4-1-3 Demand Forecasting in Practice

(1) Summary

An outline of demand forecasting is shown in the Fig. 4.1.4 flow chart. Future interzonal traffic volume was studied using EPTRM as a base, and the bus, another public mass transit system, was chosen as an alternative means of transportation in consideration of the present share of the traffic.

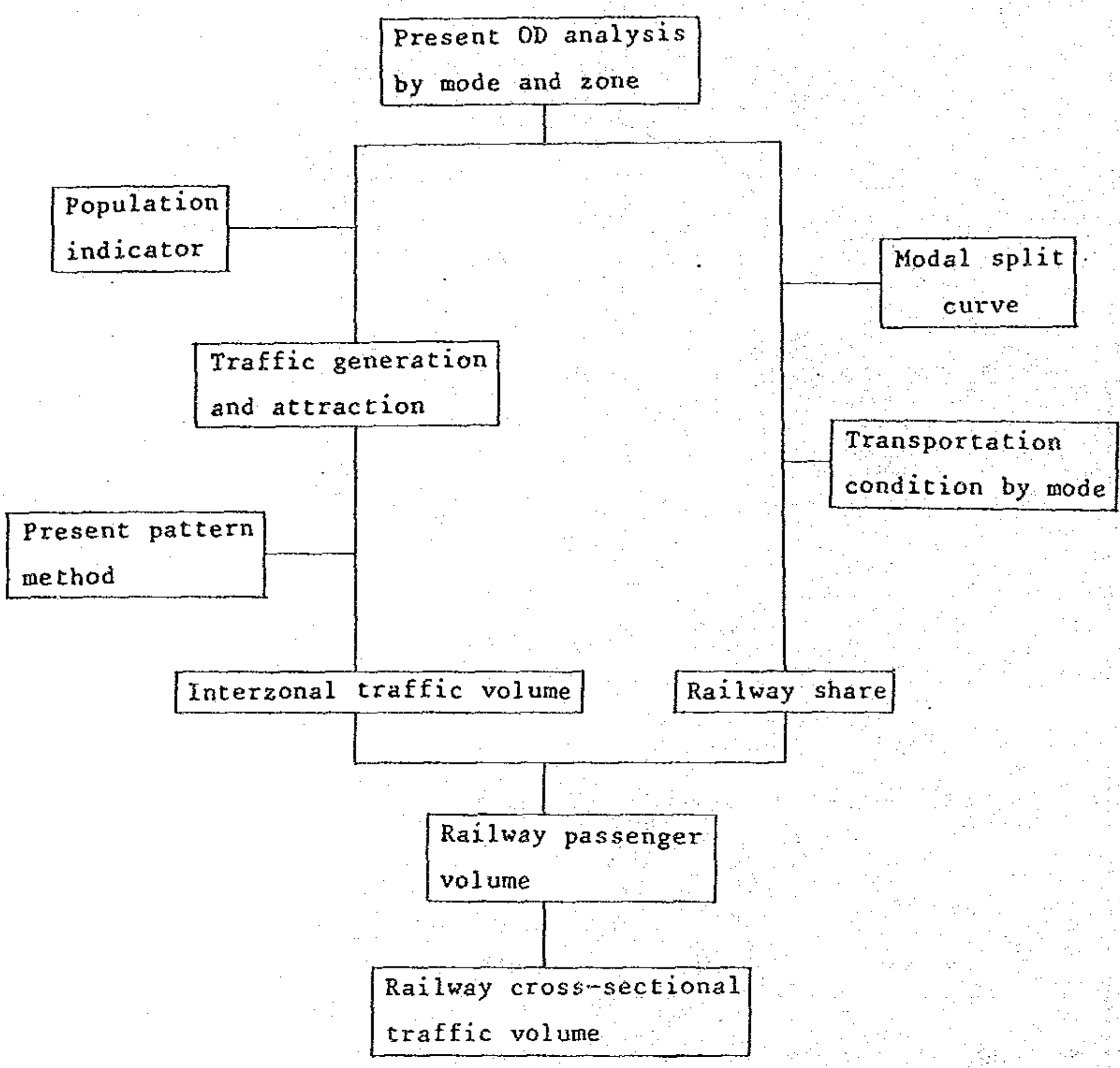


Fig. 4.1.4 Flow Chart of Traffic Volume Demand Forecasting

(2) Interzonal traffic volume

Trip generation/attraction by zone is estimated by taking future population by zone as the growth factor of trip generation/attraction.

The present pattern method is applied to interzonal traffic volume since the target region population is expected to grow only by a relative small 1.5 times and no major changes in the OD pattern are foreseen in the future. The interzonal traffic volume is obtained by iterative calculation using the Fratar Method.

(3) Railway passenger traffic volume

1) Bus and railway shares

Traffic volumes of bus passenger and railway passenger were based on the EPTRM OD table. In addition, time was adopted as the primary factor determining the share. Cost could also be considered, but it was not adopted since the range of variation is large depending on how the fare system is set up, making future forecasts difficult. The following were resorted to in determining the interzonal travel times of railways and buses.

a) The highway network with information on link distances and the scheduled speeds of buses was based on EPTRM.

b) The railway network with information on railway link distances and the scheduled speeds of trains was based on the timetable.

c) Access/egress time was based on Estudio 5 Meses*.

d) Waiting time for buses was based on Estudio 5 Meses and for trains on the number of trains operated.

Train and bus interzonal travel time was calculated on the basis of the data obtained in this preliminary work. Furthermore, shares were calculated from the number of interzonal railway and bus passengers, and based on this data, the modal split curve was plotted by taking the primary factor of intermodal competition, namely time ratio, on the horizontal axis and the share on the vertical axis.

Fig. 4.1.5 illustrates the modal split curve resulting from the above process.

*
"Estudio Económico-Financiero de Relación entre los Proyectos de la Autopista Buenos Aires-La Plata y la Electrificación de la Red Urbana de Ferrocarriles Argentinos Región Sudoeste (Linea Roca)" hereafter referred to as Estudio 5 Meses

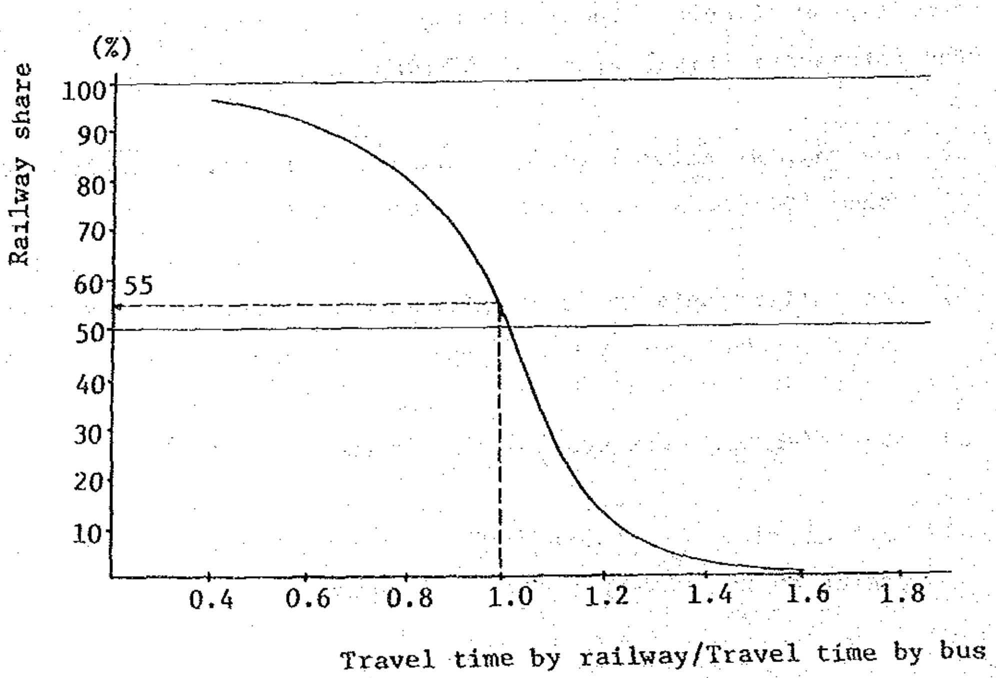


Fig. 4.1.5 Modal Split Curve

2) Interzonal railway passenger traffic volume

Future interzonal railway passenger traffic volume was calculated from four interzonal variables. These variables are bus running time, train running time, railway station and bus stop access/egress time, and railway station and bus stop waiting time. These variables, which are the primary factors governing future travel time, were estimated in the following ways.

a) Running time, access/egress time, and waiting time for buses were considered not to change in the future.

b) Railway station access/egress time was considered not to change in the future.

c) Railway running time and waiting time in accordance with the electrification plan were used.

Using these variables, the railway share was obtained according to Fig. 4.1.5. Next, the railway traffic volume was obtained by multiplying the railway share between each zone by the passenger flow between them.

The above results are shown in the Appendix 5 in the form of a railway interzonal OD table. Fig. 4.1.6 shows the railway passenger distribution pattern between each zone, and in particular, the Capital Federal in the form of a map of desired lines.

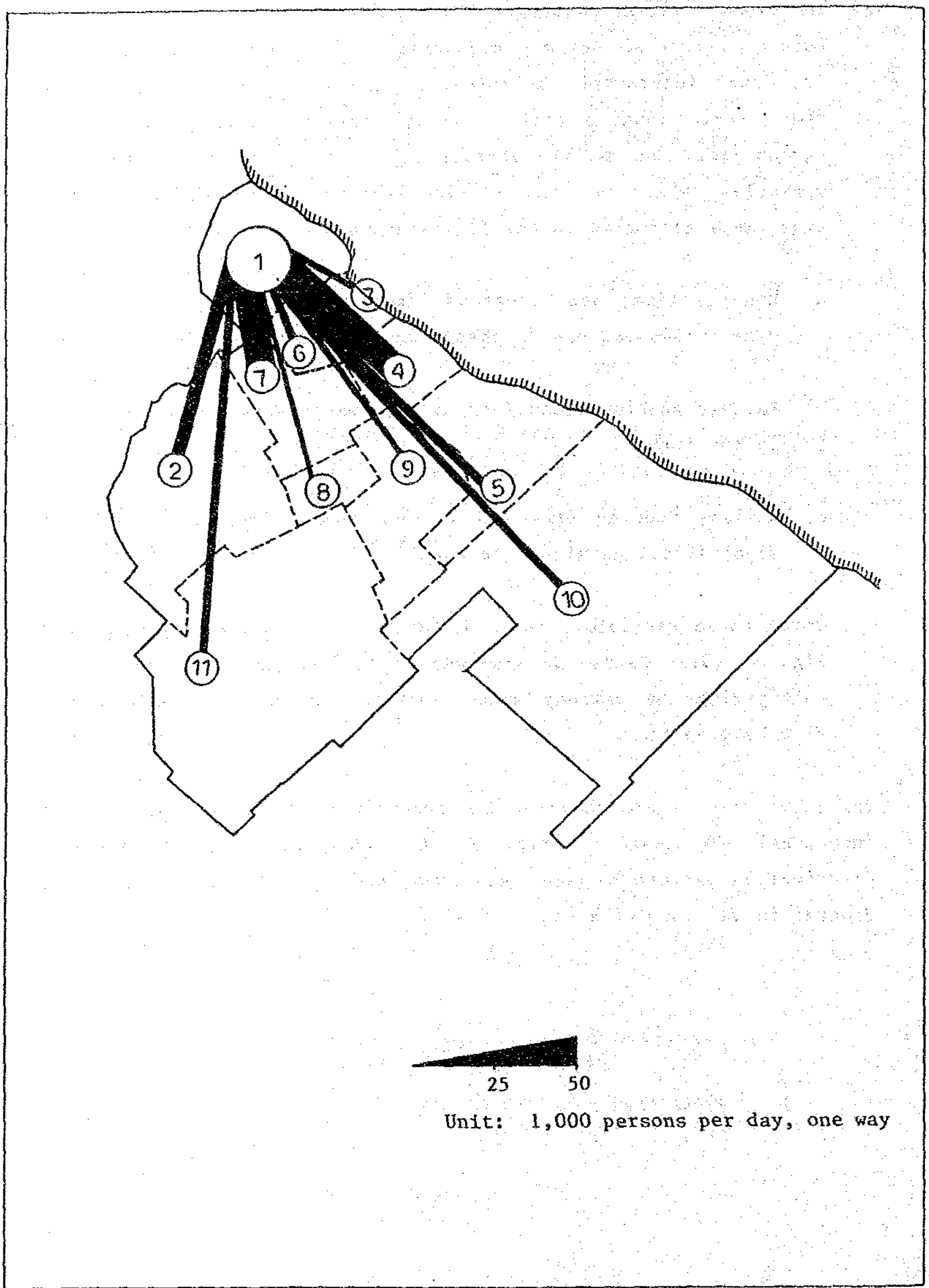


Fig. 4.1.6 Desired Lines

3) Assigned traffic volume

Future interzonal railway passenger traffic volume will be distributed over the railway network by the minimum path method. Fig. 4.1.7 and the Appendix 6 show these results in the form of cross-sectional passenger traffic. The largest cross section as seen here is the Plaza Constitución - Avellaneda section with a traffic volume of 204,500 persons per day.

4) Peak hour traffic volume

The peak rate results from the Estudios 5 Meses study were used since there is no recent peak rate data. According to this, the peak hour period is 1700-2100 hours for outbound trains (from Plaza Constitución). The average peak rate during this period is 11.3%. For inbound trains (to Plaza Constitución) the peak period is 0500-0900 hours, and the average peak rate is 11.1%. Consequently, the average peak rate of 11.3% was used. Fig. 4.1.8 and the Appendix 6 show the traffic volumes during the peak hour periods. The largest hourly cross section as seen here is Plaza Constitución - Avellaneda with 23,100 persons per hour.

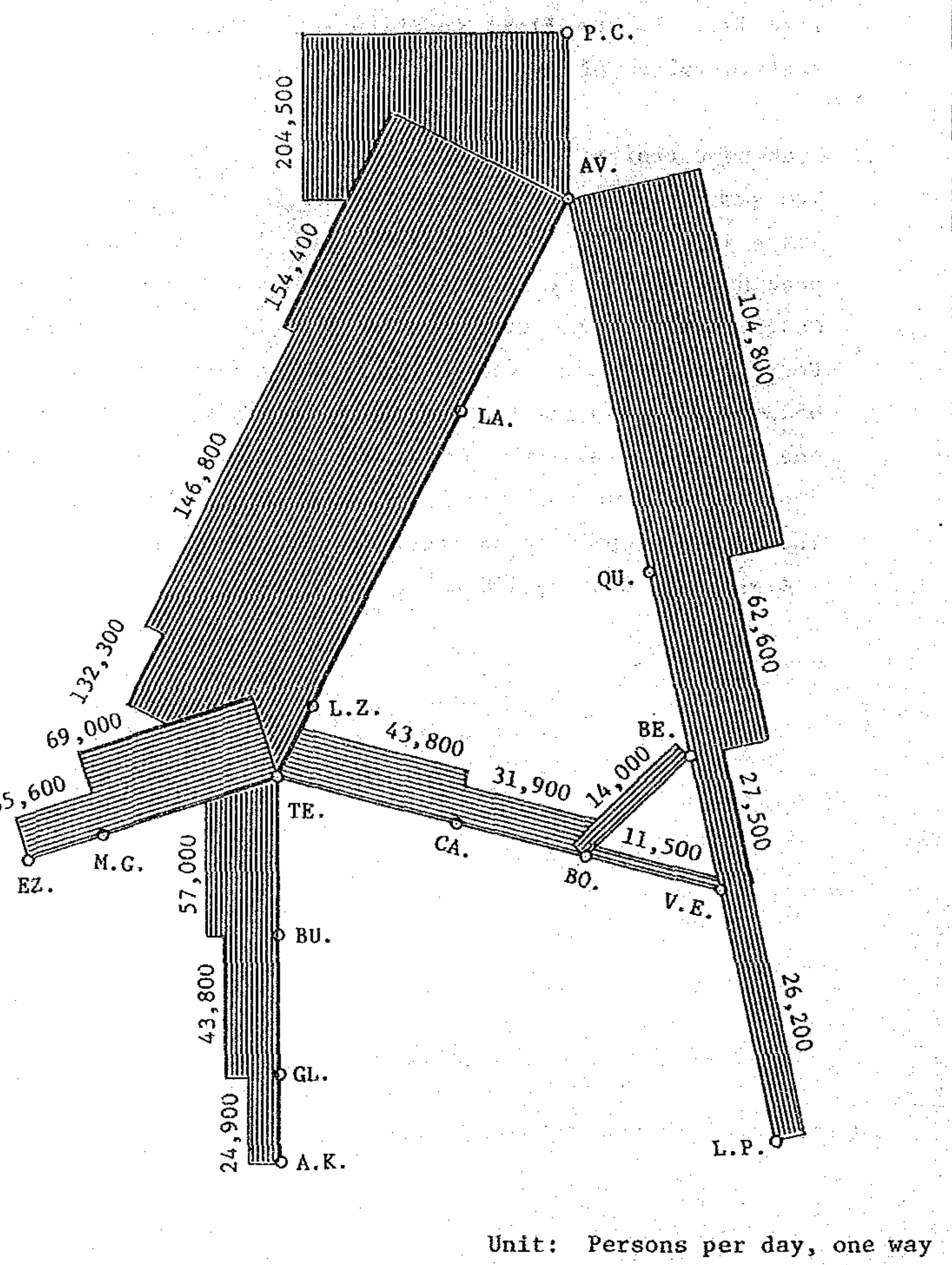


Fig. 4.1.7 Cross-sectional Passenger Traffic (A.D. 2000)

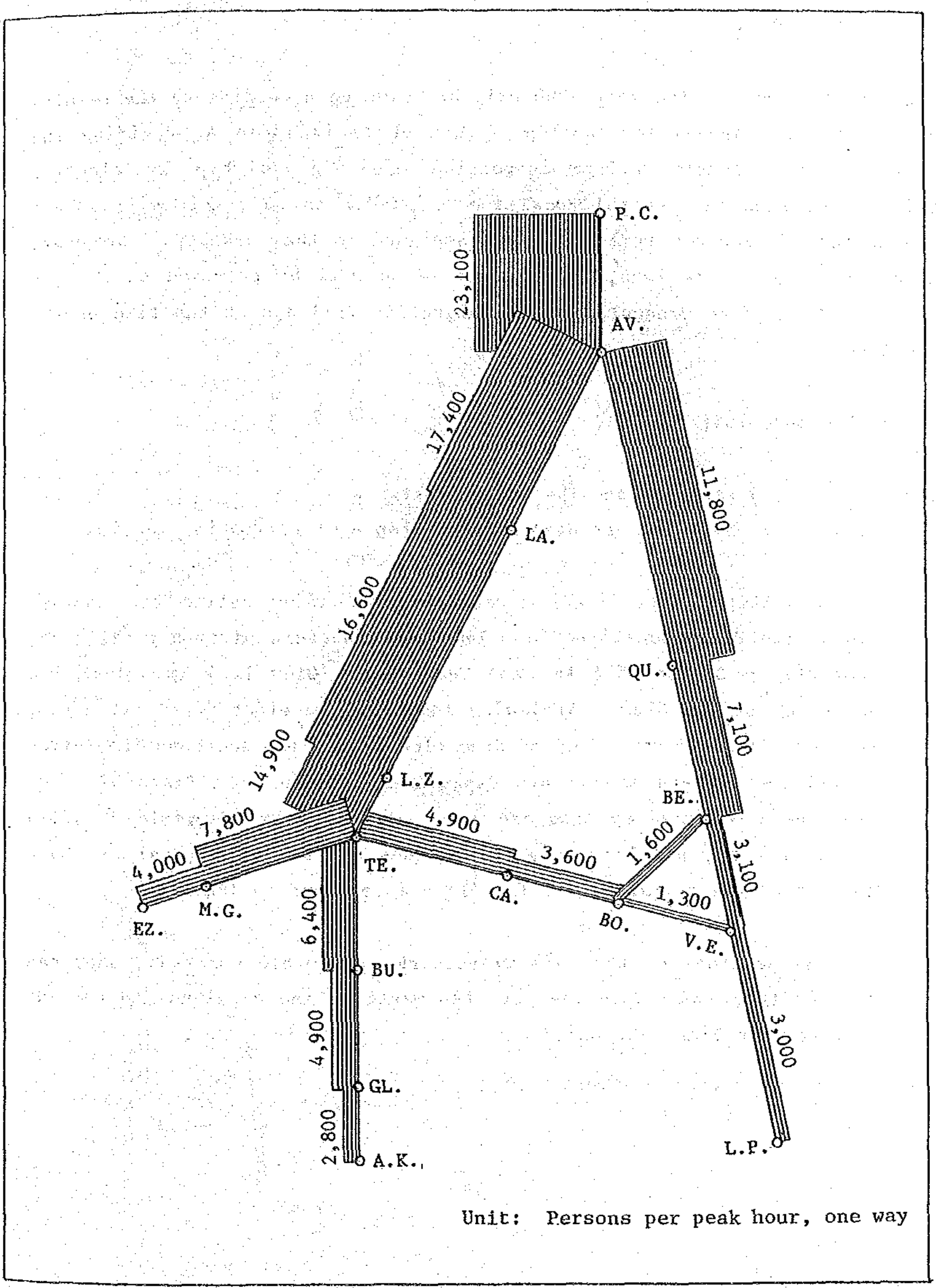


Fig. 4.1.8 Cross-sectional Passenger Traffic (A.D. 2000)

4-2 Traffic Plan

The traffic plan for the year 2000 will be drawn up according to the results of the traffic demand forecasting. This study is aimed at deciding the scale of the electric railcar inspection/repairing workshop for electric railcars used on the General Roca Line. That is to say, this will obtain the number of electric railcars to be assigned to the workshop. Moreover, plans for tracks, stations, depots, and so on will be premised on the J-C Report and the plan presented by the Argentine Railways at the time of the field survey.

4-2-1 Preconditions

(1) Electrified sections and the railway network

Fig. 4.2.1 shows the 1st Step and 2nd Step electrification sections.

The 1st Step electrification sections (hereafter called the western lines) are Plaza Constitución - Temperley (western part only) 16.8 km, Temperley - Ezeiza 15.6 km, and Temperley - Glew 12.4 km. With the inclusion of the Glew - Alejandro Korn 10.3 km electrified extension, the total is 55.1 km. The 2nd Step electrification sections (hereafter called the eastern lines) are Plaza Constitución - La Plata 52.6 km, Avellaneda - Temperley (eastern part only) 13.0 km, Temperley - Villa Elisa 31.7 km, and Berazategui - Bosques 8.3 km for a total of 105.6 km. Thus, the overall total for all the sections is 160.7 km.

All the sections of the railway network are double tracked. They can be broadly divided into the 1st Step western line sections and the 2nd Step eastern line sections.

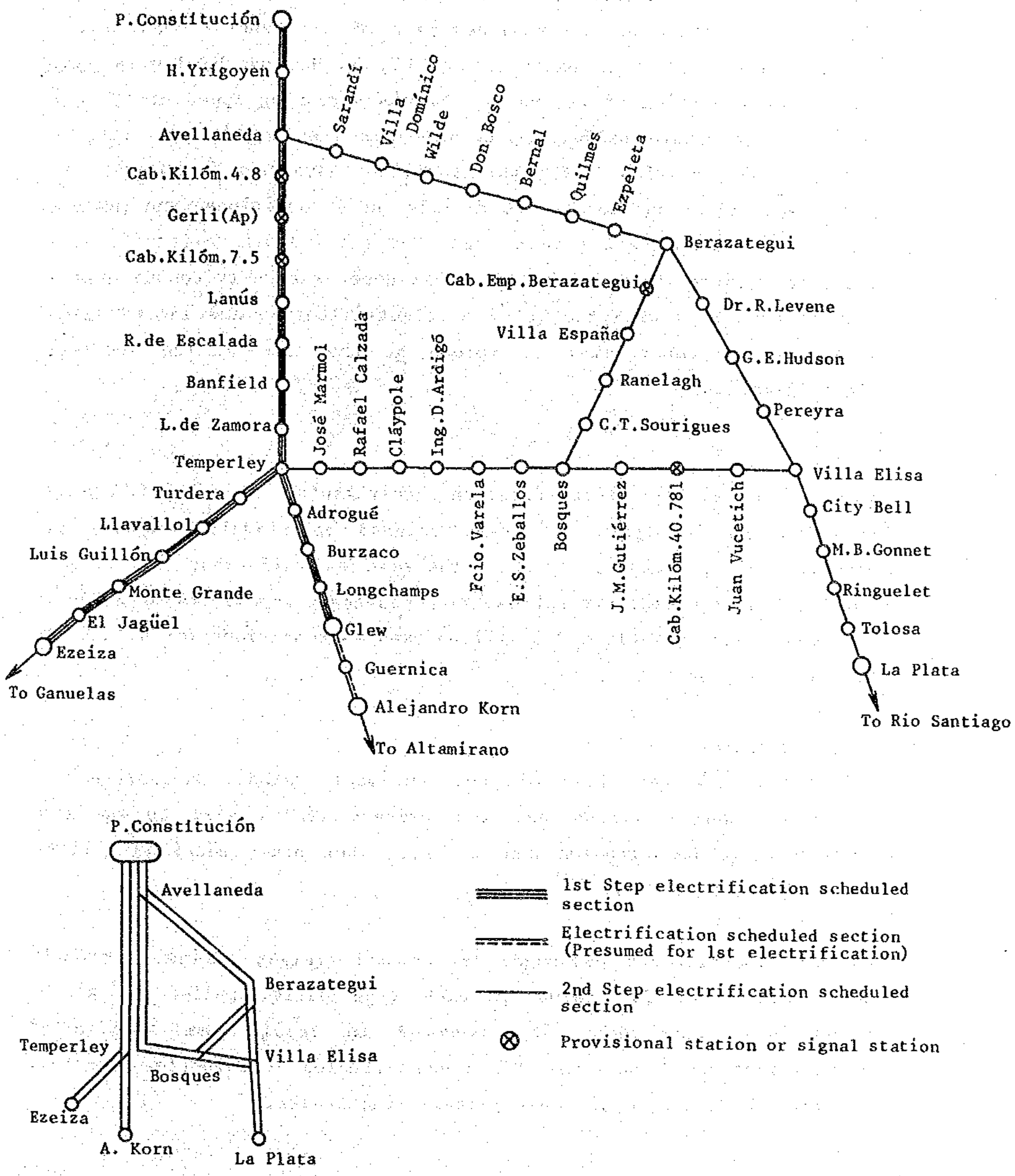


Fig. 4.2.1 Electrification Sections and Railway Network

(2) Tracks, stations, rolling stock depots, etc.

The electrification of the suburban part of the General Roca Line is planned to use a single phase, AC 25 kV, 50 Hz, overhead wire power supply for operation of trains at a maximum running speed of 120 km/h with a three-minute headway using nine-car (three units) formations. Track, signal, station, and other facilities have been improved on 1st Step electrification sections to satisfy these conditions, and the same kinds of improvements are to be made for the 2nd Step electrification sections. In addition, a rolling stock depot was newly constructed at Llavallol to cope with the 1st Step electrification and another depot will also be constructed at Tolosa at the time of the 2nd Step electrification.

(3) Railcars

To meet the 1st Step electrification requirements, 156 railcars equiped as described in Chapter 2 were assigned to Llavallol Depot, and electric railcars with practically the same specifications will be used for the 2nd Step electrification. The passenger capacities of electric railcars shown in Table 4.2.1 will be used as conditions for drawing up the traffic plan.

(4) Types of trains

All trains on western line sections are local trains. On eastern line sections, express trains and semi-express trains will be operated between Plaza Constitución and La Plata, but other sections will be served by local trains.

As for long-distance passenger trains and freight trains, currently there are about 20 trains of each type daily, pulled by diesel locomotives, and these are expected to remain the same after electrification. For the Plaza Constitución - Temperley section, however, these trains will use eastern line tracks.

(5) Stations

Types of trains stopping at each station are shown in Fig. 4.2.2 according to the Argentine Railways proposal.

Table 4.2.1 Passenger Capacity of Electric Railcars

Unit: Persons

Items	Mc	R	1 Unit (2Mc 1R)	2 Units (4Mc 2R)
Seating Capacity	64	68	196	392
Straphanging Capacity	84	88	256	512
Total	148	156	452	904
Maximum	200	200	600	1200

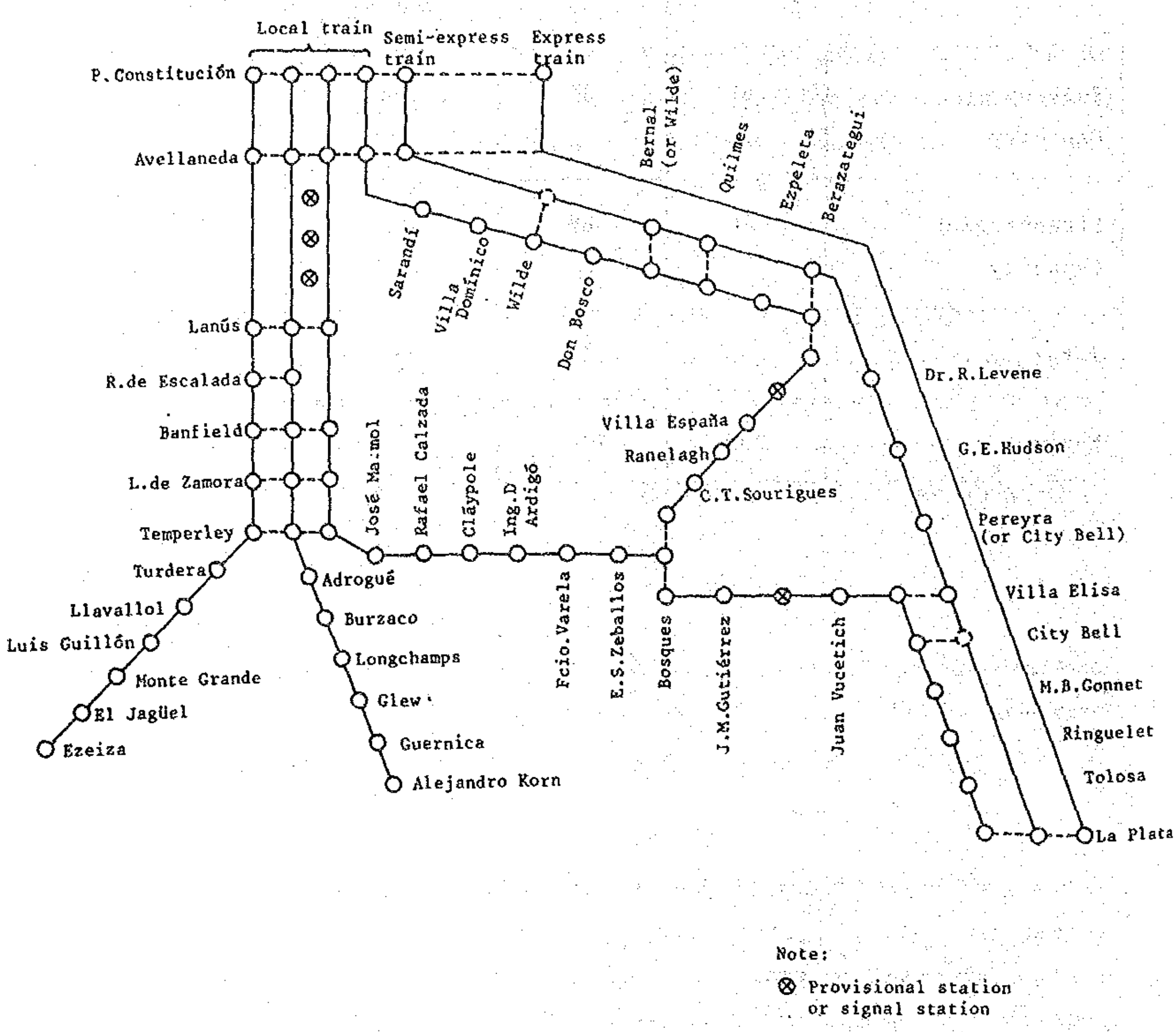


Fig. 4.2.2 Stations and Stopping Trains

(6) Travel time

Two proposals on train travel time, that studied in the J-C Report and studied by the Argentine Railways (eastern line sections only), are adopted for traffic planning. In other words, the J-C Report is used for the 1st Step electrification sections (western lines) and the proposal studied by the Argentine Railways is used for 2nd the Step electrification sections (eastern lines). However, since neither of them studied the Glew - Alejandro Korn section, a new study was made this time. Concerning powering performance in this case, the rolling stock performance as indicated to the Argentine Railways by the rolling stock manufacturer (Fig. 4.2.3) was used. As for deceleration performance, the deceleration is 2.88 km/h/sec from the standpoint of rolling stock performance, but the J-C Report figure of 2.25 km/h/sec was adopted in consideration of weather and other conditions. In addition, the speed at the time of braking will be less than 85 km/h for a 5°/°° gradient, and stopping time at stations 30 sec.

Under these conditions, train operation curves (Fig. 4.2.4, Fig. 4.2.5) are drawn, and the running times obtained are Glew → Guernica 3'15", Guernica → Alejandro Korn 5'30", Alejandro Korn → Guernica 5'15", and Guernica → Glew 3'15".

From the above results, the travel time for each section is shown in Table 4.2.2.

4-2-2 Traffic Plan

As stated in the beginning, the purpose of this study is to obtain the number of electric railcars which the workshop will be in charge of, and to be specific, a study will be made of the transport capacity needed in peak hours and based on it the required number of electric railcars will be determined.

(1) Passengers flow (Trend of traffic concentration rate)

The passenger flow (trend of traffic concentration rate) at Plaza Constitución according to Estudio 5 Meses is shown in Fig. 4.2.6. It is clear from this that there are two passenger flow peaks, 0500-0900 and 1700-2100.

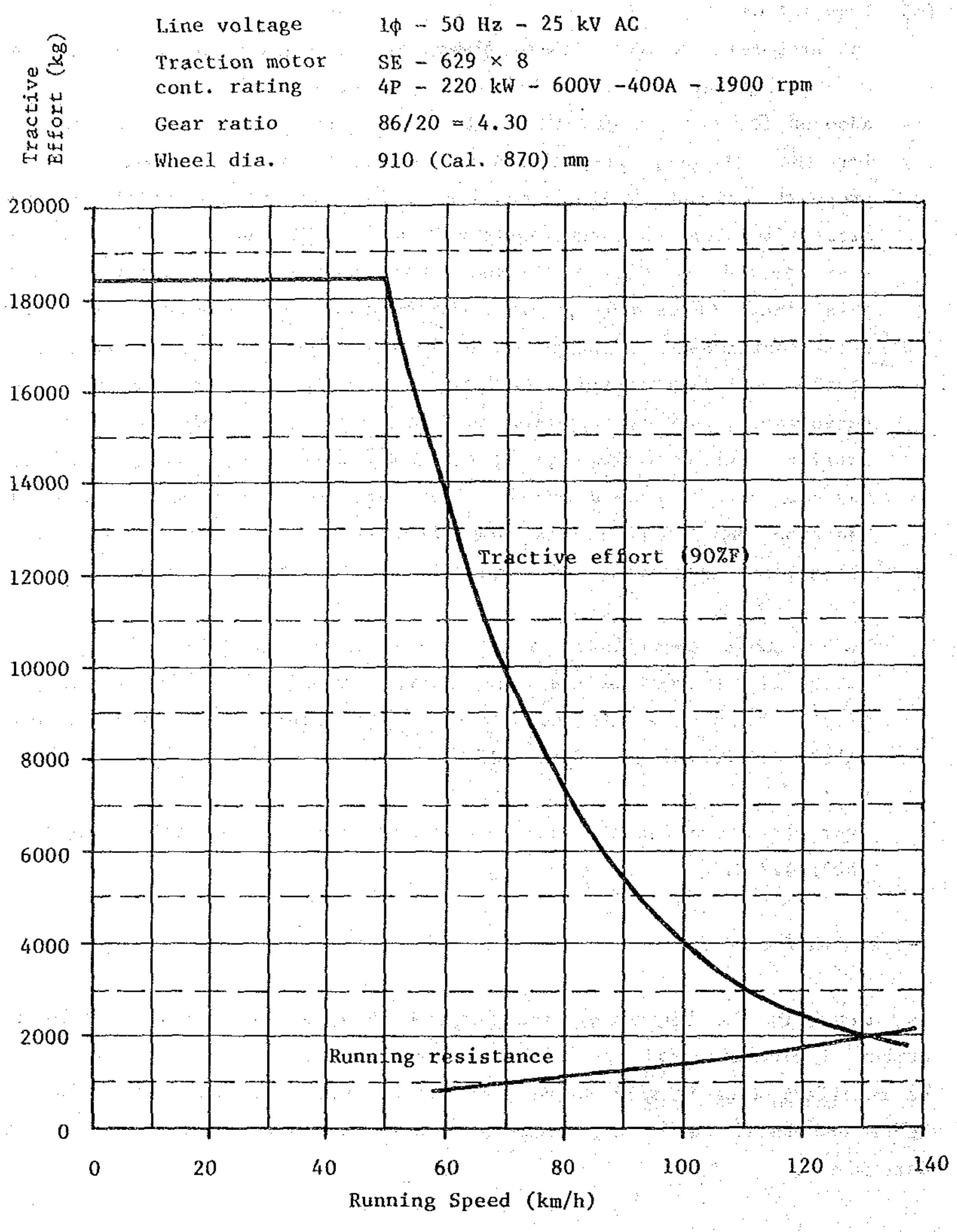


Fig. 4.2.3 One-unit Performance Curve in Powering

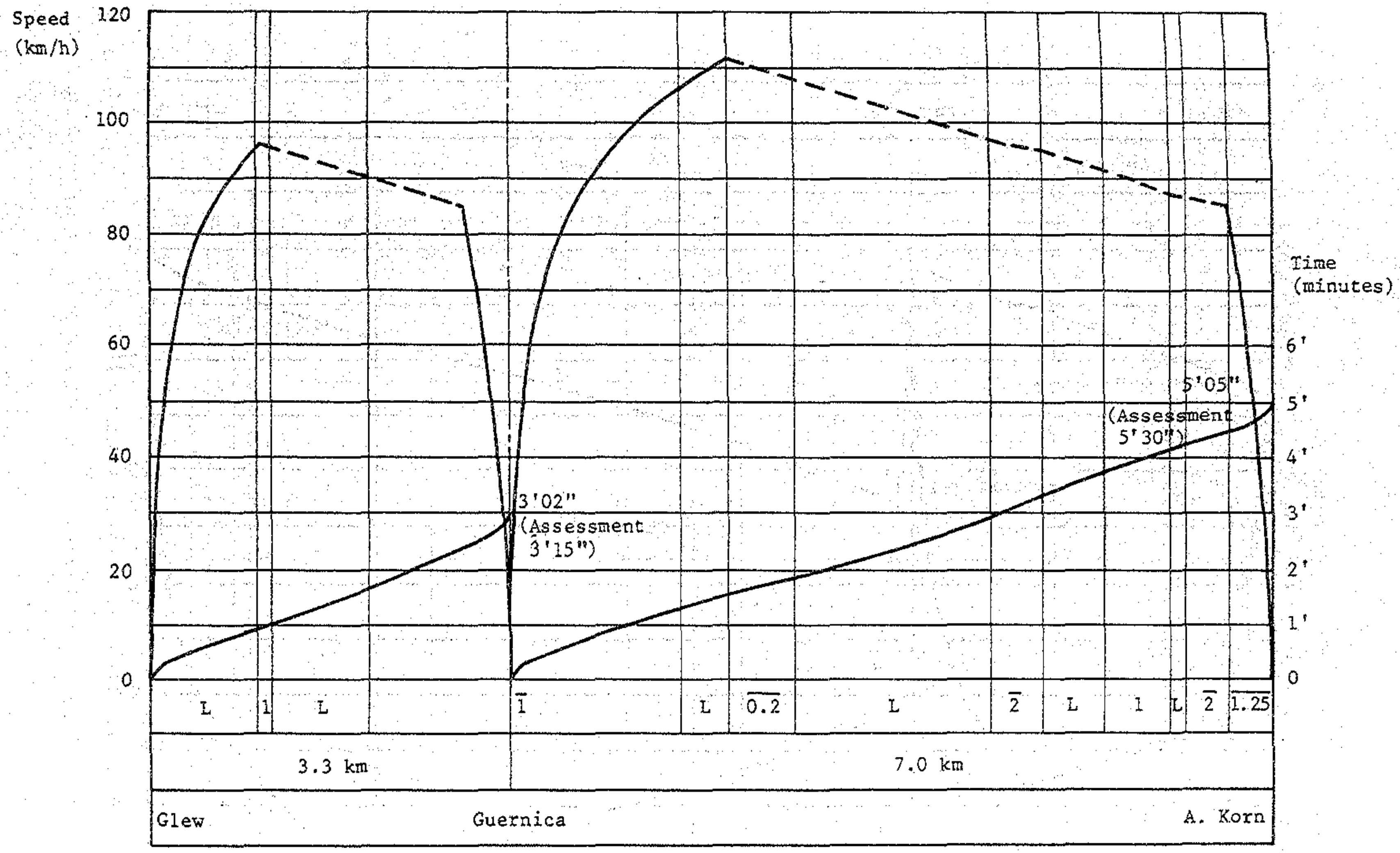


Fig. 4.2.4 Train Operation Curves (Glew → A. Korn) 8'45"

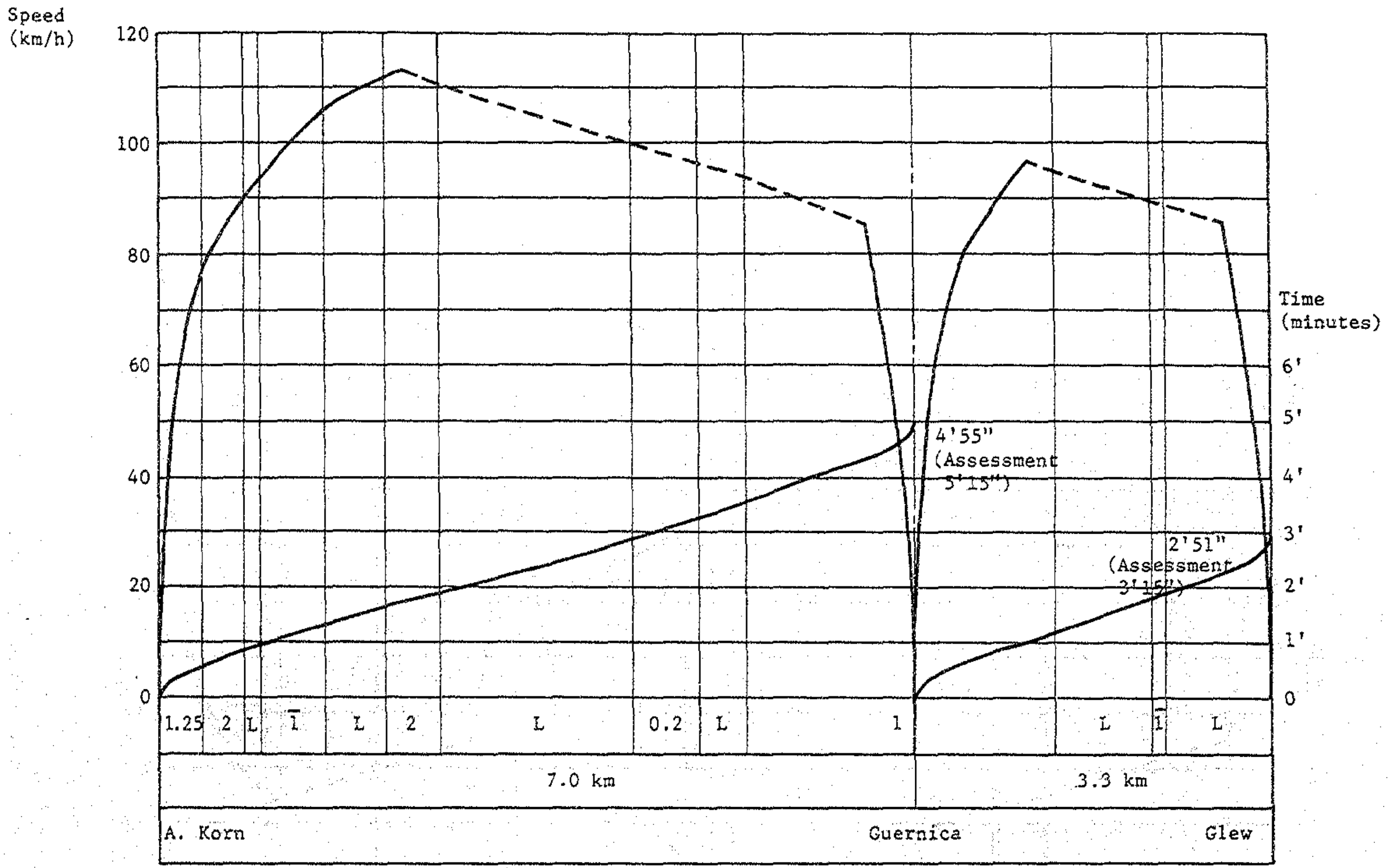


Fig. 4.2.5 Train Operation Curves (A. Korn → Glew) 8'30"

Table 4.2.2 Time Required by Section

Sections	Time Required	Distance (km)	Scheduled Speed (km/h)	Class of Train
P. Constitución-Temperley	19'15" (19'15")	16.8	52.4	Local train
P. Constitución-Burzaco	25'30" (26'15")	22.0	51.8	Local train
P. Constitución-Glew	33'15" (34'00")	29.2	52.7	Local train
P. Constitución-A. Korn	43'00" (43'30")	39.5	55.1	Local train
P. Constitución-M. Grande	30'30" (30'30")	25.8	50.8	Local train
P. Constitución-Ezeiza	37'45" (38'00")	32.4	51.5	Local train
P. Constitución-Quilmes	19'00" (19'00")	17.2	54.3	Local train
P. Constitución-Bosques (via Quilmes)	37'00" (37'40")	32.1	52.1	Local train
P. Constitución-Bosques (via Temperley)	39'00" (39'00")	33.6	51.7	Local train
P. Constitución-La Plata	35'00" (35'00")	52.6	90.2	Express train
P. Constitución-La Plata	45'00" (45'00")	52.6	70.1	Semi-express train
Bosques-La Plata	28'00" (28'00")	28.1	60.2	Local train

Note: Time required column, upper figures indicate the time required starting from P.Constitución to respective stations, lower figures for the time required arriving at P. Constitución from respective stations.

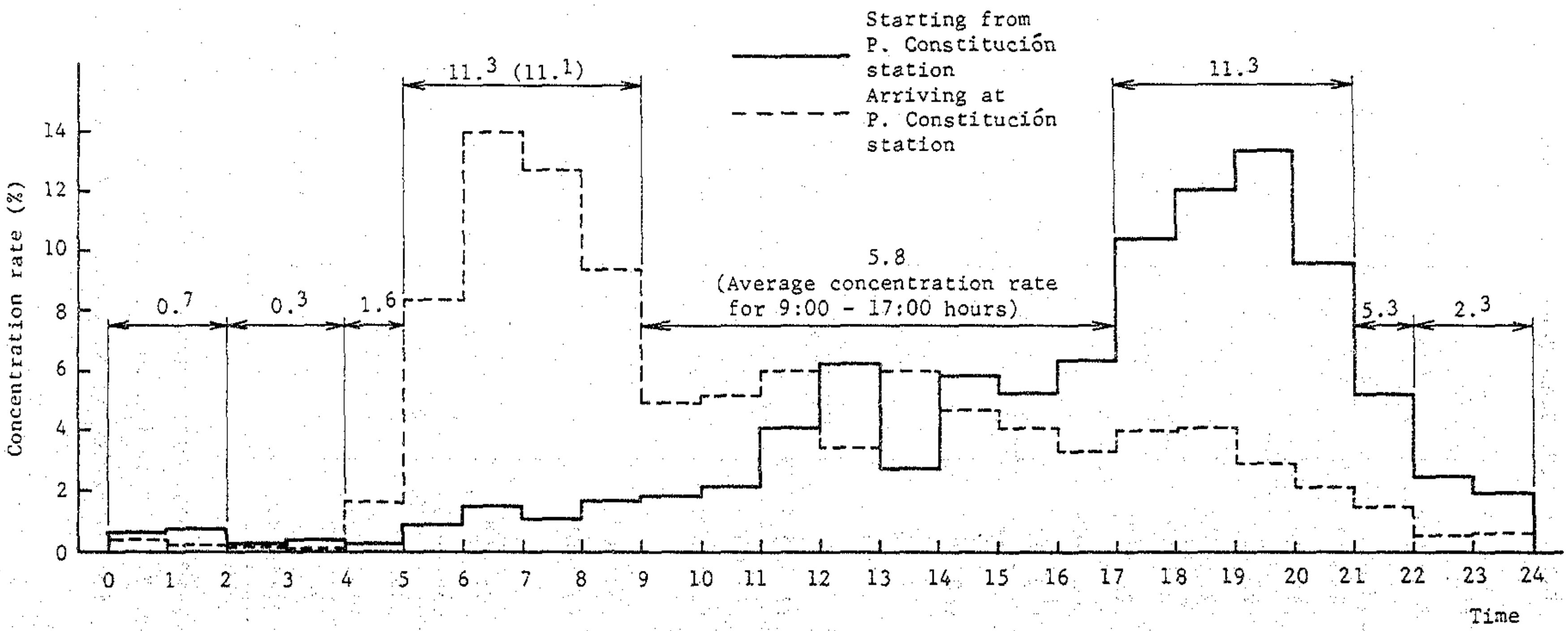


Fig. 4.2.6 Passengers Flow at P. Constitución Station
(Change of concentration rate)

In studying transport capacity, the average of the concentration rates for the two four-hour peak periods of 0500-0900 and 1700-2000 was used as the peak hour concentration rate since setting the capacity to match the highest peak hour value would result in a gap between traffic volume and capacity during nonpeak hours, giving rise to the need for an excessive amount of investment to cope with short-period traffic demand. The resulting average peak hour concentration rate is 11.3%. The actual concentration rate calculated for the 0500-0900 period is 11.1%, but since the 1700-2100 concentration rate was 11.3%, this rate is used for both periods.

(2) Traffic volume and the number of trains per hour of the peak period

Traffic volume (cross-sectional traffic volume) per peak period hour was obtained by multiplying the peak period concentration rate by the daily traffic volume (cross-sectional traffic volume), as stated 4-1.

Next, the preconditions for scheduling a train are as follows.

- o The maximum number of passengers per car will be 200.
- o One train will, in principle, be a six-car formation, but according to traffic volume, the maximum will be nine cars and the minimum a three-car formation.

Based on the above-mentioned conditions, the required number of trains for each section is studied, and Table 4.2.3 shows the required number of trains scheduled. The actual number of trains to be scheduled is studied with this as the base, plus the following preconditions:

- o The minimum headway is four minutes.
- o Alejandro Korn, Ezeiza, Bosques, and La Plata will be connected to Plaza Constitución by through trains.
- o The Argentine Railways proposal will be the base for eastern line sections.

That is to say:

- o Two express and two semi-express trains will be operated each hour on the Plaza Constitución - La Plata section.

Table 4.2.3 Traffic Volume and Number of Trains Scheduled in One Peak Hour

Sections	Traffic Volume (hundred persons)	Number of trains necessary	Number of trains scheduled
P. Constitución-Avellaneda	231	19.3	26
Avellaneda-Temperley	174	14.5	17
Temperley-Burzaco	64	5.3	6
Burzaco-Glew	49	4.1	5
Glew-A. Korn	28	2.3	3
Temperley-M. Grande	78	6.5	7
M. Grande-Ezeiza	40	3.3	4
Avellaneda-Quilmes	118	9.8	9
Quilmes-Berazategui	71	5.9	7
Berazategui-La Plata	31	2.6	4
Berazategui-Bosques	16	1.3	3
Temperley-Bosques	49	4.1	4
Bosques-Villa Elisa	13	1.1	1

Note: Train scheduling is based on six-car train formation (200 passengers on each car).

- Four local trains per hour will be operated on the Plaza Constitución - Quilmes - Bosques section and on the Plaza Constitución - Temperley - Bosques section, and two local trains per hour will be operated on the Bosques - La Plata section.
- Two trains (long-distance passenger train and/or freight train) per hour will be operated. These trains, however, will use the eastern line tracks on the Plaza Constitución-Temperley section.

Table 4.2.3 and Fig. 4.2.7 show the number of trains scheduled for each section as studied under the above-mentioned conditions.

Since the number of trains required here for Avellaneda - Quilmes is 9.8, it would fundamentally be necessary to schedule ten trains. However, considering the fact that the track capacity on the eastern line part of the Plaza Constitución - Avellaneda section would almost reach the limit if ten trains are operated, the number was set at nine, and to compensate, trains shuttling at Quilmes were made nine-car formations.

In addition, the operation of two trains per hour is sufficient for the Berzategui - Bosques section, but in consideration of the Argentine Railways proposal for four trains, this was made three trains per hour. Furthermore, the operation of one train per hour on the Bosques - Villa Elisa - La Plata section will be about enough, but considering the passengers' convenience, two trains per hour will be operated and, in exchange, formations will be of three cars.

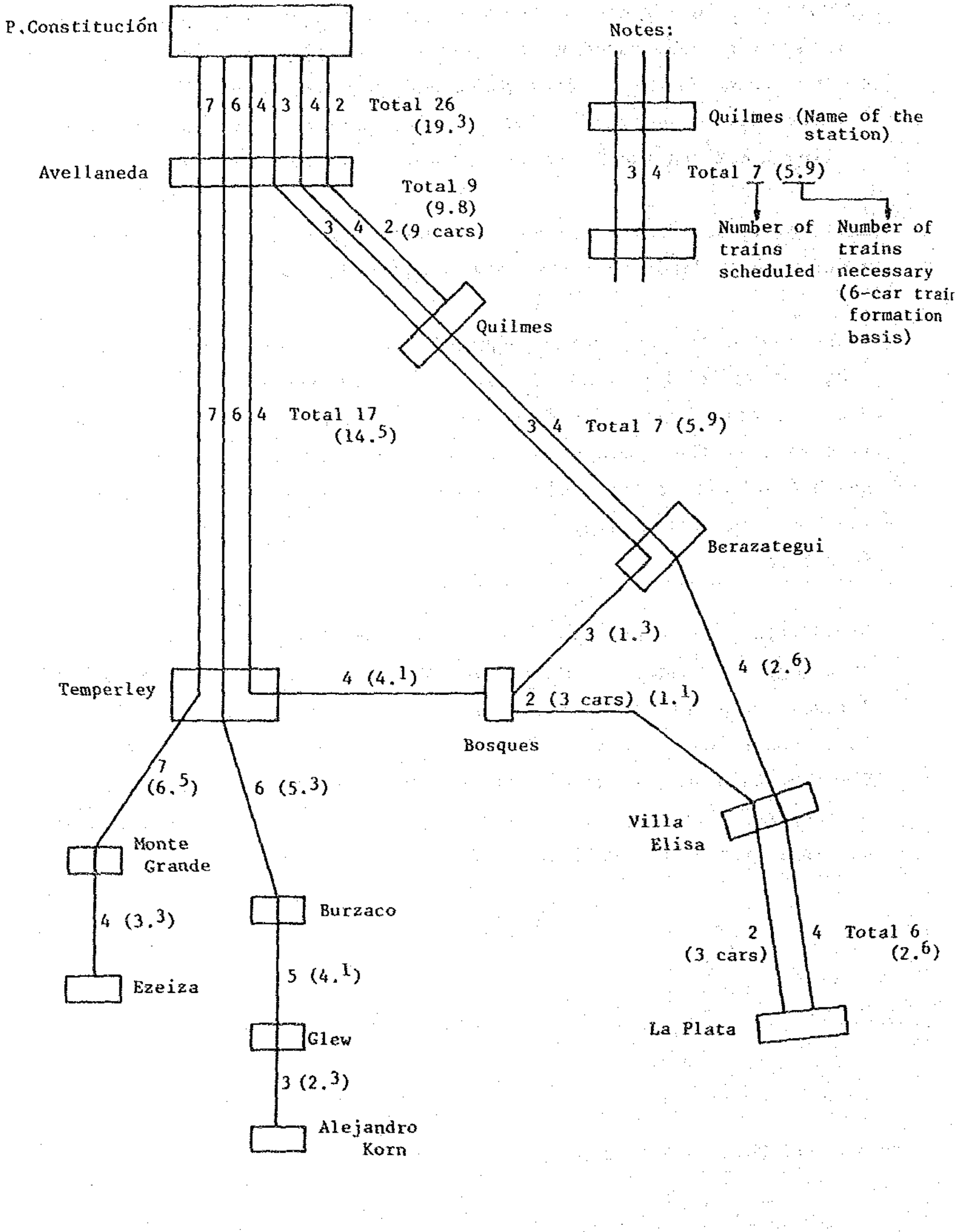


Fig. 4.2.7 Number of Trains Scheduled in One Peak Hour

(3) Train diagram of peak hours

The train diagram of peak hours was studied using the above-mentioned peak period trains per hour, and this is shown in Fig. 4.2.8. The preconditions for drawing up the diagram are as follows.

- o The minimum headway is four minutes.
- o A minimum time of five minutes will be assured for return operation of trains at the terminal.
- o Shuttle service will be scheduled at Burzaco, Glew, and Monte Grande on the western lines.
- o The Argentine Railways proposal will be the base for eastern line sections, but to assure enough transport capacity on the Avellaneda - Quilmes section, Quilmes shuttle service will be scheduled.

4-3 Calculation of Number of Electric Railcars

In addition to the number of railcars required for commercial service, reserve rolling stock is needed to make up for those under inspection or repair and for additionally operated special trains. The number of these railcars is calculated below.

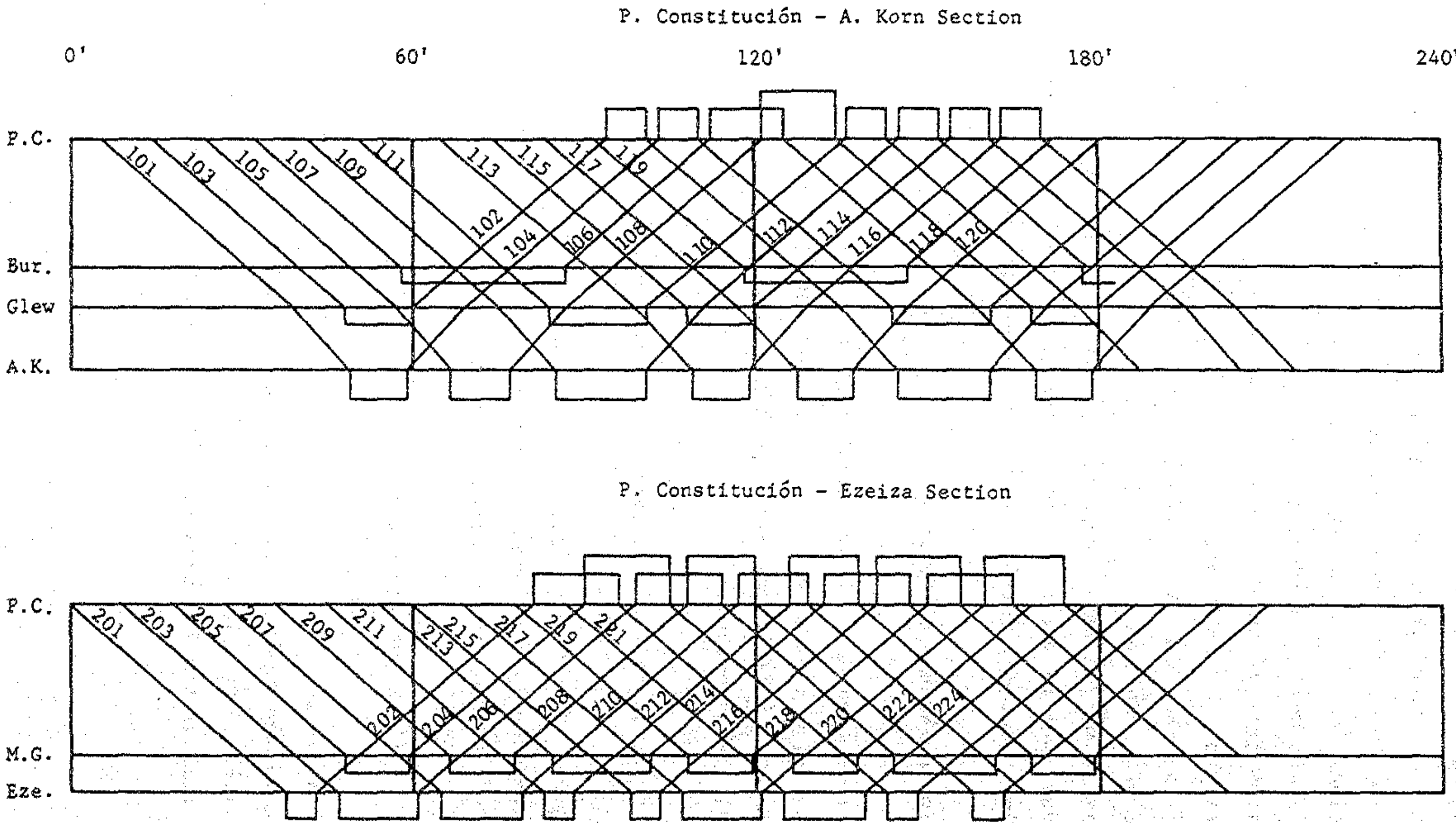
4-3-1 Number of Railcars for Operation

Table 4.3.1 shows the electric railcar operation table for the peak hour train diagram previously mentioned. According to this table, the number of railcars required for operation totals 273 cars (91 units).

4-3-2 Electric Railcar Running Distance

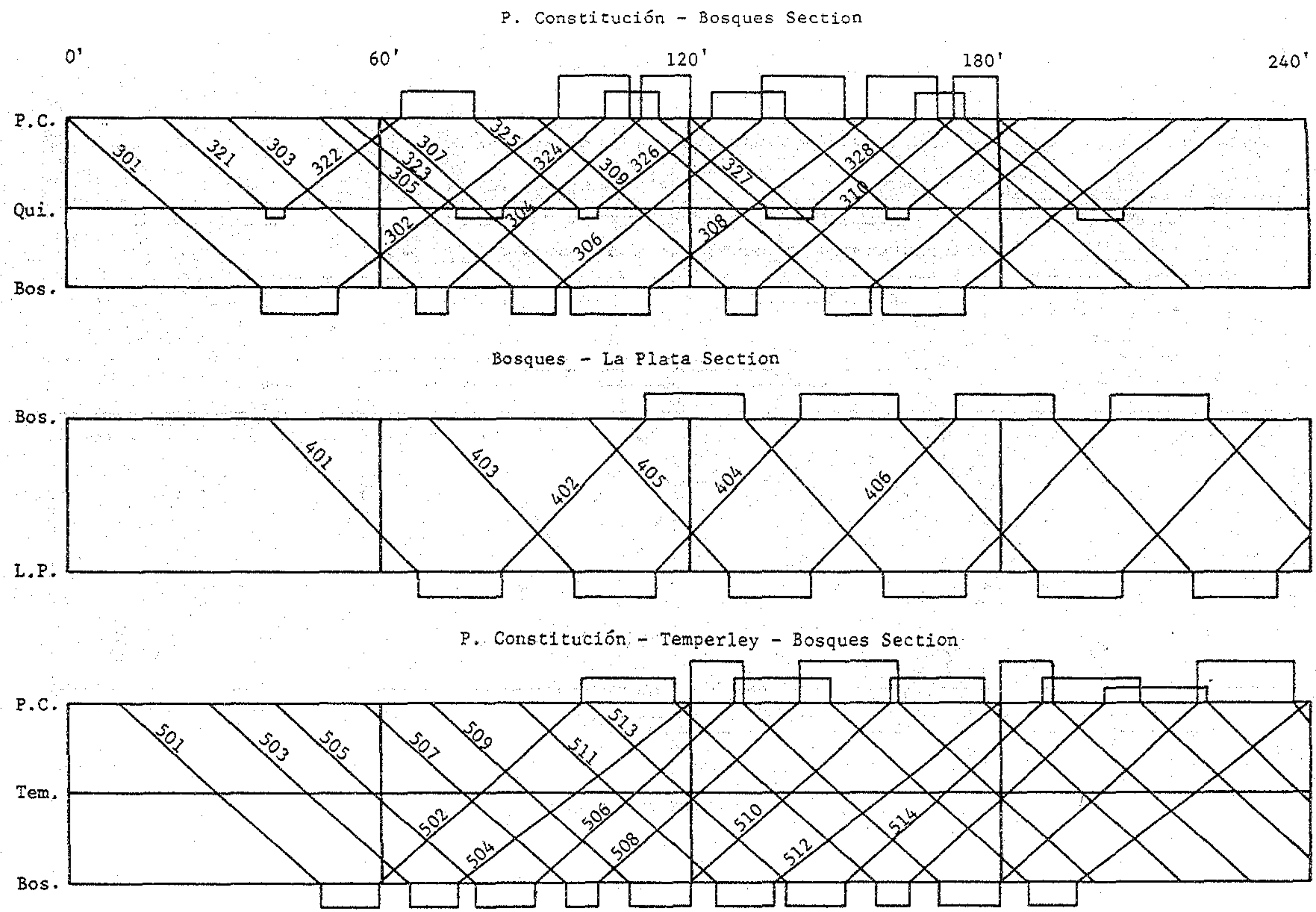
(1) Peak period car kms

According to the peak period train diagram, train kms per peak period hour are 1,874.0 km and car kms are 11,113.2 km. Thus, the car kms per electric railcar for 273 cars is 40.7 km (see Table 4.3.2).



Note: **Figures on lines are temporary train numbers.**

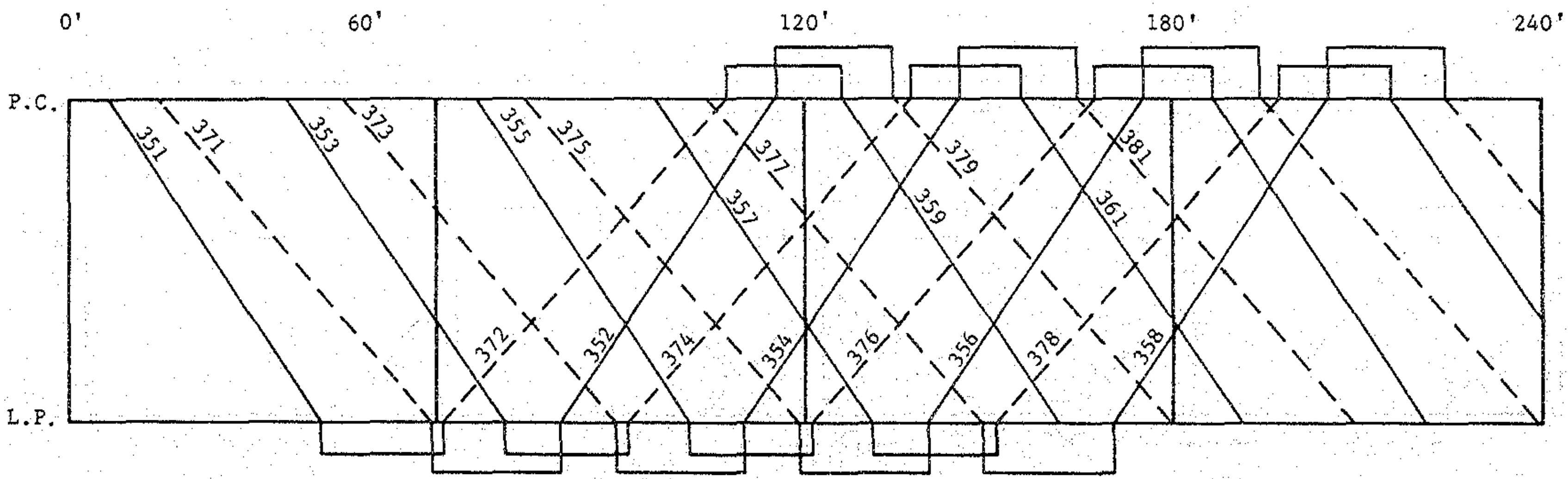
Fig. 4.2.8 Train Diagram of Peak Hours (1/3)



Note: Figures on lines are temporary train numbers.

Fig. 4.2.8 Train Diagram of Peak Hours (2/3)

P. Constitución - La Plata Section



Note: Figures on lines are temporary train numbers.

———————— Express train

---------------- Semi-express train

Fig. 4.2.8 Train Diagram of Peak Hours (3/3)

Table 4.3.1 Electric Railcar Operation Schedule Table in Peak Hours (1/2), (1 cycle)

Operation No.	Sections (P.C. Bur. Gl. A.K.)	No. of cars	Operation No.	Sections (P.C. Bur. Gl. A.K.)	No. of cars	Operation No.	Sections (P.C. M.G. Eze.)	No. of cars	Operation No.	Sections (P.C. M.G. Eze.)	No. of cars
1	101 / 104	6	9	117 / 120	6	11	201 / 202	6	19	217 / 220	6
2	103 / 102	6	10	119 / 118	6	12	203 / 206	6	20	219 / 218	6
3	105 / 108	6				13	205 / 204	6	21	221 / 224	6
4	107 / 106	6				14	207 / 210	6			
5	109 / 112	6				15	209 / 208	6			
6	111 / 110	6				16	211 / 212	6			
7	113 / 116	6				17	213 / 214	6			
8	115 / 114	6				18	215 / 216	6			
				Total	60					Total	66

Table 4.3.1 Electric Railcar Operation Schedule Table in Peak Hours (2/2), (1 cycle)

Operation No.	Sections (P.C. – Qui. – Bos.)	No. of cars	Operation No.	Sections (Bos. – L.P.)	No. of cars	Operation No.	Sections (P.C. – Tem. – Bos.)	No. of cars	Operation No.	Sections (P.C. – L.P.)	No. of cars
31	301 / 302	6	41	401 / 402	3	51	501 / 502	6	61	351 / 372	6
32	321 / 322 / 325 / 326	9	42	403 / 404	3	52	503 / 504	6	62	371 / 352	6
33	303 / 304	6	43	405 / 406	3	53	505 / 506	6	63	353 / 374	6
34	305 / 306	6				54	507 / 508	6	64	373 / 354	6
35	323 / 324 / 327 / 328	9				55	509 / 510	6	65	355 / 376	6
36	307 / 308	6				56	511 / 512	6	66	375 / 356	6
37	309 / 310	6				57	513 / 514	6	67	357 / 378	6
									68	377 / 358	6
Total		48	Total		9	Total		42	Total		48
									Grand total		273

Table 4.3.2 Number of Trains Scheduled and Train Kms in One Peak Hour

Class of Train	Sections	Distance (km)	Number of Trains Scheduled	Number of Cars of a Train Consist	Train Kms	Car Kms	Number of Cars in Operation	Car Kms for One Car
Local train	P. Constitución - A. Korn	39.5	6	6	237.0	1,422.0		
Local train	P. Constitución - Glew	29.2	4	6	116.8	700.8	60	39.8
Local train	P. Constitución - Burzaco	22.0	2	6	44.0	264.0		
Local train	P. Constitución - Ezeiza	32.4	8	6	259.2	1,555.2	66	37.6
Local train	P. Constitución - M. Grande	25.8	6	6	154.8	928.8		
Local train	P. Constitución - Bosques (via Quilmes)	31.9	6	6	191.4	1,148.4	48	36.8
Local train	P. Constitución - Quilmes	17.2	4	9	68.8	619.2		
Local train	P. Constitución - Bosques (via Temperley)	33.6	8	6	268.8	1,612.8	42	38.4
Local train	Bosques - La Plata	28.1	4	3	112.4	337.2	9	37.5
Express & semi-express trains	P. Constitución - La Plata	52.6	8	6	420.8	2,524.8	48	52.6
Total		-	56	-	1,874.0	11,113.2	273	40.7

(2) Car kms per day

As seen in Fig. 4.2.6, passenger flow varies greatly with each time of the day, and transport capacity will be provided in conformity with this variation. Fundamentally, car kms should be calculated after drawing up a day's train diagram. However, since this plan is for deciding the scale of a workshop and not for the purpose of making a day's train diagram, car kms per day will be estimated based on peak period car kms.

In other words, from Fig. 4.2.6 a day will be divided into time periods with almost equal traffic volumes, and car kms will be estimated for these same time periods. Fig. 4.2.6 shows the time period divisions and the concentration rates (average concentration rate for each time period) for these periods according to this concept. In addition, Table 4.3.3 shows the concentration rates calculated for each time period and their estimated car kms.

The preconditions for estimating car kms are as follows.

- o All passengers during the 0000-0500 time period will be able to sit, or in other words, the maximum number of passengers per car will be equivalent to the seating capacity of 65.
- o For the 0900-1700 time period, the maximum number of passengers per car including standing passengers will be a seating capacity of 65 and a standing capacity of 86 for a total capacity of 151 passengers.
- o For the 2100-2400 time period, the maximum passenger capacity will be the same as the 0900-1700 or 151 passengers per car.

As a result of calculations under the above conditions, the running distance (car kms) for one electric railcar per day will be 634.4 km with 273 cars operated.

Table 4.3.3 Car Kms per Car per Day

Time of Day	Concentration Rate (%)	Maximum Number of Passengers in a Car	Car kms per Hour (km)	Hours	Car Kms
0 - 2	0.7	65	7.8	2	15.6
2 - 4	0.3	65	3.3	2	6.6
4 - 5	1.6	65	17.7	1	17.7
5 - 9	11.3	200	40.7	4	162.8
9 -17	5.8	151	27.7	8	221.6
17 -21	11.3	200	40.7	4	162.8
21 -22	5.3	151	25.3	1	25.3
22 -24	2.3	151	11.0	2	22.0
TOTAL	-----	-----	-----	24	634.4

Note: Concentration rate is the average rate of increase in the number of passengers in a given period of time in a day at P. Constitución Station, using the figure either of departure or arrival whichever higher.

4-3-3 Reserve Electric Railcars

There are two types of reserve electric railcars inspection/repairing reserve and operating reserve. The matter of electric railcar inspection will be dealt with first since there is a close relationship between the inspection/repairing system and reserve rolling stock.

(1) Inspection/repairing of electric railcars

Electric railcar inspections will be carried out either at the depot or the workshop as shown in Table 4.3.4. This table also shows the inspection cycle, inspection time, and depot and workshop inspection capacities for each type of inspection.

(2) Number of inspection/repairing reserve cars

In the study of the number of inspection/repairing reserve cars, it is necessary to first study whether the inspection/repairing periodicity will be on the time basis or the running distance basis. Electric railcar running distance has been estimated at 634.4 km per day, but this is in relation to 273 operating railcars. If reserve railcars are also included in assigned railcars, the resulting figure will be less than 634.4 km.

Table 4.3.4 Inspections of Electric Railcars

Items / Type of Inspection	Inspection periodicity		Place of inspection	Inspecting time	Capacity of inspection	Number of cars inspected per day*
	Time	Running kms				
Daily Inspection	48 hours or less	3,000 km or less	Depot	All day 365 days/year	60 minutes/ unit	159 cars
Monthly Inspection	30 days or less	18,000 km or less	Depot	6:00 - 14:00 303 days/year	8 hours/ unit	15 cars
Intermediary Inspection	24 months or less	400,000 km or less	Workshop	6:00 - 14:00 268 days/year	14 days/ unit	6 cars
Overall Inspection	48 months or less	800,000 km or less	Workshop	6:00 - 14:00 268 days/year	19 days/ unit	6 cars

* As for number of cars for inspection, refer to 4-3-3 (2) Number of inspection/repairing reserve cars.

In calculating the running distance for assigned railcars, the number of inspection/repairing reserve cars and operating reserve cars amounts to 10% and 5%, respectively, of the total number of operating cars according to the J-C Report. With the resulting total of 15%, a provisional calculation of running distance would be:

273 cars × 15% = 41 cars → 42 cars (14 units)

for the number of reserve cars. Thus, running distance for each assigned railcar is

273 cars × 634.4 km/day ÷ (273 cars + 42 cars) = 550 km/day.

Therefore, if car kilometers are assumed to be 550 km/day, the inspection periodicity will be as follows.

o Daily Inspection

550 km/day × 48 hrs ÷ 24 hrs/day = 1,110 km < 3,000 km

Therefore, the inspection cycle will be two days (48 hrs)

o Monthly Inspection

550 km/day × 30 days = 16,500 km < 18,000 km

Therefore, the inspection cycle will be 30 days.

o Intermediary Inspection

550 km/day × 24 mos × 365 days ÷ 12 mos

= 401,500 km > 400,000 km

Therefore, the inspection cycle will be every 400,000 km running distance, namely:

400,000 km ÷ 550 km/day = 727.3 days

However, since inspections will be carried out alternately, Intermediary Inspection - Overall Inspection - Intermediary Inspection - Overall Inspection, ... the actual inspection periodicity will be:

727.3 days × 2 = 1,455 days

o Overall Inspection

550 km/day × 48 mos ÷ 12 mos × 365 days = 803,000 km > 800,000 km

Thus, the inspection periodicity will be every 800,000 km running distance or: 800,000 km ÷ 550 km/day = 1,455 days

Next, the number of cars for inspection by type per day is obtained from the above-mentioned inspection periodicities.

o Daily Inspection
  (273 cars + 42 cars) ÷ 2 days = 157.5 cars/day
o Monthly Inspection
  (273 cars + 42 cars) ÷ 30 days = 10.5 cars/day
o Intermediary Inspection
  (273 cars + 42 cars) ÷ 1,455 days = 0.22 cars/day
o Overall Inspection
  (273 cars + 42 cars) ÷ 1,455 days = 0.22 cars/day

Then, in consideration of the depot's and workshop's annual number of workdays and the necessary time for inspections, the number of cars located at the workshop and the number of cars which should be inspected daily are as follows.

o Daily Inspection
  157.5 cars/day × (365 days/365 days) = 157.5 cars/day
  → 159 cars/day
  (53 units)
o Monthly Inspection
  10.5 cars/day × (365 days/303 days) = 12.5 cars/day → 15 cars/day
  (5 units)
o Intermediary Inspection
  0.22 cars/day × (365 days/268 days) × 14 days = 4.2 cars → 6 cars
  (2 units)
o Overall Inspection
  0.22 cars/day × (365 days/268 days) × 19 days = 5.7 cars → 6 cars
  (2 units)

Concerning the 159 cars for daily inspection here, it is possible to conduct inspections during operating intervals, but considering inspecting time for the total of 27 cars which include cars which should receive Monthly Inspection and cars located at the workshop for Intermediary and Overall Inspections, it is not possible to put them into service.

Therefore, 27 inspection/repairing reserve cars are needed. However, since these 27 cars amount to 10% of the 273 operating cars and are the same as the assumed inspection/repairing 10% when estimating car kilometers, there is no need to change car kilometers, namely the assumed inspection intervals, and it is possible to set the number of inspection/repairing reserve cars at 27 cars.

(3) Number of operating reserve cars

It is necessary to study the operation of special trains and the like beforehand when calculating the number of operating reserve cars, but since special trains and the like are undecided at the present stage, the 5% value for the number of operating reserve cars adopted in the J-C Report, or

$$273 \text{ cars} \times 5\% = 13.7 \text{ cars} \doteqdot 15 \text{ cars}$$

will be used.

(4) Total number of reserve cars

According to the above results, there will be 27 inspection/repairing reserve cars and 15 operating reserve cars for a total of 42 reserve cars.

4-3-4 Total Number of Electric Railcars Required

The total number of electric railcars required in the year 2000 is estimated to be 273 operating cars and 42 reserve cars for a total of 315 cars (see Table 4.3.5).

These electric railcars will be assigned to depots at Llavallol and Tolosa, but reserve cars will be used in common by both depots.

Table 4.3.5 Electric Railcar Utilization

Depot in Charge	Number of Cars in Operation			Number of Reserve Cars									Number of Cars Assigned			Car Kms	
				for Inspection			for Operation			Total							
	M	R	Total	M	R	Total	M	R	Total	M	R	Total	M	R	Total	Per one car in operation	Per one car assigned
Llavallol Tolosa	182	91	273	18	9	27	10	5	15	28	14	42	210	105	315	km 634	km 550

CHAPTER 5 WORKSHOP CONSTRUCTION PLAN FOR ELECTRIC RAILCARS CORRESPONDING TO THE 2ND STEP ELECTRIFICATION

CHAPTER 5 WORKSHOP CONSTRUCTION PLAN FOR ELECTRIC RAILCARS CORRESPONDING TO THE 2ND STEP ELECTRIFICATION

In the Chapter 4 study, the number of electric railcars necessary for the year of 2000 was calculated to be 315 cars. This number of cars is only three cars (one unit) less than the 318 cars calculated by the Argentine Railways. Hereafter, the figure of 318 is adopted for the study of the scale of the workshop.

5-1 Scale and Location of the Workshop

The following items must be fully considered as preconditions in studying the scale and location of the workshop.

(1) The Workshop corresponding to the 1st Step electrification (KM 10 Workshop) is of the scale to handle the 156 cars assigned to it, and its location is determined at a site 10 km from Plaza Constitución in the section between Remedios de Escalada and Lanus of the western lines.

(2) The rolling stock depot corresponding to the 1st Step electrification is situated at Llavallol, further down from Temperley. Another rolling stock depot corresponding to the 2nd Step electrification is planned for construction at Tolosa, this side of La Plata.

(3) The railway network extends southward from the terminus of Plaza Constitución branching off in three directions (Fig. 1.1.3). The distances from Plaza Constitución to the end of each line are at the most 50 km or so, 32.4 km to Ezeiza, 39.5 km to Alejandro Korn and 52.6 km to La Plata.

Electric railcars necessary for the 2nd Step electrification are 162 cars (318 cars - 156 cars = 162 cars). In order to inspect and repair these cars, there are two alternatives.

(1) The KM 10 Workshop can be amplified to a scale of 318 cars and made to inspect and repair the additional 162 cars for the 2nd Step electrification.

(2) A new workshop can be constructed at a place different from the KM 10 Workshop to inspect and repair the additional 162 cars for the 2nd Step electrification.

Taking into consideration the preconditions stated above, the amplification of the KM 10 Workshop has many advantages and the construction of a new workshop for 160 cars within a scope of 50 km has various drawbacks and is wasteful as follows.

(1) In the case of the KM 10 Workshop amplification, the partial addition of buildings and machines is enough to make up for the lack of capacity. In the case of a new workshop, not only will the construction of buildings and the installation of inspection/repairing facilities of almost the same quantity and scale as the KM 10 Workshop's be necessary, but a new acquisition of land will also be needed. This will result in a duplication of investment.

(2) In the case of adding the capacity of a workshop for 160 cars or so to the KM 10 Workshop (to amplify the KM 10 Workshop to a capacity of 318 cars), only a relatively small addition of administrative staff and foremen will fill the need. In the case of constructing a new workshop, the same number of indirect personnel as that of the KM 10 Workshop is required. As for direct personnel, the required number differs little in either case, but the efficient utilization of personnel is possible in the case of the KM 10 Workshop's amplifi cation.

(3) As for the utilization of spare parts, centralized control is possible and there are few detrimental effects on the inspection/repairing process in the case of the KM 10 Workshop's amplification.

In the case of constructing a separate workshop, each workshop must have and utilize spare parts by itself, making their efficient control that much more difficult.

In this study, the Argentine Railways has the intention to resort to the "amplification of the KM 10 Workshop for the 2nd Step electrification", and since this Study Team judges that the amplification of the KM 10 Workshop is more advantageous than constructing a separate workshop, the amplification plan will be studied hereafter.

In regard to the preconditions for calculating the number of annual shop-in cars, these were determined upon discussion with the Argentine Railways when this Study Team conducted the field survey in March-April 1985. These basic items under which the amplification plan will be worked out are as follows.

(1) Number of cars assigned — 106 units (318 cars)

(2) Periodicity of inspection

Overall Inspection	800,000 km or less 48 months or less
Intermediary Inspection	400,000 km or less 24 months or less
Temporary Inspection	In case need arises, this inspection is to be carried out at the Workshop. The number of cars temporarily inspected at the Workshop in a year is to be 10% of the cars assigned to the workshop.

(3) Average running km per day — 560 km/day

(4) Annual workshop workdays — 268 days/year

(5) Inspection/repairing unit — one unit (three cars)

(6) Inspection/repairing process

Overall Inspection	19 days
Intermediary Inspection	14 days
Temporary Inspection	5 days(average)

(7) Inspection/repairing man-hours

Overall Inspection	2,400 man-hours/car
Intermediary Inspection	1,500 man-hours/car
Temporary Inspection	250 man-hours/car (average)

5-2 Items Taken into Consideration in the Study of the Workshop Amplification Plan

The following points were taken fully into account in studying the workshop amplification plan and deciding the layout and the kinds of machines and facilities of the workshop.

(1) To enable work assuring the proper function of electric railcars and the enhancement of their reliability.

(2) To enable efficient performance of inspection/repairing work.

(3) To make the best use of the facilities of the KM 10 Workshop (corresponding to the 1st Step electrification), and employ domestic products of Argentina as much as possible in adding facilities for the amplification.

(4) To carry out amplification construction work while executing the operation of the workshop (corresponding to the 1st Step electrification).

5-3 Study of the Workshop Inspection/Repairing System for the Amplification

A study is made in this section for amplification of the KM 10 Workshop assigned with 156 cars corresponding to the 1st Step electrification and to build up the capacity of its inspection/repairing system to 318 electric railcars to be assigned to it corresponding to the 2nd Step electrification.

5-3-1 Study of the Inspection/Repairing Process of One Unit Shop-in

The basic process of 19 days for Overall Inspections and 14 days for Intermediary Inspections is as shown in Fig. 3.5.1. Based on this, the processes for car-bodies, bogies, and each piece of equipment in the case of one unit of three electric railcars are studied. The work system and the method are determined based on the following preconditions.

(1) Electric railcars are processed in three-car unit at a time or in succession.
(2) They are to be applicable to the additional equipment of the electric railcars expected for the 2nd Step electrification.
(3) All work is carried out directly by railway workshop.

The works not detailed in the 1st Step are defined as follows.

(1) The car-body and bogies are separated after the seating cushions, windows, and louvers are removed.
(2) Electric rotating equipment under the floor is demounted at the car-body shop.
(3) Wheels and axles are removed from the bogie at the bogie disassembly pit.
(4) Side sliding doors are attached to the car-body before car-body painting.
(5) Car-body painting is carried out three cars at a time.

Based on these conditions, three different cases (Processes A, B, and C) can be drawn up for the Overall Inspection process program as explained below. Each process shows a 16-day inspection/reparing period out of the 19-day total, excluding the periods for Leaving Inspection and Running Tests. (The process of the Intermediary Inspection is the same as that of the Overall Inspection, except it eliminates car-body painting work and reduces mounting work by one day.)

Process A

The Process A Overall Inspection, whose work system and method are almost the same as those of the 1st step KM 10 Workshop, is shown in detail in Fig. 5.3.1.

Process B

While Process A begins with the entrance inspection of one unit, Process B omits this and begins with the one-car inspection. In this way, the process is shortened by half a day and bogie washing work can be done on the first day without waiting for the work. Then from the second day, bogie inspection/repairing work can be started. The process in detail is shown in Fig. 5.3.2.

Process C

This process eliminates the waiting for the washing of wheels and axles from Process B. Washing is carried out right after bogie disassembly. The details are shown in Fig. 5.3.3.

All of these inspection/repairing processes will be compared.

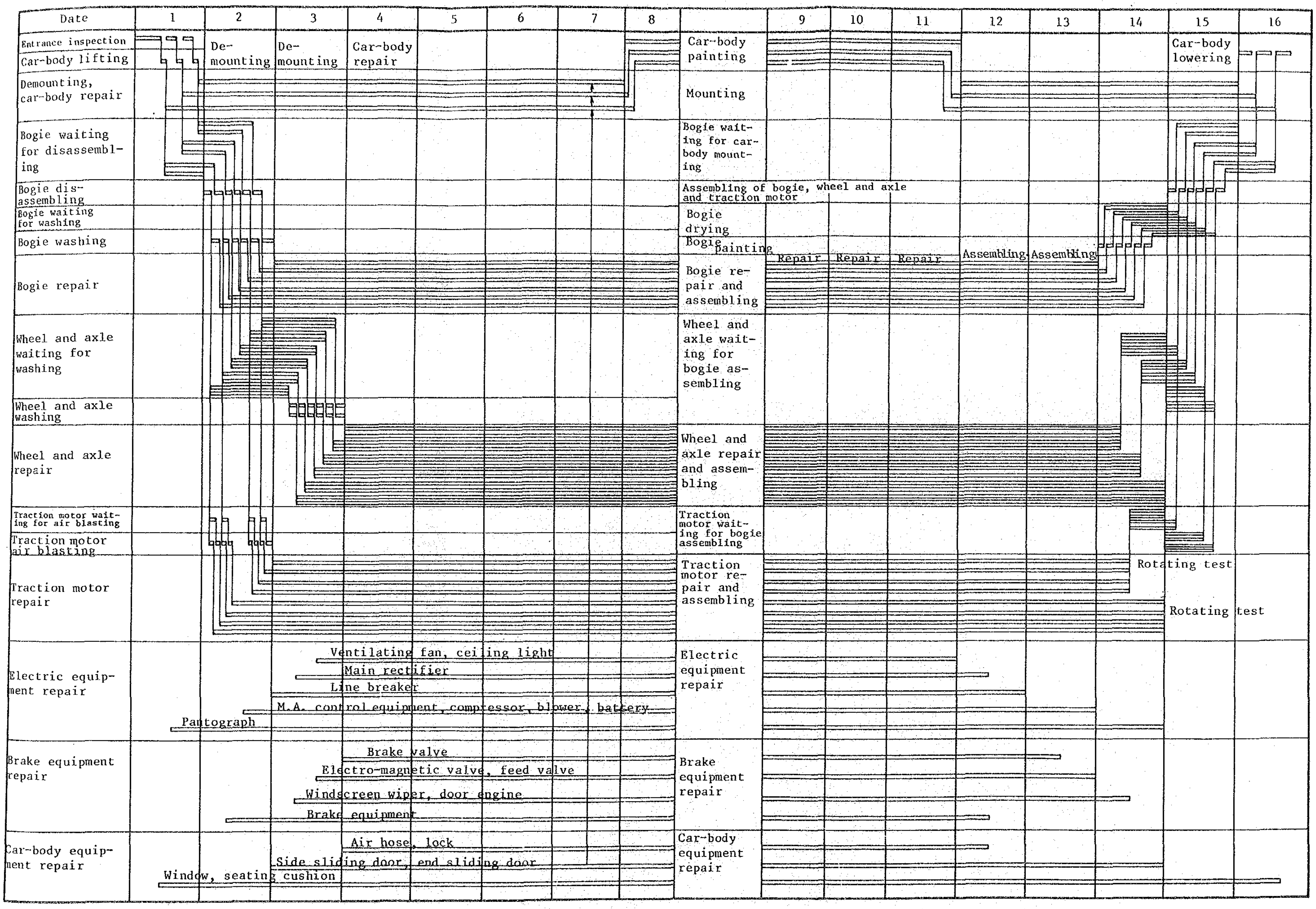


Fig. 5.3.1 Overall Inspection Process Program Process A

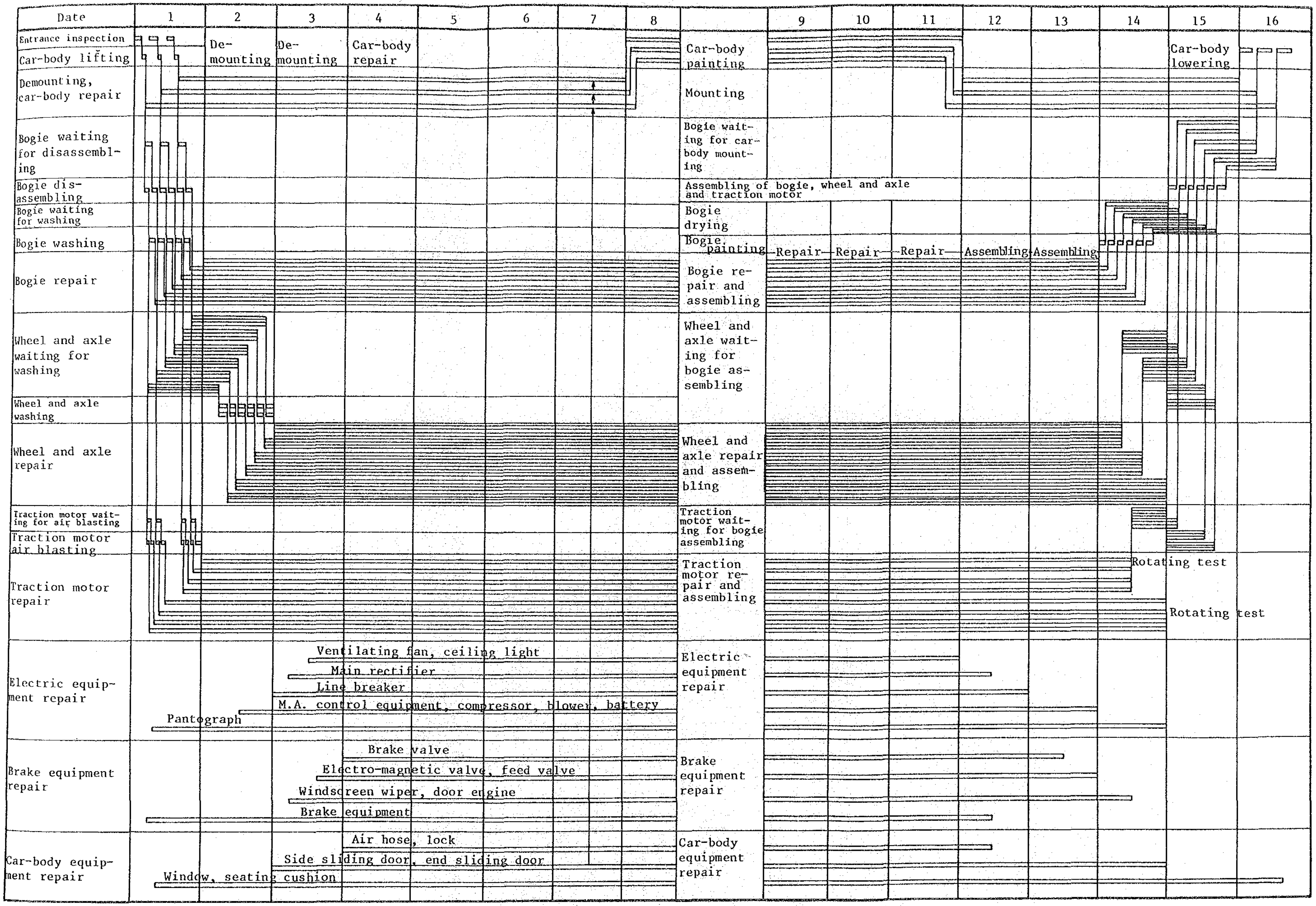


Fig. 5.3.2 Overall Inspection Process Program Process B

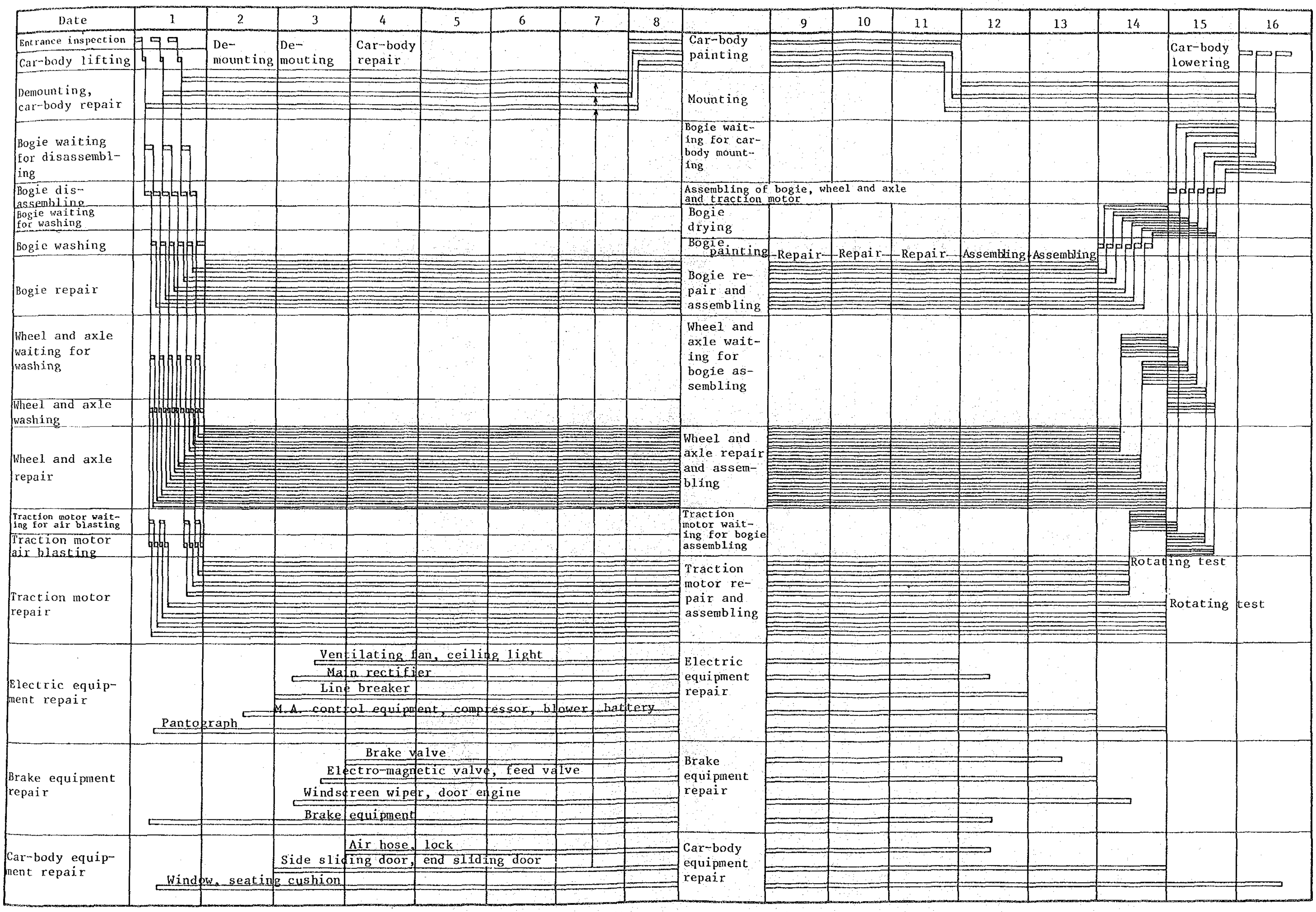


Fig. 5.3.3 Overall Inspection Process Program Process C

5-3-2 *Study of Inspection/Repairing Program of Annual Shop-in*

(1) Inspection/repairing program

In order to operate the workshop efficiently, the work should be leveled off to a constant amount. A rule should be set for the shop-in of electric railcars to control workshop operation. The important point is how to decide a standard pattern for repetition. The standard pattern is determined based on the following conditions.

a) Overall Inspections and Intermediary Inspections should be carried out alternately.
b) "Shop-in pitches" (p) for Overall Inspections and Intermediary Inspections should both be of the same fixed interval.
c) The "shop-in day difference" (d) between Overall Inspection and Intermediary Inspection should be selected appropriately to minimize the fluctuation of the work burden at each shop.

The standard pattern is determined by "shop-in pitch" and "shop-in day difference".

The shop-in pitch (p) is the number of days between one shop-in of a unit and the next shop-in of another unit for Overall Inspection. The same applies to Intermediary Inspections. The (p) is simply obtained by a numerical formula.

The shop-in day difference (d) is the number of days between one shop-in of a unit for Overall Inspection and the very next shop-in unit for Intermediary Inspection. The standard pattern varies in various ways depending on (d).

The standard pattern is the basic cycle for the workshop's operation and is an important element for the workshop amplification plan.

(2) Determination of shop-in pitch (p)

Total number of electric railcars	318 cars
Number of units	318/3 = 106 units
Electric railcar km/day	560 km/day

Electric railcar km/year	560 × 365 = 204,400 km/year

Limit of running km and number of months

Overall Inspection	800,000 km, 48 mos.
Intermediary Inspection	400,000 km, 24 mos.

Number of shop-in units per year

Overall Inspection	$106 \times \frac{204,400}{800,000} = 27.1 \rightarrow 28$ units
Intermediary Inspection	$106 \times \frac{204,400}{40,000} - 27.1 = 27.1 \rightarrow 28$ units

Workshop workdays per year	268 days/year

Shop-in pitch

Overall Inspection	p = 268/28 = 9 days
Intermediary Inspection	p = 268/28 = 9 days

As a result, the shop-in pitch for both Overall and Intermediary Inspections is nine days.

(3) Shop-in day difference (d)

Shop-in day difference (d) is the number of days between shop-ins of Overall Inspection and Intermediary Inspection. If (d) is varied from (-3) to (+5), each combination will be as shown in Fig. 5.3.4.

Since, the shop-in pitch p=9, as calculated in section (2) above, is adopted, Fig. 5.3.4 shows all combinations.(In case d = -4, this is the same as d = +5.)

Hereafter, all combinations of "Processes A, B, C" and shop-in day differences of -3 to +5 are studied as standard patterns.

Each standard pattern is shown in Table 5.3.1 by combining "process" and "shop-in day difference."

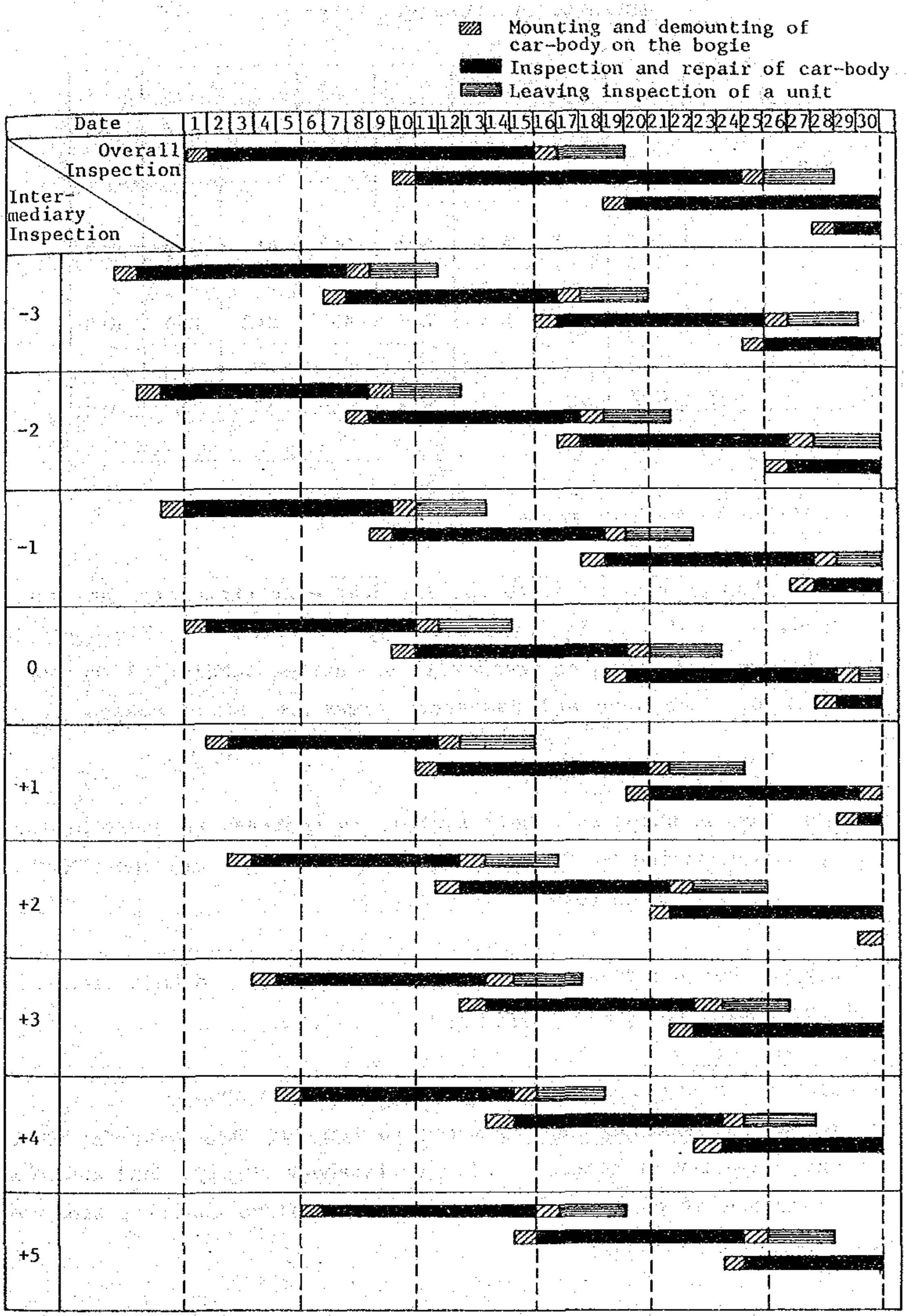


Fig. 5.3.4 Combinations of Overall Inspection Process and Intermediary Inspection Process

Table 5.3.1 Standard Patterns

(d) / Process	-3	-2	-1	0	+1	+2	+3	+4	+5
A	A-3	A-2	A-1	A 0	A+1	A+2	A+3	A+4	A+5
B	B-3	B-2	B-1	B 0	B+1	B+2	B+3	B+4	B+5
C	C-3	C-2	C-1	C 0	C+1	C+2	C+3	C+4	C+5

5-3-3 Sectioning of Working Areas

The KM 10 Workshop corresponding to the 1st Step electrification has various shops with names showing their respective type of work. In this amplification plan, however, the working areas will be further subdivided so that the work contents of each shop and necessary areas can be discussed in more detail.

The names of various shops and their symbols in contrast to those of the KM 10 Workshop corresponding to the 1st Step electrification are shown in Table 5.3.2.

5-3-4 Study of the Quantity of Parts Kept at Each Shop and Selection of the Amplification Plan Proposal

(1) Calculation of the quantity of parts kept at each shop

In the KM 10 Workshop corresponding to the 1st Step electrification, the shop-in pitch of electric railcars is about 20 days, and therefore, no congestion of parts at shops will arise and no conflict among work processes will result.

Table 5.3.2 Names of the Shops and Their Symbols

Names of the Shops of KM 10 Workshop Corresponding to 1st Step Electrification	Amplification Proposal	
	Names of the Shops	Symbols
General	Workshop yard	A
Entrance/leaving inspection shop	Entrance/leaving inspection shop	B
Demounting/mounting shop	Car-body lifting/ lowering shop	C
Electric equipment shop	Electric equipment shop	D
Car-body equipment shop	Car-body equipment shop	E
Air brake equipment shop	Air brake equipment shop	F
	Parts painting shop	G
	Seat and vestibule diaphragm shop	H
Car-body shop	Car-body shop	I
Pipe works shop	Pipe works shop	J
Car-body painting shop	Car-body painting shop	K
Bogie shop	Bogie shop	L
Wheel and axle shop	Wheel and axle shop	M
Traction motor shop	Traction motor shop	N
	Rotating equipment shop	O
Ironwork shop	Ironwork shop	P
Machine shop	Machine shop	Q
	Tool room	R
	Temporary bogie shed	S
	Cooling unit shop	T
	Car-body major repair shop	U
	Warehouse	V
Energy center	Energy center	W

At the stage of this workshop's amplification plan, however, the number of electric railcars for shop-in will be doubled and the congestion of parts at shops and conflict among work processes can arise. For this reason, the order of each work process, the overlapping of work, the quantity of parts for repair, the quantity of parts in arrears in the work flow, etc. should be studied in detail, the work method reviewed, work assignment rationalized, and additional machines introduced.

The quantity of parts kept calculated by standard patterns as in section 5-3-2 and by the sectioning of shops as in section 5-3-3 is shown in Tables 5.3.3, 5.3.4, and 5.3.5.

However, the standard patterns of AO, BO and CO are omitted because in these patterns shop-in days for Overall Inspections and Intermediary Inspections overlap making them very disadvantageous combinations.

(2) Selection of amplification plan proposal

Tables 5.3.3 ∿ 5.3.5 show, for each pattern, the quantity of parts kept at each shop, the number of days when units under inspection overlap on the inspection track, the quantity of parts in arrears in the work flow, length of parts repair delays, and the necessary facilities.

After comparing all of them, the three desirable proposals were selected. Table 5.3.6 shows the selected amplification plan proposals.

Table 5.3.3 Number of Parts Units Kept at Each Shop Process A

Shop-in day difference	-3	-2	-1	0	1	2	3	4	5
Entrance/Leaving Inspection	③1 2 2 2	③1 1 1 2 2	③1 1 1 1 1 2		2 1 1 1 1 1 1 1 1	2 1 1 1 1 2 1 1	2 1 1 1 2 2 1	2 1 1 2 2 2	③ 1 2 2 2
Overlapping of Leaving Inspection (days)	3	2	1		0	1	2	3	4
Car-body	2 2 3 3 3 3 ④ 2 1	2 2 3 3 3 3 3 2 2	3 2 3 3 3 3 3 1 2		2 3 ④ 3 3 3 3 1 1	2 2 ④④ 3 3 3 1 1	2 2 3 ④④ 3 3 1 1	2 2 3 3 ④④ 3 1 1	2 2 3 3 3 ④④ 1 1
Bogie	2 3 3 3 3 2 1 2 2	2 3 3 3 3 2 2 1 2	2 2 3 3 3 2 2 2 1		2 2 2 3 3 2 2 2 2	2 3 2 3 3 2 2 2 2	2 3 3 2 3 2 2 2 2	2 3 3 3 2 2 2 2 2	2 3 3 3 3 1 2 2 2
Wheel and Axle	2 2 3 3 3 2 1 1 2	2 2 3 3 3 2 2 1 1	1 2 2 3 3 2 2 2 1		2 1 2 2 3 2 2 2 2	2 2 2 2 3 2 2 2 2	2 2 3 2 2 2 2 2 2	2 2 3 3 2 1 2 2 2	2 2 3 3 3 1 1 2 2
Wheel and Axle Washing Equipment	No	No	No		No	No	No	No	No
Bogie Pit (tracks)	1	1	1		2	1	1	2	2
Traction Motor	2 3 3 3 3 2 1 2 2	2 3 3 3 3 2 2 1 2	2 3 3 3 3 2 2 2 1		2 2 3 3 3 2 2 2 2	2 3 2 3 3 2 2 2 2	2 3 3 2 3 2 2 2 2	2 3 3 3 2 2 2 2 2	2 3 3 3 3 1 2 2 2
Electric Equipment	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2		3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 2 2 2 2 2	3 3 3 3 3 2 2 2 2
Brake Equipment	2 3 3 3 3 2 1 2 2	2 3 3 3 3 2 2 1 2	2 3 3 3 3 2 2 2 1		2 2 3 3 3 2 2 2 2	2 3 2 3 3 2 2 2 2	2 3 3 2 3 2 2 2 2	2 3 3 3 2 2 2 2 2	2 3 3 3 3 1 2 2 2
Car-body Equipment	3 3 3 3 3 3 ④ 3 2	3 3 3 3 3 3 3 3 3	④ window and seating cushion ④ 3 3 3 3 3 3 2 3		3 ④④ 3 3 3 3 2 2	3 3 ④④ 3 3 3 2 2	3 3 3 ④④ 3 3 2 2	3 3 3 3 ④④ 3 2 2	3 3 3 3 3 ④④ 2 2
Side Sliding Door		1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1		1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1		
Bogie Waiting for Disassembling (No. of bogies)	6	6	6		6	6	6	6	6
Bogie Waiting for Washing (No. of bogies)	0	0	6		6	0	0	0	0
Delay of Bogie Repair (days)	1	1	2		2	1	1	1	1
Wheel and Axle Waiting for Washing (No. of sets)	12	12	12		12	12	12	12	12
Delay of Wheel and Axle Repair (days)	2	2	3		3	2	2	2	2

Table 5.3.4 Number of Parts Units Kept at Each Shop Process B

Shop-in day difference	-3	-2	-1	0	1	2	3	4	5
Entrance/Leaving Inspection	③ 1 2 2 2	③ 1 1 1 2 2	③ 1 1 1 1 1 2		2 1 1 1 1 1 1 1 1	2 1 1 1 1 2 1 1	2 1 1 1 2 2 1	2 1 1 2 2 2	③ 1 2 2 2
Overlapping of Leaving Inspection (days)	3	2	1		0	1	2	3	4
Car-body	2 2 3 3 3 3 ④ 2 1	2 2 3 3 3 3 3 2 2	3 2 3 3 3 3 3 1 2		2 3 ④ 3 3 3 3 1 1	2 2 ④④ 3 3 3 1 1	2 2 3 ④④ 3 3 1 1	2 2 3 3 ④④ 3 1 1	2 2 3 3 3 ④④ 1 1
Bogie	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	2 3 3 3 3 2 2 2 2		3 2 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2
Wheel and Axle	2 3 3 3 3 2 1 2 2	2 3 3 3 3 2 2 1 2	2 2 3 3 3 2 2 2 1		2 2 2 3 3 2 2 2 2	2 3 2 3 3 2 2 2 2	2 3 3 2 3 2 2 2 2	2 3 3 3 2 2 2 2 2	2 3 3 3 3 1 2 2 2
Wheel and Axle Washing Equipment	No	No	No		No	No	No	No	No
Bogie Pit (tracks)	2	2	2		2	2	2	2	2
Traction Motor	2 3 3 3 3 2 1 2 2	2 3 3 3 3 2 2 1 2	2 3 3 3 3 2 2 2 1		2 2 3 3 3 2 2 2 2	2 3 2 3 3 2 2 2 2	2 3 3 2 3 2 2 2 2	2 3 3 3 2 2 2 2 2	2 3 3 3 3 1 2 2 2
Electric Equipment	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2		3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 2 2 2 2 2	3 3 3 3 3 2 2 2 2
Brake Equipment	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2		3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2
Car-body Equipment	3 3 3 3 3 3 ④ 3 2	3 3 3 3 3 3 3 3 3	④ window and seating cushion ④ 3 3 3 3 3 3 2 3		3 ④④ 3 3 3 3 2 2	3 3 ④④ 3 3 3 2 2	3 3 3 ④④ 3 3 2 2	3 3 3 3 ④④ 3 2 2	3 3 3 3 3 ④④ 2 2
Side Sliding Door		1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1		1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1		
Bogie Waiting for Disassembling (No. of bogies)	1	1	1		1	1	1	1	1
Bogie Waiting for Washing (No. of bogies)	0	0	6		6	0	0	0	0
Delay of Bogie Repair (days)	0	0	1		1	0	0	0	0
Wheel and Axle Waiting for Washing (No. of sets)	12	12	12		12	12	12	12	12
Delay of Wheel and Axle Repair (days)	1	1	2		2	1	1	1	1

Table 5.3.5 Number of Parts Units Kept at Each Shop Process C

Shop-in day difference	-3	-2	-1	0	1	2	3	4	5
Entrance/Leaving Inspection	③ 1 2 2 2	③ 1 1 1 2 2	③ 1 1 1 1 1 2		2 1 1 1 1 1 1 1 1	2 1 1 1 1 2 1 1	2 1 1 1 2 2 1	2 1 1 2 2 2	③ 1 2 2 2
Overlapping of Leaving Inspection (days)	3	2	1		0	1	2	3	4
Car-body	2 2 3 3 3 3 ④ 2 1	2 2 3 3 3 3 3 2 2	3 2 3 3 3 3 3 1 2		2 3 ④ 3 3 3 3 1 1	2 2 ④④ 3 3 3 1 1	2 2 3 ④④ 3 3 1 1	2 2 3 3 ④④ 3 1 1	2 2 3 3 3 ④④ 1 1
Bogie	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2		3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2
Wheel and Axle	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2		3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2
Wheel and Axle Washing Equipment	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
Bogie Pit (tracks)	2	2	2		2	2	2	2	2
Traction Motor	2 3 3 3 3 2 1 2 2	2 3 3 3 3 2 2 1 2	2 3 3 3 3 2 2 2 1		2 2 3 3 3 2 2 2 2	2 3 2 3 3 2 2 2 2	2 3 3 2 3 2 2 2 2	2 3 3 3 2 2 2 2 2	2 3 3 3 3 1 2 2 2
Electric Equipment	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2		3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2
Brake Equipment	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2		3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2	3 3 3 3 3 2 2 2 2
Car-body Equipment	3 3 3 3 3 3 ④ 3 2	3 3 3 3 3 3 3 3 3	④ window and seating cushion ④ 3 3 3 3 3 3 2 3		3 ④④ 3 3 3 3 2 2	3 3 ④④ 3 3 3 2 2	3 3 3 ④④ 3 3 2 2	3 3 3 3 ④④ 3 2 2	3 3 3 3 3 ④④ 2 2
Side Sliding Door		1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1		1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1	1 1 2 2 2 2 2 1 1		
Bogie Waiting for Disassembling (No. of bogies)	1	1	1		1	1	1	1	1
Bogie Waiting for Washing (No. of bogies)	0	0	0		0	0	0	0	0
Delay of Bogie Repair (days)	0	0	0		0	0	0	0	0
Wheel and Axle Waiting for Washing (No. of sets)	1	1	1		1	1	1	1	1
Delay of Wheel and Axle Repair (days)	0	0	0		0	0	0	0	0

Table 5.3.6 Selected Amplification Plan Proposals

Proposals	I	II	III
Standard Pattern	A + 2	C + 2	C - 1

5-3-5 Study of Each Shop Area

(1) Study of Additional Machines

The installation of additional machines is necessary to cope with the increase in the number of electric railcars corresponding to the 2nd Step electrification. This is studied based on the following principles.

1) Additionally required machines to cope with the increase of work.

2) Additional machines necessitated by changes in the layout and work system.

3) Testing machines necessary to confirm performance.

4) Cleaning and washing machines necessary for the thorough inspection of flaws, corrosion and other defects, and for the elimination of dirty work.

5) Wide range of machines necessary for machining and sheet metal processing in order to reduce outside work dependecy.

6) Carts, heating units, air conditioners, etc. for improved working environment.

7) Overhead travelling cranes suitable to the shop arrangements.

8) Other necessary facilities

After considering all of the above, machines and equipment were selected as shown in Table 5.3.7.

Table 5.3.7 Machines to be Added

Shop	Machine	Proposal		
		I	II	III
A Workshop Yard	Forklift truck(1.5 t)	1	1	1
	Forklift truck(2 t)	2	2	2
	Autotruck(6 t)	1	1	1
	Autotruck(1 t)	1	1	1
B Entrance/Leaving Inspection Shop	Air brake tester	1	1	1
C Car-body Lifting/ Lowering Shop				
D Electric Equipment Shop	Parts cleaner	1	1	1
	Dielectric strength tester	1	1	1
	Buffing machine	1	1	1
	Coiling machine	1	1	1
	Dust arresting equipment	1	1	1
	Electric coil drying oven	1	1	1
	Low platform cart(1.5 t)	1	1	1
	Overhead travelling crane (3 t)	1	1	1
E Car-body Equipment Shop	Bench drilling machine	1	1	1
	Bench grinding machine	1	1	1
	Crank press	1	1	1
	Shearing machine	1	1	1
	Bending roll	1	1	1
	Bending machine	1	1	1
	Nibbling machine	1	1	1
F Air Brake Equipment Shop	Air brake valve tester	2	2	2
	Parts cleaner	1	1	1
	Air conditioner	2	2	2

Shop	Machine	Proposal		
		I	II	III
G Parts Painting Shop	Paint mixer	1	1	1
	Parts cleaner	1	1	1
H Seat and Vestibule Diaphragm Shop	Industrial sewing machine	1	1	1
	Seat transfer cart(1 t)	6	6	6
	Seat storing equipment	1	1	1
I Car-body Shop	Electric welder	6	6	3
	Scaffolding car for car-body reapir	6	6	3
	Low platform cart(1.5 t)	1	1	1
	Forklift truck (1.5 t)	2	2	2
J Pipe Works Shop	Pedestal grinding machine	1	1	1
	Threading machine	2	2	2
K Car-body Painting Shop	Car-body painting machine	3	3	3
	Scaffold for car-body painting	1	1	1
	Air heating equipment	3	3	3
	Air exhaust	3	3	3
L Bogie Shop	Hydraulic press	1	1	1
	Parts cleaner	1	1	1
	Electric arc welder	2	2	2

Shop	Machine	Proposal		
		I	II	III
M Wheel and Axle Shop	Wheel lathe	1	1	1
	Ultrasonic flaw detector	1	1	1
	Wheel and axle washing equipment	0	1	1
	Wheel and axle rotating equipment	1	1	1
	Wheel and axle traverser	1	1	1
	Turntable	3	4	4
	Overhead travelling crane (5 t)	2	2	2
	Bearing heater	1	1	1
	Roller conveyer	2	2	2
	Axle box washing machine	1	1	1
	Wheel and axle transfer track	1	1	1
	Air conditioner	1	2	2
N Traction Motor Shop	Parts cleaner	1	1	1
	Slat conveyer	3	3	3
	Pedestal grinding machine	1	1	1
	Low platform cart(1.5 t)	2	2	2
O Rotating Equipment Shop	Air filter cleaning machine	1	1	1
	Air blast booth	1	1	1
	Insulation deterioration tester	1	1	1
	Dielectric strength tester	1	1	1
	Pedestal grinding machine	1	1	1
	Overhead travelling crane (3 t)	1	1	1

Shop	Machine	Proposal		
		I	II	III
P Ironwork Shop	Electric welder	3	3	3
	Rust remover	1	1	1
	Parts cleaner	1	1	1
	Magnetic flaw detector	1	1	1
	Upright drilling machine	1	1	1
	Pedestal grinding machine	1	1	1
	Hydraulic press	1	1	1
	Bending roll	1	1	1
	Punching/shearing machine	1	1	1
	Spot welder	1	1	1
	Automatic gas cutting machine	1	1	1
	Argon gas arc welder	1	1	1
Q Machine Shop	Horizontal boring machine	1	1	1
	Centering machine	1	1	1
	Lathe (1,000)	2	2	2
	Lathe (2,000)	1	1	1
	Lathe (3,000)	1	1	1
	Upright drilling machine	1	1	1
	Radial drilling machine	1	1	1
	Vertical milling machine	2	2	2
	Pedestal grinding machine	1	1	1
	Surface grinder	1	1	1
	Universal tool grinding machine	1	1	1
	Cemented carbide tool grinding machine	1	1	1
	Drill-grinding machine	1	1	1
R Tool Room	Air conditioner	1	1	1
S Temporary Bogie Shed	Temporary bogie	12	12	6
	Bogie turntable	1	1	1

Shop	Machine	Proposal		
		I	II	III
T Cooling Unit Shop	Cleaning machine	1	1	1
	Air exhaust	1	1	1
	Cooling unit repairing carrier	6	6	6
	Cooling unit test equipment	1	1	1
	Overhead travelling crane (2 t)	2	2	2
U Car-body Major Repair Shop				
V Warehouse	Forklift truck(2 t)	2	2	2
	Low platform cart(1.5 t)	2	2	2
	Overhead travelling crane (5 t)	1	1	1
	Air conditioner	1	1	1
W Energy Center	Boiler (4 t)	1	1	1
Total		157	160	148

(2) Study of shop areas

The following items were studied in calculating the necessary area for each shop.

1) Machine area	Machine projection area and working area around the machine
2) Parts area	Area for one unit of parts multiplied by maximum number of parts kept at a time
3) Repairing area	Area of repair work bench and some area around the bench
4) Parts storage area	Area of parts waiting for repair work
5) Spare parts area	Area of spare parts to be kept at the shop (limited to heavy articles)
6) Others	Area for material shelf, tool shelf, storage room, etc. necessary for the shop

Those areas for the Entrance/Leaving Inspection Shop, Car-body Lifting/Lowering Shop, Car-body Shop, and Car-body Painting Shop are calculated by the maximum number of electric railcars existing at a time.

The area of each shop corresponding to the amplification proposals is shown in Tables 5.3.8 ∿ 5.3.10.

Table 5.3.8 Calculation of Necessary Area Proposal I

Shop	Machine Area	Parts Area	Repairing Area	Parts Storage Area	Spare Parts Area	Total	Total × 1.2
A	------	------	------	------	------	------	------
B	------	------	------	------	------	------	90 × 20 ⑥ 1,800
C	------	------	------	------	------	------	36 × 20 720
D	488	165	276			929	1,120
E	48	210	72			330	400
F	156	45	108			309	370
G	24	51	140			215	260
H	147	13	120			280	340
I	------	------	------	------	------	------	90 × 40 ⑫ 3,600
J	41	40	150			231	280
K	------	------	------	------	------	------	90 × 10 ③ 900
L	479	252	370	272	84	1,457	1,750
M	1,377	108	306	66	29	1,886	2,260
N	269	24	160	6	8	467	560
O	191	57	142			390	470
P	270	40	20	80		410	500
Q	231	40	20	40		331	400
R			10	50		60	80
Total	3,721	1,045	1,894	514	121	7,295	15,810

Note:

Symbol	Shop	Symbol	Shop
A	Workshop yard	I	Car-body shop
B	Entrance/leaving inspection shop	J	Pipe works shop
		K	Car-body painting shop
C	Car-body lifting/lowering shop	L	Bogie shop
		M	Wheel and axle shop
D	Electric equipment shop	N	Traction motor shop
E	Car-body equipment shop	O	Rotating equipment shop
F	Air brake equipment shop	P	Ironwork shop
G	Parts painting shop	Q	Machine shop
H	Seat and vestibule diaphragm shop	R	Tool room

Mark○: The maximum number of electric railcars existing at a time.

Table 5.3.9 Calculation of Necessary Area Proposal II

Shop	Machine Area	Parts Area	Repairing Area	Parts Storage Area	Spare Parts Area	Total	Total × 1.2
A	------	------	------	------	------	------	------
B	------	------	------	------	------	------	90 × 20 ⑥ 1,800
C	------	------	------	------	------	------	36 × 20 720
D	488	165	276			929	1,120
E	48	210	72			330	400
F	156	45	108			309	370
G	24	51	140			215	260
H	147	13	120			280	340
I	------	------	------	------	------	------	90 × 40 ⑫ 3,600
J	41	40	150			231	280
K	------	------	------	------	------	------	90 × 10 ③ 900
L	506	252	370	202	84	1,414	1,700
M	1,393	108	306	33	29	1,869	2,240
N	269	24	160	6	8	467	560
O	191	57	142			390	470
P	270	40	20	80		410	500
Q	231	40	20	40		331	400
R			10	50		60	80
Total	3,764	1,045	1,894	411	121	7,235	15,740

Note:

Symbol	Shop	Symbol	Shop
A	Workshop yard	I	Car-body shop
B	Entrance/leaving inspection shop	J	Pipe works shop
		K	Car-body painting shop
C	Car-body lifting/lowering shop	L	Bogie shop
		M	Wheel and axle shop
D	Electric equipment shop	N	Traction motor shop
E	Car-body equipment shop	O	Rotating equipment shop
F	Air brake equipment shop	P	Ironwork shop
G	Parts painting shop	Q	Machine shop
H	Seat and vestibule diaphragm shop	R	Tool room

Mark ○: The maximum number of electric railcars existing at a time.

Table 5.3.10 Calculation of Necessary Area Proposal III

Shop	Machine Area	Parts Area	Repairing Area	Parts Storage Area	Spare Parts Area	Total	Total × 1.2
A	------	------	------	------	------	------	------
B	------	------	------	------	------	------	90 × 20 ⑥ 1,800
C	------	------	------	------	------	------	36 × 20 720
D	488	165	276			929	1,120
E	48	210	72			330	400
F	156	45	108			309	370
G	24	51	140			215	260
H	147	13	120			280	340
I	------	------	------	------	------	------	90 × 30 ⑨ 2,700
J	41	40	150			231	280
K	------	------	------	------	------	------	90 × 10 ③ 900
L	506	252	370	202	84	1,414	1,700
M	1,393	108	306	33	29	1,869	2,240
N	269	24	160	6	8	467	560
O	191	57	142			390	470
P	270	40	20	80		410	500
Q	231	40	20	40		331	400
R			10	50		60	80
Total	3,764	1,045	1,894	411	121	7,235	14,840

Note:

Symbol	Shop	Symbol	Shop
A	Workshop yard	I	Car-body shop
B	Entrance/leaving inspection shop	J	Pipe works shop
		K	Car-body painting shop
C	Car-body lifting/lowering shop	L	Bogie shop
		M	Wheel and axle shop
D	Electric equipment shop	N	Traction motor shop
E	Car-body equipment shop	O	Rotating equipment shop
F	Air brake equipment shop	P	Ironwork shop
G	Parts painting shop	Q	Machine shop
H	Seat and vestibule diaphragm shop	R	Tool room

Mark○: The maximum number of electric railcars existing at a time.