

INTERIM REPORT
ON THE
GLASGOW INNER RING ROAD

SCOTTISH
ROADS
ARCHIVE

GMA - JMC - Copy 1
GLA/IRR/1/1 Box 1

**INTERIM REPORT
ON THE
GLASGOW INNER RING ROAD**

**SCOTTISH
ROADS
ARCHIVE**

THE CORPORATION OF THE CITY OF GLASGOW
CITY CHAMBERS - GLASGOW, C.1

SCOTT & WILSON, KIRKPATRICK & PARTNERS
4 PARK GARDENS - GLASGOW, C.3

PRINTED BY GLASGOW CORPORATION PRINTING AND STATIONERY DEPARTMENT

SCOTT & WILSON, KIRKPATRICK & PARTNERS
CONSULTING CIVIL AND STRUCTURAL ENGINEERS

(INCORPORATING SCOTT AND WILSON AND
SIR CYRIL KIRKPATRICK & PARTNERS)

MEMBERS OF THE ASSOCIATION OF CONSULTING ENGINEERS

E. O. MEASOR, A.C.G.I., B.Sc., M.I.C.E., M.I.STRU.C.E. R. W. HAWKEY, M.A., M.I.C.E., M.I.W.E.
HENRY GRACE, M.M.Sc., M.I.C.E., F.A.S.C.E., A.M.I.W.E. F. M. BOWEN, M.I.C.E., M.I.STRU.C.E.
C. G. SANG, B.Sc., A.M.I.C.E.

ASSOCIATES
J. K. M. HENRY, B.A., B.Sc., M.I.C.E.
G. M. J. WILLIAMS, M.A., M.I.C.E., F.A.S.C.E.

SECRETARY
ROBERT MOODIE, M.B.E., T.D.

4, PARK GARDENS,
GLASGOW, C.8.

TELEPHONE GLASGOW DOUGLAS 2085.

HEAD OFFICE:
47, VICTORIA STREET,
LONDON, S.W.1.
TELEPHONE ABBEY 5921/6.

Please reply to Glasgow address.

June, 1962.

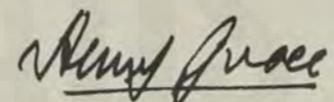
The Town Clerk,
City Chambers,
Glasgow, C.1.

Dear Sir,

We forward herewith an interim report on our proposals for the Glasgow
Inner Ring Road and on the traffic, engineering and other investigations on which
we have based these proposals.

The text of this report has been circulated to Sir William Holford, Mr. McIndoe
and Professor Robertson, who have all signified their concurrence in its proposals.

Yours faithfully,



for SCOTT & WILSON KIRKPATRICK & PARTNERS.

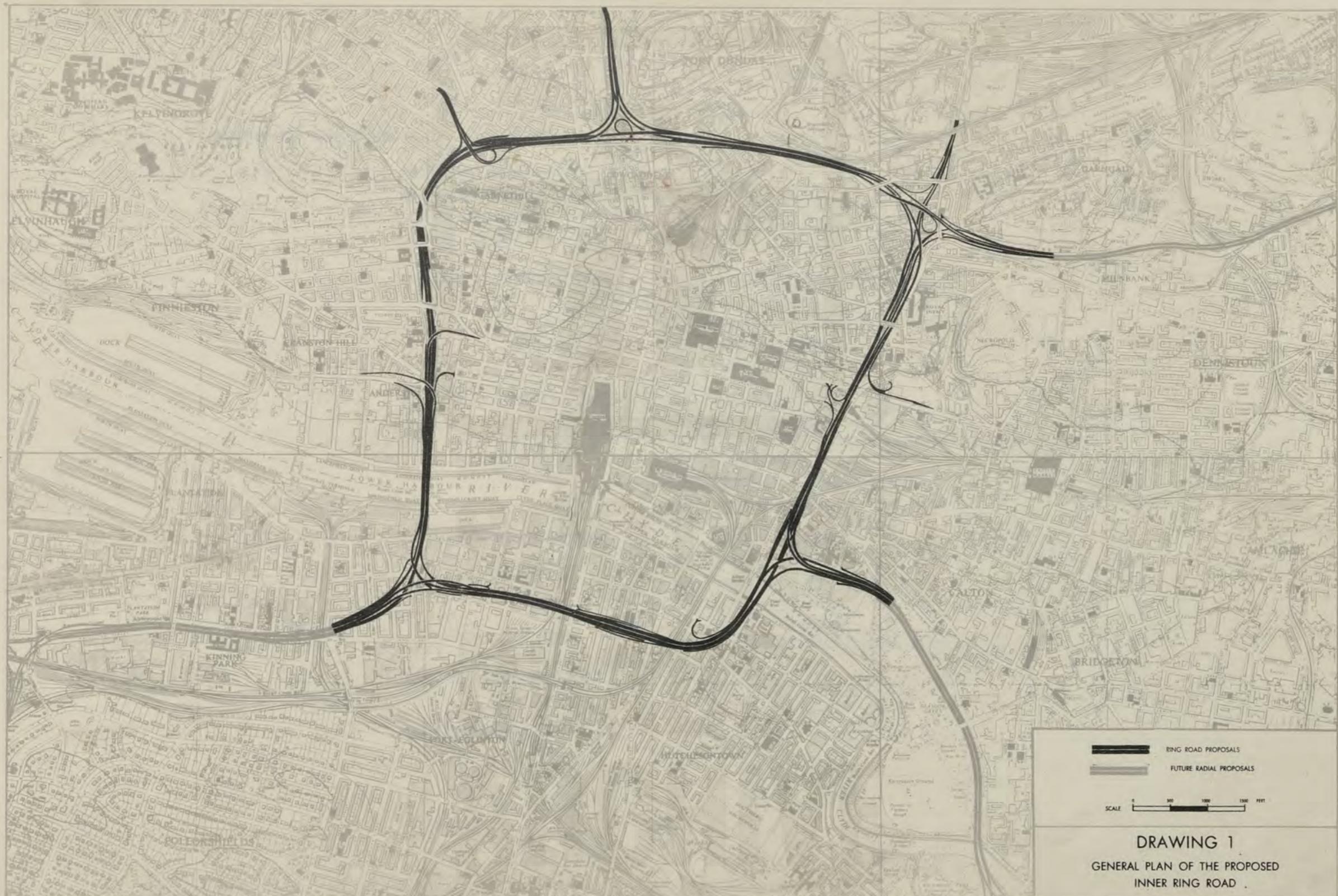


TABLE OF CONTENTS

ACKNOWLEDGEMENTS

LIST OF DRAWINGS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1—INTRODUCTION

- 1.1 Summary of Ring Road Proposals.
- 1.2 Terms of Reference.
- 1.3 The Panel of Consultants.
- 1.4 Current Proposals.
- 1.5 Outline of Report.

CHAPTER 2—TRAFFIC STUDIES

- 2.1 Study Area.
- 2.2 Current Traffic Patterns.
- 2.3 Characteristics of the Existing Streets and Traffic Flows.
- 2.4 Traffic Growth.
- 2.5 City Centre and Public Transport.
- 2.6 Future Traffic Patterns.

CHAPTER 3—ROAD STUDIES

- 3.1 Future Street System.
- 3.2 Urban Motorways.
- 3.3 Amenity and Appearance.
- 3.4 Standards of Design for the Ring Road.
- 3.5 Ring Road Proposals.
- 3.6 Civil and Structural Engineering Factors.

CHAPTER 4—CONCLUSIONS

LIST OF REFERENCES

ACKNOWLEDGEMENTS

The publication of this report was authorised by The Corporation of the City of Glasgow—Planning and Highways Committees.

We wish to acknowledge the guidance which has been received from the Working Party on Roads and Traffic in Glasgow which is composed of representatives of the following bodies—

The Corporation of the City of Glasgow—Architectural and Planning Department.

The Corporation of the City of Glasgow—Office of Public Works.

Department of Health for Scotland.

Scottish Home Department.

We also wish to acknowledge the part which has been played in this study by the following associated consultants. The nature of this association is outlined in Section 1.3.

William Holford & Partners, London, Liverpool and Edinburgh.

A. T. McIndoe, Edinburgh.

D. J. Robertson, Glasgow University.

Tippetts-Abbett-McCarthy-Stratton, New York, N.Y.

Finally we wish to acknowledge the information, assistance and advice provided by the following bodies—

All departments of The Corporation of the City of Glasgow.

Department of Health for Scotland.

Scottish Home Department.

Road Research Laboratory (D.S.I.R.)

The County Councils of the Counties of Dunbarton, Lanark and Renfrew.

The Burghs of Airdrie, Clydebank, Coatbridge, Hamilton, Motherwell and Wishaw, Paisley and Rutherglen.

British Transport Commission.

Royal College of Science and Technology.

University of Glasgow.

Clyde Navigation Trust.

Glasgow Chamber of Commerce.

Scottish Bus Group.

Road Hauliers Association.

LIST OF DRAWINGS

1. General Plan of the proposed Inner Ring Road.
2. Study Area.
3. Population of Study Area.
4. Location of Inner Cordon Survey Stations.
5. Location of Cordon and Screen Lines.
6. Desire Lines of Traffic.
7. Grouped Desire Lines of Traffic—Central Area.
8. Grouped Desire Lines of Traffic—excluding Central Area.
9. Vehicle Destinations in the Central Area.
10. Volume Flow Map for Glasgow.
11. Volume Flow Map for Glasgow Central Area.
12. Travel Times in Glasgow.
13. Travel Times in Glasgow Central Area.
14. Capacity of Radial Streets.
15. Future Electrified Railway System.
16. Travel Times by Public Transport.
17. Travel Times by Private Car.
18. Assumed Principal Traffic Roads.
19. Tentative Principal Street System.
20. Future Traffic Volumes.
21. Future Principal Traffic Streams.
22. Plan and Profiles.
23. Plan and Profiles.
24. Plan and Profiles.
25. Plan and Profiles.
26. Typical Road Sections.

LIST OF FIGURES

1. Movement of light vehicles.
2. Movement of heavy vehicles.
3. Trip purpose for trips to and from the Central Area of Glasgow.
4. Trip purpose for trips other than to or from the Central Area of Glasgow.
5. Variation in flow for one week-day at four locations.
6. Variation in flow for five week-days at the automatic counter on Alexandra Parade.
7. Daily variation for one week at four automatic counter locations.
8. Seasonal variation at two of the automatic counter locations.
9. Highest hourly traffic on Anderston Quay during year beginning November, 1960.
10. Average vehicle mileage.
11. Passenger car registration.
12. Car ownership and population.
13. Car ownership and population density.
14. Car ownership and bank clearings.
15. Car ownership, bank clearings and population density.
16. Percentage relation of car ownership in Glasgow and Great Britain.
17. Decline in growth of passenger cars with increasing car ownership.
18. Predicted car ownership for Glasgow.
19. Percentage relation of motor cycle to car ownership in Glasgow.
20. Percentage relation of goods vehicles to passenger cars in cities.
21. Methods of entry to Chicago central business district.
22. Passengers through Queen Street Low Level Station before and after electrification.
23. Car ownership and percentage of travel by public transport.
24. Decline in use of Glasgow Corporation Public Transport (1945-1960).

LIST OF TABLES

1. Total trips to Glasgow Central Area as measured in 1960 and 1961 Surveys.
2. Purpose of travel to Glasgow Central Area as measured in 1960 and 1961 Surveys.
3. Inter-district volumes of light vehicles.
4. Inter-district volumes of heavy vehicles.
5. Variation of week-day peak hours between various areas of Glasgow.
6. Variation of week-day peak hours at the automatic counter stations.
7. Travel time measurements on 5 links of the Glasgow arterial street network.
8. Average journey speeds on defined sections of the Glasgow arterial street network.
9. Directional distribution of traffic for various areas of Glasgow.
10. Increase in traffic volumes at 14 points in Glasgow between the 1954 census and 1961.
11. Growth in vehicle registration and mileage for Great Britain (1956-1960).
12. Passenger car and goods vehicle data for fifteen British cities.
13. Population and economic data for fifteen British cities.
14. Net income before tax for the financial year 1953-1954.
15. Summary of predictions of future vehicle ownership for Glasgow.
16. Summary of predictions of future vehicle ownership for areas surrounding Glasgow.
17. Summary of predictions of future vehicle ownership for Study Area.
18. A comparison of the relation between amount of travel and vehicle ownership levels for Glasgow and two American cities.
19. A comparison of parking data from two American cities with estimated figures for Glasgow.
20. A comparison of the percentage of person travel by public transport in Glasgow and Chicago.
21. A comparison of the existing and proposed electrified rail services in Glasgow and Chicago.
22. A comparison of the number of trips ending in the cities of Glasgow and Chicago by method of travel on an average week-day.

CHAPTER 1

INTRODUCTION

1.1 Summary of Ring Road Proposals

The work which we describe was initiated by the Glasgow Corporation early in 1960, at which time we were authorised to carry out studies in connection with the proposed Glasgow Inner Ring Road. Subsequently, the scope of the work was extended to embrace a comprehensive survey of Glasgow traffic (November, 1960) and a study of the entire Glasgow street network (November, 1961). The need for these additional investigations developed as a logical consequence of the initial studies, and a final report must await the completion of this further work. For this reason we have prepared the present report, the principal object of which is to present to the Corporation a definitive design for the proposed Inner Ring Road.

A general plan of our proposals is shown on Drawing 1. Since the investigations are not yet complete these proposals are subject to amendment as to the location and nature of the interchanges and ramp connections to surface streets, but we do not anticipate that any such amendment will require a move in the centre line of more than 100 feet to either side of the location as shown at present. It is already a proposal of the Corporation that the Ring Road should be constructed to motorway standards. Our investigations confirm that the road must be a motorway if it is to accommodate successfully the anticipated future traffic volumes. The design, therefore, provides for a road without any frontage access, completely separated from all crossing streets, exclusively devoted to motor vehicles and with access limited to designated junctions.

The function of the Ring Road is to relieve the City Centre streets of by-passable traffic and to improve the vehicular access to the City Centre by a redistribution of centre bound traffic. It must also accommodate the anticipated growth in vehicular traffic. The selected design capacity of the road is, therefore, adequate, both to divert traffic which has no business in the City Centre, and also to redistribute traffic bound in and out of the City Centre, not only at current traffic levels but within the foreseeable future. When completed it should permit the re-organisation of City Centre streets to develop areas of pedestrian priority. Finally, it is our conclusion that with the growth of traffic the entire arterial system of Glasgow will become overloaded to an extent that can only be relieved by a supplementary system of high capacity routes to motorway standards. The Ring Road has, therefore, been designed to accommodate future connections to such a system and these connections are also shown on Drawing 1. The actual stages of construction are a matter for further study.

The centre line location of the present proposals differs from those shown on the Town Map on the north and south flank. Both these deviations were dictated by the application of modern highway design standards. Careful consideration was given to the possible financial, traffic or planning advantages of further deviation from the Town Map line.

It will be apparent that the proposals will involve major construction projects and heavy capital expenditure. Though at this stage of our study we cannot commit ourselves to a firm estimate of cost, in our view a solution of the traffic problem and the continuing prosperity of the City Centre cannot be achieved by a less expensive type of investment.

The main conclusions of the report are given in summary form in Chapter 4.

1.2 Terms of Reference

The terms of reference for our initial appointment were set out in our letter of February 17th, 1960, and approved in a letter from the Corporation of Glasgow dated March 25th, 1960. They were as follows :—

- (i) To examine the information already collected by the Architectural and Planning Department of the Corporation of Glasgow relating to traffic and to examine their proposals for the Inner Ring Road.
- (ii) To consult with the Architectural and Planning Department, their Consultants and other Authorities concerned and to advise the Corporation of Glasgow on the general suitability of their proposals in relation to the present and future traffic requirements.
- (iii) To advise on what further information, if any, should be collected and what further studies, if any, should be made in order to prove the suitability of the proposals.

In a preliminary report made to the Corporation of Glasgow on May 5th, 1960, we outlined *inter alia* the programme of studies which we considered would best serve the purposes of the Corporation. The basic traffic study then proposed was a comprehensive origin and destination survey of the entire Glasgow Area.

At a meeting held on August 30th, 1960, in Glasgow, we were instructed by the Convener of the Planning Committee of Glasgow Corporation :—

- (1) to proceed immediately with a limited traffic study which would provide sufficient data for the design of the Inner Ring Road, and
- (2) to produce as a matter of urgency a definitive design for the Inner Ring Road.

The necessary traffic survey was carried out in September, 1960, and the present report submits our definitive proposals for the Inner Ring Road based on the traffic information collected at that time.

Subsequent to these instructions we were authorised, in November, 1960, to carry out a comprehensive traffic survey in Glasgow. This was done during June, 1961. The results have been tabulated and form the basis for the description of current traffic patterns in this report. The application of these results to road studies has only just commenced however, and the road studies described are entirely based on the more limited traffic survey carried out in September, 1960.

Finally we were authorised, in November, 1961, to advise the Glasgow Corporation on the type and location of the future principal traffic routes in the entire city. This instruction followed logically upon the studies described in this report. The necessary work is now under way and will be the subject of a further report.

1.3 The Panel of Consultants

As they have carried out the bulk of the detailed work, this report has been prepared by the Engineering Consultants appointed by the Corporation of the City of Glasgow. However, the Corporation, being conscious of the very wide implications of their proposals, appointed in 1960 a number of additional Consultants who were experts in other fields of study relevant to the problems posed by the Inner Ring Road. These appointments were :

Sir William Holford, P.R.I.B.A., P.P.T.P.I., President of the Royal Institute of British Architects, Senior Partner of the firm of William Holford & Partners, Architects and Planning Consultants, London, Liverpool and Edinburgh.

Mr. A. T. McIndoe, M.T.P.I., A.R.I.C.S., M. Inst. H.E., Chartered Surveyor and Town Planning Consultant, Edinburgh.

Professor D. J. Robertson, M.A., Professor of Applied Economics, University of Glasgow.

The whole study has been directed by a committee consisting of these Consultants and of representatives of the Engineering Consultants.

Of recent years it has become apparent that the solution of urban traffic problems would require the collection of data on a comprehensive scale and was likely to involve road construction of the urban motorway type. These are very specialised problems and, by their anticipation of them, the Engineering Consultants were able to staff their Glasgow Office with a team, all of whom had special training in these fields. Because of the magnitude

of the Inner Ring Road scheme however, they considered that it would be in the best interests of the City of Glasgow that they should be associated with an American firm who could provide a background of experience of such developments which is not available in this country. The Corporation agreed to an association with Tippetts-Abbett-McCarthy-Stratton, Engineers and Architects, New York.

Mr. T. J. Fratar, a partner of that firm, who is a Civil and Traffic Engineer of high standing in the United States of America has made his knowledge and experience available to the Consultants. The Engineering Consultants drew largely upon his experience in their early advice to the Corporation that the general concept of the Inner Ring Road was sound. Mr. Fratar has made several visits to Glasgow and he and his staff have advised upon the methods which the Engineering Consultants adopted in the collection and analysis of traffic data, and have reviewed the plans and profiles which were produced for the Inner Ring Road. However the work was carried out in Glasgow by the Engineering Consultants who also made the final decision on methods of survey and analysis, and on the plans and profiles of the Inner Ring Road which are presented in this report.

1.4 Current Proposals

The current proposals of the Glasgow Corporation were defined in their Written Statement¹ as follows :—

- (a) that, having regard to the anticipated increase in the volume of traffic in the next 15 years, an Inner Ring Road will be essential for the City.
- (b) that the said road will require to be of the scale and purpose of an urban motorway rather than a multi-purpose traffic road.
- (c) that the construction of the entire Road, including a proposed new bridge over the River Clyde on the line of Clyde Ferry/Shearer Street should, if possible, be completed within the next 10 years.

The details shown for the Inner Ring Road on the Town Map were illustrative only, but the centre line as indicated was, in the opinion of the technical officials of the Corporation, the most probable choice of location. It is now proposed that the line to be adopted should be that shown on Drawing 1. It will be observed that this deviates from the original centre line location on the south and north flanks. In both instances these changes have been dictated by modern highway standards, as have the changes in design detail. These proposals have not been made without a careful study of the possible advantage of further deviation.

¹ The Glasgow Development Plan Quinquennial Review 1960. The Written Statement. Page 119.



Since the studies are in an interim stage, the proposals are subject to the following qualifications :—

- (1) the nature and function of the Ring Road will be as shown on Drawing 1, but the location of interchanges and ramp connections are subject to review pending the completion of a master plan of future principal traffic routes.
- (2) Some amendment to the centre line may be required, due to such modification of the junctions or during the preparation of working drawings for construction purposes, but it is not anticipated that any such amendment will require a move in the centre line of more than 100 feet to either side of the location as shown at present.

1.5 Outline of Report

Chapter 2 of this report deals with the traffic studies. Its objects are :—

- (1) to define the area with a major influence on Glasgow traffic, and to review the predicted population and economic changes for this area.
- (2) to describe the current patterns of vehicular origin and destination within the study area as measured in the traffic surveys.
- (3) to describe the characteristics of the existing streets and traffic within the study area and to make some preliminary deductions on the reserve of capacity in the existing street system.
- (4) to predict the growth of traffic in the study area generally, and in the city centre, and to make some necessary deductions from this on the effect of the increase of car traffic on public transport.
- (5) in the light of this data to decide upon the future patterns of vehicular origin and destination.

Chapter 3 of this report deals with the road studies. Its objects are :—

- (1) to describe the probable form of the future Principal Traffic Routes for the city and the nature and function of the Inner Ring Road in relation to these Routes.
- (2) to summarise the advantages of the urban motorway.
- (3) to describe the design standards to be adopted for the Inner Ring Road, including standards of amenity and appearance in the urban landscape.
- (4) to describe the location proposed for the Inner Ring Road.
- (5) to describe the engineering problems which may be encountered.

Chapter 4 concludes the report with a summary of the principal findings.

CHAPTER 2

TRAFFIC STUDIES

2.1 Study Area

The City of Glasgow is the centre and overwhelmingly the largest single unit of the Clyde Valley conurbation. The social and economic life of Glasgow is interwoven with that of the adjacent areas in a way that cannot be contained by an administrative boundary. It follows that a study of the traffic patterns of the City of Glasgow must also be concerned with a wider area. Drawing 2 shows the boundary of the Study Area as defined for the traffic survey. The results of the comprehensive traffic survey show that only a little over 1 per cent. of all traffic intercepted by the survey had no purpose within this area except to get to the other side.

There are various sections of the Study Area to which repeated reference is necessary and for convenience these are defined as follows :—

CITY CENTRE.—An area of approximately 1 square mile closely corresponding to the area enclosed by the Inner Ring Road. This is the business heart of the City of Glasgow and by far the densest area of traffic generation in the City.

CENTRAL AREA.—An area of approximately 3 square miles enclosed by the Inner Cordon Line shown on Drawing 5. This area was identified as District 00 for the purposes of the traffic survey. In addition to the City Centre it contains two square miles of fringe area devoted to mixed uses including office, warehouse, light industry and residential.

GLASGOW.—The area enclosed by the External Cordon Line which corresponds quite closely to the County of the City of Glasgow.

STUDY AREA.—The County of the City of Glasgow, and the adjacent urbanised areas as defined in Drawing 2.

A number of major changes have been predicted for the Study Area. The most marked is an outward movement of population. Many of the residential areas within Glasgow which were developed at very high densities during the last century have reached the end of their useful life. Under an extensive programme of redevelopment of such areas it is proposed to resettle many of the people displaced by these schemes in reception areas beyond the City. Further, recent trends indicate that the population of Glasgow is declining quite apart from the overspill proposals. At the same time the planning authorities responsible for the adjacent urban areas are almost all anticipating a growth in population. Therefore, although the population of Glasgow is, on the latest estimate of the office of the City Architect and Planning Director, to fall by some 180,000 people, a combination of all predictions made by

the relevant authorities, which was compiled by the Department of Health for Scotland, indicates a total loss of population in the Study Area of the order of only 30,000 people. The present and predicted population for individual districts of the Study Area is shown on Drawing 3.

The trend towards lower density living is not unique to Glasgow but has been experienced by almost every major city both here and in America. In some places the decline in population of the central city has taken place in the face of a substantial overall growth of the conurbation. Recent policies directed to more compact housing layouts,² higher overall residential densities and the conservation of undeveloped land, green-belts and open spaces, have not yet altered the situation with which we have to deal.

The trend towards lower densities is also a feature of the manufacturing industries. It is stated in the survey report for Glasgow that a projection of current trends would result in a drop in overall industrial density from 80 persons per acre in 1950 to 55 persons per acre in 1980, and that such a prediction would conform to modern industrial practice. The projected spread in population and industry is likely also to encourage the establishment of secondary commercial centres for both shopping and office purposes. Provided that adequate steps are taken to ameliorate traffic conditions this dispersion should be confined to those activities which are not truly central in character and the City Centre of Glasgow should continue as the dominant centre of commercial activity in the Study Area.

This very brief summary gives the background of the traffic investigations. These were made within a great urbanised area housing nearly a million and a half people. The total population is expected to decrease only slightly over the next twenty years. When every allowance has been made for the effect of town planning controls and higher suburban densities, there is bound to be an increase in the use of land in virtually all forms of development. This spread will in itself result in an increasing volume of traffic as the distance from one activity to another becomes greater.

2.2 Current Traffic Patterns

In order to determine the probable use of a proposed new road it is necessary to know the origin and destination of the traffic which it is thought might use it. In a large city there are many alternative routes available between any two given points and it is, therefore, necessary to obtain this origin and destination information in a very detailed form. It is not sufficient to know, for example, that a trip from the south is bound for the City Centre of Glasgow. Dependent upon its exact origin, it may enter upon one of several roads whether present or proposed; dependent upon its destination it may turn either left or right on the

Ring Road. For this reason the Study Area was divided into districts, and these were in turn sub-divided into traffic zones. This division of the Study Area is shown on Drawing 2.

Most of the traffic which is expected to use the proposed Ring Road already enters the Central Area, either to stop there, or merely to cross it on its way to the other side. The most applicable initial survey was, therefore, based upon the direct interview of a sample of the drivers of vehicles entering the Central Area and this was the survey which was carried out in September, 1960. In order to obtain a complete picture the stations had to be located in such a way that no significant amount of traffic could enter the area without encountering an interview station. The location of the stations is shown on Drawing 4. This survey intercepted only those trips which enter the area enclosed by the cordon. It was extended to cover the entire City of Glasgow by a network of interview stations located on the cordon and screen lines shown on Drawing 5. The additional survey work was carried out in June, 1961. The information from both surveys was combined into a single tabulation of all significant vehicular movements within the Survey Area. Despite the lapse of 9 months between the initial survey and its extension, the results were closely comparable both from the point of view of volume, pattern and trip purpose. Table 1 compares the volumes of traffic starting or stopping in the Central Area while Table 2 compares the purpose of travel to the Central Area as measured in both surveys.

Table 1

Total trips to Glasgow Central Area as measured in 1960 and 1961 surveys on an annual average week-day (24 hours)

Vehicle Type	1960 Survey	1961 Survey	Percentage Difference
Light Vehicles	-	82,400	81,750
Heavy Vehicles	-	12,400	13,200
All Vehicles	-	94,800	94,950

Table 2

Purpose of travel to Glasgow Central Area as measured in 1960 and 1961 surveys for week-days between the hours of 8 a.m. and 7 p.m.

Survey Date	From Home to Work	Business	Shopping	Pleasure	Other
1960 Survey	15%	73.5%	3.7%	5.8%	2.0%
1961 Survey	16.8%	72.5%	3.2%	5.5%	2.0%

It is considered that results such as these have established not only the accuracy of the surveys but also the remarkable uniformity of the traffic patterns generated by Glasgow.

² H.M.S.O. 1962. Homes for Today & Tomorrow.

* The accuracy of the survey results and the day to day variations in traffic volumes are of the same order as the growth in traffic volumes between the two surveys. The percentage difference cannot therefore be taken as a measure of growth.





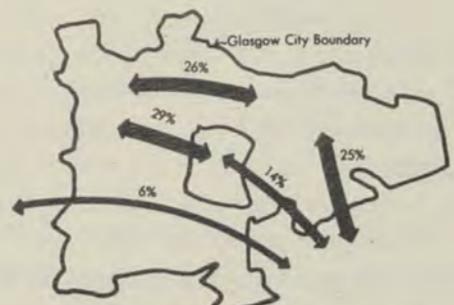






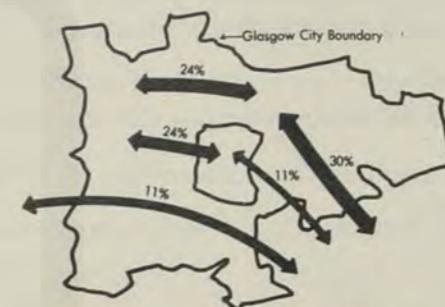






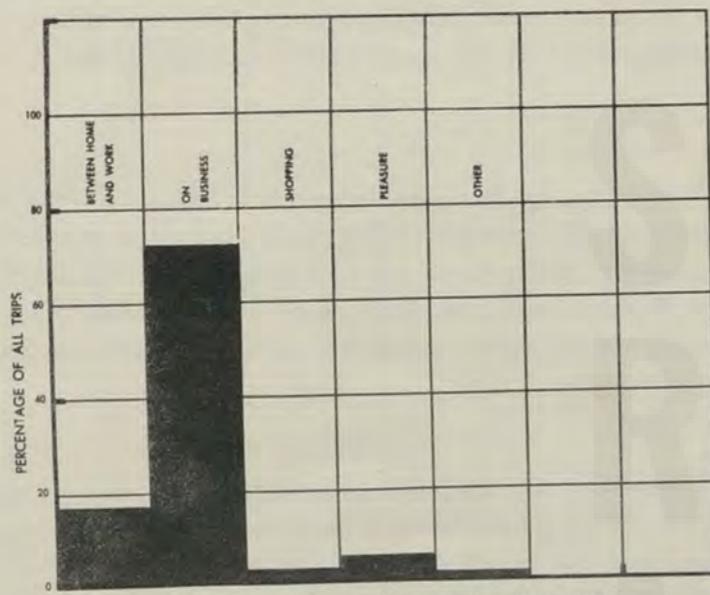
94% of all light vehicle trips started or finished in Glasgow
 55% of these both started and finished in Glasgow and only
 6% of all light vehicle trips crossed Glasgow without stopping

FIGURE 1.—MOVEMENT OF LIGHT VEHICLES



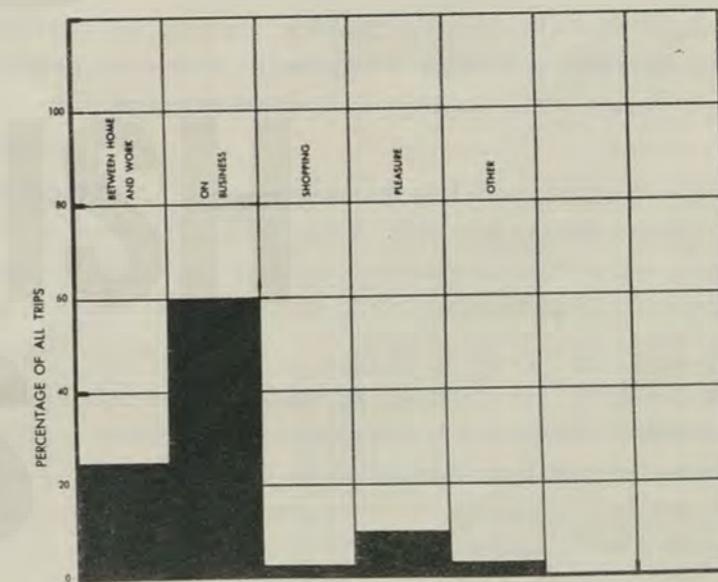
89% of all heavy vehicle trips started or finished in Glasgow
 48% of these both started and finished in Glasgow and only
 11% of all heavy vehicle trips crossed Glasgow without stopping

FIGURE 2.—MOVEMENT OF HEAVY VEHICLES



This figure refers to week-day travel between the hours of 8 a.m. and 7 p.m.

FIGURE 3.—TRIP PURPOSE FOR TRIPS TO AND FROM THE CENTRAL AREA OF GLASGOW



This figure refers to week-day travel between the hours of 8 a.m. and 7 p.m.

FIGURE 4.—TRIP PURPOSE FOR TRIPS OTHER THAN TO OR FROM THE CENTRAL AREA OF GLASGOW

The volumes of traffic which passed between the districts of the Study Area on an average week-day in 1961 are shown on Drawing 6, and Tables 3 and 4. (A separate tabulation is given for heavy goods vehicles.) It should be emphasised that in the case of the districts lying beyond the outer cordon, only those trips which crossed the Survey Area as enclosed by the outer cordon line could be intercepted. Although the survey stations were operated only from 8 a.m. to 7 p.m. all the results obtained were expanded to represent two-way 24-hour* flows on the basis of numerous traffic counts made by automatic counters throughout the City. The tabulations are merely a summary of the full survey information which has already been made available to the technical officers of the Corporation. The same information was summarised to make Drawing 7 which shows traffic to and from the Central Area, and Drawing 8 which shows traffic unconnected with the Central Area. These were built up by routing traffic on the shortest path through a network joining district centroids. The purpose of the drawings is to simplify the overall picture and to bring out the importance of secondary flows. It is obvious from all three drawings that the predominant flows are radially focused on the Central Area of Glasgow.

A simplified picture of the movement of light and heavy vehicles is given by Figures 1 and 2. The information presented here is in line with that from most large cities. Most of the traffic entering the Central Area is generated by Glasgow itself. The majority of the traffic entering the Central Area without intending to stop there, was on its way between other parts of Glasgow. It will be observed that the heavy vehicles form a greater proportion of the through traffic.

Drawing 9 is a graphical presentation of the distribution of light and heavy traffic bound for the Central Area. This area does not generate traffic uniformly. The City Centre, although only about one third of the total area enclosed by the survey points, generates much more traffic than the fringe areas surrounding it. There is again a significant difference between heavy and light vehicles with the fringe areas attracting a much greater proportion of the heavy vehicles.

The purpose of trips by light vehicles bound for the Central Area is shown on Figure 3, and for those unconnected with the Central Area is shown on Figure 4. The predominant reasons for travel are connected with work and business. This is, of course, the anticipated result of a survey of week-day traffic between the hours of 8 a.m. and 7 p.m. There is reason to believe that the journey from home to work was under-reported, as peak hour drivers in a hurry tended not to listen carefully to the explanations of the interviewer. Heavy vehicles were almost wholly reported as on business.

The full implications of the comprehensive traffic survey have not yet been explored. Nevertheless, the following general conclusions can already be drawn.

- (1) The focus of traffic in the Study Area is the City Centre of Glasgow and priority should be given to traffic improvements in this area.
- (2) The next priority for improvement will be the radial routes.
- (3) Outer and middle ring routes are of comparatively low priority.

2.3 Characteristics of the Existing Streets and Traffic Flows

About one third of all land in the City Centre is used for streets, alleys and pavements. The average use of land for streets throughout the town is of the order of 20 per cent. and the total length of streets of all categories is 967 miles. There are two basic uses for these streets. The first is to provide access to property, the second to permit the movement of through traffic. In fact the ordinary city street normally provides for both these uses in varying degree. The existing streets in the Glasgow area could be defined under three classifications as follows:—

LOCAL STREETS.—The majority of streets are primarily used to obtain access to the properties fronting on to them. Their layout is such that a through movement of traffic would be circuitous and does not normally occur. These are of minor interest in the study of traffic.

COLLECTOR STREETS.—The principal function of these streets should be to connect the local streets with the arterial street system. They also provide access to developed land. At present many of the routes which are essentially collector in character have developed into secondary arterial routes because of the overloading of the arterial system.

ARTERIAL STREETS.—These carry a majority of through traffic but in most cases they also provide for direct access to frontage development. A feature of arterial streets is the development of subsidiary shopping centres at major junctions from which good access is provided by public transport to adjoining developed areas. The increase in through traffic has led to considerable conflicts with the pedestrian movements associated with shopping. Such conflicts are among the worst features of the existing arterial system.

* A great deal of volume data was collected by automatic counter and the full 24-hour day was, therefore, a convenient working base. The 24-hour day was usually ten per cent. higher than the 16-hour day. The method of analysis assumes that there is no significant change in the patterns of origin and destination throughout the day. That this is a reasonable working assumption is indicated by the relatively constant relation of the 11-hour and 24-hour volumes. Excluding the Central Area the average relation was 1.42 with a standard deviation of 0.09.

Table 3

Inter-District Volumes of Light Vehicles

	00	11	21	31	51	61	71	81	12	22	32	42	52	62	72	82	13	23	33	43	53	63	73	83
00																								
11	4977	112																						
21	3218	905	147																					
31	12862	1558	2903	1411																				
51	17519	955	385	3133	1521																			
61	2501	93	15	238	1000	547																		
71	10290	292	83	649	1261	589	911																	
81	21018	866	379	1780	1752	267	4382	2033																
12	2233	1715	329	609	365	24	162	390	182															
22	4394	1687	518	1812	545	93	228	664	2580	124														
32	7247	685	583	7582	1631	80	328	937	439	1144	311													
42	3681	137	99	1754	2264	74	112	479	131	161	1296	82												
52	3891	186	42	446	5618	247	358	482	86	118	277	419	418											
62	2897	45	13	290	1215	1447	1020	434	54	59	110	41	491	443										
72	2059	76	20	136	255	184	2000	650	27	40	36	33	93	426	49									
82	6132	385	104	466	662	177	1047	6244	196	236	252	77	264	192	139	288								
13	2957	751	294	684	588	61	213	768	1092	2125	550	168	153	75	81	515	28							
23	5703	935	290	1422	850	78	320	1078	834	2920	957	240	198	45	50	419	417	351						
33	10768	653	633	5320	1634	136	494	1489	371	1448	4861	498	351	99	99	288	1261	3133	145					
43	1660	83	29	625	432	19	125	296	41	173	528	827	267	51	31	81	463	475	27	—				
53	12068	498	286	1673	5200	390	745	1963	272	498	1139	3797	3791	459	162	516	1242	2001	825	154	505			
63	7574	279	75	619	1931	746	1269	1547	150	264	316	249	644	1599	366	546	437	843	793	106	939	138		
73	6048	181	69	225	599	136	1217	2932	108	100	132	69	177	211	354	2081	265	321	233	57	507	80	12	
83	4896	267	89	296	630	68	836	2090	165	304	204	122	117	149	202	2912	580	594	697	171	1348	231	157	83

Table 4

Inter-District Volumes of Heavy Vehicles

	00	11	21	31	51	61	71	81	12	22	32	42	52	62	72	82	13	23	33	43	53	63	73	83
00																								
11	1648	29																						
21	198	104	9																					
31	1291	275	272	146																				
51	4033	316	46	759	398																			
61	590	36	—	70	313	197																		
71	1913	111	9	109	356	217	258																	
81	2547	272	16	130	315	37	709	134																
12	774	599	42	163	217	39	39	224	52															
22	433	259	7	399	175	3	42	39	360	27														
32	615	82	30	751	189	5	42	43	132	113	28													
42	573	78	7	190	421	16	37	38	34	5	130	21												
52	563	65	8	128	1317	79	212	52	31	37	34	143	129											
62	360	22	10	31	296	368	286	109	14	5	3	13	92	99										
72	373	23	—	9	89	77	465	155	16	—	14	4	30	71	23									
82	748	166	8	41	232	41	159	752	108	35	21	26	40	30	69	23								
13	867	403	27	142	281	35	97	134	295	183	37	57	60	4	10	137	11							
23	1338	414	25	250	669	43	127	148	318	525	162	81	122	11	44	129	98	62						
33	959	173	41	367	504	36	148	137	111	247	544	70	124	39	10	73	270	753	33					
43	165	46	4	66	224	3	26	28	8	15	28	109	47	—	28	12	70	168	—	—				
53	2490	499	35	454	2102	183	529	335	262	132	162	1047	1446	215	107	224	737	1411	238	26	252			
63	1606	267	11	203	723	173	480	150	102	51	27	187	245	318	130	226	304	715	260	31	526	78		
73	225	4	—	17	105	45	174	137	30	7	11	—	39	14	51	188	13	47	35	11	62	20	2	
83	760	125	15	88	201	40	145	229	126	45	24	38	55	17	88	688	216	224	139	20	575	171	39	17

Drawings 10 to 13 show the network of streets on which volume and travel time studies have been completed. These comprise all those streets which have been defined as arterial in character in the Survey Area. More than 500 volume counts have been carried out both manually and by machine, and continuous counts are being maintained at the four locations marked on Drawing 13, to establish the amount, composition and characteristics of the traffic using this existing street network. In addition the average speed of week-day travel has been established by trial runs on over 200 miles of the network.

There are certain patterns of traffic movement which regularly repeat themselves. The most characteristic of these is the hourly variation throughout the day. Figure 5 shows the hourly variation for a single day at each of the four locations for which continuous machine counts are being recorded. Figure 6 shows the hourly variations for five consecutive week-days at one of these locations. Table 5 summarises the relation of peak hour to 24-hour volumes for different areas of the City.

Table 5
Variation of week-day peak hours between various areas of Glasgow.
On the average 2 days were measured at each station

Location	Week-day peak hour as percentage of 24-hour week-day		Range of Evening Peak
	8 a.m. — 9 a.m.	5 p.m. — 6 p.m.	
Average of 9 Stations on the Inner Cordon -	7.9	8.6	6.7 — 10.4
Average of 12 Stations on the Middle Cordon	7.8	9.1	8.4 — 10.3
Average of 10 Stations on the Outer Cordon	7.8	9.1	8.2 — 10.8

Table 6 summarises the variation in the peak hour from day to day at selected locations.

Table 6
Variation of week-day peak hours at the automatic counter stations.
Measured during week beginning 23.10.61

Location	Week-day peak hour as percentage of 24-hour week-day		Range of Evening Peak
	8 a.m. — 9 a.m.	5 p.m. — 6 p.m.	
Gt. Western Road -	6.8	8.9	8.7 — 9.1
Anderston Quay -	9.0	8.6	8.3 — 9.1
Pollokshaws Road -	10.2	9.8	9.3 — 10.2
Alexandra Parade -	7.4	8.3	8.1 — 8.4

In most cases the morning peak hour occurred from 8 a.m. to 9 a.m. and the evening from 5 p.m. to 6 p.m. There were some exceptions, however, particularly on some City Centre streets where the peak hours of travel were in the middle of the day. In most cases the evening peak hour was the highest hour of travel. Although the results varied both from point to point and from time to time, it was observed that most of the results for the evening peak lay within the range of 8 to 10 per cent., with an average of just over 9 per cent. of the 24-hour flow on an average week-day.

An examination of Tables 5 and 6 will show that there is a greater variation between different locations than can be accounted for by the day to day variation at any one location. It will be observed that there is a greater variation in the peak hour percentages measured on the Inner Cordon than on the Middle and Outer Cordons. This is considered to be the result of the overload on certain roads such as Paisley Road West. When the daily volume increases until the peak hour percentage, in accordance with the desired pattern of travel, nears or exceeds the hourly capacity then the peak hour can grow no more. The peak hour overload is then dispersed to parallel secondary routes, where available, while the peak hour represents a decreasing portion of the daily travel. Eventually all relief routes in turn become overloaded—there is no further room for diversion—and peak hour travel is physically prevented. As yet this process does not appear to be very far advanced since the average peak hour percentages on all three cordons are very similar.

There are two further patterns of cyclical variation neither of which is nearly so pronounced as the daily pattern. The first is the variation between days of the week as shown on Figure 7 for the four counter locations. The principal difference is between week and week-end days. At most locations there is also a slight repetitive variation between week-days of the order of 3 per cent. but this was not consistent between locations, although Friday was almost universally the heaviest day of travel. The second pattern is seasonal and is shown on Figure 8 for two of the four counter locations. The data on which this is based are still tentative since complete figures are not available for a full year at each point. However, as the figure shows, the order of seasonal variation is 5 per cent.

It follows that the volumes of traffic on individual streets should be corrected for the known patterns of cyclical variation before any direct comparison is made between different streets, or for the growth of traffic on the same street. Drawings 10 and 11 show the volumes of traffic on the defined network of arterial and collector streets on an average week-day in 1961. All of the measured volumes used to build up this map were corrected to an average week-day using the known patterns of cyclical variation. The volume of traffic is represented graphically by the width of band.

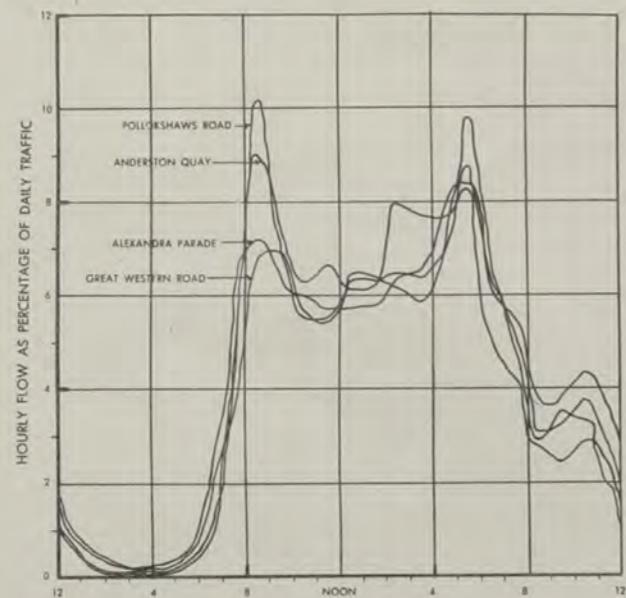


FIGURE 5.—VARIATION IN FLOW FOR ONE WEEK-DAY AT FOUR AUTOMATIC COUNTER LOCATIONS

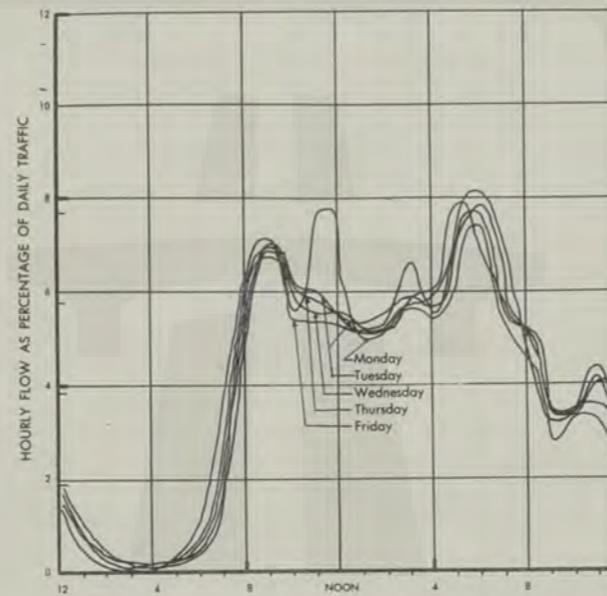


FIGURE 6.—VARIATION IN FLOW FOR FIVE WEEK-DAYS AT THE AUTOMATIC COUNTER ON ALEXANDRA PARADE

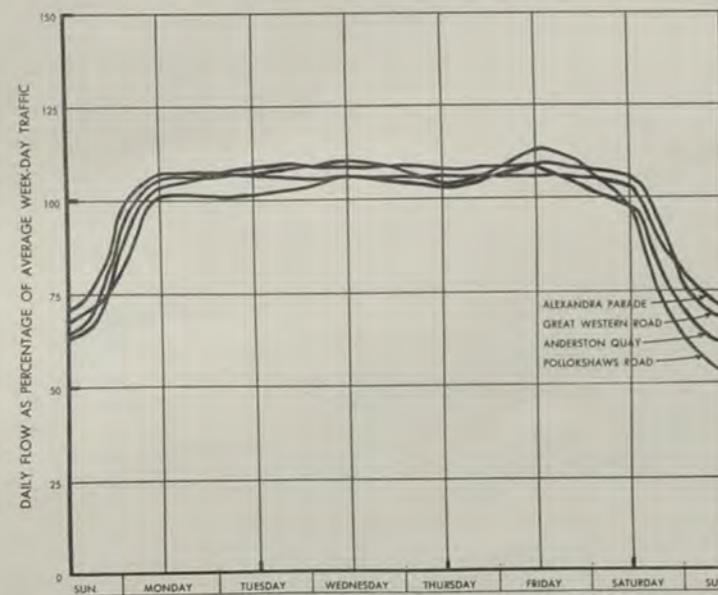


FIGURE 7.—DAILY VARIATION FOR ONE WEEK AT FOUR AUTOMATIC COUNTER LOCATIONS

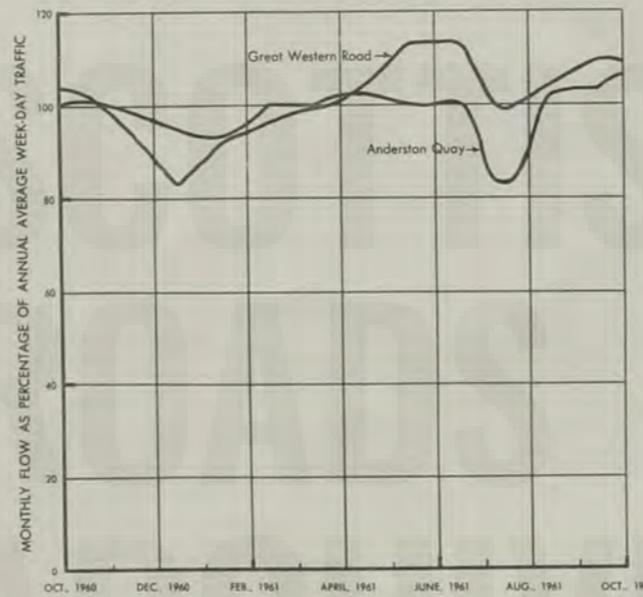


FIGURE 8.—SEASONAL VARIATION AT TWO OF THE AUTOMATIC COUNTER LOCATIONS

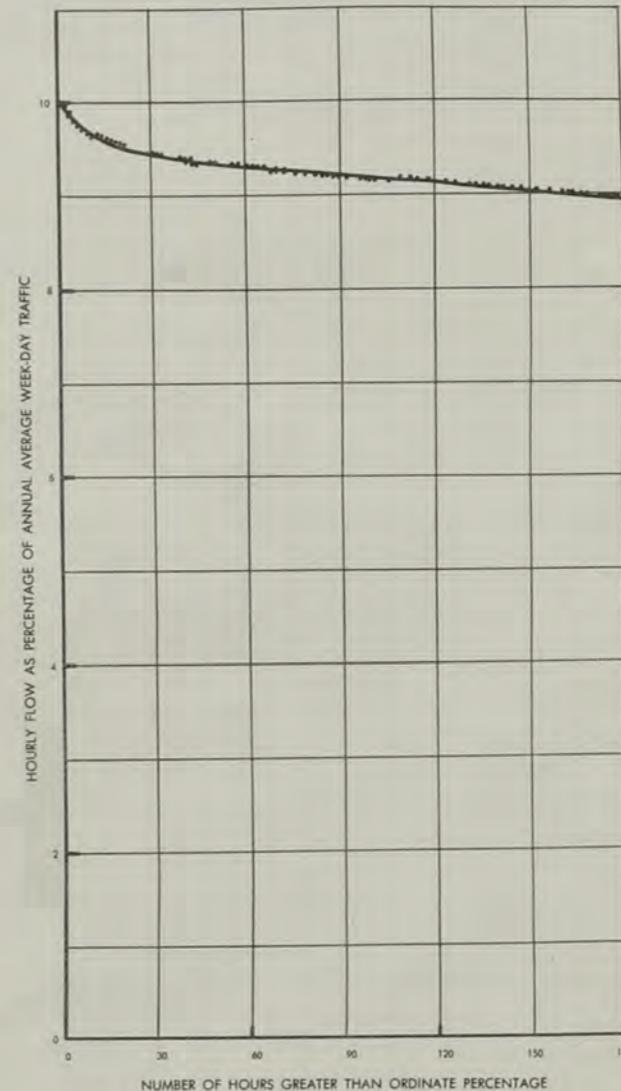
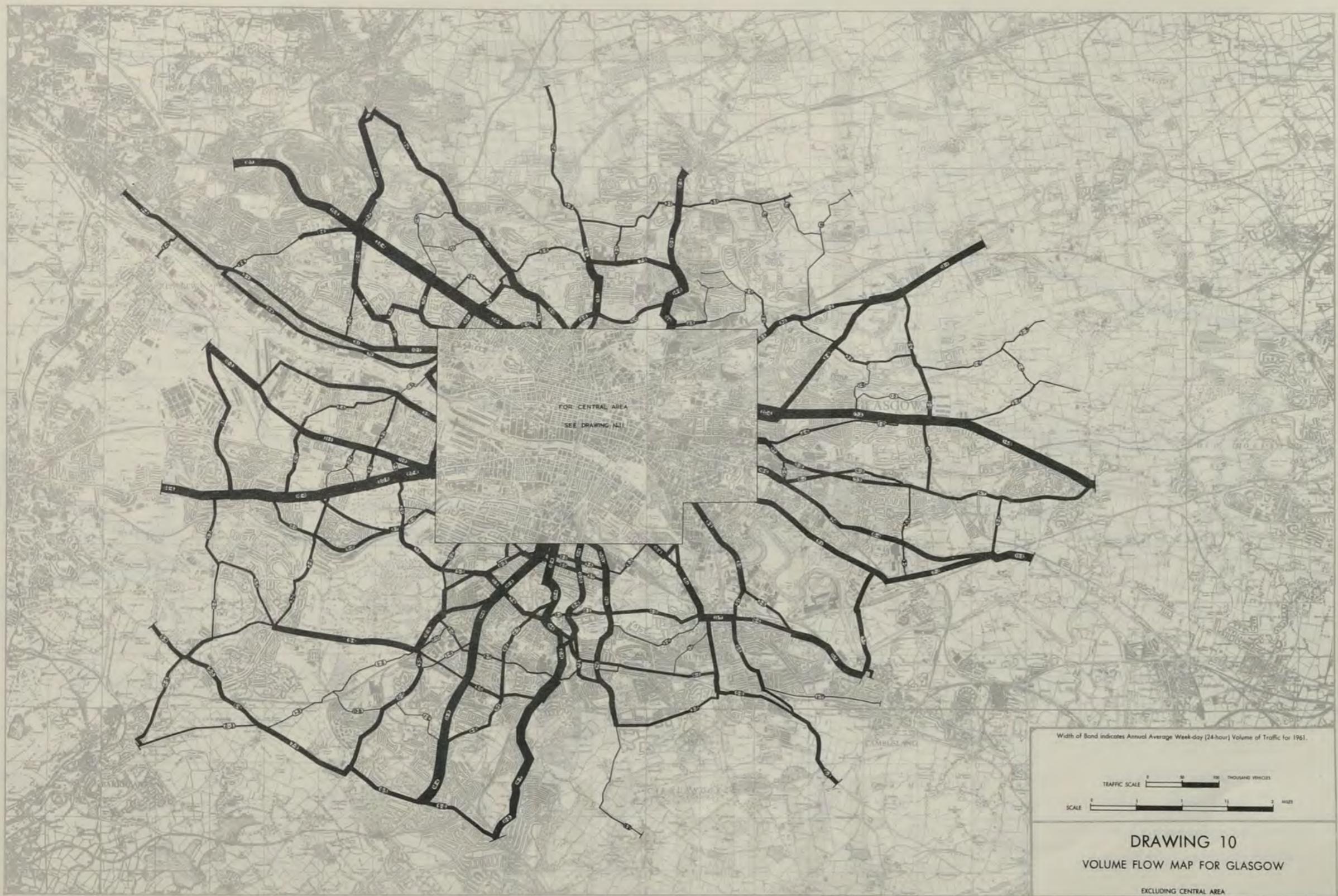


FIGURE 9.—HIGHEST HOURLY TRAFFIC ON ANDERSTON QUAY DURING YEAR BEGINNING NOVEMBER, 1960











DRAWING 13
JOURNEY SPEEDS IN GLASGOW

The speed of traffic on the defined street network was usually measured by 6 runs in each direction spaced between the hours of 8 a.m. and 6 p.m. Table 7 shows the values obtained at five locations and the standard deviation for each.

Table 7

Travel time measurements on 5 links of the Glasgow arterial street network

Location	Link	24-hour 2-way Vehicles in Veh./day	No. of Test Runs in and out	Time per Mile		Standard Deviation		Journey Speed (m.p.h.)	
				In	Out	In	Out	In	Out
Great Western Road	Annie'sland Cross to Hyndland Road	23,100	6	2.54	2.28	0.50	0.14	23.6	26.3
Balmore Road	Blackhill Road to Ashgill Road	7,800	6	2.16	2.14	0.12	0.16	27.8	28.0
Clarkston Road	Eastwoodmains Road to Merrylee Road	12,000	6	2.89	3.10	0.06	0.09	20.8	19.4
Buchanan Street	Sauviehill St. to Argyle Street	12,700	12	6.74	7.15	1.78	1.76	8.9	8.4
Argyle Street	Buchanan St. to Glasgow Cross	13,000	12	8.72	9.67	3.35	4.35	6.9	6.2

It was observed that congestion resulted in more than usual variation between one run and another and in certain cases more than 6 runs were made in order to obtain a closer average. Drawings 12 and 13 show the results obtained on the measured sections of the street network. The results underlined that congestion is not solely a function of traffic volumes but also of the interference with flow caused by intersecting streets, parked cars, heavy vehicles, etc. These are an especial feature of City Centre streets and it will be observed that both speeds and volumes in the City Centre are generally lower than on the main radials. Table 8 gives the average speed for certain defined sections of the arterial network of the City Centre, and of the remainder of Glasgow between the hours of 8 a.m. and 6 p.m. on an average week-day. This includes only those streets defined as arterial and not those defined as collectors.

Table 8

Average journey speeds on defined sections of the Glasgow arterial street network

Road System	Length (2-way) Miles	Time (2-way) Minutes	Average Speeds	
			By Sections	Overall
CITY CENTRE				
Major Arterials	-	-	22.5	138.6
Minor Arterials	-	-	15.1	78.9
EXCLUDING CITY CENTRE				
Major Arterials (Radial)	-	-	233.2	684.2
Major Arterials (Circumferential)	89.8	269.4	20.0	20.2
Minor Arterials	-	-	28.2	91.5
TOTAL	-	-	388.8	1,262.6
				18.5

The most interesting characteristic of the street system as far as this present study is concerned is the maximum number of vehicles which it can be made to carry and how close the present day values are to this limit. The first question is to decide the period to which the capacity must be related. When it is said that a road has a capacity of 25,000 vehicles per day this does not imply that no more than 25,000 vehicles could be passed in a continuous stream of constant volume. The daily capacity is related to the known pattern of hourly fluctuation. It is, therefore, assumed that when the road is up to capacity it should handle the peak hours of travel under conditions of reasonable comfort. It has been shown, however, that the peak hour itself varies from day to day and from month to month. Figure 9 is a plot of the highest hours of travel for a period of 12 months at Anderston Quay, expressed as a percentage of the average week-day volume. It will be seen that no peak hour was in excess of 10 per cent. The 30th highest hour for the period was 9.4 per cent. These figures are quite close to the measurements made in American cities where it has been found that the 30th* highest hour of travel inside built up areas is of the order of 9 to 11 per cent. of the average week-day flow. On the basis of the existing data it would seem that as a general figure the capacity of the existing streets should accommodate an hourly volume equal to 10 per cent. of the average week-day volume.

* The 30th rather than the 10th or 100th highest hour is frequently chosen since, as in this case the knee of the curve occurs at this point. To design for the lower hour would save little. To design for the higher hour could in marginal cases call for a substantial increase in design widths. In most instances, the margin between the capacity assumed for design purposes and the absolute capacities obtained in practice will accommodate the 30 higher hours with a minimum of congestion.

An analogy has commonly been made between traffic flows and tidal flows. This directional distribution of traffic can have a considerable effect on capacity, particularly on roads with divided carriageways. Table 9 shows directional distribution as measured at the peak hour at a number of locations throughout the City.

Table 9
Directional distribution of traffic for various areas of Glasgow

Location	Percentage of flow in direction of predominant flow		Range of Percentages
	Morning	Evening	
North-South Screen line in City Centre	52	53	50—60
Four Clyde Bridges	68	60	50—80
Inner Cordon	63	63	51—75
Middle Cordon	66	61	52—85
Outer Cordon	63	58	52—84

It will be observed that in the centre of the City there is an approximately even flow of traffic in both directions. At the edge of the Central Area the main radials are showing some signs of directional distribution, though the average value is still only of the order of 60 per cent. in the direction of predominant flow. The effect generally continues to increase with distance from the City Centre. However, on the outer cordon secondary centres such as Paisley or Clydebank will locally reverse the predominant trend. In most cases only one or two measurements have been made. In those instances where repeated measurements were made it was observed that there was a considerable variation from day to day in addition to the wide variation between different locations. In general measured values have been used for capacity calculations on existing streets.

The composition of traffic has also a considerable bearing on road capacity. For the purposes of this survey the following simple classification has been adopted for private and commercial traffic.

LIGHT VEHICLES.—All vehicles whether goods or private having four wheels or less. (Double wheels counted as two wheels.)

HEAVY VEHICLES.—All vehicles having six wheels or more and including articulated vehicles.

This classification is close to the isolation of all goods vehicles in excess of 3 tons unladen weight.³

The capacity of a surface road with intersecting streets is controlled by the amount of interference from crossing traffic. A method has been developed by the Road Research

Laboratory⁴ for the estimation of the maximum number of vehicles which can be carried by a given intersection. This method was used to estimate the maximum capacity of some of the more important intersections in and around the City Centre. The values of capacity so obtained do not necessarily represent the prevailing conditions and are in fact usually substantially in excess of these. No reduction has been made for the additional interference with flow which is caused by bus stops, parking and delivery vehicles and minor turning movements; and pedestrian movements have been given a separate phase only at those intersections in the City Centre which are known to be points of heavy pedestrian concentration. In fact, the values might be said to be applicable were clearway regulations to be enforced and the movement of traffic given absolute priority. In all cases the design hour was assumed to equal 10 per cent. of the estimated average week-day volume (24 hours) and the phasing of the signal lights was taken as proportional to the crossing traffic flows. The relation of existing volume to capacity for various areas is discussed below.

CLYDE BRIDGES IN THE CITY CENTRE.—The north approach to the King George V Bridge is appreciably overloaded according to these calculations. The principal factor in the overload is the right turn on to the bridge from the Broomielaw. This is in accordance with measured travel times which indicate an average week-day delay on this approach of just over 4 minutes to every vehicle, with peak hour delays rising to 15 minutes.

Of the other bridges, only the approach to the Glasgow Bridge shows an appreciable reserve capacity. This is attributed to the fact that the Glasgow Bridge leads into the intersection of Jamaica and Argyle Streets for which the travel time studies indicated an average daytime delay to all traffic on all approaches of about $\frac{1}{2}$ minute. (Again this would indicate substantial delays at peak hour periods.)

WEST-EAST STREETS IN THE CITY CENTRE CROSSING HOPE STREET.—These intersections are calculated to be carrying from 60 to 85 per cent. of possible load. The range of delays on the approaches to the various junctions indicate that this reserve could only be released by a stringent application of traffic engineering improvements and in particular the elimination of waiting vehicles.

INTERSECTIONS OF CASTLE STREET WITH ALEXANDRA PARADE AND PARLIAMENTARY ROAD.—These intersections are calculated to be operating at over 90 per cent. of their maximum capacity and this would appear to be in line with the order of the delays to traffic indicated by the travel time measurements. In relation to the City Centre there is a small amount of interference from waiting and delivery vehicles.

³ The Commercial Motor—The British Commercial Vehicle Industry. This publication identifies 434 vehicle types with six wheels or more; of these, only 74 are less than 3 tons unladen weight and these are in the 2 to 3 tons unladen weight class.

⁴ Road Research Note RN/3904/FW. Traffic Signals by F. V. Webster.



RADIAL APPROACHES TO THE CITY CENTRE IN THE VICINITY OF THE INNER CORDON.—Drawing 14 shows the relation between maximum capacity on the basis discussed above and existing volumes for the radial approach roads. For the purposes of comparison the design capacity recommended by the Ministry of Transport for dual carriageway trunk roads in rural areas is also given in each case. All of the roads considered are of lower standard than the Ministry recommendations; as against this it is generally accepted that a lesser standard of driving comfort must necessarily be accepted in urban areas.

It will be observed that all but three of the radials are at present carrying volumes in excess of the Ministry standards for rural areas. All of the radials are carrying over 50 per cent. and more than half are carrying more than 70 per cent. of their maximum capacity when calculated on an optimistic basis. In the case of Paisley Road, the present daily volume is in excess of capacity when calculated on these assumptions. In practice this means that the peak hour percentage is low with traffic building up to a high but relatively constant rate throughout the day. The peak hour load is partly absorbed by parallel secondary relief routes such as Mavisbank Quay and Scotland Street. There must also be a substantial impediment to travel which discourages some peak hour travellers from the use of their cars.

These capacity calculations have led to the following conclusions:—

- (1) The area of maximum delay to traffic in the City Centre is the northern approach from the west to the King George V Bridge. This bridge is now carrying a load substantially in excess of the capacity of the approach junction.
- (2) The intersections of Alexandra Parade and Parliamentary Road with Castle Street are close to maximum load.
- (3) The remainder of the City Centre and its approaches have some reserve of capacity, part of which could be released by traffic regulations such as the strict control of waiting and delivery vehicles. In addition, the re-organisation of the use of the existing streets by the adoption of extensive one way schemes would release some further capacity in the City Centre.

2.4 Traffic Growth

The reason for the Ring Road proposals is the rapid and continuing growth of vehicular traffic in Glasgow. It is appropriate, therefore, that the nature and amount of past growth should be carefully analysed, in order to project what the future growth may be. A report was made to the Glasgow Corporation by Professor Robertson, at an early stage in these studies, which reviewed the known methods of predicting the growth of traffic on a national level and combined these into an independent prediction of national growth. It also emphasised the currently low level of car ownership in Glasgow and predicted that there

would, in consequence, be a greater than national growth in this area. The present report continues this work, with particular reference to the special conditions prevailing in heavily built up areas. Because of the order of the predicted growth, frequent reference has been made to U.S.A., where higher rates of ownership already obtain, as the best available indication of the nature of this growth, and the conditions which may be expected to develop in this country. It should not be inferred that the American figures have in any sense been used as a model nor that the many differences between the two countries have not constantly been in mind.

The analysis and the projection of past and future growth have mainly been related to vehicle registration, rather than traffic volumes. One of the principal reasons for this is the lack of statistically stable data on traffic volumes, particularly on a local basis, and the comparative wealth of data on past trends in vehicle registration. The best available comparison of traffic volumes for the Glasgow area was between 14 points measured in a census of traffic taken in August, 1954, and measurements made during the present survey. These are shown on Table 10. All figures in this table are corrected to an annual average week-day.

Table 10

Increase in traffic volumes at 14 points in Glasgow between the 1954 census and 1961. All volumes corrected to an annual average week-day (24 hours). Growth is calculated on a compound basis.

Census Point	Location	Average Week-day 1954	Average Week-day 1961	Average Yearly Growth Per cent. Compound
8139	Dumbarton Road - - -	6,370	7,400	2.2
7345	Great Western Road (outer) - - -	7,150	12,700	8.5
8133	Great Western Road (middle) - - -	13,500	22,400	7.5
8131	Maryhill Road - - -	8,060	11,600	5.3
8132	Renfield Street - - -	7,260	12,050	8.7
8140	Argyle Street - - -	8,600	17,500	10.7
8137	Springburn Road (middle) - - -	8,000	14,800	9.4
8129	Alexandra Parade - - -	14,100	21,200	6.0
8130	Cumbernauld Road - - -	5,960	8,700	5.5
8136	Duke Street - - -	8,080	12,600	6.5
8135	Gallowgate - - -	9,320	15,400	7.4
8127	London Road - - -	6,480	9,100	5.0
8125	Dalmarnock Road - - -	7,040	9,800	4.8
8128	Paisley Road - - -	13,800	29,800	11.6
TOTAL - - -		123,720	205,050	7.5

The growth varies from point to point, usually due to special conditions, such as physical improvements or the removal of tram services. The average yearly growth between 1954 and 1961 of all the stations taken together was 7.5 per cent.; this compares well with the overall growth of vehicular registration in Glasgow, which was 7.2 per cent. compound per annum for the same period, but the data is insufficient for projection purposes, and the scatter in growth stresses the dangers of predictions made on an insufficient sample.*

A reliable national index on the growth of vehicular mileage is now available in the 50-point traffic census which was established in 1956. Table 11 shows the rates of growth of vehicle mileage and vehicle registration for cars and for all vehicles during the period 1956 to 1960 for the whole of Great Britain. ^{5,6}

Table 11
Growth of vehicle registration and mileage in Great Britain (1956-1960).
Growth is calculated on a compound basis

Vehicle Type	Vehicles with Current Licences	Vehicle Mileage
Passenger Cars and Trucks	8.7%	10.0%
All Vehicles	8.0%	8.2%

The difference between these figures is marginal compared to the total changes involved. Figure 10 shows the estimated mileage by vehicle type in this country since 1939, as supplied by the Road Research Laboratory, with the equivalent levels in U.S.A.⁷ There is no discernible trend towards change in the passenger car mileage. Any fluctuations can be largely explained by control regulations. There is apparently a slight downward trend in the goods vehicle mileage but this is somewhat dependent upon the single point for 1938 and is far from well established. An interesting point is the similarity of both figures to those measured in U.S.A. Despite the high level of ownership in that country there has apparently been no diminution in the use of individual vehicles. One recent study in America⁸ has indicated that these figures also apply to families owning more than one car.

The conclusion is drawn that increase in vehicle registration is a good measure of overall increase in travel. This conclusion must be restricted locally in areas where congestion is allowed to stifle traffic growth or where regulation is adopted to control it. The best example of this is in the centre of large cities and here the growth in travel is generally expected to be less than in the rest of the city, as discussed in Section 2.5 of this report.

Figure 11 shows the growth in the registration of passenger cars per capita in Glasgow and Great Britain. The Glasgow per capita ownership is approximately half of the average for the country. The present overall per capita ownership level in U.S.A. is 334 cars per 1000 persons (about 1 car for every family) or over 7 times the Glasgow level. The registration of passenger cars has increased in Glasgow at the rate of 111 per cent. compound over the last 9 years. If this growth were to continue for a further 118 years, the ownership level would have increased over seven times and would by then just have reached the current level in U.S.A. The purpose of these figures is to emphasise the very rapid current rate of increase, and the fact that quite startling further increases can be envisaged without exceeding levels already experienced elsewhere.

The development of the modern city has been such that in almost all cases there are contiguous urbanised areas located beyond the administrative boundary of the central parent city and quite distinct in character from the city itself. For this reason a careful distinction must be made between the city and the wider area. In the United Kingdom the parent city is in most cases the administrative area to which data on vehicle registration are related. The data which have been quoted for Glasgow refer to the County of the City of Glasgow. In terms of overall traffic growth it is finally necessary to deal with the Study Area as previously defined. However, most of the following arguments are based upon city statistics and the necessary modifications to include contiguous towns and suburban areas are made at the end of this section. Some American data is also quoted; in contrast to the British figures this is frequently related to the county containing the city which usually covers the major part of the contiguous urbanised areas. The data used to develop statistical correlations for the British cities is shown in Table 12 and 13.

* It will be observed on Figure 8 that the growth of traffic at two of the 50-point counter locations was 4 per cent. from October 1960 to October 1961. However, for the above reasons this is not considered that this figure could be accepted as a reliable index for the study area.

⁵ Ministry of Transport. Road Motor Vehicles: 1960 and 1956.

⁶ Road Research Note RND/3977/IRS. 50 Point Traffic Census. Results for 1960 by J.R. Scott.

⁷ Automobile Manufacturers Association. Automobile Facts and Figures. Page 43.

⁸ Report on Chicago Area Transportation Study. Volume II, Page 75.

⁹ As shown by Figure 16 the rate of growth of per capita car ownership in Glasgow is greater than the national average. However, because of the relative stages of growth the lower rate still produces a greater yearly absolute increase in the national figure.

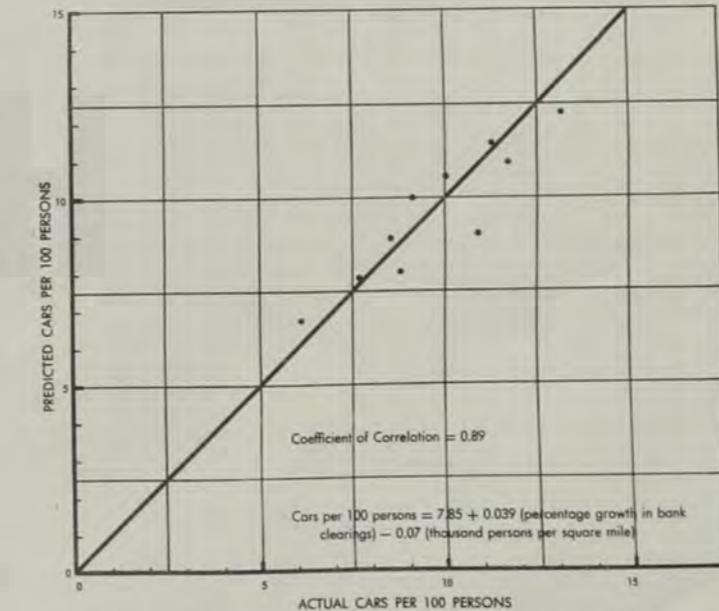
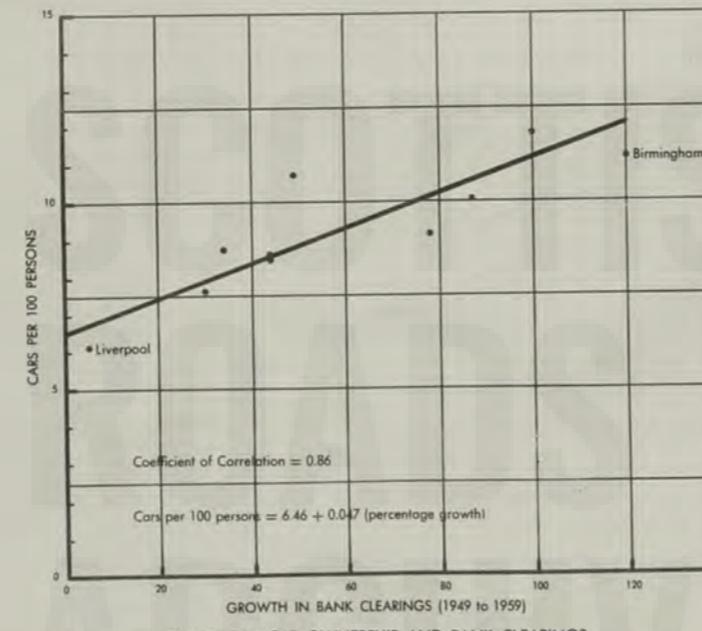
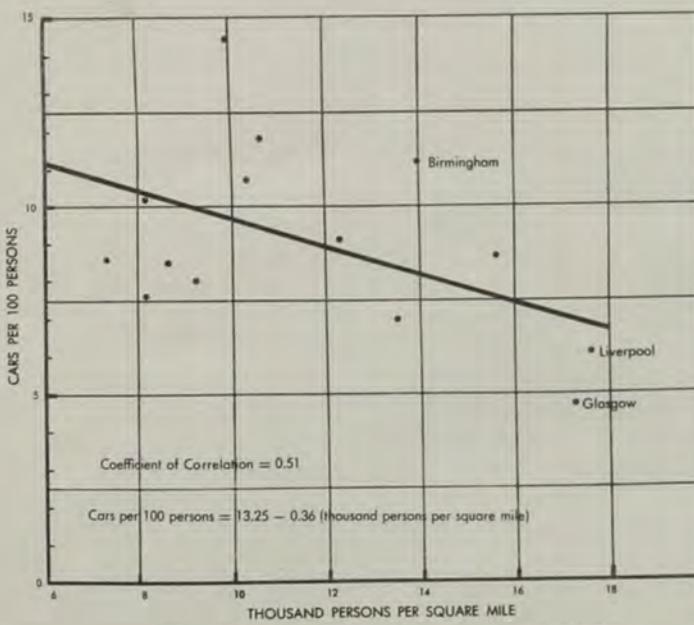
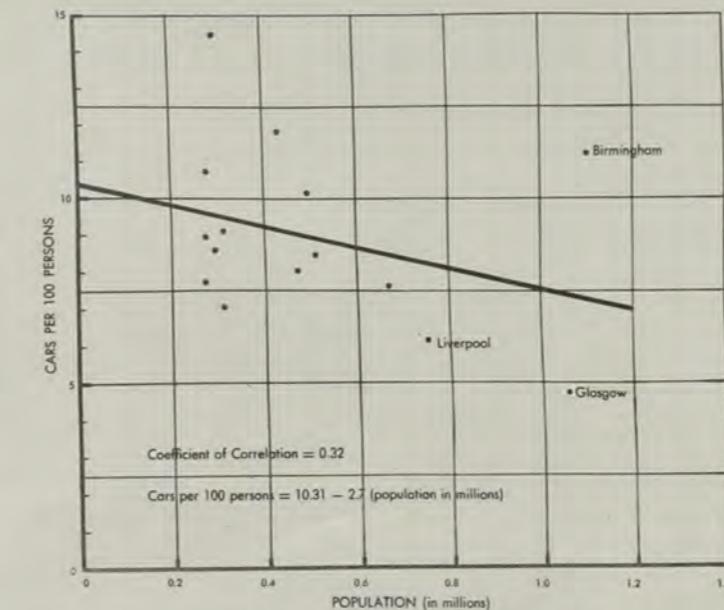
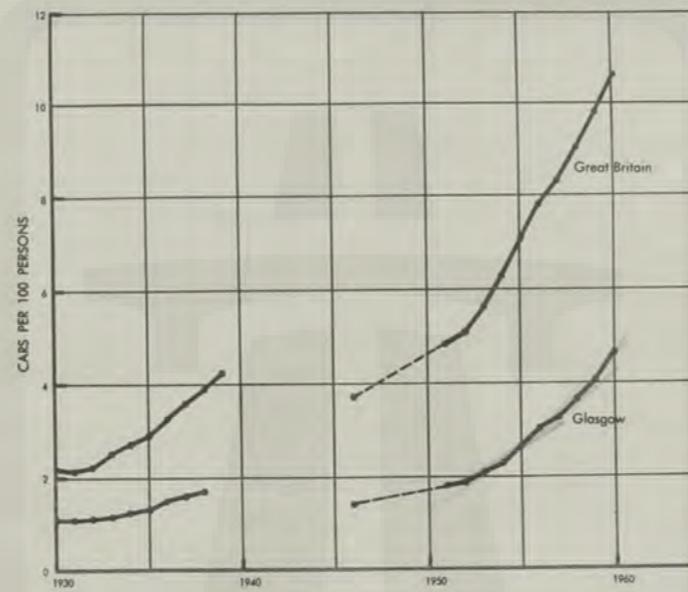
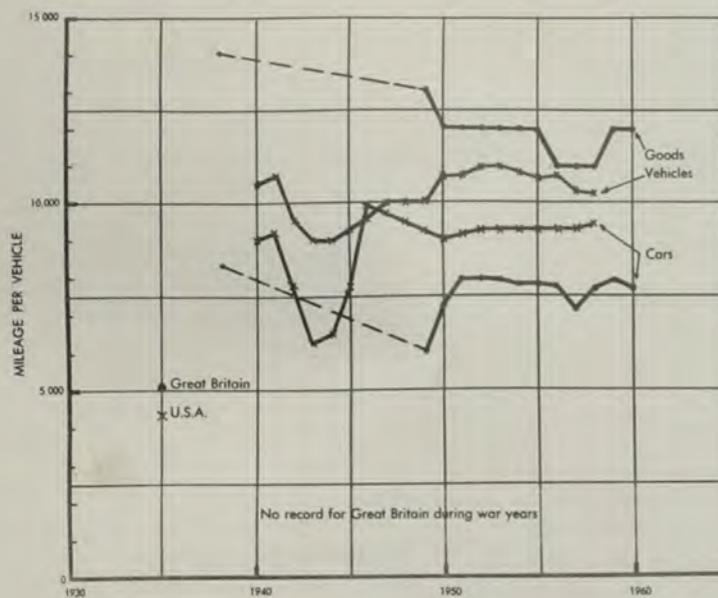


Table 12

Passenger car and goods vehicle data for 15 British cities
Source: Ministry of Transport. Road Motor Vehicles 1956-1960

City	Passenger Cars/100 persons 1960	Compound per cent. Growth in Per Capita Car Ownership 1956-1960	Registered Goods Vehicles as Percentage of Registered Cars
Bristol	11.8	8.1	28
Liverpool	6.1	10.8	38
Manchester	7.7	10.3	44
Leicester	10.7	9.1	34
Newcastle	8.7	9.5	40
Nottingham	9.1	8.9	33
Stoke	7.7	8.9	40
Birmingham	11.2	8.3	29
Coventry	14.4	8.3	16
Bradford	8.6	8.8	36
Kingston	7.0	9.8	40
Leeds	8.4	10.0	32
Sheffield	10.1	9.0	32
Glasgow	4.7	12.1	44
Edinburgh	8.0	11.3	27

The experience in America is that large cities have a lower per capita ownership rate than the national average,⁷ although the remainder of the conurbation is at or above the national average. The average ownership of passenger cars in the 15 British cities shown in Table 12 is 85 per cent. of the national average. Figure 12 shows that within this group of cities there is a very loose correlation between car ownership and population. An improved relationship is found by a correlation of car ownership on population density as shown on Figure 13. These variables are not completely independent. There is a loose positive correlation between population and population density. It cannot be concluded that the relationships are necessarily by way of cause and effect. It is probable for instance, that within cities a negative correlation could be established between population density and income level. Nevertheless, it is to some extent possible to rationalise a cause and effect relationship between low car ownership and densely populated cities in which much of the daily activity is within walking distance, and a high level of public transport is maintained.

Table 13

Population and economic data from 15 British Cities
Source: Central Statistical Office—Annual Abstract of Statistics (1960)

City	Population	Population Density persons per square mile	Percentage Growth in Bank Clearings 1949 to 1959
Bristol	437,000	10,600	100
Liverpool	753,000	17,600	5
Manchester	667,000	15,650	30
Leicester	274,000	10,300	49
Newcastle	270,000	15,600	34
Nottingham	312,000	12,300	78
Stoke	268,000	8,200	—
Birmingham	1,100,000	13,950	120
Coventry	295,000	9,900	—
Bradford	292,000	7,300	44
Kingston	303,000	13,500	—
Leeds	512,000	8,600	44
Sheffield	496,000	8,100	87
Glasgow	1,057,000	17,250	—
Edinburgh	469,000	9,200	—

It would be reasonable to expect that income level is a major factor in car ownership. Unfortunately, no completely appropriate measures of income were available for the cities under discussion. One loose measure which might be expected to correlate fairly closely with present income level is the increase in bank clearings over the past 10 years. Figure 14 shows a correlation of car ownership with the growth in bank clearings for the ten cities for which this information was available. There is a good positive correlation. A multiple correlation of car ownership on both bank clearings and population density is shown on Figure 15. This gives a further improvement in the level of correlation.

These figures indicate that income level, and some factor or factors which correlate with the high population density associated with large cities will in themselves go far to explain the wide variations in car ownership levels for these cities. Certain of these factors may persist, others may not.

⁷ Automobile Manufacturers Association. Automobile Facts and Figures. Page 34.

The difference due solely to income level will probably not persist. The reason for this statement is illustrated by the following calculations, which are admittedly over-simplified. Table 14 is based upon the net income before tax in the three counties of Lanark, Renfrew, and Dunbarton* and in the United Kingdom as a whole as reported by the Commissioners of Inland Revenue for the financial year 1953-1954.

Table 14
Net income before tax for the financial year 1953 to 1954 for the three counties of Lanark, Renfrew and Dunbarton and for the United Kingdom

Salary £	Percentage receiving more than a given income		Percentage relation of the three counties to the United Kingdom
	Lanark, Renfrew Dunbarton	United Kingdom	
400	57.4	59.3	103
600	23.6	27.5	116.5
800	8.6	11.6	135
1,000	4.5	6.0	133

Suppose that the level of income which permitted the purchase of a car was then £800 per year. This means that 8.6 per cent. of the persons receiving incomes in the three counties and 11.6 per cent. of the persons receiving incomes in the United Kingdom as a whole were in a position to purchase a car. This would account for a 35 per cent.† higher ownership in the United Kingdom than in the three counties. However, if the income distributions maintain their relative proportion but steadily increase then at the level equivalent to £600 per year income alone would only account for a 16 per cent. difference, and at the level equivalent to £400 per year to only a 3 per cent. difference from the national per capita car ownership. The conclusion reached from this data is that the lower level of per capita ownership in Glasgow will not persist in so far as it is due solely to difference in income level and that therefore a faster rate of growth in ownership than the national average should be anticipated for Glasgow. There is some evidence that this is already taking place. The per capita car ownership in Glasgow has been increasing at a compound rate of 11 per cent. as compared to the national average of 9 per cent. over the period 1951 to 1961.‡ This same trend is shown on Figure 16.

The American figures on below average car ownership in large cities indicate that there may also be a persistent factor. Figure 17 has indicated that this is apparently the case. In the figure the compound percentage growth per year for the period 1956 to 1960 for six British cities is plotted against the current level of car ownership. A figure was also available for Chicago and this indicated that this American city was in line with the British data.§ The implication of Figure 17 is that at the level of 26 cars per 100 persons there will be no further growth in the ownership of passenger cars. This method of predicting the saturation level

of vehicle ownership was suggested by J. C. Tanner,⁹ and the most recent available prediction of the national saturation level is 37 passenger cars per 100 persons.¹⁰ It is concluded that it is reasonable to expect that the saturation level of car ownership in the densely developed areas of large cities will be lower than the national average during the foreseeable future and that the best available estimate of saturation level for Glasgow is 26 cars per 100 persons.

Tanner has also suggested a method for predicting the rate at which this growth may develop. This assumes that the current rate of increase will gradually decrease; very slowly at first and then more rapidly as the saturation level is approached. This curve would not exactly correspond to a model postulated on the basis of the current net income distribution which would require an increasing rate of growth in the early stages of rapid growth. However, since such a model would in itself represent an over simplification and since the assumption of a steady decrease in growth is on the low side, it was decided to adopt the Tanner Method. Again on the low side the current rate of increase was assumed to be 10 per cent. which is 1 per cent. lower than the average growth in Glasgow for the period 1956 to 1960. These assumptions result in the curve shown on Figure 18 which predicts a fourfold increase in per capita car ownership by 1980 and a fivefold increase by 1990.

Two other vehicle types are of current importance to road traffic. These are goods vehicles and motor cycles including motor scooters. Motor cycles have always played a lesser part in Glasgow than nationally, even after due allowance has been made for the generally lower levels of vehicle ownership. This does not appear to associate with any of the other variables such as car ownership, population and population density. It is possible that a high relative use of motor cycles when compared to motor cars associates principally with the milder climate of the South of England. Figure 19 shows the percentage relation between motor cycles and passenger cars in Glasgow since 1930. The recent increases are believed to be due to the introduction of the motor scooter and appear to have reached their peak. It is considered that if car ownership reaches the very high levels discussed in the last paragraph, motor cycles, at least in Glasgow, will be of small relative importance. This would be in agreement with the conditions prevailing in U.S.A. In order to establish an estimate of the percentage relationship in 1980 and in 1990 the recent trend 1954-1960 was projected to give the figures used in Table 15.

* No equivalent data was available for Glasgow.

† In fact the national average was twice that of the three Counties at this time.

‡ There is one chance in 10 that this difference was purely fortuitous.

§ It is not suggested that the almost exact agreement is anything more than coincidental.

§ Report on Chicago Area Transportation Study. Volume II, Table 39.

¶ Road Research Note RN/3340/JCT. An analysis of increases in motor vehicles in Great Britain and the United States by J. C. Tanner.

|| Road Research Note RN/3989/JCT. Preliminary estimates of the future car population of Great Britain by J. C. Tanner.

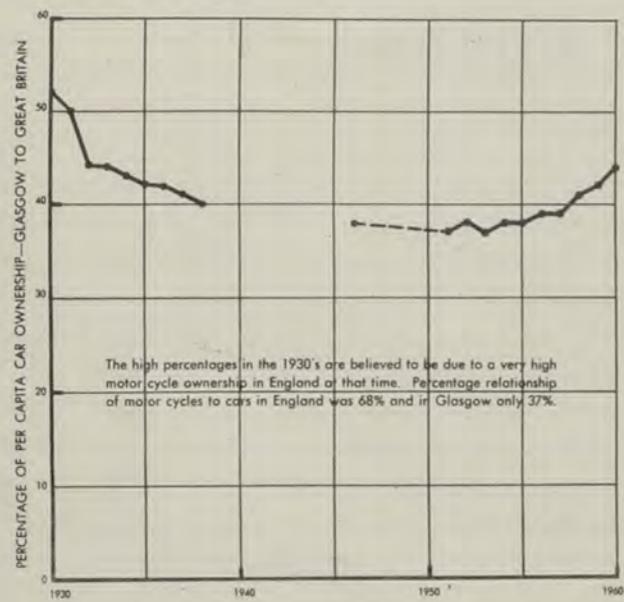


FIGURE 16.—PERCENTAGE RELATION OF CAR OWNERSHIP IN GLASGOW AND GREAT BRITAIN

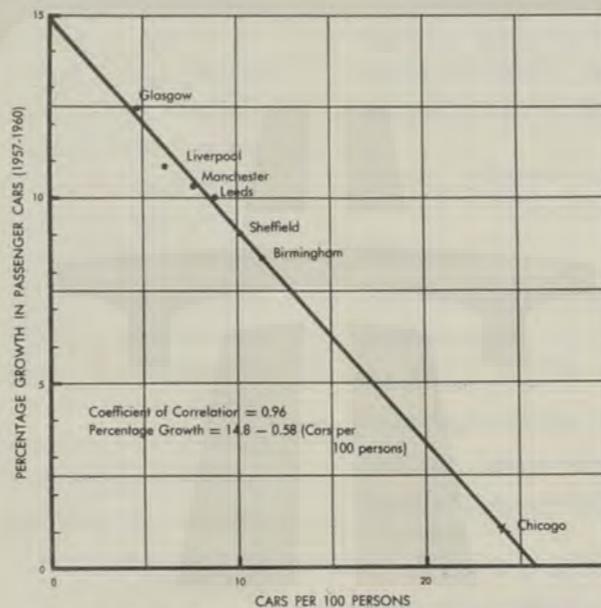


FIGURE 17.—DECLINE IN GROWTH OF PASSENGER CARS WITH INCREASING OWNERSHIP

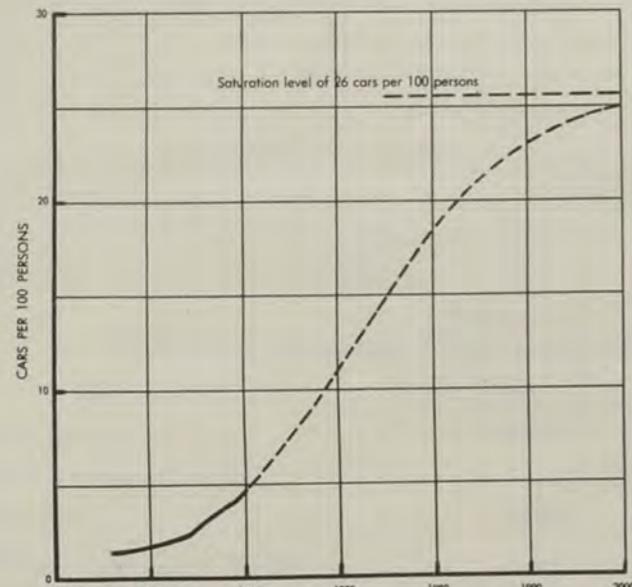


FIGURE 18.—PREDICTED CAR OWNERSHIP FOR GLASGOW

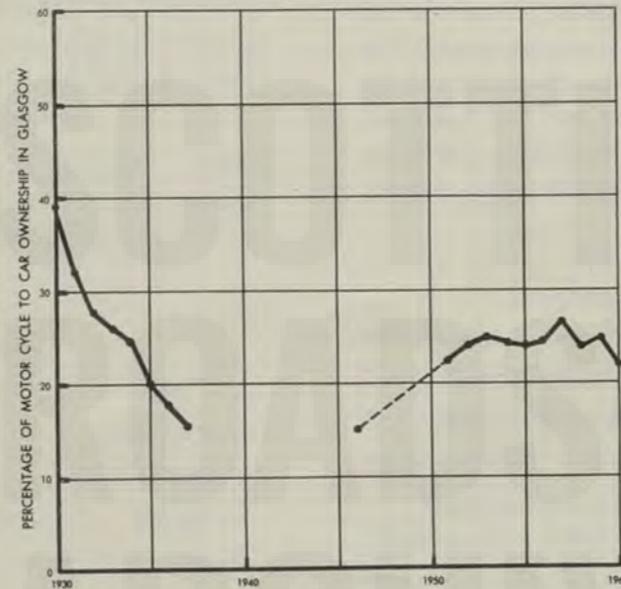


FIGURE 19.—PERCENTAGE RELATION OF MOTOR CYCLE TO CAR OWNERSHIP IN GLASGOW

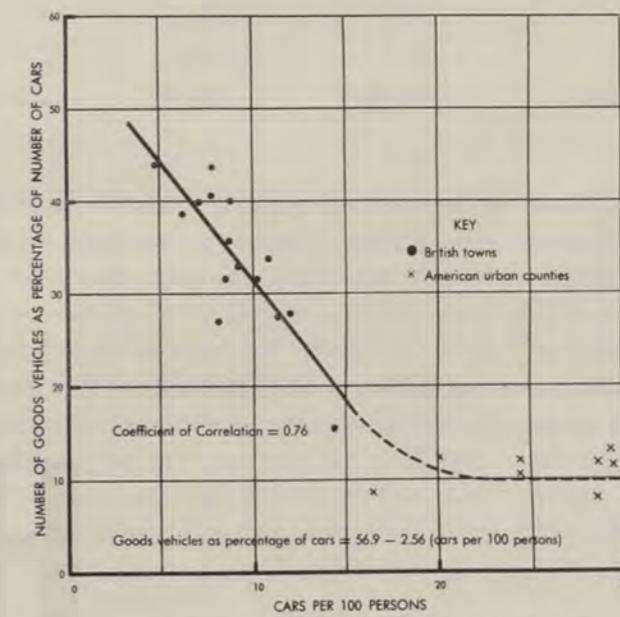


FIGURE 20.—PERCENTAGE RELATION OF GOODS VEHICLES TO PASSENGER CARS IN CITIES

212,000	212	892,000	205,000	205,000
211,000	211	572,000	205,000	205,000
237	237	572,000	205,000	205,000
30	30	1,424,000	405,000	275

A very definite association was found between the percentage relation of goods vehicles to passenger cars and the ownership of passenger cars. This relationship is shown on Figure 20 which is based upon data given in Table 12. Although there is quite a high degree of linear correlation it is obvious that this cannot be extrapolated without reaching absurdly low levels. Again reference was made to American experience⁷ which indicated an average relation of about 10 per cent. in the older cities which are most comparable to our conditions. These figures are not completely comparable since the American data in general refers to an area rather larger than the city and including some, if not all of the associated suburban areas. However, it is considered that the relationship is sufficiently well marked to justify modifying the regression line at high car ownership levels by the hand fitted curve shown on Figure 20. This curve would indicate quite a modest future increase in the per capita ownership of goods vehicles and it would be inferred that the present rate of increase should be quite low. In fact the per capita increase in goods vehicles over the period 1951-1960 has been only 3 per cent. in Glasgow and there was a 1 per cent. decrease from 1959-1960. These figures compare with an increase in passenger cars in Glasgow for the same periods of 11 per cent. and 13.6 per cent. It is concluded that the hand fitted curve shown on Figure 20 will form a reasonable basis for determining the future levels of goods vehicle ownership.

At this stage a per capita growth in passenger cars and the percentage relation of motor cycle and goods vehicle ownership to this figure have been decided. During the period of the projection it is anticipated that the population level in Glasgow will drop from 1,072,000 to 892,000. Table 15 combines all these factors to indicate the probable relation of the present registration level and those for 1980 and 1990 (which is only slightly lower than predicted saturation). This estimate refers only to the City of Glasgow.

It has already been pointed out that the growth of traffic volumes in Glasgow is related to the whole Study Area as defined on Drawing 2. It was nevertheless necessary to develop the predictions of Table 15 on the basis of registrations within Glasgow, because of the form in which relevant data is available.

Table 15 Summary of predictions of future vehicle ownership for Glasgow			
Characteristics	1960	1980	1990
Population	1,072,000	892,000	892,000
Car Ownership per 100 Persons	4.6	18.4	23.0
All Cars	49,400	164,000	205,000
Percentage of Motor Cycles to Cars	22%	10%	5%
Percentage of Goods Vehicles to Cars	44%	11.5%	10%
Total Cars, Motor Cycles and Goods Vehicles	82,000	189,000	236,000
Predicted Growth in Registration in Glasgow	1	2.3	2.9

Before drawing any conclusions as to the future growth of traffic it is now proposed to examine the surrounding areas which complete the Study Area. Table 16 shows the existing levels of vehicle ownership in these surrounding areas. This data was developed from a sample survey of the registration lists of adjoining counties.

Table 16
Summary of predictions of future vehicle ownership for areas surrounding Glasgow

Characteristics	1960	1980	1990
Population	424,500	572,800	572,800
Car Ownership per 100 Persons	8.9	31.0	35.0
Number of Cars	37,800	178,000	200,000
Percentage of Goods Vehicles to Cars	16.2	8.0	8.0
Percentage of Motor Cycles to Cars	21.2	5.0	5.0
Total Cars, Goods Vehicles and Motor Cycles	51,900	201,000	226,000
Predicted Growth in Registration in Surrounding Areas	1	3.9	4.4

It is not possible to develop data on the current rate of increase of car ownership, and hence the probable saturation level for these areas. Tanner's figure for a national saturation of 37 cars per 100 persons has, therefore, been adopted, and the future levels of car ownership derived from this. The current figure for the comparable areas of Chicago is 40 cars per 100 persons with a prediction of 43 cars per 100 persons for 1980. The percentage of commercial vehicles is now lower, and would always be expected to remain lower than in Glasgow because of the predominantly residential character of much of the surrounding areas. It has, therefore, been empirically set at 8 per cent. for 1980 and 1990. Again it is predicted that the use of the motor cycle will be nominal at the predicted rates of car ownership and an empirical value of 5 per cent. has been adopted. Table 17 combines the predictions for the Study Area.

Table 17
Summary of predictions of future vehicle ownership for Study Area

Characteristics	1960	1980	1990
Total Vehicles in City of Glasgow	82,000	189,000	236,000
Total Vehicles in Surrounding Area	51,900	201,000	226,000
Total Vehicles in Study Area	133,900	390,000	462,000
Predicted Growth in Registration in Study Area	1.0	2.9	3.4

These predictions would result in a growth of vehicular registration of 2.9 times the 1960 level in 1980 and 3.4 times the 1960 level in 1990. In accordance with the basic assumption the growth of traffic volumes in the Study Area will be closely of the same order, and for the Ring Road studies described in this report, an increase of three times the current level has been adopted for traffic other than traffic to the Central Area.

⁷ Automobile Manufacturers Association. Automobile Facts and Figures. Pages 22, 23.

2.5 City Centre and Public Transport

In the discussion of the overall growth of traffic in Glasgow a reservation was made relative to the City Centre. Experience in this country has shown that the congestion which develops with increasing traffic growth has inhibited the growth of traffic in central cities.¹¹ It is anticipated that this restricted growth will persist despite the improvement in access which will result from the construction of high capacity relief routes such as the Glasgow Inner Ring Road. Table 18^{8,12,13} compares some relevant data for Glasgow, Chicago and Cleveland.

Table 18
A comparison of the relation between amount of travel and vehicle ownership levels for Glasgow and two American cities

CITY	Characteristics	Glasgow	Cleveland	Chicago
Population	- - - - -	1,080,000	930,000	3,600,000
Land Area—Sq. Miles	- - - - -	62	56	206
Persons/Sq. mile	- - - - -	17,400	16,600	17,600
Cars and Motor Cycles/100 persons	- - - - -	5.6	28.0	24.2
Commercial Vehicles/100 persons	- - - - -	1.9	2.1	2.5
Relation of Vehicle Ownership to Glasgow				
Vehicle Ownership	- - - - -	1.0	4.0	3.5
Vehicle Destinations/100 persons	- - - - -	30	111	100
Relation of Vehicle Destinations to Glasgow				
Vehicle Destinations	- - - - -	1.0	3.7	3.3
CITY CENTRE				
Area so defined in sq. miles	- - - - -	1.2	1.0	1.2
Total Floor Area (Sq. Ft.)	- - - - -	55,000,000	Not known	92,000,000
Total Week-day Vehicle Destinations	- - - - -	64,000	112,000	144,000
Relation of Vehicle Destinations to Glasgow				
Vehicle Destinations	- - - - -	1.0	1.7	2.2

In both American cities some high capacity expressways passed through the fringes of the central area though the full expressway system was not complete.^{8,13} Despite a rate of vehicle ownership and trip making some three to four times higher than in Glasgow, the number of trips to the centre of the American cities is just over twice those made to the Glasgow City Centre. In the case of Chicago this is more emphasised by the very much greater floor area in active use. It would appear that the slower growth of vehicular traffic to the City Centre has continued in these American cities despite the very high levels of car ownership and the provision of high capacity relief routes. This is to be expected. There are no destinations on motorways. Eventually the traffic must leave the motorway and find its destination over surface streets. Therefore, the accommodation of the overall traffic

growth in the City Centre would require not merely the provision of relief routes but the redevelopment of the entire City Centre at a much lower density.* It is generally agreed in this country that it is neither feasible nor desirable to do this.

The reciprocal of these arguments is that there will always be a suppressed demand for travel by car to the centre of large cities. If no better means are found the traffic will increase until the street congestion acts as the control. The development of such congestion is intolerable. A more acceptable means of control would be based upon the level of parking provision and parking charges. It can be seen that in theory the entry to the City Centre could be closely controlled at the desired level by adjustment of the amount of and charge for parking accommodation, if alternative routes are provided for the through traffic. At the same time the prosperity of the City Centre is dependent upon providing the maximum feasible access by every means of transport. Table 18 shows that at least two large American cities are accommodating more than twice the number of vehicular trips than the equivalent area of Glasgow. This has not been achieved by increasing the street area. The respective amounts of the central square mile used for streets in Glasgow^{12*} and Chicago^{8*} are 31 per cent. and 29 per cent. It has resulted firstly from the removal of through traffic by expressways fringing the Central Area, and secondly by the removal of parked cars from the streets. Table 19 compares parking data from Glasgow and two large American cities.¹⁴

Table 19
A comparison of parking data from two American Cities with estimated figures for Glasgow

	Characteristics	Glasgow	Average of two American Cities
Conurbation Population	- - - - -	1,500,000	1,300,000
Central Area (Sq. Miles)	- - - - -	1.2	1.0
Total Parking Spaces	- - - - -	9,000	23,000
On Street	- - - - -	Over 8,000	3,300
In Car Parks	- - - - -	Under 1,000	14,800
In Garages	- - - - -	Negligible	5,500

¹¹ Report of the Road Research Board for 1960—Table 3.

⁸ Report on the Chicago Area Transportation Study. Volumes I and II. ^{8*} Volume I. Table 21.

¹² The Glasgow Development Plan Quinquennial Review 1960. The Survey Report. ^{12*} Chapter 11, Page 2.

¹³ Comprehensive Arterial Highway Plan Cuyahoga County, Ohio.

* It is not, however, suggested that there will be no further growth whatsoever in vehicular entry but merely that such growth is likely to be somewhat less than the overall traffic growth in the Study Area.

¹⁴ Eno Foundation for Highway Traffic Control—Parking.

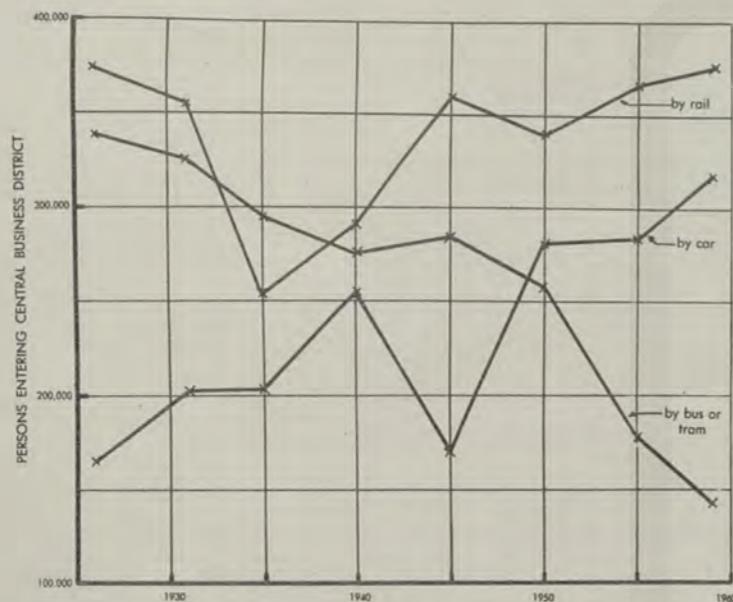


FIGURE 21.—METHODS OF ENTRY TO CHICAGO CENTRAL BUSINESS DISTRICT

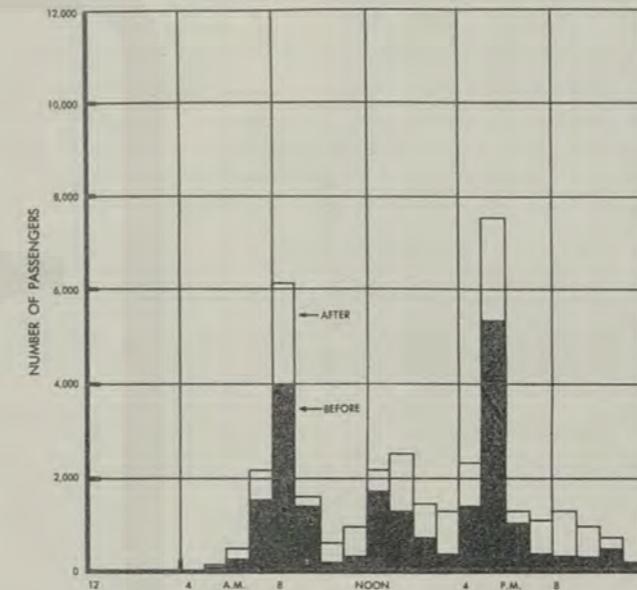


FIGURE 22.—PASSENGERS THROUGH QUEEN STREET LOW-LEVEL STATION BEFORE AND AFTER ELECTRIFICATION

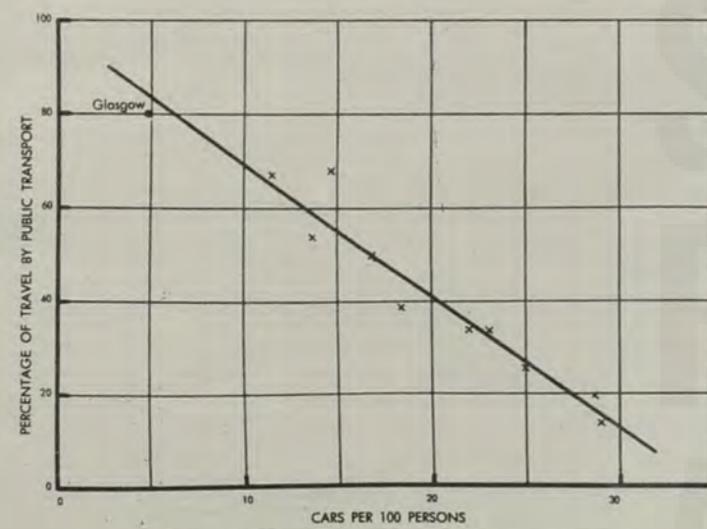


FIGURE 23.—CAR OWNERSHIP AND PERCENTAGE OF TRAVEL BY PUBLIC TRANSPORT

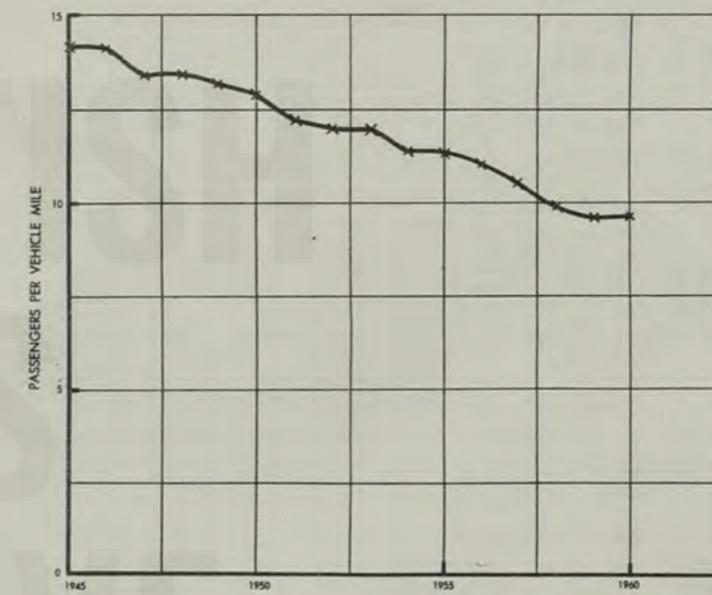
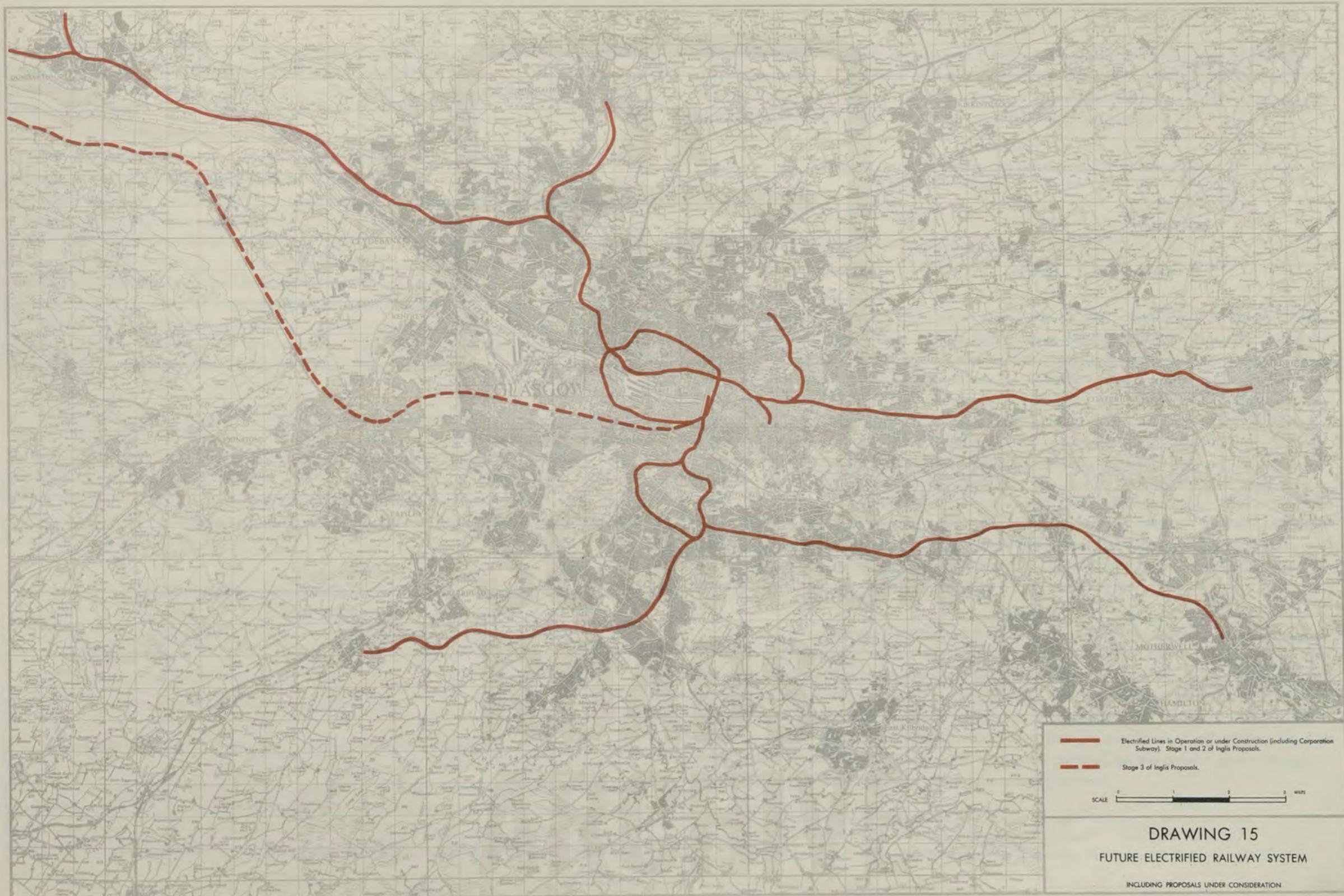


FIGURE 24.—DECLINE IN USE OF GLASGOW CORPORATION PUBLIC TRANSPORT, 1945 to 1960



Over 90 per cent. of all parking spaces are on the streets in Glasgow whereas under 15 per cent. of parking space is on the streets of the American cities. Further, the on-the-street parking in the American cities is mostly controlled by parking meters and reserved for short term parkers.

It is concluded that it is not practical to attempt to accommodate the extent of growth which is likely to occur on a city-wide basis in the City Centre. It will, therefore, be desirable to control vehicular entry to the City Centre below the level which would congest the downtown streets, and it is suggested that the level of the provision of parking accommodation and the scale of parking charges would be a possible means of control. Within the limits of the development of congestion it is considered essential to provide a maximum of access. A comparison of Glasgow with two American cities indicates that with the curtailment of street parking and the provision of relief roads an increase of double the present vehicular entry to the Central Area could reasonably be accommodated without significantly altering the existing downtown street system. It is, therefore, proposed that the Ring Road be designed to accommodate approximately twice the present level of vehicular entry to the City Centre.

It follows from these conclusions that since the private motor vehicle is, in the future, to carry a lesser proportion of people travelling to and from the City Centre than of people travelling elsewhere in the city, public transport must carry a greater proportion.* This is strikingly so in the case of Chicago. Table 20 shows that whereas in the whole of the Chicago conurbation the private motor vehicle predominates, travel to the centre square mile is predominantly by public transport, and during the morning rush hour overwhelmingly by public transport.⁸

Table 20

A comparison of the percentage of person travel by public transport in Glasgow and Chicago

Characteristics	City of Glasgow	City of Chicago
City Wide	80%	32%
To Central Square Mile	—	71%
To Central Square Mile at Rush Hour	93%	87%

A survey by Glasgow Corporation indicated that only 7 per cent. of the City Centre workers in Glasgow travel by car. On the surface this indicated a vast possible growth in motor traffic to the City Centre. In the face of the Chicago figures this does not seem so unavoidable. Both Cleveland and Chicago were served by fast suburban railways and both had plans to extend these services. In the case of Chicago data was given on the comparative importance of the various forms of public transport. Buses provided 70 per

cent. of the public transport service over the area as a whole, but to the central square mile railways provided 65 per cent. of the daily service. In both Cleveland¹³ and Chicago^{8*} rail lines both present and proposed were focused on the Central Area. Table 21 compares present and proposed rapid rail services in Cleveland¹³ and Glasgow.

Table 21

A comparison of the existing and proposed electrified rail services in Glasgow and Cleveland

Characteristics	Glasgow Study Area	Cleveland Conurbation
Existing or under construction	53 miles	22 miles
Proposed	8 miles	35 miles

The Glasgow data is taken from the Inglis Report. The first two stages of the electrification proposals made in that report have already been implemented and it is presumed that the final stage is still under consideration. The comparison of Cleveland and Glasgow is reasonably valid since both cities are similar in size and density of development. Rapid rail services in Glasgow are mostly provided by the electrification of the existing suburban railway lines. The location of both existing and proposed future services by electrified railway are shown on Drawing 15. It will be seen that the Glasgow proposals compare very favourably with those of the American city. Figure 21^{8†} shows the number of persons entering the Central Business District of Chicago by method of travel from 1926 to date. The rail lines have held their proportion of travel while the gain in car travel has been offset by the loss in bus travel. Figure 22 shows the increase in the number of passengers handled by Queen Street low level station on an average week-day, before and after electrification of the service, based on data supplied by British Railways. The pull of a rapid public transport service of this type is very evident.

It is considered that the restriction of the growth of motor traffic which has been postulated for the City Centre requires the maintenance of a high level of public transport service to this area. Further, it is to be expected that the emphasis in the method of public transport to this area will tend to move from road to rail. The increasing importance of rail travel will be accentuated by the outward movement of the population to low density suburban areas. It will be apparent in these circumstances that the provision of an efficient level of public transport service in Glasgow will be greatly assisted by the careful co-ordination of the service provided by the several public bodies concerned.

* It is, however, anticipated that travel by public transport will in all cases decrease in absolute importance.

⁸ Report on the Chicago Area Transportation Study. Volume II, Table 17. ^{8†} Map 23. ^{8†} Table 44.

¹³ Comprehensive Arterial Highway Plan for Cuyahoga County, Ohio. Plate 12.

The postulated increase in car ownership may be expected to have a very severe effect on the number of passengers carried by public transport throughout Glasgow. There are a large number of factors which have a bearing on the use of public transport but there is little doubt that the primary factor is car ownership. Figure 23 shows the relation between car ownership and the use of public transport as measured at various times during the last decade in a number of American cities.¹⁵ The city-wide figure for Glasgow is estimated from information supplied by the Corporation Transport Department and British Railways. It will be observed that the Glasgow data is in very reasonable agreement with that of the American cities. On the basis of this relationship it might be expected that the percentage use of public transport in Glasgow will fall to under half its present level by 1990 when the saturation ownership level of 26 cars per 100 people is almost reached.

Further American experience has been that the increase in total travel by all means of transport is much smaller than the increase in car ownership.^{15*} That is, most of the increase in car travel is diverted from public transport. Table 22 shows the amount of travel by different means within the cities of Glasgow and Chicago.⁸

Table 22
A comparison of the number of trips ending in the cities of Glasgow and Chicago by method of travel on an average week-day

Characteristics	Glasgow	Chicago
Population	1,080,000	3,600,000
By Bus or Tram	1,600,000	1,500,000
By Rail	200,000	600,000
By Car or Goods Vehicle	500,000	4,500,000
Destinations per Person	2.15	1.85

The data on public transport for Glasgow are only estimated in the case of railways and the regional bus services. Accurate data was available only for Corporation Transport Services and private vehicular travel. However, the figures are sufficiently accurate to indicate the range of values involved, and to confirm that any increase in total person travel is unlikely to offset the anticipated reductions in travel by public transport.

The great attraction of the motor car is its personal convenience. In an attempt to define this convenience travel contours to and from the Central Area have been drawn for all forms of public transport on Drawing 16 and for the motor car on Drawing 17. In order to obtain the travel times by public transport an empirical allowance was made for travel

between origin, destination and the public service including the frequency of service and the calculated walking time. In both cases the contours are meant to represent the average time of travel on an ordinary week-day from the edges of the area marked on both drawings which roughly enclose the three main central rail stations. The principal value of these figures is for comparative purposes and the absolute values can only be taken as a general indication of a particular travel time. A comparison of the two drawings emphasises the speed and convenience of the motor car. It will be apparent that the difficulties inherent in crosstown travel by public transport will give an even greater balance of advantage to the private car for crosstown travel. The only form of public transport which approaches the speed of the private car is the electrified train service, and in particular the electrified train service to the Central Area at the peak periods of travel. It will also be observed that the advantage of this service is quickly dissipated by distance from the station, and the effect is to produce a bubble of reduced journey times centred around the railway stations.

The peculiar advantage of public transport by rail is the complete segregation from other forms of transport. The further the distance travelled the greater is likely to be the drawing power of a rail service. It has, therefore, been argued that the outward movement of population will accentuate the relative importance of rail as compared to bus travel. It follows from this and from the other data discussed that public bus services are likely to continue to lose passengers at a rate which will be at least as serious as the recent loss of passengers per vehicle mile* of service illustrated for the Glasgow Corporation services on Figure 24. The data on which this was based was supplied by the Corporation Transport Department.

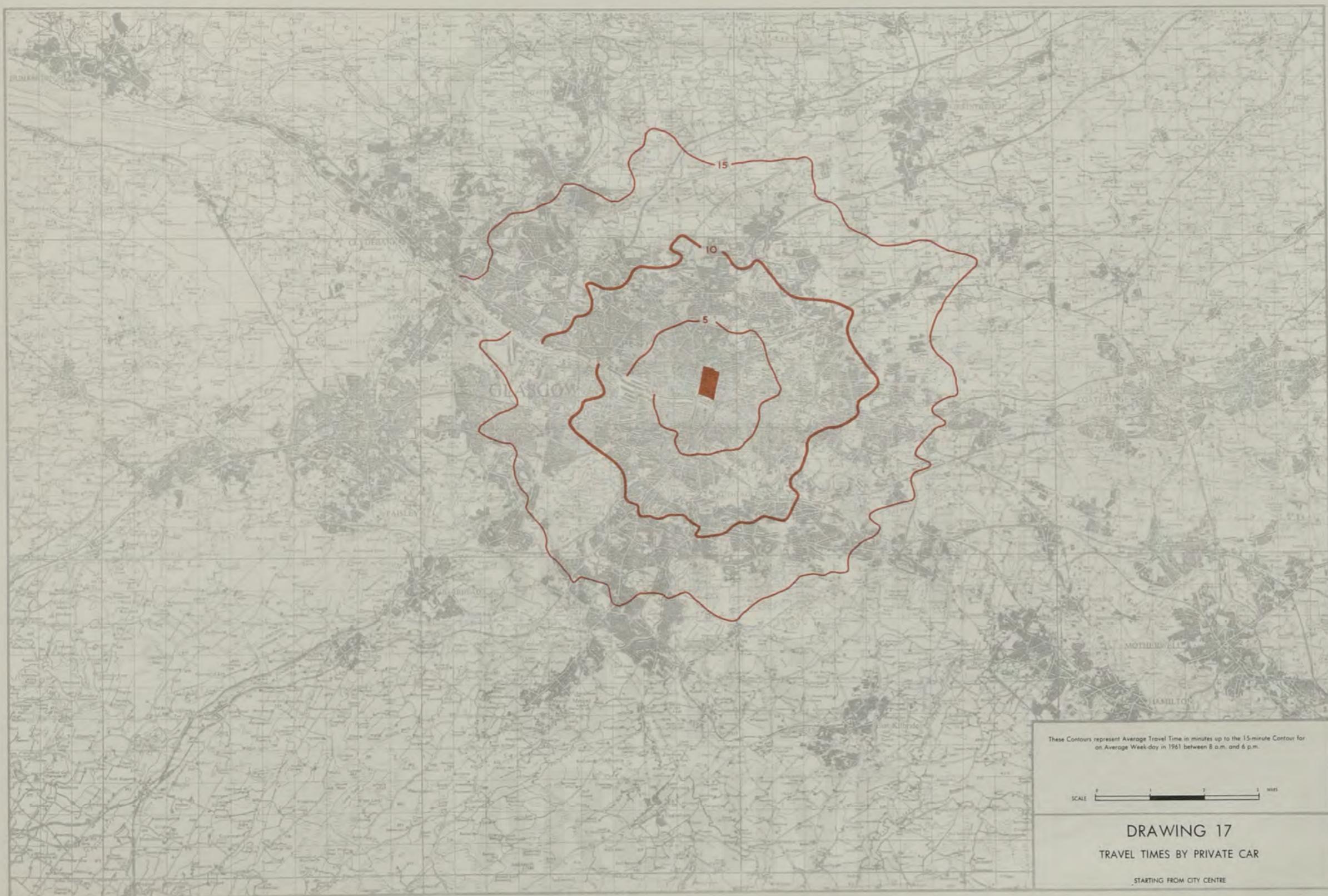
This report is primarily concerned with road proposals. The data on public transport and parking is, therefore, extremely general. The inevitable impact of one form of transport on another has enforced the general studies which are reported here. The importance of the conclusions which have been drawn in respect to parking and public transport lead to the recommendation that both these matters require exhaustive and detailed studies. Such studies should cover the origin and purpose of parkers in the Central Area, as well as the amount and time of parking, and in the case of public transport should cover the current level of travel by each service, the present origin destination patterns and the manner in which these are likely to be affected by the predicted population movements. These studies should be regarded as an essential preliminary to the framing of adequate policies relative to parking accommodation and public transport.

¹⁵ Curran and Stegmaier. Travel Patterns in 50 cities. Highway Research Board. Bulletin 203. Table 10.
^{15*} Figure 11.

⁸ Report on Chicago Area Transportation Study. Volume I.

* This is not due to any increase in the number of vehicle miles which has fallen steadily since 1951.





2.6 Future Traffic Patterns

The major change which has been predicted in future travel patterns is the enormous growth in the use of the private car. Nevertheless there is no doubt that the patterns of land development, and economic factors such as the current rate of car ownership will have a very large influence on the patterns to be followed in this growth of traffic. An estimate of the future traffic pattern is now being prepared from planning data, and the current traffic patterns as measured in the comprehensive survey. Until this is complete it has been necessary to make some simplified assumptions in the solution of the immediate design problems of the Inner Ring Road. The assumption made has been that there will be a uniform overall growth of threefold except for traffic starting or finishing within the Central Area which will, following the earlier arguments in this report, increase only by twofold. It has also been assumed that there will be a substantial reduction in the comparative importance of goods vehicles throughout the Study Area. Since the Ring Road design is based upon these assumptions it is necessary to reserve the right to modify design features particularly those relating to the junction of the Ring Road with the existing street system.

It was also necessary to decide on a value for the directional distribution of traffic during the peak hour, and for the percentage relation of the design hour to the average annual daily flow in future years. In both cases the characteristics of existing traffic in Glasgow are very similar to those which have been measured in the U.S.A. with ownership levels of the same order as those predicted for Glasgow. For this reason it has been presumed that these two characteristics are likely to remain sensibly constant. The directional distribution of Ring Road traffic has been taken as 50-50, and the design hour has been taken as 10 per cent. of the average week-day volume. Both these factors are based on the average values currently measured in the Central Area.

CHAPTER 3

ROAD STUDIES

3.1 Future Street System

It is apparent from the data on origin and destination that the City Centre of Glasgow is the focus of traffic in the Study Area. The result of this can be seen in Table 8 which shows that the average speed of traffic in the City Centre is only half of the average speed in the remainder of the town. The application of the various techniques of traffic engineering could be used to improve the existing speeds in the City Centre, as discussed in Section 2.3. Such improvement should be given every priority. Presuming however, that the predictions of Section 2.4 on traffic growth are fulfilled, this improvement will fast be absorbed by the increasing volumes of traffic. This confirms the conclusion reached by the Corporation and entered in the Written Statement that having regard to the anticipated growth in traffic, an Inner Ring Road will be an essential feature of the future street system. Having regard to the time that is required to prepare the necessary drawings, to acquire and clear the land, and to construct a project of this magnitude, it becomes a matter for urgency that the construction of the Inner Ring Road be given immediate priority. The exact stages which should be adopted in its construction are a matter for further study but bearing in mind the conclusions of Section 2.3 it would appear that first priority should be given to that part of the project which will relieve the King George V Bridge, and an almost equal priority should be given to the relief of the junction of Castle Street with both Alexandra Parade and Parliamentary Road.

The nature and function of the Inner Ring Road will in part depend upon its relation to the street system both present and future. Therefore to determine the master plan towards which the Ring Road stages should be aimed it is necessary to postulate the probable future changes in the existing street system. It has been concluded on the basis of the traffic and planning data that this future system must contain a supplementary system of urban motorways. There are two primary reasons for these conclusions.

Firstly, it is apparent from the current relation of volume to capacity that the projected increases in traffic cannot be carried by the existing radial approaches to the City Centre. This is clearly illustrated by Drawing 14 and the text of Sections 2.3 and 2.4. Nor could a sufficient improvement be made to the system by any ordinary programme of street widening. For instance, the projected volumes on Great Western Road would require more than 4 lanes

of traffic in each direction of movement, and this order of improvement would be required on most of the major radial streets. Even were such measures to be accepted the problems involved in the design of junctions, the provision of access and the control of pedestrians would be insuperable. Neither can relief be obtained by outer diversion routes. It was at one time commonly accepted that, for instance, an outer ring road would by-pass a very large amount of traffic and thus relieve the city of much unwanted traffic. This theory has almost invariably been proved wrong by a survey of actual traffic movements, which shows that most of the traffic in a large city is self generated and only a small proportion could be diverted by an outer ring road. An examination of Drawings 6, 7 and 8 and Figures 1 and 2 will show that this is also the case in Glasgow. The conclusion is inescapable that supplementary routes on new alignments will become essential, and that these, if they are to serve their purpose, must be of the very high capacity which can only be provided by complete control of access; further that the only feasible method of inter-changing and distributing the heavy volumes which they will carry is to connect them to the Inner Ring Road so that they become its primary feeders.

The second reason which argues that the future street system must contain a supplementary system of motor roads is the operation of the Ring Road itself. In early studies the Ring Road was shown as directly connected to surface streets. Since not all streets could be so connected there was necessarily an increased concentration on those which were. This concentration added to the projected growth was such that the connecting surface streets would in the future be grossly overloaded. In the later stages a motorway system was assumed as described in this section. The volumes developed by subsequent assignments on the radial motorways at the points of connection to the Ring Road were of the order of 80,000 to 100,000 vehicles per day. Volumes of this order could only be accommodated on controlled access routes of motorway standards.

Drawing 18 shows the system which has been assumed for the purpose of traffic assignment. The system as a whole obviously requires a wider study based upon the data obtained from the comprehensive survey. However, it was obvious from the traffic patterns that any proposed system would require a number of major radial routes, and these are the routes which would be connected to the Inner Ring Road and would have the major impact on its design. Therefore, although insufficient emphasis has been placed upon crosstown routes which would completely avoid the Central Area it is considered that the assumptions are adequate for the purpose for which they have been used. The following notes are relevant to the system assumed in Drawing 18.

HAMILTON BY-PASS.—That portion of the main Carlisle Road which passes through Hamilton is to be replaced on a new alignment by a road to motorway standards. This is in the design stage.

HAMILTON BY-PASS CONNECTION.—It is considered that the Hamilton By-Pass must eventually connect directly to the Inner Ring Road by a new road to motorway standards. A notional alignment for this new road is shown on Drawing 18.

EDINBURGH ROAD.—This road is to be reconstructed as a dual carriageway with partial limitation of access.

MONKLAND MOTORWAY.—It is considered that the Edinburgh Road should be directly connected to the Ring Road by an urban motorway which would be constructed along the line of the Monkland Canal. The Glasgow Corporation have had this proposal under study and a tentative design has been laid out on the line indicated on Drawing 18.

STIRLING ROAD.—This route has been reconstructed out from the Glasgow Boundary to dual carriageway standards with partial limitation of access.

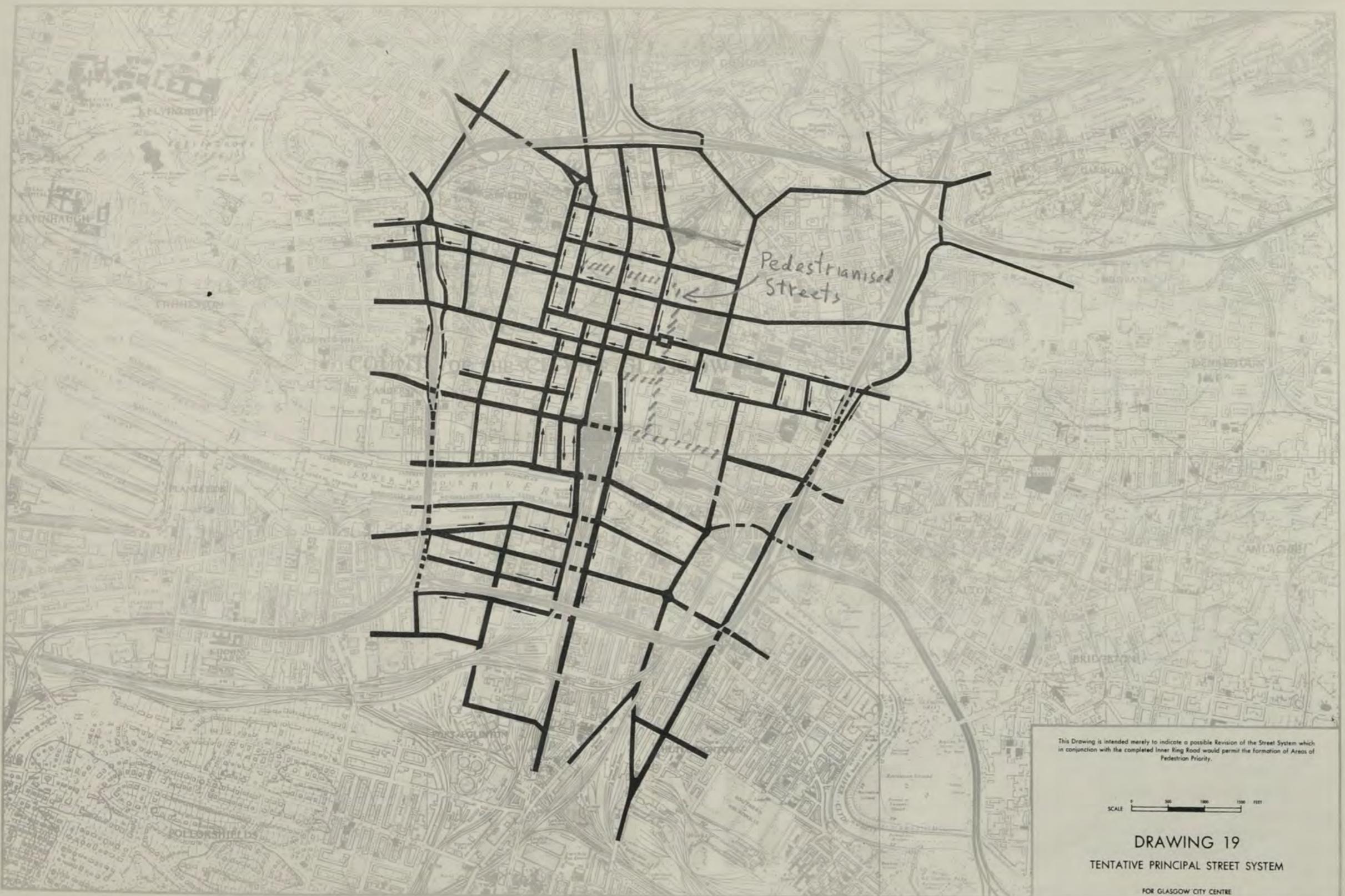
SCOTLAND STREET MOTORWAY.—There is a proposal under consideration by the Scottish Home Office and the appropriate Local Authorities to make use of part of the present Renfrew Airport to develop a new high standard radial which would connect with Edmiston Drive. This new radial would serve the proposed new Glasgow Airport at Abbotsinch, and the Roote's Group development at Linwood. In pursuance of this it is considered that this route should be extended to connect with the new radial shown as a Town Map proposal on the line of Scotland Street and hence to the Inner Ring Road, and that it should be developed to motorway standards.

NORTH WEST MOTORWAY.—It is considered that with the growth of traffic it will be necessary to relieve the Great Western Road by a new route to motorway standards which would eventually connect to the Boulevard close to the City boundary. A notional line is shown on Drawing 18.

SOUTH WEST AND SOUTH EAST MOTORWAYS.—It is considered that with the growth of traffic it will be necessary to relieve the southern arterials by one and possibly eventually two motorway routes. The notional lines are shown on Drawing 18.

C-RING ROAD.—This is part of an agreed route for an Outer Ring Road as described by the Department of Health for Scotland.

The proposals shown on Drawing 18 involve approximately 40 miles of new road construction within the City of Glasgow. It is anticipated that further crosstown links will be required when the full study is completed. These may seem to be sweeping proposals but they should be viewed in the light of the findings of this report on the current levels of traffic and the probable future growth of traffic. At present there are 967 miles of streets within Glasgow. Of these 188 miles are classified and carry the majority of the current traffic.



Much of the classified street system is already approaching capacity and the predicted traffic growth would be of the order of double its total current capacity. It is not feasible to allow for this growth in any other way than by a supplementary system of high capacity relief roads such as that shown.

The new system will carry a high proportion of the total traffic in the city. Despite the relief offered, however, there will still be considerable loads on the surface street system, and in addition to any new roads which may be constructed it will be necessary to carry out a roads improvement programme. Certain of the main arterials will continue to carry heavy traffic loads and these should desirably be improved to dual carriageway standards. As a matter of planning policy it is considered that where such surface routes are designated as major arterials the eventual aim should be to eliminate all frontage development which is likely to result in pedestrian concentrations, and in particular shopping frontage. The definition of the appropriate routes, and the preparation of a definitive master plan which will cover both a new urban motorway system and the use of surface streets is a matter for further study in the light of the comprehensive traffic survey.

This report is primarily concerned with traffic and the emphasis has been placed upon the problems of handling the projected traffic increases. The general lines of solution are dependent upon segregation of the motor vehicle and the provision of areas some primarily and others exclusively devoted to its use. The converse of this problem is the mixed use of areas by pedestrians and motor vehicles where the pedestrian should be predominant. It is considered that the general lines of the solution should again be the segregation of the pedestrian and the provision of areas, some primarily and other exclusively, for his use. The successful development of the pedestrian areas is however completely dependent upon a satisfactory traffic framework. Certain proposals have been under study for the development of areas within the business centre of the city, some of which would be exclusively or predominantly pedestrian. A tentative layout of principal streets which could form the traffic framework for such pedestrian areas is shown on Drawing 19. This is purely illustrative. The implementation of these or comparable proposals would be dependent upon the completion of sufficient of the Inner Ring to provide a satisfactory alternative route for through traffic.

3.2 Urban Motorways

This report advocates the eventual construction of a continuous system of urban motorways, and this will be the major new feature of the proposed future street system. For this reason the principal advantages of the motorway are summarised below.

CAPACITY

Motorways are capable of handling very much larger volumes of traffic than can surface streets of comparable width. Only a motorway system can accommodate the projected future traffic increases. This is the real reason for the motorway system. Not primarily to provide for high speed traffic but to protect the existing street system from the projected traffic increases by absorbing the additional load.

RELIEF OF EXISTING STREETS

The surface streets of a city can be defined as arterial, collector or local in character. It has been shown that the heavy traffic already existing on the main arterial routes has led to the development of subsidiary arterial routes using local and collector streets to the detriment of the immediate neighbourhood of these streets. The relief provided by a high capacity motorway system would facilitate the restriction of all streets to their proper use.

SEGREGATION OF DIFFERENT USES

The ideal planning situation is one in which the conflicting use of the same areas by man and machine will be totally eliminated. It is a thesis of this report that the successful development of pedestrian areas is absolutely dependent upon the successful development of a satisfactory traffic framework.

ACCIDENTS

The segregation of conflicting uses and of opposing traffic streams results in a lower accident rate on motorway systems. The increase in traffic accidents has been one most unfortunate result of increasing traffic. The one type of road which has consistently in all countries shown the lowest accident rate is the motorway.

DIRECT ECONOMIES

The elimination of start and stop driving reduces vehicle operating costs. The reduction of accidents, apart from human values, has a real monetary value. Improved travel times release time which can be utilised for work or can create a gain in leisure.

RELATION TO ECONOMIC DEVELOPMENT

Apart from immediately-apparent benefits associated with ease and speed of travel a road development of the type proposed can confer much wider benefits on the economy of the city and region. It is admittedly difficult to quantify these but they exist nevertheless. A growth of traffic of the size predicted in the foregoing could, if let loose upon the city streets, effectively paralyse the communication system of the city, and hence its economic usefulness. It is no doubt true that many would, when faced with the realities of traffic congestion in the present street system, choose to leave their cars at home, but actual traffic growth would

nevertheless be likely to reduce traffic to minimal speeds. Apart from the losses of trade and of efficiency which would be likely to afflict enterprises located in the Central Area, a congested city of this type would be constantly at risk of losing existing enterprises to new and more convenient locations and could hardly expect to be well placed to attract or to stimulate new growth. In contrast a new road system gives benefits in economic efficiency to existing enterprises and can be an attraction to new economic development. Traffic growth will create new problems in all industrial areas of the United Kingdom and those areas which do not take steps to improve communications may well lose ground in economic development to those which do. Moreover, new commercial or industrial investment can be influenced by wider considerations of amenity: an impression of modern development such as an urban motorway scheme could possibly be of major importance in attracting new growth.

3.3 Amenity and Appearance

The creation of a twentieth century road system for Glasgow on a comprehensive scale not yet attempted for a British city of comparable size is bound to be accompanied by changes in the urban structure itself. This will provide a challenge and an opportunity to improve the amenity of the more important buildings and areas contiguous to the proposed new road. Conservationist attitudes, however, may see the roadway as a threat to particular buildings such as the Cathedral, the Court House or the Mitchell Library, to open spaces such as Glasgow Green, and to further development of institutions such as the Royal Infirmary and the Royal College of Science and Technology. It could be suggested that the Central Area of Glasgow will be disturbed in the way that the railway viaducts of South London, or the level tracks of the New York Central System as they emerge in uptown Park Avenue, have tended to create blighted districts on either side of them. Changes in the appearance of the city there will certainly be. The Ring Road and the bridges over the Clyde cannot be regarded as inconspicuous traffic improvements. But the Ring Road development will at most points be associated with redevelopment of adjacent areas and, if advantage is taken of the opportunities presented by the design of a modern road system and its resolution of present traffic chaos, combined with imaginative redevelopment of the areas through which it passes, these changes could be for the better in most cases. For example, more open space and in some ways a quieter and more suitable setting could be provided for the Cathedral: the Court House could form part of a new group of adjacent buildings which could bring it into scale and sympathy with the motorway on its eastern flank; and the big traffic interchange at Townhead would be designed partly in cutting and with all its details having an eye to the buildings and precincts about to be constructed around it.

Most important of all, the Ring Road and its connections are envisaged in this report as an amenity in themselves, i.e. as an elegant and economic piece of engineering, architecture

and bridge building whose outward appearance would symbolise the renewal of the City Centre, its disengagement from traffic congestion and confusion, and a new-found capacity to deal with its rush-hour problems. Far from apologising for the intrusion of the Ring Road into the scene it can be put forward as being potentially one of its many distinguished features. Glasgow is already identified with the industrial and mechanical revolutions of the past, and it is appropriate that it should lead the way with an achievement in civil and traffic engineering which looks as good as it is.

We have, therefore, assumed throughout these preliminary studies, and included in the cost, a regard for the urban landscape and a standard of design and finish in keeping with this objective.

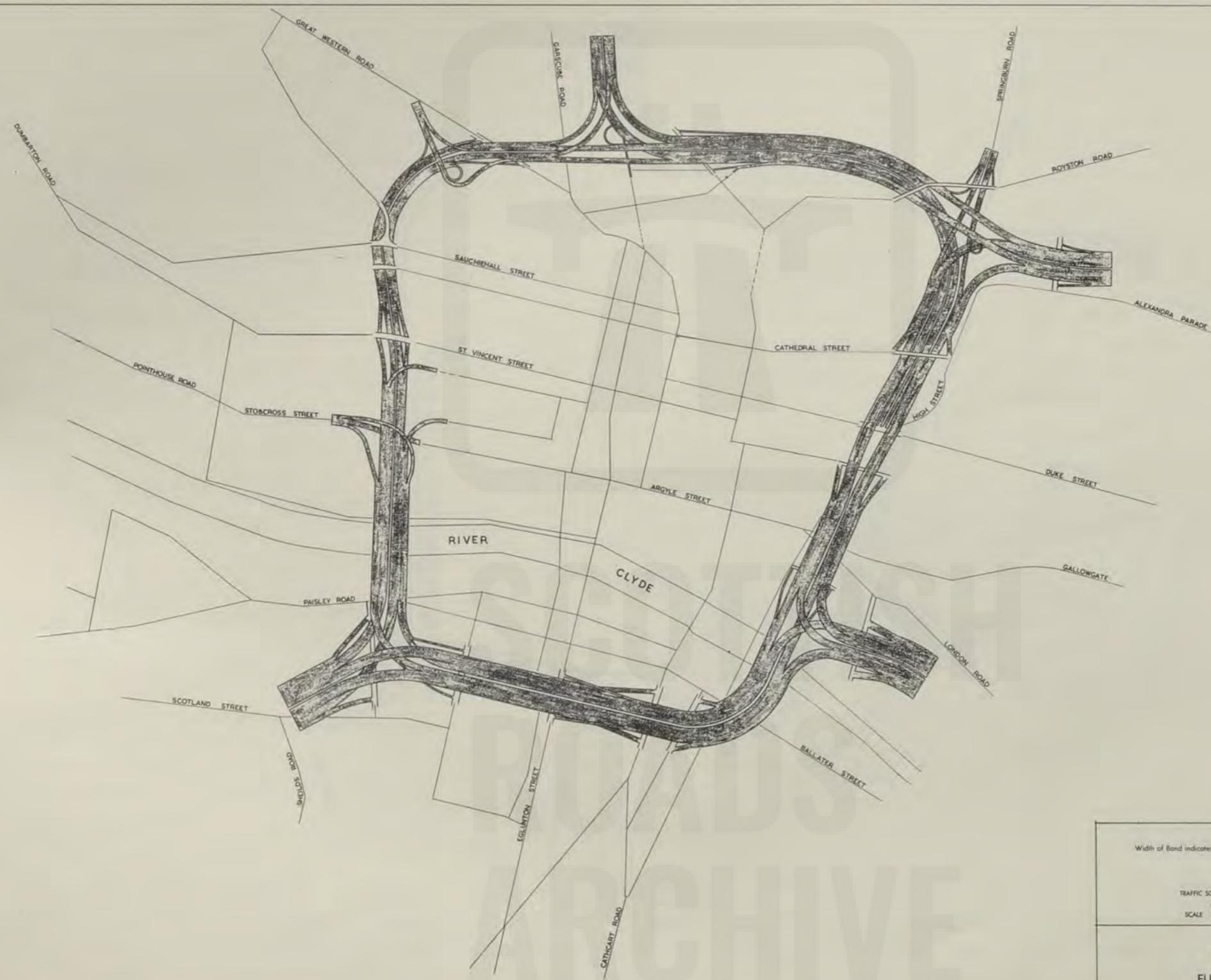
3.4 Standards of Design for the Ring Road

It is proposed that the Inner Ring Road be constructed as an urban motorway. The features of an urban motorway have been defined as follows:—

1. It is a divided multi-lane highway for through traffic with all cross roads separated in grade and with full control of access.
2. Its use will be confined to the motor vehicle and it will be prohibited to the cyclist and pedestrian.
3. No direct crossing movement of vehicles will be permitted.

The essence of the relief which the motorway system is to afford to the surface street system lies in its very high capacity. To maintain this high capacity it is essential that the features described above should be strictly maintained. Any deviation from these features will result in the loss of both capacity and safety. Again it should be emphasised that this is the only feasible solution which will accommodate the predicted traffic growth.

The standards which have been adopted for the geometric features of the Ring Road are associated with a design speed of 50 m.p.h. The design speed controls the speed at which a vehicle can safely operate with very few other cars on the road. In practice this means the speed at which horizontal curves and vertical crests and sags can be safely negotiated. In fact a much higher speed could be maintained on the open road since there are relatively few curves to the minimum standard. The design speed of 50 m.p.h. is much lower than that usually adopted for motorway design in rural conditions. There are two reasons for this. The first is the practical difficulty of achieving the higher design standards. These allow less flexibility in location and would involve a much greater disturbance



DRAWING 20
FUTURE TRAFFIC VOLUMES

ON THE INNER RING ROAD



DRAWING 21
FUTURE PRINCIPAL TRAFFIC STREAMS
ON THE INNER RING ROAD

of property. This is particularly true in the vicinity of the Central Area. The second is the fact that during most of the day the road will carry heavy volumes of traffic and under such conditions the operating speed is controlled not by the road but by the traffic. An examination of the Ring Road proposals will show the numerous and intricate connections which are necessary to redistribute the very heavy volumes of traffic using the Ring Road to the relatively low capacity surface street system without causing congestion. In using these connections many heavy traffic streams require to cross or "weave" with each other. It is the weaving of traffic streams which controls the capacity and operating speeds on the Ring Road. The design standard which has been adopted is that all traffic streams should be able to weave continuously at speeds in excess of 30 m.p.h. even when the future volumes approach capacity loading. The calculation of capacity has been based upon American methods due to the shortage of data on comparable routes in this country. A list of design standards adopted is as follows:—

RING ROAD

Design Speed	- - -	50 m.p.h.
Minimum Weaving Speed	-	30 m.p.h.
Minimum Sight Distance	-	425 feet
Minimum Radius of Curvature	-	750 feet
Maximum Superelevation	-	7%
Maximum Gradient	- -	4%
Minimum Vertical Curves	-	Sag 6,000 ft. radius
		Crest (Absolute) 6,000 ft. radius
		Crest (Desirable) 10,000 ft. radius

RAMPS (Connecting Roadways at Interchanges)

Design Speed	- - -	40 m.p.h.
Minimum Sight Distance	-	300 feet
Minimum Radius of Curvature	-	450 feet
Maximum Superelevation	-	7%
Maximum Gradient	- -	5%
Minimum Vertical Curves	-	Sag 3,000 ft. radius
		Crest (Absolute) 3,000 ft. radius
		Crest (Desirable) 5,000 ft. radius

3.5 Ring Road Proposals

Drawing 1 is a general plan of the current proposals for the Inner Ring Road. The drawing shows the completed road as visualised when the future motorway system is completed. The stages by which this would be accomplished are a matter for further study. It has been

emphasised elsewhere in this report that, although the nature and location of the Ring Road proposals are now fixed, minor amendments to surface street connections and to horizontal and vertical alignments may be required as further data becomes available from the comprehensive traffic survey. Minor amendments to alignment might also result from more detailed physical studies at the design stage. The predicted future average week-day volumes of traffic are shown by a flow diagram on Drawing 20. The estimated volume determines the width of band. This diagram has been prepared upon the assumption that the entire motorway system shown on Drawing 18 has been completed. This has been done since the design of the Ring Road is determined by the predicted future volumes which can only be accommodated by the completed system. The study of the staging of the road proposals will include assignments of traffic at the completion dates proposed for individual stages. It is of interest to observe that the range of volumes on the Ring Road had the motorway system been completed in 1960 would have been 17,000 to 36,000 vehicles per 24-hour week-day. The predicted range of future volumes is from 43,000 to 84,000 vehicles per day. The maximum recorded volume currently using Glasgow streets is 30,000 vehicles per 24-hour day on Paisley Road at Pollok Street. Drawing 21 indicates the principal streams of traffic which have been assigned to the various entry and exit points on the Ring Road. It is intended to illustrate the double function of the Ring Road in both by-passing through traffic and distributing centre bound traffic.

DRAWING 22 WEST FLANK.—The proposals for the west flank are shown to a larger scale on Drawing 22. Reading from left to right of the Drawing the Ring Road interchanges with the proposed new radial on the line of Scotland Street largely by elevated roadways which provide for direct movements in all directions of travel. The Scotland Street motorway would be elevated to cross Shields Road and the parallel railway lines. Two ramps would connect the Scotland Street motorway to Shields Road and hence distribute inbound traffic for the south side. Two ramps would connect the Ring Road west flank to the surface street system. These would distribute traffic from the north west to the local areas of the south side. The Ring Road is elevated on the south flank approach and gains further height to pass over the River Clyde with 60 feet of clearance at high tide. This clearance would permit existing dredging operations on the River Clyde to be continued.

Such a bridge would interfere with the operation of some upstream berthing. However, the zoning proposals of the Town Map indicate that the Corporation envisage the eventual displacement of this berthing. Such displacement would be in accord with the historical trends in river development, and is likely to be accelerated both by the increasing volumes of traffic in the City Centre, and, when the Ring Road is constructed, the reduced importance of a location close to the existing City Centre Clyde bridges.

In view of this it is considered that it would be unreasonable to amend drastically the Ring Road plans to accommodate a function which seems likely to be displaced for a variety of reasons besides the construction of the Ring Road bridge. The timing of the bridge construction is, however, a matter of vital importance.

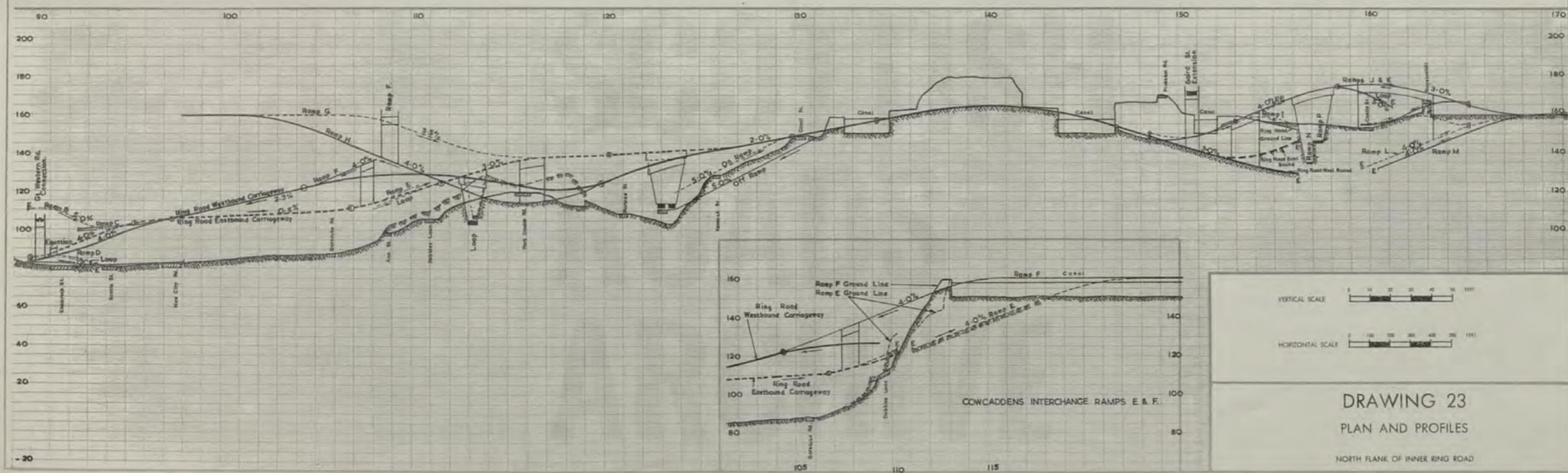
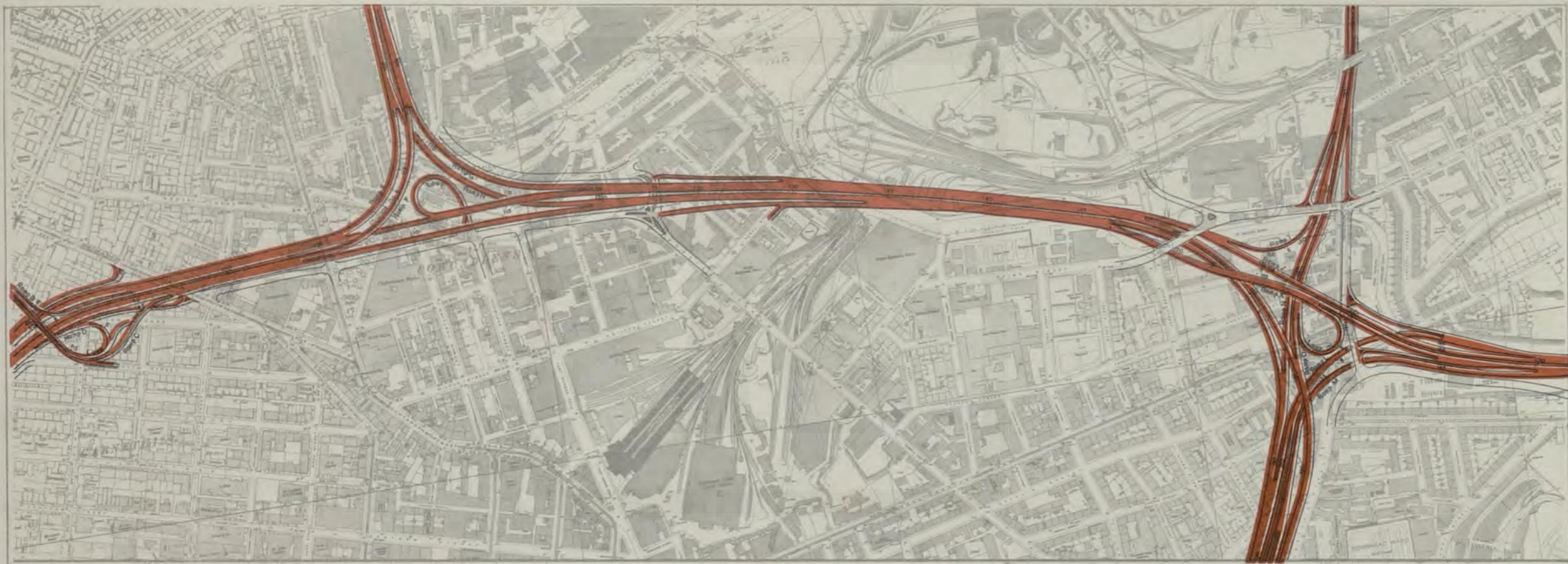
On the north side the Ring Road falls while the ground rises until the Ring Road touches ground level just short of St. Vincent Street, after clearing the junction of Stobcross and Argyle Streets at about 20 feet above ground level. This stretch of the Ring Road is very heavily loaded and will require 4 lanes of traffic in each direction. However, its capacity when the full approach system is completed will be more than the total capacity provided by all 4 existing bridges which between them have 9 lanes of traffic in each direction. Much of this load is bound to and from the City Centre and fairly elaborate connections are required to dispose of traffic without causing congestion. Direct connections are provided from the new radial proposed on the line of Stobcross Street to the Ring Road going south. This will avoid the future development of a back up of traffic similar to that caused by traffic right-turning on the King George V Bridge. Direct connections are provided to Bothwell and Cadogan Streets which would be converted to one way operation. To disperse the heavy volumes of traffic anticipated at this point an additional pair of ramps connect to North Street and a new surface street to the east side of the Ring Road. This new surface street will run from Charing Cross to the River. North of Stobcross Street it forms a one way pair with North Street. South of Stobcross Street these two routes are joined to form a single two way road underneath the Ring Road. This road could eventually be connected to Carnoustie Street by a low level bridge which would be incorporated with the Ring Road structure provided that a solution acceptable to both parties could be found for the operational problems of the Clyde Navigation Trust. North of the pair of ramp connections described above, the Ring Road is reduced to three lanes in each direction of travel and goes into open cut. It passes underneath St. Vincent Street and over the railway at Charing Cross Station. In order to provide a satisfactory clearance to the railway it will be necessary to raise and re-align a short length of Bath Street. The road then passes completely below Charing Cross still in open cut emerging at ground level to the east of St. George's Road in the vicinity of Shamrock Street. New bridges will, of course, be required to carry St. Vincent Street, Bath Street, Sauchiehall Street and St. George's Road over the Ring Road and the Ring Road over the railway.

There is an alternative vertical alignment which would be completely elevated for the whole west flank. However, our preliminary investigations indicate that the depressed profile is feasible and unless insuperable construction difficulties appeared at the design stage, the depressed profile is the more desirable.

DRAWING 23 NORTH FLANK.—With the present proposals it appears that Great Western Road will continue as one of the major surface arterials for the foreseeable future. For this reason a high standard connection has been provided which involves a short length of new road connecting Great Western Road to the Ring Road by a new bridge over St. George's Road. This will remove all but local traffic before St. George's Cross and the comparatively narrow New City Road. The area within the loop can be connected to the surface street system and may be developed usefully for parking purposes. This connection is closely followed by an interchange with a new motorway radial which will be required in the future to serve the west and north west areas. The Ring Road itself is on or close to surface at Shamrock Street rising to cross New City Road on structure. It remains elevated until part way through the north west motorway interchange when it is again close enough to ground to be constructed as a retained fill. The start of the north west motorway will be on the line and at the level of the Forth and Clyde Canal with a high retaining wall on the west side. This takes advantage of the natural development boundary caused by the sharp ground fall and releases a maximum of the Cowcaddens area for early redevelopment. The Ring Road proceeds at or close to the surface until it approaches the Townhead interchange with Springburn Road and the proposed new Monkland motorway. It is anticipated that with the present development proposals for the north of the city it will be possible to make a sufficient improvement to Springburn Road to retain it as a major surface arterial. However, this conclusion would be subject to review were agreement reached on such developments as have recently been proposed for Cadder.* Connection is shown to the Monkland motorway with no immediate connection to Alexandra Parade. This interchange is fully directional except for traffic movements from Springburn Road to the Ring Road west approach and to the Monkland motorway.

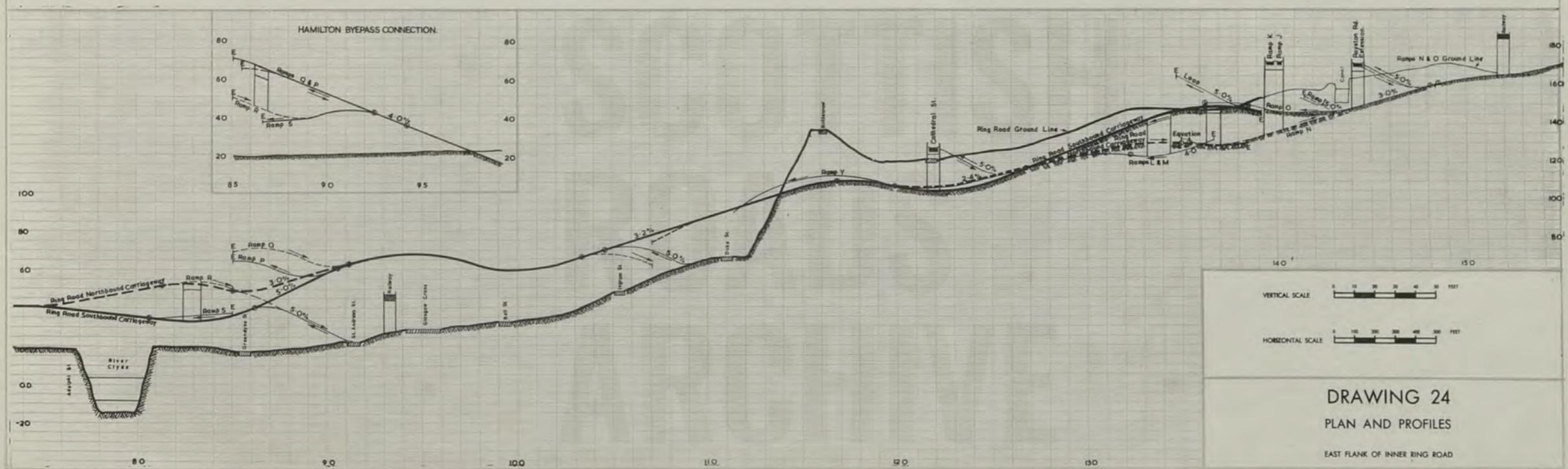
DRAWING 24 EAST FLANK.—With the present proposals there is a heavy interchange of traffic between the City Centre and the Monkland Canal and Springburn Road lines and an almost equally heavy stream from the north flank Ring Road destined for the eastern sector of the city, and the eastern City Centre. To separate these streams and consequently minimise the weaving problems, connections have been made from Cathedral Street giving direct access to the Monkland motorway but with no connection to the Ring Road itself. A converse connection has been made to George Street giving access in all directions going north but with no connection permitted between George Street and the Monkland motorway going south. The Townhead interchange is largely at or below ground level. The east flank passes underneath Cathedral Street and into

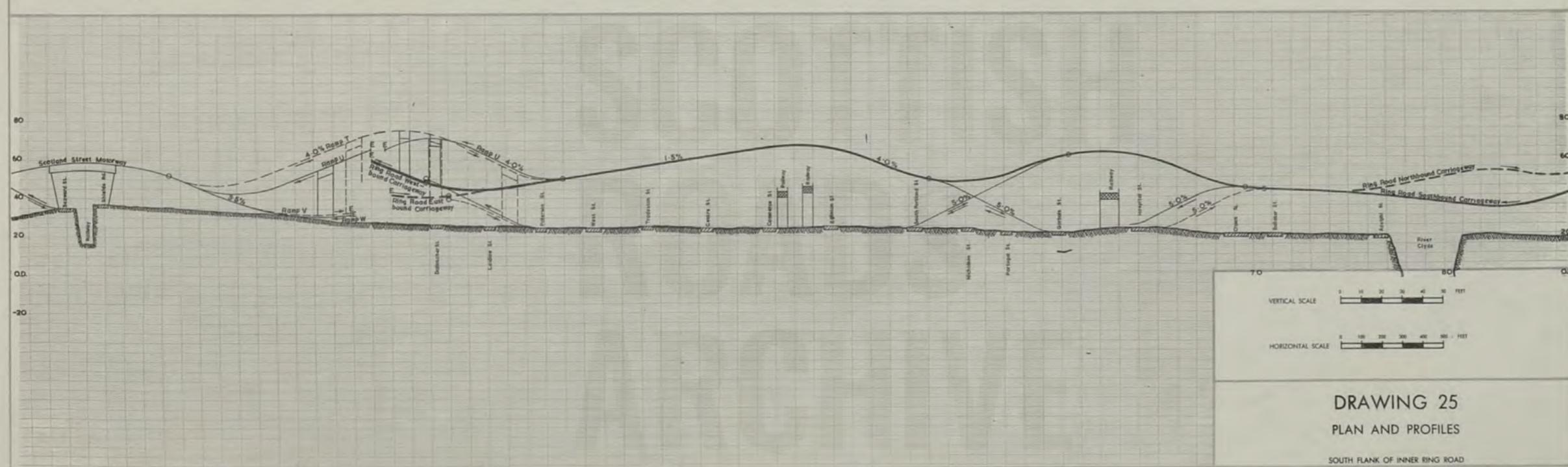
* Reported in the "Glasgow Herald" on 19th and 21st November, 1960.

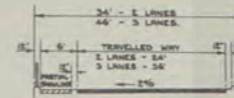
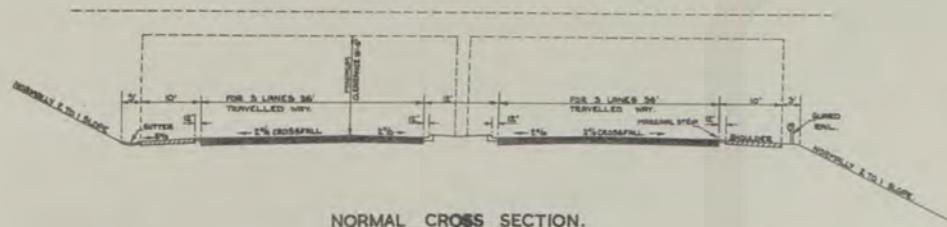


DRAWING 23
PLAN AND PROFILES

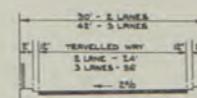
NORTH FLANK OF INNER RING ROAD







2 OR 3 LANE ELEVATED
RAMP WITH PARTIAL SHOULDERs.



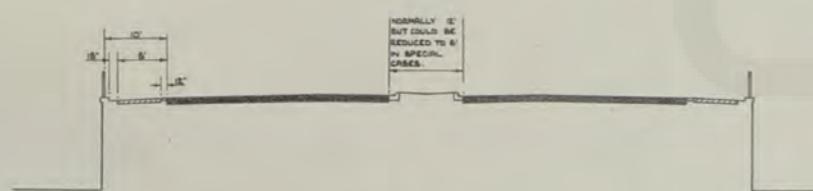
2 OR 3 LANE ELEVATED
RAMP WITHOUT SHOULDERs.



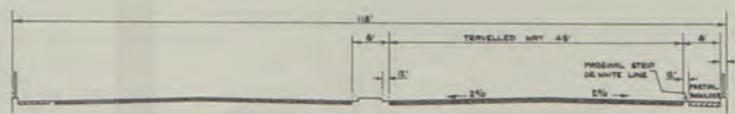
ONE LANE RAMP ELEVATED.



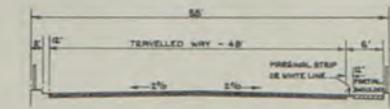
DEPRESSED SECTION WITH RETAINING WALLS.



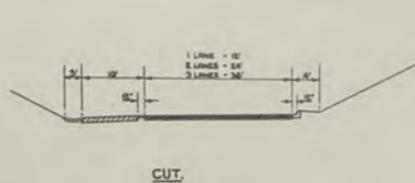
RETAINED FILL SECTION.



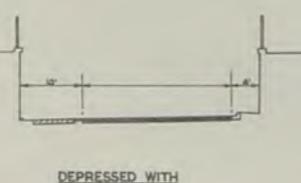
TYPICAL ELEVATED SECTION.



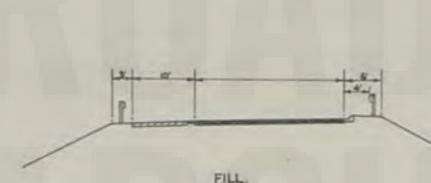
ELEVATED SECTION WITH SEPARATE STRUCTURES.



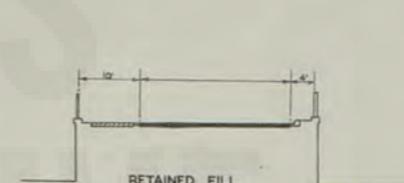
CUT.



DEPRESSED WITH
RETAINING WALLS.



EILL.



RETAINED FILL.

These Sections are preliminary and provisional and subject to modification in detail at the design stage.

SCALE 0 10 20 30 40 50 FEET

ONE WAY ROADWAYS (RAMPS)
TYPICAL SECTIONS.

DRAWING 26

TYPICAL ROAD SECTIONS

a cut of maximum depth in excess of 30 feet in the vicinity of Rottenrow. The ground level falls sharply at this point and the road emerges from cutting to cross George Street on structure, remaining elevated until connection is made with a new bridge over the Clyde parallel to Albert Bridge. At Trongate the elevated railway line which is to form an essential link in the electrification proposals, the incoming surface roads, and the railway tunnel through Glasgow Cross Station force the Ring Road some 40 feet above ground level. Connections are made from the Ring Road to High Street and Ingram Street. A further connection is made to St. Andrew's Street. A major interchange is provided with the motorway fringing Glasgow Green. This interchange will be all on structure. Free access will be given to Glasgow Green underneath the roadway. The location of this interchange is controlled by the location of the new radial motorway along the edge of Glasgow Green.

DRAWING 25 SOUTH FLANK.—The proposed south flank is completely elevated and overpasses 3 railway viaducts at each of which the Ring Road surface level is some 40 feet above ground level. Two pairs of ramps are provided in each direction of movement. The two central pairs of ramps have to be bridged over each other since there would not otherwise be room to connect them to the Ring Road. The two pairs of ramps giving access to the east flank connect to Eglinton Street and Hospital Street respectively. The two pairs of ramps giving access to the west flank connect to Gorbals Street and West Street respectively. As shown on Drawing 18 the proposed south bound radial motorways have no direct connection to the Ring Road. The route chosen is generally parallel to Cook Street but a curve has been introduced to avoid the G.P.O. telephone exchange which controls the south side of the city. The same curve would permit the Carlaw building to remain, but partially overpassed by the road structure.

It is considered that the Inner Ring Road as described in this section will lend itself to completion in a series of logical stages each of which will contribute something to the solution of the Central Area traffic problem. When completed the Ring Road is capable both of interim connection to the existing street system and of final connection to an urban motorway system.

3.6 Civil and Structural Engineering Factors

The civil engineering works will comprise bridges, elevated roads on structures, elevated roads on embankments and roads depressed below existing ground level in cuttings. The latter will require the construction of extensive retaining walls.

There will be three major bridges over the River Clyde. A high level bridge over Anderston and Springfield Quays on the line of Carnoustie Street and two bridges side by side but on different levels upstream of the existing Albert Bridge. The design and construction of these bridges would take into account the requirements of the Clyde Navigation Trust and other interested authorities.

There will also be many bridges carrying the urban motorway over other roads and railways, and some bridges carrying existing roads over the urban motorway, particularly in places where it is proposed that it should be depressed below existing ground level. In the cases of bridges over railways, close collaboration would be maintained with British Railways, both during the design and construction stages to ensure that interference with railway traffic is kept to a minimum and to comply with the safety requirements of the British Transport Commission.

Where the new motorway or other roads are required to be above existing ground level, they would normally be constructed on embankments. However, where they would be over existing roads or where the embankment would encroach on property or land to be developed in other ways, these elevated sections would be constructed to span as bridges between a series of supports. The types and spacing of these supports would be chosen bearing in mind economy, obstacles to be crossed and aesthetic appearance. Where new roads above existing ground level could be constructed on earth embankments, but there would be insufficient space for stable slopes to the sides of the embankments the earth fill would be retained by walls. In cases where the new roads would be below existing ground level, the existing ground and properties would be retained by walls where there would be insufficient space for stable cutting slopes.

A major task will be the repositioning of Statutory Undertakers Services where these would otherwise clash with proposed construction. In the cases of roads depressed below existing ground level, the amount of diversion and repositioning required would be extensive but it would appear that these works can be carried out without interruption of services. The choice of structural materials whether mass concrete, reinforced concrete, prestressed concrete or steel would be made after a detailed study, bearing in mind all the relevant factors such as cost, aesthetic appearance and suitability.

Geological Survey maps and records show that the "solid" rocks under central Glasgow are of the Carboniferous period, including Carboniferous Limestone, Millstone Grit and Coal Measures, with some igneous intrusions. After folding and partial erosion, these rocks have been overlain by glacial deposits (boulder clay); marine alluvium (sand, gravel and brick clay); and fresh-water alluvium (river terrace deposits). Because of irregular erosion during

and after their deposition, the present thickness and extent of these glacial and alluvial deposits is irregular. Broadly speaking, the fresh-water alluvium covers the southern half of the proposed route of the Ring Road; the marine alluvium extends into the north-west quarter; while in the north-east quarter, there is only boulder clay over the "solid" rock. In the southern half the rock is likely to be found at depths of about 100 to 120 feet below surface, while in the northern half the depths are generally considerably less.

The results of a large number of borings made in connection with redevelopment schemes, in the areas of Hutchesontown, Townhead, Anderston, Laurieston and Our Lady and St. Francis, were supplied by the Architectural and Planning Department of the Corporation of Glasgow, and further useful information was provided by the Office of Public Works, the Clyde Navigation Trust, the Geological Survey (Edinburgh) and Mr. H. B. Sutherland, Reader in Soil Mechanics in the University of Glasgow.

From the information referred to above, it was possible to construct a rough tentative section of the strata underlying the proposed Ring Road. This will serve as a basis for planning the extensive detailed ground investigations which will be necessary before detailed design of individual structures and earthworks can be carried out. Problems to be considered include the stability of foundations, retaining walls and earthworks, and their freedom from excessive settlement; ease of construction, with particular reference to ground water conditions; the safeguarding of adjacent property, both during and after construction; and the availability of economical materials for fill and pavement construction. For such a complex project, to be carried out in a congested area, it is to be expected that the solution of some of these problems will be relatively difficult and expensive. However, it is considered on the basis of the available information, that there are no unduly great difficulties.

It is likely that a number of different foundation types, and different construction procedures, will be employed to meet the varying requirements, and the most modern techniques will be used where appropriate. It is proposed that flexible type pavements should be provided.

It is concluded that although the building of an Urban Motorway of this nature would necessarily introduce many problems, there are none of these which could not be overcome with proper detail planning. The most careful detail planning will also be required to minimise the temporary inconveniences caused by the construction operations.

CHAPTER 4

CONCLUSIONS

A number of conclusions of major importance to future traffic and transportation planning for Glasgow are made within this report. The most salient of these are summarised below.

- (1) The current traffic patterns emphasise that first priority should go to the relief of the City Centre, followed by measures to relieve the major radial routes.
- (2) There is some reserve of capacity in most parts of the existing City Centre street system which could be released by the application of traffic controls and suitable measures should be given every priority.
- (3) Such reserve is, however, quite inadequate to meet the predicted growth in traffic volumes and, having regard to the time that is required to prepare the necessary drawings, and to acquire and clear the land and to construct a project of this magnitude, the construction of the Inner Ring Road is a matter for great urgency.
- (4) The planning of future Principal Traffic Routes should be based upon a general growth in traffic to over three times the current levels within 30 years.
- (5) It is neither feasible nor desirable to accommodate such a traffic growth within the City Centre of Glasgow. If left to itself it will continue until congestion inhibits its further development. Immediate thought should, therefore, be given to more constructive methods of control for traffic growth to the City Centre.
- (6) The predicted growth in private traffic will inevitably reduce the importance, both relative and absolute, of travel by public transport. Since rail traffic is segregated from road traffic, the predicted growth will also increase the attractive power of public transport by rail. It is, therefore, likely that rail as compared to road public transport will increase in relative importance; in so far as this will contribute to the maintenance of a high level of travel by public transport to the City Centre, and to a decrease in road congestion, this is considered to be a desirable development.
- (7) The impact of the growth of vehicle ownership on public transport operation is such as to justify a full scale survey of current public transport service to provide the data for an overall appraisal of future needs.

(8) The most promising control measure for the growth of traffic to the City Centre of Glasgow, lies in the development of a parking policy. This also should be based upon a comprehensive study of the origin, destination, and purpose of parkers in the City Centre.

(9) The predicted growth of traffic cannot be accommodated by the existing principal traffic routes, nor by any acceptable scheme of road widening on existing alignments.

(10) The only alternative, which will accommodate the predicted growth, is a complete system of supplementary traffic routes built as urban motorways away from the line of the existing routes and intended to supplement and relieve, but not to replace them.

(11) The Inner Ring Road should eventually be an integral part of this system serving both to link different parts of the system, and to distribute traffic from the system to the City Centre streets.

(12) The design of the Inner Ring Road should, therefore, allow for such future connection.

(13) The amenity problems due to the construction of the Inner Ring Road and its connections should be studied at the same time as the engineering design, so that the whole system will form an interesting and positive feature in appearance as well as function.

SCOTTISH
ROADS
ARCHIVE

LIST OF REFERENCES

1. The Glasgow Development Plan Quinquennial Review 1960. The Written Statement.
2. Her Majesty's Stationery Office. Homes for Today and Tomorrow.
3. The Commercial Motor. The British Commercial Vehicle Industry.
4. Road Research Note RN/3904/FVW. Traffic Signals by F. V. Webster.
5. Ministry of Transport. Road Motor Vehicles.
6. Road Research Note RN/3977/JRS. 50 Point Traffic Census. Results for 1960 by J. R. Scott.
7. Automobile Manufacturers Association. Automobile Facts and Figures.
8. Report on Chicago Area Transportation Study.
9. Road Research Note RN/3340/JCT. An analysis of increases in motor vehicles in Great Britain and the United States by J. C. Tanner.
10. Road Research Note RN/3989/JCT. Preliminary Estimates of the future car population of Great Britain by J. C. Tanner.
11. Report of the Road Research Board for 1960. H.M.S.O.
12. The Glasgow Development Plan Quinquennial Review 1960. The Survey Report.
13. Comprehensive Arterial Highway Plan Cuyahoga County, Ohio.
14. Eno Foundation for Highway Traffic Control. Parking.
15. Highway Research Board. Bulletin 203. Travel patterns in 50 cities by Curran and Stegmaier.



SCOTTISH ROADS ARCHIVE

SCOTTISH
ROADS
ARCHIVE