6.2.3 Power Receiving Contract

Since the electric railway should rank the top in the category of public utility enterprise and the power receiving plan is based upon the supply contract in terms of super-high voltage service, it can be estimated that the unit power tariff should rank at the lowest level. The lowest power tariff now being applied by the E.E.A. is priced at 2.6 mills. per KWH as served for the national aluminum refinery plant. The power tariff classified by industries is as shown in Table 6-2.

Table 6-2 Unit Power Tariff

mills./KWH

Industry	Max.	Min.	Average
Manufacturing	16.2	2.6	9.4
Agriculture	12.4	7.2	9.8
Governmental facilities (Large contract)	10.8	9.0	9.9
Public facilities	14.1	3.7	8.9
Governmental office	15.8	8.0	11.9

6.3 SUBSTATION

6.3.1 Substation Location

As shown in Fig. 6-2, out door type substations will be constructed at five (5) suburban sites of Qaliub, Benha, Tanta, Damanhur and Alexandria with due consideration to the site condition of each power receiving.

The sectioning posts will be installed at an intermediate point between those five (5) substations to serve as a touching part of the two neighbouring substations in normal operation and also for extended feeding in case of emergency.

Prior to determination of each substation capacity, as shown in Table 6-3, the following factors have been taken into consideration.

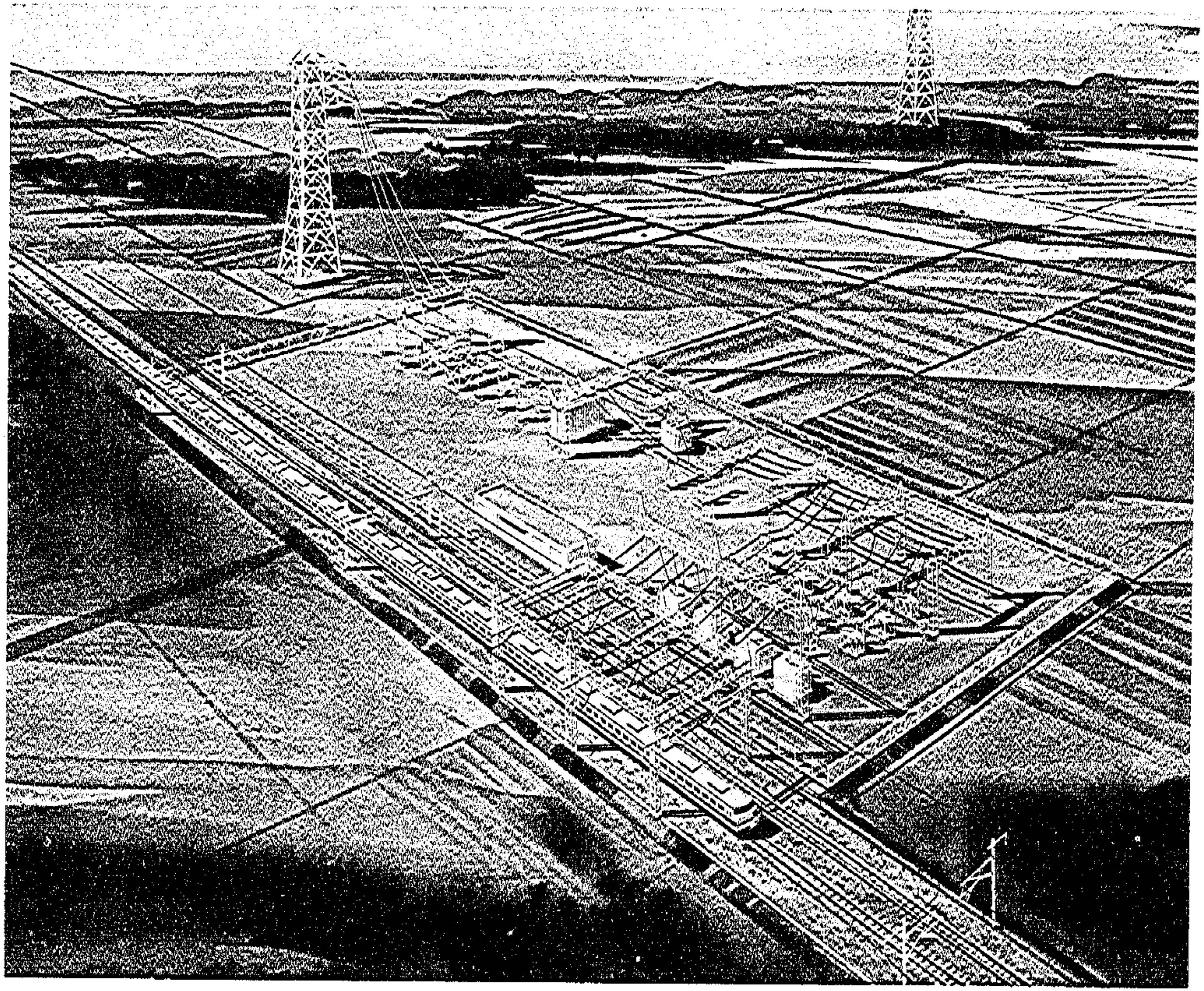
1) Increase in frequency of train operation to meet future increase of traffic volume.

2) Extended feeding at accident of power source or transmission line.

3) Extended feeding at power suspension due to failure or maintenance of substation.

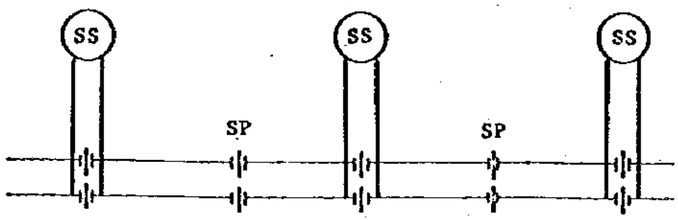
If the total number of substations to be installed is reduced to 3 or 4 sites, it means that the power receiving site will not be selected at a suitable point and the power supply system will require its stand-by system up to 100 percent coverage. This would be unacceptable as the unjustified system because of its economic disadvantage and also because of any possible need for operational restriction in case of extended feeding.

It is also necessary that the autotransformer at a winding turn ratio of 1 should be used for each substation and sectioning post, so that the line constant value of the feeding circuit can be reduced. Besides those, ATP must be installed at each intermediate point, being distanced at 10 ∿ 15 Km from one AT to the other, so as to make them serve as the countermeasures against inductive interference on telecommunication and against voltage drop.



Electric Power Substation

Table 6-3 Substation Capacity

Location of site	 				
Max. No. of trains running on track		Limited express 1 Express 1 Semi-express 1 Local 1	Limited express 1 Express 1 Local 1	Express 1 Local 1	Limited express 1 Express 1 Local 1
Max. hourly output (KW)		8,560	7,030	7,640	7,030
Max. hourly output at feeder extension (KW)		15,590		14,670	
Max. temporary output at feeder extension (KVA)	Cosθ=0.8	38,980			
Marginal load tolerance	+ 20%	46,770			
Required capacity of transformer (KVA)		50,000			
Power consumption	Limited express Express Semi-express Local	$40^{KWH}/1000^{t\text{-}Km}$ 30 " 35 " 45 "			

Then, on the basis of loading capacity and substation capacity, calculation is made as follows to examine voltage unbalance rate and the voltage fluctuation rate of power source.

1) Voltage unbalance rate

Momentary max. voltage unbalance rate (α) in the worst case of extended feeding:

$$\alpha = \frac{P_{max}}{Cos\theta \cdot Ps}$$

where, P_{max} = 15,590 KW

$Cos\theta$ = 0.8

Ps = $2,000 \times 10^3$ KVA

$$\text{Therefore,}\quad \alpha_{max} = \frac{15,590 \times 10^2}{0.8 \times 2,000 \times 10^3} = 0.97(\%)$$

Then, it has been assured that the rate would not exceed 1 percent even in any worst case.

2) Voltage fluctuation rate

As the worst example at extended feeding, the case where the trains operated at full load on the same track would get into notch-off is taken up for calculation.

Voltage fluctuation rate (β) in this case is as follows:

$$\beta = \sqrt{3}\ \frac{P_{max}}{Ps}\ \sin(\theta + \frac{\pi}{6}) \times 100(\%)$$

where, p_{max} = 38,980 KVA

Ps = $2,000 \times 10^3$ KW

$Cos\theta$ = 0.8

$$\text{Then,}\quad \beta_{max} = \sqrt{3} \times \frac{38.9}{2,000} \times 0.919 \times 100 = 3.09(\%)$$

The result, therefore, reveals that the rate would not exceed 5% even in any worst case.

6.3.2 Outline of Facilities

Figs. 6-3, 4 and 5 show the line connection diagram, facilities arrangement and main facilities externals respectively of the substation.

The construction site for the substation is selected from the rectangular area, if the circumstance permits, in parallel with the railway.

1) Receiving facility

Power will be received through the 1-circuit transmission line led into from the 220 KV network.
The gas circuit breaker will be used as the breaker for power receiving because of its less noise creation and maintenance-free nature.

2) Main transformer

Since the railway is operated at single-phase load, the modified Wood-Bridge connection type transformer, which has the convertible function without any unbalance from the 3-phase power line of direct-grounding type super-high voltage, will be used and grounded at the neutral point on the primary side, in same manner as applied to the power supply system. Connection of this transformer is as shown in Fig. 6-6.
It has such excellent characters that can display its functional effect on reduction of insulation level and restraint of neutral current by phase impedance matching.

3) Feeding facilities

Same as is the case of power receiving, the gas circuit breaker will be used for the feeding, and serve for feeding on the overhead catenary side by phases A and B. The autotransformer will be unified into a rating of 55/27.5 KV, 3,000 KVA for sole convenience of interchangeability and standardization.

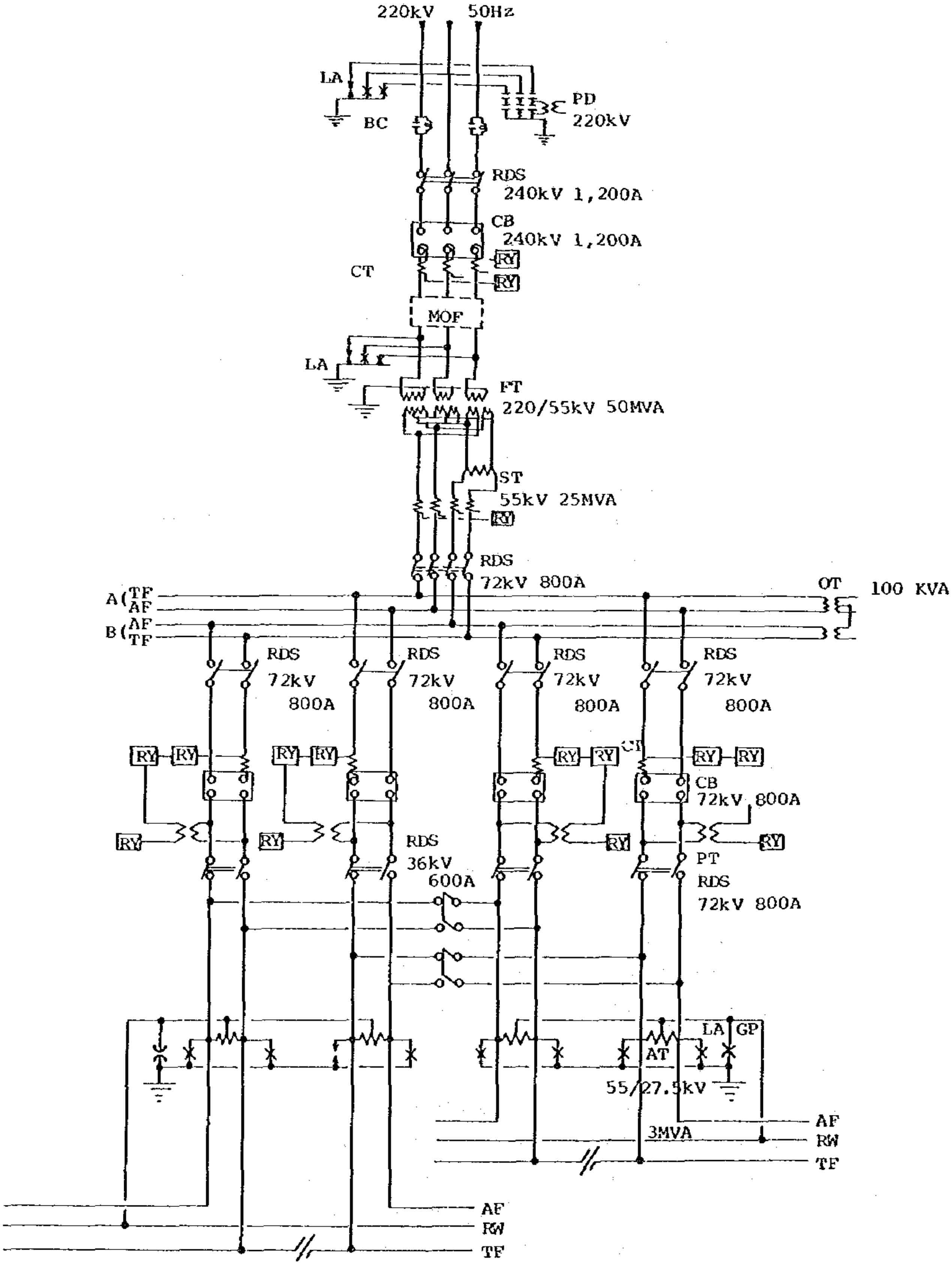


Fig. 6-3 Line Connection Diagram of the Substation

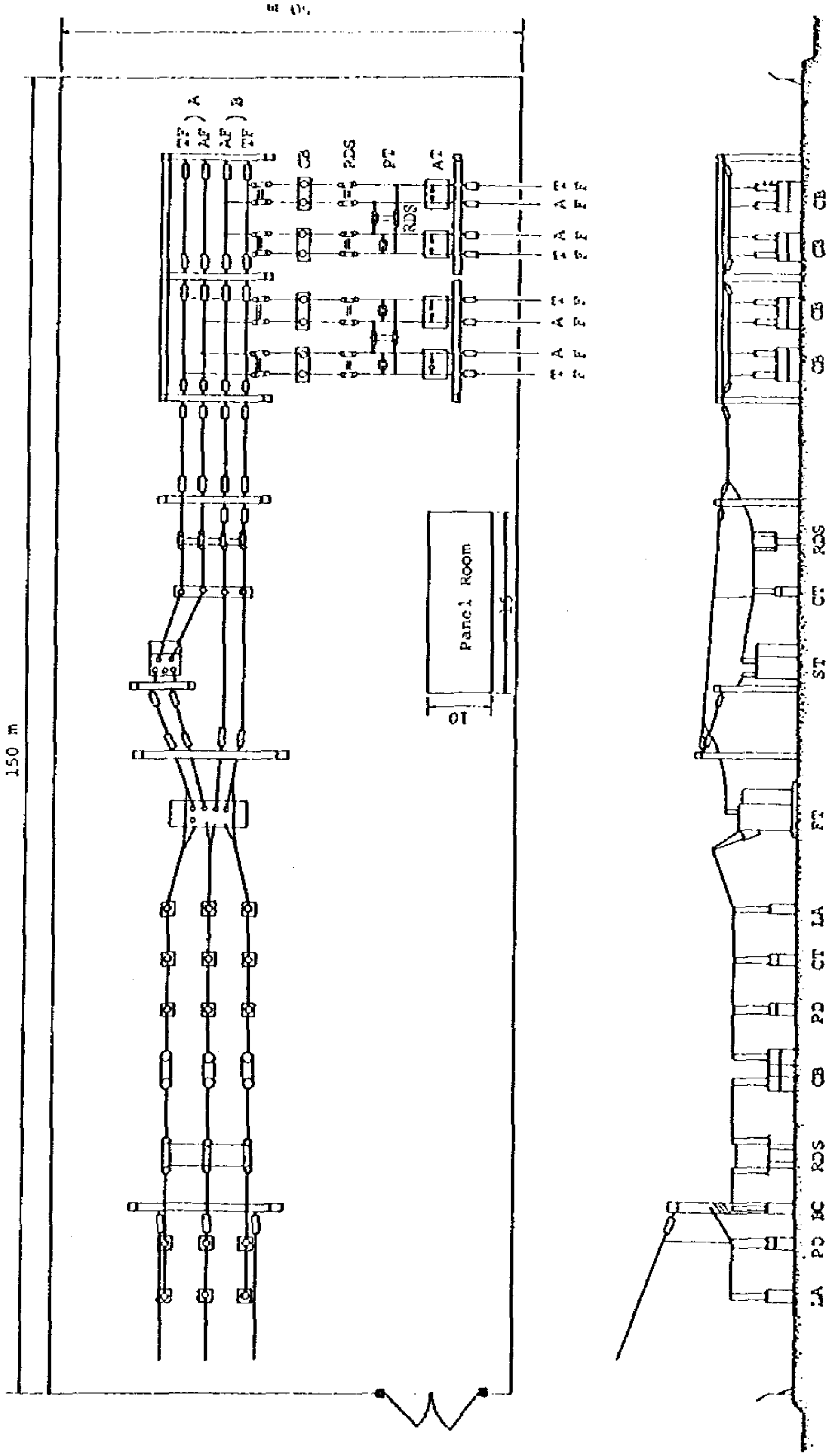


Fig. 6-4 Facility Arrangement of the Station

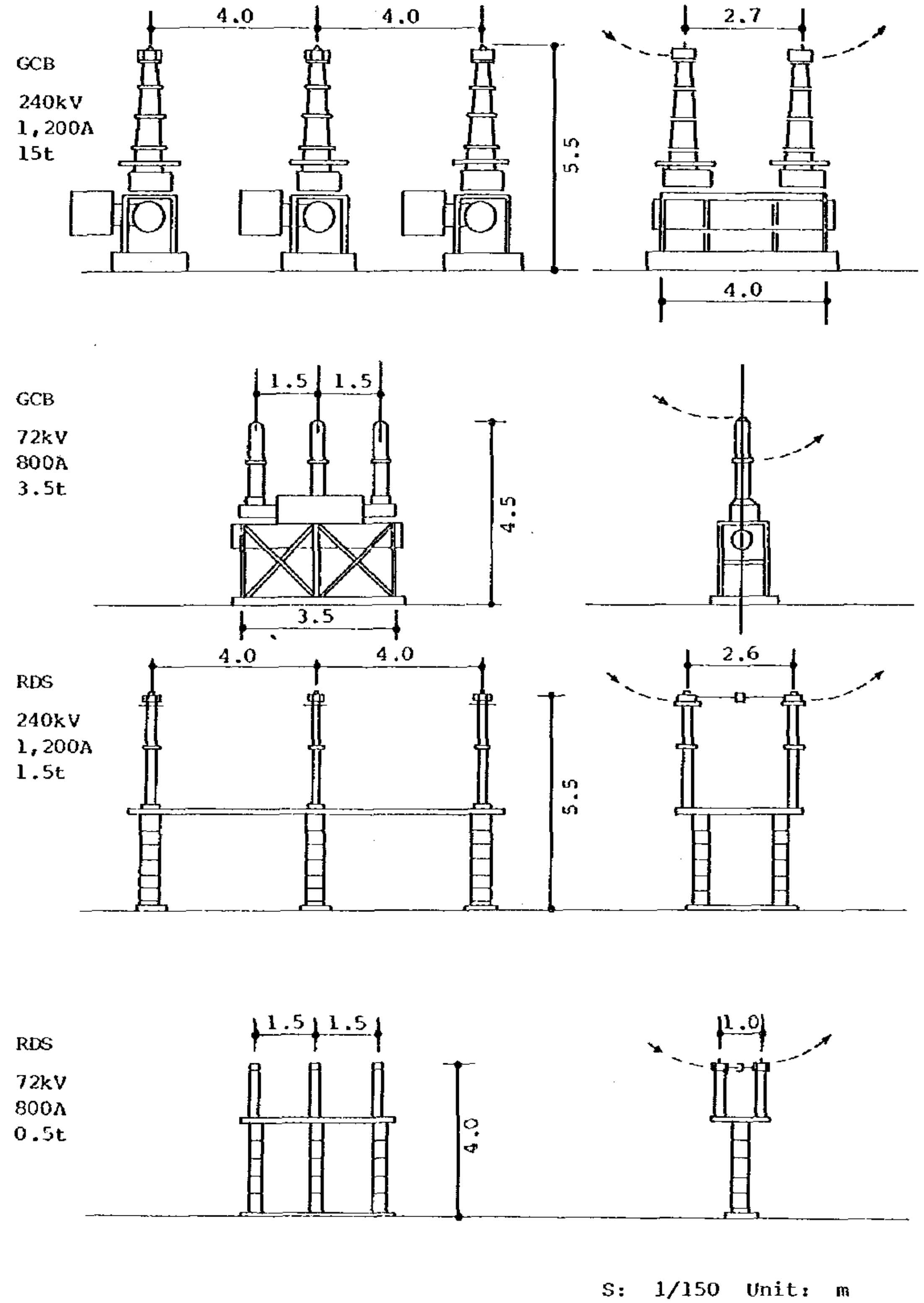
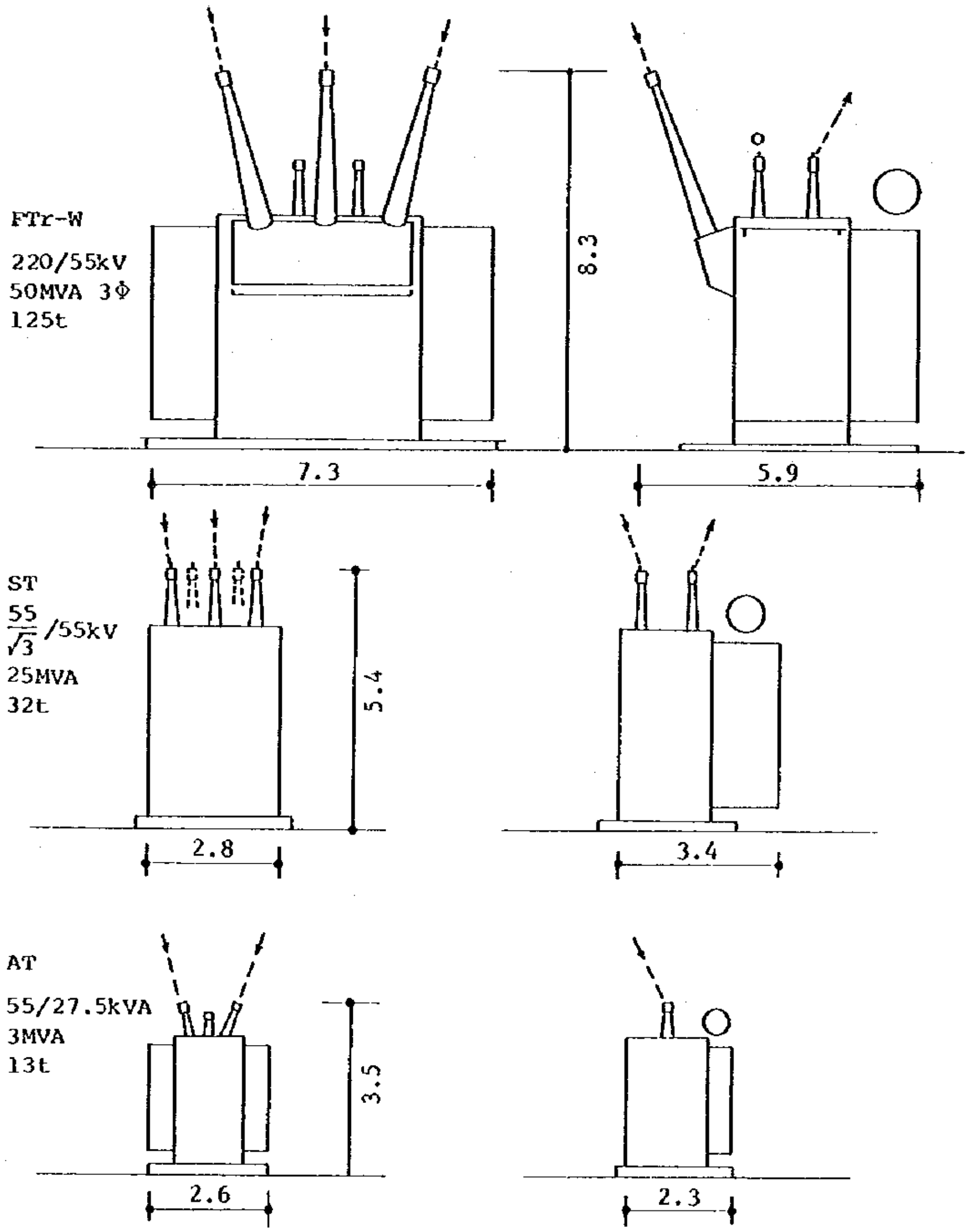


Fig. 6-5 Main Facility Externals of the Substation (1/2)



S: 1/150 Unit: m

Fig. 6-5 Main Facility Externals of the Substation (2/2)

6.3.3 Protection System

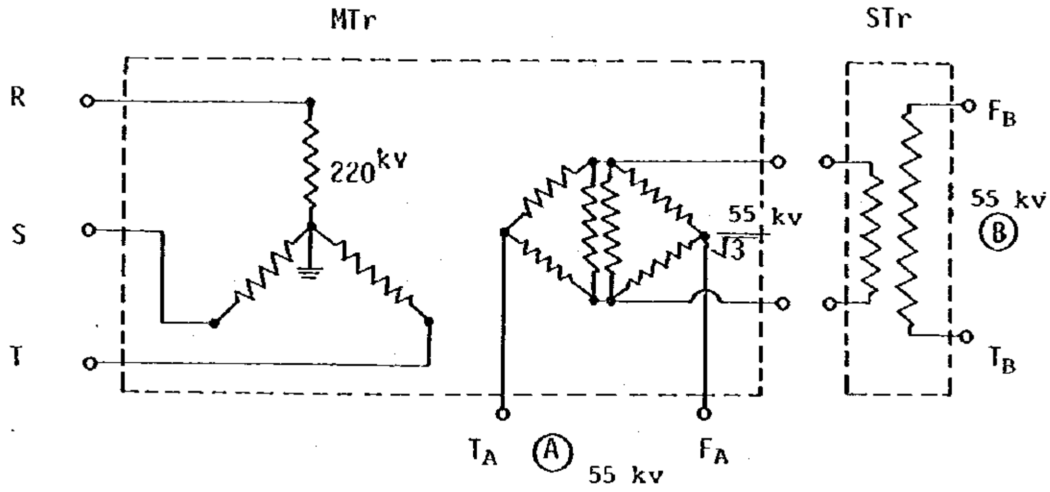
The protection system being used for a substation is diversified into various categories as shown in Table 6-4.

6.3.4 Supervisory Control System

The electric facilities for the electrified railway covers a wide range from substation to overhead catenary system.

The automatic control system for monitoring of the mechanical operating condition under normal operation, for locating of the fault at occurrence of any trouble and for operational change of the system can insure not only saving of the manpower but also speedy and accurate handling of the work.

In order to achieve this aim, the central control station will be provided in Cairo for centralised remote supervisory control over the substations divided into two groups. The data transmission line will be provided with four (4) circuits of exclusive use by either wire or radio relay. Besides that, the relaying transmission line will have to be installed between Cairo and Damanhur.



R.S.T : 3-phase power sources

T_A,F_A : Standard voltage at substation
T_B F_B

T-- Trolley line voltage to ground

F-- Feeder voltage to ground

Fig. 6-6 Deformed Wood-bridge Transformer Winding

Table 6-4 Protection of Substation

Systems	Troubles	Performance of protection relay	Circuit breakers
Receiving system	Over load	Overcurrent relay - to be energized by continuous current over the set value	Receiving circuit breaker
	Short-circuit	Short circuit relay - to be energized at high speed by overcurrent	
	Grounding fault	Grounding-fault relay - to be energized by voltage variation between earth and circuit	
Trans-former system	Internal fault of transformer	1. Pressure relay - to be energized by internal pressure increase 2. Ratio differential relay - to be energized by unbalancing of each winding current	Receiving circuit breaker and secondary circuit breaker of transformer
	Transformer overheat	Temperature relay - to be energized by higher oil temperature over the set degree	
	Transformer overload	Overcurrent relay - to be energized by continuous current over the set value	
Feeding system	Fault on feeder and overhead catenary system	1. Impedance relay - to be energized by line impedance at occurrence of trouble 2. Overcurrent relay - to be energized by continuous current over the set value 3. Selective relay - to be energized by current change ratio at occurrence occurrence of trouble 4. Reclosing relay - to be energized by limit of set time	Feeding circuit breaker
Others	Control power source failure	Overcurrent relay - to be energized by overcurrent	Alarm
	Direct current control power failure	DC voltage relay - to be energized by undervoltage below the set rating	
	Pneumatic pressure drop	Air pressure relay - to be energized by drop of air pressure for equipment operation	
	Power-off	Law voltage relay - to be energized by voltage drop	Receiving circuit breaker and secondary circuit breaker of transformer

6.4 OVERHEAD CATENARY SYSTEM

6.4.1 Fundamental Requirements

The overhead catenary system plays its role as the feeder of electricity to be received from the substation to lead to the pantograph of the train through the contact wire. Therefore, it is essential for the contact wire that it should permit smooth sliding of the pantograph with the least suffering from abrasion.

Each part of the whole structure including poles, beams and wire should be durable against any crucial physical conditions such as complicated vibration to arise from train operation, temperature and wind blow.

The overhead catenary system may vary into some different categories, depending upon the speed performance and the current collecting system, among which the simple catenary system (about 120 km/h at maximum speed) and the compound catenary system (250 km/h at maximum speed as is used for the Shinkansen of the JNR) have now general acceptance in practical use. Since this project proposes use of the AC electrification system of 25 kV at the maximum speed of 160 km per hour, the compound catenary system which excels in its high speed performance will be used for the main line construction, except that the simple catenary system will be used partially for the connecting track, refuge track and side track which may eliminate the possibility of high speed passing by any train.

Meanwhile, the movable bridge portion over the Nile and canals should be composed of an independent rigid suspension system, since the movable bridge will have to be turned round or lifted during the passage of a boat.

The supporting structure will be fabricated with the steel-composite mast, because of availability of the material, and will be coated with paint for rust proof. The scope of overhead catenary erection will be as shown in the attached drawing. (App. Fig. 4)

6.4.2 Design Condition

(1) Loading condition

The local climate condition in the Cairo-Alexandria zone is as indicated in Table 6-5 by reference to the survey result on the past record over a decade.

Table 6-5

Classification		Cairo	Alexandria
Tempera-ture	Max.	36.3°C	32.1°C
	Min.	5.1°C	3.4°C
Max. wind velocity		46 knot (24 m/s)	55 knot (28 m/s)
Thunder		Nil	Nil

The design conditions as calculated from the foregoing Table for strength of the supporting structure and for allowable sag and tension of the electric wire are as follows:

Range of temperature variation: +40°C ∿ 0°C

Temperature variation for design: +100°C ∿ 0°C

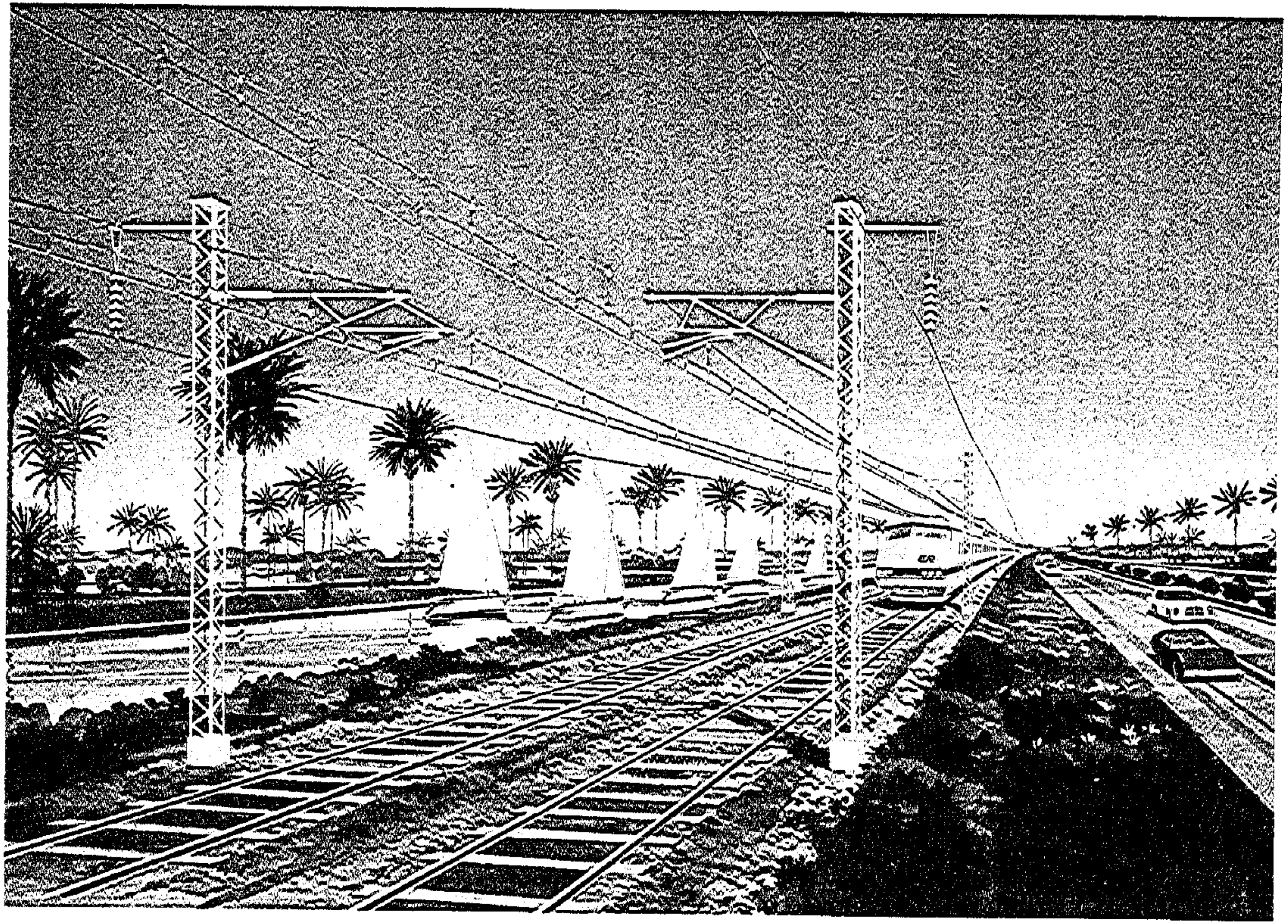
Normal temperature: +20°C

To be variable within ±20°C

Wind velocity: 30m per second at max.

(2) Countermeasures against thunder

The foregoing Table relieves the necessity to consider any countermeasure against thunder damage so seriously.



Overhead Catenary System

(3) Salt contamination problem

Since the Cairo-Alexandria region lies on the Nile delta, there may be a little possibility of being suffered, more or less, from salt contamination, only in the area of Alexandria facing the Mediterranean Sea. However, such condition will be overcome by the feature and quality of the structure to be provided.

6.4.3 Installation Criteria

The criteria for equipment installation are set up by the following standard with due consideration to the prevailing condition in Egypt.

(1) Clearance of overhead catenary system to other structures

Clearance to the grounded structure should be maintained at more than 300 mm.

(2) Safety factor

a. Tension of wire	Hard copper wire	2.2 and larger
	Others	2.5 and larger
b. Supporting structure		2.0 and larger
c. Insulator		2.5 and larger (in bending and tension)

(3) Height of contact wire

As stated in the preceding item of vehicle clearance, the standard height of the contact wire will be maintained at 5,150 mm above the rail surface of the track.

(4) Deviation of contact wire

The overhead contact wire will be given a deviation of 250 mm at standard and 300 mm at maximum on both sides, in order to prevent the localized abrasion on the contact strip of the pantograph which may result from running of the train.

Such deviation on the curved track will be 300 mm at the point of support.

(5) Gradient of contact wire

When an angle to be formed between the contact wire and the track surface exceeds a certain limit, the pantograph will cause a jumping phenomenon and come off from the wire, thus producing local abrasion of the contact wire. The maximum gradient of the contact wire to the track surface will be as follows.

Main track	3/1000 and below
Side track	15/1000 and below

(6) Adjustment of tension

Tension of the overhead catenary varies according to the temperature condition, which will, in turn, give variation to sag of the wire. Therefore, it is essential for stabilized collection of current that tension should be maintained at a constantly unvaried degree.

For this purpose, the automatic tensionning device will be installed at a fixed interval on the whole length of wire. This device may be classified by two different types; pulley type and spring type.

The pulley type comes from an application of the theoretical ground on the lever. The method is to keep the tension of the overhead catenary in balance by counter weight corresponding to the standard tension of the wire.

As sag and tension of the overhead catenary get into variation with change of temperature degree, the pulley then starts its turning automatically to bring up or down the counter weight and thereby adjust sag or tension of the wire by tightening or loosening it. Such adjusting device will be put on both ends of the overhead catenary so that the tension over a long span can be adjusted smoothly and automatically.

The spring type is so devised as to absorb sag or tension of the wire by tightening or loosening of the spring automatically as the tension of the wire may vary. This type is suitable for adjustment of the wire over a short section like the connecting track in the yard.

By application of those characteristic features the pulley type will be used for the main track and the spring type, for the connecting track, refuge track and side track.

6.4.4 Outline of Facilities

The fundamental facilities of overhead catenary system are as shown in Fig. 6-7.

(1) Feeder

Electric system:	AC, 25 kV
Feeding system:	2 circuits (up and down tracks) each track direction
Wire:	Hard aluminum stranded 300 mm^2

(2) Catenary

The overhead catenary structure is as specified below.
Pushing-up force of a pantograph will be 5.5 kg.

a. Main track

Overhead catenary system:

Compound catenary system Fig. 6-8

Wire:

Messenger wire: Galvernized steel stranded 180 mm^2 (2,500kg tension)

Auxiliary messenger wire: Hard copper stranded 150 mm^2 (1,500kg tension)

Contact wire: Circular grooved hard copper wire 170 mm^2 (1,500kg tension)

b. Side track, connecting track and refuge track

Overhead catenary system: Simple catenary system Fig. 6-9.

Messenger wire: Galvernized steel stranded 135 mm^2 (1,500kg tension)

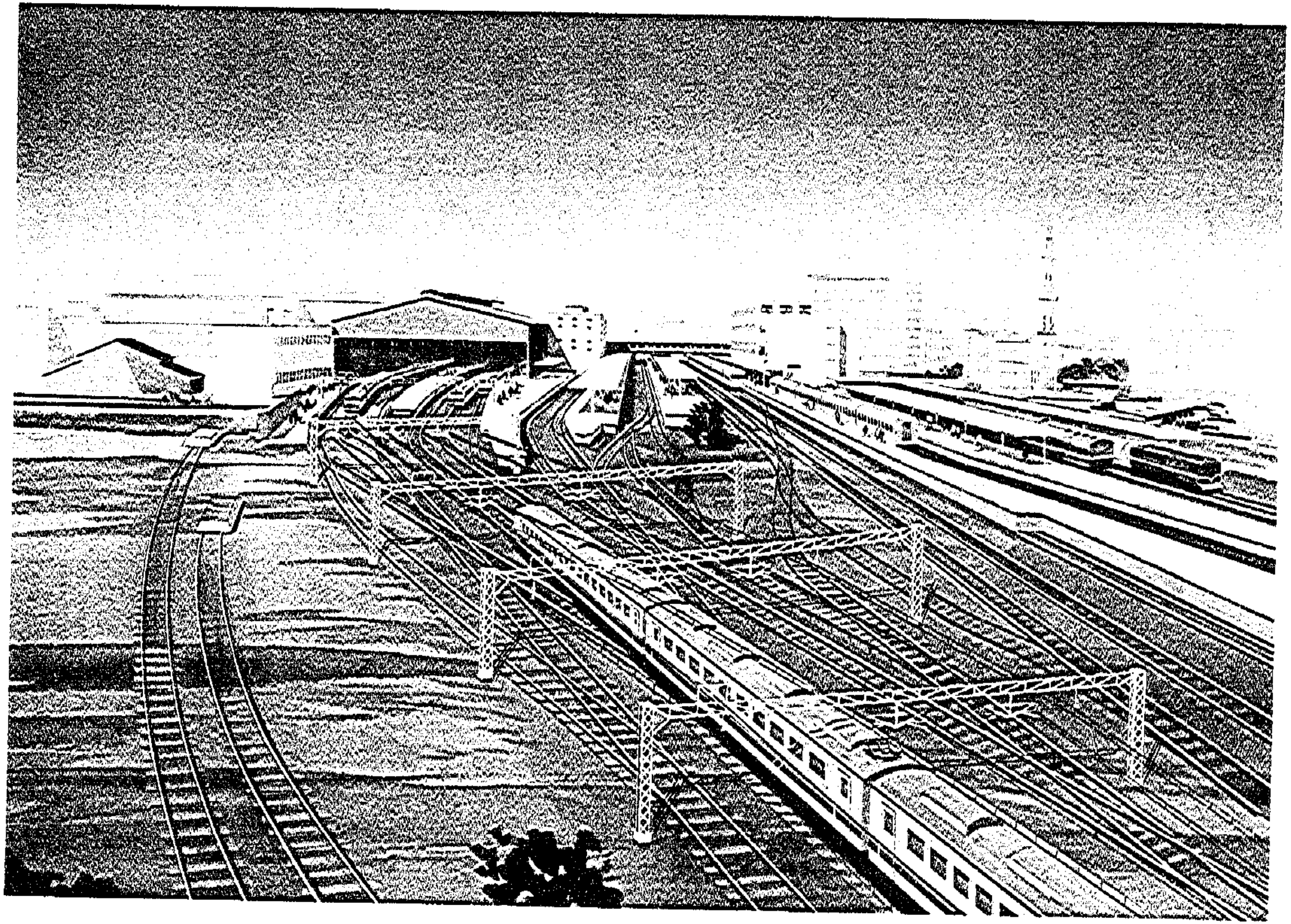
Contact wire: Circular grooved hard copper wire 170 mm^2 (1,500kg tension)

c. Movable bridge portion

Rigid suspension system: Spring-supported type

The overhead catenary system of the movable bridge section where the clearance between the high water level and overhead catenary system is less than 8 meters must be of breakable construction, for which the overhead catenary system requiring any tensile force cannot be used. For this reason, the rigid suspension system will be used for this portion. The general practice of construction by rigid suspension is to fix the member of conductive nature, such as aluminum-alloy, with T-shape section, to which the contact wire is affixed directly. This system may be acceptable to train operation at low speed but may give an unfavourable effect to the operating performance at high speed over 70 km per hour.

For this project, therefore, a certain degree of spring constant will be given to the rigid suspension system by use



Cairo Station

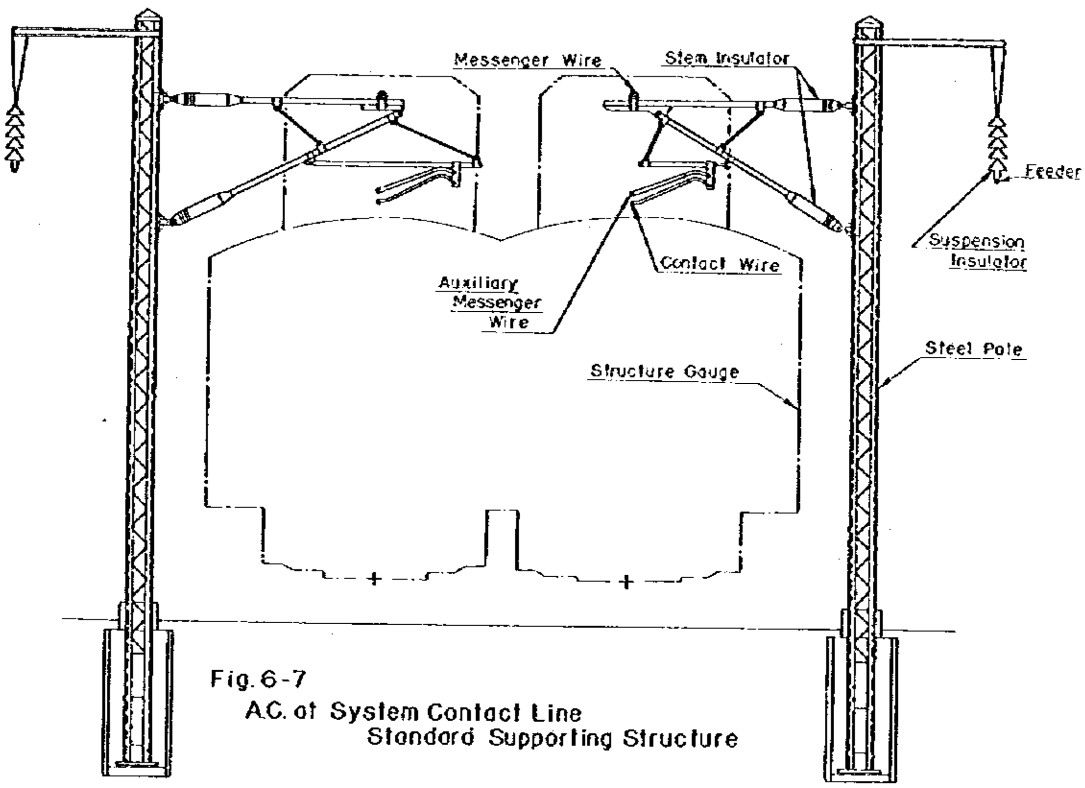


Fig. 6-7
A.C. at System Contact Line
Standard Supporting Structure

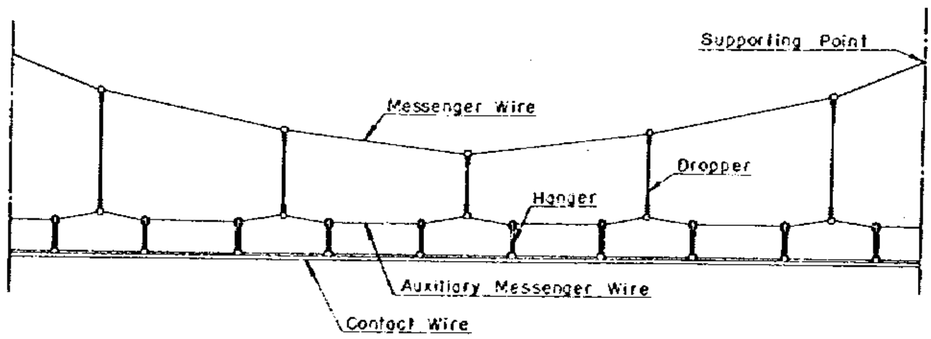


Fig 6-8 Catenary Structure of Heavy Compound Catenary System

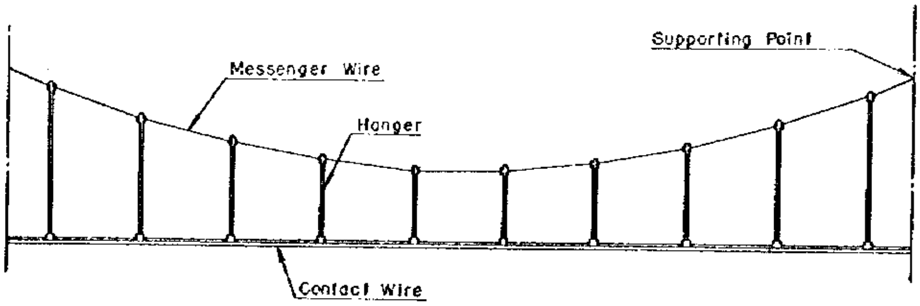


Fig 6-9 Catenary Structure of Heavy Symple Catenary System

of the spring as its support, which may be classified as the spring-supported type rigid suspension system durable for high speed train operation. As shown in Fig. 6-10, the supporting structure includes the hinged cantilever on a drop arm from the upper chord member of the bridge. The structure of break-off portion is shown in Fig. 6-11 and its detail is indicated in Fig. 6-12.

(3) Automatic tensionning device

Although each end of the overhead catenary will be affixed to the pole tightly, the wire may be subject to looseness or tightness depending upon any possible rise or fall of ambient temperature or any other temperature change due to load or current. The automatic tensionning device will be installed so as to maintain the tension at a constant level by automatic control and adjustment of any increase or decrease in tension of the wire. This system may be divided into the following two types by structure:

a. Pulley type ... for main track ... Fig. 6-13
b. Spring type ... for side track, connecting track, and refuge track ..... Fig. 6-14

(4) Crossing device for connecting track

This unit is devised to cross over the two overhead catenaries on the point of turnout on the track, so that the motor vehicle can enter into mutually from one track to the other. The crossing hardware will be set in place to eliminate any possible intrusion of the pantograph into the crossed contact wire.

Furthermore, the connector will be used for equalisation of voltage to prevent any possible potential difference. Fig. 6-15

(5) Hinged cantilever

In the case where the train will be operated at high speed of 160 km per hour, the hinged cantilever will be used to promote

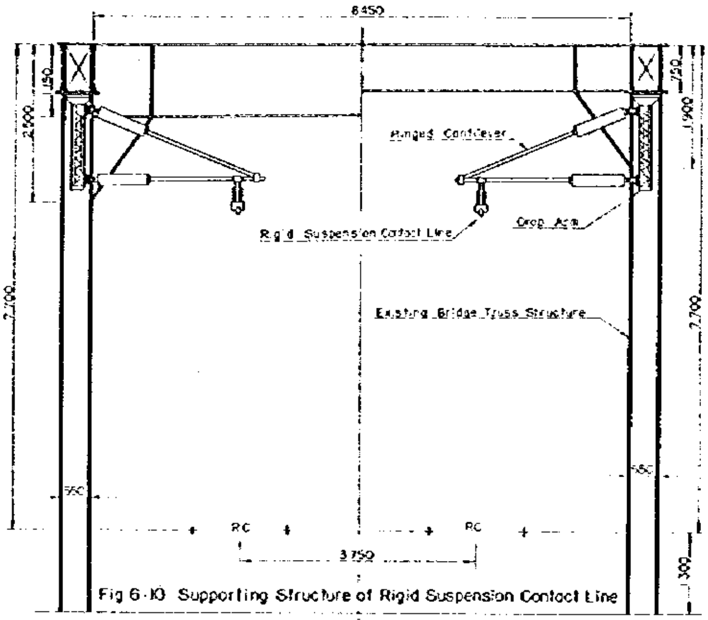


Fig 6-10 Supporting Structure of Rigid Suspension Contact Line

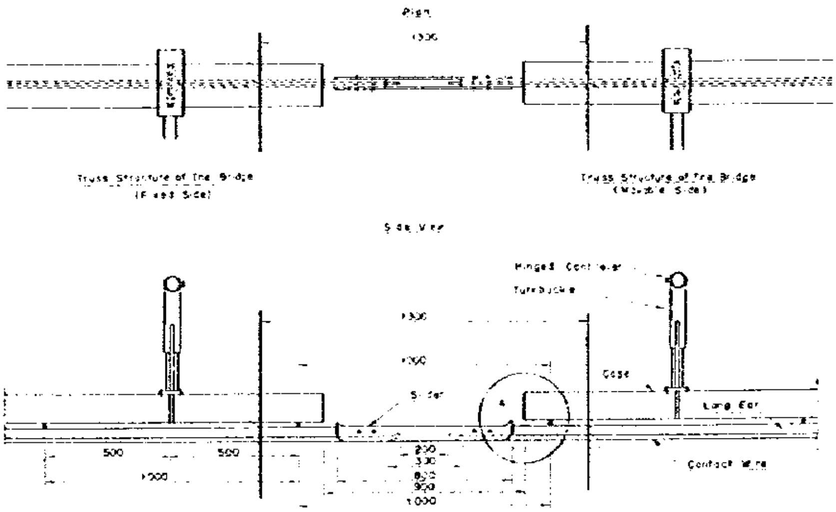


Fig 6-11 Separating Part of Rigid Suspension Contact Line

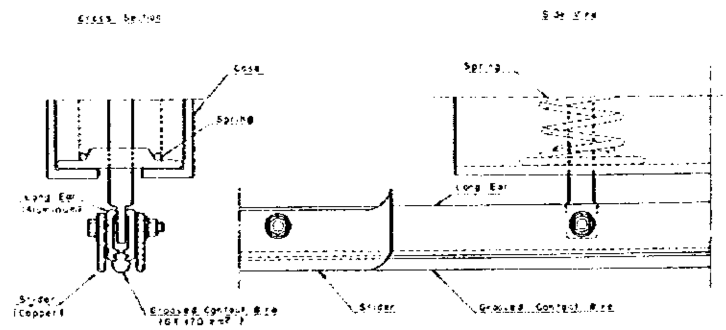


Fig 6-12 Separating Part of Rigid Suspension Contact Line
(Detail Drawing of Part "A.")

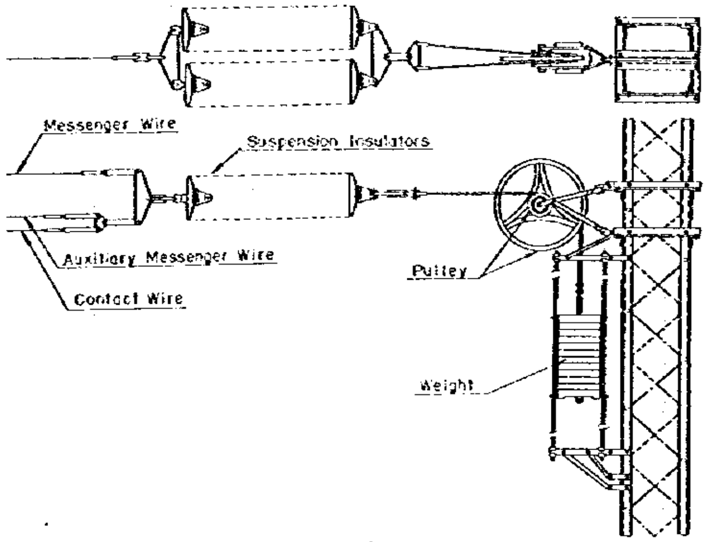


Fig.6-13 Pulley Type Tensioning Device

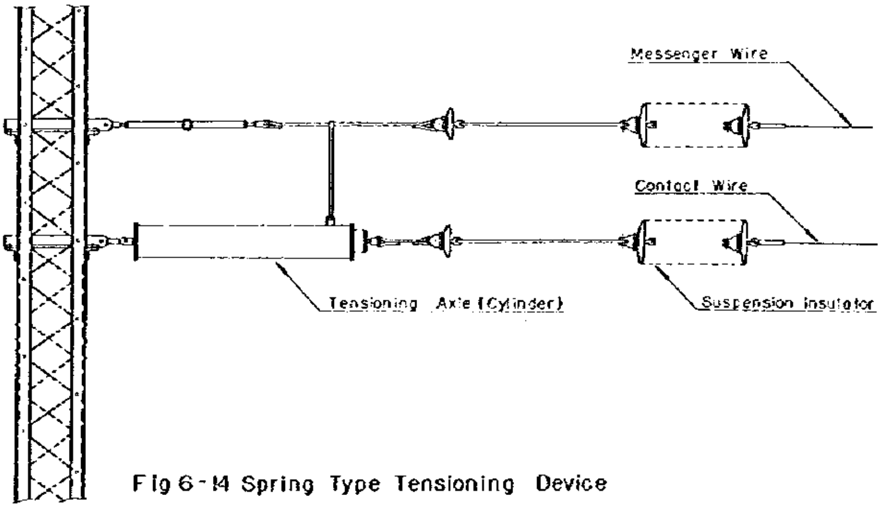


Fig 6-14 Spring Type Tensioning Device

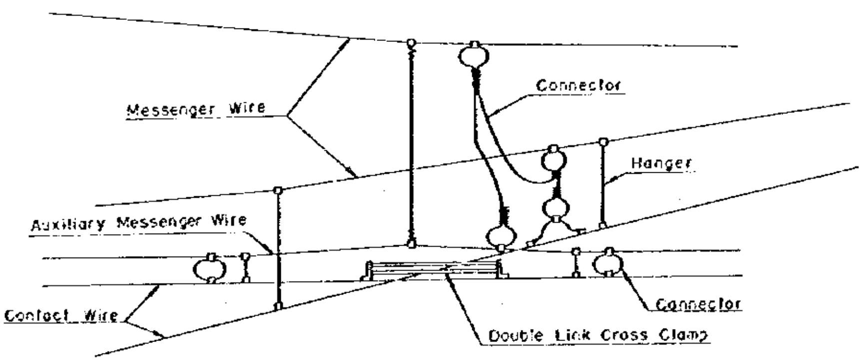


Fig. 6-15 The Structure of Crossing Point
(Compound Simple)

full performance of the automatic tensionning device for the contact wire and the messenger wire. This system is insulated by the stem insulator at the fixed point of cantilever and rotatable at the affixed point of the stem insulator to the pole, so that it may make the overhead catenary movable toward the track direction.
Fig. 6-16

(6) Section insulator

This device is used for electrical sectioning of the connecting track and the side track turnout for entry of the motor vehicle between the up and down tracks of same phase at alternating current. The slider can permit sliding of the pantograph in this section which is insulated by the insulator. Fig. 6-17

(7) Dead section

This device is used for sectioning of the portion served by different phase at alternating current, for instance, in front of the substation or sectioning post. It is of high insulation resistance because of its normal use for 25 kV class high voltage power circuit.

The dead section consists of five (5) plate-shaped pieces of fibre glass reinforced plastic (FRP) of 10 m in total length, each being of 2 m length. This will be inserted as an insulator into the auxiliary messenger wire and the contact wire.
The messenger wire will also be insulated by use of the strain insulator. When the motor vehicle will pass the dead section it will have to coast. Fig. 6-18

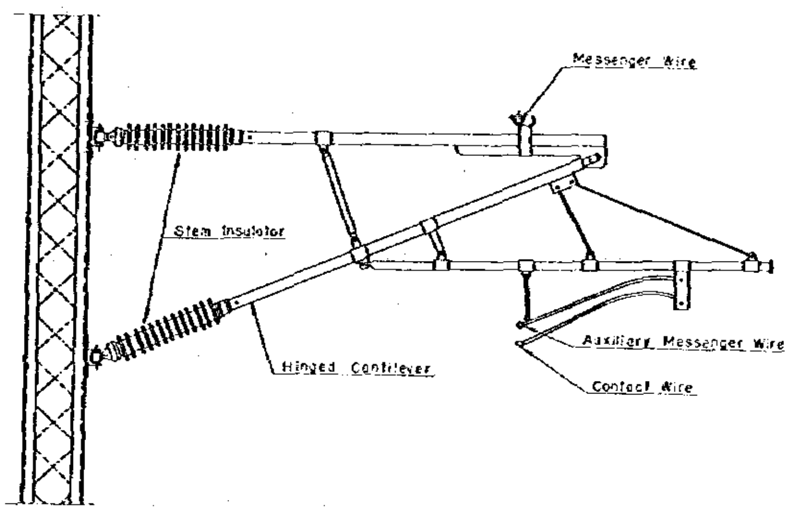


Fig 6-16 The Structure of Hinged Cantilever

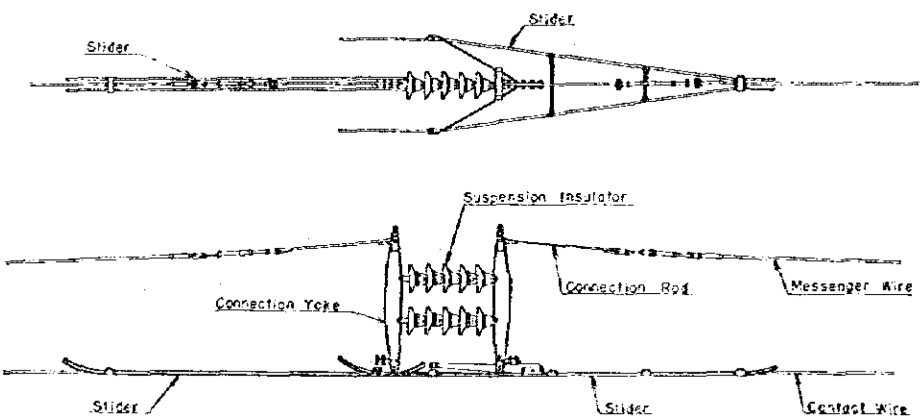


Fig. 6-17 Section Insulator

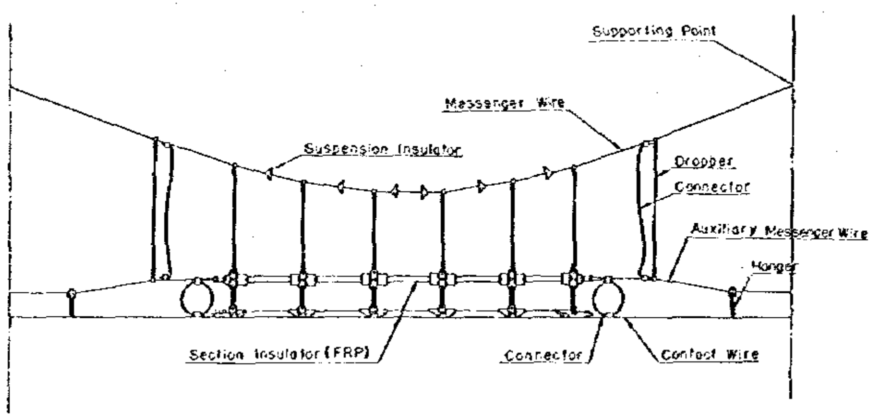


Fig. 6-18 Dead Section

6.5 MAINTENANCE SYSTEM

6.5.1 Substation Maintenance

Each substation will be located at a distance of 50 km and will be such designed that it can be put into scheduled outage for maintenance without affecting normal train operation. Therefore, functional check and inspection can be made to the fullest extent.

Namely, for those outdoor facilities any deterioration of their functions can be located by combined use of the following maintenance methods.

1) Automatic alarming unit

2) Check by service period and frequency of facilities

3) Check by inspection and measurement

For those indoor equipment including control panel and relays, check will be made by the automatic measuring system which will permit the overall functional inspection of higher reliability than the inspection on each individual body of facilities merely by human inspection.

6.5.2 Maintenance System of Overhead Catenary System

Overhead catenary system should be planned for high reliability at the early stage of construction and maintenance after opening of electric traction should be made with utmost care. In the case of overhead catenary system maintenance, the external force from the pantograph of train is one of the major factors involved in the cause of the electrical trouble. The current collecting condition of the overhand catenary system and the pantograph should be checked by measurement at a regular interval period.

In the meantime, considerable manpower will be required if the following items are checked by human work.

Namely, they are:

1) Height of contact wire,

2) Deviation of contact wire,

3) Hard point of contact wire,

4) Catenary composition of turnout point portion

5) Catenary composition of overlap portion.

6) Abrasion of contact wire

Therefore, the maintenance work should be made by such system that the data will be taken by the measuring car exclusively used for this purpose, such data will be put under control by time sequence and adjustment can be made prior to getting into trouble.

Wire and hardware to be used for the overhead catenary system are susceptible of being deteriorated mainly due to carrosion and abrasion from vibration. Therefore, maintenance for most of the parts, except special ones, will be made by either replacement or renewal with full care for their service life.

6.5.3 Organizational Structure for Maintenance (Electrical System)

The organizational structure for maintenance will consist of both inspecting and restoring services. Since for the inspecting service there still remain some room to be improved by introduction of various measures for manpower saving, such maintenance structure must be organised mainly for restoring service.

In line with this policy, the branch depot chiefly responsible for maintenance will be provide at every distance of 25 km or so for performance of inspecting and restoring services, with due consideration to the following requirements at occurrence of the trouble.

Namely,

1) Normalization of travelling time required from depot to the site in trouble

2) Security of necessary workforce for restoration from trouble

To achieve this maintenance purpose, each branch depot must be provided with spare material and mobilisable mechanism in sufficiency to fully insure smoothful performance of train operation.

7. SIGNALLING SYSTEM PLAN

7.1 PRESENT STATUS AND IMPROVEMENT PLAN

The existing signalling equipments in the Cairo - Alexandria section are of tyre type mechanical signalling system except the automatic signalling system being partially used in the Cairo - Qaliub section. The Egyptian Railways are now carrying out the following projects aiming at modernization of the existing signalling system on the condition of 50 Hz AC electrification of the railway.

(a) Conversion into automatic signalling system and introduction of CTC between Qaliub and Benha

(b) Introduction of CTC system between Benha and Alexandria

(c) Introduction of ATC (of intermittent control system) to the whole line between Cairo and Alexandria

Those projects are now under construction toward their target of completion by 1980. They should be completed as scheduled before the railway will be improved by AC-electrified train operation.

7.2 IMPACT FROM AC ELECTRIFICATION AND NECESSARY COUNTERMEASURES

In case of AC electrification, fly-back current by AC traction goes into the rail and the fundamental and higher harmonic waves may interfere the track circuits.

Such a phenomenon may be observed not only on the track circuits of the AC electrified section but also of the non-electrified section neighboured to or in parallel with the electrified section due mainly to electromagnetic induced current or stray current.

Therefore, it is first important that the track circuits of the AC electrified railway should be stabilised against any such interference as aforementioned. To meet with this requirement the track circuits will be designed for double rail track system with impedance bond. It is also necessary to select the working signal frequency in so far as it may be kept free from the impact of fundamental or higher harmonic waves to arise from electric motor vehicle current.

With regard to the interference there must be a standard to determine if any impact may arise on the track circuit. The allowable limit set out by the Japanese National Railways is the value of interference current when the induced interference voltage to the track circuit reaches one-half of the drop away voltage on the track relay.

Besides the above, the AC electrification system produces such other problems as the inductive interference into the signalling equipment or the transmission line or the possible danger to the human body of a maintenance worker due to electrostatic induced voltage. Any comprehensive measures must be taken for prevention of all those problems.

7.2.1 Measures to be Taken on Track Circuits

As a part of the foregoing project, the track circuit between Qaliub and Alexandria is being improved with the ultimate aim toward completion of the AC 50 Hz electrification project. In the meantime, the AC 50 Hz track circuits are being put in use between Cairo and Qaliub, where signal frequency coincides with power frequency for AC electrification and the absolute value of induced interference voltage to arise from electric motor vehicle current exceeds largely over the normal signal voltage. Therefore, the existing track circuits will not be serviceable after completion of AC 50 Hz electrification and will have to be improved.

7.2.2 Scope of Improvement

With regard to the existing Cairo - Qaluib 50 Hz track circuits, the required scope of improvement for conversion into the 50 Hz AC electrification system is as follows:

(a) Whole track circuits of the railway planned for 50 Hz AC electrification

(b) Track circuits in boundary to the one stated in the foregoing Item (a)

(c) Track circuits in proximity to or in parallel with the one referred to in the foregoing Item (a), being in danger of inductive interference.

The second item above is the necessary measures for prevention of the false operation due to stray current of fly-back current from the electric motor vehicle. The protective section as provided by the Japanese National Railways covers two track circuits (2 sections) in a longitudinal direction from the boundary limit or the length of the train entering or leaving the boundary limit plus one track circuit. Same measures as applied to the AC electrified section will be taken for that track circuits of protection coverage. The relationship is shown in Fig. 7-1.

With regard to the preceding Item (c), the problem may be solved by application of the measures against stray current as referred to in Item (b), in accordance with the JNR's standard, in view of the present layout and passing route of the track between Cairo and Qaliub. However, since the scrutinising check is required for actual application of the measures, it is necessary that impedance of the track circuit, admittance between rail and earth and ground conductivities should be classified by the actually measured result. The value of induced voltage by AC Traction to the track circuit must be calculated for check by use of the Formula 8-2 as stated later (Item 8.1.2).

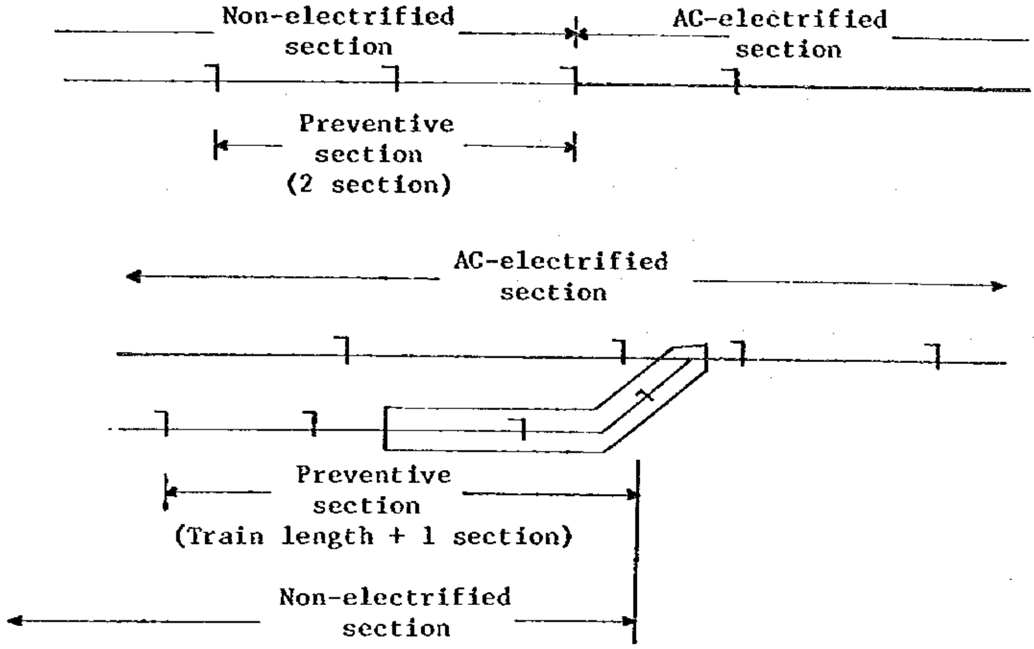


Fig.7-1 Example of Measure's Scope for
Electrified and Non-electrified
Boundary Limit Track Circuits

7.2.3 Track Circuit Improvement Method

The Egyptian Railways are now improving the existing track circuit between Qaliub and Benha as the prerequisite to implementation of the AC 50 Hz electrification project, aiming at conversion into the automatic signalling system. It is considered reasonable that the track circuits between Cairo and Qaliub should also be improved to the same system as being aimed at between Qaliub and Benha, in view of the operational and maintenance aspects.

7.3 PROTECTION OF HUMAN BODY FROM DANGER

In the AC-electrified section electrostatic voltage of high rating may be induced to the signals, signal wires and pipe lines near the AC electrified railway line from the high voltage on the overhead contact wire. When the ground fault occurs on the overhead contact wire, the potential between rail and earth will rise up sharply. Therefore, all those equipment must be connected to the earth, at earth resistance below 100 Ω, as it is extremely dangerous for human body to get in touch with those equipment.

7.4 FUTURE PLAN ON SIGNAL SYSTEM BETWEEN BENHA AND ALEXANDRIA

The signalling system in this section is now being improved into CTC system. Each section from one signal cabin to the other is treated as the one block section.

In the meantime, as the result of study from the aspect of train operation plan, it is forecasted that the said section will become tight in its carrying capacity in the future, thus forming a bottleneck in the setting of the train operation diagram.

To cope with this situation, the capacity of the said section will have to be improved by shortening the length of the existing block section.

7.5 SIGNALLING EQUIPMENT INSTALLATION PLAN WITHIN CAR DEPOT

In the proposed plan for electrification of the Cairo - Alexandria section, the car depot will have to be newly constructed for operation, storage and inspection of the new electric rolling stock. This new car depot will be provided with a complete set of signalling system including interlocking devices, track circuits and various signals.

7.6 PROTECTION FOR LEVEL CROSSING

Since the train is operated most frequently and densely in the Cairo - Qaliub section, the impact to the normal train operation would be of greatest concern once the accident should occur at the level crossing. Therefore, it is most advisable that the functional performance (brilliance of flash light and sounding level of alarm bell) of the level crossing signals should be improved. It is also necessary that the starting point of alarm should be reset (by alternation of track circuit section) in compliance with the requirement for higher speed of the train.

8. TELECOMMUNICATION SYSTEM PLAN

8.1 PRESENT STATUS AND IMPROVEMENT PLAN

The existing telecommunication system between Cairo and Alexandria consists mainly of telephones using the overhead bare wires installed in the wayside as the sole transmission line.

The Egyptian Railways are now going ahead with the following projects for the purpose of modernising the telecommunication system as stated above.

(a) Renewal of train traffic control telephone network

(b) Improvement of selective telephone network

Those projects are now under way for final completion in 1981. When completed, they will be able to support, in the area of telecommunication engineering, the future improvement of the railway traffic now being intended by electrification.

8.2 INDUCTIVE INTERFERENCE

In case of AC electrification, the communication line in proximity to or in parallel with the AC electrified overhead contact wire may be affected by inductive interference.

This is because the electro-magnetic inductive voltage of fundamental wave and higher harmonic waves of the power circuit to arise from AC traction will be induced into the telecommunication line. Main impacts from such interference include disturbance in communication service from inductive noise, false operation of the exchanger and dielectric breakdown of equipment. In addition, it may endanger the human body.

Prior to implementation of the plan for AC electrification, therefore it is most important that any appropriate measures for protection of inductive interference should be taken after making quantitative assessment of the interference.

8.2.1 AT Feeding System in View of Measures Against Inductive Interference

In case of the AT feeding system, inducing current will be smaller than load current since current is supplied through the contact wire and the rail from each autotransformer. Furthermore, since it will act contradictly against induced voltage to the communication line, the AT feeding system has an advantage to mitigate such induced voltage. Now then, the value of inducing current will be only a problem involved in inductive interference to the communication line. In this respect, Fig. 8-1 (1) shows distribution of electric motor vehicle current on the AT feeding circuit. By reference to combined result from the above, inducing current is shown in model in Fig. 8-1 (2).

8.2.2 Calculation Formula for Induction Forecast

Induced voltage to interfere the communication line may be fallen into the following categories:

(a) Induced noise voltage Vn

This is noise voltage induced in voice frequency band due to components of higher harmonic waves to arise from an electric motor vehicle. This will interfere the telecommunication service by mixture as noise into the circuit. (Assessed at 800 Hz)

(b) Normal induced voltage Vm

This is induced voltage between the communication line and the earth. It will interfere normal operation of the equipment connected with the line and endanger the human body (50 Hz).

(c) Abnormal induced voltage Va

This is induced voltage between the communication line and the earth in case of grounding fault of the feeding circuit due to any trouble. It will give damage to the equipment or endanger human body. (50 Hz)

Each of the calculation formulas for forecasting of induced voltage of the above categories may be expressed as follows.

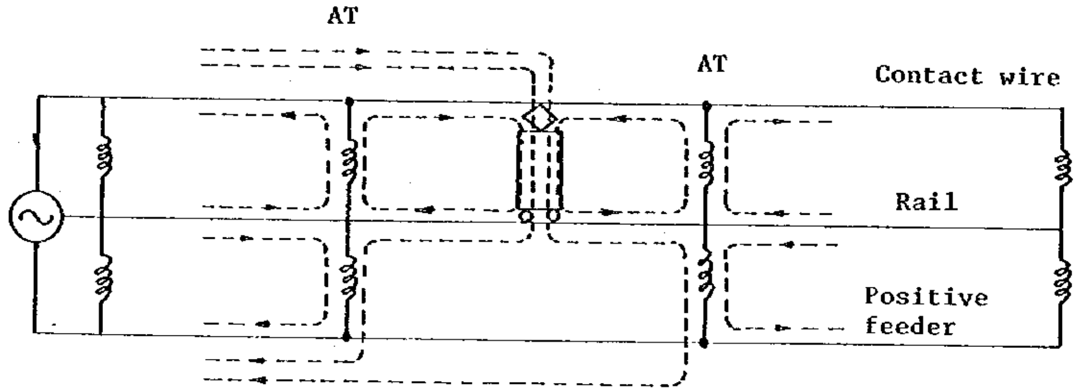
$$Vn = \omega M \frac{(Amp\text{-}Km)n}{D} \cdot Jp \cdot \lambda \cdot \ell \cdot Kn \times 10^{-3} \text{ (mV)} \quad \text{.....} [8.1]$$

$$Vm = \omega M \frac{(Amp\text{-}Km)f}{D} \cdot Ip \cdot \ell \cdot K \times 10^{-6} \text{ (V)} \quad \text{..........} [8.2]$$

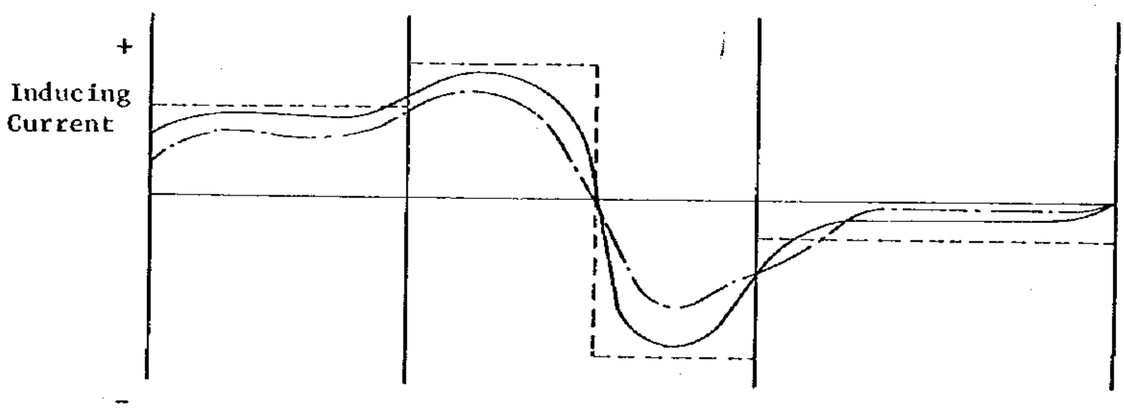
$$Va = \omega M \frac{(Amp\text{-}Km)f}{D} \cdot Ia \cdot \ell \cdot K \times 10^{-6} \text{ (V)} \quad \text{..........} [8.3]$$

where,

- ω: $2\pi f$, f=50 or 800 Hz
- M: Mutual inductance at 50 Hz or 800 Hz between catenary and communication lines (μH/km)
- Ip: Inducing current at 50 Hz in catenary
- Ia: Faulty current at 50 Hz in catenary
- $\frac{(AmP\text{-}Km)f}{D}$: Section Amp-Km at 50 Hz of normal load current and faulty current
- $\frac{(Amp\text{-}Km)n}{D}$: 800 Hz section Amp-Km of load current
- Jp: Equivalent disturbing current (per 1 Amp load current)
- λ: Balancing degree of communication line
- K: Multiple of various screening factors (50 Hz, 800 Hz)
- ℓ: Parallel length between catenary and communication line
- D: Section unit length (1 km at standard)



(1) Current Distribution



(2) Inducing current distribution

--- Admittance between earth and rail being nearly infinity

—— Large admittance between earth and rail

—·— Small admittance between earth and rail

Fig. 8-1 Current Distribution in AT Feeding Circuit

8.2.3 Allowable Limit of Induced Voltage

The allowable limit of induced voltage to arise on the communication line, in case of AC electrification, may slightly differ by countries depending upon the safety standard for protection of human life or the technical background situation in each country.

Table 8-1 shows the limit as recommended by the CCITT (Comité Consultatif Internationale Télégraphique et Téléphonique).

For referential purpose, some examples in the countries abroad are shown in Table 8-2.

This should be finally decided after consultation with the Arab Republic of Egypt Telecommunication Organization (ARETO) and other agencies concerned.

8.3 PREVENTIVE MEASURES FOR COMMUNICATION LINE AGAINST INDUCTIVE INTERFERENCE

8.3.1 Induced Voltage Forecasting

As mentioned previously the overhead bare wires for communication service is running very close to and in parallel with the railway between Cairo and Alexandria. The induction from the AC electrified overhead contact wire into the said communication line is calculated by the formulas (8.1) ∿ (8.3). This calculation should require such factors as ground conductivity, balancing degree of circuit or equipment connected thereto, and admittance between rail and earth (or screening effect of rail).

The result of calculation made, as an attempt to see the figure, by use of the figures previously obtained by the JNR reveals that induced noise voltage and normal induced voltage to the aforestated overhead bare wires would be 130 mV and 150 V respectively as against load current of 400 A (230 A at maximum per each train) and equivalent disturbing current (Jp) of 7 A, which would foretell that they would exceed largely the CCITT's recommended allowable limits. Although it is

Table 8-1 Allowable Limit of Induced Voltage

Induced Voltage	Allowable Limit	
Induced Noise Voltage (Line-Line)	1 mV	When cable is used
	2.5 mV	When Bare wire is used
Normal Induced Voltage (Line-earth)	60 V	At normal operation time
Abnormal Induced Voltage (ditto)	430 V	At abnormal operation time

Table 8-2 Allowable Limit of Induced Voltage in Other Foreign Countries

Country	Induced Noise Voltage		Normal Induced Voltage		Abnormal Induced Voltage	
	Allowable Limit	Basis	Allowable Limit	Basis	Allowable Limit	Basis
France (EDF)	-		60 V	Ordinary power Transmission line	430 V	Ordinary power Transmission line
			150 V	Highly stable power Transmission Line	650 V	Highly stable power Transmission line
West Germany (RWF)	-		15 V	Step by Step exchanges	*300 V	*Actually approx 430V because 300V is divided by a coef-ficient of 0.7 in predicting the induced voltage
			20 V	Rotary exchanges		
			65 V	Electronic exchangers		
					(1200 V)	(withstand voltage of cable is divided by 60%)
Sweden (SSPB)	1 mV	CCITT Recommen-dation	60 V	CCITT Recommendation	430 V	Ordinary power Transmission line
					650 V	Highly stable power
					(1200 V)	Transmission line
England LBEA	1 mV		15 V	Prevention of Telephone exchange malfunctioning	430 V	Ordinary power Transmission line (CCITT Recommendation)
			(60 V)		650 V	Highly stable power Transmission line (CCITT Recommendation)

necessary to confirm those values by actual measurement, it is obvious in any event that any effective measures against inductive interference to the said overhead bare wire should be required for conversion into AC electrification.

8.3.2 Countermeasures Against Interference

General practices as countermeasures to be taken on the induced side for the AC electrified section may be summarised as follows:

(a) To keep the coefficient M of mutual inductance at a small value

(b) To keep parallel length ℓ short

(c) To keep the screening factor K at a small value

(d) To keep the balancing degree λ of circuit at a small value

In view of the fact that the communication system between Cairo and Alexandria consists of a large number of bare wires over a total length of 210 km, there are to be considered as the two alternatives, eigher to take larger space between the railway and the lines (to make M small) or to replace with cable of high screening effect (to make K small).

In the former case, however, the communication line must be spaced over several hundred meters from the electrified overhead contact wire, which would make it difficult to secure any such route as may meet the convenience of construction material transportation or maintenance after completion. Furthermore, since the area to be included in the scope of communication service lies mainly along or near the railway, which would require specific approach of service by extension of each circuit to reach each service area involved, and the line of open wire system tends to be susceptible to variation of temperature and humidity with resultant lower stability and reliability in its transmission characteristic.

All those considered, the former method is not recommendable because of those problems involved.

On the other hand, in the latter case where the line will be replaced with cable, there will be no specific problems to be anticipated. Therefore, it is considered appropriate that the cable conversion method should be used basically, using together the methods of insertion of repeating coil and arrestors as protecting instruments from induced voltage, if necessary.

8.3.3 Cable Conversion Plan

Cable to be used for replacement should be aluminum sheathed cable, in view of screening effect, mechanical strength and maintenability.

In this case, further discussion will be required to determine if cable is of joint use with ARETO on of seperate use for each own. From economic viewpoint, it would be much cheaper to have it by joint use.

(1) Cable channel plan

The channel plan of cable will be determined from the operating condition of the existing circuit and the future prospect for demand. In determining the channel plan the following points must be taken into consideration.

1) Attenuation loss compensation for existing line

The cable line will increase attenuation loss per unit length larger than the conventional bare wire line (0.04 db/km → 0.6 ∿ 0.9 db/km at 1 KHz). The long distance circuit now in service such as the transit trunk line or the direct trunk line will be connected into the carrier line while the party telephone line or the subscriber's telephone line will be divided by several circuits or loaded by loading coil for improvement of attenuation loss.

2) Composition of circuits as may be required by electrification

Newly required circuits will be as follows:

(a) Remote control and supervisory line and disconnecting line between substations.

(b) Communication line for operation and maintenance of substation and overhead contact wire (Note: Wayside telephone is considered for overhead contact wire maintenance).

(c) Telephone line between new car depot and its related working offices or stations

3) Security of spare lines to meet future increase of demand

With those items above in mind, the concrete policy for implementation of the plan should be decided by consultation with the ARETO upon necessary matters including the method of cable conversion, share in expenses and division of maintenance responsibility. Incidentally, it is advisable that those main circuits such as the control line of CTC system, the remote control line of the substation and the dispatcher telephone line should be able to secure the telecommunication service, even at any trouble occurrence on the cable line, by use of spare line routes. Study on the joint use of the co-axicial cable line with ARETO is also recommended in this respect.

(2) Carrier transmission system

The carrier transmission system through the trunk cable line consists of the two alternatives, Frequency Division Multiplex as FDM and Pulse Code Modulation as PCM. PCM is considered preferrable to FDM in view of its economy and transmission performance.

The PCM system is to transmit the data by conversion into digital code which would therefore permit regenerative repeating, thus offering its own advantage to insure good quality of transmission even through the channel of which signal per noise ratio would be relatively poor. On the other hand, however, it requires two (2) pairs of carrier line and reduces the repeater spacing to a shorter distance of 2 ∿ 3 km, as compared with the FDM system (10 km or so) because of broad band transmission. Notwithstanding this handicap, the repeater now in wide acceptance is designed for remote power feeding and outdoor construction with the function of centralised supervisory. In the general point of view, therefore, it is of highly reliable system.

(3) Earthing of cable sheath

In order to improve the screening effect, the screening layer will be connected to the earth, where either joint box or repeater is installed, at a distance of 5 ∿ 10 km. The earth resistance will be set at 1 Ω/km or below.

8.4 COMMUNICATION SYSTEM PLAN WITHIN CAR DEPOT

Construction of the new rolling shock center is proposed for operation, storage, inspection and repair of the newly manufactured electric cars under the electrification project between Cairo and Alexandria.

To comply with this plan, telephone service system for management and the communication system (Loud speaker (Talk-Back) system) for various operation such as shunting, accepting or sending the rolling stock at the yard will be provided.

9. DEPOTS AND WORKSHOP

9.1 ROLLING STOCK INSPECTION AND REPAIR SYSTEM

With increse in the distance of travelling, rolling stock tends to reduce its performance efficiency due to creation of wear, deterioration and corrosion on the rolling stock. For this reason it is necessary to try to maintain its performance at the original level by inspecting the condition of rolling stock, replacing the parts and repairing the deteriorated portion after a certain period of travelling.

The category, details and cycles of such inspection and repair for the AC electric rolling stock are specified in Table 9-1 from the actual experiences in Japan. The inspection and repair will be made before either the total time or distance of train running will reach the limit of expiration, thereby insuring fundamentally the safe operation of the train up to the next time inspection. However, for any unexpected occurrence of trouble unperiodical inspection and repair will be made if and when necessary.

Table 9-1 Category, Details and Cycles of Inspection and Repairs

Category	Details	Inspection cycles			
		EMU		EL	
		Intervals time	Running distance	Intervals time	Running distance
Overhaul	Comprehensive inspection and repair parts into detail covering all of a car after dismantling	4 years within	600,000km within	5 years within	600,000km within
Principal equipment overhaul	Inspection and repair over only the principal parts traction motor, bogie, running gear, brake equipment, pantagraph, auxiliary motor, relay, contactor, coupler and meter, etc.) into detail of each part after taken out and dismantling	2 years within	300,000km within	30 months within	300,000km within
Bogie overhaul	Inspection on the principal parts of a bogie (traction motor, axle box, running gear and brake equipment, etc.) after taken out and dismantling	None	None	15 months within	150,000km within
Monthly inspection	Inspection on the operating condition, performance and function of pantograph, super high tension circuit, traction circuit, motor, control circuit, brake equipment, coupler, bogie and meter, etc., in such state as they are set in place	60 days within	30,000km within	60 days within	30,000km within
Daily inspection	Inspection for supplement or replacement of the worn-out parts and over the condition and performance of pantograph, bogie, running gear and coupler (interior equipment and door-operating device for EMU) in such state as they are inplace	48 hours within		48 hours within	

9.2 LOCATION AND GENERAL OUTLINE OF DEPOT AND WORKSHOP

9.2.1 Location of Car Depot

In selecting the site for construction of car depots the factors such as the pattern of transportation, train operation and site condition must be taken into consideration from their general point of view. In particular, the following points must be studied to a considerable depth for determination of the optimum location.

(a) In view of the transportation pattern, the depot must be located near to a large terminal station where many trains will start and arrive.

(b) The optimum size of land for the car depot must be secured without difficulty.

(c) The construction cost must be restrained to a relatively low level.

According to the foregoing rolling stock operation and diagram it is advisable that the car depot should be constructed near Cairo Station serving as the main traffic center, as shown in Table 9-2.

Table 9-2 Number of Rolling Stock in Storage by Districts

Districts	EMU		EL	
	Night	Daytime	Night	Daytime
Cairo	8 trains	4 trains	28 cars	11 cars
Benha			3	4
Tanta				2
Damanhur			3	2
Alexandria	6	4	14	9
Total	14	8	48	28

In Cairo district, the existing Farz diesel locomotive depot and Abu Ghatis passenger car depot are located suitably to meet their purposes. However, since there is no more sufficient space around them and, besides, they will have to remain as the depot in the future as well as at present, the new construction site of the rolling stock center will be selected at the north of Qaluib Station 14 km apart from Cairo.

The proposed site for the Qaluib Rolling Stock Center is good in its condition of location having a large expansion of area. Therefore, the depot will serve as the rolling stock center for all the consistent steps of inspection and repair ranging from the daily inspection to the overhaul of all kinds of electric rolling stock. In fact, however, because of the frequent need to shuttle the train along the platform of Cairo and Alexandria Station, particularly because of frequent coupling and uncoupling works with electric locomotives along the platform, the auxiliary depot will be provided within the station yard of Cairo and Alexandria respectively. By this arrangement the frequency of operating the deadhead locomotives in the Cairo and Qaliub section being restricted largely by its carrying capacity can be reduced.

According to the basic conception as aforestated, the car depot construction has been planned as stated hereunder.

9.2.2 Functional Performance and General Outline of Each Depot

(1) Rolling Stock Center in Qaliub

The proposed depot will serve as the rolling stock center, when completed, with combined function as a mere depot for storage and daily and monthly inspections and as the workshop dealing with a wide range of overhauling of electric rolling stock. Future expansion is also allowed and incorporated into the plan not only for further increase in the number of trains to be operated on the line but also for intented electrification of the existing commuter train in the suburbs of Cairo.

The performance features of the proposed center will be as shown in Table 9-3. The equipment installation plan is stated in detail in the item of 9.4.

Table 9-3 No. of Rolling Stock Allocated in the Center and No. of Rolling Stocks for Inspection and Repair

Item \ Train classification			EMU	EL
At commencement of operation	No. of rolling stock allocated in depot		168 cars (14 trains)	48 cars
	No. of cars for inspection and repair	Daily inspection	10 trains/day	10 cars/day
		Monthly inspection	1 train/day	2 cars/day
		Bogie overhaul	-	24 cars/year
		Principle equipment overhaul	72 cars/year	12 cars/year
		Overhaul	72 cars/year	12 cars/year
Long-range future	No. of rolling stock in depot		600 cars	100 cars
	No. of cars for inspection and repair	Daily inspection	15 trains/day	10 cars/day
		Monthly inspection	2 trains/day	3 cars/day
		Bogie overhaul	-	50 cars/year
		Principle equipment overhaul	200 cars/year	25 cars/year
		Overhaul	200 cars/year	25 cars/year

(2) EL Daily Inspection Depot in Cairo

The daily inspection shed and storage track of the electric locomotive will be provided at the former site of freight storage yard near Cairo Station. All the electric locomotives to be operated in the district of Cairo will be put in storage constantly at this depot to undergo daily inspection (18 cars per day at commencement) and minor repair if necessary. Those locomotives which may require such inspection and repair as may exceed beyond the scope of monthly inspection will be forwarded to the Rolling Stock Center in Qaliub.

Outline of the facilities

22 locomotives on storage track
4 locomotives on daily inspection track

(3) EL Daily Inspection Depot in Alexandria

The daily inspection shed and storage track of the electric locomotive will be provided within the station yard of Alexandria, where the electric locomotives being operated in the district of Alexandria will be put into storage for daily inspection (14 locomotives per day at commencement) and minor repair.

Outline of the facilities

14 locomotives on storage track
2 locomotives on daily inspection

9.3 DRIVERS' DEPOT

The drivers depot will be provided at the Cairo and Alexandria station respectively.

Since the time until shutling of a train at both stations is shortly limited, it is advisable to have the depot for the drivers within or very close to the station yard. There may be no need of providing such drivers' depot at any intermediate station, if the operating diagram can be so formulated as to permit him to go back to either Cairo or Alexandria by driving the another train from the intermediate station.

The accomodation facilities for train drivers will have to be provided at the Qaliub Rolling Stock Center, Benha, Tanta and Damanhur, in addition to those at Cairo and Alexandria station.

9.4 INSPECTION AND REPAIR WORKS

At the Rolling Stock Center and any other local depot, inspection and repair must be made with full accuracy and efficiency on those items covered by various inspection and repair categories as specified in the car inspection and repair system.

9.4.1 Working Process

The flow of inspection and repair work is as shown in Fig. 9-1. It is advisable that each working process should be planned basically in accordance with the following patterns.

(a) Any works of similar nature will be assembled and performed at one same place.

Example: Disassembling and assembling work

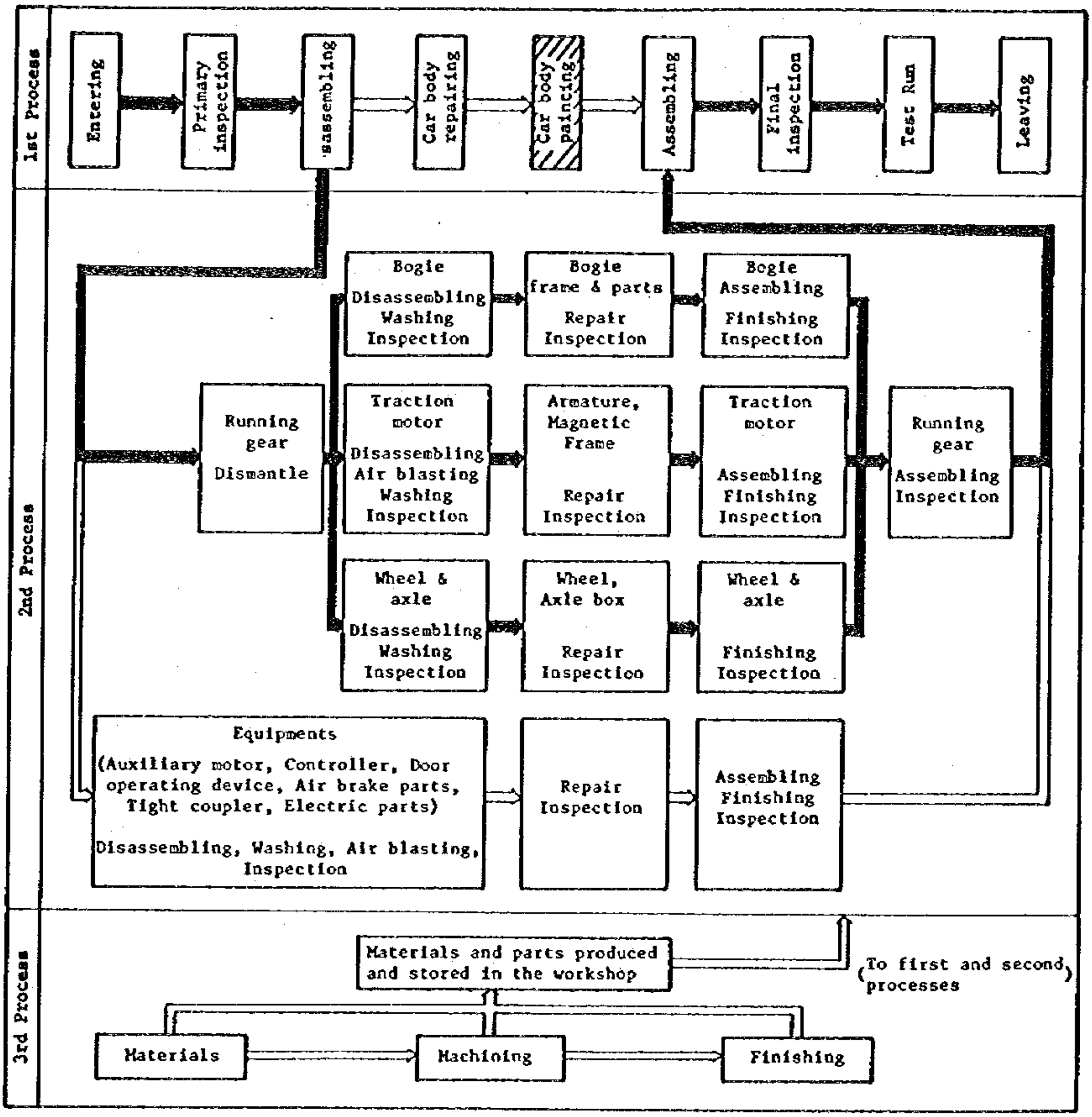
(b) Any works of entirely different nature will be performed separately at each different place.

Example: Repair and painting of car body

(c) The inspection and repair work of identical parts in relatively large quantity and in accordance with the fixed sequential procedures will be handled by the flow line system for improvement of work efficiency.

Example: Inspection and repair of wheel and axle

(d) The stationary process will be adopted for the work diversified into various jobs of identical parts but with small quantity.



(Note) (1) 'Painting' is omitted from the principal equipment inspection.

(2) Flow of EL bogie inspection process is shown by thick arrow lines.

Fig. 9-1 The Flow of Inspection and Repair Works

Example: Car repair, car body painting and bogie repair, etc.

(e) Parts required to secure the work schedule of car repairing, will be supplied by the circulating system of spare parts for replacement, so that peak or offpeak of the work can be levelled out.

Example: Wheel and axle and moter, etc.

(f) The closely interrelated workshops will be coupled into one organic system so as to facilitate closest collaboration, coordination and adjustment between the jobs.

Example: Inspection and repairing shop for bogie, wheel and axle and traction moter

(1) Procedural Working Step for EMU

1) Overhaul

(a) The EMU incoming into the inspection and repairing shop will undergo inspection and check in its make-up formation on the primary inspection track, so that the general condition at entry will be investigated and recorded.

(b) The bogie will be separated from the car body by each one unit of car. The bogie thus removed will be carried to the bogie inspection and repairing shop while the upper car body will be put on dummy bogies and transfered into the car body repair shop by a traverser. After that, all compornent parts will be taken out of the body.

(c) The car body repair work will be done in the stationary state.

(d) Painting on the car body will be done in the stationary state of the car body in the painting shop. It will then be left to the natural drying process.

(e) Wheels and axles and motors will be left out of the bogie in the stationary state. All those components will be delivered to each inspection and repair shop.

(f) The bogie will be dismantled after washing and inspected and reapired.

(g) Inspection and repair of wheels and axles will be carried out on a once-through flow line. Any repair work on a large scale will be done off the flow line at another shop.

(h) Traction motors will be dismantled, cleaned, inspected and repaired. After finish of reassembling, each motor will be tested for confirmation of its performance.

(i) Traction motors, wheels and axles will be reassembled into the bogie at the assembly shop, after completion of inspection and repair.

(j) Electrical and mechanical parts of the rolling stock will finally be checked for confirmation of their performance after going through the process of dismantling, inspection, reapir and reassembling.

(k) The bogie and all the component parts after finish of repair will be fitted up to the car body.

(l) Each car after reassembled will undergo final inspection on the final inspection track. After completion of a train make-up, it will undergo the overall test.

(m) After finish of the overall make-up test as above, the train will be put into test running within the shop yard and then on the main track.

2) Monthly inspection

Function and condition of each component part will be checked nearly in the state as it is, except each equipment will be uncovered.

3) Daily inspection and maintenance

(a) The car will be placed on the inspection track in the state as it is for check on performance and condition of its component parts as well as for supplement or replacement of the worn-out parts.

(b) In order to mitigate the workload within the yard, such maintenance work as cleaning of the car internal and water supply will be finished on the daily inspection track at the time of such inspection.

(c) The external surface of the car body will be washed out by the car washer in formation of the train make-up when it goes out of the depot.

4) Unperiodical inspection and repair

When any trouble occurs on the car during its operation, minor repair will be done in formation of the train make-up. Repair of the bogie or replacement of the other equipment will be made on the unperiodical repair track after uncoupling the car from the train formation.

(2) Procedural Working Step for Electric Locomotive

The electric locomotive will be accepted into the inspection and repair shop by each unit. Although the procedural working steps may be nearly same as in the case of the EMU, except maintenance and cleaning, there are some major points of difference as itemised hereunder.

1) Overhaul

The car body, after being separated from the bogie on the incoming track, will be placed upon the supporting stands for dismantling, repairing, painting and reassembling.

2) Bogie overhaul

The locomotive at entry into the bogie replacement track will be replaced with another stand-by bogies already inspected and repaired after lifting up the car body. The locomotive after finish of replacement with a new bogie will be put into test running for confirmation of performance of its running gear and brake equipment, etc.

3) Unperiodical inspection and repair

Any locomotive fallen into trouble during its operation will be inspected and repaired on the incoming track for the overhaul, if and when necessary.

9.4.2 Work Schedule for Inspection and Repair

In formulating a plan for rolling stock inspection and repair it is most important that the plan should be executed in accordance with the standard work schedule set up in advance for classification of rolling stocks and inspections. The standardized work schedule gives large influence to the train operation plan, inspection and repair facility plan, personnel plan and material plan. Generally, the time length to be required for inspection and repair may differ, by its nature, depending upon the substance and extent of the work for each rolling stock, even though such inspection and repair may fall into the same category, may increase or decrease even depending upon the worker's skill and ability. Therefore, as the normal practice the standard work schedule should be set up solely on the basis of the past experience and actual results and, thereafter, should be improved by shortenning of time length after careful review of the actual result of work to be done by such original schedule and also by accumulated effort for improvement in equipment, working precedure and technical management.

The standard work schedule referred to herein is, therefore, based upon such general conception as aforementioned. It fully reflects the need to level off the quality of work, on the basis of the actual past experience in Japan and the local situation in Egypt. As the result, Fig. 9-2 is given as an example of the standard work schedule for the EMU 12-car make-up train to be entered for inspection and repair. Fig. 9-3 is another example of the advanced standard work schedule for the EMU-make-up on an improved basis of 1.5 and 2 times of repairing capacity, both of which are drafted specifically for the purpose of calculating any possible expansion for future provision with anticipated increase in the number of trains. Fig. 9-4 is an example of the standard work schedule for the electric locomotive.

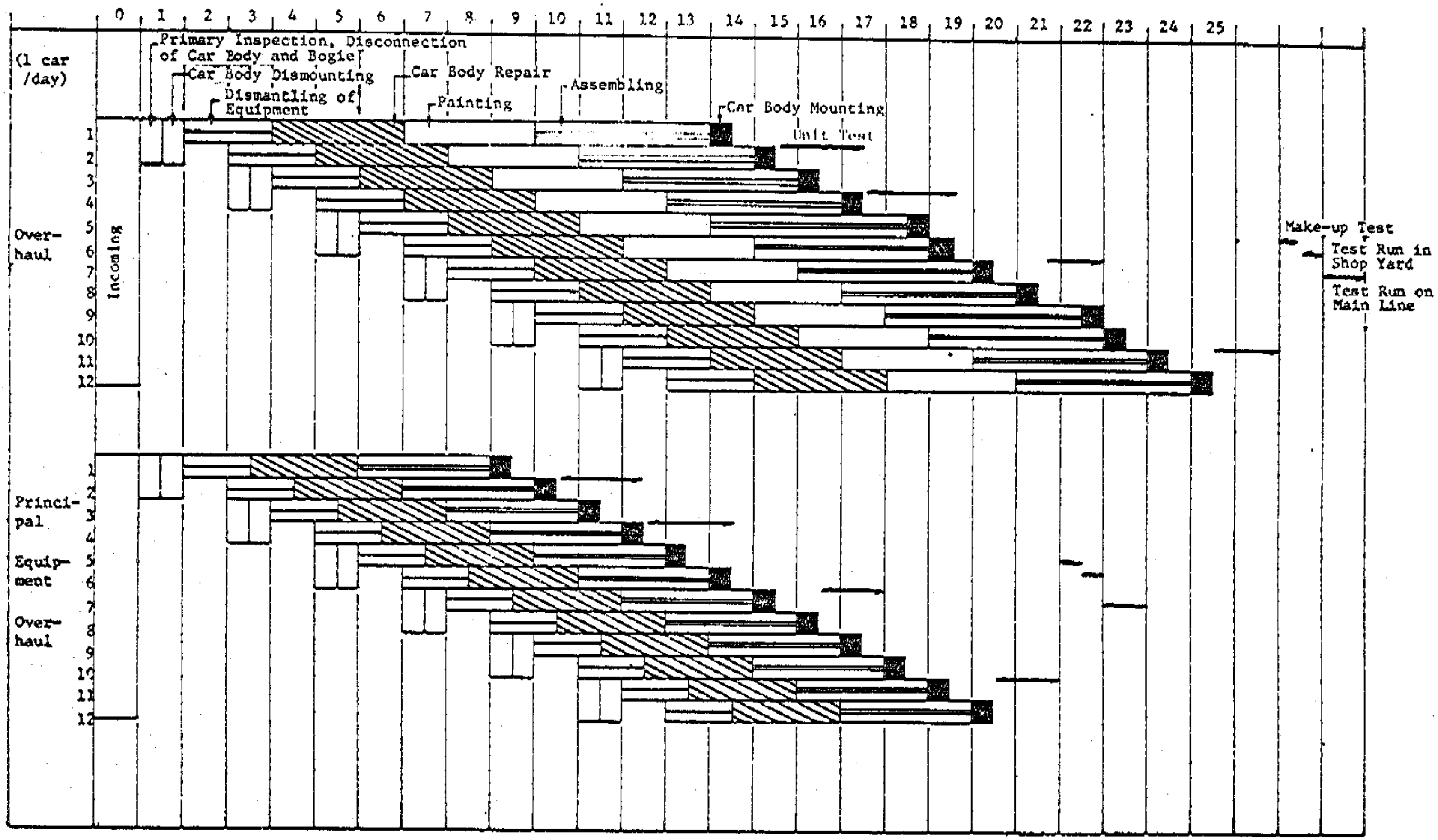


Fig. 9-2 Example of Standard Schedule of EMU Inspection and Repair Work

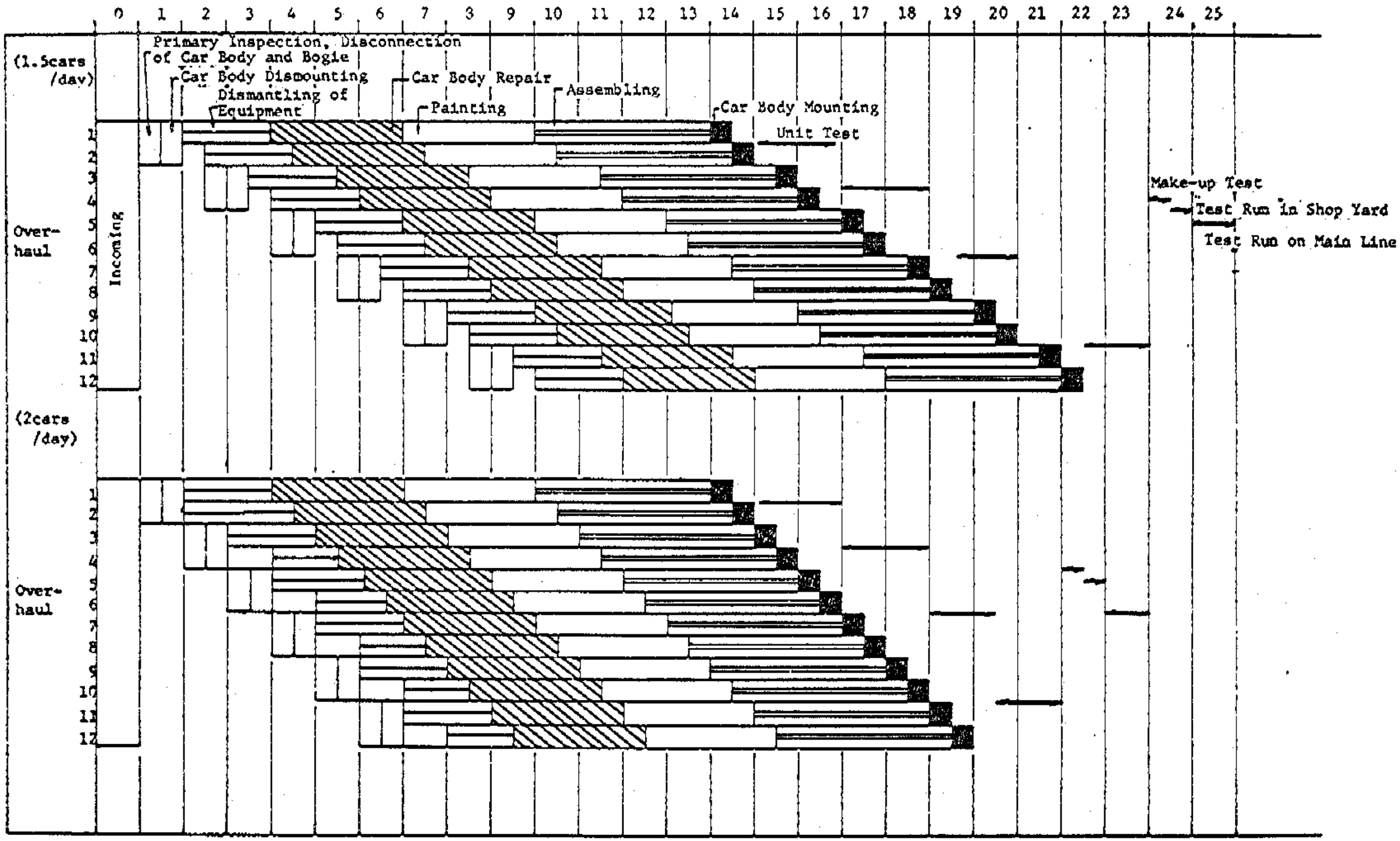


Fig. 9-3 Advanced Examples of Standard Schedule of EMU Inspection and Repair Work

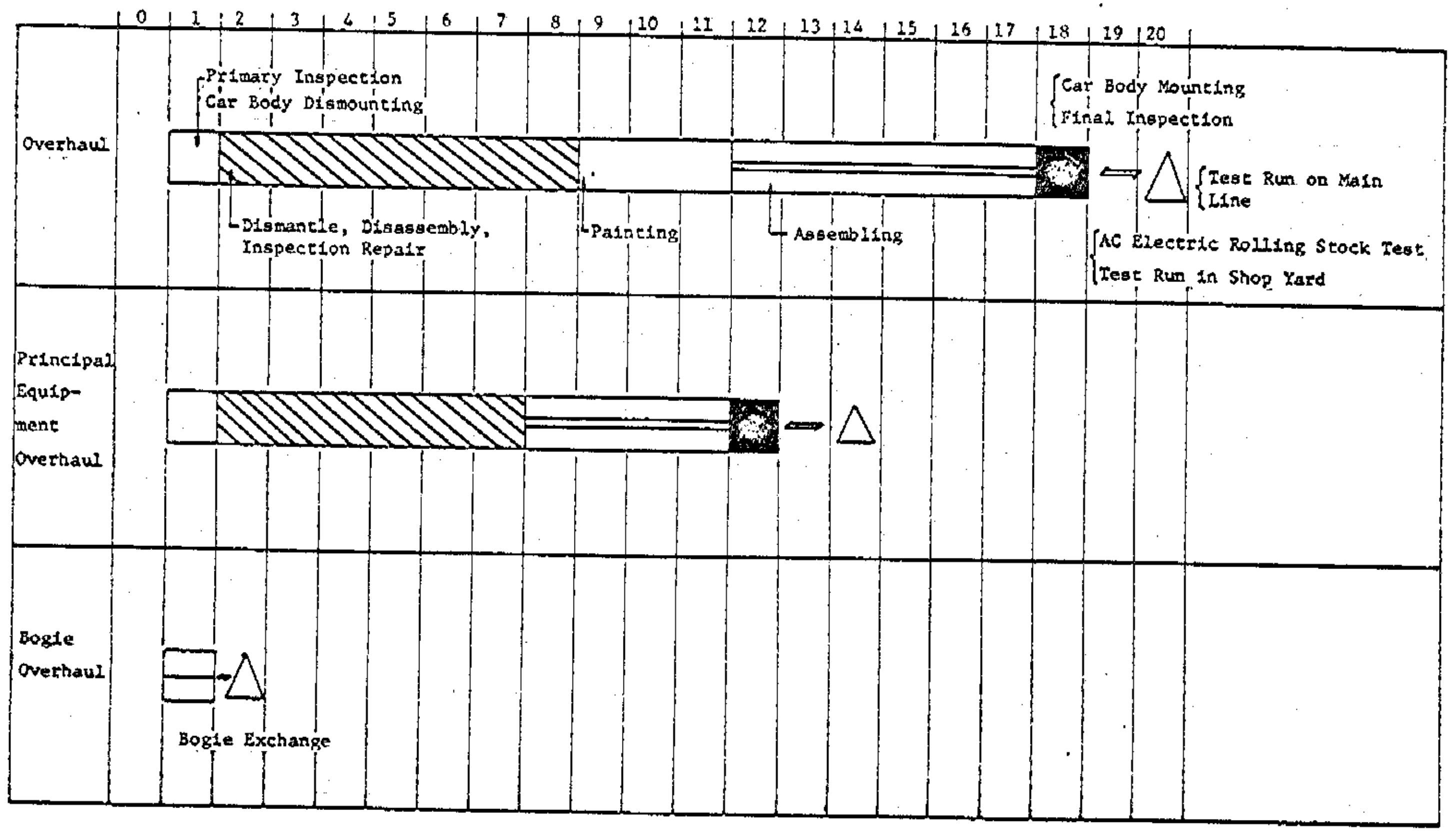


Fig. 9-4 Example of Standard Schedule of EL Inspection Inspection and Repair Work

9.5 INSTALLATION PLAN FOR QALIUB ROLLING STOCK CENTER

In formulating the plan for construction of Qaliub Rolling Stock Center, full consideration must be given to the increased length of train make-up, the probable increse in the number of train and the conversion of the existing commuter train into the electric car system in the suburbs of Cairo, as the result of the increase in total traffic volume.

9.5.1 Track Layout within Yard

Since the train to be accepted into the Center may be classified into EMU and EL, the whole yard will be divided largely into those two types of train. Track layout will be such arranged that the work can be performed in a very efficient manner by functionally interconnected tracks of different service groups, such as for accomodation, maintenance and inspection and repair.

For the EMU train, the track layout will be made so as to permit the smoothful procedural steps to be taken by daily inspection, cleaning and monthly inspection without disbanding of its make-up formation.

Any inspection work which requires overhauling beyond the level of bogie inspection will be carried out in parallel by use of each own line so that the work for both EMU and EL may not be interfered by each other.

On the basis of such principle as above, the track layout is planned as follows.

(1) Access Track

The access track will be provided by extension of double track (incoming and outgoing) from the arrival and departure track at Qaliub Station and connected to the EMU storage track and passage track.

(2) EMU storage track

The storage track will be interconnected directly with the access track, inspection and repair tracks.

The effective length of the track will be of such sufficient length (350 m) as can accomodate a 14-car make-up train in the future.

(3) Daily and monthly inspection track; and primary and final inspection track for EMU.

The track will be of sufficient length to accomodate one complete make-up train and have the shed.

(4) Unperiodical repair track

The track is neighboured to the primary and final inspection track and is of sufficient length for one complete make-up train.

(5) Make-up replacement track

The make-up replacement track will be provided within a group of the storage tracks in order to facilitate replacement of train make-up if and when necessary.

(6) Test run track

The track will be provided to carry out the running test within the yard after finish of repair work.

(7) Wheel Milling Track

For the time being, the wheel cutting work can be done by the spare capacity of the wheel lathe in the wheel and axle shop after dismantling the wheel and axle. In the future, however, such work will preferably be done by using the wheel milling machine without dismantling. The space will be secured for such future provision.

(8) EL storage track

The storage track will be linked to the access track through the passage track. Each track can accomodate two locomotives so that any sequential change of operation can be readily made.

Track layout will be such arranged that each locomotive can be operated, irrespective of the other one, to pass through the procedural steps of in-and-out, daily and monthly inspections.

(9) Daily and monthly inspection tracks for EL

Inspection tracks with installation of the shed will be neighboured to the storage track.

(10) EL repair track

The track with installation of service sheds for overhauls will be connected to the storage track.

Fig. 9-5 shows the outlined track layout drawing in the Qaliub Rolling Stock Center.

(App. Fig. 7)

9.5.2 Inspection and Repair Facilities

The track layout of inspection and repair facilities is planned as shown in Table 9-4 and Fig. 9-5, taking into account the work volume at the time of commencement and in the future as estimated from the rolling stock operation on the basis of the foregoing train operation plan, together with the method of inspection and repair as aforesaid.

The outlined plan of major workshops is as stated hereunder.

(Table 9-6)

(1) Electric Multiple Unit (EMU)

1) Daily and monthly inspection facilities

The facilities will include the inspection pit for underfloor equipments, the inspection deck for roof equipments and the lifting deck. In addition to those, the appurtenant facilities will be provided to serve for the maintenance work such as cleaning and water supply.

2) Unperiodical inspection and repair facilities

a. The bogie replacement track will be provided with the inspection pit, drop pit jack and overhead crane for replacement of the bogie.

b. The repair track will be provided with the overhead crane and the deck for replacement of roof equipments, the pit for piping and the electric arc welding machine for small welding job.

Table 9-4 Track Layout of Qaliub Rolling Stock Center

Track	At commencement (1984)	Long-range future
Access	2 tracks	2 tracks
EMU storage	350m × 8 tracks	350m × 15 tracks 250m × 10 tracks
Draw-out	350m × 1 track	350m × 1 track
Replacement	350m × 2 tracks	350m × 2 tracks
Passage	1 track	1 track
Daily & monthly inspection	350m × 3 tracks	350m × 6 tracks
Primary and final inspection for repair	350m × 2 tracks	350m × 3 tracks
Unperiodical repair	350m × 2 tracks	350m × 2 tracks
EL storage	60m × 2 tracks	60m × 9 tracks
Daily & monthly inspection	60m × 2 tracks	60m × 2 tracks 30m × 2 tracks
Repair	150m × 4 tracks	150m × 4 tracks
Test run	1000m × 1 track	1000m × 1 track
Wheel-tread milling	-	700m × 1 track

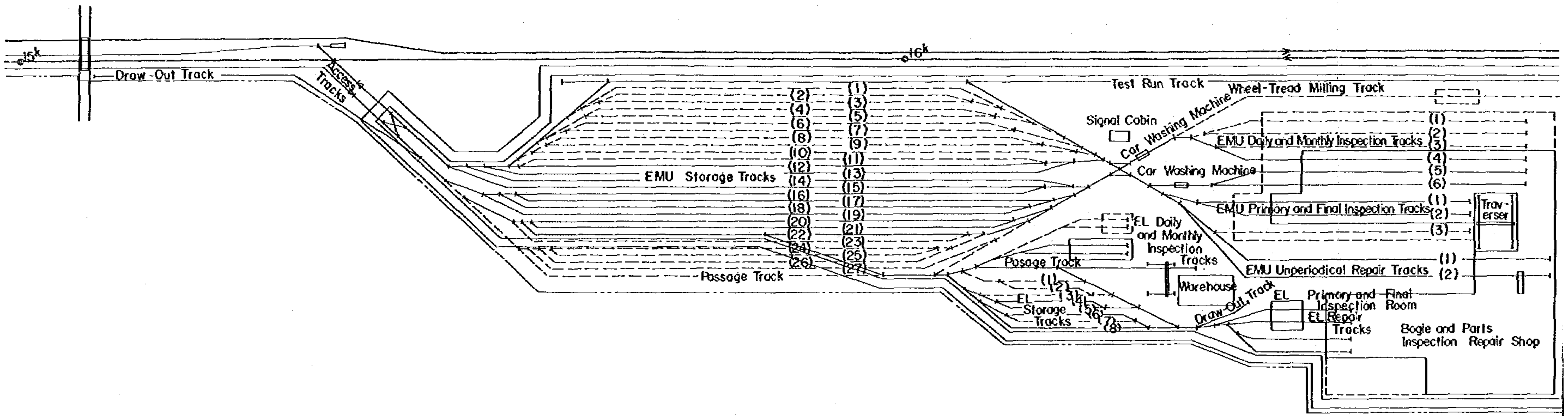


Fig. 9-5 Layout of Tracks in Qaliub Rolling Stock Center

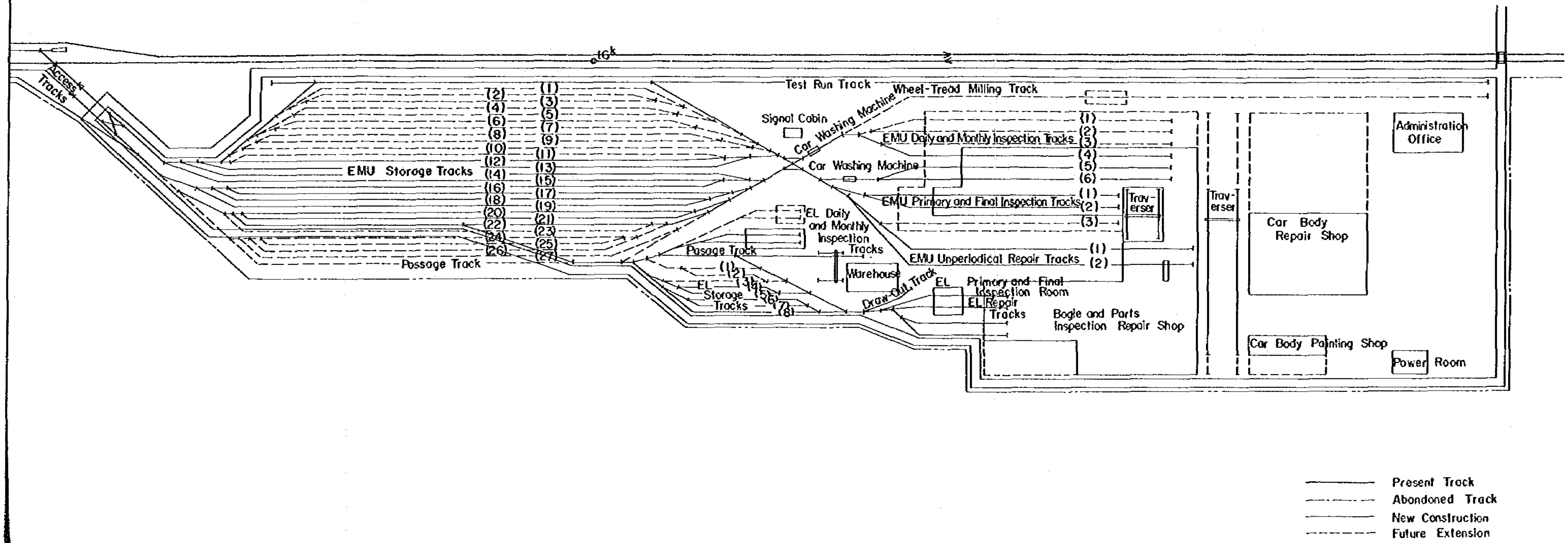


Fig. 9-5 Layout of Tracks in Qaliub Rolling Stock Center

3) Overhaul facilities

(a) Primary and final inspection shop

The primary and final inspection track will be provided with the inspection pit for underfloor equipments and the inspection deck for equipments on the roof.

(b) Car body lifting and lowering shop

The car body lift shop will be located close to the primary and final inspection shop through a traverser for transfer of a car body and dummy bogie to the neighbouring track. The tracks of the shop are also linked to the car body repair shop through another traverser. One track for dummy bogies will be installed in parallel with those aforesaid tracks. An overhead crane will also be provided for jointing or disjointing of the car body and the bogie and for moving of the car body and the bogie.

(c) Car body repair shop

The accomodating capacity will be 12 cars on 6 track lines (2 cars per each line). The building of repair shop contains also the other shops directly associated with the disassembling and assembling work and the repair work of car body, such as electric parts, air brake equipments, sewing and piping shops.

(d) Car body painting shop

The accomodating capacity will be 4 cars on 2 track lines (2 cars per each line). The shop will be located close to the car body repair shop so that the car body can be transfered to the neighbouring shop by traverser.

(e) Bogie, wheel and axle and motor repair shop

The shop for disassembling or assembling of the bogie will be provided at extension from the car body lifting and lowering shop. Around this shop as the center, each parts repair shop for bogie, wheel and axle and traction motor will be arranged.

(f) Iron work and machine shop

The shop will be located in proximity to the bogie, wheel and axle and motor repair shop, centralising the iron work including cutting, bending of steel plate, welding and padding and repair work of coupler, and the machine work of car component parts.

(2) Electric Locomotive (EL)

1) Daily and monthly inspection facilities

The inspection track will be provided with the inspection pit for underfloor equipments, inspection deck for equipments on the roof and lifting deck, etc.

2) Unperiodical inspection and repair facilities

The unperiodical inspection and repair will be made by use of the facilities for the overhaul as stated later.

3) Bogie overhaul facilities

The bogie replacement track will be provided with the overhead crane and bogie pit for replacement of the bogie.

4) Overhaul facilities

(a) The shop-in-and-out track will be provided with the overhead crane and the pits for jointing or disjointing of the car body and bogies and overhauling of the bogie.

(b) The shops for car body and bogie repair will be located at the extension from the shop-in-and-out track. The bogie repair shop will be provided with the overhead crane for repair and transportation.

(c) Since the EMU facilities will be utilised to the possible maximum for inspection and repair work of rotators, wheel and axle of the locomotive, these shops for the electric locomotive will be located close to those for the EMU.

(d) The iron work and machine work will be done by joint use of the EMU facilities.

(e) The primary and final inspection room will be provided with the pits and deckes to make necessary adjustment for the test run of the electric locomotive.

(3) Others

1) Power room

The power room will be equipped with the electric power receiving and distributing equipments, air compressor and boiler to supply electricity, compressed air, steam and water for this Rolling Stock Center.

2) Material warehouse

The warehouse will be equipped with the necessary equipments for receiving, storing, and delivering of spare parts and other materials for car repair.

3) Others

The administrative office will be installed.

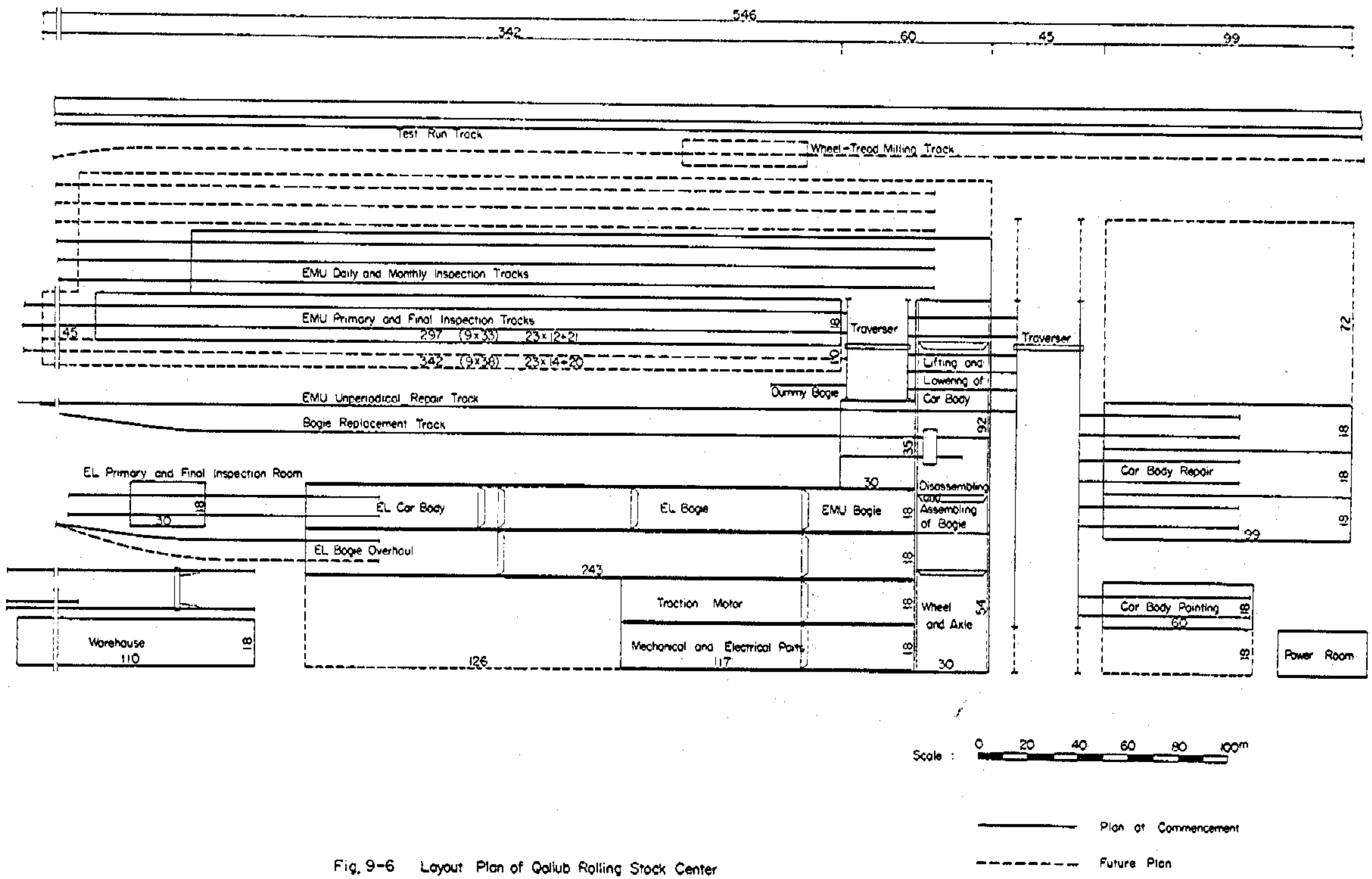
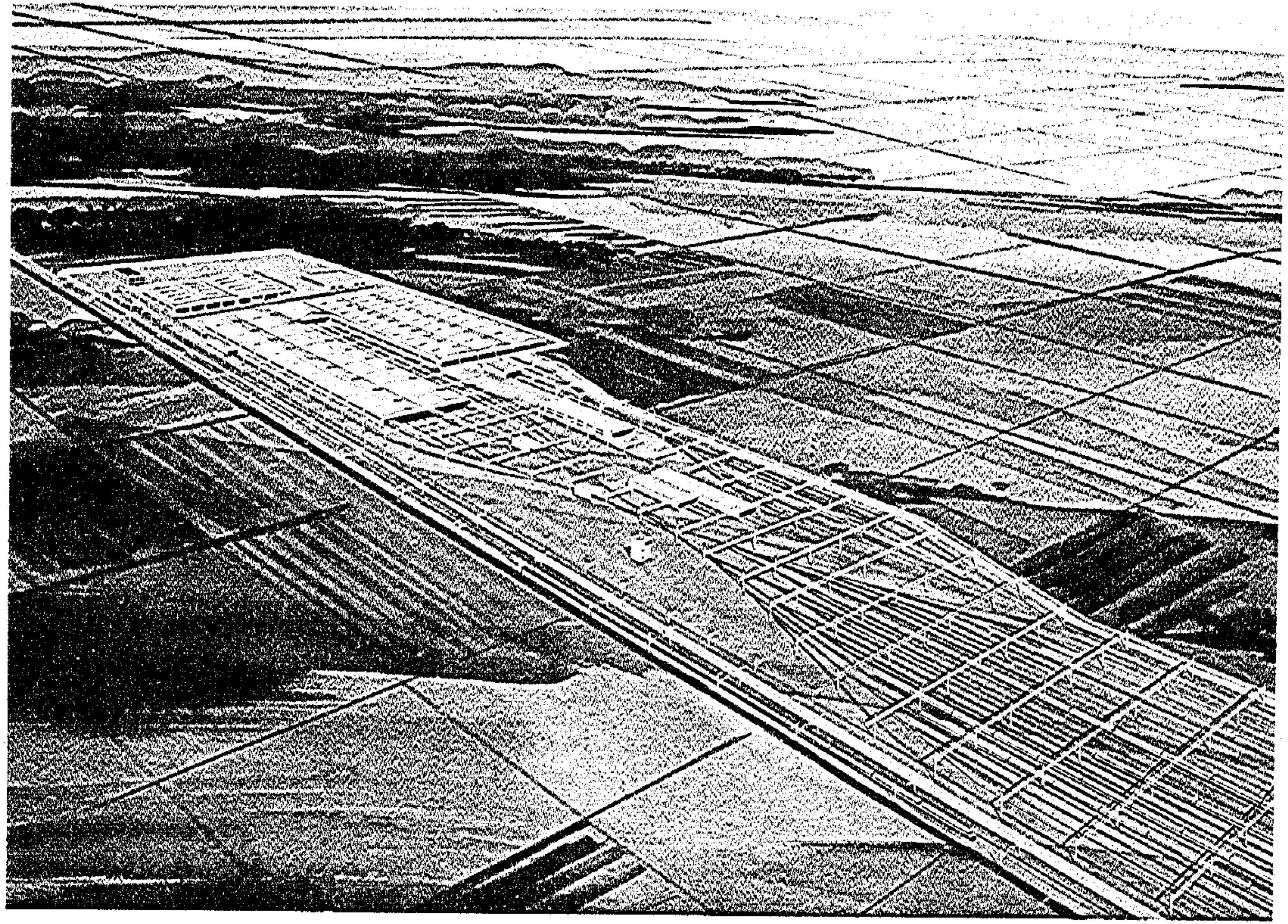


Fig. 9-6 Layout Plan of Qaliub Rolling Stock Center



Qaliub Rolling Stock Center

Table 9-6 Contents of Major Work and Main Equipment by Workshop

Workshop	Major works	Main equipment	Remarks
Daily and monthly inspection depot	Daily and monthly inspection	* Car washer equipment, others	Both for EMU and EL
Bogie replacement and unperiodical repair	Trouble car repair	* Drop pit-jack, Overhead crane, Electric arc welder	For EMU
Bogie overhaul	Bogie replacement	Overhead crane	For EL
(Overhaul) Primary and final inspection	a. Primary inspection, car body lift-up preparation b. Assembly adjustment and final inspection	* Car wiring testing machine Air brake testing machine, others	Equipment marked * is for EMU, others, for EMU and EL.
Car body lifting and lowering	a. Car body lift-up and down	Overhead crane * Traverser * Dummy bogie transferring machine	" "
Car body repair	a. Mantle and dismantle of overroof and underfloor equipments b. Inspection and repair of car body c. Piping of car body, inspection and repairing of wiring	* Equipment for mantling and dismantling and carrying underfloor equipments Piping processor, Electric arc welder Monorail crane	" "
Car body painting	a. Cleaning and washing of outside and interior of car body b. Painting preparation and painting of car body	* Painting unit Ventilator	For EMU
Bogie repair	a. Disassembling, repair, assembling and inspection of running gear b. Disassembling, repair, assembling and inspection of bogie	Overhead crane, Bogie and parts Washing machine, Magnetic detector	Both for EMU and EL
Wheel and axle repair	a. Disassembling, repair, assembling and inspection of wheel and axle b. Disassembling, repair, assembling and inspection of axle boxes	Overhead crane, Washing equipment Press and lathes for wheel and axle	" "
Traction motor repair	a. Disassembling, repair, assembling and inspection of main motor, auxiliary motor and electric compressor	Overhead crane, Electric insulation testing unit, Armature lathe, Rotating test unit, others	" "
Electrical parts repair	a. Repair and inspection of electric equipments	Test equipment for high voltage equipment and control equipment, Rectifier testing unit, Pantograph inspection equipment, others	" "
Air brake parts repair	a. Repair and inspection of air brake parts	Parts testing units, Cleaning unit	" "
Other	a. Repair and inspection of coupler b. Manual finishing and painting of sliding doors, hinged doors, windows, interior parts, etc. c. Repair of seats d. Mechanical processing of parts e. Forging, sheet metal processing, welding f. Repair of shop tools and facilities	Coupler inspection and repair unit Door operating device inspection and repair unit Mechanical processing machines Air hammer, Heating furnace, Electric arc welder Steel plate processing machines	" "
(Others) Power room	Power supply	Electric power source unit, Compressor, Boiler, Water supply pump, others	
Material warehouse	Stock and supply of inspection and repair materials	Carrying equipment, others	

10. TRACK AND CIVIL WORK CONSTRUCTION

10.1 STRUCTURE GAUGE

The new structure gauge after addition of the current collector is determined as follows with due consideration to the UIC Code and the Japanese National Railways standard.

The clearance from the existing maximum loading gauge (4,620 mm) to the contact wire will be maintained at 330 mm minimum and 530 mm standard. The required height for the suspending unit of the contact wire will be set at 1,500 mm standard but reduced to 1,000 mm when the compound catenary would be used. The insulating clearance to the structure will be set at 300 mm.

Accordingly, the normal structure gauge will be set up at 6,950 mm from the top surface of rail. And, at the over bridge or the like, it is reducible to 6,250 mm by taking possible minimum clearance to the contact wire and also by using the wire suspending unit of reduced size. For the existing over bridge of a small width the clearance may be further reducible to 5,750 mm by setting the middle of the suspension points at that position. The lateral gauge for the current collecting until will be set at 2,600 mm on the basis of the vehicle gauge newly set up. All as aforementioned are shown in Fig. 10-1.

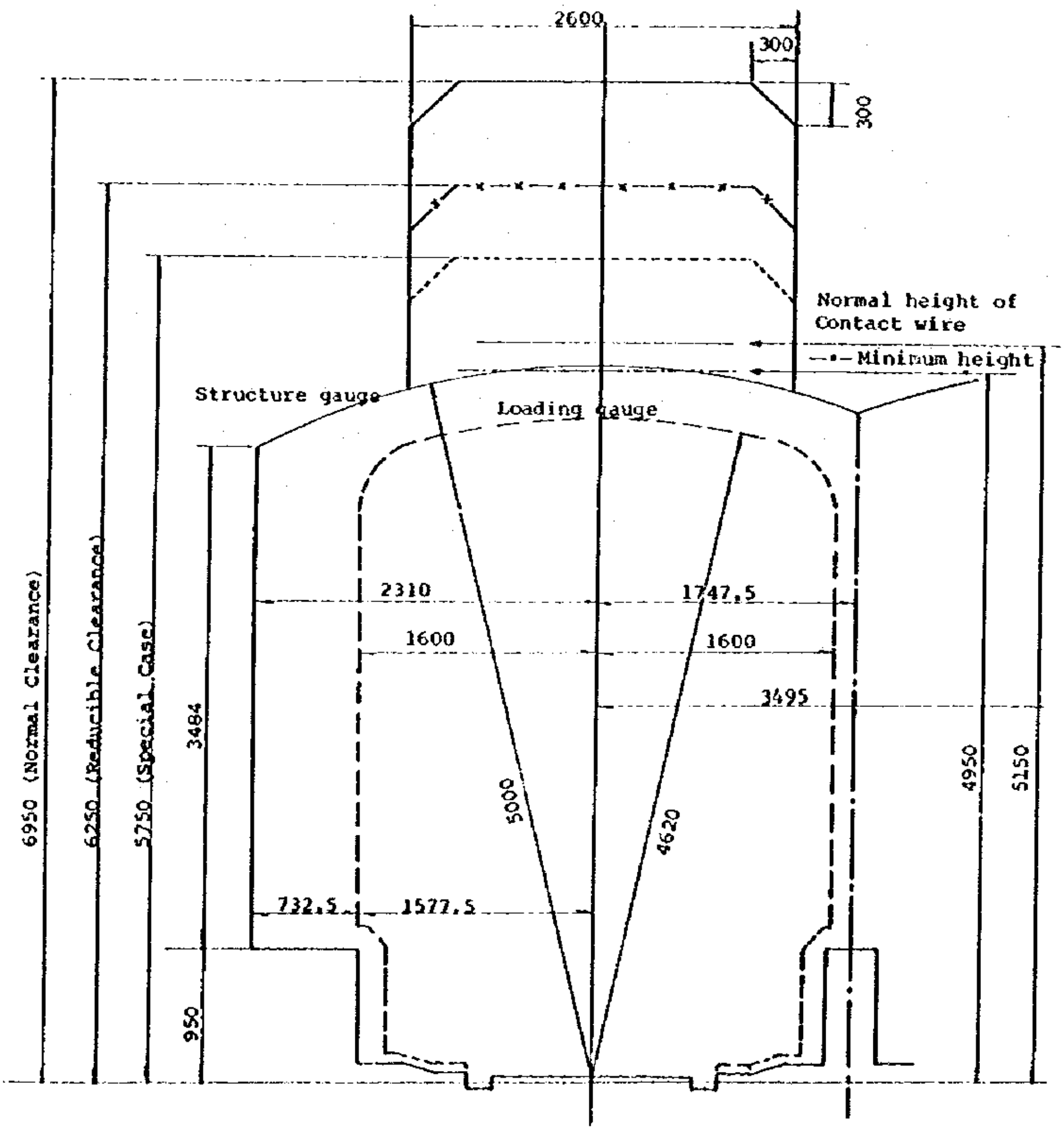


Fig. 10-1 Structure Gauge

10.2 TRACK STRUCTURE

Deterioration in quality of the track depends largely upon the axle load of the passing train, the frequency of train operation and, furthermore, the running speed of the train. According to the train operation plan after completion of electrification under the proposed project, it is anticipated that the frequency of train operation and the frequency of repeated wheel cycling due to prolonged length of the whole train make-up will be increased though there may be no difference in wheel load. Since the maximum train speed is planned at 160 km per hour, further increase in track irregularities is also anticipated.

Today, the Egyptian Railways are pushing forward the project to strengthen the track between Cairo and Alexandria aiming at completion by 1981. When completed, it will certainly become the essential condition to further demonstration of the effect from electrification.

The track structure now under way for strengthening is as shown in Table 10-1 and is of sufficient strength enough to serve as the track for the high speed electric operation. However, in order to bear the maximum allowable speed of 160 km per hour after completion of electrification, full maintenance care will be needed. With regard to the speed limit to be put on the straight side of turnout, there are two ideas. One is that the ordinary type turnout should be placed under the speed restriction and replaced with the swing-nose crossing for high speed, and the other is that the ordinary type turnout may be kept free from any speed restriction.

In the case where the ordinary type turnout may be used without speed restriction, full maintenance care must be paid to the turnout.

Table 10-1 Track Structure

Design features	
Max. allowable speed	160 km/H
Frequency of operation (at commencement)	Single way 150......Section of most frequent operation 60~80.... Other section
Axle load	EL 22 ton EMU 15 ton
Track structure	
Rail	UIC 54 kg/m or 52 kg/m to be considered to convert to long welded rail.
Tie	PC with K fastener and wooden tie Quantity: 1,556 ~ 1,722/km
Ballest	Crushed stone About 300 mm from tie bottom

10.3 OBSTRUCTIVE STRUCTURE AND IMPROVEMENT PLAN

10.3.1 Over Bridge

As stated in the foregoing item, the electrification entails an enlargement in the structure gauge due to installation of the current collector. In the consequence, the line will be obstructed at its overhead clearance by existence of foot bridges, highway overbridges and signal towers. Of all those obstructions, the footbridge and the signal tower can be rebuilt to secure adequate clearance because they are of rather simplified construction, while the highway overbridge would require a great deal of time and cost for reconstruction and cause some traffic inconvenience because of its large size structure. Therefore, for most of the existing highway bridges it is advisable that adequate clearance should be maintained by lowering down the subgrade of railway though alignment may turn into somewhat undesirable shape. Table 10-2 shows the method of taking clearance to the over bridges.

Table 10-2 Over Bridge Clearance

Name of bridge	Km	Clearance from rail	Description
Abu Ghattes foot path	1.372	5.40 (m)	Reconstruction
El Tawdeeb foot path	4.946	5.00	Reconstruction
High way Road Bridge	26.500	5.03	Subgrade down
Tokh foot path	33.100	5.00	Reconstruction
Etyal El Barud foot path	121.949	5.26	Reconstruction
Damanhur New foot path	147.077	5.05	Reconstruction
- " - foot path	147.265	5.38	Reconstruction
- " - Road Bridge	147.330	5.13	Reconstruction
- " - foot path	147.532	5.035	Reconstruction
- " - New Road Bridge	148.429	5.00	Subgrade down
Abu Hummns foot path	163.730	5.12	Reconstruction
Kafr El Dawar foot path	180.737	5.12	Reconstruction
Kafr El Dawar New Road Bridge	184 km	about 5.00	Subgrade down
El Hadra Road Bridge	205.800	4.83 4.90	Reconstruction

10.3.2 Movable Bridge

As shown in Table 10-3, there are eight (8) movable bridges between Cairo and Alexandria, seven (7) out of which are swing bridges and the remaining one (now under construction) is a lift bridge. The Shubra and Kobry El Dalgamm swing bridge will shortly be reconstructed as lift bridges.

Of those bridges, Benha Nile and Kafr El Zaiyat Nile are truss bridges and all the remainders are girder bridges. Those truss bridges have sufficient clearance of 6.24 m and 6.51 m respectively, from rail surface to top chord member, for erection of the overhead catenary without any difficulty. However, the movable portion will be of special construction as explained in the preceding item 6.4.4.

It is stipulated that the required minimum of clearance to the movable portion of a bridge should be maintained at 8 m from the H.W.L. Since under this provision most of the movable bridges would fail to secure a clearance of 8 m between the catenary and the H.W.L., the bridge must be designed for such special catenary construction as referred to in the preceding Chapter 6 - Item 4.

There are two alternative types of rail joint between the fixed and movable portions of the bridge; one is to use the ordinary type joint with insertion of the short-cut rail for adjustment in a joint gap and the other one is to use the same joint construction as used for the ordinary section with installation of an expansion joint on one side for adjustment of gap. In view of the intended purpose of electrification for increase of running speed and frequency of trains, it is preferrable to adopt the expansion joint type which can completely cover the weak point of the track.

Table 10-3 Movadle Beidges

Name of bridge	Km	H.W.L. (m)	R.L. (m)	Description
Shubra Swing Bridge	5.480	15.85	21.26	Rebuilt as lift bridge
Benha Lift Bridge	44.490	12.55	15.53	
Benha Nile Bridge (SW)	46.654	15.02	17.27	
Birket El Sabar Swing Br.	66.079	10.76	13.71	
Kobry El Dalgamun Sw. Br.	101.572	7.30	10.80	Rebuilt as lift bridge
Kafr El Zayiyat Nile Br.(SW)	104.550	9.50	11.65	
Khandak El Sharki Sw. Br.	108.858	8.23	10.10	
Hagar El Nawatia Swing Br.	200.850	1.95	6.33	

10.4 IMPROVEMENT OF STATION YARD

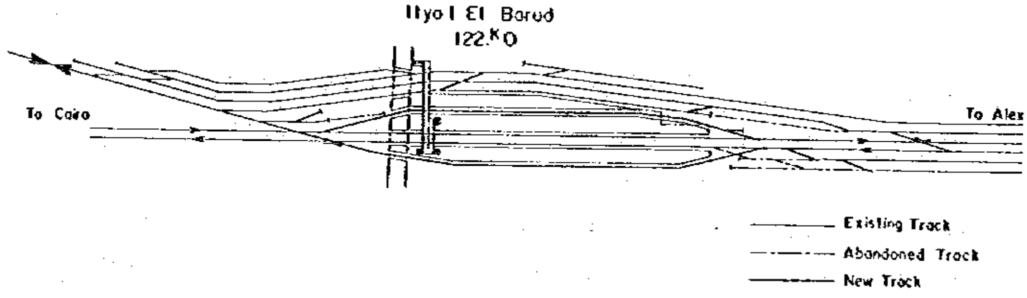
The electrification project will be carried out on a precondition that the existing track installation should be utilized most effectively to the possible extent but will require, at least, improvement of the following facilities.

(1) New installation of refuge track

New installation of refuge track will be required to permit smooth operation of trains at higher speed and in increased number.
Such track will have to be installed at Ityal El-Barud (up and down tracks) and Abu-Aummus (down track only). Fig.10-2

(2) New installation of EL. Storage track

Electric locomotive Storage tracks will have to be newly installed, together with the daily inspection tracks, to keep the electric locomotive stay at the former freight yard adjacent to the present diesel locomotive depot within the compound of Cairo Station.
For the purpose of shunting the electric locomotive for the train going into the branch line or the terminating train at any intermediate station, the storage tracks will have to be installed at



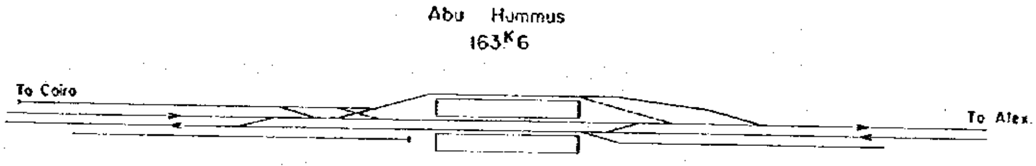


Fig 10-2 Track Layout of New refuge Tracks

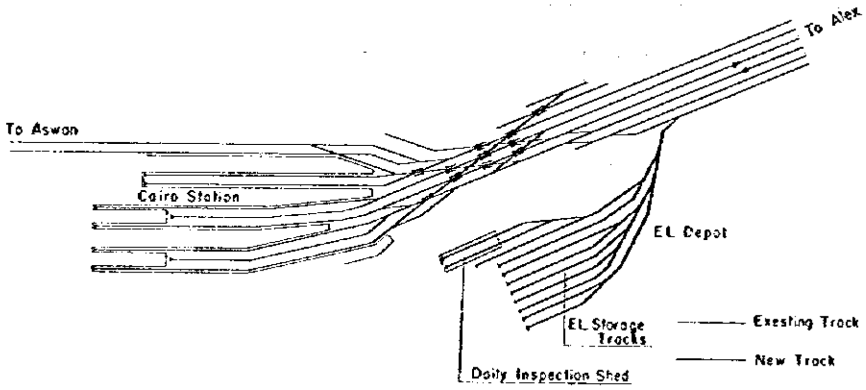


Fig 10-3 Layout of Tracks in Cairo EL Depot

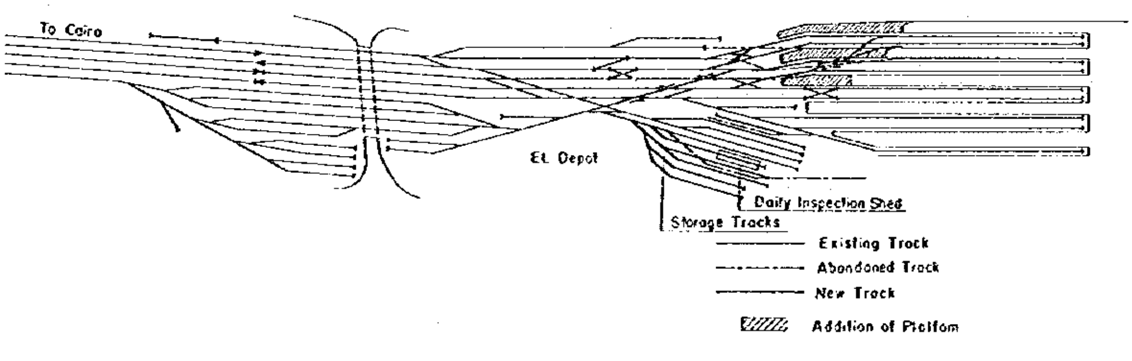


Fig.10-4 Layout of Tracks in Alexandria Station Yard

such intermediate stations as Benha, Tanta and Damanhur. As a matter of fact, however, the existing track will be utilized for this purpose in so far as it is possible.
For Alexandria as the terminal station the daily inspection track and El Storage tracks will be newly installed as the result of the station yard improvement. Fig.10-3

(3) Effective length extension of departure and arrival track at Alexandria Station

There are now nine (9) tracks existing for departure and arrival at Alexandria Station. Since there are very few numbers of track for possible departure and arrival of EMV as planned at the initial stage of commercial operation, the effective length should be extended in anticipation of future increase in train make-up. Fig.10-4

11. CONSTRUCTION PLAN

11.1 ESTIMATION ON CONSTRUCTION COST AND ROLLING STOCK COSTS

Estimation of construction and rolling stock costs has been made on the basis of the prevailing prices and wage in Egypt as well as with due regard to the actual cost on the previous similar projects in Japan.

(1) Civil work construction cost

Rail, turnout and other accessories will be off-share purchased. Any rail to be produced during renewal work of rail will be reused for EL Storage track construction or others.

(2) Electrical Construction Cost

1) Electrical facilities for substations and wire and hardware for catenary system will be off-shore purchased.

2) The majority of signal and telecommunication facilities will be off-shore purchased.

3) The cost does not include any installation cost of the lead-in transmission line of the substation.

4) All construction machine and equipment will be procured in Egypt. The greater portion of the installation work and the construction work will be performed by the Egyptian engineers and workers.

(3) Mechanical work cost

All the mechanical instruments for inspection and repair of rolling stock will be off-shore purchased.

(4) Rolling stock

All the electric motor vehicle will be off-shore purchased.

(5) Others

All the off-shore purchased goods are priced on the C.I.F. basis in 1979. The cost does not include any future possible price escalation. The exchange rate is set at 1 US$ = 0.7 L.E = 200 yens. (As of the beginning of 1979)

The off-shore purchase price includes duties and taxes.

Table 11-1 shows the estimated construction and rolling stock costs. It should be noted that the construction cost as estimated herein refers only to the initial investment cost at the time of completion, not including any additional investment thereafter.

Table 11-1 Estimated Construction and Rolling Stock Costs

(Unit: Million LE)

Item	Sum
Land acquisition	9.7
Civil work (including building)	16.0 (3.3)
Substation	33.3 (32.2)
Catenary system	78.8 (46.1)
Signal and telecommunication	12.4 (11.5)
Mechanical	18.2 (17.7)
Rolling stock	138.5 (131.0)
Design & supervision	13.1 (9.4)
Total	320.0 (251.2)

( ): Requoted foreign currency portion

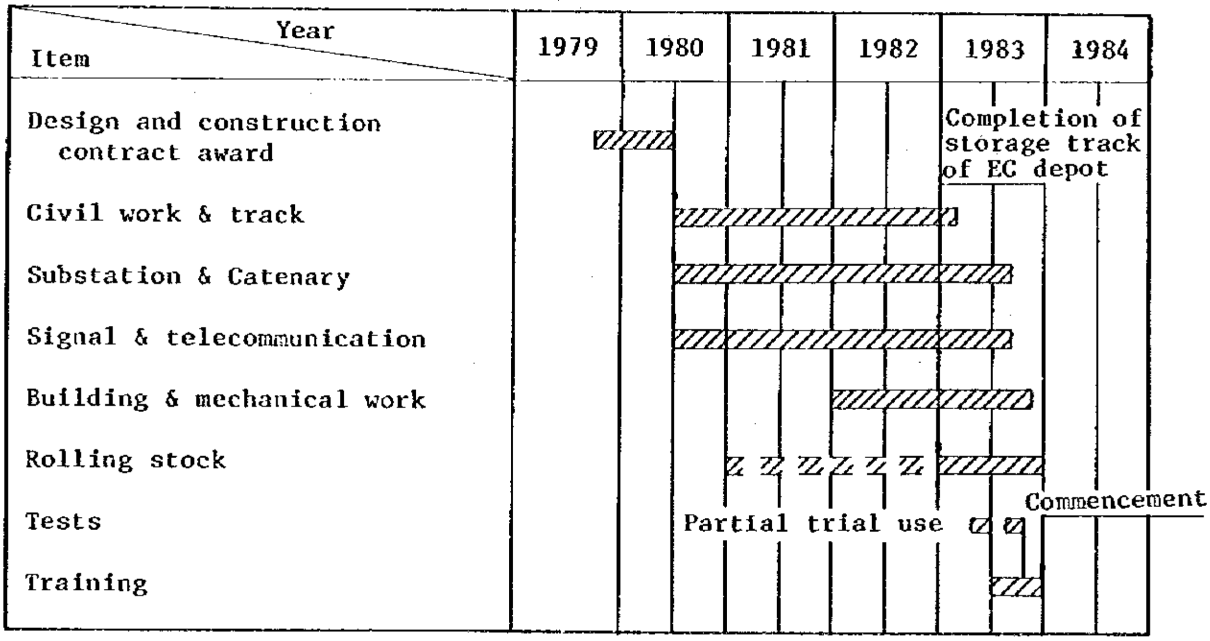
* Required land area: Car depot about 273,000 m^2
Substation & others about 53,000 m^2

11.2 CONSTRUCTION SCHEDULE

In principle, the construction schedule is so planned that the whole railway line will be put into initial commercial operation at the same time. In reality, however, the construction work will be planned on the condition that a part of the whole section should be put into trial use in advance for the purpose of training the operation and maintenance personnel.

The construction schedule will be set up as shown in Table 11-2.

Table 11-2 Construction Schedule



The following considerations must be paid to the items of work related to the electrification project.

11.2.1 Civil Work

The civil work which should require the longest time for completion will be the construction work for Qaliub Rolling Stock Center. Large expantion of area will require huge volume of embankment and long extension of track, which may give a vital influence upon the whole work progress. Full care must be taken for control over the construction schedule.

11.2.2 Electrical Work

For overhead catenary construction, the supporting structure will be, first of all, constructed in sequent order starting from the section where the work can be proceeded with without any difficulty.
In this manner, the catenary erection will be completed in two years after completion of the supporting structure construction work.

11.2.3 Tests

After completion of the construction, speed improvement test and other various tests including aging will have to be carried out for electrical facilities and equipment in the depot.

A - Ground tests

a) Code transmission characteristic test of remote control system for substation.

b) Energizing test of substation

c) Measuring of feeding circuit constant

d) Overhead catenary system dielectric strength test

e) Feeding test

f) Measuring of track potential

g) Measuring of telecommunication line inductive potential

h) Measuring of electrostatic inductive potential

i) Radio noise test

B - Tests on the car

a) Structure clearance test

b) Pantograph running test

c) Electric traction test (Locomotive)

d) Electric traction test (Multiple unit)

11.2.4 Trial Operation for Trainig

In order to reduce the operational problems after opening of electrification and to maintain the train operation constantly in the normal condition, the training prior to commencement of the electrified operation must be provided for train operating crews and maintenance workers to make them fully familiarized with new techniques of operation and maintenance. The required period for training will be six (6) months.

From the overall construction schedule it is estimated that the time to be required for completion of the whole project will be four (4) years and half.

12. ECONOMIC EVALUATION

12.1 PURPOSE AND METHOD

Inasmuch as goods and service to be provided by the public sector like the railway enterprise are generally for the best interests of the public, it is customary to place restriction upon the fare and charge when they are decided. For this reason, it would be often inappropriate to determine the public investment only from the expected revenues and expenditures. As the method to evaluate the appropriateness of the public investment, the cost-benefit analysis has gained wide acceptance.

To make analysis of cost and benefit, especially to the latter, the approach has been made in a concrete form of direct effect plus indirect effect as the primary approximation to the increment of the total surplus, by which evaluation is made on an item-by-item basis as is observed in many other projects. In this case, however, it should be noted that the aggregate total of each enumerated item is not necessarily equal to the increment of the total surplus. Therefore, any shortage or duplication must be scrutinized with full care.

12.2 TRAFFIC DEMAND

Various benefits are produced by introduction of a new system. There are two alternative methods as follows for evaluation of such benefits. One is the comparative study between the case with and without the new system. The other is comparison before and after introduction of such new system. The former one makes it possible to compare the both cases at the same point of time, which the latter does not, This report is based, needless to mention, upon the former method.

As referred to in Chapter 3, the future traffic demand is forecasted in both cases where the project may and may not be carried out (with and without). The main result of forecast can be summarised as shown in Table 12-1.

Table 12-1 Traffic Demand Forecast

1 million passenger - km

	Electrified	Not-Electrified
1984	3015	2541
89	3693	3113
94	4527	3814
99	5543	4672
2004	6790	5724

12.3 MEASUREMENT OF BENEFITS

12.3.1 Principal Benefits

Major benefits to be expected from implementation of the proposed project may be as itemised hereunder.

(1) Saving of train operating cost

Saving of the train operating cost can be expected as the result of switching over from diesel operation to electrical operation.

(2) Travelling time curtailment

The passenger can enhance utility of the railway by utilising its improved service. For the proposed project it is estimated that travelling time can be shortened by 25 per cent at average.

(3) Saving of bus transportation cost by demand transfer to railway

Because of increase in riding comfortability after electrification of the railway, it is anticipated that considerable number of passengers will be transferred from the other means of transport, especially from bus service, to the railway.
As the result, the bus transport cost can be saved as much as the traffic volume transferrable.

(4) Reducible capital cost by reuse of rolling stock

After completion of electrification, most of the passenger trains now running on the project section will be replaced with the EMU and the EL-hauled trains. Then, those diesel cars and locomotives which will become out of use can be reused on any other railway divisions wherever necessary, as the result of which the capital cost can be reduced as much as they can be reused.

(5) Easy maintenance of rolling stock

As compared with the diesel car, the electric car and electric locomotive will be easier in maintenance with less cost and time consumption. This will eventually contribute toward betterment of efficiency in rolling stock operation.

(6) Solution of road congestion

The project will help greatly, when completed, to solve the traffic jam on the road as the result of passengers' transfer to the railway traffic system.

(7) Increase in number of sightseers

As the result of remarkable curtailment in the required time length for travelling between Cairo, where there are many historical remains, and Alexandria, one of the world well-known health resorts, the jumping increase of foreign sightseers can be expected.

(8) Large decrease of noise

By shift from internal combusion engine to electric motor there will be remakable decrease of noise with resultant increase of external effect to be given to not only the passengers but also the wayside inhabitants.

(9) Decrease of car emission gas

It is expected in conjunction with the foregoing item (6) that the car emission gas by car will be reduced in total number of occurrence.

(10) Decrease of traffic accident on road

It is expected in conjunction with the foregoing item (6) that the traffic accident by car will be reduced.

12.3.2 Preconditions for Measurement

Calculations as to economic evaluations as stated hereuender are based upon the following preconditions.

(1) The period of measurement shall cover 25 years including the term of construction work (1977–1983) and the term of commercial operation (1984 ∿ 2003).

(2) All the prices shall be quoted at the current level in the beginning of 1979.

(3) The standard point for time discounting shall be fixed at the end of 1979.

(4) Share in local and foreign currency portions constituting initial and additional investments shall be as shown in Table 12-2 and Table 12-3 respectively.

(5) The exchange rate of currency shall be 1 US$ = 0.7 LE = 200 Yens.

(6) Foreign currency does not include customs and other taxes.

Table 12-2 Capital Investment List (Electrified)

Million LE

	Year	Ground facilities		Rolling stock		Total		
		Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Total
Initial	1979 1983	61.3	99.8	7.5	107.8	68.8	207.6	276.4
Addi-tional	1984 1988	0.7	1.2	10.8	6.6	11.5	7.8	19.3
	1989 1993	9.3	8.3	0.8	61.4	10.1	69.7	79.8
	1994 2003	13.5	25.3	11.6	68.8	25.1	94.1	119.2

The ground facilities cost includes the land acquisition cost.

Table 12-3 Capital Investiment List (Not electrified)

Million LE

	Year	Ground facilities		Rolling stock		Total		
		Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Total
Initial	1977 1983	14.8	10.8	7.7	37.3	22.5	48.1	70.6
Addi-tional	1984 1988	1.9	6.5	12.4	60.1	14.3	66.6	80.9
	1989 1993	34.3	26.5	6.2	30.2	40.5	56.7	97.2
	1994 2003	17.6	33.7	17.0	81.3	34.6	115.0	149.6

The ground facilities cost includes the land acquiistion cost.

12.3.3 Tangible Benefits

Various benefits as referred to in the foregoing item of 'Principal benefits' include a great deal of intangible benefits. For instance, the 'large decrease of noise' is measurable physically by nature but it is almost impossible to convert it into the monetary term.

It is for this reason that only such benefit items as may be convertible into the monetary term have been measured while the other items have been regarded merely as the qualitative benefits.

(1) Benefit from saving of train operating cost

The operating cost will decrease due to the changeover from diesel to electric trains. However, how far it may decrease will depend upon each different railway division, subject to how the trainmen are operated, power cost and traffic volume. Besides that, it must be taken into consideration that the diesel locomotive and cars and the electric train is also composed of the electric locomotive and EMU, whose numbers allocated should bear a large weight in the variation of the operating cost. In the general macroscopic view, however, it is said that the variable portion of the operating cost, when the cost is divided into the fixed and the variable, may be partially reducible. From this viewpoint, by reference to the date available from the Egyptian Railways the attempt has been made to seek the approximation formula for breakdown of the fixed and variable portions of the operating cost, thereby to calculate the savable sum of the cost, as shown in Table 12-9, on the assumption that a part of the variable would be reducible.

(2) Benefit from shortening of travelling time

The benefit to be expected from shortening of the conventionally required time for travelling when the transport facilities have been improved and utilized after such improvement, may generally be expressed in terms of 'time value '. The total benefit from such time saving can be expressed by the following formula:

[Time saving] × [Time value at average]

Usually 'time value' is measured by the two alternative methods, 'income approach' and 'cost approach'. The former one is based upon the thought that the incremented income to be gained, when time savable by utilisation of the improved transport facilities is invested for earning of the income, may be regarded as an evaluated value for the time saved. This method gains wide acceptance in evaluation of the time value.

It should be noted, however, that this approach should take accout of any such factors as difference between commuters and non-commuters, scale of employment opportunity and actual spending status of the saved time.

In this paper, however, due mainly to lack of necessary data the weight is roughly given as follows on a very macroscopic basis, having taken into account such factors as above to some extent.

Table 12-4 Commuters Versus Non-Commuters on Main Line

1 million passenger kilometer

Commuters	Non-commuters	Total
815 (18.3%)	4453 (81.7%)	5268 (100.0%)

According to the data available, the ratio between commuters and non-commuters on the main line in 1976 is 18.3 versus 81.7, as shown in Table 12-4 in terms of passenger-kilometers carried. Now, let it be assumed that the time value for the commuter and business passenger of non-commuter would be 1 while that for the other passenger would be 0.5. If the ratio of the business passenger is assumed at 0.5 of non-commuter passenger, its weight may be sought approximately as follows:

$$0.5 \times (0.817 \times \frac{1}{2}) + 1 \times (0.817 \times \frac{1}{2} + 0.183) = 0.80$$

Then, the time value in 1979 as obtainable from the foregoing income approach can be sought by the data* available as follows.

* "Statistical Yearbook" (Central Agency for Public Mobilization and Statistics, 1977)

Since the annual average wage per capita in 1979 is estimated at about 360 LE throughout all the industrial sectors, the hourly average time value would be about 0.15 LE on a basis of 45 working hours a week. The calculated result as multiplied by the foregoing weight is as shown in Table 12-9.

(3) Benefit from saving of bus transportation cost

The alternative means of transport to be considered as the object for this analysis includes buses and private cars. With regard to those private cars the total number of users are still limited to only a few who undoubtedly enjoy the convenience that the car can only provide apart from its transferrability from one place to the other. For this reason, the analysis made hereunder does not include the private car but include only the bus as the object. As shown in Table 12-5, the savable number of buses are calculated from the estimated volume of transfer from bus to railway after completion of electrification.

Table 12-5 Savable Number of Buses

Year	Volume of transfer (million psgr.-km)	No. of Buses
1985	494	376
1990	605	460
1995	742	565
2000	906	689

1) Running cost of bus

Because the pertinent data is not available, the bus running cost is estimated by rather conservative analogy from the domestic market price of fuel oil, to such an extent that the purpose of analysis may not be affected adversely, as shown in Table 12-9.

2) Capital oost

The savable number of bus can be calculated from the traffic volume corresponding thereto, useful life and stand-by ratio. The capital cost is as shown in Table 12-9.

(4) Reducible capital cost by reuse of rolling stock

As the result of changeover to new rolling stock for electrification, 133 cars of DMU and 42 diesel locomotives will become surplus, which will be reused for reinforcement of the carrying capacity on the other railway divisions, helping reduction of the capital cast in the Cairo - Alexandria section. The service life of those rolling stock is aged at 13 years at average as of the beginning in 1978 (Ref. Transmark, July 1978). Therefore, the serviceable length of those rolling stock by reuse after completion of electrification can be estimated at 6 years on the basic of 25-year useful life. Then, the reducible capital cost by reuse of the rolling stock is as shown in Table 12-9.

12.4 MEASUREMENT OF COSTS

12.4.1 Various Costs

As stated in the preceding Chapter 3'Demand Forecast' considerable increase of the traffic volume can be forecasted even in the case where the project will not be implemented. Such demand increase should require more or less investment. Accordingly, the investment corresponding to the benefit to the gained after electrification should be equalised to the difference in value of the investment between the two alternative cases of 'Electrified' and 'Not electrified'.
The costs to be incurred in either one of the above cases will include the capital costs for installation of the ground facilities and for purchase of rolling stock and their operating costs.

12.4.2 Method of Measurement

Initial and additional investment sums are as shown in Table 12-2 and 12-3 respectively. The useful years of the ground facilities and the rolling stock are set at the length of 30 and 25 years respectively on a macroscopic basis. Therefore, the portions for the depreciations beyond time range of measurement have been incorporated into the benefit as the residual value.

12.4.3 Measured Cost

(1) Initial investment

The annual sum of initial investment is as shown in Table 12 - 6 in which the left half indicates the figures in case of 'Electrified' while the opposite half contains those figure in case of 'Not electrified'.

Table 12-6 Initial Investment

Million LE

Year	Electrified			Not electrified		
	Facilities	Rolling stock	Total	Facilities	Rolling stock	Total
1979	2.1		2.1			
1980	27.4		27.4			
1981	31.1		31.1	3.2		3.2
1982	51.5		51.5	10.0		10.0
1983	49.0	115.3	164.3	12.4	45.0	57.4

(2) Additional investment

As detailed in the foregoing Chapter 3 'Demand Forecast', it is obvious that in either case of 'Electrified' or 'Not electrified' there will be an absolute increase in the traffic volume, for which the corresponding investment will be required.

Table 12-7 covers the additional investment to be further required to absorb such future increases.

Table 12-7 Additional Investment

Million LE

Year	Electrified			Not electrified		
	Facilities	Rolling stock	Total	Facilities	Rolling stock	Total
1984 ~ 1988	1.9	17.4	19.3	8.4	72.5	80.9
1989 ~ 1993	17.6	62.2	79.8	60.8	36.4	97.2
1994 ~ 2003	38.8	80.4	119.2	51.3	98.3	149.6

12.5 CALCULATION AND ANALYSIS

12.5.1 Determination of Costs

Those benefits already mentioned in the preceding items are, needless to mention, the results to be obtained from completion of electrification. Therefore, it may be reasonable that the investment sum as may correspond to that requirement should be regarded as a difference in the investment between the two comparative cases of 'Electrified' and 'Not electrified. Table 12 - 8 shows each difference in this respect by reference to the foregoing Tables 12 - 6 and 12 - 7 respectively.

Table 12-8 Difference in Investment

Million LE

Year	Facilities	Rolling stock	Total
1979 ∿ 1983	135.5	70.3	205.8
1984 ∿ 1988	Δ 6.5	Δ 55.1	Δ 61.6
1989 ∿ 1993	Δ 43.2	25.8	Δ 17.4
1994 ∿	Δ 12.5	Δ 17.9	Δ 30.4

12.5.2 Cost-Benefit Analysis

As is commonly known, the discount rate, by which the present value of all the resources (costs) invested for the time range of measurement could be equalised to the present value of the net benefits to be yielded from result of such investment, is the internal rate of return IRR. As noted from Table 12 - 9, the discount rate of the net benefit is 7.5 per cent. Therefore, the IRR for this project can be said to coincide with 7.5 per cent.

It should be noted, however, that those benefits taken as the basis for calculation of the IRR have been limited only to those directly measurable ones, and there still remain intangible benefits which can not be incorporated into calculation.

Besides the above, when the multiplied effect of utilising the hydro electric power in addition to saving of crude oil of scarcity value is taken into account, it can be concluded that the proposed project is economically feasible in view of the economic analysis.

In addition to such direct effects as stated above, there are to be considered some other indirect effects such as wide dispersion of the urban population, wide expansion of the marketing sphere and homogenized economic growth between the regions. All those things considered, it can be further concluded that the proposed project will be of great significance in the socio-economic development of the nation.

Table 12-9 Internal Rate of Return

Million LE

Year	Cost			Benefit						Benefit minus Cost	Discount Rate 7%		Discount Rate 8%	
	Initial Investment	Additional Investment	Total	Time Value	Saving Bus		Savable Operating Cost	Capital to be Yielded by Reuse of Rolling Stock	Total		Present Worth Factor	Present Value	Present Worth Factor	Present Value
					Running Cost	Capital Cost								
												6.39		Δ7.49
1979	2.1		2.1							Δ2.1	1.00000	Δ2.10	1.00000	Δ2.10
1980	27.4		27.4							Δ27.4	0.93458	Δ25.61	0.92593	Δ25.37
1981	27.9		27.9							Δ27.9	0.87344	Δ24.37	0.85734	Δ23.92
1982	41.5		41.5							Δ41.5	0.81630	Δ33.88	0.79383	Δ32.94
1983	106.9		106.9							Δ106.9	0.76290	Δ81.55	0.73503	Δ78.57
1984		Δ6.5	Δ6.5	5.33	0.21	15.16	3.40	0.44	24.54	31.04	0.71299	22.13	0.68058	21.29
1985				5.56	0.22	0.63	3.55	0.44	10.40	10.40	0.66634	6.93	0.63017	6.55
1986				5.78	0.23	0.63	3.69	0.44	10.77	10.77	0.62275	6.71	0.58349	6.28
1987				6.01	0.24	0.67	3.85	0.44	11.21	11.21	0.58201	6.52	0.54027	6.06
1988		Δ55.1	Δ55.1	6.25	0.25	0.71	4.01	0.44	11.66	66.76	0.54393	36.31	0.50025	33.40
1989				6.50	0.26	0.71	4.17	0.44	12.08	12.08	0.50835	6.14	0.46319	5.60
1990				6.78	0.27	0.80	4.35		12.20	12.20	0.47509	5.80	0.42888	5.23
1991		Δ5.7	Δ5.7	7.09	0.28	16.00	4.53		27.90	33.60	0.44401	14.92	0.39711	13.34
1992		Δ20.8	Δ20.8	7.38	0.30	1.47	4.72		13.87	34.67	0.41496	14.39	0.36770	12.75
1993		9.1	9.1	7.70	0.31	1.51	4.91		14.43	5.33	0.38782	2.07	0.34046	1.81
1994		2.1	2.1	8.00	0.32	1.60	5.12		15.04	12.94	0.36245	4.69	0.31524	4.08
1995		6.5	6.5	8.33	0.33	1.64	5.33		15.63	9.13	0.33873	3.09	0.29189	2.66
1996		5.0	5.0	8.66	0.35	1.64	5.55		16.20	11.20	0.31657	3.55	0.27027	3.03
1997		6.0	6.0	9.01	0.36	1.81	5.78		16.96	10.96	0.29586	3.24	0.25025	2.74
1998		12.0	12.0	9.44	0.38	17.05	6.01		32.88	20.88	0.27651	5.77	0.23171	4.84
1999				9.79	0.39	2.60	6.26		19.04	19.04	0.25842	4.92	0.21455	4.09
2000				10.18	0.41	2.60	6.52		19.71	19.71	0.24151	4.76	0.19866	3.92
2001		Δ3.9	Δ3.9	10.60	0.43	2.81	6.79		20.63	24.53	0.22571	5.54	0.18394	4.51
2002		Δ14.0	Δ14.0	11.04	0.44	2.94	7.08		21.50	35.50	0.21095	7.49	0.17032	6.05
2003		Δ44.1	Δ44.1	11.49	0.46	2.90	7.37		22.22	66.32	0.19715	13.07	0.15770	10.46
	Δ63.6	75.6	12.0			Δ10.49			Δ10.49	Δ22.49	0.18425	Δ4.14	0.14602	Δ3.28

$$\text{Internal Rate of Return (IRR)} = 7 + \frac{6.39}{6.39 + 7.49} \doteqdot 7.5\ (\%)$$