by ability to pay for the site or location. This ability to pay declines as one moves away from the centre since transport costs are higher, thus yielding smaller net returns. The theory is advanced by the suggestion that resulting pattern of land use in an urban area is therefore determined by relative accessibility. The price of land decreases as distance from the central area increases and as a result, land inputs are lessened relative to other inputs and the intensity of land use diminishes, thus suggesting declining residential densities. Alonso showed that the amount of land consumed by a household (a function of the income of the household) increases with distance from the centre of the city. This suggests that, allowing for variations in the size of household, population densities will decline as distance from the centre increases. Under the particular model developed by Muth, net population density must decline in a negative exponential fashion with increasing distance from the city centre.

Working within the framework of this general theory, Muth also presents a multiple regression model of the factors believed to be important in explaining the differences in density gradients between cities - implicit in this belief is the notion that these factors must affect the form of the density gradients for them to explain the differences in that form between cities.

> "Only size of the Standard Metropolitan Area and proportion of manufacturing outside the central city clearly appeared to bear significant relationships to 'b' (the slope of the regression line), though per capita car registrations showed significant partial correlation and the signs of other factors such as median income indicated behaviour in the right direction."[11]

Barry et. al. extend Muth's work by postulating that the density gradient is a function of city size, shape, distortion and proportion of manufacturing outside the central city, but the results of the analysis under this framework have scarcely been conclusive.

It is somewhat surprising that, in these considerations of the form and differences in slope of density gradients, no attention has been directed to the amount or location of different types of housing in the urban area. It is clear that if the large population densities that exist in the central areas of cities were not partly accommodated in multiple occupancy residential structures, then these high population densities would of necessity be lowered, since the single family house or duplex structure cannot support such densities, other things being equal. It is argued here, therefore, that since population densities decline in a negative exponential fashion as distance from the city centre increases, it is expected that the density of multiple occupancy residential structures will also decline in this manner as distance from the city centre increases.[12]

In this study, it was decided to examine two hypotheses concerning density gradients for multiple occupancy residential structures. It was hypothesised that the gradients for the structures, and also the number of units, would have a form similar to that of the regularities obtained for urban population densities, i.e. a negative exponential form. It was also hypothesised that these density gradients would vary through time in a similar fashion as the urban population density gradients, i.e. they would become less steep through time and there would be a downward displacement with the decline in central densities.

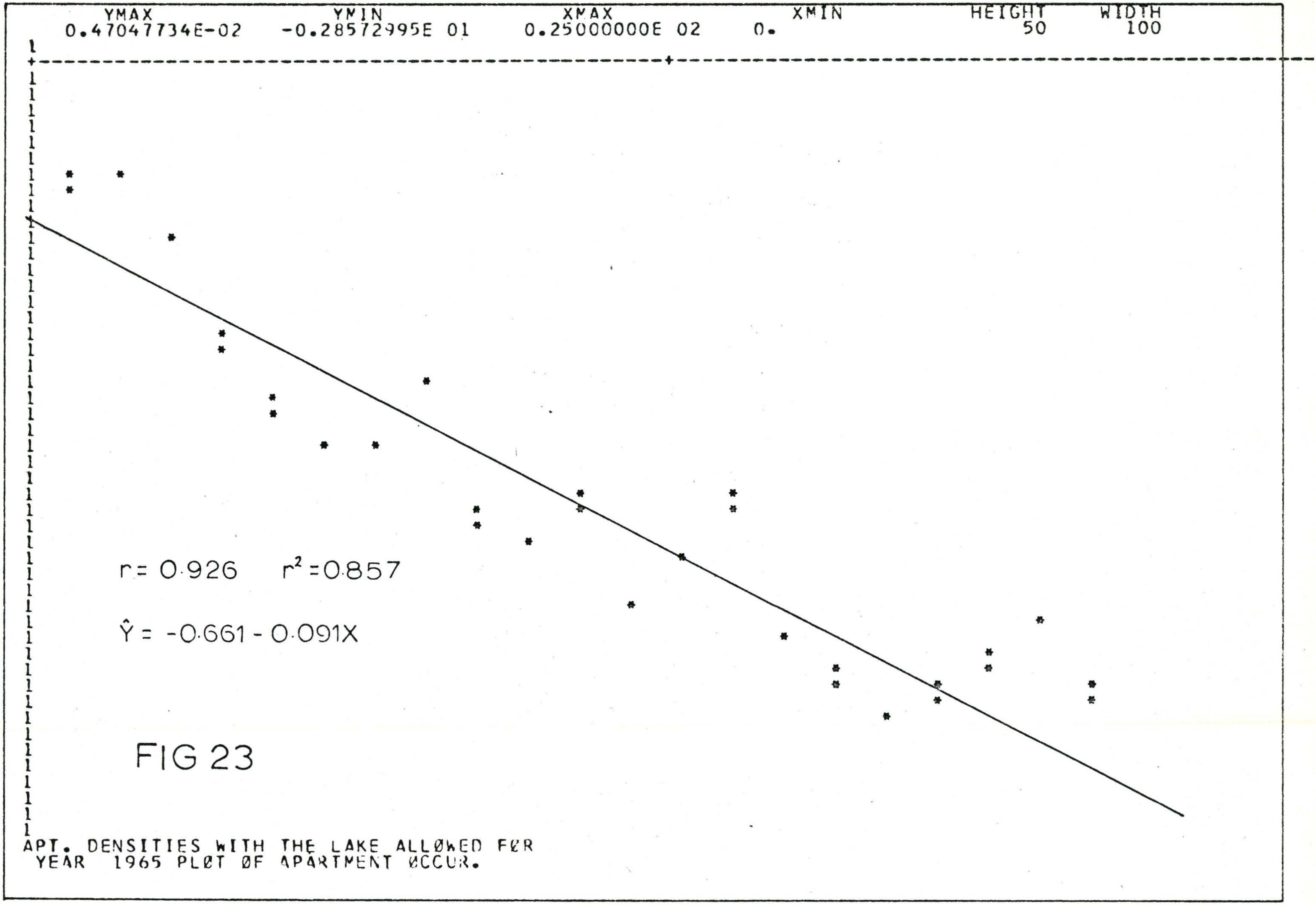
Method of constructing density gradients.

The abstract 'cities' employed by Alonso, Muth and Berry et. al. in their theoretical work are circular in nature with the centre of the city and the centre of the circle coincident. As Berry et. al. point out, however, such cities are rare - "Assymetry and lopsidedness are common, elongations and crenulations many."[13] Hamilton as a lakeshore city is distorted by the lake shoreline from this circular 'ideal city', and also by the eccentric nature of its central area.[14] As a result it was decided to calculate the density gradients for an 'ideal Hamilton' based on concentric circles and also for the actual city area, excluding those parts of circles beyond the city boundary. The densities, slopes and intercepts necessary for the construction of the density gradients were calculated using an IBM 7040 computer (see Appendix B.). This program also calculated the correlation coefficients for number of occurrences of the structures per acre and distance and number of apartment dwelling units per acre and distance.

Distance was operationally defined and measured in terms of concentric belts at quarter mile intervals and these belts were centred on a major intersection at the core of the Central Business District.[15] Thus, the outer concentric belts were composed of areas which lay beyond the city limits and areas which lay within the city while the innermost belts contained areas lying completely within the city. For one set of density gradients, no allowance was made for those areas beyond the city boundary - this is the 'ideal Hamilton'. For the second set of gradients, the densities were calculated using only areas within the city limits.[16] The present city limits were used in the calculations for each of the four time periods so that changes in the density gradients through time could not be attributed to changes in the area of the city. It is reasonable to assume that in the earlier time periods of 1939 and 1956, there were no multiple occupancy residential structures in those areas that were later to be incorporated into the present city by 1961. Thus, the use of the present limits would not distort the calculations for these earlier periods.

Test of the hypotheses.

Figures 23 to 38 show the results obtained for the density gradients using the two methods of calculation previously outlined. These diagrams, together with their accompanying correlation coefficients,



YMAX 0.47047734E-02
YMIN -0.28572995E 01
XMAX 0.25000000E 02
XMIN 0.
HEIGHT 50
WIDTH 100
r= 0.926 r² =0.857
Ŷ = -0.661 - 0.091X
APT. DENSITIES WITH THE LAKE ALLØWED FØR
YEAR 1965 PLØT ØF APARTMENT ØCCUR.

FIG 23

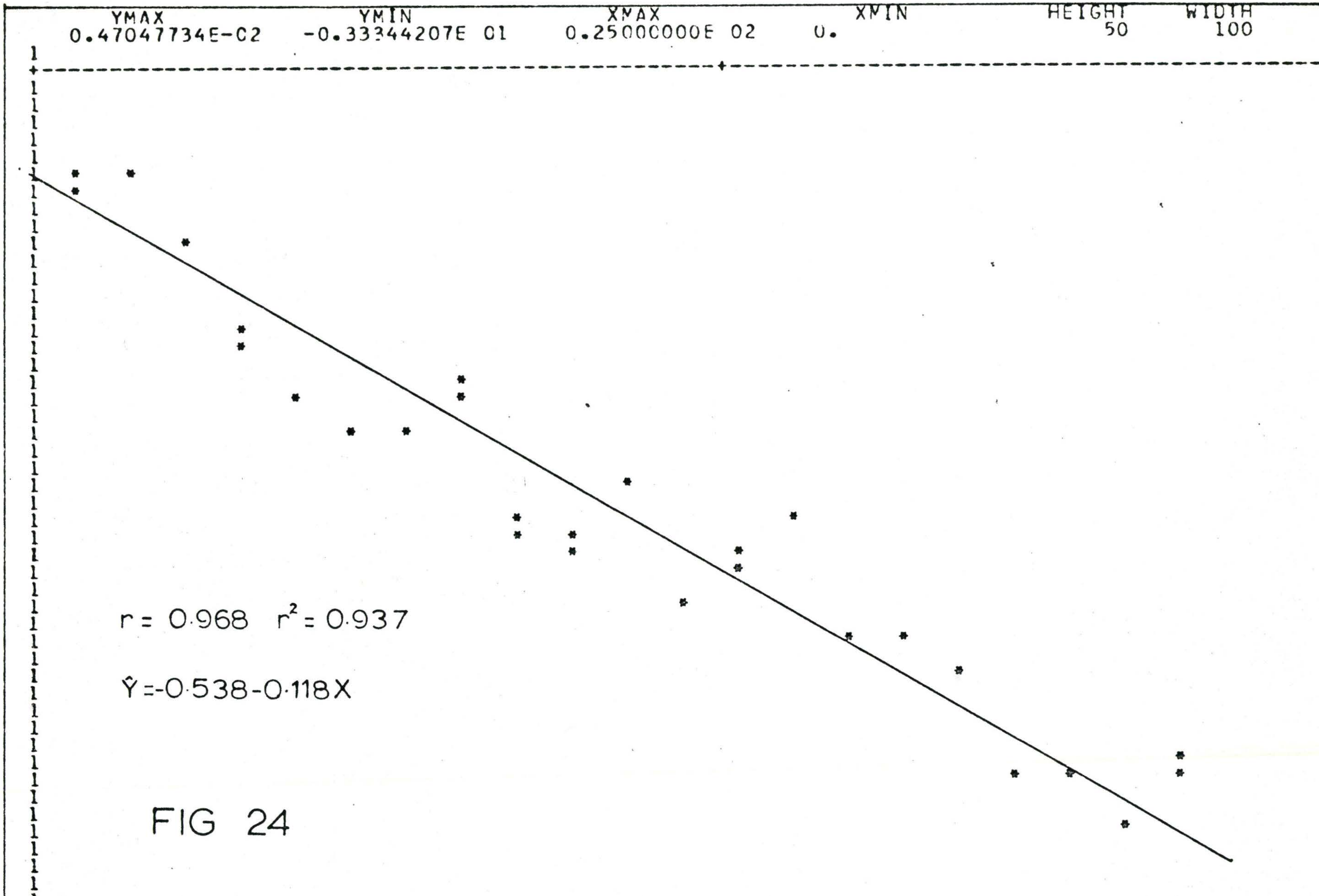


FIG 24

APT. DENSITIES WITH THE LAKE ALLØWED FØR
YEAR 1961 PLØT ØF APARTMENT ØCCUR.

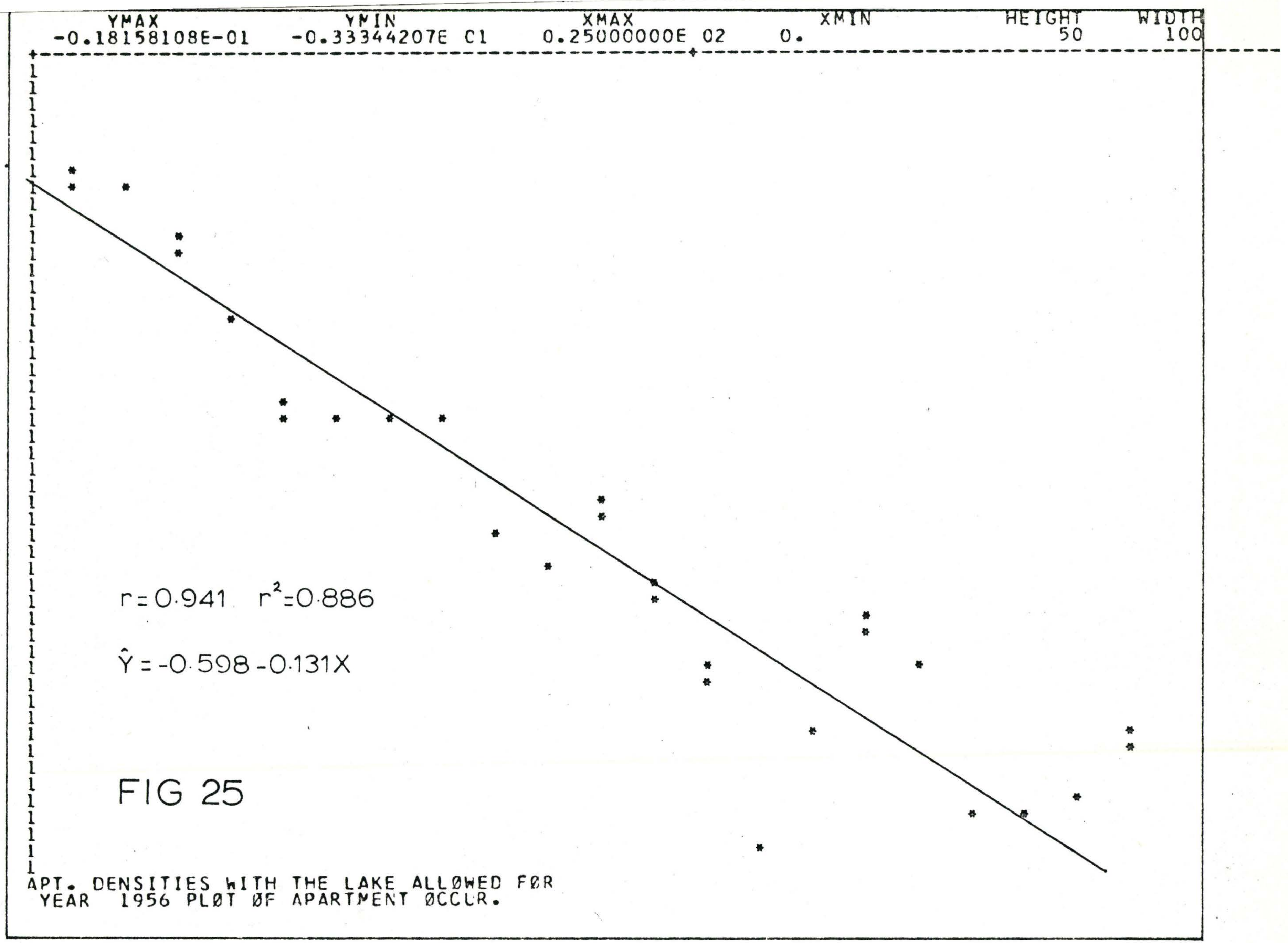

YMAX
-0.18158108E-01
YMIN
-0.33344207E C1
XMAX
0.25000000E 02
XMIN
0.
HEIGHT
50
WIDTH
100
r=0.941 r²=0.886
Ŷ=-0.598-0.131X
APT. DENSITIES WITH THE LAKE ALLØWED FØR
YEAR 1956 PLØT ØF APARTMENT ØCCUR.

FIG 25

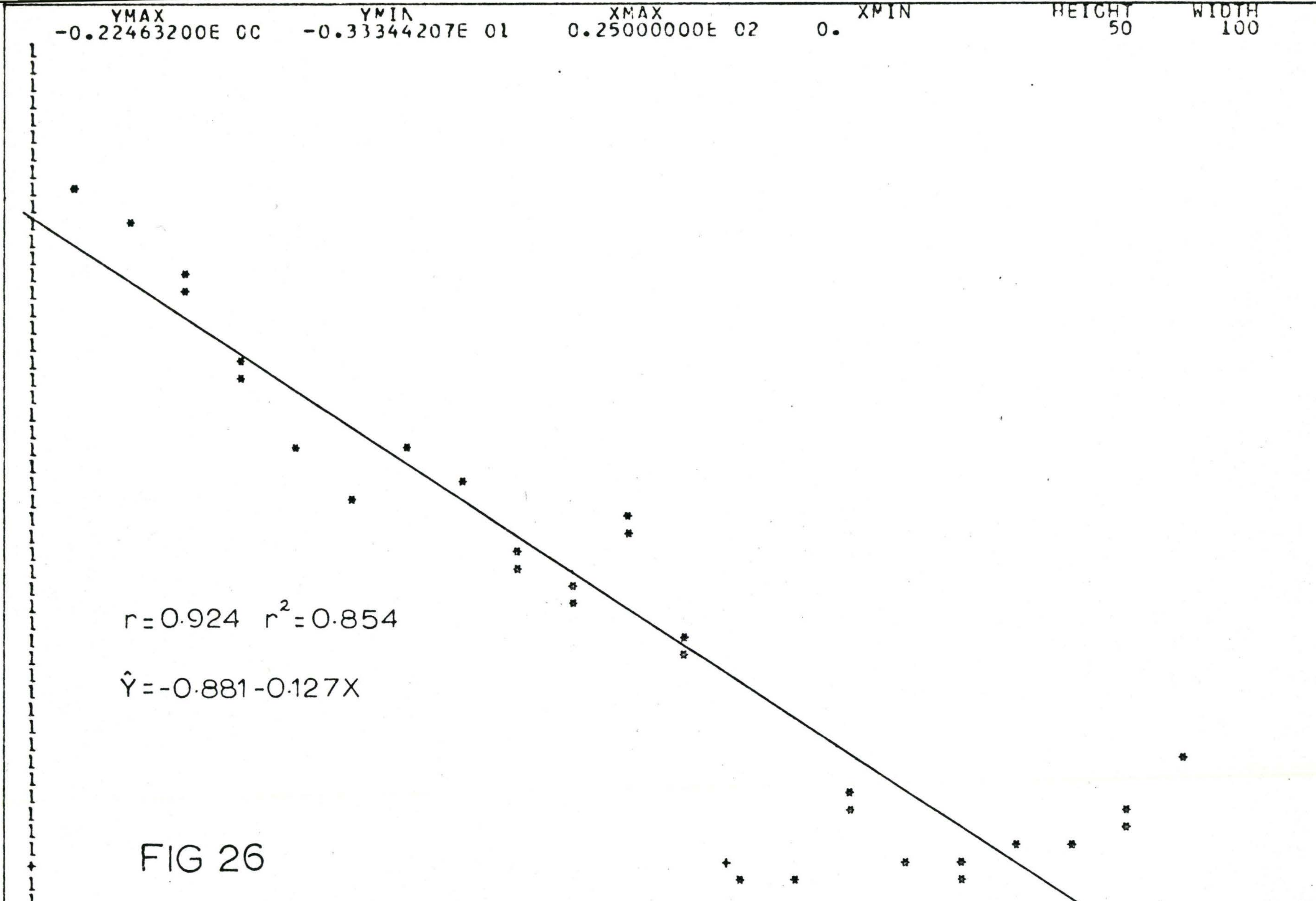


FIG 26

APT. DENSITIES WITH THE LAKE ALLØWED FØR
YEAR 1939 PLØT ØF APARTMENT ØCCUR.

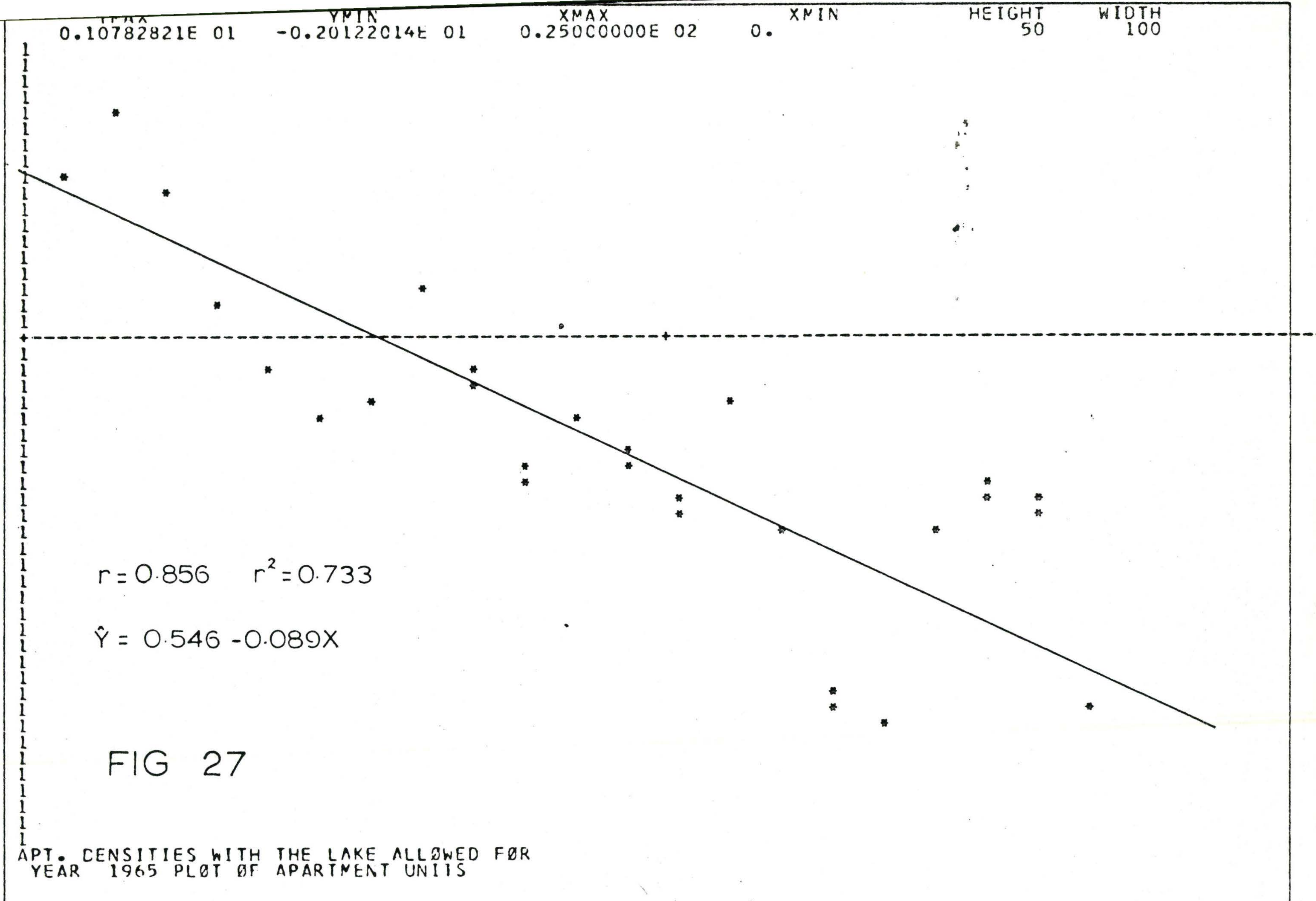


FIG 27

APT. DENSITIES WITH THE LAKE ALLØWED FØR
YEAR 1965 PLØT ØF APARTMENT UNITS

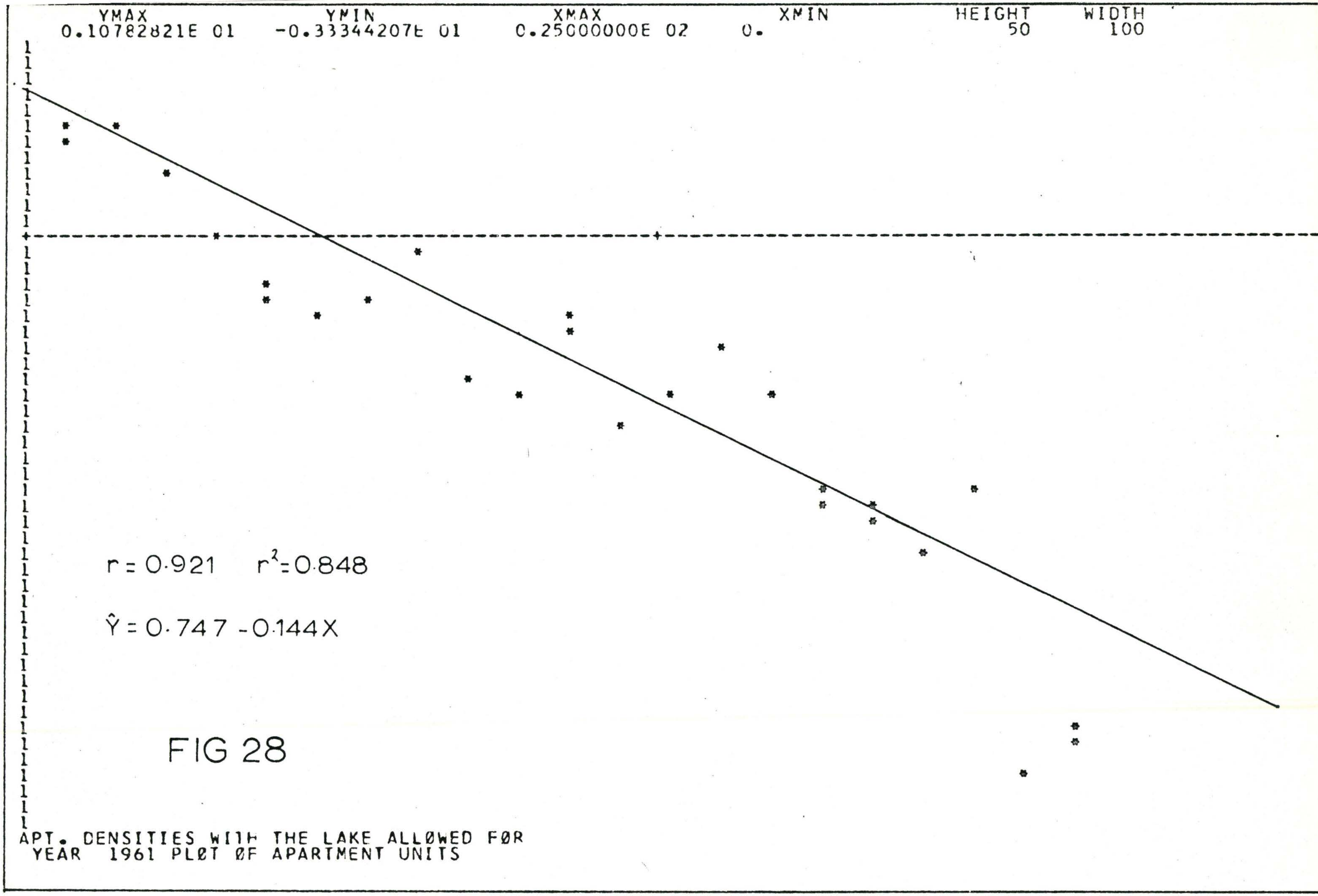

YMAX YMIN XMAX XMIN HEIGHT WIDTH
0.10782821E 01 -0.33344207E 01 0.25000000E 02 0. 50 100
r = 0.921 r^2 = 0.848
$\hat{Y}$ = 0.747 - 0.144X
APT. DENSITIES WITH THE LAKE ALLØWED FØR
YEAR 1961 PLØT ØF APARTMENT UNITS

FIG 28

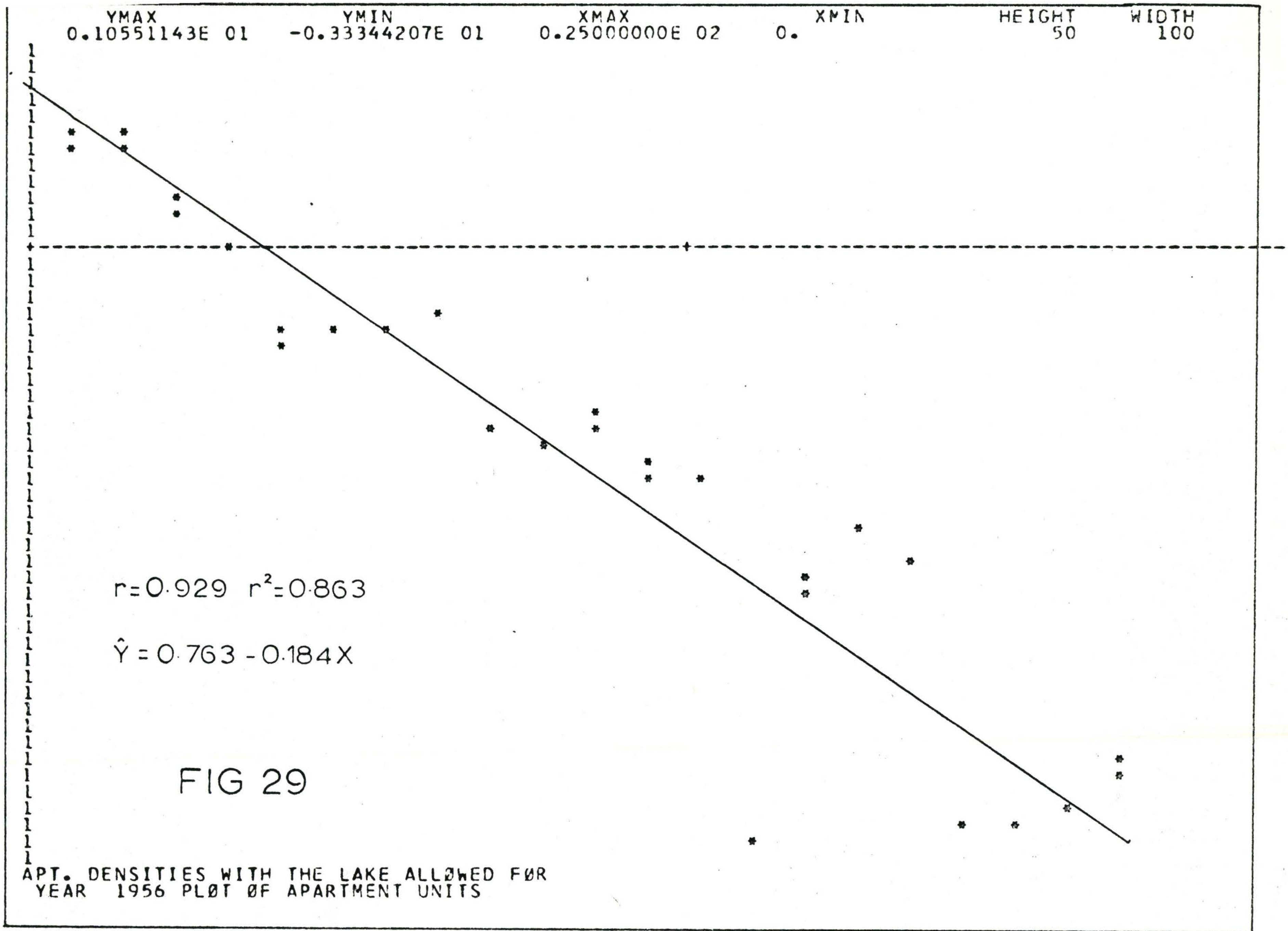
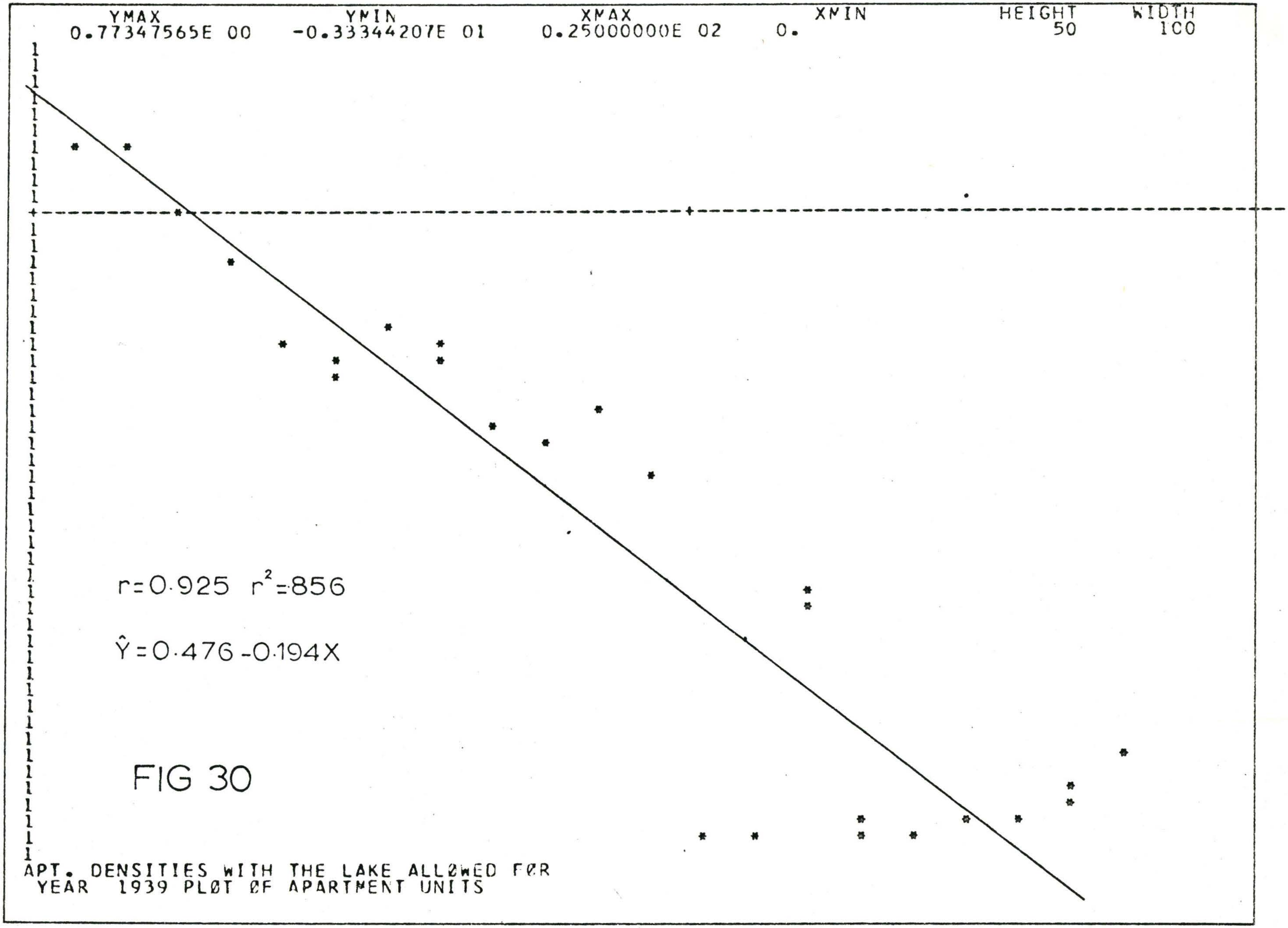
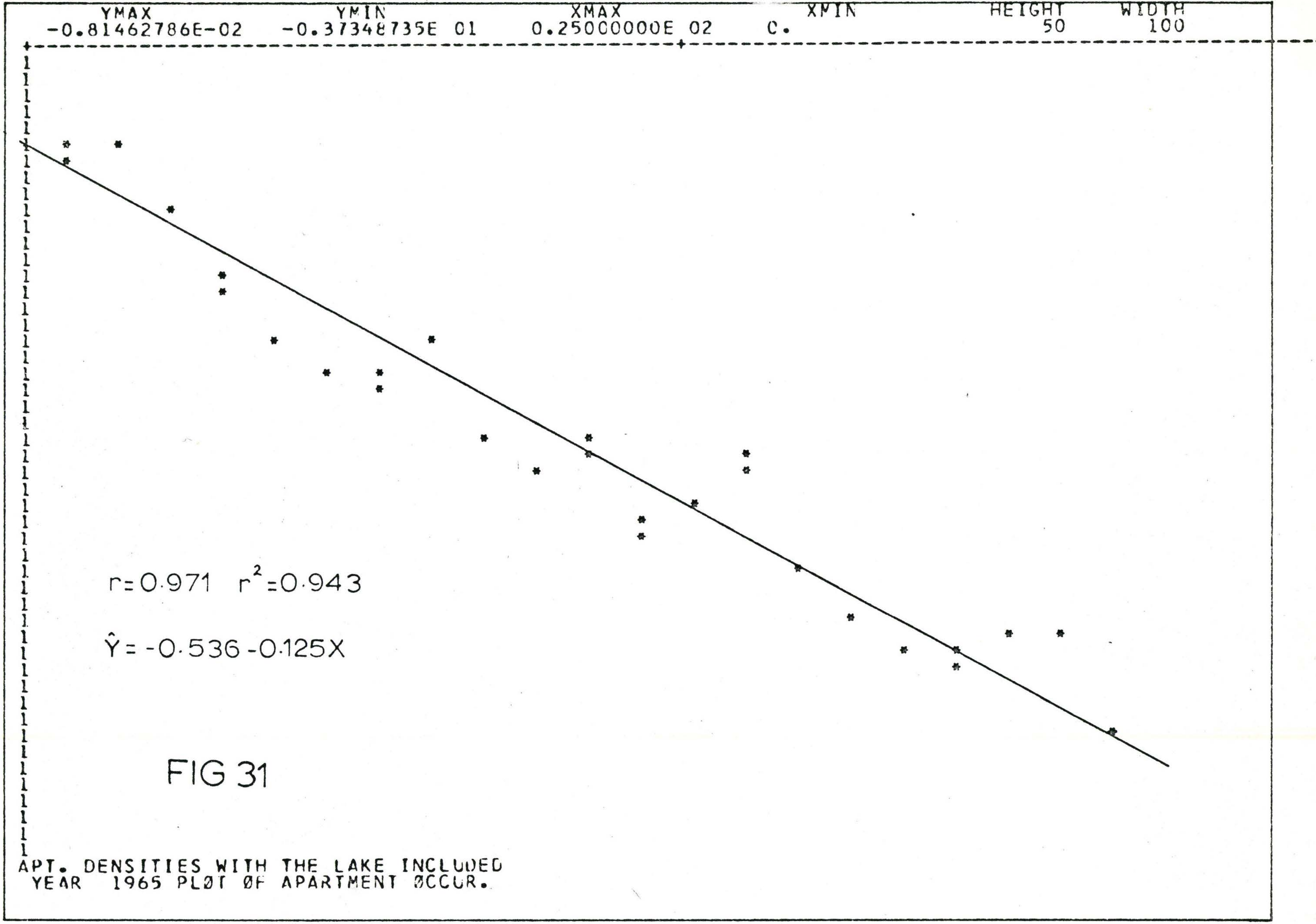


FIG 29

APT. DENSITIES WITH THE LAKE ALLØWED FØR
YEAR 1956 PLØT ØF APARTMENT UNITS


YMAX
0.77347565E 00
YMIN
-0.33344207E 01
XMAX
0.25000000E 02
XMIN
0.
HEIGHT
50
WIDTH
100
r=0.925 r²=856
Ŷ=0.476-0.194X
FIG 30
APT. DENSITIES WITH THE LAKE ALLØWED FØR
YEAR 1939 PLØT ØF APARTMENT UNITS



YMAX
-0.81462786E-02
YMIN
-0.37348735E 01
XMAX
0.25000000E 02
XMIN
C.
HEIGHT
50
WIDTH
100
r=0.971 r²=0.943
Ŷ= -0.536 -0.125X
APT. DENSITIES WITH THE LAKE INCLUDED
YEAR 1965 PLØT ØF APARTMENT ØCCUR.

FIG 31

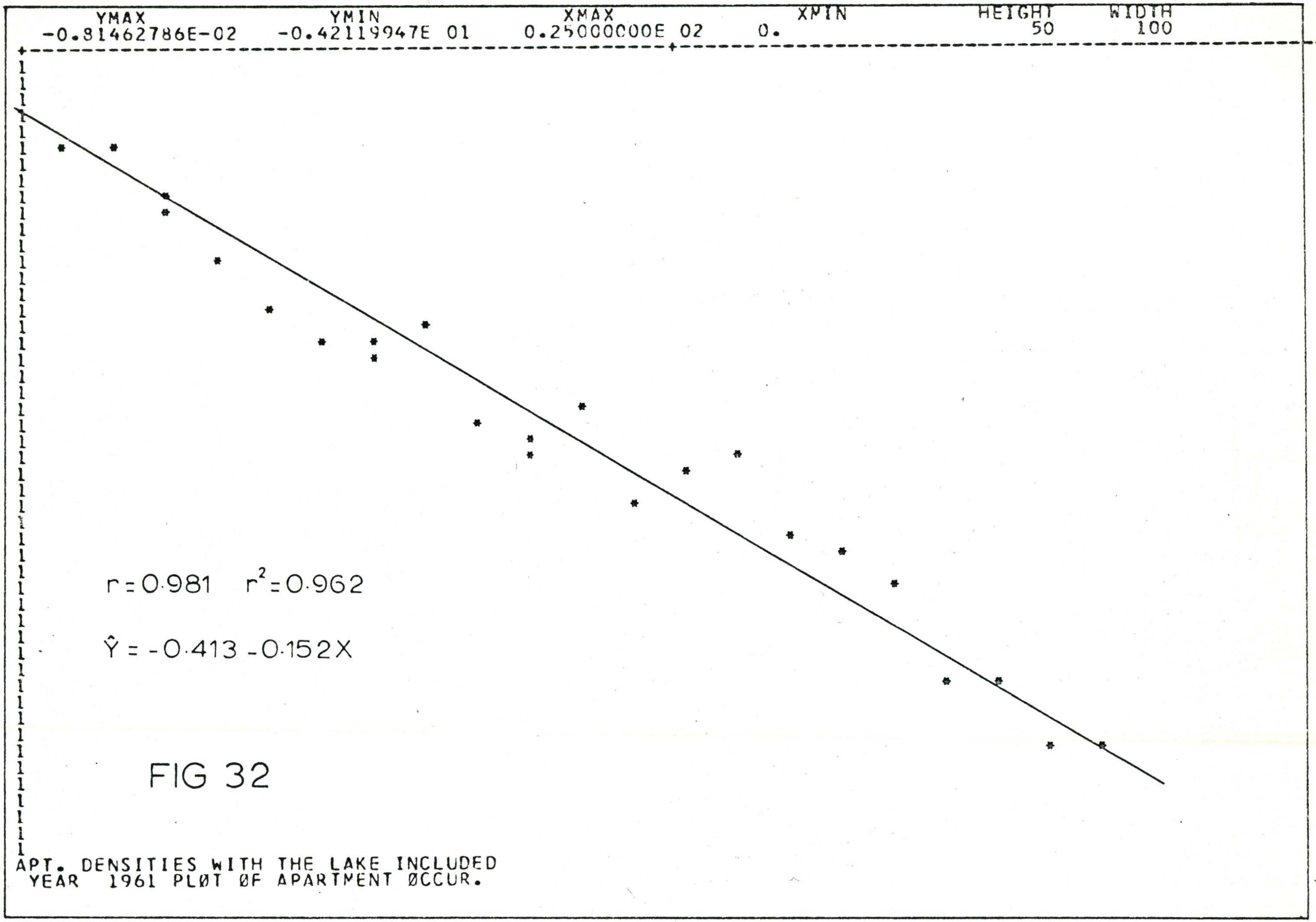


FIG 32

APT. DENSITIES WITH THE LAKE INCLUDED
YEAR 1961 PLØT ØF APARTMENT ØCCUR.

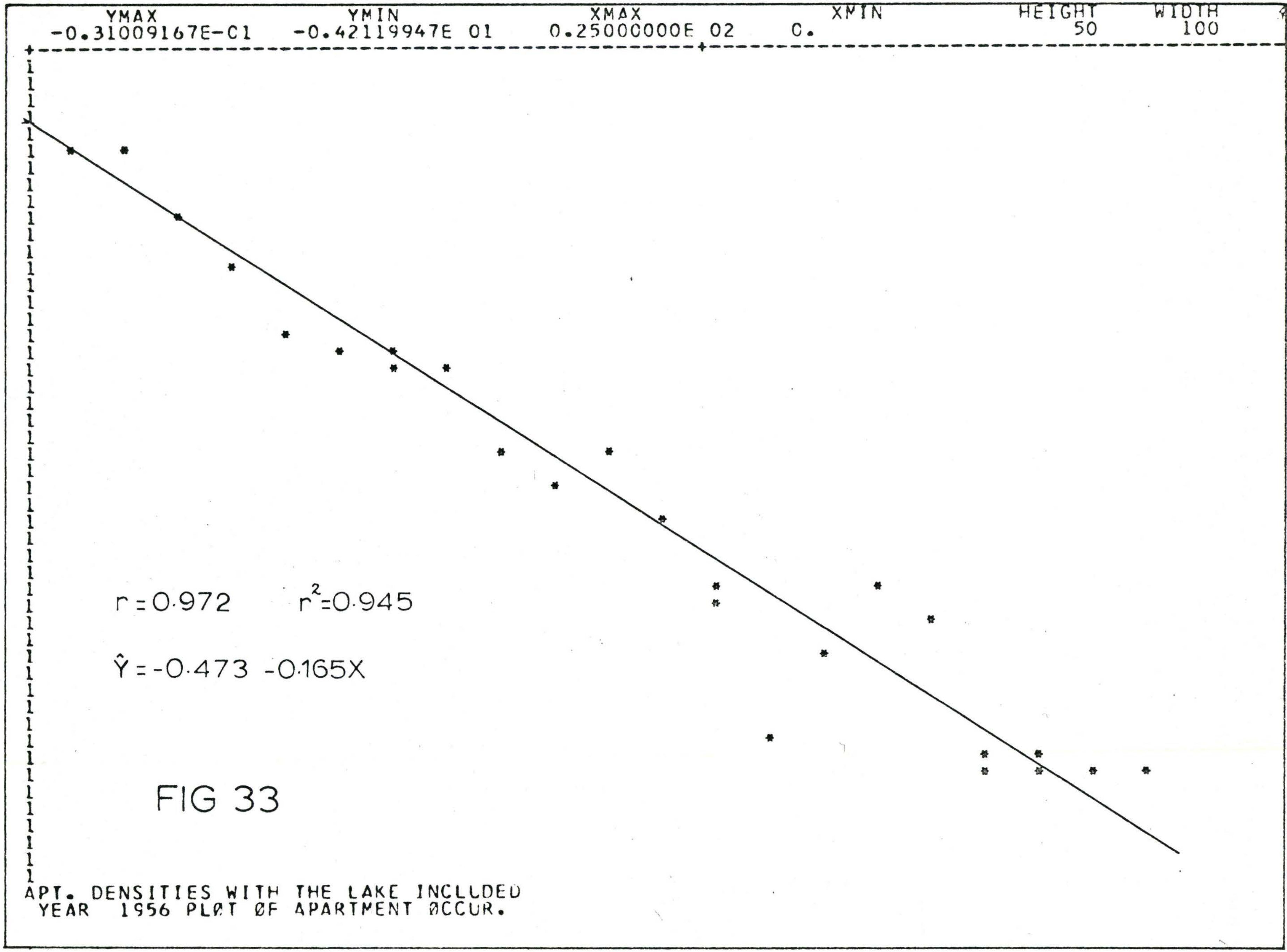
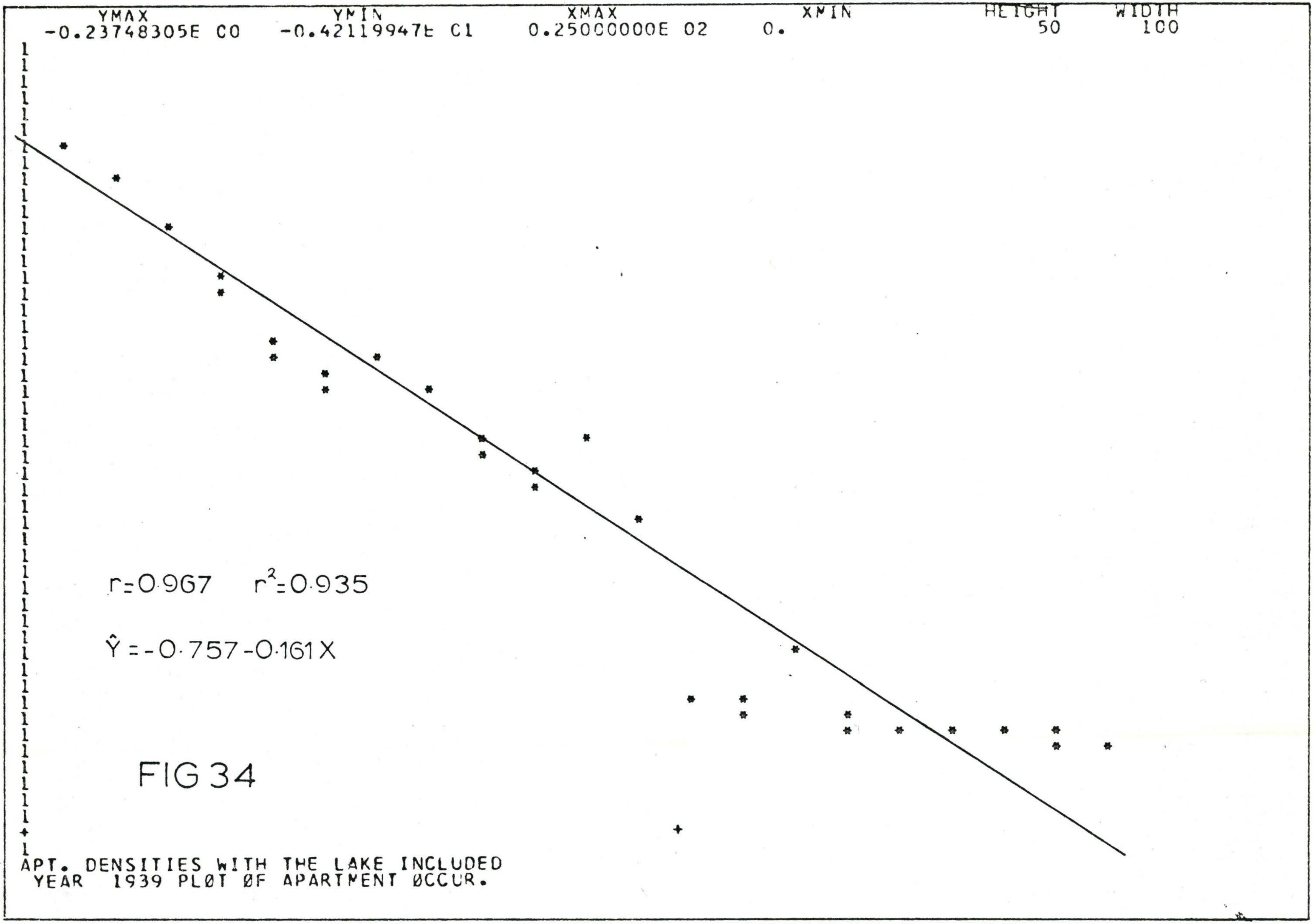

YMAX
-0.31009167E-C1
YMIN
-0.42119947E 01
XMAX
0.25000000E 02
XMIN
C.
HEIGHT
50
WIDTH
100
r = 0.972   r² = 0.945
Ŷ = -0.473 -0.165X
APT. DENSITIES WITH THE LAKE INCLLDED
YEAR 1956 PLØT ØF APARTMENT ØCCUR.

FIG 33


YMAX YMIN XMAX XMIN HEIGHT WIDTH
-0.23748305E 00 -0.42119947E 01 0.25000000E 02 0. 50 100
r=0.967 r²=0.935
Ŷ=-0.757-0.161X
APT. DENSITIES WITH THE LAKE INCLUDED
YEAR 1939 PLØT ØF APARTMENT ØCCUR.
FIG 34

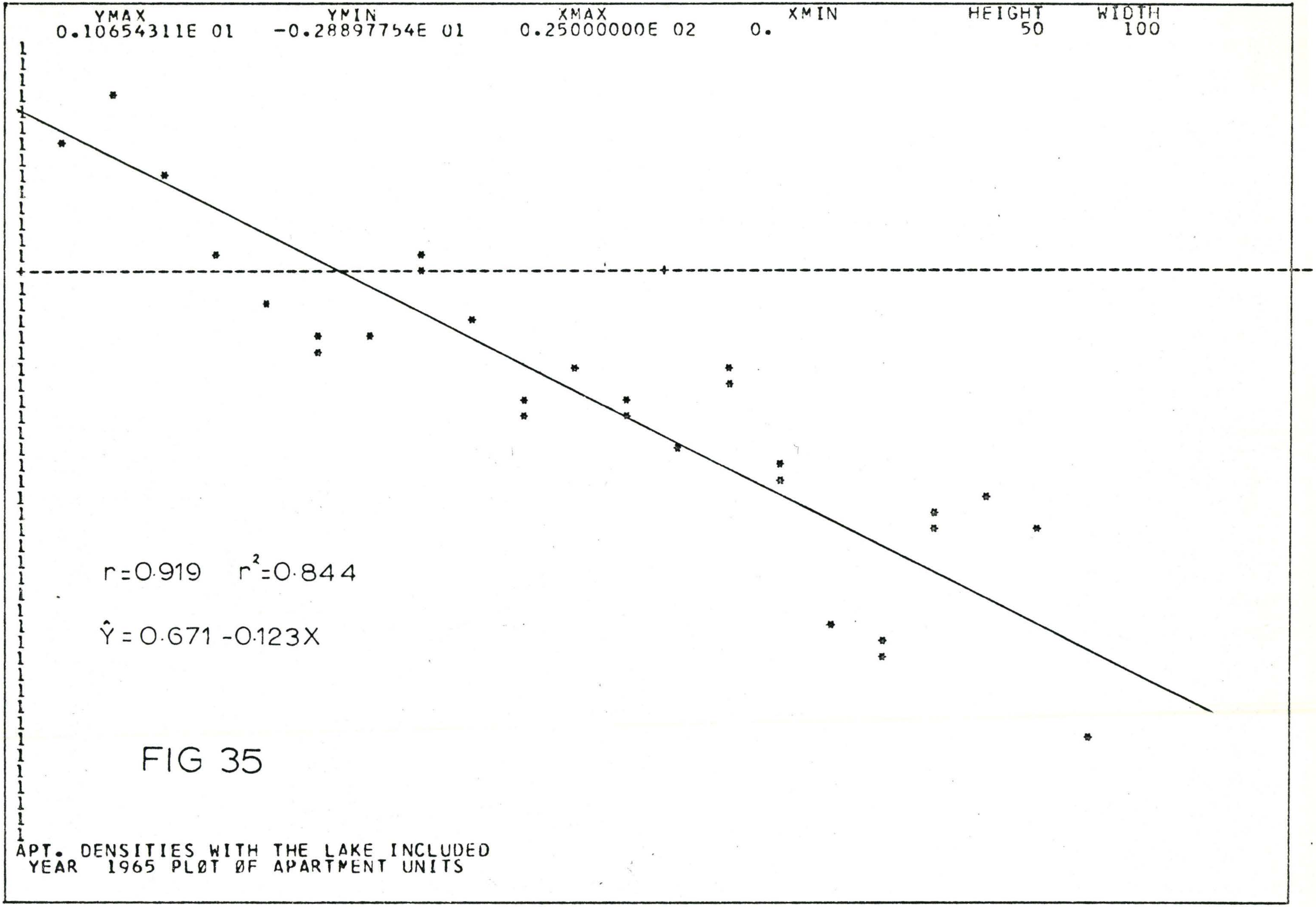

YMAX 0.10654311E 01
YMIN -0.28897754E 01
XMAX 0.25000000E 02
XMIN 0.
HEIGHT 50
WIDTH 100
r=0.919 r²=0.844
Ŷ = 0.671 -0.123X
APT. DENSITIES WITH THE LAKE INCLUDED
YEAR 1965 PLØT ØF APARTMENT UNITS

FIG 35

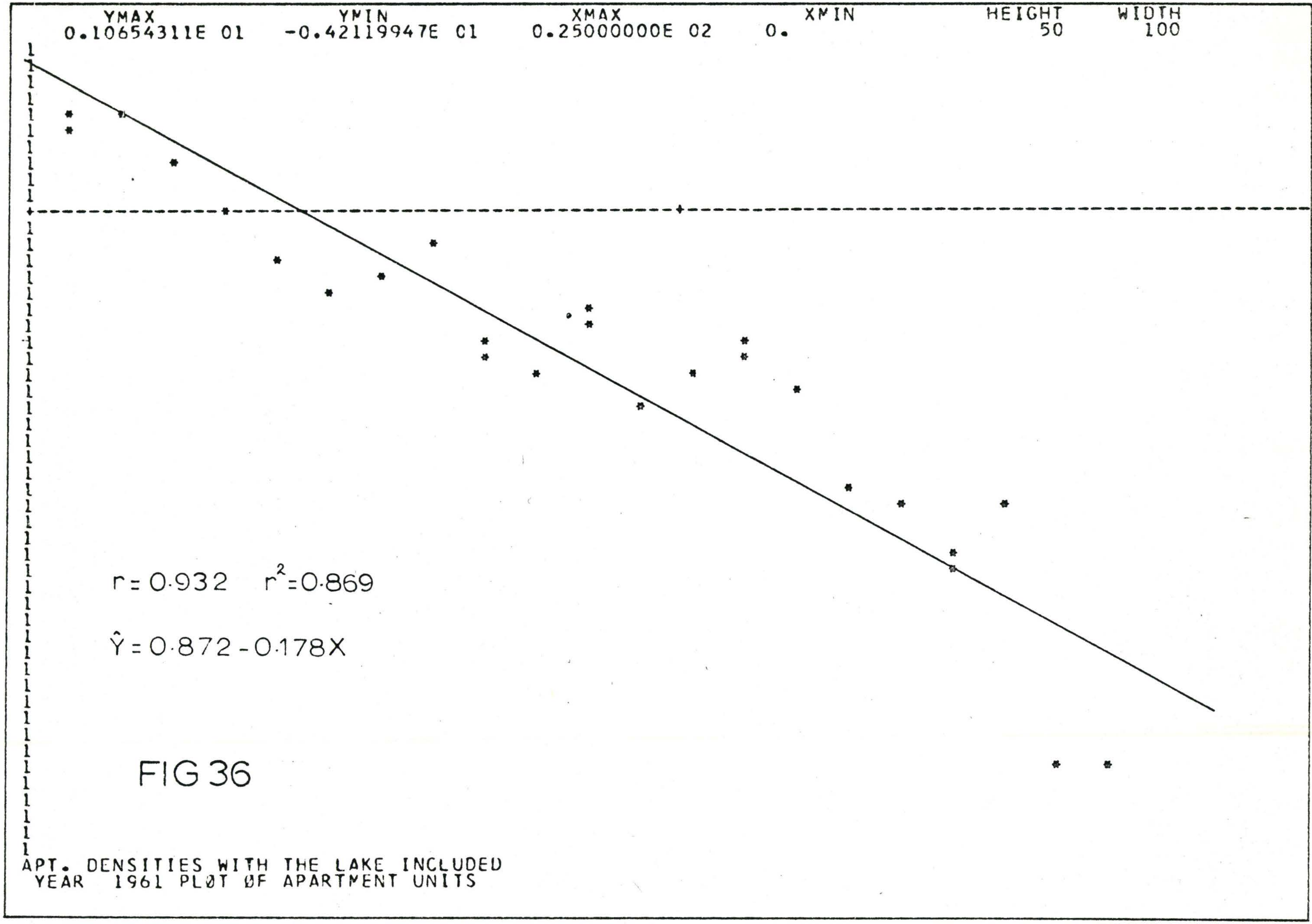

YMAX
0.10654311E 01
YMIN
-0.42119947E 01
XMAX
0.25000000E 02
XMIN
0.
HEIGHT
50
WIDTH
100
r = 0.932 r^2 = 0.869
$\hat{Y} = 0.872 - 0.178X$
APT. DENSITIES WITH THE LAKE INCLUDED
YEAR 1961 PLØT ØF APARTMENT UNITS

FIG 36

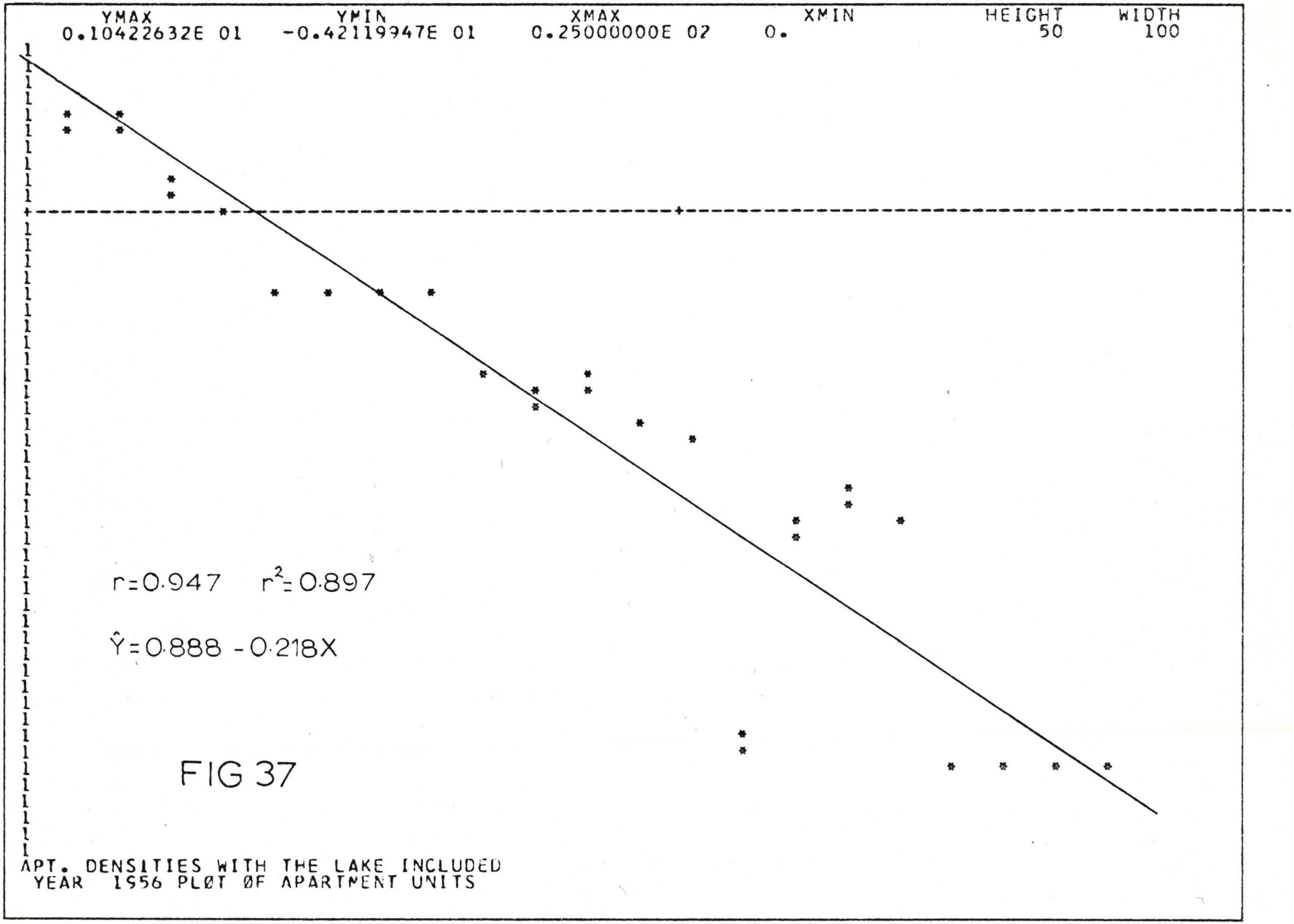

YMAX 0.10422632E 01
YMIN -0.42119947E 01
XMAX 0.25000000E 02
XMIN 0.
HEIGHT 50
WIDTH 100
r=0.947 r²=0.897
Ŷ=0.888 -0.218X
APT. DENSITIES WITH THE LAKE INCLUDED
YEAR 1956 PLØT ØF APARTMENT UNITS

FIG 37

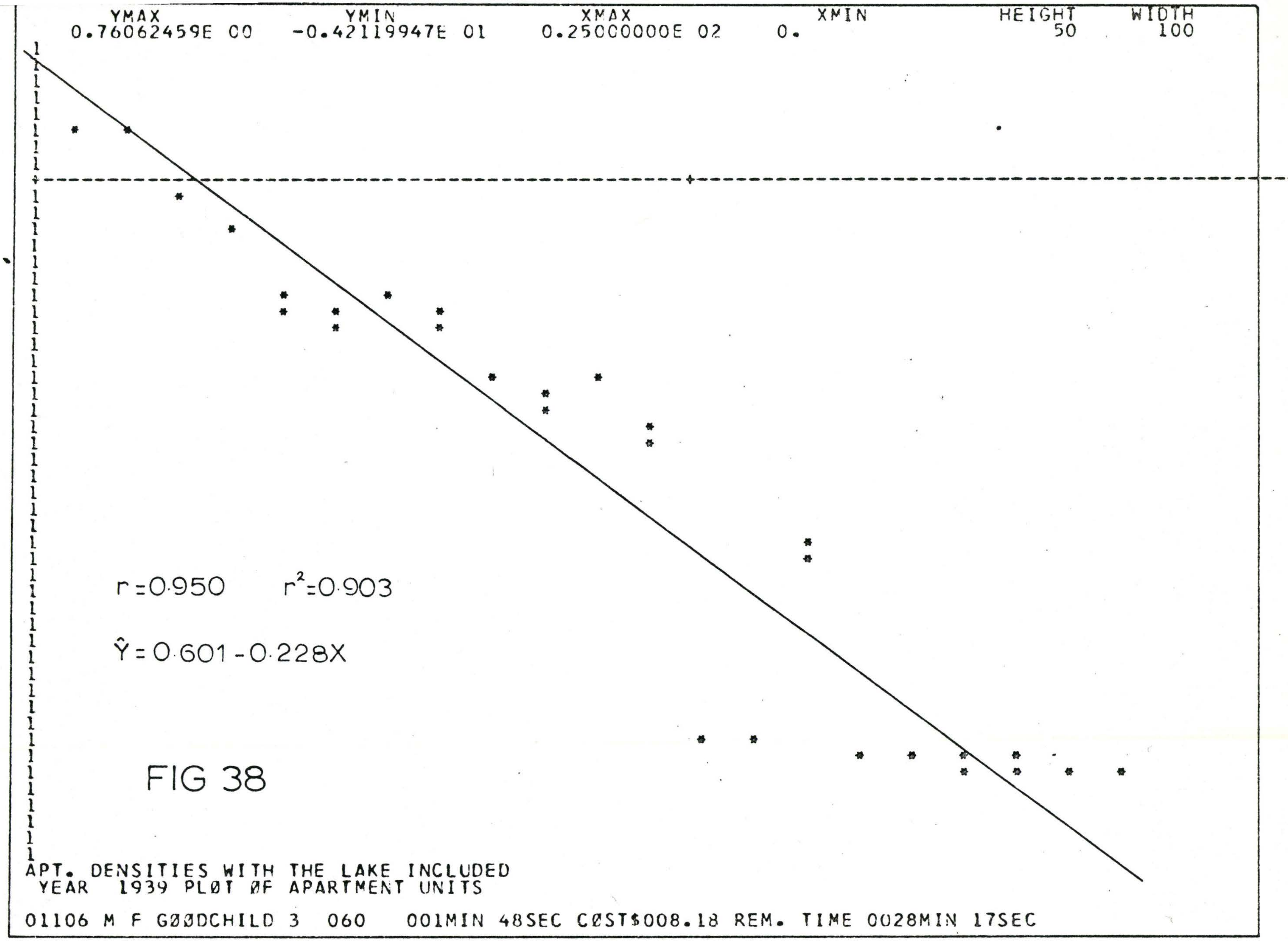
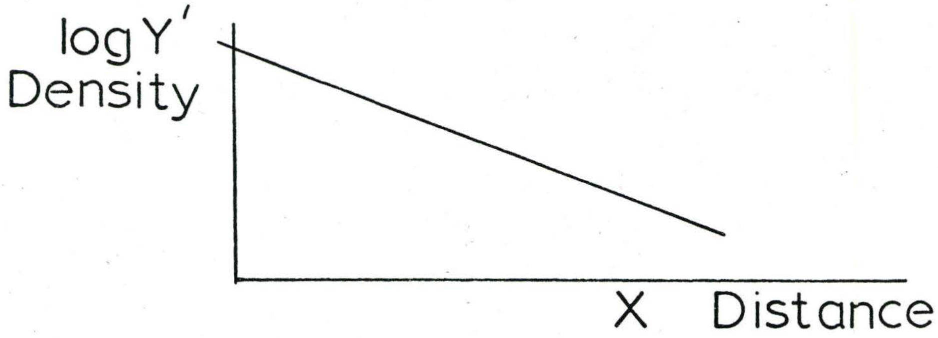

YMAX 0.76062459E 00
YMIN -0.42119947E 01
XMAX 0.25000000E 02
XMIN 0.
HEIGHT 50
WIDTH 100
r=0.950 r²=0.903
Ŷ=0.601-0.228X
APT. DENSITIES WITH THE LAKE INCLUDED
YEAR 1939 PLØT ØF APARTMENT UNITS
01106 M F GØØDCHILD 3 060 001MIN 48SEC CØST$008.18 REM. TIME 0028MIN 17SEC

FIG 38

suggest that there is a strong negative exponential relationship between density of structures and distance from the centre of the city. This is also true for density of apartment dwelling units and distance from the city centre. The strength of this relationship is greater than might be expected with the use of a quarter mile interval in measuring distance from the city centre. The use of mile intervals would probably have led to even higher correlation coefficients.[17] The correlation coefficients were tested and found to be significant at the 0.001 level.[18]

All the density gradients have the general form shown in the sketch below.



A formal proof will now be presented to show that these gradients have the same form as the urban population density gradients. This allows acceptance of the first hypothesis which was that the density gradients for both the number of structures and the number of dwelling units would have a negative exponential form.

$$\log_{10} Y' = \log_{10} e . \log_e Y'$$

$$= 0.4343 \times \log_e Y'$$

$$\log_{10} e . \log_e Y' = a - bX$$

$$\log_e Y' = \frac{1}{\log_{10} e} (a - bX)$$

$$Y' = e \frac{a}{\log_{10} e} . \frac{e - bX}{\log_{10} e}$$

$$= d_o . e^{-bX}$$

Hence, $d_x = d_o e^{-bX}$

where d_x is the population density d at distance x,

d_o is the central density as extrapolated,

and b is the density gradient.

Since this is the form of the relationship expressed by Clark, the first hypothesis can be accepted.

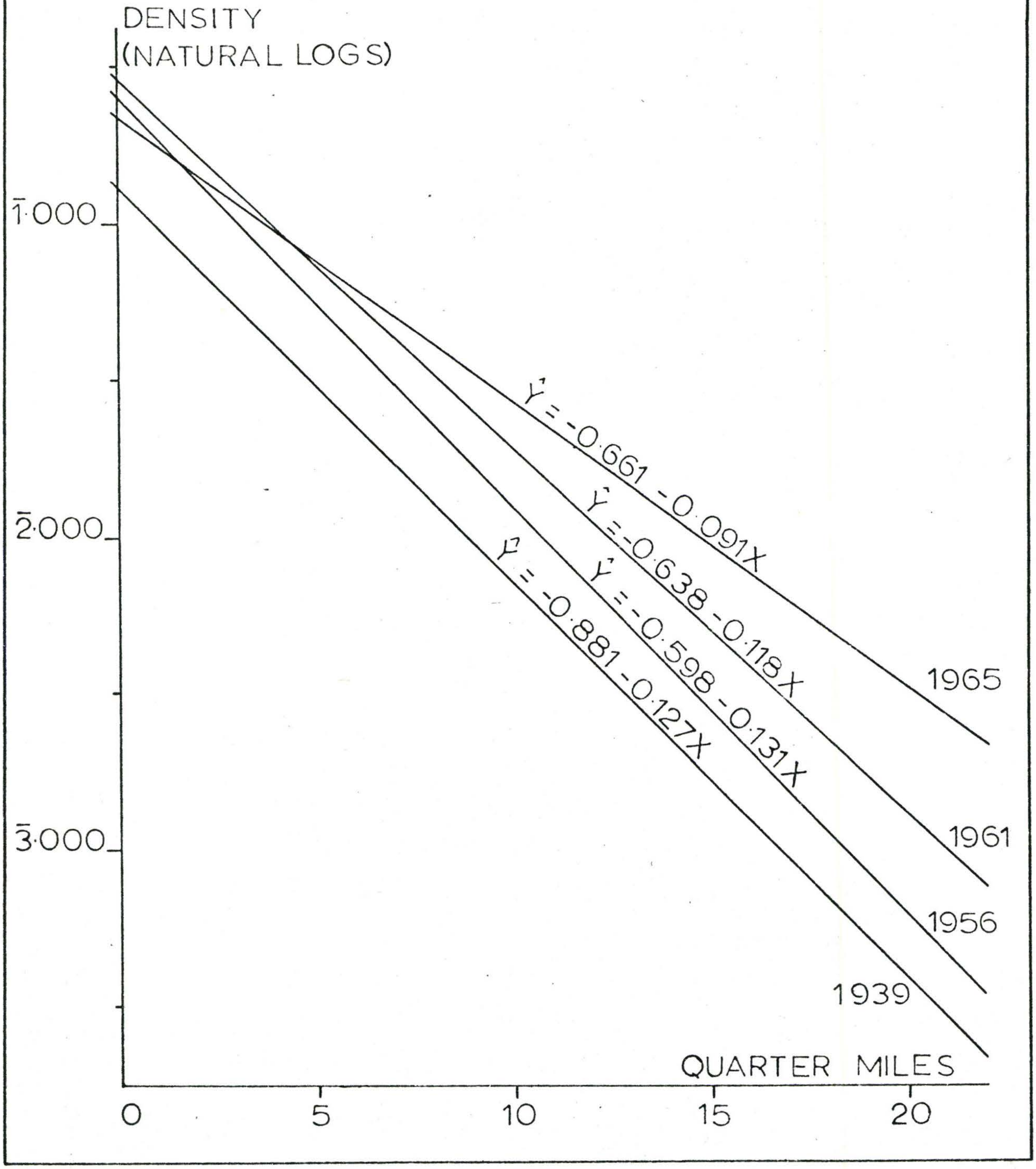
With respect to the second hypothesis, that the density gradients would become less steep through time, and that there would be a downward displacement with the decline in central densities, the results do not permit its complete acceptance. In order to consider the gradients behaved through time, the 'b' values obtained from the regression equations were tabled and examined (see Table 8). This table shows that as one moves through time from 1939 to 1965, the gradients become less steep in all cases except one. The one exception occurs with an increase in the gradient of structures from 1939 to 1956 for Hamilton (adjusted). For ease of comparison, the behaviour of the density gradients through time is shown graphically in Figs. 39 to 42. It seems reasonable, therefore, to accept the first part of the second hypothesis.

It was also hypothesised that the central densities would decline causing a downward displacement in the gradients as one moved forward in time. One method of obtaining these central densities is to take the intercept of the regression equations (the 'a' values) as the density at zero distance.[19] The central densities obtained in this way are shown in Table 9. This table shows that the central densities do decline from 1939 onwards but that, by 1964, the densities begin to rise again. This is an indication of the increasing development in the central area of the city. In the case of the units, the pattern is less clear with a rise in the density followed by a slight decline, then a greater decline.

It seems reasonable that, for the purposes of comparison from one time period to another, these central densities should be weighted. At each time period, the number of structures and the number of units represent a differing proportion of the total number of residential structures and dwelling units in the city. The central densities were weighted by these respective proportions to standardise comparisons. This weighting, the results of which are also shown in Table 9, place the 1961 central densities above those of 1956. This illustrates the fact that the increasing central development had made its influence felt actually by 1961 rather than in 1964. Otherwise, the trends remain the same.

It is possible, however, that these comparisons may be suspect

FIG39 DENSITY GRADIENTS OF NUMBER OF STRUCTURES: HAMILTON (ADJUSTED) 1939-1965



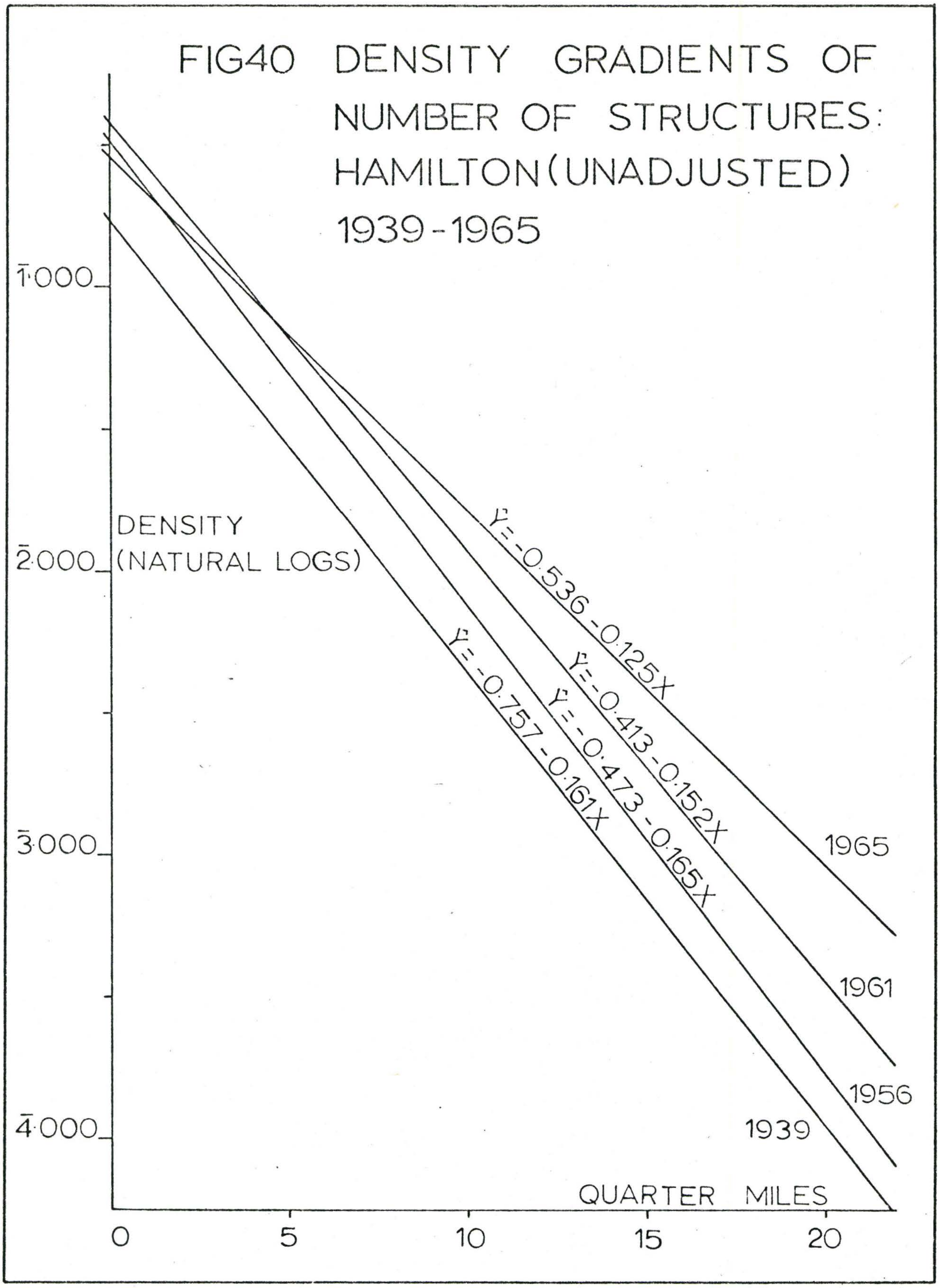


FIG40 DENSITY GRADIENTS OF NUMBER OF STRUCTURES: HAMILTON (UNADJUSTED) 1939-1965
$\bar{1}$·000
$\bar{2}$·000
$\bar{3}$·000
$\bar{4}$·000
DENSITY (NATURAL LOGS)
Y=-0·536-0·125X
Y=-0·413-0·152X
Y=-0·473-0·165X
Y=-0·757-0·161X
1965
1961
1956
1939
QUARTER MILES
0
5
10
15
20

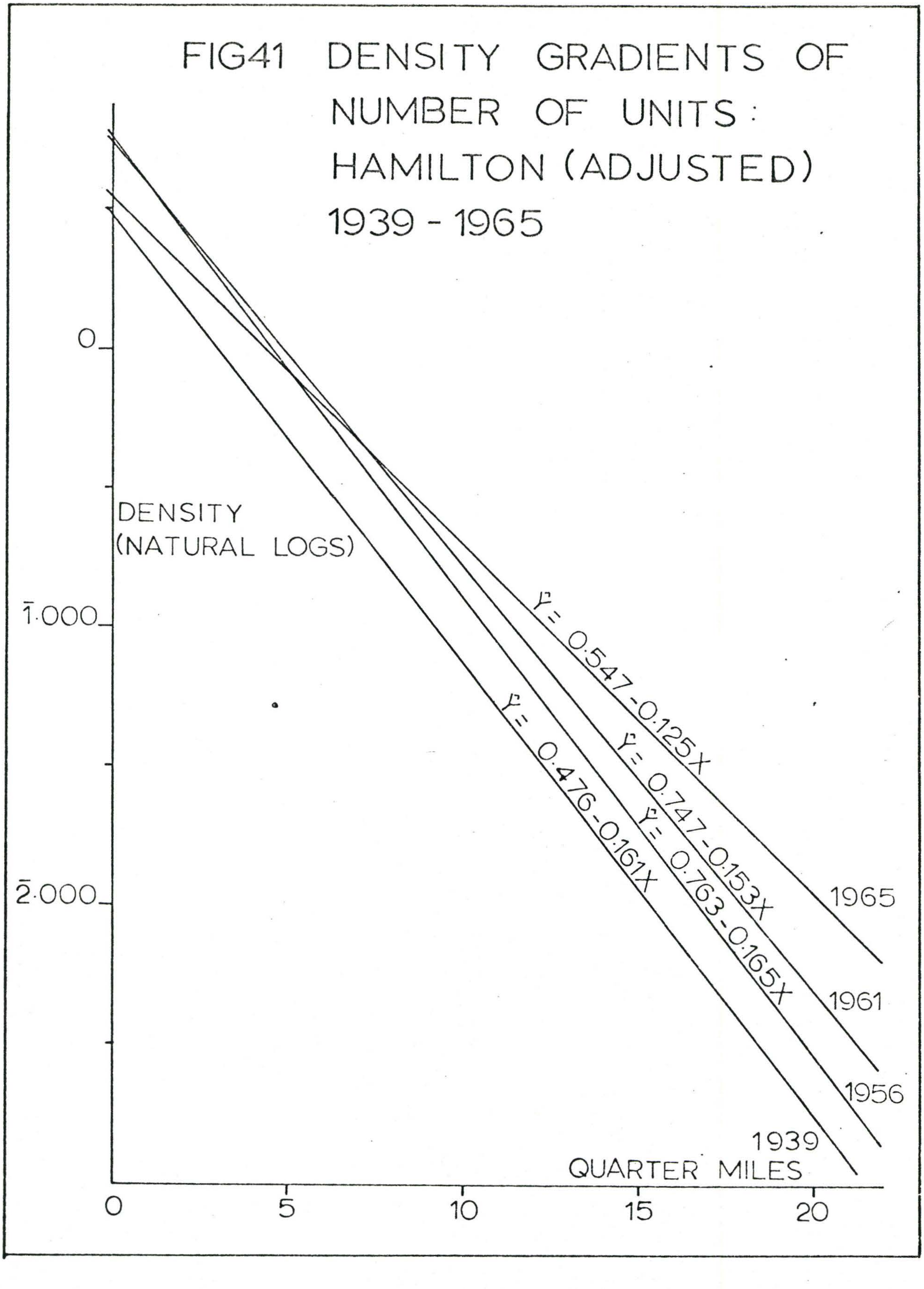


FIG41 DENSITY GRADIENTS OF NUMBER OF UNITS: HAMILTON (ADJUSTED) 1939 - 1965
DENSITY (NATURAL LOGS)
0
1̄·000
2̄·000
Y= 0·547-0·125X
Y= 0·747-0·153X
Y= 0·763-0·165X
Y= 0·476-0·161X
1965
1961
1956
1939
QUARTER MILES
0
5
10
15
20

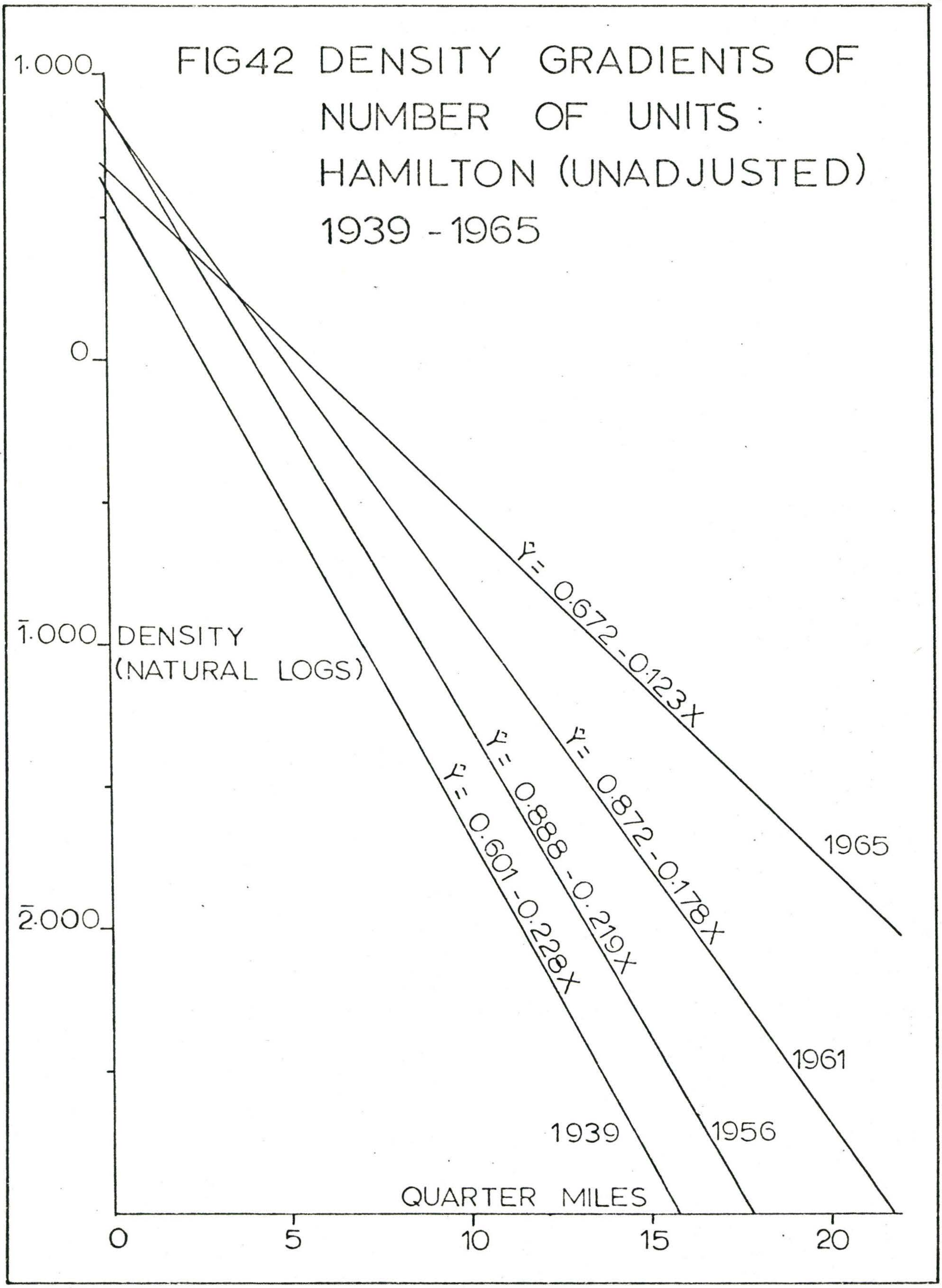


FIG42 DENSITY GRADIENTS OF NUMBER OF UNITS: HAMILTON (UNADJUSTED) 1939 - 1965
1·000
0
$\bar{1}$·000
DENSITY (NATURAL LOGS)
$\bar{2}$·000
Y= 0.672-0.123X
1965
Y= 0.872-0.178X
1961
Y= 0.888-0.219X
1956
Y= 0.601-0.228X
1939
QUARTER MILES
0
5
10
15
20

TABLE 8

The Values of 'b' - the regression slope.

YEAR	HAMILTON (adjusted)		HAMILTON (unadjusted)	
	Structures	Units	Structures	Units
1965	-0.0914	-0.1255	-0.0890	-0.1231
1961	-0.1187	-0.1528	-0.1441	-0.1782
1956	-0.1311	-0.1652	-0.1848	-0.2189
1939	-0.1271	-0.1612	-0.1943	-0.2284

Note: Adjusted describes the case where the city boundary was taken into consideration and only those parts of the concentric belts lying within the city measured. Unadjusted is the other case where the city limit was disregarded. This applies to all tables where this distinction is made.

TABLE 9

Central Densities - obtained by using the 'a' value as the extrapolated central density.

YEAR	HAMILTON (adjusted)				HAMILTON (unadjusted)			
	Structures		Units		Structures		Units	
	non-wtd	wtd	non-wtd	wtd	non-wtd	wtd	non-wtd	wtd
1965	-0.6610	0.9461	-0.5465	-0.8967	-0.5361	-0.8212	-0.6715	-1.0217
1961	-0.5385	-0.8169	0.7473	1.0340	-0.4135	-0.6919	0.8723	1.1590
1956	-0.5986	-0.7861	0.7631	0.9392	-0.4737	-0.6612	0.8881	1.0642
1939	-0.8820	-1.0482	0.4763	0.6592	-0.7570	-0.9232	0.6013	0.7842

TABLE 10

Central Densities - obtained by the alternate method described in the test.

YEAR	HAMILTON (adjusted)				HAMILTON (unadjusted)			
	Structures		Units		Structures		Units	
	non-wtd	wtd	non-wtd	wtd	non-wtd	wtd	non-wtd	wtd
1965	4.1106	4.3957	4.1130	5.4632	4.0765	4.3616	4.0789	5.4291
1961	4.0833	4.3617	4.0579	5.3446	4.0492	4.3276	4.0238	5.3105
1956	4.0709	4.2584	4.0172	5.1933	4.0368	4.2243	3.9831	5.1592
1939	4.0749	4.2411	4.0077	5.1906	4.0408	4.2070	3.9736	5.0565

Note: The terms non-wtd and wtd refer to the weighting procedure described in the text.

in that an examination of Figs. 23 to 38 shows that, in general, the regression equation under-predicts the densities in the central area. An alternative method of obtaining central densities was used, so that the trends noted from the first analysis could be checked against a second set of results. The central density d_o was calculated from the equation

$$d_o \quad = \quad (10^5 /2)b^{-1}.$$

This equation is derived by Berry et. al., by integrating the work of Weiss, who developed an expression for the density gradient in terms of the population of the metropolitan area,[20] and their own developments from Clark's original statement.[21] The central densities obtained by this second method are shown in Table 10. These densities show that in the case of structures there was a general increase in central densities except that there was a slight decline from 1939 to 1956. However, when the second set of central densities was weighted in the manner described previously, to allow for the varying proportions of multiple structures and units in the total housing stock over time, there was an increase in central density for both structures and units as one moved forward in time. These latter results seem to conform more accurately to what has happened in central development of multiple occupancy residential housing in Hamilton. Thus, in the light of these results, it is difficult to accept the second part of the second hypothesis concerning the decline of central densities and the consequent displacement of the density gradients.

This method of analysis was further extended to include an examination of density gradients within sections of the city. With the confirmation of the first hypothesis, the question was raised as to whether the same forms obtained within the urban area. This part of the analysis also serves as a further piece of description of the spatial pattern of the multiple occupancy residential structures. The third hypothesis was developed that, within the urban area, the density gradients exhibited the same form as did the city-wide density gradients. The city was divided into four sections (see Fig. 42a), and the density gradients calculated for each of the four sections. These resultant gradients are shown in Figs. 43 to 52 and they give clear confirmation of the hypothesis, since they all exhibit the negative exponential form. There is considerable variation in the slope of the density gradients. They are generally much steeper than the city-wide density gradients, except in the second section, where development of multiple occupancy housing is more widespread. This steepness is not necessarily a function of the eccentricity of the city centre, since the variations were also observed in the density gradients calculated by the process which used the concentric circles, but disregarded the limiting role of the city boundary. The behaviour of the gradients through time is reasonably consistent. The increasing marginal development in the city is reflected in the slope of the 1965 gradients, while in some areas, notably Section 1, the low level of multiple occupancy residential development is indicated by the closeness of the density gradients.

In conclusion, the first and third hypotheses and part of the second hypothesis can be accepted. The first hypothesis was that the density gradients for the multiple occupancy residential structures and for the dwelling units would have a form similar to the negative exponential form of the urban population density gradients. The results

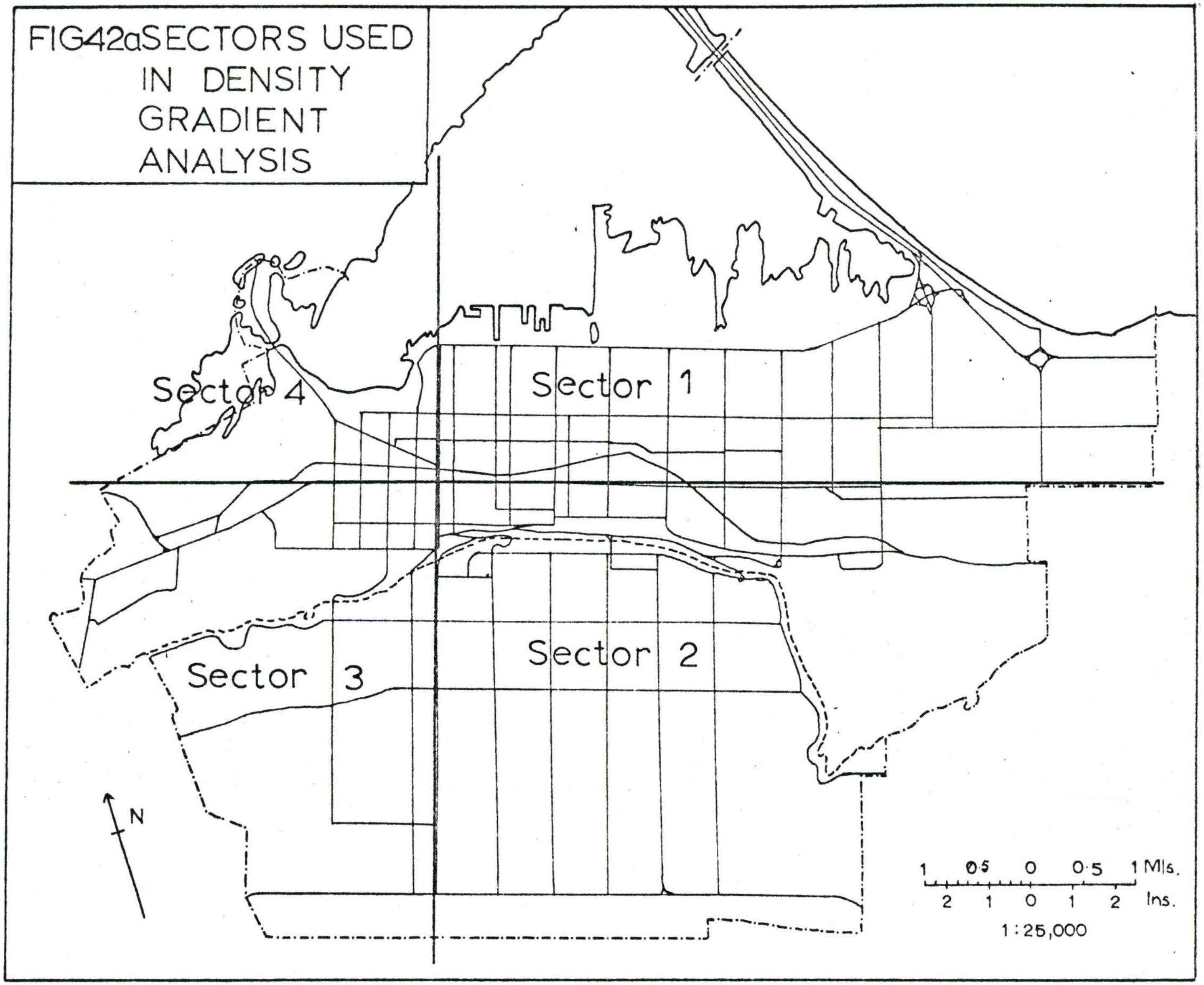


FIG42a SECTORS USED IN DENSITY GRADIENT ANALYSIS
Sector 1
Sector 2
Sector 3
Sector 4
N
1 0·5 0 0·5 1 Mls.
2 1 0 1 2 Ins.
1:25,000

FIG 43 DENSITY GRADIENTS OF NUMBER OF STRUCTURES: HAMILTON (ADJUSTED) 1939 - 1965 SECTION 1

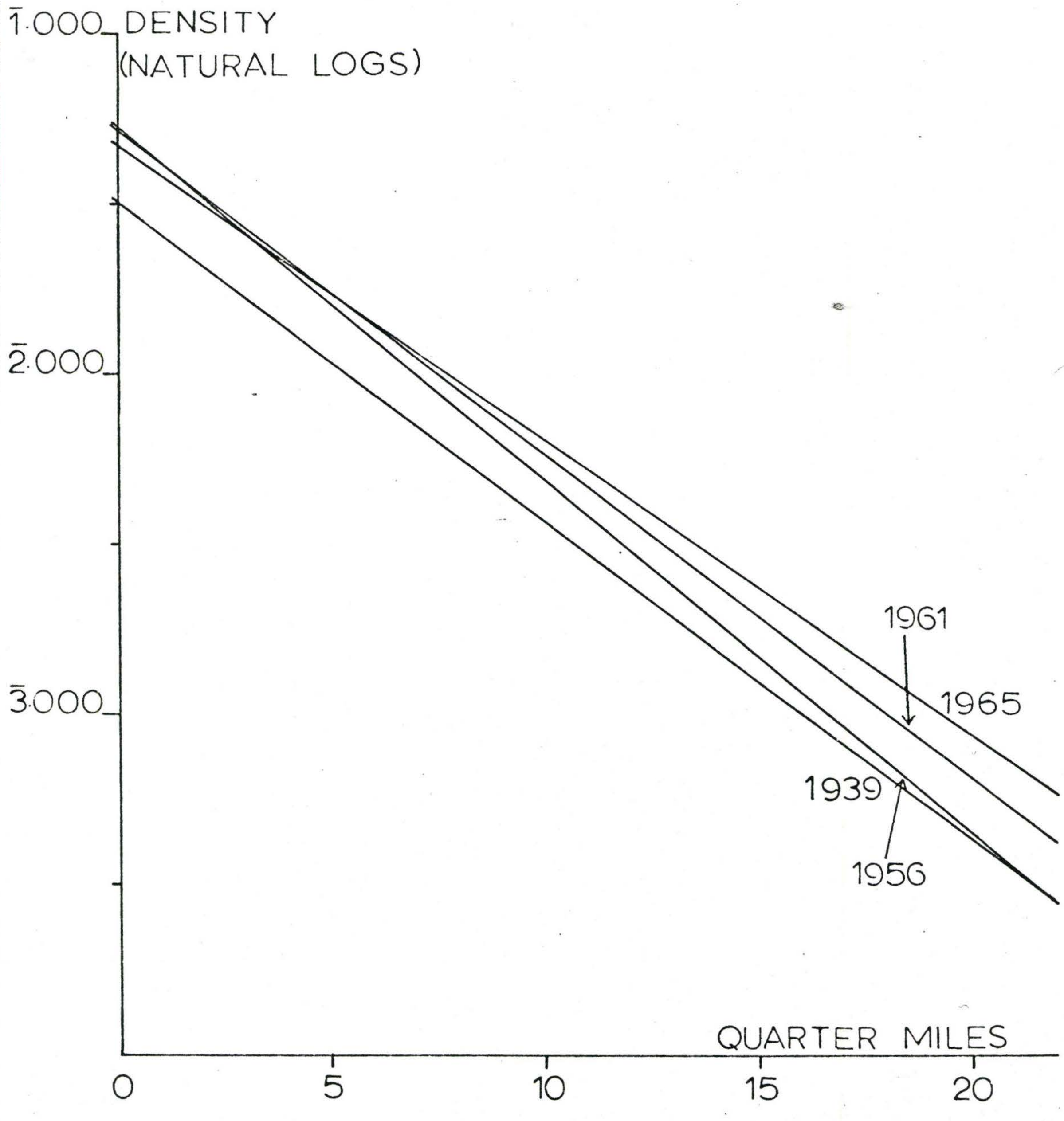


FIG44 DENSITY GRADIENTS OF NUMBER OF STRUCTURES: HAMILTON (UNADJUSTED) 1939 - 1965 SECTION 1

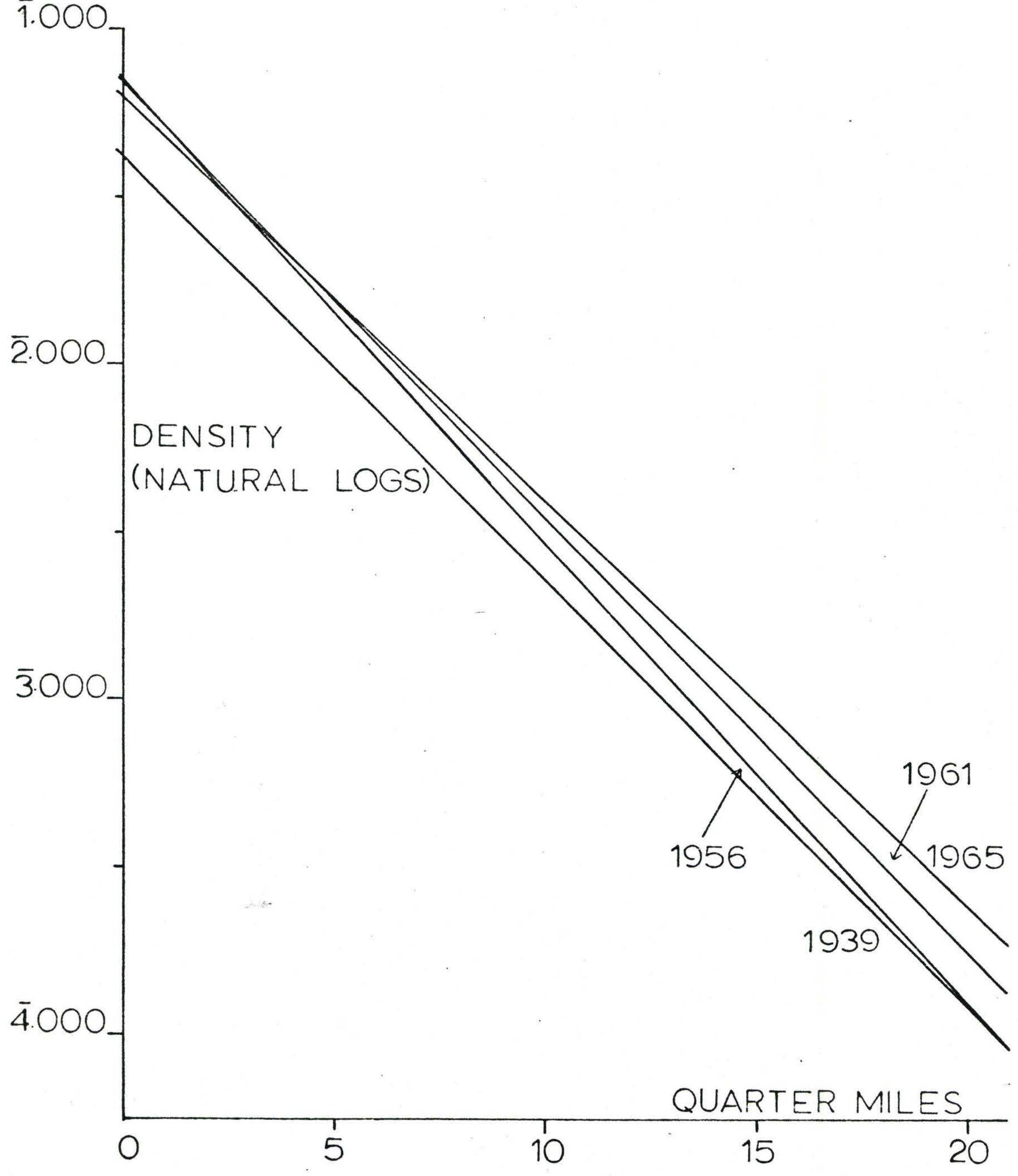


FIG45 DENSITY GRADIENTS OF NUMBER OF STRUCTURES HAMILTON 1939 - 1965 SECTION 2

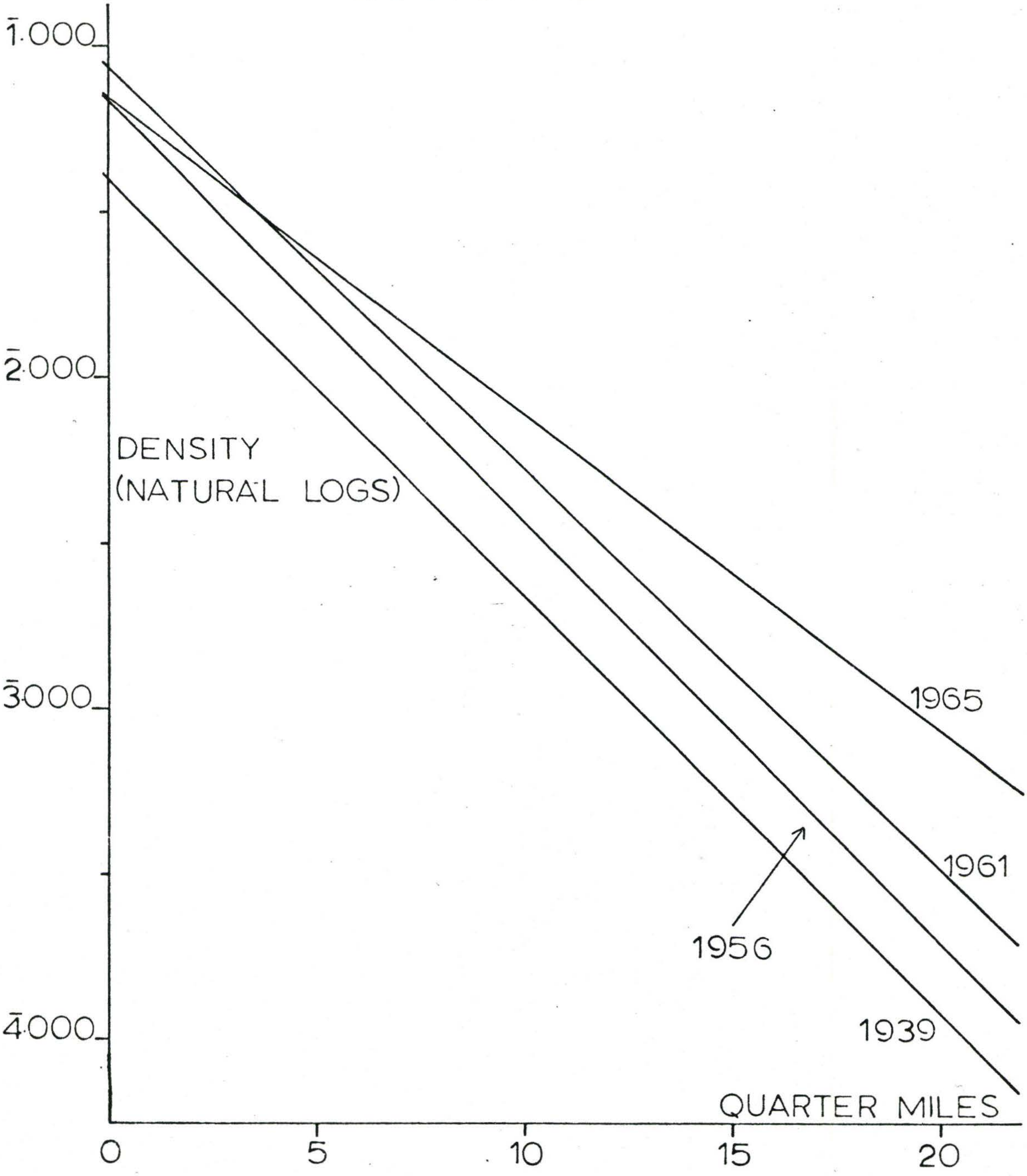


FIG46 DENSITY GRADIENTS OF NUMBER OF STRUCTURES HAMILTON 1939 - 1965 SECTION 3

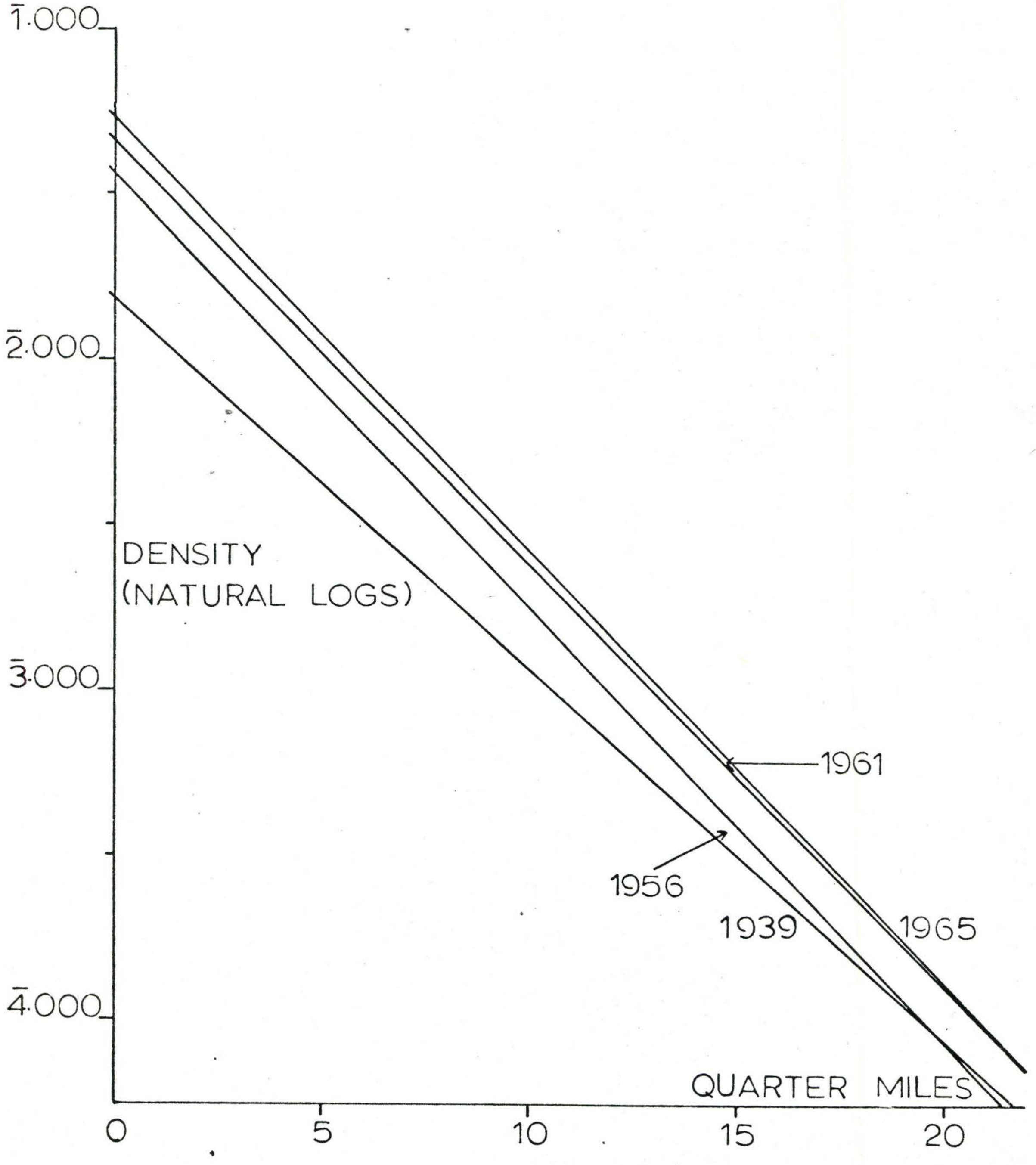


FIG47 DENSITY GRADIENTS OF NUMBER OF STRUCTURES HAMILTON 1939 - 1965 SECTION 4

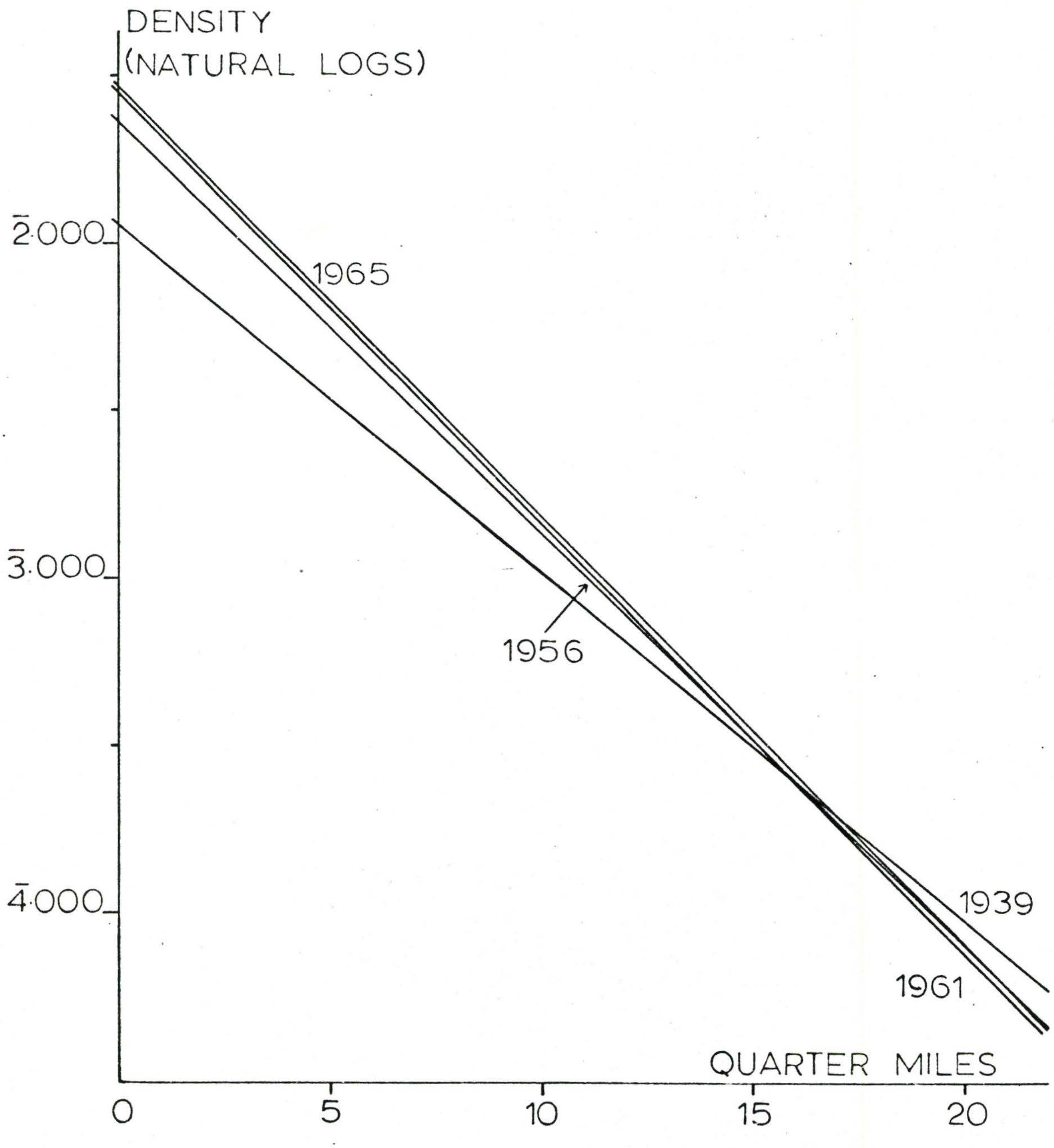


FIG48 DENSITY GRADIENTS OF NUMBER OF UNITS HAMILTON (ADJUSTED) 1939 - 1965 SECTION 1

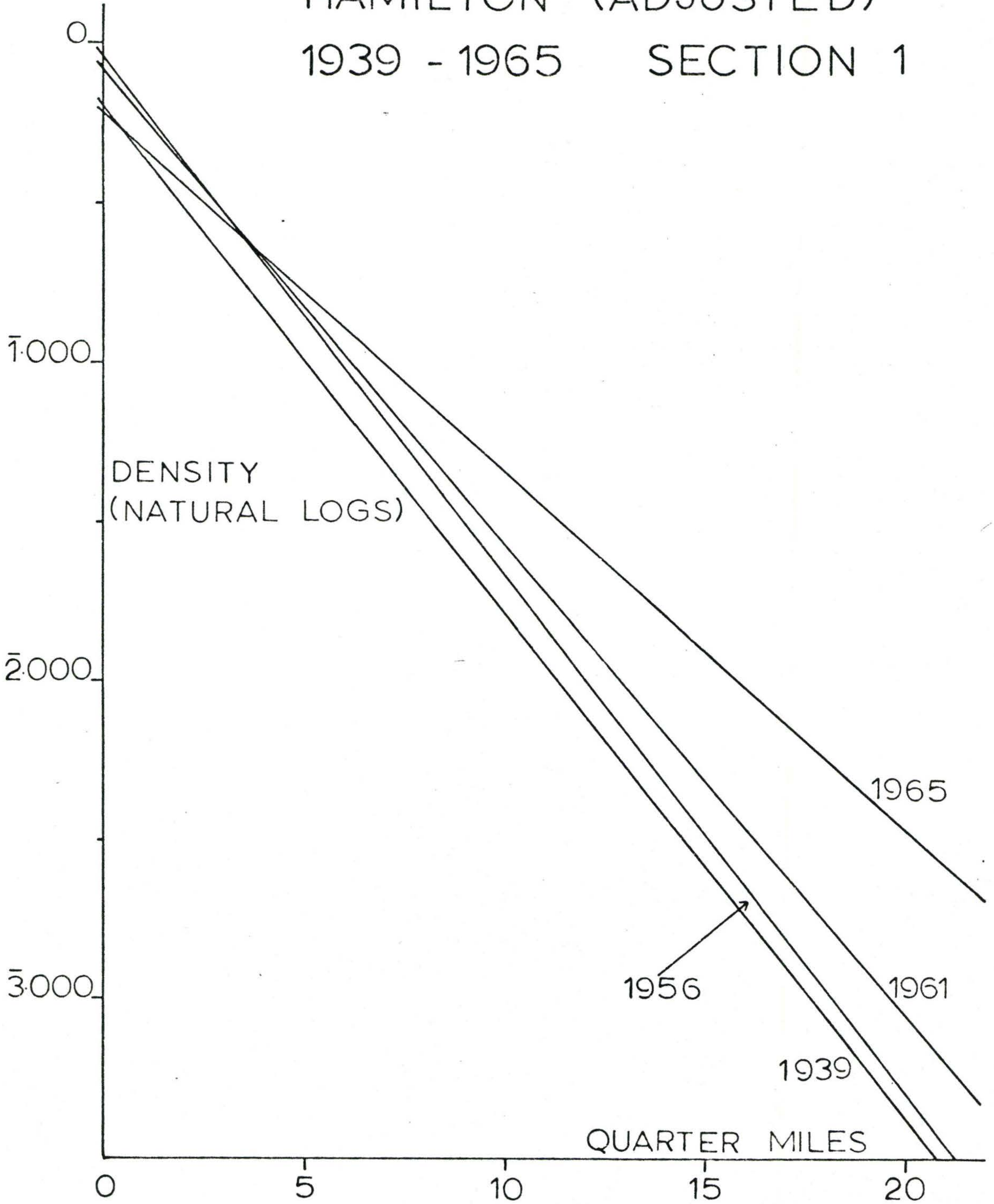


FIG49 DENSITY GRADIENTS OF NUMBER OF UNITS HAMILTON (UNADJUSTED) 1939 - 1965 SECTION 1

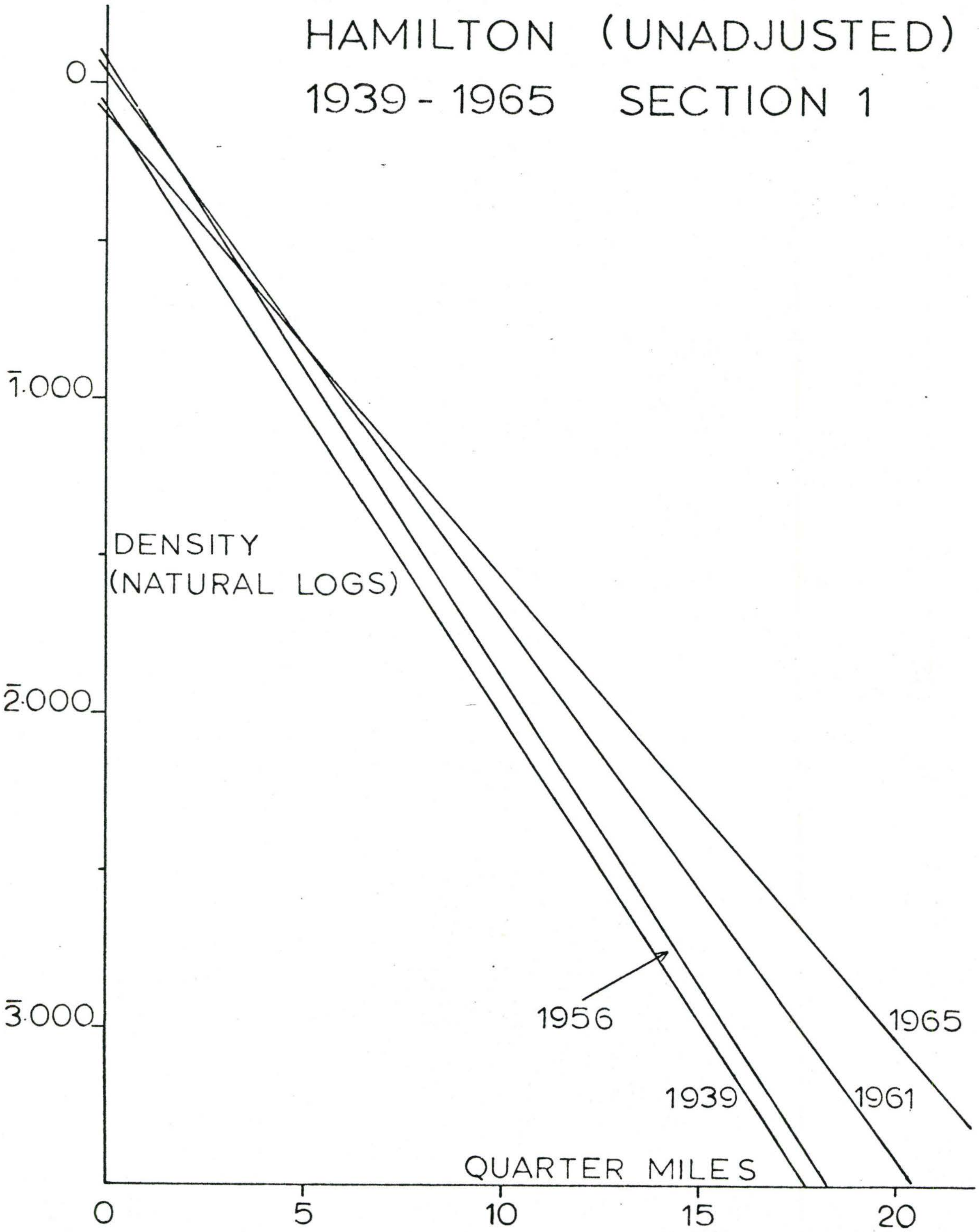
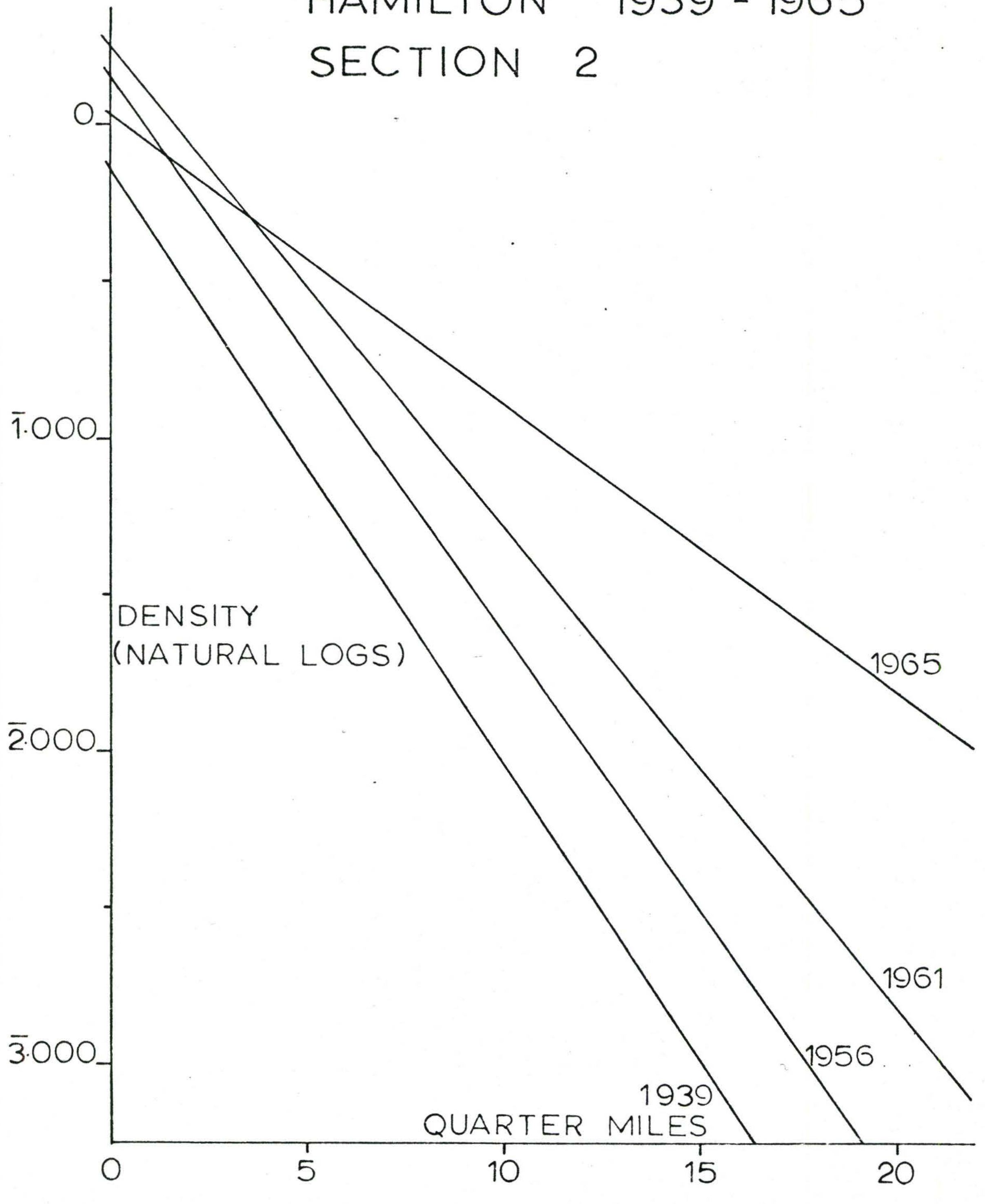


FIG50 DENSITY GRADIENTS OF NUMBER OF UNITS HAMILTON 1939 - 1965 SECTION 2



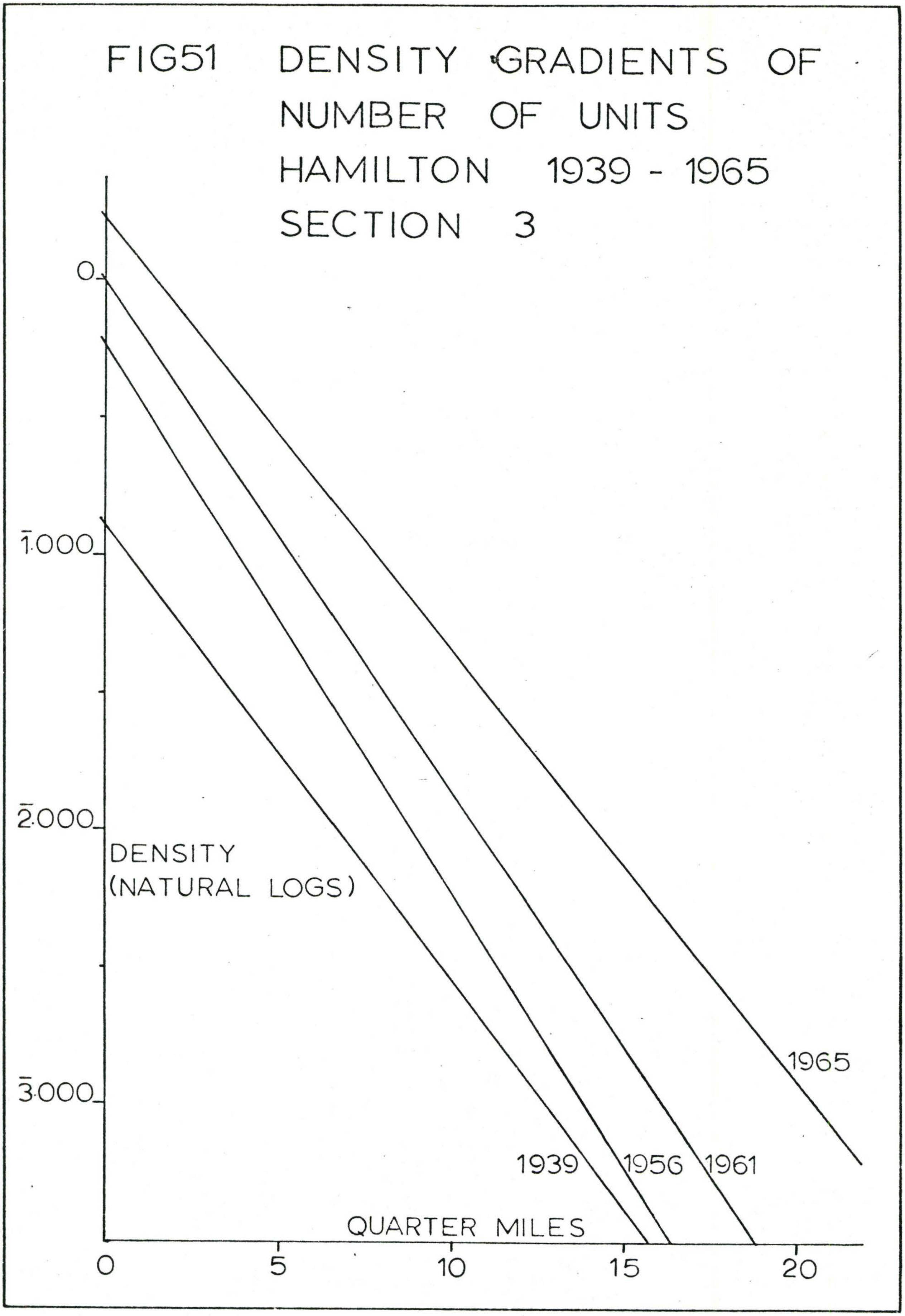
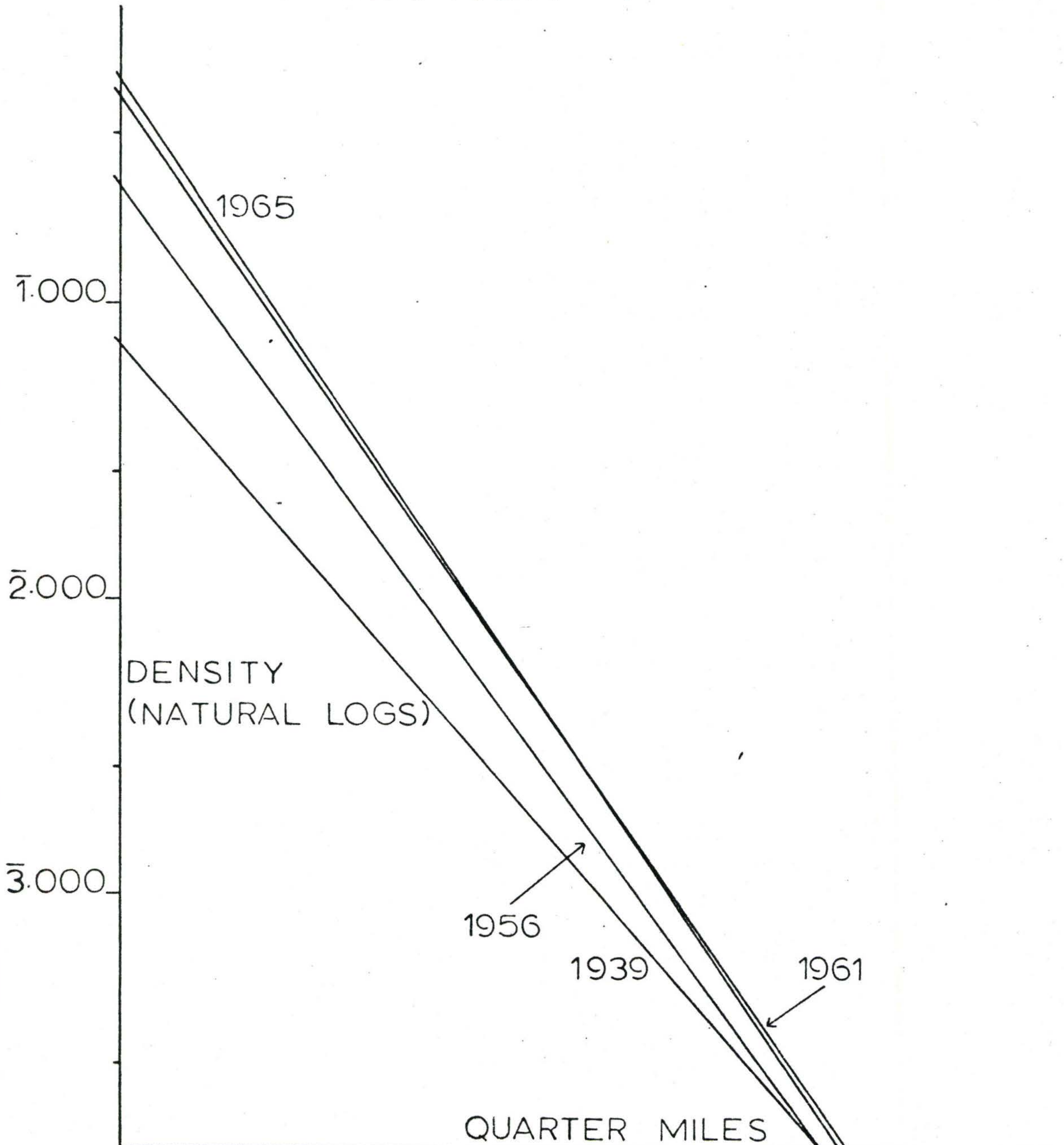


FIG51 DENSITY GRADIENTS OF NUMBER OF UNITS HAMILTON 1939 - 1965 SECTION 3
0
1̄·000
2̄·000
3̄·000
DENSITY
(NATURAL LOGS)
1939
1956
1961
1965
QUARTER MILES
0
5
10
15
20

FIG 52 DENSITY GRADIENTS OF NUMBER OF UNITS HAMILTON 1939 - 1965 SECTION 4



obtained confirm this hypothesis. The second hypothesis was that the density gradients would vary through time in a similar fashion as the urban population density gradients, i.e. they would become less steep through time and there would be a downward displacement of the gradients with the decline in central densities. The analysis shows that, while the first part of this hypothesis can be accepted, there is no confirmation of the second part of the hypothesis. The third hypothesis was that, within sections of the city, the density gradients for the structures and the units would exhibit the same form as the city-wide density gradients. The results allow confirmation of this third hypothesis.

Another conclusion reached is that the analysis using the 'ideal Hamilton' yielded higher correlations between density of structures and of units, and distance from the city centre. This is to be expected since the 'ideal' city represents the conditions under which the relationship would be better developed - the 'interference' role of the city boundary being removed. This chapter has served a dual purpose. It has provided a further precise description of the distributions under consideration and, secondly, it has shown that, in some respects, the location of multiple occupancy residential structures exhibits the same kind of regularity over space and through time that is exhibited by the night time, residential location of people in urban areas.

FOOTNOTES - CHAPTER V

1. P. HAGGETT, op. cit., p. 153, Fig. 8, 2A, p. 216

2. There is an interesting parallel here between the importance of slopes in physical and human geography.

3. E.W. BURGESS, "The determination of gradients in the growth of the city", American Sociological Society, Publications, Vol. 21 (1927), p. 178.

4. Ibid, p. 187

5. C. CLARK, "Urban Population Densities", Journal, Royal Statistical Society Series A Vol. 114 (1951), pp. 490-496.

6. This is another example of how geographers had failed to follow up an avenue of research suggested by a worker in another field - in this case, by Burgess. It is clear also that other earlier leads had been neglected. Haggett suggested that interest in such gradients goes back to Von Thunen's research in 1826 (J.H. VON THUNEN, Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalokonomie, (Hamburg 1875) cited in Haggett, op. cit.) Both Clark and Berry et. al. noted the importance of Mark Jefferson's contribution. (M. JEFFERSON, "The Anthropogeography of some great Cities," Bulletin, American Geographical Society Vol. 41 (1909), pp. 537-566 cited in Clark, op. cit. and in B.J.L. BERRY, J.W. SIMMONS, and R.J. TENNANT, "Urban Population Densities: Structure and Change", Geographical Review Vol. 53 (1963), p. 389). European researchers were also interested in density gradients. Population density maps of 19th century European cities and their declining population densities were provided and observed by Meuriot. (P. MEURIOT, Des Agglomerations Urbaines dans l'Europe Contemporaine (Paris: Belin Freres 1898) cited in Clark op. cit., p. 490). It has also been claimed that Heinrich Bleicher discovered the rule that Colin Clark was to re-discover some sixty years later. (H. BLEICHER, Statische Beschreibung der Staat Frankfurt am Main und ihrer Bevolkerung, (Frankfort on Main, 1892) cited in B. NEWLING, "Urban Growth and Spatial Structure", Geographical Review Vol. 56 (1966), pp. 214).

7. BERRY, et. al., op. cit., p. 389.

8. BERRY, et. al., op. cit., p. 389.

9. ALONSO, op. cit.

10. R. MUTH, "The Spatial Structure of the Housing Market", Papers and Proceedings, Regional Science Association Vol. 7 (1961), pp. 207-220.

11. BERRY, et. al., op. cit., p. 398.

12. This parallels an argument which is well expressed in T.R. ANDERSON, "The Social and Economic Factors Affecting the Location of Residential Neighbourhoods", Papers and Proceedings, Regional Science Association, Vol. 9 (1962), pp. 161-170 especially pp. 162-163.

13. BERRY, et. al., op. cit., p. 398.

14. As the city expanded from its original nucleus, certain physical barriers such as the lake and the Chedoke Valley in the West channeled the city's growth in such a way that the greater part of the city now lies south and east of the Central Business District.

15. J. FRIAR, op. cit.

16. The areas within those belts that lay within the city limits were measured by a polar planimeter.

17. The interval of one mile has been employed in previous studies, e.g. Clark op. cit., and Berry, et. al., op. cit.

18. A number of ways exist to test the significance of 'r'. The method employed was an analysis of variance test - H. BLALOCK, Social Statistics, (New York: McGraw Hill Co., Inc., 1960) p. 304.

19. CLARK, op. cit. operationally defines central density in this manner.

20. H.K. WEISS, "The Distribution of Urban Population and an Application to a Servicing Problem", Operations Research, Vol. 9 (1961), pp. 860-874 cited in BERRY, et. al., op. cit., p. 389.

21. BERRY, et. al., op. cit., p. 395.

CHAPTER VI

SELECTED SPATIAL RELATIONSHIPS OF MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES

The purpose of this chapter is to examine the spatial relationships between multiple occupancy residential structures and some selected urban variables. It is argued that the location of multiple occupancy residential structures at any one time period results from the decisions of private developers operating in the market of rental housing (they may also be involved in land development).[1] These locational decisions of the developers are made with respect to a number of factors which interact in the urban area - these are referred to as locator variables.[2] The review of literature has helped identify some of these locator variables. This was also the purpose of interviews discussed in the Research Design.

As indicated in Chapter III, there were two principal sets of respondents - planners employed by a number of Southern Ontario municipalities and private developers involved in the process of providing multiple occupancy housing. There were some fundamental differences in approach between these two sets of respondents. One group seeks to maximise public benefit while the other group is concerned with having a profitable development. In spite of these differences, certain common factors emerged in discussion with the two types of respondents.

Central Development

Even within a set of respondents, the importance of the locator variables varied. For some developers, proximity to the Central Business District is not perceived by them to be important. Such developers assemble tracts of suburban land and then propose a "comprehensive development".[3] This development would normally include retail and service outlets, residences of a number of types and range of prices (rarely including low income housing) and have land available for municipal services such as schools and recreational open space. In contrast, there are developers who are wholly concerned with central development. In many cases, this actually means central re-development, since central sites almost invariably have to be assembled and cleared before development takes place.[4] Alternatively, the private developer may undertake development on sites made available by publicly-sponsored urban renewal schemes.[5]

Much of this central development occurs on the periphery of the commercial core of medium and large urban areas. This central core is dominated by business and institutional activities.[6] Private developers rarely consider residential development within the central district, due to prohibitive land values. If residential units are to be developed within this area then it appears as if the best, i.e. most profitable, form of development is that of a 'high-rise', multi-functional structure containing retail, residential and office units.[7] Is there also a lower threshold of land values beyond which development of multiple occupancy residential structures would probably not be profitable? If such exists, the developers were unable to identify it in money terms. Some developers argued that, if land was cheap, higher profits could be achieved, if there was a successful development. This assumes that the site possesses characteristics which would ensure the success of a development; the possession of these characteristics could possibly be reflected in higher land values.[7]

At central locations, the value of accessibility is high. Within walking distance, or a short journey by public transit, from central apartment developments, there is a considerable variety of activities. As a consequence, by occupying these residential locations, people can satisfy many of their demands for employment, consumer goods and services, and recreation and entertainment for only small expenditures of time and effort. Therefore, these central locations can be regarded as superior to non-central locations; only by locating non-central developments in close proximity to major urban traffic arteries, thus increasing the opportunities of the occupants by facilitating movements through the urban area, can other developers compete against central developers with respect to accessibility.[9]

Having decided to develop within this general area of the periphery of the Central Business District, the private developer is seemingly less demanding with respect to other locational requirements. Existing development often attracts other development, since the developer can use the existing development as a guide or an 'index of success' for the locale; the existence of other developments usually means suitable zoning exists or is obtainable.[10] Open areas in the central core or on the fringe of the central core are also attractive to developers, since this reduces the claustrophobic effect that can result from apartment 'ghettos' - such open areas are unfortunately few in the central areas of large cities. Often, it is the availability of land on the market, and ease of assembling a site for development, which are the principal influences in the final siting of a project.

Planners' attitudes to central development

Generally, planners are favourably disposed toward central developments of multiple occupancy residential structures. The importance was stressed of building up the residential population in, or close to, the central core so that the urbanity and vitality of the central area can be maintained in the face of suburban developments. Planners are aware of the demand for this form of accommodation and the development of centrally located land for residential purposes does achieve a number of goals. It leads to a reduction in traffic flows into the central area from suburban and non-central locations, which helps check the congestion of central areas, a factor often quoted as a reason for the decline of the central area.[11] For the occupants of central apartment units, there is a reduced amount of travelling involved in the satisfaction of their various demands (mainly with respect to employment and retail/service purchases) and this makes time available for other activities. On the basis of both the field interviews and readings of planning literature, it seems as if planners hold the opinion that people regard time spent in making such trips as wasteful and, therefore, if a reduction of the duration of trips is achieved, this will be to the satisfaction of most people. Planners also regard this type of development as a means of offsetting decreases in central tax revenues.

The central location of these structures also brings problems for the municipal planner, influencing his reaction to development in this area. A consequence of central development could be the overloading of existing service facilities, necessitating costly replacements - for example, sewage facilities. Another problem may be the provision of adequate open space for the residents of multiple occupancy residential structures. Although some planners now recognise that the provision of open space is perhaps less critical in apartment areas than in other areas, others still regard this inadequacy as a major problem. However, the legislation and mechanisms exist for municipalities to overcome this problem (given the desire of the municipality).[12] Also developers are increasingly aware of the benefits that derive from attractive, spacious developments. Publicly-sponsored urban renewal schemes may also increase the amounts of open space in the built-up areas of cities. It was noticeable that as the scale of the urban community and the central area increased e.g. Toronto, the planners were concerned that central multiple occupancy residential structures should have good access to public transit - in the case of Toronto, accessibility to the subway was stressed.

Non-central Development

As pointed out, planners recognise the need for multiple occupancy residential structures, but they have no desire to see them overly concentrated in the central area.[13] With the spread of facilities, such as the transportation network, especially highway development and retail outlets to serve the single family area, some developers have seized the opportunity to create developments in suburban and non-central locations in relation to these spreading facilities. This development has taken the form of infilling, of a peripheral nature, and as part of "comprehensive development" already discussed.[14]

The importance of a location which has good access to a major urban traffic artery and, especially, the intersection of two such arteries, becomes clear from the comments of private developers and planners. The value of such a location in allowing ready access to the communications net and facilities has been outlined. Major city streets are regarded as suitable sites for multiple occupancy residential development. Such locations are held to be unsuitable for single family houses because of the factors of noise, danger to children and general unattractiveness. These sites are, however, suited to commercial development, especially to retail establishments, since the latter can draw upon volumes of passing traffic; such activities need to be accessible to large numbers of potential customers. Retail locational practices and planning concepts have given rise to the integrated shopping centre or plaza as a preferred form of retail activity along major city streets, the old linear form of development being, in the opinion of both operators and planners, less satisfactory from the point of view of performance and amenity. It was evident from the interviews that some planners regard multiple occupancy residential housing as a logical next best use along arterial streets. Development on major city streets enjoys the value of quick access to the remainder of the city.[15] There are usually retail establishments within reasonable proximity to the residential structures (see below), to meet the demands of the occupants. By allowing at, or channeling development to, such locations, planners can bring about "buffers" between a single family area and the major city streets and preserve the 'sanctity' of the single family unit neighbourhoods, where opposition to multiple occupancy developments is strong and vocal.

There appears to be a natural locational relationship in the minds of the developers and planners interviewed with respect to the relationship between retail establishments and multiple occupancy residential structures. They believed that similar locational influences were at work in both cases and, therefore, one would expect to find the two phenomena in close proximity.[16] Some developers observed that the retail outlets and the apartment structures enjoyed an inter-acting relationship. The developers know that tenants of a development located near retail establishments would have easy access to a certain range of retail goods; they also noted that, especially in suburban locations, concentration of structures often generates a small cluster of retail shops serving the occupants of these structures. Another common characteristic is to find a number of apartment units above retail establishments; this usually occurs in the central commercial core or on the older commercial 'string' streets.[17] This type of development has declined in recent years, but a larger scale, more modern version has re-appeared in the heart of the Central Business District.[18] Those private developers who were involved in large land developments tried to create a centre or focus to the development, where retailing was adjacent to high density residential development. They felt that this relationship was mutually beneficial and that it gave the centre some compactness and degree of urbanity appropriate to its role as centre of a large development.[19]

The factor of open space in non-central developments was discussed briefly by both planners and private developers. Again, as in the central area, planners were concerned that the occupants of the multiple residential structures should have enough open space for "lungs" and as areas of recreation. The private developers, while recognising the need for such open space, were more concerned with the scenic attractions of a site, since this would enhance the value of a development e.g. sites overlooking a valley or water are actively sought out.

General factors affecting development patterns

Other factors also entered into the discussions. The existence of previous developments attracts others as has already been noted. The imitation of success encourages the growth of concentrations, usually of a similar nature, i.e. equivalent levels of intensity, rentals etc. - this assumes site and zoning conditions allow further development. Developers tend to avoid undertaking a project in an area not zoned for multiple occupancy residential development, since the delays and opposition can often be prejudicial to the success of a project, especially with respect to investment in the development.

There seems to be a conflict between planners and developers over the amounts of land zoned for multiple occupancy housing. In order to carry out their tasks, the planners invariably divide the urban area into a number of planning districts, but the rationale of the division is not always explicitly set out, and the meaningfulness of the resultant districts is not always made clear. For these planning districts, residential densities are established. These densities are regarded by planners as being most suitable for the areas, i.e., if these densities are exceeded, then not only is there residential overcrowding, but the facilities and municipal services of the area will also be insufficient for the needs of the inhabitants.

In the establishment of these residential densities under a zoning code, planners may well be concerned with the maintenance of the "status quo" or, at least, only allowing minor modification of the existing pattern. This can result from either the planners' overdue concern with conserving an area or political pressures; some communities or areas will not approve of increased residential densities. The planner is further hindered in his approach, since the negative nature of the zoning which embodies these densities clashes with the more positive approach of the developer.[20] Again, the planner cannot be flexible, within a district, with respect to development. Once a density has been established, deviations from this are not permissible. The planning district boundaries also remain inviolate. A proposed development may logically relate to the patterns existing in an adjacent planning district, but, because it disturbs the densities established for the district containing the proposed development, the development would not be allowed. It is on such grounds that planners and developers come into conflict. Sometimes the developer does not take the overview of the neighbourhood, because of the nature of his development (the assembly and development of <u>one</u> site). In this case, his objection may have less merit.

Many developers tend to identify the planners with the maintenance of existing zoning standards and levels of density. Since these act as constraints on the achievement of the goals of the developers, there is a conflict of interest. Therefore, in some cases, the developer will challenge these existing standards and levels. These developers take a chance on the delays involved in the hope of making a greater profit. Land acquired under a lower intensity zoning code will normally be cheaper than land intended for a high density use. Therefore, if a zoning challenge is successful, the profit margins on a development are likely to be greater, with costs per unit being lower than they would otherwise be. The results of these challenges are developments isolated in an area of lower density use or a zoning change in the face of a number of challenges, allowing this type of high density residential use.[21]

The description of this conflict of interest is of what might be termed the theoretical position. In reality, the position is less rigid than that described. The decision-makers are the municipal councils and they are often willing to 'bend' the principles set out by the technical planners in order to obtain a share of the urban growth (and tax revenues) that future development implies. This is particularly true of municipalities that have a strong single family dwelling unit component and that are also in competition with neighbouring municipalities for a portion of a given amount of urban growth.

The effects of financial decisions with respect to the spatial pattern of multiple occupancy residential structures are perhaps less clear. It was apparent, however, in discussion with private developers that, for proposed developments in certain parts of urban areas, mortgages were reasonably available. Financial companies such as large insurance companies considered many of the locator variables already identified in their assessment of a project - they also assess the general character of an area. Areas or sites of proposed developments not exhibiting a suitable mix of locator variables are not regarded as meriting financial backing.[22]

It seems clear that, from the interviews held with developers and planners, a number of locator variables enter into their consideration of a project or the establishment of zoning standards. While these variables have been identified somewhat in isolation from each other, in the actual process of development, these variables are weighed one against the other. The weighing process continues until the proponent of the scheme believes that the particular location for his development possesses the best mix of locator variables (that is compared to other sites that may have been available to him) - 'best' to the developer means most likely to be profitable under the given conditions. The planner will consider the locator variables in assessing whether or not a proposed structure is harmful to the community interest and if it fulfills a need; also, in the establishment of zoning standards, these variables will enter his deliberations. The variables that emerge from the discussions, such as proximity to the central area, distance from major city streets and urban highways, the pattern of land values, the proximity to retail establishments, the relative importance of open space, the amount of suitably zoned land and the pattern of residential densities, the pattern of existing municipal services and the decisions of the investors tend to confirm and supplement those factors identified from the review of the literature as having an influence on the spatial pattern of multiple occupancy residential structures in urban areas.

Selection of Variables for Multi-variate Analysis.

The next step in the examination of the spatial relationships was to select the variables to be employed in a multiple regression analysis. The reasons for choosing this type of analysis were outlined in the Research Design. The value of employing a small number of variables was indicated but, to re-emphasise, an effort was made not to discard what appeared to be relevant information. Therefore, an attempt was made to use variables in the regression analysis that could represent one or more of the identified locator variables.

As was discussed in Chapter V, a punctiform distribution can be reduced to a density surface, variations in which are brought about by the interaction of various forces, which work to shape the surface. It has been argued that the distribution of multiple occupancy residential structures in urban areas has been brought about by the decisions of private developers and municipal councils (acting on the advice of their technical planners) under the consideration of a number of locator variables.[23] It seemed reasonable, therefore, that an explanation of the density surface of multiple occupancy residential structures could serve as an explanation of their spatial distribution, the two being but the continuous and discrete expressions of the same phenomenon. This explanation will be expressed in terms of the spatial relationships of the multiple structures and the selected variables.

Since the dependent variable was conceived in the form of a density surface, some form of areal unit was required as a base. The effect of the size of areal units upon the results of regression analyses has already been discussed.[24] As was observed in the Research Design, the scale of analysis was altered to give three different areal units, (including the initial grid). It was decided that a reasonable approach would be to cover the study area of the City of Hamilton with a square grid of cells. By a process of aggregation of cells, two additional grids were created and the regression analysis carried out at each level of scale, (note the similarity of this procedure and the filter mapping technique). The initial grid contained 1,128 cells which were 1,000 feet square, (approx. 330 yards square). This provided a relatively close grid and was chosen so that the operational definitions of the variables were more realistic than if a larger grid had been used - with an increase in cell size, the operational definitions become more crude. This occurs because the independent variables cannot be defined at a scale lower than that at which the dependent variable is conceived. Thus the cell is the basic unit of analysis and the smaller the cell, the more closely the definitions approach reality. At the highest level of scale, the grid contained 72 cells which were 4,000 feet square, (approx. 1,330 yards square).

Other possible areal units were considered, but the difficulty of handling and measuring such irregular areas as census tracts, traffic data zones and city street blocks led to their rejection in favour of the uniform grid. The dependent variable was then defined as the number of multiple occupancy residential structures per cell.

The selection of the independent variables to be utilised in the regression analysis was the next step. A wide range of locator variables had been established on the basis of the interviews and the review of literature already described. It seemed reasonable to select a few variables from this range and proceed on the assumption that other locator variables could be incorporated into the analysis to replace any of the original variables that exhibited a weak spatial relationship with the dependent variable. It will be remembered that the advantages of keeping the regression analysis simple, yet meaningful, by employing only a small number of independent variables, were emphasised. Thus, in the selection of the independent variables, it was decided to choose from the range a few variables that appeared to be important, that were relatively easy to handle operationally and which could be used to represent some of the other locator variables in the range. It was felt that, if a selected variable could be used as an approximation for another locator variable, then this strengthened the use of that variable in the analysis. This does, however, raise the problem that, if a relationship is established between two of the independent variables to allow this kind of substitution, then, if the second independent variable was to be incorporated into a later stage of the analysis as an independent variable with an operational definition, this would bring about interconnection between independent variables, a major problem in regression analysis.

Distance from the central area.

The first variable selected was distance from the central area, the commercial and service core of the city. This variable has been previously utilised in the description of the spatial pattern in Hamilton by the use of density gradients reported in Chapter V. Significantly high correlations were obtained between distance from a point within the Central Business District and the density of multiple occupancy residential structures. Thus, it was expected that this variable would contribute to a considerable part of the explanation of the variation of the dependent variable. It should be noted, however, that these high correlations were obtained in an analysis which used large areal units, i.e. 21 concentric belts of quarter-mile width, and this fact probably contributed to the nature of the coefficients.

Primarily, this first variable served to measure the important locator variable of proximity to the central area. It can be argued that this variable also served to measure other locator variables. One of the range of locator variables was land values. Distance from the central area can be employed as a substitute for the pattern of land values. This assumes that land values vary directly with the distance from the Central Business District - this seems to be a reasonable assumption although the relationship may be weakening with the recent rise in land values on the periphery of urban areas.[25] This particular substitution or representation had great practical value, in that it removed the need for obtaining actual land values, a task that would have been complex and time-consuming.

This first variable can also be regarded as a measure of accessibility. Any discussion of accessibility must always consider the question "accessibility to what?" In general, people living in urban areas have a number of demands which they seek to satisfy; in order to do this, they make a number of journeys from their place of residence to other parts of the urban area. Most of these journeys take the form of journeys-to-work, trips for retail purchases or the use of services for entertainment and recreational purposes. The central area remains the focal point for the majority of trips, in spite of the increasingly dispersed distribution of industry and the spread of retail and other services throughout the urban area.[26] It is this concept of accessibility that was held by developers when they discussed the benefits of locating on, or close to, major city streets or urban highways. Other areas of the city, notably the central core, are accessible to the residents of multiple occupancy developments at such locations, since they can utilise the highway network to which they have immediate access. Since it has been shown that most trips still focus on the Central Business District, this area being the location of the major trip generators, it is argued that distance from the central area is an alternate method of expressing accessibility.

It is common to measure accessibility in terms of time rather than distance.[27] This follows from the congestion of the central areas, where it takes longer to travel any given distance than it takes to travel the same distance outwith the central areas. Thus, the typical isochrone map has time bands focused on the Central Business District; these bands are of increasing width as distance from the centre increases. They are distorted by the lower travel times along the axes of major urban streets and highways. A further consideration for using time as a measurement is that people consider trips in a temporal sense - it is more important that the individual know the time spent on a trip than the distance of that trip.[28] Thus, distance from the central area is less satisfactory in this respect as a measure of accessibility. For practical reasons, however, it was decided to accept a less satisfactory conception of accessbility, but one which could be used with regard to other locator variables and which was easier to measure. To have used accessibility to the central area as one of the variables in the regression analysis and to have measured accessibility with respect to time would have involved a great deal of labour. It would have been necessary to establish an average travel time from each multiple occupancy residential structure to some point in the central area. The Hamilton Area Transportation Study does give an indication of automobile and public transit travel time in the Hamilton area, based on trips to the junction of King Street and James Street in the Central Business District. However, these times are only applicable for 1961 and the class intervals of less than ten minutes, ten to twenty minutes and twenty to forty minutes are rather broad, giving only three categories into which a structure could be assigned. In the light of changing traffic conditions since the nineteen-thirties, it would be unrealistic to apply these travel times to the other time periods. The width of the class intervals would reduce the amount of distortion involved; the greatest distortion would occur at areas close to class interval boundary.

This discussion of accessibility has shown that the central area is a prime location for retail establishments and also for employment opportunities. Distance from the central area was, therefore, a measure of the spatial relationship between the occurrences of multiple occupancy residential structures and the locator variables of proximity to retail outlets and proximity to employment opportunities, (although it is recognised that there are other concentrations of retailing and employment in the urban area). It is evident then, that distance from the central area, while being an important element in the spatial structure of an urban area, is also a useful expression of other elements of this structure.

Distance from a major city street.

The second variable chosen was distance from a major city street.

Major city streets or urban highways have been identified as an important locator variable and this was especially evident in the interviews. It has been argued that the location of multiple occupancy residential structures along such streets represents, in part, an effort, by the developer, to create for the occupants of these structures a residential site that possesses the characteristic of accessibility. However, this variable is not used to reflect, or as a measure of, accessibility, since a number of conceptual difficulties were encountered. Major city streets are commonly defined in terms of volumes of traffic. Even where the capability or capacity of a street is used as a criterion for ranking, these indices themselves are thought of in terms of ability to handle certain volumes of traffic. The volume of traffic on a city street is not necessarily a good indication of the accessibility of locations along that street - it only indicates the number of vehicles being distributed to other parts of the urban area. Congested streets tend to be those carrying the greatest volumes of traffic and, if major streets are defined in terms of volume, the likelihood is that they will be congested - this tends to reduce accessibility rather than promote it. There also exists a two-way interaction between traffic volumes and the development of multiple occupancy residential structures. For example, a city street may become classed as major, as a result of the increased traffic volumes generated by these developments.[29] Because of these problems, and since accessibility can reasonably be handled under the first variable, this second variable was chosen as an approximation of other locator variables, such as the occurrence of retail establishments, employment opportunities and the zoning pattern.

An examination of the literature, together with observation in urban areas, shows that there is a strong spatial relationship between major urban streets and retailing units.[30] In urban areas, retailing is concentrated (1) in the central commercial core, (2) along major arterial streets and (3) where such traffic arteries intersect, especially in mid-town and suburban locations.[31] In all of these locations, the retail establishments can attract custom from the passing traffic, as well as be accessible to customers whose purchases were pre-determined. With the existence of this strong relationship, distance from a major city street can be regarded as an alternative measure of proximity to retail establishments.

It is common to find land immediately adjacent to major city streets zoned for high intensity commercial use, thus permitting retail, service and other commercial development. As was brought out in the discussion of the interviews, this type of zoning is frequently found in conjunction with zoning for high density residential land use. Even where such zoning is not available, it would be reasonable to expect that an attempt to change the zoning to allow multiple occupancy residential development would have more success here than an attempt to 'invade' an area zoned for single family residential development. Furthermore, the provision of suitable zoning along arterial streets facilitates the development of 'buffers' of apartment structures.[32] Thus, to some extent, a measurement of the distance between a multiple occupancy residential structure and a major city street is also a measure of the association between such structures and land zoned for high density residential use.

It is also clear that, outwith the Central Business District and the large industrial districts of an urban area, the activities located along major urban arterial streets represent a sizeable element of the urban employment structure. Therefore, distance from a major urban street can be substituted for distance from employment opportunities (in the same way as distance from the central area also represents distance from employment opportunities). Another useful characteristic of the first two selected variables is that they reflect the distance from any structure to existing development. For example, a structure at a short distance from the central area is likely to be close to other structures as a result of their clustering around the central area. Similarily, a structure located on a major urban street is likely to be closer to other developments than a structure not located on such a street. This is somewhat crude generalisation, but it has some value.

The abstraction of data required for the exact measurement of such locator variables as proximity to retail outlets and proximity to land zoned as suitable for this form of residential land use, would have been a time-consuming task. It was felt that, for the initial regression analysis, the selection of the relatively simple measure of distance from a major city street would be sufficient, especially in view of its utility in approximating a number of locator variables.[33]

Distance from open space.

The third variable chosen was distance from open space. This emerged as an increasingly attractive and important variable, both from the interviews and the review of the literature; it was felt that this variable deserved consideration in the analysis. This locator variable is not handled under the first two variables and, therefore, stands on its own; it has the advantage of being simple to define and the measurement of the variable was also straightforward. It can be argued that this variable helps strengthen the consideration of land values, since the attractiveness of sites in proximity to open space (including areas of scenic value) will probably mean that they will exhibit high land values. Therefore, proximity to open space might also suggest proximity to high land values.

Density of Employment Opportunities.

The fourth variable selected was density of employment opportunities in the city. This was an attempt to strengthen the examination of the relationship between the location of multiple occupancy residential structures and the distribution of employment opportunities. Employment opportunities have already been related to the Central Business District and to major urban streets or highways, but industrial concentrations of employment have not been considered. While the literature does suggest that the concentrations of employment opportunities that might attract the interest are non-industrial in character, this was primarily with respect to a medium to high rental type of apartment building - the low quality, low rental structure which can serve the industrial labout force was not considered. This variable is, however, of minor importance.

To summarise this section, four variables were selected for use in the regression analysis. These were:

(1) Distance from the central area,
(2) Distance from the nearest major street,
(3) Distance from the nearest open space
(4) Density of employment opportunities.

Each of these variables represented one of the range of locator variables already established. Other locator variables were not chosen for this initial analysis, on the grounds that some would prove very difficult (though not impossible) to handle operationally; also, those variables not chosen could later be incorporated into the analysis, if any of the initial variables exhibited a weak relationship and warranted replacing. Again, some of the variables not selected were subsumed under the first two variables chosen and, in this way, some consideration of the relationship of these variables with the dependent variable was achieved. The locator variables not considered or subsumed at this stage in the research were the pattern of municipal services and the financial decisions of investors.

Operational Definitions.

This is a brief section, since the operational definitions have been touched on in the discussion on the selection of the four variables, while the terms used have been defined in Chapter III, in the discussion on data collection for the regression analysis. The dependent variable was defined as the number of multiple occupancy residential structures in a cell of the city-wide grid. For the independent variables, the definitions were:

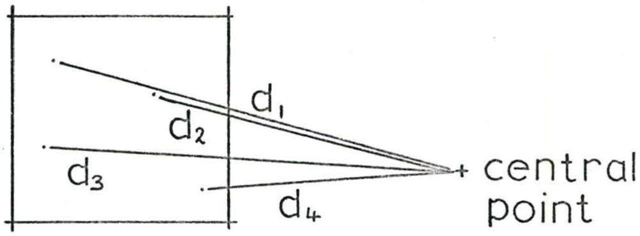
1. the mean airline distance of all structures within a cell from the intersection of James Street and Main Street in the Central Business District,
2. the shortest mean road distance from every structure in a cell to the edge of the nearest major city street,
3. the shortest mean road distance from all structures in a cell to the nearest open space

and 4. the density of employment opportunities in a traffic data zone.

In each case, any structure would be associated with one time period, that period being the one when the existence of the structure was first recorded. For that structure, the measurements required for the analysis were made with respect to the pattern that existed at that time. For example, a structure developed in 1954 would be first recorded in 1956. The measurement to the C.B.D. did not change with time, but the measurements with respect to major streets and open space were made with 1956 data for those distributions. Since there is only one set of data on employment, this resulted in a constant through time for the fourth variable.[34] Clearly, the locational decisions made in 1954 referred to the patterns that existed in 1954, not 1956. While this is a weakness, it has to be accepted by virtue of the nature of the study.

The Regression Analysis.

The data required for this analysis was collected from the sources noted in Chapter III and the appropriate measurements made. These measurements were added to the basic data deck used in the study (see Appendix B). For the fourth variable, the identification number of the traffic data zone in which a structure was located was added to the main data deck; a separate deck was then constructed containing density of employment opportunities in a zone divided by the area of the traffic zone. Where a traffic data zone boundary ran through a cell, a weighted average density of employment was calculated for that cell. This analysis was carried out on an IBM 7040 computer. The program was designed so that only those cells in the grid containing multiple occupancy residential structures were dealt with under the dependent variable. Thus, an explanation of the total density surface was not achieved, since areas lacking development were ignored. What is explained is the occurrence of multiple occupancy residential structures in terms of their spatial relationships with the selected variables. The independent variables, although operationally defined in distances from a structure to the central area, etc., were of necessity aggregated into average distances from the cell to the various phenomena. Thus



The actual value used in the calculations would be $(d_1 + d_2 + d_3 + d_4)/4$. The results of the analysis are shown in Table 11. No attempt was made to test the significance of the results obtained, since it would be very difficult to establish significance levels against which the coefficients could be tested. It should be remembered that these regression coefficients refer to the operational definitions within which the analysis was carried out. Thus, they do not refer to the variation in the pattern of the individual structures, but to the cells, and it is not possible to dis-aggregate the coefficients in such a way as to relate them to the structures. One possible method of assessing the significance of the coefficients would be the creation of an ideal

TABLE 11.

MULTIPLE REGRESSION ANALYSIS OF MULTIPLE OCCUPANCY RESIDENTIAL STRUCTURES AND FOUR SELECTED VARIABLES.

VARIABLE NAME	REGRESSION COEFFICIENT	CORRELATION COEFFICIENT	PERCENT VARIATION EXPLAINED
Scale 1.	Sample size[a] - 201		
Distance from central area	-0.16948	-0.25707	6.61
Distance from major street	0.18398	0.02375	0.05
Distance from open space	0.07226	0.01403	0.02
Density of employment	-0.00255	-0.01039	0.01
Scale 2.[b]	Sample size - 101		
Distance from central area	-0.55178	-0.38749	15.01
Distance from major street	1.70160	0.10812	1.15
Distance from open space	-0.14334	-0.01215	0.01
Density of employment	0.07580	0.10590	1.12
Scale 3.	Sample size - 38		
Distance from central area	-1.81953	-0.48286	23.31
Distance from major street	1.80205	0.05988	0.36
Distance from open space	-3.53263	-0.10465	1.10
Density of employment	0.25249	0.11301	1.28

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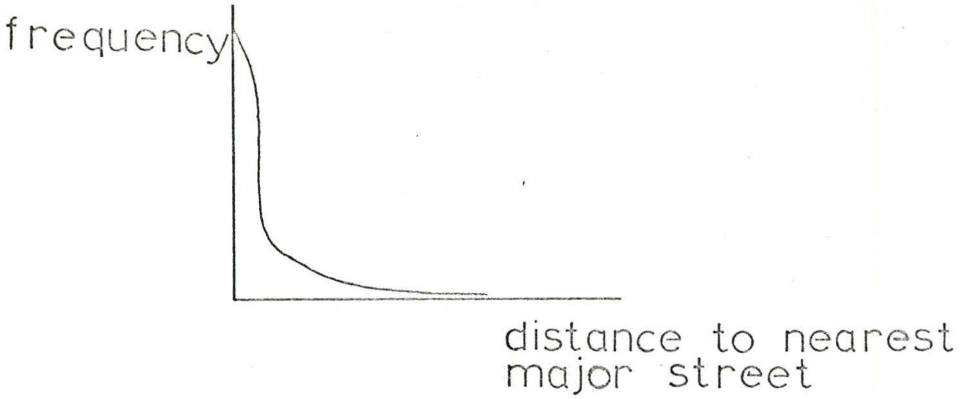
a - The sample size is the number of cells in the grid containing multiple occupancy residential structures.

b - The scale change was brought about by the introduction of a scale reduction factor which reduced the number of cells in the grid by a factor of four to produce Scale 2 and by a factor of sixteen to produce Scale 3.

distribution of multiple occupancy residential structures. One would have to know exactly how many structures would be in any cell of a grid placed over the area of study. If this distribution was aggregated into cells, it should be possible to say how much this affects regression coefficients, since there would be a decline from the perfect relationship existing in the ideal distribution. Thus, if one could assess the effects of aggregation on the coefficients, it might then be possible to take the coefficients obtained in this analysis and say something meaningful about the relationships they indicate.

From Table 11, it can be observed that reasonable amounts of explained variation are only obtained for the variable, distance from the central area. The increase in explained variation from about 7%, through 15%, to 23% confirms the statements noted that the scale of analysis affects the results of regression analysis. The remaining three variables do not contribute to any extent to the explanation. To some degree, this was expected with the third and fourth variables, distance to an open space and density of employment opportunities, although a greater contribution had been hoped for with the third variable. The low percentage of explained variation with respect to the second variable, distance from a major street, was contrary to expectations. However, an explanation of this may be found in an examination of this variable's distribution. The distance from a structure to the nearest major street is either zero or very small. Even when this is aggregated over a cell the distances will be small. Thus, the distribution of this variable will have a general form:



As can be seen, there is little variation in this distribution and thus, one cannot expect this to contribute a significant amount towards the explained variation. This could be verified by an examination of the actual data and a distribution constructed both for the distance with respect to individual structures and with respect to cells. If the distributions are similar, then the variation cannot be expected to be high. This would actually approximate a chi-square test. The distribution with respect to structures would be the observed distribution and the distribution with respect to cells the expected distribution.

However, considering the crude operational definitions that have been employed in this analysis, the results are perhaps not unreasonable, especially for the first variable. It should be remembered that the explained variation does not refer to the variation in the density surface of multiple occupancy residential structures, since those cells that did not contain structures were not considered in the analysis. The explained variation is with reference to the occurrences of the multiple occupancy housing. The logical next step in this type of analysis would be the replacement of those variables that had contributed little to the explained variation by others, selected from the range of locator variables. This process would normally continue until the mix of variables providing the 'best' set of coefficients and highest amounts of explained variation was achieved. However, the results obtained suggest that the approach used here was not suited to the problem at hand. The operational definitions were of necessity crude, since the dependent variable was conceived in terms of a density surface which, therefore, required the use of an areal unit. The choice of what was believed to be the most suitable areal unit contributed to the crudity of these definitions. Thus, what appeared to be a precise operational definition, distance from a multiple occupancy residential structure to a point or line, was aggregated into an average distance from a cell to a point or a line.

Perhaps an alternative approach which would reduce the problem of aggregation would be to express the dependent variable as the average distance from a multiple occupancy residential structure to its three nearest neighbours. This approach can easily be linked to a conception of density - short average distances will occur in an area with many structures and the distances will increase as the intensity of development declines. This approach would allow the use of less crude operational definitions and lead to a potential increase in explained variation.

Another approach that should be considered is that of utilising simulation techniques. In the Research Design, a distinction was made between deterministic and probabilistic techniques of analysis. As an alternative to the areal association approach utilised here, a probabilistic approach using simulation techniques might be useful. This method would allow some statements to be made concerning the value of the range of the locator variables identified in this study.[35]

FOOTNOTES - CHAPTER VI

1. The role of the municipal councils should not be ignored. The function of the councils could be described as 'holding the ring' or establishing the ground rules under which development takes place. Under the powers of the Planning Act of Ontario, the Municipal Councils have the power to allow or reject a proposed development. Briefly, a developer seeks approval from the Planning Board of a municipality, This Planning Board receives advice from its technical planners and also gauges public reaction to the development. If the decision is contrary to the developer's interest, he can take the issue before the Municipal Council and, beyond that, to the Minister of Municipal Affairs. The Minister may pass a decision on the appeal or refer it to the Ontario Municipal Board.

2. D.M. HILL, "A Growth Allocation Model for the Boston Region", Journal of the American Institute of Planners, Vol. 31, No. 2 (1965), p. 113.

3. This was the description employed by one of the respondents who was involved in this form of development.

4. Assuming that permission for the proposed development is obtained.

5. In some United States literature, there has been criticism of early publicly-sponsored urban renewal schemes which resulted in the displacement of low income groups, who were living in crowded residential conditions on high value land, the clearance of this land and re-development by private developers. The latter then erected 'high rise' projects, with high to medium rentals. These rentals were usually beyond the means of the previous inhabitants of the area who moved into another low quality residential area. Thus, this type or urban renewal action, while eradicating some slums, helped create others.

   As a consequence of publicly-sponsored urban renewal schemes, especially where there has been rehabilitation with spot clearance, developments of multiple occupancy residential structures can be observed in renewal areas. A local example is the Marina Towers apartment development in the North End Urban Renewal Area of Hamilton.

6. R. MURPHY and J. VANCE, "Delimiting the C.B.D.", Economic Geography Vol. 30 (1954), p. 189.

7. Local examples of this type of development can be observed at the Colonnade on Bloor Street West in Toronto and at Terminal Towers in central Hamilton.

8. The application of zoning regulations may prevent spontaneous patterns of development. Thus, a site that possess character-

istics which may ensure successful development need not have a high value, if it is zoned for a low intensity use - the value usually reflects the intensity of use permissible under the zoning by-laws.

9. Residents of developments on major city streets and urban highways usually benefit from ease of access to other parts of the city, including the central area. Congestion on such streets, however, may offset some of this advantage to an extent.

10. Once development has taken place, successive developers can use the arguments put forward by the initial developer. Having allowed this initial development, many Planning Boards would find it difficult to refuse subsequent applications. Possibly, if reaction to the initial development had been strong and adverse, this might lead them to reject subsequent proposals.

11. See R. VERNON "The Changing Economic Functions of the Central City" (New York: Committee of Economic Development, 1959).

12. Under the Planning Act of Ontario, developers of new residential sub-divisions are required to convey to the municipality for public purposes other than highways, land to an amount determined by the Minister of Municipal Affairs but not exceeding 5 per cent of the sub-division. Note that this land need not be from the sub-division in question. Furthermore, in lieu of the amount of land, the municipality may receive a sum of money not exceeding the value of 5 per cent of the land in the sub-division; all such monies must be paid into a special account. Under this arrangement, there is no guarantee that a municipality will receive land that might be suitable for recreational purposes. Also, this does not apply to re-developments but only to the development of a new residential sub-division. Some municipalities argue that, because of the numbers of people housed in apartment buildings, there is a need for more inclusive legislation.

13. Vancouver Technical Planning Board, op. cit., p. 3.

14. By peripheral development is meant development of multiple occupancy residential structures at the margins of the built up area of a city or suburb.

15. See Footnote 9, Chapter VI.

16. Academic researchers have also commented on this relationship, See MARBLE, op. cit., and HOYT, "Expressways and Apartment Sites", op. cit.

17. See Chapter IV for the pattern in Hamilton. Observation in other cities also confirms this relationship.

18. See again Footnote 7, Chapter VI.

19. The relationship between the occupants of multiple residential structures and retail outlets in these suburban centres is similar to the relationship that exists between the occupants of central apartment units and the downtown retail establishments - the differences are of degree.

20. An excellent source for the examination of the arguments put forward by both sides, in the challenges to zoning by-laws that result from this conflict would be the records of the sessions of the Ontario Municipal Board (see also Chapter VII).

21. The pattern of municipal services is an important factor in these conflicts over zoning. Usually, non-serviced land is zoned to exclude development and is not liable to many challenges. The over-burdening of existing services is also used as a means of turning back callenges to the zoning by-laws.

22. The process is similar to the one undertaken by Central Mortgage and Housing Corporation in its mortgaging insurance policies.

23. Supra, p. 84.

24. Chapter III, p. 37.

25. The belief that land values decline with increasing distance from the Central Business District is one fundamental to much of urban land economics - see ALONSO, <u>op. cit.</u>, pp. 5-15 for a discussion of different approaches to this problem; also p. 57, Fig. 17 for a representation of this relationship.

More recent evidence from Yeates confirms the relationship but it also indicates a rise in land values at the periphery. M.H. YEATES, "Some Factors Affecting the spatial distribution of Chicago Land Values" 1910-1960, <u>Economic Geography</u>, Vol. 41, (January 1965).

26. J.R. MEYER, J.F. KAIN and M. WOHL, <u>The Urban Transportation Problem</u> (Cambridge, Mass; Harvard University Press, 1965), see especially Chapter 2 and 3 and relevant references.

27. W. HANSEN, "How Accessibility Shapes Land Use", <u>Journal, American Institute of Planners</u>, Vol. 25, No. 2 (1959), pp. 73-76.

28. It is often true that people do not know actually how long they spent on a trip; what is important is that they thought they spent a certain time. "It's about a ten minute car ride to downtown", is an example of this perception.

29. In Hamilton, this is clearly what happened on Mohawk Road East, between Upper Ottawa and Upper Kenilworth.

30. One good example is B.J.L. BERRY "Commercial Structure and Commercial Blight" (Chicago; Dept. of Geography Research Paper, No. 85, University of Chicago, 1963).

31. These mid-town or suburban locations are either occupied by unplanned retail units operating independently or by an integrated planned shopping centre or plaza.

32. See above p. 90 for planners' attitudes towards 'buffers'.

33. See the description in Chapter IV and the review of literature for the confirmation of the relationship between multiple occupancy residential structures and major urban streets.

34. See Chapter III, p. 42 for discussion on this point.

35. See H.H. McCARTY and J.B. LINDBERG, A preface to Economic Geography (Englewood Cliffs, N.J.; Prentice-Hall, Inc., 1966), pp. 83-84 for a concise discussion of the usefulness of simulation techniques in testing hypotheses concerning spatial distributions and spatial processes.

For an example of this technique, see R.L. MORRILL, "Development of spatial distributions of towns in Sweden: an historical-predictive approach", Annals Assoc. Amer. Geog., Vol. 53, (1963), pp. 1-14.

CHAPTER VII

CONCLUSIONS

It will be remembered that the purpose of this study is to describe and attempt to explain the spatial pattern of multiple occupancy residential structures in Hamilton through time. The principal conclusions of the analysis have already been set out at various stages in the study. This chapter, however, serves to provide an overview of these conclusions and also indicates future lines of research that might prove profitable.

The first major conclusion was that the spatial pattern of multiple occupancy residential structures in Hamilton has the same general form and characteristics as that which has been observed for this type of residential land use in other North American urban areas. This conclusion is based on the research reported in Chapters II, IV and V. In Chapters IV and V, descriptions were presented concerning the nature of the spatial pattern of these particular residential structures in Hamilton, at each of the four time periods of 1939, 1956, 1961 and 1965.[1] These descriptions were compared to the idealised spatial pattern that was developed in Chapter II. Although there are only a relatively few studies that are concerned with the spatial pattern of multiple occupancy housing in urban areas, it was felt that enough information was available to allow the development of the idealised spatial pattern.

Following from the descriptions in Chapters IV and V, it was possible to conclude that the spatial pattern in Hamilton possessed such characteristics as central clustering, a strong linear element, especially well developed along certain arterial streets, and non-central groupings that were both linear and clustered (usually on, or close to, major city streets); there was also a scattering of isolated structures or small groups of two to four structures throughout the urban area. The decline in the intensity of development, as one moves away from the central area, was clearly brought out in Chapter V. The construction of the density gradients established the negative exponential relationship that exists between the density of multiple occupancy residential structures and distance from the central area. The establishment of this spatial regularity (similar to that shown to exist for urban population densities) confirms the statements, noted in the review of literature, concerning the spatial variation in the intensity of development of this type of structures in urban areas. This confirmation is the more acceptable since the relationship is expressed in a more precise manner than in previous work.

The exhibition of these characteristics by the spatial pattern of this type of residential land use in Hamilton allowed the development of the first major conclusion, since these characteristics were also evident in the spatial patterns of multiple occupancy housing described for other North American urban areas. Further conclusions concerning the nature and development of the Hamilton spatial pattern were possible. The development of the spatial pattern by re-development in the central area, infilling in areas of existing apartment buildings and by the spread of these structures to certain locations, at, or close to, the margins of the built-up area, shows a similarity to the movements and changes in the spatial patterns observed elsewhere. The data presented on the size of structure, rates of change and relative importance of various districts in the city-wide pattern, enabled conclusions to be drawn about the spatial pattern in Hamilton. The striking differences between such parts of the city, as the Northern district, with a number of structures with few units and a declining position in the total pattern, and the West End district, with fewer structures but containing a larger number of units and holding an increasingly important position in the total pattern, were supported by data from the other districts and could be generalised. Therefore, a significant conclusion was that, a major distinction could be made between the older parts of the city and the more recently developed and currently developing sectors.[2] Except for the Central district (and, in particular, one central cluster), the older districts are generally characterised by a large number of structures with small to medium numbers of units, and relatively slow rates of increase. Their position in the total pattern is either declining or static. On the other hand, the newer districts have fewer structures, but these areas are exhibiting faster rates of increase and are increasingly more important in the city-wide pattern.

These conclusions, based on the description of the spatial pattern, are of value in two ways. In the first case, it has increased existing knowledge of some aspects of the spatial pattern of multiple occupancy residential structures in Hamilton. More important perhaps, is the confirmation of the utility of the idealised or generalised pattern that was developed on the basis of previous research. If it is accepted that geography as a discipline can make a rapid advance by the search for generalities, then any research that increases our awareness of these general forms makes a contribution in this respect. The more it can be shown that general forms (or approximations to general forms) exist, the more likely it is that some researcher will develop some general principles to explain the growth, shape and nature of these forms. This is less likely to occur if spatial patterns are examined solely for the increased knowledge concerning the patterns themselves, although this does not imply that such studies are without value.

The development of general principles concerning the nature of the spatial pattern of multiple occupancy residential structures in urban areas, and their incorporation into planning practice, might help alleviate some of the general public's uneasiness concerning this form of residential development. This public uneasiness might be diminished, if the public was aware of the need for this type of accommodation and if they were more aware of the locational requirements of this type of structure. General principles are likely to be of more value here than specifics. To a degree, this public uneasiness is reflected in the conflict of interest that was observed between planners and private developers. The developers seek to satisfy the demand for this type of accommodation, while the planner must also consider the attitudes of a considerable section of the population who do not favour this form of housing.[3] If these general principles could be established, they might form a framework within which planning and private development decisions could be taken.[4]

The importance of the central area for future developments, not only in Hamilton, but elsewhere, was evident. The sociological studies cited in Chapter II indicate some of the socio-economic characteristics of the population demanding apartment units at a central location. It is clear that these sections of the population are increasing and thus, the demand for centrally located units is likely to remain high. A more complete understanding of the relationship between centrally located structures and the central area itself might develop from a study of the spatial interactions of the occupants of these centrally located structures. The degree of integration of these residents with the central area and its functions has importance for, for example, transportation problems, particularly the journey-to-work. It could be argued that the greater a person's integration with the central area, the greater will be that person's demand for a centrally located residence. An obvious problem in examining this hypothesised relationship is that the amount of integration may be a function of central residential location. Assuming that demand for a centrally located residence is high, the person seeking such a residence is more likely to pay higher rentals. An initial working hypothesis might well be that the higher the rentals of multiple occupancy residential structures, the more likely it is that the residents will be integrated functionally and socially with the central area.

From the attempted explanation of the occurrences of the multiple occupancy residential structures in Hamilton, only limited conclusions can be drawn. The first achievement in this part of the study was the identification of the range of locator variables that are believed to be at work in shaping the decision-making processes that create the spatial pattern that is the concern of this study. This range of variables, based on the review of literature and the interviews with the planners and developers, is of value to a researcher who is interested in developing the general principles discussed in this chapter. With regard to the regression analysis, which utilised four variables selected from this range of variables, it must be concluded that it did not provide a satisfactory explanation of the occurrences of the structures, with respect to those selected variables. Considering the nature of the operational definitions, however, it does seem reasonable to conclude that distance from the central area is a significant locator variable. Perhaps a more important conclusion was one of a negative character - that the approach of areal association utilised in this study was not suited to the realisation of the objective. If this has achieved nothing else, it has indicated that other approaches could be more profitable. While this may not be a conclusion of major importance, and while it may lack a desirable degree of firmness, it is a type of conclusion that reasearchers in urban problems will often arrive at, as they attempt to handle complex phenomena with techniques that are not ideally suited to the problem.[5]

While some future avenues of research have already been indicated, certain others suggested themselves as a result of the research on the attempted explanation of the occurrences of the multiple occupancy residential structures. One area of research is the re-structuring of the approach toward the attempted explanation. It was suggested that expressing the dependent variable in terms of distance to nearest neighbour might overcome some of the problems encountered. Also, it will be noted that no attempt was made to explain the changes in the spatial pattern of structures in Hamilton through time. This line of research could be taken up relatively easily. The dependent variable could be expressed as the change in average distance from a structure to its three nearest neighbours, from one time period to another. The same problem could be approached using cells (as in this study), and the two sets of results compared. On the other hand, it was also suggested that a probabilistic approach utilising simulation techniques might lead to a more adequate explanation of the spatial pattern and, in view of the results of this study, this seems likely.

It was noted that the measurement of land values, in such a way as to make this variable operational, would be a complex task. It is recommended that some study should be directed to an examination of the spatial relationships between the pattern of land values and the pattern of multiple occupancy residential structures. Particular attention should be directed to the level of land values before and after development. This would throw some light on whether or not apartment structures are developed in areas of high land values, or whether, in fact, they generate high land values. As a consequence of the discussion on accessibility, an area of research that suggests itself concerns the journey-to-work patterns of the occupants of apartment units. These journey-to-work movements would be of significance in testing the hypothesis that apartment dwellers endeavour to reduce their journey-to-work, and that they accept some disadvantages associated with apartment living, in order to achieve this. This type of study would almost certainly involve comparison with the journey-to-work patterns of occupants of single family homes. Also, in the present study, although the multiple occupancy residential structures were differentiated on the basis of location and number of units, no differentiation was made on the basis of quality, as reflected in rentals. If data on rentals could be obtained, then greater depth would be possible in the existing knowledge of the spatial pattern in Hamilton. Research in this field could be compared to Clark's research on the spatial patterns of residential rents in U.S. cities. Further work is also required on the application of filter mapping techniques to this type of study. This is especially important, since it would increase our knowledge concerning the effects of changes in scale on spatial analyses, a topic that certainly demands attention.

The number of research possibilities in the spatial analysis of this aspect of residential land use, that exist, or have been suggested here, show that the present study has barely begun to carry out research in this field; furthermore, it is restricted to one city. In spite of, or perhaps because of, the exploratory nature of this research, some definite conclusions, both limited and general in character, were possible. It is felt that knowledge has been increased concerning the spatial pattern of multiple occupancy residential structures in Hamilton through time. Some insights were also obtained with respect to the locator variables that are believed to be important in the decision-making processes. Certain approaches used in this study have been found to be less than satisfactory and other approaches have been suggested, as well as numerous research possibilities.

FOOTNOTES - CHAPTER VII

1. It will be remembered that different kinds of description were employed - verbal, statistical and cartographic.

2. These old districts, as well as recently developed and currently developing ones, were identified in Chapter IV. 'Old' included the Central district, Northern, Mid-Town East and Mid-Town West, whereas the remaining districts of West End, East End and Mountain are the newer ones.

3. According to BOSSELMAN, (footnote 21, Chapter II, second article), these fears concerning the spread of apartment structures are more properly directed at the occupants of the structures. Residents in single family home areas tend to have pre-conceived notions of the type of occupants in apartment buildings and they tend to distrust them considerably. Bosselman discusses the basis for this mistrust.

4. Active research should be encouraged in this field. These conflicts find expression in the various arguments put forward at meetings concerning changes in zoning, to permit multiple occupancy residential housing to be developed. The records of local Planning Board, City and Town Council and Ontario Municipal Board sessions are valuable repositories of relevant information of this topic.

5. Curry's comment on regression analysis is again very relevant here - "we still really do not know what we are doing in spatial regression". CURRY, op. cit., p. 97.

APPENDIX A

List of respondents interviewed.

Developers.

Mr. A. Vail, Consolidated Building Corporation, Toronto.

Mr. Milani, Milani Development Co., Toronto.

Mr. Walton, Hamilton.

Mr. B. McGeary, Hamilton.

G.S. Shipp, Ltd., - a telephone conversation with a representative of this company.

Mr. Fraleigh, Burlington.

Planners.

Mr. Crerar, City of Toronto.

Mr. Wires, Metro Toronto.

Mr. Code, Burlington.

Mr. Curtis, North York.

Mr. Buckley, Mimico.

Mr. Waram, Hamilton.

Mr. Emslie, Secretary of the Hamilton North End Urban Renewal Committee.

The Planning Director, St. Catharines.

Two telephone conversations with Toronto and Hamilton officers of Central Mortgage and Housing Corporation.

APPENDIX B

This is a list of the computer programs used in this study, together with the basic data deck.

PROGRAM FOR THE CALCULATION OF THE ARITHMETIC MEAN CENTRE

```
$IBJOB        NODECK
$IBFTC
      DIMENSION DIST(800),THET(800),IYR(766,4),X(800),Y(800)
      READ(5,900)((DIST(J),THET(J),(IYR(J,K),K=1,4)),J=1,766)
  900 FORMAT (5X,2F5.0,3X,4I1)
      DO 102 J=1,766
      X(J)=10.0+2.0*0.189*SIN(2.0*3.1416*THET(J)/360.0)*DIST(J)
  102 Y(J)=10.0-2.0*0.189*COS(2.0*3.1416*THET(J)/360.0)*DIST(J)
      DO 101 J=1,4
      SUMD=0.
      SUMT=0.
      ISUM=0
      DO 100 K=1,766
      IF (IYR(K,J).NE.1) GO TO 100
      ISUM=ISUM+1
      SUMD=SUMD+X(K)
      SUMT=SUMT+Y(K)
  100 CONTINUE
      FF=FLOAT(ISUM)
      CED=SUMD/FF
      CET=SUMT/FF
  101 WRITE(6,901) J,CED,CET,ISUM
  901 FORMAT(1H0,4HYEAR,I4,2X,8HDISTANCE,F8.2,3X,5HTHETA,F8.2,3X,8HNO UN
     1ITS,I5)
      STOP
      END

                          CD TOT   0027
```

PROGRAM FOR FILTER MAPPING

```
$IBJOB          NODECK
$IBFTC
      DIMENSION IS(4,30,25),FS(30,25),FIS(4,30,25),AD(4,30,25),FIC(4)
      DO 40 J=1,4
      DO 40 K=1,30
      DO 40 L=1,25
      AD(J,K,L)=0.
   40 IS(J,K,L)=0
      DO 2 J=1,4
      DO 2 L=1,20
    2 READ (5,5)(IS(J,K,L),K=1,25)
    5 FORMAT(2X,26I3)
      JJJ=-1
      DO 33 J=1,4
      JJJ=JJJ+1
      FJK=J+JJJ
      DO 33 K=1,25
      DO 33 L=1,20
      FIS(J,K,L)=IS(J,K,L)
   33 FIS(J,K,L)=FIS(J,K,L)/(FJK*FJK)
   17 DO 6 J=1,4
      WRITE(6,20)J
   20 FORMAT(1H1,9HMATRIX,NO,I2)
      DO 6 L=4,20
    6 WRITE(6,9)(FIS(J,K,L),K=2,25)
    9 FORMAT(1H0,24F5.1)
      DO 21 J=1,25
      DO 21 K=1,20
      AD(1,J,K)=FIS(1,J,K)
   21 FS(J,K)=0.
      DO 24 L=2,4
      WRITE(6,29)L
   29 FORMAT(1H1,9HMATRIX,NO,I2)
      LL=L-1
      DO 22 J=1,25
      NJ=J+LL
      DO 22 K=1,20
      MJ=K+LL
   22 AD(L,NJ,MJ)=FIS(L,J,K)
      DO 24 K=4,20
   24 WRITE(6,23)(AD(L,J,K),J=2,25)
   23 FORMAT(1H0,24F5.1)
      WRITE(6,45)
   45 FORMAT(1H1,6HMATRIX,3X,12HSUMS SQUARES,3X,9HVAR QUOI.,25HPER CENI
     1EXP BY SCALE CH.)
      AN=24.*17.
      DO 41 L=1,4
      FIB=0.
      FID=0.
      FIC(L)=0.
      DO 42 K=2,25
      DO 42 J=4,20
      FIB=FIB+AD(L,K,J)
   42 FID=FID+AD(L,K,J)*AD(L,K,J)
   41 FIC(L)=FID-(FIB*FIB)/AN
      DO 43 L=1,3
      FE=FIC(L+1)/FIC(L)
      FF=(1.-FE)*100.
```

```
43 WRITE(6,44)L,FIC(L),FE,FF
44 FORMAT(1H0,4X,I3,3X,F10.2,3X,F8.4,15X,F10.2)
   STOP
   END
```

CD 101 UU63

PROGRAM TO CALCULATE DENSITY GRADIENTS

```
$IBJOB          NODECK
$IBFTC
      DIMENSIONA(25),Y(5),R(1000),TH(1000),N(1000),IB(1000,4),FC,IK),FU(
     125),V(4,25),SV(3),SVV(3,3),AL(3)(XP(25),YP(25),TT(2,10)
      READ(5,11) JA,(Y(K),K=1,4),AL(2),AL(3)
   11 FORMAT(I3,6A6)
      READ(5,13) (A(J),J=1,21)
   13 FORMAT(16F5.0)
      READ(5,12)((TT(NZ,J),J=1,10),NZ=1,2)
   12 FORMAT(10A6)
      READ(5,10)(R(J),TH(J),N(J),(IB(J,K),K=1,4),J=1,JA)
   10 FORMAT(5X,F5.2,F5.1,I3,4I1)
      DO 20 NZ=1,2
      WRITE(6,50)(TT(NZ,J),J=1,10)
   50 FORMAT(1H1,10A6)
      IF(NZ.NE.2)GOTO 40
      DO 21 IR=1,21
   21 A(IR)=3.1416*FLOAT(IR**2-(IR-1)**2)*40.0
   40 DO 20 NA=1,4
      DO 101 IR=1,21
      FC(IR)=1.0
  101 FU(IR)=1.0
      DO 22 J=1,JA
      IF(IB(J,NA).EQ.0)GOTO 22
      IR=R(J)/1.32+1.0
      FC(IR)=FC(IR)+1.0
      FU(IR)=FU(IR)+FLOAT(N(J))
   22 CONTINUE
      DO 25 K=1,3
      SV(K)=0.0
      DO 25 L=1,3
   25 SVV(K,L)=0.0
      WRITE(6,30) Y(NA)
   30 FORMAT(1H0,25HANALYSIS OF APTS IN YEAR ,A6)
      DO 23 IR=1,21
      V(1,IR)=IR
      V(2,IR)=ALOG10(FC(IR)/A(IR))
      V(3,IR)=ALOG10(FU(IR)/A(IR))
      DO 23 K=1,3
      SV(K)=SV(K)+V(K,IR)
      DO 23 L=1,3
   23 SVV(K,L)=SVV(K,L)+V(K,IR)*V(L,IR)
      DO 24 K=2,3
      RS=(SVV(K,1)-SV(K)*SV(1)/21.0)/(SVV(1,1)-SV(1)*SV(1)/21.0)
      RC=RS*((SVV(1,1)-SV(1)*SV(1)/21.0)/(SVV(K,K)-SV(K)*SV(K)/21.0))**0
     1.5
      RI=(SV(K)-RS*SV(1))/21.0
      WRITE(6,31) AL(K),RS,RC,RI
   31 FORMAT(1H ,A6,3(6X,F10.5))
   24 CONTINUE
      WRITE(6,33)
   33 FORMAT(1H0,35HDENSITIES BY OCCURRENCES AND UNITS )
      WRITE(6,34) ((V(K,J),K=2,3),V(1,J),J=1,21)
   34 FORMAT(1H ,3(F10.5,6X))
   20 CONTINUE
      STOP
      END
```

```
PROGRAM TO CALCULATE THE PLOTS OF THE DENSITY GRADIENTS
$IBJOB          NODECK
$IBFTC
      DIMENSIONA(25),Y(5),R(1000),TH(1000),N(1000),IB(1000,4),FC,IK),FU(
     125),V(4,25),SV(3),SVV(3,3),AL(3)(XP(25),YP(25),TT(2,10)
      READ(5,11) JA,(Y(K),K=1,4),AL(2),AL(3)
   11 FORMAT(I3,6A6)
      READ(5,13) (A(J),J=1,21)
   13 FORMAT(16F5.0)
      READ(5,12)((TT(NZ,J),J=1,10),NZ=1,2)
   12 FORMAT(10A6)
      READ(5,10)(R(J),TH(J),N(J),(IB(J,K),K=1,4),J=1,JA)
   10 FORMAT(5X,F5.2,F5.1,I3,4I1)
      DO 20 NZ=1,2
      IF(NZ.NE.2)GOTO 40
      DO 21 IR=1,21
   21 A(IR)=3.1416*FLOAT(IR**2-(IR-1)**2)*40.0
   40 DO 20 NA=1,4
      DO 101 IR=1,21
      FC(IR)=1.0
  101 FU(IR)=1.0
      DO 22 J=1,JA
      IF(IB(J,NA).EQ.0)GOTO 22
      IR=R(J)/1.32+1.0
      FC(IR)=FC(IR)+1.0
      FU(IR)=FU(IR)+FLOAT(N(J))
   22 CONTINUE
      DO 25 K=1,3
      SV(K)=0.0
      DO 25 L=1,3
   25 SVV(K,L)=0.0
      DO 23 IR=1,21
      V(1,IR)=IR
      V(2,IR)=ALOG10(FC(IR)/A(IR))
      V(3,IR)=ALOG10(FU(IR)/A(IR))
      DO 20 K=2,3
      DO 201 J=1,21
      YP(J)=V(K,J)
  201 XP(J)=V(1,J)
      YMAX=YP(1)+0.5
      YMIN=YP(21)-0.5
      CALL PLOT3 (XP,YP,21,YMAX,YMIN,25.0,0.0,50,100,50)
      WRITE(6,50)(TT(NZ,J),J=1,10)
   50 FORMAT(1H ,10A6)
   20 WRITE(6,202) Y(NA),AL(K)
  202 FORMAT (1H ,6H YEAR ,A6,18HPLOT OF APARTMENT ,A6)
      STOP
      END

                    CD TOT    0048
```

```
 PROGRAM TO CALCULATE DENSITY GRADIENTS BY SECTORS
$IBJOB          NODECK
$IBFTC
      DIMENSIONA(25),Y(5),R(1000),TH(1000),N(1000),IB(1000,4),FC,IK),FU(
     125),V(4,25),SV(3),SVV(3,3),AL(3)(XP(25),YP(25),TT(2,10)
      READ(5,11) JA,(Y(K),K=1,4),AL(2),AL(3)
   11 FORMAT(I3,6A6)
      READ(5,13) (A(J),J=1,21)
   13 FORMAT(16F5.0)
      READ(5,12)((TT(NZ,J),J=1,10),NZ=1,2)
   12 FORMAT(10A6)
      READ(5,10)(R(J),TH(J),N(J),(IB(J,K),K=1,4),J=1,JA)
   10 FORMAT(5X,F5.2,F5.1,I3,4I1)
      DO 20 NNN=1,4
      THTL=90*NNN
      THBL=90*(NNN-1)
      WRITE(6,35) THTL,THBL
   35 FORMAT(1H ,36HANALYSIS IN SECTOR BETWEEN BEARINGS ,I3,5H AND ,I3)
      DO 20 NZ=1,2
      WRITE(6,50)(TT(NZ,J),J=1,10)
   50 FORMAT(1H1,10A6)
      IF(NZ.NE.2)GOTO 40
      DO 21 IR=1,21
   21 A(IR)=3.1416*FLOAT(IR**2-(IR-1)**2)*40.0
   40 DO 20 NA=1,4
      DO 101 IR=1,21
      FC(IR)=1.0
  101 FU(IR)=1.0
      DO 22 J=1,JA
      IF(IB(J,NA).EQ.0)GOTO 22
      IF(TH(J).GT.THTL.OR.TH(J).LT.THBL) GO TO 22
      IR=R(J)/1.32+1.0
      FC(IR)=FC(IR)+1.0
      FU(IR)=FU(IR)+FLOAT(N(J))
   22 CONTINUE
      DO 25 K=1,3
      SV(K)=0.0
      DO 25 L=1,3
   25 SVV(K,L)=0.0
      WRITE(6,30) Y(NA)
   30 FORMAT(1H0,25HANALYSIS OF APTS IN YEAR ,A6)
      DO 23 IR=1,21
      V(1,IR)=IR
      V(2,IR)=ALOG10(FC(IR)/A(IR))
      V(3,IR)=ALOG10(FU(IR)/A(IR))
      DO 23 K=1,3
      SV(K)=SV(K)+V(K,IR)
      DO 23 L=1,3
   23 SVV(K,L)=SVV(K,L)+V(K,IR)*V(L,IR)
      DO 24 K=2,3
      RS=(SVV(K,1)-SV(K)*SV(1)/21.0)/(SVV(1,1)-SV(1)*SV(1)/21.0)
      RC=RS*((SVV(1,1)-SV(1)*SV(1)/21.0)/(SVV(K,K)-SV(K)*SV(K)/21.0))**0
     1.5
      RI=(SV(K)-RS*SV(1))/21.0
      WRITE(6,31) AL(K),RS,RC,RI
   31 FORMAT(1H ,A6,3(6X,F10.5))
   24 CONTINUE
      WRITE(6,33)
   33 FORMAT(1H0,35HDENSITIES BY OCCURRENCES AND UNITS )
```

```
      WRITE(6,34) ((V(K,J),K=2,3),V(1,J),J=1,21)
   34 FORMAT(1H ,3(F10.5,6X))
   20 CONTINUE
      STOP
      END
```

CD TOT 0064

BASIC DATA DECK 9

COLUMN1-2 DECK IDENTIFICATION NUMBER
COLUMN 3-5 M.O.R.S. IDENTIFICATION NUMBER
COLUMN 6-10 LINEAR DISTANCE FROM THE CITY CENTRE TO A STRUCTURE
COLUMN11-15 ANGULAR BEARING OF STRUCTURE FROM 0 DEGREES -JAMES ST N
COLUMN16-18 NUMBER OF UNITS
COLUMN19-II EACH COLUMN REPRESENTS ONE YEAR- A 1 INDICATES THE EXISTENCE
STRUCTURE AT THAT TIME
COLUMN 23 A 1 INDICATES THAT THE STRUCTURE IS ON THE MOUNTAIN
COLUMN24-26 STREET DISTANCE TO NEAREST MAJOR CITY STREET
COLUMN 27-29 STREET DISTANCE TO NEAREST OPEN SPACE
COLUMN 30-31 IDENTIFICATION NUMBER OF TRAFFIC DISTRICT IN WHICH STRUCTUR
CATED

```
1  118.2 253.6 521      0.00.039
1  218.7 248.0 8511     0.00.039
1  318.60248.2 3211     0.00.039
1  418.65247.8 6611     0.00.039
1  517.95253.9 521      0.00.039
1  617.87253.0 581      0.00.039
1  717.68253.5 281      0.00.039
1  818.10249.0 3411     0.00.539
1  918.04249.3 3411     0.00.439
1 1017.91250.0 2211     0.00.439
1 1118.38246.6 4811     0.50.939
1 1217.67251.3  71      0.00.239
1 1317.75251.0  611     0.00.239
1 1417.77250.8  611     0.10.339
1 1518.12247.6 521      0.71.239
1 1618.22247.3 581      0.71.139
1 1717.96248.4 1111     1.21.739
1 1817.95248.0  711     1.11.739
1 1917.94247.9  711     1.11.639
1 2017.92247.7  711     1.01.539
1 2117.91247.5  711     1.01.439
1 2217.90247.3 1111     0.91.339
1 2318.20246.8 241      0.71.239
1 2416.46254.7 1311     0.20.039
1 2516.27254.8 121      0.20.539
1 2616.07254.5 1111     0.10.639
1 2715.28254.1 11111    0.01.239
1 2812.58254.5  71      0.00.236
1 2912.10255.2 12111    0.00.136
1 3012.04255.3 12111    0.00.336
1 3110.89257.1 10111    0.00.536
1 3210.83257.1  6111    0.00.536
1 3310.12263.3 11111    0.01.237
1 34 9.95266.2 121111 1.00.737
1 35 9.84264.5 141111 1.20.837
1 36 9.56267.9 131111 0.90.637
1 37 9.47268.6 121111 0.80.537
1 38 9.52257.32351      0.00.036
1 39 9.38257.32351      0.00.036
1 40 8.60270.7 121111 0.01.037
1 41 8.60268.7 3211     0.01.237
1 42 8.26271.0  8111    0.00.837
1 43 7.96269.3  611     0.10.737
1 44 7.80271.2  8111    0.00.737
1 45 7.60268.0 271      0.40.937
1 46 7.30273.8 15111    0.50.437
```

1	47	7.37271.3	13111	0.00.637	
1	48	7.29269.5	18111	0.00.737	
1	49	7.18269.5	18111	0.00.837	
1	50	6.91269.1	91	0.71.237	
1	51	7.09243.3	61111	0.10.6	6
1	52	7.14242.5	61111	0.00.5	6
1	53	6.64240.6	15111	0.01.0	6
1	54	6.55240.3	15111	0.01.1	6
1	55	6.80239.4	6111	0.01.0	6
1	56	6.75239.0	121111	0.01.1	6
1	57	5.75247.2	61111	1.11.7	6
1	58	6.38236.8	181	0.11.3	6
1	59	5.28281.2	71111	0.00.7	7
1	60	5.21288.1	16111	0.30.5	7
1	61	5.13288.7	16111	0.40.4	7
1	62	5.01289.0	16111	0.50.3	7
1	63	4.90289.3	16111	0.60.1	7
1	64	4.84288.8	16111	0.60.0	7
1	65	5.30300.7	61111	0.10.2	7
1	66	4.96293.2	61111	0.80.0	7
1	67	4.91279.3	241	0.00.4	7
1	68	4.54279.8	391	0.00.0	7
1	69	5.70311.7	2311	1.00.0	7
1	70	5.61312.2	2311	1.00.0	7
1	71	4.10280.0	6111	0.00.0	7
1	72	4.04267.7	7111	0.11.0	7
1	73	5.20230.9	121111	0.01.7	6
1	74	4.48302.0	61111	0.00.7	7
1	75	4.21293.0	6111	0.80.0	7
1	76	3.99284.0	61111	0.10.0	7
1	77	3.97256.0	10111	0.90.9	6
1	78	4.06252.1	6111	1.20.7	6
1	79	5.05229.8	9111	0.01.8	6
1	80	3.23280.3	9111	0.11.1	7
1	81	3.36274.1	431	0.21.0	7
1	82	3.17273.8	121	0.01.4	7
1	83	3.38271.9	431	0.01.4	7
1	84	3.66251.1	6111	0.80.5	6
1	85	3.58251.1	6111	0.70.6	6
1	86	3.33248.5	431	0.50.0	6
1	87	3.69247.2	631	0.50.0	6
1	88	3.54246.0	481	0.50.0	6
1	89	4.55223.5	6111	0.01.7	6
1	90	2.80275.0	8111	0.32.1	7
1	91	2.90272.0	27111	0.02.2	7
1	92	2.82272.0	27111	0.02.3	7
1	93	2.76272.0	6111	0.02.3	7
1	94	3.83227.0	81111	0.21.0	6
1	95	4.40221.4	221111	0.01.6	6
1	96	2.70311.7	81111	0.01.0	2
1	97	2.58287.2	6111	0.02.2	2
1	98	2.56282.0	241111	0.02.2	2
1	99	2.43282.8	241111	0.02.1	2
1100		1.97285.5	111111	0.01.7	2
1101		2.20275.0	111111	0.22.4	2
1102		2.04273.5	301111	0.02.2	2
1103		2.20267.0	7111	0.02.3	2
1104		1.93266.5	121111	0.02.1	2

1105	2.21265.0	11111	0.22.2 2
1106	2.59264.0	311111	0.01.9 2
1107	2.38263.8	10111	0.32.1 2
1108	2.02262.7	12111	0.52.3 2
1109	2.50260.0	14111	0.22.0 2
1110	2.12258.0	7111	0.52.2 2
1111	2.07258.0	6111	0.62.3 2
1112	2.46256.3	191	0.21.1 2
1113	2.07245.9	6111	0.61.9 6
1114	2.45243.0	121111	0.41.4 6
1115	2.40242.5	121111	0.51.5 6
1116	2.36241.8	121111	0.51.6 6
1117	2.28240.8	6111	0.61.6 6
1118	2.22240.0	81111	0.61.7 6
1119	2.26237.0	25111	0.71.4 6
1120	2.50232.5	6111	0.61.1 6
1121	2.58232.3	1111	0.61.1 6
1122	8.43 91.5	81111	0.01.114
1123	2.98234.0	91111	0.41.214
1124	2.84224.2	301	0.61.414
1125	3.50226.3	1911	0.01.014
1126	8.35 91.5	91111	0.01.014
1127	3.16215.5	211111	0.61.9 6
1128	3.49218.2	6111	0.41.8 6
1129	3.91217.3	6111	0.22.1 6
1130	3.70342.8	15111	0.01.3 8
1131	2.56329.7	6111	0.00.1 8
1132	1.56324.2	61111	0.01.2 8
1133	1.62306.0	10111	0.01.6 2
1134	1.26308.0	6111	0.01.1 2
1135	1.19305.0	101111	0.01.0 2
1136	1.17294.8	611	0.00.7 2
1137	1.00287.3	201111	0.21.1 2
1138	1.59266.0	711	0.00.3 2
1139	1.53266.0	111111	0.01.8 2
1140	1.48266.0	61111	0.01.7 2
1141	1.43266.0	61111	0.01.7 2
1142	1.41261.0	221111	0.01.8 2
1143	1.46249.51751		0.00.0 2
1144	2.04144.0	861	0.00.5 5
1145	1.68241.0	151	0.20.2 6
1146	1.77235.3	61111	0.22.2 6
1147	1.66237.5	81111	0.02.3 6
1148	1.90234.0	521111	0.22.1 6
1149	1.85232.5	641111	0.22.2 6
1150	1.78231.0	471	0.00.5 6
1151	2.10231.2	911	0.31.1 6
1152	1.95226.0	641	0.00.8 6
1153	2.19226.0	1011	0.31.1 6
1154	2.43220.0	1111	0.31.4 6
1155	2.29216.0	11111	0.01.7 6
1156	2.30215.5	8111	0.01.7 6
1157	2.81217.0	351	0.01.7 6
1158	2.65210.3	6111	0.02.2 6
1159	2.91210.7	9111	0.22.2 6
1160	2.77208.8	201111	0.02.4 6
1161	1.56224.5	7111	0.12.6 5
1162	1.57216.0	7111	0.52.4 5

1163	1.64214.5	12111	0.72.5 5
1164	1.77216.0	81111	0.32.3 5
1165	1.63216.2	161111	0.42.4 5
1166	1.85214.0	10111	0.22.2 5
1167	1.83212.5	11111	0.22.2 5
1168	1.74210.0	161111	0.32.4 5
1169	8.52 91.5	161111	0.01.214
1170	2.08214.5	11111	0.01.8 5
1171	2.01213.8	411	0.11.2 5
1172	1.93208.3	601	0.31.2 5
1173	2.37210.0	91111	0.02.1 5
1174	2.51208.0	1611	0.01.5 5
1175	2.46205.0	591	0.01.7 5
1176	2.43203.2	91111	0.02.4 5
1177	3.02211.3	81111	0.32.0 6
1178	2.96209.0	7111	0.22.0 6
1179	2.77201.0	2311	0.22.0 5
1180	2.96359.2	17111	0.01.3 8
1181	2.71358.7	9111	0.01.1 8
1182	2.57358.8	61111	0.01.0 8
1183	2.28359.0	8111	0.01.1 8
1184	2.25345.0	9111	0.00.8 8
1185	1.98355.3	611	0.00.2 1
1186	1.85357.0	71111	0.01.4 1
1187	1.41358.0	91111	0.21.0 1
1188	1.13327.0	61111	0.21.0 1
1189	0.87326.0	8111	0.10.6 1
1190	0.79331.5	111111	0.10.6 1
1191	0.96313.0	7111	0.00.7 1
1192	0.86318.0	7111	0.00.6 1
1193	0.65341.0	8111	0.00.3 1
1194	0.66314.0	7111	0.00.5 1
1195	0.55325.0	8111	0.00.4 1
1196	0.49317.0	101111	0.20.5 1
1197	0.89304.0	71111	0.00.7 1
1198	1.13221.0	81111	0.52.0 5
1199	1.11219.0	101111	0.62.1 5
1200	1.15219.0	81111	0.62.1 5
1201	1.14218.0	81111	0.62.3 5
1202	1.21216.5	1811	0.50.4 5
1203	1.05212.5	81111	0.72.0 5
1204	1.10211.0	6111	0.62.0 5
1205	1.14210.2	17111	0.61.9 5
1206	0.97199.0	21111	0.51.7 5
1207	1.02198.0	81111	0.41.6 5
1208	7.80269.5	811	0.00.937
1209	1.28207.0	36111	0.62.0 5
1210	1.25205.0	36111	0.51.9 5
1211	1.22202.0	32111	0.51.8 5
1212	1.14192.0	161111	0.21.7 5
1213	1.13183.0	81111	0.21.6 5
1214	1.12186.0	171111	0.11.5 5
1215	1.54207.5	2211	0.50.7 5
1216	1.51205.3	26111	0.62.4 5
1217	1.47201.2	12111	0.52.3 5
1218	1.45199.0	29111	0.52.2 5
1219	1.34198.7	271111	0.21.9 5
1220	1.34196.3	161111	0.21.8 5

1221	1.37193.2	121111	0.01.7	5
1222	1.63200.0	71111	0.62.4	5
1223	1.58196.8	131111	0.52.3	5
1224	1.56189.0	29111	0.32.1	5
1225	1.55190.5	101111	0.32.1	5
1226	1.86202.5	28111	0.52.1	5
1227	1.83200.7	12111	0.62.0	5
1228	1.78198.0	36111	0.61.9	5
1229	1.72189.8	141111	0.31.6	5
1230	1.73188.3	141111	0.21.6	5
1231	1.71183.7	14111	0.11.6	5
1232	1.89181.21271		0.11.5	5
1233	1.88183.3	8111	0.01.4	5
1234	2.20199.0	611	0.51.4	5
1235	2.14193.0	611	0.51.6	5
1236	2.34197.8	3811	0.01.6	5
1237	2.50187.7	21111	0.11.5	5
1238	2.27193.0	6111	0.51.9	5
1239	2.36187.5	15111	0.21.6	5
1240	2.40187.2	13111	0.21.6	5
1241	2.68284.8	81111	0.52.1	5
1242	2.67283.7	91111	0.62.0	5
1243	2.65282.8	141111	0.61.9	5
1244	2.64281.7	61111	0.51.9	5
1245	2.63280.0	1011	0.52.0	5
1246	2.79279.3	711	0.52.2	5
1247	2.59273.2	81111	0.11.6	5
1248	2.59270.8	231111	0.01.5	5
1249	2.68270.7	10111	0.01.5	5
1250	2.75270.8	10111	0.01.6	5
1251	3.25273.7	8111	0.00.7	5
1252	9.45271.5	1511	10.30.047	
1253	9.46272.8	3911	10.60.147	
1254	9.77272.9	8111	10.50.047	
1255	9.83274.2	2811	10.70.147	
1256	6.34 4.5	8111	0.41.4	9
1257	3.39 5.8	911	0.01.5	8
1258	2.78 2.0	81111	0.01.0	8
1259	2.11 2.3	71111	0.00.9	8
1260	1.34 5.0	16111	0.00.9	1
1261	1.26 5.0	10111	0.00.8	1
1262	1.09 18.0	81111	0.30.6	1
1263	0.23109.0	81111	0.00.6	1
1264	0.64134.5	81111	0.40.8	4
1265	1.66171.5	6111	0.21.3	5
1266	1.84167.2	91111	0.10.9	5
1267	1.97179.0	131111	0.01.2	5
1268	2.00173.3	7111	0.21.0	5
1269	2.05179.0	7111	0.01.2	5
1270	3.06177.5	3511	0.01.0	5
1271	3.20177.7	8111	0.01.0	5
1272	2.85166.5	12111	0.31.2	5
1273	2.80164.2	8111	0.01.0	5
1274	3.02165.8	141111	0.31.3	5
1275	3.03166.8	1311	0.31.2	5
1276	3.10166.3	131111	0.31.4	5
1277	3.09168.5	131111	0.41.6	5
1278	6.10180.0	611	10.01.348	

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1279 6.37179.7 3111   10.01.648
1280 6.49179.8 3611   10.01.748
1281 6.60180.0  6111 10.01.848
1282 6.55176.7 771    10.01.648
1283 9.20179.6  61    10.00.348
1284 9.33179.6  61    10.00.348
1285 9.50179.6  6     10.00.548
128614.33179.5  611  10.00.052
1287 3.87 20.5 121111 0.31.7 8
1288 3.28 15.0 171111 0.00.8 8
1289 3.17 25.2  6111   0.41.0 8
1290 2.70 29.8  61111 0.30.8 8
1291 1.06 55.5 161111 0.00.3 1
1292 1.47 65.7 181111 0.01.0 1
1293 1.16 66.5 131111 0.00.3 1
1294 1.30139.0  61111 0.61.4 5
1295 1.36141.5  71111 0.61.3 5
1296 1.72142.5  91111 0.40.8 5
1297 2.39158.3 30111   0.00.2 5
1298 2.43156.8 15111   0.10.1 5
1299 2.70156.5 2811    0.00.0 5
1300 2.74154.0 1411    0.00.0 5
1301 3.12155.5  6111   0.00.5 5
1302 2.96152.2 18111   0.00.5 5
1303 3.00150.7 30111   0.00.4 5
1304 3.18147.0  7111   0.00.2 5
1305 2.12141.3 1411    0.50.8 5
1306 2.18142.2 1311    0.60.9 5
1307 2.30125.5  6111   1.11.3 5
1308 1.83 83.5 151111 0.41.1 1
1309 1.95 78.0 101111 0.51.1 1
1310 1.72 68.8  6111   0.01.2 1
1311 1.68 69.3  6111   0.01.1 1
1312 2.13 45.0  81111 0.51.5 3
1313 5.69 18.7  6111   0.91.4 9
1314 2.15 78.8  7111   0.00.7 3
1315 2.30 80.5  8111   0.00.5 3
1316 2.57 81.7  6111   0.00.2 3
1317 2.31 86.2 121111 0.00.5 4
1318 2.60 86.5  61111 0.00.2 4
1319 2.66 85.0 10111   0.00.1 4
1320 2.46 88.0  8111   0.00.7 4
1321 2.45 88.0  8111   0.00.6 4
1322 2.59 94.0  61111 0.00.6 4
1323 3.85115.1  8111   0.10.6 4
1324 4.17147.8 581    10.30.048
1325 6.12155.8  611   10.01.048
1326 6.27156.8 101    10.01.148
1327 4.25 41.3  7111   0.00.911
1328 4.53 47.7  61111 0.01.311
1329 4.46 48.8  6111   0.01.211
1330 3.03 78.0  6111   0.20.311
1331 3.10 78.0 101111 0.30.211
1332 3.39 86.0  91111 0.00.310
1333 2.83 93.8 451     0.00.510
1334 3.35 93.8  61111 0.10.510
1335 3.00 95.2  71111 0.20.510
1336 3.00 96.9  81111 0.30.410
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1337 3.20 95.0  71111 0.20.510
1338 2.85 99.3  81111 0.00.610
1339 2.88100.5  61111 0.00.510
1340 2.87101.8  91111 0.00.410
1341 3.38 97.5  61111 0.50.310
1342 3.40 99.1  81111 0.60.210
1343 3.24111.2  811    0.00.010
1344 3.52124.014311    0.21.410
1345 4.82136.5 151    10.00.848
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