REPORT ON THE SURVEY FOR THE DEVELOPMENT PROJECT OF THE URBAN TRAFFIC IN CARACAS, VENEZUELA

MARCH 1970

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

Preface

The Government of Japan, in response to a request from the Venezuela Government, entrusted to the Overseas Technical Cooperation Agency (OTCA) the task of conducting a preliminary survey in Caracas in Venezuela.

The OTCA, fully realizing the importance of the Development project of the urban traffic in Caracas, organized a six-member team of experts and dispatched it to Venezuela on March 7, 1965 for over a month on-the-spot survey under the leadership of Mr. M. Ichimura, managing director of the Teito Rapid Transit Authority.

The OTCS, which was established on July 1, 1962, serves as an excuting agency of the Japanese Government to conduct Japan's government-level technical cooperation to Asia, the Near and Middle East, Africa and Latin America. Its principal activities are acceptance of overseas trainees, assignment of technical experts, establishment of overseas technical cooperation centers and the conducting of preliminary surveys for development projects.

It is my sincere hope that this report will prove to be useful in the field of technical help to the Development Project of the urban traffic in Caracas and will also help to foster closer technical ties and better understanding between Venezuela and Japan.

Lastly, on behalf of the OTCA, I wish to take this opportunity to express our greatest appreciation and sincere thanks to the various agencies of the Venezuela Government for their invaluable help and cooperation given to the Survey Team, without which it would not have been possible for the Team to conduct a smooth survey on the spot.

October 1965

Shinichi Shibusawa

Director General

Overseas Technical Cooperation Agency

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THE URBAN TRAFFIC IN CARACAS, VENEZUELA

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1. INTRODUCTION

1.1 Details concerning the matter of dispatching the survey team.

The Government of Japan decided the dispatch of the above-mentioned survey team at its expense in view of the agreement reached between Mr. Sato, Charge d'Affaires of the Japanese Embassy in Venezuela, and Dr. Jose Sandval, Director de Planiamento under the instructions of Dr. Leopold Sucre Figarella, Ministro de Obras Publicas. The Japanese Government, in organizing a survey team of traffic experts to elaborate a traffic network project of Caracas, hoped that such cooperation would prove helpful to the development of Venezuela by means of making an effective technical suggestion with regard to the traffic problem now confronting Caracas City. It believes that these experts have extensive experience in the project and construction work of urban rapid transit facilities of mass transport. Because it is well known that the underground railway in Tokyo is being constructed on the largest scale in the world; that a monorail tramcar line has been completed (between the International Airport and the center of Tokyo) as the world's first urban traffic facilities. Those experts have been and are still in close touch with these construction works.

1.2 Members of survey team.

The members of the survey team are as follows:

Masuo Ichimura	: Chief of team, Managing Director, the Teito Rapid Transit Authority
Tsutomu Shimizu	: Consulting Engineer, the Teito Rapid Transit Authority
Katsumi Amimoto	: Technical Committeeman, Japan Monorail Association
Shigeo Mori	: Engineer, Railway Supervision Bureau, Ministry of Transportation, Government of Japan
Toshika Matsushige	: Engineer, Divisional Office for New Tokaido Line, Japanese National Railways
Utaka Hitaka	: Staff, Overseas Technical Cooperation Agency

1.3 Prosecution of survey work.

The survey team arrived at Caracas on March 11, 1965 and prosecuted its work until April 16 over a stretch of 37 days.

Table 1. List of Direction

1. Direccion General: Ministerio de Obras Publicas

2. Direccion de Planeamiento: "

3. Direccion de Vialidad: "

4. Direccion de Tránsite Terrestre: Ministerio de Comunicación Institúto Municipal de Transporte Colectivo del Distrito Federal

5. Oficina Municipal de Planeamiento Urbano

6. Concejo Municipal del Distrito Federal

7. Concejo Municipal de Districto Sucre del Miranda Estado

8. Centro Cimon Bolivar C. A. Direccion de Programa y Proyecto

9. Servicio Municipal de Contrastes

10. C. A. La Electricidad de Caracas

11. Gerente Departamento de Caracas

Table 2. List of Data

C. S. T.		
No. 1	Programa Tentativo para Estudio de Caracas. Enero de 1965	M. O. P.
No. 2	Caracas y Sus Unidades de Agrupacion (oficina municipal de planeamiento urbano) Caracas 1964	
No. 3	Comisión para el Desarrollo urbano y La Vivienda	
No. 4	Oficina Metropolitana de Planeamiento urbano	
No. 5	Projecto de Oficina Metropolitana de Planeamiento Urbano	
No. 6	El Subsuelo de Caracas	M. O. P.
No. 7	Area Metropolitana de Caracas, Esquema de Viaridad Basica	
No. 8	Area Metroporitana de Caracas, Estimaciones de Población para el 30 de Junio de cada Año	
No. 9	Relación Residencia y Trabajo de la población Activa	
No. 10	Censo, Noveno General de Población	
No. 11	Centro Simon Bolivar	
No. 12	Norma y Regularización de la Unidad Vecinal para Proyectos de Urbanizaciones	
No. 13	Instituto municipal de Transporte (Collectivo del Distrito Federal)	
No. 14	Mapa de Caracas 1/5000 1/10000 1/25000	
No. 15	Dibujo de Aspecto Vertical de Carretera de Caracas	
No. 16	Dibujo de Crucero Cúbico de Autopista del Este (El Pulpo)	
No. 17	Aerofotografía de Caracas	

Through the courtesy of the proper authorities of the Ministerio de Obras Publicas the team was able to proceed on with its work in close cooperation with the Oficina Ministerial del Transporte, a committee which had been set up in 1964 for the purpose of investigating, projecting, executing and managing this rapid transit means. The officers of the committee with whom the team was in touch were Dr. L. Azpurula, Chairman, Dr. A. Bocalandro and Dr. R. Rivas who were both committee members. The team was also allowed to open its office in the committee.

It visited the government offices in charge where useful data and informations were obtained. It also made efforts to grasp the present situation and the trend of future development of Caracas, which were necessary to make an estimate of the potential traffic demand. After making a series of detailed field reconnaissance of the topography, geology, circumstances, obstacles, etc. it mapped out a plan of the railway line. (Tables 1 and 2) Thanks to the attentive guidance and wholehearted assistance of the proper authorities it was made possible for the team to grasp a full portrait of the city in spite of the extremely limited space of time.

1.4 Quotation of the First Report.

In leaving Caracas after having finished its survey work the team submitted, through the Japanese Embassy, the 'First Report' which was the first of a series of its reports, to the Ministro de Obras Publicas. As the present report is the enlargement of the First Report, containing no basic revisions, the First Report will be quoted here in its entirety.

PRIMER INFORME

por

LA MISION PARA EL ESTUDIO DEL TRANSITO DE

ALTA VELOCIDAD URBANA DE CARACAS

CONFIDENCIAL

INTRODUCCION

Ante todo, esta Misión para el Estudio del Tránsito de Alta Velocidad Urbana se permite señalar que es aconsejable iniciar urgentemente los trabajos de construcción del ferrocarril subterráneo en la ciudad de Caracas. Ahora mismo, determinando el Proyecto del ferrocarril subterraneo y, al mismo tiempo, en relación con todo el proyecto urbano actual quese está desarrollando, debe tenerse en cuenta que habrá que salvar muchas dificultades que ocasionará la realización de los trabajos de construcción del ferrocarril subterráneo, — por las edificaciones que se hagan en lo futuro.

También es deseable que los trabajos de construcción del ferrocarril subterráneo se comiencen lo más pronto posible, en razón de que el tráfico en las calles de Caracas aumentará cada día más, y también aumentará el período de construccion y el costo de construcción, tal como sucedió en la ciudad de Tokyo.

Con relación al monorriel, en nuestro país se han construído como prueba 3 líneas de corta distancia, especialmente para el turismo, y en 1964 se construyó por primera vez en el mundo el monorriel como medio de transporte entre el centro de la ciudad y el Aeropuerto Internacional de Tokyo, con una distancia de 13 kms. Este monorriel tiene capacidad para transportar 150.000 personas diariamente y está Operando normalmente. Solo hace apenas 6 meses que está al servicio del público y todavía estamos continuando las pruebas del mismo. Por consiguiente, hemos llegado a la conclusión de que el ferrocarril subterráneo es preferible al monorriel como medio de transporte de alta velocidad.

En resumen, la recomendación de esta Misión es la siguiente:

1. Línea (Fig 3, Fig 4)

Recomendamos la primera propuesta como la red de línea. Según nuestra investigación en el corto tiempo que dispusimos desde la llegada al país, hemos percibido al principio que el proyecto de la red del ferrocarril de alta velocidad en esta ciudad lamentablemente ya perdió oportunidad. Por consiguiente, se prevee que, para efectuar dicha propuesta, sería necesario cambiar las instalaciones actuales, o modificar el proyecto determinado. Como hemos dicho ya, recomendamos más laprimera propuesta, aunque su realización sería muy dificil por las causas arriba mencionadas.

Consideramos que en cualesquiera propuestas es necesario tener en cuenta los siguientes puntos:

(a) Para elevar la capacidad del transporte por aumento de la velocidad programada y, al mismo tiempo, bajar los gastos de los trabajos de construcción y los gastos posteriores a la apertura de la operación, las distancias entre las estaciones, en principio, deben tener más de 700 metros.

(b) Es necesario unir todas las líneas, por lo menos, en un sitio, para dar facilidades a los pasajeros, intensidad de las plantas de vagones y economía de los vagones reservados.

(c) Para facilitar la conexión con los vehículos (bus, taxi, automóvil particular), debe tenerse en cuenta el establecer las paradas públicas en terminales o estaciones principales.

(d) Es necesario establecer una gran estación colectiva en las cercanías del Centro Simón Bolívar, con el objeto de dar las facilidades a los pasajeros aglomerados allí. Es deseable establecer una gran plaza en el subterráneo de ese lugar, modificando, si es posible, una parte del proyecto determinado ya.

(e) En otros sitios, es deseable que el proyecto de cada estación, pasaje subterráneo conectado a los edificios, o estación subterránea sea preparado junto con el proyecto del trabajo del ferrocarril subterráneo.

(f) Según nuestra experiencia, es muy costoso y dificultoso el trabajo de mejoras o extensión de la construcción subterránea una vez terminado. Por tal motivo, cuando se — planea el proyecto de construccion, se tiene que poner — mucha atención para no arrepentirse después para evitar los gastos temporales.

Capacidad de transporte

Vamos a explicar sobre las instalaciones y vehículos en el Capitulo Cuarto. En caso de que el tren del ferrocarril subterráneo sea integrado por ocho (8) vagones y corra por intervalos de dos minutos, la capacidad del transporte por línea, ruta y hora es como sigue:

	personas en 1 hora
En un vagón de 150 personas	36.000
En un vagón de 200 personas	48.000
En un vagón de 250 personas	60.000

Método de construcción

Juzgando por los datos conseguidos, consideramos que la geología de esta Ciudad no presenta ningún inconveniente para la — construcción del ferrocarril subterráneo. Por eso, durante el trabajo de la construcción, limitando solamente una parte del tránsito terrestre, se puede adoptar el método de construccion del ferrocarril subterráneo económioo y más popular, o sea el de cavar desde la superficie de la tierra. Si adoptamos este método de construcción, podríamos situar la instalación de la estación en el punto somero del subterráneo y sería conveniente en todo caso.

Instalación, vagón, etc.

El ferrocarril subterráneo en la Ciudad de Tokyo tiene la historia de cuarenta años desde la iniciación de su operación. Los trabajos de construcción, a pesar de suspensión temporal, han establecido cincuenta kilómetros y más en los últimos 15 años pasados lleganso su extensión total a setenta y cinco kilómetros. Durante dicho tiempo, el ferrocarril subterráneo en Tokyo, basado en su experiencia, ha estudiado fervientemente sobre los ferrocarriles subterráneos extranjeros y ha mejorado sus instalaciones y vagones. Por tal motivo, queremos adoptar en principio el sistema del ferrocarril subterráneo de Tokyo sobre la instalación, vagones, etc., como sigue:

(a) Entrevias; 1,435 metro

(b) Método y voltaje del suministro de corriente eléctrica;

Sistema de tercer riel. 750 voltios D.C.

(c) Sistema de Señal;

Sistema de control automatico del tren y parada automatica del tren.

(d) Dimensión de un vagón;

Longitud 18 metros

Ancho; 2,790 metros

Altura; 3,495 metros

(e) Capacidad de pasajeros en un vagón;

Vagón de asientos largos;

64 sentados
= total 150 pasajeros
96 de pié

Vagón de asientos cruzados;

60 sentados
= total 130 pasajeros
70 de pié

5. Referencia

Para economizar en los gastos de los trabajos de construcción, cada línea tiene que adoptar la estructura de la línea semisubterránea, elevada, o terrenal en la parte de los alrededores de la Ciudad, con excepción de su centro.

Lamentamos mucho que, a pesar de la magnífica colaboración de las Autoridades del país, no pudimos explicar los detalles del trabajo de la construcción, instalaciones, manejo, etc., ni — presentar la estimación bruta de los gastos de la construcción, por causa de nuestra corta permanencia en el país.

Queremos prometer a Vd(s) que suministraremos la información de esos detalles por intermedio de la Embajada del Japón en Venezuela.

2. OUTLINE OF CARACAS CITY.

The City of Caracas, being 900 m above sea level, is situated at the southern foot of Mt. Avila which faces the Caribbean Sea. It is the capital of the Republic of Venezuela and the center of the politics, culture and economics of the country. Although it is an old city whose history can be traced back four hundred years, it is now making rapid strides with the advance of the industrial and economic prosperity of the country after the World War II.

2.1 Area and population.

Caracas extends about 23 kilometers from east to west and 15 kilometers from north to south, having an area of 360.3 square kilometers. The streets stretch along the River Guaire and its tributaries which flow in Valley Caracas; the shape of the city is long from east to west and short from north to south, only 4 kilometers in its narrowest part.

The population of the city has been on the increase; while it was only 265,007 in 1936, it has in a quarter of a century increased to 1,336,464 in 1961, as shown in Table 3. This population growth, when classified by the districts of the city, is conspicuous in Petare (eastern district), Sucre (northwestern), El Valle (southern) and Baruta (southeastern), which are all environs of the city and are developing as residential districts.

2.2 Outline of town.

The city consists of the old town which has existed for a long time, a new town which

Table 3. Population of each area

PARROQUIAS Y MUNICIPIOS	POBLACION			SUPERFICIE
	1961	1950	1936	Km^2
AREA METROPOLITANA DEPARTAMENTO LIBERTADOR (Distrito Federal)	1,336,464	693,896	265,007	360,3
Parroquias Urbanas				
Altagracia	41,247	33,356	20,783	3,9
Candelaria	49,411	33,299	22,623	4,5
Catedral	76,837	40,648	24,109	2,7
La Pastora	25,125	54,860	27,435	10,9
San Agustin	40,162	36,818	17,712	1,7
San Jose	48,563	25,305	14,628	5,5
San Juan	96,653	74,407	34,859	5,8
Santa Rosalia	139,726	74,276	21,895	9,5
Santa Teresa	16,149	9,337	9,082	1,1
Sucre	202,990	112,553	10,123	31,5
Parroquias Foráneas				
Antimano	37,440	12,116	5,247	44,5
El Recreo	102,137	55,983	13,050	18,1
El Valle	110,616	38,312	8,188	52,4
La Vega	64,545	19,501	4,033	20,1
DISTRITO SUCRE (Estado Miranda)				
Baruta (a)	45,565	6,950	4,564	61,8
Chacao	64,006	25,788	4,664	21,1
El Hatillo (a)	3,249	2,252	4,976	16,0
Leoncio Martinez	44,412	16,930	6,135	21,8
Petare (a)	77,631	21,205	7,036	27,4

(a) Está incluida solamente una parte del Area Metoropolitana has recently developed, and a zone to be developed in future. The old town lies a little west of the city center, the new town to the east of the old town, and the southeastern and southwestern districts constitute a zone expected to be developed in future.

The midtown area is composed of the government office streets centering around El Silencio and the business streets centering around Av. Urdaneta. Next to the composite building of the government offices which is in El Silencio a project of a new government office street, etc. is being contemplated by Centro Simon Bolivar A. C. This district, part of which is now under construction, is certain to gain importance as the city center in future, and the old low buildings in Altagracia and Santa Teresa districts around the midtown are expected to start their life afresh as new business streets after the re-development of the city.

In addition to the above, Sabana Grande and Chacaito districts, which lie in the new town and are developing rapidly as a pivot of shopping and amusement, are getting tinged with the character of the city sub-center.

The residential district is gradually expanding with the population growth. In such environs of the city as Petare, Sucre and El Valle stand the houses of the small income groups roof by roof, while the district around Chacao which is a residential section of high class is full of stately residences, and Baruta is being developed as a dwelling portion of the middle classes.

The industrial zone is now situated in Vista Alegre and Los Cortijos de Lourdes, and a new zone is being developed in Industrial La Yaguara and Antimano which are both in the southwestern district. There are no large scale factories, but small scale ones of home industry type are scattered mainly in the old town.

3. TRAFFIC IN CARACAS.

Although there are fine expressways (autopistas) and cubic crossings at principal junctions in the city, and, in addition, strong traffic control is being enforced, the arrangement of the roads and other traffic measures cannot catch up with the increasing number of automobiles, resulting in the extreme traffic congestion.

As for the urban traffic facilities, the surface car line has been already removed, and the present traffic means consist of bus'es, taxis (there are two kinds: taxis of an ordinary type called 'Libre' and taxis of bus type called 'Propuesto' running on regular routes of service), and private cars. Such a type of transport facilities as serving a great number of passengers has not been introduced yet, and the private cars are making the traffic so much congested that they are giving rise to various problems of the urban traffic.

3.1 Number of motorcars.

The underdeveloped means of mass transport in Caracas as well as the rise of the income level due to the prosperous national economy after the World War II have accelerated the motorization, a tendency common to all large cities in the world, at no less quick tempo than that of other advanced cities. As shown in Table 4, in comparison with the population growth by 90% during the ten-year period between 1947 and 1956, the number of automobiles registered during the same period increased by 313%; the latter figures represent a rapid increase 3.5 times as large as the former. Thus, the motorcars increased so greatly in number that there was in 1958 one car for every ten persons in Caracas. It is presumed that in 1965 the city will have 200,000 motorcars, of which private cars will represent the highest percentage. The number of private cars of the city in 1959 classified by districts is shown in the following list, by which we find the number of such cars in the eastern residential section overwhelmingly large; it means that the traffic is congested on the roads between the midtown and the eastern district.

	Population (thousand persons)	Number of private cars	Population per car person/car
City center	151	10,266	14.7
Northern district	139	11,852	11.8
Northwestern district	326	6,904	47.2
Southwestern district	125	7,657	16.3
Southern district	253	12,731	19.9
Eastern district	346	53,677	6.4
Total	1,340	103,087	13.0

3.2 Street conditions.

The streets of Caracas are laid out at right angles in the midtown where the traffic is most jammed. However, except such main streets as Av. Bolivar, Av. Urdaneta and Av. Universidad which run from east to west and Av. Fuerzas Armadas and Av. Baralt which run from north to south, all streets in the city are from 8 to 10 m wide, which are narrow as

Table 4. Relation of Passengers and Vehicles

	Car	Population	Passengers/Car
1947	26,097	568,178	21.8
1948	36,076	610,458	16.9
1949	46,419	656,098	14.2
1950	50,021	705,528	14.1
1951	62,970	733,045	11.7
1952	66,187	788,067	11.9
1953	68,900	845,944	12.3
1954	77,320	906,678	11.7
1955	96,042	970,269	10.1
1956	107,736	1,080,617	10.0
1957	116,619	1,167,327	10.0
1958	124,232	1,260,994	10.1

(Reference) Number of Motor Cars in 1959

Private Cars	90,736
Taxis	12,351
Total	103,087

(Invetigating report of transportation for Caracas) compared with the traffic density; besides, they are not enough provided with car parking places outside the street.

The following are the arterial roads leading from the city center to the environs:

Northwestwards	Av. Sucre
Southwestwards	Av. San Martin
Southwards	(1) Av. Fuerzas Armadas - Av. Nueva Granada - Autopista El Valle
	(2) Av. Baralt - Ar. Páez
Eastwards	(1) Av. Bolivar - Autopista Este
	(2) Av. Universidad - Av. Colón - Av. Abraham Lincoln - Av. Francisco de Miranda
	(3) Av. Urdaneta - Av. Andre Bello

The characteristics of the above arterial roads may be summarized as follows:

(1) The midtown streets, as mentioned above, have not enough capacity to deal with the traffic volume concentrating from all directions of the city.

(2) The arterial roads passing through the city center are not adequate, and, particularly the vast site of the country club allows only one through road to run from east to west in spite of the large traffic volume between the midtown and the residential section in the east.

(3) Those arterial roads are poorly connected with each other, at the same time, lacking in their continuity, and many of them are badly arranged with other ordinary roads.

(4) Spurs of low hills are close to the midtown, which makes it difficult to arrange by-passes round the city center.

3.3 Present situation of street traffic.

With the increase in the number of motorcars the traffic jam of the city is growing more and more intensified every year; it is especially consipicuous in the midtown where the traffic is concentrated from all directions, and also on the road connecting the city center and the residental section in the east.

To illustrate the relation of the registered number of motorcars to the traffic volume of the motor cars entering and leaving the city center:

Year	Traffic volume of motorcars entering and leaving the city center (number of cars per day)	Number of registered motorcars
1948	180,600	36,076
1953	263,300	68,900
1955	257,200	96,042
1958	441,200	124,232

This means that on the average 3.5 cars per day car were coming in and out of the midtown. Figure 1. shows the transition of the traffic density of the cars entering and leaving the city center, and to classify it by districts, the eastern district represents 47%, northwestern 20%, southwestern 18% and southern 15% respectively in 1959. Again, according to the figures of 1958, the relation of the traffic density of the cars towards the city center to the road capacity, when classified by sections is:

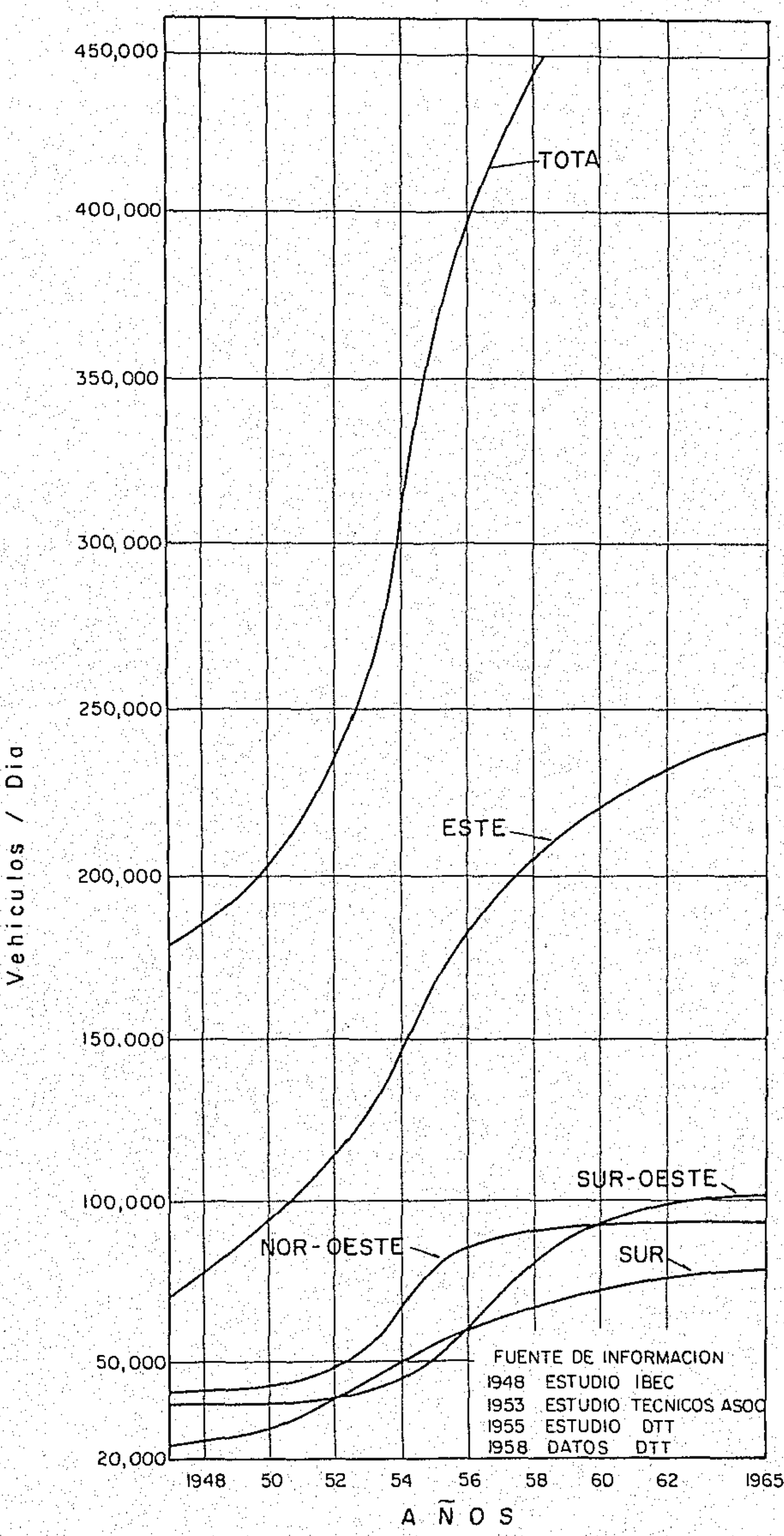
Sections	Road capacity (Number of cars per hour)	Traffic volume towards city center (number of cars per hour)	Balance (Number of cars per hour)
East	6,800	8,508	-1,708
Northwest	2,890	3,390	- 500
Southwest	2,600	3,300	- 700
South	2,000	2,485	- 485

This indicates the shortage of road capacity in all directions, which is the cause of the traffic jam; traffic from and to the east, the road capacity being the least in this case, takes more than an hour in rush hours, while taking less than a quarter of an hour when the traffic volume is less; thus the special expressways are completely paralyzed for a time and their utility is much spoilt.

In addition to the above-said deficiency in the road capacity, the bad arrangement and poor interconnection of various streets are causing traffic jam everywhere in the urban streets; furthermore, a large number of cars parking on the midtown streets together with 'Propuesto' making arbitrary stops for their passengers render the traffic all the more inconvenient.

Although strong traffic control is being enforced throughout the city, the insufficient capacity of the parking places outside the road makes it inevitable to allow parking on both sides of the narrow streets, except the main streets, which in turn reduces much of their traffic capacity, resulting in the major cause of traffic paralysis.

FIG I



MOVIMIENTO DE VEHICULOS ENTRE LOS DIFERENTES SECTORES DE CARACAS Y EL CASCO URBANO

4. FUTURE SITUATION OF URBAN TRAFFIC AND MEASURES TO BE TAKEN.

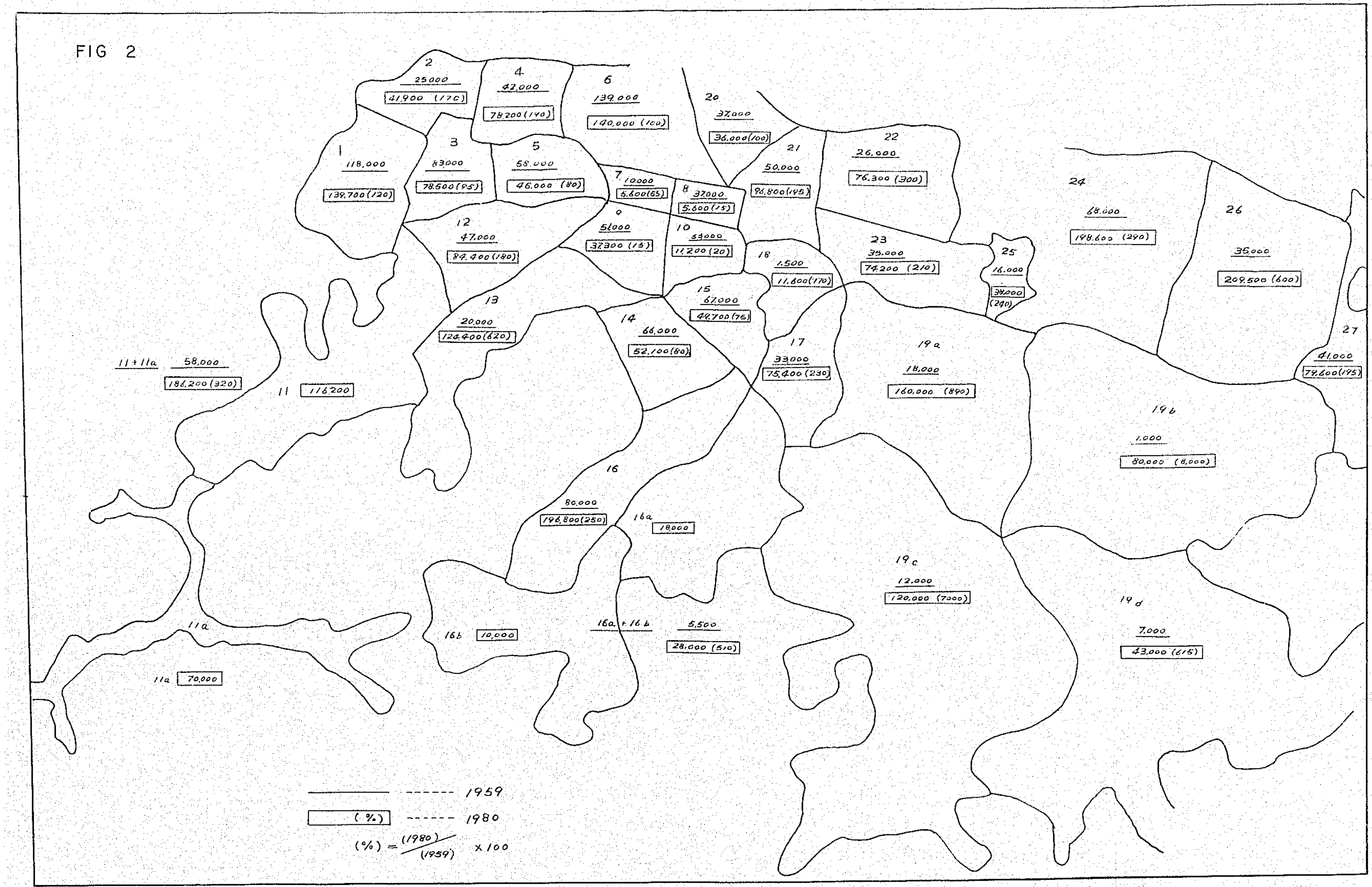
The latest information about the urban traffic has not been made available yet, and the Government has recently arranged to map out a new traffic program by means of establishing the 'Oficina del Transporte (O. M. T.) which will, on the basis of Programa Tentativo para Estudio', perform investigations and obtain data concerning the traffic question. Consequently, there was no way for the survey team but to refer to 'Annexed Documents to the Traffic Investigation Report' published in 1959 as the sole synthetic source material which had been lent by O. M. T. and recommended to the team by Dr. L. Azpurula, Chairman of O. M. T. In estimating the potential urban traffic and considering the measures to deal with it the team decided to attach importance to the above data.

4.1 Estimate of traffic volume.

The 'Annexed Documents to the Traffic Investigation Report' published in 1959 has made the estimate of the traffic density in 1980 on the basis of the city area divided, as shown in Fig. 2, into 34 sections, each of which containing a certain anticipated population, taking, at the same time, the characteristics and land utilizing programs of each section into consideration, and combining them with the existing data by the application of the law of gravitation. The prerequisits to the above estimate are enumerated as follows:

	1959	1980
Population (persons)	1,340,000	2,585,000
Number of motorcars		
Private cars	90,736	517,000
Commercial cars	12,351	8,617
Number of trips per head of population (trip/day)	1.45	1.78
Number of passengers per car (persons/car)		
Private cars	1.39	1.4
Commercial cars	2.07	1.5
Number of trips per car (trip/day)		
Private cars	5.0	3.5
Commercial cars	16.0	20.0

FIG 2



	1	2	3	4	5	6	7	8	9	10	11	11a	12	13	14	15	16	16a	16b	17	18	19a	19b	19c	19d	20	21	22	23	24	26	26	27
Area (ha) (x100)	393	195	203	227	205	401	72	85	195	143	836		354	558	266	213	528	643		262	180	1043	1684	2516	2204	211	248	399	359	1205	96	890	726
Poblacion 1959 (x100)	1180	250	830	420	580	1390	100	370	510	530	580		470	200	660	670	800	65		330	15	180	10	120	70	370	500	260	350	680	160	350	410
" 1980 (x100)	1397	419	785	782	460	1400	56	56	373	112	1162	700	844	1244	521	497	1968	180	100	764	116	1600	800	1200	430	360	968	763	742	1986	380	2095	796

	1959	1980
Traffic volume in business zones (trip/day)	335	550
Traffic volume in industrial zones (trip/day)	200	250

The estimated traffic volume of persons and cars in the whole city in the years of 1959 and 1980 have been counted follows:

	1959		1980	
Movement of persons	trip/hectare		trip/hectare	
Private cars	857,455	44 %	2,533,300	55 %
Taxis	409,066	21	258,510	6
Bus'es	670,500	35	1,807,172	39
Total	1,937,021	100	4,598,982	100
Movement of cars				
Private cars	453,680	62	1,809,500	78
Taxis	197,616	27	172,340	7
Bus'es	85,065	11	349,736	15
Total	736,361	100	2,331,576	100

The municipal authorities as well as the Government have already mapped out a project of new construction and improvement of roads, and it is expected that a series of construction work will have been completed by 1980. However, even after the completion of the building work under the present program the traffic volume arising out of the entering and leaving the capital will amount to 900,000 cars a day. It follows that, in spite of the increased road capacity, as shown in the list below, traffic will become by far heavier and, except that in the northwestern section, completely paralysed especially in the streets from the eastern residential section to the midtown.

Sections	Traffic volume towards center (number of cars per hour)	Road capacity (Number of cars per hour)	Balance (Number of cars per hour)
Northwestern	3,811	5,250	+ 1,439
Southwestern	9,724	6,000	- 3,724
Southern	6,041	4,000	- 2,041
Eastern	36,172	13,450	-22,722

4.2 Measures to deal with urban traffic.

The estimate of the traffic demand, which has been stated above, will have to be naturally revised when new data concerning traffic have been made available and ways and means of dealing with urban traffic have been established. However, in view of the possible development of Caracas due to the prosperity of Venezuela it will not be long before the traffic volume of the city is doubled. In our opinion, therefore, it would be necessary to take urgent measures in order to deal with the traffic demand around the sub-center as well as the center of the city, especially that of the road connecting the eastern residential section with the midtown. Such ways and means should firstly be:

(1) To recondition the section where traffic is stagnant due to the poor connection and defective arrangement of the streets by means reviewing the conditions of the existing streets.

(2) To prohibit the parking of cars in the street in such congested places as the center, sub-centers of the city by means of constructing parking places outside the road.

(3) To promote the rationalization and efficiency of traffic by means of reviewing the ways of traffic control.

(4) To give priority to the construction work of the section where the traffic is heavy when prosectuting the already established road building program, and, at the same time, to construct such by-passes as go round the city center.

These measures are all considered urgently needed, but, at the same time, the following steps in connection with the use of traffic facilities would be also necessary in order to make effective and efficient use of the limited number of the existing roads:

(1) To establish a definite bus-transport system by means of integrating as well as liquidating the swarming bus enterprises, reorganizing the bus routes and modernizing as well as rationalizing the facilities and business management.

(2) To realize the gradual reduction in number of 'Propuesto' by means of imposing restrictions on the traffic of 'Propuesto' and at the same attracting the passengers to bus'es through the improvement of bus-transport system.

(3) To draw the users of private cars to bus'es as far as possible, as in the case of 'Propuesto' passengers.

However, there is a limit in the construction of roads to deal with the ever increasing motorcar traffic, as is demonstrated by the examples in other large cities; indeed, mere road construction would be impossible to meet the potential traffic demand. Even in the case of establishing with success bus termini and other facilities including the routes for their exclusive use there is naturally a limit in the enlargement of bus service, as the unit transport capacity is small.

It is of course indispensable as a future measure to expedite the improvement of the existing roads as well as the construction of new ones in accordance with the established program to deal with the traffic demand, but it is also urgently needed to construct rapid transit facilities of mass transport which do not make use of the road surface for the purpose of giving relief to the congestion and bringing about the smoothness of street traffic. It is considered necessary, centering around the above said idea, to establish organic traffic routes in the city based on the following measures:

(1) The rapid transit facilities should, as the nucleus of the transport facilities for the general public, constitute a network of arterial roads in the city in order to perform rapid and mass transport of the passengers travelling a comparatively long distance.

(2) The bus should resign its post as a major means of urban transport in favor of the rapid transit facilities and take special charge of the local transport of short distance where the rapid transit facilities are unavailable.

(3) Each of the above two means of transport should establish its own field of business and, in close cooperation with each other, prosecute a reasonable and efficient treansport business.

(4) In order to draw as many passengers as possible who utilize private cars or commercial cars (Libre and Propuesto) to the rapid transit facilities, stations in the environs of the city should be equipped with parking places which will provide the passengers with convenience in transfer.

5. RAPID TRANSIT FACILITIES OF TRANSPORT.

As we have stated above, the City of Caracas cannot depend on motorcars alone as a means of transport in order to deal with its present traffic situation, but it is an urgent necessity for it to construct a rapid transit means of transport in view of its anticipated development. Generally speaking, two types of rapid transit facilities are conceivable for urban mass transport:

an overhead railway and an underground railway. Although the construction cost of the former is lower than that of the latter, the former, when constructed along the road, is attended with such problems as the difficulty of acquiring necessary land for the railway in the established town, inconvenience caused by the construction work to the surface traffic, and defilement of the appearance of the town. Therefore, our proposition is to construct a rapid transit railway in which are properly combined the two types, one being an underground railway in the congested town area, the other an overhead railway in the outskirts of the town in order to save the time and cost of construction.

Besides, there is also a new type of urban traffic means — monorail — which has various advantages over the underground railway in that its construction cost is less: when compared with the ordinary elevated railway, its structure is lighter and simpler, and it can also make use of the space over the town by passing over the street and public-owned waters. However, it has not been long in use as a means of transport for the general public, and our studies of this type are inadequate. This is the reason why we should like to recommend a combined type, consisting mainly of an underground railway and partially of an elevated railway.

5.1 Alignment of railway network.

The streets of Caracas with its old town as its center, stretch in four strips in the four directions of northwest, southwest, south and east, and the main tide of traffic flows roughly along these four streets from the center of the city. However, the traffic around Sabana Grande and Chacaito sections, which are both being developed as the sub-centers of the city, is also worthy of attention.

All of the traffic from those four sections to the city center and the above-said sub-centers is so much congested that it is in need of an urgent relief measure.

Besides, the traffic from the southeastern section, which is now making big strides as a new residential district, should also be taken into consideration.

Accordingly, the network of the potential rapid transit railway should contain the following routes connecting the above-said five sections with the city center:

(1) A route from Catia which is in the northwestern section to the city center

(2) A route from Antimano and Bella Vista which are in the southwestern section to the city center

(3) A route from Choche and Los Rosales which are in the southern section to the city center

(4) A route from Prados del Este and Los Naranjos which are in the southeastern section to the city center

(5) A route from Patare and Chacao which are in the eastern section to the city center.

In addition to the above, the center and sub-centers should be linked directly with each other.

We have mapped out a plan of forming an organic network, while considering the satisfaction of the various prerequites to the routes which we had stated in our First Report, which stretches from the above-said five sections to the city center, each route being linked with the other. The gist of the network is as follows:

(a) Each route should pass through the city center, and, at the same time, contribute to the future development of the city.

(b) Priority routes should be connected with each other.

(c) The routes and their connections with each other should be determined after having carefully investigated the traffic congestion in the street and fully considered the correlation with the street traffic.

(d) Times of changing cars should be made as few as possible, and transfer as convenient as possible.

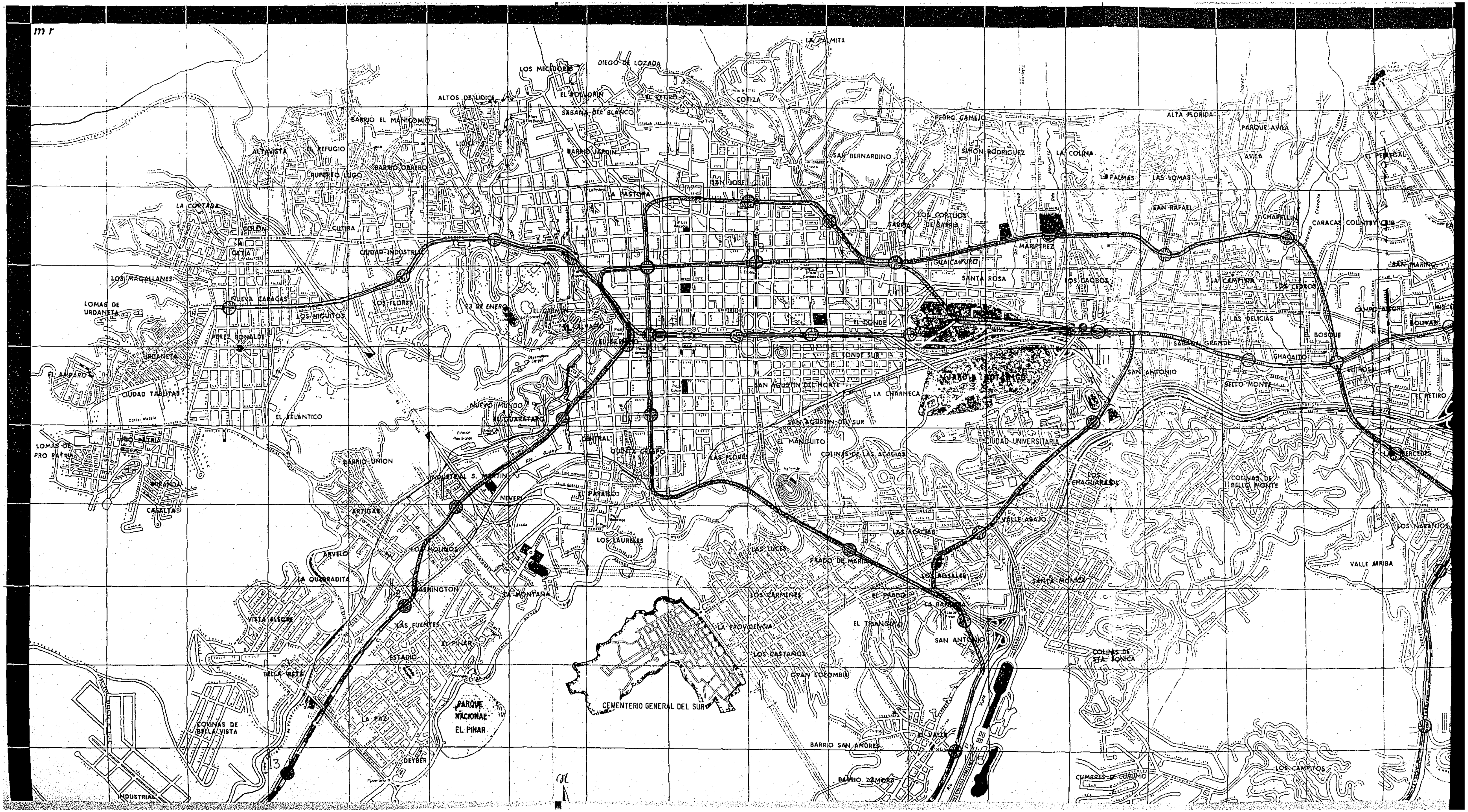
(e) The tracks of each route should be joined together so as to make an economical use of cars and an intensive use of repairshops.

(f) The selection of the routes should be based on the principle of utilizing the underground of the existing roads, and, at the same time, considering the use of such open space as rivers and greens.

The network plan thus made out is shown in the map attached to the First Plan and the Second Plan. (Fig. 3 and 4)

Both Plans which contain three routes respectively have been made out on the basis of the above idea, taking into consideration the correlation of the routes with each other.

The First Plan has been formed in close touch with the reality of the traffic situation, regardless of the construction work and existing program, but it may contain more attractive routes than the Second Plan, as will be seen later, dependent upon the idea of the station facilities.



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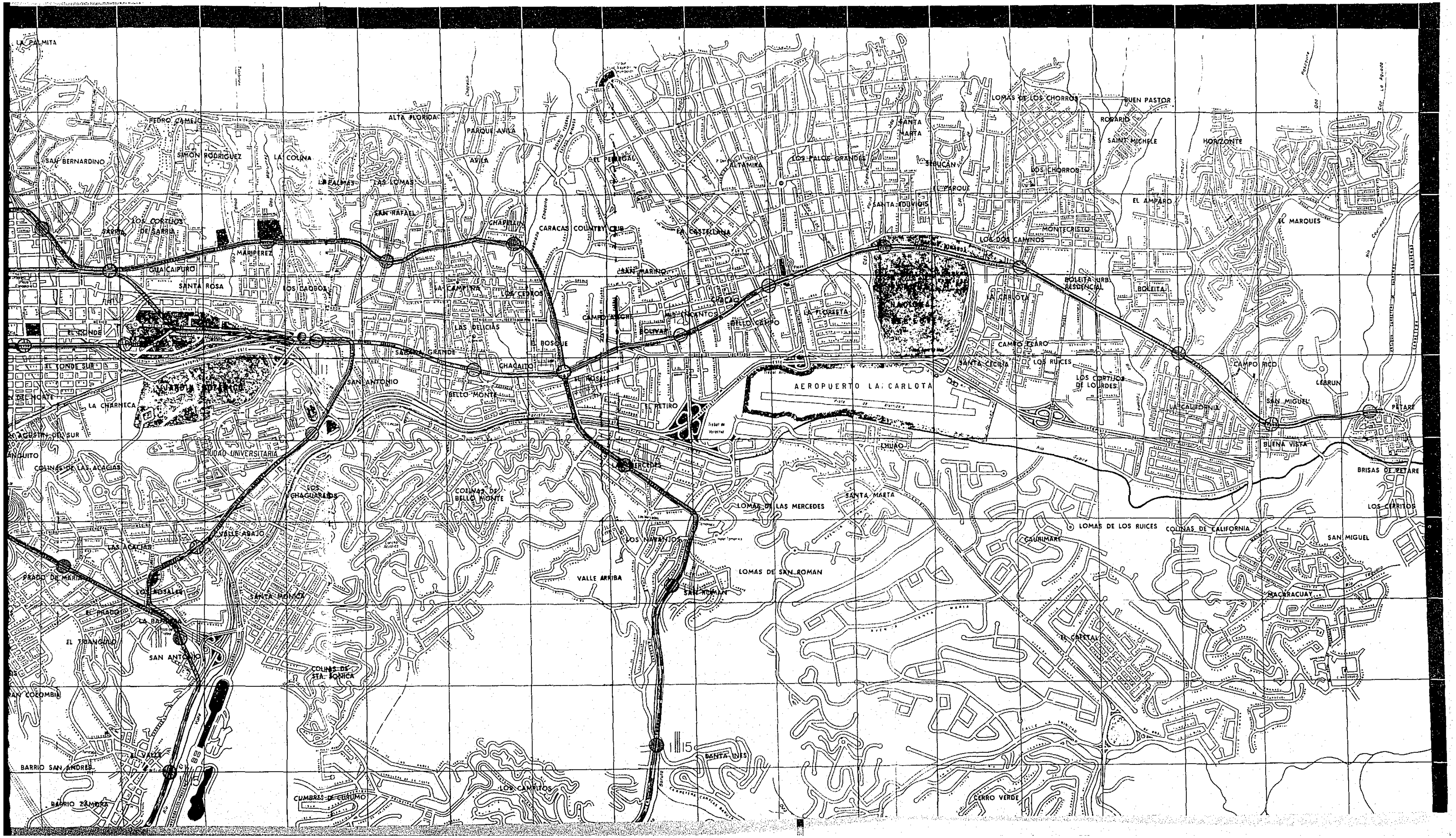

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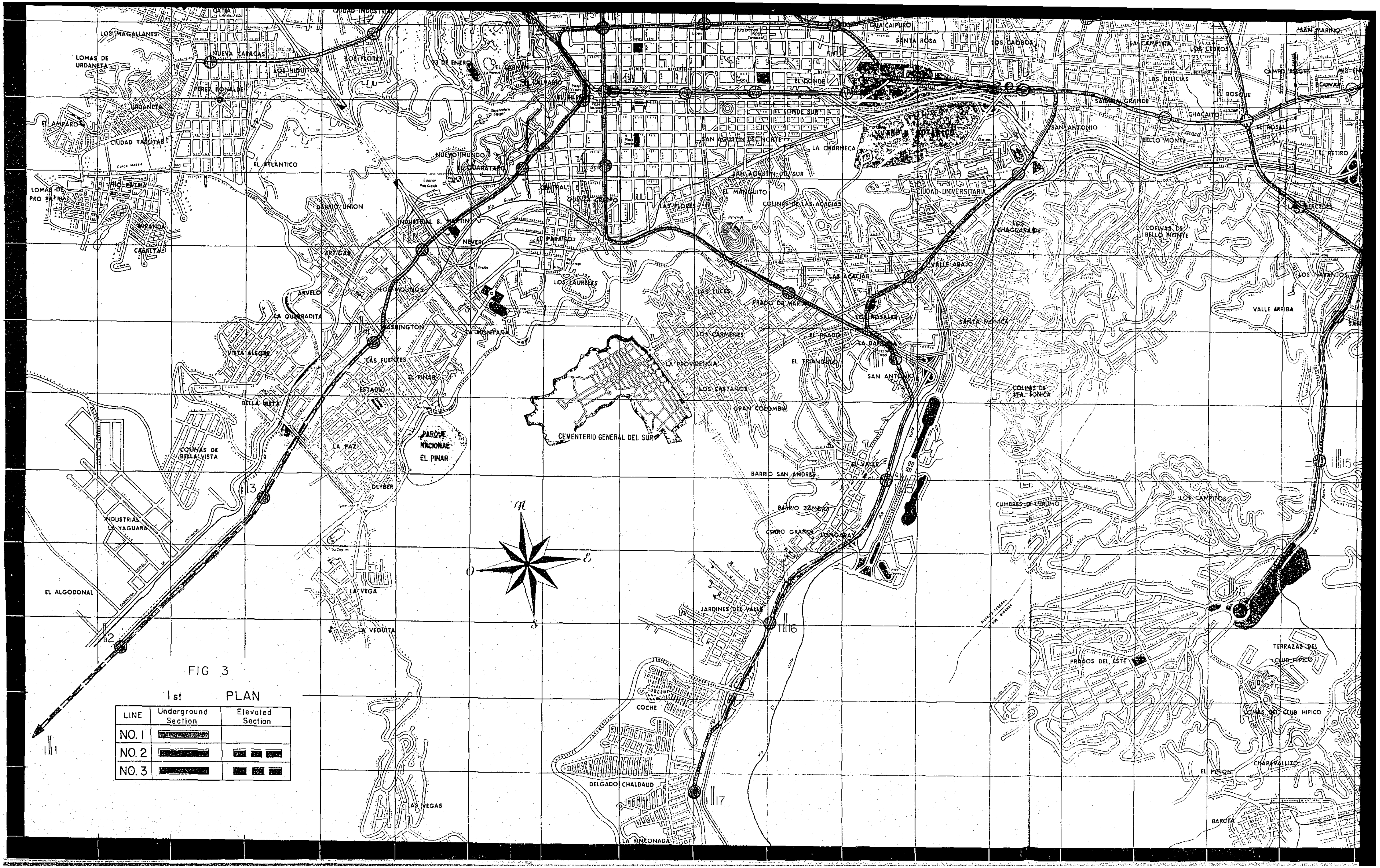

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FIG 3
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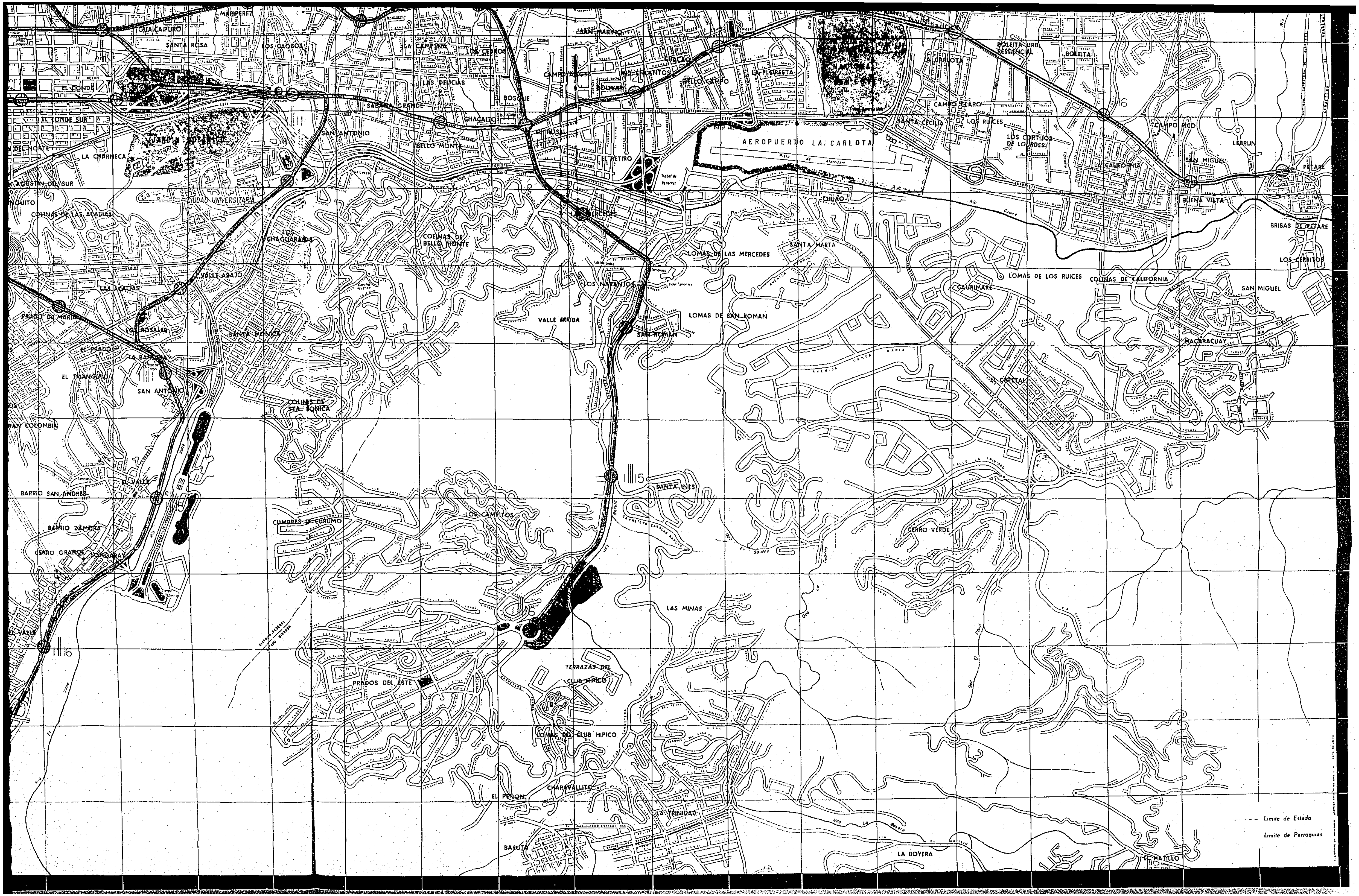

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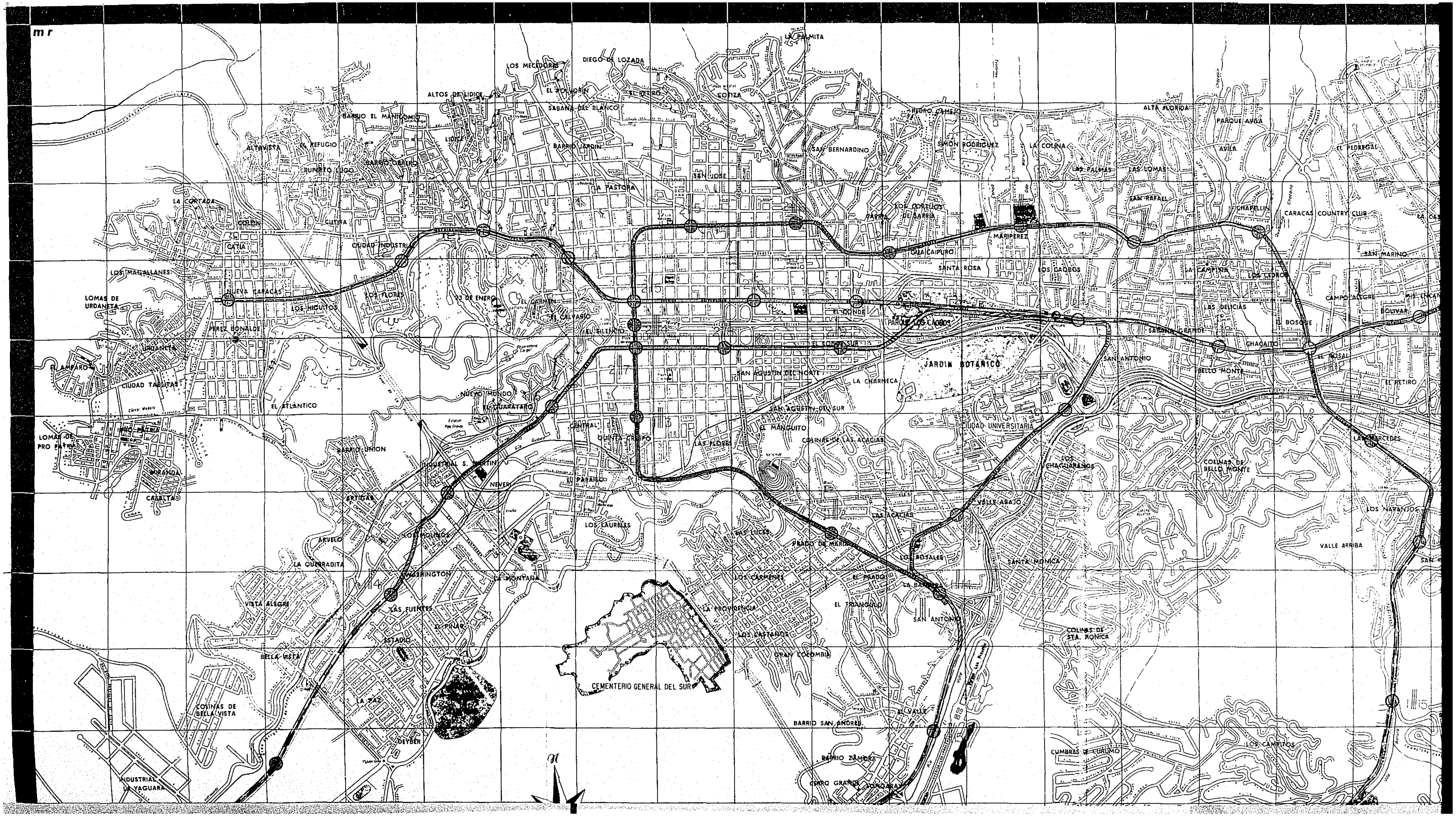
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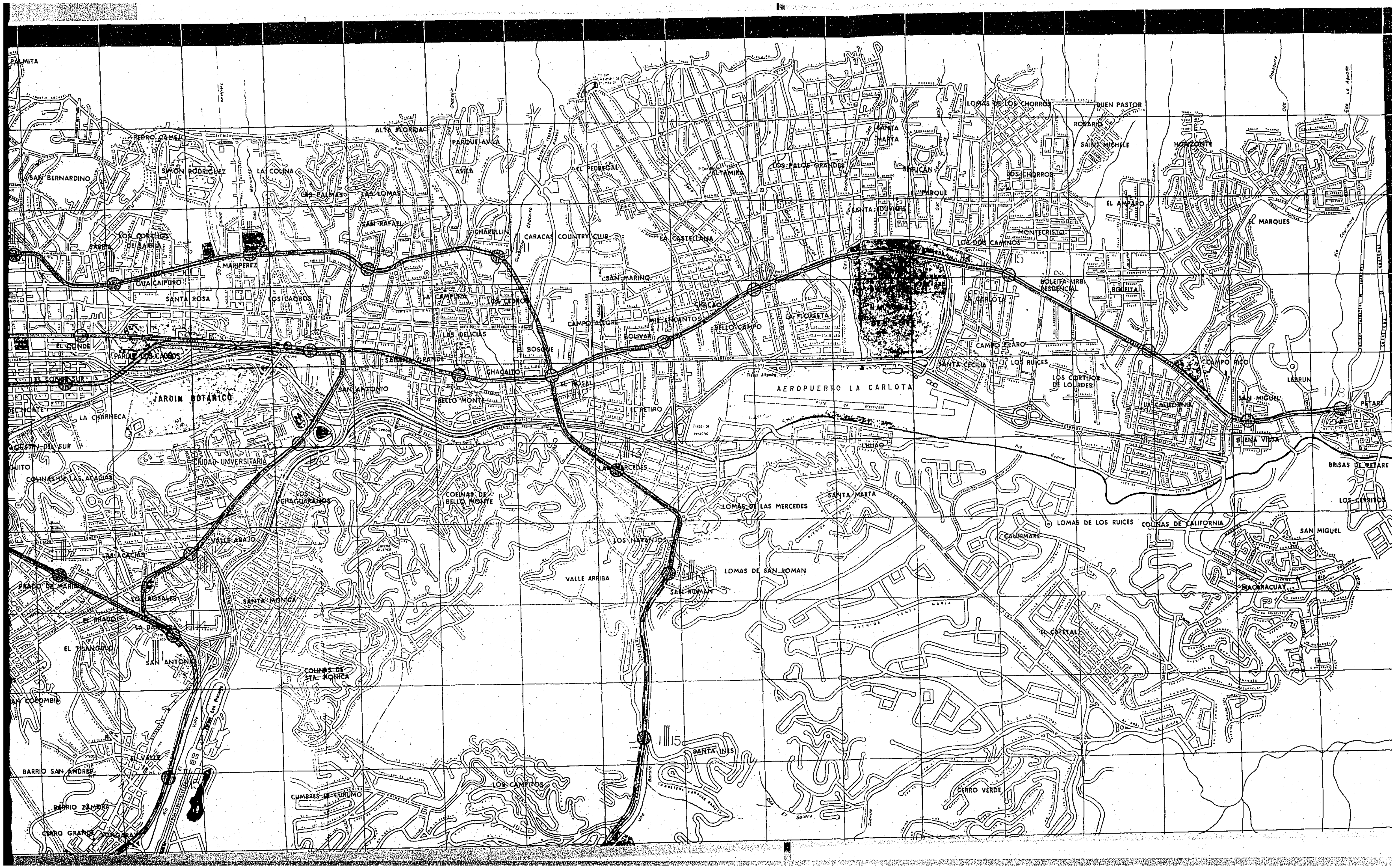

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BARRIO ZAMORA
CERRO GRANDE

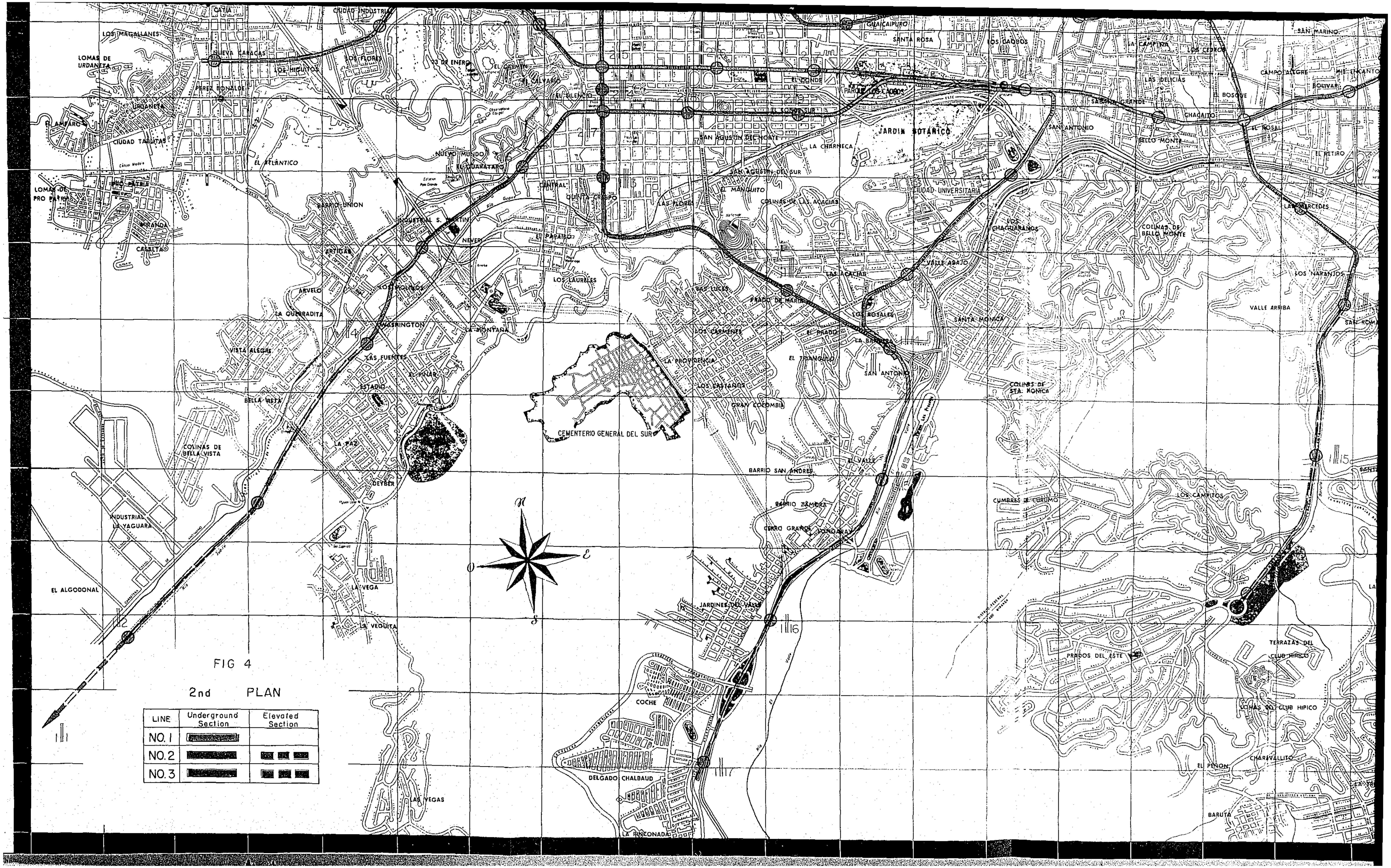
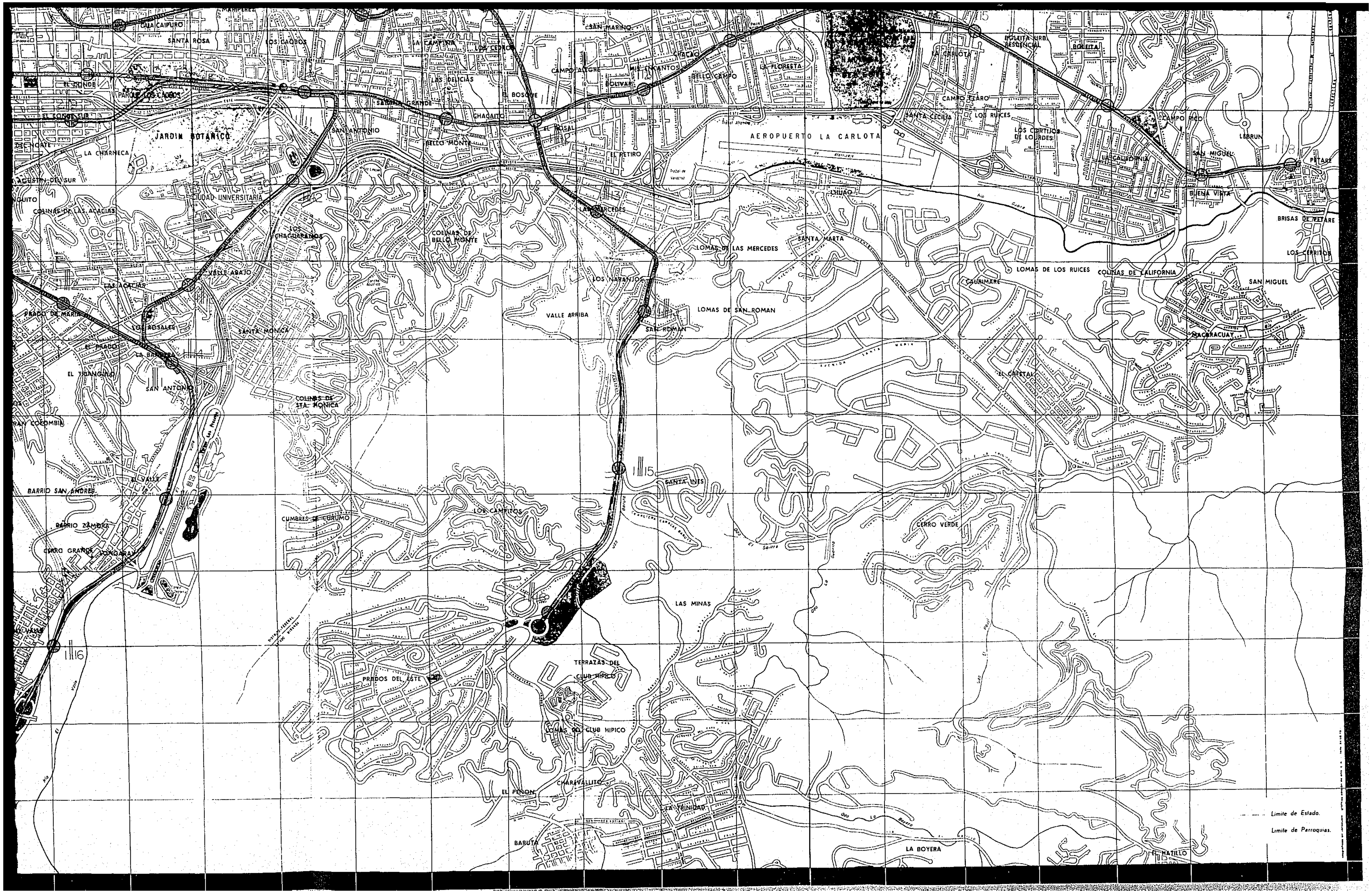


FIG 4

2nd PLAN


GUAICAIPURO
SANTA ROSA
LOS CAOBOS
LA CAMPIÑA
LOS CEDROS
SAN MARINO
CHACAO
CAMPO ALEGRE
MIS ENCANTOS
BOLIVAR
BELLO CAMPO
LA FLORESTA
BOLEITA URB. RESIDENCIAL
BOLEITA
LA CARLOTA
EL CONDE
PARQUE LOS CAOBOS
LAS DELICIAS
SABANA GRANDE
EL BOSQUE
CHACAITO
EL ROSAL
CAMPO CLARO
SANTA CECILIA
LOS RUICES
CAMPO RICO
EL CONDE SUR
JARDIN BOTANICO
SAN ANTONIO
BELLO MONTE
AEROPUERTO LA CARLOTA
LOS CORTIJOS DE LOURDES
LEBRUN
LA CHARNECA
EL RETIRO
LA CALIFORNIA
SAN MIGUEL
PETARE
CIUDAD UNIVERSITARIA
LAS MERCEDES
BUENA VISTA
BRISAS DE PETARE
COLINAS DE LAS ACACIAS
LOS CHAGUARAMOS
COLINAS DE BELLO MONTE
LOMAS DE LAS MERCEDES
SANTA MARTA
LOS CERRITOS
VALLE ABAJO
LOMAS DE LOS RUICES
COLINAS DE CALIFORNIA
LAS ACACIAS
LOS NARANJOS
CAURIMARE
SAN MIGUEL
PRADO DE MARIA
VALLE ARRIBA
LOMAS DE SAN ROMAN
LOS ROSALES
SANTA MONICA
SAN ROMAN
MACARACUAY
EL PRADO
LA BANDERA
EL CAFETAL
EL TRIANGULO
SAN ANTONIO
COLINAS DE STA. MONICA
GRAN COLOMBIA
EL VALLE
SANTA INES
BARRIO SAN ANDRES
CUMBRES DE CURUMO
LOS CAMPITOS
CERRO VERDE
BARRIO ZAMORA
CERRO GRANDE
LAS MINAS
TERRAZAS DEL CLUB HIPICO
PRADOS DEL ESTE
LOMAS DEL CLUB HIPICO
EL PEÑON
CHARAVALLITO
LA TRINIDAD
BARUTA
LA BOYERA
EL HATILLO
Limite de Estado.
Limite de Parroquias.

The Second Plan may be considered a second best one, although its construction work is comparatively easier than that of the First Plan.

Of the lines No. 1 and No. 2 the sections to be laid in the southern district which is outside the town area should be of an overhead structure. Stations in the environs of the city should be located with long intervals between them, while those in the midtown with an interval of not more than 700 m.

Table 5 Length of line and number of stations; First Plan

Line		Length of line		Number of stations
No. 1	Underground section Elevated section	17.50 km 0	17.50 km	18
No. 2	Underground section Elevated section	12.20 10.60	22.80	17
No. 3	Underground section Elevated section	14.00 4.00	18.00	16
Total	Underground section Elevated section	43.70 14.60	58.30	51

Table 6 Length of line and number of stations; Second Plan

Line		Length of line		Number of stations
No. 1	Underground section Elevated section	17.30 km 0	17.35 km	17
No. 2	Undergroun section Elevated section	11.17 10.60	21.77	16
No. 3	Underground section Elevated section	13.64 4.00	17.64	15
Total	Underground section Elevated section	42.16	56.76	48

5.2 Indication of station names.

The indication of the station names appearing in Fig. 3 and Fig. 4, which are attached network maps, should be interpreted as follows:

$_1{}^{I}{}_{12}$ Station .... The 12th station of No. 1 Line, First Plan

$_2{}^{II}{}_{10}$ Station .... The 10th station of No. 2 Line, Second Plan

$_1{}^{III}{}_{4}$ Station .... The 4th station of No. 3 Line, First Plan

In case that the location of a station of the First Plan coincides with that of the Second Plan, the same indication has been employed.

6. CONSTRUCTION PROGRAM .

In the construction of the network, which line should be started first and when it should be completed are the matters to be determined by the traffic demand. It is indisputable that, of the three lines, the priority line is No. 1 Line either in the case of the First Plan or the Second Plan.

As for No. 1 Line, the section between Silencio and Sabana Grande (6. 85 km in the First Plan and 6. 70 km in the Second Plan) should be assigned to the first construction period, and the section between the stations $1^{I}5$ and $1^{I}11$ should be opened for service, first of all, to meet the demand of the citizens. This section may be possible to be completed in two years if the construction work is started simultaneously throughout the whole line. For the business of this primary section 26 cars will be enough, operating a train composed of 4 cars at an headway of 5 minutes.

These cars are hauled underground through an inclined shaft which makes use of the greens of Parque los Caobos to the east of the $1^{I}9$ station. The parking place of those cars should be a tunnel stretching from the station $1^{II}11$, the terminal station in the east, to the vicinity of the station $1^{I}12$. Pits for the temporary inspection of cars should be dug under the track at some places in the tunnel.

The next section to be constructed should naturally be the rest of No. 1 Line which will be completed by the extension of the line as far as Catia ($1^{I}1$ station) in the west and Petare ($1^{I}18$ station) in the east respectively. During this second construction period a parking place for all rolling-stock of No. 1 Line and a workshop should be built in a lot on the north of No. 1 Line, by means of braching off the track somewhere short of Petare, the terminal station. This workshop should be so designed as to admit of enlargement in case of constructing No. 2 and No. 3 Lines in future.

The section and progress schedule of the construction work of the lines No. 1 and No. 2 might be determined by the business results of No. 1 Line together with the consideration of the traffic situation to be brought about by the development of Caracas.

7. TRANSPORT PROGRAM.

7.1 Estimate of transport volume.

It is anticipated that there will be in Caracas in 1980, if the trend of things remains the same, a traffic demand amounting to 4,598,982 persons, of which 39% are considered to utilize bus'es, 6% taxis, and the rest, or 55%, private cars. The percentage shared by each means of transport would naturally vary with the completion of the rapid transit railway. As stated above, the objects of the rapid transit facilities would be as follows, if a reasonable and efficient management of various types of transport means were realized:

(1) All traffic demand anticipated to utilize bus'es

(2) 50% of the traffic demand anticipated to utilize taxis

(3) 10% of the traffic demand anticipated to utilize private cars

This traffic demand, which would be the object of the rapid transit railway, when classified by districts as in Table 5, will amount to 2,195,427 persons. The number of reciprocal arrival and departure of each district found by means of following the estimation method employed in 'Annexed Documents to the Traffic Investigation Report' published in 1959 is shown in Table-6, which excludes the transport in the same district or neighboring ones and also in the district where bus'es are considered more convenient than the rapid transit railway, assuming that the transport of all such districts will depend on bus'es.

A tentative computation of the passengers of each line who would be the objects of the above-said rapid transit facilities would be as follows:

Line	First Plan (persons)	Second Plan (persons)
No. 1	829,600	844,500
No. 2	590,700	603,400
No. 3	677,900	651,300

The number of transit passengers of each line is shown in Fig. 5 and Fig. 6; the maximum number of transit passengers of each line per day and the number of transit passengers per rush hour are presumed as follows (in 1980):

Table 5. SUBWAY PASSENGERS EXPECTED TO TRANSFER FROM OTHER MEANS OF TRANSPORTATION

(Upon & down passengers per day.)

Zone.	Numbers of person			Total	Bus * 100%	Taxi * 50%	Private Car * 10%	Total	Remarks:
	Bus	Taxi	Private Car						
1	68,048	14,001	29,711	111,760	68,048	7,000	2,971	78,019	Subway passengers expected to transfer from other means of transportation. 100% of Bus 50% of Taxi 10% of Private Car
2	20,417	4,200	8,903	33,520	20,417	2,100	890	23,407	
3	38,239	7,868	16,693	62,800	38,239	3,934	1,669	43,842	
4	38,092	7,837	16,631	62,560	38,092	4,369	1,663	44,124	
5	22,395	4,611	7,794	36,800	22,395	2,306	779	25,480	
6	70,680	13,960	119,760	204,400	70,680	6,980	11,976	89,636	
7	2,759	558	3,851	7,168	2,759	279	385	3,423	
8	2,759	558	3,851	7,168	2,759	279	385	3,423	
9	18,393	3,714	25,637	47,744	18,393	1,857	2,564	22,814	
10	5,522	1,116	7,698	14,336	5,522	558	770	6,850	
11	100,979	11,636	72,143	184,758	100,979	5,818	7,214	114,011	
11a	60,833	7,009	43,458	111,300	60,833	3,505	4,346	68,684	
12	73,339	8,451	52,406	134,196	73,339	4,426	5,241	83,006	
13	108,102	12,456	77,238	197,796	108,102	6,228	7,724	122,054	
14	20,498	5,211	26,391	52,100	20,498	2,606	2,639	25,743	
15	19,557	4,971	25,172	49,700	19,557	2,486	2,517	24,560	
16	77,444	19,680	99,676	196,800	77,444	9,840	9,968	97,252	
16a	7,082	1,800	9,118	18,000	7,082	900	912	8,894	
16b	3,933	1,000	5,067	10,000	3,933	500	507	4,940	
17	29,669	7,541	38,190	75,400	29,669	3,771	3,819	37,259	
18	4,565	1,159	5,876	11,600	4,565	5,795	588	10,948	
19a	136,036	15,992	246,372	398,400	136,036	7,996	24,637	168,669	
19b	68,015	7,995	123,190	199,200	68,015	3,998	12,319	84,332	
19c	102,029	11,992	184,779	298,800	102,029	5,996	18,478	126,503	
19d	36,907	4,338	66,821	108,066	36,907	2,169	6,682	45,758	
20	30,610	3,597	55,433	89,640	30,610	1,799	5,543	37,952	
21	65,296	7,675	118,261	191,232	65,296	3,838	11,826	80,960	
22	64,873	7,626	117,488	189,987	64,873	3,813	11,749	80,435	
23	63,089	7,415	114,254	184,758	63,089	3,708	11,425	78,222	
24	168,859	19,850	305,805	494,514	168,859	9,925	30,580	209,364	
25	32,340	3,798	58,482	94,620	32,340	1,899	5,848	40,087	
26	178,129	20,939	322,587	521,655	178,129	10,470	32,259	220,858	
27	67,684	7,956	122,564	198,204	67,684	3,978	12,256	83,918	
Total	1,807,172	258,510	2,533,300	4,598,982	1,807,172	135,126	253,129	2,195,427	

Table 6. PASSENGERS BETWEEN EACH ZONE

Zone	1	2	3	4	5	6	7	8	9	10	11	11a
1		—	250	444	184	820	24	23	123	31	—	433
2	—		—	—	509	1,136	57	42	244	61	833	595
3	4,435	—		1,594	709	1,663	82	62	369	92	1,522	961
4	5,063	—	2,360		—	—	120	85	497	116	2,825	1,561
5	617	259	425	—		—	32	22	150	35	497	301
6	3,548	1,174	2,176	—	—		254	170	537	196	4,763	2,631
7	10,047	3,667	6,623	7,296	4,150	15,609		560	1,329	755	12,954	7,456
8	5,425	2,794	4,991	5,139	2,323	10,511	497		2,545	—	12,639	6,982
9	7,957	2,356	4,514	4,637	2,534	1,910	508	353		772	10,061	9,473
10	751	222	419	407	351	694	43	—	259		1,551	624
11	—	553	1,274	1,507	656	2,553	144	139	1,397	290		—
11a	612	115	257	319	127	544	25	23	207	48	—	
12	3,511	713	—	2,265	595	3,513	166	153	1,670	349	6,975	3,385
13	4,278	766	1,664	3,019	1,012	4,882	221	224	2,226	453	9,237	4,511
14	1,030	360	656	553	151	1,101	43	54	363	95	1,971	1,061
15	1,159	405	738	628	171	1,259	43	73	409	163	1,868	1,032
16	2,545	822	1,619	1,378	570	1,947	107	101	895	205	4,459	—
16a	247	564	157	134	55	189	10	10	370	26	434	—
16b	535	176	333	283	119	405	21	22	178	33	656	—
17	1,505	496	373	738	334	1,140	58	85	464	164	2,409	1,311
18	107	32	65	65	29	79	4	6	35	12	174	95
19a	846	265	484	397	175	975	40	49	309	101	1,169	754
19b	514	161	290	240	105	321	23	20	190	53	698	448
19c	462	137	263	208	92	449	20	72	154	44	500	288
19d	404	119	226	193	67	417	12	19	134	38	525	366
20	1,265	424	783	667	73	2,483	72	138	400	178	1,603	928
21	1,650	510	963	829	946	4,296	86	170	627	189	2,326	1,347
22	1,262	380	708	603	525	2,149	49	85	406	110	1,505	921
23	3,522	1,012	1,930	1,643	1,663	6,811	224	225	1,502	490	5,202	3,140
24	2,812	817	1,540	1,311	923	3,642	153	154	993	259	3,637	2,231
25	2,254	641	1,217	1,036	1,003	6,992	118	119	972	246	3,359	2,056
26	2,594	737	1,400	1,192	898	3,458	110	111	846	220	3,239	2,036
27	802	225	432	368	230	1,040	34	129	264	69	1,009	637
Total	72,820	21,104	40,514	39,731	22,347	85,881	3,419	3,362	23,502	5,944	110,945	57,802

Zone	12	13	14	15	16	16a	16b	17	18	19a	19b	19c
1	551	690	172	125	540	47	29	189	53	932	357	599
2	641	813	298	267	1,242	107	60	411	112	1,578	691	1,148
3	—	1,603	435	418	1,812	157	91	594	148	2,402	1,064	1,765
4	2,454	3,393	484	486	2,018	175	101	691	165	2,576	1,153	1,839
5	423	547	64	62	404	35	21	168	38	552	245	392
6	3,759	5,151	945	909	9,707	243	143	1,165	267	6,259	2,475	3,952
7	11,052	15,139	2,315	2,225	9,640	834	457	3,112	526	16,022	6,919	10,672
8	10,140	13,859	2,879	3,326	9,028	761	438	4,479	1,170	19,353	7,568	11,793
9	16,596	23,145	2,941	2,827	12,248	1,053	575	3,917	1,119	15,494	8,063	12,623
10	1,298	1,764	299	422	1,665	108	45	558	145	2,293	886	1,339
11	4,930	6,021	1,095	687	4,178	361	196	1,336	381	4,815	2,114	3,394
11a	750	1,027	188	158	—	—	—	236	66	1,000	440	694
12		—	1,261	1,010	4,813	416	220	1,497	427	5,127	2,180	3,457
13	—		1,651	1,347	6,417	555	293	1,995	570	6,836	2,936	4,609
14	1,575	2,134		—	2,048	177	93	927	238	2,752	1,076	1,676
15	1,475	2,020	—		2,304	139	105	1,054	336	3,097	1,211	1,897
16	1,221	4,277	1,214	1,168		477	379	2,314	582	6,735	6,758	4,141
16a	246	474	118	114	530		29	184	57	703	269	—
16b	664	910	227	219	1,551	107		423	110	1,316	544	—
17	1,870	2,562	938	902	3,908	270	176		—	—	2,024	—
18	135	165	56	73	251	22	12	—		420	140	216
19a	855	1,172	368	354	1,533	143	73	—	222		—	2,138
19b	491	675	104	187	810	73	41	365	194	—		2,141
19c	426	583	166	159	670	—	—	—	84	1,680	1,170	
19d	379	517	146	140	606	545	32	253	72	1,358	—	—
20	1,218	1,668	314	330	1,209	108	59	566	—	3,037	1,433	2,113
21	1,768	2,421	561	420	1,664	151	83	766	219	4,129	2,585	3,745
22	1,691	1,495	357	284	2,049	197	98	765	—	4,110	2,304	2,317
23	4,601	5,480	1,696	1,031	7,073	699	332	2,638	753	14,160	8,032	11,611
24	2,651	3,624	1,159	1,115	4,244	392	206	1,565	453	6,513	—	9,939
25	2,434	3,335	961	924	4,573	430	219	1,706	498	9,172	—	9,643
26	2,315	3,203	876	843	3,979	373	209	1,486	424	7,982	—	7,311
27	724	991	273	262	1,242	112	62	464	132	2,432	—	2,420
Total	78,423	112,120	24,661	23,660	103,353	9,265	4,866	35,853	3,834	159,857	64,604	121,006

Zone	19d	20	21	22	23	24	25	26	27	
1	223	180	339	378	313	936	148	1,065	374	10,889
2	424	393	689	751	592	1,717	277	2,033	673	15,429
3	660	588	1,042	1,120	905	2,714	421	3,092	1,063	32,856
4	735	655	1,160	1,247	1,007	3,022	469	3,443	1,164	39,061
5	154	347	649	527	495	1,032	229	1,258	437	10,409
6	1,572	2,410	6,606	4,393	4,127	6,293	1,766	9,874	3,306	92,494
7	4,259	4,705	7,569	6,230	8,415	21,615	3,294	19,560	6,690	235,146
8	4,496	8,262	14,725	10,769	8,423	21,635	3,297	10,586	6,702	259,912
9	4,771	2,670	9,212	7,841	8,603	19,427	4,112	22,634	7,940	252,604
10	502	613	956	796	1,049	2,409	289	2,222	771	25,429
11	1,305	1,007	2,116	1,992	2,041	5,362	973	5,986	2,078	61,720
11a	285	186	399	399	394	1,050	190	1,201	419	11,337
12	1,327	1,104	2,369	2,084	2,265	5,628	1,016	6,174	2,150	67,966
13	1,769	1,472	3,078	2,777	3,019	7,503	1,368	8,231	2,666	91,244
14	633	341	915	850	1,197	3,075	501	2,362	1,010	31,660
15	719	529	861	792	1,348	3,462	564	3,281	1,137	34,254
16	1,579	805	1,667	2,635	2,957	6,650	1,414	7,551	2,730	73,162
16a	159	82	104	336	314	635	150	327	277	6,734
16b	336	163	326	567	568	1,326	277	1,614	550	14,760
17	1,112	641	1,253	1,826	1,866	4,214	892	4,952	1,722	40,274
18	81	—	90	—	135	304	65	358	125	3,562
19a	797	459	859	1,300	1,338	4,922	639	3,551	1,235	25,635
19b	—	293	761	991	1,025	—	—	—	—	11,389
19c	—	236	602	778	795	2,605	457	2,600	886	16,675
19d		203	474	559	586	1,841	334	2,028	—	12,651
20	788		—	1,407	1,587	2,757	756	2,899	1,167	32,490
21	1,277	—		4,001	2,822	5,759	1,307	6,732	2,274	56,674
22	1,085	668	2,727		2,303	3,778	1,197	6,524	2,167	45,225
23	3,815	2,543	6,513	7,770		19,501	5,055	20,680	6,869	156,056
24	3,047	1,175	3,524	3,392	5,189		4,733	19,806	6,586	99,765
25	2,209	1,627	4,054	5,470	6,545	24,056		14,559	5,900	116,189
26	2,675	966	3,298	4,672	4,389	15,797	2,282		10,906	91,437
27	—	356	1,003	1,393	1,309	4,715	817	9,790		33,843
Total	43,409	36,704	79,225	80,303	78,221	206,016	39,436	217,602	82,120	2,095,194

FIG 5 FLOW MAP OF SUBWAY PASSENGERS

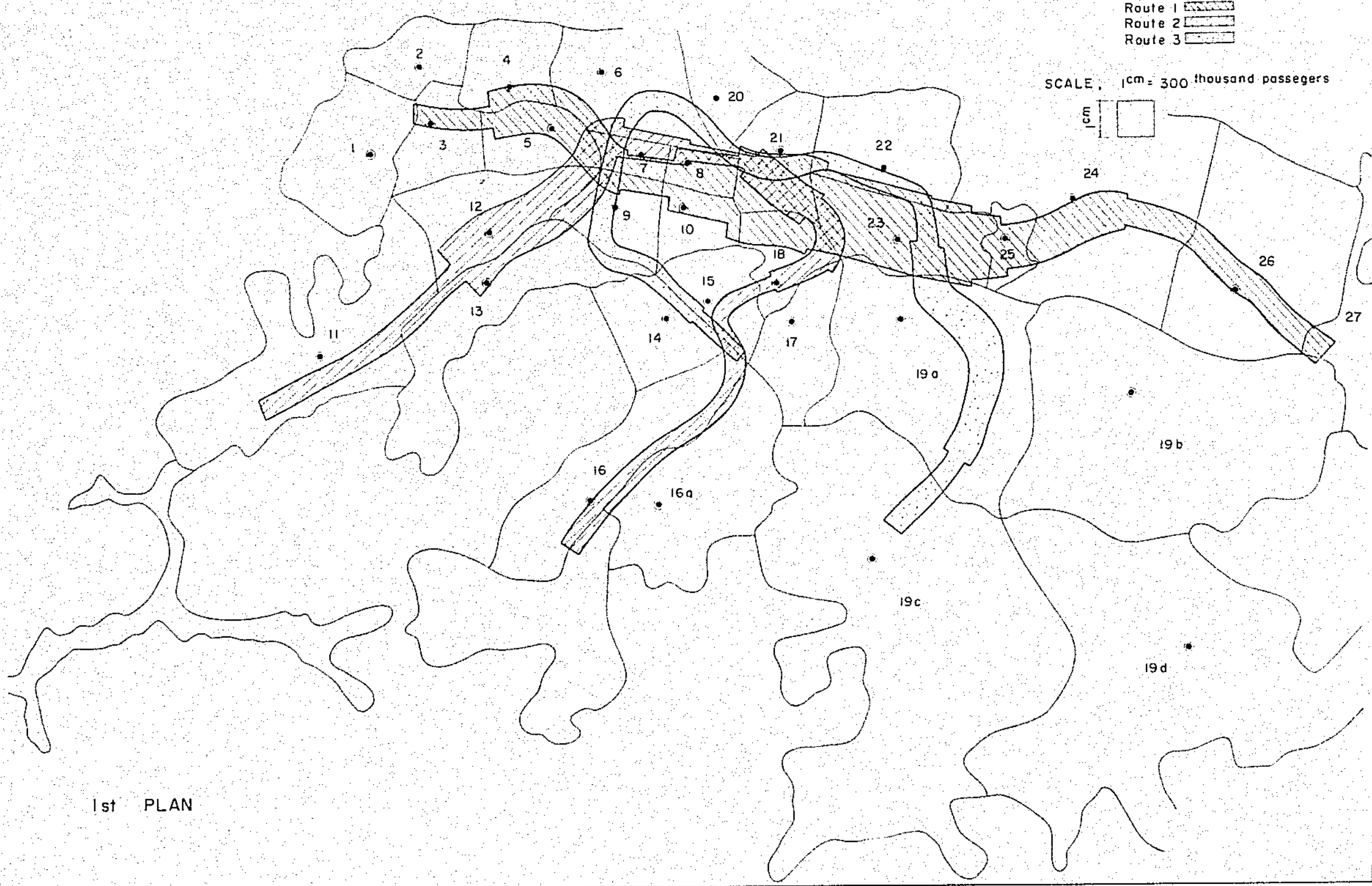
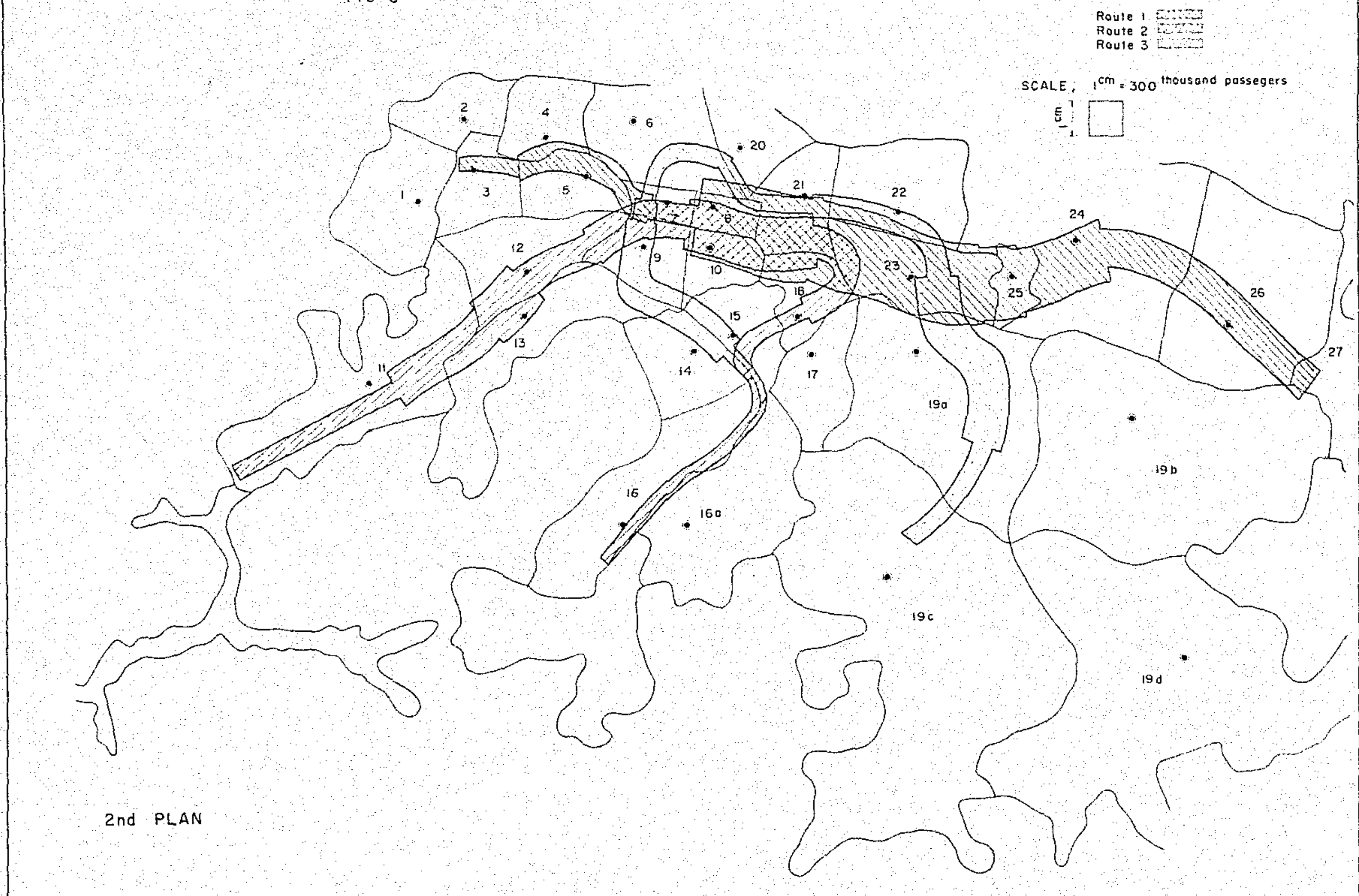


FIG 6 FLOW MAP OF SUBWAY PASSENGERS



Line	First Plan	
	Transit passengers per day (both ways) (persons)	Transit passengers per rush hour (one way) (persons)
No. 1	745,600	37,300
No. 2	513,600	25,700
No. 3	377,300	18,900

Second Plan

	Transit passengers per day (both ways) (persons)	Transit passengers per rush hour (one way) (persons)
No. 1	754,400	37,800
No. 2	465,400	23,300
No. 3	377,300	18,900

In this case the ratio of the number per rush hour to the number per day is supposed to be 10% in consideration of the probable change in the manners and customs of life in Caracas, although the actual figures in the street traffic of the city are 8%. Besides, the frequency of transfer in each line is shown in Fig. 7-20.

Notes: Above is the rough computation of the traffic demand. New estimation will become necessary when the collection and arrangement of new data as well as the investigation concerning traffic have been completed.

7.2 Minimum headway of train operation, formation of train and transport capacity.

If the number of passengers per car is limited to 150 from the viewpoint of comfortableness of ride, and, if, at the same time, the headway of trains is assumed to be 2 minutes, the transport capacity per hour will be:

8-car train: 150(persons) x 8(cars) x 30(times/day) = 36,000(persons)

6-car train: 150(") x 6(") x 30(") = 27,000(")

4-car train: 150(") x 4(") x 30(") = 18,000(")

Therefore, the schedule of train operation, both in the case of the First Plan and the Second Plan, has been made out as follows:

No. 1 Line:	8-car formation	2-minute headway
No. 2 Line:	6-car "	" "
No. 3 Line:	4-car "	" "

FIG 7 Section of lines & points for change of cars

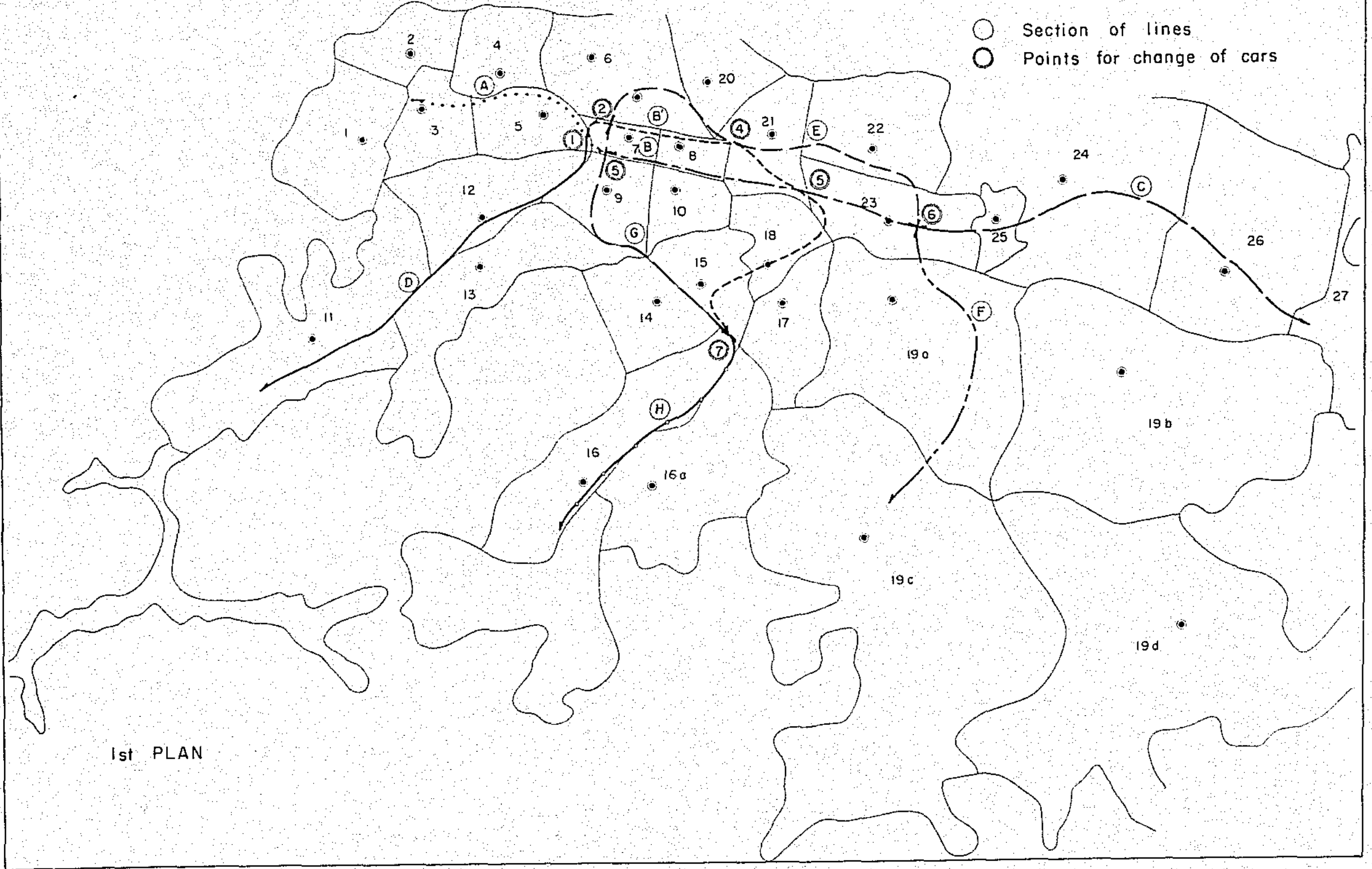
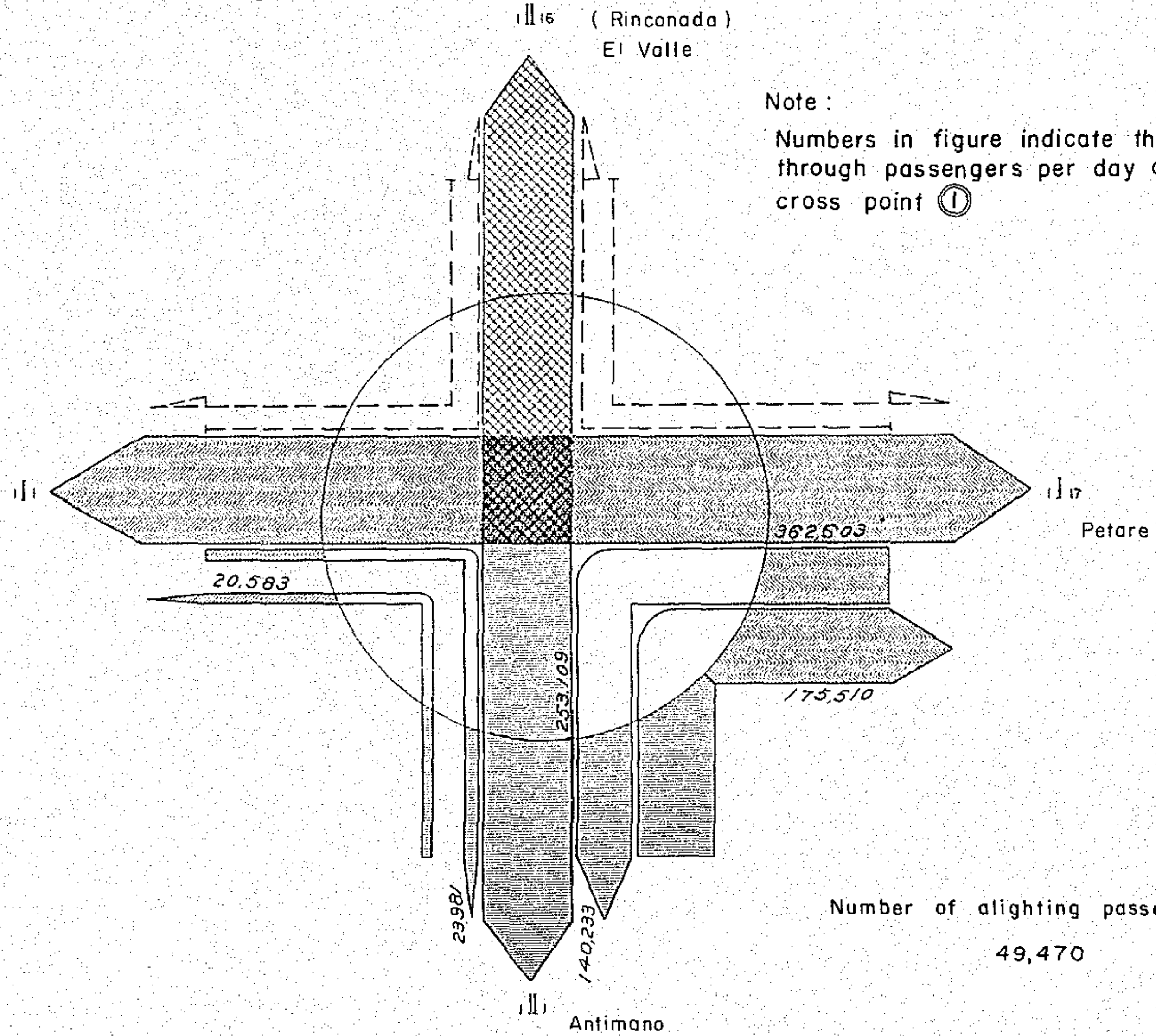


Fig 8 Figure for change of cars (1st plan)



Note :
Numbers in figure indicate the through passengers per day at cross point ①

Number of alighting passengers
49,470

Fig 9 Figure for change of cars (1st plan)

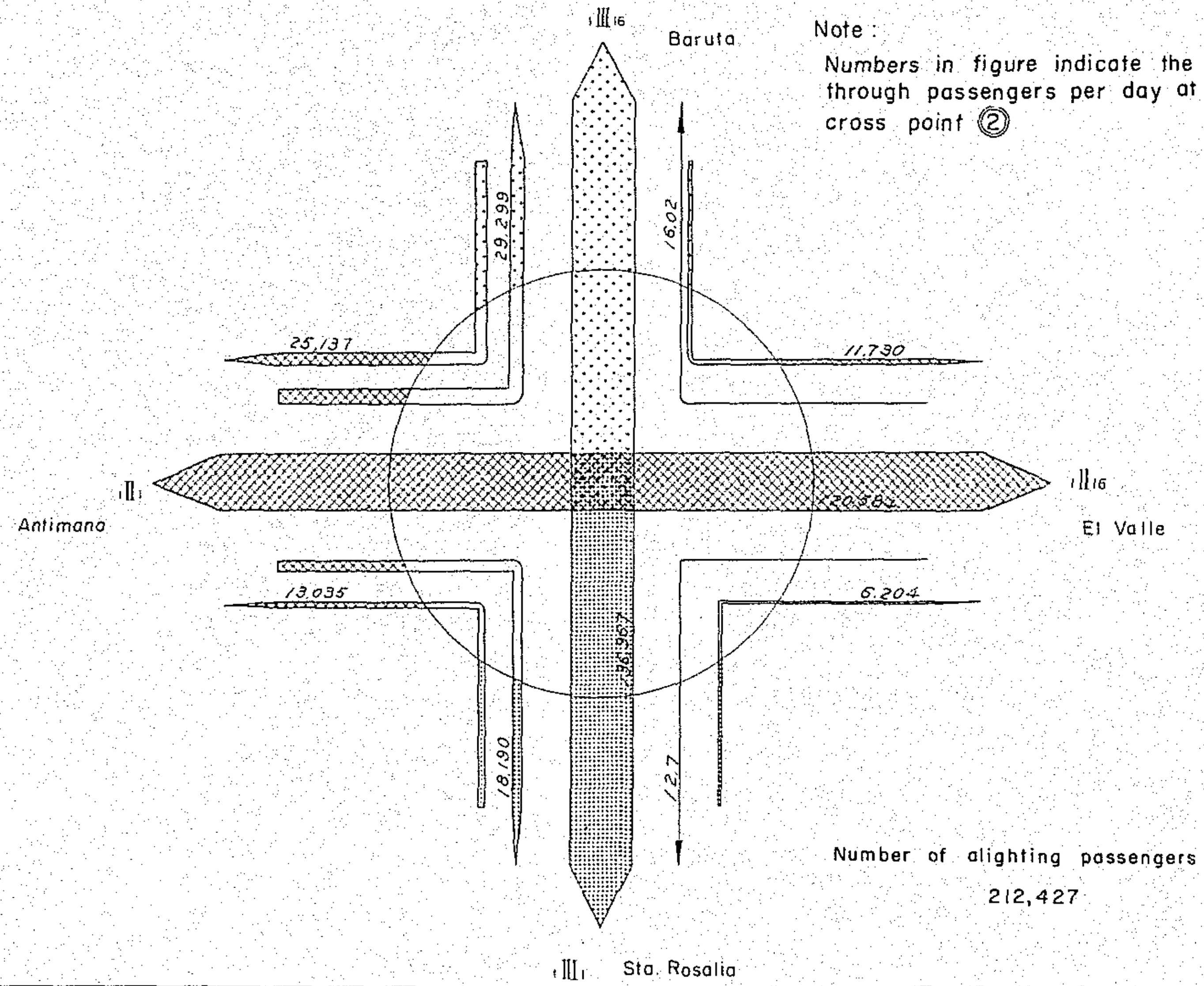


Fig 10 Figure for change of cars (2nd plan)

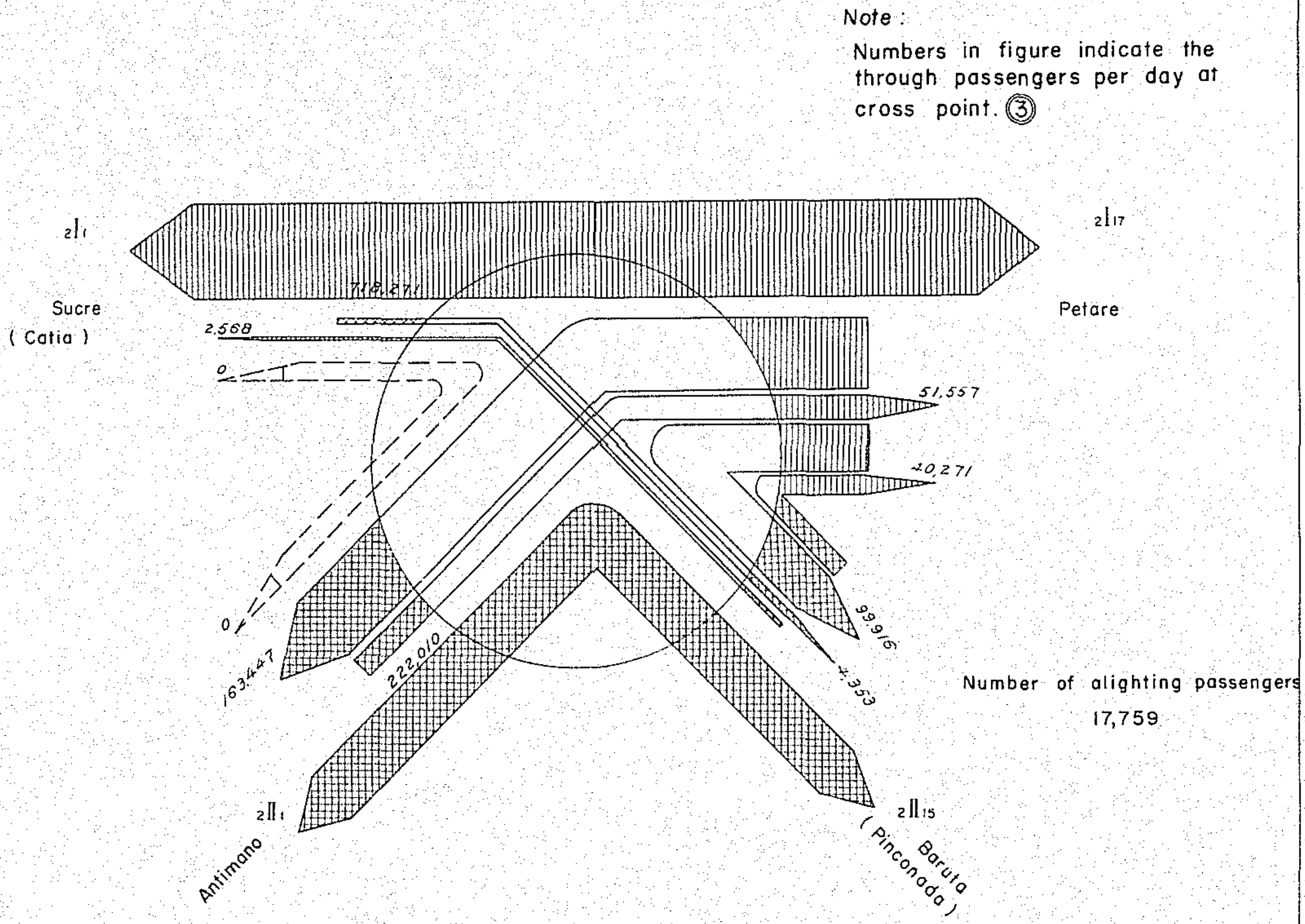


Fig. 11 Figure for change of cars (1st plan)

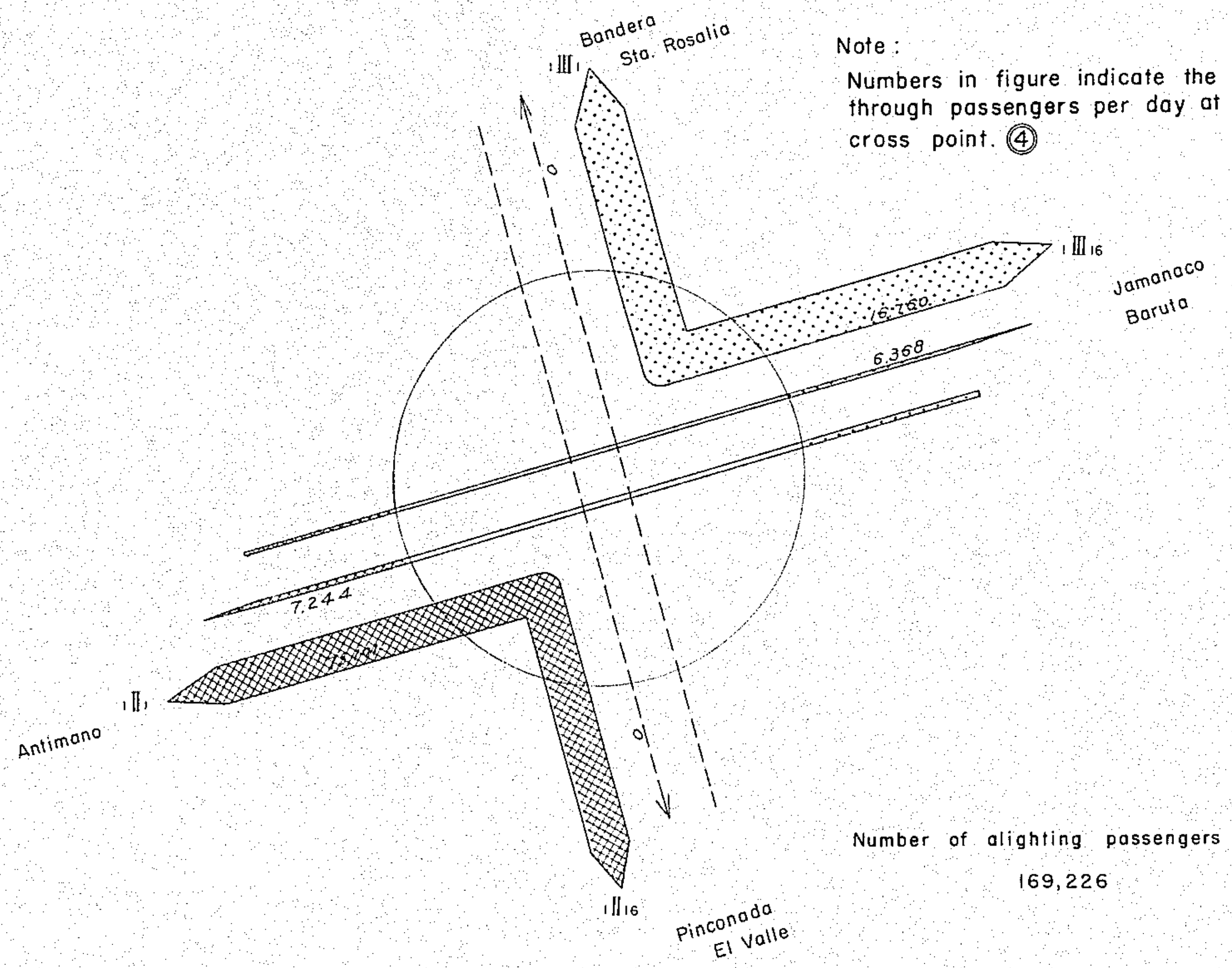


Fig 12 Figure for change of cars (Ist plan)

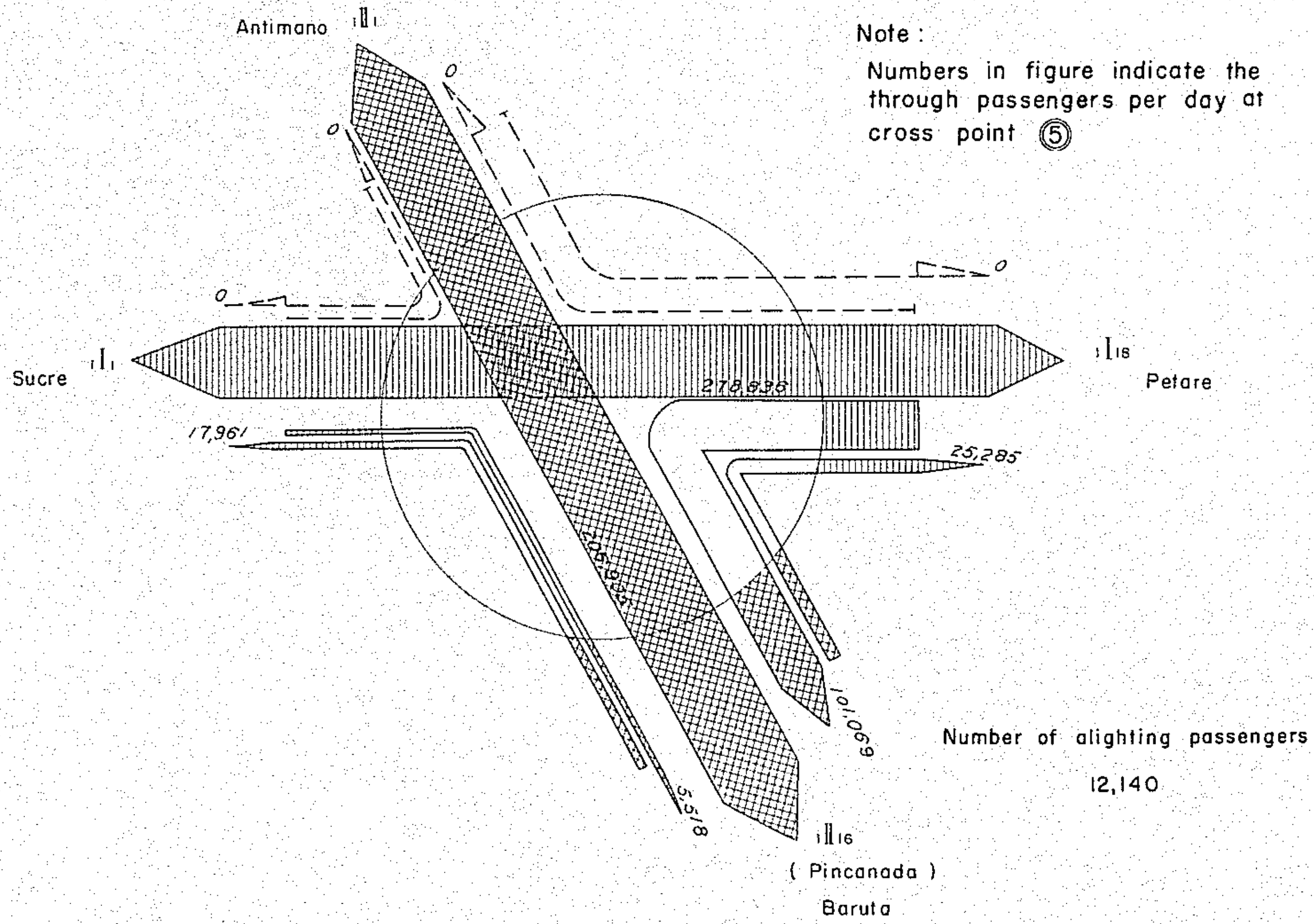


Fig 13 Figure for change of cars (Ist plan)

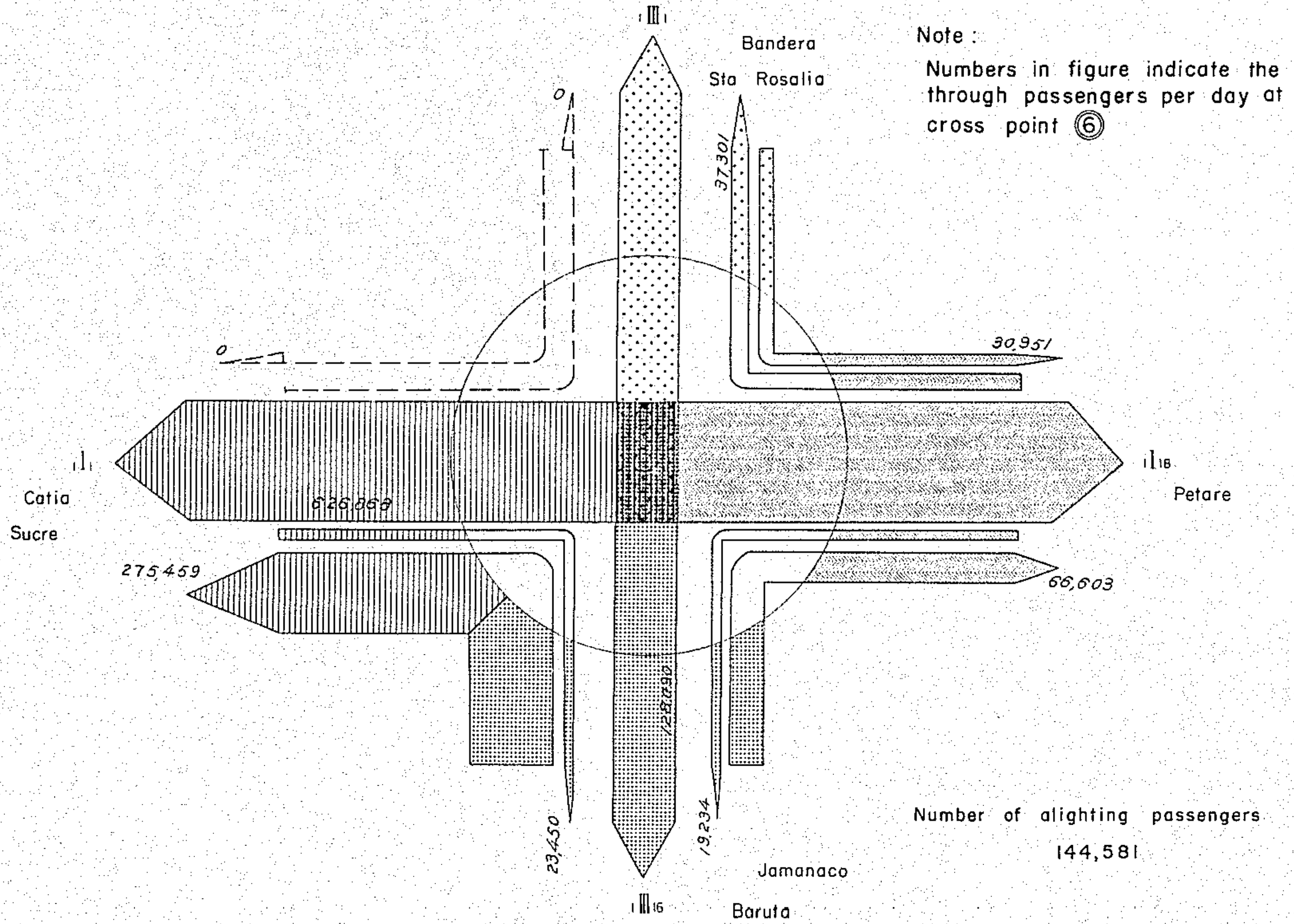
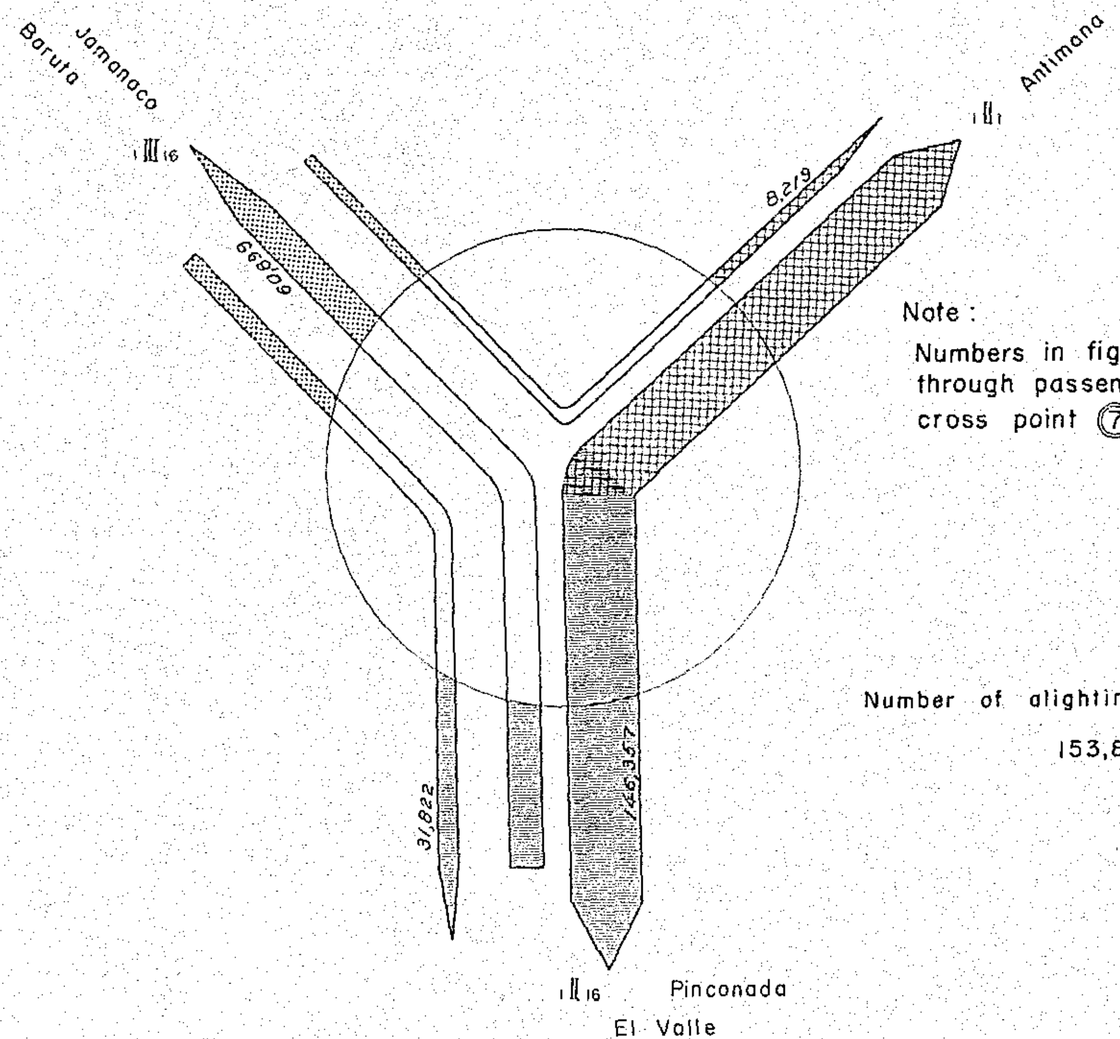


Fig 14 Figure for change of cars (1st plan)



Note :
Numbers in figure indicate the through passengers per day at cross point ⑦

Number of alighting passengers

153,843

FIG 15 Section of lines & points for change of cars

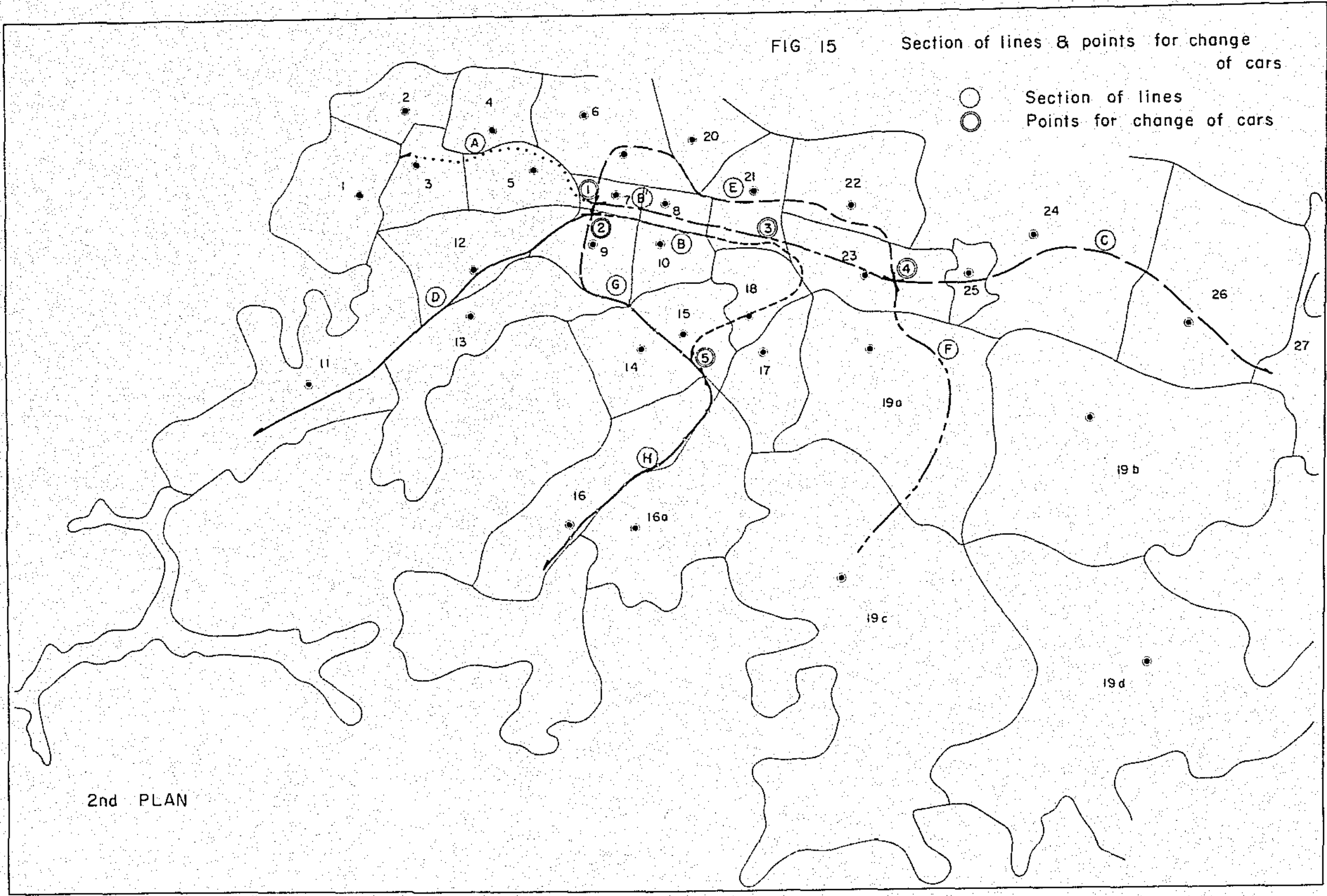


Fig 16 Figure for change of cars (2nd plan)

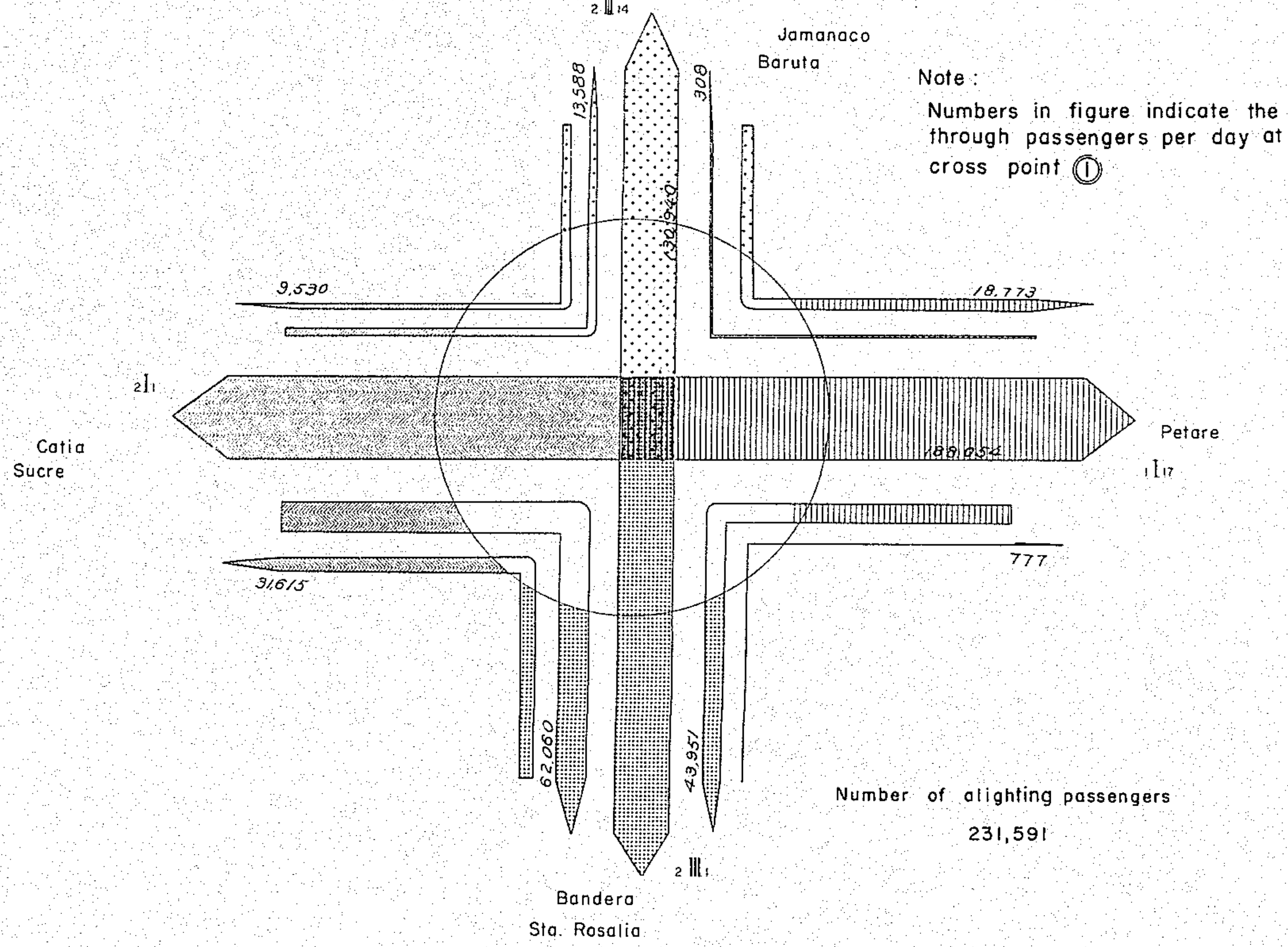
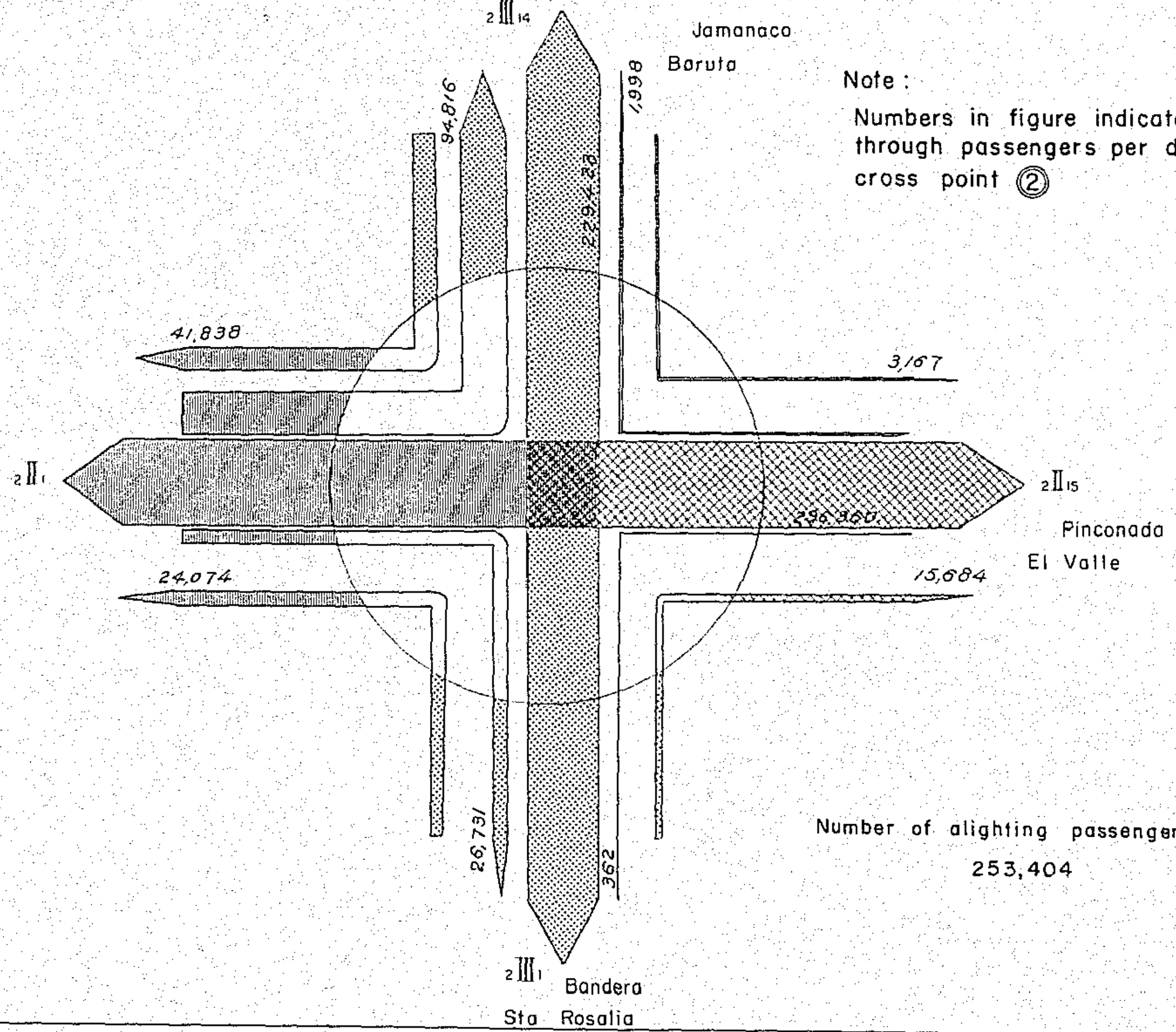


Fig 17 Figure for change of cars (2nd plan)



Note :
Numbers in figure indicate the through passengers per day at cross point ②

Number of alighting passengers
253,404

Fig 18 Figure for change of cars (2nd plan)

Note:
Numbers in figure indicate the *through passengers per day* at cross point ③

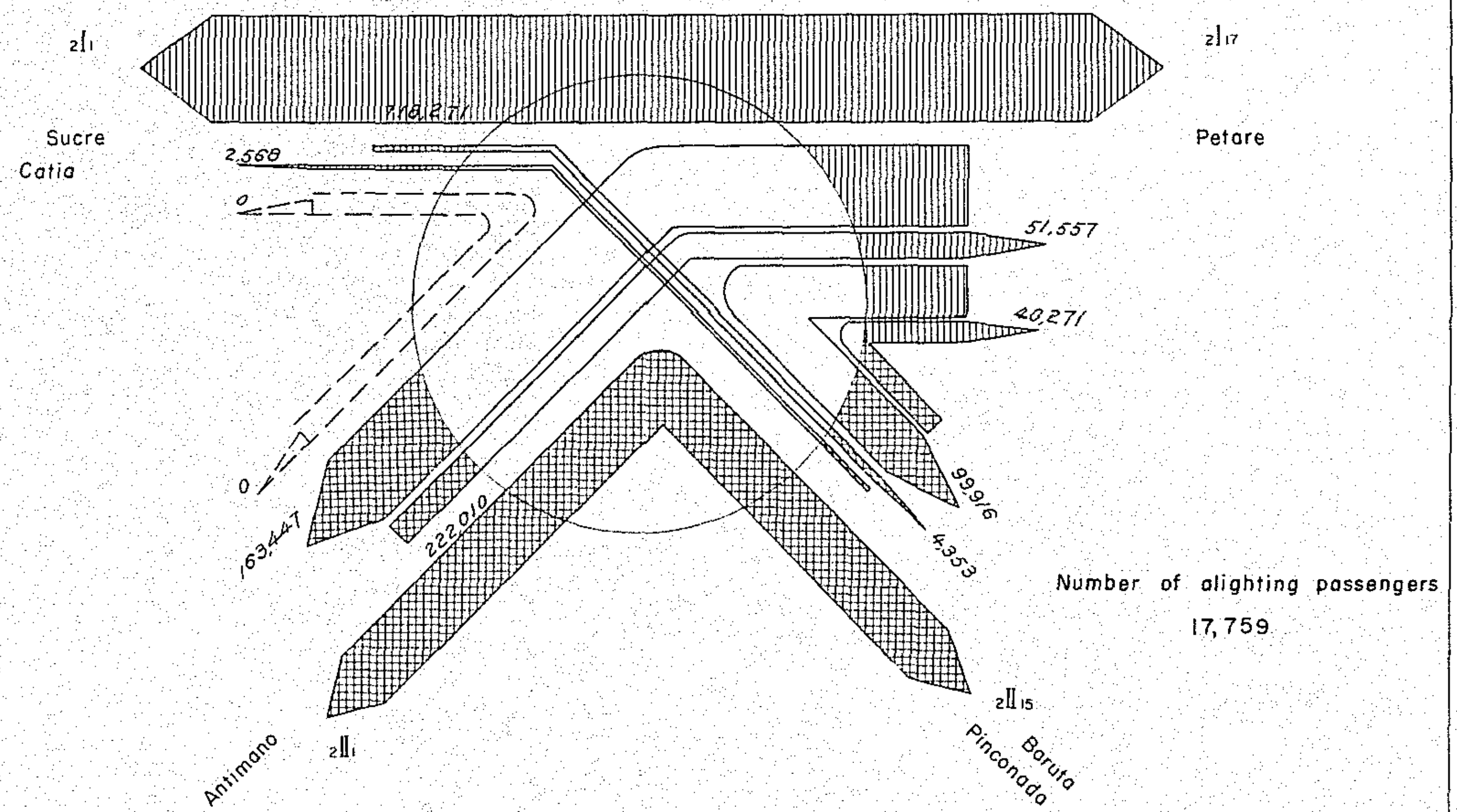
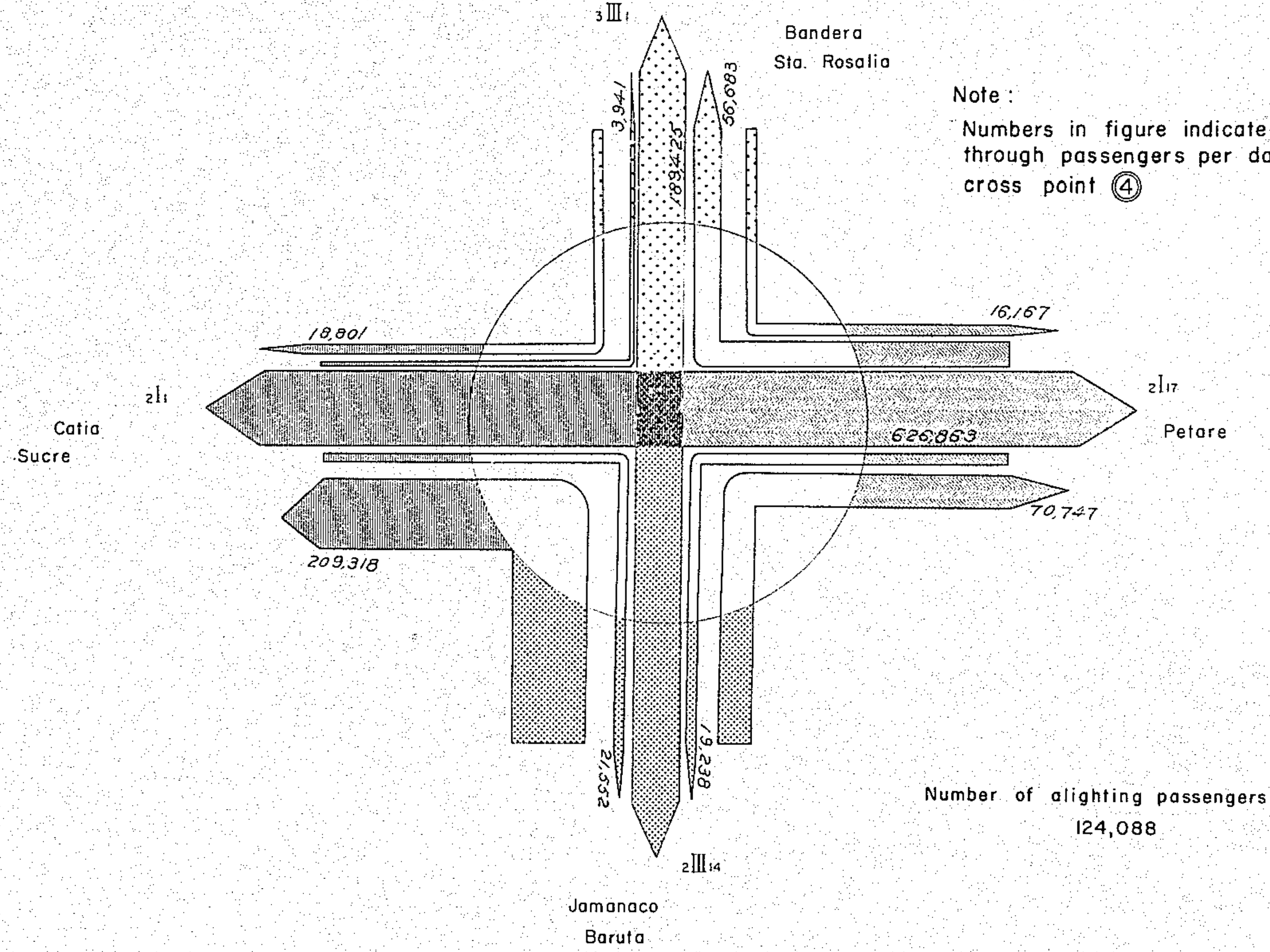
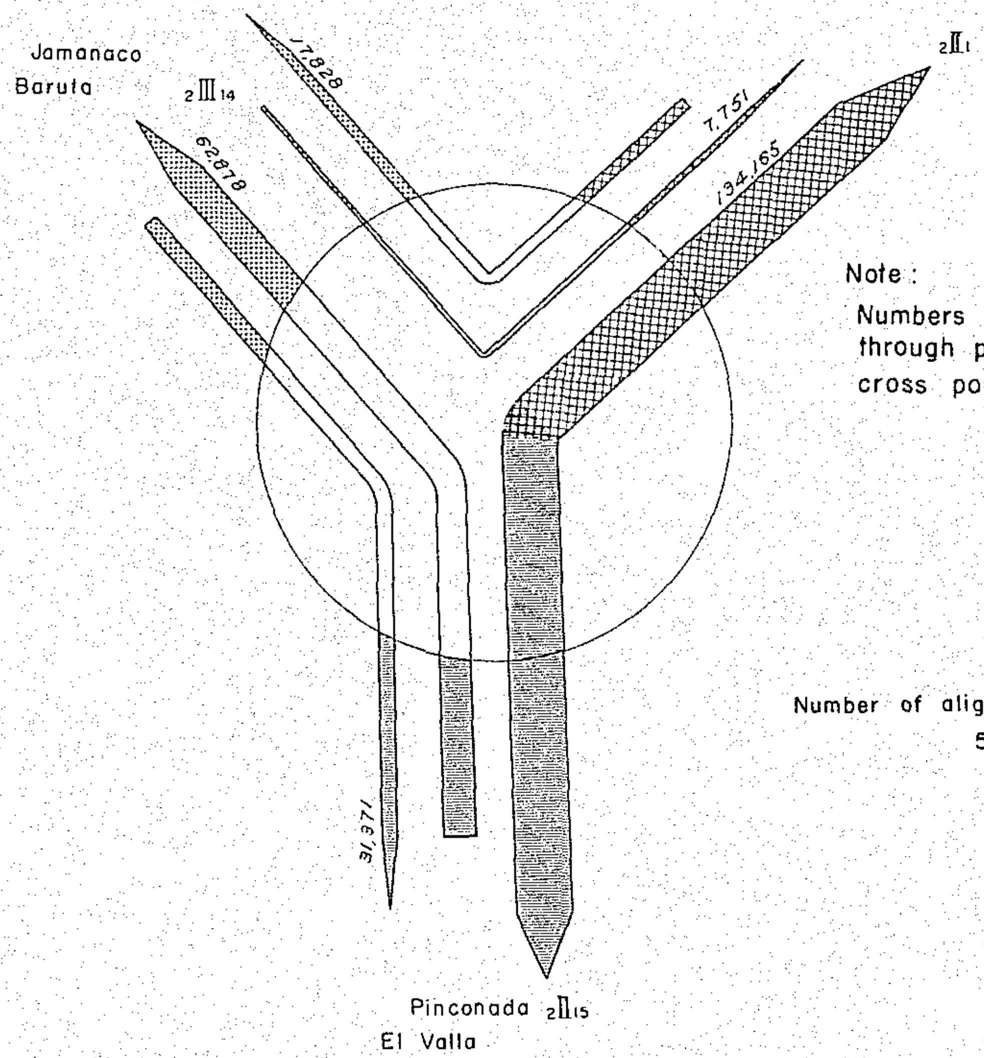


Fig 19 Figure for change of cars (2nd plan)



Note :
Numbers in figure indicate the through passengers per day at cross point ④

Fig 20 Figure for change of cars (2nd plan)



Note:
Numbers in figure indicate the through passengers per day at cross point ⑤

Number of alighting passengers
54.720

As for the station equipments, the platforms of No.1 and No.2 Lines should be so arranged as to admit 8-car formation trains, and those of No. 3 Line, 6-car formation trains. Signal equipments on the ground should enable the train operation at 2-minute headway.

As for the number of trains operated per day and the timetable of those trains, the headway and the number of trains per time belt of a day have been figured out as in Fig. 7, assuming that 10% of the daily transport volume is concentrated on the maximum rush hour, and, at the same time, considering that the noon recess is long enough to allow many people to go home for lunch. As there may be no need of midnight operation of trains, the operation time belt has been assigned to the interval between 0500 and 2400. The regulation of train operation to match the variable transport volume is conducted by the headway of trains, although there is another regulation method of coupling and uncoupling cars. This question may as well be studied when the actual operation commences.

Table 7 Number of train operation (minimum headway : 2 min.)

Time belt (hr.)	Headway (min.)	Number of trains (frequences/hr.)
5 - 6	8	7.5
6 - 7	4	15
7 - 8	2	30
8 - 9	2	30
9 - 10	4	15
10 - 11	4	15
11 - 12	4	15
12 - 13	2	30
13 - 14	4	15
14 - 15	4	15
15 - 16	4	15
16 - 17	4	15
17 - 18	2	30
18 - 19	2	30
19 - 20	4	15
20 - 21	4	15
21 - 22	6	10

Time belt (hr.)	Headway (min.)	Number of trains (frequences/hr.)
22 - 23	8	7.5
23 - 24	10	6
Total		331

7.3 Schedule speed.

The specifications of the rolling-stock — in this case we refer ourselves to the underground railway of Tokyo — should be in conformity with those which have been stated elsewhere; all of the rolling-stock should be electric motor cars, two cars representing a unit, for the purpose of increasing the speed and improving the efficiency of electric brakes, each car being equipped with four 100KW motors.

As for the feed system, a third rail system should be employed in order to reduce the sectional area of the tunnel. The voltage of the third rail should be 750V D.C.; the voltage of the electric motor, 350V; the motors are connected in permanent series two by two.

The maximum speed of this car is 100 km/hr, acceleration 3.5 km/hr/S, regular deceleration, 4.0 km/hr/S and emergency deceleration 5.0 km/hr/S.

In the case of this car the relation of the distance between stations to the time required for running the distance computed in level sections of the run curves are shown in Fig. 21. By making use of the above relation to find the time required for operating between each station with 20 seconds' stoppage-time at each station, the schedule speed of each line will be computed as follows:

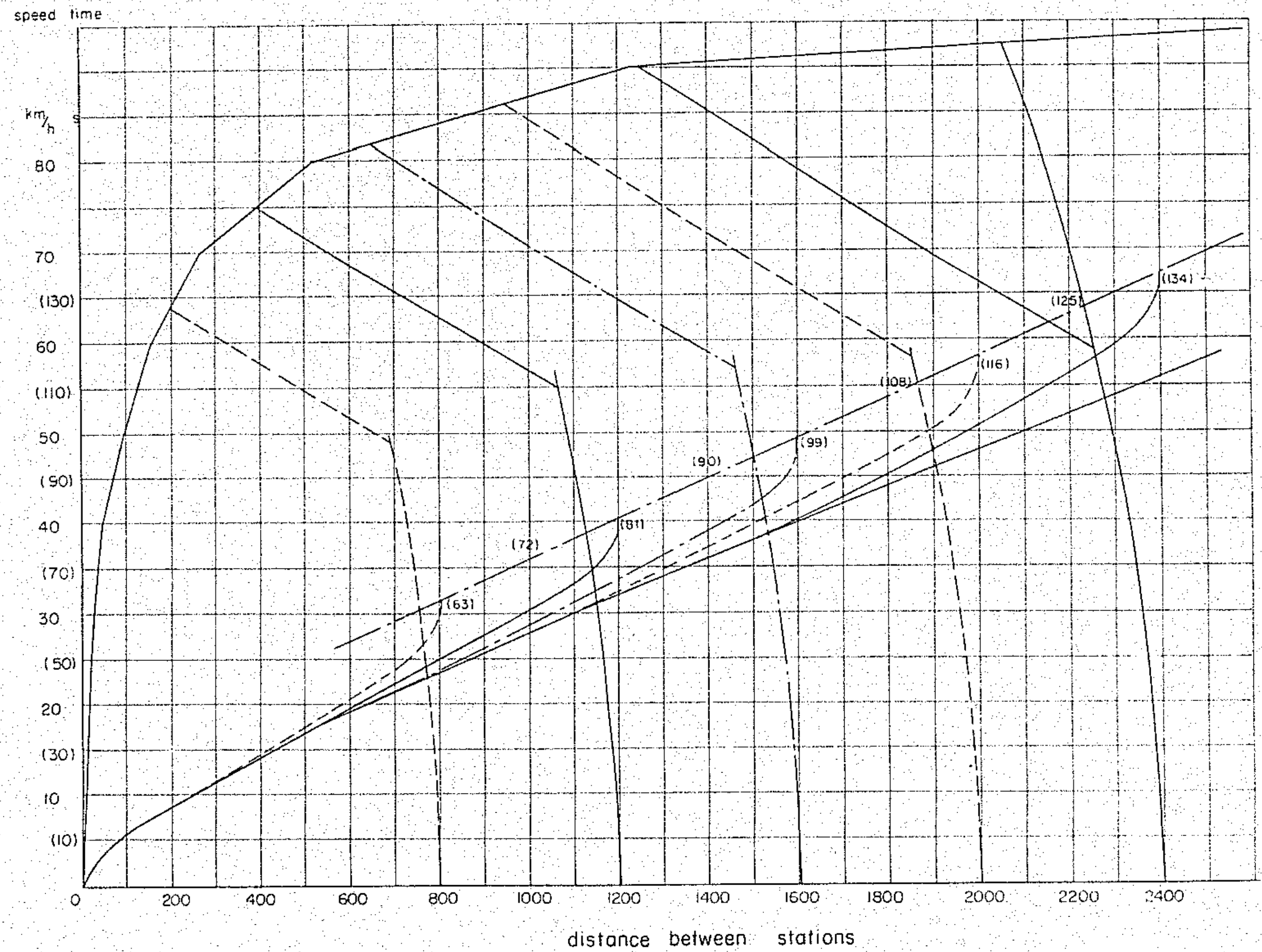
	Line	Business line (km)	Schedule speed (km/hr)
First Plan	No. 1	17.300	40.1
	No. 2	22.000	46.1
	No. 3	17.450	42.8
Second Plan	No. 1	17.150	41.2
	No. 2	20.970	46.6
	No. 3	17.090	43.9

If we compute the schedule speed by means of drawing a run curve of the train operation on No. 1 Line of the First Plan, taking into consideration the curves and gradients, we get an average of 38.5 km/hr in both directions, upwards and downwards. Regarding the other lines as almost equal to the above, and reducing the schedule speed of the other lines to 96% of the above,

FIG 21

The speed-distance curve and time-distance curve for level line

(The operation time for the various distance between stations)



we determine as follows:

Line	Initial schedule speed (km/hr)	Modified schedule speed (km/hr)	Time of Operation (one way) (min., sec.)
First Plane			
No. 1	40.1	38.5	27 - 0
No. 2	46.1	44.0	30 - 0
No. 3	42.8	41.0	25 - 30
Second Plane			
No. 1	41.2	39.5	28 - 0
No. 2	46.6	44.5	28 - 20
No. 3	43.9	42.0	24 - 20

7.4 Number of necessary cars.

The number of the necessary cars will be obtained: first find the number of trains to be formed by necessary cars per maximum rush hour of each line, assuming the time required for the turning back operation at the terminal station to be 4 minutes; then add to this value its 10% which is the number of reserved cars. The result is tabulated as follows:

	Line	Number of trains	Number of cars
First Plan	No. 1	32	282
	No. 2	34	224
	No. 3	30	132
	Total		638
Second Plan	No. 1	31	274
	No. 2	33	218
	No. 3	29	128
	Total		620

7.5 Train kilometer per day and car kilometer per day.

The train kilometer per day and car kilometer per day are tabulated as follows:

	Line	Train kilometer	Car kilometer
First Plan	No. 1	11,453	91,624
	No. 2	14,564	87,384
	No. 3	11,552	46,208
	Total	37,569	225,216

	Line	Train kilometer	Car kilometer
Second Plan	No. 1	11,353	90 824
	No. 2	13,882	83,292
	No. 3	11,313	45,252
	Total	36,548	219,368

8. STANDARDS OF STRUCTURE.

8.1 Principal standards.

The most fundamental items of standards are those concerning the track gauge, current collecting device and voltage of power. In view of our experience and taking into consideration the standards of the rapid transit railways of other cities in the world we have determined the standards as follows:

Track gauge: 1.435 m

Current collecting device : third rail system

Voltage : 750 V

The 'third rail' system, when employed in the underground railway requires less cross sectional area of the tunnel structure than the pantograph system, resulting in the advantage of reducing the construction cost by 8%. However, a 'third rail' through which high voltage current flows has to be laid in parallel with the railway track ; this means that its maintenance has to encounter some obstacles. Furthermore, the section of route which lies above the earth surface has to be equipped with safety fences, etc. in order to keep the general public from approaching. This precaution cannot be neglected. In spite of such defects, which are more or less troublesome, the third rail system can still be considered advantageous.

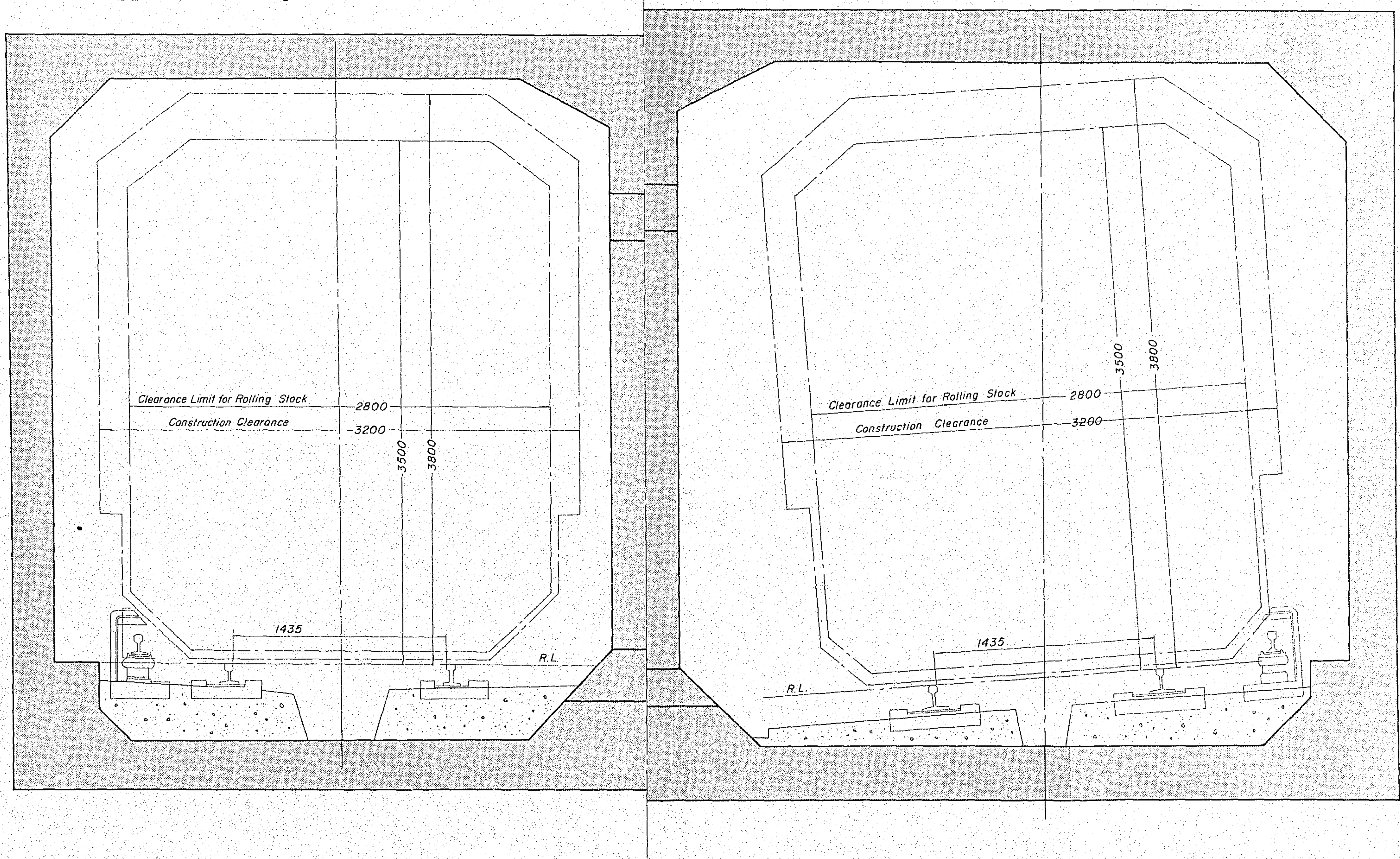
8.2 Clearance limit for rolling-stock and construction clearance.

The clearance limit for rolling-stock is that which limits the maximum dimensions of the cross-section of a car, while the construction clearance is a prescribed clearance outside the clearance limit for rolling-stock to allow a car to proceed without hindrance.

The size of a car should be determined by the examination of two factors: transport volume and construction cost. Our determination, as shown in Fig. 22, is as follows:

FIG 22 at Straight Truck

at Curved Truck



clearance limit for rolling-stock (width x height) 2.800 m x 3.500 m

Construction clearance (width x height) 3.200 m x 3.800 m

The construction clearance has been so designed as to leave a clearance, outside the clearance limit for rolling-stock, of 200 mm in width on both sides respectively and 300 mm in height.

8.3 Dimensions of tunnel.

The dimensions of tunnel should be so determined as to leave room, outside the construction clearance, for the installation of signals, communication cables, power cables, etc. As shown in Fig. 22, the room has been left as wide as 300 mm toward the side-wall, 200 mm toward the central pole, and 100 mm toward the upper slab.

The above figures are applicable to the straight section, but in the curved section a level deviation of a car due to the curve and a vertical deviation due to the rail cant should be added to the minimum structure gauge.

8.4 Curve and gradient.

Routes of the urban rapid transit railway are usually laid in the road site, and, consequently, many of them are subject to the curves and slopes of such roads they pass through. In locating the railway line the limit of the curve and slope should be fixed first.

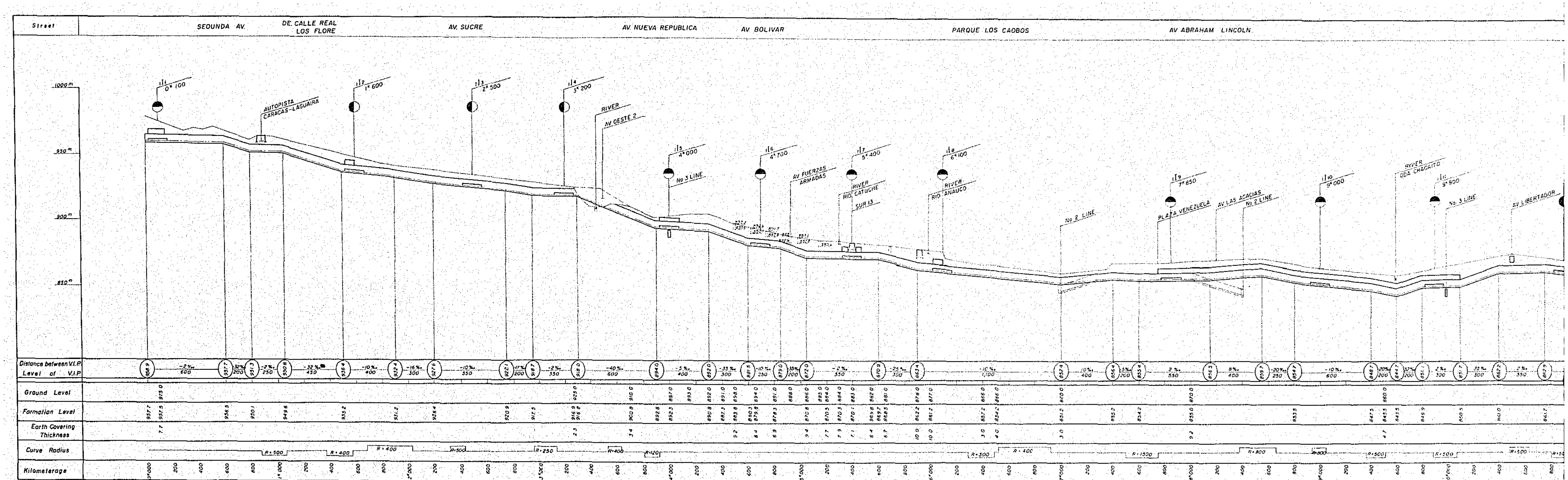
(a) Minimum curve radius.

A small curve radius would be an effective way of reducing the construction cost, but a large radius might be better for the train operation and maintenance of equipments. According to our design, it is desirable that the minimum curve radius will be, in principle, as long as 160 m and, even in a special case, not less than 120 m ; as for the track along the platform, the limit will be not less than 500 m, in view of the opening between the train and platform.

(b) Maximum and minimum gradient.

The maximum gradient of the line should be in principle 35/1000, and even in a special case, had better be less than 40/1000. In the case of an underground railway it is desirable that the line will be made inclined in view of the necessity of draining the tunnel, the minimum gradient of which would be about 2/1000.

The attached figure, Fig. 23, shows the longitudinal cross-section of No. 1 Line of the First and Second Plans designed in accordance with the above-mentioned limits of curve


Street
SEGUNDA AV.
DE CALLE REAL
LOS FLORE
AV. SUCRE
AV. NUEVA REPUBLICA
AV BOLIVAR
PARQUE LOS CAOBOS
AV ABRAHAM LINCOLN
1000 m
950 m
900 m
850 m
AUTOPISTA
CARACAS-LAGUAIRA
RIVER
AV OESTE 2
No 3 LINE
AV FUERZAS
ARMADAS
RIVER
RIO CATUCHE
SUR 13
RIVER
RIO ANAUCO
No 2 LINE
PLAZA VENEZUELA
AV LAS ACACIAS
No 2 LINE
RIVER
QDA CHACAITO
No 3 LINE
AV LIBERTADOR
Distance between V.I.P.
Level of V.I.P.
Ground Level
Formation Level
Earth Covering Thickness
Curve Radius
Kilometerage

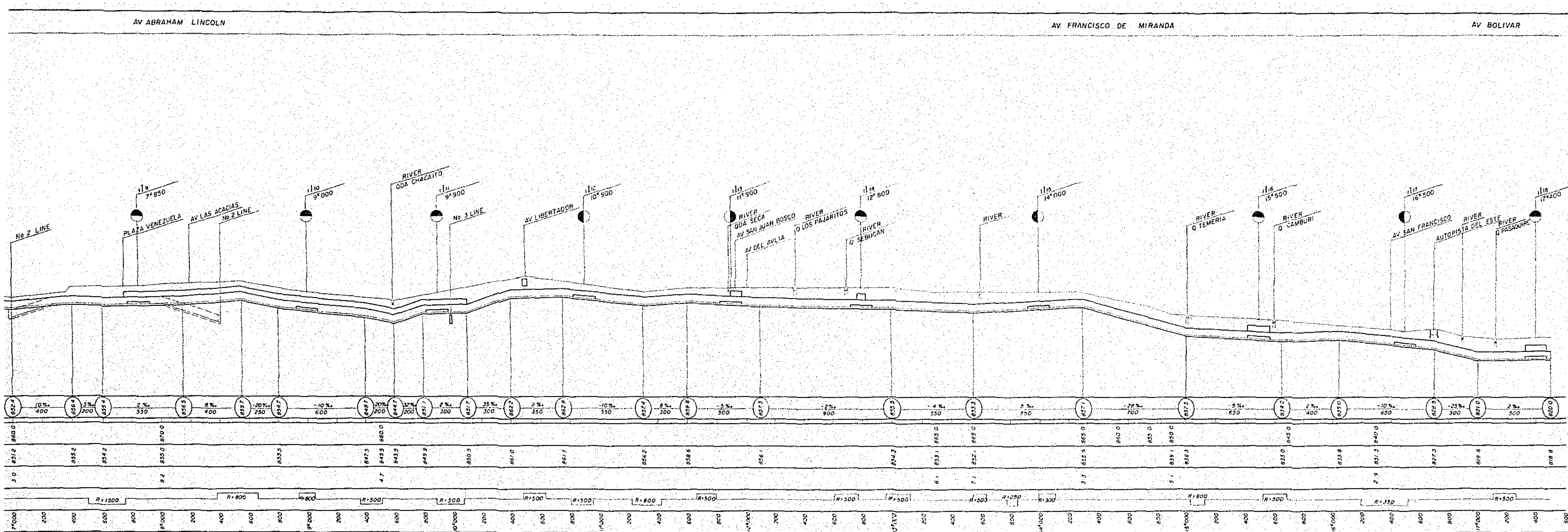


FIG 23

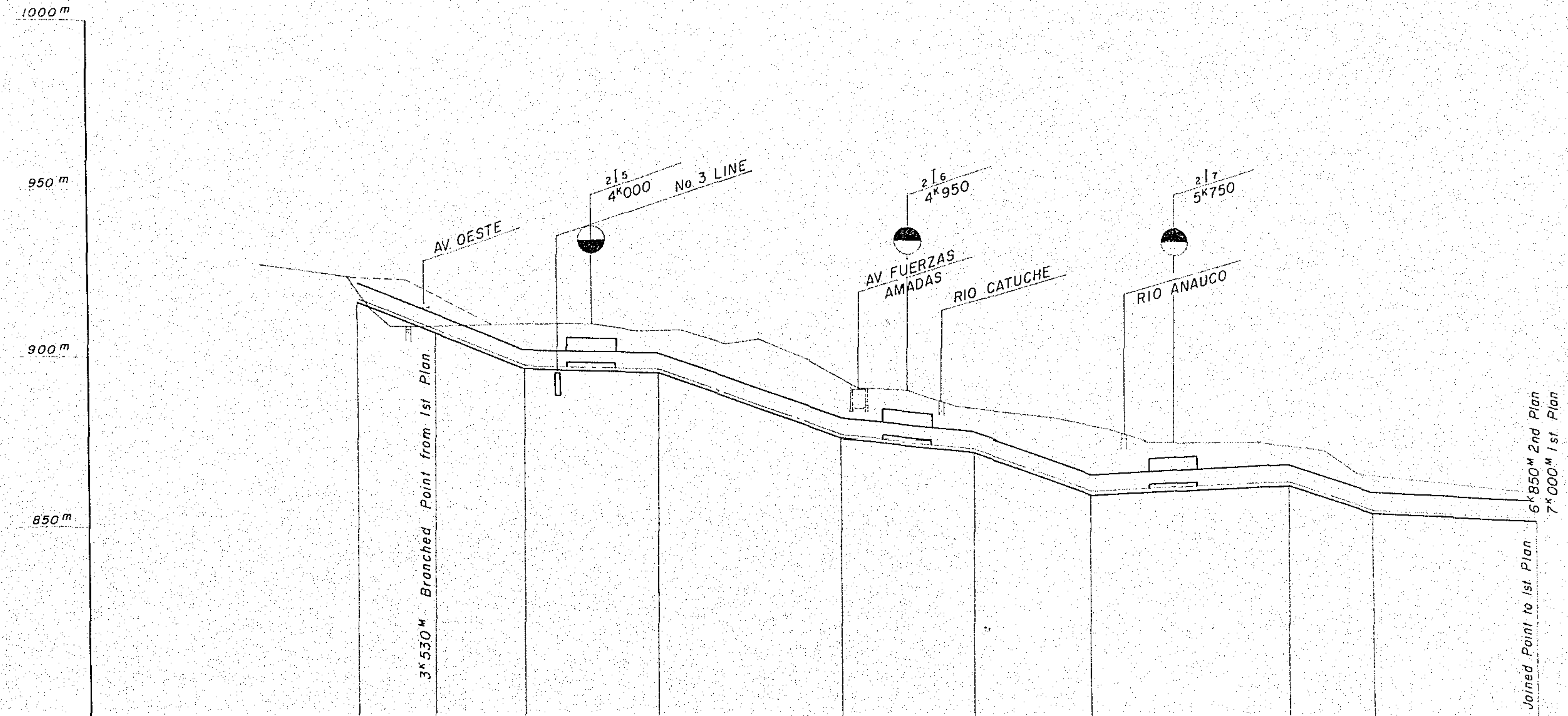
PROFILE

NO.1 LINE 1st PLAN

longitudinal 1 / vertical 10

Street	AV. SUCRE	AV. UNIVERSIDAD	AV. MEXICO

FIG 24



Distance between V.I.P. / Level of V.I.P.	918.0; −40‰ 500; 898.0; −4‰ 400; 896.4; −35‰ 550; 877.2; −10‰ 400; 873.2; −35‰ 350; 860.9; +5‰ 600; 863.9; −32‰ 250; 855.2; −7‰ 500; 852.4
Ground Level	911.0, 909.0, 909.0, 905.0, 906.5, 900.5, 892.0, 892.0, 886.5, 884.0, 880.0, 876.0, 876.0, 874.0, 867.0
Formation Level	916.8, 896.8, 896.0, 895.4, 895.2, 893.5, 888.7, 884.7, 879.5, 876.0, 875.5, 874.2, 872.5, 872.0, 865.0, 859.7, 860.0, 860.6, 863.2, 862.7, 860.7, 856.3, 854.7, 852.6, 852.2
Earth Covering Thickness	5.2, 7.8, 9.7, 10.5, 16.0, 15.2, 10.7, 8.0, 8.2, 13.2, 14.2, 5.6, 7.0, 7.5, 4.9
Curve Radius	R=160, R=1500
Kilometrage	400, 600, 800, 4K000, 200, 400, 600, 800, 5K000, 200, 400, 600, 800, 6K000, 200, 400, 600, 800

PROFILE

NO. 1 LINE 2nd PLAN

longitudinal / vertical = 1 / 10

and gradient. However, this figure has not been made out on the exact survey of the undulations of earth surface, and we hope that it will be regarded as a specimen of longitudinal cross section drawings.

9. GEOLOGY OF CARACAS.

During its stay in Caracas the survey team has had no time to conduct boring to investigate the geology along the proposed line of the railway. However, judging from the existing structures and in view of the foundation work of the buildings now under construction we feel that there is nothing in the geology of this city which might be unsuitable for the underground railway, not to mention for the overhead structures. Furthermore, we obtained, while in Caracas, a useful printed matter titled "El Subsuelo de Caracas --- Datos de Exploración" (published in 1961), the study of which has convinced us that :

The elevated structures can be reinforced enough by the foundation piles driven into the ground under the props; as for the construction of the underground railway, the cut-and-cover method, which is most widely employed as will be stated later, is applicable also to this case.

However, careful examination of the geology prior to the actual design is necessary by means of boring at several spots on the proposed line.

10. STANDARD STRUCTURE.

10.1 Tunnel structure. (Fig. 25)

Tunnels had better be constructed as near the earth surface as possible, because, considered in all its aspects, this type of construction has such advatages as the easiness of the work, reduction of the cost and convenience to the passengers after completion. However, an earth covering, which is at least 2.20 m - 2.50 m in thickness, should be preserved in order to hold the pipe-line laid under the road. When the tunnel structure passes under the river bed the earth covering ahead and behind the cross-river section will have to be left thick. As for the construction work of the section crossing rivers, the structure as well as the work method can remain the same as those of the other sections, if the progress schedule can be so arranged as

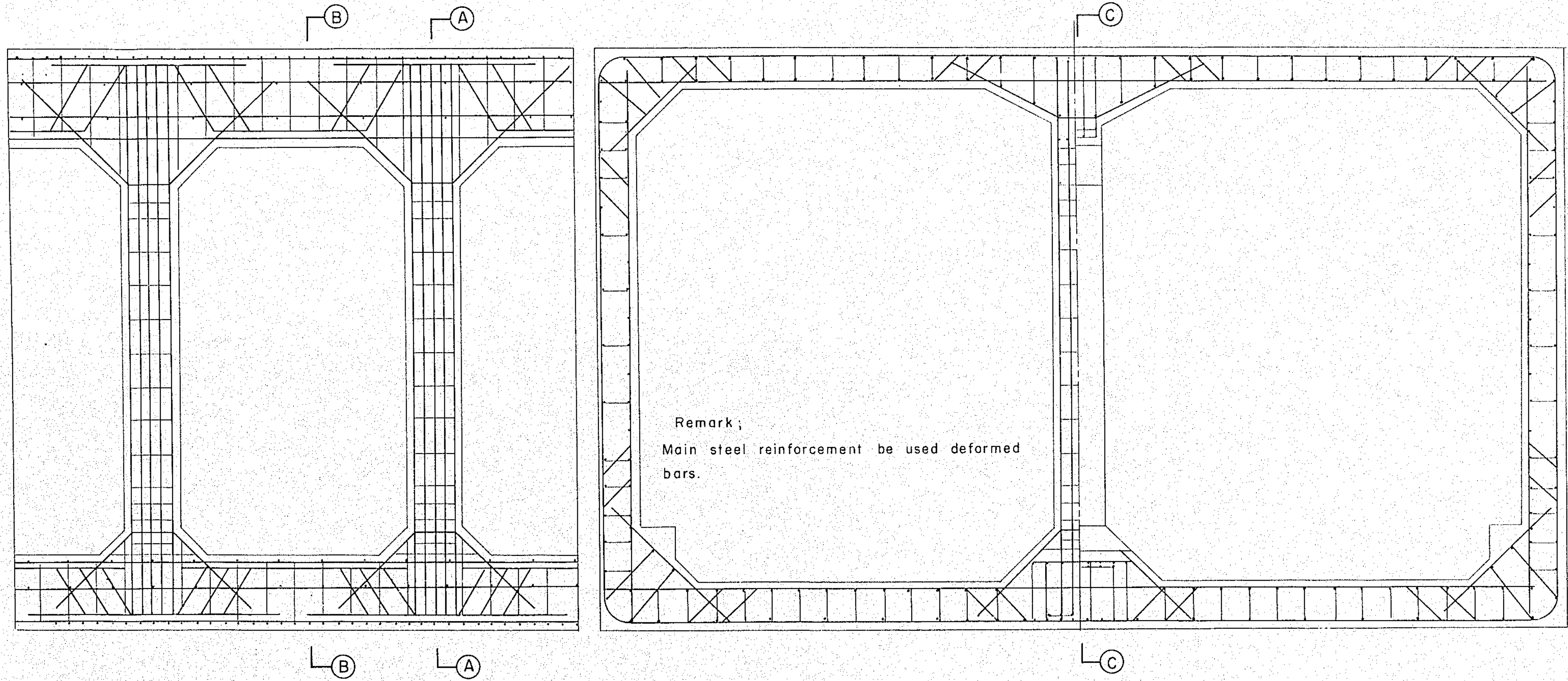
FIG 25

Two Track Tunnel

SECTION C-C

SECTION A-A

SECTION B-B



to carry out the work during the dry season when there is little rain.

In accordance with the above statement, a shallow type underground railway by means of the cut-and-cover method will be adopted here ; the structure is of box-shape reinforced concrete both in the general tunnel section and the station section. A structure of box-shape cross-section has the advantage which enables all structures, from the simple tunnel structure of a double-track line section to the complicated station structure, to be designed as rigid-frame structure, economically and reasonably.

10.2 Elevated structure.

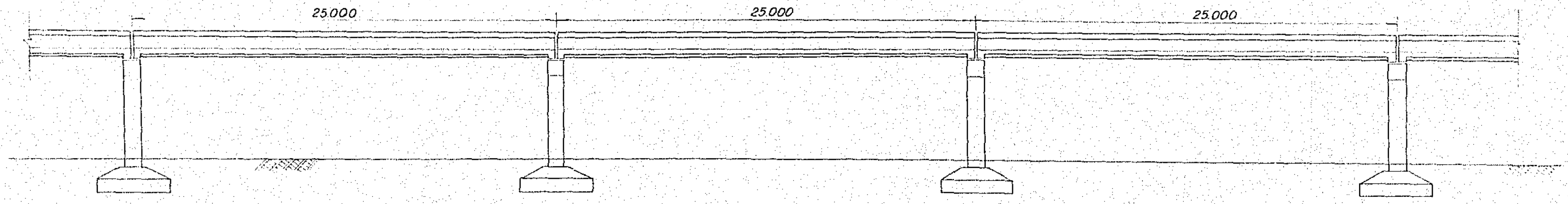
As stated above, we have mapped out a plan of an overhead structure, stretching 10.60 km on No. 2 Line and 4.00 km on No. 3 Line, respectively. (common to the First and Second Plans) Generally speaking, there are two kinds of overhead railway; one runs on embankments and the other on a series of viaducts. It is most economical to utilize an elevated structure of embankment type in the suburbs where the acquision of lot is easy, and the traffic on both sides of the line is comparatively light, when viaducts are built only at such points as the line crosses the road, the rest of the line being laid on the embankment. However, viewed from the point of potential development of the suburbs, it is advisable to employ the elevated structure of bridge type as far as possible. The structure design is almost the same as that of the viaducts of the expressway for motorcars.

In designing this type of structure it should be taken into consideration that the fine view of the town can not be spoilt, the noise of the railway can be made as little as possible, and, in some cases, the space under the overhead tracks can be used properly and efficiently. This is a reinforced concrete structure of slabs combined with P. S. concrete beams shored up by one or two props, an illustration of which is shown in Figs. 26 and 27.

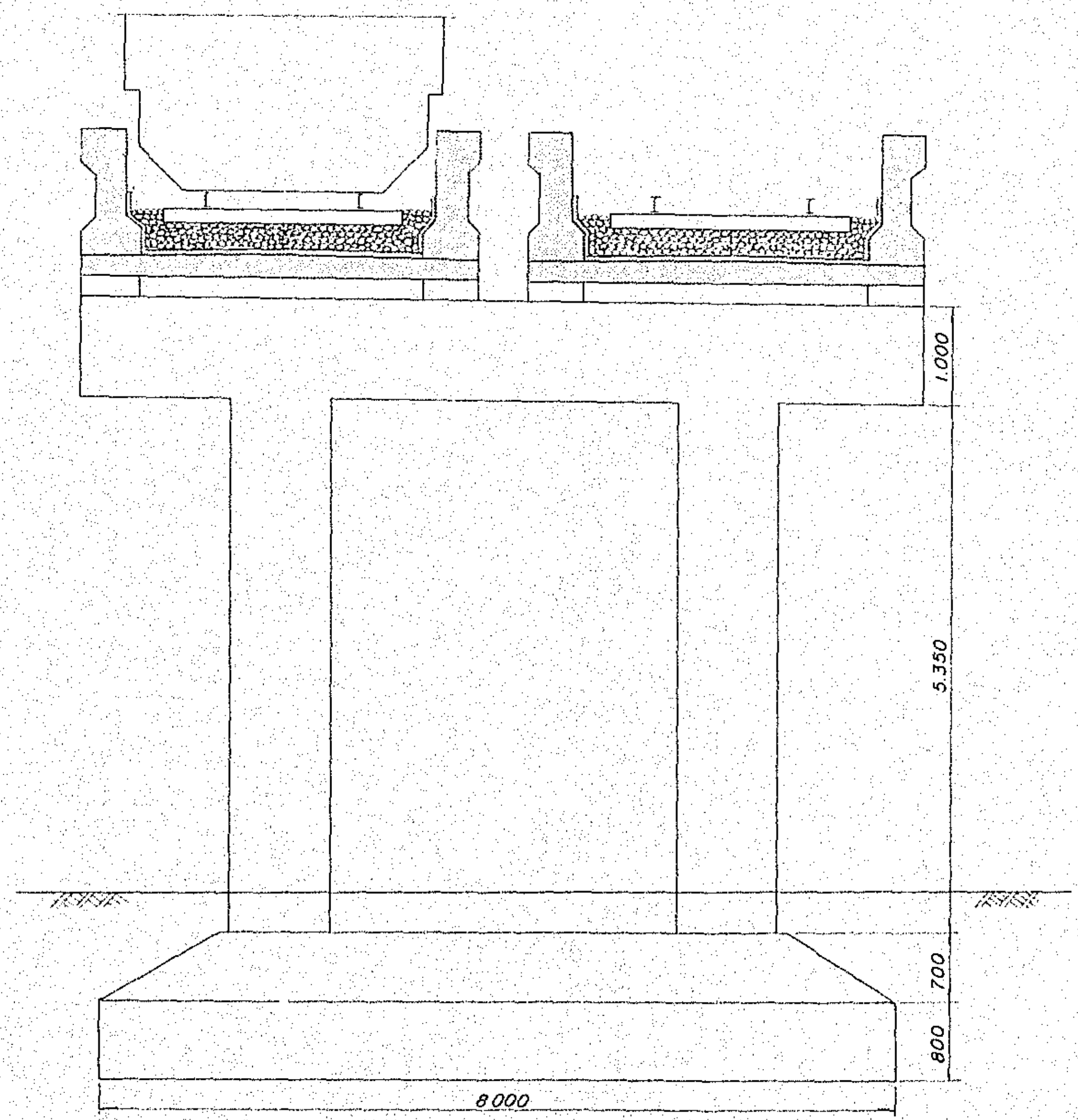
11. CONCEPTION OF STATION.

The first consideration in the location of stations is naturally the convenience to passengers, but too many stations and too short a distance between them will increase the operating cost as well as the construction cost ; not only that, but it will reduce the operation speed of trains and end in the loss of the essential function of a rapid transit railway. In our design, therefore, the distance between stations has been made as long as possible in the suburbs, and, FIG 26 Viaduct I

(Piers & Pre-stressed Concrete Girders)



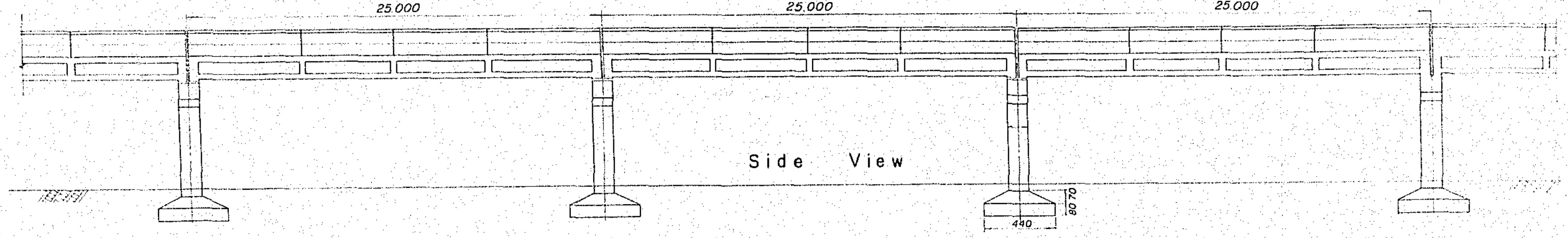
Side View

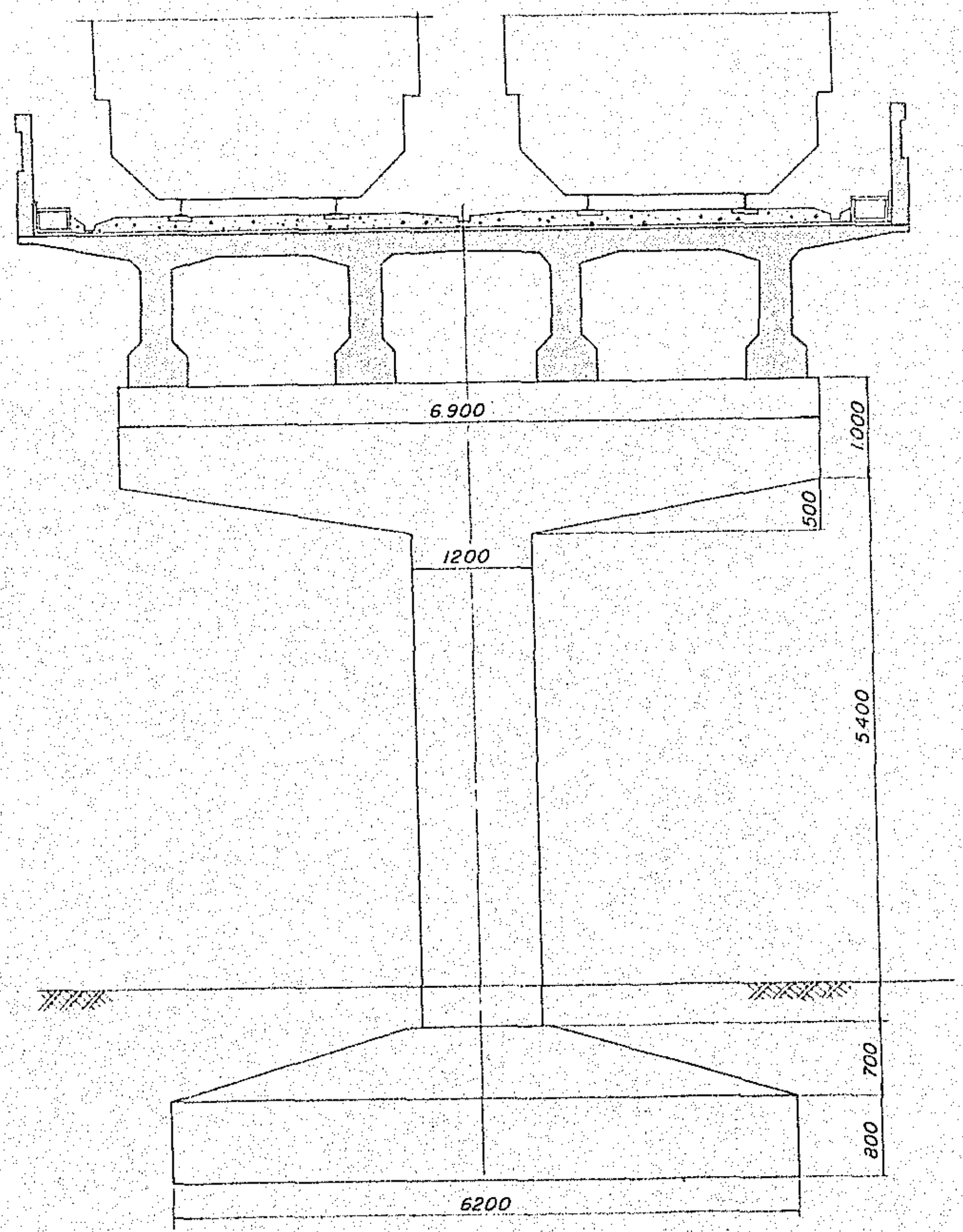


Section

FIG 27 Viaduct II

(Post, Tensioned Piers & Pre-stressed Girders)





Section

in the midtown not more than 700 m.

Besides, in designing the midtown stations the floor space had better be made to contain enough room, which will be available for the enlargement of station equipments for increased passengers in future.

As suburban stations enjoy a wide sphere of influence, it is advisable that they will be equipped with station squares in front of them which include parking places for the passengers who utilize bus'es or taxis.

11.1 Side platform and island platform.

There are two kinds of platform : a side platform and an island platform.

In the former the line of track remains straight, which enables the station structure to be comparatively simple ; in the latter, on the contrary, the curved section should be put between the line ahead and behind the platform and also the line will have to be laid deep in the ground owing to the existence of the mezzanine which is usually necessary in the underground railway to deal with the passengers. However, this has a great utility because one platform can be used in common by trains running in different directions. In the case of a side platform either a passage under the track or a mezzanine will have to be built to connect the platforms installed on both sides of the line.

Thus, each of these two types has merits and demerits; which of them to adopt will be determined by the conditions of location of stations. Generally speaking, island-type platforms are adopted in such midtown stations as dealing with a number of passengers. (Figs. 28 and 29)

11.2 Length and width of platform.

According to the train operation program based on the transport demand in 1980, which has been stated above, trains will be run on each line at a headway of two minutes, when the composition of trains are : for No. 1 Line eight cars ; for No. 2 Line six cars ; for No. 3 Line four cars. Therefore, the effective length of the platforms, which is required by the above number of coupled cars will be approximately as follows (maximum train length + 8 m) :

For a train consisting of 8 cars	152 m
" 6 "	116 "
" 4 "	80 "

FIG 28

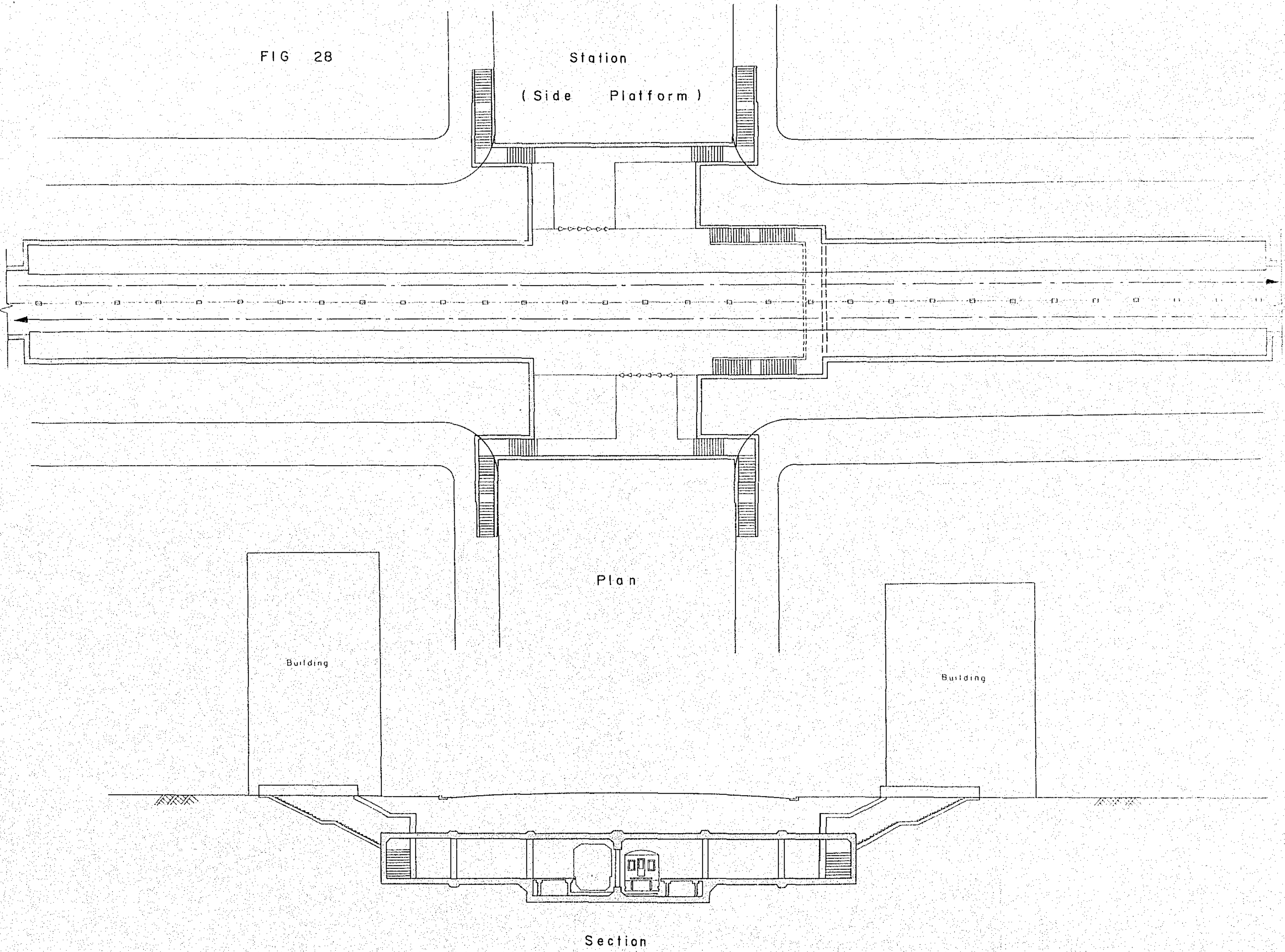
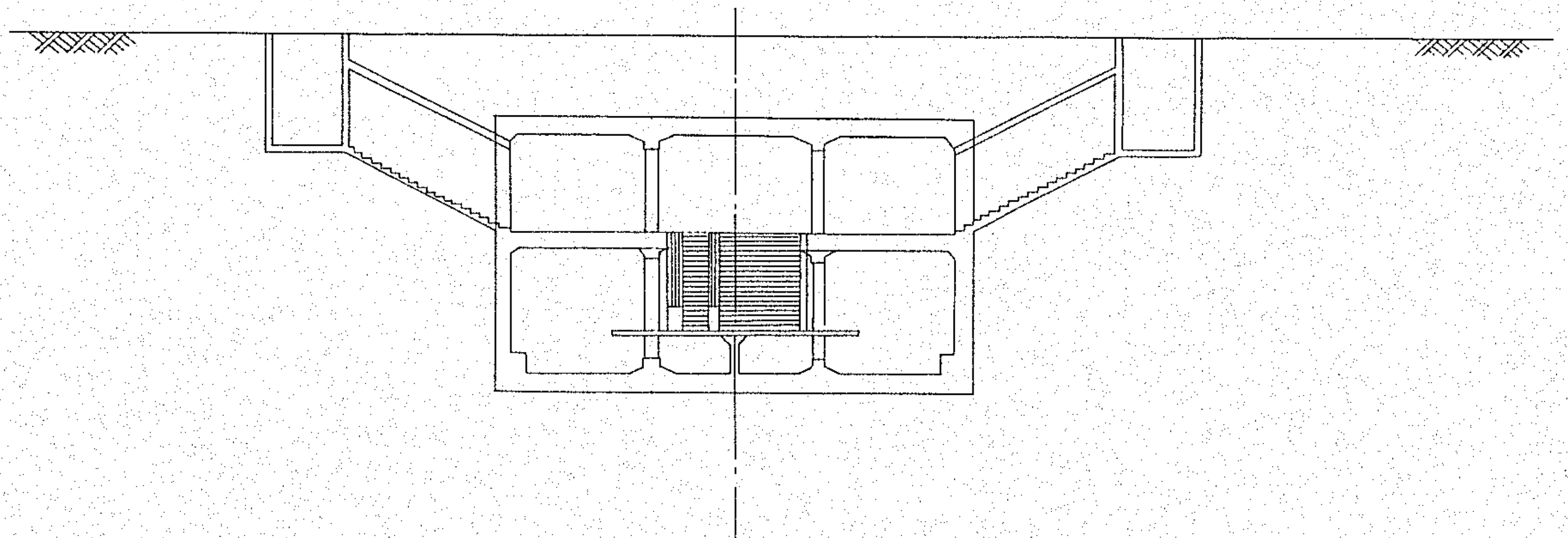
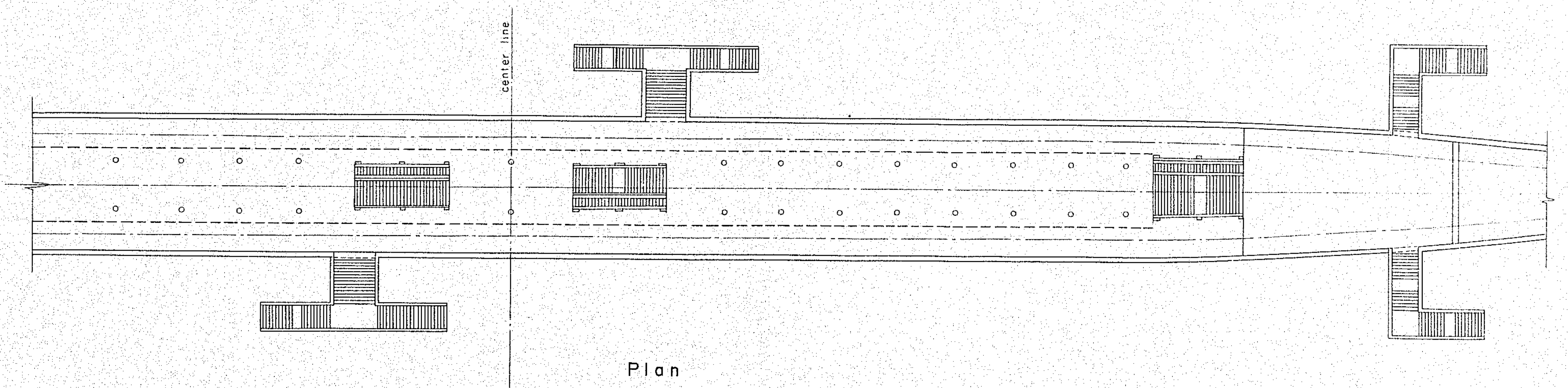


FIG 29 Station

(Island Platform)



Section



Plan

However, the reconstruction and enlargement of underground structures are generally attended with extreme difficulty, in anticipation of which the construction from the first is advisable of such cross-section as leaving room for the potential extension of platforms so that the platforms of No. 2 Line may be available for an eight-car train and those of No. 3 Line for a four-car train.

The width of platform should be determined essentially by the number of anticipated passengers, but in many cases it is subject to the topographical conditions, such as the width of roads. An approximate standard for the platform width will be 3.500 m - 5.000 m for each platform in the case of a side type,and 7.00 m - 10.00 m in the case of an island type.

Next, will be outlined the general idea of the principal station.

11.3 Grand composite station at Silencio.

We have made out a blueprint of a magnificient central station at Silencio. The ${}_1I_5$ station of the First Plan will be connected underground with ${}_1II_7$ and ${}_1III_4$ stations, which will be constructed in future, to make a magnificient composite station which will be a common junction of the three lines, furnishing convenience to the passengers to and from all directions.

Similar idea is applicable to the ${}_2I_5$ station of the Second Plan ; this station, combined with the stations ${}_2II_7$ and, ${}_2III_4$ has been also designed to be a composite station.

11.4 Station to be correlated with city-center project.

Each of the station ${}_1I_6$, ${}_1II_7$ and ${}_1I_8$ is located in the area of the city-center project now under way. This project which aims at the redevelopment of the midtown would prove a greater success, if the above-said stations could be ingeniously correlated with the proposed new establishments of the project. This is the reason why we should like to recommend the First Plan as containing more attractive lines than the Second Plan.

11.5 Additional construction of public underground passage.

The three stations, ${}_1I_9$, ${}_1I_{10}$ and ${}_1I_{11}$ (common to the First and Second Plans), in Sabana Grande being connected with each other by a mezzanine, will constitute an underground passage stretching as long as about two km. This road will be opened for traffic as a public road, which will not only make a comfortable underground promenade free from motorcar traffic but also prove a great convenience to the shopping people of this district, as it is accessible from any entrances to be built in the buildings or any places on the earth surface nearby.

11.6 Junction station.

The location of the station ${}_{1}I_{9}$ (common to the First and Second Plans) has been arranged to be parallel with the ${}_{1}II_{11}$ station of No. 2 Line, by which the ${}_{1}I_{9}$ will be made not only a junction station but also a point of exchanging cars between the lines No. 1 and No. 2.

The ${}_{1}I_{11}$ station (common to the First and Second Plans) has been designed to be a junction station for No. 3 Line. When No. 1 Line is constructed, the structure of the station ${}_{1}III_{12}$ of No. 3 Line, which is expected to cross underneath the ${}_{1}I_{11}$, should be built at the same time.

The station ${}_{1}II_{14}$ has been designed to be a junction station for the lines No. 2 and No. 3. This station has been arranged to be parallel with the ${}_{1}III_{1}$ of No. 3 Line, and the change of cars between the two lines has been made possible.

According to the First Plan, the two stations, ${}_{1}II_{8}$ and ${}_{1}II_{10}$, have been designed to be connected with the two stations ${}_{1}III_{5}$ and ${}_{1}III_{8}$ respectively to form junction stations.

12. CONSTRUCTION METHOD OF UNDERGROUND RAILWAY.

In the case of a box-shape structure built at a shallow position from the earth surface, the standard construction method is the cut-and-cover method. This will also be applied to the construction of the proposed underground railway. Here is the outline. (Fig. 30)

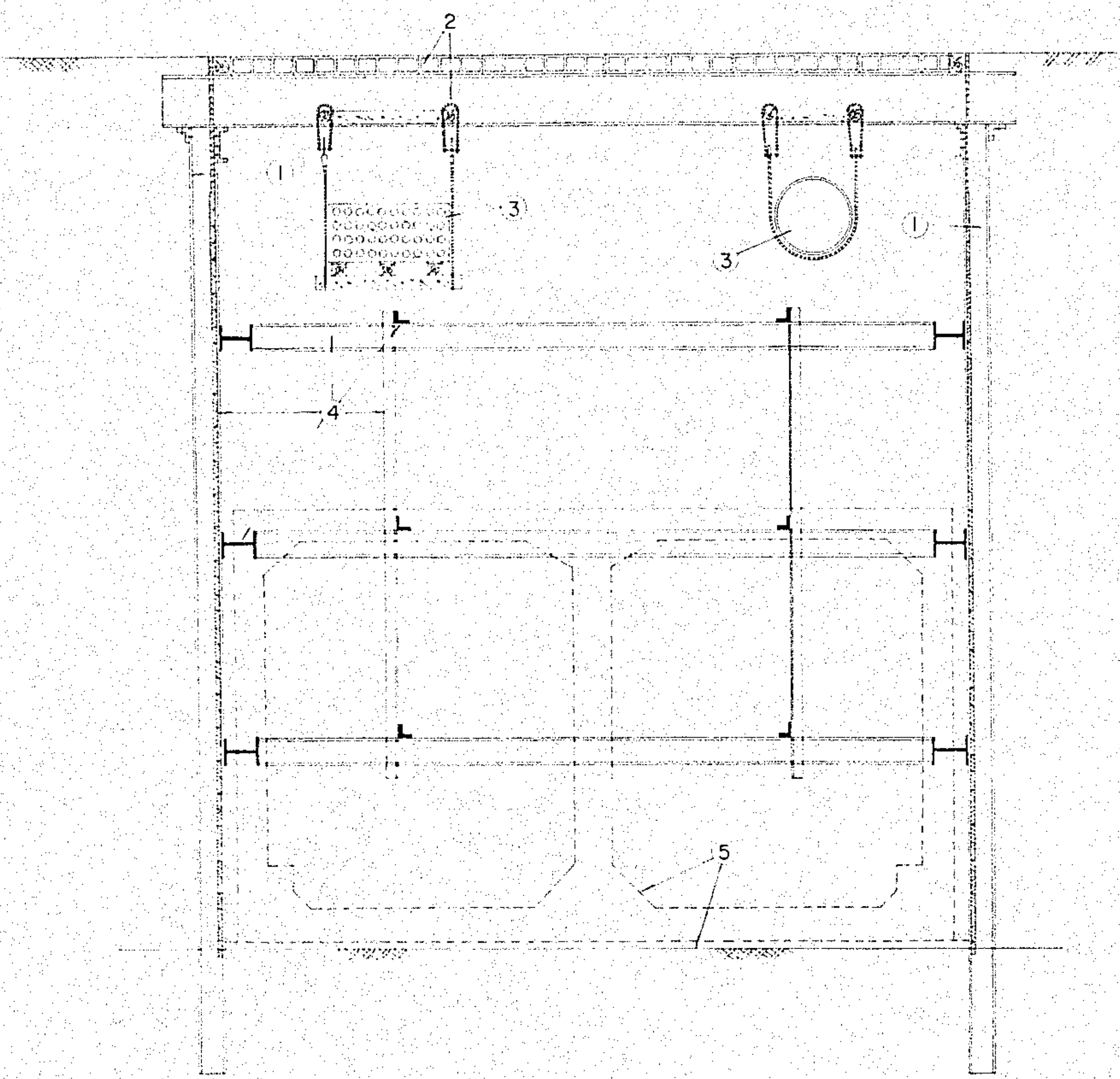
12.1 Shoring and surface planking.

'Cut-and-cover' means the method of excavating from the earth surface and refilling the gap after completion of the structure.

At the beginning, at regular intervals (1.20 m - 1.70 m) on both sides of the tunnel are driven steel sheathing piles (either I beam of 300 x 150 or H beam of 300 x 300 - 300 x 200) ; various types of pile drivers are employed, such as drop hammers, steam hammers, diesel hammers, etc. Where the geology is especially soft or heavy buildings with shallow foundation are found nearby, steel sheet piles instead of steel piles are driven into the earth. When it is difficult to drive steel piles because of hard layers, such as gravel layers, piles are erected in the holes bored in the layer by means of earth drills or augers.

The the excavation of the intervening space between the rows of the piles is commenced; as this earth work advances and in the case of employing I beams, timber laggings are inserted

FIG 30 Execution by the Open-cut-and-cover Method



Order of Construction

1. Pile driving
2. Decking
3. Hanging of buried pipes
4. Excavation, lagging and shoring
5. Waterproofing and reinforced concrete placing
6. Soil covering
7. Taking off road decking
8. Pile extracting
9. Surface repavement

between the flanges of the beams. In order to resist the lateral pressure of the earth bridging struts are applied as bracing and shoring. Such struts are sometimes timbers with a large cross-section, but in our design steel H beams are preferable, as they can answer the purpose of a sure work and can be used several times more than timbers, which means, more economical in the end. The sectional dimentions of this material and its interval between each other when employed can be estimated from the calculation of the earth load according to the nature of the ground. In the case of employing H beams of 300 x 300 the standard distance between each of them is horizontally 2m - 3m and vertically 3m - 3.5m.

In constructing an urban underground railway in the road site the road surface is often planked, prior to the excavation, in order to ensure the surface traffic. The surface is sometimes boarded over or set with rows of timber beams, but this decking method cannot be free from such defects as breakage and clattering noise. In our design, therefore, either steel plates or ductile cast iron plates are preferable as decking materials.

The planking work is prosecuted as follows : the heads of the sheathing piles are fastened up with steel shapes of angle and channel to form abutments, upon which are spanned crossbeams (I beam of 600 x 190) at an interval of 1.30m - 2.00m; then the above-mentioned decking plates are placed on these crossbeams. Such construction work, even when carried out in the busy towns, can minimize the traffic disturbance, if measures are taken to complete it in a short time at midnight by means of travelling cranes, etc.

12.2 Excavation.

Elevators and hoppers should be installed at intervals of 30m - 60m on the earth surface to shovel up the excavated earth which is loaded in trucks to be carried away. Various mains, such as pipe-lines of water work, sewage, electric power, communication, gas, etc. which have been laid underground within the space of excavation width, should be dug out beforehand by careful hand work to be suspended from the beams of the decking. One cannot be too much careful in this work, as accidents often result from the breakage of such pipe-lines through carelessness.

As the bridging struts, with their tie-bars, which are placed lengthwise and crosswise, the function of large-sized excavating machines is limited, it is sometimes advisable to employ belt conveyors, small-sized bulldozers and power shovels, and, if necessary, clamshell dredgers.

12.3 Construction and waterproofing work.

When the excavation has reached the prescribed depth, foundation concrete of about 10 cm in thickness is placed, upon which is constructed the underground railway structure of box shape. The concrete placing work of this reinforced concrete structure is almost the same as the usual cases.

As the underground railway structures are built often below the ground water level, their circumference must be protected by perfect waterproofing layers.

How to construct the waterproof layer should be determined by the conditions of the geology and ground water. For such geology of Caracas as containing little amount of water the following design is considered to good purpose : (Fig. 31)

In the case of a station structure membrane type waterproof work will be applied to the upper slab, while its side-wall and bottom slab are coated with a layer of mortar mixed with waterproof material. For the tunnel sections other than stations the whole circumference of the structure is coated with a mortar layer mixed with waterproof material. For the transverse joint clearance of the concrete placing which is designed to be formed at every 15 m - 20 m, the side-wall and upper slab will be wound round with membrane type waterproof material, which is about 1 meter wide, in order to prevent the waterproof layer of mortar from cracking.

13. TRACK.

As for the track structure, concrete roadbed has been preferred, and, moreover, the rail is designed to be laid directly on the concrete roadbed without sleepers by means of elastic fastening.

An ideal structure for the underground railway would be such as capable of reducing the amount of maintenance work, making useless the maintenance except in the case of replacing the parts of worn-out materials, and, moreover, causing the least noise and vibration. For this reason we have recommended a structure, which is the latest device, brought about by years' study, and already in use in Tokyo, to be adopted in the present project. According to this device, as shown in Fig. 32, the rail is perfectly elastic-fastened, both vertically and horizontally by means of a rubber material, which causes the least noise and vibration. This is a structure which, we believe, is well worth our recommendation in view of the comfortable ride in the car and the reduced amount of maintenance work.

FIG 31 Waterproofing Work

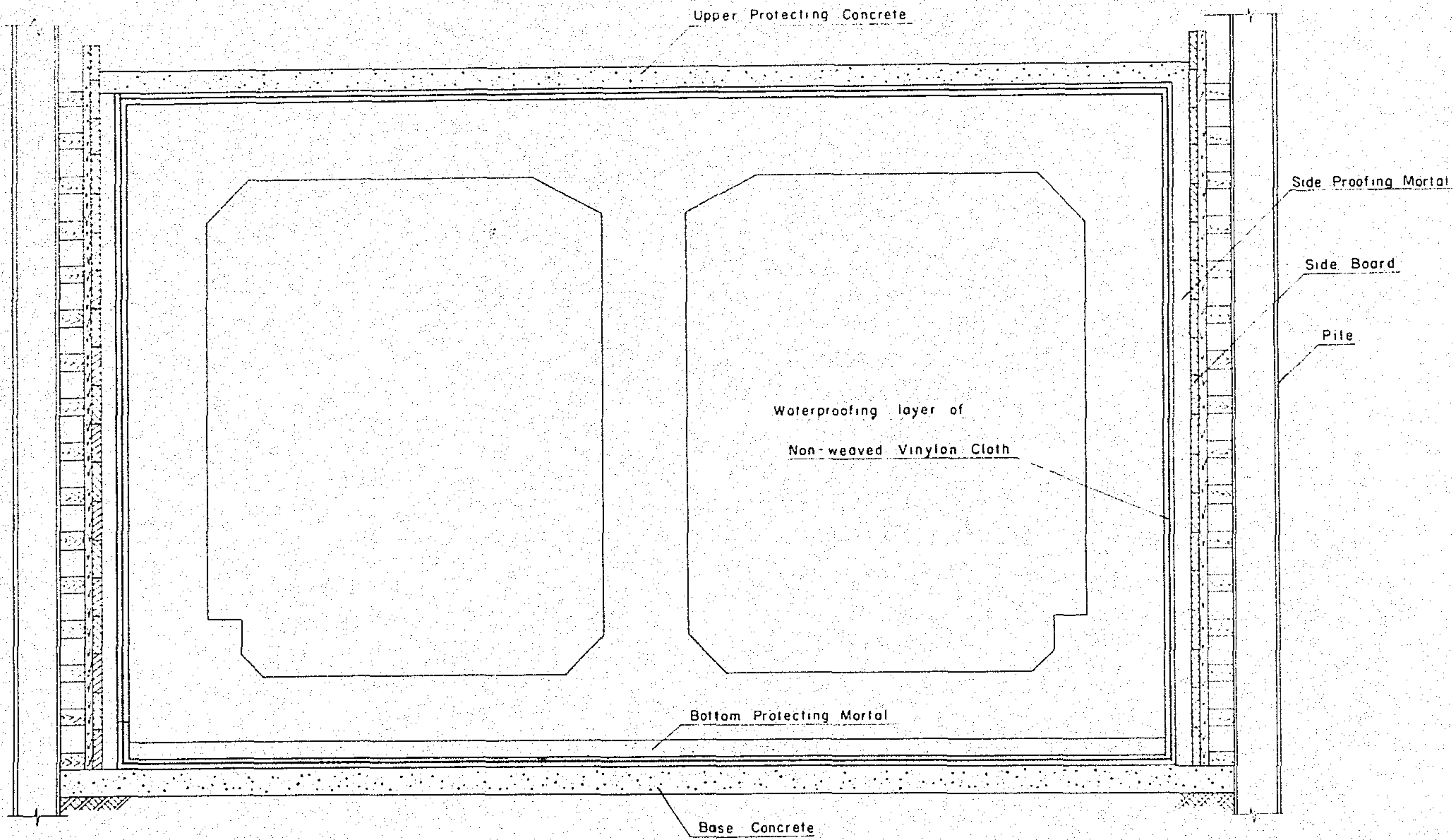
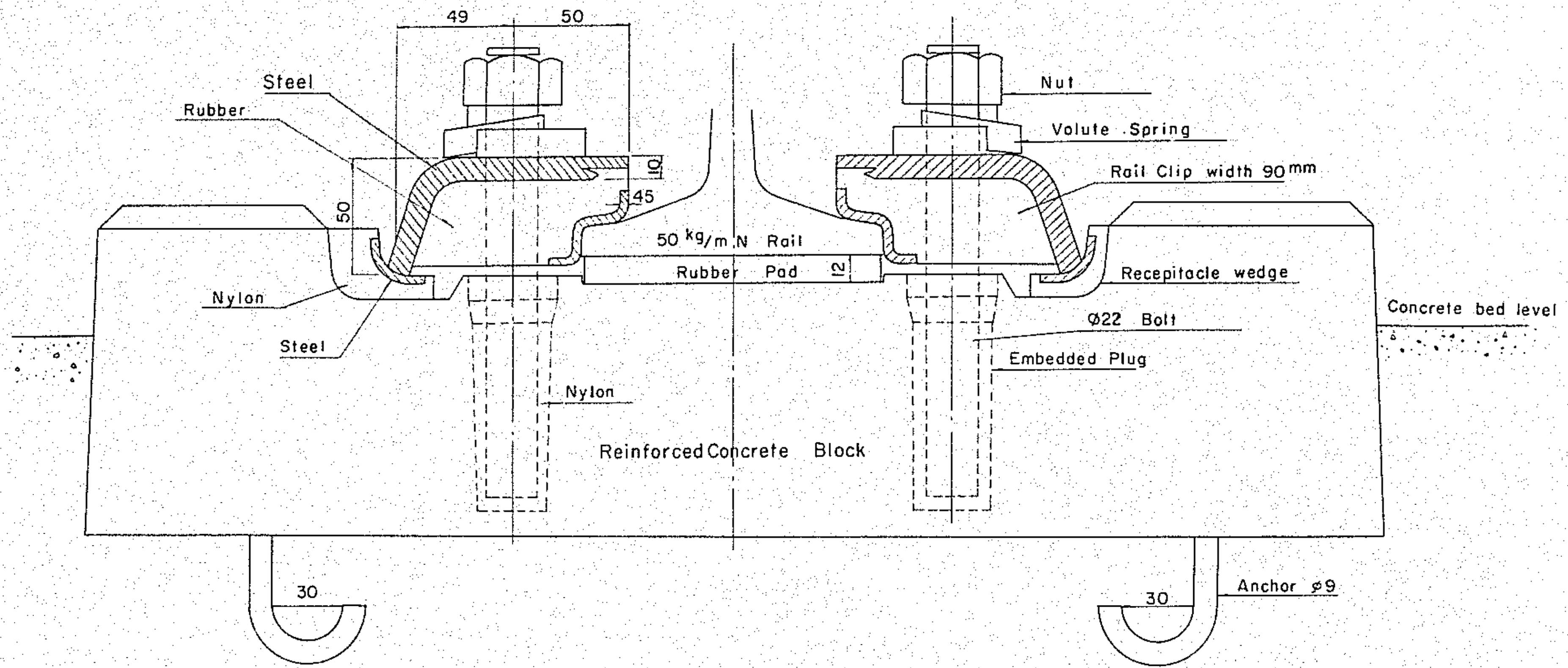


FIG 32 Elastic Fastening (unit : mm)



The rail is 1.435 m in gauge, 50 kg per meter in weight and 25 m in length. The joint clearance of rail in the straight section and the curved section with a radius of more than 500 m is welded, but that of signal points is insulated.

Frogs No. 10 should be employed for crossovers.

Besides, the cross-section of the tunnel where a frog is installed should be of a special shape which is as long as 80 m and without central props; this means that the position of frogs should be determined at the beginning of designing. For instance, in the case of the section of No. 1 Line assigned to the First Construction Period, a double crossover will have to be installed for the turn back of trains at a point short of the ${}_1I_5$ station (the ${}_2I_5$ station of the Second Plan) and the ${}_1I_{11}$ station (common to the Second Plan), and a single crossover at a any halfway point for emergency.

14. DRAINAGE.

Although the whole tunnel structure is sheathed with waterproof layers, it cannot be free from some leakage; besides, measures should be taken to drain the rain-water from the entrances of stations and ventilating holes as well as slop of the stations. All such water is first gathered into the central ditch in the tunnel roadbed, and, flowing along the track gradient, led into the catch-basin of the pump room, from where pumped out the tunnel. The pump rooms are placed in the recesses along the longitudinal slope, and the proper distance between them should be less than 1 km.

15. VENTILATING DEVICE.

The ventilation of the tunnel sections between stations is conducted by the natural ventilation which makes use of the piston movement of running trains. For this purpose, on both sides of the tunnel, ventilating holes, with a distance of about 100 m between them, are dug in the road surface so that the air may come into and go out of the tunnel.

Such common stations as dealing with an average number of passengers may rely on the ventilating holes on the road surface, and entrances and exits of passengers for natural ventilation.

However, for main stations dealing with a large number of passengers forced draft system should also be employed, and the corresponding equipments such as engine rooms, wind channels, etc. would be necessary; such equipments can be utilized also for cold blast when it becomes desirable in future by the increased number of passengers and trains.

16. DESIGN OF ELECTRIC POWER SUPPLY.

16. 1 Outline of power supply to electric cars.

The feed voltage for electric cars is 750 V. D. C. The current, 3-phase 60c/s 33 KV, from La Electricidad de Caracas is transformed to 750 KV. D. C. by the silicon rectifier at the D. C. subsation of the underground railway and fed to cars through the third rail. The distance between each substation has been designed to be about 2 km on No. 1 Line, about 2. 3 km on No. 2 Line and about 2. 7 km on No. 3 Line, in consideration of the voltage drop of the third rail, and measures to be taken in time of accidents to machinery.

The layout of the D. C. substations, as shown in Fig. 33, amounts to 24 in total : 9 on No. 1 Line; 10 on No. 2 Line (out of which No. 2-6 substation is to be amalgamated with No. 1-4 one of No. 2 Line); 7 on No. 3 Line (out of which No. 3-1 one is to be amalgamated with No. 2-8 one of No. 2 Line).

This is the idea of the substations according to the First Plan, and in the case of the Second Plan the total number remains the same, although there is some alterations in their locations. The unit capacity of the converters to be installed in each substation has been designed to be 2, 000 KW or 1, 500 KW respectively. The number of the converters needed is determined by the computation of the load of substations as shown in next paragraph.

The system of feeding is of parallel with the neighboring substations and provides 4 lines from each substation to feed respective lines and in both directions.

Besides, seperate feeders should be provided for the car inspection sheds and repair-shops.

16. 2 Electric power required per day and maximum electric power per hour.

The electric power per day, which is necessary for the design of substations, is

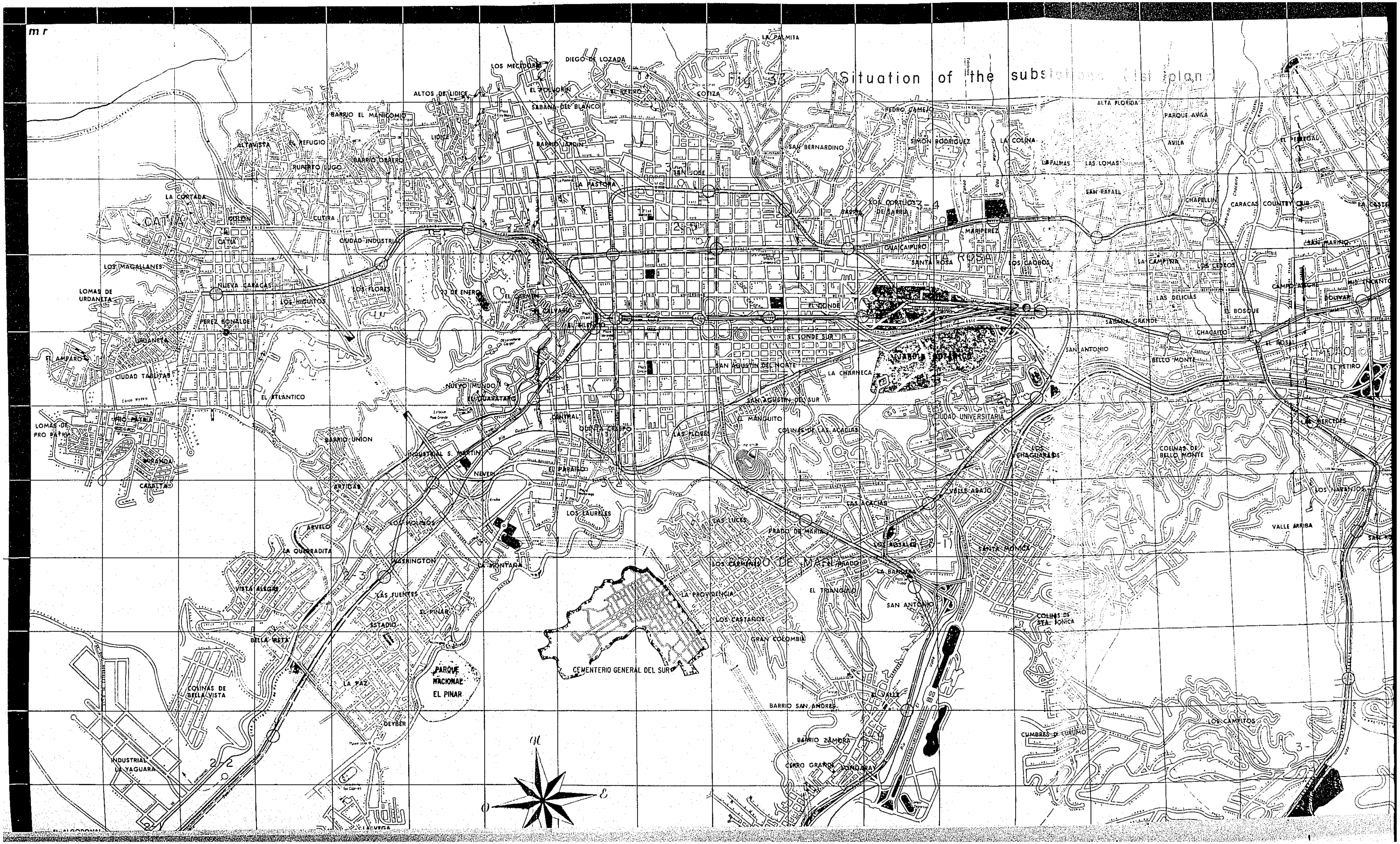
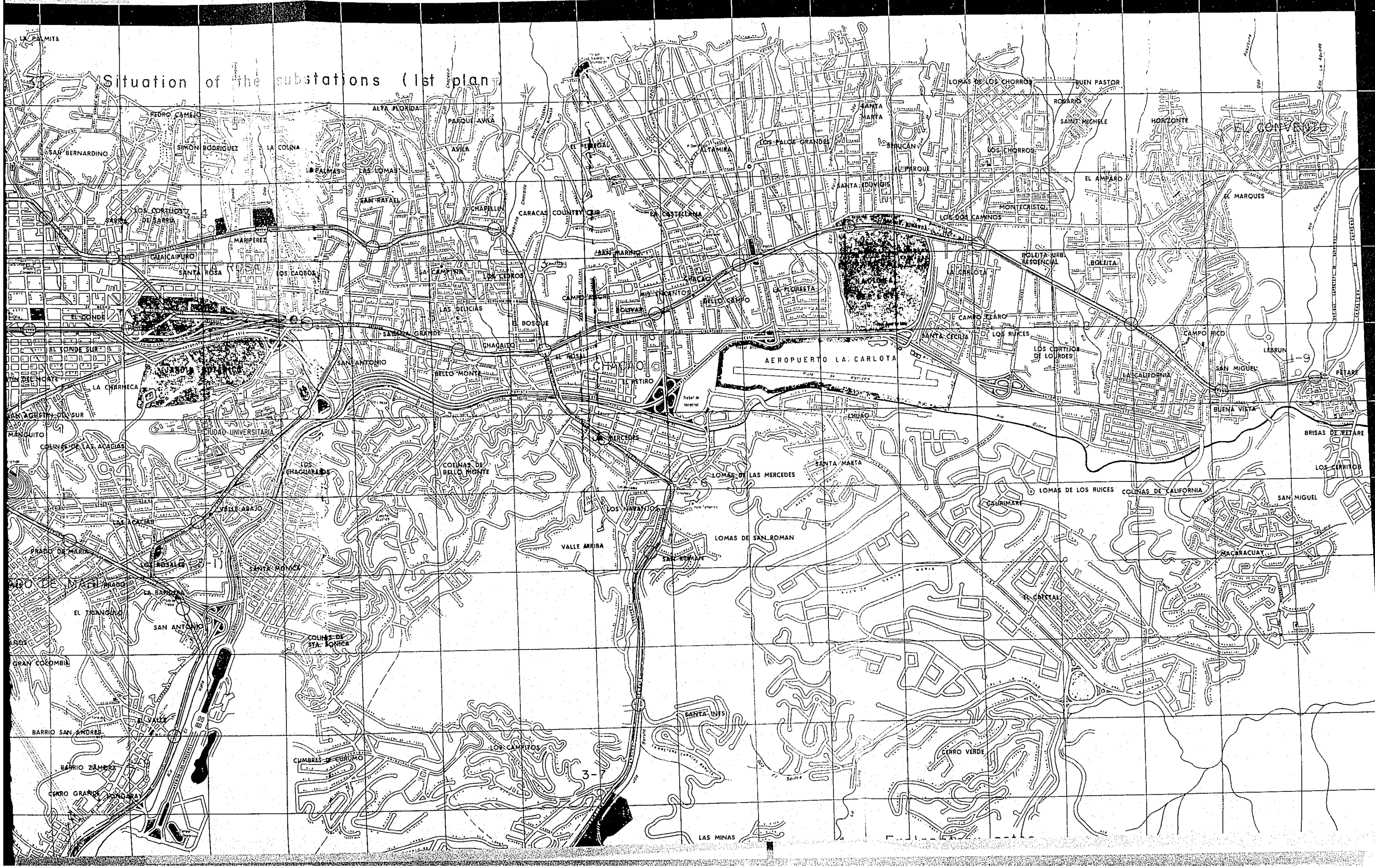
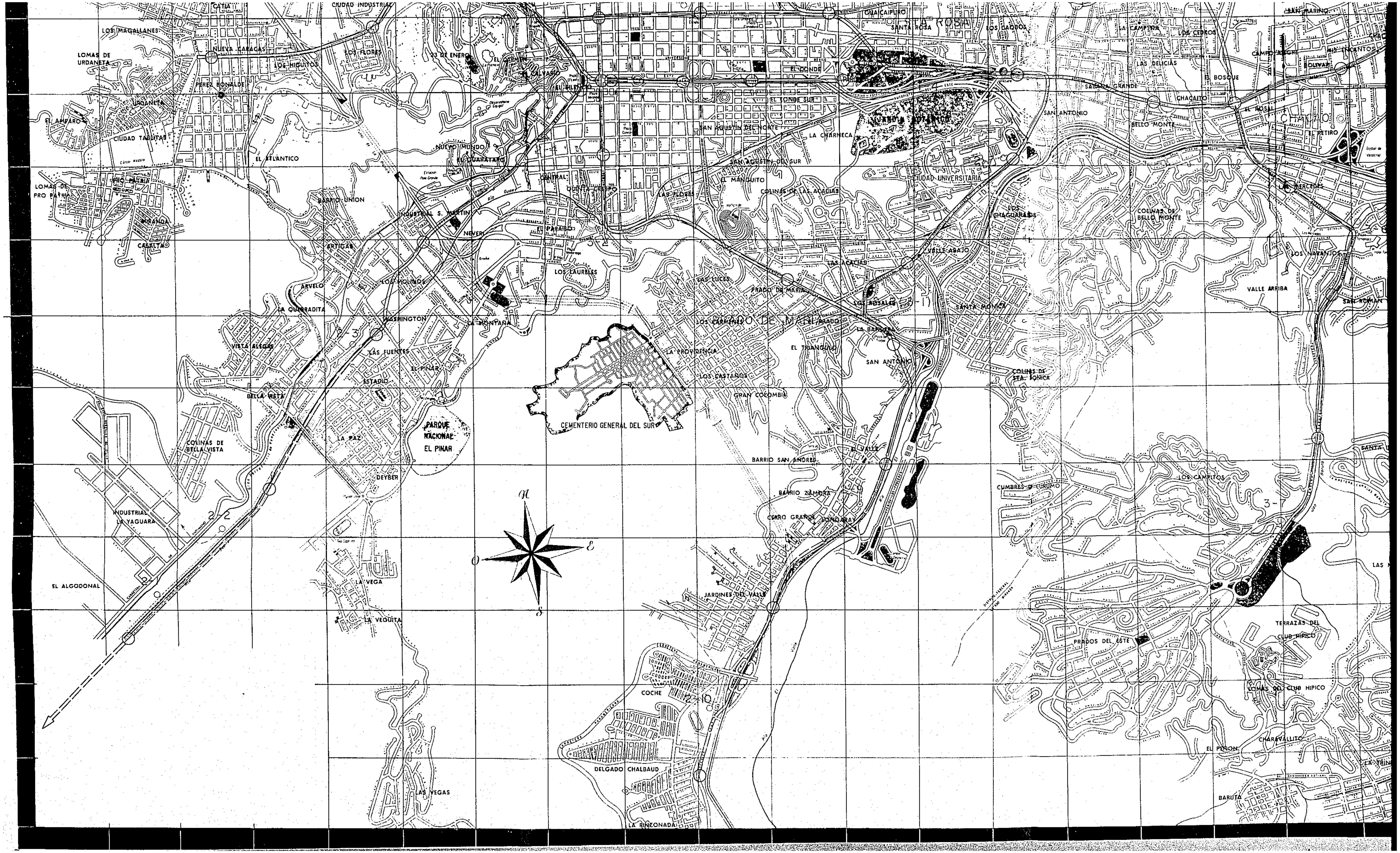


Fig. 37 Situation of the substations (1st plan)


Situation of the substations (1st plan)
LA PALMITA
PEDRO CAMEJO
SAN BERNARDINO
SIMON RODRIGUEZ
LA COLINA
ALTA FLORIDA
PARQUE AVILA
AVILA
LAS LOMAS
SAN RAFAEL
CHAPELLIN
CARACAS COUNTRY CLUB
LOS CORTIJOS DE SARRIA
MARIPEREZ
GUAICAIPURO
SANTA ROSA
LOS CAOBOS
LA CAMPIÑA
LOS CEDROS
LAS DELICIAS
EL BOSQUE
SABANA GRANDE
CHACAITO
EL CONDE
EL CONDE SUR
SAN ANTONIO
BELLO MONTE
EL ROSAL
CHACAO
EL RETIRO
LA CHARNECA
SAN AGUSTIN DEL SUR
CIUDAD UNIVERSITARIA
COLINAS DE LAS ACACIAS
LOS CHAGUARAMOS
COLINAS DE BELLO MONTE
LAS MERCEDES
VALLE ABAJO
LAS ACACIAS
PRADO DE MARIA
LOS ROSALES
SANTA MONICA
LA BANDERA
EL TRIANGULO
SAN ANTONIO
COLINAS DE STA. MONICA
GRAN COLOMBIA
BARRIO SAN ANDRES
BARRIO ZAMORA
CERRO GRANDE
LOS CAMPITOS
CUMBRES DE CURUMO
3-7
LAS MINAS
LOS NARANJOS
VALLE ARRIBA
LOMAS DE SAN ROMAN
SAN ROMAN
SANTA INES
LOMAS DE LAS MERCEDES
SANTA MARTA
CHUAO
EL PEDREGAL
ALTAMIRA
LA CASTELLANA
LOS PALOS GRANDES
SANTA EDUVIGIS
SAN MARINO
CAMPO ALEGRE
BOLIVAR
LOS PALOS GRANDES
BELLO CAMPO
LA FLORESTA
AEROPUERTO LA CARLOTA
LOMAS DE LOS CHORROS
SANTA MARTA
SEBUCAN
EL PARQUE
LOS CHORROS
BUEN PASTOR
ROSARIO
SAINT MICHELE
HORIZONTE
EL CONVENTO
EL AMPARO
MONTECRISTO
LOS DOS CAMINOS
EL MARQUES
BOLEITA URB. RESIDENCIAL
BOLEITA
LA CARLOTA
CAMPO CLARO
SANTA CECILIA
LOS RUICES
LOS CORTIJOS DE LOURDES
CAMPO RICO
LEBRUN
1-9
LA CALIFORNIA
SAN MIGUEL
PETARE
BUENA VISTA
BRISAS DE PETARE
LOS CERRITOS
LOMAS DE LOS RUICES
COLINAS DE CALIFORNIA
CAURIMARE
SAN MIGUEL
MACARACUAY
EL CAFETAL
CERRO VERDE



CATIA
CIUDAD INDUSTRIAL
LOS MAGALLANES
LOMAS DE URDANETA
NUEVA CARACAS
LOS HIGUITOS
LOS FLORES
23 DE ENERO
EL CALVARIO
PEREZ BONALDE
URDANETA
EL AMPARO
CIUDAD TABLITAS
EL ATLANTICO
LOMAS DE PRO PATRIA
PRO PATRIA
MIRANDA
CASERITA
BARRIO UNION
NUEVO MUNDO
EL GUARATARO
INDUSTRIAL S. MARTIN
ARTIGAS
NEVERI
EL PARAISO
LOS LAURELES
ARVELO
LOS MOLINOS
LA QUEBRADITA
WASHINGTON
LA MONTAÑA
VISTA ALEGRE
LAS FUENTES
EL PINAR
ESTADIO
BELLA VISTA
COLINAS DE BELLA VISTA
LA PAZ
PARQUE NACIONAL EL PINAR
DEYBER
INDUSTRIAL LA YAGUARA
EL ALGODONAL
LA VEGA
LA VEGUITA
LAS VEGAS
CEMENTERIO GENERAL DEL SUR
GUAICAIPURO
SANTA ROSA
LOS CAOBOS
LA CAMPIÑA
LOS CEDROS
LAS DELICIAS
EL BOSQUE
SAN MARINO
CAMPO ALEGRE
BOLIVAR
LOS ENCANTOS
SABANA GRANDE
CHACAITO
EL CONDE
EL CONDE SUR
SAN AGUSTIN DEL NORTE
LA CHARNECA
SAN AGUSTIN DEL SUR
EL MANGUITO
COLINAS DE LAS ACACIAS
CIUDAD UNIVERSITARIA
SAN ANTONIO
BELLO MONTE
EL ROSAL
EL RETIRO
LAS MERCEDES
LOS CHAGUARAMOS
COLINAS DE BELLO MONTE
LAS FLORES
LAS ACACIAS
VALLE ABAJO
LAS LUCES
PRADO DE MARIA
LOS ROSALES
SANTA MONICA
LOS NARANJOS
VALLE ARRIBA
SAN ROMAN
LOS CARMENES
EL PRADO
LA BANDERA
LA PROVIDENCIA
EL TRIANGULO
SAN ANTONIO
LOS CASTAÑOS
GRAN COLOMBIA
COLINAS DE STA. MONICA
EL VALLE
BARRIO SAN ANDRES
BARRIO ZAMORA
CERRO GRANDE
LONGARAY
LOS CAMPITOS
CUMBRES DE CURUMO
JARDINES DEL VALLE
PRADOS DEL ESTE
TERRAZAS DEL CLUB HIPICO
LOMAS DEL CLUB HIPICO
COCHE
DELGADO CHALBAUD
LA RINCONADA
EL PEÑON
CHARAVALLITO
BARUTA
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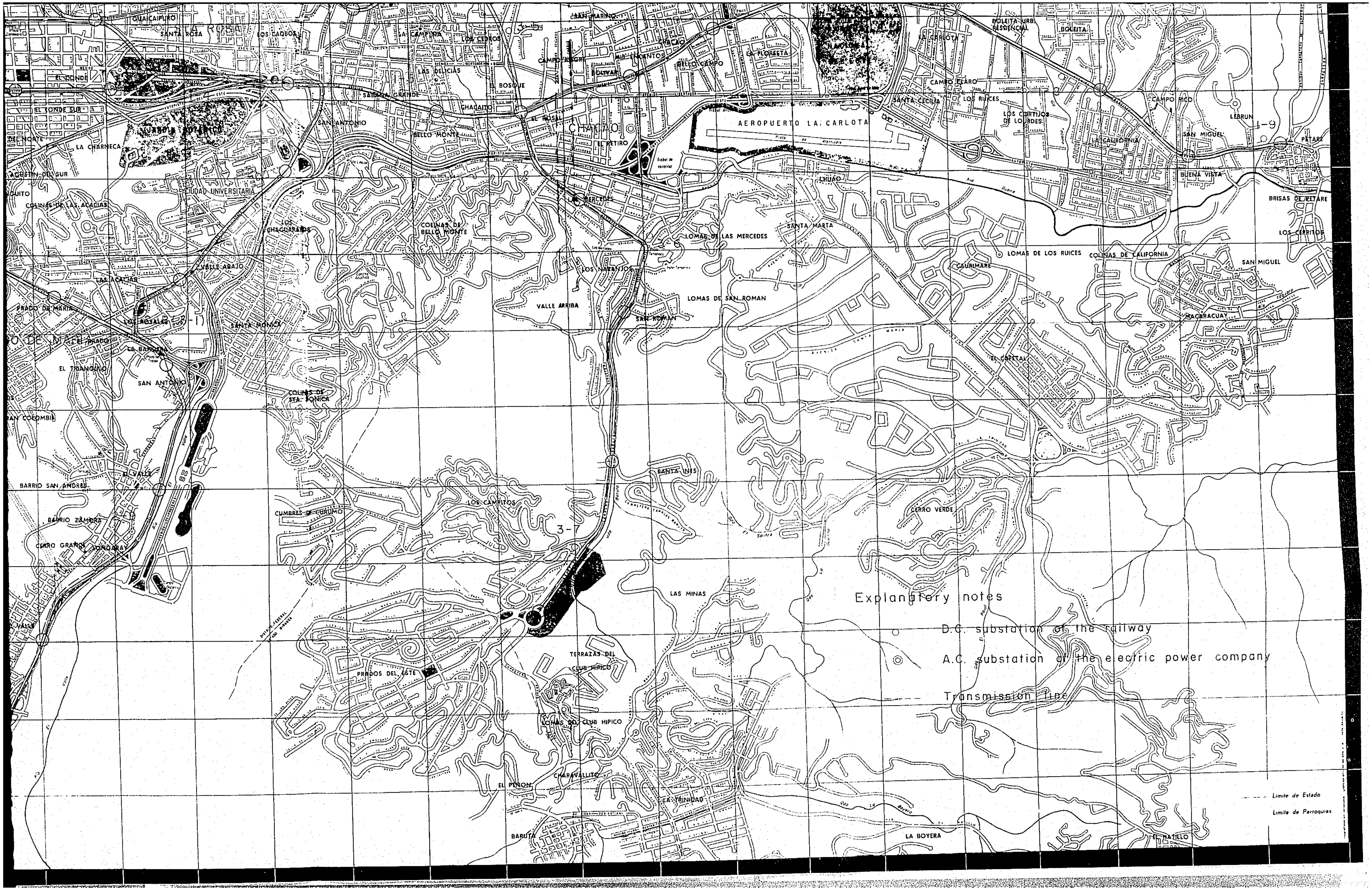


GUAICAIPURO
SANTA ROSA
LOS CAOBOS
LA CAMPIÑA
LOS CEDROS
SAN MARINO
CHACAO
LOS ENCANTOS
BELLO CAMPO
LA FLORESTA
CAMPO ALEGRE
BOLIVAR
BOLEITA URB. RESIDENCIAL
BOLEITA
LA CARLOTA
EL CONDE
LAS DELICIAS
SABANA GRANDE
EL BOSQUE
CHACAITO
CAMPO CLARO
SANTA CECILIA
LOS RUICES
CAMPO RICO
LEBRUN
PETARE
EL CONDE SUR
SAN ANTONIO
BELLO MONTE
EL ROSAL
CHACAO
EL RETIRO
AEROPUERTO LA CARLOTA
LOS CORTIJOS DE LOURDES
LA CALIFORNIA
SAN MIGUEL
BUENA VISTA
JARDIN BOTANICO
LA CHARNECA
CIUDAD UNIVERSITARIA
CHUAO
LAS MERCEDES
BRISAS DE PETARE
COLINAS DE LAS ACACIAS
LOS CHAGUARAMOS
COLINAS DE BELLO MONTE
LOMAS DE LAS MERCEDES
SANTA MARTA
LOS CERRITOS
LOMAS DE LOS RUICES
COLINAS DE CALIFORNIA
VALLE ABAJO
LOS NARANJOS
CAURIMARE
SAN MIGUEL
LAS ACACIAS
LOMAS DE SAN ROMAN
PRADO DE MARIA
VALLE ARRIBA
SAN ROMAN
LOS ROSALES
SANTA MONICA
MACARACUAY
LA BANDERA
EL CAFETAL
EL TRIANGULO
SAN ANTONIO
COLINAS DE STA. MONICA
GRAN COLOMBIA
SANTA INES
EL VALLE
BARRIO SAN ANDRES
CUMBRES DE CURUMO
LOS CAMPITOS
CERRO VERDE
BARRIO ZAMORA
CERRO GRANDE
LONGARAY
3-
LAS MINAS
Explanatory notes
D.C. substation of the railway
A.C. substation of the electric power company
Transmission line
TERRAZAS DEL CLUB HIPICO
PRADOS DEL ESTE
LOMAS DEL CLUB HIPICO
EL PEÑON
CHARAVALLITO
LA TRINIDAD
BARUTA
LA BOYERA
EL HATILLO
Limite de Estado
Limite de Parroquias

estimated as follows, assuming the specific power consumption per car kilometer to be 3.5 KWH, which includes all the power for the operation of car, lighting, attached facilities, etc., and the maximum electric power required per hour is estimated also as follows, the number of trains being 30:

Line	Electric power required per day (KWH)	Max. electric power per hour (KWH)
the First Plan		
No. 1	320,000	29,100
No. 2	306,000	27,700
No. 3	162,000	14,600
Total	788,000	71,480
the Secound Plan		
No. 1	318,000	28,800
No. 2	292,000	26,400
No. 3	158,000	14,400
Total	768,000	69,600

The load factor in both Plans is 46%. The load curve of the total electric power of the First Plan is shown in Fig. 34.

16.3 Calculation of load of each substation.

In calculating the maximum load per hour of each substation, the feeding distance alloted to each is assumed to be half the distance between adjacent substations, as each of them conducts a parallel feed.

The load per km is expressed by the equation.

$$W = \frac{2 \times 60 \times w \times c}{H}$$

where w = specific power consumption, which is 3.5 KWH per car km calculated at the receiving side of D. C. substation, including the power for car operation, lighting and attached facilities; c = number of cars forming trains; H = headway.

By the application of the above equation the load per km of each Line is :

No. 1 Line	8-car train with 2 min. headway	1,680 KWH/km
No. 2 Line	6-car train with 2 min. headway	1,260 "

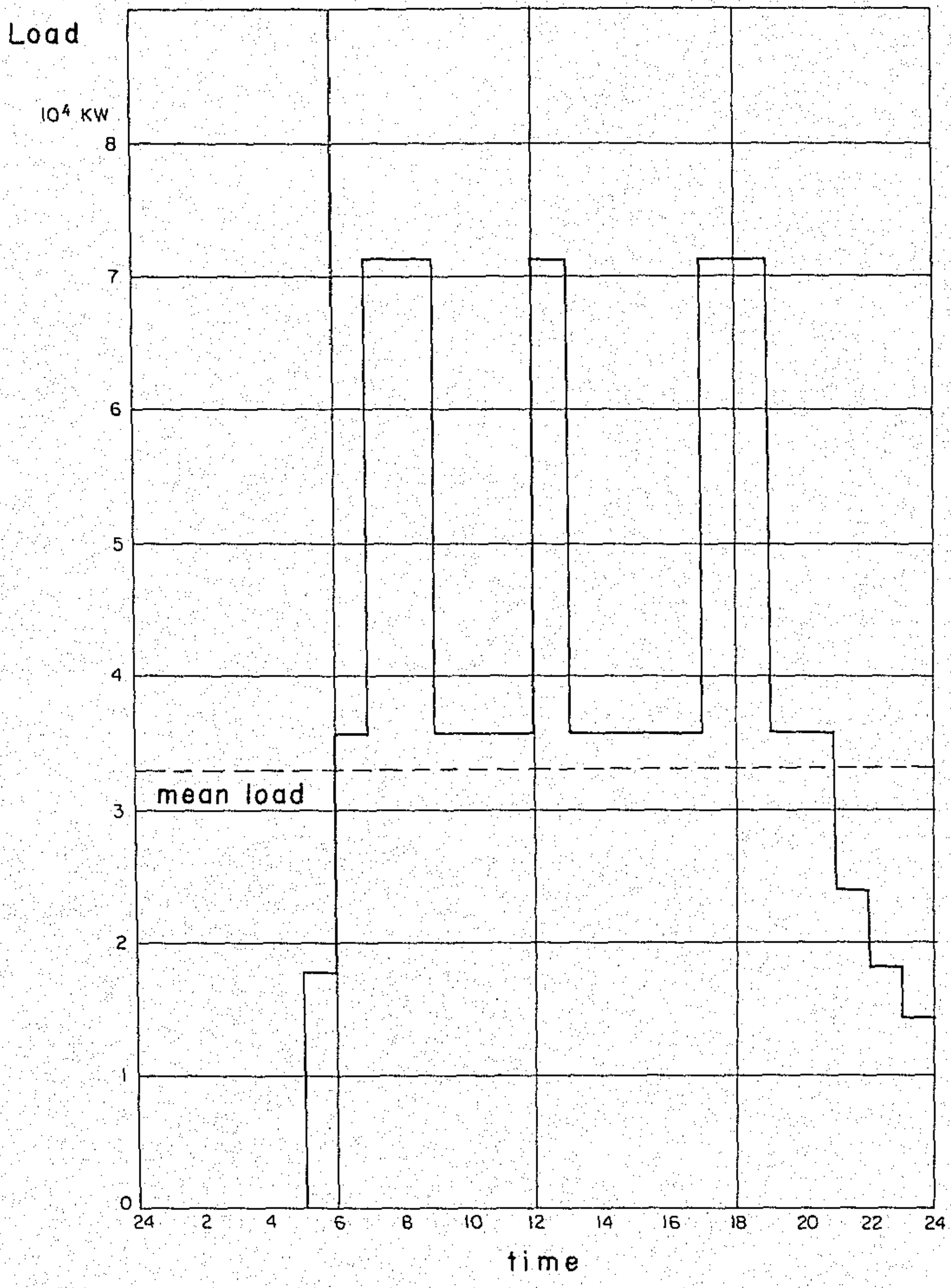


FIG 34 Load curve

No. 3 Line 4-car train with 2 min. headway 840 KWH/km

The load of substation is W x L; here L is the feeding distance (km) alloted to substation. This compulation is tabulated into Table 8.

The number of converters for each substation is 2 or 3, one of which being a spare unit.

16.4 Power receiving program.

(a) Power demand and supply program of Caracas Electric Power Company (La Electricidad de Caracas).

According to the data of the Caracas Electric Power Company, the electric power demand and supply program from 1964 to 1980 is tabulated into Table 9. Two electric cycles, 50 c/s and 60 c/s, are in use in Venezuela, and they are being brought to a uniform standard of 60 c/s. The only area of 50 c/s at present is Caracas City, where the above-mentioned company is going to complete the standardization by 1968.

Table 9 indicates that the whole power supply will be made by the company's own power plants, but, in addition to this, there will be, in view of the power generation project of all Venezuela, an ample power supply also to Caracas district from the hydraulic power stations in the basin of the River Orinoco by the Corporación Venezolane de Guayana. Therefore, so far as the electric power balance is concerned, it is presumed that there will be no need of worrying about the power supply to the underground railway.

(b) Power receiving program.

The maximum amount of power per hour needed by this project for the transport volume in 1980 is, in the case of the First Plan, approximately 29,000 KWH for No. 1 Line, 28,000 KWH for No. 2 Line and 15,000 KWH for No. 3 Line, totalling 72,000 KWH. By the time this project is carried out the cycle change program of the Caracas Electric Power Co. will have been completed; therefore, the supply current at that time is designed to be 3-phase A. C. 60 c/s 33 KV. In case that the completion of the cycle change program happens to be too late for the present project, the progress schedule of the cycle change work should be made to keep pace with the power receiving program of the substations of the underground railway.

Power should be supplied, in principle, from those substations of the company which are equipped with 33KV bus bars: the substations, Catia, St. Rosa, Chacao, El Convento and Prado de Maria. In addition, the substation of Piedras is expected to be newly built in a few years, when the power supply from this substation will also be made possible.

Table 8 The load and capacity of D. C substations

No. 1 line

No. of substation	(1-1)	(1-2)	(1-3)	(1-4)	(1-5)	(1-6)	(1-7)	(1-8)	(1-9)	Total sum
Feeding distance KW	1,800	2,100	2,025	1,975	2,000	2,050	2,100	2,025	1,225	17,[illegible]
Load KW (A)	3,620	3,590	3,420	3,320	3,260	3,440	3,530	3,420	2,060	29,600
Capacity KW (B)	2,000 x 3	2,000 x 3	2,000 x 3	2,000 x 3	2,000 x 3	2,000 x 3	2,000 x 3	2,000 x 3	2,000 x 2	Total capacity 52,000 Do. (except a spare unit.) 34,000
Load factor % (A/B)	59	59	58	56	57	58	60	58	52	Total capacity 56 Do. (except a spare unit.) 86

No. 2 line

No. of substation	(2-1)	(2-2)	(2-3)	(2-4)	(2-5)	(2-6)	(2-7)	(2-8)	(2-9)	(2-10)	Total sum
Feeding distance KW	2,900	2,300	2,275	2,300	2,325	2,225	2,100	2,175	2,350	1,050	22,000
Load KW (A)	2,500	2,900	2,870	2,900	2,930	2,800	2,640	2,740	2,960	2,460	27,700
Capacity KW (B)	1,500 x 3	1,500 x 3	1,500 x 3	1,500 x 3	1,500 x 3	2,000 x 1	1,500 x 3	1,500 x 3	1,500 x 3	1,500 x 3	Total capacity 42,500 Do. (except a spare unit.) 29,000
Load factor % (A/B)	56	64	64	64	65	Installed in the (1-4) Sub.	59	61	66	55	Total capacity 65 Do. (except a spare unit.) 96

No. 3 line

No. of substation	(3-1)	(3-2)	(3-3)	(3-4)	(3-5)	(3-6)	(3-7)	Total sum	Total sum of ? lines
Feeding distance KW	1,650	2,700	2,750	2,750	2,750	2,750	2,100	17,450	56,750
Load KW (A)	1,380	2,270	2,310	2,310	2,310	2,310	1,700	14,600	71,400
Capacity KW (B)	1,500 x 1	1,500 x 3	1,500 x 3	1,500 x 3	1,500 x 3	1,500 x 3	1,500 x 2	Total capacity 27,000 Do. (except a spare unit.) 18,000	121,500 81,000
Load factor % (A/B)	Installed in the (2-8) Sub.	59	51	51	51	51	59	Total capacity 54 Do. (except a spare unit.) 81	59 88

Table 9. Plan for power supply and demand of Caracas Electric Power Company.

	Demand power (MW)		Supply power (MW)	
	50 Cycle	60 Cycle	50 Cycle	60 Cycle
1964	289	20	396	48
1965	165	171	258	222
1966	30	333	62	440
1967	0	385	0	516
1968		414		562
1969		446		562
1970		481		562
1971		515		702
1972		555		702
1973		598		842
1974		643		842
1975		690		890
1976		738		938
1977		796		994
1978		855		1067
1979		918		1207
1980		987		1207

In the absence of proper neighboring substations, that is, in the vicinity of Antimano, Coche and Parque Humbolt, power supply is made from the branch of the overhead transmission lines of 33 KV.

Although it was conceivable to get the power supply from the branch lines of the underground cable of 33 KV in the city, this idea has been abandoned owing to the uncertainty of the excess cable capacity in future.

Each substation should be so built as to utilize two system of power source, providing against the interruption of service in the regular power line by means of installing auxiliary lines or interconnecting transmission cables with each other.

Fig. 35 shows the diagram of the electric power receiving system.

16.5 Interconnecting cables between D. C. substations.

The interconnecting cables between substations should be of 33 KV, the size being either 100 mm^2 or 150 mm^2, and, in the tunnel, contained in ceramic trough laid at the foot of the side-wall.

16.6 Outline of D. C. substation facilities.

The outline of the facilities to be installed on No. 1 line of the First Plan is as follows:

The D. C. substation (1-1) receives two-line supply by means of cables derived from the 33 KV bus bar of the company's Catia substation; so do the D. C. substation (1-4) from St. Rosa, the D. C. substation (1-6) from Chacao, and the D. C. substation (1-9) from El Convento. The lengths of these cables are :

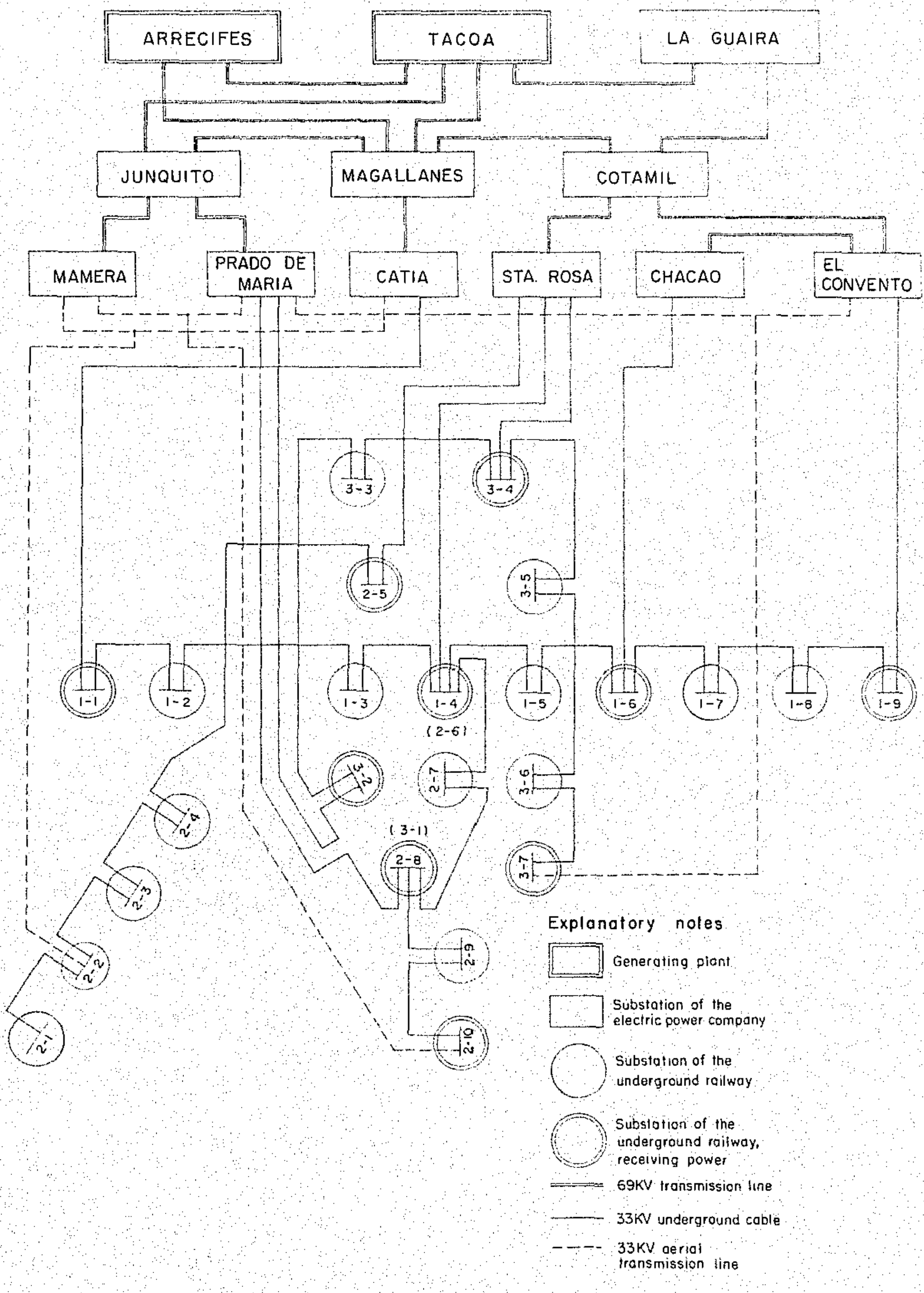
from	(1-1)	substation to	Catia	substation	1.7 km
"	(1-4)	"	St. Rosa	"	0.7 "
"	(1-6)	"	Chacao	"	0.7 "
"	(1-9)	"	El Convento	"	3.6 "

The laying work of these cables had better be left to the electric power company. Besides, in deriving lines from the 33 KV bus bar exclusive circuit breakers should be installed.

Interconnecting cables of 33 KV should be laid at necessary places, as stated above, between each D. C. substation.

As for attached power facilities, three units of transformer, singlephase 33 KV/5KV 1000KVA, are installed at the (1-4) substation, and two-line supply cables of 3-phase 5KV should be laid all along the railway line to distribute power to the switch house of each station, which will be later mentioned.

FIG 35 Block diagram of power receiving



When a substation cannot be built on the earth surface because of the lack of proper site or its noise, or where there is much room for it because the tunnel is in the deep place, it is built underground. Out of the 9 substations of the First Plan 4 have been designed to be on the earth surface and 5, underground. The surface substations should be of indoor type, and the building of reinforced concrete and two-storied, to save the site and prevent the noise.

The equipments of the substation of No. 1 Line are as follows:

(a) (1-4) substation

Building: reinforced concrete; two-storied.

Power receiving equipments: 3-phase A.C. 33 KV single-line supply from the power company.

Power transmission equipments: 3-phase A.C. 33 KV two-line supply to adjacent substations (3-line supply in case of supplying to No. 2 Line)

Transformer equipments for attached facilities: single-phase 1,000 KVA, 3 units.

Distribution equipments: 3-phase A.C. 5 KV 4-line supply (8-line supply in case of supplying to No. 2 Line), two-line distribution to switch house of station in each direction.

Converter equipments: silicon rectifier 750 V 2,000 KW, rating D, 3 units (4 units in case of supplying to No. 2 Line)

Feeding equipments: 4-line supply (8-line supply in case of supplying to No. 2 Line)

Supervisory and remote control equipments: central control room being installed in the proper station, each substation is managed operatorless.

Rating D means that kind of rating at which a machine can be used continuously without any hindrance to its practical purpose, in spite of its employment for two hours with a load 1.5 times as large as the rated output and for one minute with a load 3 times as large as the rated output, after its temperature has reached the ultimate constant value by its continuous employment at the rated output.

(b) (1-5) substation

Building: constructed underground; together with the underground railway tunnel incorporated into one unit.

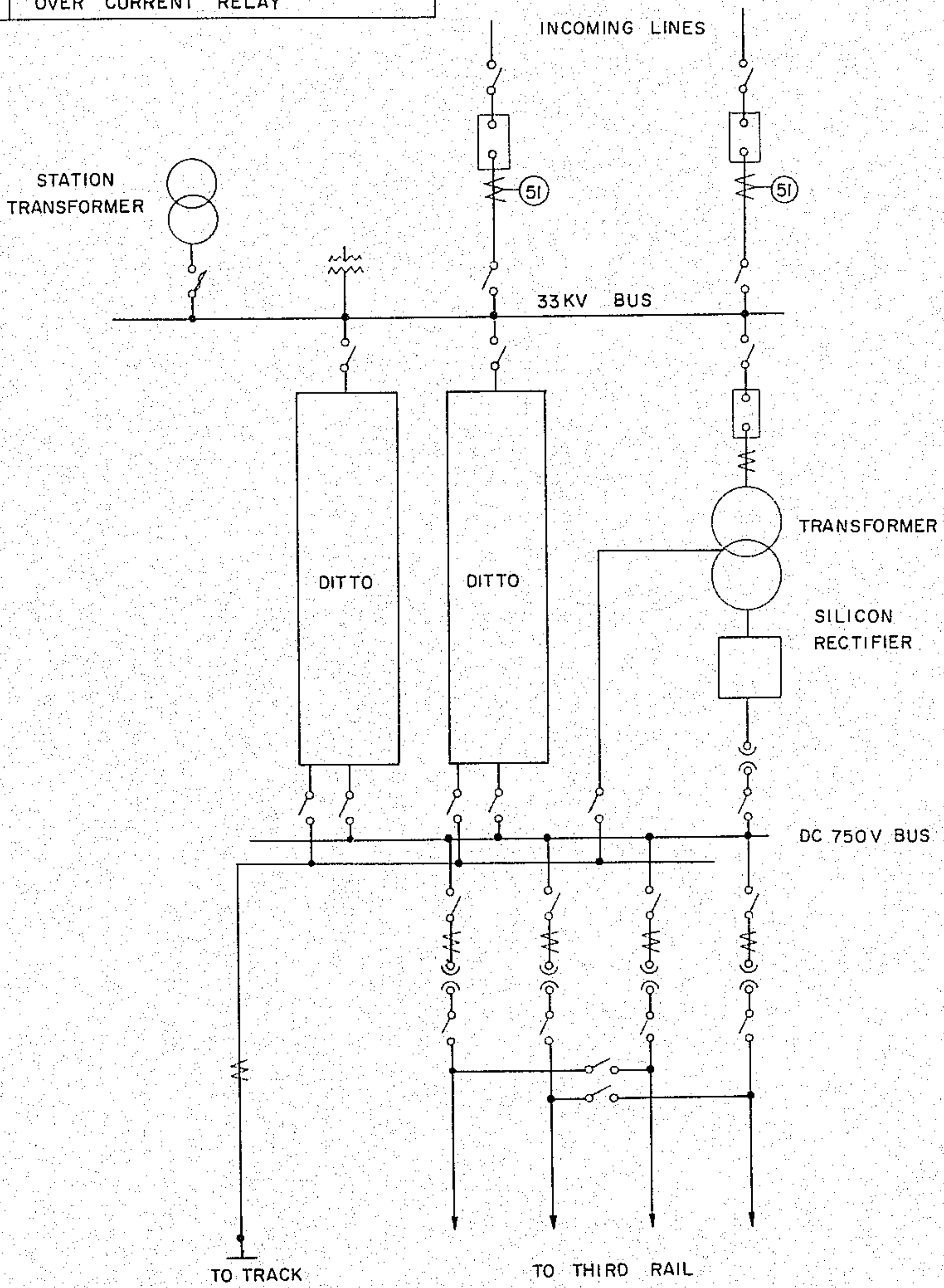
Power receiving equipments: 3-phase A.C. 33 KV two-line supply. Converter equipments: 750 V 2,000 KW silicon rectifier, rating D. 3 units,

Feeding equipments: 4-line supply.

FIG 36

SCHEMATIC DIAGRAM OF SILICON RECTIFIER SUBSTAION

REFERENCE	
	DISCONNECTING SWITCH
	CIRCUIT BREAKER
	HIGH SPEED CIRCUIT BREAKER
	CURRENT TRANSFORMER
	POTENTIAL TRANSFORMER
51	OVER CURRENT RELAY



Supervisory and remote control equipments: controled from the central control room.

Fig. 36 shows the skeleton diagram of this substation.

(c) Central control room of supervisory and remote control system.

This control room, together with the train dispatching room, should be in a proper station. The system should be transistorized.

17. THIRD RAIL AND THE OTHER FEEDING EQUIPMENTS.

17. 1 Third rail.

(a) Structure and installation of third rail.

The third rail should be laid along the side of one of the rails; along the wall side of the tunnel in the straight section and curved section with a radius of over 300 m; along the outer rail side in the curved section with a radius of less than 300 m; on the opposite side of the platform in the station.

The third rail should be of low carbon steel, 50 kg/m in weight and of top-contact type. The structure is shown in Fig. 37. The interrupted sections of the third rail should be connected with jumpers.

17. 2 Return rail bond.

Rails should be joined by welding as far as possible, but where welding is impossible compressed bonds or welded bonds should be employed.

17. 3 Feeder line.

Feeder lines should be laid between the bus bar of substations and the third rail.

Kind of wire ----------- chloroprene-armored rubber jacket cable

Size of wire ----------- $500mm^2$

Number of lines -------- 4

Number of wires ------ 2 per line

17. 4 Return line.

Negative feeder lines should be laid from the negative bus bar of substation to the impedance bond in the tunnel.

Kind of wire ---------- polyvinyl chloride insulated wire

FIG 37

GENERAL EQUIPMENT OF THIRD RAIL

FOR UNDERGROUND RAILWAY