FINAL REPORT

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TRACTION POWER SYSTEM DESCRIPTION

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Chapter 1

INTRODUCTION

1.1 BACKGROUND

This report describes the basic Traction Power System. The report includes a top level functional diagram and a narrative description of each subsystem, and its associated functional elements.

The report is based on the Southern California Rapid Transit District (SCRTD) established design criteria and supplementary instructions received from the Metro Rail Project staff. In this chapter the equipment associated with each subsystem is briefly identified; it is described in later chapters. Certain portions of the description may not necessarily reflect the final configuration of the Traction Power System, and any description or diagram that may be modified in the future will be so noted in this report.

1.2 PURPOSE

The report describes the functional elements of the traction power subsystems in sufficient detail to allow preparation of an assessment of the work remaining to complete the preliminary engineering design.

1.3 GENERAL SYSTEM DESCRIPTION

The Metro Rail Traction Power System will provide direct current (dc) electrical power to each train for vehicle propulsion. The dc power supply will also be used for operation of all other onboard electrical equipment such as lighting, control, communications, and air conditioning.

In addition to the train onboard power requirements, the Traction Power System will also supply 60 hertz, alternating current (ac) power for operation of the various wayside subsystems.

Overall, the Traction Power System will be designed so as to ensure adequate levels of train performance, operational flexibility, safety measures, equipment protection, and corrosion control.

1.4 TRACTION POWER SUBSYSTEMS

At this time, the Traction Power System will be composed of four subsystems:

- o Traction power substations
- o Wayside distribution
- o Emergency trip stations
- o Equipment operation supervision

A further subsystem, gap-breaker stations, may be added at a later date if the final configuration of the railway track system requires this addition.

A representation of typical traction power subsystem elements, which are required to convey power from the incoming electric utility company feeders to a passenger vehicle, is depicted on the top level functional diagram, drawing 16-CAD-TP-000-, "Traction Power Arrangement in the Vicinity of a Substation." These elements are further identified and described in later chapters.

Also identified in later chapters are safety related features which will be incorporated in the design of the traction power subsystems for protection of the public and Metro Rail personnel against injury.

1.4.1 Traction Power Substations

The traction power substations will transform and convert high-voltage ac power, supplied from power utility feeders, into dc power suitable for Metro Rail rapid transit train operation. The substations will also distribute and control traction power to the wayside distribution subsystem.

The traction power substations will be located along the Metro Rail route at suitable intervals. The spacing of the substations and capacity of the subsystem elements will be based on the power requirements of the trains during peak traffic periods. Peak period demand will require that the substations be capable of supplying traction power to the maximum number of trains which may start simultaneously under the minimum headway operating schedule. Generally, this entails meeting the power demand of 6-vehicle trains operating at 2-minute headway intervals, during peak periods of two hours, with the ability to accelerate two 6-vehicle trains simultaneously along adjacent trainways.

With any one traction power substation out of service, the remainder of the substations will be capable of maintaining train operations, albeit with reduced performance.

Each traction power substation will be composed of the following elements:

- High-voltage ac distribution equipment
- Power conversion equipment
- Dc traction power distribution equipment
- Control power supply and distribution equipment
- Substation ac and dc power busways
- Power and control cables, with associated raceways
- Supervisory control interface and local annunciation equipment

1.4.2 Wayside Distribution

The wayside distribution subsystem collects power from the traction power substations and delivers it to the trains.

The wayside distribution subsystem will be composed of the following elements:

- Third rail (positive contact) and associated hardware
- Support insulators
- Third rail protective coverboard and associated hardware
- Dc power cable
- Raceways and other cable supports

1.4.3 Emergency Trip Stations (ETS)

Traction power emergency trip stations (ETS) will be installed at strategic locations along the Metro Rail System. The ETS will provide Metro Rail personnel and passengers with the capability to remove power from a section of the third rail during an emergency.

The ETS subsystem will be composed of the following elements:

- o Trip stations
- o Blue location lights
- o Control cables and associated raceways

1.4.4 Equipment Operation Supervision

All the essential element operation and control functions of the traction power subsystems will be supervised remotely from Central Control. The traction power substations (and any gap-breaker stations) will normally operate unmanned. Local control and annunciation (alarm indication) facilities will also be provided at each traction power substation (and gap-breaker station) for maintenance and emergency use.

The operation supervision facilities at Central Control for the Traction Power System (outlined in Chapter 6) are incorporated in the Data Transmission System (DTS). (The DTS is a part of the Metro Rail Communications System, which is described in a separate report, "Communications System Description". Elements of the traction power operation supervision subsystem will be located at each traction power substation (and gap-breaker station). These elements will provide the supervisory control interface between the DTS and the traction power subsystems.

Each equipment operation supervision subsystem will be composed of the following elements:

- o Supervisory control interface terminal cabinet
- o Local annunciator panel

1.4.5 Gap-Breaker Stations

Gap-breaker stations are not illustrated on the top level functional and single-line diagrams, since they are not planned at this time. However, they would normally be located at trainway track crossovers and pocket tracks, which are not located near a traction power substation. The function of the gap-breaker stations will be to bridge the physical gap between sections of the third rail thus maintaining electrical continuity over the entire Traction Power System during normal operating conditions. During maintenance, repairs, or emergency conditions, the gap-breaker stations would be used to isolate appropriate sections of the third rail.

A gap-breaker station will be composed of the following elements:

- o Dc distribution equipment
- o Control power supply and distribution equipment
- o Supervisory control interface and local annunciation equipment
- o Power and control cable with associated raceways

Chapter 2

FUNCTIONAL REQUIREMENTS

2.1 GENERAL

The functional requirements of the Traction Power System are to provide an adequate supply of propulsion power to all trains operating on the Metro Rail System, in a safe, secure and economical manner. The overall design of the Traction Power System will be such, that it will achieve these functional requirements.

2.2 TOP LEVEL FUNCTIONAL AND SINGLE-LINE DIAGRAMS

The top level functional and interface diagram (16CAD-TP-004) illustrates the functions of the Traction Power System elements.

Mainline electrification single-line diagrams for the Metro Rail System (16CAD-TP-001, -002, -003) identify the Traction Power System interconnections in schematic form.

The following narrative subsections describe the functional and single-line diagrams. A detailed description of each traction power subsystem is given in subsequent chapters.

2.2.1 Primary Power Supply

Redundant primary-power feeders to each traction power substation will be furnished by the Los Angeles Department of Water & Power (DWP) at 34,500 volts ac, or by the Southern California Edison (SCE) utility company at 16,000 volts ac. These incoming feeders will furnish the normal and backup power supplies to the whole of the Metro Rail Traction Power System.

Primary power will be controlled by high-voltage ac switchgear located in each traction power substation. Only one utility company power feeder will be connected to the main ac switchgear bus at any time.

2.2.2 Traction Power Conversion and Distribution

High-voltage ac power from the ac switchgear will be converted to 750 volts dc (nominal) traction power at each traction power substation by dual transformer and rectifier elements located within the substation area. Positive dc current from each transformer/rectifier element will be fed to the dc switchgear in the substation through dc busways.

Positive current from the dc switchgear at each substation will be fed by the wayside distribution subsystem to the two sections of the third rail for each trainway.

The third rail will transmit positive dc current, to the train onboard traction equipment, by sliding-contact with collector shoes attached to each passenger vehicle.

The negative dc current from the onboard traction equipment will return to the rectifier elements through the vehicle wheels to the running rails, impedance bonds, the negative bus (collector) box, and the associated negative return power cables. This will complete the dc-loop circuit for train traction power flow.

The third rail will be a prime element of the wayside distribution subsystem. It will normally be electrically continuous throughout the Metro Rail System, except in the yards and shop area. Therefore, dc power supply to each section of the third rail will be furnished from every traction power substation. This arrangement will prevent a momentary loss of power to trains should a traction power failure occur at any substation, and will allow train traction loads to be shared between the other substations.

The interconnection of third rail sections will also distribute power that will be regenerated by trains while braking. This power will be utilized by other trains that may be accelerating, thereby improving the overall efficiency of the Traction Power System.

The third rail system will be physically sectionalized to allow selected rail sections to be isolated in an emergency and to permit maintenance and repair work to be performed. Gaps in the third rail sections will be provided near the traction power substations and at special running-rail (track) sections, such as railway crossover points and pocket tracks.

Electrical interconnection of the third-rail section gaps will be performed by dc switching equipment, comprised of circuit breakers and disconnecting switches. These switching elements will be located in the traction power substations and at any gap-breaker stations, should they be required for the Traction Power System. (See Subsection 1.4.5.)

The switching equipment will normally bridge the gap between third rail sections and will so maintain electrical continuity of the complete traction power distribution system. Should a section of third rail develop a fault, it would be automatically isolated by operation of the appropriate dc circuit breakers, which would open the links with adjacent healthy rail sections. It will also be possible to operate the switching equipment remotely from Central Control, or from an emergency trip station, to isolate any rail section in an emergency or for maintenance purposes.

2.2.3 Control Power

Control power for traction power substation equipment operation will be supplied by a 125 volt dc battery and distributed to the equipment through a dc distribution panel. The battery will be charged, as required, through a battery charger fed from the substation auxiliary ac power distribution panel. Additionally, any low-voltage ac control power requirements will be satisfied by this ac distribution panel.

The traction power equipment operations will normally be controlled and monitored (supervised) at Central Control facilities. Central Control supervision will be implemented through supervisory control and data transmission elements, which interact with the substation equipment through a supervisory control interface terminal cabinet.

Each traction power substation will have a local annunciator panel which will indicate the status of substation equipment.

Chapter 3

TRACTION POWER SUBSTATIONS

3.1 GENERAL

Traction power substations will be located adjacent to most passenger stations. This location will minimize the drop in voltage and power losses along the third rail during a period of peak power consumption when two trains accelerate to leave a station.

Intermediate traction power substations will also be located between passenger stations where the station-to-station distance exceeds two miles.

The intended locations of 18 mainline traction power substations along the Metro Tail trainway route are indicated on Figure 3-1. Fourteen substations will be in the vicinity of passenger stations and four intermediate substations will be located between certain stations. An additional traction power substation will be located at the main vehicle storage yard near Union Station. The traction power substations will be installed either below street level, or at street level, depending on their location on the Metro Rail route.

SCRTD Metro Rail Project

PROPOSED ROUTE AND STATIONS

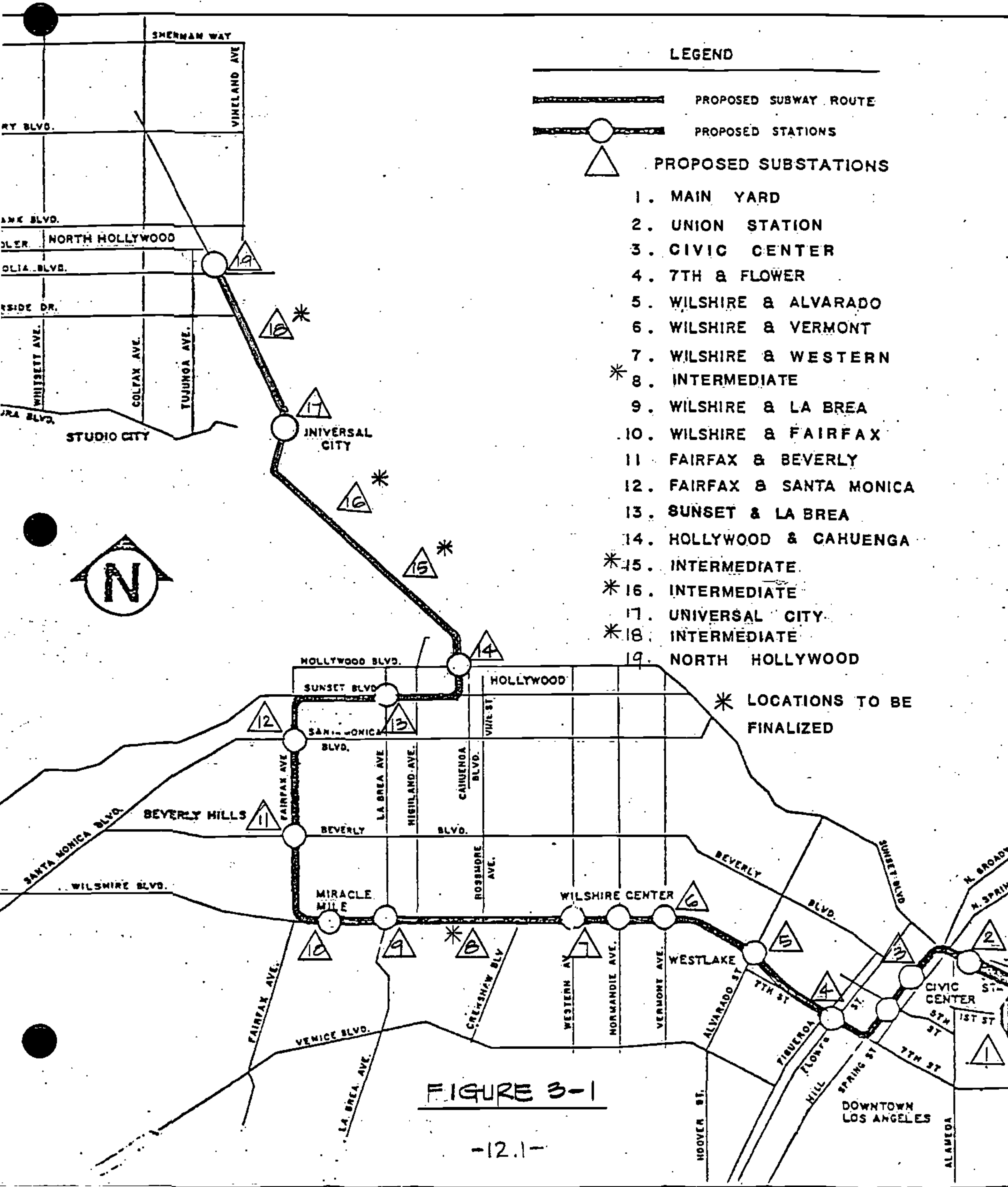


FIGURE 3-1

3.2 TRACTION POWER SUBSTATION EQUIPMENT

SPARES/Tool LOCATIONS

A typical traction power substation equipment arrangement is shown on drawing 16CAD-TP-005.

Certain elements of the Auxiliary Power System will also be housed in the traction power substation. These elements are defined in the Auxiliary Power System Description. Therefore, these elements are not described in this document. The traction power equipment within each substation will be composed of the elements discussed with the following subsections.

3.2.1 Power Utility Service

Primary power to all the Metro Rail traction power substations, with one possible exception, will be supplied by the Los Angeles Department of Water & Power (DWP) at 34,500 volts. The substation at the Fairfax and Santa Monica passenger station will be located beyond the Los Angeles city limits. It will be supplied by Southern California Edison (SCE) at 16,000 volts, unless an appropriate agreement between SCRTD and SCE can be reached permitting DWP to supply power to this substation at 34,500 volts as well.

The utility company will provide two redundant, three-phase, 60 hertz incoming power circuits to each traction power substation. Each circuit will have sufficient capacity to supply the substation maximum power demand. The two incoming power circuits will either both be energized, or one circuit will be energized and the other will be a standby, and de-energized, pending an agreement between SCRTD and the utility company.

Where possible, each circuit will originate from a separate utility company substation and will be routed underground to the Metro Rail substation. The service voltage variations and the maximum available fault level at the point of delivery are expected to be ± 7.5 percent of the nominal voltage and 1,500 MVA symmetrical. RMS (root mean square), respectively.

A space of 40 ft x 40 ft x 18 ft high, will be allocated in each traction power substation for the utility company service equipment, including primary switching apparatus, potential transformers, current transformers, lightning arresters, control, and metering devices. This space will be secured for use solely by utility company personnel.

3.2.2 High-Voltage Ac Switchgear

The high-voltage ac switchgear will receive power from the utility company service equipment and will distribute it to the traction power conversion equipment, and to the passenger station auxiliary power system, described in report 16CAD12. The ac switchgear assembly will also provide the means for metering and controlling the distributed ac power.

The switchgear assembly will consist of indoor, metal-enclosed, self-supporting units, complete with high-voltage circuit breakers or load-break fused disconnect switches, which will be electrically operated.

All necessary protective relays and meters will be provided, to protect and monitor the traction power conversion and station auxiliary power equipment, and Metro Rail personnel.

3.2.3 Ac to Dc Conversion Equipment

Two sets of ac to dc conversion equipment will be provided at each traction power substation to covert high-voltage, 3-phase, 60 hertz ac power to 750 volts dc (nominal) power, for transit vehicle traction and auxiliary power.

Each set of conversion equipment will be composed of a rectifier transformer and a rectifier, designed as a package unit. Each power conversion unit will meet the loading requirements consistent with the American Public Transit Association (APTA) guidelines and those specified in the National Electrical Manufacturers Association (NEMA) Standard RI-9, for extra-heavy-duty traction service.

The equipment will be capable of withstanding the short-circuit and over-voltage conditions that are expected. All necessary devices will be provided to protect both the equipment and personnel.

The ac to dc conversion equipment will be composed of the following elements:

A. Rectifier Transformer. Each rectifier transformer will be a 3-phase, 3-winding, metal-enclosed, ventilated dry-type unit, suitable for extra-heavy-duty traction service. The transformers will be designed for either indoor or outdoor service, consistent with the locations of the traction power substations at or below street level.

The transformers will have an adequate capacity, to meet the maximum traction power demands. Each transformer will have 2 low-voltage windings, which will be connected to the power conversion rectifier by an ac busway.

B. <u>Rectifier</u>. The rectifiers will be of the silicon diode-type, contained in a free- standing, indoor metal-clad enclosure, and air-cooled by natural convection. The rectifiers will be designed for extra heavy-duty traction service, with 750 Vdc nominal output using 12-pulse double-way rectification.

A disconnect switch will be used for isolating the traction power negative return current from the rectifier negative terminal. The switch will be of the indoor-type, single-pole, single-throw, unfused, rated 1000 Vdc, and will be incorporated within the rectifier enclosure.

3.2.4 Dc Switchgear

Dc power supplies to the wayside distribution subsystem, from the transformer-rectifier conversion equipment, will be controlled by dc switchgear.

The dc switchgear will be composed of rectifier cathode (positive current) circuit breakers and way-side distribution feeder circuit breakers. Each rectifier cathode breaker, will electrically connect the positive dc current output from one transformer-rectifier conversion unit, to the dc switchgear bus. Each feeder breaker will electrically connect a section of the wayside distribution subsystem to the dc bus.

One feeder breaker will normally supply positive dc current to a section of third rail. Two adjoining sections of third rail are normally interconnected electrically through their respective feeder breakers and the dc switchgear bus. Any section of third rail can be isolated, by opening the associated dc feeder breakers supplying power at each end of the rail section, without interrupting the power supply to adjoining rail sections. This arrangement of feeder breakers will provide flexibility of train operation, especially during maintenance, repairs and emergency conditions.

3.2.5 Control Power Supply and Distribution

A dedicated control power supply will be installed in each traction power substation and gap-breaker station, to provide 125 Vdc control power for the operation of all switching equipment and associated protective, control and indicating devices.

Low-voltage ac control supply will be obtained from a local ac distribution panel, which is a part of the Auxiliary Power System. Ac control power requirements will be limited to space heaters within equipment rooms to facilitate humidity control (where required), and to control devices which cannot operate from the 125 Vdc source.

enough heat from equipment!

The 125 Vdc control power supply will be composed of the following elements:

A. Battery. The battery will be designed for switchgear service with nickel-cadmium or lead-acid type cells, producing a nominal voltage of 125 Vdc.

Constant current for NiCads

B. Battery Charger. The battery charger will be of the silicon controlled rectifier, constant-voltage type, convection cooled, and rated according to the battery capacity. Necessary devices and meters will be provided to protect equipment and personnel.

Miniature Circuit Breakers

C. Dc Distribution Panel. A panel will be used to distribute the necessary dc control power required by the electrical equipment. It will be a general purpose, surface-mounted unit, equipped with a main incoming molded-case circuit breaker, a sufficient number of molded-case branch circuit breakers, and provisions for future additional breakers. Individual breakers will be fitted with overload and overcurrent trip devices to protect equipment and personnel.

3.2.6 Negative Bus Box

One negative bus box will be installed at each traction power substation. The bus box will provide a common termination point for negative current return cables from the wayside impedance bonds to the negative terminal of the traction power rectifiers, and for any utility drainage cables required for stray current mitigation (corrosion control).

The bus box enclosure will be a free-standing, nonmetallic, indoor-type. Bus bars will be of tin-plated, high-conductivity copper.

3.2.7 Substation Ac and Dc Busways

Busways (ducts) will be used to connect equipment such as the rectifier-transformer to the rectifier, and the rectifier to the dc switchgear. They will be made of either copper or aluminum bars and capable of carrying continuously rated current and overloads, without exceeding the maximum allowable temperature rise.

Ac bus way will be used between the rectifier transformer and the rectifier. The Dc bus way will be used between the rectifier and the dc switchgear.

3.2.8 Local Annunciator Panel

Each traction power substation will be provided with a local equipment status annunciator (alarm) panel. The annunciator panel will annunciate trouble locally and, through the supervisory control interface terminal cabinet (SCITC), remotely at Central Control. It will be a floor or wall-mounted, electro mechanical or solid-state type, having a sufficient number of individual status indicators, with back lit nameplates and a dc control power isolation switch.

why

The panel will be designed to operate on 125 Vdc. Local alarms will be annunciated by means of a flashing indication of the applicable status indicator, together with an audible warning.

3.2.9 Supervisory Control Interface Terminal Cabinet (SCITC)

A terminal cabinet will be provided at each traction power substation to be used as an interface point, to interconnect the Supervisory Control System to the traction power system equipment. The cabinet will be of steel construction, indoor-type. Terminal blocks will be provided, mounted on a removable interior panel within the cabinet. All interface connections will be made at these terminal blocks. A sufficient number of spare terminal points will be provided for future equipment requirements.

Chapter 4

GAP-BREAKER STATIONS

4.1 GENERAL

Gap-breaker stations will be provided on the Metro Rail System, to control special rail track sections, but only when these sections are too remote to be effectively controlled from the nearest traction power substation.

The gap-breaker stations will house electrical power switching equipment, for protection of the special track third rail sections, in a similar manner to the mainline sections controlled by equipment located at the traction power substations. (See Chapter 3.)

4.2 EQUIPMENT

Equipment at each gap-breaker station will include dc switchgear, control power supply and distribution equipment, annunciator panel, and a supervisory control interface terminal cabinet (SCITC), similar to equipment previously described for traction power substations in Chapter 3. The gap-breaker station auxiliary ac power will be supplied from the nearest passenger station auxiliary power source as defined in the "Auxiliary Power System Description."

Chapter 5

WAYSIDE DISTRIBUTION

5.1 GENERAL

The wayside distribution subsystem will complete the dc power circuit between the traction power substation and railway vehicle onboard equipment. This subsystem will be composed of the elements described below.

5.2 THIRD RAIL AND ASSOCIATED HARDWARE

The third rail will be of bimetallic construction, fabricated from steel and aluminum elements, and bonded together by pressure applied through bolts or equivalent methods. The contact surfaces between the two metals will be thoroughly cleaned before assembly, to minimize the electrical resistance between the different metal parts, and tightly sealed to prevent the ingress of polluting or corroding matter.

The continuity of the third rail will be broken at traction power substations and any required gap-breaker stations to provide definitive (localized) sections. Adjoining third rail sections will be separated by a gap dimensioned so that it can be bridged by the front and rear current-collecting shoes of a vehicle. Sufficient protection will be provided to prevent a previously deenergized section of third rail from being reenergized by a vehicle accidentally connecting it to an adjoining live third rail section.

Third rail sections will be composed of rail lengths (approximately 40 foot long) joined together by means of splice joint assemblies. Jumper cables will provide electrical continuity at all special rail track locations where it is necessary to have separations in the third rail. Jumper cables will also be provided across rail expansion joints to maintain electrical continuity across the joint. The jumper cables will have an electrical conductivity equal to, or higher than, the conductivity of the third rail. Ramps will be provided at the ends of each third rail section to facilitate collector shoe transfer between rail sections without significant bounce.

Rail anchors will be provided at 1,000 foot maximum intervals, with expansion joints installed midway between anchor points. Spacing of the anchors will be adjusted to provide anchorage near the middle of curved sections, with expansion joints placed at the ends of the curve.

5.3 SUPPORT INSULATORS

The third rail will be supported at approximately 10-foot intervals by post-type insulators of either wet-process-type porcelain or fiberglass. The relative position of the third rail to the rail track and the configuration of the support insulators will be as shown on Figures 5-1, Single Track Arrangement.

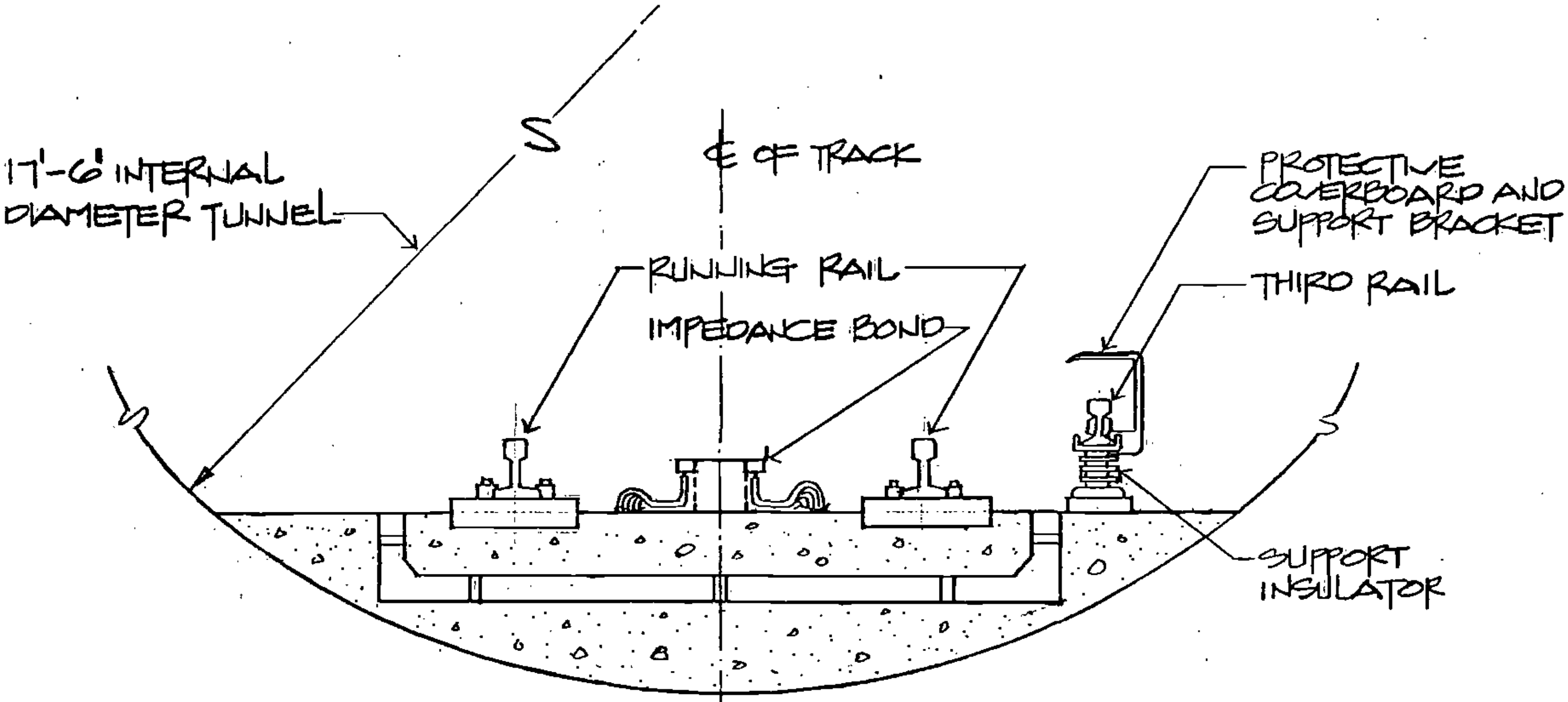


FIGURE 5-1

SINGLE TRACK ARRANGEMENT

Except at special running rail locations, the position of the third rail relative to the running rails will generally be as follows:

- Through passenger stations: at the side of the running rails opposite the platform

- Through trainway tunnel sections: at the side of the running rails opposite the access walkway

- At storage yard and workshops: in the area between the adjacent trackways

5.4 PROTECTIVE COVERBOARD AND ASSOCIATED HARDWARE

A protective coverboard will be provided over the third rail to protect passengers and Metro Rail personnel from accidental contact with the energized third rail. The coverboard will also protect the rail from foreign objects that might fall or be thrown onto it.

The coverboard will be made of a noncombustible, non-conductive material, and be designed to provide protection against electrical hazard. The coverboard will be supported at intervals by molded brackets, attached directly to the bottom flange of the third rail. The brackets will be spaced at suitable intervals to meet strength and deflection criteria, but never more than every five feet.

The coverboard will consist of a top panel only. Adequate clearance will be provided between the top panel and the third rail to permit insertion of the vehicle current collection shoe paddles. At third rail gap end-ramps, the coverboard will be maintained at the same uniform height relative to of the running rail, and will extend a minimum of 12 inches beyond the tip of the end-ramp.

5.5 RUNNING RAIL, ASSOCIATED HARDWARE, AND IMPEDANCE BONDS

Running rails, hardware, and bedwork are elements of the Rail Track System. Impedance bonds are elements of the Train Control System, and are discussed in detail in the "Train Control System Description".

5.5.1 Running Rails and Associated Hardware

The Rail Track System is not a part of the Traction Power System and therefore is not fully discussed here. In general, the running rails will be insulated from the roadbed by the use of insulated track fasteners. The track ballast will be clean, dry, and well drained, and will be kept clear of the running rails. The rails for mainline operation will be approximately 132 pounds per linear yard, RE section grade, and will be welded in continuous lengths.

Both running rails of each trainway will normally serve as negative current conductors for the Traction Power System. At special locations, within the interlocking area of crossovers or pocket tracks, only one running rail will be used for negative current return, while the other rail will be used for the Train Control System signals.

5.5.2 Impedance Bonds

At locations requiring insulated joints for the Train Control System, the negative-current return circuit continuity will be maintained by the use of impedance bonds and jumper cables. The impedance bonds will provide a low-resistance path for direct current and a high-impedance path for train control signals.

Running rails will also be cross bonded for traction power negative current equalization through impedance bonds at maximum intervals of 2,000 feet. Where train control impedance bonds occur within the rail cross bonding spacing interval, these bonds will also be used for running rail cross bonding.

5.6 DIRECT CURRENT (DC) POWER CABLE

All direct current power cables will be composed of nonshielded, insulated, stranded-copper conductors. The cables will have a minimum insulation life of 20 years and the maximum operating temperature will not exceed the permissible insulation design limits. A single size of conductor will be used, which will be selected for the lowest installed cost.

The dc traction power feeders will be composed of multiple cables, connected in parallel, to match the individual feeder required current rating. Positive and negative current feeders to each section of third rail will have the same current carrying capacity. The feeders will have a sufficient current rating to permit full use of the traction power substation equipment's maximum design overload capacity, and maintain voltage levels along the third rail within allowable limits.

5.7 CABLE SUPPORTS

5.7.1 Substation Interior Supports

Traction power dc cables within the traction power substation or gap-breaker station enclosures will be installed in appropriate raceways, such as metal or nonmetallic trays, cable trenches, or on racks. Such raceways will be of adequate size to permit a neat alignment of the cables and to avoid twisting.

In metal raceways, a nonflammable, flat insulating separator will be installed between the metal and the cables, to provide maximum isolation between the cables and the metal parts, and also to provide a uniform, smooth support. Positive and negative cables will be run in separate raceways.

When the cables are installed on racks, porcelain or fiber insulators will be used on the supporting arms. Supporting arms will be spaced so as to avoid excessive weight or pressure against the cable insulation. Cables will be arranged in not more than two layers.

5.7.2 Wayside Supports

Traction power dc cables along the wayside to the third rail connection locations will be installed in rigid nonmetallic conduits, concrete encased for physical protection. Wherever this does not prove practical, the cables will be placed in conduits mounted on supports attached to concrete walls or slabs.

5.8 CABLE TERMINATIONS

Since the third rail is subject to vibration, provision will be made in the design of all cable terminations to the rail to prevent cable failure due to the vibration. The traction power wayside distribution cables, with standard conductor stranding, will be terminated at a junction box adjacent to the third rail sections. From this junction box, extraflexible conductor cable will be used for the bolted or welded connections to the third rail.

5.9 DC DISCONNECT SWITCHES

Dc power disconnect switches will be used in special locations throughout the mainline system, in the yard, and in maintenance facilities, to isolate a section of the third rail during maintenance, repairs, and emergency conditions.

These tie switches will be of the no-load type, single-pole, single-throw, unfused, and manually or electrically operated. Switches will be rated 1000 Vdc, with adequate continuous current-carrying capacity and short-circuit withstand capability. They will be housed in a nonmetallic indoor- or outdoor-type enclosure, depending upon location, in the traction power substation or at the wayside.

Wall-mounted, manually operated switches will also be provided to bypass the traction power dc switchgear feeder circuit-breakers during breaker maintenance or repairs. These switches will electrically tie adjacent third rail sections together and maintain continuity of the traction power distribution subsystem.

Chapter 6

EQUIPMENT OPERATION SUPERVISION

6.1 GENERAL

The traction power substations and gap-breaker stations will be designed to operate unmanned. All the essential functions of switchgear operation and control will normally be performed remotely from Central Control by means of the Data Transmission System (DTS). (See Subsection 1.4.4.) All essential status indications, such as voltage level, current level and circuit breaker positions, will be telemetered for selective display at Central Control.

Local controls will be provided within each substation and gap-breaker station to permit manual operation of all switching equipment. During local operation, supervisory control for each device locally operated will be bypassed. Permission of Central Control, however, will be required in order to activate local controls.

6.2 FUNCTIONS

Tables 6-1 and 6-2 list the various local and supervisory control functions for traction power substations and gap-breaker stations, respectively.

Table 6-1

LOCAL AND SUPERVISORY CONTROL FUNCTIONS IN TRACTION

POWER SUBSTATIONS

Function	Control Local	Control Remote	Indication Local	Indication Remote
Switching				
Ac Incoming-line Breakers			X	X
Ac Feeder Breakers	X	X	X	X
Dc Rectifier Breakers	X	X	X	X
Dc Feeder Breakers	X	X	X	X
Ac Motorized Disconnect Switch	X	X	X	X
Alarms				
Substation Trouble				X
Control Battery Low Voltage			X	X
Substation High-ambient Temperature				X
Ac Incoming-line Voltage (high/low)				X
Third Rail Loss of Voltage				X
Rectifier Transformer High-temperature Alarm			X	X
Rectifier High-temperature Alarm			X	X
Rectifier Voltage Surge (ac bus)			X	X
Rectifier Voltage Surge (dc bus)			X	X
Transformer-rectifier Lockout				X
Rectifier Enclosure Energized				X
Rectifier Transformer High-temperature Trip			X	
Rectifier High-temperature Trip			X	
Ac Overcurrent				X
Rectifier Diode Failure Alarm			X	
Rectifier Diode Failure Trip			X	
Transfer-Trip Pilot Wire Failure			X	
Dc Switchgear Grounded Enclosure			X	X
Dc Switchgear Energized Enclosure			X	
Dc Switchgear Lockout				X
Transformer Cooling Fan Failure			X	

Table 6-2

LOCAL AND SUPERVISORY CONTROL FUNCTIONS IN GAP-BREAKER STATIONS

Function	Control Local	Control Remote	Indication Local	Indication Remote
Switching				
Dc Feeder Breakers	X	X	X	X
Alarms				
Gap-breaker Station Trouble				X
Third Rail Loss of Voltage				X
Dc Switchgear Grounded Enclosure			X	
Dc Switchgear Energized Enclosure			X	
Dc Switchgear Lockout			X	X
Control Battery Lockout			X	X
Station High-ambient Temperature			X	X
Transfer-trip Pilot Wire Failure			X	X

6.3 SUPERVISORY SYSTEM AND INTERFACES

6.3.1 Power Control Center

The power control center at the Central Control facility will serve as a central location for the control and monitoring of electrical power systems which will supply the Metro Rail trains, transit facilities, and other loads essential for maintaining continuous rapid transit operations. The power control center will include a power supervisory control console and a power system status mimic board.

The power supervisory control console will provide the operating attendant with facilities for remote control of equipment at traction power substations, gap-breaker stations, and motorized switching equipment installed at the wayside. The console will indicate the status of third rail sections and other selected subsystem elements. It will also give immediate alarm and visual indication of status changes, faults, or other abnormal conditions associated with traction power elements.

The power system status mimic board will provide a graphic portrayal of the entire Traction Power System. In addition, changes in the status conditions will be placed in a direct-access memory storage system, along with the time and date of entry, for diagnostic and documentation purposes.

The power control center will interface with the traction power equipment through a data transmission system (DTS) and cable transmission system (CTS), which are elements of the Communications System. The Central Control facility is also described elsewhere and is not part of the Traction Power System.

6.3.2 Local Control and Annunciation Interface with Supervisory Control

A supervisory control interface terminal cabinet (SCITC) will be installed at each traction power substation and any gap-breaker station, to provide an interface between the DTS system and the traction power system equipment. A number of sensing devices will be provided at specific traction power elements, where required; the sensing devices will be hard-wired to the terminals of the interface cabinet.

The traction power elements will also have provision for local control and indication. All alarms will be annunciated at a local annunciator panel located in each substation and any gap-breaker station.

Chapter 7

EMERGENCY TRIP STATIONS

7.1 GENERAL

Traction power emergency trip stations (ETS) will be installed at strategic locations throughout the Metro Rail System. These will provide Metro Rail personnel and passengers with the capability to remove power from sections of third rail during an emergency.

Each ETS will contain switches to trip (open) and lockout the appropriate dc feeder circuit breakers (dc contactors at maintenance facilities), thereby removing power from the affected sections of third rail.

The trip switches will be equipped with a mechanical interlock mechanism, which will preclude restoration of power, once the emergency trip station has been activated, until the interlock has been manually reset. Only after the mechanical lockout is manually released can power be restored by the Central Control operator. Central Control will be advised by qualified transit personnel, through the emergency telephone, as to the manual release.

Also included at each ETS will be an emergency telephone, which will communicate directly with Central Control, and a blue light for identification purposes.

7.2 ETS LOCATIONS

Location of emergency trip stations (ETS) will be as follows:

- At the ends of each station platform; within each of the cross-passages between trainways; and exit passages from trainways to the surface

- Installed as needed to limit the distance between them to no more than 500 feet, and to provide at least one visible ETS location from any point on the rail tracks

- Provided at maintenance yards and special rail track locations, as required

APPENDIX A

DRAWINGS

DEVICE FUNCTION NUMBERS

2	PREFIX NO.2 —DEVICE FOR 34.5 KV AC EQUIPMENT.
1	PREFIX NO.1 —DEVICE FOR 750 V DC EQUIPMENT.
	NO PREFIX NO. — DEVICE FOR 480 V AC EQUIPMENT.
126/DT	RECTIFIER DIODE TEMPERATURE DEVICE.
27	UNDERVOLTAGE RELAY.
27/CP	LOSS OF CONTROL POWER RELAY.
132	DC INSTANTANEOUS REVERSE CURRENT TRIP DEVICE.
33	DOOR INTERLOCK DEVICE.
46	PHASE BALANCE CURRENT RELAY.
47/AP	SINGLE PHASING, REVERSE PHASE OF AUXILIARY POWER RELAY.
149/DT 1	RECTIFIER DIODE TEMPERATURE MONITORING DEVICE, STAGE 1.
149/DT 2	RECTIFIER DIODE TEMPERATURE MONITORING DEVICE, STAGE 2.
149/FS	COOLING FAN THERMAL OVERLOAD RELAY.
149/WT1	HOT SPOT WINDING TEMPERATURE DEVICE — STAGE 1.
149/WT2	HOT SPOT WINDING TEMPERATURE DEVICE — STAGE 2.
50	AC INSTANTANEOUS OVERCURRENT PHASE RELAY.
50 G	AC INSTANTANEOUS OVERCURRENT GROUND (RESIDUAL) RELAY.
150	DC RATE OF RISE RELAY.
51	AC TIME OVERCURRENT PHASE RELAY.
51 G	AC TIME OVERCURRENT GROUND (RESIDUAL) RELAY.
51 A	AC TIME OVERCURRENT PHASE RELAY.
51 B	AC TIME OVERCURRENT PHASE RELAY.
151	DC INVERSE — TIME OVERCURRENT RELAY.
52	AC CIRCUIT BREAKER.
55	POWER FACTOR RELAY.
59	OVERVOLTAGE RELAY.
164/164G	ENCLOSURE POSITIVE BUS FAULT AND GROUND DETECTOR.
69	PERMISSIVE CONTROL DEVICE.
172	DC CIRCUIT BREAKER
74	ALARM RELAY.
74 X	AUXILIARY ALARM RELAY.
176	INSTANTANEOUS SERIES DIRECT-ACTING BI-DIRECTIONAL OVERCURRENT TRIP DEVICE.
180/DM	RECTIFIER DIODE FAILURE DEVICE
81	FREQUENCY RELAY.
182	AUTOMATIC RECLOSING RELAY.
185	TRANSFER TRIP PILOT WIRE RELAY
87	DIFFERENTIAL PROTECTIVE RELAY.
195	LOAD MEASURING DEVICE.
196	EMERGENCY TRIP RELAY.
298-1	KWHR AND KW DEMAND METER.
298-2	KWHR TOTALIZER
199-1	AC BUS SURGE PROTECTIVE DEVICE.
199-2	DC BUS SURGE PROTECTIVE DEVICE.
86	LOCK-OUT RELAY

DEVICE SYMBOL

(196)	CONTROL OR PROTECTIVE DEVICE (FUNCTION NUMBER SHOWN)
(A)	AMMETER
(V)	VOLTMETER
CS	CONTROL SWITCH
ANN	ANNUNCIATION DEVICE — INDICATING TYPE
FS	FAN STARTER
AL	AUDIBLE ALARM DEVICE
VT	VOLTAGE TRANSDUCER
AT	AMPERE TRANSDUCER
ETS	EMERGENCY TRIP STATION
I/O	INPUT—OUTPUT OF MULTIPLEXING SYSTEM
MR	MANUAL RESET
	COMPUTER RECORDING & AUDIBLE ANNUNCIATION
	DRAW—OUT DEVICE
	CIRCUIT BREAKER, 34.5 KV.
	BUS DUCT
	DC CIRCUIT BREAKER WITH SERIES
	TRIP DEVICE
	CURRENT TRANSFORMER OR CURRENT SENSOR OF SOLID STATE TRIP DEVICE.
	CURRENT TRANSFORMER, WINDOW TYPE.
	POTENTIAL TRANSFORMER.
	NEUTRAL CONNECTION.
	FUSE
RES	RESISTOR
	DC SHUNT
	SHORTING TYPE TERMINAL BLOCK.
	RECTIFIER POWER DIODE.
Δ	DELTA CONNECTION.
	WYE CONNECTION.
	OPEN DELTA CONNECTION.
T3	POWER TRANSFORMER, 2—WINDING. (WITH TRANSFORMER IDENTIFICATION)
	INTERPHASE TRANSFORMER.
	RECTIFIER TRANSFORMER, 3—WINDING.
	LIGHTNING ARRESTER WITH GROUND CONNECTION.
	CABLE TERMINATION.
	DIRECTION OF CONTROL OR INDICATION SIGNAL.
K	KIRK—KEY INTERLOCK.
	GROUND CONNECTION.
	BRIDGEABLE GAP — CONTACT RAIL.
	EQUIPMENT METALLIC ENCLOSURE.
	NON—BRIDGEABLE GAP — CONTACT RAIL
	DISCONNECT SWITCH, NO—LOAD BREAK TYPE
LB (M)	MOTORIZED, LOAD BREAK TYPE DISCONNECT SWITCH.
	IMPEDANCE BOND.
AS	AMMETER SELECTOR SWITCH.
VS	VOLTMETER SELECTOR SWITCH.
ER	ELECTRICAL RESET.
	CIRCUIT BREAKER, 480 V AC.

ABBREVIATION DESIGNATION

SWGR	34.5 KV SWITCHGEAR.
DC SWGR	DC SWITCHGEAR.
MCC	480 V AC MOTOR CONTROL CENTER.
NC	NORMALLY CLOSED DEVICE.
NO	NORMALLY OPEN DEVICE.
ACB	AIR CIRCUIT BREAKER.
XFMR	TRANSFORMER.
SIC	INTERRUPTING CAPACITY IN AMPERES (SYMMETRICAL)
MVA	SHORT CIRCUIT WITHSTANDING CAPABILITY IN MEGAVOLT—AMPERE.
3ϕ	THREE PHASE CIRCUIT.
4 W	THREE PHASE CIRCUIT WITH NEUTRAL (4 WIRE)
TC	TRAIN CONTROL.
E	ELECTRICALLY OPERATED.
M	MANUALLY OPERATED
LOCAL	DEVICE LOCATED IN PROXIMITY OF THE EQUIPMENT.
CCS	DEVICE LOCATED REMOTE AT CENTRAL CONTROL FACILITY.
RT	RECTIFIER — TRANSFORMER POWER CONVERSION UNIT.
BKR	CIRCUIT BREAKER.

LOGIC DIAGRAM SYMBOL

	AND GATE
	OR GATE
	NOT GATE
E-2 (3)	CONTINUE TO LOGIC E-2 SIGNAL (3)
(G)	INDICATING LIGHT — GREEN
(R)	INDICATING LIGHT — RED
(W)	INDICATING LIGHT — WHITE
(CL)	INDICATING LIGHT — CLEAR
	AUDIBLE SIGNAL

DESCRIPTION	DESIGNED BY A. SMITHSUWAN Date 6APR83	
	DRAWN BY Y. S. OH Date 6APR83	
	CHECKED BY G. C. PARK Date 6APR83	

Kaiser Engineers California

SUBMITTED BY ______ PROJECT MANAGER ______ REG. NO.

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT

RTD

APPROVAL RECOMMENDED ______ Reg. No. ______

APPROVED ______ Date ______ MANAGER / CHIEF ENGINEER Reg. No. ______

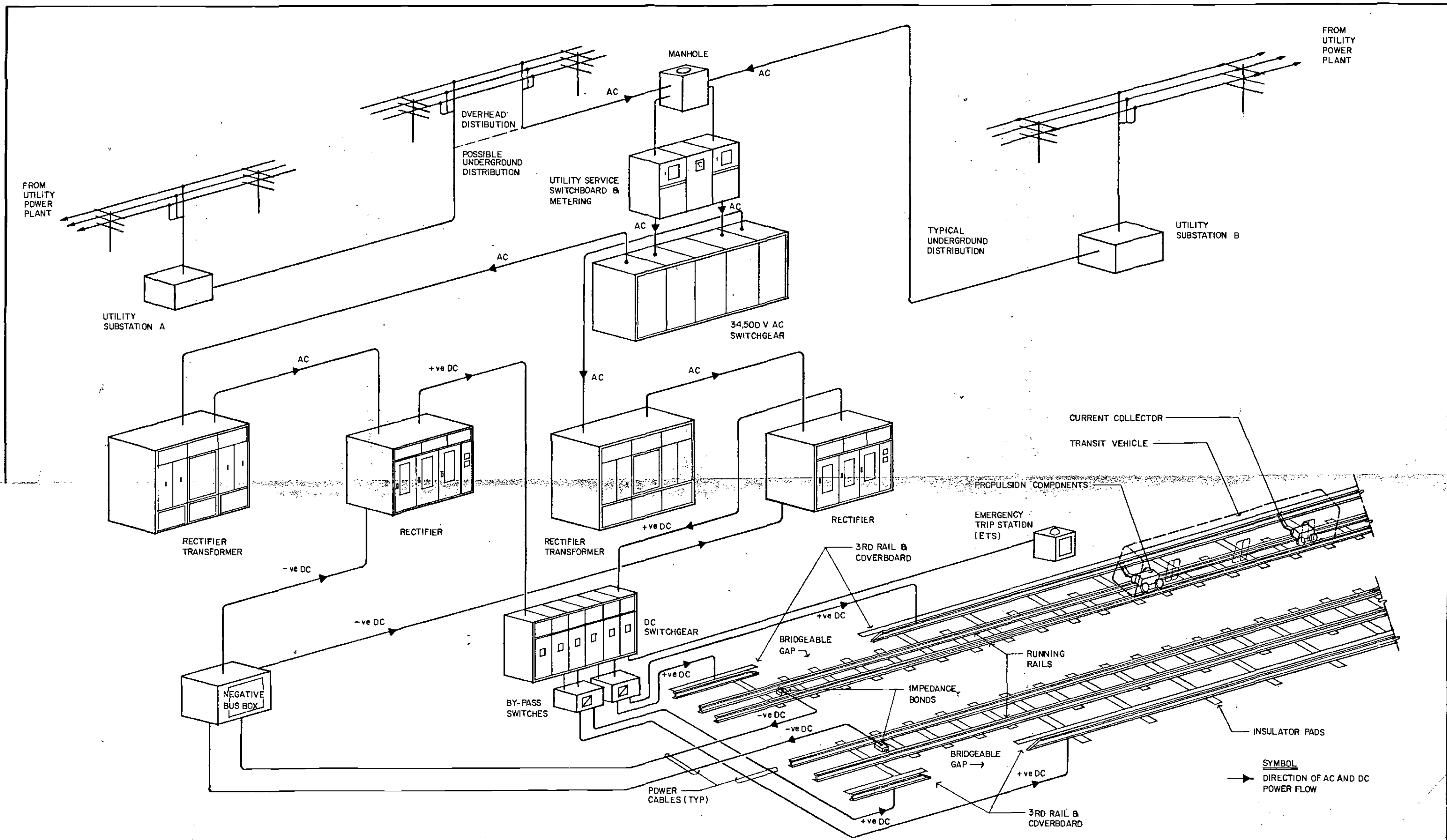
ELECTRICAL SYMBOLS & ABBREVIATIONS

CONTRACT NO.

DRAWING NO. 0-TP-01

SCALE NO SCALE

SHEET NO. 1



DATE	BY	APP.	DESCRIPTION

DESIGNED BY J. NEHME Date 1 MAR 83
DRAWN BY Y. S. OH Date 2 MAR 83
CHECKED BY I. SHAFIR Date 4 MAY 83

Kaiser Engineers California
Kaiser Engineers (California) Corporation
A Subsidiary of Raymond Kaiser Engineers Inc
300 Lakeside Drive
Post Office Box 23210
Oakland, California 94623-2321

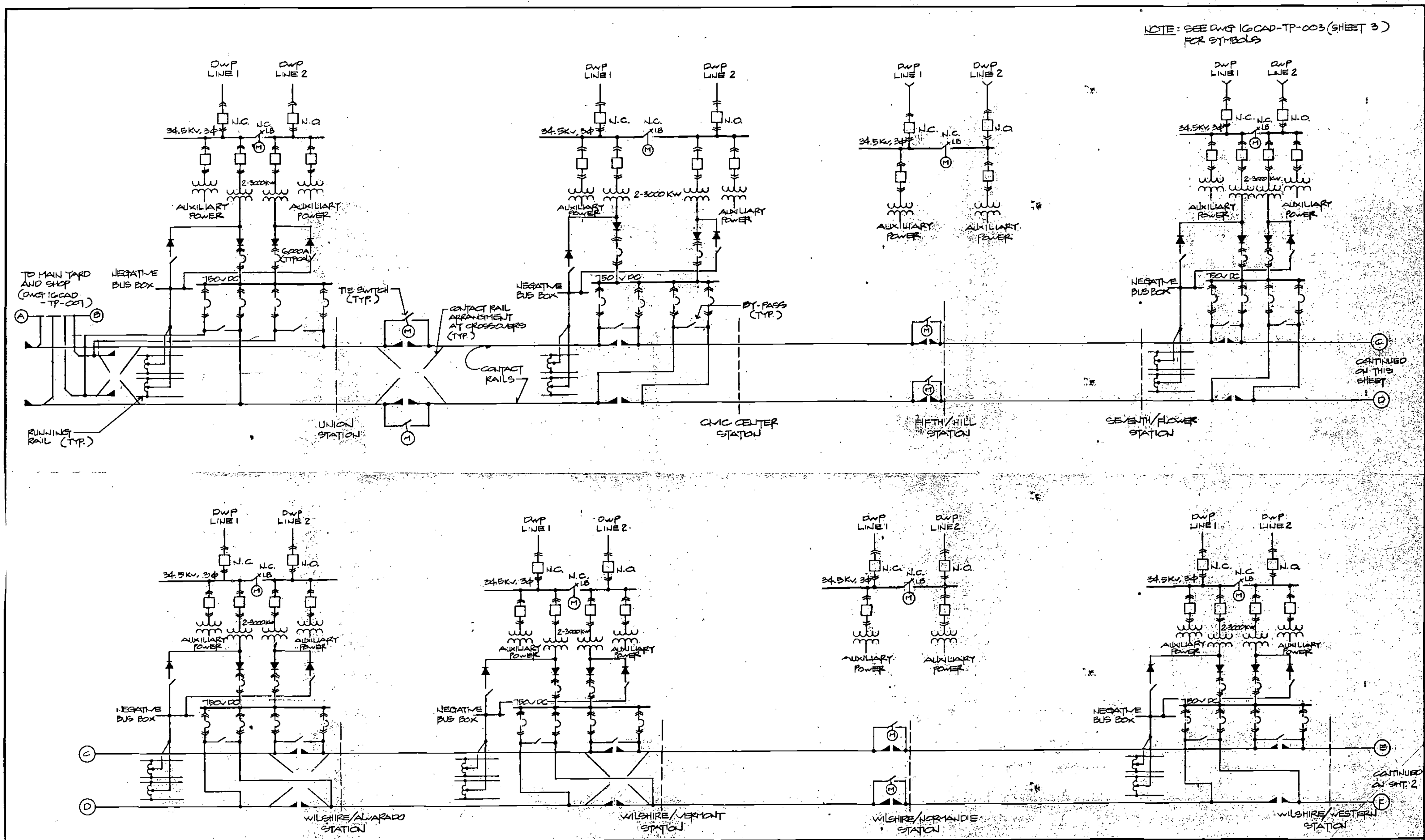
SUBMITTED BY: ______ PROJECT MANAGER ______ REG NO.

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

APPROVAL RECOMMENDED ______ Reg. No. ______
APPROVED ______ Date ______ MANAGER / CHIEF ENGINEER Reg. No. ______

TRACTION POWER ARRANGEMENT IN THE VICINITY OF A SUBSTATION

CONTRACT NO.
DRAWING NO. 16CAD-TP-00
SCALE NO SCALE
SHEET NO.



REV.	DATE	BY	APP.	DESCRIPTION

DESIGNED BY I. SHAFIR Date 2/22/83
DRAWN BY Y. S. OH Date 2/22/83
CHECKED BY R. BELARDO Date 3/21/83

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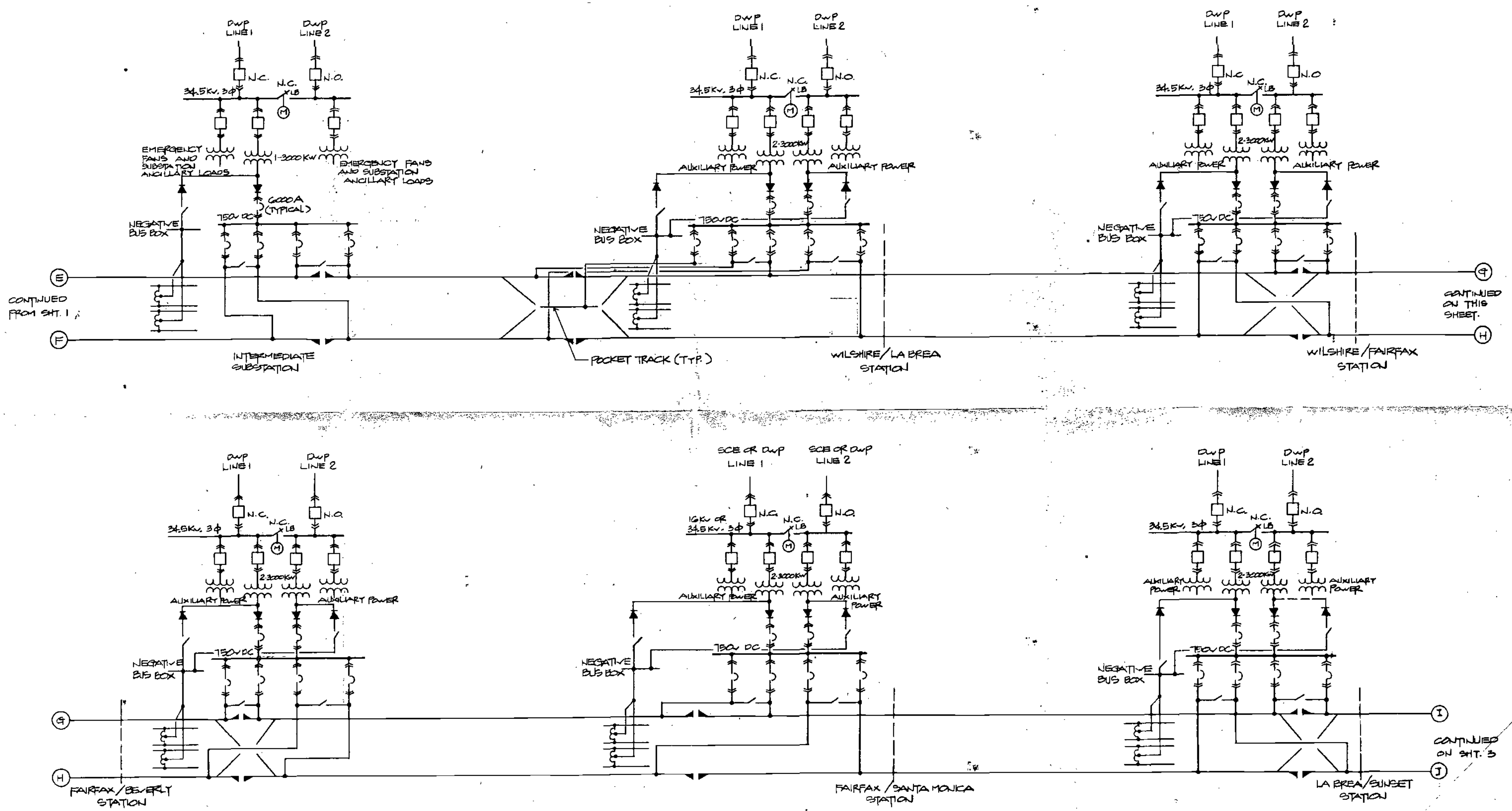
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

APPROVAL RECOMMENDED Reg. No.
APPROVED Date MANAGER / CHIEF ENGINEER Reg. No.

MAINLINE ELECTRIFICATION SINGLE LINE DIAGRAM

CONTRACT NO.
DRAWING NO. 16CAD-TP-001
SCALE NO SCALE
SHEET NO. 1 OF 3

NOTE: SEE DWG 16CAD-TP-003 (SHEET 3) FOR SYMBOLS



REV.	DATE	BY	APP.	DESCRIPTION

DESIGNED BY I. SHAFIR Date 2/22/83
DRAWN BY Y. S. OH Date 2/22/83
CHECKED BY R. BELARDO Date 3/4/83

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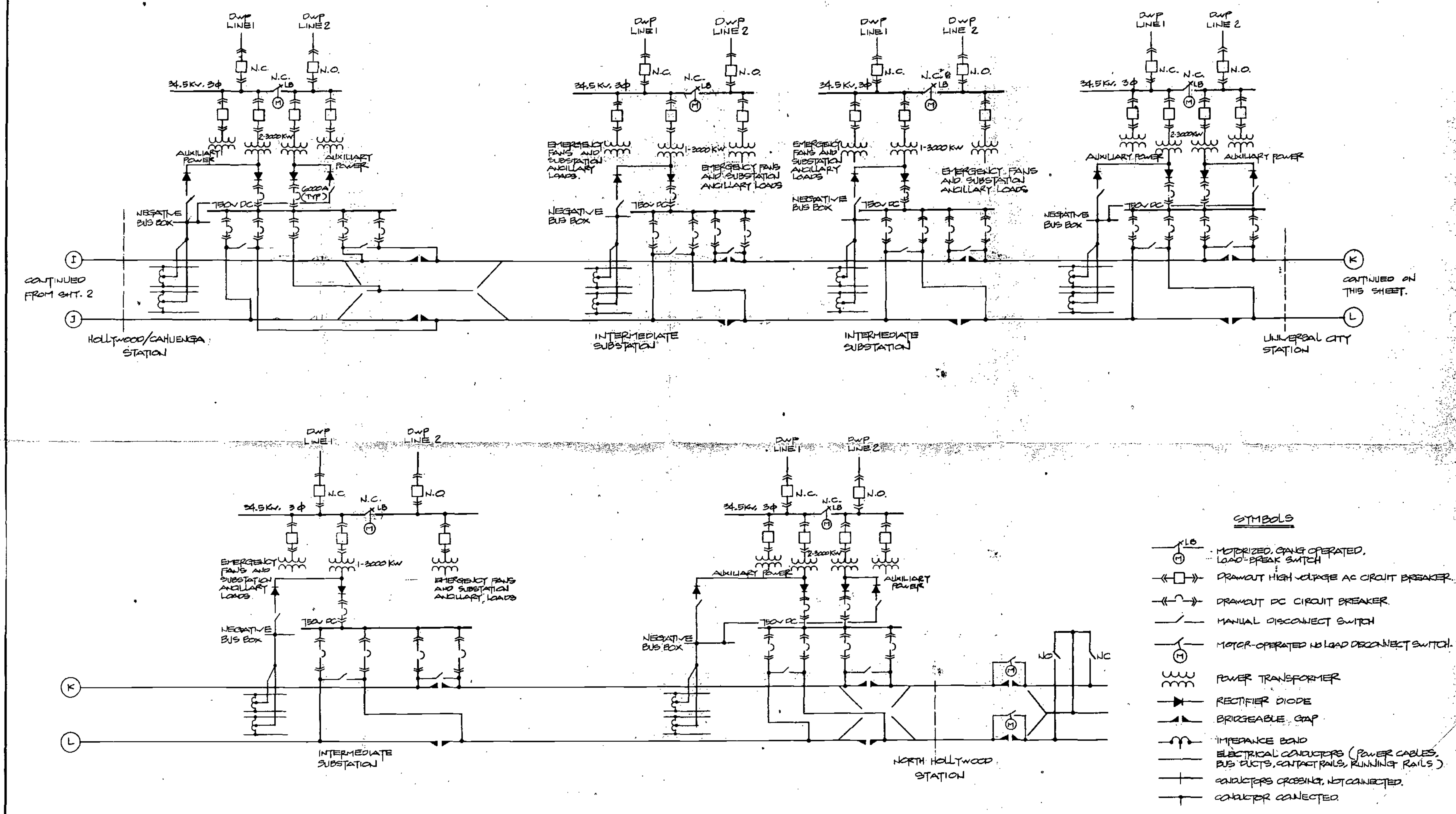
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

APPROVAL RECOMMENDED Reg. No.
APPROVED Date
MANAGER / CHIEF ENGINEER Reg. No.

MAINLINE ELECTRIFICATION SINGLE LINE DIAGRAM

CONTRACT NO.
DRAWING NO. 16CAD-TP-002
SCALE NO SCALE
SHEET NO. 2 OF 3



REV.	DATE	BY	APP.	DESCRIPTION

DESIGNED BY I. SHAFIR Date 2/22/83
DRAWN BY Y. S. OH Date 2/22/83
CHECKED BY R. BELARDO Date 3/29/83

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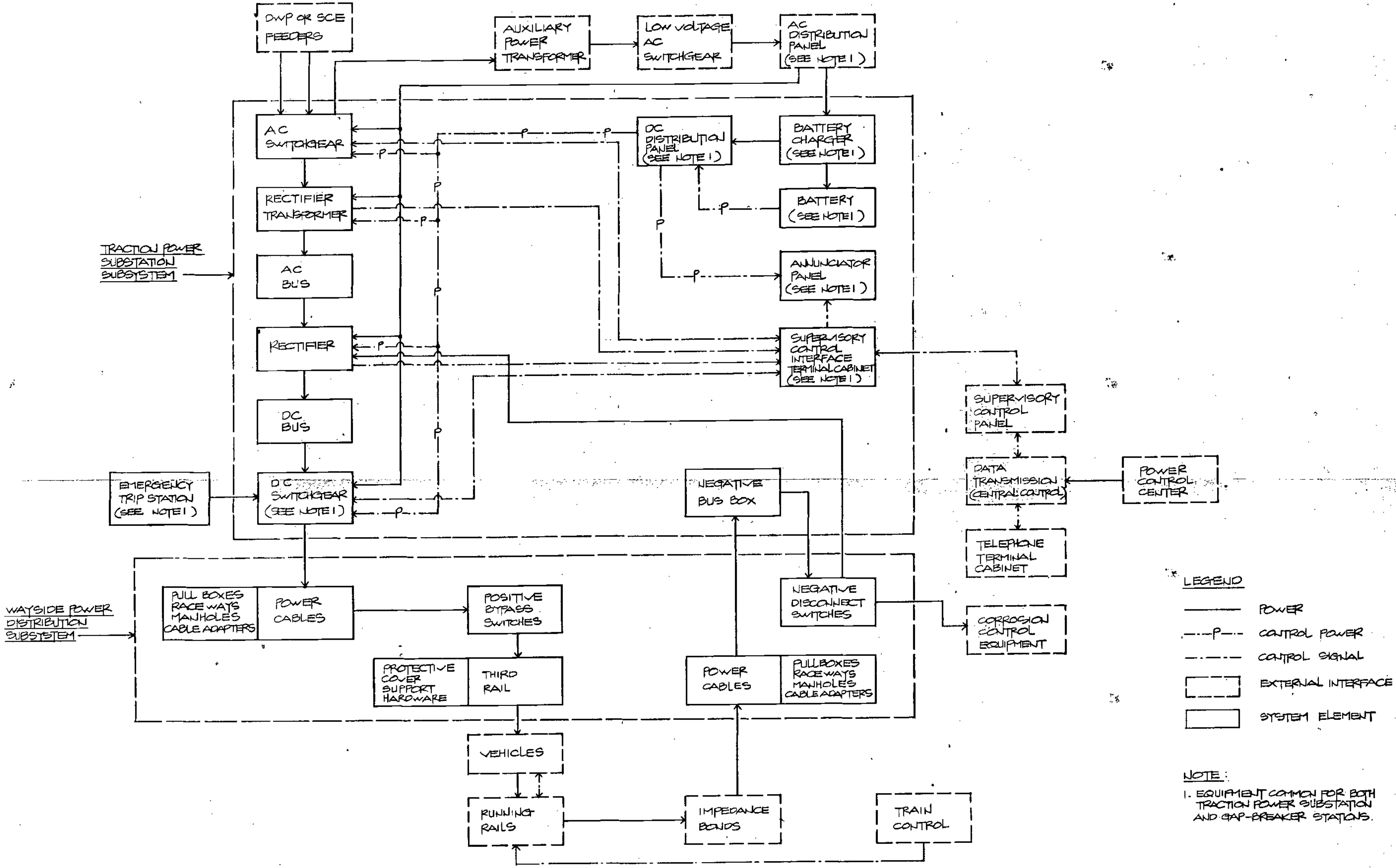
SUBMITTED BY: PROJECT MANAGER REG. NO.

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

APPROVAL RECOMMENDED Reg. No.
APPROVED Date
MANAGER / CHIEF ENGINEER Reg. No.

MAINLINE ELECTRIFICATION SINGLE LINE DIAGRAM

CONTRACT NO.
DRAWING NO. 16CAD-TP-003
SCALE NO SCALE
SHEET NO. 3 OF 3



REV.	DATE	BY	APP.	DESCRIPTION

DESIGNED BY I. SHAFIR Date 2/18/83

DRAWN BY Y. S. OH Date 2/22/83

CHECKED BY I. SHAFIR* Date 2/23/83

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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT

RTD

APPROVAL RECOMMENDED Reg. No.

APPROVED Date: MANAGER / CHIEF ENGINEER Reg. No.

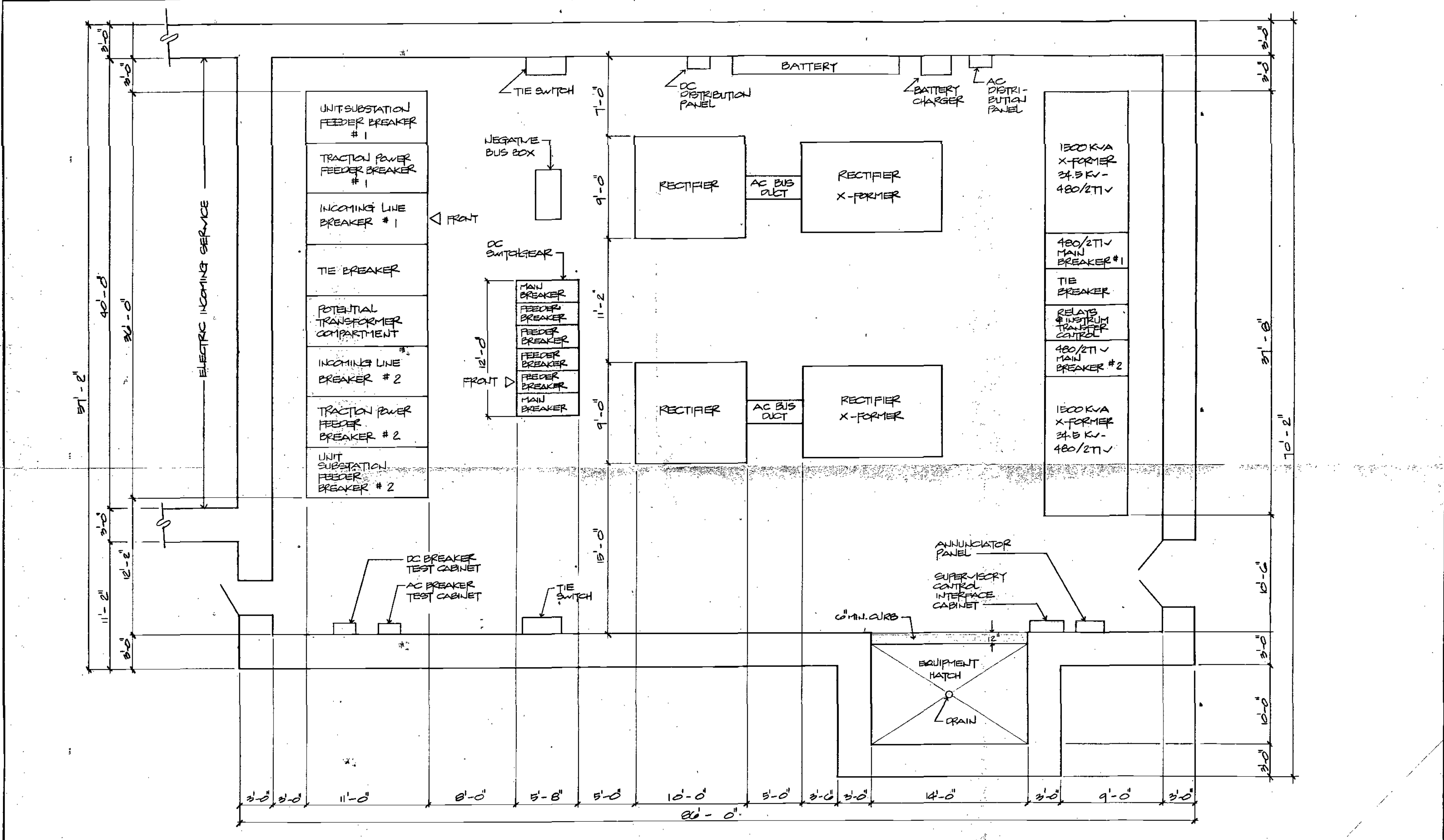
TRACTION POWER SYSTEM FUNCTIONAL & INTERFACE DIAGRAM

CONTRACT NO.

DRAWING NO. 16CAD-TP-004

SCALE NO SCALE

SHEET NO.



REV.	DATE	BY	APP.	DESCRIPTION

DESIGNED BY J. NEHME Date 11/20/82
DRAWN BY Y. S. OH Date 11/21/82
CHECKED BY I. SHAFIR Date 11/22/82

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SUBMITTED BY: PROJECT MANAGER REG. NO.

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

APPROVAL RECOMMENDED Reg. No.
APPROVED Date MANAGER / CHIEF ENGINEER Reg. No.

TRACTION POWER SUBSTATION EQUIPMENT LAYOUT (CONCEPTUAL FOR SUBSTATIONS LOCATED ABOVE THE TRAINWAY)

CONTRACT NO.
DRAWING NO. 16CAD-TP-005
SCALE 1/4" = 1'-0"
SHEET NO.