5-1-2 Power network

Fig. 5-3 illustrates a power network for the commuter service electrification project, which is composed mainly of 115 kV transmission lines owned by MERALCO.

Fig. 5-4 shows a geography of railways, stations, MERALCO's power plants, substations and transmission lines, all concerned with the project.

MERALCO's power network is composed of transmission grids of 115 kV and distribution grids of 34.5 kV and lower. MERALCO has power plants at Tegen, Rockwell and Gardner. MERALCO's system is interconnected to NPC's at Balintawak and Novaliches substations. The 115 kV transmission grids form a loop, and a failure of one member of the loop can be backed up by the other member for no-break power service. The 115 kV substations and transmission lines and 34.5 kV distribution lines are located near roads and railways.

FIG. 5-3 OUTLINE OF POWER NETWORK

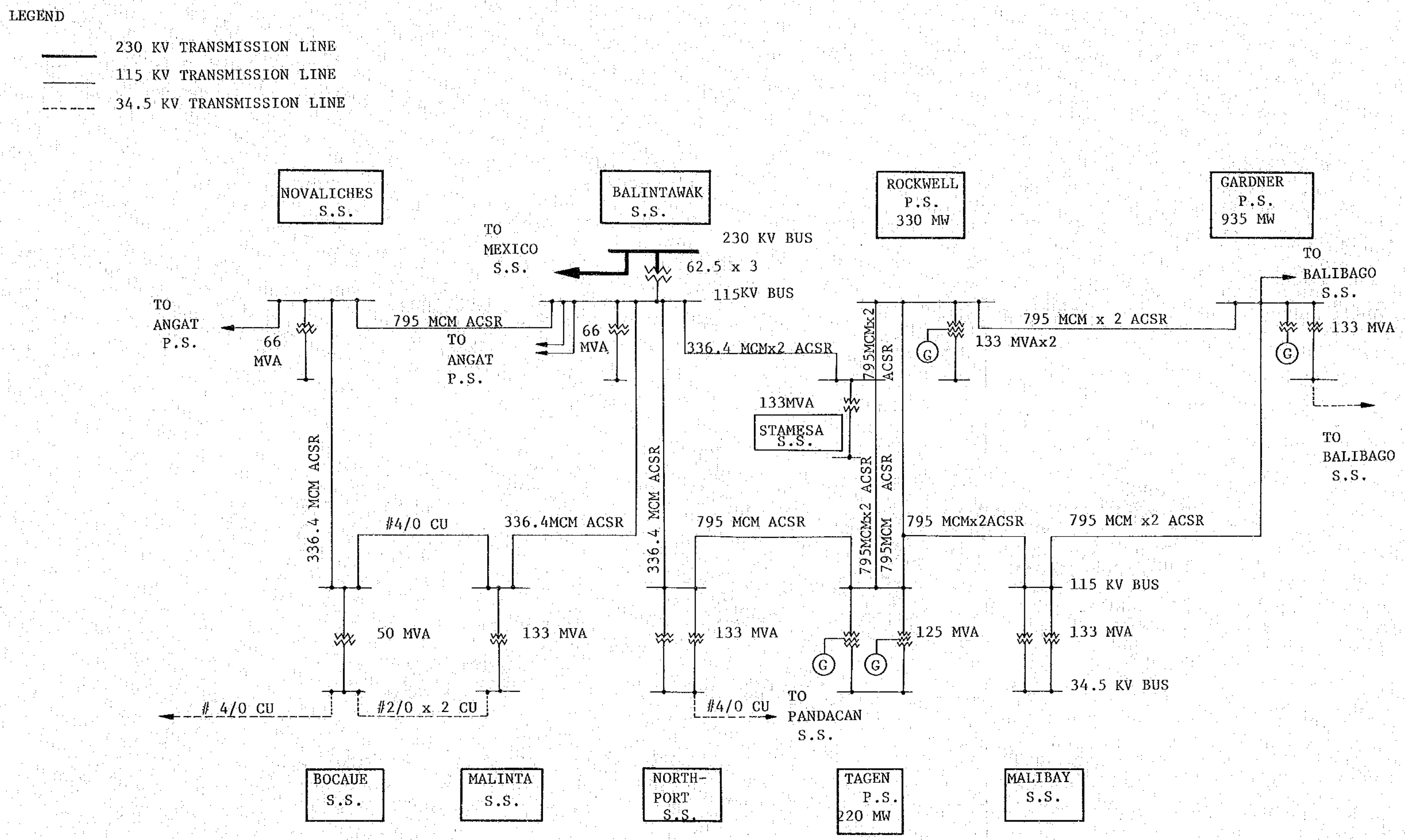
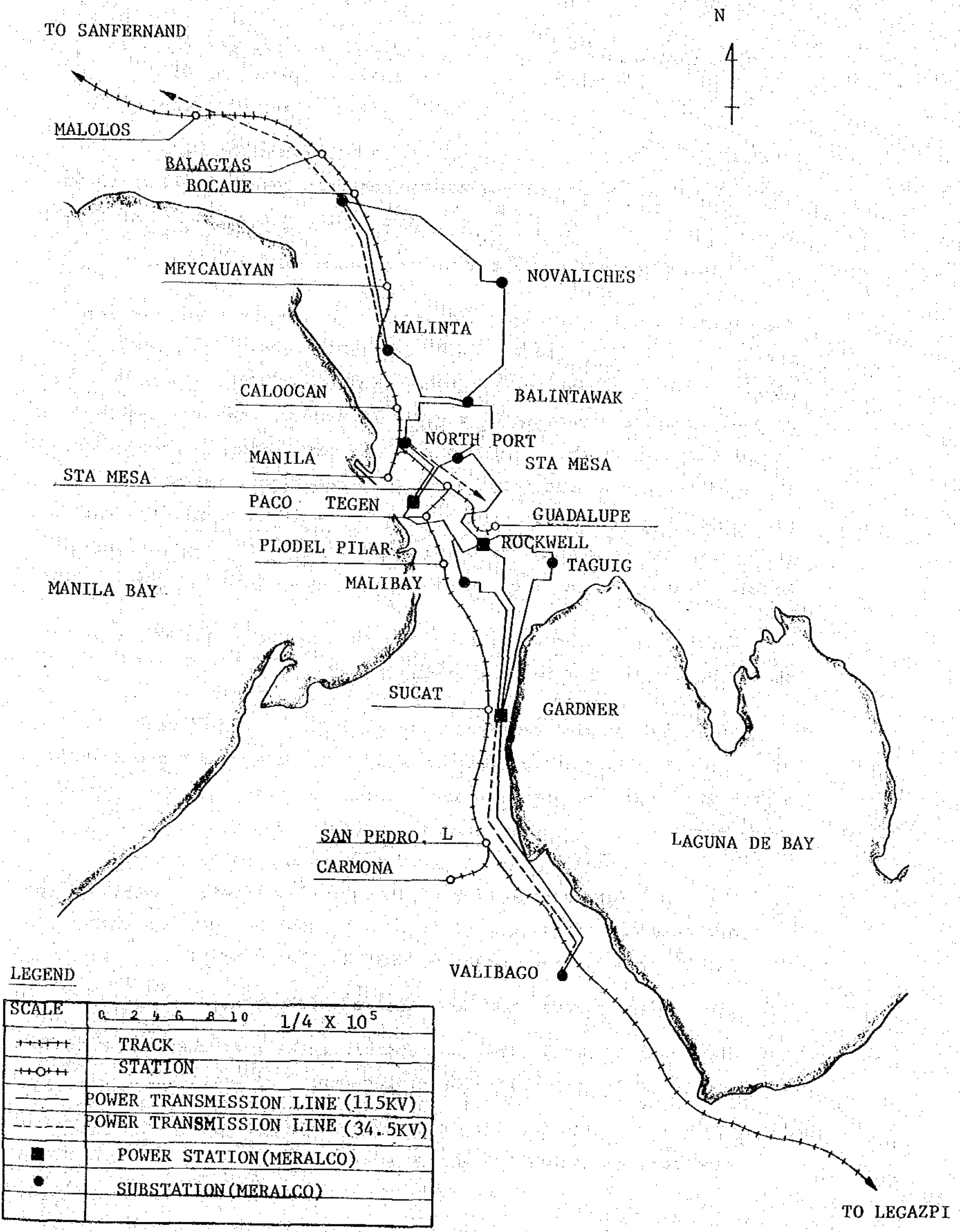


FIG. 5-4 POWER NETWORK IN COMMUTER SERVICE AREA



5-2 System of Electrification

The system of railway electrification is classified as follows.

DC system

AC system - Single phase - Commercial frequency (50 or 60 Hz)
Special frequency (16-2/3 or 25 Hz)

AC system - Three phase

The electrification systems most widely accepted in the world for rapid mass transit railways are DC system (1,500 V or 3,000 V), single-phase AC commercial frequency system and single-phase AC special frequency system. Of the two AC system, the single-phase AC commercial frequency system has become prevailing in recent years. The single-phase AC special frequency system necessitates a special generator or a frequency converter for exclusive use with the railway, and is limited to some parts of West Germany, Switzerland, Austria, Norway, Sweden, U.S.A. etc. where it was employed in the past.

Whether DC system or single-phase AC commercial frequency system should be adopted is the crux of the project.

Table 5-1 shows a comparison between DC system (1,500 V) and single-phase AC commercial frequency system. The merits and demerits of the AC system are as enumerated below.

Merits

(1) The costs for construction of transmission lines, substations and overhead contact wire facilities are much cheaper than those for DC system. (See Chap. 6 "CONSTRUCTION COSTS")

(2) The feeding circuit can be protected with ease.

(3) The contact wire is less susceptible to wear as compared with DC system, and least calls for replacement.

(4) The future extension into the neighboring areas can be accomplished more economically than DC system.

Demerits

(1) If the railway is powered from a substation operated marginally, it is likely to affect other users because of voltage unbalance and fluctuations.

(2) PNR's signalling system installed last year is available to DC system, but not to the AC system, and has to be modified.

(3) The telecommunication lines along the railways will be affected by induction interference, and have to be replaced with shielded cables.

(4) Because of high feeding voltage, the insulating clearance between railways and their adjacent structures has to be made greater than in the DC system.

(5) AC electric car is 10 to 20% higher in price than DC one.

Each system has merits and demerits as explained above, and JNR uses both AC and DC systems. Accordingly, the cars running between these two different systems are of the AC-DC dual purpose type. Employment of AC-DC dual cars poses problems in that costly cars are required and that the substations located at the both sides of AC-DC junction point must be fortified since the substations for one system cannot feed another system. For PNR, electrification is a new experience. To make a good start, in-depth studies and investigations should be conducted before choosing between the two systems. The discussions in this report are therefore limited to the comparison of AC and DC systems from the viewpoint of engineering without favor or prejudice.

Table 5-1 AC Electrification vs. DC Electrification comparison

Item	AC system (60 Hz, single-phase, 25 kV)	DC system (1.5 kV)
I. Ground facilities		
1. Installations		
(1) Transmission lines	Traction substations can be located with a high degree of freedom over a comparatively wide area. AC system requires a less number of traction substations than DC system, and its transmission lines cost less than DC system's. Where the capacity of the power supply is not enough, voltage unbalance and fluctuations may affect other users.	Traction substations are required to be installed within a comparatively narrow area. DC system necessitates a good number of traction substations, sending up the construction costs for its transmission lines. The construction of transmission lines may be hampered by the problems concerning environments and right-of-way depending on location.
(2) Traction substation	The construction cost for traction substation is by for lower than DC system's. 1. Usually, the spacing between traction substations can be made as long as 30 to 40 km (for BT system), 60 to 80 km (for AT system), making it possible to reduce the number of traction substations. 2. AC traction substation is simple in arrangements; its major equipment is limited to transformer, switches, etc.	The construction cost is by far higher than AC system's. 1. Usually, the spacing between traction substations is 5 to 15 km. 2. DC traction substation uses transformer, rectifier, AC and DC switches, and is somewhat complicated.

Item	AC system (60 Hz, single-phase, 25 kV)	DC system (1.5 kV)
(3) Contact wire system	The load current is small, and the conductor size can be small. The construction costs for the contact wire system are smaller than DC system.	The load current is far and away larger than AC system; the size of the feeder must be 10 times as much as that for AT system.
(4) Signalling system (track circuit)	Frequency divider and doubler or AF track circuit is needed.	AC commercial frequency track circuit can be used.
(5) Telecommunication	The nearby communication lines are seriously affected by induction interference, and it is required to install BT or AT and shield the bare conductors by employing cables.	Induction interference with communication lines is less, and there is no need of installing special equipment except for filters at traction substations.
2. System		
(1) Measures against voltage drop	The voltage drop expected to be developed when the load is increased in future can easily be compensated by installing series capacitors and voltage regulators.	It is necessary to install additional feeders, traction substations or sectioning posts.
(2) Insulation clearance	The feeder voltage is high, and the insulation clearance must be larger than DC system's. Usually, the cross section of tunnel must be made a little larger than DC system's.	The feeder voltage is low, and the insulation clearance can be small.
(3) Protection	The differences between load current and fault current in phase angle and amplitude are large, and the discrimination of them is easly. Fault point can be easily find out by fault locator.	The load current is very large, and the discrimination of load current and fault current from each other is made by detecting the current increment ΔI. For the purpose of enhancing protection reliability, interlinked breaking device, etc. are necessary, making

Item	AC system (60 Hz, single-phase, 25 kV)	DC system (1.5 kV)
		the protective system more complicated than in AC system.
(4) Electrolytic corrosion	No fear of electrolytic corrosion.	Where the rail leakage resistance is small, electrolytic corrosion due to leakage DC current might happen.
(5) Energy efficiency	The loss in the contact wire system is less, and the overall energy efficiency is a little higher than in DC system.	
3. Maintenance		
(1) Traction substation	The number of traction substations is smaller, and the facilities are simpler, making the maintenance easier.	Calls for much maintenance efforts.
(2) Contact wire facilities	The contact wire current is smaller, and the contact wire wear is less. Little or no replacement of contact wire will be needed. Because of high feeder voltage, hot-line maintenance work is difficult.	The contact wire wears away easily, and must be renewed every 5 to 10 years, sending up the maintenance costs extremely. Hot-line maintenance work is possible.
4. Others		
(1) Train operation	Usually, dead section is required. This puts the operator to some trouble because he must cut off the motor there for coasting.	No dead section is required.

Item	AC system (60 Hz, single-phase, 25 kV)	DC system (1.5 kV)
(2) Expansion work	Usually, economically done.	Costs much. In DC electrified section is expanded with AC system, AC-DC dual purpose cars are required, sending up the rolling stock costs. AC traction substation cannot feed DC section, and vice versa. Thus, traction substations located at the AC-DC junction point must be reinforced.
(3) Trackage-right operation	If a subway of DC system is to be used, AC-DC dual purpose cars are necessary.	Trackage-right operation is easy if both systems have the same feeder voltage.
II. Rolling stock		
1. Facilities		
(1) Transformer and converter	Transformer and rectifier are to be carried on board a car. The car carrying these is several tons heavier.	
(2) Auxiliaries	Simple, sturdy induction motor can be employed. The power supply facility for fluorescent lights and air conditioner is simple.	Complicated DC motor is necessary. Motor-generator set is necessary for controls, fluorescent lights, and air conditioner.

Item	AC system (60 Hz, single-phase, 25 kV)	DC system (1.5 kV)
2. System		
(1) Speed control	Speed can easily be controlled by changing transformer tap position or by phase-controlled thyristor.	In the case of rheostatic control car, the speed is controlled by adjusting resistors and changing the motor connections. This scheme is somewhat complicated. Starting power consumption is much.
3. Maintenance	Transformer and rectifier are static equipment, and their maintenance calls for not so much labor.	Maintenance is easy.
4. Rolling stock cost	AC car is 10 to 20% higher in cost than DC car.	Not expensive.

5-3 Master Plan for AC Electrification

The single-phase AC commercial frequency system is classified in many feeding systems. Of them, the most typical feeding systems are illustrated in Fig. 5-5. PNR's railways are running through the centers of major cities, and the simple feeding system (Fig. A), the simplest and cheapest of all, cannot be applied because of no measures against induction interference with telecommunication lines.
The AT system (auto transformer system) (Fig. B) in which JNR has much experience and the BT system (booster transformer system) (Fig. C) are provided with measures against induction interference.
Of these two, the AT system is better because it is high in reliability and easy in maintenance.

Fig. 5-6 shows an AT power feeding system, and Fig. 5-7 the location of traction substations for it.

FIG. 5-5 TYPICAL FEEDING SYSTEM OF A.C. ELECTIFICATION

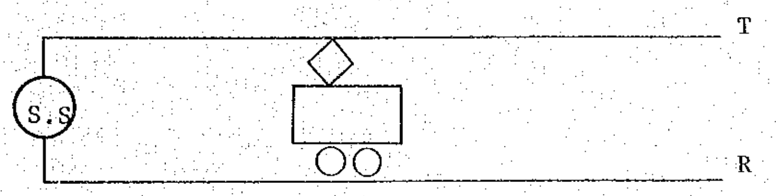


FIG. A SIMPLE FEEDING SYSTEM

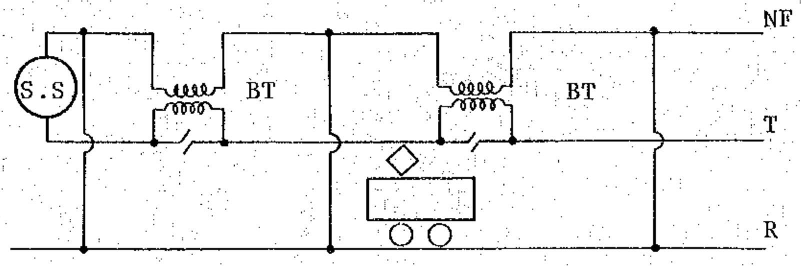


FIG. C BT FEEDING SYSTEM

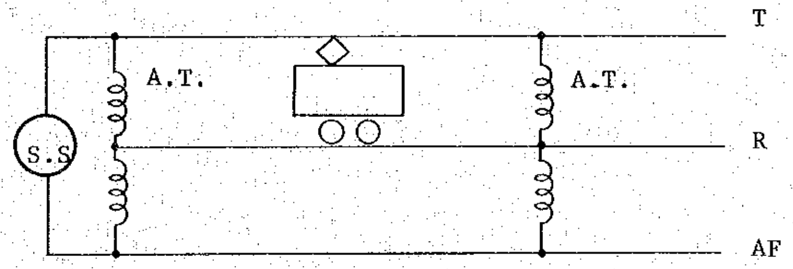


FIG. B A.T. FEEDING SYSTEM

LEGEND

S.S.	TRACTION SUBSTATION
A.T.	AUTO TRANSFORMER
B.T.	BOOSTER TRANSFORMER
T	CONTACT WIRE
R	RAIL
A.F.	AT FEEDER
N.F.	NEGATIVE FEEDER

FIG. 5-6 ELECTRIC POWER FEEDING SYSTEM (AC. SYSTEM)

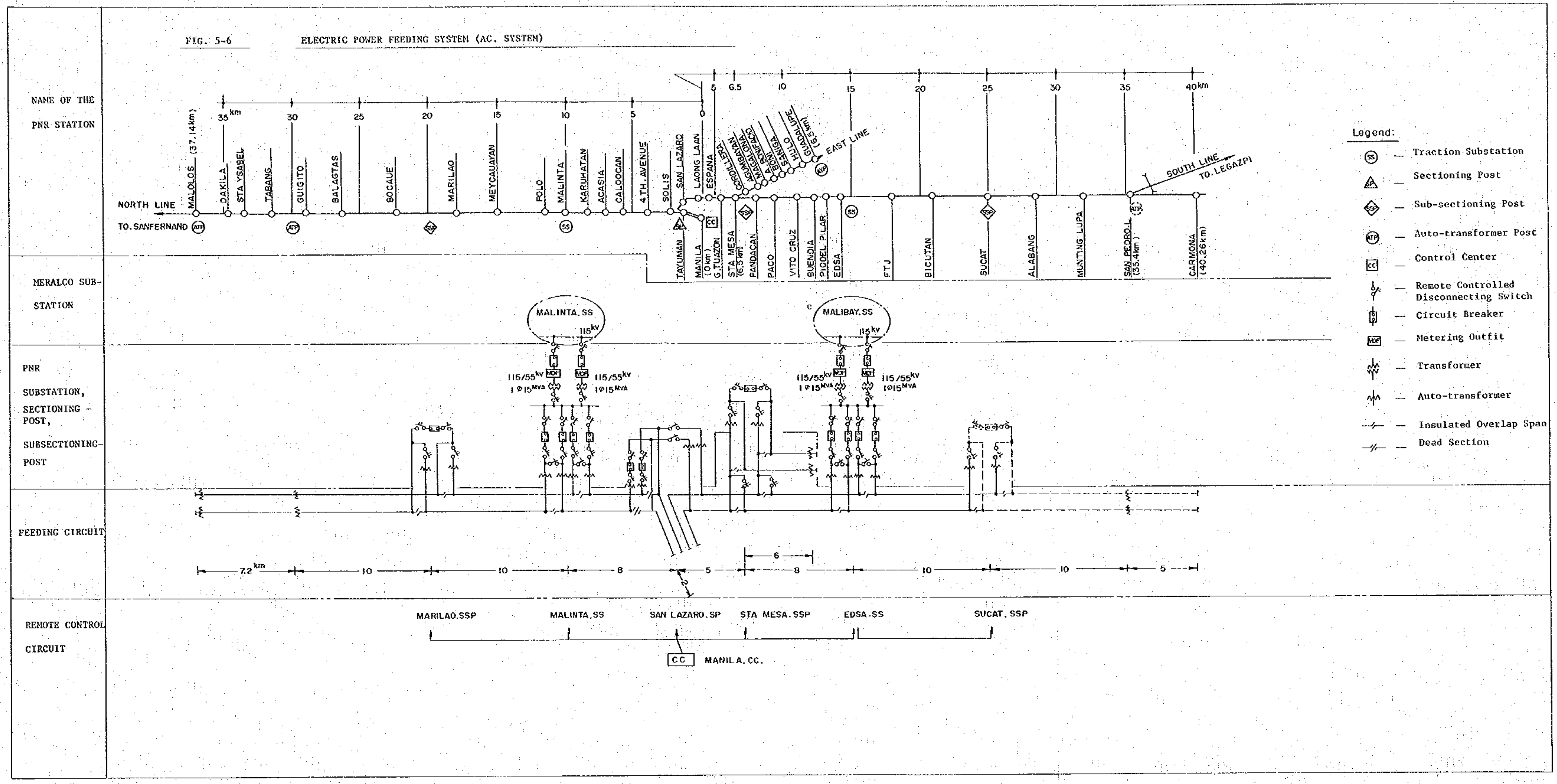
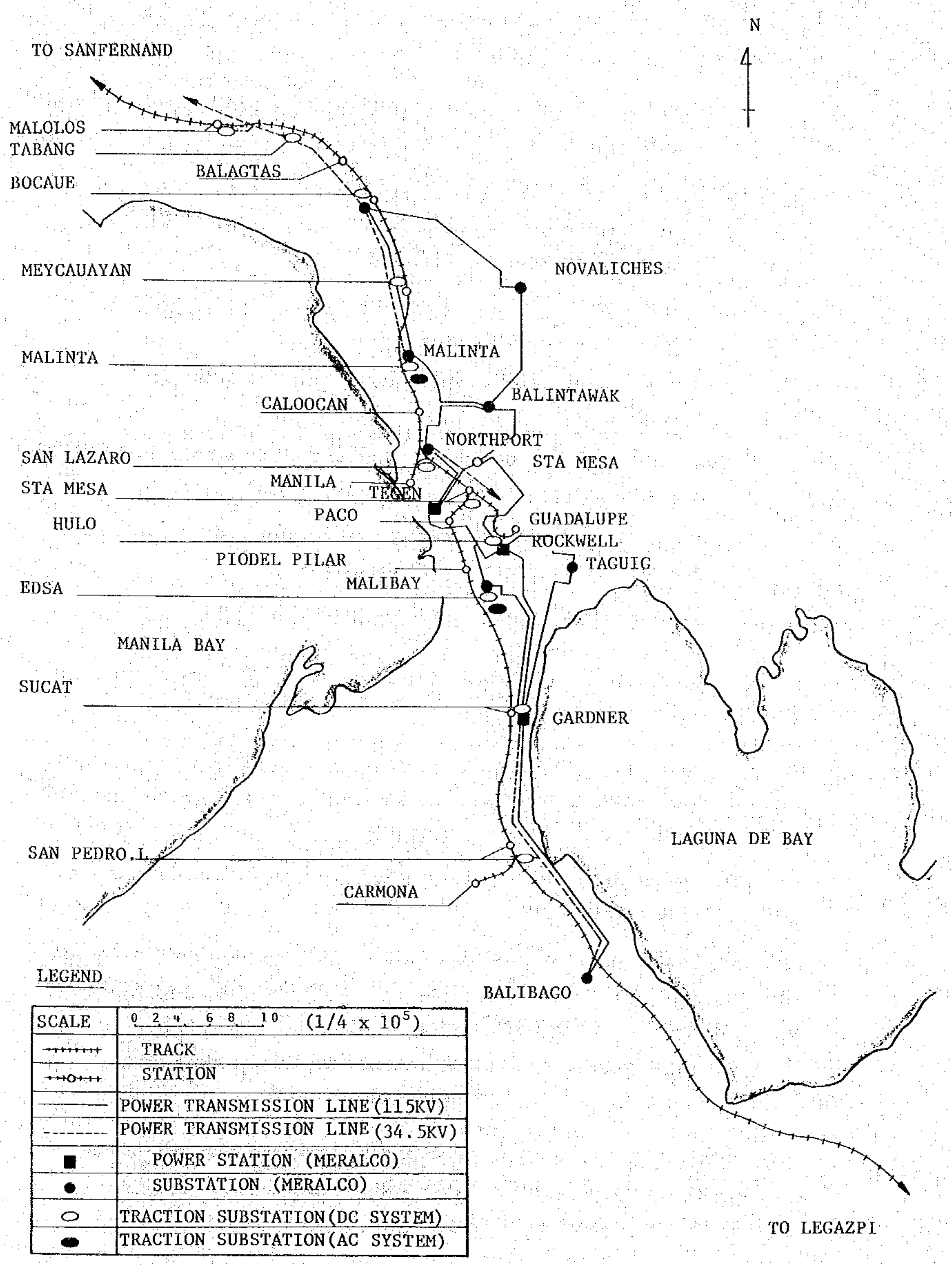


FIG. 5-7 LOCATION OF TRACTION SUBSTATION



5-3-1 Concepts of power feeding system, and location of traction substations

What must be reckoned with in planning a power feeding system and its facilities includes these:

(1) Ability to supply high-quality electricity in a reliable way (i.e., electricity of stabilized voltage and of least vulnerable to blackout failure).

(2) Protection of general users from evil effects resulting from railway electrification.

(3) Protection of telecommunication lines from induction interference.

(4) Ability to instantaneously interrupt power supply to defective circuits subjected to, for example, ground fault.

(5) Protection of electric railway facilities from vital damage due to natural hazards such as storms.

(6) Easy maintenance and inexpensive construction.

As regards items (1) through (3) above, the following measures are available.

(1) Installation of two substations so as to make it possible to keep power supply from one substation when the other gets out of order.

(2) Installation of two transformers per substation with one as a standby.

(3) Minimization of such troubles as voltage unbalance and fluctuations by receiving power from MERALCO's 115 kV busbar which has a big fault level.

(4) Installation of auto transformers at an interval of not exceeding 10 km.

Installation of traction substations somewhere near MERALCO's Malinta, Northport and Malibay substations shown in Fig. 5-3 was put to comparison studies. The findings are as follows.

Northport is located near Manila Station and at the center of the railway loads, but is rejected because it is short from other substations, because it will have to feed over some 40 km if electrification covers up to Carmona in future, and also because the substation premises are narrow yet complicated. For this reason, Malinta and Malibay are recommended. In this case, the lowest normal voltage for the train operation diagram in 2000 is 22.5 kV, and the lowest emergency voltage when one substation is in failure is 20.8 kV or above 19 kV necessary for train operation. Thus, this arrangement is acceptable.

A sectioning post (SP) is required to be installed on the north of Tayuman "Y" in order to divide electric power between the two substations unless in case of emergency. This is because the power systems in the premises of Manila yard should at any rate be unified, the power systems for the South and the North Line should preferably be separated from each other.

It is also required to install subsectioning posts (SSP) for the purpose of minimizing operation troubles by localizing and rejecting faulty points.

The auto transformers should be installed for SS, SP, SSP and ATP at a spacing of not more than 10 km in order to provide against induction interference with telecommunication lines. Malinta and Malibay substations should each have 2 units of 15 MVA transformer, and each of the auto transformers should be rated at 2.5 MVA.

5-3-2 System of power supply from MERALCO to traction substations

What should be borne in mind in planning the traction substations is the fact that the 115 kV single-phase power received from MERALCO substations is to be stepped down to 55 kV through single-phase transformers. MERALCO is seriously concerned about the evil effects of single-phase power reception. But the following explanation made in reference to a comparison between single-phase and three-phase power reception will demonstrate that MERALCO is meeting trouble halfway. Table 5-2 shows a comparison between single-phase reception and three-phase reception.

Table 5-2 Single-phase reception vs. three-phase reception

Item	Single-phase reception	Three-phase reception
Transmission line	Two wires alone are necessary if ground wire is counted out. Construction costs less than three-phase transmission line.	Three wires are required if ground wire is counted out.
Traction substation	Because of single-phase equipment, the construction cost is low, and maintenance is easy.	Because of three-phase equipment, the construction cost is high, and maintenance is complicated. (Transformer is required to be of the three-phase to two-phase conversion type like Scott-connected one.)
Voltage unbalance factor	Greater than in three-phase reception. So far as PNR is concerned, the voltage unbalance factor can be limited to within 1%, and there will be no problem.	Smaller than in single-phase reception.
Number of dead sections	Where a pair of traction substations are used, the number of dead sections is one. For the train operation, the smaller the number of dead sections, the better.	In the case of a pair of traction substations, the number of dead sections is three.

As is clear from the table, the single-phase reception is cheaper because single-phase transmission lines and single-phase equipment can be used to simplify the system arrangements. From the viewpoint of train operation, the single-phase reception scheme dispenses with a dead section at the substation when the three-phase scheme necessitates it as two-phase voltages stepped down are different in phase angle by 90°. Namely, the train operator is relieved of otherwise taking trouble to cut off the motor and coast clear of the dead section.

The voltage unbalance factor is defined as follows, and its tolerance limit is usually set at less than 3%.

In the case of single-phase transformer:-

$$K = \frac{P}{P_S} \times 100\ (\%)$$

In the case of T-connected transformer:-

$$K = \frac{P_A \sim P_B}{P_S} \times 100\ (\%)$$

Where, K: voltage unbalance factor, %

P_S: short circuit capacity at receiving point, kVA

P_A, P_B: 2-hr. mean load of teaser, kVA

P: 2-hr. mean load of single-phase transformer, kVA

According to MERALCO, Malinta and Malibay substations currently have a P_S of about $1{,}926 \times 10^3$ kVA and $4{,}002 \times 10^3$ kVA, respectively. As discussed later, these substations are expected to have, in 1987, a one-hour maximum mean load under normal operating conditions of about 6,900 kVA and 9,200 kVA, respectively. (The two-hour mean load is a little smaller than the one-hour maximum mean load.) This means that these substations will have a voltage unbalance factor of respectively 0.36% and 0.23% in 1987. Even in a poor condition that one traction substation has to feed the entire railway load when the other is in failure, the voltage unbalance factor will remain as little as 0.84% for Malinta and less than 0.4% for Malibay, by far less than the limit 3%.

The single-phase reception system is a standard practice for AC railway electrification chiefly in Europe. In Japan, AC railway electrification was made when the electric supply system was not strong, and three-phase-to-two-phase transformers like Scott-connected ones are still used except for specific sections.

The on-off control of the circuit breakers and disconnecting switches located at SS, SP and SSP should be carried out from the control center to be installed at Manila Station.

5-3-3 Electric power necessary for railway electrification

Table 5-3 shows the power and energy required to be delivered by Malinta and Malibay substations in 1987 and 2000.

Table 5-3 Electric power and energy necessary for railway electrification

Name of substation	Power (kW)		Electric energy (10^6 kWh)	
	1987	2000	1987	2000
Malinta	5,500	10,100	22	36
Malibay	7,400	13,000	46	76

5-3-4 Overhead contact wire facilities

The electric power from traction substations is supplied to the cars through overhead contact wire facilities consisting of contact wires, supporting structures, insulators, etc.

1. Requisites to overhead contact wire facilities

The overhead contact wire facilities should satisfy the following requirements.

(1) to have an ample electrical strength to satisfactorily accommodate high-speed large-capacity moving loads.

(2) to be least susceptible to electrical faults, such as contact wire breakdown, and to be high in reliability.

(3) to cause little or no chattering between contact wire and pantograph.

(4) to have an ample mechanical strength to stand against temperature changes and such external forces as winds.

(5) to be easy in maintenance and low in maintenance cost.

(6) not to hamper the field of vision of the train.

2. System of overhead contact wire

At present, many kinds of overhead contact wire systems have been employed in the world. For PNR, the two systems illustrated in Fig. 5-8 are recommended.

o Main lines ..... Simple catenary suspension system

This system is suitable for high-speed transit service of not exceeding 100 km/hr., and is easy and inexpensive in maintenance and construction because of its simple structure.

o Lines within car depot ..... Direct suspension system

This system is suitable for low-speed operation of not exceeding 45 km/hr., and its construction cost is less because of its simple structure.

FIG. 5-8 CATENARY SYSTEM

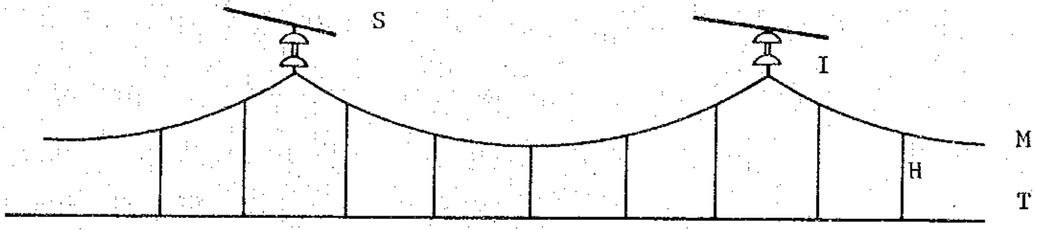


FIG. A SIMPLE CATENARY SUSPENSION SYSTEM

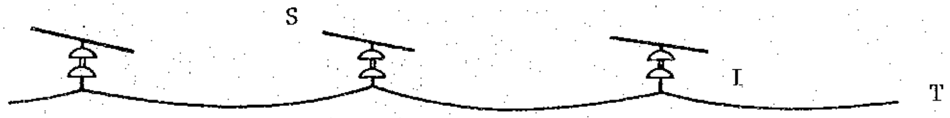


FIG. B DIRECT SUSPENSION SYSTEM

LEGEND

M:	MESSENGER WIRE
T:	CONTACT WIRE
H:	HANGER
I:	INSULATOR
S:	SUPPORTING STRUCTURE

3. Arrangement of overhead contact wire facilities, and standard structure

The major components of overhead contact wire system and their standard structure are shown in Fig. 5-9 for two-track sections and Fig. 5-10 for the Manila-Tayuman "Y" four-track section.

The wires, their functions, materials and sizes are as follows, provided that the materials and sizes should be determined upon further studies and investigations.

AT feeder (AF)

This is a wire to feed electric power to the contact wire. Its maximum to-the-ground voltage is 27.5 kV. The voltage between the AT feeder and contact wire is 55 kV. The AT feeder is made of aluminum, and has a cross-sectional area of 95 mm^2.

Contact wire (T)

This is a wire for feeding electric power to the cars. The car takes in electric power by bringing its pantograph against the contact wire. The to-the-ground voltage of the contact wire is 27.5 kV. The contact wire is a copper conductor with a cross-sectional area of 110 mm^2.

Messenger wire (M)

This suspends the contact wire. It is made of steel and has a size of 90 mm^2.

Protective wire (PW)

This establishes a metallic circuit in the case of a ground fault as developed by a flashover fault of insulators for the purpose of ensuring ground fault detection by a relay. It is connected to the rail at an interval of several kilometers. The protective wire is made of ACSR and has a size of 40 mm^2.

Ground wire (GW)

The ground wire is installed for the purpose of protecting the contact wire system from lightning fault. It is made of steel and has a size of 55 mm^2.

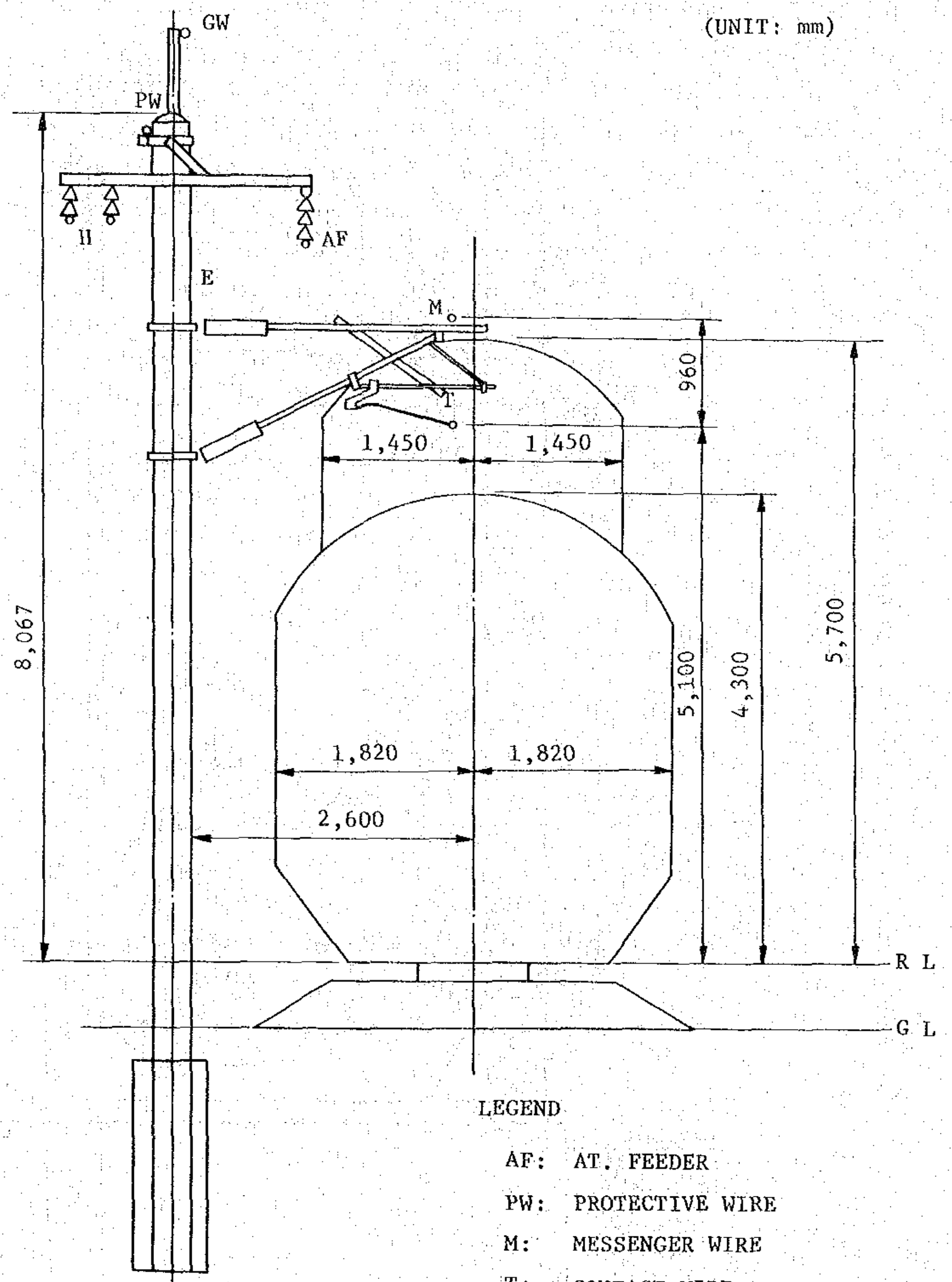
Power distribution line for signal (H)

Where the power distribution line is not available, this line is installed for the power distribution line of signal.

The heights of contact wire and others shown in Figs. 5-9 and 5-10 are standard values. The contact wire and messenger wire may have a minimum height of 4,550 mm and 4,900 mm respectively depending on location. Accordingly, the overbridges of 5,000 mm high which are seen in Sta Mesa, Malinta, etc. do not affect the contact wire system at all.

Fig. 5-9 STANDARD STRUCTURE BETWEEN STATION
(AC A.T. SYSTEM)

(UNIT: mm)



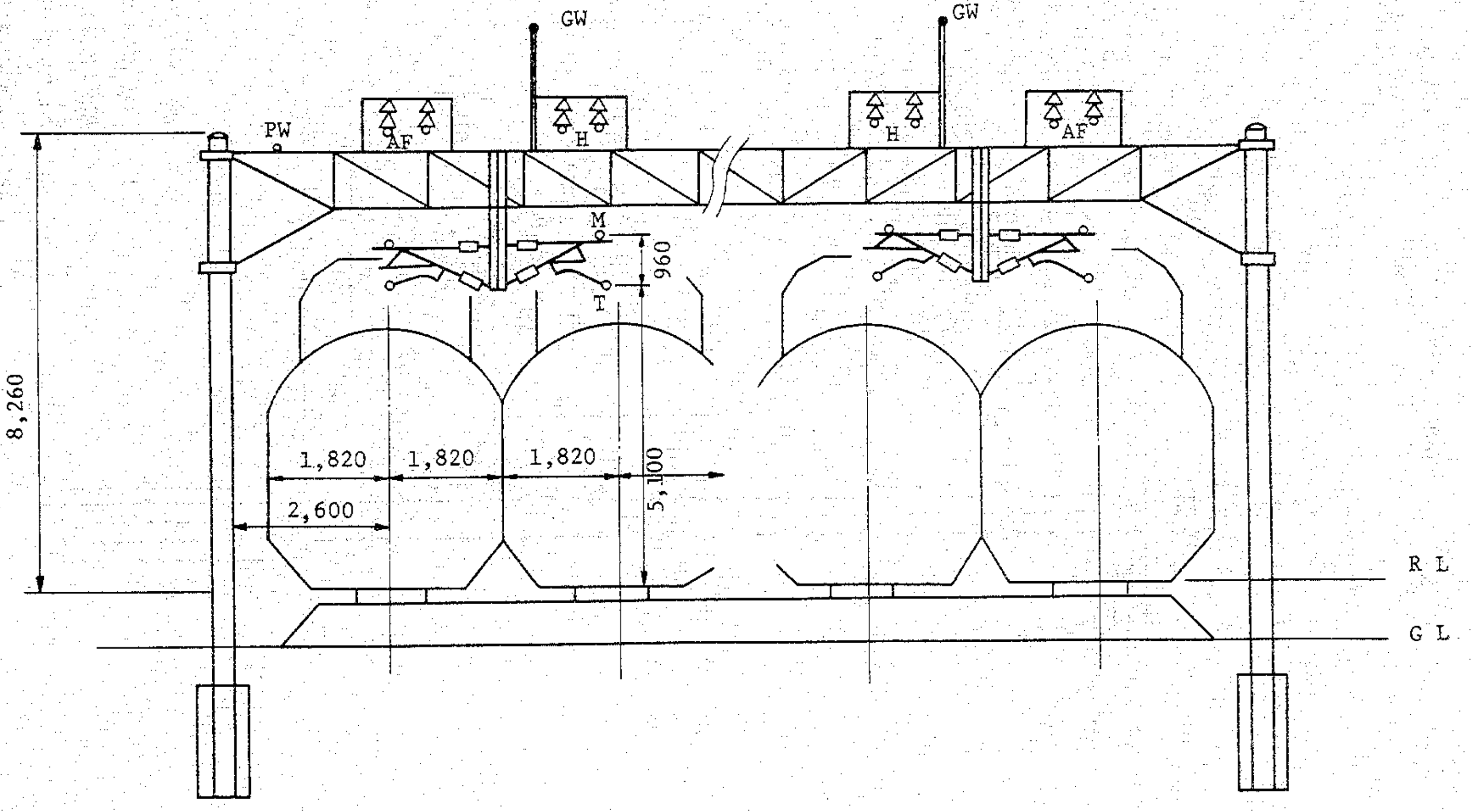
LEGEND

AF: AT. FEEDER
PW: PROTECTIVE WIRE
M: MESSENGER WIRE
T: CONTACT WIRE
GW: GROUND WIRE
E: EARTH LEADING WIRE
H: POWER DISTRIBUTION LINE FOR SIGNAL

Fig. 5-10 STANDARD STRUCTURE IN 4 TRACKS SECTION BETWEEN STATION

(AC, AT SYSTEM)

(UNIT: mm)



4. Supporting structures for the contact wire system

Concrete poles, steel poles and wooden poles are available as supporting structures of the contact wire system.
Except for specific parts of the four-track section, it is recommended to employ concrete poles. The concrete poles can serve almost permanently, dispense with maintenance because they are passivated against corrosion, and their costs of construction are less than steel poles'.
The beam for supporting the messenger wire and contact wire is available in the following types.

Steel fixed beam, Span catenary wire beam, Hinged cantilever beam (shown in standard structure)

The hinged cantilever beam has its fulcrum moving in the lengthwise direction of the contact wire to absorb the expansion and contraction of contact wire with temperature changes, and also facilitates maintenance work.
Thus, it is recommended to use this beam for ordinary sections and the fixed beam for station premises and the like where a good number of overhead wires are to be supported.

5. Tension adjust device

The catenary expands and contracts under the influence of ambient temperature changes, load changes and secular creep elongation. But for the purpose of ensuring good current collecting performance, the catenary tension must be kept, as far as possible, at a constant value. To this end, the wheel tension balancer is installed.

5-4 Master Plan for DC Railway Electrification

The voltage of the contact wire system used in the DC electrification of rapid mass transit railway is mostly either 1,500 V or 3,000 V. The 1,500 V system in which JNR and other major railway companies have much experience is studied for the electrification of PNR commuter service. Fig. 5-11 shows a feeding system, and Fig. 5-7 the location of traction substations.

5-4-1 Concepts of feeding system, and location of traction substations

What must be considered first in the planning of the feeding system and other facilities is just the same as with AC electrification. To put it more concretely, the following must be taken into account for the planning of the DC feeding system.

(1) The DC traction substation is far less in unit capacity than the AC one, is a three-phase load, and thus should be served from a 34.5 kV transmission system.

(2) The traction substation should be fed from the 34.5 kV bus line where MERALCO's substation is available or is served direct from the transmission line if not available.

(3) Adjacent DC traction substations should be run in parallel.

(4) Each DC traction substation should be provided with a filter for the purpose of preventing induction interference with the communication lines.

The location of the DC traction substations should be determined after due consideration of the following.

(1) The minimum allowable supply voltage to the cars is 900 V. The running speed of the cars is nearly proportional to the supply voltage, and the supply voltage should be kept more than 1,100 V so far as the punctuality is a must as on a commuter line. If one traction substation gets out of order, its adjacent substation should back up it. In this case, a minimum voltage of 900 V may be permitted exceptionally.

(2) The traction substations should be located near MERALCO's substations.

(3) The dead-end traction substation should be located at such a place that will permit oneway feeding.

(4) The dead-end traction substation should be installed with two units of silicon rectifier with one as a standby for the purpose of increasing its operating reliability. This engineering consideration is necessary because if the dead-end substation is plunged into a total failure, the section it has covered will no longer be assured of a normal voltage even with the extended feeding by the adjacent substation.

The considerations above lead to the installation of ten traction substations for the Malolos-Sucat section as illustrated in Fig. 5-7. For the electrification of the line from Sucat all the way to Carmona, it is only necessary to install an additional DC traction substation at San Pedro L.

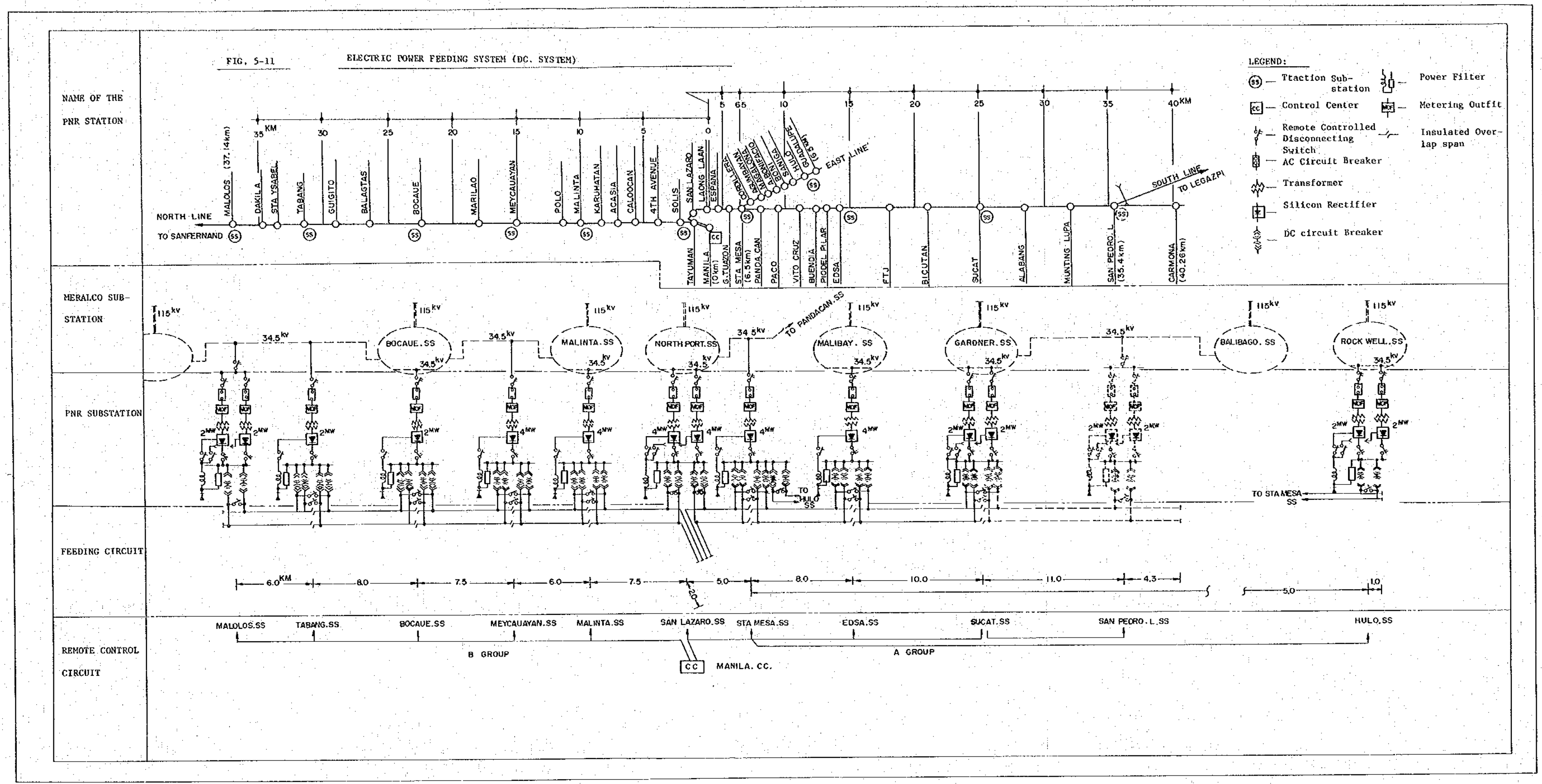
5-4-2 System of power reception of DC traction substations

The DC traction substation is smaller in unit capacity than the AC one, and is able to receive three-phase power. Namely, it does away with such a powerful line as 115 kV system indispensable for AC traction system. It can be served direct from the 34.5 kV system without developing voltage unbalance or fluctuation that may sacrifice the general consumers. The major equipment to be installed at the DC traction substation includes silicon rectifier, transformer, DC breaker, AC breaker, disconnecting switch, switchboard, control apparatus and so on.

The capacity of the silicon rectifier varies depending on substation. The larger substation will use a silicon rectifier set of 4 MW, while the smaller substation will be rated at 2 MW per set.

All these traction substations will be remote controlled from the control center to be located at Manila Station.

FIG. 5-11 ELECTRIC POWER FEEDING SYSTEM (DC. SYSTEM)



5-4-3 Contact wire system

Given here are the disparities of DC contact wire system from the AC counterpart.

The major components of which the contact wire system are composed and standard structure are illustrated in Fig. 5-12 for the two-track sections and in Fig. 5-13 for the four-track sections. The nomenclatures, functions, materials and sizes of wires are as follows.

Feeder (F)

This is a wire for feeding electric power to the contact wire. Its to-the-ground voltage is 1,500 V. It is made of two aluminum conductors of 510 mm^2.

Contact wire (T)

The contact wire is connected to the feeder at an interval of 250 m. It is made of copper, and has a size of 110 mm^2.

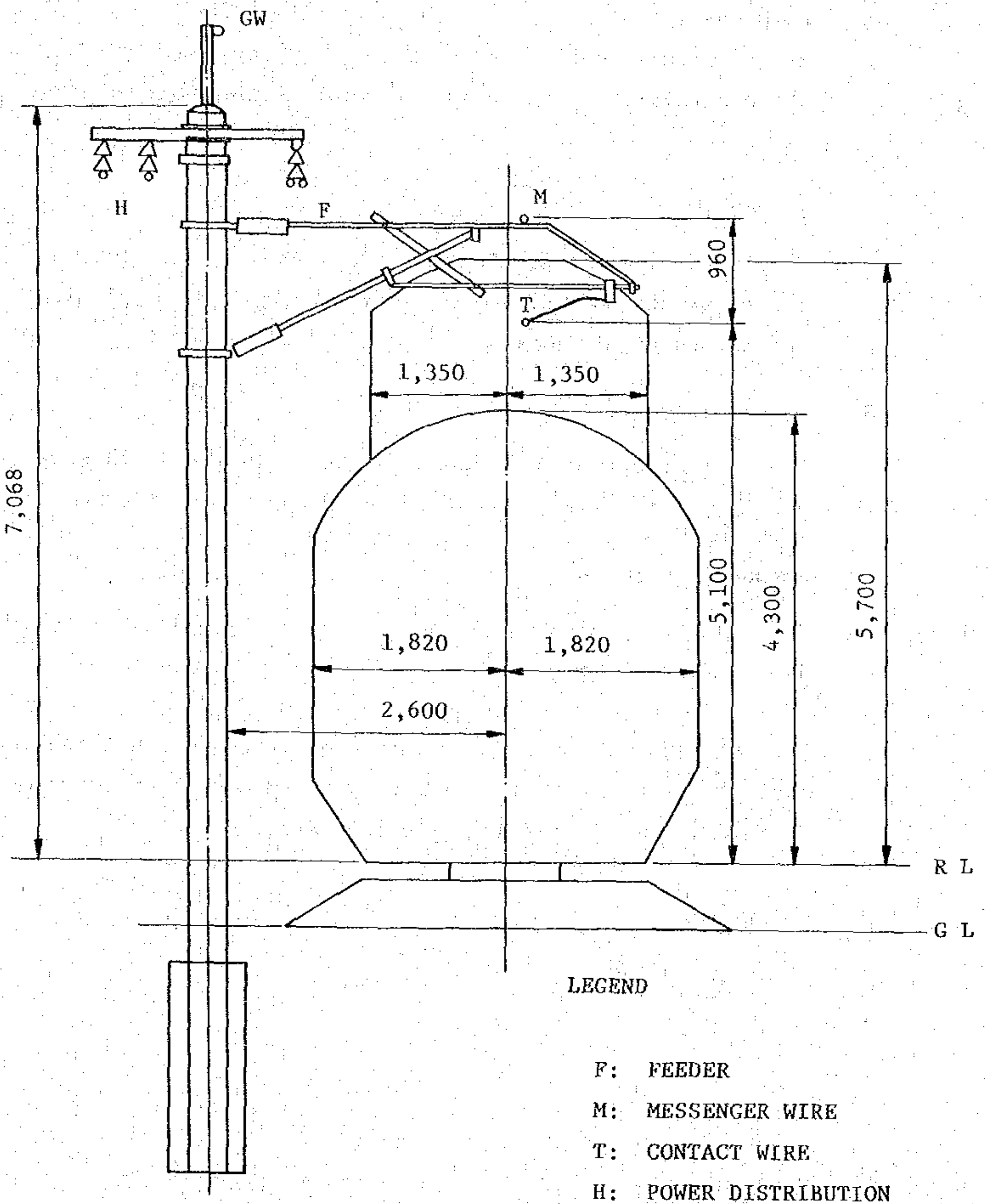
Messenger wire (M)

This wire suspends the contact wire, and is made of steel. Its size is 90 mm^2.

The heights of contact wire and others are just the same as with the AC system. The contact wire supporting structures and tension adjust device are also the same.

Fig. 5-12 STANDARD STRUCTURE BETWEN STATION
(D. C. SYSTEM)

(UNIT: mm)

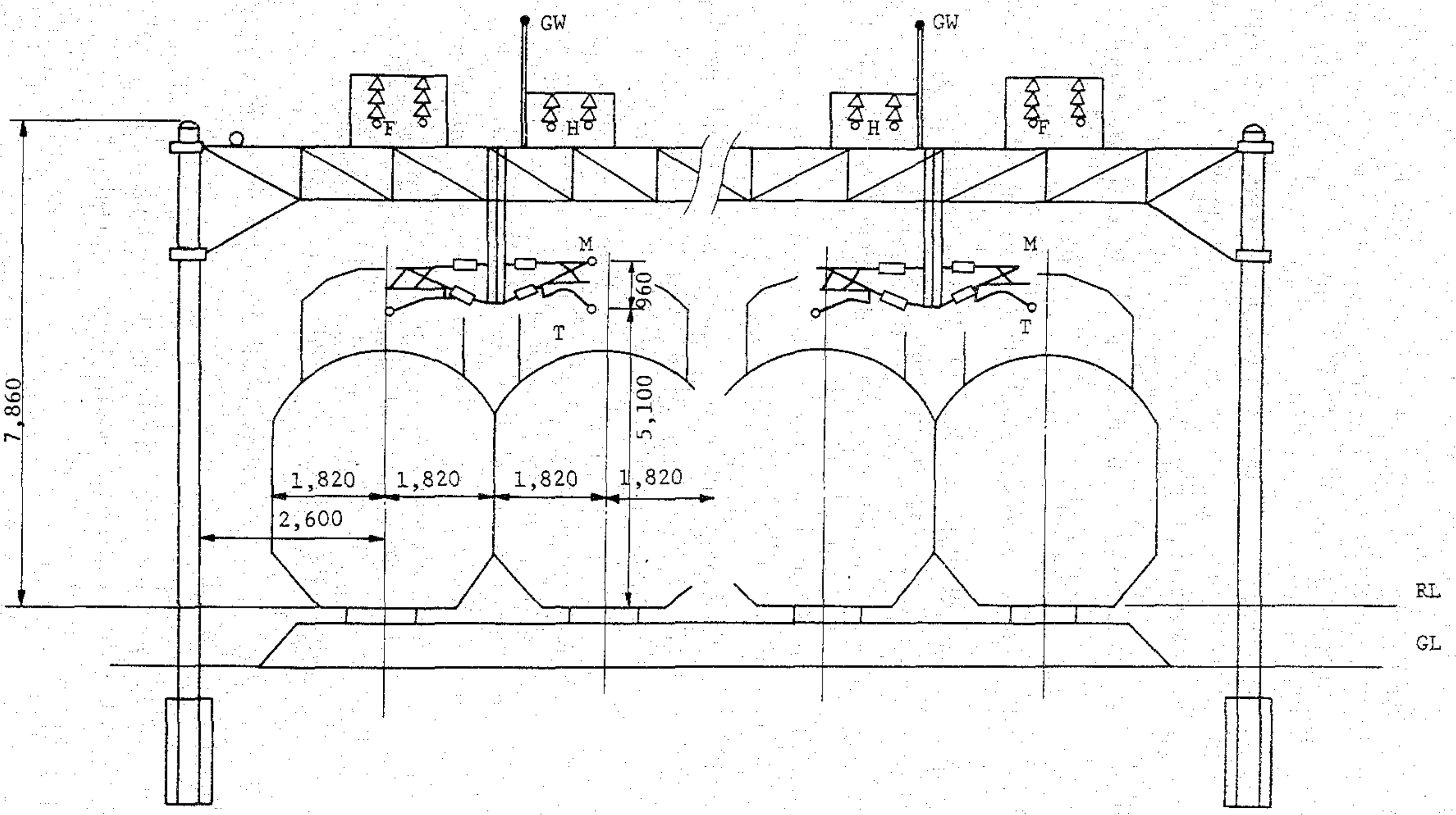


LEGEND

F: FEEDER
M: MESSENGER WIRE
T: CONTACT WIRE
H: POWER DISTRIBUTION
LINE FOR SIGNAL
GW: GROUND WIRE

Fig. 5-13 STANDARD STRUCTURE IN 4 TRACKS SECTION BETWEEN STATION

(D.C.SYSTEM) (UNIT: mm)



6. Rough Estimate of Construction Costs

6-1 Presuppositions

1. The costs for electrification work are to be calculated for each section (Manila-Sucat; Sta Mesa-Guadarupe; Manila-Meycauayan; Meycauayan-Malolos).

2. The construction costs are to be calculated for both AC and DC electrification.

3. The construction costs to be calculated are as follows.

   o Costs of ground facilities for electrification (substations, overhead contact wire system, etc.)

   o Costs for improvement of signalling and telecommunication facilities

   o Rolling stock costs

4. The materials and supplies available in the Philippines will be made the best use of, provided that the electrical machines and appliances will be imported.

5. All the construction work will be undertaken by local labor.

6. The prices of imports are in terms of CIF, Manila Port, and do not include the charges for unloading, warehousing, transport and cargo handling, provided that the prices for rolling stock are in terms of FOB, Japan.

7. Import duties are excluded.

8. The costs for substation lots and rights-of-way are not included.

9. The costs for improving the existing signal facilities between Caloocan-Bictan section are included.

10. In the case of AC electrification, the costs for cabling the unshielded overhead telecommunication lines along the railways are included.

11. The escalation of commodity prices in future is not taken into account.

12. The exchange rates are set as follows.

    1 US$ = 7.25 ₱, 1 ₱ = 33 ¥

6-2 Construction Costs

The costs of ground facilities for electrification calculated according to the conditions set forth in para. 6-1 are as listed in Table 6-1.

The costs of ground facilities necessary for electrification between the Malolos-Sucat section are estimated to amount to about 126 × 10^6 ₱ (of which about 105 × 10^6 ₱ by foreign currency) for the AC scheme and about 139 × 10^6 ₱ (of which about 112 × 10^6 ₱ by foreign currency) for the DC scheme, showing that the AC electrification costs a little less than the DC electrification.

For the DC electrification of the Manila-Sucat section (Step 1), some 60 × 10^6 ₱ will be required.

6-3 Costs for Rolling Stock

Assuming that the number of cars required in 2000 is 300, the costs for them will amount to about 830 × 10^6 ₱ for AC electrification and 760 × 10^6 ₱ for DC electrification.

Table 6-1 Rough estimate of electification work

(in 10^3 ₱)

Section / Work	AC electrification (AT system)					DC electrification				
	Manila ≀ Sucat	Sta Mesa ≀ Guada-lupe	Manila ≀ Meycau-ayan	Mey-cauayan ≀ Malolos	Total	Manila ≀ Sucat	Sta Mesa ≀ Guada-lupe	Manila ≀ Meycau-ayan	Mey-cauayan ≀ Malolos	Total
Substation	24,200	3,600	21,300	7,600	56,700	29,200	7,500	13,100	19,500	69,300
Contact wire system	23,500	4,600	11,400	17,900	57,400	26,700	5,300	12,900	20,400	65,300
Signalling	5,200	0	600	0	5,800	4,200	0	500	0	4,700
Communications	1,900	500	1,300	1,900	5,600	0	0	0	0	0
Total	54,800	8,700	34,600	27,400	125,500	60,100	12,800	26,500	39,900	139,300

Note: The foreign currey portion in the estimate above is as follows.

AC electrification .... 105,100 (10^3₱)

DC electrification .... 112,300 (10^3₱)

7. Investigations and Studies to be made before Electrification

The problems PNR is now facing are the easing of traffic congestion in Metro Manila and the improvement in transport services required in the immediate future.

PNR should therefore improve the existing track facilities and operating plans for increasing the transport capacity. The electrification is only a part of the processes to realize the reinforcement of transport capacity in an economical manner, and the following programs should be pushed forward concurrently.

1. Double-tracking work.
2. Improvement of car depot, storage tracks and station facilities.
3. Extension of platforms.
4. Grade separation.
5. Repair and upgrading of tracks.
6. Improvement of bridges and other elevated structures.
7. Improvement of signalling and communication facilities.
8. Modernization of track maintenance work.
9. Technical education and training.

To promote these problems, the following studies and investigations will be conducted from the technical point of view.

(1) Studies and investigations about the double-tracking facilities and station facilities for increasing commuter train services on the North and East Lines, procedure for double-tracking and station improvement, etc.

(2) Traffic engineer-assisted studies and investigations about the grade separation work necessary for increasing commuter train services.

(3) In-depth technical studies and investigations about the improvement of Manils Station facilities for the purpose of increasing commuter train services, along with cargo transport plans.

(4) Studies and investigations about the maintenance strategies and maintenance depot setup for commuter trains.

(5) In-depth technical studies and investigations about the track and rolling stock maintenance standards and the tooling for periodic track maintenance work for the purpose of preventing derailment troubles in the commuting sections.

(6) Technical education and training for the purpose of enhancing the state of art in the maintenance of tracks and electrical facilities.

In additiona, the following should also be studied for improving the transport services.

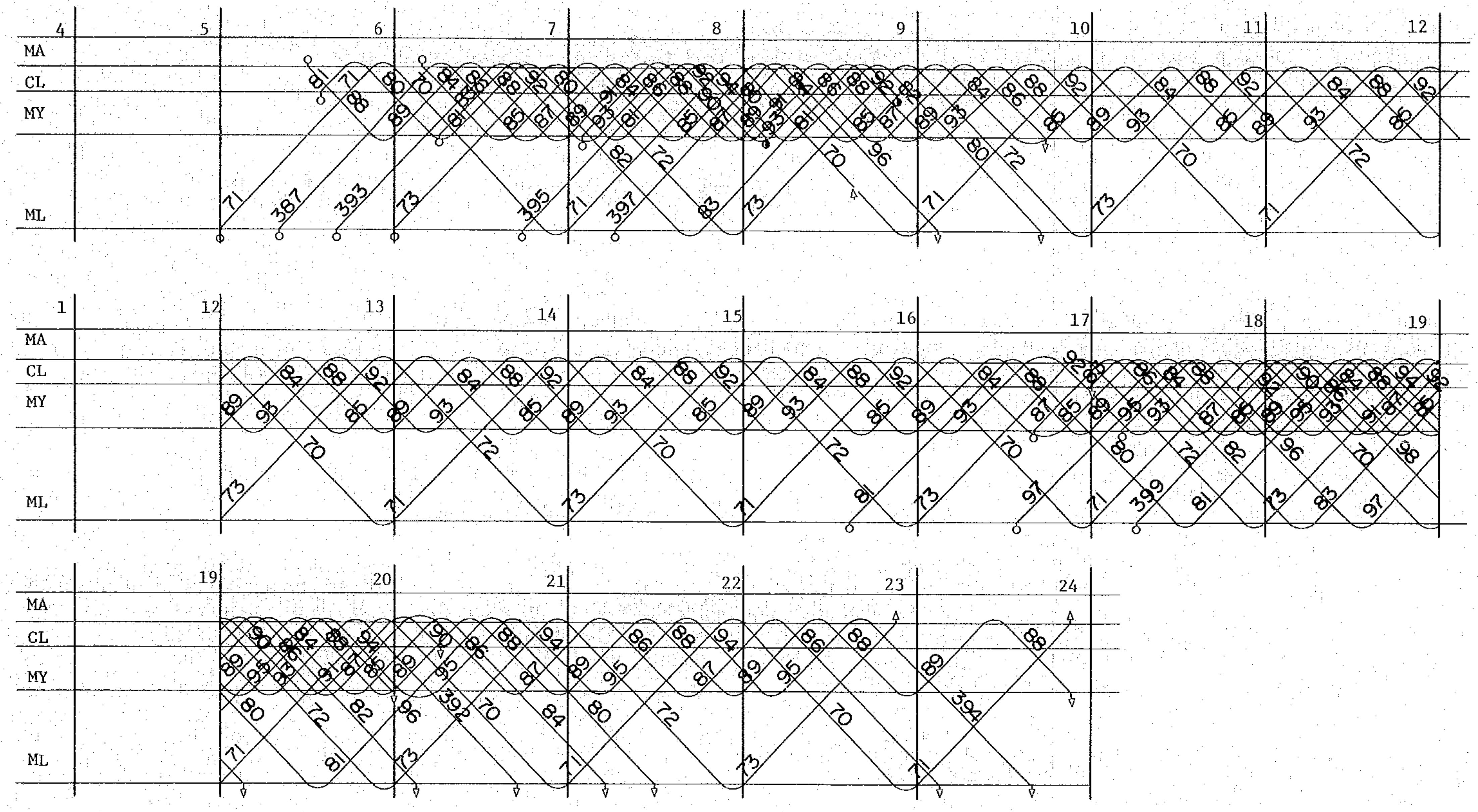
(1) Efficient ticket vending system and barrier system.

At present, ticket clipping and collection is carried out manually, and should be replaced with an efficient system with increase in the number of passengers.

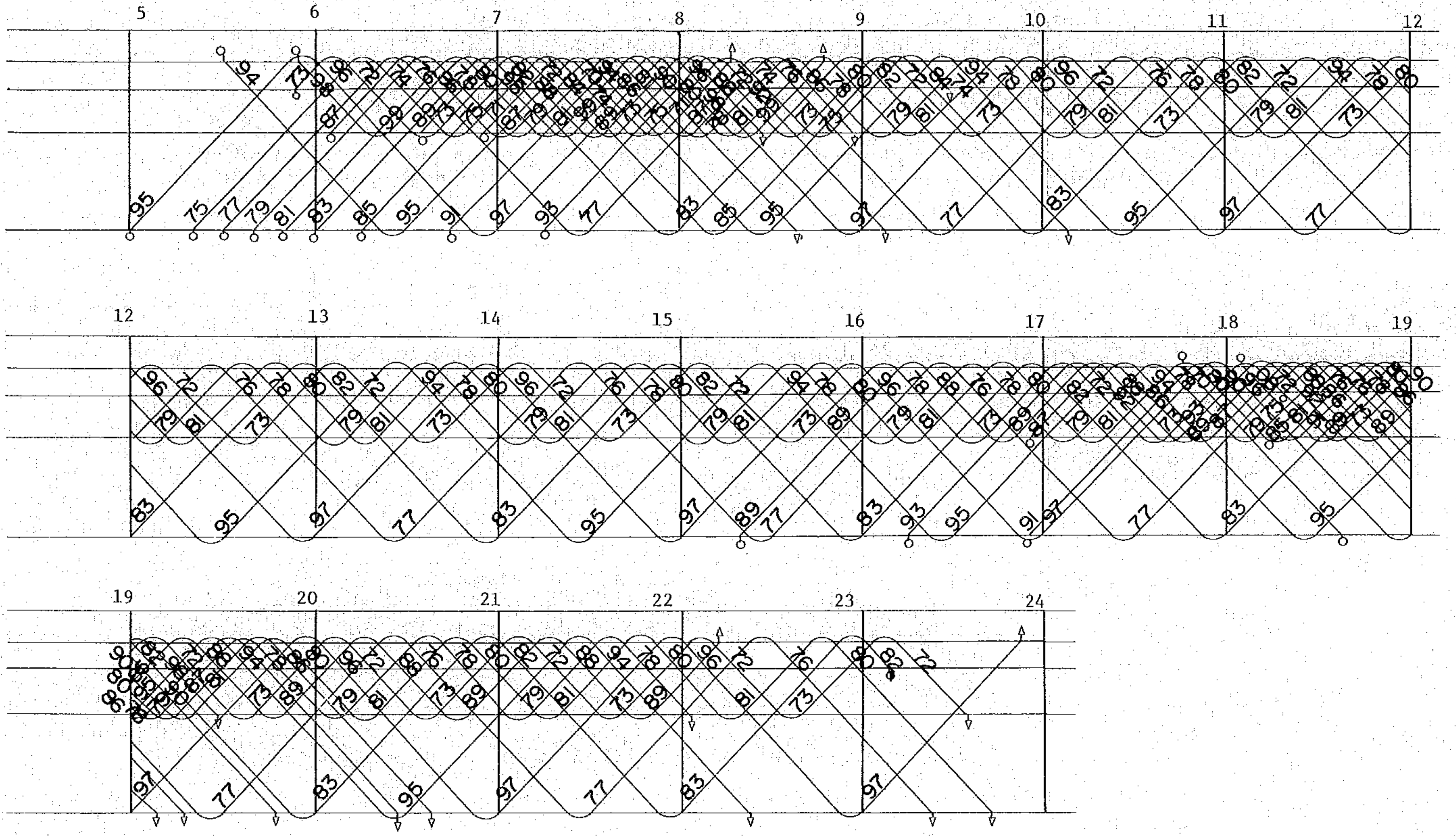
(2) Improved information service.

At present, the passengers are informed of train services by announcement and time table. The directional signs, markings and other types of information about train services to be carried by trains or installed on the platforms should be improved.

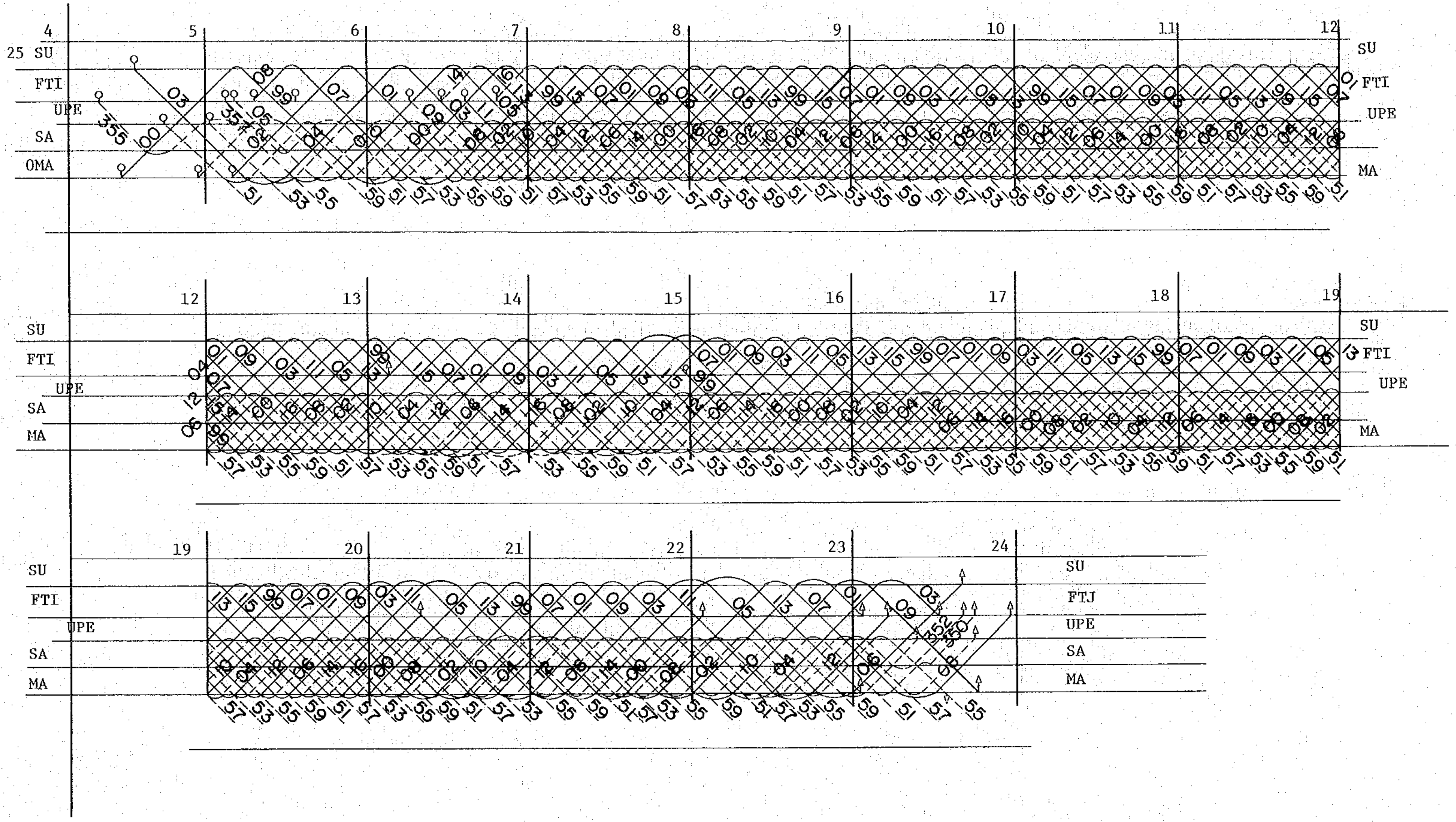
Tentative train operating diagram of north line (1987)



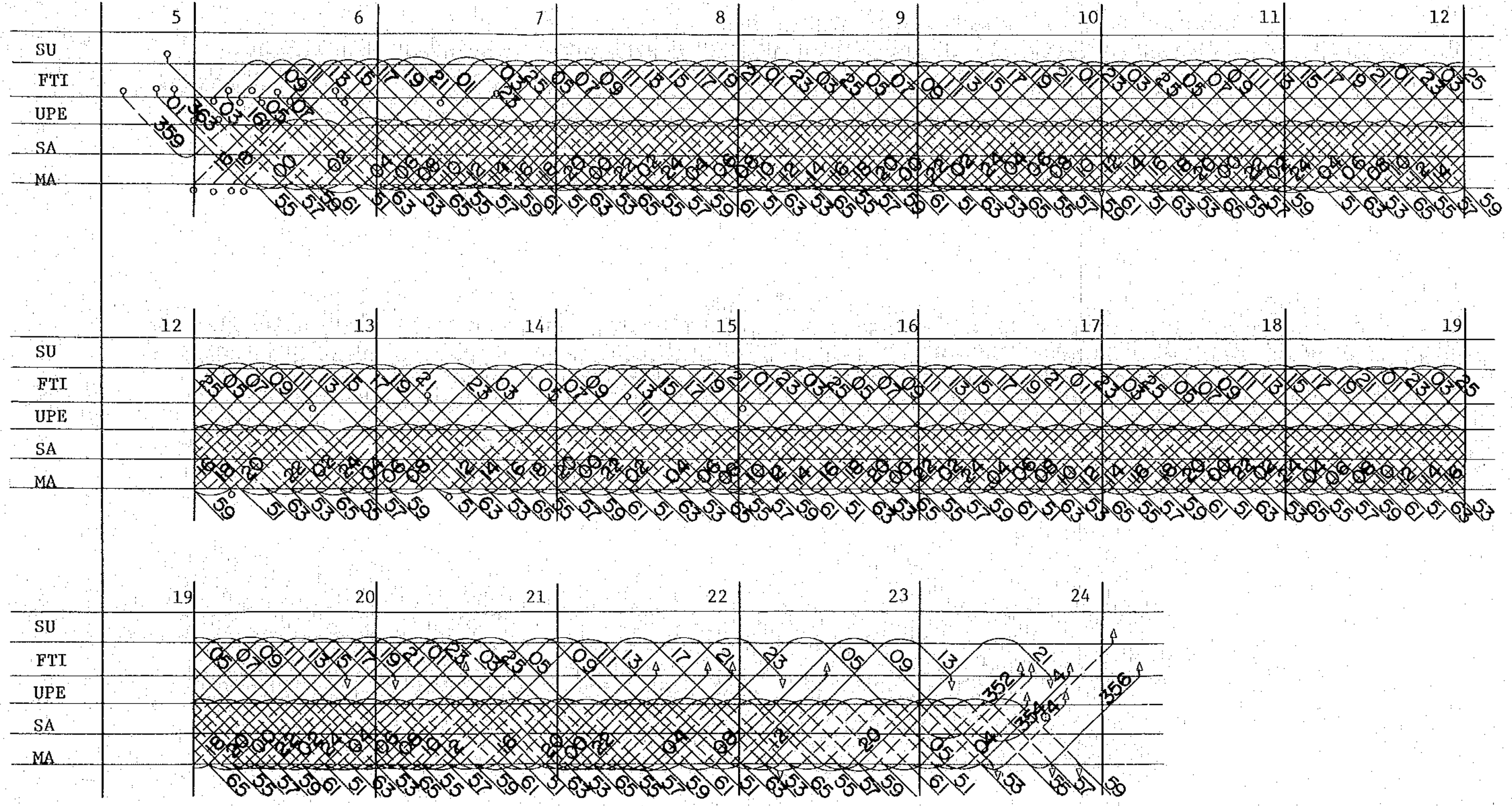
Tentative train operating diagram on north line (2000)



Tentative train operating diagram of south line (1987)



Tentative train operating diagram of south line (2000)

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