SOUTHERN CALIFORNIA

RAPID TRANSIT DISTRICT

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

MAY 1968

KAISER ENGINEERS · DANIEL, MANN, JOHNSON, & MENDENHALL

A JOINT VENTURE

PROJECT DOCUMENTATION

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I. GENERAL SYSTEM CRITERIA

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PRELIMINARY DESIGN CRITERIA

A. DESIGN CAPACITY

1. System facilities design shall be based on 1980 + 30% passenger volumes.

2. Equipment shall be provided to handle the 1980 passenger volumes under the initial construction program.

B. OPERATING DATA

1. System design shall be based on train loading of 1,000 passengers per train operating on 90 second headway.

2. System shall be designed for maximum train speed of 75 mph.

3. Schedule dwell time at stations shall be 20 seconds.[1]

C. VEHICLE

1. The system will operate with two basic types of cars, end cars (A car) containing the automatic control equipment and middle cars (B car). Trains will be operated with minimum two-car multiple units (2-A cars) up to any combination of 8 cars for a maximum length of 600 feet (nominal).

2. The following general characteristics of the cars will be used for design purposes:

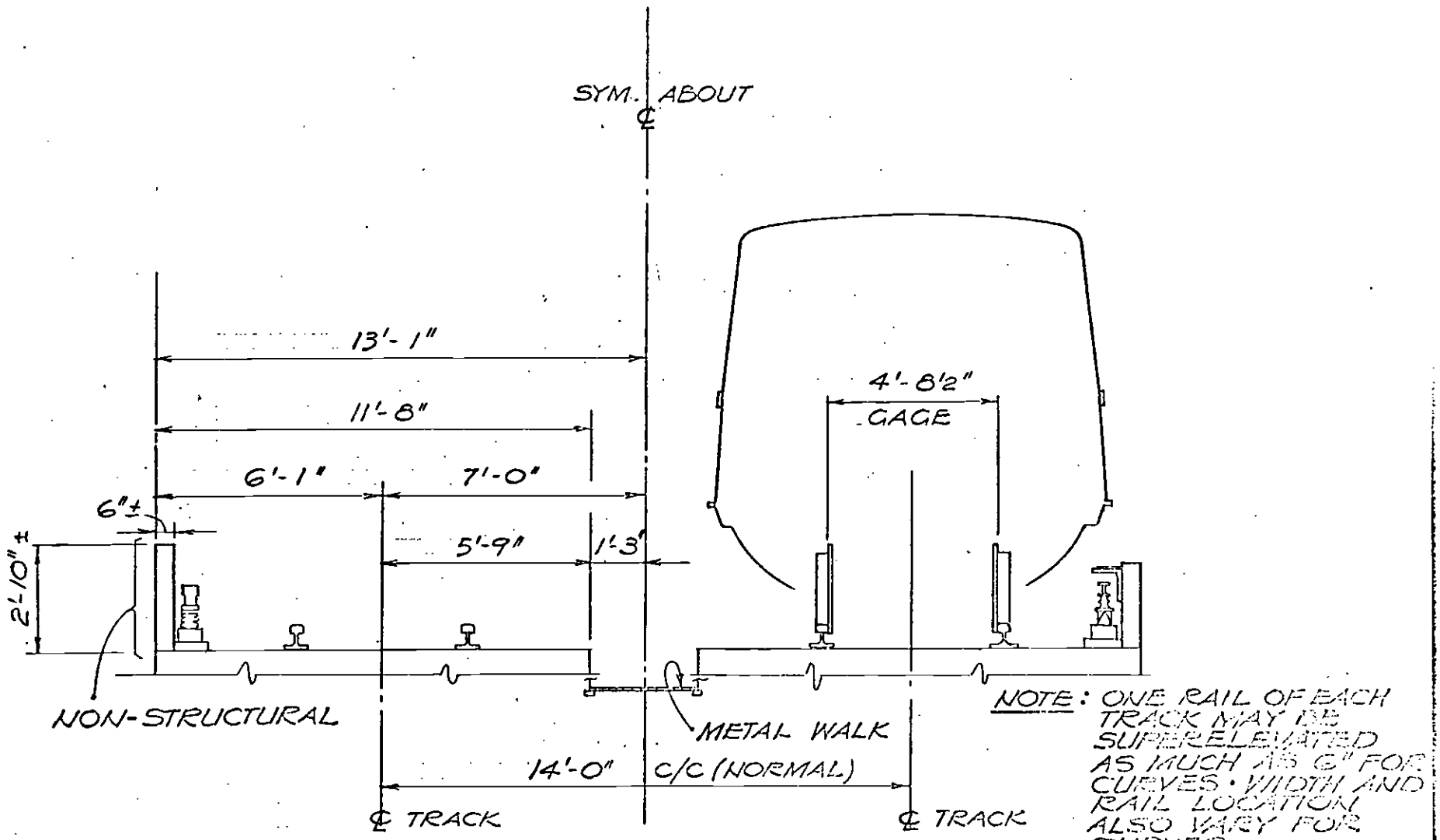
. Car Length (nominal)	75'-0"
. Car Width	10'-6"
. Car Height	10'-10"
. Floor Height Above Rail	3'-4"
. Track Gauge	4'-8½"
. No. of Doors (each side)	3
. Width of Door Opening	4'-6"
. Car Weight (empty)	65,000#
. Seating Capacity	80
. Scheduled Passenger-loading per car	125

[1]For all stations except the 7th & Flower and Western Avenue stations on the Airport Southwest Line. Details concerning dwell times at these stations can be obtained by referring to report prepared by Day & Zimmerman, Inc.

• Suspension System Frequency (max.)	1.5 cps
• Maximum Design Velocity	75 mph
• Acceleration Rate	3.0 mphps
• Service Brake Rate	2.6 mphps

D. GEOMETRY & CLEARANCE

Minimum Clearance in Tunnels (incl. curves):	9"(6" to clearance envelope; 5" to wall.)
Walkway-Minimum Width:	1'-10"(1'-6" minimum at 6'-6" up)
Walkway-Minimum Clear Height:	6'-6" @ ℄ walk (min. 5'-6" at edge)
Walkway Location-Subway & Tunnel:	Within 12" vertical & 8" horizontal of car floor.
Configuration of Aerial Way Structure Girders:	See Figure I-1
Tunnel Configuration:	See Figure I-2

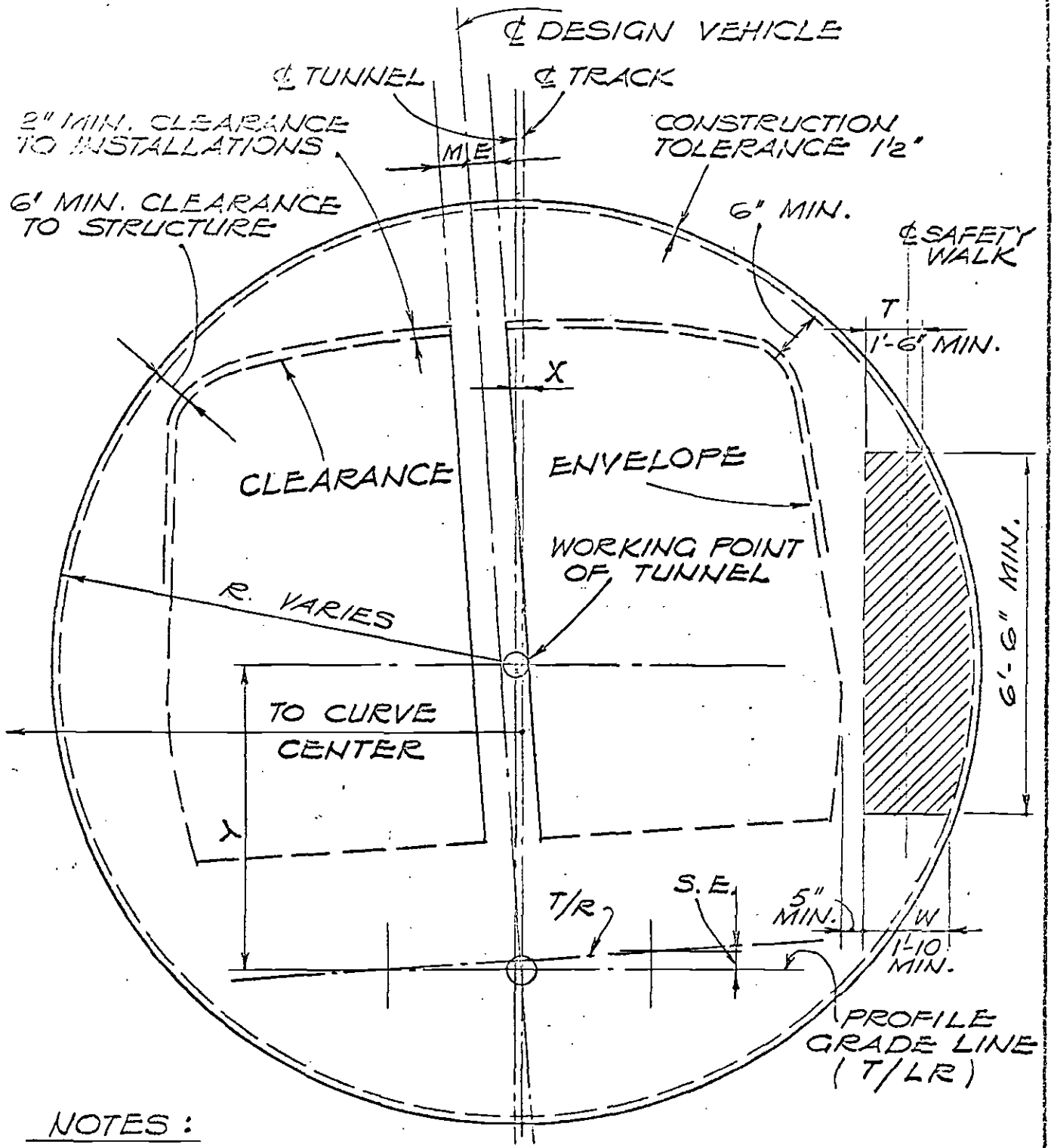


TYPICAL OVERHEAD CONFIGURATION

SCALE: 1/4" = 1'-0"

FIGURE 1.

SEPT. 29, 1967



NOTES:

1. CLEARANCE ENVELOPE REPRESENTS CAR DISPLACEMENT FOR MOVEMENTS DUE TO SUSPENSION SYSTEM AND WHEEL AND RAIL WEAR.
2. E AND M REPRESENT END AND MIDDLE OVERHANG DIMENSIONS FOR 75'-0" LONG CARS ON CURVES. (BASED ON CAR WIDTH OF 10'-6").
3. E, M, R, T, W, X, Y AND S.E. VARY WITH RADIUS OF CURVE.

CIRCULAR TUNNEL CLEARANCE DIAGRAM — CENTER OF CURVE LEFT

NO SCALE

FIGURE II.

SEPT. 29, 1967

II. TRANSIT VEHICLE

II. TRANSIT VEHICLE

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

A. GENERAL SCOPE

This brief criteria and specification is for estimating and planning purposes. The work to be included in the estimate includes all of the parts, accessories, equipment, apparatus, supplies, engineering and labor required to deliver, assemble, test and adjust rapid transit vehicles at the SCRTD property in Los Angeles, California. The Contractor shall deliver, complete, the vehicle as described herein and is responsible for all items except the District shall furnish the automatic train control equipment for installation by the Contractor.

B. GENERAL

This criteria and specification describes briefly the salient features of the proposed SCRTD rapid transit vehicle having steel wheels for operation on two steel rails. The trains will be operated in various lengths up to about 600 feet. Trains will be composed of 2 A cars and the appropriate number of B cars to complete the train of the desired length. The A car units will be longer than the B cars. The car lengths being considered for the rapid transit car for the SCRTD system are:

	B Car	A Car
Basic Car	75'	80'

These lengths are over the coupler faces for the B Cars. The A cars are measured from coupler face to buffer-sill (bumper) face.

The additional extension at the end of the A car will be cantilevered beyond the nominal truck locations of the B cars so that truck spacings will remain constant. The extended ends will be contoured so that additional clearances will not be required on curves. The ends will be shaped and contoured to create a modern, swift, efficient appearance. Plastics and corrosion resistant materials shall be used wherever appropriate in this vehicle.

C. VEHICLE AND SYSTEM DATA

The following information provides requirements and characteristics of the SCRTD system and vehicle in a brief form. Some of the vehicle information is repeated or presented in more detail in the appropriate section of the specification. (Some information shown is tentative and may not reflect the latest decisions for SCRTD. The data is shown to indicate the status at the time of writing.

1. Vehicle System

(a)	Propulsion	Electrical Motor
(b)	Power Source	3rd rail pick-up (each side of each truck)
(c)	Voltage at 3rd rail	900 v d-c
(d)	Length of train	2 cars - 160 ft., minimum 8 cars - 610 ft., maximum
(e)	Passenger loads	
	Seated passengers	80 passengers per car
	Scheduled passenger load	125 passengers per car

Crush passenger load	267 passengers per car

(f) Weight ("B" Cars)

Empty vehicle - goal	865 lbs. per foot (65,000 lbs. for 75' car)
Weight ("A" Cars)	(add 4,000 lbs. for A car 80' long)

(g) Maximum weight (crush) ("B" Cars):

(75' car)	1400 lbs./ft.(105,000)

2. Vehicle Performance (2-car trains

(a) Maximum speeds

Main line	75 mph
Yards (hostling)	10 mph

(b) Scheduled maximum speed 70 mph

(c) Average schedule speed (total system) 35 mph (approx.)

(d) Acceleration

Maximum allowed	3.5 mph ps, instantaneous

Maximum time with weight of maximum scheduled passenger load:

to move 600 feet from stop	18 seconds
to reach 60 mph from stop	40 seconds
to reach 75 mph from stop	60 seconds

(e) Deceleration

Maximum allowed	3.3 mphps, instantaneous
Full service (75 mph to 0)	2.6 mphps
Normal	2.4 mphps up to 2.6 mphps

(f) Jerk, maximum 1.5 mphpsps

(g) Headways, scheduled 90 seconds, minimum

(h) Fully Automatic Train Control (Automatic line supervision, speed control and train operation, including door operation.)

(i) Each end of each train will have a shaped end which will house some train control equipment and the train attendant.

3. Car Body

(a)	Minimum design life (not economic life)	25 years
(b)	Fixed sash in windows. Tinted safety glass	
(c)	Double-leaf, bi-parting, sliding doors on each side of each car, spaced along train at 25 feet. (Doors interlocked with train control). Clear width of opening 4'-6".	/Three doors,
(d)	Body width (maximum outside dimensions)	10'-6"
(e)	Length of car (coupler faces) (B-cars)	75'-0"
	(A-cars)	80'-0"
(f)	Car height (top of rail to top of car)	10'-10" maximum
(g)	Ceiling height (over aisle) minimum	7'-2"
(h)	Floor height (from top of rail)	3'-4"
(i)	Truck spacing	52'
(j)	Design impact load	3 g.
(k)	Exterior finish - corrosion-free materials	

4. Car Interior

(a)	Two-and-two, transverse seating arrangement, generally.	
(b)	Seat width, per passenger, approx.	22"
(c)	Seat spacing	$30\frac{1}{2}$" to 32"
(d)	Seats per foot of car length, approx.	1.0 seats/foot
(e)	Stanchions and hand holds for 40% standing load. (Load factor 1.5)	

(f) Floor covering — carpet

(g) No painted surfaces

(h) Continuous aisle and end doors allowing passenger movement between cars in a moving train. (Sound and weather protection between cars).

5. Truck Description

(a) Suspension — air or air-and-coil spring

(b) Bearing location — inboard or outboard

(c) Level control tolerance — plus and minus $\frac{1}{2}$"

(d) Vertical movement limits

up — 2"

down — 3"

(e) Natural frequency of vertical system — 1.5 cps, maximum

(f) Materials and methods — steel (fabricated or cast) aluminum (fabricated)

(g) Wheel base — 7'-6", maximum

(h) Wheel tread — (undecided)(multi-wear)

(i) Wheel gauge — 4'-7 11/16" or greater

(j) Wheel type — resilient or aluminum-centered

(k) Wheel diameter — 28" or 30"

6. Miscellaneous Equipment

(a) Battery and charger — 32 Volt d-c (24 to 40)

(b) Inverter for lighting — At least 400 H_z, probably 3,000 H_z

(c) Fluorescent lights — About 35 foot candles at reading plane

(d) Annunciator system — On each car and trainlined to attendant's console on A cars

(e) Communications:
- To train — Two-way voice transmitter on each A car
- On trains — Public address and intercom on each car

(f) Coupler
- Draft gear energy absorption — fully automatic 20,000 ft. lbs. at 150,000 lbs. max., 3" of travel
- Electrical — side or bottom, 60 circuits
- (Note: Retractable coupler for mechanical connection only, is required at end of trains.)

7. Braking Systems

(a) Dynamic braking range — 75 (limited) to 10 mph

(b) Friction brake capacity — full service
type — disc or tread

(c) Blending — complete

8. Air Comfort System

(a) Heating, cooling and ventilating modes shall be included.

(b) Controls — fully automatic

(c) Heating by electric resistance heaters (in ducts)

(d) Cooling by electric motor driven vapor cycle

(e) Ventilation by electric motor running continuously. Minimum rate — (4,000 cfm, 75' car) 55 cfm per foot of car

(f) Conditions inside with ambient below 95°F. — Winter, 72°F; Summer, 78°F

(g) Steady state temperature under the most demanding of the two conditions:

Case I	(97°F outside ambient (107°F air at the condenser intake (1.6 passengers per foot of car (full sun load (ambient air velocity over car of (30 mph	85°F, inside car
Case II	(110°F outside temperature (115°F air at the condenser intake (1.6 passengers per foot of car (no sun load (ambient air velocity over car at (30 mph	85°F, inside car

(h) Humidity controls — none

(i) Fresh air flow, minimum — 17 cfm per foot of car (10 cfm per passenger, normal load)

(j) Air velocities in car — 15 to 65 fpm limits
25 to 35 fpm optimum

(k) Air duct velocities — 2,500 fpm, maximum

(l) Air distribution, supply — Through under-window supply grills with air directed over glass.

(m) Ambient design conditions, outside — Winter, 30°F
Summer, 97°F, 40% relative humidity

(n) Maximum design temperature of air at condenser (without reducing critical pressures)

full operation	125°F
reduced operation	140°F

(o) Voltage — Main power of 900 v d-c or as converted. Battery 32 v d-c, also.

9. Maintenance Requirements

(a)	Inspection cycle	15,000 miles (goal)
(b)	Overhaul cycle	500,000 miles
(c)	Exterior washing	3 to 7 days
(d)	Interior	
	cleaning	daily
	pick-up	4 hours
(e)	Exceptions:	
	Inspection:	filters, as required

10. Track and Roadbed Geometric Data

(a)	Horizontal curves	
	Mainline	500'
	Yards and terminals	275'R
(b)	Vertical curves	
	Maximum rate of change	1.0 per 100' (parabolic)
	Usual rate of change	0.4% to 0.8% per 100'
	Maximum grades	3%
(c)	Continuous welded steel rail	
(d)	Track gauge (tangent and curve)	4'-8½" (± 1/8")
(e)	Track spacing (minimum)	14'-0" (centers)
(f)	Unbalance track superelevation	
	Maximum	5"
	Optimum	3"
(g)	Superelevation	
	Maximum	6"
	Optimum	5"
(h)	Cant of rail	1:40
(i)	At stations:	
	Maximum grade	1.0%

Vertical alignment Tangent

Horizontal alignment Tangent

(j) Clearances to vehicles (minimum permissable) 2"

D. WEIGHT AND NOISE

It is important that this vehicle be as lightweight and as quiet as possible. The target weight for the empty vehicle shall be no more than 865 pounds per foot of car length. Noise reduction techniques shall be employed wherever possible.

E. STRUCTURE

The car body framing and sheathing shall be constructed of aluminum or the car body framing and sheathing shall be constructed of stainless steel at the option of the supplier. The car body shall be a welded structure with no exposed fasteners. The car body shall be designed as a semi-monocoque structure.

F. IMPACT RESISTANCE

The car body shall be designed to withstand up to 3 G's (G equals empty weight of car, ready-to-run) applied at the buffer sills.

G. LIFTING PROVISIONS

The car body shall be designed so that jacking pads may be located at each corner of the car to permit lifting an empty car including the truck. Jacking pads shall also be provided under the side sills of the car inboard of each truck.

H. DOORS

1. Side Doors

Three door sets shall be provided on each side of the 75' car. These doors shall be bi-parting, sliding type doors which extend into door pockets at each side of the opening. Operation shall be by automatic electric operators which will open and close the doors in a total of 4 seconds. All door operators will be equipped to permit manual operation in an emergency. Door controls will be by remote train line operation giving a continuous signal to hold the doors in an open position. Door controls will be interlocked so that the train cannot operate unless all side doors are closed. Closing force shall be about 25 pounds, maximum.

2. End Doors

End doors shall be single leaf sliding doors with either power operated or power assisted door movement. They shall remain closed except when in use.

I. INTERIOR TRIM AND APPOINTMENTS

1. Interior Finish

The ceiling, sides, and walls shall be covered with a material having an integrally colored facing on the exposed side such as gel-coated fiberglass, vinyl or melamine. The materials shall be preformed to the appropriate contours.

2. Hand Holds and Stanchions

The necessary hand holds and stanchions for the safety and convenience of standing passengers shall be exposed, unpainted stainless steel or aluminum. Design shall provide for a load factor of 1.6.

3. Wind Screens

Materials for the wind screens shall be the same as the material used for the walls and ceilings.

4. Windows and Frames

Windows shall be held in extruded aluminum frames. The glass shall be uniformly tinted to resist heat and light. The windows shall provide clear view for standing passengers.

5. Floor Covering

The floor covering will be selected to provide maximum resiliency and comfort to the passengers. The floor covering must support the overall decorative scheme of the car. The covering shall be a high quality carpet and pad.

6. Seating

The passenger seats will be fixed individual bucket type seats with foam rubber cushions and backs. A hand hold or a stanchion will be provided at the aisle of all transverse seats. The upholstery material shall be a combination of woven wool fabric and vinyl covered fabric.

J. AIR DISTRIBUTION SYSTEM

The air distribution system shall consist of longitudinal ducts running the full length of the car, supplying 55 CFM of air per lineal foot of car. Distribution shall supply the air at the window sills. Return air shall be through the seat pedestals of the seats, between trucks only.

K. HEATING AND COOLING SYSTEM

A thermostatically controlled heating and cooling system shall be used to prepare the air to its proper temperature before entering the car. The total supply of air shall be composed of 30% fresh air and 70% return air. The cooling equipment shall be rated at between 10 and 15 tons, depending on car construction details, glass size and type and car length.

The heating shall be provided by electric duct heaters. About 30 kw of heating will be required.

L. LIGHTING

1. Interior Lights

Interior lighting shall be from high frequency fluorescent lights. They shall be arranged to give good general illumination and provide about 35 foot candles of intensity with a mininum of glare. Emergency lighting shall be supplied from the battery.

2. Exterior Lights

Two headlights and two taillights shall be provided on the contoured ends of the A cars. Warning lights shall be provided at all other car ends.

M. PROPULSION EQUIPMENT AND CONTROLS

Each car shall be provided with a complete set of electrical propulsion equipment designed to operate trains of at least 2 cars up to 600 feet in length from a 900 v. dc contact rail. The propulsion equipment shall be capable of accelerating a two-car train with a passenger loading of 265 pounds per foot at a rate not exceeding 3.5 miles per hour per second with a jerk limit of 1.5 miles per hour per second to meet the following conditions: (use predicted train resistance)

(1) accelerate from 0 to 60 mph in 40 seconds

(2) accelerate from 0 to 75 mph in 60 seconds

(3) travel 600 ft. from a stop in 18 seconds

(4) provide an average acceleration of 3.0 mphps for seconds 2 thru 10 from a stop

1. Dynamic Braking

Dynamic braking shall be utilized to assist in decelerating the train at controlled rates up to 3.0 miles per hour per second from 75 miles per hour to less than 10 miles per hour.

N. BRAKING SYSTEM

In addition to the dynamic brake operating through the propulsion motors and controls under the conditions mentioned in the preceding section the braking system shall include a friction brake. The friction brake shall furnish the required pressure and controls to apply mechanical friction brakes to blend with the dynamic braking so as to function smoothly and automatically with the dynamic brake to provide the specified retardation for service.

1. Friction Brake

The friction brake shall be fail-safe. It may be actuated by air, hydraulics or electricity. A trainlined, electrically operated parking brake capable of holding each car on a 5% grade shall be provided.

O. AUXILIARY ELECTRICAL EQUIPMENT

A motor alternator unit shall supply AC power for air conditioning and ventilation equipment and other auxiliary loads as appropriate. A 32 volt battery with battery charger shall be supplied. An annunciator system shall be installed on each car and trainlined to a console on the end car.

P. TRUCKS

The trucks shall be the 4-wheel type with pneumatic springs or combination pneumatic and coil springs. Either outboard or inboard journals may be used. The suspension system shall be

capable of leveling the car floor plus or minus $\frac{1}{2}$ inch under all loading conditions, and shall provide load-weighing information to the propulsion braking system. The truck shall be standard gauge 30" wheels. (Perhaps 28" wheels will be used.)

1. Materials

   Trucks may be fabricated of steel or aluminum, or made of cast steel.

2. Natural Frequency

   The truck suspension system shall have a maximum natural frequency of 1.5 cps in the vertical direction.

Q. NOISE LEVEL CRITERIA

The interior noise level design criteria shall be that the maximum noise level, at 60 to 70 mph, be NC-65 to NCA-65, and that the noise of the air conditioning system and other auxiliaries shall be approximately NC-55 to NCA-55 when the vehicle is stopped.

III. PASSENGER STATIONS

III. PASSENGER STATIONS

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

A. GENERAL

1. Stations shall be designed to accommodate 1980 plus 30% passenger volumes. Fare collection equipment shall be provided to handle 1980 volumes with provision to add equipment in the future.
2. Station platforms, mezzanine, ticket lobby, stairs, escalators and other passenger services shall be designed to accommodate design passenger volumes without undue congestion and with the maximum normal delay of any passenger not to exceed 30 seconds throughout passage of the station facilities except that station minimum size shall be adequate for not less than 900 passengers alighting in peak 20 minutes. Peak volumes less than 900 may be used for sizing fare collection equipment.
3. Station platform and ticket lobby shall be laid out to take advantage, where possible, of directing or channelizing opposing traffic to minimize congestion at points of high traffic density.
4. Entrances shall be fitted with a suitable barricade which shall effectively close off station areas during periods when the transit system is not operating.
5. All above ground stations shall be provided with a minimum 200 feet long canopy over the platforms. Extent of the shelter should be such that the platform width is sheltered from the sun and rain by a horizontal and/or vertical element and extend to provide protection for the train doors. This extension shall be such that it and the car profile provide a maximum cut-off angle of 45°.
6. All access bridges, ticketing area and vertical circulation shall be weather protected to allow continuous protection for the passengers.

B. VERTICAL CIRCULATION

1. Maximum convenience for patrons shall be achieved through proper sizing and layout of the vertical circulation elements.

   Escalators shall be provided in addition to stairs where rise exceeds approximately 12 feet. Escalators shall also be provided for down traffic when descent height exceeds 16 feet. Minimum width of escalator shall be 48". Escalator speed shall be 90 feet per minute with provision for future increase to 120 feet per minute, except where minimum standards obviously will provide over-capacity for the station passenger volume. Due regard shall be given to minimum requirements for fire and panic safety.

2. The layout of the vertical circulation elements should encourage the use of escalators rather than stairs.

3. There should be a minimum of 15'-0" unobstructed space as run-off at both ends of the escalator.

4. Escalators will be heavy-duty reversible type, capable of operating under full load conditions in either direction.

   Speed: 120 feet per minute.

   Capacity: 135 persons per minute on a 4'-0" (nominal) width tread. (120 fpm speed)

5. Exterior escalators (entrances at subway stations) that are not protected by a shelter will be of weatherproof design, and will be designed to allow for thermal expansion and contraction.

6. Stairs or escalators, extending to or through public sidewalks, shall not reduce net remaining width of sidewalk to less than 5' 0". Provision shall be made to minimize possible surface water infiltration into the facility from sidewalks and adjacent gutters. Splash shield shall be installed where stairs are located immediately adjacent to street gutters.

C. PLATFORM

1. Platforms shall be 600 feet long.

2. The minimum distance from the edge of the platform to any obstruction shall be 11 feet. Platform widths shall be designed to accommodate passenger design volumes in accordance with applicable criteria contained herein.

3. Columns and other obstructions at the platform level shall be minimized to allow efficient circulation and reduce problems of passenger surveillance, minimize crime potential, increase feeling of safety and passenger comfort.

4. Platforms shall have a 1 foot wide strip of a non-skid surface along each platform edge nearest the track and be of contrasting color to the platform area.

5. Platform levels shall be 3' 4" above the top of rail

6. Minimum unobstructed space in front of stairs, at top and bottom, shall be 10' beyond last riser. For stairs more than 6' wide, minimum distance shall be increased accordingly. Tread and riser relationship should have a component of thirty degrees (30^{o}) with a minimum riser of 6-1/2" and a maximum riser of 7".

D. MAINTENANCE AND SANITATION

1. One water closet and one lavatory shall be provided in each station, except terminal and CBD stations. These facilities shall be provided for the station attendant and will normally be locked.

2. Terminal stations shall be provided with separate men's and women's restrooms. Men's rooms shall be fitted with 2 lavatories, 2 water closets and 1 urinal. Women's rooms will be fitted with 2 water closets and 2 lavatories.

3. CBD stations will have separate men's and women's restrooms of 2 urinals, 2 water closets, 2 lavatories and 3 water closets and 2 lavatories, respectively.

4. All facilities will be in the paid area side of turnstiles.

5. Convenience outlets and water shall be provided within the ticket lobby and adjacent areas for cleaning and maintenance.

E. STATION EQUIPMENT

1. This section describes the equipment which is used to control and facilitate passenger movement through the stations. Included are:

   . Escalators used for vertical circulation between street level and the ticketing concourse
   . Fare vendors and money changers in the free area
   . Entrance and exit turnstiles
   . Ticket readers in the attendant's offices
   . Transfer dispensers in the paid area
   . Escalators for vertical circulation between the ticketing concourse and the loading platform.

2. The selection and arrangement of station equipment must satisfy the following conditions:

   . Simplification of the fare collection operation
   . Implementation of the graduated fare structure
   . Comprehension by the patrons
   . Sufficient flexibility for expansion or equipment conversion
   . Adequate surveillance and security
   . Practical economy and maximum passenger convenience.

3. All escalators throughout the system shall -

   . Have a nominal width of 48" and an actual tread width of not less than 44"
   . Be capable of operating at speeds of 90 and 120 feet per minute

- Be considered as having an actual capacity of 100 and 135 persons per minute at the noted speeds
- Be provided in sufficient quantity to clear the platform at any given station of the average number of passengers expected to alight at one time during the peak period.

- Be provided in quantity not less than that determined above to transport the same passenger flow from the ticketing concourse to the street level or other point of public access.

Each station platform shall have a minimum of one escalator operating in each direction. Those escalators required in excess of the minimum will operate in the direction of the peak load.

There shall be a key-operated reversing switch and an emergency stop button at the top and bottom of all escalators. The direction of travel and cause of any stoppage of all escalators shall be monitored in the station attendant's office.

F. FARE COLLECTION

Entry and exit to the transit stations will be controlled by automatic fare collection equipment. The ticketing sequence will be:

- Money Changer (if needed).
- Fare Vendor.
- Entry Gates.
- Exit Gates.

Commuters carrying tickets will not stop at changers or vendors.

1. Fare Vendors

Location -

- The fare vendors within the "free" areas will be placed to serve incoming passengers and will not normally be used by those exiting.
- The vendors must be clearly visible on entry to the station but placed so as not to impede the direct flow between entry and ticket gates.
- All fare vendors and changers should be built-in flush with wall surfaces. Provisions should be made for an access corridor (3'-0" wide minimum, 4'-0" preferred) behind them for money removal and maintenance, with a high security door 2'-6" wide minimum.
- There must be at least one vendor and one changer in the "free" area in the vicinity of each set of entrance gates.
- In the layout of all fare vending equipment, space must be provided for future expansion.

Quantities and Dimensions of Fare Vendors -

- In "free" areas, one vendor must be provided for every 250 people boarding during the peak 20 minutes.

- Rate of operation of fare vendors: Four to six persons per minute (average 10 seconds per person). 8'-0" queue space must be provided at fare vendors.
- Dimensions of fare vendors: approximately 3'-0" wide x 2'-6" deep x 6'-0" high, spaced 4'-0" on center.

2. Money Changers

Quantities and Dimensions of Money Changers -

- One changer to every two fare vendors.
- Rate of operation of money changers: Four to six persons per minute. 8'-0" queue space must be provided at changers.
- Dimensions of money changers: Approximately 3'-0" wide x 2'-6" deep x 6'-0" high, spaced 4'-0" on center.
- Money changers should be grouped at the end of a bank of vendors, nearest approaching passengers. With two directions of approach, changers should be grouped at each end of bank of vendors.

3. Ticket Gates

Ticket gates are power operated and are capable of magnetic reading, assessing and canceling. All gates are reversible (for exit or entry). In a bank of gates, the outermost gates will not normally be reversed. The right hand gates to the entering flow will be "entry" gates; the right hand gates to the exiting flow will be the "exit" gates. The remaining center gates will be reversed to suit the major directional flows. All gates will be designed for right hand operation in either direction.

Quantities and Dimensions of Ticket Gates -

- The ticket "gates" consist of a path between two flanking machine units containing ticket processing units. The path is blocked by swing doors or turnstiles opened by the insertion of a valid ticket.
- The dimensions of the machine units are approximately 4'-0" long x 3'-6" high x approximately 1'-0" wide, and 3'-0" on center (leaving a path approximately 2'-0" wide).
- The number of gates to be installed initially per station is based upon one gate per 300 persons in the peak 20 minutes in 1980.
- Space for additional gates must be provided in the barriers adjacent to the ticket gates.
- Gates will operate at the rate of 30 persons per minute. Queue space on either side of the gates (in "paid" and "free" areas) is based on the possible failure of one or more gates during the peak hour (in normal) usage, no queuing is theoretically necessary. Provide queue space of 20'-0" each side of gates.
- In addition to the required queue space, a 10'-0" additional surge space should be provided between the ends of escalators that can feed toward a queue and the start of any queue space.
- In no case should less than three gates be provided in any single gate location.

4. Emergency Exit Gates

Ticket gates do not provide satisfactory means of escape in emergency. In every barrier adjacent to the ticket gates sufficient emergency exit way must be provided. This passage should be closed by hinged

gates equipped with panic release hardware and audible alarms, to discourage misuse.

5. Service Gate

a. To every "paid" area there must be a 4'-0" wide double-doored service gate in the barrier. This may be used by the handicapped, maintenance and service staff, emergency crews (police, fire, etc.).

b. The service gate will be controlled by the station agent, and should be immediately adjacent to the booth. The service gate may provide part of the required emergency egress width, but in that case must be equipped with panic hardware and an alarm.

6. Transfer Equipment

Quantities and Dimensions of Transfer Equipment -

- Transferring from train to train will require no ticketing procedure.
- Provide one transfer dispenser for every 400 passengers during the peak 20 minutes for bus transfer.
- Dimensions of transfer dispenser are approximately 2'-6" wide x 2'-6" deep x 3'-6" high, spaced 3'-0" on center.
- Rate of operation of dispenser: 40 persons per minute (1.5 seconds per person).
- A minimum of 8'-0" queue space should be provided.

7. Station Agents Booth

a. All fare vendors, money changers, and ticket gates should be in immediate view and in reasonable proximity to the station

agent's booth for direct supervision, or they must be indirectly supervised by closed circuit T.V.

b. The station agent's booth should be located in line with the gates and either centrally located with respect to the gates or to the right of the entry gates as patron circulation dictates.

IV. ARCHITECTURAL

IV. ARCHITECTURAL

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

A. GENERAL

Finish surfaces are to be hard, dense, non-porous, acid and alkali resistant for long life and low maintenance. Interior colors are to be predominantly light in tone to aid in maintaining high illumination levels. Texture of materials should be smooth, or with minor surface variation but not so deep as to create difficult cleaning situations or to be easily damaged. The unit size of materials should be large enough to minimize the number of joints and small enough to make the units easy to replace. Joints are to be small, flush, limited in number, and of material that will not produce unsanitary cracking. Costs should be consistent with the useful life, overall aesthetic and functional qualities.

B. STANDARDS

Materials are to be selected so that quality and maintenance requirements will be consistent throughout the system and to satisfy the following standards:

1. Safety -

   . Fire resistance and smoke generation. To reduce hazard from fire by using materials with minimum burning rate and smoke generation consistent with code requirements.

   . Non-slip. To increase pedestrian safety by using floor materials with non-slip qualities.

2. Durability -

   To provide for long and economical service by using materials with wear strength and weathering qualities consistent with their initial cost.

3. Ease of Maintenance -

. Cleaning. To reduce cleaning cost by using materials which do not soil or stain easily, which have surfaces that are easy to clean and on which minor soiling is not apparent.

. Repair or replacement. To reduce maintenance cost by using materials which if damaged are easily repaired or replaced without undue interference with the operation of the system.

4. Aesthetic Qualities -

To create a feeling of good quality and attractiveness.

5. Performance Standards -

Standards will be established in the various categories and materials will be tested prior to approval.

Methods of testing and reporting data will be standardized for the purpose of comparing the relative merits of material produced by different manufacturers and relating their performance to the established standard.

C. FINISH MATERIALS

Materials Selection -

The following Drawing Nos. A-58 and A-243 lists material for stations. Drawing No. A-58 is related to station drawing numbers A-1 through A-52 and Drawing No. A-243 is related to station drawings A-201 through A-240. Materials are selected to meet the standards indicated.

SUBWAY

BCO	W-1	UNION STATION	W-10	WILSHIRE-CRENSHAW	W-16	WESTWOOD
	W-2	CIVIC CENTER	W-11	WILSHIRE-LA BREA	W-17	BARRINGTON
	W-6	ALVARADO	W-12	FAIRFAX	LB-1	OLYMPIC
	W-7	VERMONT	W-13	LA CIENEGA	LB-2	WASHINGTON
	W-8	NORMANDIE	W-14	BEVERLY HILLS	LB-13	LONG BEACH
	W-9	WILSHIRE-WESTERN	W-15	CENTURY CI.		
BSCO	W-4	7TH & FLOWER				
BSDT	W-3	8TH & BROADWAY				
BCT	W-5	LUCAS	SF-3	VINE		

AERIAL

ASU	SF-6	NORTH HOLLYWOOD	SF-11	SHERMAN CIRCLE	LB-5	GAGE
	SF-9	BURBANK BOULEVARD	LB-3	ADAMS	LB-6	FIRESTONE
	SF-10	VAN NUYS	LB-4	VERNON AVENUE		
AST	SF-7	LAUREL CANYON	SF-13	BALBOA	LB-10	DEL AMO
	SF-8	FULTON	SF-14	LINDLEY		
	SF-12	SEPULVEDA	SF-15	TAMPA		
ACU	SG-7	EL MONTE	SF-5	UNIVERSAL CITY	LB-8	IMPERIAL

CUT

XSO	SF-1	BEVERLY BLVD.
	SF-2	SANTA MONICA BLVD.
	SF-4	HOLLYWOOD-LA BREA

AT-GRADE

GCT	SG-1	COUNTY HOSPITAL	SG-5	SAN GABRIEL	LB-7	WATTS
	SG-3	FREMONT	SG-6	ROSEMEAD	LB-11	WARDLOW
					LB-12	PACIFIC COAST
GCO	SG-2	STATE COLLEGE	LB-9	COMPTON		
	SG-4	GARFIELD				

	FLOOR												BASE												WALLS																								GLAZING			CEILING								COLUMNS			
	CONCRETE & HARDENER	CONCRETE W/ABRAS. FIN.	TERRAZZO W/GRANITE CHIPS	RESILIENT COVERING (VINYL)	CONCRETE W/WATERPROOFING	CONCRETE W/ABRAS.	PRECAST CONCRETE						TERRAZZO COVED	CONCRETE COVED											CONCRETE - SMOOTH	CONCRETE - PRE-CAST	CONCRETE W/WATERPROOFING	CEMENT PLAS. W/STUD WALL	VITREOUS CHINA TILE	METAL PANELS-ANOD. ALUMINUM	METAL LOUVERS	METAL GRILLES-ROLLING/SLIDING		CURTAIN WALL-ALUM. & GLASS	PRECAST CEMENTITIOUS	PRECAST TERRAZZO FACING		STAINLESS STEEL BALUSTRADE	PRECAST CONC GUARD RAILS	TERRAZZO GUARD RAILS	1/4" HEAT ABSORBENT	1/4" LAMINATED SAFETY	1/4" TEMPERED		CONCRETE-EXPOSED	CONCRETE-PRECAST	CERAMIC PLASTER	ALUMINUM PANELS-PERFORATED	ALUMINUM PANELS-SOLID	EXPOSED STRUCTURE		CONCRETE	ALUMINUM COVERED	PRECAST TERRAZZO FACING	
CONCOURSE - FREE AREA																																																											
CONCOURSE - PAID AREA																																																									
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STAIRWAYS - PUBLIC																																																									
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STORAGE ROOM																																																									

- ○ TERRAZZO WAINSCOT 7' HIGH
- ○ TERRAZZO WAINSCOT 7' HIGH
- TERRAZZO BENCHES
- SIDEWALK ENTRANCES EQUIPPED W/ROLLING SHUTTER CLOSURE
- SIDEWALK ENTRANCES EQUIPPED W/ROLLING SHUTTER CLOSURE
- ○ TERRAZZO WAINSCOT 7' HIGH
- ○ TERRAZZO WAINSCOT 7' HIGH
- ○ TILE @ SERVICE SINK
- 1-HR
- 1-HR
- 2-HR
- 1-HR
- AST ONLY
- ACOUSTIC TREATMENT @ FACE OF PLATFORM
- ○ TERRAZZO WAINSCOT 7' HIGH
- ○ TILE @ SERVICE SINK
- 1-HR
- 1-HR ○ AT BELOW GRADE
- 2-HR
- 2-HR
- 1-HR
- ○ TERRAZZO WAINSCOT 7' HIGH
- ○ TERRAZZO WAINSCOT 7' HIGH
- SIDEWALK ENTRANCES EQUIPPED W/ROLLING SHUTTER ENCLOSURE ○ AT STREET LEVEL
- SIDEWALK ENTRANCES EQUIPPED W/ROLLING SHUTTER ENCLOSURE
- ○ TERRAZZO WAINSCOT 7' HIGH
- ○ TILE @ SERVICE SINK
- 1-HR
- 1-HR ○ BELOW GRADE EXT WALL
- 2-HR
- 1-HR
- ○ BELOW GRADE EXT WALL
- ACOUSTIC TREATMENT @ FACE OF PLATFORM
- TILE @ SERVICE SINK
- 1-HR
- 1-HR ○ AT BELOW GRADE
- 2-HR ○ AT BELOW GRADE
- 1-HR

APPROVALS

DATE	1 DEC 67	
DRAWN BY	KENJAN	
CHECKED BY	SCHMID	

KAISER ENGINEERS
A JOINT VENTURE
DANIEL, MANN, JOHNSON, & MENDENHALL
ARCHITECTS · ENGINEERS

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
LOS ANGELES, CALIFORNIA 90015

FINISH SCHEDULE

DRAWING NO. A58

TITLE

DRAWING NO. A 58

F I N I S H   S C H E D U L E

STATION

SUBWAY

BCO	BROADWAY	ASC-2
BCO	BUNKER HILL	ASC-3
BSCO	7TH & FLOWER	ASC-4 & 2A
BCO	CONVENTION CENTER	ASC-5

AERIAL

ASU	EXPOSITION PARK	ASC-6
AST	WESTERN	ASC-7
AST	CRENSHAW	ASC-8
ASU	LA BREA	ASC-9
AST	MANCHESTER	ASC-10
AST	CENTURY	ASC-11
AST	EL SEGUNDO	ASC-12
ASU	ROSECRANS	ASC-13
ASU	L. A. X	ASC-3A

AT-GRADE

GCO	METROPORT	ASC-1 & 1A

Station	Item	Floor: Concrete w/hardener	Floor: Concrete w/abbras. fin.	Floor: Terrazzo w/granite chips	Floor: Resilient covering (vinyl)	Base: Cove	Base: Applied	Base: Terrazzo	Base: Concrete	Base: Rubber	Base: Aluminum	Walls: Concrete - smooth	Walls: Concrete - pre-cast	Walls: Concrete block	Walls: Metal panels - stainless steel	Walls: Metal panels - anod. aluminum	Walls: Metal panels - porc. enamel	Walls: Metal louvers	Walls: Metal grilles - rolling sliding	Walls: Curtain wall - alum. & glass	Walls: Ceramic tile	Walls: Movable partitions	Walls: Glass balusters	Walls: Stainless steel balusters	Walls: (unlabeled)	Glazing: 1/4" heat absorbent	Glazing: 5/16" plate	Glazing: 1/4" tempered	Ceiling: Concrete - exposed	Ceiling: Concrete - precast	Ceiling: Cement plaster	Ceiling: Keene cement	Ceiling: Aluminum panels - perforated	Ceiling: Aluminum panels - solid	Ceiling: Height - fin. flr. to fin. clg.	Columns: Concrete	Columns: Aluminum covered	Remarks
SUBWAY	CONCOURSE - FREE AREA			●		●	●	●			●					●																	●	●	11		●	
SUBWAY	CONCOURSE - PAID AREA			●		●	●	●			●					●																	●	●	11		●	
SUBWAY	PLATFORMS			●		●		●				*																					●	●	11			TERRAZZO BENCHES *AT ENDS OF PLATFORM
SUBWAY	TRAIN SCREEN																			●							●										●	
SUBWAY	TRACK AREA	●										●																										
SUBWAY	STAIRWAYS - PUBLIC			●												●																						SIDEWALK ENTRANCES EQUIPPED W/ROLLING SHUTTER CLOSURE
SUBWAY	STAIRWAYS - SERVICE		●									●																										
SUBWAY	ESCALATORS														*	●								●														SIDEWALK ENTRANCES EQUIPPED W/ROLLING SHUTTER CLOSURE *BALUSTRADE SKIRTS
SUBWAY	ATTENDANT'S OFFICES			●			●				●											●						●					●		10			
SUBWAY	STAFF TOILET			●		●		●						●							●											●			8			
SUBWAY	PUBLIC TOILETS			●		●		●						●							●											●			8			
SUBWAY	MAINTENANCE ROOM	●				●			●			●									*								●						12			* TILE - SERVICE SINK
SUBWAY	FARE VENDING SERVICE VAULT			●		●		●				●										●											●		11			1 - HR
SUBWAY	TRAIN CONTROL ROOM				●		●			●						●																	●		10		●	1 - HR
SUBWAY	ELECTRICAL ROOM	●				●			●			●		●															●						12			
SUBWAY	SUBSTATION	●				●			●			●		●															●						16			2 - HR
SUBWAY	MECHANICAL ROOM	●				●			●			●		●															●						12			1 - HR
SUBWAY	STORAGE ROOM	●				●			●			●		●															●						12	●		
AERIAL / AT-GRADE	STATION EXTERIOR	●										●	●						●	●						●										●		
AERIAL / AT-GRADE	DETACHED CONCOURSE EXT.															●										●												
AERIAL / AT-GRADE	CONCOURSE - FREE AREA			●		●	●	●			●					●			●														●	●	13'6"			
AERIAL / AT-GRADE	CONCOURSE - PAID AREA			●		●	●	●			●					●						●											●	●	13'6"			
AERIAL / AT-GRADE	PLATFORMS		●			●			●				*							●						●							●	●	10		●	* GUARD RAILS
AERIAL / AT-GRADE	TRACK AREA	●																							*													* ACOUSTIC TREATMENT - FACE OF PLATFORM
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AERIAL / AT-GRADE	STAIRWAYS - SERVICE		●																																			
AERIAL / AT-GRADE	ESCALATORS														*								●															* BALUSTRADE SKIRTS
AERIAL / AT-GRADE	PEDESTRIAN OVERPASS(ES)			●		●		●												●						●								●	*			* 10' - VARIES AT ESCALATORS
AERIAL / AT-GRADE	PEDESTRIAN UNDERPASS(ES)																																					
AERIAL / AT-GRADE	ATTENDANT'S OFFICES			●			●				●					●						●						●					●		10			
AERIAL / AT-GRADE	STAFF TOILET			●		●		●						●							●											●			8			
AERIAL / AT-GRADE	PUBLIC TOILETS			●		●		●						●							●											●			8			
AERIAL / AT-GRADE	MAINTENANCE ROOM	●				●			●							●					*	●									●				10			* TILE - SERVICE SINK
AERIAL / AT-GRADE	FARE VENDING SERVICE VAULT	●					●				●					●																	●		10			1 - HR
AERIAL / AT-GRADE	TRAIN CONTROL ROOM				●		●			●						●						●											●		10			1 - HR
AERIAL / AT-GRADE	ELECTRICAL ROOM	●				●			●					●																			●		10			
AERIAL / AT-GRADE	SUBSTATION - ABOVE GRADE	●				●			●							●		●											●						15			2 - HR
AERIAL / AT-GRADE	SUBSTATION - BELOW GRADE	●				●			●			●		●															●						15			2 - HR
AERIAL / AT-GRADE	MECHANICAL ROOM	●				●			●					●																	●				10			1 - HR
AERIAL / AT-GRADE	STORAGE ROOM	●				●			●							●						●												●	10			

PRELIMINARY ENGINEERING ONLY
FOR COST ESTIMATING PURPOSES
SUBJECT TO CHANGE IN FINAL DESIGN

A243

APRIL, 1968
DRAWN BY D. B.
CHECKED BY GTH
APPROVALS
M.A.N. & CO.
KE - DMJM
SCRTD

M. A. NISHKIAN & CO.
CONSULTING ENGINEERS
LONG BEACH LOS ANGELES

RTD

SOUTHERN CALIFORNIA
RAPID TRANSIT DISTRICT
LOS ANGELES, CALIFORNIA 90015

FINISH SCHEDULE
AIRPORT-SOUTHWEST CORRIDOR

A243

V. C I V I L

V. CIVIL

PRELIMINARY DESIGN CRITERIA

A. HORIZONTAL ALIGNMENT

1. Circular Curves shall be defined by the arc definition and specified by radii in feet.

   - Minimum mainline radius shall be 500 feet.
   - Minimum yard radius shall be 275 feet.
   - Reverse curves shall be provided with spiral transition curves meeting at the point of reversal.
   - Curves for parallel mainline tracks shall be placed on concentric curves.
   - Curves shall be designed to sustain maximum velocity of trains where allowed by topography by the following formula within limits of superelevation set forth below:

$$R = \frac{3.782\ V^2}{E + 5}$$

R= Radius in ft.
V= Max. Velocity in mph
E= Actual super-elevation in inches

2. Spiral Transition Curves shall be provided for all transitions from tangent to circular curves for easements in horizontal transition of vehicles, and superelevation of outer rail.

   - Minimum spiral length shall be 75 feet.
   - Spiral length shall be provided by the following formula:

$$Ls = CV\ E$$

Ls= Length of spiral in ft.
C = Constant equal to 1.00
V = Max. Velocity in mph
E = Actual super-elevation in inches

3. Superelevation shall be provided as required to maintain equilibrium and sustain velocity of vehicles on curves. Superelevation shall be constant through circular curves, transitioned linearly along length of

spiral curves determined above and accomplished by raising the outer rail. Superelevation shall be limited to 5" for track in tunnels, 6" on structures, and, 5" for the effect of allowable unbalancing for a low center-of-gravity transit vehicle. The amount of superelevation shall be determined by the following formula for established radius of curvature:

$$E = \frac{3.782\ V^2 - U}{R}$$

E = Actual super-elevation in inches
V = Maximum Velocity in mph
U = Unbalanced super-elevation in inches
R = Radius in ft.

B. VERTICAL ALIGNMENT

1. Profile Gradients

Track profiles shall be identified as top of rail, and the low rail used as reference on superelevated curves. All grades shall be joined by vertical curves at crests and sags.

- Minimum grade for drainage shall be 0.3%.
- Maximum gradient for sustained mainline grades shall be 3%.
- Maximum gradient for short ramps shall be 4%.

2. Vertical Curves

The following data has been checked to provide vertical transitions at summits with lifting accelerations at less than 0.05 G (gravity) for comfort to passengers. The value of 0.05 G is as recommended by American and Japanese railway tests.

- Minimum length shall be 300 feet.
- Additional length shall be provided at rate of 100 feet per 1% algebraic difference in gradient changes, in excess of 3%.

C. ACCESS CONTROL

The rapid transit right-of-way shall be protected in such a manner as to prevent unauthorized persons or vehicles from gaining access to the tracks, except at stations where controlled access is provided to parking areas and station platform.

D. TRACKWORK

1. Track Anchorage

- The track fastening for running rails shall be a compression rail clip device.
- In subways the track shall be fastened directly to the invert of the structure. On aerial structures the track shall be fastened directly to the deck of the structure.
- Mainline track at grade shall be a ballasted section with prestressed concrete crossties.
- Track at grade in yard areas shall be a ballasted section with wood crossties.

2. Gage

Track gage shall be $4'-8\frac{1}{2}"$.

3. Turnouts shall be the following sizes:

- Junctions of mainline routes - No. 10.
- Mainline crossovers and turnbacks - No. 8.
- Yards - No. 6 minimum.

E. CLEARANCES

1. Horizontal Clearances

Minimum horizontal clearances measured from centerline of track on tangent alignment shall be as follows:

- Centerline of adjacent track - 14'-0".
- Fixed structure in open - 7'-6".

2. Vertical Clearances

Minimum vertical clearances, measured from the top of low rail:

- Fixed structure in open - 13'-6".

F. DRAINAGE

1. Open Sections of Rapid Transit

- Volume of water shall be calculated for 50 year frequency by means of formula:

$Q = ACi$

Q = Volume of water in c.f.s.
A = Area in acres
C = Constant
i = Intensity of rainfall in inches per hour

2. Subway Sections of Rapid Transit

- Pumping stations in subway to be selected for a maximum volume of water of 1000 g.p.m.
- Each pumping station shall have 2 pumps. Each pump shall have a minimum capacity of 1000 g.p.m.

V. CIVIL

OUTLINE SPECIFICATIONS

A. TRACK WORK

1. Rails

a. Running Rails

The standard section to be used for running rails shall conform to the requirements of A.R.E.A. designated R.E. section weighing 100 lbs. per yard.

Rail sections for curves with a radius of 1900 feet or greater shall be control cooled. Rail sections for curves with a radius between 950 feet and 1900 feet shall be surface heat treated. Rail sections for curves with a radius of 950 feet or less shall be fully heat treated.

b. Restraining Rails

The standard section to be used for restraining rails shall conform to the requirements of A.R.A.-A designated section weighing 90 lbs. per yard.

c. Guard Rails

The standard section to be used for guard rails shall conform to the requirements of A.R.A.-A designated section weighing 90 lbs. per yard.

2. Rail Joints

a. Continuous Welded Joints

The running rail shall be provided with continuous welded joints. The joints shall be butt-welded by the use of

original rail metal to present an unbroken section of rail.

b. Bolted Joints

The restraining and guard rails shall be provided with bolted joints. The joint bar shall be the flanged or head-contact type conforming to requirements of the A.R.E.A. Track bolts and nuts shall be provided as shown on the plans.

3. Ties

a. Concrete Ties

Prestressed concrete tie dimensions shall be in accordance with details shown in the plans and spaced 30 inches center to center. Every fourth tie shall be a third rail tie.

b. Timber Ties

Timber ties shall be used in yards and other areas designated on the plans. Timber tie dimensions shall be in accordance with details shown on the plans and spaced 24 inches center to center. Every 4th tie shall be a third rail tie.

4. Ballast

Ballast shall be composed of prepared stone, slag or gravel in accordance with A.R.E.A. specifications.

5. Miscellaneous Track Special Ties

a. Cross-over and Turnouts

Switch rails for cross-over and turnouts shall consist of the same rail sections as the parent track. Frog numbers for cross-overs and turnouts shall conform to details shown on the plans.

b. Compression Rail Clip

The compression rail clips shall be composed of high-carbon, heat treated spring steel.

c. Tie Plate

Steel tie plates shall be the double shoulder type conforming to dimensions shown on the plans. The tie plate shall be tapered in thickness, from the outer to the inner edge of the rail seat, on a slope of 1 in 40. The rail seat and the bottom of the tie shall be flat.

d. Tie Pads

Tie pads shall withstand extremes of temperature, moisture, mildew and sand, and it shall be resilient without permanent set.

e. Car Stops

Car stops shall be composed of semi-rigid shoes of steel or malleable iron fastened directly opposite each other to the rails, in pairs.

B. DRAINAGE FACILITIES

1. Pumps

Pumps for drainage of tunnel and open cut sections shall be non-clog heavy duty vertical sump pumps. Two identical pumps shall be mounted over the storage chambers as shown on the plans. These pumps shall be equipped with an automatic control system including float switches with an alternator and local and remote alarms.

The alternator shall start first one pump and on the next operation the other and automatically cut in the second pump for parallel operation and double capacity when the load requires dual operation.

2. Piping

a. Cast Iron Pipe

Cast iron pipe shall be the size, type and pressure class specified on the plans and shall conform to applicable specifications of the American Water Works Association.

b. Concrete Pipe

Concrete pipe shall be extra strength, manufactured in accordance with requirements of the American Society for Testing and Materials. Concrete pipe shall be furnished in sizes specified on the plans.

c. Reinforced Concrete Pipe

Reinforced concrete pipe shall be the size, type and strength specified on the plans and shall be manufactured in accordance with requirements of the American Society for Testing and Materials.

d. Clay Pipe

Clay pipe shall be extra strength, manufactured in accordance with requirements of the American Society for Testing and Materials and shall be furnished in sizes specified on the plans.

e. Subsurface Drains

Subsurface drains shall be the size specified on the plans and shall be either clay drain tile, concrete drain tile, perforated asbestos-cement pipe, perforated clay pipe or perforated metal pipe, all manufactured in accordance with the American Society for Testing and Materials.

3. Concrete Structures

Concrete for catch basins, manholes, lift station storage chambers and similar concrete structures shall, unless otherwise specified or indicated on the plans, develop a 28-day strength of at least 3,000 lbs. per square inch in compression.

Steel reinforcement bars and welded wire fabric for concrete structures shall be furnished in accordance with Section VI of the Structural Outline Specifications.

D. RIGHT OF WAY AND TRAFFIC CONTROL FACILITIES

1. Fencing

Materials, dimensions and components of fencing are as indicated on the plans. The fence shall be composed of chain link fabric, posts and braces with three strands of barbed wire carried on extension arms above the fabric. The base material for the manufacture of steel pipe used for fence components shall conform to specifications of the American Society for Testing and Materials. All fence components including barbed wire shall be galvanized, unless otherwise specified.

2. Concrete Block Walls

Concrete block for walls shall conform to specifications of the American Society for Testing and Materials. Concrete block walls shall be laid true, level and plumb in accordance with the plans.

3. Raised Bumper Blocks

Raised bumper blocks shall be constructed of concrete and conform to dimensions shown on the drawings. Raised bumper blocks shall be set on the finished pavement with an approved adhesive.

4. Bus Actuated Traffic Signals

Bus actuated traffic signals shall be traffic control signals which are supervised by electronic or electro-mechanical control devices in accordance with varying demands of bus traffic.

5. Barrier Beam

Barrier Beams shall be semi-flexible type traffic barriers consisting of rail elements, terminals, bolts, nuts and other fittings and shall conform to specifications of the American Association of State Highway Officials. All metal components of the barrier beam shall be galvanized unless otherwise noted.

Posts and blocks shall be construction grade Douglas fir, and be pressure treated with an approved wood preservative.

E. STATION SITE DEVELOPMENT

1. Crushed Aggregate Base

Crushed aggregate base shall consist of any one or a mixture of broken stone or crushed gravel, natural material having the same qualities of angularity and roughness as broken stone, and natural rough surfaced gravel. It shall be free from vegetable matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm stable base.

2. Pavements

a. Concrete

Concrete pavements including sidewalks, curbs and gutters shall develop a 28-day strength of at least 2,500 lbs. per square inch in compression, unless otherwise noted on the plans.

b. Asphaltic Concrete

Asphaltic concrete pavement shall be a mixture of mineral aggregate and paving or liquid asphalt mixed at a central mixing plant and conforming to the Standard Specifications, California Division of Highways.

VI. STRUCTURAL

VI. STRUCTURAL

PRELIMINARY DESIGN CRITERIA

A. GENERAL

These criteria shall govern the design of all structures constructed as part of the rapid transit system for the Los Angeles area, Southern California Rapid Transit District.

B. DESIGN CODES, MANUALS, AND SPECIFICATIONS

Unless otherwise specified herein, the structural design shall be governed by the latest editions of the following codes, manuals, or specifications:

1. General

   The Uniform Building Code of the International Conference of Building Officials.

2. Concrete

   For concrete, reinforced concrete, or prestressed concrete structures, other than those subjected to railroad of highway loading, the current edition of the "ACI Standard Building Code Requirements for Reinforced Concrete", (ACI 318), hereinafter referred to as the ACI Code.

3. Structural Steel

   For structural steel structures, other than those subjected to railroad or highway loading, the current edition of the "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" of the American Institute of Steel Construction, hereinafter referred to as the AISC Code.

4. Timber

For timber structures, other than those subjected to railroad or highway loading, the current edition of the "National Design Specification for Stress-Grade Lumber and its Fastenings."

5. Cast Iron

For cast iron structures, the current edition of "The Gray Iron Castings Handbook" of the Gray Iron Founders' Society.

6. Railroad Loading

For structures subjected to railroad loading, the current edition of the "Manual of Recommended Practice of the American Railway Engineering Association", hereinafter referred to as AREA Manual.

7. Highway Loading

For structures subjected to highway loading, the current edition of the "Standard Specifications for Highway Bridges" of the American Association of State Highway Officials, hereinafter referred to as the AASHO Specification.

C. LOADS AND FORCES

The rapid transit structures shall be proportioned for the following loads and forces when they exist:

Dead Load (DL)

Live Load (LL)

Impact (I)

Centrifugal Force (CF)

Seismic (S)

Normal Acceleration or Deceleration (An)

Maximum Acceleration (Am)

Horizontal Earth Pressure (E)

Buoyancy (B)

Wind Load (W)

Shrinkage Force (S)

Snow (SN)

Thermal Force (T)

Stream Flow (SF)

Differential Settlement (DS)

1. Dead Load (DL)

   a. Structures Constructed by Cut and Cover Methods

   The dead load for structures constructed by cut and cover methods shall consist of the weight of the basic structure, the weight of secondary elements permanently supported by the structure, and the weight of the earth cover supported by the top of the structure and acting as a simple gravity load. Minimum compaction of backfill over stations shall be 90% of the optimum density obtainable by the American Society for Testing Materials (A.S.T.M.) D 1157-64T. The dead load shall be applied in stages to realistically represent the life history of the design structure. For example, removal of the earth cover from a prestressed concrete span at some future date may create a serious upward deflection problem and should be analyzed as a separate loading case.

The design unit weight of earth, both above and below the groundwater table, shall not be less than 125 pcf. In making calculations with regard to dead weight resisting flotation of the structure, the actual unit weight of backfill placed over the structure shall be used. In those cases where full hydrostatic pressure below the groundwater table is used as a design load, a submerged design unit weight of not less than 63 pcf shall be used for earth below the groundwater table.

b. Earth and Mixed Face Tunneled Structures

The long term dead load for earth and mixed face tunneled structures shall be the same as for cut and cover structures. For construction and short term loading cases, refer to the Soils Consultant's report covering the particular location under consideration.

c. Rock Tunneled Structures

For construction and long term loading cases, refer to the Soil Consultant's report covering the particular location under consideration.

d. Minimum Earth Cover for Design

8'-0" shall be used as the minimum depth of earth cover for design of cut and cover box sections in order to clear existing utilities. The depth of cover shall be measured from ground surface or surface of street paving to top of structure. Except as otherwise instructed, structures

constructed under private properties shall also conform to the above criteria.

e. Loads from Adjacent Building Foundations or Other Structures

Consideration shall be given to the maximum and minimum loads which can be transferred to the design structure from adjacent structures. Design weights and design loads shall be assumed as those for which the adjacent structure was designed but, in the absence of this information, shall be as provided for by the actual weights and the heaviest occupancy for which the building is suitable. Horizontal and vertical distribution of loads from foundations of existing buildings shall be in accordance with the recommendations of the Soils Consultant.

f. Aboveground Structures

The dead load for aboveground structures shall consist of the weight of the basic structure and the weight of secondary elements permanently supported by the structure.

g. Miscellaneous Loads

Consideration shall be given to any system or facility which will apply a permanent load or force to the design structure.

h. Design Weights of Materials

The design weights of materials shall be as listed in Table VI.1, "Weights of Building Materials".

TABLE VI.1

WEIGHTS OF BUILDING MATERIALS

Aluminum alloys	175	pcf
Asphalt mastic, bituminous macadam	150	"
Ballast, crushed stone	120	"
Ceilings, plaster board, unplastered	3	psf
gypsum ceiling tile, 2", unplastered	9	"
pressed steel	2	"
Ceramic glazed structural facing tile. 4"	33	"
Floors, gypsum floor slab, per inch	5	"
asphalt mastic	5	"
ceramic tile, on 1" mortar bed	23	"
terrazzo, 1" on $\frac{1}{2}$" mortar bed	18	"
marble, 1" on $\frac{1}{2}$" mortar bed	20	"
linoleum, $\frac{1}{4}$"	2	"
maple, 7/8" on sheathing, 2" cinder fill, no ceiling	18	"
oak, 7/8" on sheathing, wood joists at 16" centers, no ceiling	11	"
Glass	160	pcf
Gravel, sand	120	"
Iron, cast	450	"
Partitions, plaster, 2", channel stud, metal lath	20	psf
plaster, 4", channel stud, metal lath	32	"
hollow plaster, 4" metal lath	22	"
gypsum block, solid, 3") -- both sides	19	"
gypsum block, hollow, 5") plastered	22	"
marble wainscoating, 1"	15	"
steel partitions	4	"
ceramic glazed structural tile, 4"	33	"
Roofs, roofing felt, 3 ply, and gravel	$5\frac{1}{2}$	psf
5 ply	$6\frac{1}{2}$	"
sheathing, 3/4" thick	$3\frac{1}{2}$	"
Steel	490	pcf
Timber, untreated	48	"
treated	60	"
Walls, brick solid, per inch	10	psf
terra cotta tile 4") -- plastering - add	25	"
8") 5 psf per side	33	"
12")	45	"
glass, structural, per inch	15	"
windows, frame, glass, sash	8	"
stone, 4"	55	"
steel sheet, 14 gage	3	"

2. Live Load (LL)

Live load shall consist of any non-permanent gravity load placed on the structure.

a. Rapid Transit Loading

See Figure VI. 1 for car dimensions and weights. Any combination of train lengths and loadings which produces the critical design loading shall be used for structural design. Track gage is 4'-8½". Maximum vehicle suspension system frequency shall be 1.5 cycles per second.

b. Roadway Loading

Roadway live loads on underground rapid transit structures shall be based on the HS 20-44 loading according to the AASHO Specification. Superimposed wheel loads from this loading shall be distributed in accordance with the AASHO Specifications to a maximum depth of four feet. At depths between 0 feet and 5 feet, a uniform live load of 600 psf shall be used. At depths between 5 feet and 20 feet a uniform live load of 600 psf minus 40 psf per foot of cover in excess of 5 feet shall be used. Below a depth of 20 feet, no uniform live load is required. The depth used in LL calculations shall be measured to the top of the underground structure's roof slab.

c. Pedestrian Areas

Station platforms, stairways, pedestrian ramps, mezzanines, and other pedestrian areas shall be designed for a uniform load of 100 psf.

d. Storage Space and Machinery Rooms

Electrical equipment rooms, pump rooms, service rooms, storage space and machinery rooms shall be designed for a uniform load of 250 psf, to be increased if storage or machinery loads dictate.

e. Escalators and Passenger Conveyors

Structures supporting escalators or passenger conveyors shall be designed for the maximum reactions from any of the manufactured units.

f. Railings

A horizontal force of 150 plf and a vertical force of 100 plf shall both be applied at the top of railings.

g. Gratings

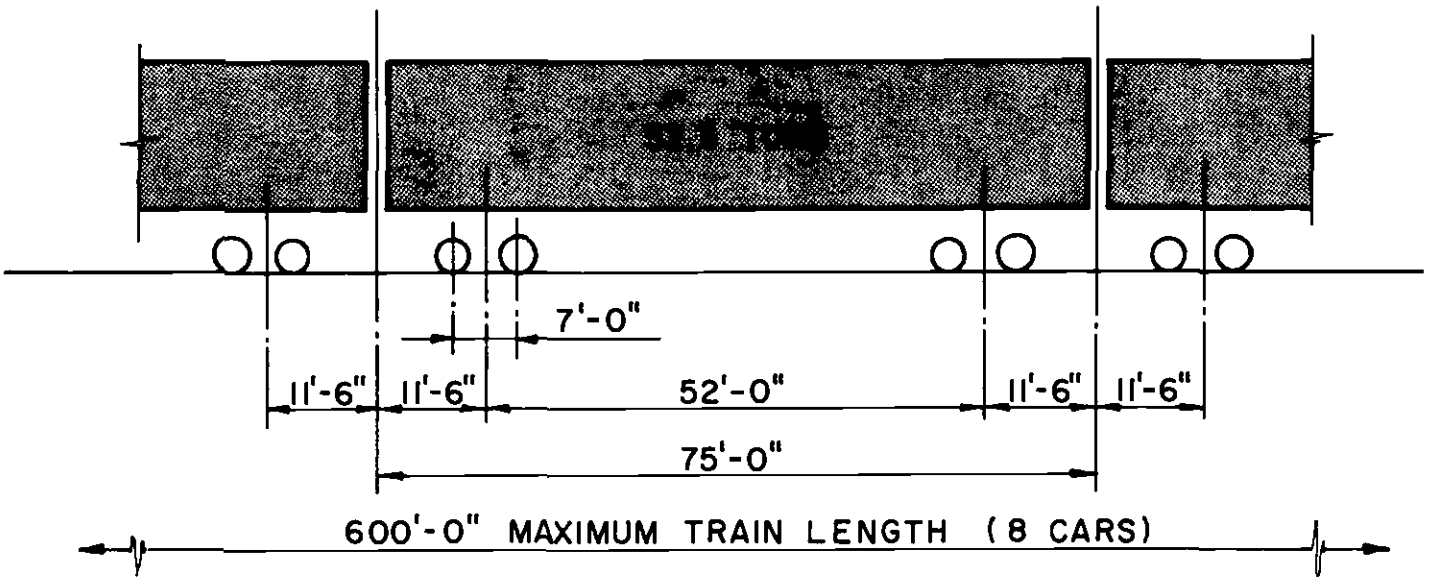
Ventilation shaft gratings in street or in sidewalk shall be designed to carry HS 20-44 loading in accordance with the AASHO Specifications. Gratings protected from vehicular traffic shall be designed for a uniform load of 250 psf.

h. Curbs

A horizontal force of 500 plf shall be applied at the top of curbs both on temporary decking structures and permanent structures.

i. Safety Walks

Safety Walks in underground structures except in stations, shall be designed for a uniform load of 85 psf of walkway area.



1. DESIGN LOADS——— VEHICLE——— 65,000 LB.
   267 PASSENGERS @ 150 LB. 40,000 LB.
   TOTAL RAPID TRANSIT LOADING (LL)—— 105,000 LB.
2. AXLE LOAD (WITHOUT IMPACT)——— 26,250 LB.
3. VERTICAL IMPACT——— 25% of Moving Weight (Cars & Passengers)

   HORIZONTAL IMPACT 10% of Moving Weight (Cars & Passengers) Applied 3'-7" above top of rail
4. CENTRIFUGAL FORCE——— [.0012xSPEED^2(MPH)xDEGREE OF CURVE (DEG.)] % LL
5. NORMAL ACCELERATION* ——— 13.7% of Moving Weight
6. NORMAL DECELERATION* ——— 11.9% of Moving Weight
7. MAXIMUM ACCELERATION* ——— 16.0% of Moving Weight
8. MAXIMUM DECELERATION* ——— 13.7% of Moving Weight
9. MAXIMUM DESIGN VELOCITY——— 75 mph

*LOAD APPLIED AT TOP OF RAIL

S C R T D E N G I N E E R I N G S T A N D A R D S

RAPID TRANSIT VEHICLE
DESIGN LOADING
FIGURE VI.1

3. Impact (I)

Impact loads are statically equivalent loads resulting from vertical or horizontal acceleration of the live loads.

a. Impact considerations for aerial structures supporting rapid transit loading is covered under "Design of Rapid Transit Aerial Structures" in this section.

b. Design of the top slab of underground rapid transit structures supporting roadway loading shall conform to the following:

0'-0" to 1'-0" earth cover	I = 30% LL
1'-1" to 2'-0" earth cover	I = 20% LL
2'-1" to 3'-0" earth cover	I = 10% LL
Greater than 3'-0" earth cover	I = 0% LL

The depth of cover shall be measured from the top of ground or paving to the top of the underground structure.

c. Structures supporting special vehicles, equipment, or other dynamic loadings which cause significant impact shall be considered individually using the best technical information available.

d. Impact shall not be considered for foundations, stairways, mezzanines, station platforms, or other pedestrian areas.

4. Centrifugal Force (CF)

On curves a percentage of the rapid transit loading per track equal to 0.0012 x speed^2 (MPH) x degree of curvature (degree) shall be applied horizontally 5 feet above the top of low rail, on all tracks.

5. Seismic (S)

Loads shall be applied per the latest lateral force requirements of the Structural Engineers Association of California, which states that V=KCW, where W is the structure dead load (track used for vehicle storage is designed with weight of vehicles as DC) applied at the center of gravity; $C = 0.05/\sqrt[3]{T}$, where T is the natural period of the structure in seconds; where K is 1.0 for aerial structures and 2.0 for aerial structure columns.

6. Normal Acceleration or Deceleration Force (An)

A force equal to 13.7% of the moving weight for normal acceleration and 16.0% of the moving weight for normal deceleration per track shall be applied at the top of rail on all tracks.

7. Maximum Acceleration or Deceleration Force (Am)

A force equal to 16.0% of the moving weight for maximum acceleration and 13.7% of the moving weight for maximum deceleration per track shall be applied at the top of rail on all tracks.

8. Horizontal Earth Pressure (E)

Structures which retain earth shall be designed for side pressure due to earth abutting against the structure, load surcharges resting on abutting earth, and hydrostatic pressure below the groundwater table. The Soils Consultant will furnish all available soils information to the Section Designer.

a. Rapid transit loading may be assumed as a uniform surcharge equal to three additional feet of earth.

b. Live and dead loads from adjacent foundations shall be considered in computing horizontal pressures.

c. Where railroad loading occurs, the surcharge shall be determined by the AREA Manual, Chapter 8, Part 5, Paragraph C-1.

d. Hydrostatic pressure shall be computed at 62.4 pounds per square foot per foot of depth below groundwater table.

e. The rock pressures to be used in design shall be as recommended by the Soils Consultant.

9. Buoyancy (B)

Buoyancy shall be considered as it affects the design and construction of any structure. During construction and backfill operations the elevation of groundwater shall be observed and controlled so that the calculated total weight of structure and backfill shall always exceed the calculated uplift due to buoyancy by at least ten percent.

10. Other Loads and Forces

Other loads and forces to be considered, including wind loads, shrinkage and thermal forces, are covered under "Design of Rapid Transit Aerial Structures".

D. DESIGN PROCEDURES - EARTH RETAINING STRUCTURES

All earth retaining structures shall be classified in one of the categories listed below. For each of these structures the following assumptions shall be made:

1. Reinforced Concrete Box Sections

These structures retain earth but are not free to yield. Three loading cases shall be considered in design:

Case I: Full vertical and maximum long-term horizontal load, as recommended by the Soils Consultant.

Case II: Full vertical load, maximum long-term horizontal load on one side and minimum long-term horizontal load on the other side, as recommended by the Soils Consultant. In underground structures which could be subjected to unequal lateral pressures, the structural analysis shall consider both sidesway and sidesway restrained in arriving at maximum shears, thrusts and moments.

Case III: Full vertical load with minimum short-term horizontal load on both sides, as recommended by the Soils Consultant.

For design, the horizontal earth pressure distribution diagram shall be rectangular giving a total load on the sides of the structure equivalent to the load produced by an assumed trapezoidal pressure diagram.

2. Reinforced Concrete Rigid Earth Tunnel Sections

The method of driving these tunnels is proposed to be full shield with machine or hand mining. Temporary tunnel support would be provided by steel ribs and wood lagging and permanent support by steel ring or concrete lining.

These sections shall be designed as rigid structures using working stress design methods. Horizontal earth pressure shall be calculated using an earth pressure factor recommended by the Soils Consultant.

The structural design shall be checked using ultimate strength design methods. The maximum concrete stress, considering rectangular stress distribution, shall not exceed 85% of the required 28-day concrete strength. Horizontal earth pressure factors recommended by the Soils Consultant shall be used in these analyses.

3. Flexible Earth Tunnel Sections

Drawings of single track earth tunnel section have been prepared by the General Engineering Consultant based on recommended earth pressures, groundwater elevations and other soils constants furnished by the Soils Consultant.

4. Reinforced Concrete Retaining Walls

These are structures which are free to yield to earth pressure. In retaining walls up to 20'-0" in height, the design earth pressure shall be as recommended by the Soils Consultant for an equivalent fluid pressure. Retaining walls above 20'-0" in height shall be designed on the basis of specific soils information relating to the backfill material and in accordance with recommendations by the Soils Consultant.

5. Rock Tunnel Linings

The tunnels shall be provided with structural support designed to withstand rock and overburden loads corresponding to the recommendations of the Soils Consultant.

In areas of unsound rock quality a reinforced concrete lining, placed either by cast-in-place or shotcrete methods, shall be designed to provide permanent tunnel support.

In designing the permanent reinforced concrete lining, structural analysis shall include the following loading cases:

(1) Running Track Tunnel Sections

Case I: Vertical and horizontal rock loads as recommended by the Soils Consultant. No hydrostatic pressure. Loads shall be applied to the concrete tunnel section above the invert.

Working stress design methods shall be used.

Case II: Hydrostatic pressure with buoyant vertical and horizontal rock loads computed from information furnished by the Soils Consultant.

Ultimate strength design methods shall be used with the capacity reduction factor, as defined in the ACI code, considered unity ($\phi = 1.0$).

(2) Station Tunnel Sections

Vertical and horizontal loads shall be considered as recommended by the Soils

Consultant. Positive drainage shall be provided behind the entire lining.

Working stress design methods shall be used.

The following types of temporary tunnel supports or combinations thereof shall be considered:

Steel ribs

Shotcrete

Temporary support methods and design shall be left to the option of the Contractor except at portal sections where the Section Designer shall provide a design for the temporary support of the tunnel.

E. DESIGN OF RAPID TRANSIT AERIAL STRUCTURES

The criteria set forth in this section shall pertain specifically to the design of rapid transit aerial structures.

1. Design Codes and Specifications

The ACI code shall govern the design and construction of reinforced concrete, prestressed concrete and composite concrete flexural members, except that torsional design shall be based on Title 56-36 ACI "Design of Beams Subject to Torsion Related to the New Australian Code" together with published comments and other published recommendations.

The AASHO Specification shall govern the design and construction of structural steel and composite steel-concrete flexural members.

Both the above codes shall be modified by the specific requirements outlined below.

2. Loads and Forces

Where applicable, loads and forces listed in Section IV.C shall be used for the design of rapid transit aerial structures. Other loads and forces to be considered include:

a. Dead Load (DL)

The dead load of aerial structures shall consist of the gravity loads of the basic supporting girders and structure.

Trackwork and appurtenances and secondary elements supported by the structure and added after construction of the basic structure shall be considered as superimposed dead load.

b. Live Load (LL)

Refer to Section VI.C for live load magnitudes. Where a transit car wheel load is transmitted to a slab through rail mountings placed directly on the slab, the wheel load shall be assumed to be uniformly distributed on the slab over a 3'-0" length of rail

and a 1'-2" width normal to the rail and centered at the rail. In addition, the slab shall be designed to support a concentrated load of 13,125 pounds located anywhere on the slab surface and uniformly distributed over one square foot.

c. Impact (I)

Impact shall be applied to the superstructure, and generally those members of the structure which extend down to the main footings. The portion above the ground line of concrete or steel piles rigidly connected to the superstructure as in rigid frame or continuous design is included. Impact shall not be considered for abutments, retaining walls, wall-type piers, piles, footings and safety walks, except the portion of piles rigidly connected to the superstructure.

Vertical impact force factor for the design of simply supported longitudinal girders for aerial structures shall be as follows:

I = 25 percent of the moving weight (cars and passengers) in the vertical direction.

I = 10 percent of the moving weight (cars and passengers) in any horizontal direction.

d. Stream Flow Pressure (SF)

Anticipated flood elevations shall be determined by a study of official flood records. Stream flow pressures shall be included in the design of aerial structures where applicable. All piers and other portions of structures which are subject to flood forces shall be designed in accordance with sound engineering practice. The requirements outlined in the AASHO Specification shall be used as a guide.

e. Shrinkage and Creep Forces (S)

These forces are described under "Reinforced and Prestressed Concrete Design".

f. Thermal Forces (T)

Provision shall be made for stresses and deformations resulting from temperature changes as follows:

Concrete:

Temperature Rise 30°F

Temperature Fall 30°F

Coefficient of Expansion 0.0000060 inch/inch/ degree F.

Steel:

Temperature Rise 50°F

Temperature Fall 50°F

Coefficient of Expansion 0.0000065 inch/inch/ degree F.

g. Wind Load on Structure (W)

The forces and loads given herein are based on a wind velocity of 70 miles per hour, as recommended in the final report (1961) of the ASCE Task Committee on Wind Forces.

A horizontal, uniform wind load shall be applied simultaneously at the centroid of all exposed areas.

For girders and beams: 20 psf. to 60' high and 25 psf 60' and above (based on 125% of actual area to compensate for shielded girder or girders beyond).
For train: 225 plf to 60' high and 280 plf 60' and above, transverse applied 6'-0" above top of rail.
For open roof structures: 15 psf uplift.

3. Loading Combination and Unit Stresses

The basic unit stresses for various materials in structures supporting the rapid transit system are defined in their respective sections. The following combinations of loadings shall be considered in design:

		Allowable Percentage of Basic Unit Stress
Group I	= DL + LL + I	100%
Group II	= DL + LL + I + S (or W)	133-1/3%
Group III	= DL + LL + I + An + T + 0.5 W	125%

(For double track structures, either or both tracks loaded for maximum stress)

		Allowable Percentage of Basic Unit Stress
Group IV	= DL + LL + I + Am	125%

Where DL = Dead Load

LL = Live Load

I = Impact

W = Wind

S = Seismic

T = Thermal Force

An = Normal Acceleration or Deceleration

Am = Maximum Acceleration

Above load combinations to be combined with centrifugal force, stream flow, snow, buoyancy, earth pressure and differential settlement if applicable; unsymmetrical loading should be considered for worst condition.

4. Special Design Considerations

a. Vibration Limitations

To limit potential dynamic interaction between aerial structure girders and rapid transit vehicle, the aerial structure shall be designed so that the unloaded natural frequency of the first mode of vibration of the longitudinal girder spans equal to, or less than 120 feet is not less than 2.0 cycles per second and is not less than 1.75 cycles

per second for spans greater than 120 feet. Combine all aerial girders for full dead load deflection plus 3/4 full live load deflection.

b. Fatigue

Consideration shall be given to the effect of significant change of stress levels caused by passage of rapid transit trains over the structure. Over the life of the structure, 100 million passages of individual rapid transit vehicles shall be used in estimating number of repetitive load cycles.

c. Uplift

Provision shall be made for adequate attachment of the superstructure to the substructure should any loading or combination of loading produce uplift at any support.

d. Friction

Frictional effects shall be considered in the structural design.

5. Reinforced and Prestressed Concrete Design

Reinforced and prestressed concrete members for rapid transit aerial structures shall conform to the requirements of Section VI.1 except as modified below.

a. Camber and Deflections

As a guide in design, the total long term predicted camber growth shall be limited to 1/2000 of the span length for prestressed concrete aerial structures. The short term camber growth prior to trackwork construction shall be limited to 1/4000 of the span length. A minimum 2-month period between structure construction and trackwork installation is assumed.

b. Live Load Deflections

Girders shall be designed so that the deflections due to live load plus impact shall provide safe vehicle operation, but shall not exceed 1/800 of the span for 80% of maximum live load. The design modulus of elasticity for 5,000 psi concrete shall be 3,750,000 psi for hard rock concrete and shall be 2,500,000 psi for lightweight concrete.

c. Longitudinal Tension Stresses in Prestressed Members

Longitudinal tension stresses shall not be permitted under any combination of loads, except in the bottom fibers where tension will be permitted for impact loading only. Reinforcing bars shall be added to resist the tension stresses resulting from impact loads.

d. Shrinkage and Creep

Stresses and movements resulting from concrete shrinkage and creep shall be considered in the design and included in all load combinations. The shrinkage coefficient shall be assumed to be 0.0002 inches per inch for both prestressed and reinforced concrete.

e. Structure Deformations and Settlements

All structure deformations, including foundation settlement, shall be considered, not only for their effect on structural behavior, but also for their effect on trackwork. The control of deformations through proper structural design is of paramount importance in obtaining acceptable riding quality for the rapid transit trains.

6. Structural Steel Design

Structural steel and composite steel-concrete flexural members for rapid transit aerial structures shall conform to the requirements of Section IV.H.

The requirements governing live load deflections and structure deformations and settlements as outlined for Reinforced and Prestressed Concrete Design shall also apply to Structural Steel Design.

7. Foundations

Foundations for girder spans up to 150 feet in length, shall not have total settlements greater than 1" nor differential

settlements greater than $\frac{1}{4}$". For spans over 150 feet in length, the Section Designer shall develop settlement values which meet the approval of the General Engineering Consultant.

Allowable foundation loads shall follow the recommendations of the Soils Consultant.

The type of foundation shall depend on local soil conditions and can be classified into two types as follows:

a. Spread Footings

The design shall keep the maximum soil pressure within the allowable bearing value and soil pressures as nearly uniform as practicable.

b. Driven and Poured-in-Place Concrete Piles

Pile footings shall be designed so that the load on any pile does not exceed its allowable load and the uplift force on any friction pile does not exceed 50% of its allowable downward load for any loading combination.

F. SOILS AND GEOLOGICAL CRITERIA

Earth and water pressures on the underground structures vary considerably with geographical location. Recommended earth pressures and other soil constants will be furnished by the Soils Consultant. Allowable bearing values for rock or earth in its natural bed shall be based on the above mentioned information.

G. SUPPORT OF EXISTING STRUCTURES

The Soils Consultant will furnish specific information and recommendations as to underpinning and dewatering requirements.

The economics and feasibility of various underpinning and dewatering methods for structures influenced by excavation or tunneling shall be investigated by the Section Designer as required. Recommendations shall be made as to the method best suited to the particular site.

All designs in this section shall be subject to the specific approval of the General Engineering Consultant and the Soils Consultant.

Special provisions shall be made in the contract plans and specifications, requiring the construction contractor to maintain, protect and be responsible for the safety, stability and integrity of all buildings and structures which may be affected by his work.

1. Special Underpinned Structures

These shall be defined as buildings or structures which extend over the excavation to such an extent that they must be temporarily supported during construction and permanently underpinned. Buildings or structures immediately adjacent to the underground rapid transit structure, which must be carried on underpinning walls braced to act as retaining walls supporting the sides of the excavation, are included in this

category. Also included are structures under which the subway is tunneled, and other structures as determined by the General Engineering Consultant.

Detailed plans for the support of these structures shall be prepared for inclusion in the contract plans and specifications.

Underpinning walls or piers supporting buildings or structures and forming a portion of the excavation support system shall be extended to a minimum depth of 2'-0" below subgrade elevation of the underground rapid transit structure.

Methods used to underpin or protect these buildings or structures shall depend on local soil conditions and may include the following:

a. Pier, Pile or Caisson Method of Underpinning

If soil conditions, structure size, and proximity to the underground rapid transit structure dictate underpinning piers, piles or caissons, they shall in general, extend below a sloped line drawn from the side of the excavation at subgrade elevation to intersect with the vertical projection of the underpinned building foundation. The slope of this line shall be determined according to recommendations of the Soils Consultant.

b. Retaining Wall Method of Structure Protection

Under some soil conditions the supporting system for the excavation will be sufficient to protect light structures.

Under heavier loading conditions a reinforced concrete cut-off wall, constructed in short clay slurry filled trenches or bored pile sections and braced with pre-loaded struts, could be considered as an alternate to underpinning or to avoid settlement due to dewatering.

c. Stabilization of Soil

In general, techniques such as freezing and chemical injections for the stabilization of soil under buildings in lieu of underpinning shall not be specified in the design phase. However, after consultations with the General Engineering Consultant and the Soils Consultant these techniques may be considered as an alternate to solve a localized soils problem.

2. Other Underpinned Structures

Buildings or structures outside the normal supporting system of the excavation but having foundations influenced by the underground rapid transit structure shall be underpinned or otherwise protected to ensure their safety and integrity during construction. These structures shall be listed in the contract documents, but underpinning design should be left to the construction contractor.

3. Structures Affected by Groundwater Lowering

In certain areas uncontrolled lowering of the groundwater for rapid transit construction may cause settlements of buildings

both adjacent to and some distance away from the cut and cover or tunneled excavation.

These areas will be designated by the Soils Consultant with recommendations for limitations on or control of the construction dewatering. Such limitations and control measures should be incorporated in the design studies and should be included as appropriate in the contract documents.

H. STRUCTURAL STEEL DESIGN

Consideration shall be limited to the following types of structural steel. Other types can only be used with the approval of the General Engineering Consultant.

1. Structural Steel

For normal use: ASTM A36 Structural Steel

2. High Strength Structural Steel

For uses requiring higher strength steels or where economically justifiable: ASTM A242, A440 and A441 structural steel.

3. Connectors

Shop connections as detailed by the Section Designer shall be welded unless otherwise approved by the General Engineering Consultant. All welding shall be in accordance with the current specifications of the American Welding Society.

Field connections shall be designed for high strength bolts unless otherwise approved by the General Engineering Consultant. High strength bolts shall be ASTM A325 bearing bolts with threads excluded from the shear plane.

I. REINFORCED AND PRESTRESSED CONCRETE DESIGN

1. Cements

Type I Portland Cement ordinarily shall be specified for concrete mix design; however, consideration shall be given to the use of an approved expansive type cement, manufactured to compensate for the normal drying shrinkage of Portland Cement concrete.

Type II Portland Cement shall be specified for concrete construction in soils having low ph values or high sulphate content.

Type III Portland Cement may be specified for concrete mix design requiring a high early strength.

2. Concrete Design

Concrete shall be designed to the following allowable stresse

Prestressed: 5000 psi minimum

Foundation and Structural Concrete: 3000 psi minimum

Stations, Special Structures and Aerial Structures (except Foundations): 4000 psi minimum

Non-Structural Concrete: 2500 psi minimum

Prestressed concrete structures shall be designed by th elastic theory and shall be checked by ultimate stren design methods. Prestressing steel rods shall have f's = 160,000 psi (min.) and prestressing steel wir strand shall have f's = 270,000 psi (min.).

3. Reinforcing Steel

a. All reinforcing steel shall be ASTM A-15, intermediate grade, or ASTM A432 (allowed only in aerial support columns or where structure is not subjected to repeated dynamic loadings).

b. Spacing

In general, main reinforcing bars shall be spaced at multiples of some pre-selected module, not less than 3", but preferably 6", in tunnels, cut and cover box sections stations. Maximum bar spacing shall be 18". Exceptions to this rule include beams, stairways, thin slabs, track beams, etc. This requirement is intended to simplify design, checking, bar placing and field inspection.

c. Shrinkage and Temperature Reinforcing

Temperature and shrinkage reinforcement for sections not exceeding 50 feet in length shall not be less than 0.15% of the gross concrete area. A minimum of #3 bars at 10" and a maximum of #7 bars at 18" centers in each face shall be used. Temperature bars shall generally be placed at 18" centers. For sections longer than 50 feet between contraction joints, construction procedures shall be specified and reinforcement provided to reduce shrinkage cracking to a minimum.

The above requirements do not apply to rock tunnels.

J. DESIGN OF CIRCULAR SEGMENTAL TUNNEL LINERS

1. Design Considerations

Segments should be designed to resist individual jack thrusts of 125 tons spaced at approximately 2.5 feet on centers. Maximum allowable buckling stresses, maximum liner plate deflections and possibility of corrosion shall also be considered in the design.

2. Materials

a. Structural steel. Refer to Section VI.H of this manual.

b. Cast iron shall conform to the current edition of ASTM A48.

K. TEMPORARY STREET DECKING SYSTEMS

Detailed design of the temporary street decking system shall be prepared by the construction contractor. Criteria and standards for design shall be included in the contract drawings.

The contract drawings and specifications shall cover comprehensively, the detailed arrangements for traffic diversions, allowable restrictions and necessary construction stages which have been approved by the public authorities. Acceptable locations shall also be indicated for construction access ramps or any other construction facility which affects the temporary street decking system design.

Temporary decking systems, including decking, beams, piles, lagging and bracing struts, shall be designed for HS 20-44 loading, earth pressures, utility loads and other applicable construction loads. Because of the temporary nature of the loading and construction, the design stresses, except for stresses in bracing struts, may be increased to 120% of the basic allowable unit stresses. In struts the design stresses shall be limited to 75% of the basic allowable unit stresses.

Emphasis shall be placed on adequate design and detailing of member connections. Web stiffeners shall be specified at all strut to wale connections and other points of concentrated forces.

VI. STRUCTURAL

OUTLINE SPECIFICATIONS

A. WAY STRUCTURES

1. Aerial Way Structures:

a. Concrete (except as noted otherwise on drawings):

Prestressed lightweight (110 pcf) girders:	fc': 5 ksi
Columns & Arms:	fc' :4 ksi
Foundations & Retaining Walls:	fc': 3 ksi
Non Structural:	fc': 2.5 ksi
All Other:	fc': 4 ksi

b. Reinforcing Steel:

#14S & #18S	ASTM A-408
#14S & #18S in columns:	ASTM A-432
All Other (Intermediate Grade):	ASTM A-15

c. Prestressing Steel:

Pretensioning strand:	ASTM A-416
Post-tensioning rods:	ASTM A-322 & A-29

d. Structural Steel: ASTM A-36

e. Painting of Structural Steel:

Red lead primer:	State of California Specification 58-G-53
Finish Coat:	Oil base paint or alkyd enamel

2. Tunnels:

a. Concrete Lining:	fc': 3 ksi
b. Reinforcing Steel (Intermediate Grade):	ASTM A-15
c. Structural Steel Ribs:	ASTM A-36
d. Structural Steel Liner Rings:	ASTM A-36 or ASTM A-441

3. Cut and Cover Subway Construction:

a. Concrete:	fc': 4 ksi
b. Reinforcing Steel:	
#14S & #18S:	ASTM A-408
All Other (Intermediate Grade):	ASTM A-15

4. Special Structures:

a. Concrete (except as noted otherwise on drawings):	fc': 4 ksi
b. Reinforcing Steel (Intermediate Grade):	ASTM A-15
c. Structural Steel:	ASTM A-36
d. Painting of Structural Steel:	
Red lead primer:	State of California Specification 58-G-53
Finish Coat:	Oil base paint or alkyd enamel

B. STATIONS

1. Aerial and At-Grade Stations:

a. Concrete:	
Prestressed and conventional lightweight (110 pcf) girders:	fc': 5 ksi

Columns & Arms:	fc': 4 ksi
Foundations:	fc': 3 ksi
Non-Structural:	fc': 2.5 ksi
All Other:	fc': 4 ksi

b. Reinforcing Steel:

#14S & #18S:	ASTM A-408
#14S & #18S in columns:	ASTM A-432
All Other (Intermediate Grade):	ASTM A-15

c. Prestressing Steel:

Pretensioning strand:	ASTM A-416
Post-tensioning rods:	ASTM A-322 & A-29

d. Structural Steel: ASTM A-36

e. Painting of Structural Steel:

Red lead primer:	State of California Specification 58-G-53
Finish Coat:	Oil base paint or alkyd enamel

2. Underground Stations:

a. Concrete:

Non-Structural:	fc': 2.5 ksi
All Other:	fc': 4 ksi

b. Reinforcing Steel:

#14S & #18S:	ASTM A-408
All Other (Intermediate Grade):	ASTM A-15

c.	Structural Steel:	ASTM A-36
d.	Painting of Structural Steel:	
	Red lead primer:	State of California Specification 58-G-53
	Finish Coat:	Oil base paint or alkyd enamel
e.	Waterproofing:	
	Asphalt:	ASTM D-449
	Fabric:	ASTM D-173
f.	Soil Solidification:	
	Primer solution:	Sodium silicate
	Catalyst:	Calcium chloride

VII. PROPULSION POWER

VII. PROPULSION POWER

PRELIMINARY DESIGN CRITERIA

A. SCOPE

The traction electrification of the SCRTD system has a design based on providing an adequate, reliable, and economic power conversion for propulsion of transit vehicles. The following design criteria have been compiled to provide a reasonable standard to achieve this goal.

B. GENERAL

Electrification design is based on a computer program simulating the power and energy requirements for a specified train and load operating over a chosen traction system route. Basic data is calculated from the program output and combined with constants derived from train schedules and consists to develop required substation capacity, power demand, and energy consumption. From these figures, switchgear, cable and wire size requirements are calculated to determine the constants of the a-c and d-c distribution systems. Alternative arrangements and configurations are considered to optimize the final design.

C. TRAIN SIMULATION PROGRAM INPUT

1. Route Date - curves, grades, ruling speeds, distances, average schedule speed - 70 mph.

2. Train Data -

Train length -	600	ft.
Number of cars -	8	
Weight - empty	260	tons
- full	335	tons
Passengers per car -	125	

2. Train Data - (Continued)

Wheel diameter -	28	inches
Gear ratio -	4.79:1	
Number of traction motors -	32	total
Track voltage -	900	volts
Initial acceleration -	3.0	mphps
Service brake rate	2.6	mphps
Coefficient of air resistance -	0.2460	
Dynamic braking down to -	10	mph
Station run leeway time -	5	percent
Station dwell time -	20	seconds
Power for car auxiliaries -	24	KW

3. Traction Motor Data -

(a) GE Traction Motor #1255AL 300/600 volt Series Wound

Maximum Speed - 75 mph, modified for 450/900 volts.

Rating - modified for 450 volts

Continuous 130 horsepower 240 amperes 450 volts

1-hour, cold start 140 horsepower 258 amperes 450 volts.

(b) Traction Motor Performance -

GE Characteristic Curve #41H137770 8/2/66.

(c) Operating Mode

0 - 12 mph 4 motors in series.

12 - 24 mph 2 motors in series parallel, full field.

24 - 36 mph transition.

36 - 70 mph 2 motors in series parallel, weak field.

Dynamic braking, full field, variable load resistance.

D. SUBSTATION CAPACITY, DEMAND, AND ENERGY CALCULATIONS

1. Track -

Each route consists of double track of standard gage. Each track has associated with it a third rail or contact rail supplying 900 volt d-c power. Both running rails of each track are used to carry d-c traction return current. Guard rails are not utilized.

(a) Running Rail -

Each route has continuous welded running rails. At appropriate intervals both tracks are cross-bonded so that the four running rails form an effectively single low resistance path for return current from any train.

Rail weight - 100 lb/yard.

Electrical resistivity - 12:1 copper equivalent.

(b) Contact Rails -

Contact rails are continuous between substations except for gaps bridged by circuit breakers. Main line contact rails of separate tracks are connected only at passenger stations or substations and at the midpoint of runs over four miles in length.

Rail weight - 150 lb/yard.

Electrical resistivity - 7:1 copper equivalent.

2. Train Schedules and Consists -

(a) Substation Ultimate Capacity -

Consist - 8 cars per train.

Headway - $1\frac{1}{2}$ minutes, all routes.

(b) Substation Initial Capacity -

Consist - 8 cars per train.

Headway - $1\frac{1}{2}$ and 3 minutes. Airport route - local - 3 minutes

Express - 12 minutes.

(c) Substation Demand and Energy Consumption -

Consists - 4, 6 and 8 cars per train.

Headway - 2 and 4 minutes. Airport route - local - 4 minutes,

Express - 15 minutes.

(d) Operating Schedule -

Daily Operation - 5:00 A.M. to 1:00 A.M.

Peak Periods - 7:00 A.M. - 9:00 A.M. 4:00 P.M. - 7:00 P.M.

3. Substation Loading -

Each substation consists of two equal half-capacity rectifier units without a standby. The substation is sized to carry the load of two trains starting simultaneously at each passenger station at specified headway frequency with only 5 percent contingency allowance.

If the load of a passenger station is shared by two substations carrying loads from other passenger stations, the loads, at a substation are added as if the trains were starting at random between the two passenger stations being added. If the station run time approximates the headway, a possibility of headway resonance or 4 trains starting simultaneously arises; in this case the substation loads are added to provide capacity for this contingency.

4. Rectifier Capability -

Augmented NEMA Class III for Traction Service - 100% rated load amperes continuously until a constant temperature is reached after which 150% rated load amperes for two hours with a cyclic superimposed load consisting of five periods of 300% rated load amperes for one minute followed by one period of 450% rated load amperes for 15 seconds.

The 300%, one-minute cycles are to be equally spaced throughout the two-hour period. This rectifier capability is to apply when one diode is out of service in each parallel group.

5. Substation Voltage -

Substation rated voltage is tentatively 1000 volt D.C. Voltage regulation of rectifier transformer and rectifier combined - 6%.

6. Train Voltage -

Nominal System Voltage -	900 volt D.C.
Minimum Train Voltage -	600 Volt
Maximum Train Voltage -	1080 Volt
With one train accelerating -	825 Volt
With two trains accelerating -	675 Volt

7. 34.5 KV AC Distribution -

A group of traction substations is to be fed from a single metering and billing point supplied from a utility with the most suitable and conveniently placed power receiving station in the area. Duplicate three-phase cables lines parallel the right-of-way and are fed by duplicate peddler circuits from the receiving station. Each line is to be sized to carry the total load of the substation group.

In normal operation, each line carries half of the traction load; if one line is dropped due to a fault, then the remaining line carries all load. Normally, the rectifier units of each traction substation are fed from separate lines.

If feasible provision should be made to provide power to or receive power from a neighboring substation group through normally open 34.5 KV circuit breakers. For this contingency all lines are considered to operate in parallel as for normal operation.

With these circuit configurations, the following voltage regulation appears acceptable, -

Normal operation - 4% from the receiving station high voltage primary terminals to the traction substation primary input of any in the group.

Emergency operation - 10% from the receiving station high voltage primary terminals to the traction substation primary input of the farthest substation in the neighboring group.

VII. PROPULSION POWER

OUTLINE SPECIFICATIONS

A. GENERAL

Propulsion power is divided into the following categories:

- High Voltage Cable System
- Rectifier Substations
- Contact Rail System
- Storage Yard Propulsion Power

The high voltage cable system includes all cable, conduit, and switchgear required to distribute 34.5 KV power to all rectifier substations. Rectifier substations include the station high voltage switchgear, rectifier transformers, rectifiers, D.C. switchgear, negative bus, and DC feeders to the contact and return rail. Also included are the rail gap tie breaker assemblies. The contact rail system includes the third rail and DC switchgear associated with track isolation installations such as crossovers and turnbacks. Storage yard propulsion power includes all traction power installation required in yards.

Separate procurement specifications have been prepared for the following items of equipment:

- Rectifier Substations
- Main & Tie Circuit Breakers (34.5 KV Switchgear)
- Track Circuit D.C. Switchgear Stations

The following items are not included in this specification:

. Station lighting and power including the critical power transformer and associated low voltage switchgear.

. Storage yard and shop lighting and power.

. Control center lighting and power.

. Tunnel lighting and power.

. Control and communication system.

B. HIGH VOLTAGE CABLE INSTALLATION

34.5 KV single conductor, ungrounded, shielded cross linked polyethylene insulated cable is used as the conductor. Two three conductor circuits parallel the entire route. Installation is as follows:

. Subway: Fiber conduit. Four 6 inch ducts per tunnel. Pull boxes are located every 2000 feet.

. On Grade: Fiber conduit. Six 6 inch ducts in a concrete envelope. Handholes are located every 2000 feet. This duct bank is for both circuits.

. Aerial: Rigid conduit, number and size as required. Pull boxes are located every 1000 feet, one per circuit.

High voltage cable is terminated in every passenger station that has a space designated for a traction power substation. Cables are routed through the passenger station in rigid conduit (800 feet per circuit).

High voltage switchgear is used for two purposes. A four unit assembly is used to connect the two power company feeder circuits to the distribution circuits. A two unit assembly is used as an intertie between segments of the system that are fed from separate power company feeders. The switchgear is outdoor metalclad drawout type, 1500 MVA interrupting capacity, 200 KV, BIL, 80 KV withstand voltage.

C. RECTIFIER SUBSTATIONS

Each substation consists of:

- One 3 unit high voltage indoor switchgear assembly.
- Two rectifier transformers, oil filled 34.5 KV primary, one or two secondary windings as required by the size of the transformer.
- Two silicon diode rectifiers, indoor, air cooled, 1000 volt D.C.
- One 6 unit DC switchgear assembly containing two single pole drawout cathode breakers and four single pole feeder breakers sized according to Table I which follows.
- A two unit negative bus cubicle containing a drain bus and a disconnect switch for each rectifier negative pole.
- A substation control cubicle containing all of the control and metering relays.

The high voltage switchgear is connected to each rectifier transformer with No. 2/0 AWG 34.5 KV cable installed in 4 inch rigid conduit. Allow 10 feet of conduit and 60 feet of cable for each rectifier transformer.

The DC switchgear and bus duct sizes are as follows:

TABLE I

SUBSTATION SIZE - MW	CATHODE BKR. AMPERES	FEEDER BKR. AMPERES	BUS DUCT AMPERES
3.0	3000	3000	2500
4.0	4000	4000	3000
5.0	4000	4000	4000
6.0	6000	6000	5000
7.0	6000	6000	6000
8.0	8000	8000	6000
9.0	8000	8000	7000

The rectifiers are connected to the DC switchgear and the negative bus cubicle with one pole ventilated bus duct of the ratings listed above. Allow 40 feet of duct per rectifier with 12 elbows and 4 pair of end fittings.

At some locations rail gap tie circuit breaker assemblies are required. These consist of one four unit DC switchgear assembly with one breaker rated 4000 amperes.

D. D.C. FEEDERS

There are four feeders and two return cable assemblies from each substation. Cable and conduit sizes for each of these six cable assemblies are as follows:

SUBSTATION SIZE MW	NO. OF CONDUITS	NO. OF CABLES PER CONDUIT
3.0	1	9
4.0	2	6
5.0	2	8
6.0	2	9
7.0	3	7
8.0	3	8
9.0	3	9

Each conduit is six inch. Each cable is 500 MCM. Each conduit is terminated in a contact rail junction box at the track. At side platform stations there are four extra contact rail junction boxes and 40 extra feet of feeder.

Rail gap tie breaker assemblies require only four feeders each consisting of two six inch conduit containing eight 500 MCM cables.

E. CONTACT RAIL SYSTEM

The contact rail system is rated 3000 amperes RMS and is supported by 5 KV post insulators spaced on 10 foot centers. A wood or plastic coverboard is run continuous over the contact rail mounted on brackets also spaced on 10 feet centers.

At double crossover points the following electrical installation is required:

D.C. Switchgear	2 Units
Enclosure	1 Unit
Contact Rail Junction Box	12 Units
Contact Rail	0.4 M
6 Inch Rigid Conduit	2.8 C
500 MCM Cable	2.7 M

At single track turnouts the following electrical installation is required:

Contact Rail Junction Box	2 Units
6 Inch Rigid Conduit	0.4 C
500 MCM Cable	0.4 M

At turnbacks the following electrical installation is required:

D.C. Switchgear	4 Units
Enclosure	2 Units
Contact Rail Junction Box	10 Units
Contact Rail	1.4 M
6 Inch Rigid Conduit	3.8 C
500 MCM Cable	3.5 M

C = 100 feet; m = 1000 feet; E, Ea = Each; Pr = Pair

(PRELIMINARY PROCUREMENT SPECIFICATIONS)

RECTIFIER SUBSTATIONS

PROPULSION POWER RECTIFIER SUBSTATIONS

PRELIMINARY SPECIFICATION

REVISION ONE - MARCH 1968

TABLE OF CONTENTS

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

SUPPLIER _____ DATE _____

SUBSTATION RATING	COST 1000 VOLTS	
	INDOOR	OUTDOOR
3 MW		
4 MW		
5 MW		
6 MW		
7 MW		
8 MW		
9 MW		

Prices should be current estimating cost based on delivery in Los Angeles, and should include conventional factory tests only and installation supervision and checkout on site only. Include sufficient spare parts, particularly diodes and fuses for operational checkout. Please indicate the type of 34.5 KV circuit breaker to be used.

The attached preliminary specification is based on a 1000 volt substation up to 9 MW capacity for a 900 volt propulsion power system. The substation capacity rating is the total continuous full load rating of two identical rectifiers in full operation without a standby unit.

I. GENERAL

The propulsion power rectifier substations consist of complete coordinated parts as outlined hereinafter and include all integral equipment, devices, buses, internal wiring, etc., required for supplying "D-C" traction power to a 900 volt Rapid Transit System.

II. STANDARDS

The rectifier substations shall be designed, manufactured and tested in accordance with the requirements of all applicable NEC, NEMA, IEEE, and ASA Specifications, and the State of California Electrical Safety Orders.

III. ARRANGEMENTS

A. GENERAL

Propulsion power substations are designed to convert 34.5 KV, 3 phase, 60 Hz power to a 900 volt D.C. Propulsion Power System. Each substation is composed of two identical transformer-rectifier units. Some indoor substations are arranged double-ended and others parallel in plan. Each rectifier unit is connected to a common D.C. positive bus by a main circuit breaker and to a common D.C. negative bus by a disconnect key interlocked with the main breaker.

B. ENCLOSURES

All equipment shall be suitable housed in a heavy duty fabricated metal clad enclosures. The metal enclosures for the rectifier and D.C. switchgear for each substation shall be insulated from ground and from any connection with any other grounded item such as the main transformers and shall be provided with ground detection and

protective relays and devices. The ground protection equipment, in the event of a failure to ground of the substation 1000 volt D.C. equipment, shall automatically shut down the rectifiers and open all D.C. main and feeder breakers in the substation.

IV. A.C. SWITCHGEAR AND CONTROLS

A. GENERAL

A metal clad enclosed, floor mounted, indoor heavy duty line up for 34.5 KV service and consisting of:

1. Three (3) circuit breaker sections for roll-out type circuit breaker.

2. Two (2) control sections.

3. One (1) fused disconnect section.

4. One (1) potential transformer section.

B. 34.5 KV A.C. SWITCHGEAR SECTIONS

Seven (7) metal-enclosed heavy duty A.C. switchgear sections complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

1. Two (2) main circuit breakers 34.5 KV, 3 phase, 60 Hz, 1500 MVA interrupting capacity, current rating according to total substation load. Each circuit breaker section includes one control switch with green and red indicating lights and three (3) current transformers.

2. One (1) tie breaker section with tie breaker 34.5 KV, 3 phase, 60 Hz, 1500 MVA interrupting capacity, to be able to take half the load from one main breaker. Section includes control switch, red and green indicating lights and two sets of three (3) current transformers and lockout relay.

3. Two (2) Control Sections complete with stationary and removable elements including disconnect devices and including:

   (a) Each one (1) voltmeter to 38 KV with voltmeter switch to measure main bus.

   (b) Each one (1) ammeter with ammeter switch to measure main bus current.

   (c) Each one (1) watthour demand meter.

   (d) Each two (2) potential transformers 34.5 KV, ratio 300:1, fused for instrument and relay potentials.

   (e) Each six (6) instantaneous overcurrent relay with time overcurrent relay (50/51).

   (f) Each two (2) ground overcurrent relay (51N).

   (g) Each one (1) reverse phase undervoltage relay (47).

   (h) Each one (1) lockout relay (86).

4. One (1) potential transformer section with four (4) potential transformers 34.5 KV, ratio 300:1, with fuses, for undervoltage relay (47), and voltmeter on incoming line with necessary mounting and connecting equipment.

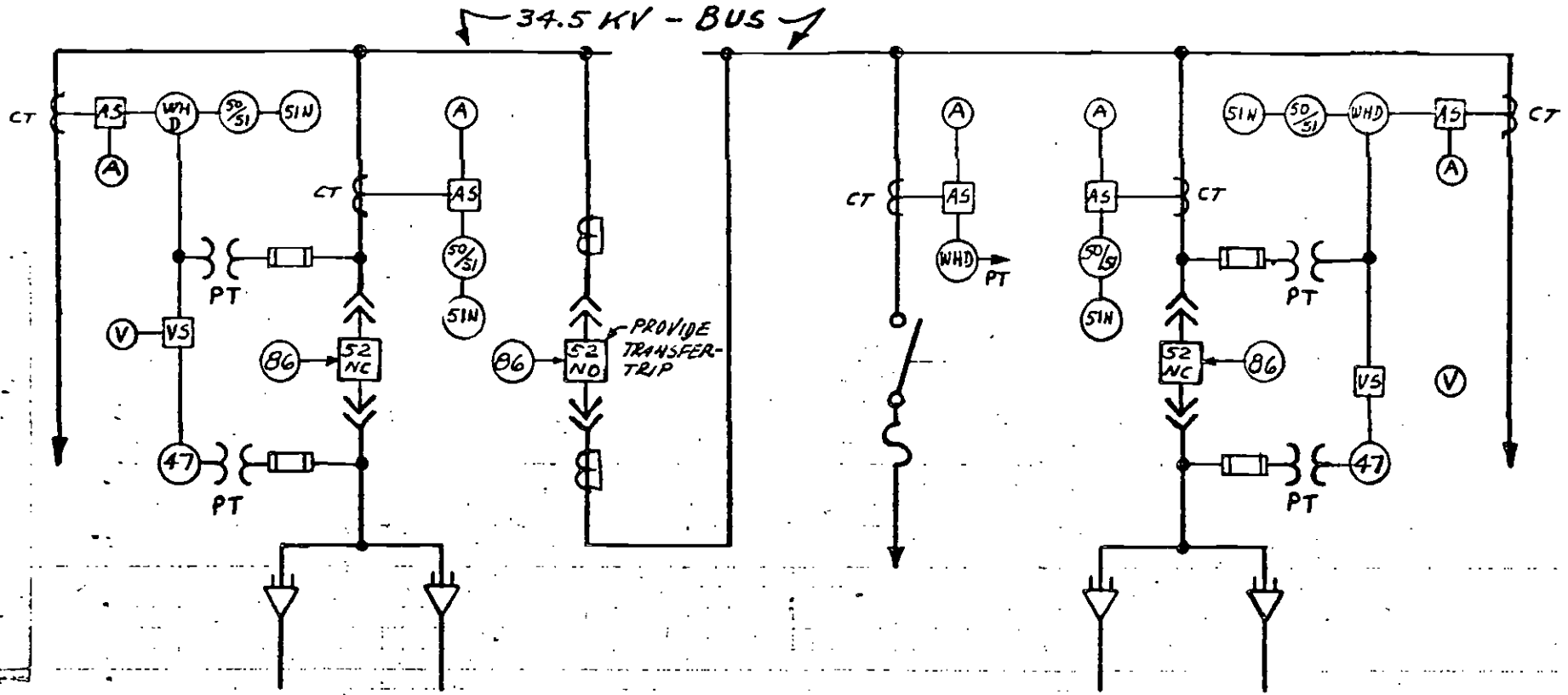
5. The circuit breakers shall be coordinated with the rectifier unit and shall be fast enough to clear a bolted fault at the rectifier output terminals without damage to the rectifier.

6. One (1) auxiliary fused disconnect switch, 34.5 KV, 3 phase, 60 Hz, fused to 10 amp., to be able to carry passenger station critical load with manual operated handle, mechanically linked to switch, red and green indicating lights, ammeter and ammeter switch, watthour demand meter and three current transformers. Auxiliary power is to be furnished by others.

RECTIFIER TRANSFORMERS

A. TRANSFORMER DATA

Type	OA oil immersed, self cooled.
Insulation	Thermally upgraded Class A or better.
Temperature Rise	Not exceeding 65° C. at rated full load for hot spot temperature and not permitting impairment to insulation during normal rated duty cycle.
Ambient Temperature	105° F.
Primary Voltage	34,500 volts.
Primary Phases	3 phase.
Frequency	60 Hz.
Primary Winding	Delta connected with 200 KV BIL withstand.
Primary Taps	Four $2\frac{1}{2}\%$, two above and two below.
Tap Changer	Manual, no load.
Primary Bushings	Cover mounted on side-wall.
Secondary Windings	As recommended by vendor to provide 12 phase or equivalent 12 phase rectification.
Secondary Bushings	Side-wall mounted for connections to metal clad rectifier section.



SYMBOL DESCRIPTION

52 — 34.5 KV-CIRCUIT BREAKER	CT — CORRENT TRANSF.
47 — REV. PHASE U/V-RELAY	PT — POTENTIAL TRANSF.
50/51 — TIME OVER CURRENT RELAY WITH INSTANTANEOUS UNIT	
51N — GROUND RELAY	
86 — LOCKING OUT RELAY	

ONE LINE DIAGRAM
A.C.-SWITCHGEAR

S4-1

A.C. CIRCUIT FUNCTION

REFER TO SK-1

The circuit breaker No. 1 main and No. 2 main will stay closed under normal load, the tie breaker remains open under the same conditions. The relay 50, 51 will trip the breaker and lock it out on overcurrent from the No. 1 or No. 2 rectifier unit, with an alarm indication on the switchgear and supervisory board.

The relay "51N" will trip the specific breaker in case of ground in the circuit with an alarm indication on the switchgear and supervisory board and breaker lockout.

The relay 47 prevents closing a breaker on undervoltage, overvoltage, phase unbalance, or reverse phase conditions. The breaker will trip for sustained undervoltage or subtransmission line trip out; after a twenty-second time delay, the tripped breaker will lock out, the N.O. tie breaker will close, and relay tripping functions will transfer from the locked out tripped breaker to the tie breaker.

B. CIRCUIT PROTECTION

Relaying to give warning light or signal and resulting in tripping of primary circuit protection for following conditions:

1. Transformer low liquid level.
2. Overtemperature of oil.
3. Sudden pressure.
4. Ground fault.
5. Transformer winding hot spot indication.

VI. RECTIFIER SECTIONS

A. Consists of an indoor, floor mounted metal clad enclosed, forced air cooled silicon rectifier assembly, with twelve (12) phase or equivalent 12 phase rectification 1000 volt D.C.

B. DUTY CYCLE

The rectifier unit shall supply 100% rated load current continuous service until a constant temperature in rectifier and transformer is reached, following the 100% rated load the equipment should be capable of operating at 150% rated load for 2 hours with a superimposed cyclic overload consisting of five (5) periods at 300% full current for 1 minute equally spaced throughout the 2 hour period, followed by one period of 450% full load current for fifteen (15) seconds at the end of the two-hour period. The unit is to operate daily at rated full load continuously plus the overload cycle twice daily spaced apart about seven hours.

Rectifier shall withstand bolted fault at output terminals until cleared by primary circuit breaker. Fault withstand time shall include circuit breaker interrupting time plus relay operating time.

C. RECTIFIER ARRANGEMENT

Each set of silicon diodes mounted on air-cooled heat sinks, connected in groups for twelve (12) phase or equivalent twelve (12) phase rectification. Provide extra diode in each set over and above the number required by the phase group rating, thus the loss of a single diode per group will not affect the rating.

D. SURGE PROTECTION

The rectifier equipment shall be adequately protected against surges which may occur on the system, except a direct lightning stroke at the substation.

E. REGULATION

The rectifier unit shall be so designed that, with sustained rated primary sinusoidal voltage on the normal tap of the rectifier power transformer, the combined inherent characteristics of the transformers, regulating devices, and any other part of the equipment affecting the D.C. voltage characteristics at the rectifier shall result in a regulation of 6%, based on individual power per rectifier unit, based on 1000 volts at all rectifiers and 100% continuous load.

F. COOLING

The rectifier compartment shall be designed for forced-air cooling. Baffles, interior ductwork and cooling fans or blower shall be provided to maintain necessary air flow. The fans or blowers shall be complete with motors and thermostatic and air flow protective devices for both alarm and tripping purposes to protect against poor air circulation, blower motor stoppage and air overtemperature. The air intake to the compartment shall be provided with a permanent cleanable filter.

G. RECTIFIER CONTROL SECTION

The rectifier control section compartment located in the DC switchgear line up shall contain all switches, meters, relays, motor starters, annunciators and other devices necessary for the operation and protection of the rectifier, rectifier transformer and switchgear. This equipment shall include, but shall not be limited to, the following:

1. D.C. ammeter with ammeter switch "On-Off" and shunt device.
2. D.C. circuit breaker control switch with indicator lights.
3. D.C. voltmeter with voltmeter switch "On-Off".
4. Combined watt-meter totalizer and voltmeter recorder complete with equipment (for one rectifier control section only).
5. High-resistance ground protection and relaying for rectifier metal-enclosure.
6. Light indication with drop callout on nameplate.

H. DIODE PROTECTIVE DEVICES

1. High speed current limiting diode fuses.
2. Provision for remote warning of diode loss; provision for unloading rectifier for loss of second diode in phase group or diode leg.
3. Surge protective networks with fuses and open fuse indicator lights.
4. For parallel diodes, current division within 1% per diode/per leg.
5. Add one additional diode to each phase group of parallel diodes over and above rating requirements.
6. Warning signal for loss of rectifier cooling (temperature indicator) and provision for unloading rectifier.
7. High resistance ground protective unit as called for on Page 13 and Sketch "SK-8".

II. D.C. SWITCHGEAR AND CONTROL

A. A metalclad enclosed, floor mounted, indoor, heavy duty lineup for 1000 volt D.C. service and consisting of:

Two (2) main circuit breaker sections for roll-out type circuit breaker.
Four (4) feeder breaker sections for roll-out type circuit breaker.
Two (2) control sections.

B. D.C. MAIN BREAKER SECTIONS

Two (2) metalclad enclosed, heavy duty, floor mounted switchgear sections with 1000 volt D.C., single pole, electrically operated, semi-high speed main circuit breakers with series long and short

time adjustable overcurrent relays and instantaneous reverse current relaying, shunt trip devices for remote control tripping, and control switch "Hand-Off-Auto", or equal. The breaker shall be door interlocked for safety purposes and key interlocked with the negative disconnect switches in the negative bus cubicle.

C. D.C. FEEDER BREAKER SECTIONS

Four (4) metalclad enclosed, heavy duty, floor mounted switchgear sections with 1000 volt D.C., single pole, electrically operated, semi-high speed feeder circuit breakers with series long time adjustable overcurrent and instantaneous forward current relaying, shunt trip devices for remote control tripping and reclosing features with lock-out relay, and control switch "Hand-Off-Auto", or equal. The breaker shall be door interlocked for safety purposes. Each feeder circuit breaker shall have capability to carry the continuous rated load and duty cycle of one rectifier unit.

D. CONTROL SECTIONS

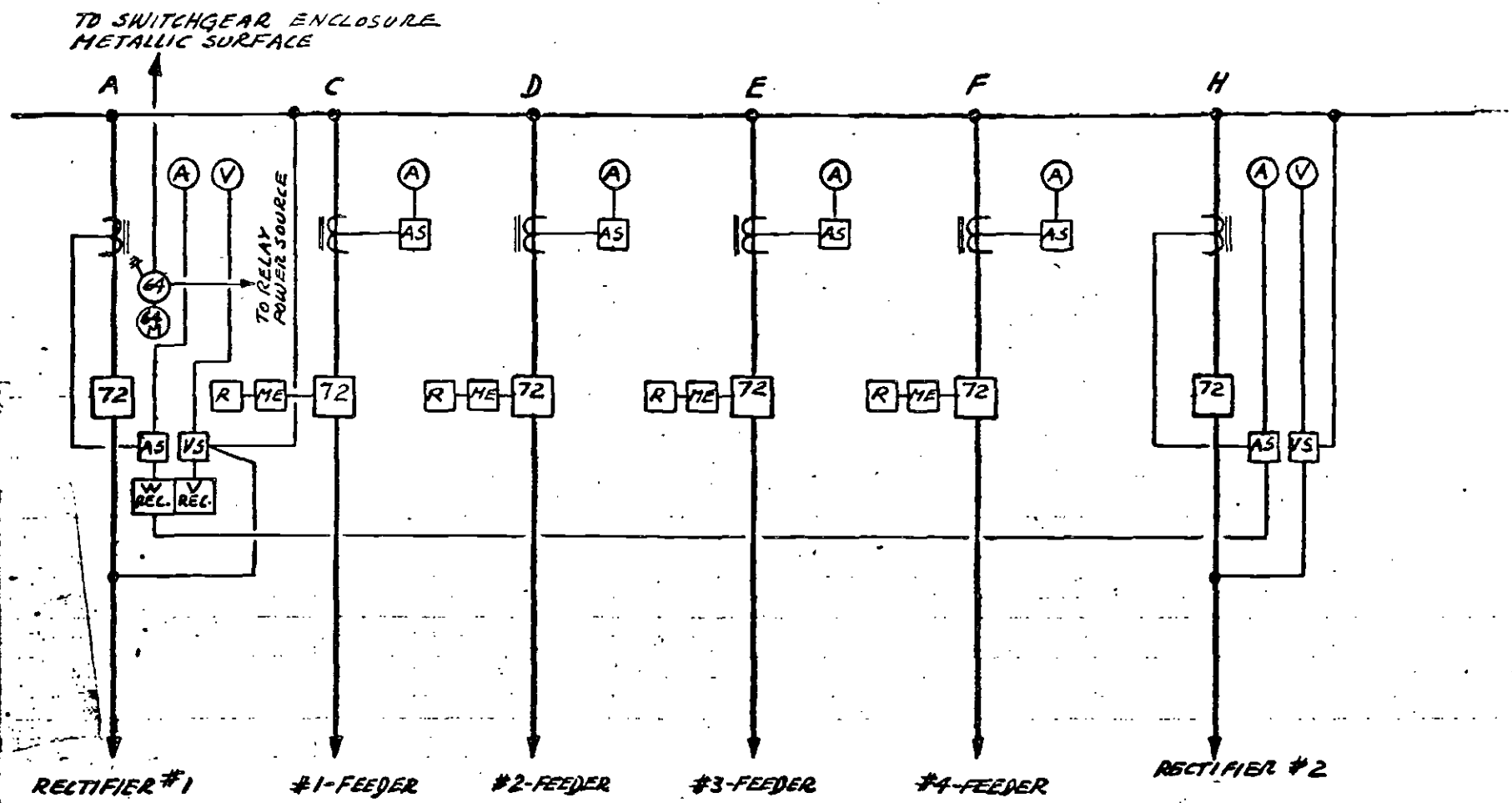
Two (2) metalclad enclosed, heavy duty, floor mounted, switchgear sections with control equipment for main breakers, feeder breakers and transformer and rectifier and shall be complete with stationary and removable elements including primary and secondary disconnect devices and including, but not limited to, the following in each control section:

1. Two (2) reclosing relays (R).
2. Two (2) measuring devices (ME) (for reclosing timing).

3-13-68

W. W. STENL

ONE LINE DIAGRAM
D.C. - SWITCHGEAR



RELAY AND EQUIPMENT LIST

- R — RECLOSING RELAY
- ME — MEASURING DEVICE
- 72 — DC-LINE CIRC. BREAKER WITH OVERCURRENT DEVICES
- AS — AMM. SWITCH
- VS — VOLTMETER SWITCH
- TRANSDUCTOR
- W REC. — WATTMETER RECORDER (TOTALIZER)
- V REC. — VOLTMETER RECORDER
- 64 — HIGH RESISTANCE GROUND RELAY (FOR INDOOR STATIONS ONLY)

NOTES: FOR CIRCUIT FUNCTIONS SEE SKETCH "SK-2A"

SK-2

D.C. CIRCUIT FUNCTIONS

REFER TO SK-2

Circuit breakers (72) will stay closed under normal load. Each circuit breaker shall be equipped with adjustable, timed and instantaneous overcurrent trip devices to provide overcurrent protection against overloads and faults on the D.C. system. Should an overload or circuit fault arrive and a breaker will trip, then the feeder equipment will provide the following automatic control functions:

A. The operation of the control switch will set up the automatic reclosing apparatus.

B. A bridge-type circuit will be connected to measure the resistance of the load or propulsion distribution circuit.

C. If the load resistance is equivalent or higher than the setting of the dial-type calibrating device, the apparatus will initiate the closing of the feeder circuit breaker, 72.

D. The circuit breaker will remain open until the load resistance is higher than the equivalent dial setting for stub-feed.

E. If voltage exists on the load side of the feeder circuit breaker the apparatus will be automatically recalibrated for multiple feed or voltage reclosing.

F. Under such conditions the feeder breaker will remain open until the load voltage is equal to or above the voltage setting of the dial-type calibrating device for multiple feed.

3. One (1) high resistance ground relay unit (64).

4. One (1) monitor relay (64M) (to monitor ground relay).

5. One (1) A.C. power unit for ground and monitor relay.

6. Rectifier control equipment per Paragraph VI G.

E. The main positive bus shall be housed in the D.C. switchgear and extend continuously between the two main circuit breakers.

F. The main negative current return bus shall be housed in a metalclad cubicle (see SK-3), isolated from the D.C. switchgear. Connected to it are two disconnect switches for isolating the two rectifier units during maintenance. The disconnect switches shall be manually operated and key interlocked with their respective positive main breakers to prevent opening under load. Provision shall be made for connecting two feeders with top or bottom entry to the cubicle. Each feeder must safely carry the current load of one rectifier. Each feeder shall be attached to the bus by a bolted link, or equivalent, to provide for easy isolation of the negative bus from the track circuit. Provision shall be made for attaching six track leakage return current drain cables to the bus, each with 500 ampere current capacity.

VIII. INDOOR SUBSTATION CONFIGURATION

The indoor traction substation equipments as described in Sections IV, V, VI and VII are arranged in four groups, namely:

One (1) A.C. Switchgear and Controls Group.

Two (2) Transformer and Rectifier Groups.

One (1) D.C. Switchgear and Controls Group.

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DATE 3-13-68

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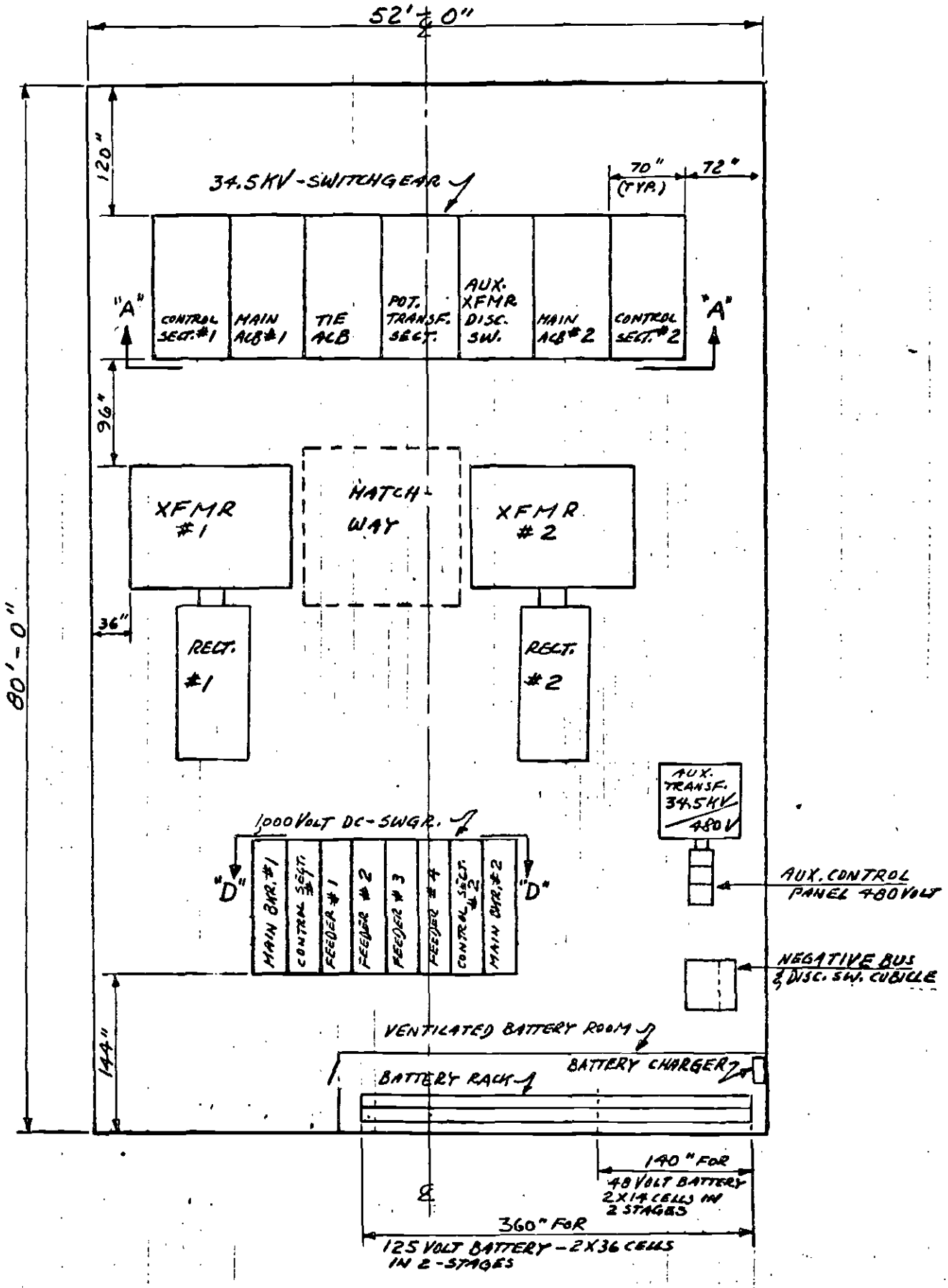
1,000 VOLT PROPULSION POWER SUBSTATION
INDOOR - PARALLEL



TYPICAL INDOOR SUBSTATION

SCALE: 3/32" = 1'-0" APPROX.

SK-3

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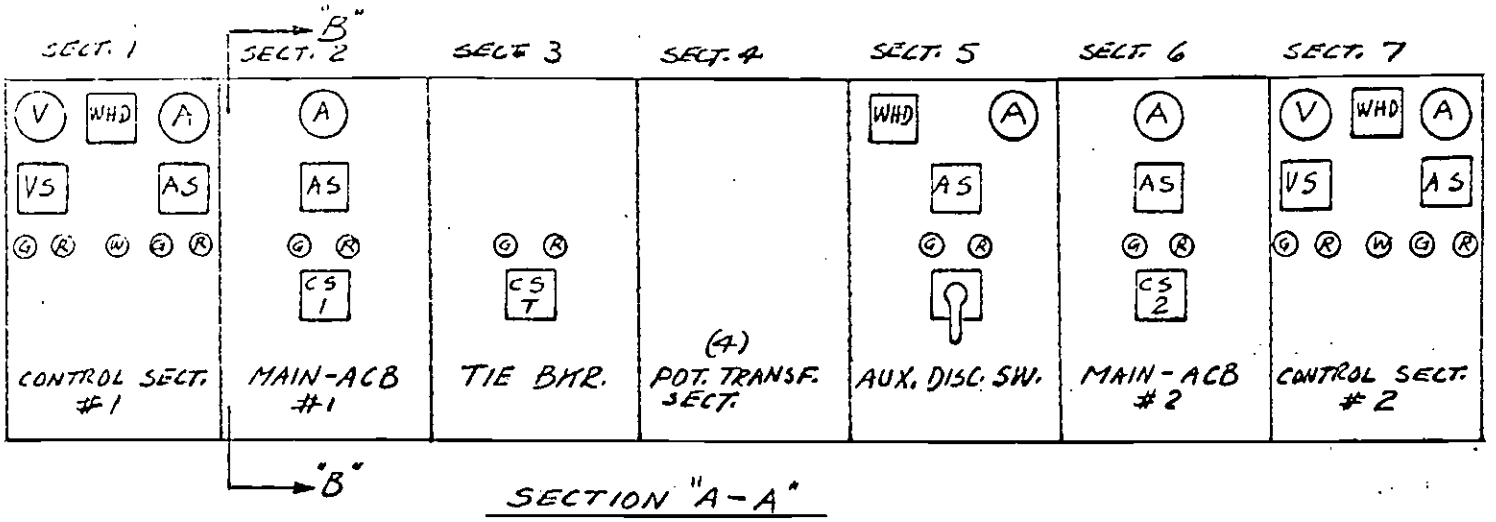
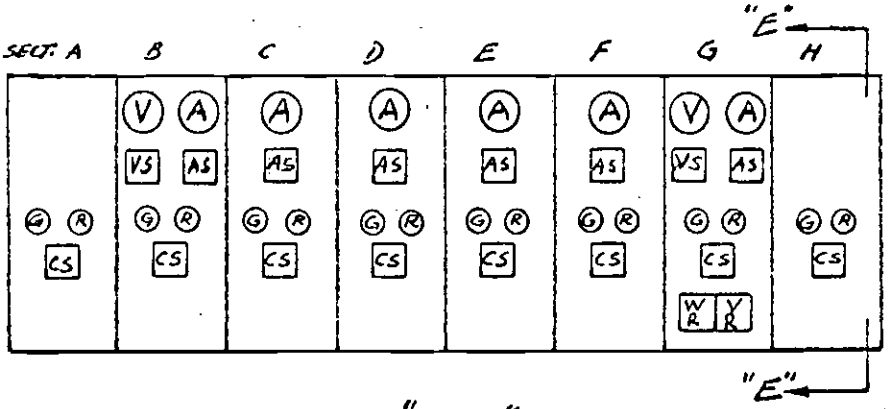
TYPICAL INDOOR SUBSTATION DETAILS



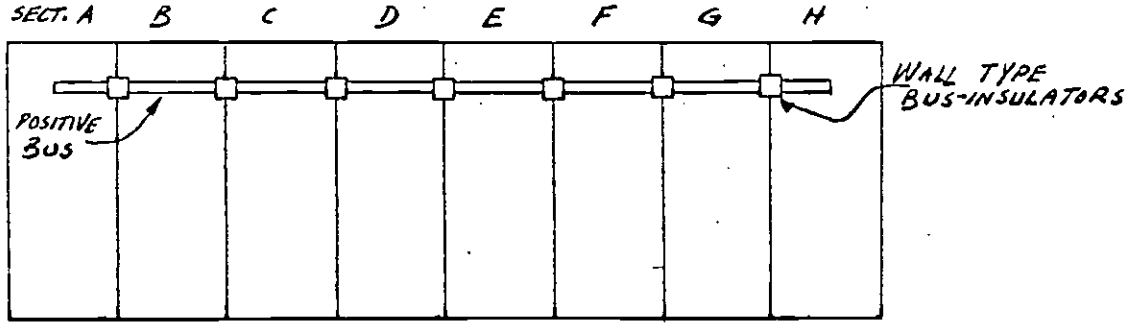
SECTION "A-A"

FRONT VIEW OF 34.5 KV-SWITCHGEAR



SECTION "D-D"

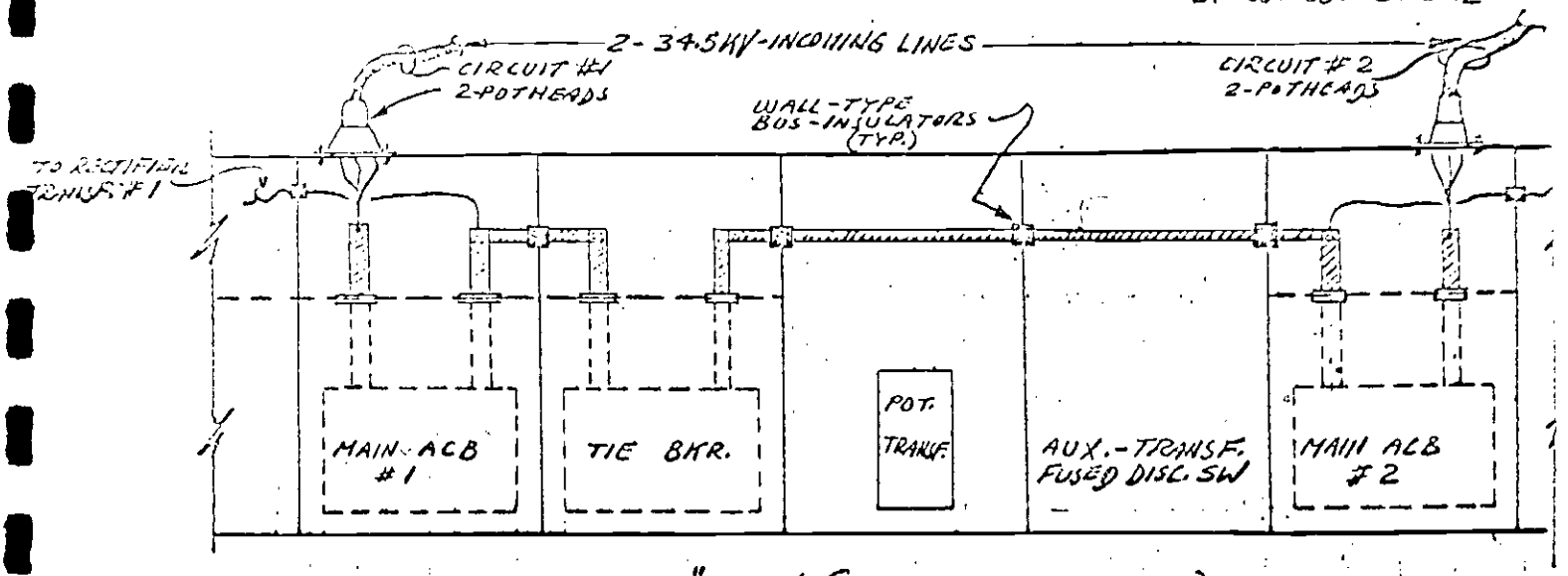
FRONT VIEW 1,000 VOLT DC-SWITCHGEAR



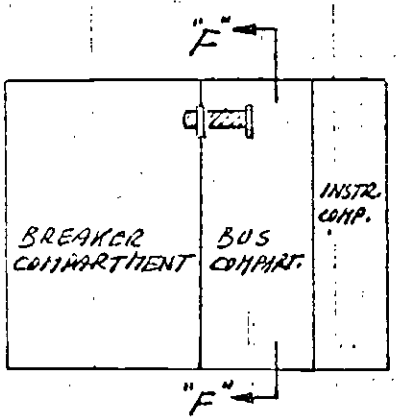
SECTION "F-F"

DC-BUS ARRANGEMENT

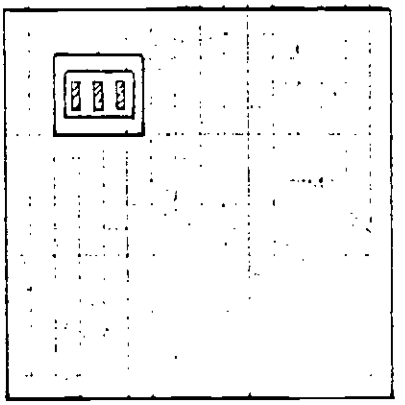
SK-4



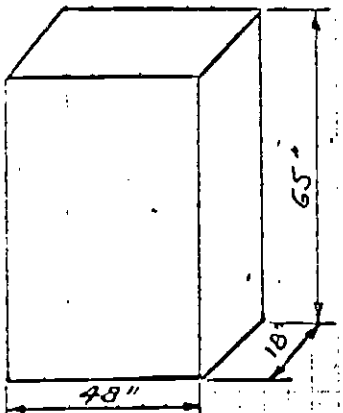
SECTION "C-C" (34.5KV-SWITCHGEAR)
BUS ARRANGEMENT



SECTION "E-E"
BUS ARRANGEMENT WITH INSULATED WALL SUPPORT THROUGH METAL CLAD 1,000 VOLT-DC-SWITCH GEAR



SECTION "B-B"
ISOLATED BUS 34.5KV



1,000 VOLT DC-NEGATIVE BUS AND
DISCONNECT SWITCH CUBICLE

SW-5

All groups are well isolated and arranged rectangularly. The front of the D.C. switchgear faces the front of the A.C. switchgear. The transformer-rectifier groups are identical in construction and lie in parallel between the A.C. and D.C. switchgears. Vault construction details such as columns may require some change in the proposed arrangements.

IX. DOUBLE-ENDED INDOOR SUBSTATIONS

A. GENERAL

One (1) metalclad enclosed, heavy duty, indoor switchgear for 34.5 KV, 3 phase, 60 Hz service, as left-side unit, as shown on SK-6, and complete with stationary and removable elements, including primary and secondary disconnecting devices and including as part of each unit the sections as follows:

1. A.C. Switchgear

   Two (2) metalclad enclosed, heavy duty, control section.

   Two (2) metalclad enclosed, heavy duty, main circuit breaker section.

   One (1) metalclad enclosed, heavy duty, tie circuit breaker section.

   One (1) metalclad enclosed, heavy duty, auxiliary disconnect switch.

   One (1) metalclad enclosed, heavy duty, potential transformer section.

2. Two (2) Rectifier Transformers, one for left side and another for right side unit and should be the same as described in Section V.

3. Two (2) Rectifier Cubicles, metalclad enclosed, heavy duty, indoor, complete with stationary and removable elements, including primary and secondary disconnecting devices and each cubicle shall consist of:

One (1) rectifier section.

Auxiliary power section.

The rectifier cubicle shall conform with units described in Section VI.

4. One (1) D.C. Switchgear, metalclad enclosed, heavy duty, indoor, for 1000 volt D.C. service, half of the switchgear for the left side units, the other half for the right side units, complete with stationary and removable elements, including primary and secondary disconnecting devices and shall include the following sections:

(a) Sections A & H

Two (2) metalclad enclosed, heavy duty sections, in indoor switchgear, 1000 volt D.C., for No. 1 and No. 2 main breaker, complete with stationary and removable elements, including primary and secondary disconnect devices, with front-door mounted control switch with green and red indicating lights. Each breaker shall be of the roll-out type and electrically interlocked with the door, to prevent door-opening under load. This section includes the same equipment as called for in Section VII - B. (See SK-7).

(b) Sections B & G

Two (2) metalclad enclosed, heavy duty sections, in indoor switchgear, 1000 volt D.C., for No. 1 and No. 2 control complete with stationary and removable elements, including primary and secondary disconnect devices. This section shall include the same equipment as called for in Section VII - D. (See SK-7).

(c) Sections C, D, E & F

Four (4) metalclad enclosed, heavy duty sections, in indoor switchgear, 1000 volt D.C., for No. 1, 2, 3 and 4 feeder breaker complete with stationary and removable elements, including primary and secondary disconnect devices. Each breaker shall be of the roll-out type and electrically interlocked with the door to prevent door-opening under load. This section includes the same equipment as called for in Section VII - C. For sections and details see SK-6 and SK-7.

X. GROUND FAULT PROTECTION ON ENCLOSURES OR CASES OF RECTIFIER TRANSFORMERS, RECTIFIERS AND D.C. SWITCHGEAR.

A. RECTIFIER TRANSFORMER GROUND FAULT PROTECTION

The case of the rectifier transformer shall be well insulated from ground and from the enclosure of the rectifier unit. The case shall then be solidly grounded from the grounding lug to the station ground by threading the grounding conductor through an A.C. current transformer and through a D.C. current transformer or transductor. Each

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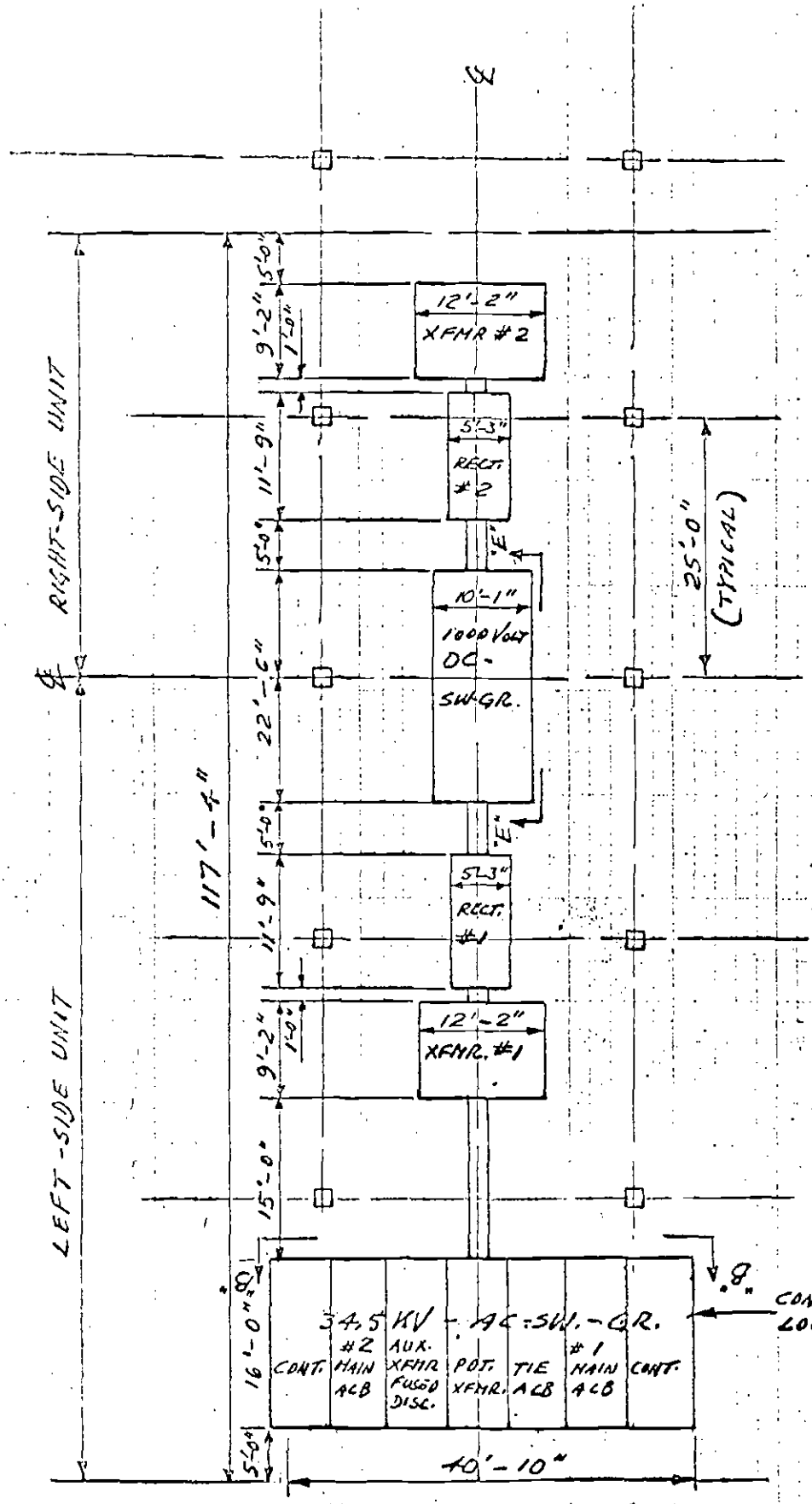
DATE 2-9-68

SUB-STATION LAYOUT

SK-6 - INDOOR SUBSTATION

BY W.W. STEH



SK-6

DOUBLE-ENDED SUBSTATION

SCALE: 1/8" = 2'-0"

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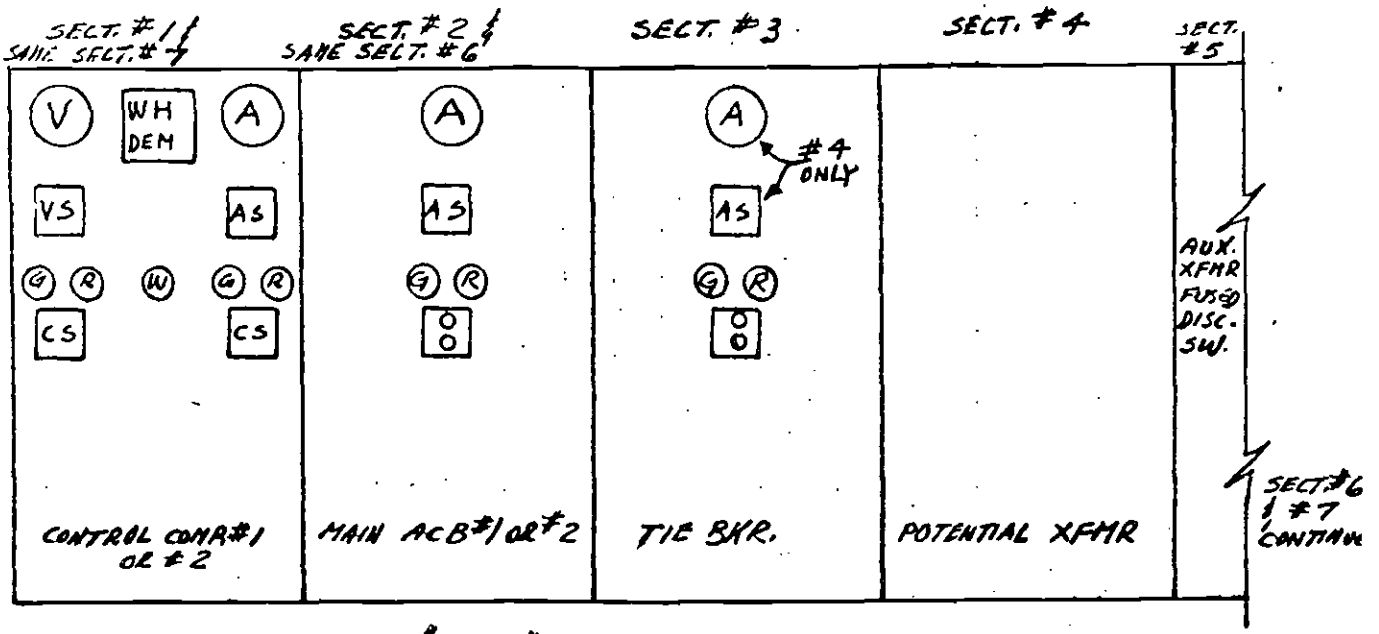
JOB NO. 6657 - 25 SHEET 34 OF

DATE 11-1-67

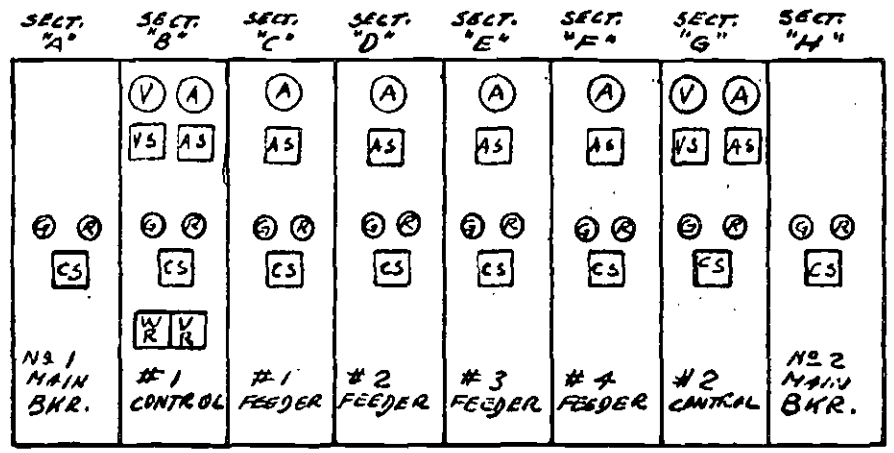
BY W. W. STEHL

TRACTION POWER RECTIFIER SUBSTATION
OUTDOOR UNIT - DOUBLE-ENDED STATION



SECTION "B-B" OF 34.5KV-SWITCHGEAR

SEE SHEET "SK-6" FOR PLAN VIEW



SECTION "E-E" OF 1,000 VOLT D.C.-SWITCHGEAR

SEE SHEET "SK-6" FOR PLAN VIEW

SK-7

current transformer will be connected to a high speed adjustable pickup relay, 64 A.C. and 64 D.C. respectively, both relays to be supplied in the same case. The relays will initiate alarms and primary circuit breaker and secondary main circuit breaker trippings.

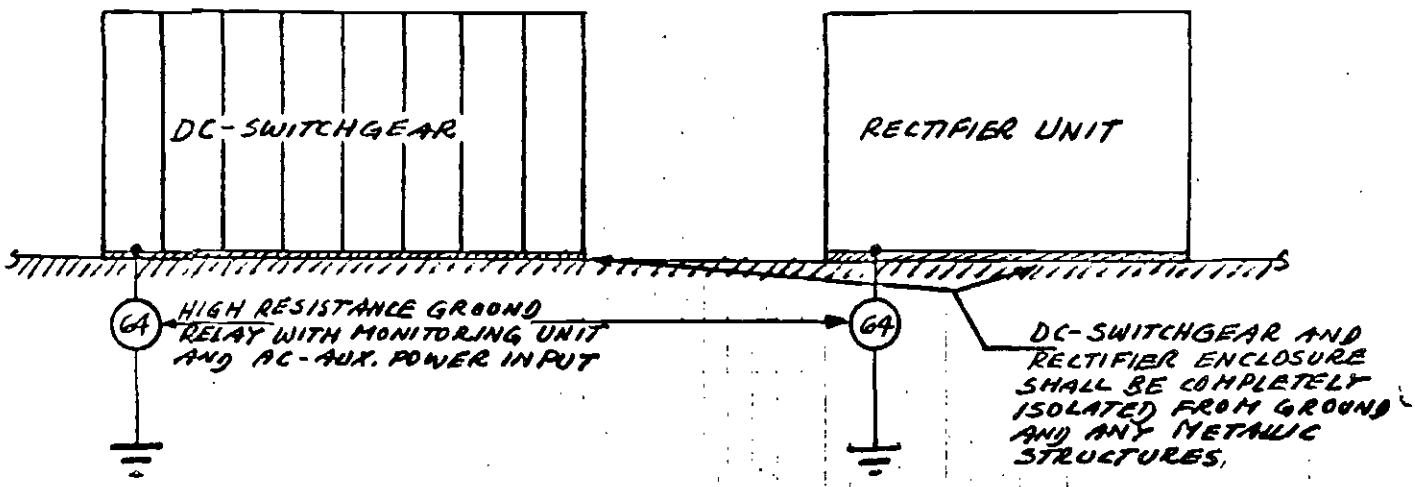
B. RECTIFIER ENCLOSURE GROUND FAULT PROTECTION

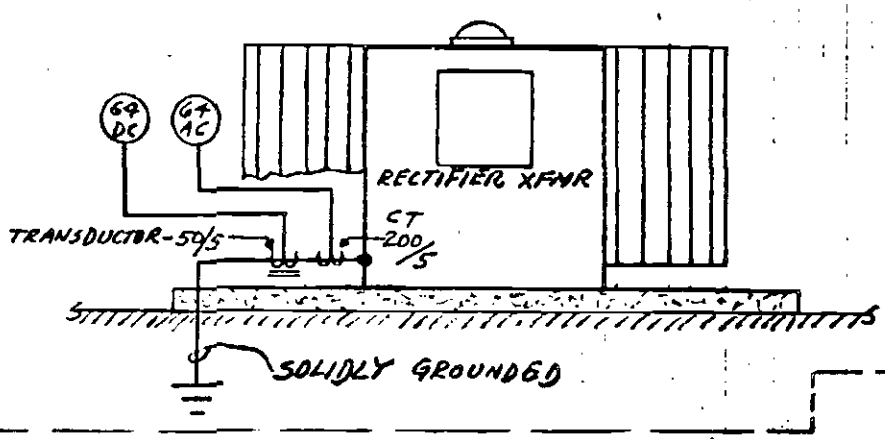
The enclosure shall be insulated from the transformer and all metallic structures. The enclosure shall be grounded through a resistance and protected from ground fault by the relay scheme shown on SK-8.

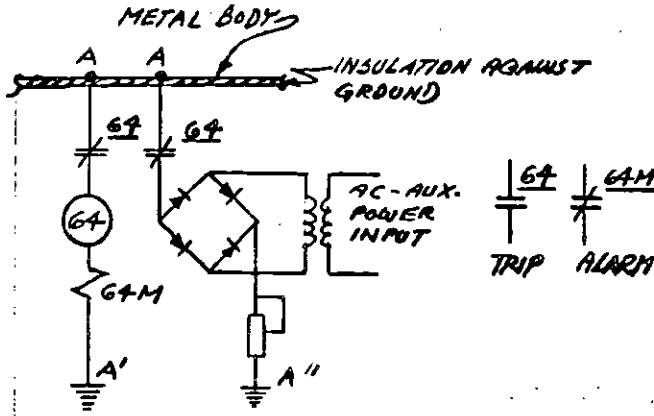
C. D.C. SWITCHGEAR ENCLOSURE

See SK-8 (similary to B, above).

GROUNDING SYSTEMS ON STATION UNITS







SINGLE LINE DIAGRAM FOR DC-GROUND RELAYING

A HIGH RESISTANCE GROUND RELAY "64" CONNECTIONS TO METAL BODY

A' GROUND RELAY MONITORING UNIT "64M" CONNECTION TO GROUND

A'' POTENTIAL INPUT TO GROUND

(64) HIGH RESISTANCE, INSTANTANEOUS, HAND-RESET GROUND RELAY

64M MONITOR RELAY

(64 DC) DC-GROUND RELAY WITH TRANSDUCTOR TYPE CT FOR RECTIFIER UNIT, ADJUST. HIGH SPEED

(64 AC) AC-GROUND RELAY FOR RECTIFIER DIRECT GROUND, ADJUST. HIGH SPEED

XII. FUNCTIONS TO BE MADE AVAILABLE FOR A SUPERVISORY CONTROL SYSTEM

The Supervisory Control System shall include control and monitoring of the following substation equipment:

SYSTEM FUNCTION	DESCRIPTION
RECTIFIER START	CLOSING THE A.C. CIRCUIT BREAKER
RECTIFIER STOP	TRIPPING THE A.C. BREAKER
BREAKER INDICATION	RED LIGHT FOR BREAKER CLOSED GREEN LIGHT FOR BREAKER TRIPPED
RECTIFIER DIODE FAILURE	VISIBLE INDICATION BY FAILURE OF ANY DIODE OR FUSE LOCAL AND REMOTE
RECTIFIER LOCKOUT	LOCKOUT RELAY HAS INITIATED A.C. CIRCUIT BREAKER TRIP AND LOCKS OUT RECTIFIER
TRANSFORMER SUDDEN PRESSURE	SUDDEN PRESSURE RELAY OPERATION TRIPS A.C. BREAKER
TRANSFORMER OIL OVER TEMPERATURE	TRANSFORMER THERMOSTAT INITIATES A LOCAL AND REMOTE ALARM AND LIGHT
TRANSFORMER, RECTIFIER & D.C. SWITCHGEAR CASE GROUND FAULT	GROUND RELAY INITIATES A.C. & D.C. MAIN BREAKER AND LIGHT INDICATION LOCAL AND REMOTE
TRANSFORMER LOW LIQUID LEVEL	INDICATES "LOW LEVEL" ON LOCAL & REMOTE PANEL
AUXILIARY DISCONNECT SWITCH FUSE OPEN	OVERCURRENT OPENS FUSE GIVES LIGHT INDICATION LOCAL AND REMOTE
D.C. MAIN CIRCUIT BREAKERS OVERCURRENT	OVERCURRENT RELAY INITIATES D.C. BREAKER TRIP AND LIGHT INDICATION LOCAL AND REMOTE
D.C. FEEDER BREAKER OVERCURRENT	OVERCURRENT INDICATION BY ALARM
D.C. SWITCHGEAR CASE GROUND FAULT	GROUND RELAY INITIATES D.C. MAIN AND FEEDER BREAKER TRIP AND LIGHT INDICATION LOCAL AND REMOTE
INSTRUMENTS & METERING:	D.C. TOTALIZING WATTMETER RECORDER #1 & #2 - RECTIFIER D.C. AMMETERS #1 & #2 - RECTIFIER D.C. VOLTMETERS #1 & #2 - A.D. MAIN BUS VOLTMETERS A.C. AMMETER-AUXILIARY TRANSFORMER A.C. POTENTIAL TRANSFORMERS

MAIN & TIE CIRCUIT BREAKER

MAIN AND TIE CIRCUIT BREAKERS

FOR

A GROUP OF TRACTION RECTIFIER SUBSTATIONS

PRELIMINARY SPECIFICATION

REVISION ONE - MARCH, 1968

TABLE OF CONTENTS

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

SUPPLIER _____ DATE _____

METAL CLAD SWITCHGEAR

	COST	
	34.5 KV	
	INDOOR	OUTDOOR

FIVE (5) SECTION INTERFACE
MAIN BREAKER UNIT

THREE (3) SECTION, TIE
BREAKER UNIT

Prices should be current estimating cost based on delivery in Los Angeles, and should include conventional factory tests only and installation supervision and check-out on site only.

Please indicate the type of 34.5 KV circuit breaker to be used.

The attached preliminary specification is based on a 34.5 KV indoor or outdoor METALCLAD SWITCHGEAR, ONE FIVE (5) section and one three (3) section unit.

I. GENERAL

The work to be performed under the terms of this specification shall consist of furnishing and delivering the equipment for interface indoor or outdoor metalclad switchgear and indoor or outdoor tie breaker metalclad switchgear.

The switchgear shall consist of complete coordinated parts as outlined hereafter and shall include all integral equipment, devices, buses, internal wiring, etc., required for the proper operation of the interface and section tie breaker switchgear for the 34.5 KV feeders to propulsion power substations in a section of the Rapid Transit System.

II. STANDARDS

The interface and tie breaker metalclad switchgear shall be designed, manufactured and tested in accordance with the requirements and all applicable NEC, NEMA, IEEE and ASA Specifications and the State of California "Electrical Safety Orders".

III. ARRANGEMENT

A. GENERAL

Interface metalclad switchgear is designed to provide an interface switching between a power company and a section of the Southern California Rapid Transit System for the 34.5 KV AC main power source.

The normally open tie circuit breaker metalclad switchgear is designed to provide AC power to an adjacent section of the Rapid Transit System during an operating condition of emergency.

B. ENCLOSURE

All equipment shall be suitably housed in heavy duty fabricated metalclad enclosures. The metalclad enclosures for the AC switchgear shall be provided with a ground bus to connect metal frames and housings of electrical equipment. All outdoor enclosures shall have thermostatically controlled space heaters installed to prevent formation of moisture condensation.

IV. 34.5 KV INTERFACE MAIN BREAKER SWITCHGEAR

A. 34.5 KV INTERFACE MAIN BREAKERS AND CONTROL

A metalclad enclosed, floor mounted, indoor or outdoor heavy duty switchgear for 34.5 KV service and consisting of:

1. Four (4) circuit breaker sections for roll-out type circuit breakers.

2. One (1) control section.

B. 34.5 KV INTERFACE SWITCHGEAR SECTIONS

Four (4) metalclad enclosed heavy duty AC switchgear sections complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

1. Four (4) main circuit breakers 34.5 KV, 3 phase, 60 Hz, 200 BIL, 1500 MVA interrupting capacity, current rating up to but not exceeding 1200 A. Each circuit breaker section includes one control switch with green and red indicating lights and three (3) current transformers. #1 and #11 breaker sections each

include one (1) white indicating lamp and switch to measure by selection either feeder from the incoming line.

2. One (1) control section complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

   (a) Two (2) recording voltmeter to 38 KV scale, one (1) for Line #1, one (1) for Line #2.

   (b) Two (2) twin recording ammeter, to measure main bus current one (1) for Line #1, one (1) for Line #2.

   (c) Four (4) watthour demand meters, to measure Line #1 and Line #2 load.

   (d) Four (4) reactive voltampere-hour meters, to measure Line #1 and Line #2 load.

   (e) Twelve (12) time overcurrent relays (with instantaneous units), (50/51).

   (f) Four (4) overcurrent ground relays (51N).

   (g) Two (2) undervoltage relays (47).

   (h) Four (4) reclosing relays (79).

   (i) Four (4) lock-out relays (86).

   (j) Four (4) potential transformers (fused).

34.5 KV TIE BREAKER SWITCHGEAR

A. A metalclad enclosed, floor mounted, indoor or outdoor heavy duty switchgear for 34.5 KV service and consisting of:

1. Two (2) circuit breaker sections for roll-out type circuit breakers.

2. One (1) control section.

B. 34.5 KV TIE BREAKER SWITCHGEAR SECTIONS

Two (2) metalclad enclosed heavy duty AC switchgear sections complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

1. Two (2) tie breaker circuit breakers 34.5 KV, 3 phase, 60 Hz, 200 BIL, 1500 MVA interrupting capacity, current rating 1200 A. The tie breaker sections including:

   (a) Circuit breaker control switch with green and red indicating light, in Section #1 and section #3.

   (b) Two (2) white indicating lights, one (1) for #1 tie breaker and one (1) for #2 tie breaker control potential.

   (c) Three current transformers in each of Section #1 and #3.

2. One (1) control section complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

(a) One (1) voltmeter with voltmeter selector switch, to select #1 or #2 tie breaker potential.

(b) One (1) ammeter with ammeter selector switch, to select #1 or #2 tie breaker current.

(c) Four (4) potential transformers, fused, two (2) for #1 and two (2) for #2 tie breaker potential and instrumentation

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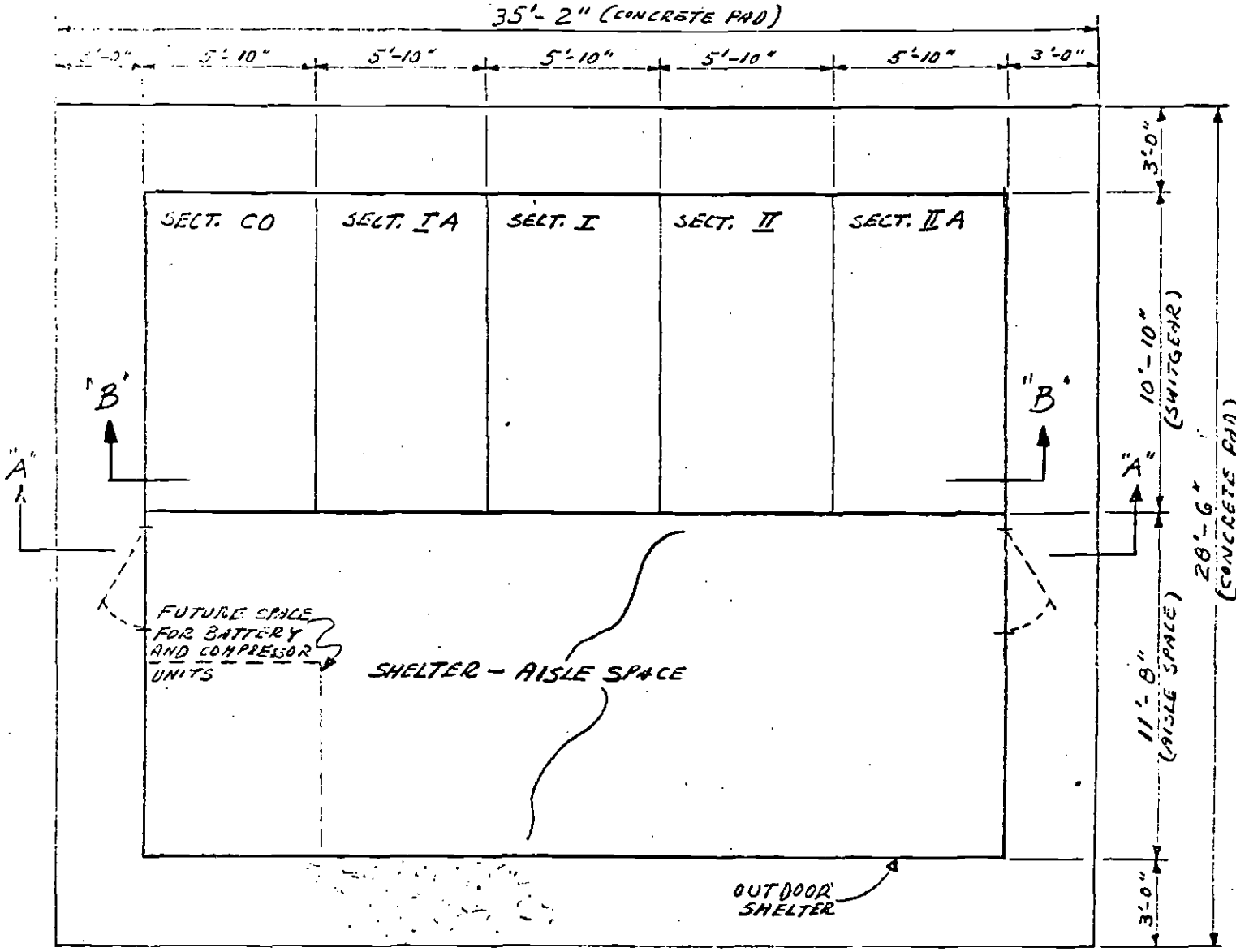
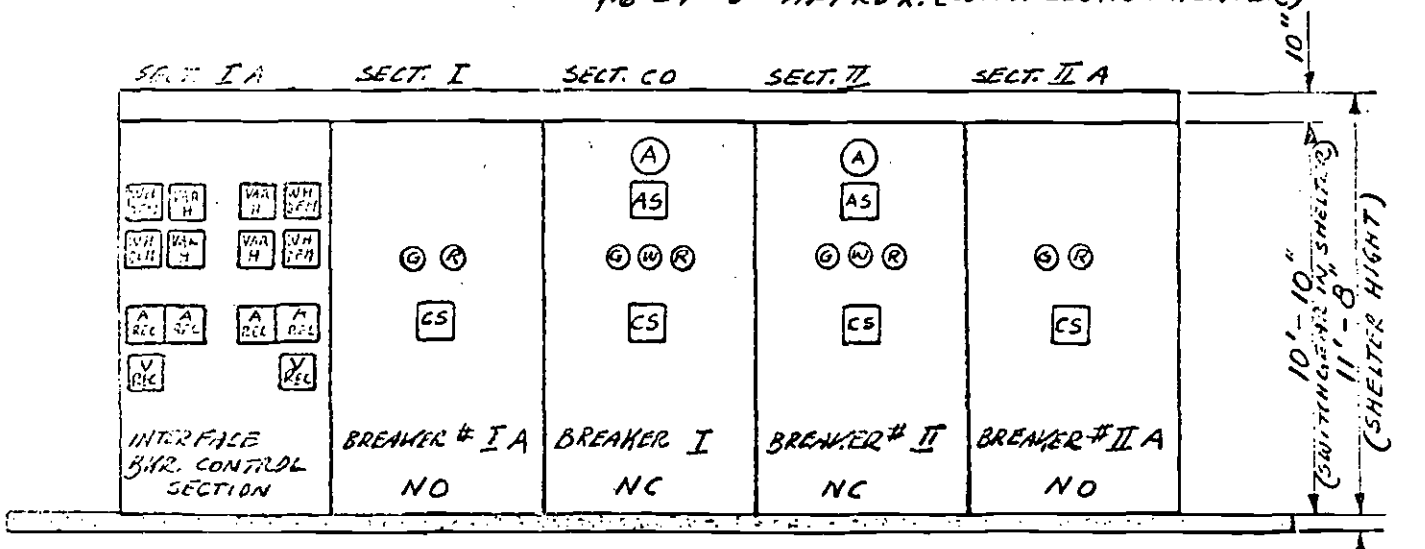
LAYOUT OF 34.5KV - INTERFACE - SWITCHGEAR



PLAN VIEW OF 34.5KV INTERFACE SHELTERFORM SWITCHGEAR

SCALE: 3/16" = 1'-0" APPROX. (WITH SECTION HEATER)



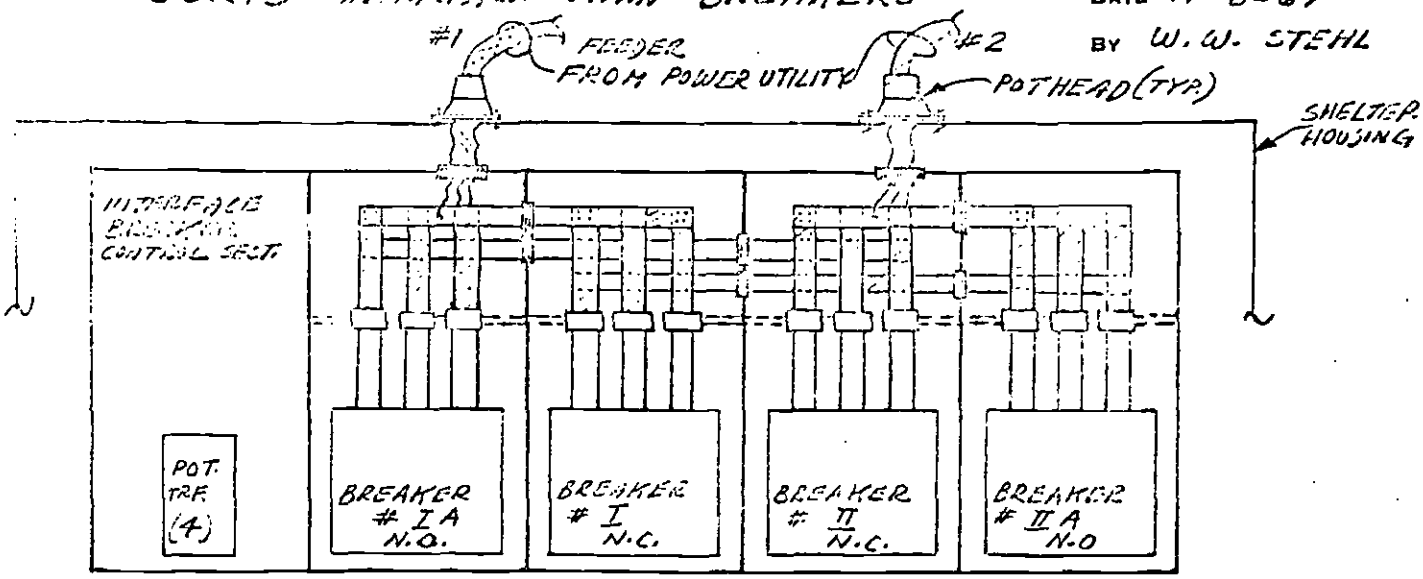
SECTION "A-A"

FRONT VIEW OF 34.5KV - INTERFACE SHELTERFORM SWITCHGEAR

SCALE: 3/16" = 1'-0"

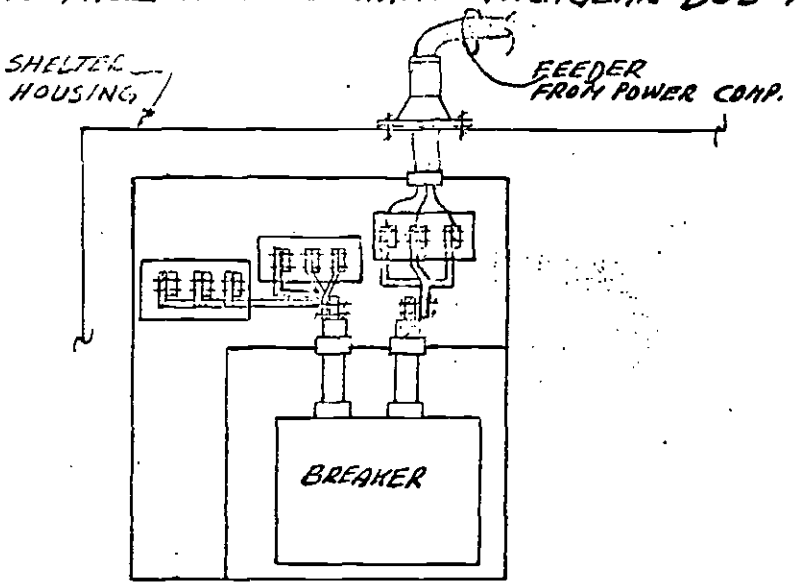
SK-9

SCR'D - INTERFACE MAIN - BREAKERS



SECTION "B-B"

INTERFACE MAIN BREAKER SWITCHGEAR BUS ARRANGEMENT



SECTION "C-C"

SHOWING BUS CONNECTIONS

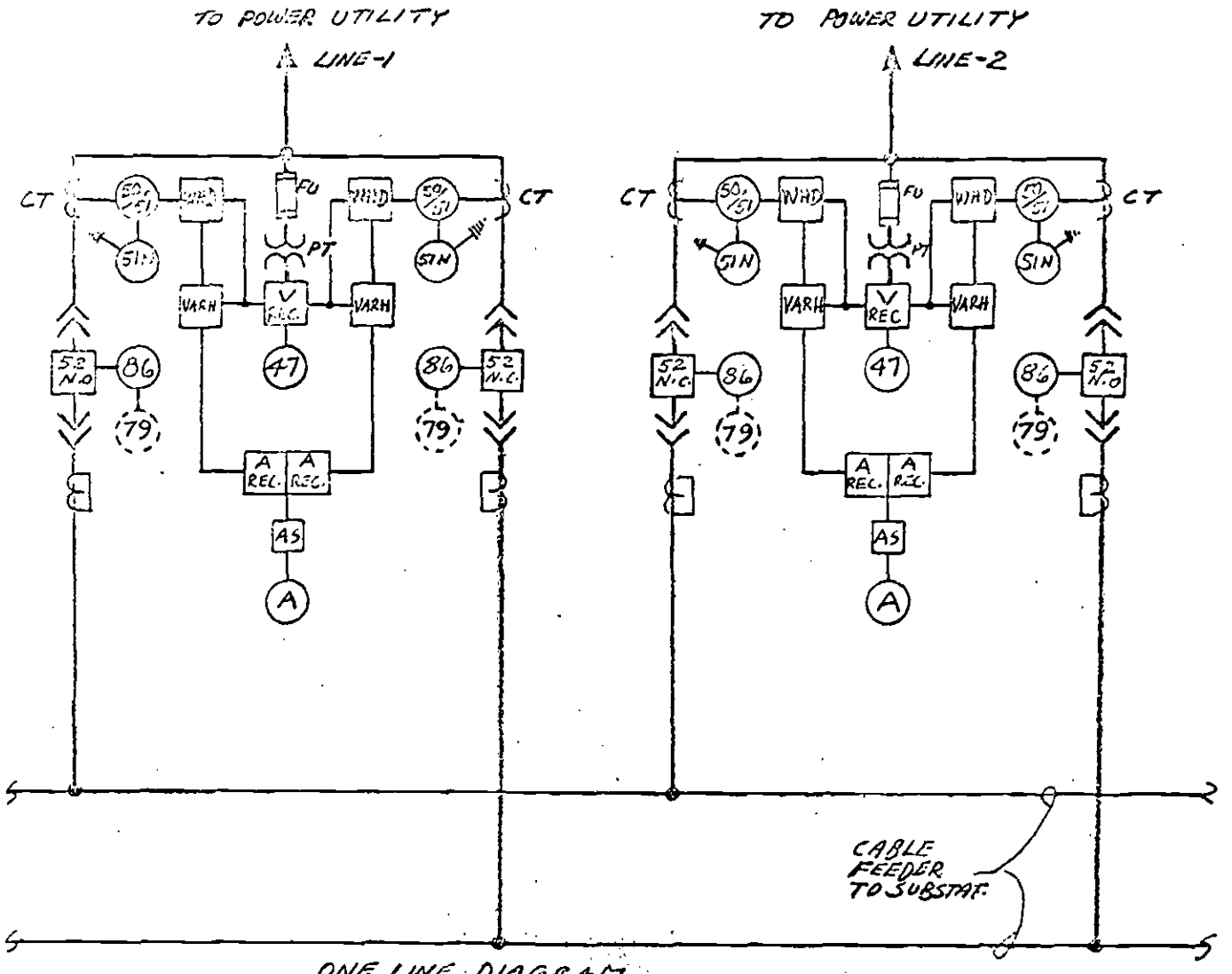
DANIEL, MANN, JOHNSON & MENDENHALL

JOB NO. 6657 -25 SHEET 37 OF

DATE 11-2-67

BY W. W. STEIL

SCRTD - III INTERFACE MAIN BREAKERS



ONE LINE DIAGRAM
OF 34.5KV INTERFACE MAIN CIRCUIT BREAKER SWITCHGEAR

(47) UNDER VOLTAGE RELAY

(50/51) TIME OVERCURRENT/INSTANTANEOUS RELAY

(51N) GROUND OVERCURRENT RELAY

WHD WATT-HOUR DEMAND METER

VARH REACTIVE VOLTAMPERE-HOUR METER

(79) AC-RECLOSING RELAY (FUTURE)

(86) AC-LOCK-OUT RELAY

A REC | A REC TWIN AMMETER RECORDER

V REC VOLTMETER RECORDER

AS AMMETER SWITCH

(A) AMMETER

FU PT FUSED POTENTIAL TRANSFORMER

SK-11

DANIEL, MANN, JOHNSON & MENDENHALL

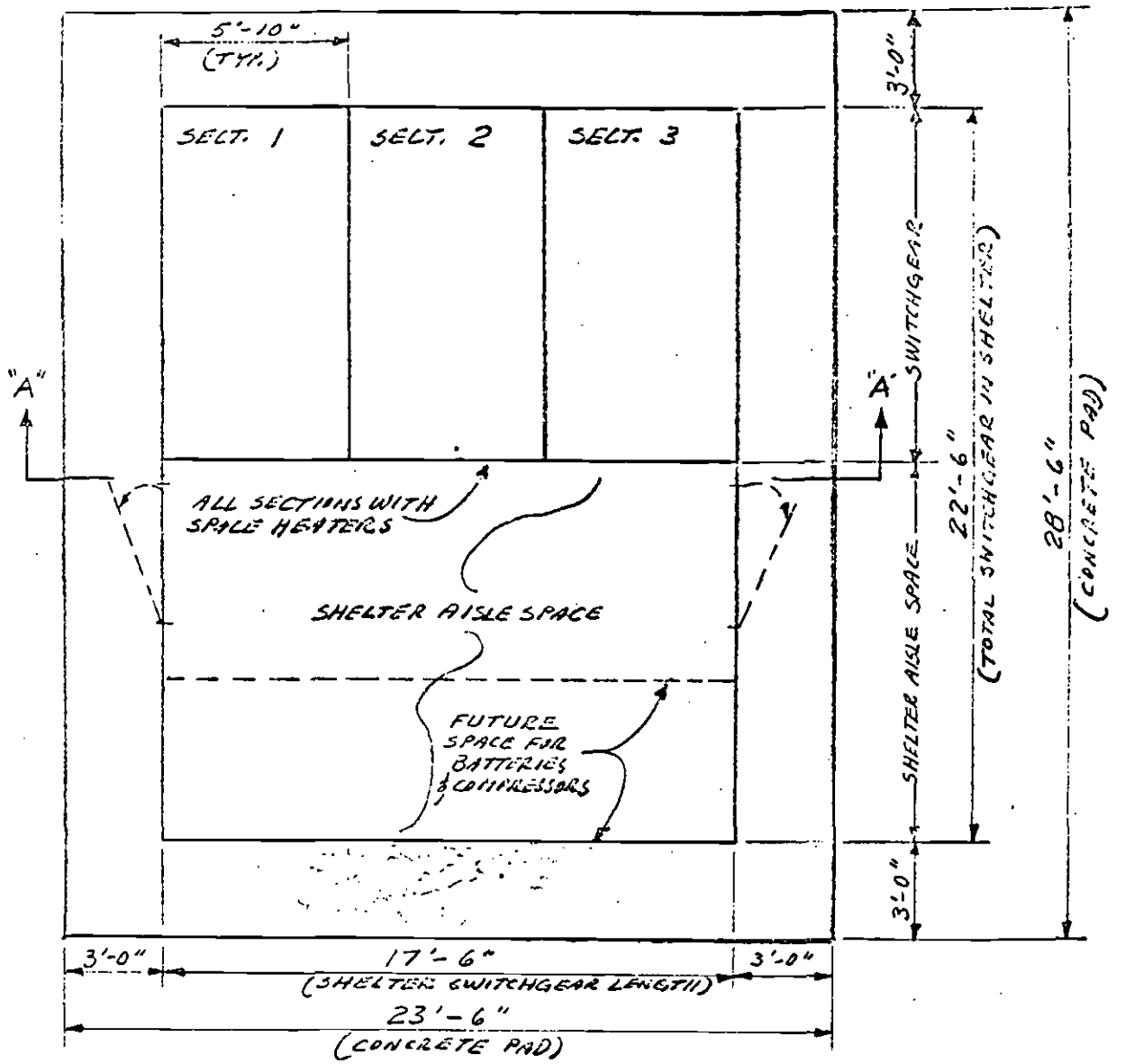
JOB NO. 6657 - 25

SHEET OF

DATE 3-20-68

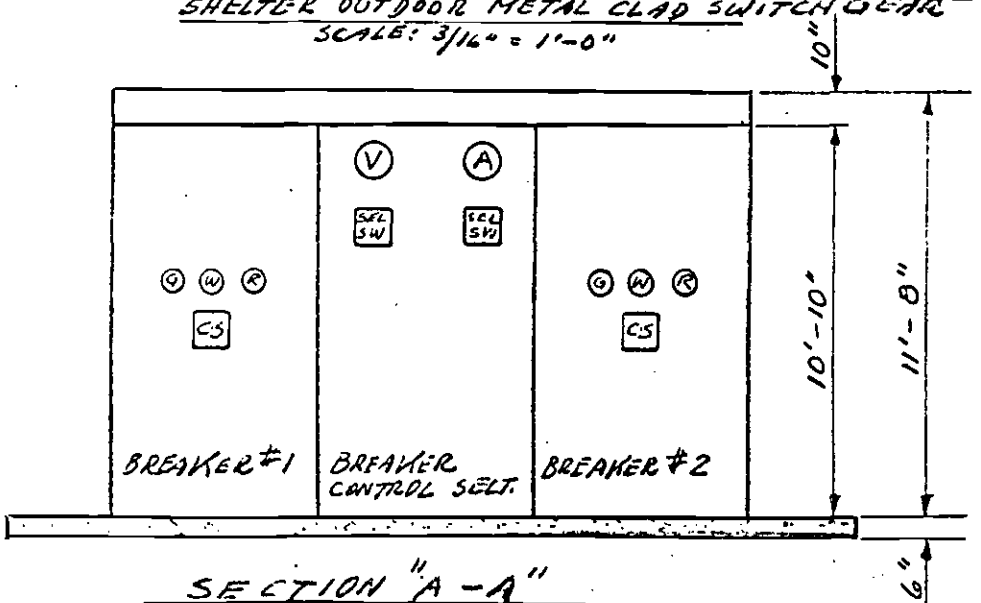
BY W. W. STEHL

SECTION TIE-BREAKER OUTDOOR SHELTER FORM METAL CLAD SWITCHGEAR



PLAN VIEW OF 34.5KV SECTION TIE-BREAKER SHELTER OUTDOOR METAL CLAD SWITCHGEAR

SCALE: 3/16" = 1'-0"



SECTION "A-A"

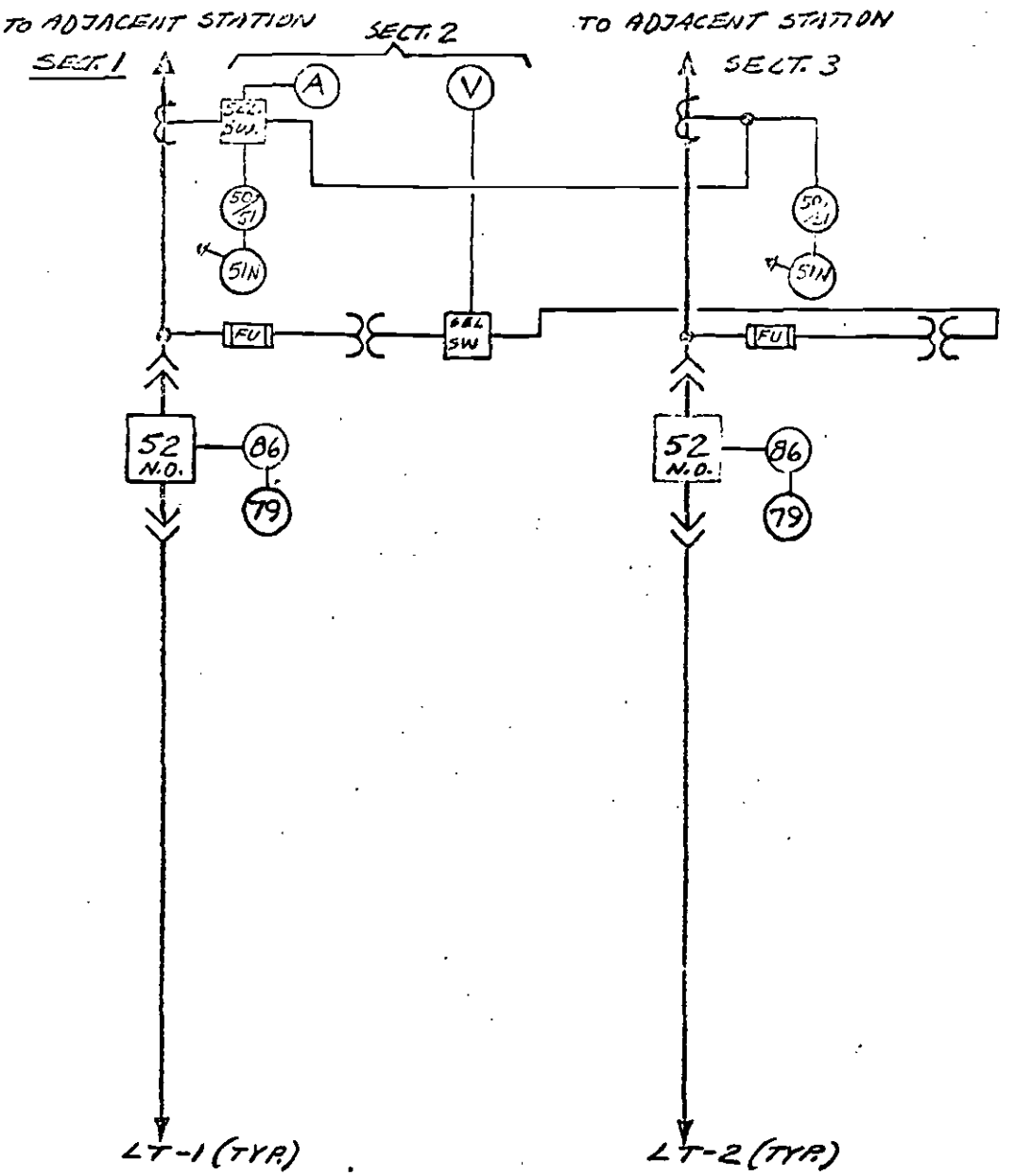
FRONT VIEW OF 34.5KV SECTION TIE-BREAKER SHELTER FORM SWITCHGEAR - SCALE: 3/16" = 1'-0"

SK-12

DANIEL, MANN, JOHNSON & MENDENHALL JOB NO. 6657-25 SHEET OF

SECTN. TIE-BREAKER OUTDOOR METAL CLAD SWITCHGEAR 34.5 KV DATE 11-9-67

BY W. W. STEPHL



ONE LINE DIAGRAM
OF TIE-BREAKER METAL CLAD SWITCHGEAR 34.5 KV

- SEL. SW. — SELECTOR SWITCH FOR CURRENT OR VOLTAGE
- 50/51 — TIME OVERCURRENT/INSTANTANEOUS RELAY
- 51N — GROUND OVERCURRENT RELAY
- 79 — AC RECLOSING RELAY
- 86 — AC LOCKOUT RELAY

SK-13

V. FUNCTIONS TO BE MADE AVAILABLE FOR SUPERVISORY CONTROL SYSTEM

The supervisory control system shall include control and monitoring of the following equipment:

A. INTERFACE SWITCHGEAR SYSTEM FUNCTION	DESCRIPTION INTERFACE SWITCHGEAR
Energize section line or lines	Closing interface AC circuit breakers
De-energize section line or lines	Tripping interface AC circuit breakers
Ground fault or overcurrent on section line	Tripping interface AC circuit breakers Light indication local and remote
Breaker indication	Red light for breaker closed Green light for breaker tripped
Breaker trips on overcurrent or fault	Alarm and light indication local and remote
Indicate switchgear loading	Monitor ammeter and voltmeter instruments

B. TIE BREAKER SWITCHGEAR	DESCRIPTION (TIE BREAKER SWITCHGEAR)
Section tie breaker closing	Initiates lights and indication local and remote
Section tie breaker trip	Initiates lights and indication local and remote
Section line ground fault	Ground relay initiates tie breaker trip and light indication with alarm local and remote
Section line overcurrent	Overcurrent relay initiates tie breaker trip and light indication with alarm local and remote

TRACK CIRCUIT DC SWITCHGEAR STATIONS

TRACK CIRCUIT DC SWITCHGEAR STATIONS

PRELIMINARY SPECIFICATION

REVISION ONE - MARCH, 1968

TABLE OF CONTENTS

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

SUPPLIER _____ DATE _____

METAL ENCLOSURE	COST 1000 VOLTS INDOOR	OUTDOOR
Four (4) Section Unit		
Two (2) Section Unit (With Bus)		
Two (2) Section Unit (Without Bus)		
Ten (10) Section Unit		
One (1) Section Unit (Without Bus)		
Three (3) Section Unit		

Prices should be current estimating cost based on delivery in Los Angeles, and should include conventional factory tests only and installation supervision and checkout on site only. Include sufficient spare parts.

The attached preliminary specification is based on 1000 volt D.C. metal outdoor enclosure for 900 volt traction system.

I. GENERAL

The track circuit DC switchgear stations consist of complete coordinated parts as outlined hereinafter and include all integral equipment, devices, buses, internal wiring, etc., required for supplying DC traction power to storage and transfer tracks and inspection yards, at 900 volt D.C. and for sectionalizing the mainline contact or third rail circuits at rail gaps.

II. STANDARDS

The traction station units (consisting of various sections) shall be designed, manufactured and tested in accordance with the requirements of all applicable NEC, NEMA, IEEE, and ASA Specifications, and the State of California Electrical Safety Orders.

III. ARRANGEMENTS

A. GENERAL

The track circuit stations are designed to connect various transfer zone contact rails, storage track contact rails, or rail gaps by D.C. switchgear. Each unit is composed of various outdoor metalclad enclosed sections 1000 volt D.C.

B. ENCLOSURE

All equipment shall be suitably housed in heavy-duty fabricated metal enclosures. The metal enclosures for each unit shall be insulated from ground and from any connection with any other grounded item and shall be provided with low resistance ground protective devices. The ground protection equipment, in the event of a failure to ground of the unit, shall automatically open all D.C. switching devices in the unit.

IV. DC INDOOR/OUTDOOR METALCLAD ENCLOSURE AND CONTROLS

A. GENERAL DESCRIPTION

Eight (8) metalclad enclosed, floor mounted, heavy-duty units, for 900 volt service and consisting of:

1. One (1) section unit for one (1) single pole circuit breaker, semi-high speed, (roll-out type). (See SK-21 DOM. Unit-1).
2. Four (4) two section units, three with and one without positive bus compartment for one single pole circuit breaker, semi-high speed (roll-out type) in each section. (See SK-21, DOM. Unit-2 and DOM. Unit-4; and SK-22, Section "E-E" and Section "G-G", and SK-15 and SK-16 with bus compartment; and SK-17, without bus compartment).
3. One (1) three section unit, for one single pole circuit breaker, semi-high speed (roll-out type) in each section. (See SK-21, SK-22, SK-23).
4. One (1) four section unit, for one circuit breaker in each section. (See SK-13, SK-14).
5. One (1) ten section unit, where two (2) sections will be equipped with one (1) main unit bus feeder circuit breaker (roll-out type) in each section, and eight (8) sections will be equipped with one (1) single pole circuit breaker (roll-out type) in each section. (See SK-18, SK-19, SK-20).
6. One low-resistance ground protective device and specific control and relay equipment will be mounted in each individual unit.

B. DETAILED DESCRIPTION (See SK-21, DOM. Unit-1)

1. One (1) Section Unit

One (1) metalclad enclosed, floor mounted, outdoor, heavy duty for 900 volt D.C. service with a 1000 volt D.C., single pole, 2000 amperes, electrically operated, semi-high speed single pole circuit breaker, and the unit shall be complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

(a) One (1) control switch with position "local and remote", including green and red indicating lights.

(b) One (1) low-resistance ground protective device.

2. Four (4) Two-Section Units (See SK-15, SK-16, SK-17, SK-21, SK-22, SK-23).

Each of these units shall consist of: A metalclad enclosed, floor mounted, outdoor, heavy duty, for 900 volt D.C. service with 1000 volt D.C., single pole, 2000 amperes single pole circuit breaker, semi-high speed (roll-out type), in each section of three (3) units, and 1000 amperes circuit breakers in each section of one (1) unit, and each unit shall be complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

(a) One (1) control switch with green and red indicating lights for each single pole circuit breaker in each section.

(b) One low-resistance ground protective device for each individual unit (2 sections).

3. One (1) Three-Section Unit (See SK-21, SK-22, SK-23)

A metalclad enclosed, floor mounted, outdoor, heavy duty, for 900 volt D.C. service with 1000 volt D.C., single pole, 1000 amperes, electrically operated, semi-high speed single pole circuit breaker (roll-out type) and shall be complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

(a) One (1) control switch with green and red indicating lights for each single pole circuit breaker in each section.

(b) One (1) low resistance ground protective device.

4. One (1) Four-Section Unit (See SK-13, SK-14)

A metalclad enclosed, floor mounted, indoor, heavy duty, for 900 volt D.C. service, with 1000 volt D.C., single pole, 3000 amperes, electrically operated, semi-high speed single pole feeder circuit breaker, roll-out type, and shall be complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

(a) One (1) control switch with green and red indicating lights for each feeder circuit breaker in each section.

(b) One (1) low resistance ground protective device.

5. One (1) Ten (10) Section Unit (See SK-18, SK-19, SK-20)

A metalclad enclosed, floor mounted, outdoor, heavy duty, for 900 volt D.C. service, with 1000 volt D.C., single pole, 2000 amperes main-unit bus single pole feeder breaker, (roll-out type)

in section "D" and section "H" and 1000 amperes single pole circuit breaker, semi-high speed (roll-out type) in Sections A, B, C, E, F, G, and 1500 amperes single pole circuit breaker, semi-high speed (roll-out type) in sections K and L (See SK-18), and shall be complete with stationary and removable elements, including primary and secondary disconnect devices and including, but not limited to, the following:

(a) One (1) control switch with green and red indicating lights for each circuit breaker and main unit bus feeder breaker.

(b) One (1) low resistance ground protective device.

6. Ground Devices and Control Relays

(a) Each unit metal housing shall be connected to a low resistance ground protective device which shall open all circuit breakers within the specific metal housing in the event of a ground fault to the metal housing. (For example see: SK-20).

(b) One (1) D.C. overcurrent relay (76) to connect in each breaker feeder line.

C. CIRCUIT BREAKER TYPE

1. Circuit breakers are the same type and kind normally used as D.C. feeder breakers in the traction rectifier substation. They shall be roll-out, heavy duty with the same current interrupting capacity so fault detection relaying may be coordinated with substation feeder breakers of total substation rectifier capacity up to 9 MW. Each circuit breaker shall be provided with series adjustable instantaneous and long time characteristic relaying devices for overcurrent and fault protection and a shunt relay tripping device for local and remote control.

IV. FUNCTIONS TO BE MADE AVAILABLE FOR A SUPERVISORY CONTROL SYSTEM

The supervisory control system shall include control and monitoring of the following traction station equipment:

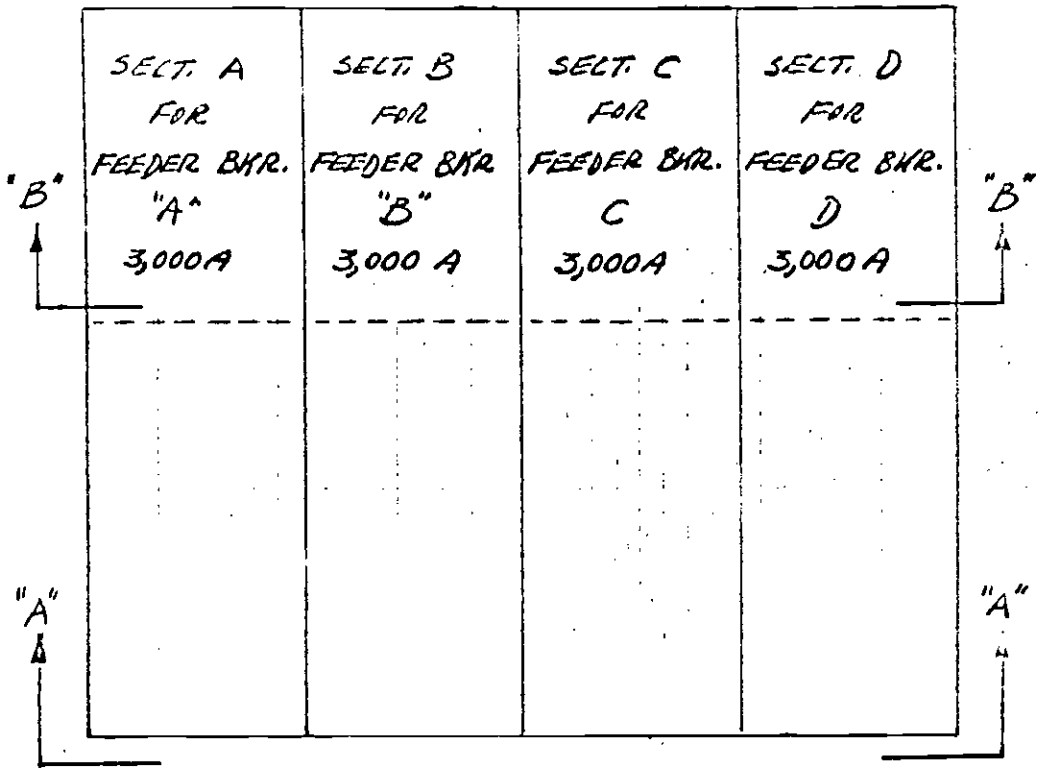
TRACTION STATION SYSTEM FUNCTION	DESCRIPTION TRACTION STATION
ENERGIZE ANOTHER SIDE OF CROSSOVER GAP OR TURNBACK GAP OR YARD CONNECTION FROM MAIN LINE GAP OR RAIL GAP TIE	CLOSING CIRCUIT BREAKERS
DE-ENERGIZING GAP AS CALLED FOR ABOVE	TRIPPING CIRCUIT BREAKERS
GROUND FAULT OR OVERCURRENT ON FEEDER LINES	TRIPPING SINGLE POLE CIRCUIT BREAKER OR MAIN BUS UNIT FEEDER BREAKER IN STORAGE YARDS PROPULSION POWER, AND LIGHT INDICATION LOCAL AND REMOTE
BREAKER INDICATION	RED LIGHT FOR BREAKER CLOSED GREEN LIGHT FOR BREAKER TRIPPED
BREAKER TRIPS ON OVERCURRENT OR FAULT	LIGHT INDICATION AND VISIBLE ALARM LOCAL AND REMOTE
GROUND FAULT ON TRACTION STATION METALCLAD ENCLOSURE	LOW RESISTANCE GROUND PROTECTIVE DEVICE RELAY TRIPS ALL BREAKERS IN THAT SPECIFIC METALCLAD UNIT AND INITIATES THE ALARM CIRCUIT

[illegible] Job No. 6657 - 25 Sheet of

Date 11-14-67

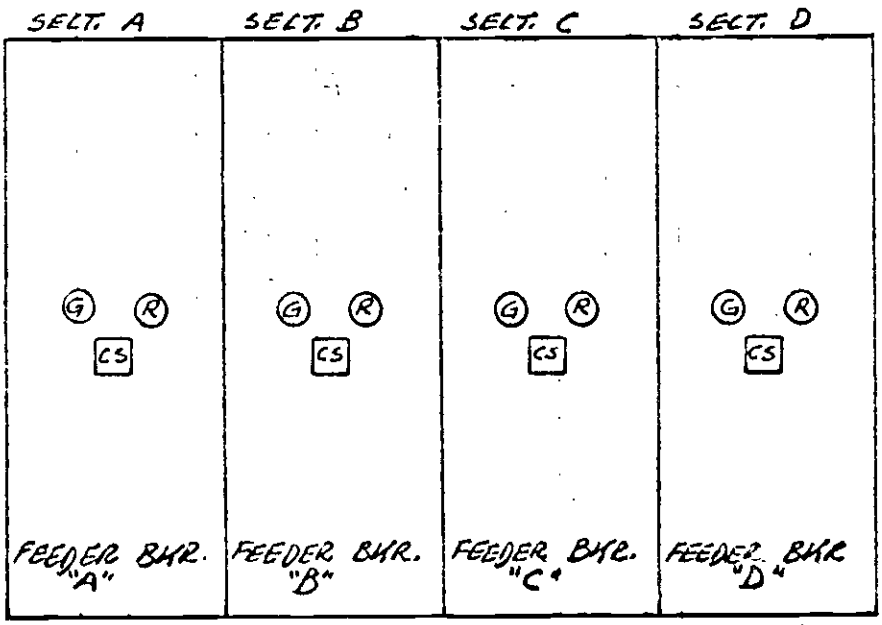
By W. W. STEHL

TRACTION STATION (RAIL GAP TIE)
900 VOLT D.C.



PLAN VIEW

TRACTION STATION FOR RAIL GAP TIE



SECT. "A-A"

FRONT VIEW

SH-13

REV. MARCH 1968

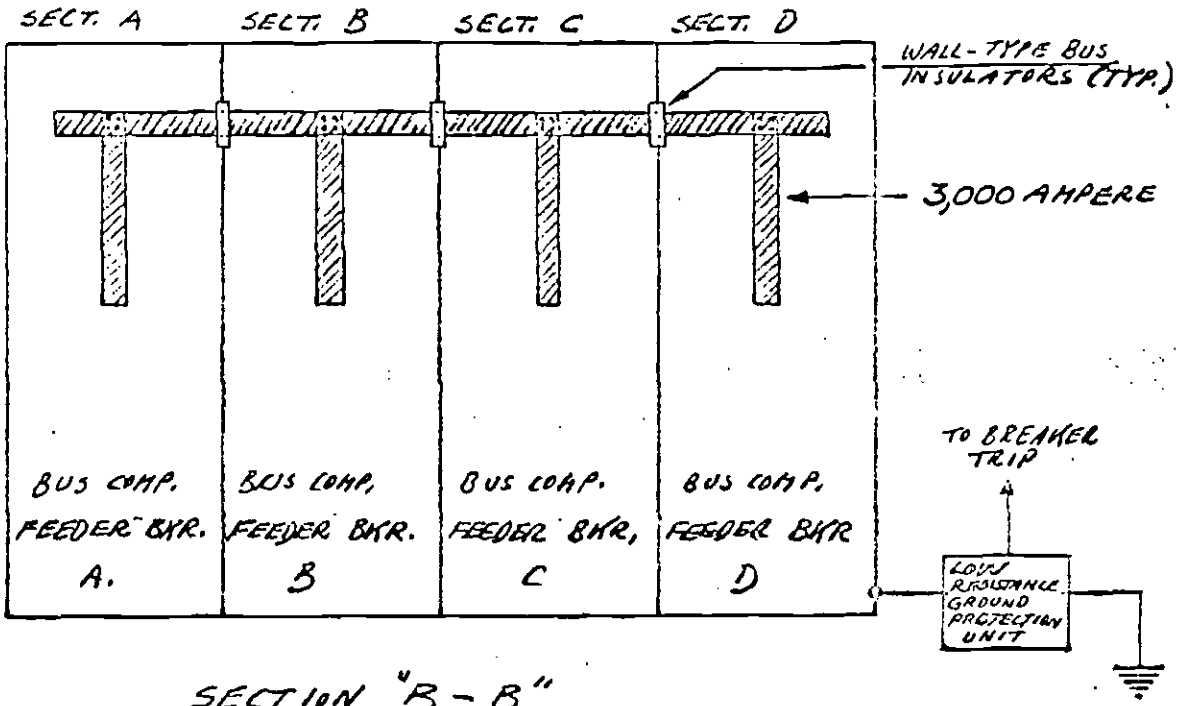
ENHALL

JOB NO. 6657 - 25 SHEET OF

DATE 11-15-67

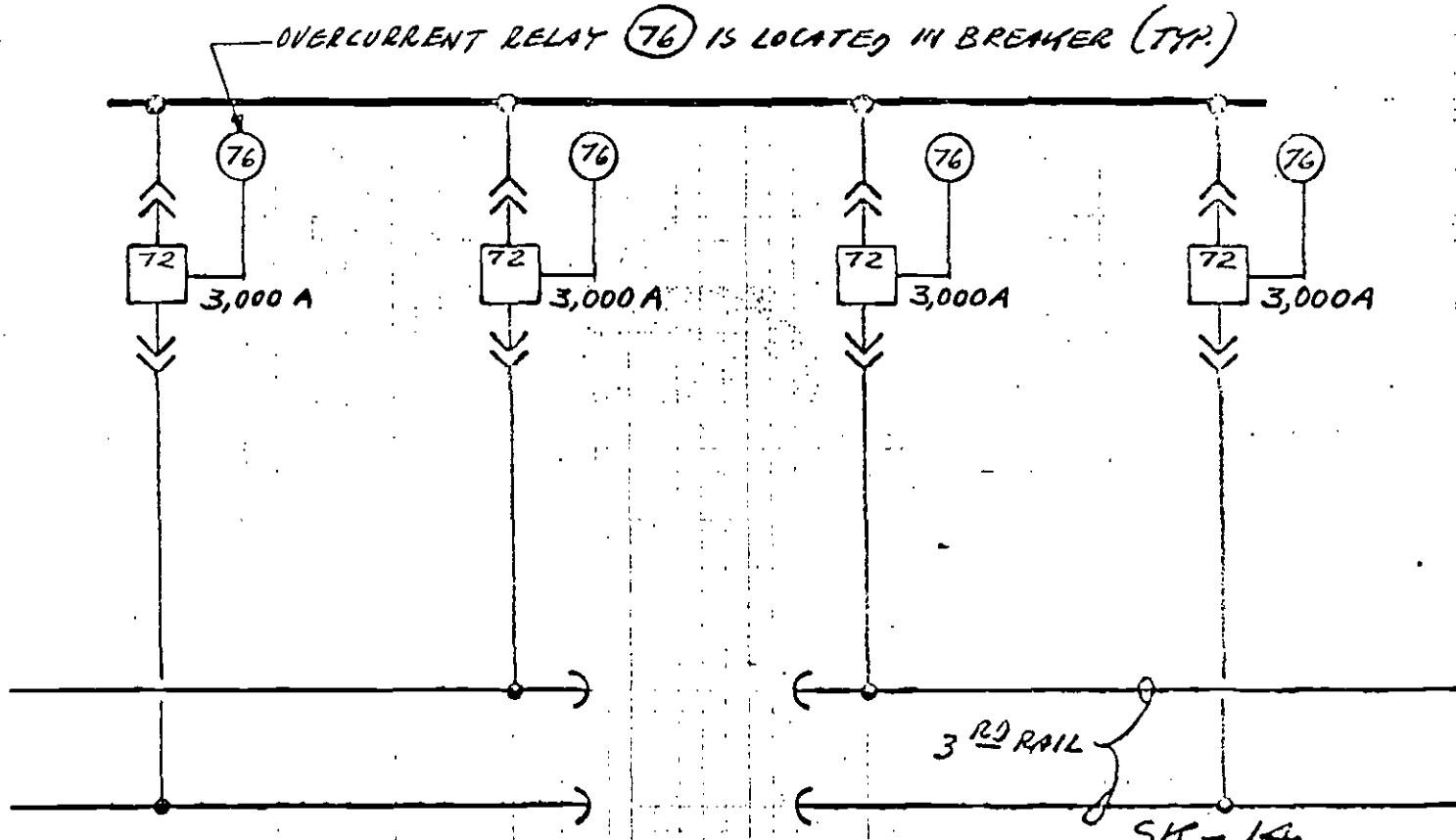
BY W. W. STEHL

TRACTION STATION (RAIL GAP TIE)
900 VOLT D.C.



SECTION "B-B"

BUS ARRANGEMENT TRACTION STATION FOR RAIL GAP TIE



SK-14

REV. MARCH 1968

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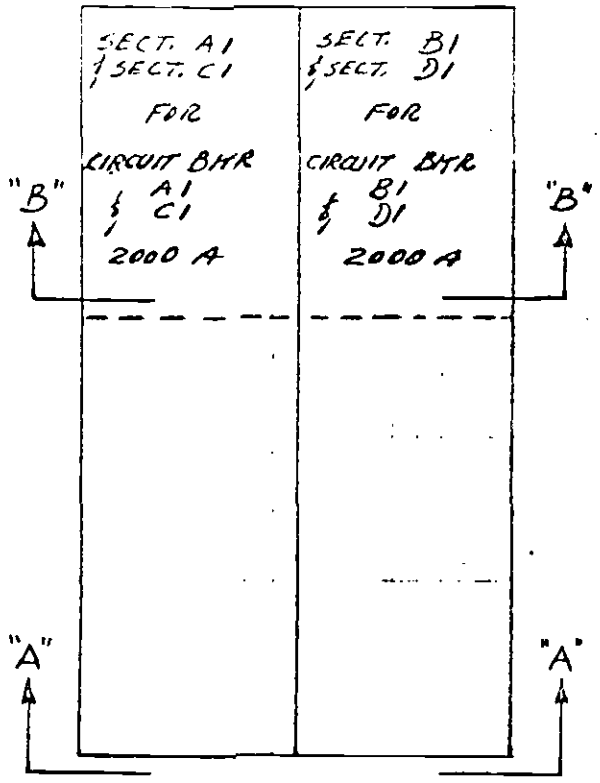
JOB NO. 6657-25 SHEET OF

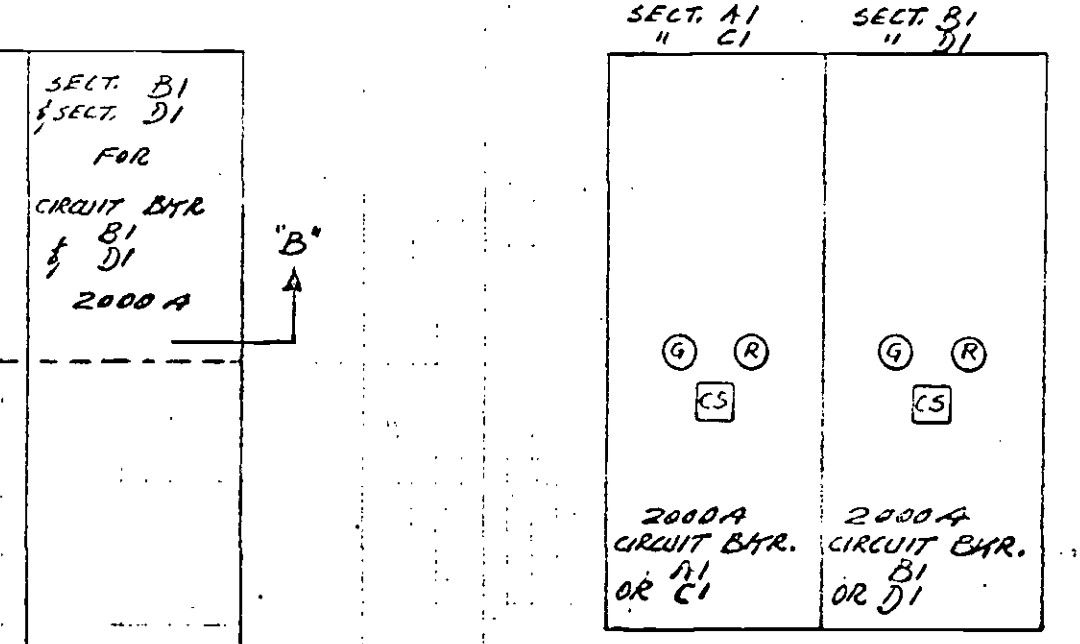
DATE 11-15-67

BY W. W. STEHL

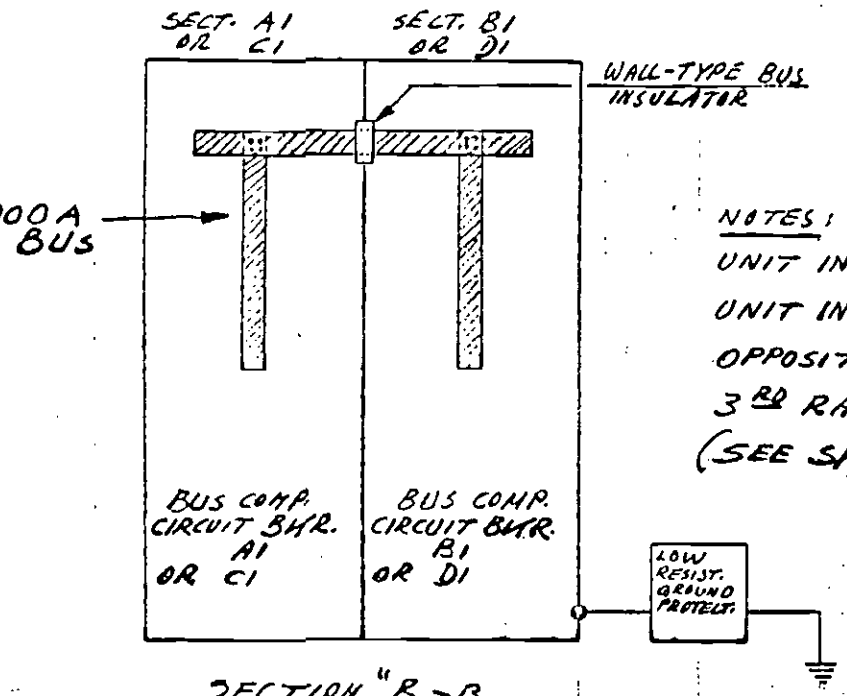
TRACTION STATION "OF YARD CONNECTION FROM MAIN LINE" AND " " " " "TURNBACK"



PLAN VIEW - TRACTION STATION OF YARD CONNECTION FROM MAIN LINE AND TURNBACK.



SECTION "A-A" FRONT VIEW



SECTION "B-B" FRONT VIEW

NOTES: TRACTION STATIONS CONSISTING OF ONE UNIT INVOLVING SECT. A1 & SECT. B1, THE OTHER UNIT INVOLVING SECT. C1 & SECT. D1; AND LOCATED OPPOSITELY IN SAME AREA, CONNECTED TO 3RD RAIL AND DEPENDING ON EACH OTHER. (SEE SK-16)

SK-15
REV. MARCH 1960

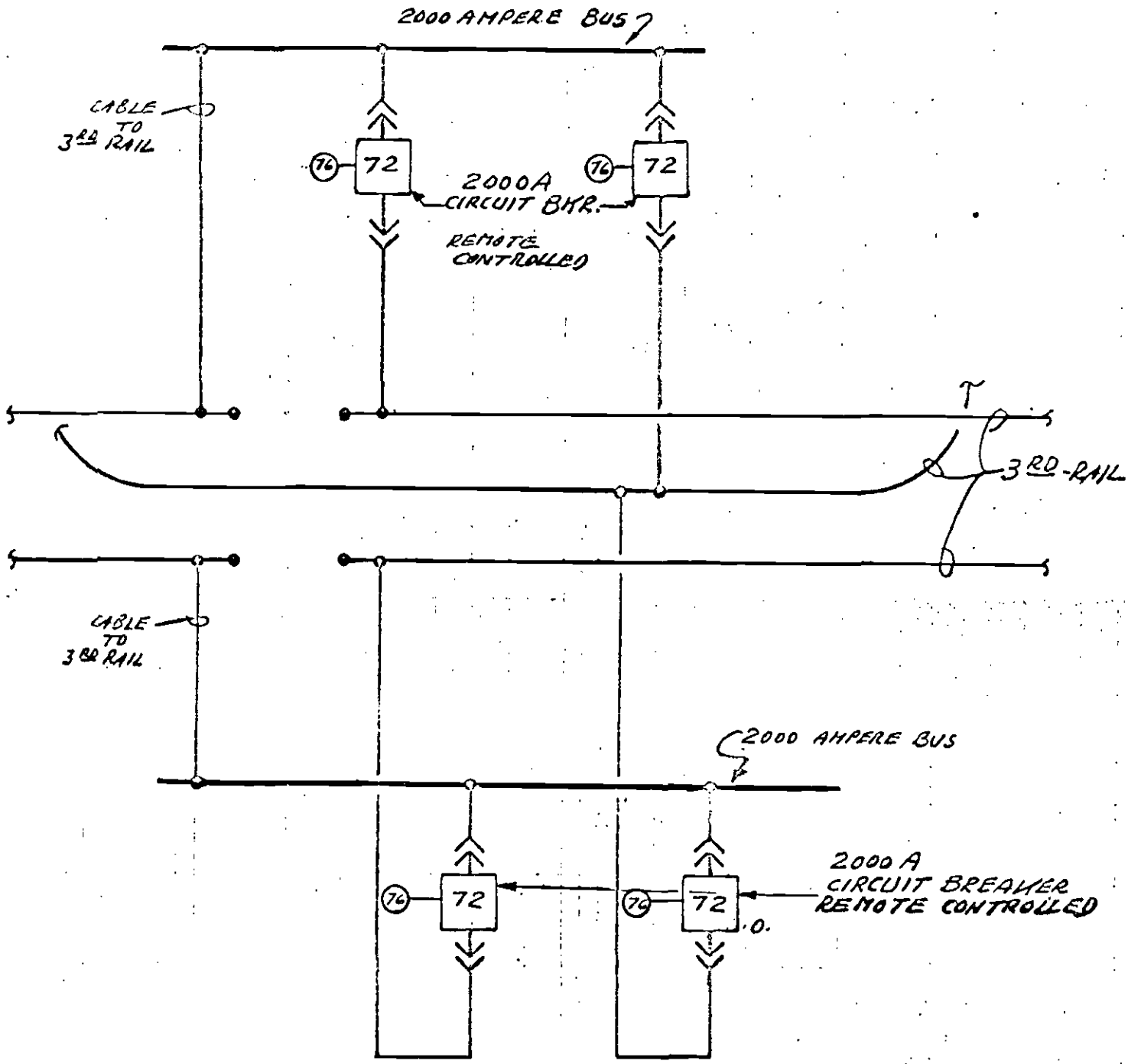
INITIAL

JOB NO. 6657 -25 SHEET OF

DATE 11-15-67

BY W. W. STEHL

TRACTION STATION OF "YARD CONNECTION OF MAIN LINE"
AND " " "TURNBACK" 900V-DC



ONE LINE DIAGRAM OF TRACTION STATION FOR YARD CONNECTION OF MAIN LINE AND FOR TURNBACK, WHICH IS IDENTICAL

(76) DC-OVERCURRENT AND FAULT RELAY, LOCATED IN BREAKER

SK-16

REV. MARCH 1968

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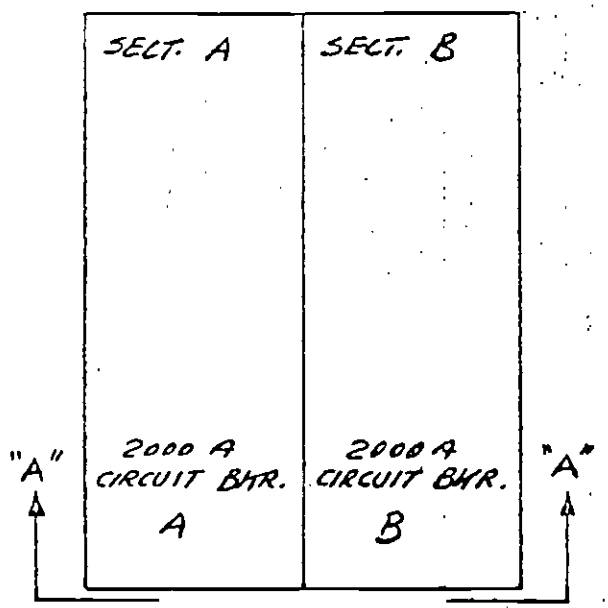
Job No. 6657 - 25 Sheet of

Date 11-16-67

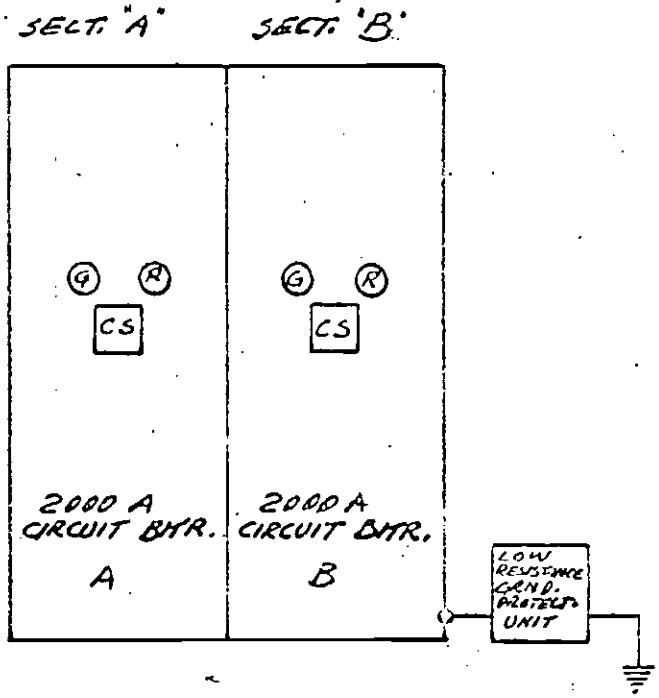
By W. W. STEHL

TRACTION STATION FOR "SINGLE CROSSOVER" AND "DOUBLE CROSSOVER" 900 V-DC



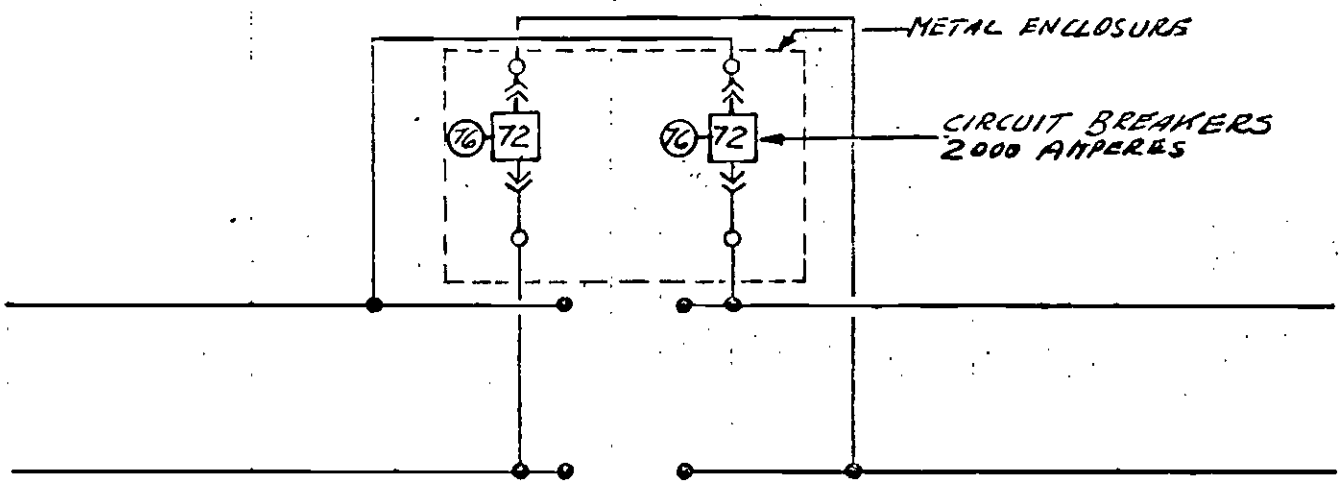
PLAN VIEW

FOR SINGLE AND DOUBLE CROSSOVER



SECTION "A-A"

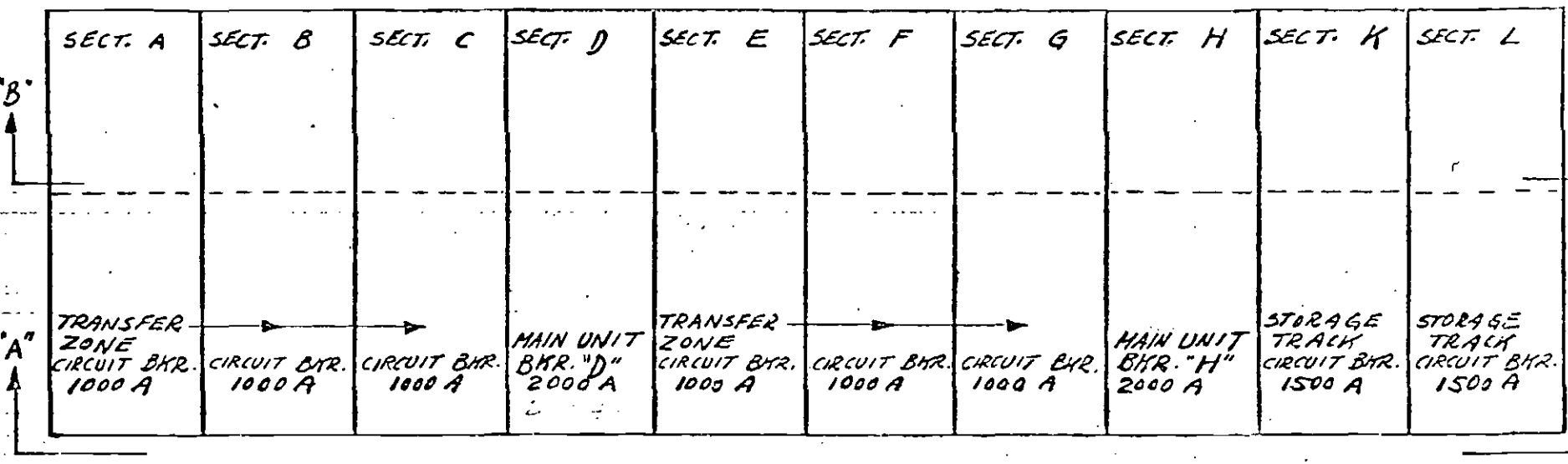
FRONT VIEW



ONE LINE DIAGRAM FOR SINGLE AND DOUBLE-CROSSOVER

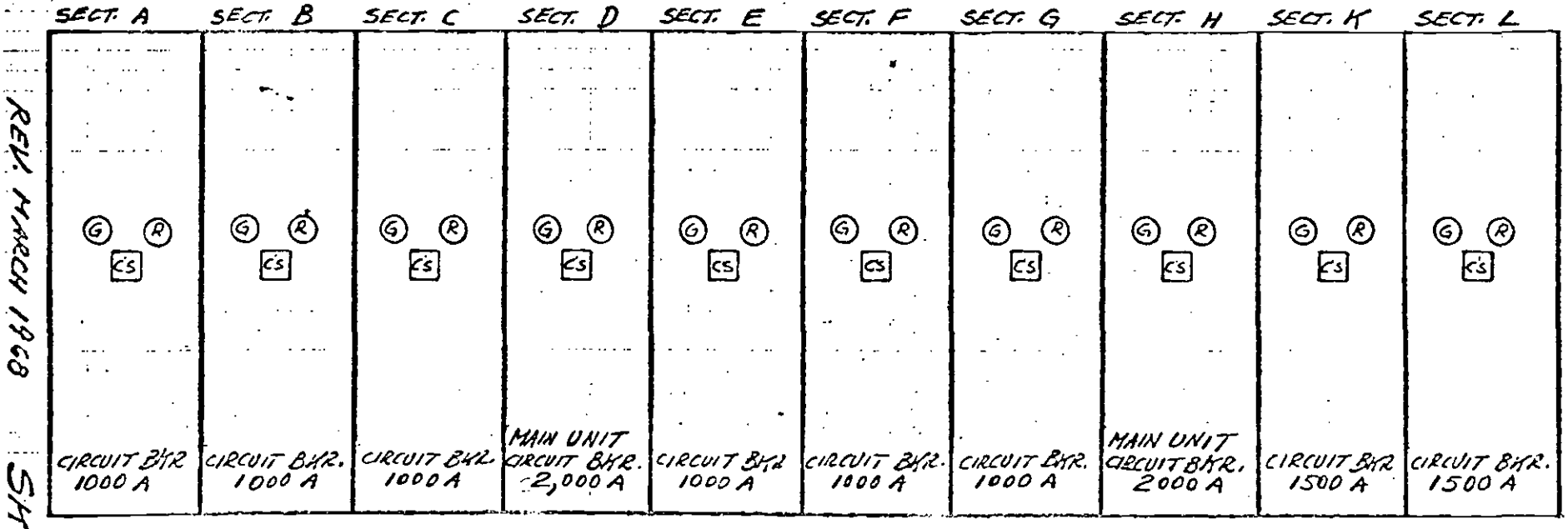
SK-17

REV. MARCH 1968



PLAN VIEW

TRACTION STATION FOR STORAGE YARD – PROPULSION POWER



SECTION "A-A"

FRONT VIEW

TRACTION STATION – STORAGE YARDS PROPULSION POWER 900 VOLT DC

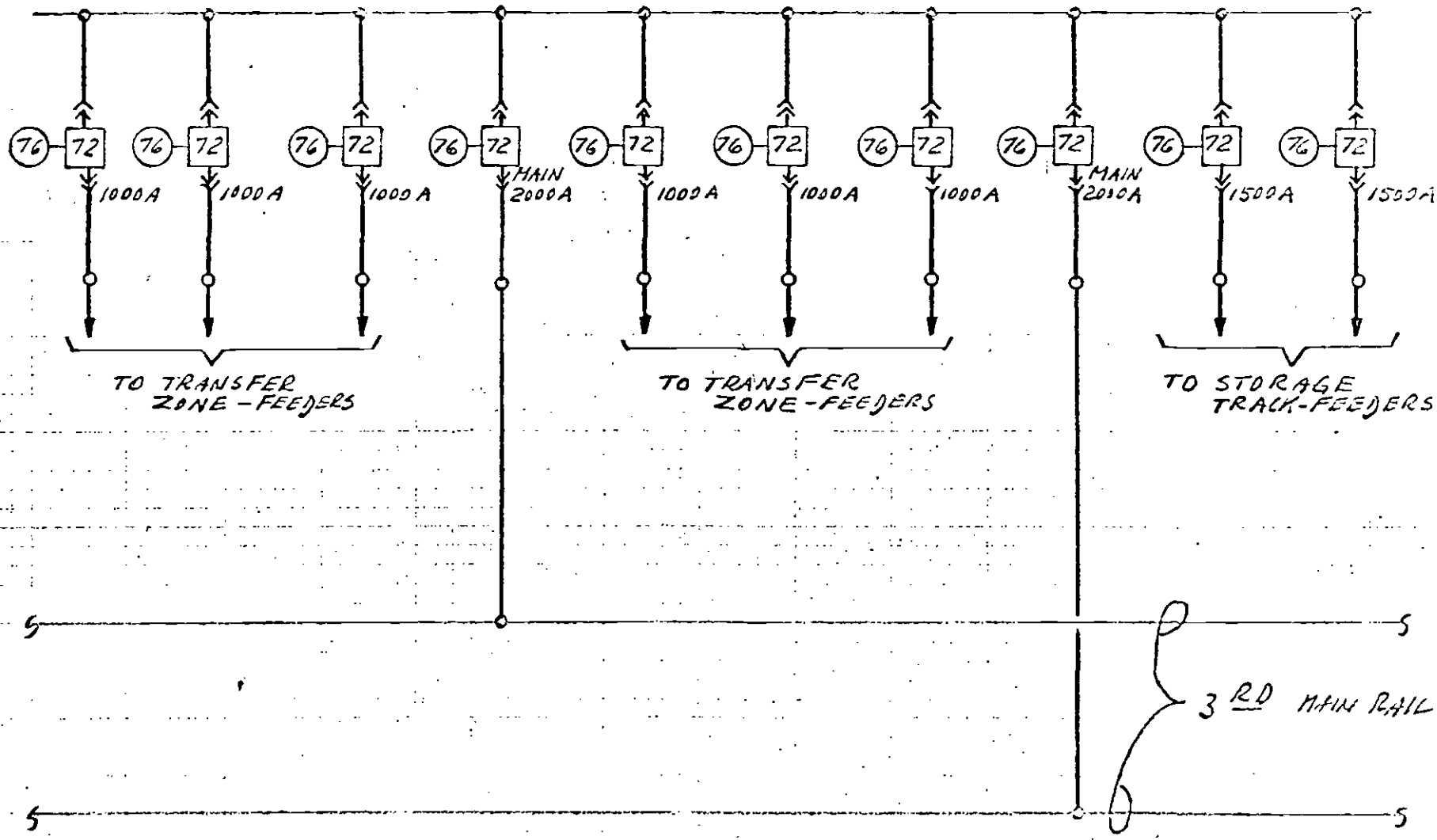
JOB No. 6657-25 SHEET OF

DATE 11-16-67

BY W. W. STEHL

REV. MARCH 1968 SK-13

SK-13



ONE LINE DIAGRAM

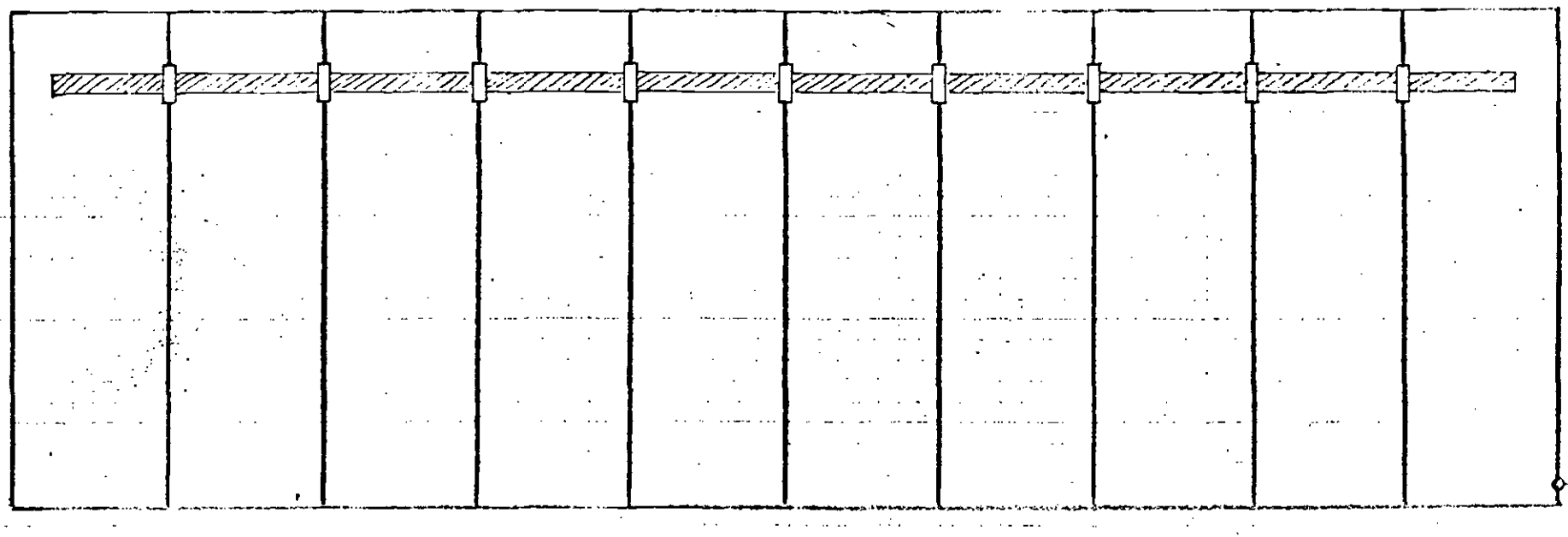
ON TRACTION STATION FOR STORAGE YARD - PROPULSION POWER

SK-19

TRACTION STATION STORAGE YARDS PROPULSION POWER
900 VOLT - DC

JOB NO. 6657 -25 SHEET OF
DATE 11-16-67
BY W. W. STEHL

REV. MARCH 1968 SK-19



SECTION "B-B" BUS ARRANGEMENT

TRACTION STATION FOR STORAGE YARD - PROPULSION POWER (SEE SK-18)

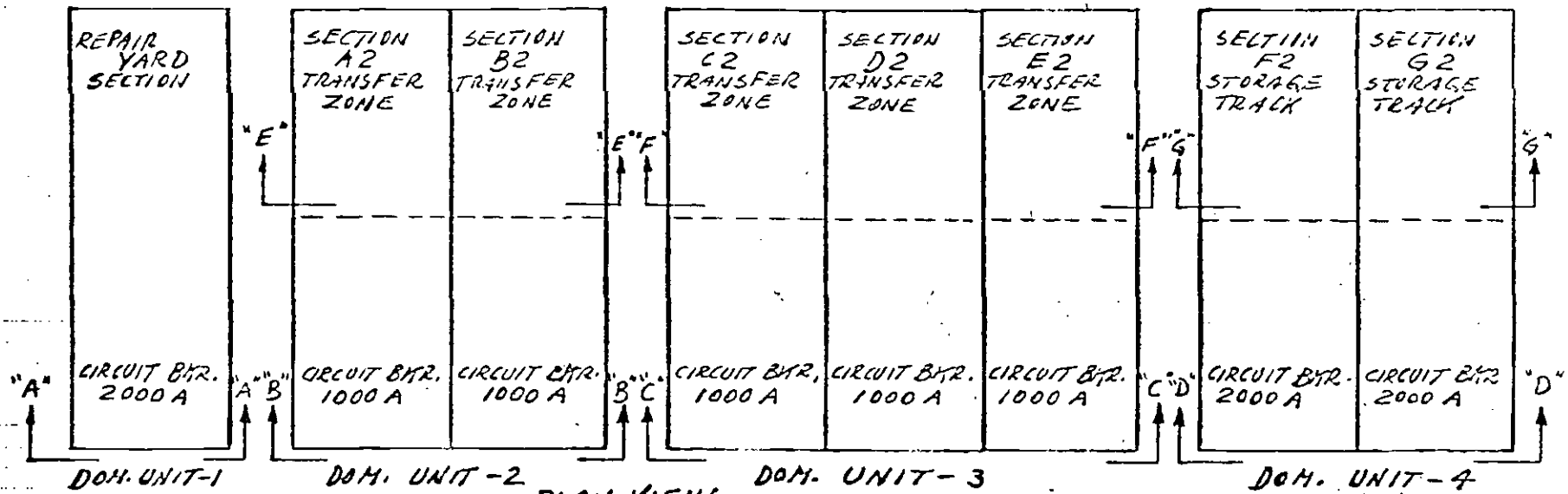
JOB NO. 6657-25 SHEET OF

DATE 11-16-67

BY W. W. STEHL

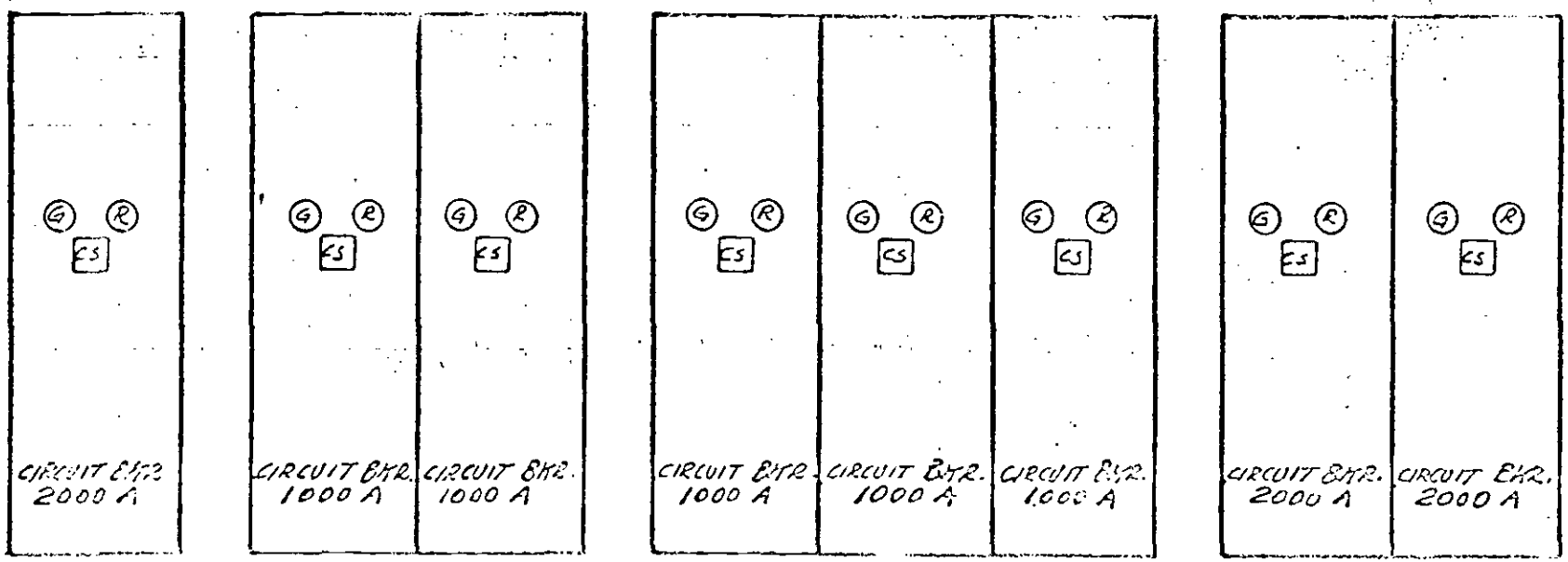
SK-20

REV. NUMBER SK-20



PLAN VIEW

OF DOMINGUEZ YARD - PROPULSION POWER - METAL ENCLOSURE "DOM. UNIT-1, 2, 3, 4



SECTION "A-A"
FRONT VIEW

SECTION "B-B"
FRONT VIEW

SECTION "C-C"
FRONT VIEW

SECTION D-D
FRONT VIEW

NOTES: FOR SECTIONS ON BUS ARRANGEMENTS SEE: SK-22

SK-21

TRACTION STATION DOMINGUEZ YARD PROPULSION POWER
900 VOLT - DC

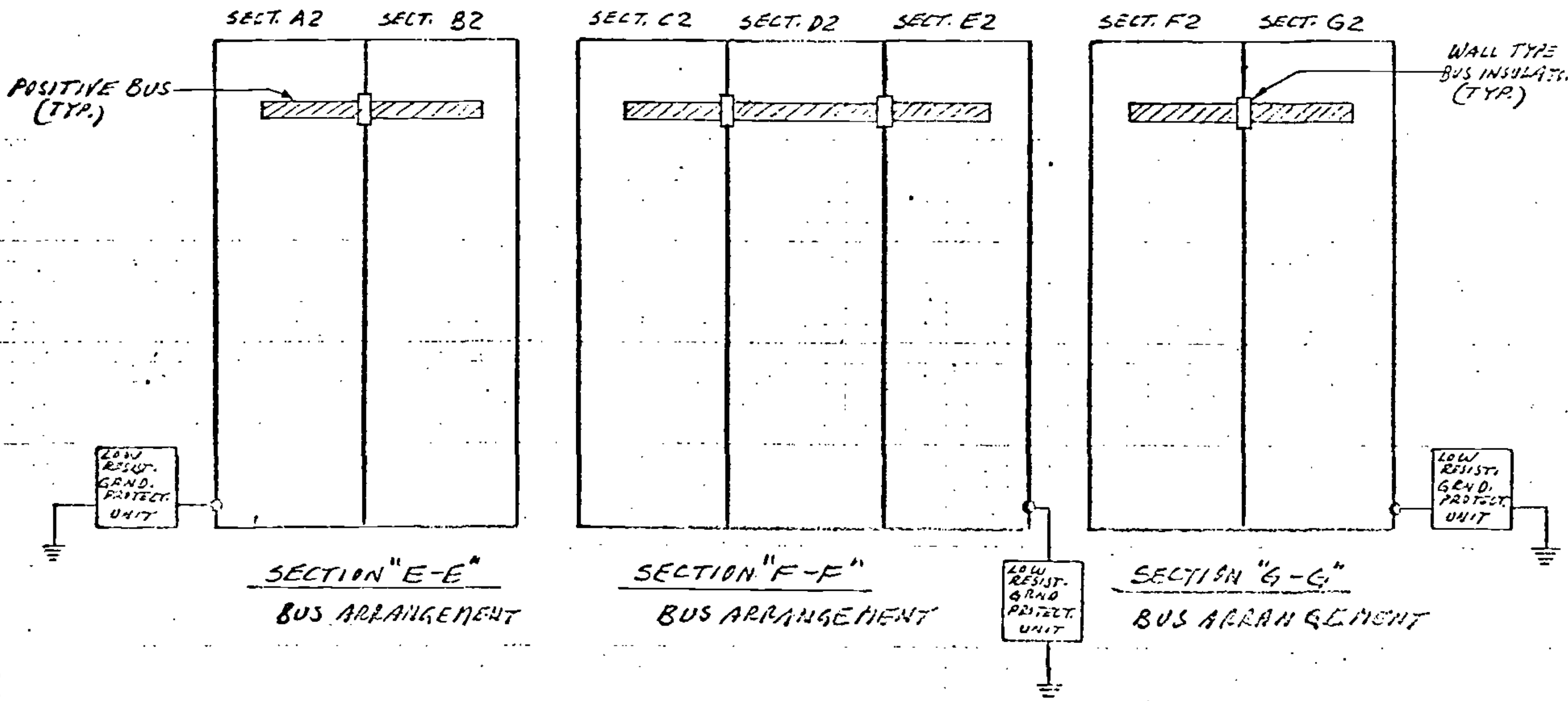
JOB NO. 6657-25 SHEET OF
DATE 11-16-67
BY W. W. STEIN

REV. MARCH 1968

SK-21

TRACTION STATION DOMINGUEZ YARD PROPULSION POWER
900 VOLT DC

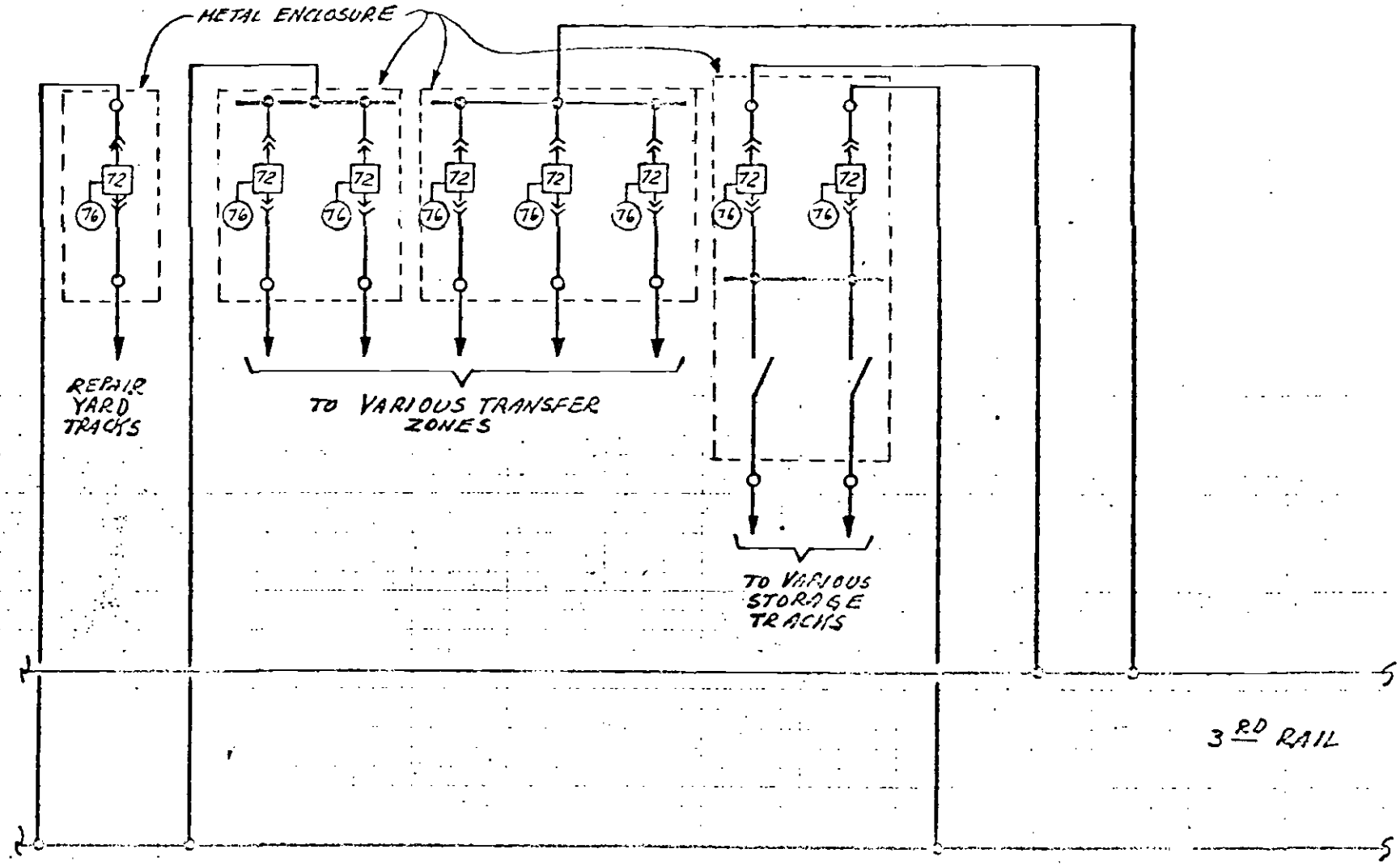
JOB No. 6657 - 25 SHEET OF
DATE 11-17-61
BY W. W. STEHL



NOTES: FOR PLAN VIEW SEE SK-21

SK-22
REV. MARCH

SK-22



SINGLE LINE DIAGRAM
DOMINGUEZ YARD PROPULSION POWER

NOTES: FOR DETAILS SEE SK-21 & 22

SK-23

REV. MARCH 1970 SK-23

TRACTION STATION DOMINGUEZ YARD PROPULSION POWER
900 VOLT DC

JOB NO. 6657-25 SHEET OF
DATE 11-17-67
BY W. W. STAHL

VIII. ELECTRICAL FACILITIES

VIII. ELECTRICAL FACILITIES

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

A. ELECTRICAL INSTALLATIONS

1. The electrical installations as hereinafter mentioned will be provided in fixed facilities such as passenger stations, tunnels, parking lots, central control building, shops, and maintenance and storage yards and which are separate and distinct from the train electrification, train control, communications, and fare collection systems, even though power will be provided to the latter three systems.
2. All these installations will conform to the City of Los Angeles Electrical Code, State of California Electrical Safety Orders, and the National Electrical Code.

B. PASSENGER STATIONS

1. The descriptions of the electrical installations in the stations as given herein apply to passenger stations of all types and traffic densities.
2. The analyses of electrical systems for basic types of passenger stations appear in the form of calculations in the technical portion of this report.

C. STATION NORMAL POWER SUPPLY

1. The normal power service to the individual stations will be supplied by Southern California Edison Company or City of Los Angeles Department of Water and Power and will serve both normal and critical loads. The normal loads include the following:

a. Normal 480/277V Lighting.

b. Normal 208/120V Power.

c. Station Air Conditioning Equipment.

d. Station Ventilation Fans

e. Escalators.

f. Hot Water Heaters.

g. Space Heaters.

h. Undercar Heat Removal Fans (Partial).

2. The service will be 3-phase, 60 cycle, 480/277 volts or higher, depending upon the station electrical load, location, and power company's distribution voltage in the locality.

3. The service entrance will be underground from the distribution source to the station Electrical Room.

4. SCRTD owned distribution transformers will be provided in the station Electrical Room to provide the 480/277 volt 3-phase utilization voltage when the service voltage is higher.

D. STATION CRITICAL POWER SUPPLY

1. Critical power will be provided at 480/277V, 3-phase, 60 cycle. The critical loads include the following:

a. Train control system.

b. Communications systems.

c. Fare collection system.

d. Station critical lighting.

e. Tunnel walkway critical lighting.

f. Exit sign critical portion.

g. Undercar heat removal fans (partial).

h. Tunnel ventilating fans and dampers.

i. Station sewage pumps.

j. Tunnel sump pumps.

k. Door operation air compressors.

l. Emergency power supply battery charger.

m. Electric clocks.

2. Critical power at stations with a traction power substation will be supplied by the traction power 34.5 kv system through a fused interrupter switch and 34.5 kv-480/277 volt 3-phase transformer located in the same substation.

3. Critical power at stations without a traction power substation will be supplied by the 34.5 kv feeder for traction power system in the vicinity of the station through a fused interrupter switch and 34.5 kv-480/277 volt 3-phase transformer located in the station.

4. The critical loads will automatically be transferred to the critical power supply upon loss of normal power.

E. STATION EMERGENCY POWER SUPPLY

1. Emergency power will be provided for the station emergency lighting, exit sign emergency lighting and tunnel emergency lighting loads which will be energized upon loss of area lighting or during transition from normal to critical power.

2. The emergency power supply will be a 125 volt, d-c battery plant complete with nickel-cadmium battery, automatic battery charger and controls, and necessary equipment, controls and accessories. The Emergency Power supply will be in accordance with the Emergency Class "B" Supply System requirements of Los Angeles Electrical Code.

F. STATION DISTRIBUTION CENTER

A motor control center type distribution center with normal and critical bus, automatic transfer switch to transfer critical bus from normal to critical power, and including circuit breakers and combination circuit breaker type magnetic motor starters will be provided in the station Electrical Room. Motor control center construction will be Class II, Type B or C, in NEMA 12 enclosure.

G. STATION DRY TYPE TRANSFORMERS

480-208/120 V transformers for lighting and miscellaneous power will be dry type; transformers supplying sensitive loads will have electrostatic shielding.

H. STATION PANELBOARDS

The normal and critical power panelboards will be circuit breaker type.

I. STATION EMERGENCY DISTRIBUTION PANELBOARDS AND AREA CONTROL PANELS

The emergency power distribution panelboards will be circuit breaker type. Area control panels will sense loss of power within a specific area and energize only that portion of the emergency lighting system.

J. STATION MOTORS

Motors will generally be NEMA Design "B" (normal starting torque). Typical motor enclosure types are as follows:

Motor	Type of Enclosure
Tunnel sump pump	Totally enclosed fan cooled
Station sewage pump	Drip-proof
Tunnel ventilating fan	Totally enclosed fan cooled
Station ventilating fan	Drip-proof
Escalator	Drip-proof

K. STATION MOTOR STARTING AND CONTROL EQUIPMENT

1. Typical motor starting and control equipment will be as follows:

Motor	Item in Distribution Center	Items at Driven Equipment
Tunnel sump pump	Combination Motor Starters	2 float switches, mechanical alternator, and 2 non-fused disconnect switches, all with NEMA 4 enclosures
Station sewage pumps	Combination Motor Starters	2 float switches, mechanical alternator, and 2 non-fused disconnect switches, all with NEMA 12 enclosures.
Tunnel or station ventilating fans or undercar heat removal fans	Combination Motor Starters	Non-fused disconnect with NEMA 4 enclosure in tunnel and NEMA 12 enclosure in station.
Escalator	Circuit breaker	NEMA 12 control panel with disconnect provided with escalator.
Station air conditioning unit	Circuit breaker	Non-fused disconnect and control panel with starters near unit, all NEMA 12.

2. All the starters mentioned above will be combination circuit breaker type, magnetic, full-voltage start, single speed, non-reversing type, except starters for escalator motors will be reversing type. Each starter will be equipped with control transformer, 120 volt 60 cycle operating coil, and three (1 per phase) thermal overload relays.

L. STATION WIRING DEVICES

1. 15 amp, 120 VAC grounding type duplex convenience outlets will be provided for portable equipment and for connection to plug-in type equipment. The outlets in the station concourse and platform areas will be locking and tamper-proof type.

2. Lighting switches will be provided in offices, maintenance rooms, and similar areas. Switches will be 20 amp 277 VAC rated mechanically-quiet toggle switches.

M. STATION WIRES AND CABLES

1. The 34.5 kv cables will be the same as those provided for traction power systems.
2. Power cable for circuits 15 kv or below will be as follows:
   a. 600 Volt Power Cable - All 600 volt power wire will have type THW or RHW insulation. Size #4/0 AWG and smaller wire will have stranded copper conductors. Wire larger than #4/0 AWG will have stranded aluminum conductors and type RHW insulation. Minimum wire size will be #12 AWG.
   b. 5000 Volt Power Cable - All 5 kv cable will be rubber-insulated and neoprene-jacketed, with stranded copper conductors. The 5 kv cable will be shielded where required by National Electrical Code and the State of California Electrical Safety Orders.
   c. 15 KV Power Cable - All 15 kv cable will be rubber-insulated, shielded, with neoprene jacket and stranded copper conductors.
3. Control wiring will be single conductor or multi-conductor cable with stranded copper conductors, and rated for 600 VAC service. Minimum wire size will be #14 AWG.
4. All wiring for lighting branch circuits will be single conductor with copper conductor and type TW insulation. Minimum wire size will be #12 AWG; size #10 AWG wire and smaller will have solid copper conductors.

N. STATION CONDUITS

All conduits will be rigid galvanized steel, rigid aluminum, electrical Metallic tubing or non-metallic duct. Minimum conduit size will be 3/4".

1. All embedded or underground conduit will be rigid galvanized steel or non-metallic duct. Any underground conduit not embedded in structural concrete will be encased in concrete.
2. Electrical metallic tubing will be used only for lighting circuits in interior areas protected from physical damage.

O. CENTRAL CONTROL FACILITY

The electrical installations in the Central Control Facility will be similar to applicable installations in passenger stations, except critical power (back-up power) will be provided by a second independent service to the facility. Normal and critical 208/120 volt, 3-phase, 60 cycle busses will be provided to supply computer power requirements.

P. SERVICE AND STORAGE YARDS

Yard lighting and the car washer in each yard will be supplied from the service building. Electrical wiring methods and materials will be similar to that described for the passenger stations.

Q. SERVICE BUILDINGS AND SHOPS

Service buildings and shops within a yard will be supplied by a single service from the power company, and will be provided with normal power only. Electrical wiring methods and materials will be similar to that described for the passenger stations.

R. UTILIZATION VOLTAGE OF LOAD EQUIPMENT

The utilization voltages of load equipment in all areas will be as follows:

Equipment	Voltage
Motors, 1/2 hp & larger	460 volt 3 phase
Motors, under 1/2 hp	115/230 volt 1 phase
Fluorescent lighting fixtures	277 volt 1 phase (except as noted herein)

Equipment	Voltage
Mercury vapor & metallic vapor lighting fixtures	277 volt 1 phase
Incandescent lighting fixtures (critical & normal lighting only)	120 volt 1 phase
Incandescent lighting fixtures (emergency lighting)	120 volt d-c
Exit signs, fluorescent (critical	120 volt a-c
Exit signs, incandescent (emergency)	120 volt d-c
Information sign, fluorescent	120 volt 1 phase
Service pit lighting, fluorescent	120 volt 1 phase
Fare collection equipment	120 volt 1 phase
Train control equipment	120 volt 1 phase
Communications equipment	120 volt 1 phase
Electric clocks	120 volt 1 phase
Water heaters	277 volt 1 phase
Space heaters	208 volt 1 phase
Portable cleaning machines	120 volt 1 phase

S. LIGHTING FIXTURE TYPE & ILLUMINATION LEVELS

Area	Type of Lighting Fixture	Average Footcandle
1. Subway Station		
Street entrance or exit	Street lighting standard by City	-
Excalator or stairs between street & concourse	Ceiling-recessed fluorescent, gasketed	40
Immediately after street entrance of escalator or stairs	Ceiling-recessed fluorescent, gasketed, (adaptation lighting for daylight hours)	100
Concourse free area	Ceiling-recessed continuous row fluorescent	40

Area	Type of Lighting Fixture	Average Footcandle
2. Aerial Station		
Passenger overcrossing	Ceiling-recessed continuous row fluorescent	40
Passenger underpass	Pendent-mounted continuous row fluorescent	40
Concourse free area	Ceiling-recessed continuous row, gasketed fluorescent	40
Covered platform	Ceiling-recessed, continuous row, gasketed fluorescent	30
Open platform	Pole-mounted fluorescent luminaire	25
3. Surface Station		
Covered platform	Ceiling-recessed, continuous row, gasketed fluorescent	30
Open platform	Pole-mounted fluorescent luminaire	25
Passenger overcrossing	Ceiling-recessed, continuous row, fluorescent	40
Concourse free area	Ceiling-recessed continuous row, fluorescent	40
4. All Station Types		
Concourse paid area	Ceiling-recessed continuous row, fluorescent	40
Ticket vendors & transfer equipment location	Supplementary fluorescent	80
Escalators & stairs	Ceiling-recessed fluorescent	40
Attendant's office	Ceiling-recessed fluorescent	80

	Area	Type of Lighting Fixture	Average Footcandle
	Train control room	Ceiling-recessed continuous row, radio frequency shielded fluorescent	50
	Electrical room	Pendent-mounted industrial type fluorescent	50
	Mechanical room	Surface-mounted industrial type fluorescent	30
	Substation	Pendent-mounted industrial type fluorescent	50
	Toilet	Surface-mounted fluorescent	30
5.	Emergency Lighting In All Areas	120 VDC incandescent	0.1 watt/ft.^{2} minimum in accordance with City of L.A. Electrical Code
6.	Tunnel Walkway	Surface-mounted vapor tight fluorescent	2
7.	Parking Area	Pole-mounted mercury vapor luminaire	5
8.	Service & Storage Yards		
	Storage tracks	Pole-mounted metallic vapor floodlights	5
9.	Service & Repair Shops		
	Shops	Pendent-mounted industrial type fluorescent	100
10.	Central Control Facility		
	Offices	Ceiling-recessed continuous row fluorescent	80
	Control rooms	Ceiling-recessed continuous row radio frequency shielded fluorescent	80

IX. COMMUNICATIONS

IX. COMMUNICATIONS

PRELIMINARY DESIGN CRITERIA

The transit system communications network design shall include consideration of leasing channels for data communications as well as voice communications from the local telephone companies to interconnect each fixed facility with each other and the Control Center.

A. VOICE COMMUNICATION

Two-way voice communication links shall be provided between the Control Center and every train, passenger station, storage yard and maintenance yard. Public address systems shall provide for transmitting voice messages onto station platforms and into all cars in each train. Voice communication via land line telephone shall be utilized whenever possible.

Wayside call phones shall be located at approximately quarter mile intervals along all routes for emergency reporting. A maintenance communication network shall provide for voice transmission and reception at closely-spaced intervals.

B. DATA COMMUNICATIONS

A data communications network shall provide connections between the Control Center and all remote operating elements. Response time for communicating train control data shall be approximately two seconds. Response time for communication supervisory data shall be approximately four seconds.

Accuracy and security of communicated messages shall be specified at the highest levels consistent with industry standards. Storage registers shall be inserted at each data location to hold data until they are required in control, indication, computation or logging procedures.

C. SUPERVISORY SYSTEM

Traction power substations, passenger station safety and security systems, and miscellaneous support elements shall be supervised from the Control Center. The supervisory signals shall be transmitted via the data communications network and shall be compatible with the train control data transmissions so a single data communication system may be utilized.

IX. COMMUNICATIONS

OUTLINE SPECIFICATIONS

A. GENERAL

Work will include design, manufacture, testing and delivery of equipment comprising a complete voice communication system. Installation, check-out and start-up will be considered as a separate unit of performance.

B. SYSTEM CONFIGURATION

A major portion of required voice communications channels will terminate at a control and communication center, which may be located in the Downtown Los Angeles vicinity. Efficient voice communication will be required between and among offices in the center, and between those offices and various locations throughout the transit system. General arrangement of the system is illustrated by Figure IX-1 The arrangement includes voice communication facilities at seven types of locations:

- The control center
- Each passenger station
- Each train
- Each storage yard
- The maintenance yard
- Wayside call phones
- One Main and one Standby two-way, two channel radio station.

The two-way, two-channel radio system, which is planned as a separate subsystem is connected to the PABX system via the radio main station, as illustrated by the solid line. The dashed line between the radio station and the train symbol illustrates that voice communication between the control center and trains may be via the radio system.

1. Control Center

The control center will be the hub of all voice communication facilities. Essentially all voice messages, between any two of the locations will follow a path through a private automatic branch exchange (PABX) located at the center. As illustrated by Figure IX-2, the PABX will also route voice messages among approximately twenty telephones located in various rooms at the control center. It will also accept three voice channels from an existing SCRTD administrative center.

2. Passenger Station

Figure IX-3 illustrates a PABX extension planned for a typical passenger station. The matrix at right illustrates which of the telephones should be capable of interconnection with other instruments by means of selector buttons. In addition, each telephone position should have a button to place an incoming call from the PABX on "hold", while selecting another position; and another button to "buz" the selected instrument.

The two lock boxes will be connected in parallel with the station agent's position. Each lock box should be provided with an external light which becomes illuminated when a call is received via the PABX and remains illuminated until a receiver is lifted from one of the seven instruments. They should also become illuminated when "Station Agent" is selected and the buzzer is depressed on the "Maintenance", "Train Control Room" or "Mech. Room" instrument, and remain illuminated until a receiver is lifted on the station agent instrument or one of the lock box instruments.

A two-way, two-channel radio base station is contemplated for each typical passenger station, as illustrated in the upper rectangle. A dashed-line rectangle is used because the radio equipment is considered as a separate subsystem and planned as a separate element of performance.

3. Passenger Trains

Figure IX-4 illustrates voice communication requirements on each passenger train. The location of wayside equipment, as drawn in the diagram, is not intended to suggest that the equipment should be physically located above the train; but merely that messages must be introduced and received by some method, such as electromagnetic, inductive, or even sliding contact.

The audio train line (AT) carries demodulated voice signals to two loudspeakers in each car. The train line must be suitable for passing through intercar couplers. Trains may be from two to eight cars long. When the handset is removed from its holder, all received messages will be routed to its speaker only; but not to the loudspeakers.

Although an A car will normally be used at either end of every train, only the front-end transmitter and receiver will be used.

The rear-end radio equipment should be suitable for use in case of a malfunction in the front end equipment.

4. Storage Yards

At a typical storage yard, voice communication facilities are planned as illustrated by Figure IX-5. The two storage area phones and the transfer track phone will be connected in parallel with the yard control office phone. Each of the four instruments should be suitable for selecting and buzzing, or ringing, any of the other three positions; or for selecting the PABX and dialing another element of the voice communication system.

The two-way, two-channel radio station is shown enclosed in a dashed-line rectangle because the radio equipment is considered as a separate subsystem and planned as a separate element of performance.

5. Maintenance Yard

Voice communication facilities at the maintenance yard will be equivalent to those at a typical storage yard, illustrated by Figure IX-5. Three phones in the maintenance area will be connected in parallel with a phone in the maintenance office. A two-way, two-channel radio station at the maintenance yard will be part of the radio subsystem which is planned as a separate element of performance.

6. Wayside Call Phones

Approximately seven call phones will be located at regular intervals between each pair of adjacent passenger stations. Each set of seven will be connected by one common line to the PABX at the control center.

Preliminary operating plans call for an attendant, or operator at the PABX console to monitor all incoming calls on the wayside call phone system. Routine calls will be from employees who are performing maintenance or inspection along the right-of-way. The PABX attendant will connect the desired element in the voice communication network.

Wayside call phones will also serve for emergency reporting if the need should arise. Thus the PABX attendant will screen all incoming calls for emergencies. Procedures will be established for quick routing and recording of all emergency calls.

7. Two-Way Radio System

A two-way, two-channel voice radio system is planned to interface with other communication facilities by an interconnection between the PABX at the control center and the main station, as illustrated by Figure IX-1. Proposed voice communication systems that use space radio to transmit voice messages onto trains, and receive voice messages from trains, will also interface at those locations, as illustrated by the dashed line. Proposed systems that use some other means of communicating with trains need not connect at more than the one point, however.

Wire facilities to connect the remote control center with the main and standby stations will be furnished by others.

Figure IX-6 summarizes the radio subsystem configuration.

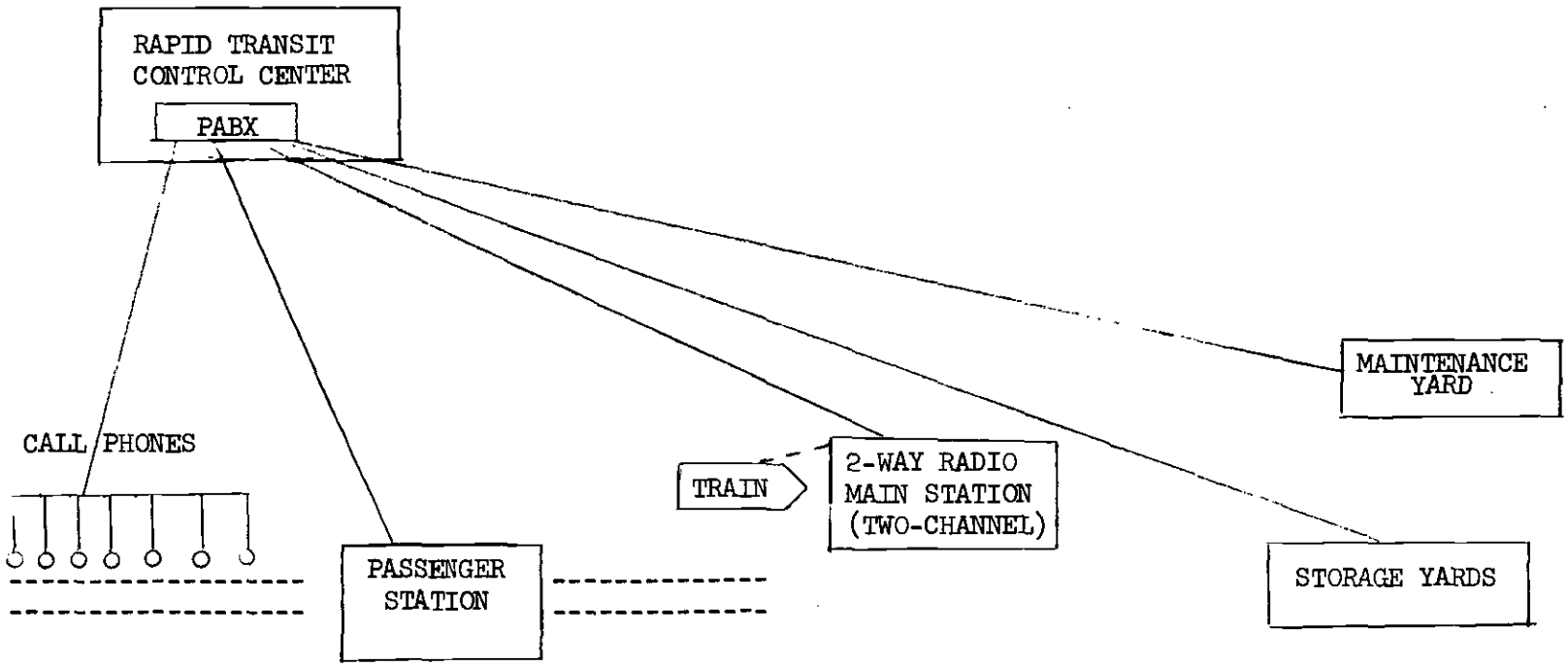


FIGURE IX -1

VOICE COMMUNICATION SYSTEM GENERAL ARRANGEMENT

ROOM NAME	NUMBER OF TELEPHONES	NUMBER OF LINES
COMPUTER ROOM	3	1
CENTRAL CONTROL ROOM	4	4
MECH. EQUIP. ROOM	1	1
ELEC. EQUIP. ROOM	2	1
SPARE PARTS ROOM	1	1
VITAL RECORDS VAULT	1	1
CONTROL EQUIP. ROOM	3	1
CONT. EQUIP. MAINT. ROOM	1	1
OFFICES (4)	4	4
TOTAL	20	15

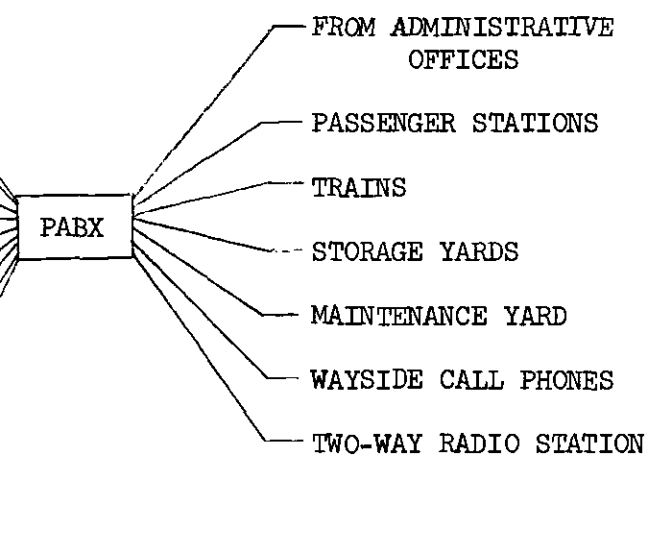
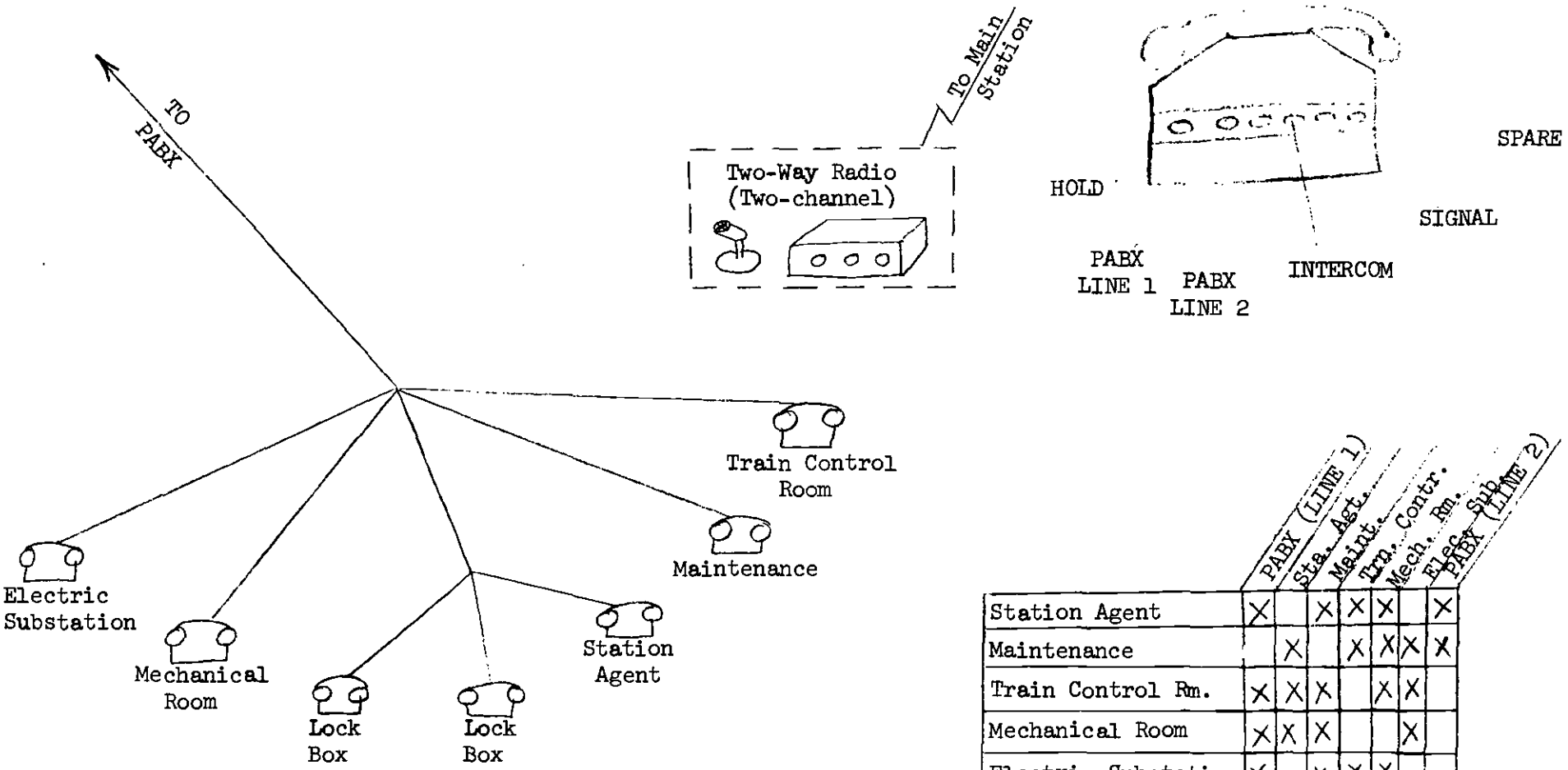


FIGURE IX-2

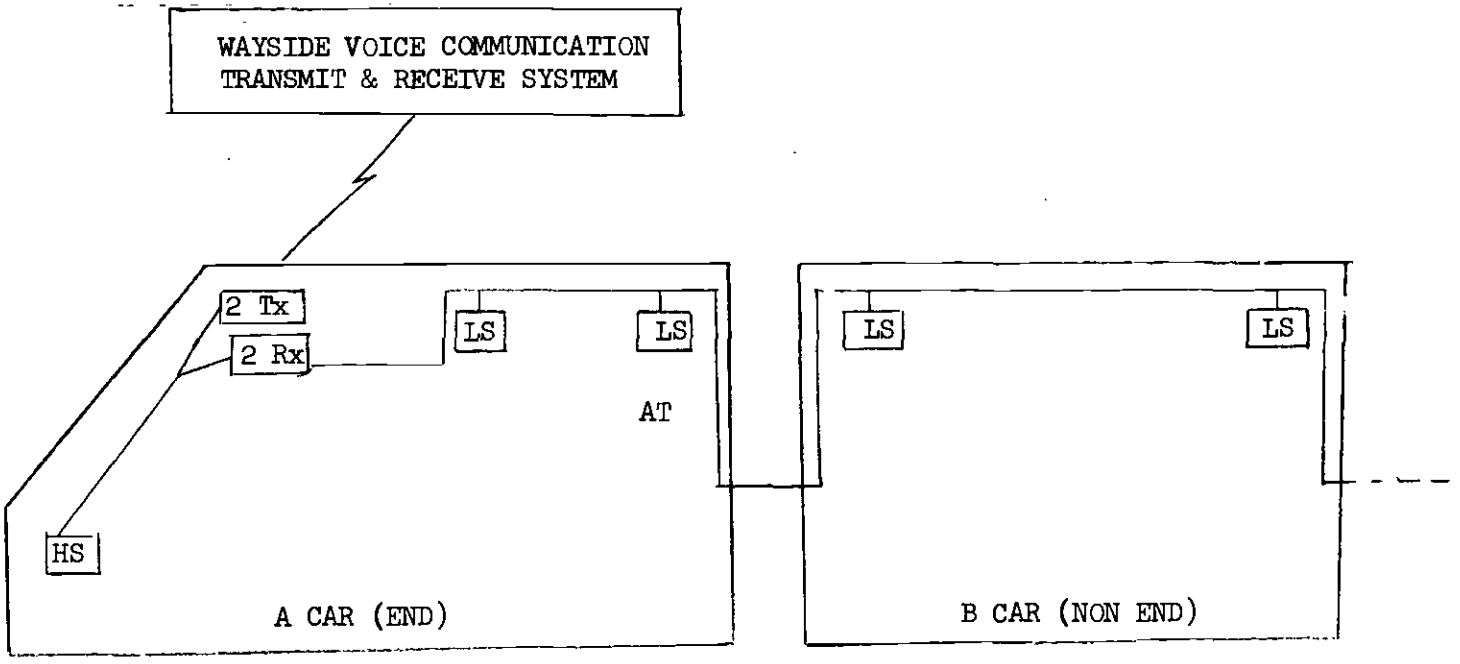
CONTROL CENTER VOICE COMMUNICATION FACILITIES



	PABX (LINE 1)	Sta. Agt.	Maint.	Trn. Contr. Rm.	Mech. Rm.	Elec. Sub.	PABX (LINE 2)
Station Agent	X		X	X	X		X
Maintenance		X		X	X	X	X
Train Control Rm.	X	X	X		X	X	
Mechanical Room	X	X	X			X	
Electric Substation	X		X	X	X		

FIGURE IX-3

VOICE COMMUNICATION SYSTEM AT A TYPICAL PASSENGER STATION



Legend: 2 Tx = Two-Channel Transmitter
2 Rx = Two-Channel Receiver
AT = Audio Train Line
HS = Microphone-Speaker Handset
LS = Loudspeaker

FIGURE IX-4

PASSENGER TRAIN VOICE COMMUNICATION SYSTEM

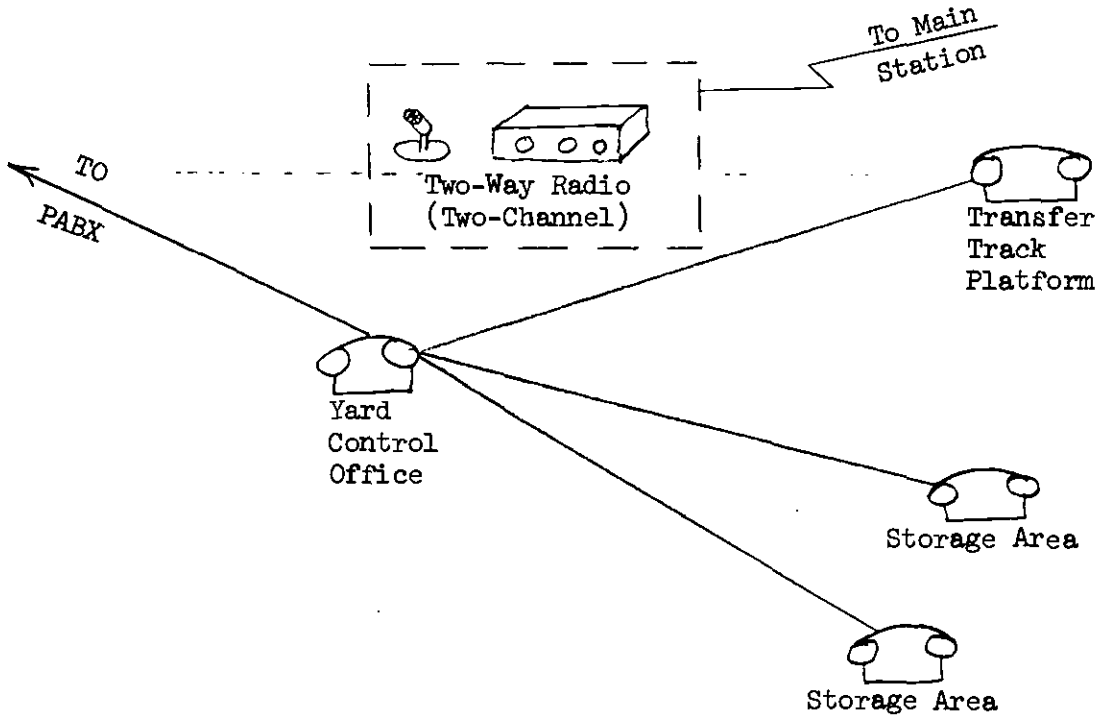


FIGURE IX-5

VOICE COMMUNICATION SYSTEM AT A TYPICAL STORAGE YARD

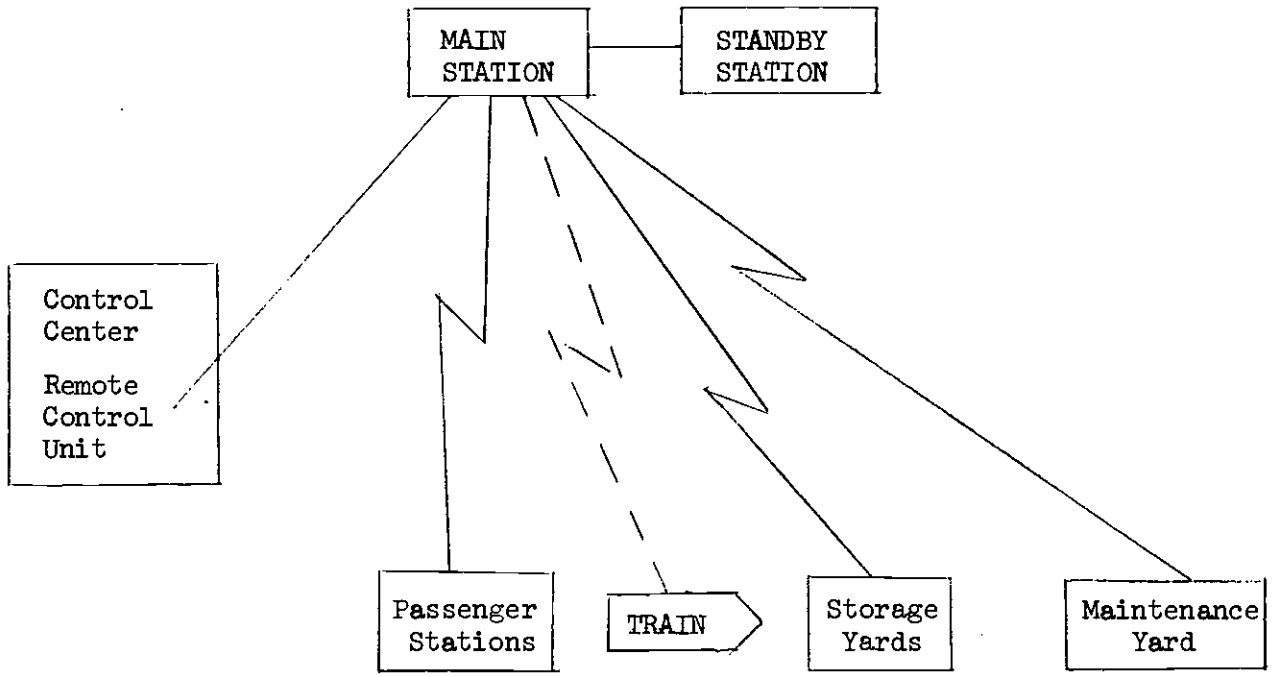


FIGURE IX-6

TWO-WAY TWO-CHANNEL RADIO SUBSYSTEM

X. TRAIN CONTROL

X. TRAIN CONTROL

PRELIMINARY DESIGN CRITERIA

A train control system consists of three subsystems, each of which performs a category of functions.

- A safety subsystem provides safety to patrons, employees and equipment.
- An automatic train-operation (ATO) subsystem controls the operation of every vehicle.
- A central supervision subsystem coordinates and optimizes all train movements.

A. SAFETY

1. The train control system shall enforce safety through the use of a subsystem which is traditionally called a train protection system. The safety subsystem shall employ the basic concepts that have proved to be very dependable in existing transit systems.

2. The safety subsystem shall divide the full extent of all transit routes into discreet zones ranging in length between one train-length and approximately one mile. It shall continuously detect vehicle occupancy in every zone and transmit to other zones intelligence that differentiates between occupancy and non-occupancy.

3. Safety subsystem equipment that establishes route zones, such as electrical track circuits, shall be of the type that does not limit the use of running rails for propulsion current return; such as the frequency overlay type, or equivalent.

4. The safety subsystem shall continuously enforce safe separation between vehicles by transmitting, onto every operating train, intelligence confirming occupancy or non-occupancy of adjacent and nearby zones. Logic circuits shall be equipped to deduce safe operating speed for safe separation. Safe separation shall be equal to maximum stopping distance plus thirty-five percent.

5. The safety subsystem shall include route protection to insure that trains cannot find their way onto conflicting routes. Route interlocking circuits shall detect positions of all track switches surrounding a route. Using that information, plus occupancy and elapsed-time information, the interlocking circuits shall automatically deduce route protection intelligence and transmit it to all trains approaching the route. Train-carried equipment shall enable a train to proceed onto a route only when interlocking information confirms that: (1) all switches are properly lined and locked, (2) the route is completely unoccupied and, (3) no other vehicles are moving toward a forthcoming conflict.

6. Speed limits shall be enforced by equipping trains to operate only while receiving speed-limit information transmitted from the wayside. Non-receipt of that information shall cause trains to come to a controlled stop. Speed limits shall reflect track conditions such as curvature.

7. Detectors shall be provided to sense the presence of hazards such as earth slides, broken or distorted track, etc. Output from the detectors shall interrupt enabling control signals that are otherwise transmitted to the trains.

B. AUTOMATIC TRAIN OPERATION (ATO)

1. The ATO system shall continuously respond to an enabling signal from the safety subsystem, which signifies that normal operation is safe. It shall automatically bring the train to a controlled stop if the enabling signal is not received for more than a preset time period, which should be adjustable from approximately 0.1 to 2.5 seconds.

2. The ATO system shall be capable of operating trains at normal performance level and at least one level above and below normal. Each performance level shall produce sufficient tractive effort to yield preset rates of acceleration, running speed and deceleration. The system shall operate at normal performance level until and unless it

receives external control information calling for shorter or longer than scheduled run time. After performance level has been adjusted to a level above or below normal, it shall continue at that level until it receives a revised performance level instruction. When performance level adjustments are required, they shall be transmitted to trains during station departure after doors are closed and the train is in motion.

3. Passenger-weight sensors shall be used to adjust propulsion and braking efforts for load-weight variations that would otherwise change run times significantly. The control system shall regulate speed within a range of approximately 2.5% above and below assigned value.

4. Changes in acceleration and deceleration rates shall be controlled to a maximum jerk rate of 1.5 miles per hour per second. An elapsed-time circuit shall provide for limiting repeated, successive changes to approximately 1.0 mphpsps.

5. ATO shall blend friction and electrical braking and smooth the transition at high and low speeds.

6. ATO shall control deceleration and precise berthing of trains at stations. Wayside devices shall initiate the programmed stop and confirm distances at enough points to assure accurate control. Berthing accuracy shall be within plus or minus 2 feet.

7. Every train shall bear identifying information by which wayside equipment can sense the train's destination and its length. Those two data shall be transmitted to stations approximately twenty seconds before a train's arrival and destination shall be displayed by illuminated signs on the platform to inform patrons.

   Each train's destination information shall also be transmitted to route interlocking circuits so that routes will be lined and reserved.

   Any alternative operating method that involves manual manipulation of track switches shall not be considered.

8. A key-locked switch on every car shall provide for changing operation from automatic to manual, for use in yards and shops and during unusual circumstances. Manual-operation equipment shall be limited by the safety subsystem in the same way that ATO is. Manual override equipment shall provide for an operator to move cars or trains when the safety subsystem is inoperative. The override equipment shall require continuous hand pressure on an override control handle and shall restrict speed to a preset limit, adjustable between five and thirty-five miles per hour. Operating rules shall require careful voice communication between the Control Center and any vehicle that is operated by methods that by-pass or override normal safety provisions.

9. Train-carried devices shall detect berthing accuracy at platforms and transmit a confirming signal to a door control circuit. Upon receipt of a berthing signal and another signal confirming zero movement, the door control circuit shall open all doors.

10. Trains shall normally remain berthed with doors open for a time period which should be adjustable between 10 and 40 seconds.

C. CENTRAL SUPERVISION

1. Precise times of arrival and departure of trains at all stations shall be transmitted to a Control Center which shall supervise and coordinate all operating elements of the transit system. A computer at the Control Center shall continuously compare actual train performance with scheduled performance. Continuous performance within reasonable range of scheduled service throughout the system shall allow trains to run at normal performance level. However, performance level adjustment shall be a primary corrective measure.

2. In the event of severe departures from scheduled traffic movements the Control Center shall automatically select and implement combinations of the following strategies:
   - Lengthened or shortened dwell times by selected trains at selected stations.
   - Change order in which trains enter merging routes.

- Change length of trains entering service.
- Add unscheduled trains into service.
- Withdraw scheduled trains from service.
- Modify routes of selected trains.

D. TRAIN CONTROL BLOCK SIGNAL LAYOUT

1. Assumptions

Approach Velocity (V) is 70 mph maximum

Service Brake Rate (d) is 2.6 mph/s

Maximum Brake Rate (dm) is 3.0 mph/s

Full reverse running permitted

90 Second headway design on all lines

2. Calculated

Optimum Approach Velocity (V_o) is 26 mph

Safe Following Distance (S_f) is 1700 ft.

Distance to stop from V_o (S_o) is 250 ft.

Distance to decelerate from V to V_o (S_m) is 1500 ft.

Distance to permissive block (S_b) is 2650 ft. minimum

Distance to permissive block for 40 second station stop time is 2700 ft. maximum

Head to tail train separation at 70 mph, with 80 second spacing, for 600 foot trains is 7600 feet.

3. Rules for Layout

a. Minimum of 3 blocks between stations (not counting station zone) (2 optimum blocks plus one permissive block).

b. Maximum mainline block length is 5000 feet.

c. Optimum speed block (1st block ahead of station zone) must be between 550 and 600 feet long.

d. Permissive block must not be further than 2100 feet from the end of the station for 40 second stop time from 70 mph.

e. Any three blocks (slow, stop, occupied) must not total over 7500 feet for 80 second spacing; 15000 feet for 160 second spacing.

4. Layout

No. of Blocks Per Track	Station Spacing Max. 1000 Ft.	Mi.	Blocks (Add 1 Station Block) OPTIMUM	PERMISSIVE	SEPARATION
3	2.7	.5	2	1*	0
4	4.4	.8	2	2+	0
5	9.3	1.7	2	2	1 @ 4500
6	10.8	2.0	2	2	2 @ 3000
7	12.3	2.3	2	2	3 @ 2500

From 7 up to maximum station spacing add blocks at 2500 Ft. (.45 M) intervals.

On line planned for 3 minute headway 3 blocks could total 15000 feet yielding the following:

5	9.8	1.8	2	2	1 @ 5000
6	14.8	2.8	2	2	2 @ 5000
7	19.8	3.7	2	2	3 @ 5000

From 7 up to maximum station spacing add blocks at 5000 Ft. (.9 M) intervals.

* Va = 45 mph max.

+ Va = 61 mph max. for symmetrical layout (i.e. Full Reverse Running)

5. Definitions

Definitions for the distances and speeds used in the above discussion are as follows:

S_f = Safe following distance

$$S_f = \frac{(1 + m)^2 V^2}{(1 - n)\ 2dm} + VT_r$$

Where m = Speed uncertainty assumed to be 10%

n = Braking rate uncertainty, also assumed to be 10%

V = Following train velocity

d_m = Maximum braking rate

T_r = Brake system reaction time (assumed to be 1 second)

S_o = Distance to stop from V_o

$$S_o = \frac{1.35\ V_o^2}{2\ d_m} + V_o T_r$$

V_o = optimum headway speed

S_m = Distance to decelerate from V to V_o

$$S_m = S_f - S_o + V_o T_r$$

S_b = Distance from station to permissive block

$$S_b = \text{Station length} + S_t + S_o + S_m \text{ (minimum)}$$

S_t = Head to tail separation of trains while both are stopped (300 feet)

$$S_b = S + t_c V$$

$$S = V/2d$$

t_c = time to traverse from block gate to program stop point at V.

$$V_o = \frac{\text{Optimum Headway Speed}}{}$$

$$V_o = \sqrt{\frac{2adL}{(2a+d)\quad(1.47)}}$$

a - Average acceleration from start to station clear

d = Service brake rate

L = Train length

X. TRAIN CONTROL

OUTLINE SPECIFICATIONS

A. GENERAL

Work will include design, manufacture, testing, and delivery of equipment comprising a complete train control system, including all communications equipment required to accomplish the specific control functions. Installation, check-out and start-up will be considered as a separate unit of performance.

B. OPERATIONAL CRITERIA

Following are preliminary operational criteria that relate to train control.

Maximum Train Speed	75 mph
Operating Speed Limit	70 mph
Average Acceleration to 60 mph	1.5 mphps

C. TRAIN OPERATION AUTOMATION

The April, 1967 issue included specifications for four levels of train operation automation. The level selected and specified herein shall provide you completely automatic operation (ATO) for mainline revenue service and manual operation with cab signals, continuous over-speed control and on-train voice communication for yard area operation. Complete ATO includes continuous speed regulation, acceleration and braking control, precision stopping, and automatic train door control.

D. TRAIN CONTROL FUNCTIONS

The following tabulations correlate train control functions with transit system elements in which they occur.

1. Speed Control Zones

A basic type of train control zone will be used along route portions that have no stations or switches. Known as speed control zones, they will provide for the following basic train-control functions:

a. Detect occupancy by train, car or maintenance vehicle.

b. Transmit occupancy detection intelligence.

c. Accept occupancy detection intelligence.

d. Detect train malfunction.*

e. Transmit train-malfunction indication.*

f. Detect and transmit rail defect.**

g. Transmit hazard alarm.***

h. Detect train direction.

i. Transmit direction indication.

j. Accept gate positions.

k. Accept locally-set speed limit.

l. Determine most-restrictive speed limit.

m. Transmit speed limit to train.

*Car-carried units will be in an alarm state for any of a number of car malfunctions. Units will be connected so wayside will detect only train malfunction, rather than car malfunctions.

**Including, at least, distorted track and broken rail.

***Owner-furnished sensors will detect occurrence of an event such as an earth slide or unauthorized entry.

2. Transfer Zones

In transfer zones, trains will be changed from hostling mode to the train-operation mode used for passenger-carrying service; and back again. A typical transfer zone will provide for berthing on either side of a central platform and for cable-connected departure testing, or lay-up testing on both sides. Functions performed there are as follows:

a. Detect occupancy by train, car or maintenance vehicle.
b. Transmit occupancy detection intelligence.
c. Accept occupancy detection intelligence.
d. Detect train malfunctions.*
e. Detect and transmit rail defect.**
f. Transmit hazard alarm.***
g. Accept gate position.
h. Accept locally-set speed limit.
i. Determine most-restrictive speed limit.
j. Transmit speed limit to train.
k. Accept performance-level command.****

l. Transmit performance-level to train.

m. Detect train identity.

n. Transmit train identity.

o. Accept destination and direction command.

p. Transmit destination and direction assignment to train.

q. Accept departure-test failure indication.

r. Transmit test-failure indication.

*Car-carried units will be in an alarm state for any of a number of car malfunctions. Units will be connected so wayside will detect only train malfunction, rather than car malfunction.

**Including, at least, distorted track and broken rail.

***Owner-furnished sensors will detect occurrence if an event such as an earth slide or unauthorized entry.

****At least one above normal and one below normal.

3. Interlocking Zones

Interlocking zones contain one or more track switches. Functions are listed as follows:

a. Detect occupancy by train, car or maintenance vehicle.

b. Transmit occupancy detection intelligence.

c. Accept occupancy detection intelligence.

d. Detect train malfunction.*

e. Transmit train-malfunction indication.*

f. Detect and transmit rail defect.**

g. Transmit hazard alarm.***

h. Detect train direction.

i. Accept gate position.

j. Accept locally-set speed limit.

k. Determine most-restrictive speed limit.

l. Transmit speed limit to train.

m. Accept route request from train.

n. Accept locally-set route.

o. Determine switch position for route.

p. Detect and transmit switch positions.

q. Perform route locking.

r. Perform time locking.

s. Position switches.

t. Confirm switch-move completion.

u. Lock switches.

v. Perform gate logic.

w. Transmit gate condition.

*Car-carried units will be in an alarm state for any of a number of car malfunctions. Units will be connected so wayside will detect only train malfunction, rather than car malfunction.

**Including, at least, distorted track and broken rail.

***Owner-furnished sensors will detect occurrence of an event such as an earth slide or unauthorized entry.

4. Station Zones

Station zones will be provided at loading platforms in passenger stations. Functions to be performed in station zones are as follows:

a. Detect occupancy by train, car or maintenance vehicle.

b. Transmit occupancy detection intelligence.

c. Accept occupancy detection intelligence.

d. Detect train malfunction.

e. Transmit train-malfunction indication.*

f. Detect and transmit rail defect.**

g. Transmit hazard alarm.***

h. Accept gate position.

i. Determine most-restrictive speed limit.

j. Transmit speed limit to train.

k. Accept performance-level command.****

l. Transmit performance-level to train.****

m. Detect train identity.

n. Transmit train identity.

o. Accept train identity.

p. Display train identity.

q. Transmit arrival time.

r. Detect train movement. (Either forward or backward).

s. Transmit open-door request.

t. Accept dwell-adjustment command.

u. Transmit close-door request.

v. Transmit departure time to central control.

w. Accept run-through command.

x. Transmit run-through command to train.

y. Display run-through.

*Car-carried units will be in an alarm state for any of a number of car malfunctions. Units will be connected so wayside will detect only train malfunction, rather than car malfunctions.

**Including, at least, distorted track and broken rail.

***Owner-furnished sensors will detect occurrence of an event such as an earth slide or unauthorized entry.

****At least one above normal and one below normal.

5. Direction-Reversing Zones

Running direction will be reversed only in direction-reversing zones. Functions are listed as follows:

a. Detect occupancy by train, car or maintenance vehicle.

b. Transmit occupancy detection intelligence.

c. Accept occupancy detection intelligence.

d. Detect train malfunction.*

e. Transmit train-malfunction indication.*

f. Detect and transmit rail defect.**

g. Transmit hazard alarm.***

h. Accept gate position.

i. Accept locally-set speed limit.

j. Determine most-restrictive speed limit.

k. Transmit speed limit to train.

l. Accept performance-level command.****

m. Transmit performance-level to train.****

n. Detect train identity.

o. Transmit Train identity.

p. Accept destination and direction assignment.

q. Transmit assignment and direction to train.

*Car-carried units will be in an alarm state for any of a number of car malfunctions. Units will be connected so wayside will detect only train malfunction, rather than car malfunctions.

**Including, at least, distorted track and broken rail.

***Owner-furnished sensors will detect occurrence of an event such as an earth slide or unauthorized entry.

****At least one above normal and one below normal.

6. Yard Functions

In yards, all train operation will be in hostle mode, train-protection functions will prevent unsafe train moves through switches and yard switches will be controlled from a yard-control panel. Functions are listed as follows:

a. Detect occupancy by train, car or maintenance vehicle.

b. Transmit occupancy detection intelligence.

c. Accept occupancy detection intelligence.

d. Detect and transmit switch positions.

e. Postion switches.

f. Confirm switch-move completion.

g. Lock switches.

h. Perform detector locking.

i. Perform time locking.

j. Perform time locking.

k. Determine and display wayside signal aspects.

7. Correlation of Functions With Zones

Table X-1 tabulates all data listed in Train Control Functions, Section D, Articles 1 through 6. It illustrates where functions occur in single or more-than-one zone.

8. Programmed Stops*

Stopping zones will be provided in locations where trains will be stopped in accordance with programmed speed-distance profiles. They will coincide with, or overlap station zones and speed control zones. Programmed-stop functions are:

TABLE X-1a

CORRELATION OF FUNCTIONS WITH ZONES

TRAIN CONTROL FUNCTIONS / Train Control Zone	Speed Control Zone	Transfer Zone	Inter-Locking Zone	Station Zone	Direction Reversing Zone	Storage Yard
1. Detect occupancy.	X	X	X	X	X	X
2. Transmit detection intelligence.	X	X	X	X	X	X
3. Accept detection intelligence.	X	X	X	X	X	X
4. Detect train malfunction.	X	X	X	X	X	
5. Transmit train-malfunction indication.	X	X	X	X	X	
6. Detect and transmit rail defect.	X	X	X	X	X	
7. Transmit hazard alarm.	X	X	X	X	X	
8. Detect train direction.	X		X			
9. Transmit direction indication.	X					
10. Accept gate position.	X	X	X	X	X	
11. Accept locally-set speed limit.	X	X	X		X	
12. Determine most-restrictive speed limit.	X	X	X	X	X	
13. Transmit speed limit to train.	X	X	X	X	X	

TABLE X-1b

TRAIN CONTROL FUNCTIONS (Train Control Zone)	Speed Control Zone	Transfer Zone	Inter-Locking Zone	Station Zone	Direction Reversing Zone	Storage Yard
14. Accept performance-level command.		X		X	X	
15. Transmit performance-level to train.		X		X	X	
16. Detect train identity.		X		X	X	
17. Transmit train identity.		X		X	X	
18. Accept destination and direction command.		X			X	
19. Transmit destination and direction assignment to train.		X			X	
20. Accept route request from train.			X			
21. Accept locally-set route.			X			
22. Determine switch position for route.			X			
23. Detect and transmit switch positions.			X			X
24. Position switches.			X			X
25. Determine and display wayside signal aspects.						X
26. Confirm switch-move completion.			X			X
27. Lock switches.			X			X
28. Perform route locking.			X			
29. Perform detector locking.						X

TABLE X-1c

TRAIN CONTROL FUNCTIONS	Train Control Zone	Speed Control Zone	Transfer Zone	Inter-Locking Zone	Station Zone	Direction Reversing Zone	Storage Yard
30. Perform time locking.				X			X
31. Perform gate logic.				X			
32. Transmit gate indications.				X			
33. Accept train identity.					X		
34. Display train identity.					X		
35. Detect train movement.					X		
36. Transmit open-door-request.					X		
37. Accept dwell-adjustment command.					X		
38. Transmit close-door request.					X		
39. Transmit departure time to central Control.					X		
40. Accept run-through command.					X		
41. Transmit run-through command to train.					X		
42. Display run-through.					X		
43. Accept departure-test failure indication.			X				
44. Transmit test-failure indication.			X				
45. Transmit Arrival Time					X		

a. Transmit wayside location reference points.

b. Accept train length indication from train.

c. Determine and transmit berthing location.

*These functions to be added to speed control zones and station zones as required.

9. Control Functions Required in A Cars*

An A car will be used on each end of every train. Functions that are to be accomplished on board A cars, and between A cars and other system elements are:

a. Accept and remember destination assignment.

b. Accept performance level adjustment.

c. Accept speed limit assignment.

d. Develop tractive-effort signal complying with speed limit and performance level assignment.

e. Transmit tractive-effort signal to other cars.

f. Remember reducing-speed profiles.

g. Detect wayside location-reference points.

h. Follow speed-distance profiles.

i. Remember and transmit identity.**

j. Request route alignment.**

k. Measure and evaluate distance to berth.

l. Transmit open-door and close-door commands to other cars.

m. Accept door commands.

n. Detect door-not-closed.

o. Transmit door-open indication.

p. Accept tractive-effort signal.

q. Measure axle-rotation speed.

r. Limit acceleration.

s. Detect train malfunction.***

t. Accept malfunction indication to wayside.***

u. Transmit malfunction indication to front car (when on rear end).***

v. Transmit malfunction indication to wayside.***

w. Receive voice communications.****

x. Transmit voice communications.****

y. Display cab signal aspects.****

*A-cars will be used on head end and rear end of trains. Head-end and rear-end functions will be interchanged when direction is reversed.

**Under all Alternates, automatic route alignment is to be accomplished in a local-wayside method; i.e., without dependence on communication between switch locations and central control.

***Car-carried units will be in alarm state for any of a number of car malfunctions. Units will be connected so wayside can detect train malfunctions, rather than car malfunctions.

****Required for hostle mode.

10. Central Supervision Functions

The basic functions that will be performed at central control are:

a. Accept, and display, occupancy indications.*

b. Accept, and store, train identification.*

c. Accept, and store, train consist.*

d. Accept, and display train direction.*

e. Transmit, and store, route assignment.**

f. Transmit, and store performance assignment.** ***

g. Accept and store departure time.*

h. Accept, store and display on command (o.c.) switch positions.

i. Accept, store and display o.c. switch locking status.*

j. Accept, store and display o.c. gate positions.*

k. Accept and store arrival times.*

l. Transmit dwell adjustment requests.**

m. Accept and display hazard indication.*

n. Accept and display train-malfunction indications.*

o. Compute, store and display o.c. run time.

p. Compute, store and display o.c. dwell time.

q. Compute, store and display o.c. average speed.

r. Compare performance with schedule.

s. Accept and display rail defect indication.*

t. Accept and display hazard indication.*

u. Display alarm for beyond-limits deviation.

v. Analyze off-schedule situation.

w. Select and display corrective strategies.

x. Log daily performance record.

y. Process maintenance data and log.

z. Accept car inventory data.*

aa. Transmit car-requirement data to yards.**

bb. Compute maintenance schedules.

*All communications channels into and out of central control will be furnished by others.

**All intelligence transmitted from central will be via data communications channels.

***At least one above normal and one below normal.

11. Yard Control Panel Functions

Traffic in train yards will be controlled from a control-and-indication panel which will incorporate the following functions:

a. Accept and display occupancy indications.

b. Accept and display switch positions.

c. Accept and display gate positions.

d. Determine switch positions for route.

e. Transmit switch movement command.

f. Accept switch move completion indications.

g. Accept signal indications.

h. Accept signal indications.

i. Receive voice communications.

j. Transmit voice communications.

k. Accept and print-out dispatch instructions.

l. Compile and transmit inventory data.

XI. SUPERVISORY CONTROL & DATA COMMUNICATION

XI. SUPERVISORY CONTROL & DATA COMMUNICATION

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

A. GENERAL

Work will include design, manufacture, testing and delivery of equipment comprising a complete supervisory control and data communication system. Installation, check-out and start-up will be considered as a separate unit of performance.

Responsibility will include the furnishing of termination equipment that will interface functionally with equipment furnished by others.

B. SUPERVISORY CONTROL FUNCTIONS

Supervisory control will consist of five functions, (1) control, (2) indication, (3) alarm monitoring, (4) identification communication and (5) numerical-value communication.

For purposes of these specifications, response time is defined as the elapsed time after a set of data and a ready-to-send signal are presented to the communication channel, until the supervisory control function is initiated at the remote location. Expected response time is defined as the response time of 99.7% of all transmissions, based on a reasonably large sample, observed under actual operating conditions.

Accuracy of supervisory control functions and security of communicated messages will be specified at high levels, conforming with industry standards.

Functions that deal with two-state data, such as on-or-off, open-or-closed, etc., will include storing of the current state at the received location and maintaining the storage in a non-volatile manner.

1. Control

   This function consists of causing a change in state of a remote device, or of a function at a remote location. Controls will be initiated at the control center either manually or automatically, at the discretion of control center personnel. Manual initiation will be accomplished by positioning and actuating control panel devices to select a remote location, device and desired operating state and to cause control intelligence to be sent. Automatic initiation will be used when programmed or computed actions are appropriate responses for certain operational situations.

2. Indication

   This function consists of representing, at the control center, intelligence corresponding to location, identity and operating state of remotely located equipment. At remote locations a change in the operating state of a device will automatically initiate the indication function. Transmission from remote locations and reception at the control center will also be automatic.

3. Alarm Monitoring

This function consists of continuously monitoring the status of remotely-located devices and initiating an alarm at the control center when a pre-determined status exists. It also represents, at the control center, identification and location of alarming points.

4. Identification Communication

This function consists of registering at a remote location unique identities related to devices or locations. Identifications will be transmitted in both directions between the control center and remote points.

5. Numerical Value Communications

This function accepts quantitative data at various communication terminals, transmits the data to other terminals and presents it to adjacent equipment for storage or display. The function also includes registration, at the receiving terminal, of location and identity of numerical value sources.

C. SUPERVISORY CONTROL RESPONSIBILITIES

The specified system will be responsible for exercising supervisory control over two categories of remote equipment, (1) electrical substations, and (2) remote support facilities.

1. Supervisory Control and Monitoring of Electrical Substations

Propulsion power will be supplied to transit vehicles by way of electrical substations located throughout the system. The normally unattended substations will be continuously supervised, controlled and monitored from a centrally located control room. Figure VIII-1 lists a set of functions performed at a typical substation. Coded information and reasonable numbers of spare points are added to represent approximate quantities of supervisory control and monitoring points required for each substation.

2. Supervisory Control and Monitoring of Support Facilities at Stations

At a typical passenger station approximately eight types of devices will be supervised, controlled or monitored, via communications channels, from the control center. Quantities of functions performed and coded information associated with each type are listed in Figure VIII-2. Reasonable numbers of spare points for all functions are added to represent approximate total quantities of supervisory control and monitoring points and functions.

3. Alarm Monitoring of Support Facilities at Storage Yards

At storage yards approximately five types of devices will be monitored from the control center. The following quantities will be monitored for alarm conditions:

- Fire Alarms	10
- Communications Failure	2
- Power Failure	1
- Yard Facilities Malfunction	1
- Spares	1
- Total	15

D. DATA COMMUNICATION RESPONSIBILITIES

The data communication system will be responsible for communicating data used for three purposes: (1) supervisory control and monitoring of electrical substations, (2) supervisory control and monitoring of support facilities, and (3) central supervision of train control.

Data used for the first responsibility are described in section C 1 and data used for the second responsibility are described in sections C 2 and C 3. The third responsibility is described in section D 1 and data required for its performance are described in section D 2.

1. Train Control Supervision Responsibility

Basic train operation, and protection against unsafe situations are the responsibility of remote equipment and thus do not depend on communication with the control center. However, effective central supervision depends on fast, efficient data communication between the control center and remote communication terminals located throughout the transit system.

Train control supervision is responsible for overall coordination and optimization of transit vehicle movements. Central supervision enables the train control system to respond to variations in patronage and to compensate for unexpected operational irregularities.

At the control center, the data are displayed, processed or stored by a subsystem having a responsibility separate from the communication system. At remote stations, train control data are sensed by equipment that is also separate from the data communication responsibility. The data communication system is responsible for delivering and accepting train control data to and from the adjacent equipment at the central and remote locations.

2. Data Communication Requirements for Central Supervision of Train Control

Data that will be communicated between the central location and remote terminals are tabulated in Figure XI-3. Also shown are approximate quantities of points at which the data will terminate and functions for which the data will be used. Reasonable numbers of spare points are added to those for a typical station, so that total estimated, system requirements are computed.

E. DATA COMMUNICATION SYSTEM INTERFACE REQUIREMENTS

At the control center and at remote communication terminals, the data communication system will interconnect with data storage equipment or data processing equipment. The interconnections will conform to Electronic Industries Association Standard RS-232-B, where applicable. The standard defines a means of exchanging control signals and binary serialized data signals between data processing terminal equipment and data communication equipment.

At all of the communication terminals, signal converters will be required as part of the data communication equipment. The signal converters will change data signals into a form suitable to the transmission medium, or the reverse, as described in paragraph 1.5 of the EIA Standard. The signal converters will be needed to accept data from, and present data to the interface in more than one form.

Some connecting devices will handle data in a serialized form. Other interconnecting devices store or display data in parallel form. Interface with devices that handle data in stored-parallel form will conform to industry-accepted standards similar to telegraph loop standards.

FIGURE XI-1

Supervisory Control & Data Communications Requirements for Electrical Substations

Number of Points At a Typical Substation / Function / Coded Information	Control	Indication	Alarm		
High Voltage Breakers	3	6	3		
H-V Local/Remote Control		3			
Cathode Breakers	2	2	2		
Feeder Breakers	4	8	4		
Rectifier Substation		2	2		
Gap Breakers					
Measured Quantities					
Spares	1	2	2		
Totals	10	23	13		

Total Number of Points for Supervisory Control of a Typical Electrical Substation = 46

FIGURE XI-2

Data Communications Required for Supervisory Control of Support Facilities

Number of Points at a Typical Station / Function / Coded Information	Control	Indication	Alarm	
Station Alarms			10	
Fans	6	6		
Dampers	4			
Pumps	2			
Sump Level		2		
Communications Failure			2	
Auxiliary Power Failure			1	
Station Facilities Malfunction			1	
Spares	1	1		
Totals	13	9	15	

Total number of points for Supervisory Control of Support Facilities at a typical station = 37

FIGURE XI-3

Data Communications Required for Central Supervision of Train Control

Coded Information \ Function	Control	Indication	Alarm	Identification	Numerical Value
Zone Occupancy		12			
Train Identification				2	
Train Direction		2			
Route Assignment	1				
Performance Assignment	2				
Departure Time					1
Switch Position		2			
Switch Locking Status		2			
Gate Position		2			
Arrival Time					1
Dwell Time Modification	2				
Hazard			1		
Train Malfunction			1		
Rail Defect					
Spares	1	2	1	1	1
Totals	6	22	3	3	3

Total Number of Points for Train-Control Central-Supervision at a Typical Station = 37

XII. VENTILATION OF TUNNELS AND SUBWAY STATIONS

XII. VENTILATION OF TUNNELS AND SUBWAY STATIONS

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

A. GENERAL

1. Temperature at any point in the system shall not exceed 115°F.
2. Temperature at any point on the platforms, mezzanines, stairways or other public areas shall not exceed 72°F. or local ambient plus 2°F., whichever is greater. Ambient temperature is defined as the air temperature in the shade at 5 feet above sidewalk level in the vicinity of the station exits.
3. Any point on the platforms, mezzanines, stairways or other public areas shall be free of occasional or intermittent inflows of heated tunnel air.
4. Relative humidity at any point in the system shall not exceed 80%, except that this shall not apply when compliance would require the reduction of the absolute humidity of any inflow of ambient air.
5. Maximum velocity of air movement at any point on the platforms, mezzanines, stairways or other public areas shall not exceed 900 fpm. (15 fps., 10 mph.).
6. Ventilation at any point on the platforms, mezzanines, stairways, or other public areas shall provide at least five changes of air per hour. Ventilation shall prevent accumulation of any damp, musty or unpleasant odor.
7. Emergency ventilation shall provide, with trains not in motion, air movement of not less than 100 fpm. at any point in the tunnels. Movement shall be away from the stations and toward an emergency vent, which shall discharge to the surface.

8. Certain portions of the system shall be equipped with mechanical refrigeration to assure cooling on hot days of platform, mezzanine and stairway areas to temperatures between local ambient and that maintained within the air-conditioned cars.

B. TUNNEL INTERMEDIATE VENT SHAFTS

1. An intermediate vent shaft shall contain the ventilation openings from one or both tunnels to the surface at a location outside the limits of the stations.
2. A center partition in each shaft shall prevent the flow of air from one tunnel to the other at any point beneath the ground surface.
3. Cross-sectional area of the shaft ventilation opening at any point shall be not less than 145 sq. ft. gross per tunnel. Reduction of the effective cross-sectional area by gratings, screens, structural members, minor utility conduits, dampers and emergency exhaust fans has been anticipated and is permitted.
4. Surface openings shall be located in either:
    a. A street median island with traffic and flood-water curb. Openings shall be covered by a grating adequate to sustain accidentally intruding vehicles or pedestrians, but shall have the maximum proportion of open area without concern for the heels of women's shoes.
    b. In a location not subject to flooding, to vehicular parking or to vehicles standing while awaiting clearance of traffic lights, a street or off-street paved area flush with the pavement surface. Openings shall be covered by a grating adequate to sustain the anticipated traffic but shall have the maximum proportion of open area without concern for the heels of women's shoes.

c. An area at any unpaved off-street location either surrounded by a protective railing or raised at least 2' 6" above the surface. Openings shall be covered by a grating adequate to sustain trespassers.

5. Rain or other liquids entering the shaft shall drain either to the tunnels or to a sump incorporated into the vent shaft, depending on local conditions.

6. Shaft configuration shall prevent any direct line-of-sight path from the surface to a train, to prevent contact with train of falling or thrown objects.

7. One intermediate vent shaft approximately midway between adjoining stations shall contain the emergency ventilation fan for each tunnel. Fan shall be a propeller-type.

8. Any intermediate vent shaft shall be equipped with dampers closing automatically when the emergency ventilation fans operate to guarantee positive flow of air from the stations to the emergency fans.

C. Under-platform Induced Draft System

1. The under-platform system shall provide a flow of air under train cars approaching, standing at, or leaving a station. This flow shall be at right angles to the car centerline. The system shall operate at all times that passengers may be in the station.

2. Air flow under each car shall have an average velocity of 100 fpm. minimum through the open areas between the car floor, all sub-floor equipment, the car trucks and the base of the rails.

3. Space under the station platform floor shall be employed as a plenum. Each plenum shall be independent of similar plenums or ducts, to prevent cross-circulation between tunnels.

4. The plenum face toward the tracks shall be covered by a trash screen of wire mesh or expanded metal. Provision shall be made to bolt 6-inch wide vertical strips of sheet metal to the track-side face of the screen to cover any desired portion of the screen. This method will be employed to adjust the air flow to obtain uniform distribution along the train.

5. The trash screen or covers shall be no closer than 8'-0" to the track centerline, to provide refuge space.

6. Space in the plenum may be employed for piping or electrical conduits, provided that:

    a. Interruption of the under-platform induced draft system for conduit or piping maintenance is limited to the 7:00 P.M. to 5:00 A.M. hours.

    b. Allowance is made for the conduit and piping cross-section in calculating air flow velocities.

    c. Such usage meets the appropriate electrical and piping criteria.

7. Velocity of air flow through the plenum shall not exceed 2,400 fpm. A velocity of not more than 1,500 fpm. is preferable.

8. Two axial-flow fans mounted beneath the platform shall move air from each plenum (i.e., four fans per two-track station). Each fan shall provide half of the total capacity required for its plenum. No spare fan is needed as the system will operate at half capacity during fan maintenance. Fan design temperature shall be 135°F.

9. Fans shall be directly driven, with motors mounted on the fan shaft within the air stream. Motors shall be totally enclosed, and rated for continuous service in an air stream of 135°F.

10. A working space for access to the fans shall be provided beneath the station platform. Fan housing and ducts shall isolate this space from the air flow from the plenum. The access hatch (normally closed) into this working space shall be designed to provide at least 40 sq. ft. of open hatch per fan, to allow adequate ventilation and heat removal during maintenance periods.

11. Flows from more than one plenum may be combined beyond the fans. Duct velocity shall not exceed 3,000 fpm.

12. Air shall be discharged through a surface opening as follows:

    a. Most preferable discharge is through a 2'6" or higher raised structure in a median, surrounded by a traffic and floodwater curb 1' 6" or more wide on all sides. Discharge shall be vertically upward, at a velocity not exceeding 3,000 fpm. Opening shall be covered with a grating adequate to support a person and to exclude trash.

    b. Next most preferable discharge is through a grating in a median, surrounded by a traffic and floodwater curb 3' 0" or more wide on all sides. Discharge shall be vertically upward, at a velocity not exceeding 3,000 fpm. Grating shall be fenced-off or screened over in a manner to divert pedestrians.

    c. Next most preferable discharge is through a structure on off-street property similar to that of paragraph a.

    d. An acceptable discharge is through a duct to a point not accessible to the public on a building or structure roof or wall or in an off-street area. Discharge shall be at a velocity not exceeding 3,000 fpm.

D. STATION VENTILATION SYSTEM

1. The ventilation system shall provide a flow of fresh air to the station, and shall operate at all times that passengers may be in the station.

2. One or more rooms within the station structure shall serve as a plenum or plenums for the station fresh air supply. Air shall flow into each room through its duct from the surface. Duct velocity shall not exceed 1,500 fpm.

3. Air inlets shall be through surface openings as follows:

   a. Most preferable inlet is through a flush grating in a median, surrounded by a traffic and floodwater curb. Grating shall sustain the weight of accidentally intruding vehicles or pedestrians, but shall have the maximum proportion of open area, without concern for heels of women's shoes. Velocity shall not exceed 1,500 fpm.

   b. Next more preferable inlet, in an off-street location not subject to flooding nor to vehicular or pedestrian traffic, is a flush grating without a curb. Grating and velocity maximum shall be the same as in a.

   c. An acceptable inlet is in a sidewalk or in a paved off-street area not subject to obstruction by standing vehicles. Grating shall support the anticipated traffic and shall be acceptable to women. Velocity shall not exceed 1,000 fpm.

   d. An inlet through street paving is not acceptable.

4. Plenum rooms shall be the source of air for station ventilation, station air conditioning "heat dump" air, cooling air for any sub-station and cooling air for the train controls. Inlets shall be sized to meet the maximum requirements for these purposes.

5. Ventilation air shall be drawn from a plenum room through filters. Filter face velocity shall not exceed 500 fpm.

6. Total ventilation air capacity shall be divided equally between two fans. No spare fan is needed, as the system will operate at half capacity during fan maintenance. Fan design temperature shall be 90°F. Selection of same fan as employed for the under-platform induced draft system is preferable.

7. Ventilation ductwork shall be incorporated into the station structure, preferably into the spaces above the platforms and tracks. System shall provide uniform distribution of air to the full length of the platforms. Duct velocity shall not exceed 1,500 fpm. During operation with only one fan, distribution may no longer be uniform, but air flow to any outlet of the ductwork shall not be less than 25% of that at full capacity.

8. Openings from the ductwork shall be placed to obtain uniform air distribution, with louvered fittings as required. One such opening per train screen door pair is preferred. Velocity through the openings shall not exceed 500 fpm.

9. Air movement velocities produced by the ventilation system while all train screen doors are closed in spaces which may be occupied by passengers shall not exceed 100 fpm.

10. Ventilation air capacity shall be the maximum required for the sum of the following:

    a. Leakage air flow through the train screen door clearances into the track areas.

    b. Air flow to the track areas through open train screen doors.

    c. Air flow up the stairways and escalators to the mezzanine and to the street.

11. Ventilation air flow from the platforms to the mezzanine shall be adequate to produce a minimum of five air changes per hour.

12. Ventilation air flow to the platforms, mezzanines, stairs and escalators and other public areas shall be adequate to prevent accumulation of any damp, musty or unpleasant odor. Ductwork to convey fresh air to any cul-de-sac or other isolated point to meet this requirement shall be provided.

E. STATION HEATING

1. No provision for general station heating is required.

F. ELECTRICAL FACILITIES ROOM VENTILATION

1. Cooling air for substations, train control equipment and other major electrical facilities incorporated into a station shall be drawn from a ventilation air inlet plenum. Heated air shall be discharged to the track area or to the surface.

2. Surface discharge openings shall comply with the criteria for under-platform system discharge openings (paragraphs C.12.a. through C.12.d.)

XIII. SUBWAY FIRE PROTECTION

XIII. SUBWAY FIRE PROTECTION

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

A. TUNNEL STANDPIPE SYSTEM Standard fire department siamese hose connections served by a 4-inch dry standpipe shall be provided in each subway tunnel at intervals not exceeding 1000 feet. Preferred locations shall be at the cross connections between tunnels. One siamese connection shall be located on each side of the cross connection door either in the passage or in the subway bore.

Fire department siamese inlet connections shall be provided at the surface level either in a concrete box at ground, street or sidewalk level or flush mounted in a concrete wall.

Where more than one hose station must be served from one inlet, the piping shall be sized to provide a minimum flow to each of the two most remote hose stations of 500 gpm (or a total of 1000 gpm) while maintaining 50 psi pressure at the most remote hose station.

B. TUNNEL PORTABLE FIRE EXTINGUISHERS One 20 lb. dry chemical type portable fire extinguisher with rating not less than 4A 30BC shall be provided at each fire department siamese hose connection in the subway tunnels. It shall be mounted so that the top is not more than 5 feet above the walkway.

C. STATION SPRINKLER SYSTEM All public areas of mezzanines below ground, concession areas, storage areas, and station attendants' rooms shall be sprinklered. Subway platforms, substations, train control and other electrical equipment rooms and mechanical equipment rooms generally will not be sprinklered.

All unenclosed vertical openings between platforms and mezzanines shall have sprinklers placed to fully cover them.

For stairs and escalators extending from a mezzanine to the street, sprinklering at the mezzanine level shall extend to the point where penetration of the ground surface begins. Escalators outside the mezzanine limits shall be sprinklered.

The sprinkler system shall be of the wet-pipe type, discharging water immediately from individual sprinkler heads activated by the heat of a fire. Installation of sprinklers shall conform to National Fire Protection Association Standard No. 13, "Sprinkler Systems, 1964". An occupancy classification defined as "Ordinary Hazard" by the N.F.P.A. shall be the basis of design and installation of the sprinkler system.

D. STATION STANDPIPE AND HOSE SYSTEM All stations shall be equipped with wet standpipe systems having the supply valve open and water pressure maintained at all times.

Except as herein specified, the design and installation of standpipe hose systems shall conform to National Fire Protection Association Standard No. 14, "Standpipe and Hose Systems, 1963". Class III service shall be provided in all subway stations.

Fire hose stations connected to the wet standpipe system shall be provided throughout the mezzanine and platform areas. Each hose station shall consist of a cabinet equipped with 100 feet of $1\frac{1}{2}$" hose, hose rack, standard fire department hose connection, valves and a portable fire extinguisher.

Hose stations shall be spaced at intervals not exceeding 210 feet and preferably be located near each exit.

E. STATION PORTABLE FIRE EXTINGUISHERS One 20 lb. dry chemical type portable fire extinguisher with rating not less than 4A 30BC shall be located at each hose station. In no case shall travel distance between extinguisher locations exceed 210 feet.

One extinguisher shall be located near each entrance in each mechanical and electrical equipment room.

Each extinguisher shall be mounted so that the top is not more than 5 feet above the floor.

XIV. L A N D S C A P E

XIV. LANDSCAPE

PRELIMINARY DESIGN CRITERIA AND OUTLINE SPECIFICATIONS

A. GENERAL DESIGN POLICY

The following principles should guide the overall design character:

- Landscape design should recognize local conditions and be based on standards for the system as a whole which will emphasize continuity of character.
- A comprehensive visual survey must be completed showing station and route alignments, grading cuts and fills, and exact location of existing trees, walls and other landscape features.
- Recommendations for landscape treatment for the system must be based on information regarding visual qualities of the corridors.
- Existing plant material to be retained must be tagged.
- The survey must also include a soil sample analysis from all areas to be planted, to allow proper selection of plant materials for existing soil conditions.
- Visual consideration for SCRTD passengers must allow for the speed perceptual factor. Moving at 60-70 miles per hour within tight bounds of the rights-of-way directs views to broad regional glimpses. Detailed design at short distances (50' - 60') will be blurred and unintelligible at these speeds.

B. GENERAL PLANTING DESIGN CRITERIA

1. Plant materials will be used in compositions that are architectural in quality. Groupings of plants will be of significant numbers and used in simple forms upon the ground plane. Plants should be enmassed over a surface area of significant size to be of meaningful visual consequence. There should not be random plantings, petite planter wells, or lines not relating to structures, circulation and parking lot layout.

2. Plants should generally be massed:

   - to make a clear statement, eliminating confusion, and incongruity;
   - to allow for the perceptive factor involved in high speed views from transit coaches. Broad regional views will be more important than gardenesque qualities.

3. Plantings will be chosen from a selected palet, especially in station areas:

   - to reduce possible maintenance problems by using suitable plant material for the site conditions;
   - to implement simplicity of design;
   - to promote continuity of design.

   The plant materials palet is based upon the criteria in the following section.

C. PLANT CRITERIA SELECTION

Selection of plant materials must be made on the basis of the following criteria:

1. Plants must have low maintenance characteristics, minimum watering, pruning, feeding and pest control needs.
2. Moderate to fast growth plants, rather than very fast, will produce a sturdier branching structure and better resist wind damage.
3. Shrubs must be low branching wherever possible to minimize the need for ground cover.
4. Shiny, tough, glabrous leaves are preferred where dust is a problem.
5. Nearly mature plants shall be planted to achieve immediate effect in areas deemed visually important (i.e., larger size plants for screening along rights-of-way; all plantings in station areas will be established materials such as 24" - 36" box trees). Ground covers along corridors will be hydro-mulch spray-on technique.

D. LANDSCAPE TREATMENT - STATION AREAS

1. Parking Lot Areas

The design of external station facilities must be handled by reference to the specific local requirements of traffic, site acquisition and character. Minimum standards for parking area landscape design are included in the following points:

- The main entrance to and the circulation routes within the station parking area must be emphasized to give identity and orientation to the pedestrian and vehicle operator. A straightforward handling of plant materials must be employed to properly identify points of ingress/egress and station ticketing entrance. The driver or pedestrian should have no difficulty in determining where he wants to be going, whether parking his car, catching a train, dropping someone off, or leaving the station area.
- Parking areas must be screened from surrounding buildings when desirable by planting, fences, walls, berms, or changes in grade.
- Tree specimens are to be located around the perimeter and along the pedestrian walks leading to the ticket area to achieve scale, subdivision of the site, and to emphasize the major pedestrian route to the station. These trees should be part of an existing street tree pattern established by the surrounding community where such a pattern exists. This relationship is desirable where identification can be made with the community by recognizing and reflecting the character of existing plant materials.
- Trees planted within the parking lot areas are (1) to emphasize the direction of important internal traffic and minor pedestrian circulation, and (2) to function as spatial dividers by breaking down large expanses of paving into areas of two acres maximum.

E. LANDSCAPE TREATMENT - CORRIDORS

Treatment of the corridor rights-of-way will be relatively simple. By utilizing a spray-on operation of seeding, with plant seeds mixed into a slurry, the initial cost of ground cover installation and maintenance can be greatly reduced. Trees specified along the corridor rights-of-way are to be well established materials (24" - 36" box) to (1) enhance the landscape initially, (2) provide screening for residential privacy, and to establish identity for the transit system. Shrub screening material will be of 1 gallon and 5 gallon sizes. Irrigation is to be provided by a quick coupler rainbird system for the first two years. All lawn areas are to be on an automatic sprinkler system. Trees will be accommodated with water sumps at the drip line distance.