APPENDIX A OF THE FINAL REPORT

TO THE

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

SUBMITTED BY

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

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PREFACE

This portion of the Planning and Preliminary Engineering Report is essentially a technical supplement to the summary presented in the Final Report. While the summary mainly treated the results and findings of the program, this supplement deals in greater detail with the factors and alternatives considered in arriving at those conclusions. Yet even this is of necessity a summary, representing more than 300 drawings, numerous technical reports dealing with individual elements of the program in technical detail, and several detailed comparative analyses leading to selection of specific electrical, mechanical, structural, or architectural concepts. This depth of study and design was necessary in order to arrive at a reliable estimate of the costs to be incurred in constructing a truly modern and efficient transit system in Los Angeles, and to assure that the selected system and its components will adequately meet the needs of region.

In addition, this report is supplemented by the Preliminary Report, published in October, 1967, which contained the essential discussion of the planning and economic evaluation process which lead to the preliminary selection of routes and station locations. That report presented a detailed discussion of these factors which are omitted from this report to allow adequate discussion of the technical aspects of the system, ancillary equipment, and facilities.

This technical supplement also includes, in total, a summary report on the Airport Southwest Corridor prepared by M. A. Nishkian Co. under a sub-contract to the Joint Venture for specific aspects of that corridor. Discussions relating to special station requirements, airport express, and route plan and profiles are included therein.

TRANSPORTATION TECHNOLOGY REVIEW

The advance of technology, particularly in the Aerospace field and in virtually every aspect of American life, over recent years has created a demand for a so-called breakthrough in transportation system concepts. This problem comes under particular scrutiny when an entirely new mode of transportation is being contemplated for a given city in the form of mass public transit. The purpose of this review is to briefly examine the current and proposed rapid transit technology, and to place them in perspective with the proposed program of new public rapid transit in Los Angeles.

SUMMARY AND CONCLUSIONS

In recent years, the rapid growth of urban areas throughout the United States has tended to focus attention on the need to improve public transportation. Such attention largely arises from an ever increasing traffic and congestion problem primarily caused by the growth and development patterns fostered by the automobile and its facilities. In general, both transportation planners and urban planners agree that the automobile alone cannot satisfy the transportation demands of an increasing urban population.

The system and concepts proposed to supplement auto transportation may be divided into two general categories or approaches. One is a *personalized system* which includes a further evolution of the automobile and its facilities and new small vehicle concepts. The other broad classification is for *mass transportation systems* which include the improvement and innovation of bus transit and fixed facility transit. Although in both cases some of the systems appear revolutionary, the concepts are essentially evolutionary.

The conclusions reached with respect to each of these categories are as follows:

. Personalized Transportation

For the next decade at least, personalized transportation will most likely continue to be provided by the automobile in much the same manner as it is at present. Propulsion power may experience gradual modification to battery powered electric vehicles, largely for urban use. Such vehicles are likely to be relatively small and might be the initial step toward an automated system. However, any appreciable use of automated guidance for small personal vehicles in the near future is highly unlikely due to its high cost.

. Mass Transportation Systems

Of the new concepts, the air cushion vehicle appears to hold the greatest potential as one of the most feasible long range High Speed Ground Transport systems, and could be the next generation of urban rapid transit systems. However, to be practical in urban usage, jet engines or propeller-driven vehicles would be unacceptable because of the high noise factor. Therefore, use of tracked air cushion vehicles in urban transit appears to depend upon development of a technically and economically feasible linear induction motor. At present, no definite estimate is available of the time which will be required for research and development to produce a proven system. The results of current Department of Transportation (DOT) programs may provide a more positive answer and a timetable for a workable system. In conclusion, based upon available data, the air cushion vehicle coupled with the linear induction motor will not be available for use in the current Los Angeles program.

. For revolutionary concepts such as the "Tube Flight Train" and "Gravity Vacuum System", it is concluded that the likelihood is remote of these concepts becoming operational within the time frame of this transit program for Los Angeles.

. The application of an all-bus system providing service equivalent to rail rapid transit for Los Angeles has been studied by Simpson and Curtin, Consulting Engineers. The conclusion reached was that an all-bus system, in the present state of the art, is not capable of meeting the public transportation needs projected for the Los Angeles Metropolitan Area.

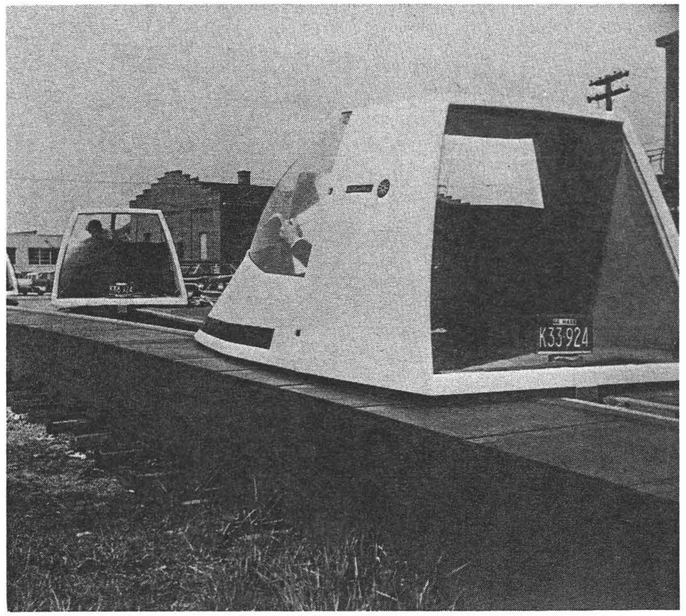
. The most significant advances in transit technology are in the areas of automated train control, acoustic control, fare collection, and lightweight car design. The continuing studies of power and propulsion systems are largely devoted to supply voltage and alternating current systems. These improvements, combined with closer attention to the aesthetic appeal of stations and way structure, as well as car design, are producing a dual rail system which is far superior to what is generally considered a "conventional" transit system. Therefore, dual trail transit is likely to continue as the standard throughout the transit industry for some time to come with innovations such as the Westinghouse Transit Expressway and "monorail" systems used in certain special situations.

In designing or planning an urban system to be built in the near future, the immediate concern must be to plan and build a system which will serve the needs of today, and be compatible with the systems of tomorrow. By far, the greatest cost in system development is in the fixed facility portion consisting of rights-of-way, way structures and stations. It is significant, therefore, that if the air cushion vehicle becomes a practical replacement for present day transit, the existing fixed facilities may be modified to accommodate the change-over with relative ease by removing the rails, repaving the track bed, and installing the reaction rail. Control and communications, as well as electrical power and power distribution may be expected to be compatible. Thus, the dual rail system appears to offer the greatest potential for future convertability. This system, using steel wheels and steel rails has been adopted as the system to be used in the preliminary design.

PERSONALIZED TRANSPORTATION

The development of electronic computer technology has contributed in large measure to efforts directed at increasing capacity on freeways and streets, and thereby improving personalized transportation. These efforts range from present day techniques of ramp metering to regulate traffic volume on freeways and volume sensing signal systems on surface streets, to visionary predictions of fully automated freeways. Proponents of full automation estimate that traffic carrying capacity of a freeway lane could be increased by as much as 100%. However, it is apparent that much tighter control over vehicles condition and performance characteristics would be required because mechanical failures would present even more serious consequences under automated control than occur at present. Lane changes and entering and leaving the mainstreams of traffic are other problems which will require careful attention.

In addition to the automation of the standard automobile, several "small car" concepts have been proposed. Alden Systems of Westboro, Mass., one of the early proponents of such a system, has developed a prototype model of the Self-Transit Rail and Road Car (StaRRcar). M.I.T. has also proposed a similar concept (Commu-Car) as has Cornell Aeronautical Laboratory (Urbmobile). These concepts are based upon a small vehicle carrying two to four people, electrically powered, and capable of independent operation on standard streets in addition to having the ability to operate on an exclusive right-of-way guideway under automatic control.



StaRRcar

Speeds for these vehicles on the automatic guideway are projected in the 60 mph range. The dual function capability of these vehicles, combined with their small size and resulting reduction in required parking area, offers a potential system which should have great public appeal. However, how soon any such concept could be made fully operational cannot be predicted. Many of the detail problems of automated freeways such as vehicle headways, speeds, lane changing, merging, and exiting are present in the small car systems as well as serious financial and economic questions of vehicle ownership and operating costs.

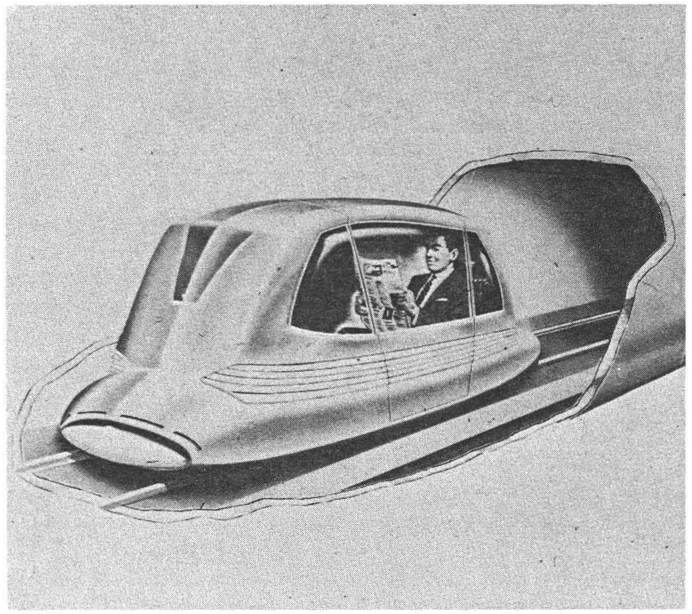
One transportation concept, Teletrans, shares the personalized approach of the "small car" concept but lacks the dual mode capability. In this approach, the small two-passenger car operates on an exclusive right-of-way either above or below ground surface. The fact that this system is restricted to its own facility, coupled with the relatively low passenger carrying capacity per lane, limits its potential for high volume, public transportation service. This system, along with others of similar operating characteristics such as the Lockheed Skyrail, may have some future possibilities as secondary distribution systems in dense urban areas.

StaRRcar

MASS TRANSPORTATION SYSTEMS

Mass transportation has also experienced a marked increase in attention in recent years. Proposals for several new concepts and innovations have been made, and a number of research programs are in progress. The majority of the advanced concept research has been directed at high speed ground transport on an inter-urban basis, while intra-urban transit has been largely directed toward innovation and modernization. Due to the difference in trip length and station spacing, much of the work done in inter-urban transport in confined to an entirely different speed regime and is not directly applicable to intra-urban use. However, some of the concepts are also adaptable for lower speed (up to 100 mph) application. This potential secondary application is worthy of review when combined with the large physical size of the Los Angeles region and the resulting potential desire for express service between stations 10 to 20 miles apart.

The greatest emphasis in the High Speed Ground Transportation under the Department of Transportation has been directed at three general vehicle concepts: Rail Systems, Tracked Air Cushion Vehicles, and Tube Vehicles.



Teletrans

RAIL SYSTEMS

The impetus for high speed rail systems had its beginning in 1964 with the new Tokaido Line running from Tokyo to Osaka, Japan. This train operates on a 125 mph schedule speed and has a top speed of approximately 160 mph. In the United States, several rail system prototype designs either under test or scheduled for testing at an early date are directed at providing similar performance.

The Pennsylvania Railroad has a demonstration program underway utilizing an electrically propelled Budd built car over a 21 mile track between Trenton and New Brunswick, New Jersey. These trains are designed for speeds up to 150 miles per hour.

Perhaps the United Aircraft Turbotrain represents the most unique approach to high speed rail transport. In this approach, both propulsion and suspension are revolutionary for rail systems. The cars feature lightweight aircraft fabrication techniques and use turbine engines for propulsion. The suspension is designed to provide a "banking" condition on turns to reduce the lateral load on the passengers, and thus attain high speed capabilities over existing trackage. Such trains could operate between the cities of Santa Barbara, San Bernardino, or San Diego to Downtown Los Angeles, and reduce travel time to within 40 to 45 minutes. While these trains are not appropriate for intra-urban use, some of the lightweight vehicle structural concepts, particularly those of the Turbotrain, may be applicable to urban transit vehicles.

TRACKED AIR CUSHION VEHICLES

The Air Cushion Vehicle concept may prove to be the most significant breakthrough in high speed ground transport as well as urban transit. The importance of this development is particularly significant when combined with the linear induction motor as a source of propulsion power. In this concept, the vehicle rides on a thin film of air rather than on wheels, and could be capable of a wide range of speeds up to 500 mph.

The French Aerotrain represents the most advanced development of a tracked air cushion system. A half scale prototype vehicle powered by an aircraft engine and carrying four passengers has been successfully tested over a seven mile test track near Paris. By using a small jet engine for added power, this vehicle has attained unofficial speeds in excess of 200 mph. A full scale operational line between Paris and Orleans is being projected for completion by 1970.

In Great Britain, research in both linear induction motors and air bearing vehicles has been underway for a number of years. These two concepts have been successfully combined in a small scale model of a Hovercraft vehicle which was first tested in 1966. The British Government has recently accelerated research in this combined concept and is anticipating a demonstration model in the near future. Expected speeds are in the range of 300 miles per hour.

In the United States, interest in this concept has only recently reached a significant level under the influence of the Northeast Corridor Program (now part of the High Speed Ground Transport Program). General Motors Corp. has developed an air bearing machine (Hovair) which has received considerable acceptance in industrial applications, but only recently have transportation related programs been investigated. These are largely limited to small secondary distribution systems for use in CBD areas of urban development, and linear induction propulsion with the motor windings in the roadbed and a passive vehicle are contemplated. This approach may be appropriate at the projected high line density and small 2-4 passenger vehicles.

In the late 1950's, Ford Motor Company experimented with an air bearing concept (Levacar) vehicle, supported by air bearing pads on a special steel rail, and powered by propellor engines. Research on this program has been abandoned.

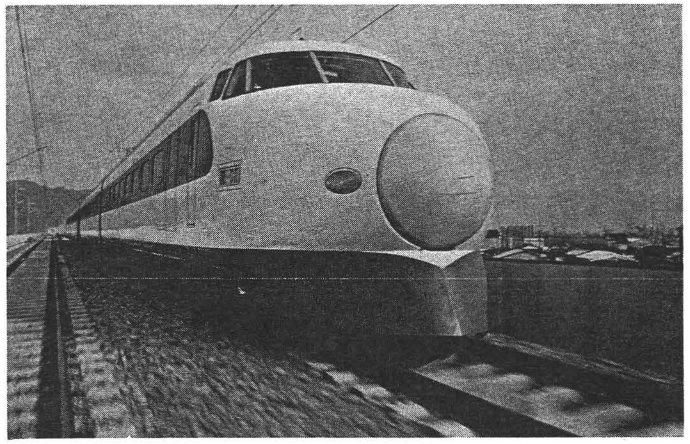
Research into linear induction motors is increasing in the United States. Airesearch Manufacturing Company, a division of the Garrett Corporation, completed a feasibility study of this concept for application to high speed ground transport in 1967 and was awarded a contract to develop a prototype motor. The motor is expected to undergo testing in late 1968 or early 1969 on a test track and to produce speeds up to 250 mph. The initial test vehicle is expected to use steel wheel on steel rail suspension with later adaptation to air bearing. The test motor is designed as a prototype for the current High Speed Ground Transport program and is expected to produce 2500 horsepower. Actual motors for the operating system will be 5000 HP. Electric power generation is to be by an on-board generator because the problems of electrical pickup from wayside distribution at these high speeds have not been satisfactorily resolved.

TUBE VEHICLES

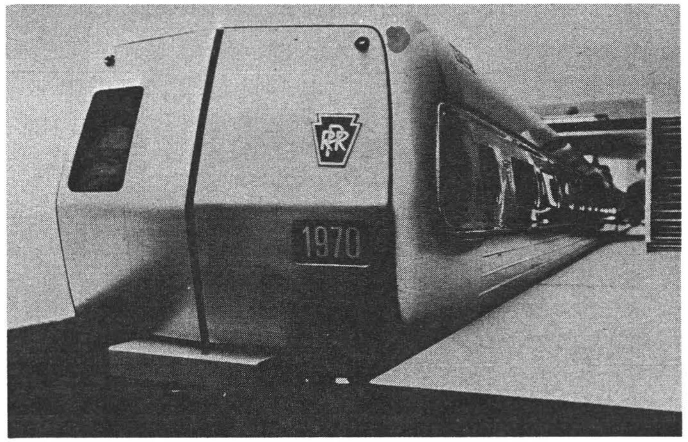
Of all ground based transportation proposals, the longest range and most revolutionary are probably the tube vehicles typified by the Rensselaer Polytechnic Institute studies of a "Tube Flight Train," and L. K. Edwards' "Gravity Vacuum Tube." Both systems envision trains traveling at speeds approaching 500 mph or more in deep underground tubes. The "tube flight" concept utilizes turbo fans for propulsion while the "gravity vacuum" concept, as its name implies, uses a combination of gravity and reduced air pressure ahead of the vehicle to provide motive power. Current research in these concepts includes a 2500 foot test track for a 12 inch model projected for the tube flight vehicle and a concept review of the gravity vacuum system by the New York Regional Planning Board. An application is pending for funding of a gravity vacuum test program. Major problems to be faced in either of these concepts include unknown cost factors of construction at the great depths anticipated (as much as 3500 feet in the gravity vacuum system), critical tube alignment at extremely high speeds, construction tolerances, and evacuation of passengers in the event of a failure. In addition, the tube flight concept must contend with heat, noise, and exhaust fumes for the turbo-fan engines.

URBAN MASS TRANSIT SYSTEMS

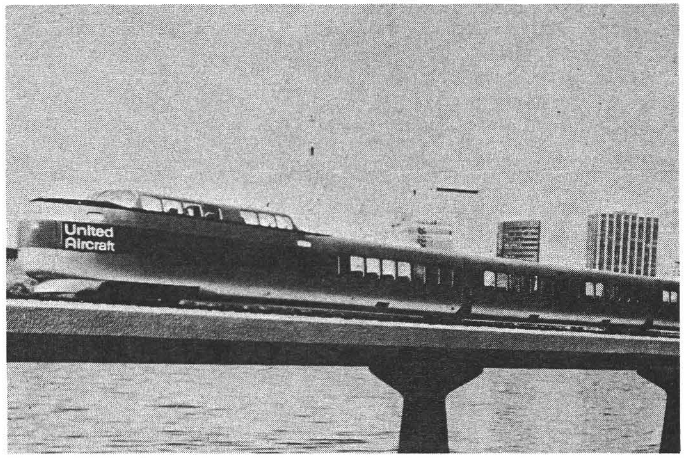
In addition to the inter-city transportation systems under investigation by D.O.T., many other programs largely aided by the Department of Housing and Urban Development (H.U.D.) are under consideration for transportation applications within the urban area.



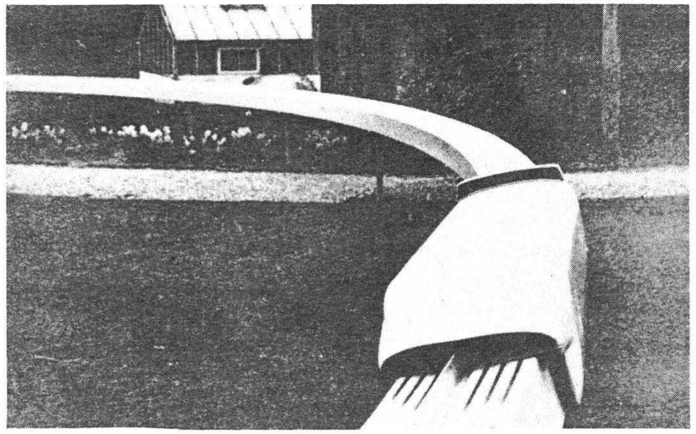
Tokaido Express



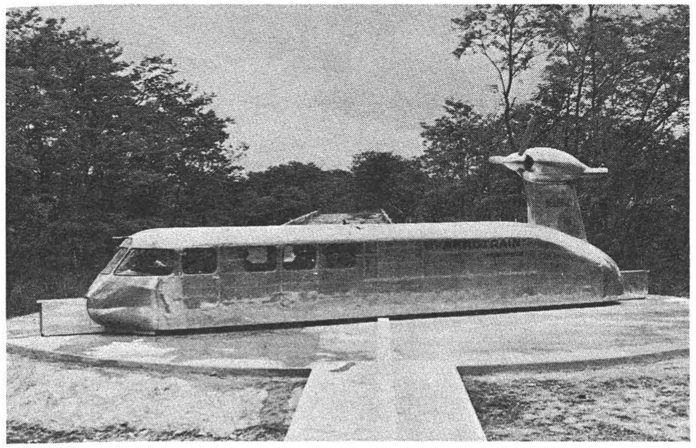
Budd High Speed Car



United Aircraft Turbotrain



Hovercraft



Aerotrain

The primary methods of urban mass transit include rubber-tired systems consisting of the various bus concepts; fixed rail rapid transit including all of the proposed "monorail" systems; and conventional dual rail transit.

BUS SYSTEMS

Proposals relating to mass transit based on bus systems are primarily devoted to operating concept innovation rather than technological modification. An example of this innovation is the General Motors proposal for a "Metro-Mode" system using all buses and some grade separted exclusive trunk busways. These buses would circulate in suburban areas using existing street systems to load the bus, and then proceed to the exclusive busway for a non-stop journey to the destination area where they would again use existing surface streets for distribution. Some advantages claimed for this concept are (1) closer approximation of "door to door" one seat service, (2) lower capital investment, and (3) greater flexibility of routing.

Some of the obvious disadvantages of the system are (1) a requirement for a high correlation of origin and destination areas, (2) one operator/driver per 50-60 passenger capacity vs. one operator per 1000 – 1500 passenger capacity in rail systems (operator's salaries account for well over one-half of total bus operating cost), (3) headway problems for the passenger when he must wait for a specific bus to get to a specific destination, and (4) street capacity in the urban core areas to handle the number of buses required to give reasonable headways to all outlying service areas.

Some technological innovations have been proposed and tested in conjunction with improving the operational aspects of bus service. A hybrid bus, combining steel flange wheels and rubber tires to constitute a "rail-bus," has been developed and tested in Massachusetts. In this concept, the bus would follow normal street and highway operation in suburban areas, drive onto a railroad line and lower retractable steel wheels to proceed by rail into the urban center, and again use streets to distribute passengers after retracting the steel flange wheels. This project was dropped for the intended application when it was found that the bus was essentially inoperable on the rail section during the winter season because snow caused severe loss of traction.

The articulated bus developed by the A-C Transit System in the San Francisco Bay Area represents another technological innovation which improves the ratio of passengers to drivers and affords much improved passenger accommodations for longer haul commute trips. There are also proposals to use linked buses and bus trains in automated busways. However, the advantages of these systems over conventional bus operation on exclusive lanes or conventional rail transit operations is not apparent.

Rail Bus

Articulated Bus

In summary, while busses are and will remain an essential element of mass transit, the probability of bus systems supplanting rail transit as the primary mode in major urban complexes does not seem likely. Buses, of varying size and type, will undoubtedly continue to fulfill an essential role as feeders and local distributors.

RAIL SYSTEMS

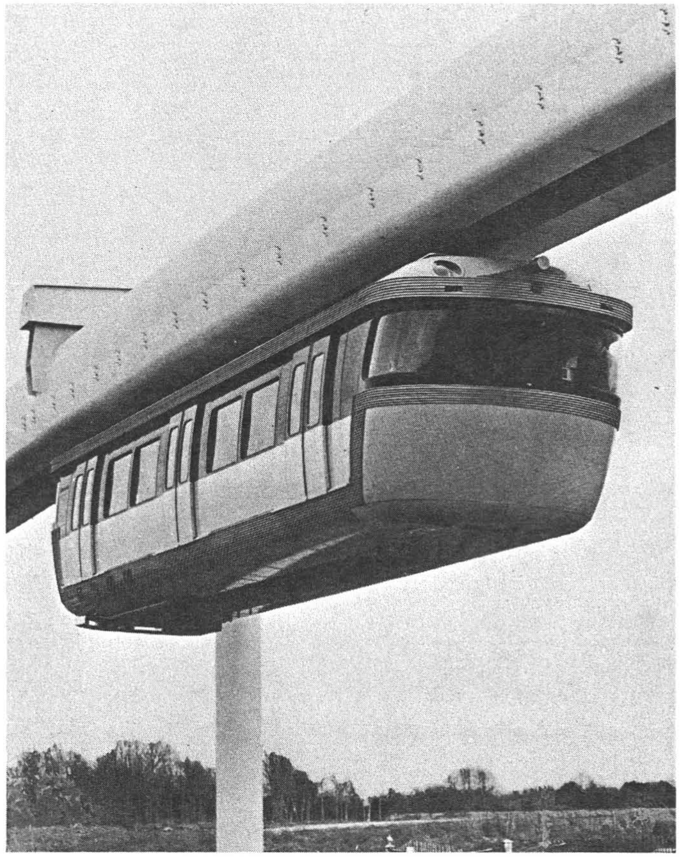
Advances in rail rapid transit have been largely evolutionary through improvement in comfort, speed, automation, and operating efficiency. Rail systems may be generally divided into two catagories: dual rail and monorail systems. Monorail systems involve two major concepts. In one case, the vehicle straddles a beam, and in the other it is suspended from an overhead beam. Alweg is the most familiar straddle system. It has been installed in reduced scale at Disneyland, and at full scale in Seattle and Tokyo. Suspended systems represent an earlier entry into transit service. The oldest system is still operating at Wuppertall in Germany. More familiar and of recent origin is the S.A.F.E.G.E. System with a test track located near Paris, France. Other suspended systems, such as the Goodell, are generally of smaller size and capacity than vehicles required for full scale urban transit service. All of these concepts have some serious technical problems when applied to urban service. Switches are slow and cumbersome, subway tunnels may be substantially larger than for dual rail systems, and because they are uni-directional, they require physical turnaround at terminals.

The most common dual rail system is the steel wheel, steel rail vehicle employed by most of the transit system of the world. Because of its long history, this concept represents the most proven of all systems designs in terms of safety, cost, and operation. Nearly every urban area considering improved public transit has evaluated the other system concepts and then selected steel on steel. The new Bay Area Rapid Transit District system and the Washington, D. C. system are both using steel wheel and rail. These various comparisons have been made on the basis of satisfying a specific set of requirements relating to passenger volume, system operation, and construction conditions applicable to the areas under study. The general conclusion of all of these comparisons was that of all concepts available now or in the near future, the steel wheel vehicle satisfied all requirements as well or better, and at less cost than any other concept.

Two cities of the world using a dual rail concept incorporate rubber tires on a concrete track. Paris, France was the first city to place a rubber tired system into operation and extended this concept into several lines of the system. At least part of the basis for selection of a rubber tired system in Montreal was the requirement to negotiate steep grades imposed by ground conditions. The higher adhesion of rubber tires on concrete rails permitted steeper grades and therefore faster entry into the rock formation on either side of stations.

In addition to better adhesion, the rubber tired systems are often stated as being more quiet than steel wheels. However, noise comparison tests conducted on many systems throughout the world for the Washington, D.C. study, and individual comparisons of noise levels in the new Toronto and Montreal systems derived no clear-cut conclusions. Noise levels appeared to be more related to age of the system, track and roadbed design, maintenance and condition than to wheel and rail material. Either system may be expected to attain comparable and acceptable noise levels if adequate care and attention is given to sound attenuation in the design of the facilities. One important factor bearing on the selection of wheel and rail combinations is related directly to projected line volumes on the transit system. Where line volume is heavy, as is projected in Los Angeles, current trends are toward a large vehicle. This results in substantial savings in vehicle cost. Present day tire technology has not produced a tire with adequate load carrying capacity to accommodate loads imposed by a 75-foot or longer car. Therefore, consideration of rubber tires on rapid transit vehicles must include line volume demands in light of equipment utilization and overall economies related to car size.

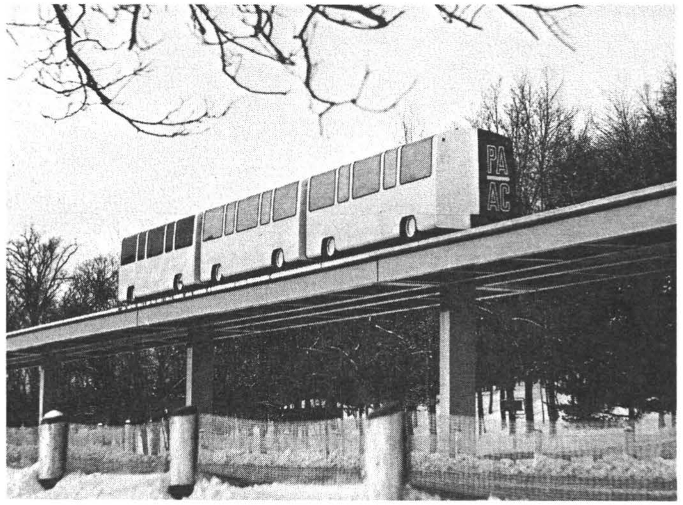
The Westinghouse Transit Expressway represents an innovation in dual rail transit directed at medium density applications. This system uses smaller cars (30 passenger), running on rubber tires with a single axle on each end of the car, using standard truck components in the running gear. Propulsion power is supplied by electric motors at each axle. The cars are fully automated and may be operated either singly or in multiple car trains. The system recently completed a demonstration program at Pittsburg, Pennsylvania, and further design studies are underway. Pittsburg has announced plans for a full scale test installation of the Transit Expressway to be placed into public transit use.



S.A.F.E.G.E.

Alweg

Westinghouse Transit Expressway



Surface Bus

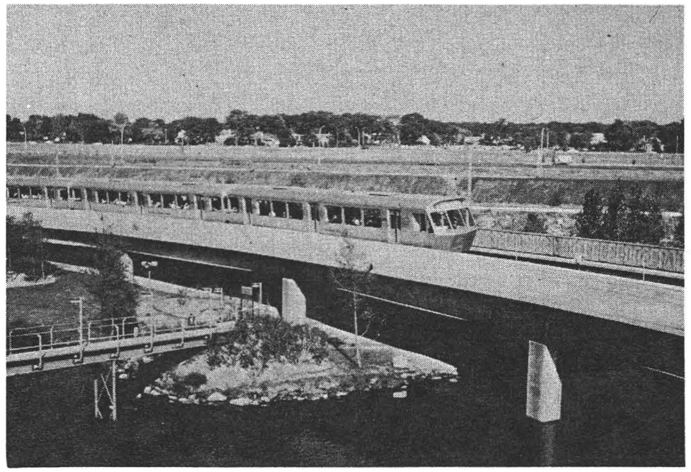
FUTURE TRANSPORTATION SYSTEMS

Urban transportation is and will continue to be one of the most critical problems in urban design and planning as cities continue to grow and expand. It is becoming increasingly clear that a single transportation mode, either public or private, cannot adequately cope with the problems. It is therefore apparent that a total transportation system must be evolved made up of sub-systems, each performing the task for which it is best suited. The variation of trip purpose as well as the needs and desires of the individual will likely become broader rather than more confined. Any given individual will probably find private transporatation more advantageous in one situation, while in another, public or mass transportation will fulfill his needs better. The transportation system of the future may well require all of these various concepts and proposals plus many more to adequately answer all needs.

Based upon the present evaluation of system proposals and concepts, the most satisfactory total system for urban transportation appears to be a highly sophisticated network of freeways, some automated to varying degrees, combined with public transportation systems providing both local service and trunk line routes through heavily travelled corridors. Local service in lower density areas may continue to be accomplished by buses Small secondary distribution systems, including such equipment as moving sidewalks, the Goodyear "People Mover" now operating in Disneyland, or the "Teletrans" system, may complement existing modes supplying transportation in the dense urban core of the city. Feeder operations to the trunk line transit may be afforded by some of the "small car" concepts which may be either in public or private ownership or on a lease basis. Long range express systems will undoubtedly become necessary as the areas grow, and one of the air bearing vehicles may be utilized with widely spaced station stops connecting with the trunk line rapid transit system. In any event, the private auto will likely retain an important role and will become more useful as alternate modes are created to relieve congestion on the streets and highways.

Freeway

Rail Rapid Transit



SYSTEM DESCRIPTION

There are two potential system concepts under consideration: The Recommended Five-Corridor System and an abbreviated Four-Corridor System. These systems are shown on the facing map and were generally described in the main body of the Final Report. The following paragraphs provide a more detailed description of the operation of transit service in each corridor and system.

SYSTEM OPERATION

RECOMMENDED FIVE-CORRIDOR SYSTEM

Trains operating in the system will generally follow two patterns. One is along the east-west alignment of San Gabriel Valley—Wilshire Corridors from El Monte to Barrington, and the other is the north-south alignment of San Fernando Valley—Long Beach Corridors from Tampa Avenue to Long Beach. This arrangement was determined as the best balance for passenger traffic forecasts in initial operation.

Major transfer points in this system occur at the Western Avenue station at the Wilshire-San Fernando Valley interchange, and at the 7th and Flower station at the Wilshire-Long Beach interchange. In non-typical train routing, transfers may be made at 6th and Broadway or at Olympic and Broadway. In addition, transfer may be made at any station in the common section along Wilshire Boulevard. While the Airport-Southwest Corridor is operationally independent, inter-line transfer of local passengers will be accommodated at the 7th and Flower Street interconnection with the Airport Line, and at the Civic Center Station at First and Broadway. There will be no operational equipment interchange capability; however, a service track connection is provided to permit access to the Main Repair Shops in the Dominguez Yard for all major transit car repair and service.

Trains will normally operate between terminal stations for complete circuits. However, in an emergency or other special circumstances it may be desirable to turn back trains at intermediate points along the line. Two types of track crossovers have been provided for this purpose. The operational turnback consists of switches connecting both main line tracks with a third parallel track 610 feet in length. This arrangement will permit a train to pull off of the main line tracks and remain on the turnback track until it can fit into the schedule in the reverse direction. The second type of crossover is for emergency use only and has no storage track. These crossovers, as well as the operational turnbacks, have been strategically placed throughout the system to minimize delays in the event of equipment failures and to provide the optimum in operational flexibility.

SAN GABRIEL VALLEY - WILSHIRE CORRIDORS

Trains operating on this line will originate from the Rio Hondo and from the Macy Yards. The yards provide for storage of trains during off-peak hours and daily service of car units. During two peak 20-minute periods each day certain trains from the Long Beach Line may be diverted to the San Gabriel Valley Corridor and placed in day storage to balance traffic through the common section of Wilshire. This diversion represents a nontypical operational pattern and requires a full interchange capability at 7th and Broadway through fully grade separated trackage. Car units scheduled for periodic inspection or major overhaul will be transferred to the Main Repair Shops at the Dominguez Yard.

An operational turnback track has been provided for the intermediate station at Garfield, the terminal station at El Monte on the San Gabriel Valley Line, and at the terminal station on the Wilshire Line. Emergency track crossovers have been provided for Alvarado, Western, Fairfax, and Century City on the Wilshire Line. The yard track connection to the Macy Yard will cross the mainline at grade with grade separation provided at the Rio Hondo Yard. A 610-foot dispatch track will be provided between mainline tracks at yard connections to transition trains in and out of service.

SAN FERNANDO VALLEY - LONG BEACH CORRIDORS

Trains operating on this line will originate from the San Fernando Valley Yard and from the Dominguez Yard. Car units scheduled for periodic inspection or major overhaul will be handled at the Main Repair Shop at the Dominguez Yard.

An operational turnback track has been provided for the intermediate station at Universal City and the terminal station on the San Fernando Valley Corridor and for the intermediate station at Compton and the terminal station at Long Beach. Emergency track crossovers have been provided for the stations at Beverly Blvd., Hollywood-La Brea, Fulton and Sepulveda on the San Fernando Valley Corridor and at Vernon Avenue, Watts and Wardlow on the Long Beach Line.

The yard connection to the Valley Yard will be made as a continuation of the line from the terminal station and to the Dominguez Yard with a grade separation from the main line. A dispatch track between mainline tracks at the Dominguez Yard connection will transition trains in and out of service.

AIRPORT-SOUTHWEST CORRIDOR

An important operational feature of the Airport-Southwest Corridor is in the introduction of an Airport Express service. This service will provide premium fare, express service between the Downtown Air Terminal at Union Station and the Los Angeles International Airport with only one stop enroute at the 7th and Flower Station. The Airport Express service will operate over the same trackage as Airport-Southwest local service and will provide an overall travel time between Downtown and LAX of 18.5 minutes. Transit cars will be modified to provide a special seating arrangement and baggage storage. There are no intermediate operational turnbacks in this corridor. Emergency crossovers are located north of the Convention Center Station at 39th Street, at the Inglewood Station, and just north of the Airport Express turnout at Century Boulevard.

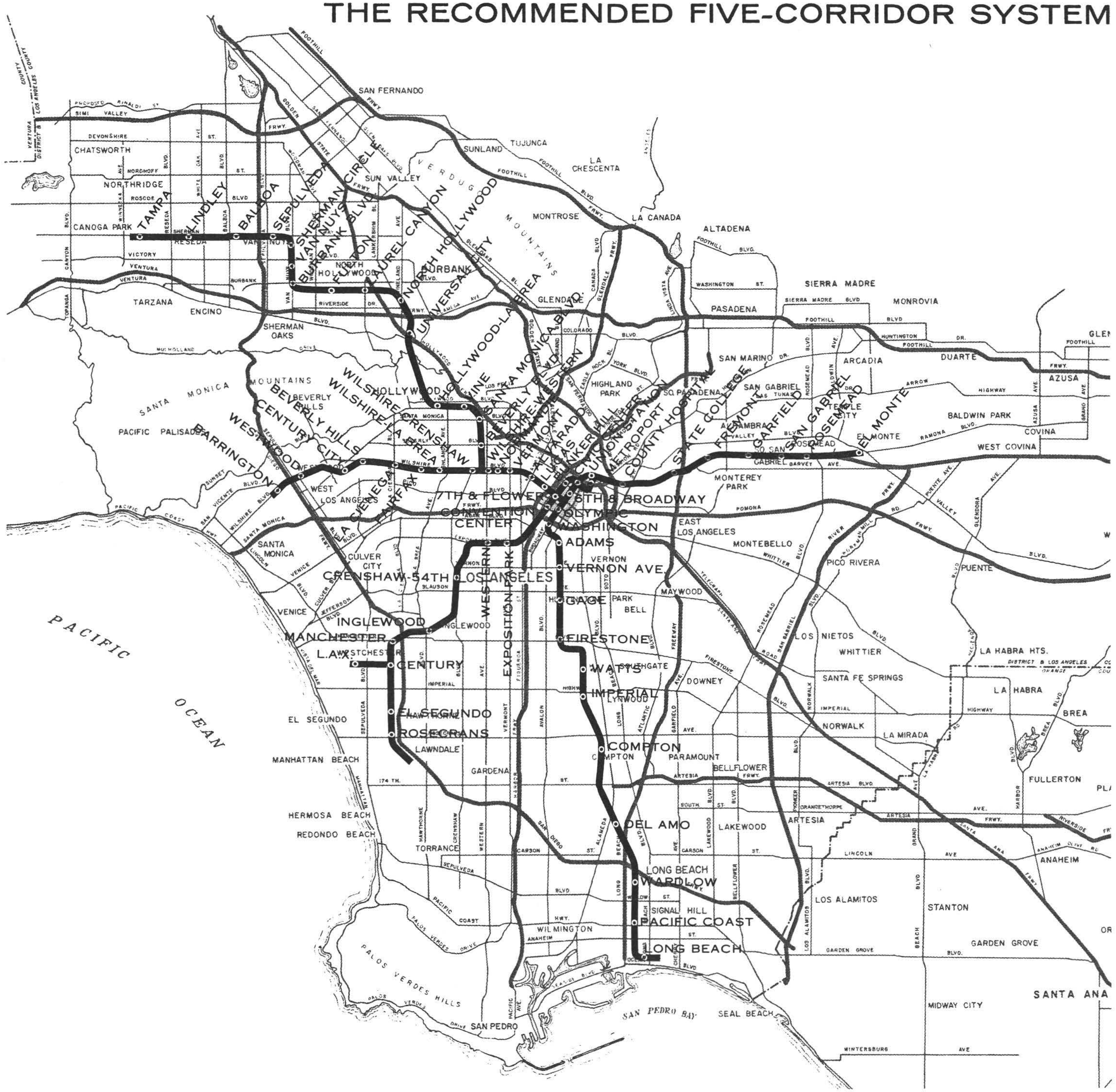
SCHEDULING

The scheduling of trains will be responsive to the patronage traffic patterns. This requires programming trains to handle diverse loading at stations as well as peak loads throughout daily operation. Traffic loads follow historic patterns in daily peaking; i.e., it can be predicted what proportion of people will be riding in peak and off-peak hours on the basis of work, social, and recreational habits. The predicted loadings at stations are more elusive, subject to variable factors of neighborhood development, travel patterns, and work destinations.

Response to the system's traffic is met with two adjustments in train scheduling consisting of variable train lengths and variable headways. Train lengths can be varied from a maximum of eight cars to a minimum of two. Maximum train length, established on the basis of patronage projections, has determined the length of stations and demands on the traction power system. Headways are limited to a minimum of 90 seconds on the basis of safe separation distance between trains as set by proposed control systems, and at a maximum of 15 minutes in off-peak periods for convenience of passengers. Safe operation of trains at these close headways at speeds up to 75 mph requires precise and consistent control and this has been achieved only by recent developments in automatic train control. For this system, automatic train control will be accomplished by on-board computers that will electronically start and stop trains, open and close doors, and maintain safe train separation. An electronic computer in the system control center will manage the overall train operation, and maintain a check of each train position against schedule in order to adjust to changing conditions.

Peak-hour scheduling will be based upon 90 second train headways through that section of the Wilshire Line common to trains operating in the north-south and east-west configuration. This common use of the Wilshire section allows 3 minute minimum headways on the outlying legs of the system.

THE RECOMMENDED FIVE-CORRIDOR SYSTEM



Forecasts by the traffic consultant indicate the 1980 movement of passengers in the peak hours and peak 20-minute periods for each of the corridors will occur as shown in the following table:

PEAK LINE VOLUMES
RECOMMENDED FIVE-CORRIDOR SYSTEM

	Peak Hour		Peak 20 Min.	
	AM	PM	AM	PM
*Wilshire	10,800	12,600	4,200	4,800
**San Fernando Valley	16,600	17,000	6,900	8,000
***Wilshire Common	26,600	28,700	9,900	12,400
San Gabriel Valley	21,500	24,000	8,600	9,700
Long Beach	17,500	15,800	7,600	6,600
Airport-Southwest	12,600	11,800	5,300	5,000

* Max. volume in Wilshire Corridor west of Western Avenue

** Max. volume in San Fernando Valley Corridor north of Wilshire Blvd.

*** Max. volume in Common Section between Western Avenue and 7th and Flower Stations.

Based on a capacity of 1000 passengers per 8-car train, the movement of trains through the common section of the Wilshire Line limits the number of through trains which may be scheduled. The imbalance of passenger loads established in the above table led to the development of the Wilshire-Long Beach interchange at 7th and Broadway, consisting of grade-separated interconnected ramps in a subway structure. The full interchange capability provides for flexibility in scheduling trains during the critical 20-minute peaks. During two 20-minute periods of the day, designated trains from the Long Beach Line can be diverted to the San Gabriel Valley Line in order to maintain 90 second headways in the common section of Wilshire. During other periods of the day, all trains will maintain their normal east-west and north-south configuration.

The Airport-Southwest Corridor will function independently of the train operation in the four corridor system. For service on this line, two types of operation are contemplated: express service between L. A. International Airport and the Downtown Metroport, and local service for passengers between Rosecrans Terminal Station and the Central Business District. Express service will be provided at 15 minute intervals. Local service will provide a maximum of 4 local trains scheduled between express units. A passing track at the intermediate station at Western will permit uninterrupted movement of express trains. The Airport-Southwest Corridor Line will be provided with a service track connection to the Long Beach line near Washington and Broadway for access to the Main Repair Shop at the Dominguez Yard.

THE FOUR-CORRIDOR SYSTEM

System operations and scheduling under the Four-Corridor System will be similar in pattern and frequency to that of the Recommended Five-Corridor System. The only exceptions will be the deletion of the Airport-Southwest Corridor, and a reduced length on the San Fernando Valley and Wilshire routes. The fully grade separated interchange at Broadway and 7th Street will still be required.

TRAIN PERFORMANCE DATA

The derivation of train performance for SCRTD's rapid transit system was accomplished by computer application of Kaiser Engineers' train simulation program.

The data comprises the speed-time-power relationship of the proposed vehicle system interacting with physical environment of the route alignments. Utilization of the data was made for further studies in the areas of:

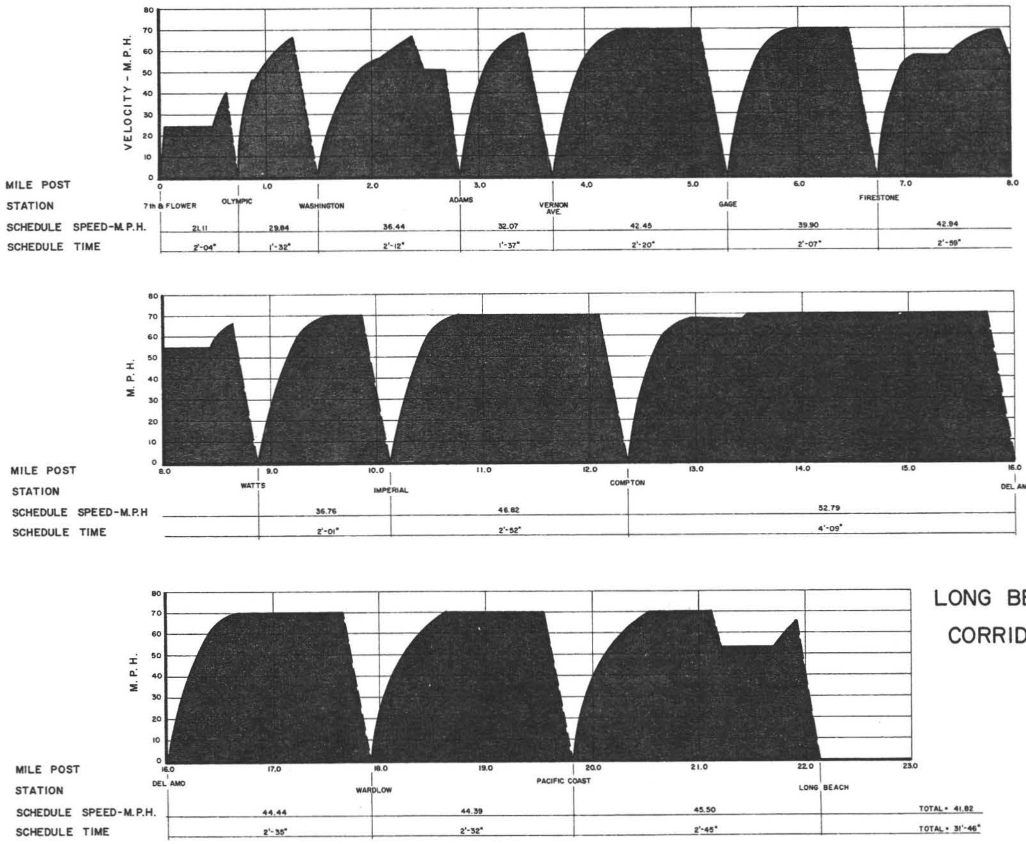
- System scheduling and operation
- Electrical traction power
- Subway ventilation systems

Simulation creates a mathematical model of a vehicle reacting to the physical characteristics of a system. For train performance studies, the conditions of alignment are resolved in mathematical terms for distance, curvature, gradients, speed restrictions, resistances, etc.; the vehicle characteristics must be assigned for equipment studies for traction motors, size, length, braking, etc.; and system characteristics must be assigned for train consists, station dwell time, leeway factors.

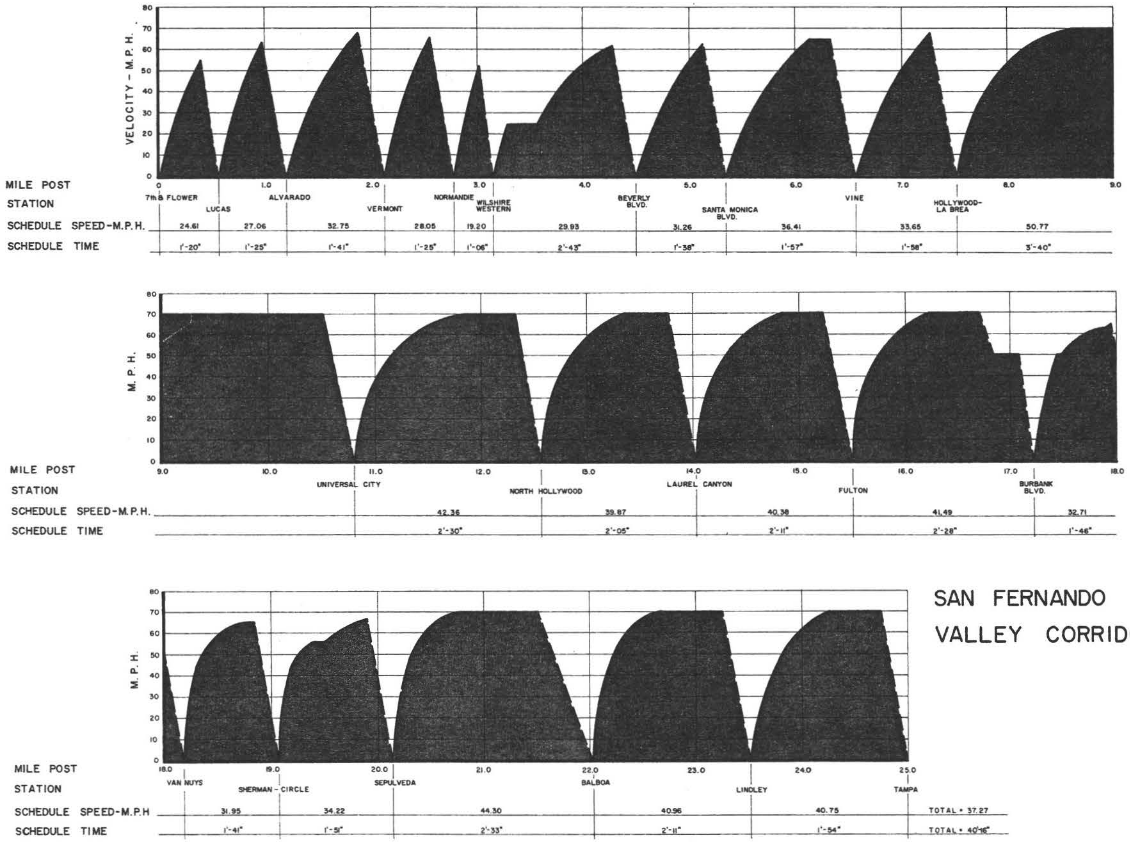
For the SCRTD studies, the conditions used for train simulation are summarized in the following list:

- Eight car train, 600 feet in length
- Empty train weight, 263 tons
- Passengers per train, 1000
- Total passenger weight, 75 tons
- Train weight, 338 tons
- Motor, 140 HP continuous rating
- Motors per train, 32
- Gear ratio, 4.79 to 1
- Wheel diameter, 28 inches
- Station stops, 20 seconds
- Dynamic braking down to 10 mph
- Maximum velocity, 70 mph
- Maximum acceleration, 3.0 mphps
- Maximum decleration, 2.6 mphps
- Leeway time factor, 5%

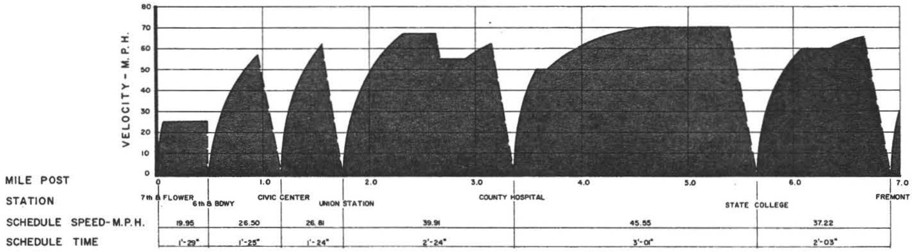
The results of velocity data achieved from computer studies are shown in the following profiles for velocity-distance relationship for all corridors of the Recommended Five-Corridor System.

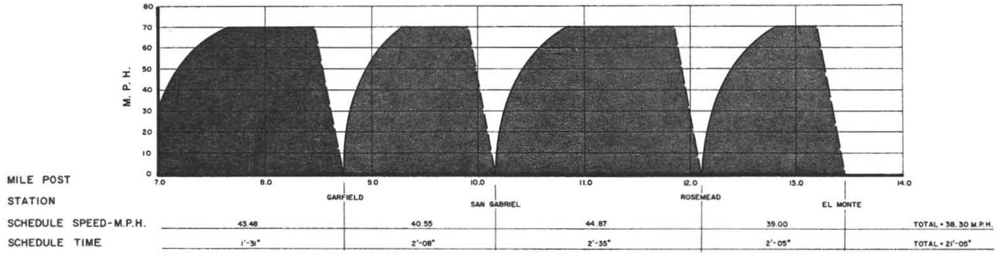


LONG BEACH CORRIDOR

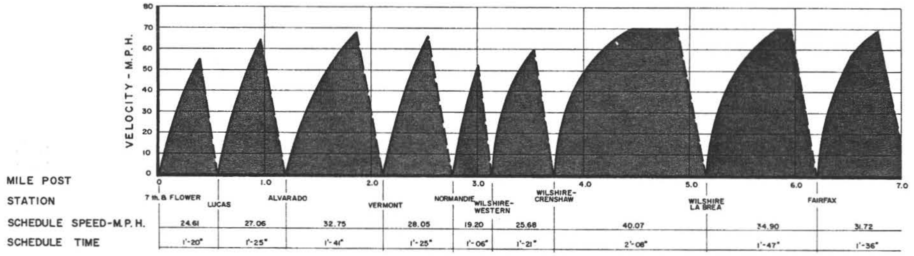


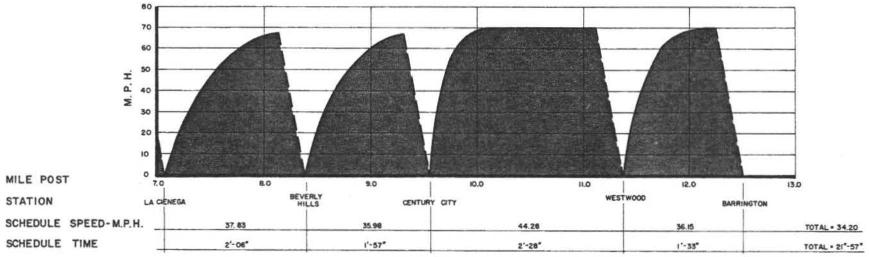
SAN FERNANDO VALLEY CORRIDOR



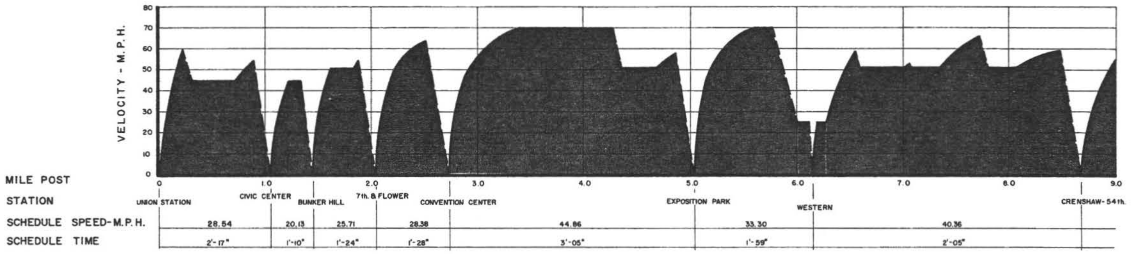


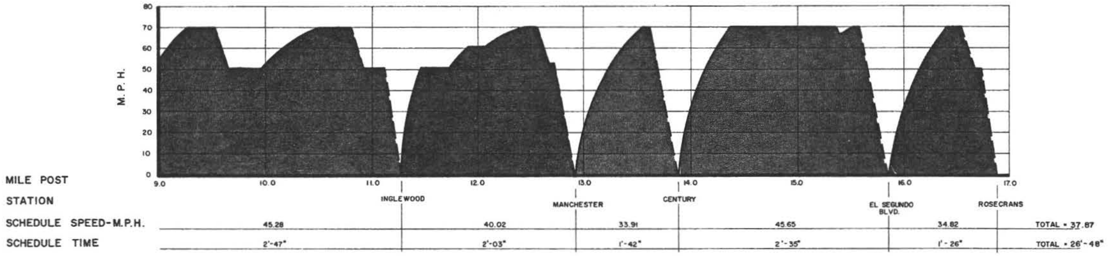
SAN GABRIEL VALLEY CORRIDOR



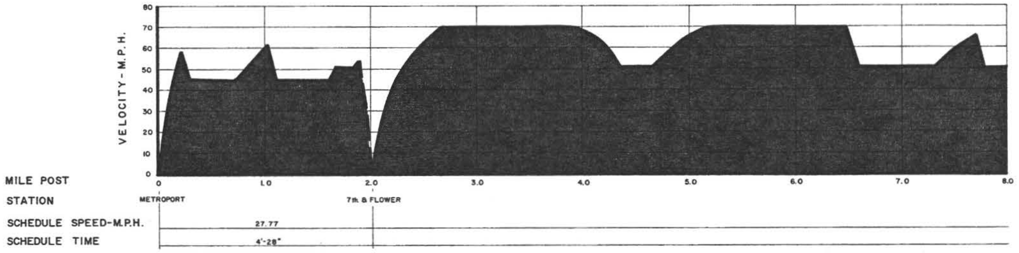


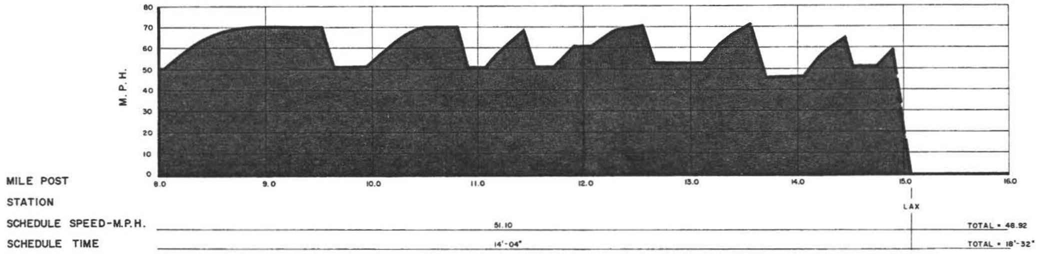
WILSHIRE CORRIDOR



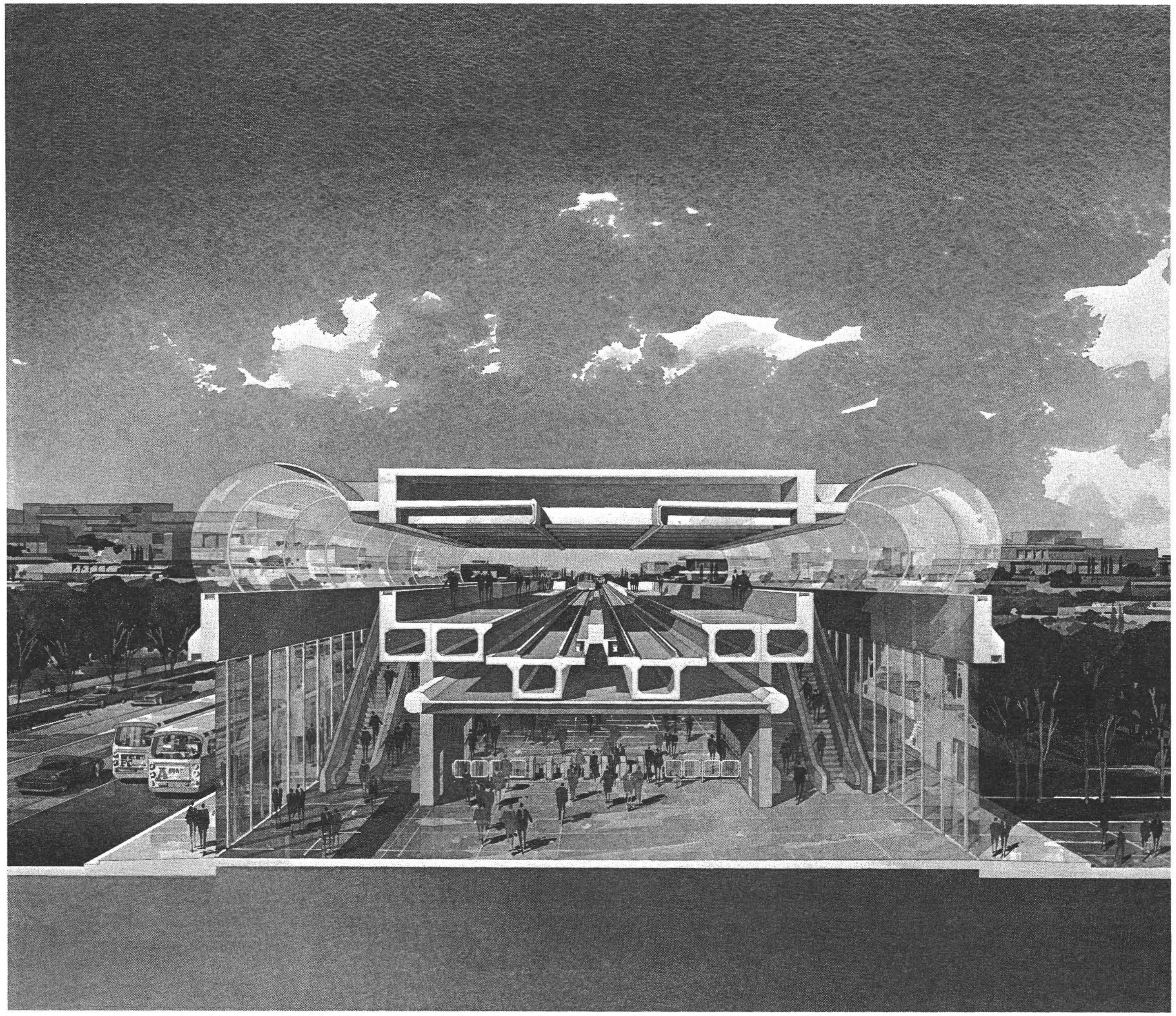


AIRPORT - SOUTHWEST





AIRPORT EXPRESS



TRANSIT FACILITIES

Transit facilities include the stations, the way structure, and the vehicles which together comprise the elements of the system having the most immediate and visual impact on both the rider and the community. The facilities also include all of the essential ancillary systems such as the electrification for power and propulsion, the control and communication systems, fare collection, air-conditioning and climate control of vehicles and subway stations, among others. They constitute the vital parts of the transit system which provide safety, comfort and reliability and combine with the visual impact of the system to make a trip via rapid transit a pleasant experience.

This section discusses the various transit facilities in considerable detail and indicates the process involved in reaching design conclusions. Each element was subject to detailed analysis and comparisons of alternative concepts and equipment as well as functional relationships to the system as a whole. In the case of stations and way structures, this analysis also involved the relationship of the system to the community and the surrounding neighborhoods.

STATION DESIGN

Stations are conceived to be incorporated into the community environment in a positive manner with the ability to be a strong design element adding visual scale to the neighborhood. The transit system may either blend, compliment, or contrast without being obstrusive, with the surroundings both initially and in the future. The multi-level concourse platform systems will allow for extensions, equipment additions, station enclosure and potential use of air rights around and over the station.

The basic function of the station is to accomplish a transfer between various travel modes for large numbers of people in the most direct manner, conveniently and quickly. A certain degree of standardization will establish an identity for the transit system as a whole and enable patrons to find their way easily, even in stations new to them. Standardization of certain elements throughout all stations is also necessary from the standpoint of economy and function. Continuity is achieved by the use of specific materials, certain standard items of equipment and prefabricated units, and similar orientation of spaces and their relationships in all stations. The best solutions are repeated where applicable and form the basis of the system. Site conditions, location, way structure type, and passenger volumes result in variations in the facilities within the framework of these established standards.

Station areas basically related to passenger movement are platforms, concourse area, and horizontal and vertical connections between these areas and the street or buildings. Visual connection between spaces and elements of the station have been given a high priority. Open mezzanines which bridge the platforms present both horizontal and vertical views to orient the passenger; high ceilinged platform spaces without obstructions reduce the sense of enclosure and, in subway facilities, a labyrinth of passages and spaces is avoided. Glassed access bridges afford visual openness in areas connecting concourse and platforms in the aerial and above ground stations. They also assist the movements of passengers between areas and contribute to his awareness and feeling of safety, reducing any apprehension and confusion. The passenger proceeds from one area of the facility to another, the areas articulated primarily by vertical separation and with some nodal definition achieved by volume and lighting. These spaces are adequately sized to allow passenger movement to be cyclic and discontinuous. A feeling of spaciousness, achieved through variations in height and width relating to functions of the stations, has been developed through a rigorous analysis and is the basis of the facilities design. Human sensibilities are the determining factor.

Skylights, openings and glassed area afford views of buildings, trees, and landscaped plazas; assist in the passenger recognition of the internal organization of the facility; and allow awareness of the station as part of the community and landscape. It is essential that the transit facilities, like the system as a whole, perpetuate the vitality of the City. A major effort has been made to make the facilities equatable with the rest of the cities artefacts.

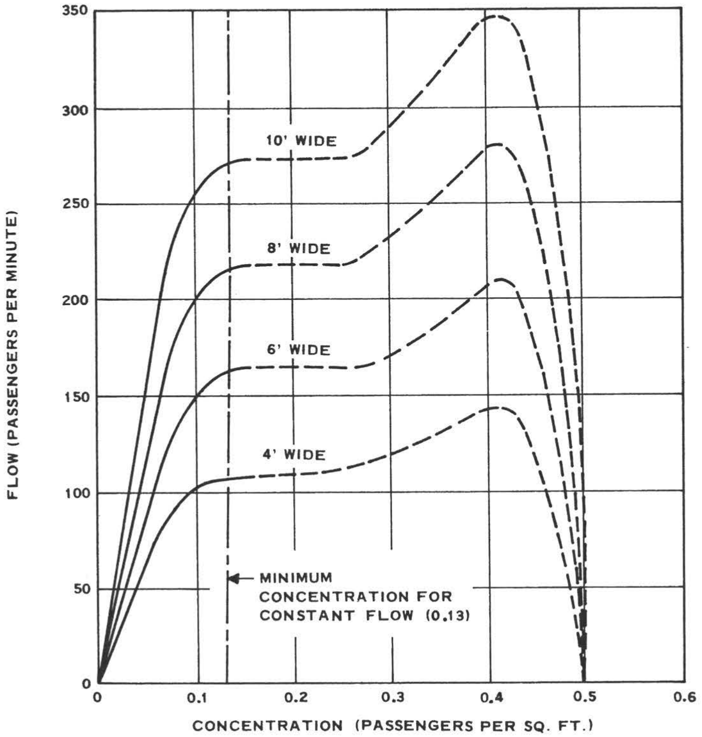
FUNCTIONAL REQUIREMENTS

Station efficiency depends upon passenger circulation in a logical and direct manner through spaces of adequate size with proper internal organization. The determination of these sizes and circulation patterns has received particular emphasis and analysis.

Horizontal Circulation

Normal walking speed adjusts with changing concentration such that nearly constant flow is maintained once the practical maximum concentration level is reached. For passages over 4 feet wide, maximum unrestricted flow is directly proportional to width and is rated at 27 persons per minute per foot of width. In actual application, average walking speed is constant (free flow speed of 3.6 miles per hour) up to a certain concentration. These flow relationships are shown in Figure 1. The flat portion of the flow curve results from the fact that the rate of decrease of walking speed, which accompanies the increase in concentration, produces a constant passenger flow rate over a wide range of speed versus concentration relationships. The minimum level of concentration to produce constant flow represents the optiumum relationship of these factors. At concentrations greater than this minimum some penalty is incurred, usually in the walking speed and, therefore, in total time required for a passenger to clear the station.

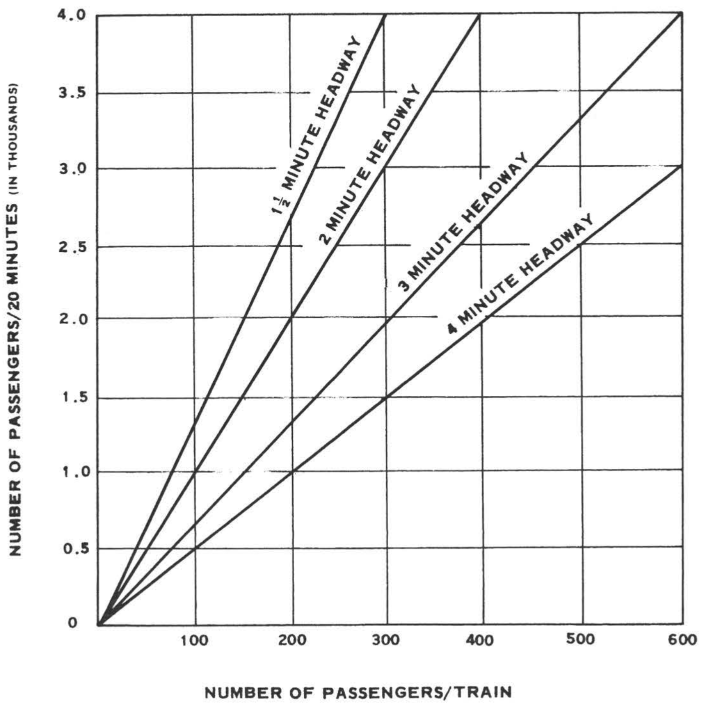
FIGURE 1 **PASSENGER FLOW IN LEVEL PASSAGES**



Passenger Volume

Station areas, the width of platforms, number of escalators, quantity of turnstiles and related equipment and the amount of space devoted to runoff and queuing are all governed by the need to limit delay in movement through the station. In this system, the desired high quality of service has established that this delay must not exceed an accumulated total of 30 seconds beyond normal traversing time. The 30-second delay factor imposes a stringent design requirement upon the passageways and equipment within the stations. The average number of passengers per train and a calculated "peak accumulation" are important in determining the width of platform, the number of escalators and, in turn, the number of turnstiles. It is apparent from Figure 2 that passenger concentration at any one time related to projected station volume is a direct function of train headways. Because of the peaking nature of transit patronage, the maximum number of arrivals that can be expected is taken to be one and one-third times the average within the 20-minute peak.

FIG. 2 **AVERAGE NUMBER OF PASSENGERS PER TRAIN AS A FUNCTION OF VOLUME AND HEADWAY**



Station Platforms

The 600 foot platform capable of accommodating an eight car train will be side or center loaded. Passenger distribution combined with boarding and alighting efficiency affect dwell times and are important in relation to system line capacity. To eliminate all normal sources of delay, platforms are designed to allow for non-walking surfaces such as the space occupied by seating area, safety strips, persons standing on the platform prior to boarding, two-way flow of arriving and departing passengers, accumulation around train doors during boarding and alighting, and cross flow to and from the escalators. A maximum standing density of 2 square feet per person would theoretically allow 3000 people on a typical side platform and over 6000 on a typical center platform. Factors of safety, psychology, aesthetics, economy and structure related to sizes established for existing and projected systems, resulted in a design factor of .067 passengers per square feet (15 square feet per person). This will allow an occupancy of 400 passengers at one time (approximately 2500 passengers per 20 minutes) for a typical side platform station or an average of 1000 passengers at one time for a center loaded subway station. These are above operating capacity of the system and allow adequate capacity for exiting of total platform and train passengers under emergency conditions.

The expected distribution along the platforms for boarding passengers will be dependent upon platform width and escalator positions, but in addition will be governed by train occupancy, destination station layout and available seating. Door capacity allows 20 people per 4' - 6" door to alight or board in the 20 second dwell period, (15.5 seconds being allocated for the time the doors are open). For the eight car peak hour train, 480 passengers can board or alight. Passengers will distribute themselves along the platform to board and travel comfortably.

Eleven feet has been determined as the minimum distance between a continuous obstruction and the edge of the platform. Intermittent obstructions will be permitted as close as nine feet. Center platforms will be limited to a minimum width of twenty-two feet plus additional width as may be dictated by placement of stairs and escalators.

STATION EQUIPMENT

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.

Station equipment is selected and arranged to satisfy the following conditions:

- Simplification of the fare collection operation.
- Comprehension by the patrons.
- Sufficient flexibility for expansion or equipment conversion.
- Ease of control and surveillance.
- Practical economy and maximum passenger convenience.

All escalators throughout the system will be:

- Capable of operating at speeds of 90 and 120 feet per minute.
- Considered as having an actual capacity of 100 and 135 persons per minute at the rated speeds.
- 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.
- 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.

In those stations where projected volume requires multiple escalator installation, they will be reversible and operated in the direction of the peak load. However, each platform will have a minimum of one escalator operating in each direction.

There is 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 will be monitored in the station attendant's office.

The required number of escalators is directly related to station passenger volume and headway as shown in Figure 3. The number of escalators has been based on the passenger volume boarding and alighting per inbound or outbound train and the necessity to clear the platform without causing the accumulated total delay to exceed 30 seconds. Projected peak boarding and alighting numbers are reversed for A.M. and P.M. movements. Escalators and other equipment are sized for different surge characteristic of the peak passenger movements depending on whether they result from passengers alighting from a train, coming from the street, or are metered by another piece of station equipment.

In the smaller stations where the escalators are located near the center of the platform, the median walking distance is 150 feet. However, due to the riding habits of the regular commuter, more passengers will alight in the vicinity of the escalators than at the extreme ends of the platform. The average walking distance can be estimated at 100 feet and requires a walking time of 20 seconds at 3.5 mph.

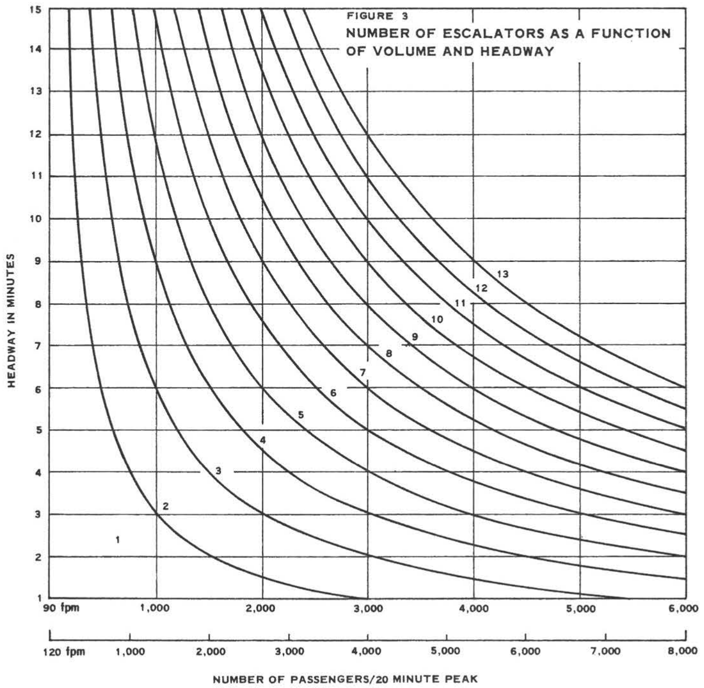


FIGURE 3
NUMBER OF ESCALATORS AS A FUNCTION OF VOLUME AND HEADWAY

All portions of the station are designed for the projected loadings except that 900 passengers in the primary direction alighting in the peak 20 minutes is considered minimum. Peak volumes less than 900 are used, where indicated, only for sizing fare collection equipment.

The concourse level primarily functions as the ticketing area of the station and allows passenger access vertically by escalators directly to the train platforms. The fare system necessitates the checking of all passenger tickets at both entry and exit by insertion of tickets into automatic fare equipment.

The location of the various fare devices at the concourse level area:

- Money changers - Located in the free area at one or both ends of a row of vendors, nearest approaching passengers.
- Fare vendors - Located in the free area, clearly visible upon entering, and placed so as not to impede the direct flow between the entrance from the street and the turnstiles. All fare vendors and adjacent changers are built flush into one wall of a vault or secure room with a minimum of 4'-0" wide access behind for money removal and maintenance.
- Transfer Equipment - Located in the paid area, just off the line of exit flow from each of the escalators to the turnstiles.

- Turnstiles - Located across the line of direct flow as the primary barrier between the free area and the paid area, and in such a manner as to provide maximum surveillance with a minimum of personnel.
- Ticket reader - Located in the attendant's office.

Description of Fare Collection Equipment:

- Money Changers

  Quantity - one changer per two ticket vendors
  Rate of Operation - four to six persons per minute
  Queue space - 8'-0"
  Dimensions - approximately 3'-0" wide x 2'-6" deep x 6'-0" high
  Spacing - 4'-0" on center

- Ticket Vendors

  Quantity - one vendor per 250 boarding passengers in the peak 20-minute period
  Rate of Operation - four to six persons per minute
  Queue space - 8'-0"
  Dimensions - approximately 3'-0" wide x 2'-6" deep x 6'-0" high
  Spacing - 4'-0" on center

- Transfer equipment

  Quantity - one transfer dispenser in each paid area per 500 passengers in the 20-minute peak period
  Rate of Operation - 40 per minute
  Queue space - 6'-0"
  Dimensions - approximately 30" wide x 30" deep x 3'-6" high
  Spacing - 3'-0" on center

- Turnstiles

  Operating in direction of primary flow
  Quantity - Three turnstiles per escalator from the platform - initial
  - Provision is made for future installation of one additional turnstile per escalator from the platform

  Operating in direction of reverse flow
  Quantity - One turnstile per 340 reverse flow passengers in the 20-minute peak period
  - Provide for future installation of additional turnstiles
  Rate of Operation - Entrance - 30 passengers/minute
  - Exit - 30 passengers/minute
  Queue space - 20'-0" each side
  Dimensions - approximately 14" wide x 56" long x 38-1/2" high
  Spacing - 31" on center

- Service Gate

  Quantity - one per Paid Area. Available for use by the handicapped, maintenance and service staff, emergency crews, etc

- Emergency Exit Gates

  Quantity - To provide satisfactory means of escape in emergency. Exit gates are located adjacent to the turnstiles and are equipped with panic release hardware and audible alarms.

- Ticket Reader - Attendant's office

  Quantity - one per attendant's office
  Rate of Operation - 4 to 6 passengers/minute
  Dimensions - 3l" high x 22" deep x 15" wide for under counter installation.

MATERIALS

Materials have been selected so that quality and maintenance requirements will be consistent throughout the system and to satisfy standards of safety, durability, ease of maintenance, economy, and aesthetics.

The design of the facilities and materials selected are related to economy and technologies of mass production consistent with human use and occupancy. Mass production is used to allow a range of interchangeable options rather than relentless repetition of an invariable product. These options will permit design which responds to similar requirements for different configurations of the stations. Where possible, the materials are prefabricated and those which require painting are avoided. Minimum use is made of materials where control of the finished surface is difficult. Materials have been selected with characteristics to meetthe following criteria:

Safety

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

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

- Durability

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

- Ease of Maintenance

  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.

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

- Aesthetic Qualities

  To create a feeling of good quality and attractiveness.

  Surfaces are hard, dense, non-porous, acid and alkali resistant for long life and low maintenance. Colors are predominantly light in tone to aid in maintaining high illumination levels.

  Texture of materials is 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 is large enough to minimize the number of joints and small enough to make the units easy to replace.

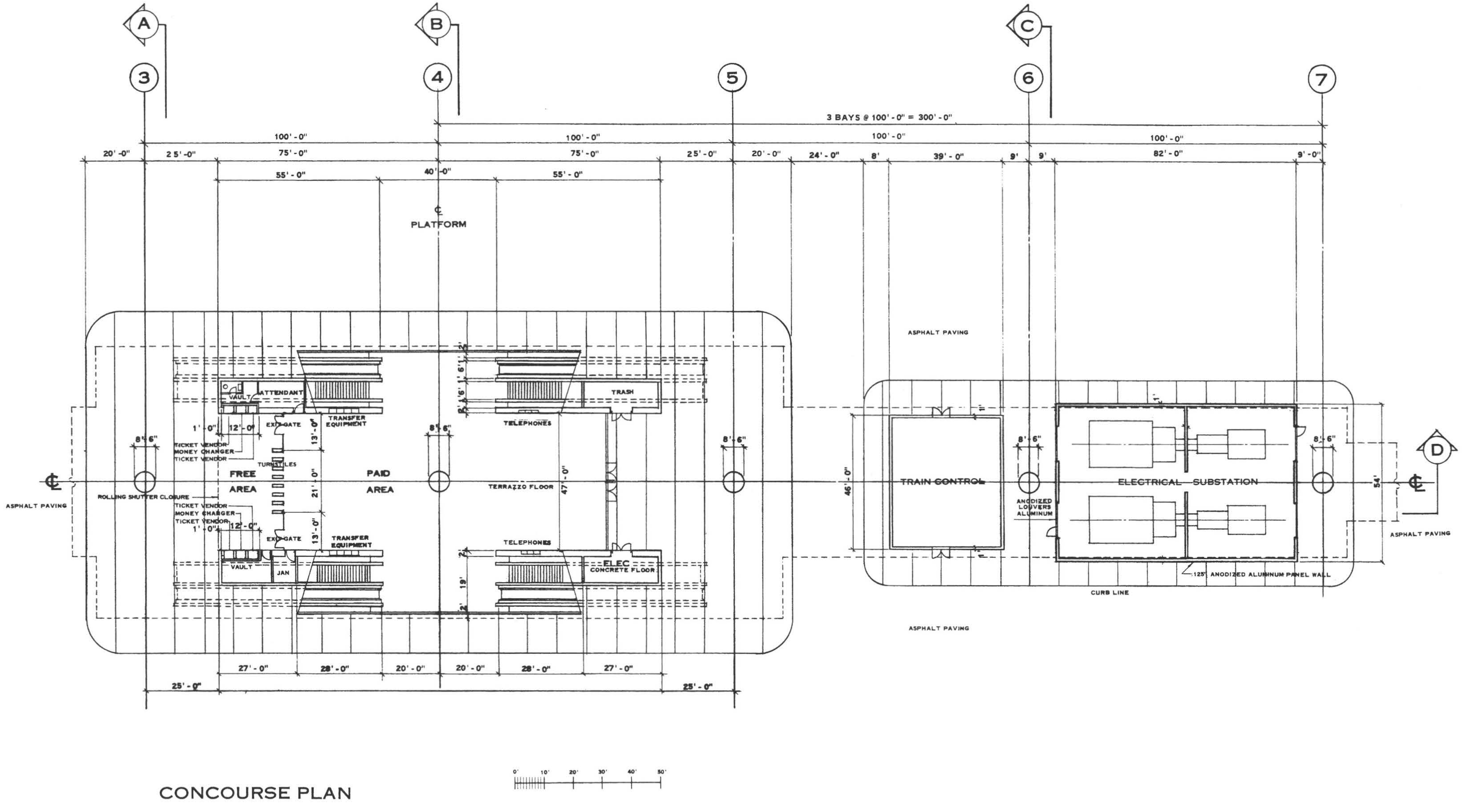
  Joints are small, flush, limited in number, and of material that will not produce unsanitary cracking.

  Precast concrete, terrazzo, glass, anodized aluminum and stainless steel are the basic materials for the transit facilities.

  Costs are consistent with the useful life, overall aesthetic and functional qualities.

TYPICAL STATIONS

These basic parameters, combined with the design elements, have guided the architectural treatment of stations throughout the system. In addition, each station must reflect the way structure configuration with which it will be used. This has resulted in development of four basic station configuration which were then adapted to meet individual site requirements of passenger volume, site area, and relationship to other modes of travel feeding the station.



CONCOURSE PLAN

AERIAL

The aerial way structure provides structural economy when the track centers are kept to the minimum 14-foot dimension. The maintenance of this standard at as many aerial stations as possible provides the most dominant design feature to be found in this series of facilities; that is, side platforms with separate sets of escalators and stairs which lead directly to the PAID AREA of the concourse below or to an intermediate level and overcrossing which in turn leads to a detached concourse. A description of these two conditions and their locations in the system follows. The former is applicable to stations in private right-of-way, and is illustrated on these two pages with plans and sections of the preliminary design. The latter version is used when the alignment is in a street median.

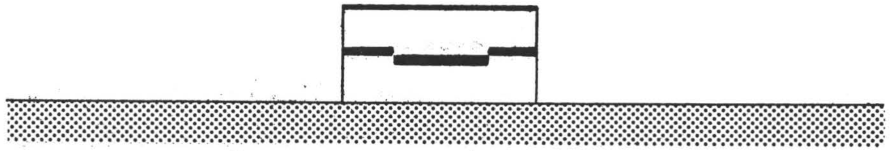
Aerial, side platforms, concourse under (ASU)

The concourse plan illustrates a typical arrangement of the public and non-public areas. The space noted as FREE AREA contains the fare vending equipment and money changers as well as a display of the fare and operating schedules. Tickets are purchased in this area and used to activate the turnstiles and admit transit patrons to the PAID AREA which includes the escalator lobby at the concourse level and the platforms at the track level. The station attendant's office is accessible to patrons in either the FREE or PAID AREAS who have need of assistance or additional travel information. At all station turnstiles and escalators, there will be lighted enunciators to indicate the direction of travel for which they are set to operate.

Loading platforms are 600 feet long. A weather protective enclosure is provided at all aerial stations for the stairs, escalators and the center 200 feet of platform. The platform width is 11 feet, including the one foot-wide safety strip on the edge nearest the track.

The remaining areas are devoted to operational and maintenance activities and include the vaults which provide access to the rear of the fare vendors, rooms for storage, janitorial equipment and supplies, trash awaiting collection, mechanical, electrical, automatic train control equipment and the traction power substation.

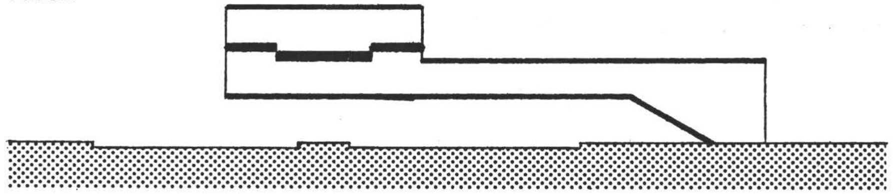
This facility is typical of that for the NORTH HOLLYWOOD, BURBANK BOULEVARD, VAN NUYS and SHERMAN CIRCLE stations on the San Fernando Valley route, the EXPOSITION, INGLEWOOD and ROSECRANS stations on the Airport-Southwest route and the ADAMS, VERNON AVENUE, GAGE and FIRESTONE stations on the Long Beach route.



Aerial, side platforms, concourse detached (AST)

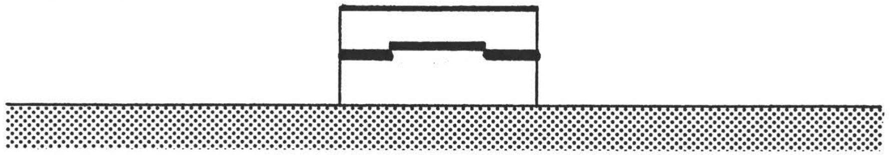
Stations located in street medians normally have their ticketing facility detached from the main structure and located on property beside the street right-of-way. Such medians are seldom wide enough to accommodate the entire concourse and, in any event, would present a severe visual barrier to street traffic unless the entire structure were elevated. Grade-separated access is required in either case and since tunnel undercrossings are favored by neither the public nor city agencies, an overcrossing is used to connect the concourse structure with the elevator lobby below the platform. All nonpublic areas are housed within the detached building.

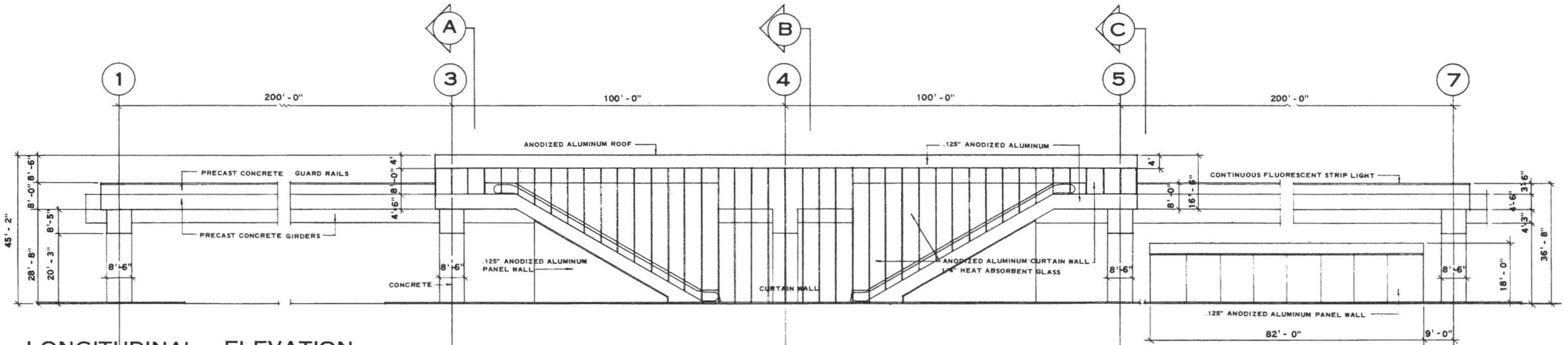
This design is used at the DEL AMO station on the Long Beach route, at the CRENSHAW-54th, MANCHESTER, CENTURY and EL SEGUNDO stations on the Airport- Southwest route and at LAUREL CANYON, FULTON, SEPULVEDA, BALBOA, LINDLEY and TAMPA on the San Fernando Valley route.



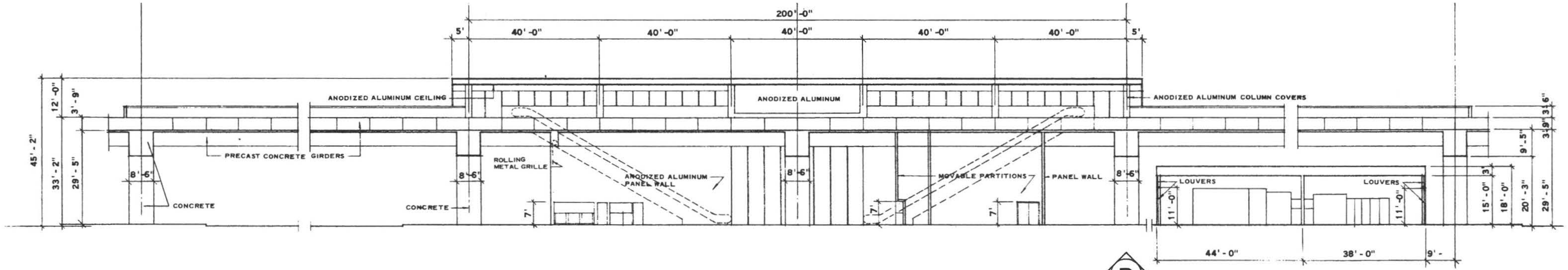
Aerial, center platform, concourse under (ACU)

A third type of aerial station has been dictated by special site or design considerations and employs a center platform with the ticket concourse beneath it. It is appropriate where the tracks are already separated or may be separated without paying a premium in land or structure. The UNIVERSAL CITY station is located between a tunnel portal and a turnback-track, both of which cause the mainline tracks to be spread sufficiently to accommodate a center platform. The IMPERIAL station has the approaching trackage on-grade in the median of the proposed Industrial Freeway. The station and the adjacent roadways form a bridge between two sections of embankment. The ticket concourse and access is at street level beneath the freeway structure. The EL MONTE station is the present terminal for the San Gabriel Valley route. Very high patronage projections and an extremely unidirectional flow (AM boarding, PM alighting) dictated the use of a center platform which permits maximum utilization of the platform area and escalator equipment and simplifies the movement of passengers where train arrivals and departures alternate between the two tracks on either side of the platform. The concourse immediately below the platform is elevated above the ground level. Access is by escalator from the vehicular loading area below and by an overcrossing with a moving walk extending the length of the parking area to the south.





LONGITUDINAL ELEVATION



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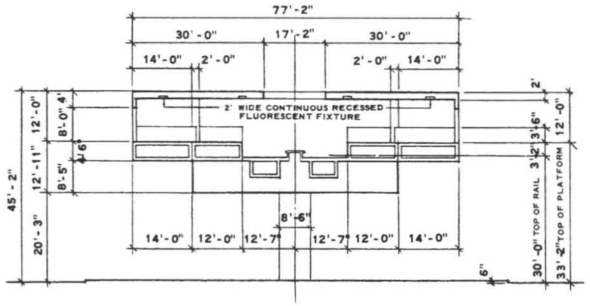

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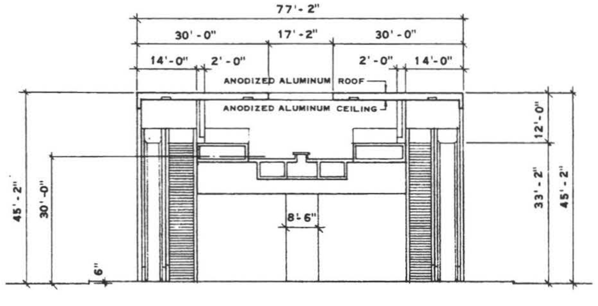

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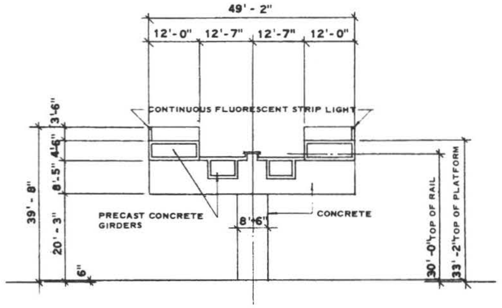
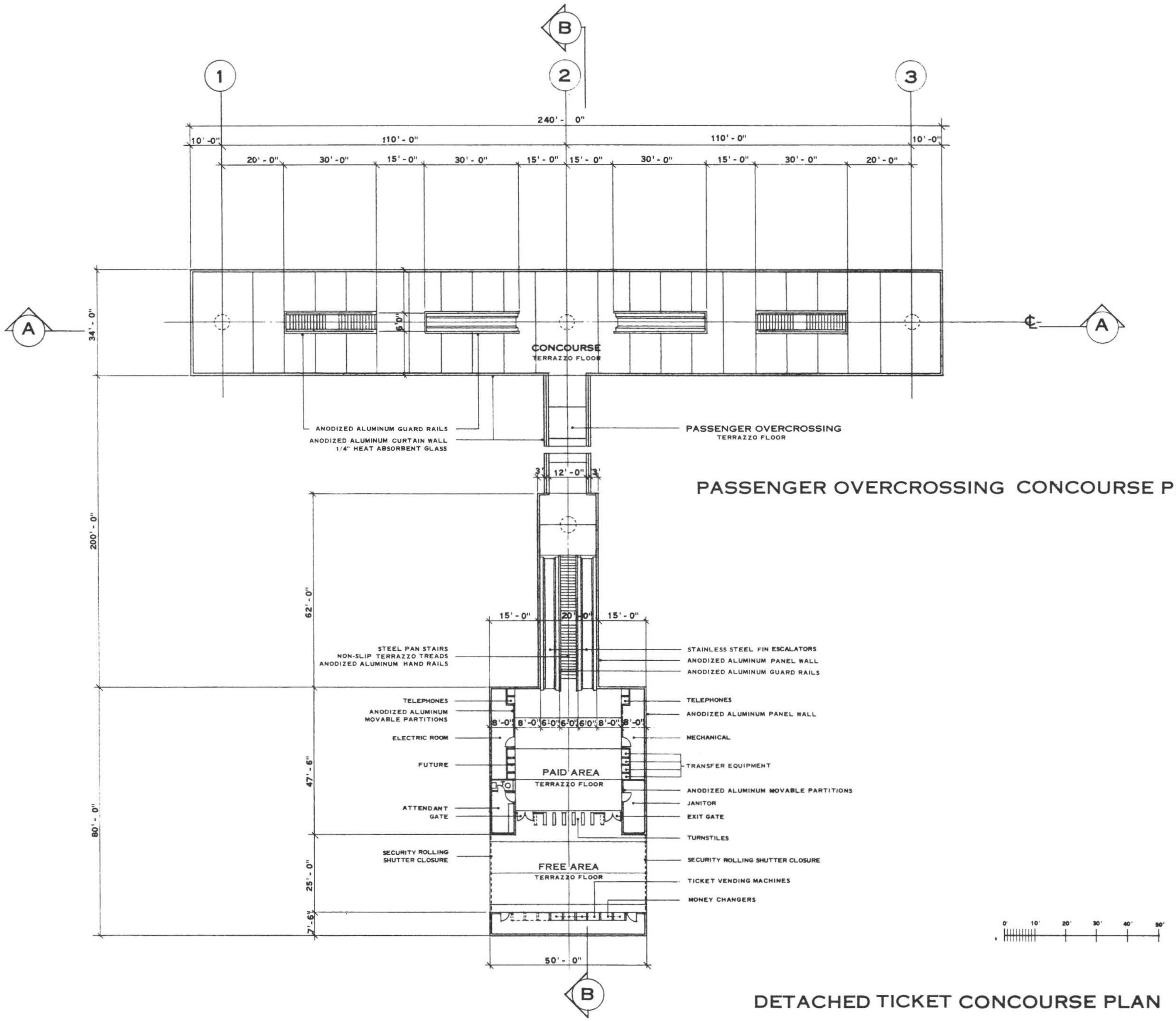


C CROSS SECTION

0' 10' 20' 30' 40' 50'



PASSENGER OVERCROSSING CONCOURSE PLAN

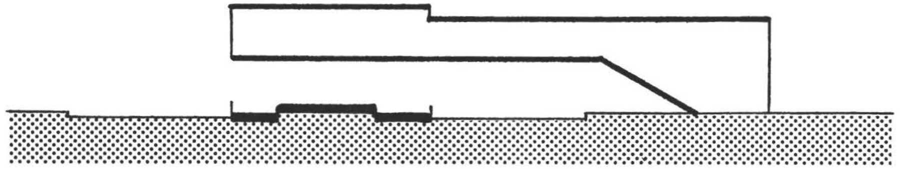
DETACHED TICKET CONCOURSE PLAN

ON-GRADE

In the nomenclature of the report, the term on-grade refers to the trackage and platform location at existing ground level. Normal access is from above and results in most of the station facilities being elevated. Rights-of-way alongside or in the median of thoroughfares which have existing or proposed total grade separation have been used to excellent advantage in the system. In all cases where this basic design is utilized, an escalator lobby over the platform provides weather protection of a portion of the loading area below and is connected to the actual station entry on either or both sides of the thoroughfare by an enclosed pedestrian overcrossing. The substation and train control rooms are below grade at the end of the platform.

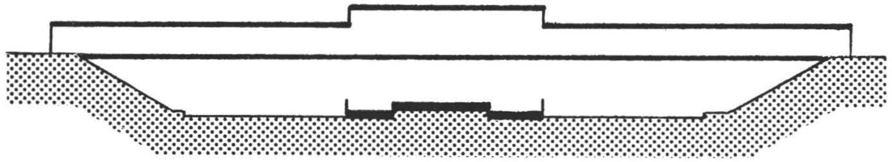
On-grade, center platform, detached concourse.(GCT)

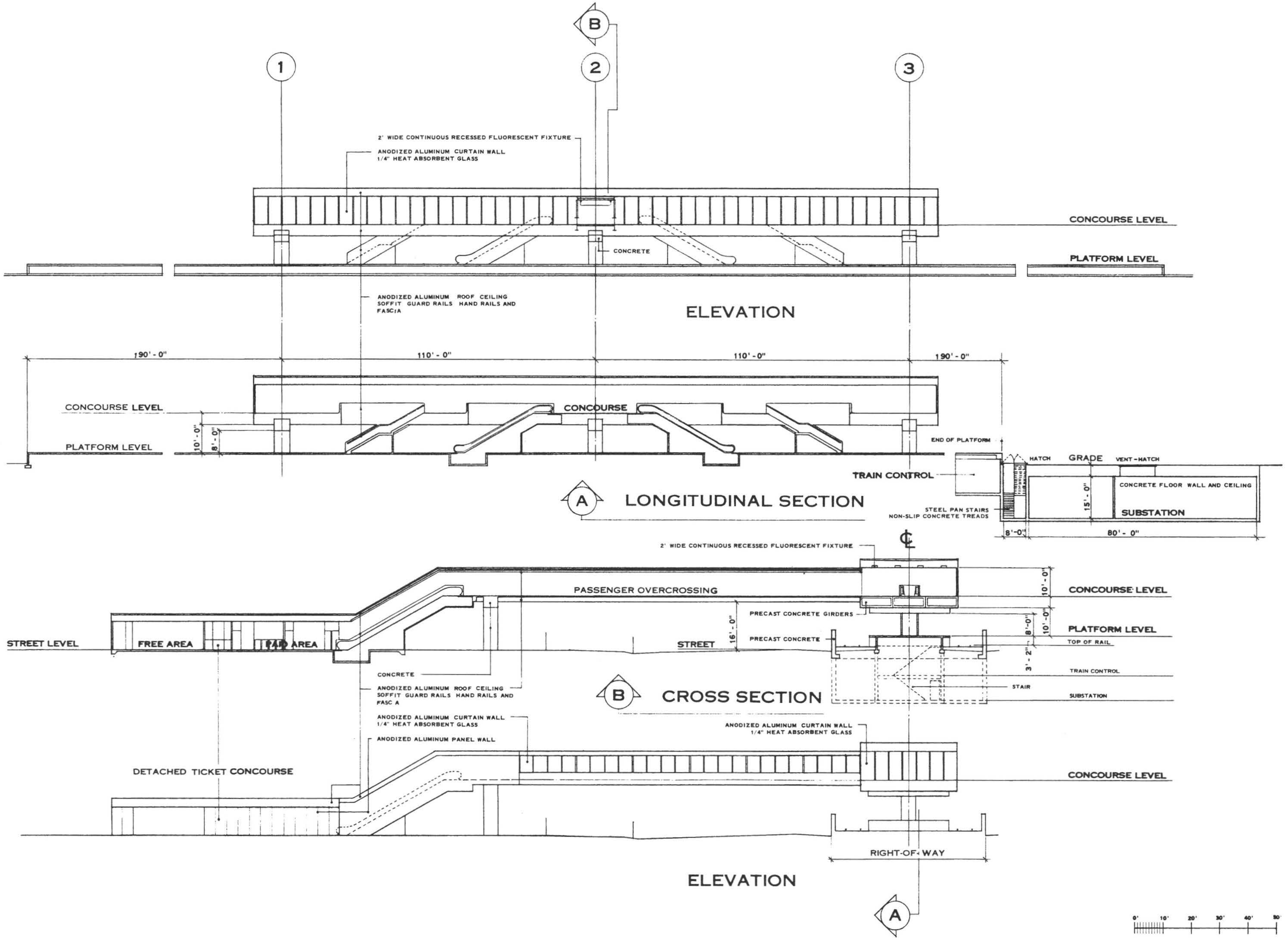
Where access is required to one side only, the ticketing facility is located at the point of entry. The drawings on these two pages illustrate this concept. Local site conditions dictate minor variations. At the FREMONT, SAN GABRIEL, and ROSEMEAD stations in the San Gabriel Valley Corridor, the overcrossing spans one side of the San Bernardino Freeway and provides escalators to descend to the ticket concourse on-grade beside the freeway. The COUNTY HOSPITAL station on the same route lies between an embankment and the Southern Pacific right-of-way. The overcrossing is at street level and escalators are not required at the ticket concourse. The WATTS station on the Long Beach Corridor is located in a cut section of the proposed Industrial Freeway and the overcrossing similarly lands at street level. Two other stations on the same route, WARDLOW and PACIFIC COAST, are located between the levee of the Los Angeles River and the proposed De Forest Drive. The overcrossing spans both north and southbound lanes and connects to the ticket concourse on land acquired for parking and bus access.

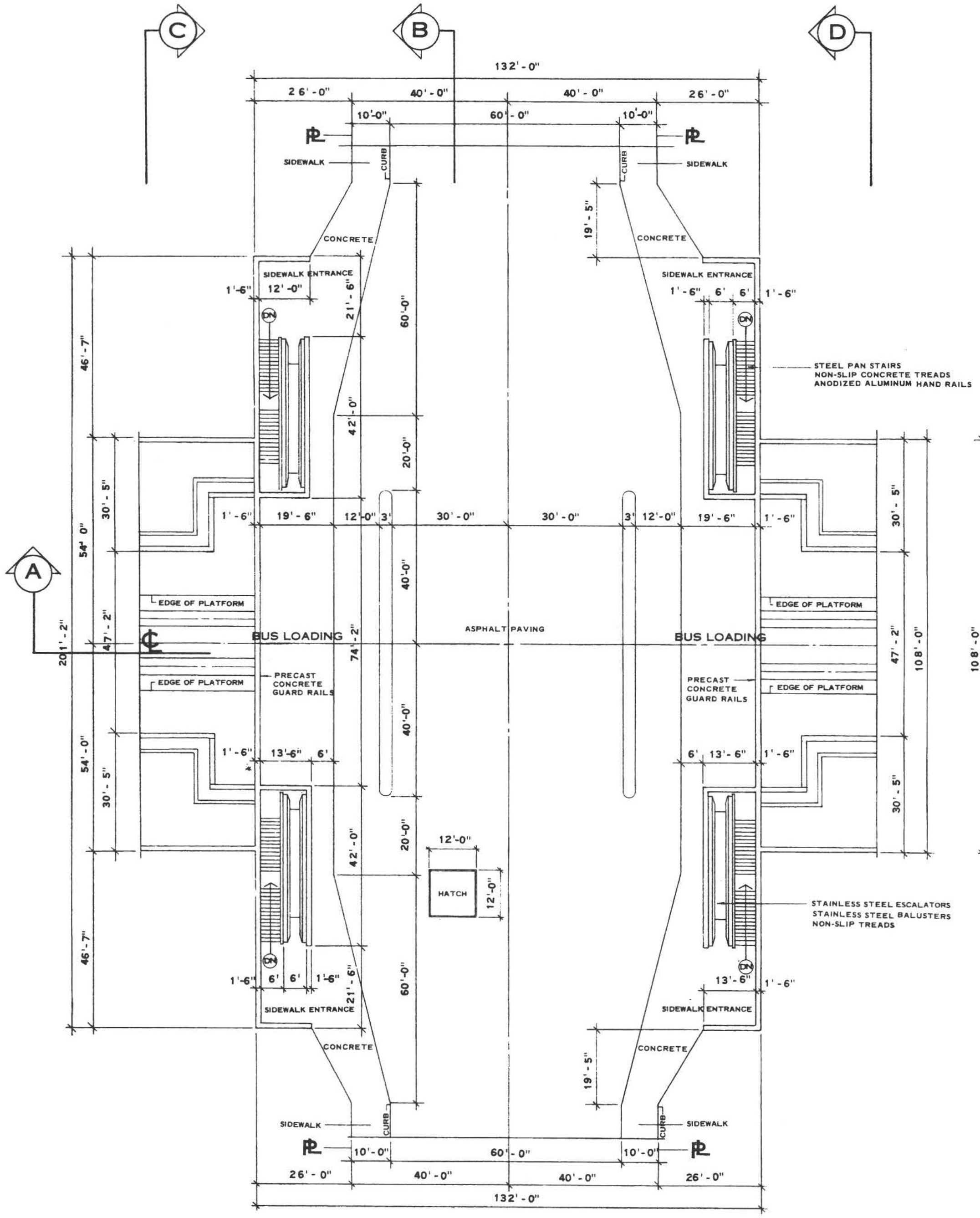


On-grade, center platform, concourse over. (GCO)

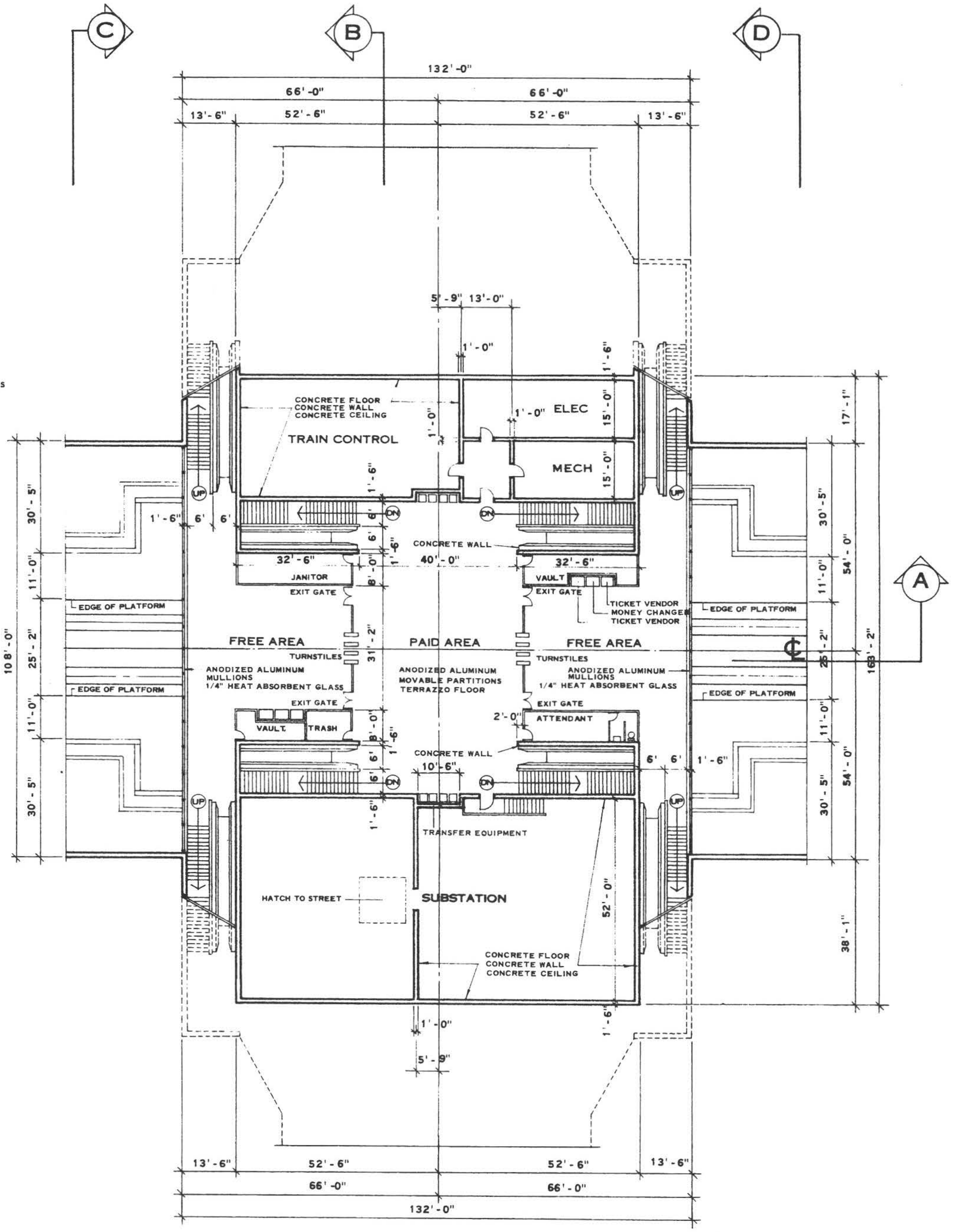
Where access is required from both sides of the freeway or transit right-of-way, the ticketing facility has been incorporated in the elevated structure over the platform to avoid duplication of the fare vending and fare collecting equipment. Both overcrossings are within the FREE AREA and will facilitate use of the bus operation independent of the rail system. At STATE COLLEGE station on the San Gabriel Valley line, the overcrossing to the north side leads to escalators which carry up the embankment and discharge at a landing in the campus parking lot. The crossing to the south side descends with escalators to a traffic island which accommodates buses on one side and kiss-and-ride vehicles on the other. The GARFIELD station on the same route has crossings to both the north and south sides of the San Bernardino Freeway with escalators descending to station entrances. The COMPTON station on the Long Beach line, located in a cut section of the proposed Industrial Freeway, has a similar requirement for access from both sides. However, the overcrossings are at street level and require no escalators at the points of entry.




B
1
2
3
2' WIDE CONTINUOUS RECESSED FLUORESCENT FIXTURE
ANODIZED ALUMINUM CURTAIN WALL 1/4" HEAT ABSORBENT GLASS
CONCOURSE LEVEL
CONCRETE
PLATFORM LEVEL
ANODIZED ALUMINUM ROOF CEILING SOFFIT GUARD RAILS HAND RAILS AND FASCIA
ELEVATION
190' - 0"
110' - 0"
110' - 0"
190' - 0"
CONCOURSE LEVEL
CONCOURSE
PLATFORM LEVEL
10' - 0"
8' - 0"
END OF PLATFORM
HATCH
GRADE
VENT-HATCH
TRAIN CONTROL
CONCRETE FLOOR WALL AND CEILING
15' - 0"
SUBSTATION
STEEL PAN STAIRS NON-SLIP CONCRETE TREADS
8'-0"
80' - 0"
A
LONGITUDINAL SECTION
℄
2' WIDE CONTINUOUS RECESSED FLUORESCENT FIXTURE
PASSENGER OVERCROSSING
10' - 0"
CONCOURSE LEVEL
PRECAST CONCRETE GIRDERS
8'-0"
10'-0"
PLATFORM LEVEL
16' - 0"
STREET LEVEL
FREE AREA
PAID AREA
STREET
PRECAST CONCRETE
TOP OF RAIL
3' - 2"
TRAIN CONTROL
STAIR
SUBSTATION
CONCRETE
ANODIZED ALUMINUM ROOF CEILING SOFFIT GUARD RAILS HAND RAILS AND FASCIA
B
CROSS SECTION
ANODIZED ALUMINUM CURTAIN WALL 1/4" HEAT ABSORBENT GLASS
ANODIZED ALUMINUM PANEL WALL
ANODIZED ALUMINUM CURTAIN WALL 1/4" HEAT ABSORBENT GLASS
DETACHED TICKET CONCOURSE
CONCOURSE LEVEL
RIGHT-OF-WAY
ELEVATION
A
0'
10'
20'
30'
40'
50'



STREET LEVEL PLAN



CONCOURSE LEVEL PLAN

OPEN CUT

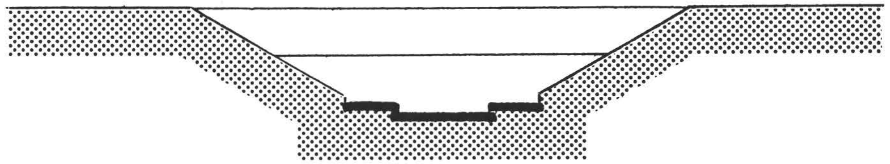
The relationship of street, concourse and platform levels of the open cut station is similar to that found in typical subway stations. An important exception is the natural light and ventilation obtained with this design. The lone section of landscaped cut configuration in the initial system, that portion of the San Fernando Valley Corridor running north from Wilshire Boulevard, has stations at BEVERLY BOULEVARD and SANTA MONICA BOULEVARD.

Excavated cut, side platforms, concourse over platforms.(XSO)

The street plan, as shown on the left, illustrates that this type station begins as a vehicular bridge is made wider to accommodate bus lanes, stairs and escalators and is given a second level to house the concourse and non-public areas. Separate escalators, fare vending equipment and turnstile banks in the two FREE AREAS permit both eastbound and westbound bus passengers to enter the rapid transit system without crossing the boulevard at street level and thus eliminate the need for any form of traffic control that would slow the progress of surface vehicles.

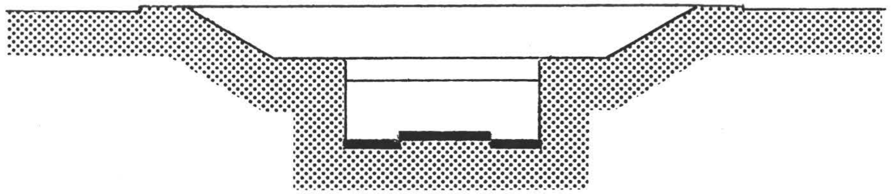
The non-public areas are contained within the bridge structure under the street thus minimizing land acquisition and simplifying access to the electrical substation through a street hatch.

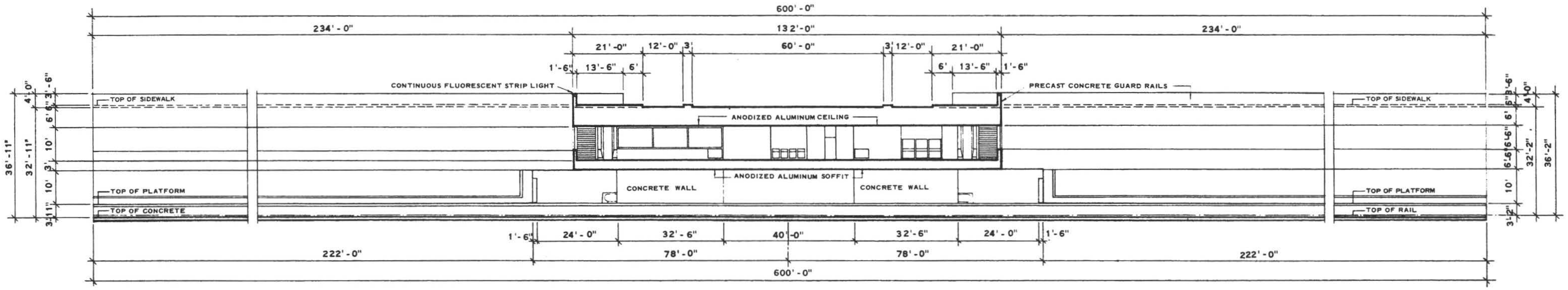
During the period the system is not operational, rolling shutter closures form a barrier at the sidewalk entrances.



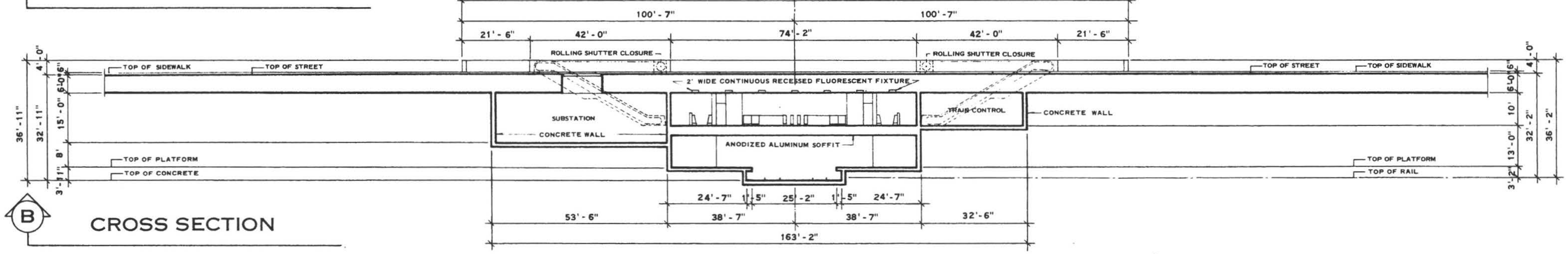
Excavated cut, center platform, concourse over. (XCO)

A modification of this design is employed at the HOLLYWOOD-LA BREA station. The site occupies an entire block and, though the alignment is in subway on either side of the station, the platform has been opened to natural light and air. Separate concourses at each end have access from a landscaped park surrounding the station facility. The curb perimeter is reserved for bus and auto loading zones.





A LONGITUDINAL SECTION



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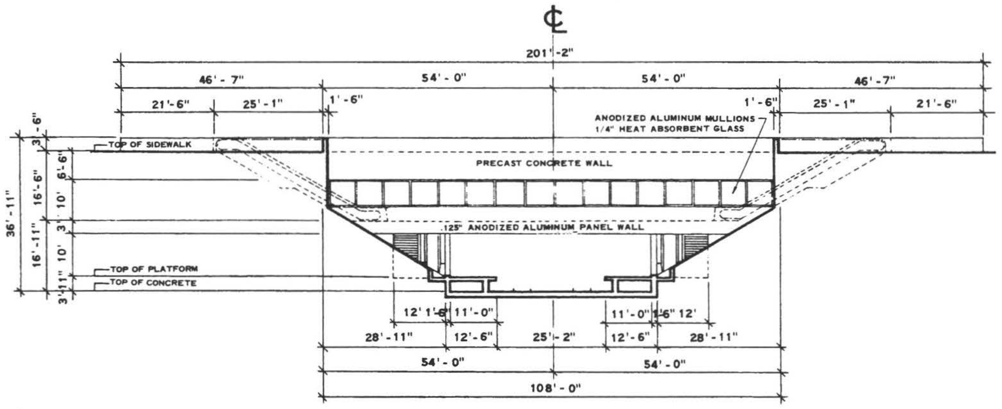

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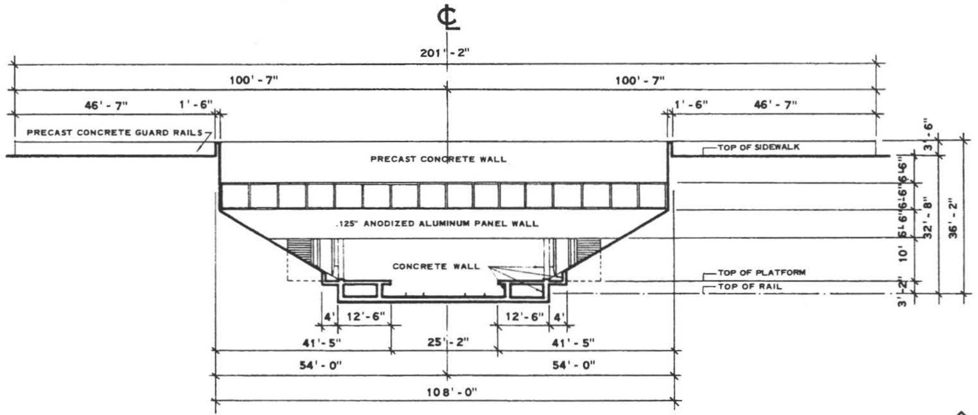
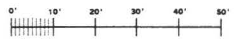
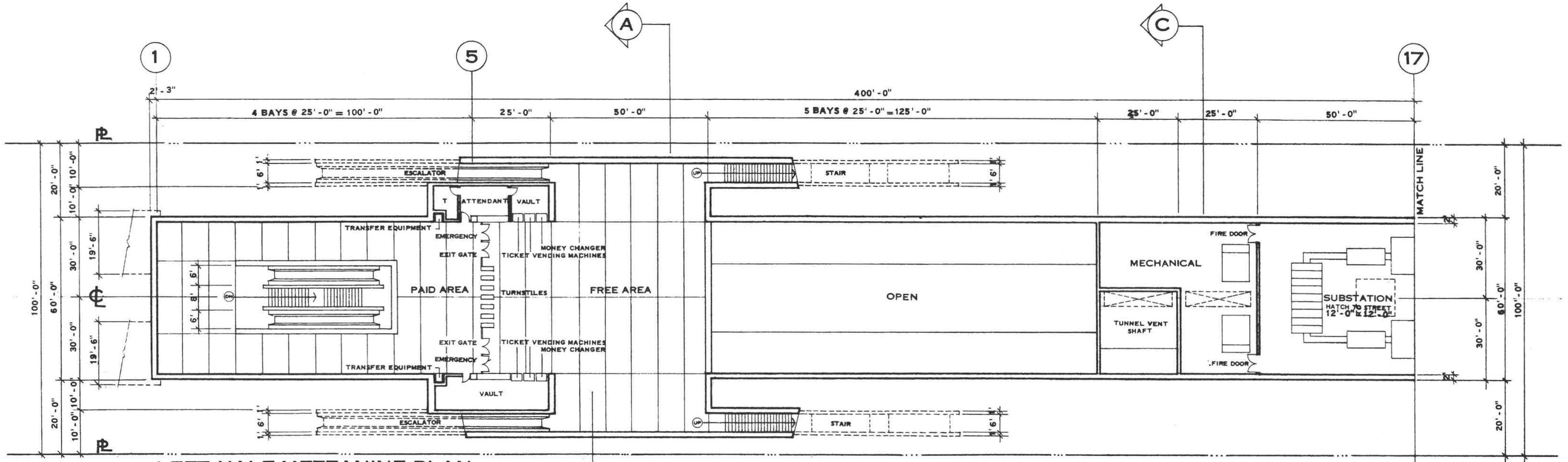
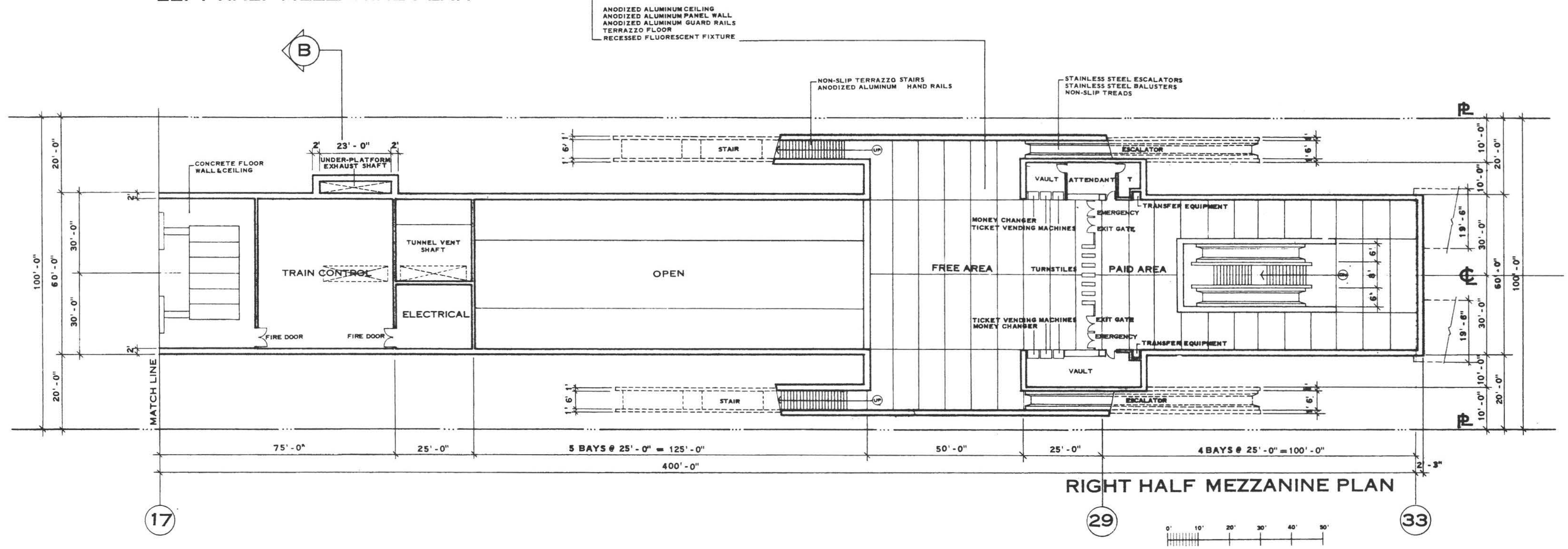


CROSS SECTION D





LEFT HALF MEZZANINE PLAN



RIGHT HALF MEZZANINE PLAN

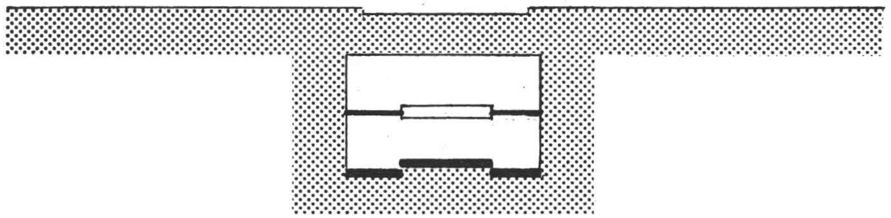
SUBWAY

The design of a typical subway station begins with the recognition of the requirement to construct a two and sometimes three-story building beneath the streets of an established metropolitan area where existing footings, storm drains and sewers as well as many non-gravity utilities must be maintained throughout the construction period. Despite these complexities, a typical design has been conceived and adapted to nearly all sites with only a few variations and exceptions.

Subway, center platform, concourse above (BCO)

The drawings on these two pages illustrate this typical design. Sidewalk entrances are shown although, wherever feasible, provisions are made to reduce sidewalk congestion through the use of off-street entrances. These disbursed points of entry lead to ticketing concourses at each end of the station. Turnstiles admit patrons to the PAID area where escalators carry them to the end-loaded platform below. Train screens are employed to separate the heat and air blast of approaching trains from the station interior. Stations to which these drawings generally apply are ALVARADO, VERMONT, WILSHIRE-WESTERN, LA CIENEGA, BEVERLY HILLS, CENTURY CITY, WESTWOOD, BARRINGTON on the Wilshire Line, OLYMPIC, WASHINGTON and LONG BEACH on the Long Beach line and the CONVENTION CENTER station on the Airport-Southwest Corridor. Special conditions dictate alternate placement of the mechanical and electrical areas in otherwise similar solutions at stations at FAIRFAX and NORMANDIE on Wilshire Boulevard. The CIVIC CENTER station is an expanded version to accommodate a very high patronage estimate in an L-shaped structure which serves trains on both the Wilshire and Airport lines. The VINE station in Hollywood utilizes the end-loaded platform concept but has the ticketing facilities flanking the upper level of the station at its center.

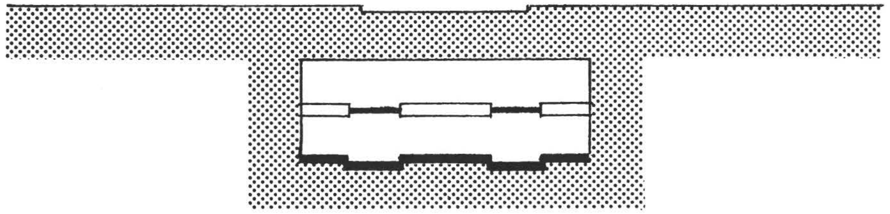
A modification using a center-loaded platform with a single ticket concourse is considered adequate for the minimum loading projections developed for the stations at WILSHIRE-CRENSHAW, WILSHIRE-LA BREA, LUCAS and UNION STATION. A larger version has been developed for the BUNKER HILL station in conjunction with an underground parking structure.



Subway, side and center platforms concourses over (BSCO)

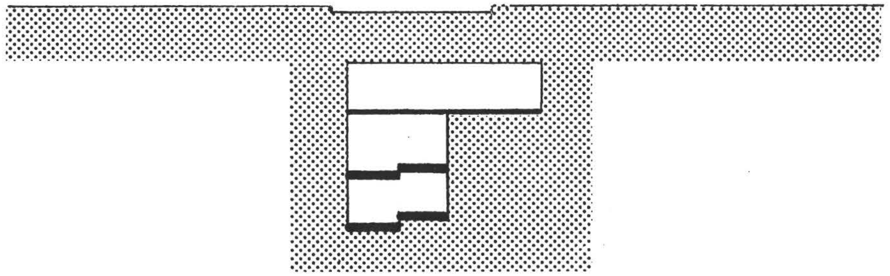
The configuration of the 7th and FLOWER station was influenced by three primary factors: a very high patronage projection, its location at the juncture of the Wilshire and Airport routes and its status as the main transfer point in the system.

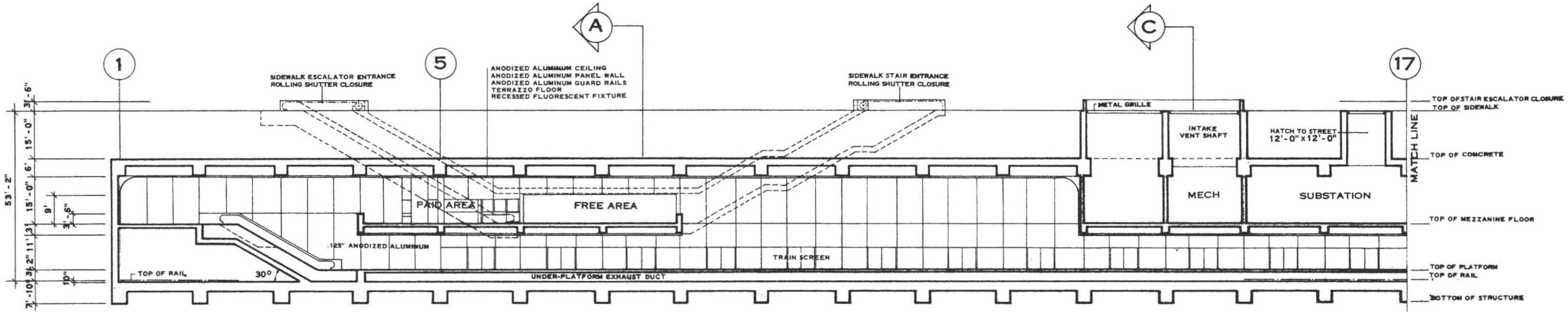
A three-platform scheme was developed in which the side platforms serve local traffic and the third platform in the center between the tracks handles all transfering passengers. Each of the two side platforms have two escalator lobbies leading to ticketing facilities above the platform level. The center platform will normally be used only by passengers changing trains and therefore stairs have been provided at each end as emergency exits. The FREE AREA of the concourse between the two ticketing areas overlooks the platforms below and has two banks of escalators leading to an off-street entrance at ground level.



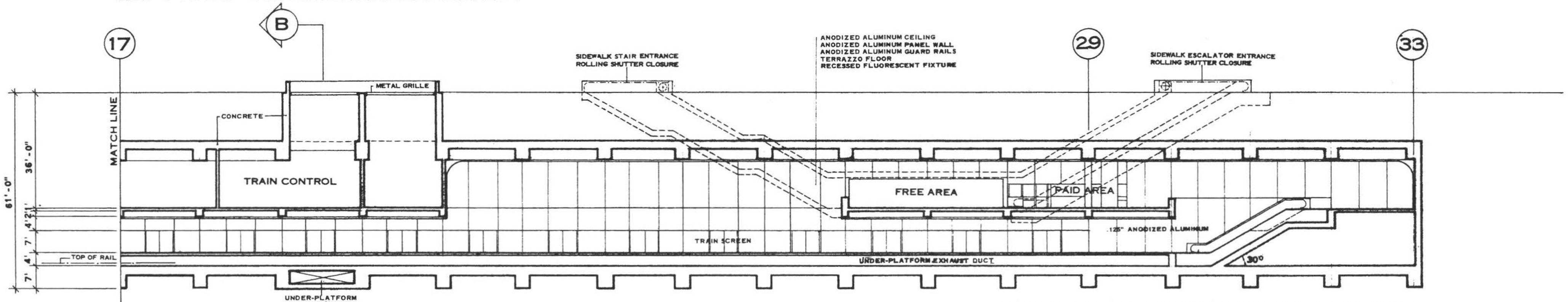
Subway, side platforms, double decked, concourses detached (BSDT)

Site and operational conditions require that the two subway tubes be placed one above the other along the portion of the Wilshire line under Broadway between 5th and 6th streets in the Central Business District. The result is a three-level station, with separate sets of escalators connecting each of the two side platforms to the level of the ticketing facilities. Two concourses, each containing turnstiles and fare vending equipment are offset to the east side of the right-of-way and have escalators rising to points of entry within private property.

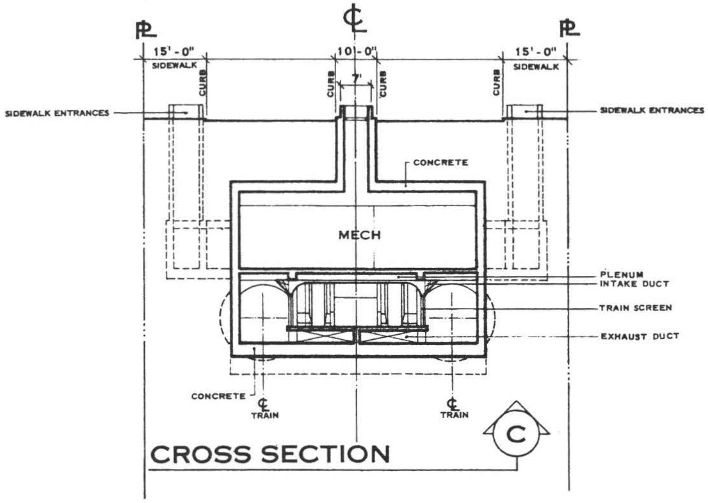




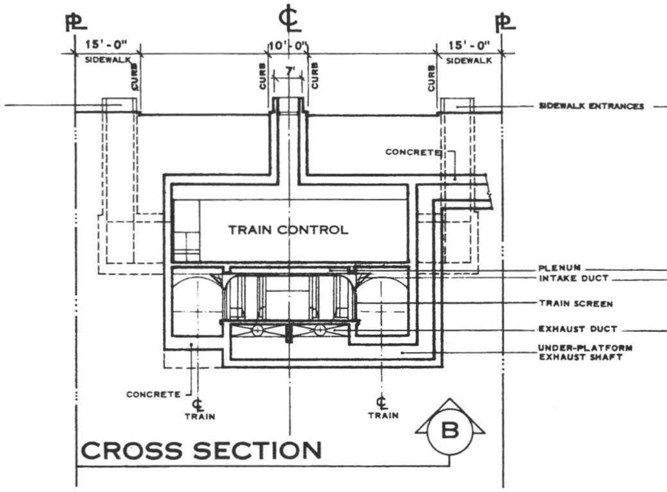
LEFT HALF LONGITUDINAL SECTION



RIGHT HALF LONGITUDINAL SECTION



CROSS SECTION



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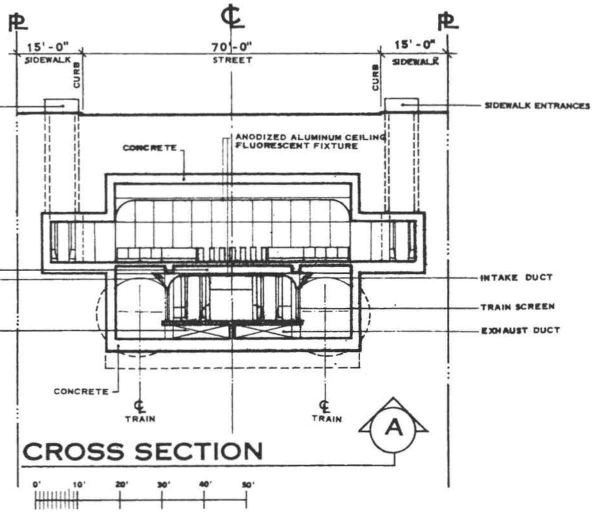


CROSS SECTION

STRUCTURAL CONSIDERATIONS-STATIONS

Design loads and criteria for stations are consistent with general local practice, and basically follow the Uniform Building Code (U.B.C.) except as modified by the criteria established for aerial structures as described elsewhere in this report. Platforms, walkways, stairs, escalators, and mezzanine floors have been designed for a live load of 100 psf. Free standing platform roof and above-grade roof live loads are in accordance with U.B.C. Equipment rooms, electrical and mechanical rooms, and storage rooms have been designed for a live load of 250 psf. Loads from the rapid transit trains and seismic loads are the same as those for the typical aerial way structures. Wind loads are also similar except for the added provision of a design uplift load of 15 psf on platform roofs.

In general, concrete strengths of 400 psi have been used for both above and below grade construction, except for piles and pile caps which have been designed for 3000 psi. All concrete is hard rock concrete, except way girder sections and prefabricated platform or mezzanine sections, which are light-weight aggregate concrete weighing 110 pcf.

Reinforcing steel is intermediate grade conforming to ASTM A-15, with a basic allowable stress of 20,000 psi, except that column vertical reinforcing conforms to ASTM A-432, with a basic allowable stress of 24,000 psi.

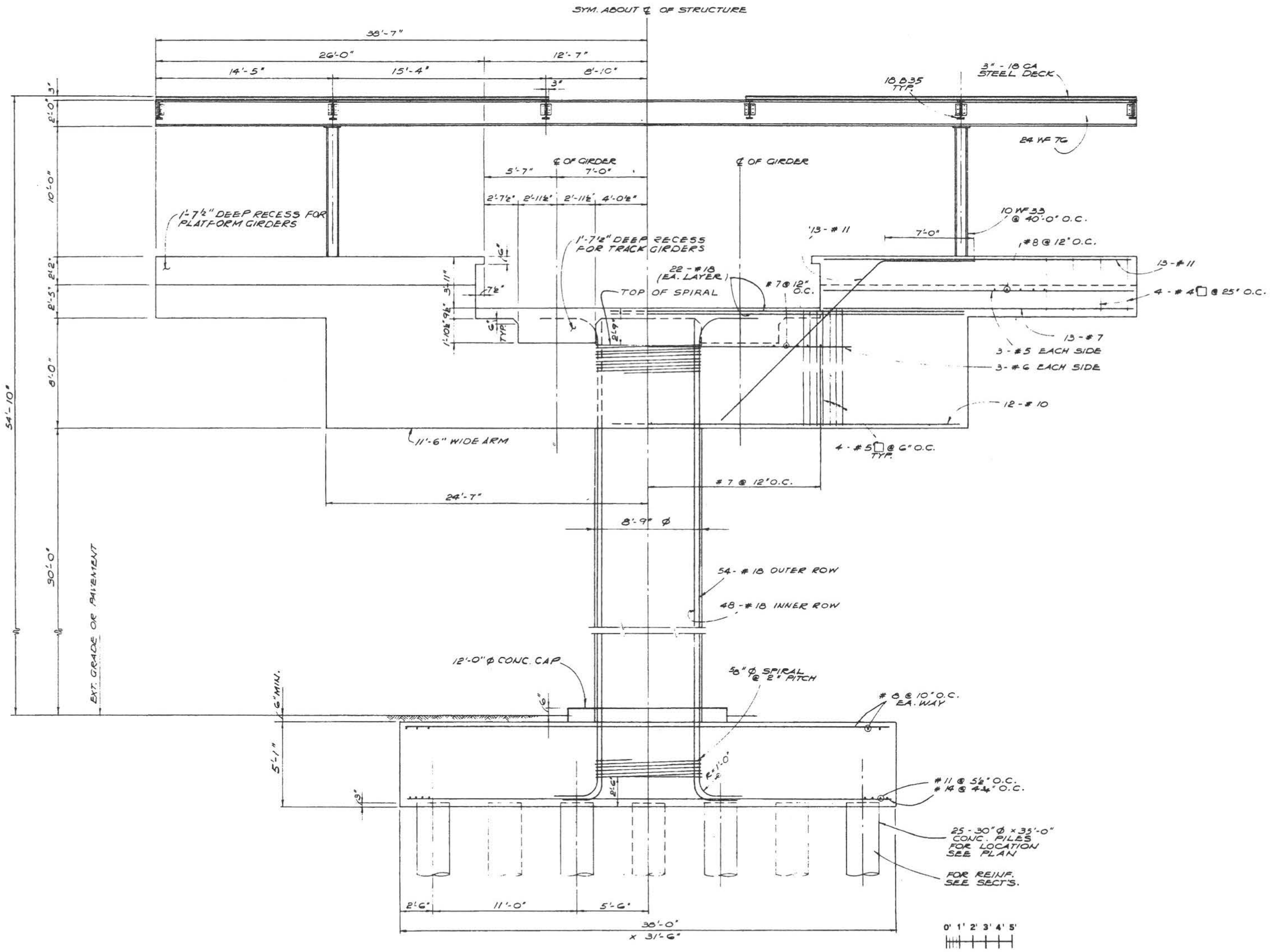
Structural steel conforms to ASTM A-36, with a basic allowable stress of 22,000 psi.

Concrete designs are in accordance with the American Concrete Institute Building Code Requirements for Reinforced Concrete (ACI 318-63). Structural steel designs are in accordance with the Steel Construction Manual of the American Institute of Steel Construction, Sixth Edition.

Aerial Stations

General configuration of aerial stations, including platform sizes, column spacing, locations of escalators, and clear heights, is established by architectural and functional requirements.

The track girders and platform girders are supported on common support columns and arms. The basic span of 100 feet selected for the station support arms is in keeping with the length of span frequently encountered throughout the system for aerial girders.



ELEVATION SECTION - TYPICAL AERIAL STATION SUPPORT ARM

The station columns will be larger than the way girder support columns because of the larger width and weight of structure supported. Both the way girder support arms and station support arms will be constructed as part of the way structure to permit continuous erection of girders through the station portion of the aerial system.

The clear height of 30 feet selected for the support arms permits horizontal access across adjacent streets to a mezzanine level below the track level with vertical access to the platform level via escalators, and also permits traffic to clear the walkways crossing the streets.

Typical way structures and aerial station platform construction has been predicated on the concept of prefabricated construction units. However, the option of poured-in-place construction may be provided to the contractor.

Materials selected for the different elements of the station structure are compatible with those used for typical way structure girders and supports. The use of structural steel to support platform roofs compliments the openness and lightness of the platform enclosure.

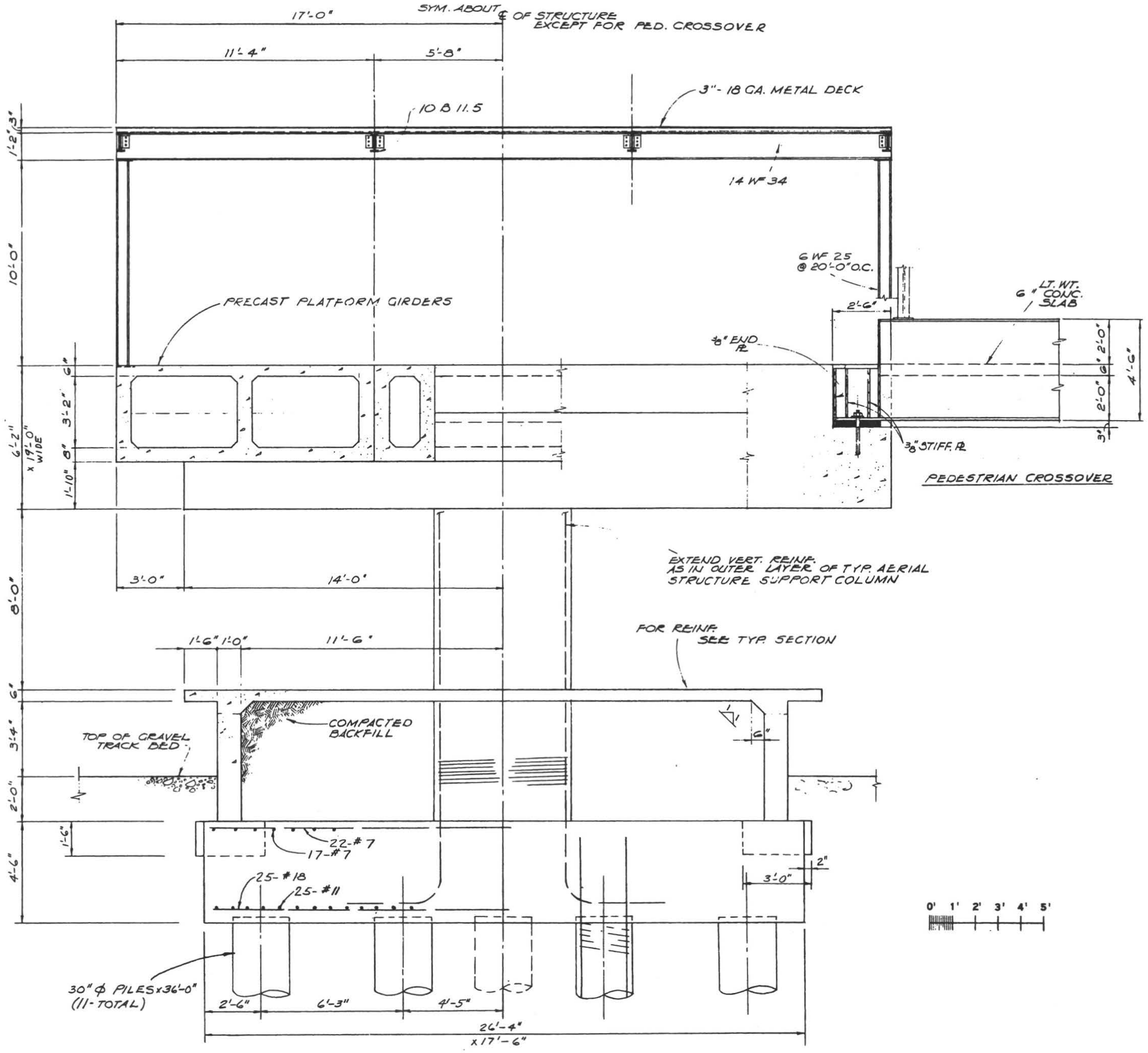
At-Grade Stations

As with aerial stations, general arrangement of at-grade stations is dictated by architectural and functional requirements.

The platforms are located at-grade and the mezzanine structure above them, with overhead access across the tracks and streets or freeways where required. The mezzanine structural system is similar to that for the aerial station, and includes the same concept of single column support arms. Column diameters of 6'-0" and spans of 110 feet were established to accommodate escalator placement and platform width.

The basic precast unit concept for the mezzanine floor was used; however, these stations could readily be poured in place since no conflicts will exist with other construction.

The design loads and criteria are the same as those for the aerial stations.



ELEVATION SECTION - TYPICAL AT-GRADE STATION SUPPORT ARM

Underground Stations

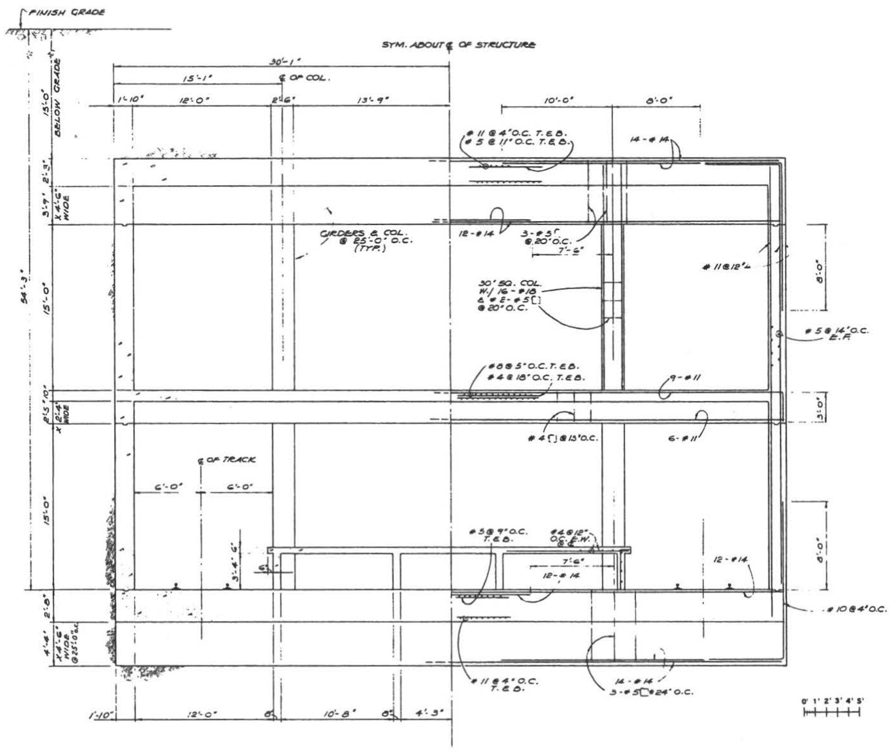
Underground station design necessitates careful consideration of construction techniques. In general, streets cannot be completely closed because of disruption of both traffic capacity and businesses fronting them. In addition, most existing utilities must be maintained in place, require relatively rigid support, and limit access to the construction below. To accommodate these requirements, only half of the street will generally be opened at one time. Prior to excavating the street, soldier piles will be driven around the perimeter of the excavation site. As one-half of the street is excavated to a depth sufficient for working space, steel struts and temporary framing will be installed at the upper lever, and support provided for the utilities. This half will then be covered over with wood decking to permit passage of traffic. The process is then repeated on the other half. Excavation and construction will then proceed to completion below the wood decking.

The most economical design is a continuous box-like structure without projections beyond exterior walls. Vent shafts and similar structures are generally incorporated within the station structure. Reinforced concrete construction was used throughout for the basic station structure.

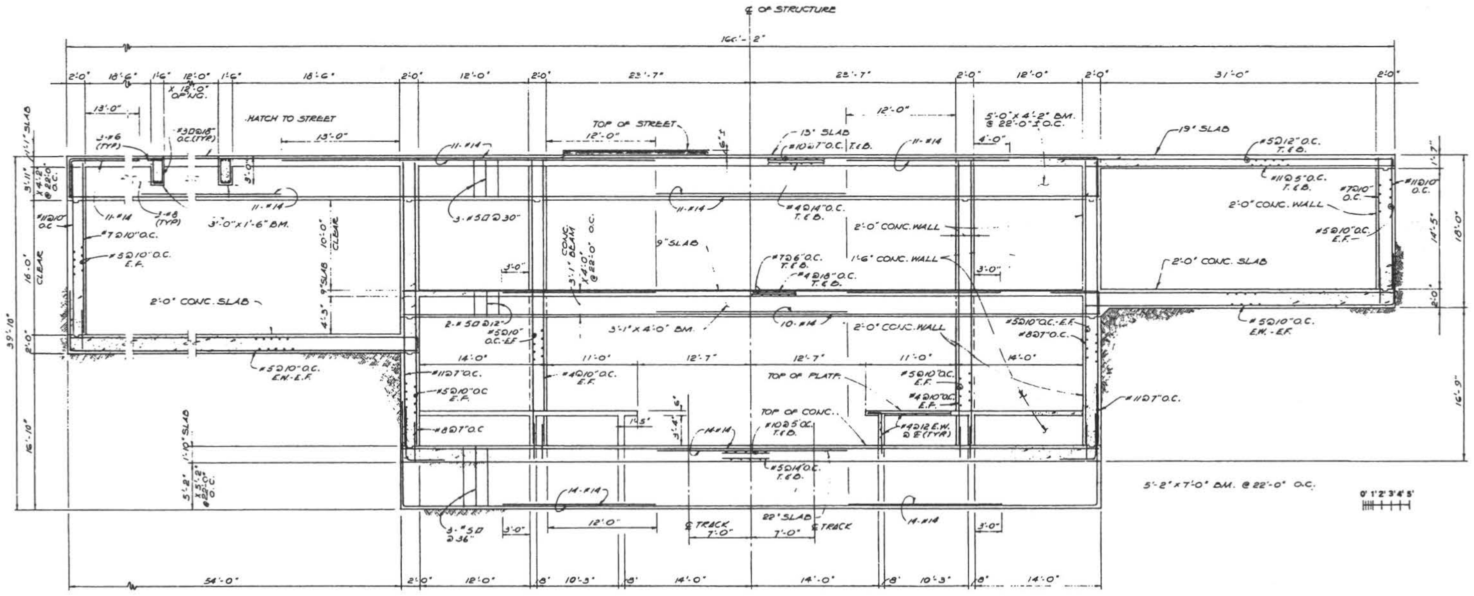
Soil weight of 125 pcf and lateral pressure of 30 pcf equivalent has been established and used for preliminary design. Where underground water condition exists, sub-surface tile drains will be provided to reduce hydrostatic pressures on the structure.

Open Cut Stations

Open cut stations require access from the street level to platforms below. In general, open cut construction at stations will utilize side retaining walls to minimize right-of-way width. Thus, retaining wall construction engenders a structural design similar to that for below-grade stations. The mezzanine level will span both the track area and platforms and will be supported on bearing walls at the back of the platforms.



TYPICAL SECTION - INTERIOR OF TYPICAL UNDERGROUND STATION



TYPICAL SECTION OF OPEN-CUT STATION

SUBWAY ENVIRONMENT

A particularly favorable climate is one of the amenities of Southern California which has contributed to the rapid growth and development of the Los Angeles area. However, residents have learned that in-door summer temperatures should and can be modified and controlled for greater comfort. Climate control is regarded as a necessary feature of today's office and factory, super-market and theatre, car and bus. Residents will expect and accept no less from the rapid transit system. With the exception of the vehicle itself, the most critical facility elements in respect to climate control are the subway portions of the system.

Summer climates make the uncontrolled environment of the world's subways inhospitable. Particular attention has been given to adequate environmental control for the SCRTD system. In Los Angeles, summer heat and smog will be added to the heat produced by motors, brakes, lights and people. Without control measures, winds and dust course through the tunnels, propelled by high speed trains. None of these elements of discomfort are new to railroading or rapid transit, but as train speeds have doubled, power consumption and tunnel heat loads have increased four-fold.

In this system, these conditions are definitely recognized, and specific design measures have been incorporated to provide a comfortable subway environment.

DESIGN CRITERIA FOR SUBWAY TUNNEL AND STATION VENTILATION

Temperature at any point in the system shall not exceed local ambient plus 20 degrees F. or 115 degrees F., whichever is greater.

Temperature at any point on the platforms, mezzanines, stairways or other public areas shall not exceed 72 degrees F. or local ambient plus 2 degrees 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.

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.

Maximum velocity of air movement on the platforms, mezzanines, stairways or other public areas shall not exceed 900 fpm. (15 fps., 10 mph.).

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.

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 discharge to the surface.

HEAT SOURCES

In order to meet the criteria established and assure that adequate climate control measures were incorporated, it was first necessary to accurately predict not only the source of heat to be dissipated but also the amount. This involved a detailed analysis of train performance in all sections of the system, and under varying operating conditions.

This detailed analysis was made possible through use of a train simulation program employing a high speed electronic computer. In this program, all variable functions of the train operation are incorporated including passenger load, motor characteristics, braking requirements, etc., as well as specific alignment data such as speed restrictions, grades and curvature, station spacing, etc. With these several inputs, an actual run of the train through the system can be simulated based upon the operating schedule anticipated in actual system operation, and an accurate prediction of power demand, train speed, braking effort, etc., is produced. These factors are then related to heat energy produced at any point in the system, and heat loads determined.

Based upon these computer simulations, it is apparent that the greatest heat production results from the propulsion and braking efforts and is directly related to speed and station spacing. The next most important heat source is the combination of mechanical resistance and auxiliary systems such as air-conditioning, car lighting, etc. Heat produced by passengers in the station, while significant by itself, is almost negligible in comparison to the other major sources of heat. It is also apparent that the most critical section of the system is in the Wilshire Corridor and CBD stations, where close station spacing and high train volume combine to produce extreme heat buildup.

The magnitude and importance of this problem is clearly evident when related to temperature rise in the subway section from Western Avenue to 7th and Flower if no ventilation or climate control were to be provided. A single passage of an eight-car train through this section would produce a rise of 12 degrees F.

In addition to predicting the total amount of heat to be dissipated, it is also essential to predict the location within the subway where heat production will occur. The train simulation program also indicates these data derived from the train functions and time-distance relationship. From the standpoint of the passenger, heat accumulation in station areas is most critical under normal peak hour operation. Therefore, this is the primary area of concern. In addition, possibility of equipment failure is increased with high temperature and passenger safety is affected in the event of a failure which may require evacuation into tunnel areas. The following table indicates the total heat generation and the relative distribution of heat between station areas and tunnels.

HEAT GENERATION & DISTRIBUTION

		IN STATIONS (Below Platform Level)		IN TUNNELS	
HEAT SOURCE	TOTAL[§] BTU/HR.	%	BTU/HR.	%	BTU/HR.
Traction motor heat					
Propulsion	6,900,000	0.0	0	100.0	6,900,000
Braking[†]	5,900,000	50.8	3,000,000	49.2	2,900,000
Resistor bank heat					
Acceleration[†]	8,000,000	50.8	4,100,000	49.2	3,900,000
Braking[†]	39,800,000	50.8	20,200,000	49.2	19,600,000
Friction braking[‡]	1,300,000	41.3	500,000	58.7	800,000
Resistances[‡]					
Wind, flanges, journals, etc.	7,300,000	41.3	3,000,000	58.7	4,300,000
Car lighting, air-conditioning[‡]	7,300,000	41.3	3,000,000	58.7	4,300,000
Passengers[‡]	1,400,000	41.3	600,000	58.7	800,000
Total	77,900,000		34,400,000		43,500,000

[†] *50.8% to 49.2% distribution based on analysis of heat dissipation at typical station stop.*

[‡] *41.3% to 58.7% distribution based on time under-car sources are in front of station platform.*

[§] *The table is based on 8-car trains at 90-second headways. Total heat load for other traffic conditions will be directly proportional to number of cars per hour. For example, 2-car trains at 90-second headway would produce 25% of each of these hourly quantities.*

On the basis of this study related to the Southern California climate, it has been concluded that provision of a ventilation system alone could not possibly provide an acceptable environment in subway stations and that the use of mechanical refrigeration is essential.

Several alternative methods of climate control have been investigated. The two methods found most feasible were the system of air-conditioning the station platform and concourse areas only by isolating them from the track area by a system of train screens, and the alternate system of air-conditioning the total subway.

In the former, separation between station platforms and track cavities is accomplished in the same manner as a building's lobbies are isolated from its elevator shafts. A wall is interposed, with broad multiple doors matching the position of the car doors and coordinated with their movements. With this method, the subway stations 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. Refrigeration equipment shall have capacity to maintain temperatures on the platforms at 10 degrees F. below ambient. This is the system used in the preliminary engineering and design of facilities and cost estimating.

In the latter method, the entire subway system is air-conditioned by mechanical means. The final system selection will be made during the final design period.

Management of the controlled environment of subway stations in the train screen system has been solved by an integrated and balanced combination of five ventilation systems discussed in the following paragraphs.

UNDER-CAR SWEEP

The modern rapid transit vehicle contains numerous pieces of car-bourne equipment which is essentially electrical machinery, and most of it is located in the space under the car floor. During a programmed stop with dynamic braking, electrical energy is absorbed by the resistors and converted to heat. While standing at a station, this heat cannot be allowed to accumulate, nor can it be allowed to enter the platform area. Control is attained by sweeping air slowly but positively from beneath the cars, by fans mounted below the station platforms. The full length of the platform structures is employed as two independent plenums, one for each track. The air intake openings are screened, with partial covers adjusted to assure uniform flow distribution beneath each car.

The under-car sweep concept is well established in subway technology and has been successfully used in Chicago. In this system, under-platform exhaust not only provides cooling of under-car equipment by positive air movement and diversion of heat from the passenger by maintaining a downward air flow between car and platform, it also accomplishes removal of more than half of the tunnel heat in the most economical manner. When combined with train screens, it also maintains slightly reduced pressures in the track areas to assure controlled flow of platform air around passengers moving between the platform and vehicle.

POSITIVE FLOW VENTILATION

Mechanical clearance requirements dictate that several inches of open space must exist between the train side and any platform fixtures. If hot tunnel air is allowed to fill this volume, the opening of the vehicle doors would permit heated air to flow quickly into the air-conditioned cars around the heads of the passengers as the cooled air poured out past their feet. The environmental control system used in the preliminary design precludes this transfer of tunnel air into the transit vehicle.

In this system, air from the surface is drawn into the subway stations through grills in median islands, sidewalks or other selected locations. Cleansed and filtered air is blown continuously throughout the length of each platform. Seeking an exit, it flows up each escalator and stairway, through the mezzanines and corridors to the street. The platform areas are slightly pressurized, precluding leakage of tunnel air into the station around the platform door edges.

Upon arrival of a train, the appropriate platform doors open. Impelled by the pressurization of the platform and the reduced pressure in the tunnels, the station air flow to the Mezzanines decreases, and station air moves through the platform doors, into the tunnel and around the cars. The passenger stepping between station and train is surrounded by platform air. With the reduced thermal differential driving force, the overturning exchange of air between car and station is diminished. The patron is never aware that his train is running and stopping in an atmosphere in the track area which is as much as 40 degrees warmer than that around him.

AIR-CONDITIONING

Mechanical refrigeration capacity is provided to cool the full flow of station ventilation air ten degrees below the ambient and distribute it through air ducts so cool filtered air reaches all public areas. Thermostatic control maintains station temperatures midway between those on the street and in the trains, eliminating any problems of rapid temperature adjustment for the passenger. Cooling is discontinued when the temperature level of the car air-conditioning is reached.

TRAIN PISTON ACTION

To carry away the great amount of heat produced in the tunnel, massive movements of ventilating air are necessary. Fortunately, the trains running through the circular shield-driven tunnels act much like a piston, and produce such massive air flows. Tunnel winds move before and behind each train, even through the station tracks, at speeds up to 35 miles per hour. Strategically placed vent shafts, opening to the surface through median islands or carefully located pavement gratings, exhaust hot air out of and draw cooler air into the subways. Tunnel ventilation, both from train piston action and the under-car sweep fans, is equivalent to a replacement of 50 percent of the tunnel air by each train.

EMERGENCY TUNNEL VENTILATION

In order to assure a safe system, it must be assumed that equipment or a temporary power failure could occur which will produce a situation where passengers must leave a train and exit via the tunnel catwalk. Train movement will have ceased, and piston action will not exist, making emergency ventilation a necessity.

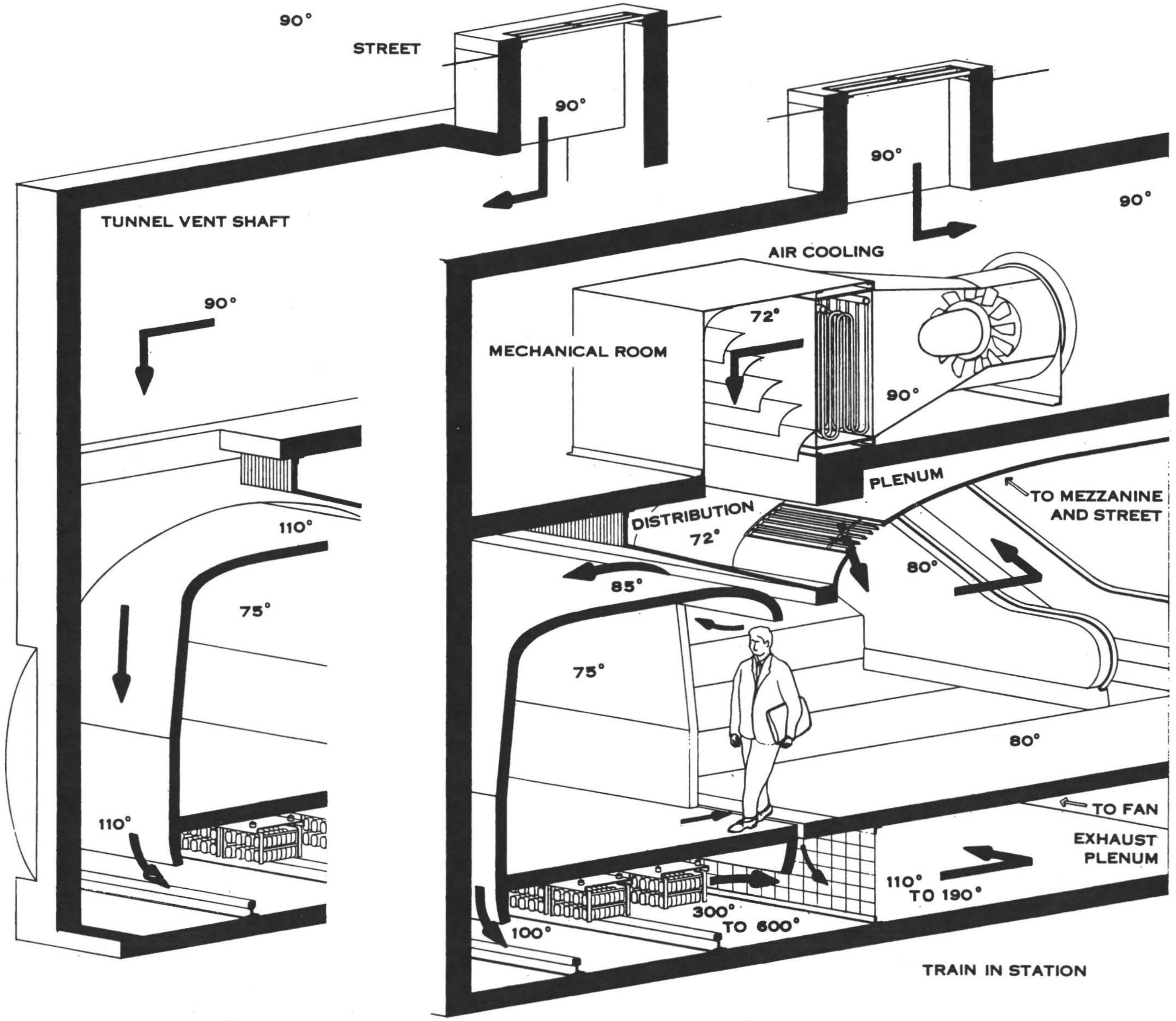
In the event of such an emergency situation, passengers would be directed to walk toward the nearest station. Therefore, emergency fans are located in tunnel vent shafts to discharge hot air from the subways to the surface. The under-car sweep fans, which would interfere with this system, are automatically shut down when the emergency fans start.

SECTION A

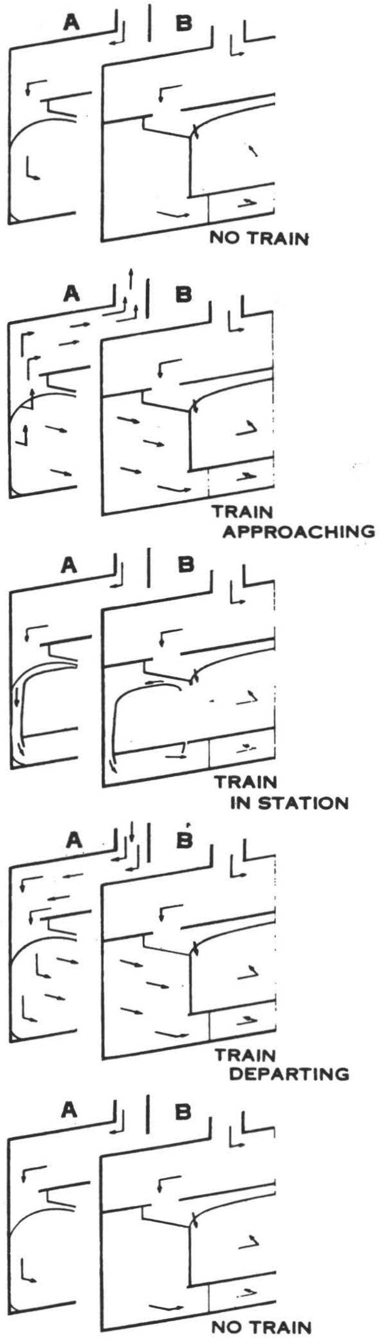
TUNNEL AIR INTAKE/EXHAUST

SECTION B

STATION AIR INTAKE



TYPICAL AIR FLOWS AND SUMMER TEMPERATURES
AIR CONDITIONED SUBWAY STATION



FARE COLLECTION

The graduated fare structure considered for the rapid transit system requires more complex collection techniques than are represented by the conventional "token" method employed in systems with a flat fare base. In particular, the need to accurately and speedily verify ticket validity at the point of exit presents problems not inherent in the flat fare structure. In the past, graduated fare collection has been performed primarily by manual means, using conductors on commuter railraods and station gatekeepers in rapid transit systems. The advent of inexpensive, reliable solid state electronic circuitry, coupled with magnetically encoded tickets have made it possible to consider the use of unmanned fare collection equipment. Comparative cost analysis of gatekeeper manned systems versus three types of electronic based, unmanned or automatic methods for the SCRTD system revealed that although the capital cost for the automatic system was higher, the overall annual cost was lower than for the manned system and this made the automatic system economically feasible.

SYSTEMS CONSIDERED

The three types of automatic fare systems considered were:

- Stored ride base
- Point to point base
- Stored fare base

The stored ride method uses an automatic system that performs all fare collection fundtions. With this method, tickets are sold on the basis that a trip is valid between any two stations for which the ticket ride value is equal to or greater than the actual fare. Entrance gates admit a patron if the ticket has at least one ride remaining. The gate encodes the entrance station, subtracts one ride, and releases the ticket. Exit gates read the entrance station and ride value, compute the fare from the entrance station and release the ticket for a valid trip. Vending machines dispense tickets for a quantity of rides of specified value for correct total money inserted.

This system has a slightly higher capital cost than the point to point system, but is considerably less expensive than the stored fare method.

Automatic ticket vendors store blank ticket stock, and establish the type of ticket and value only at time of issue. If ticket vending methods are considered to make full use of existing services, pre-printing of tickets may be a necessity. If so, a small number of ticket combinations is an advantage . Since the ticket combinations are based on the discrete number of fares rather than station pairs, there are only about 16 unique one way ticket combinations.

The point to point method uses an automatic system to perform all fare collection functions. With this method, tickers are sold on the basis that rides are valid only between unique pairs of stations. Entrance gates admit patrons if the ticket is encoded with the correct entrance station and one ride is subtracted. Exit gates release if ticket is encoded with the correct station identification. Vending machines dispense tickets with station pair and quantity of rides for correct total money inserted.

This system has the lowest capital cost of the three systems; however, there are over ove thousand unique combinations for a one-way ticket, which suggests that a slightly more sophisticated system is appropriate.

The stored fare method is similar to the stored ride method, except that tickets are sold on the basis that a trip between any two stations for which the ticket contains enough value to cover the ride is a valid trip. Entrance gates admit a patron if the ticket has at least the minimum fare remaining. The gate encodes the entrance station. Exit gates read the entrance station, compute the fare from the origin, subtract the value of the ride from the ticket and release it as a valid ticket. Vending machines dispense tickets encoded with monetary value for total money inserted.

The stored fare system is the most expensive of those considered. Since cash is traded for transit fare, there are no ticket combinations in the usual sense. This permits tickets to be pre-printed in discrete monetary untis. The stored fare concept is the most convenient for the patron. He can trade a partially expended ticket and cash for a new ticket of increased value, thus allowing complete flexibility concerning time and place of ticket purchase. The patron can also purchase or upgrade a ticket to any value convenient for him rather than to suit the requirements of a fixed tariff schedule. Further, the rider can exit at all stations in the system without penalty, since the exact fare will be deducted from his ticket. Thus, he will not have overpaid his fare by virtue of exiting at an intermediate station, or be required to use a special gate when exiting at a station beyond his normal destination.

PRELIMINARY DESIGN SYSTEM

Following evaluation of the three systems, the stored ride method was selected as the most desirable system for two reasons.

- It is more flexible than the point to point system for the non-commuter rider.
- The high percentage of commuter patronage would tend to minimize the convenience value inherent in the more sophisticated stored fare system.

Tickets suitable for use in the automatic system are the key to a successful operation. The tickets must be of convenient size and shape, inexpensive, durable, and capable of retaining the data necessary for fare collection transactions at the turnstiles. At present, a plastic ticket similar in size and shape to commercial credit cards is contemplated. A part of the ticket would contain magnetic material that would store transactional data. It must be suitable for erasures and re-writing because each turnstile transaction involves reading the encoded data, erasing some of the data and writing new data. It is planned that commute tickets would have the ride value visually displayed on the ticket at the time of purchase. Because the vendors store only blank ticket stock, commute tickets once used would not be re-usable. For this reason, ticket life is based on the maximum number of rides obtainable from cummute tickets.

Individual items of equipment associated with the fare collection system are ticket vendors, turnstiles, agent readers, transfer dispensers, and, as a convenience, change makers.

The ticket vendors accept coinage and one dollar and five dollar bills up to the amount required for a twenty ride ticket of the highest ride value. The vendors do not accept pennies nor will they dispense change. When issued, ticket is magnetically encoded with the ride value and the number of rides. The patron may select a one way, round trip, or twenty ride commute ticket. The selection push button and the coin and bill acceptor are located on the front face of the vendor. A fare table displaying the ride cost between each station pair is also located on the front face of each vendor. It is estimated that transactions at these machines would take ten to fifteen seconds.

Turnstiles are designed for use as entrance and exit gates. They are normally programmed by the station agent to operate in only one direction, but are easily reversed for changes in peak traffic direction. In entrance mode, the gate accepts a ticket, ascertains that it is valid for at least one ride, encodes the origin information, subtracts one ride and releases the gate for entrance. In exit mode, it accepts the ticket, reads the origin information and ride value, and compares the ride cost from the origin station with the ticket ride value. If the ticket ride value is equal to or greater than the actual ride cost, the gate releases for exit. If the ticket has remaining rides, the ticket is returned to the patron, otherwise it is captured and stored in the gate. Turnstiles are designed to handle thirty patrons per minute.

The agent reader is capable of displaying all of the information stored on the ticket. Generally, this would consist of ride value, number of rides remaining, number of rides initially purchased, and the number of the vending machine that dispensed the ticket. After the first turnstile transaction, the origin station, date, and hour would be encoded on the ticket and available for display. In addition, the tickets contain all of the information encoded prior to the last transaction which can also be displayed on the reader. The purpose of the reader is to allow a station agent to determine why a particular ticket is being rejected by the automatic equipment.

Transfer dispensers are available in the paid area of stations where bus connections are allowed.

Change makers accept coins and one dollar bills, and return specific combinations of change. These machines are located adjacent to ticket vendors.

STATION SITING

The basic station location is dictated by several factors, the most important of which is service. How well a particular location satisfys the service needs of an area is related to the nature and character of the area, i.e., whether it is an origin or destination area, the accessibility of the location by other modes of surface travel, and the relative density of the surrounding service area. Travel time is also materially influenced by station location. Station spacing is the most significant influence on average system speed. Selection of station location has been predicted upon a balance of these service factors with the result that suburban stations, largely origin in nature, are more widely spaced than destination stations in the urban centers.

Many of these same factors govern individual site development. For example, suburban stations must rely heavily upon automobile access to bring patrons to the system, and will require adequate parking. Urban station in densely developed areas such as Wilshire Boulevard and the CBD will depend more on walk-in and bus transfer passengers. Therefore, vehicle access and circulation at suburban stations becomes an important element. Conversely, pedestrian concentrations in the urban center will be much heavier than at suburban locations, and must be accommodated without undue interference to sidewalk flow or capacity. Recognizing these factors, it is apparent that each station site requires careful and individual consideration in its layout and development. However, most of these considerations can be illustrated by a typical station site development plan since the site elements are common to all, and vary only in the manner in which they are accommodated.

In all cases, one of the most important aspects of site development is the requirement to provide a pleasant surrounding for both the transit patron and the adjacent community. Landscaping can assist in accomplishing this by screening certain areas, visually dividing large areas to add character, and relating the overall site to the surroundings. A subsequent section of the report deals in detail with landscape concepts.

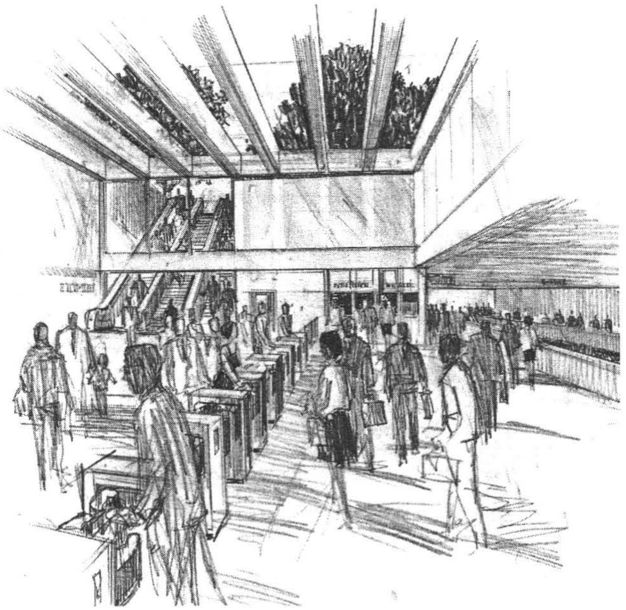
ACCESS AND CIRCULATION

Access and site circulation are important in all stations, and vital in suburban areas. Access to the site from the surrounding area is best provided where several routes and entry points can be developed. This will reduce conflict with other traffic during peak hours, and also facilitate movement of transit oriented traffic. These considerations are also improved for the private automobile where site access is not made directly from major arterials, but rather from secondary streets where some queuing capacity can be provided. However, a large percentage of transit patrons will utilize the feeder bus system to reach the stations. Bus operations are best accommodated on the major arterials where local service is also required, and where greater street width and capacity permit easier bus operation and better scheduling. Therefore, station sites must be easily accessible from major arterials and as close to them as practicable to provide direct routes and avoid delays in bus operation.

Within the site, passenger safety and convenience are best served if the various feeder modes are physically separated from each other, and from pedestrian circulation. Also, passenger loading and unloading must be as convenient to station entrances as possible. This is generally accomplished by providing off-street bus loading areas at one side of the station complex, adjacent to the street and automobile loading areas, with short-term parking for "kiss and ride" patrons on the opposite side of the station. In addition, the "kiss and ride" area must be separated from the long-term parking areas, and also have a separate vehicle entrance to avoid traffic conflict. Further, pedestrian access to the "kiss and ride" area and the short-term parking should not cross vehicle circulation patterns.

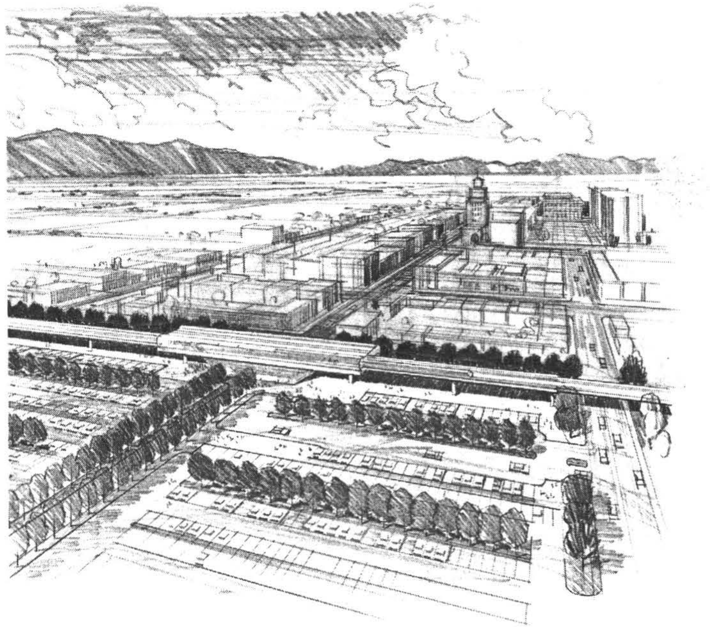
Long-term parking areas must accommodate both vehicular circulation seeking a parking stall and pedestrian circulation leading to the station entrance. The patterns must be arranged to minimize conflict, improve safety, and to reduce delay. This is best accomplished with multiple vehicle entrances leading directly to circulation aisles, and with wheel bumpers between parking aisles spaced adequately to permit pedestrian circulation between parked automobiles rather than in the drive aisles. These pedestrian aisles should lead to a central walkway leading directly to the station.

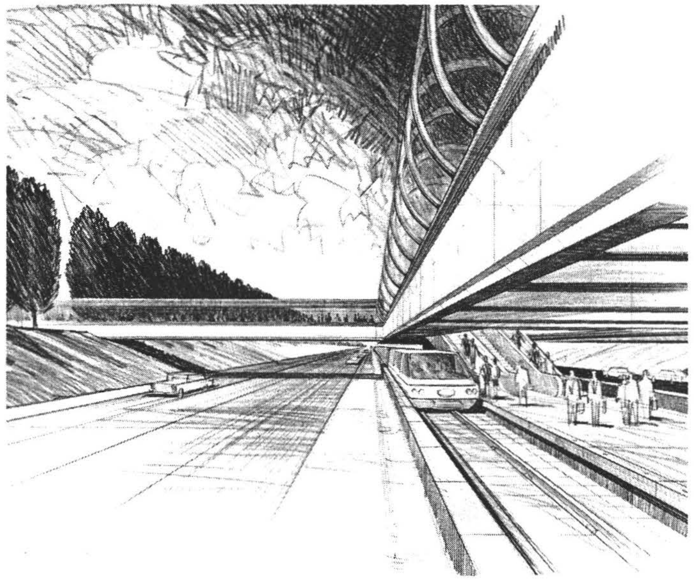
At each station, space should be provided for a paved pedestrian area around the station. This space will alleviate pedestrian congestion and cross movements adjacent to the station entry during peak hours.



Off-Street Subway Entrance

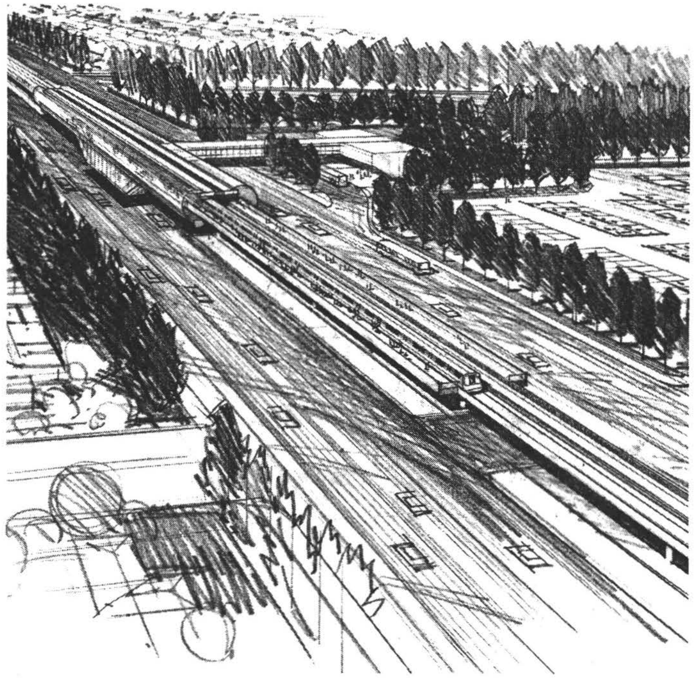
Aerial Station and Parking

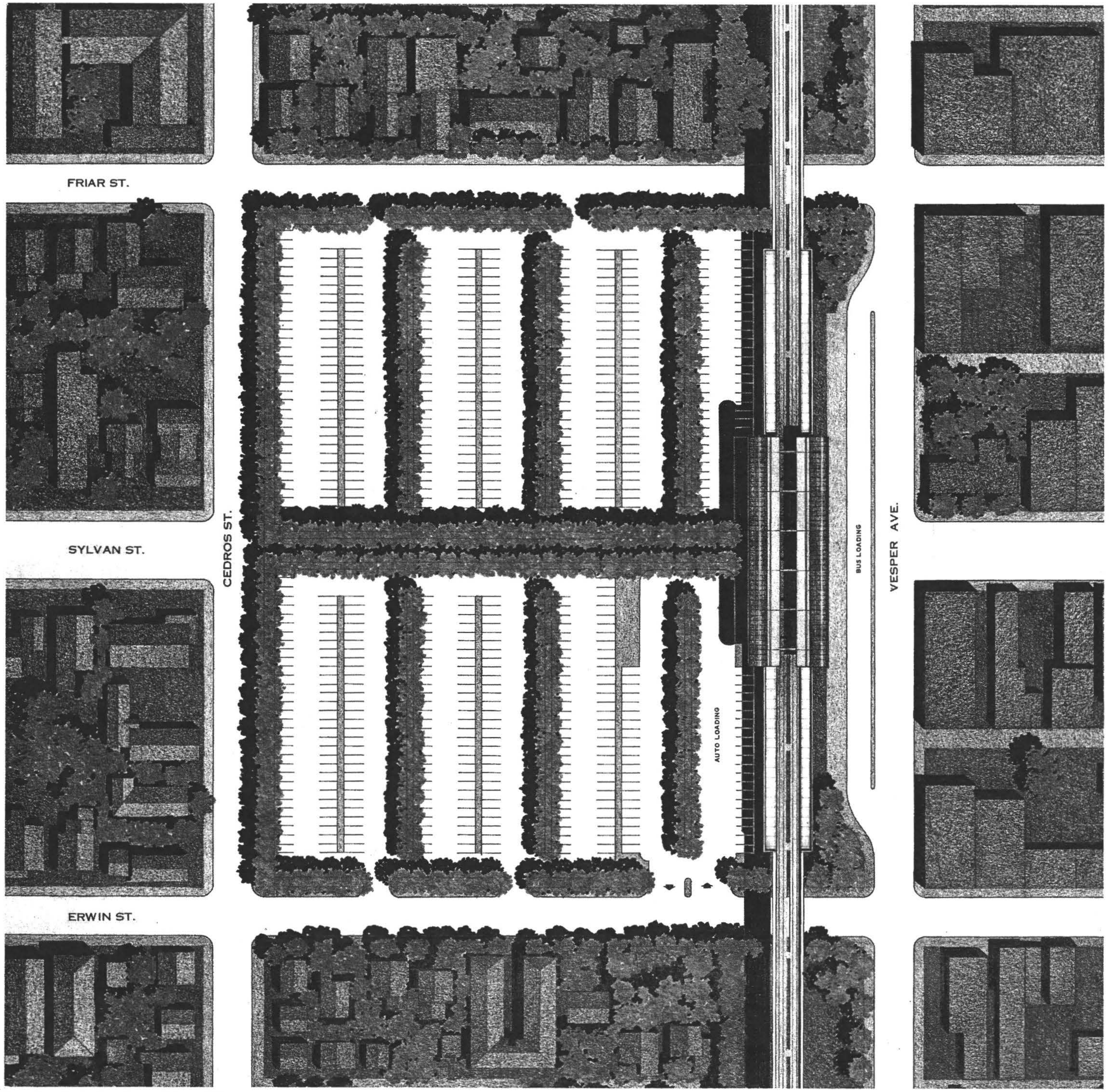




Station in Depressed Freeway

Feeder Buses and Parking





Typical Suburban Site Plan

LANDSCAPE CONCEPT

Landscape considerations in this preliminary state of design are intended to set forth a basic concept of landscape treatment as applied to the total system. The system is divided into two broad categories. These are the station sites, and the rights-of-way with their various configurations. The stations serve as nodes, collection points, or centers along the corridor, with the rights-of-way providing the connecting links.

The treatment of stations and their respective sites should contrast visually with the rights-of-way, so that station areas are more readily identifiable and make the station an accent along the corridor length. This treatment will also assist in passenger orientation within the particular locale. Therefore, station areas are to receive a maximum amount of visual quality and treatment. For example, these areas are to receive larger size, more mature trees at initial installation; receive more irrigation; use of special paving in appointed areas; and use of more sophisticated plants and materials.

In contrast, rights-of-way are to receive landscape treatment requiring minimal irrigation, maintenance and care. This is achieved by the use of drought tolerant plant materials, including adaptable California natives and hardy Australian species. From the standpoint of economics, low maintenance plus judicious use of plant materials is the key to maximum treatment and resulting visual enhancement of the rights-of-way.

Visual considerations for property owners and adjacent communities along the rights- of-way are of top priority in providing a visual foil, and to baffle the sounds of the system. Visual consideration for passengers must allow for the speed perception factor. Moving at 60-70 miles per hour directs views to broad regional glimpses. Therefore, detailed design at short distances (50′-60′) will be blurred and unintelligible at these speeds. Since the right-of-way alignments are established and the bounds fixed, limitations on right-of-way treatment to be viewed by passengers are limited within this framework. These reasons are added to the rationale supporting a simple, direct treatment of the right-of-way, with the prime concern for people who must live with the system on adjacent properties and in surrounding communities.

PLANTING DESIGN CRITERIA

Plant materials will be grouped in compositions that are architectural in quality. Groupings of plants will be of significant number and used in simple forms upon the ground plane. Plants will 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.

In general, the massing of plants provides a clear statement, eliminating confusion, incongruity and enhance the perceptive factor involved in high speed views from transit coaches. Broad regional views will be more important than gardenesque qualities. Intricacies must be avoided in selection and arrangement of plant materials.

Plantings will be carefully selected 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.

PLANT SELECTION CRITERIA

Selection of plant materials will be made within the following criteria:

. Plants must have low maintenance characteristics, minimum watering, pruning, feeding and pest control needs.
. Moderate to fast growth plants, rather than very fast, will produce a sturdier branching structure and better resist wind damage.
. Shrubs must be low branching wherever possible to minimize the need for ground cover.
. Nearly mature plants shall be planted to achieve an immediate effect in areas deemed visually important (larger size plants for screening along rights-of-way and all plantings in station areas will be established materials.)
. Ground covers along route right-of-way will be seeded by the hydro-mulch spray-on technique.

STATION LANDSCAPE TREATMENT

The design of external station facilities will be handled in keeping with the specific local requirements of traffic, site acquisition and character. However, the parking areas around the stations, because of size and use, have significant impact on the appearance and function within the community. Therefore, it is essential that minimum standards be set for their design and layout.

. The main entrance and the circulation routes within the station parking area will be emphasized to give identity and orientation to the pedestrian and motor vehicle operator. A straightforward handling of plant materials will be employed to facilitate identity of ingress/egress points and station ticketing entrance.
. Parking areas will be screened from surrounding buildings when desirable, by planting, fences, walls, berms, or changes in grade. Structure screening or barrier walls will be considered only when insufficient depth of land is available for visual control.
. Trees will 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. Main walkways will be planted with two rows of trees to distinguish them from parking aisles. 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.
. Small and medium sized tree plantings will be located to achieve secondary subdivision of the site. Trees planted within the parking lot areas are to emphasize the direction of important internal traffic and minor pedestrian circulation, and to function as spatial dividers by breaking down large expanses of paving into smaller areas.
. Ground cover and shrubs will be used to lend textural contrast to the paved surfaces. These plantings will be located within curbed areas of significant size and proportion with a minimum area of 300 square feet.

RIGHTS-OF-WAY LANDSCAPE TREATMENT

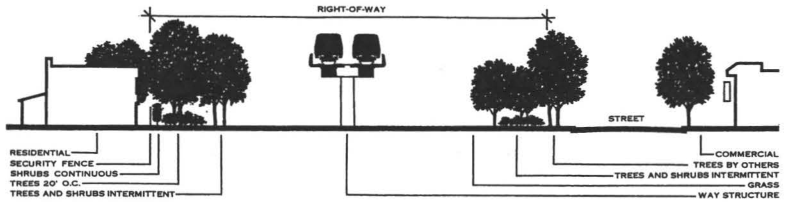
Simplicity and ease of maintenance will be emphasized in the treatment of the route rights- of-way. By utilizing a spray-on method of seeding with plant seeds mixed into a slurry, the economical initial cost of ground cover installation is achieved and maintenance can be minimized. All trees specified along the rights-of-way are well established materials (24″ - 36″ box) to:

. Enhance the landscape initially,
. Provide a partial noise baffle,
. Provide screening for residential privacy,
. Establish the identity for the transit system.

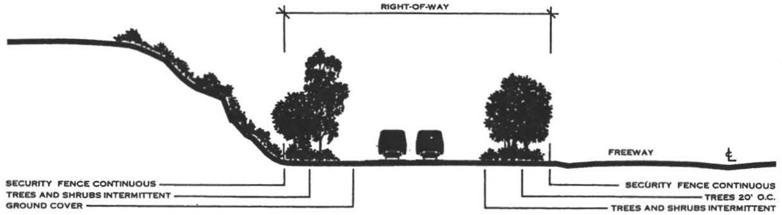
Shrub screening material will be of one gallon and five gallon sizes.

Irrigation will be provided by a quick coupler Rainbird system for the first two years. This system may be permanently installed or leased. All lawn areas will be on an automatic sprinkler system. Trees will be accommodated with water sumps at the drip line distance.

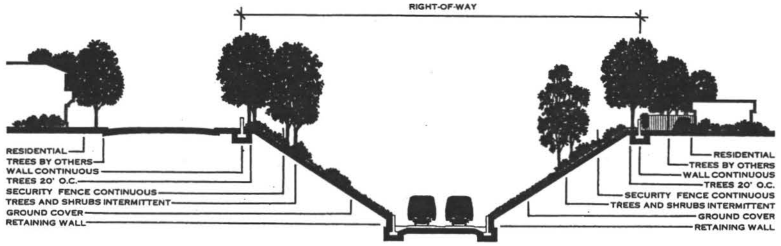
RIGHT-OF-WAY LANDSCAPING



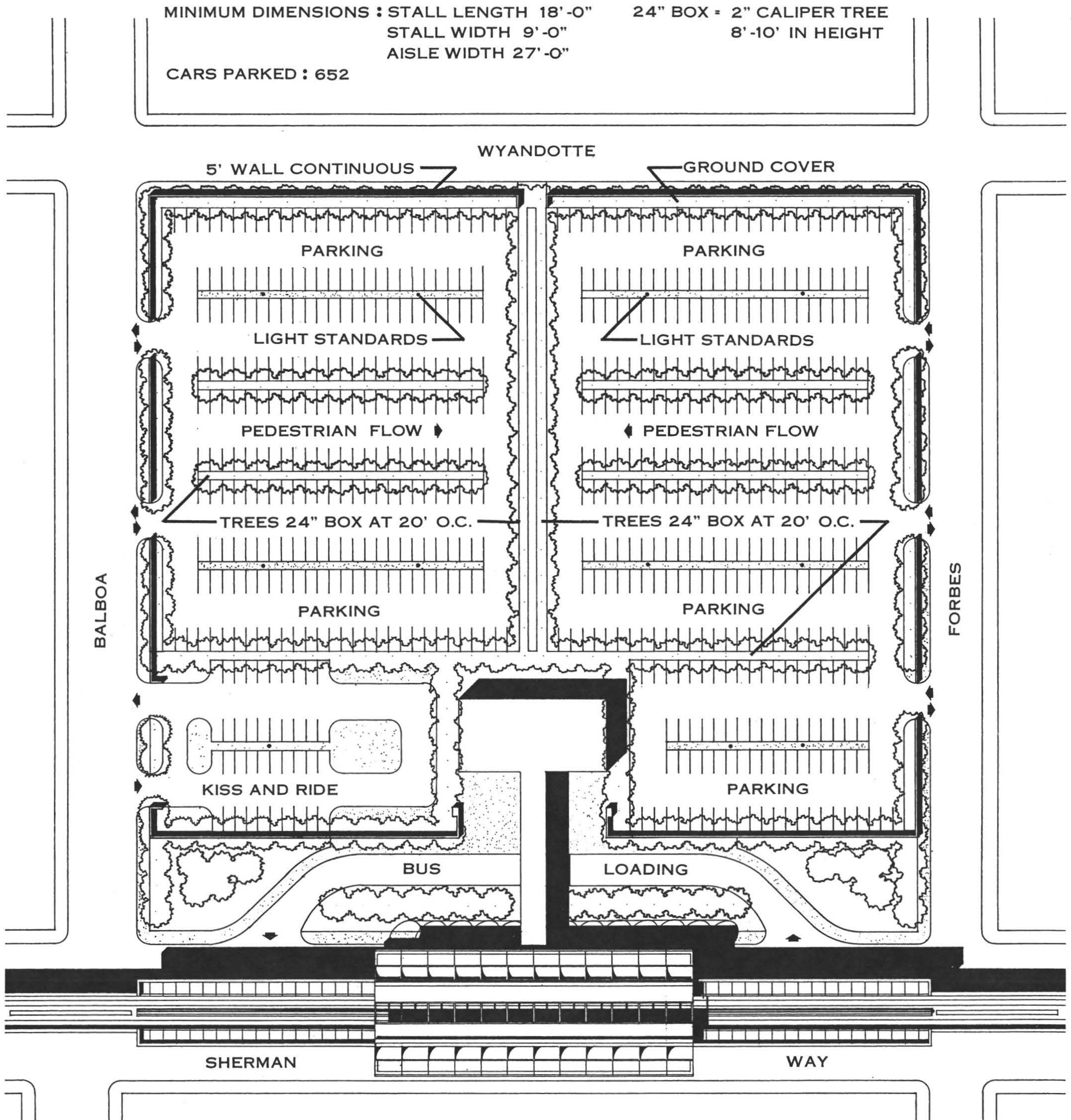
AERIAL



ON-GRADE



OPEN CUT



STATION LANDSCAPING

THE TRANSIT VEHICLE

The vehicle design has been developed in response to specific requirements of the transit needs of the Los Angeles area. In general, these requirements include frequent service, easy access and entry, maximum riding comfort, and high performance. Two basic types of vehicles will be employed for this system: one for rapid transit service, and one for airport express service. The cars will be similar except for differences in the airport service car to accommodate airline passengers and luggage.

CRITERIA

The basic vehicle criteria can be expressed as follows:

. Speed—capable of reaching a speed of 75 miles per hour with the scheduled load of passengers onboard.

. Safety—All critical pieces of equipment and components must be "fail safe" so that failures or malfunctions will result in prescribed safe action.

. Acoustics—The sound level, both on the vehicle and at locations adjacent to the track, will be controlled by use of accepted sound control techniques so that noise levels will be reduced to a minimum to permit normal conversation onboard the trains and normal land use in areas adjacent to the right-of-way.

. Reliability—The vehicle performance must be reliable to permit realistic scheduling and use of automatic controls.

. Comfort—Smooth performance and riding characteristics will assure a high level of passenger comfort, acceptable to both standing and seated passengers. The interior will be designed to enhance passenger comfort by providing comfortable seats, adequate lighting, and climate control.

. Capacity—The trains will have a normal capacity of 1,000 passengers, a maximum length of 600 feet, and performance characteristics permitting operation of the system on 90 second headways.

. Appearance—The exterior will be designed to provide a lasting, appealing appearance whether the vehicle is viewed in the stations, on aerial structures or on the track at ground level. The interior design will be attractive and inviting to promote a feeling of security and comfort suitable for conversations, reading or resting.

. Economy—The selection of the designs, materials, and equipment has been made to obtain optimum value. First cost and maintenance cost both have been considered in the selection of the vehicle and its components.

DESIGN PROCESS

In order to provide a system which will have the greatest public appeal and equipment durability, the preliminary vehicle design reflects the most advanced thinking in transit technology. The basic requirements for the system were developed into brief specifications, and distributed to the manufacturers of transportation equipment and other representatives of the transit industry to encourage developments in the state of the art and to reach conclusions concerning the most suitable methods and materials. The comments and suggestions received from the industry are reflected in the design.

The design and equipment selections are based on the latest proven advancements and technology. The styling and mechanical equipment of the vehicle have been carefully studied and are representative of the latest design available. The performance features are achievable. They have been established at the highest practical level to encourage improvements in the state of the art by the transit equipment industry. They are realistic guidelines and their use has produced realistic estimates.

The equipment selections are shown to be more economical and efficient than any other alternative system of comparable or appropriate capacity. However, this is not to say that the final design for the Los Angeles system has been made. This system is the basis for the estimates in this report, and it has been reflected in the design of facilities throughout the system. However, this does not prevent the use of any other system or concept which, upon further demonstration and analysis, proves to be superior. Technological advancements will continue to be reviewed, and the incorporation of these advancements will certainly continue throughout the design and development of the Los Angeles system.

OPERATING PROCEDURES

Each vehicle in the Los Angeles transit system will be self-propelled by electric motors, and each axle will be powered. The vehicle will be supported on flanged metal wheels running on steel rails. Operating procedures have not been finalized at this time, but it has been determined that consist changes will generally be made before and after each peak period. It is assumed that these changes will be made on yard tracks. The trains for the system will be composed of two end cars (A cars), and when greater length is required, middle cars (B cars) will be coupled between the end cars. The end cars will contain automatic train control equipment, the attendant's space, and will be about 5 feet longer than the middle cars. Minimum train length will be two end cars, and the maximum train will be two end cars and six middle cars for a total length of about 600 feet. All routine operations on the mainline for all phases of scheduled train performance will be accomplished by automatic train controls. Override controls will be available for the train attendant to permit manual control of trains from the A cars should the need arise. Signals may be displayed in the cab for the attendant's information. Capability of operating the individual or combined cars within the yards will be provided on all cars for yard hostling purposes.

The selection of the A and B car for the system has been based upon analysis of the costs of various methods of providing the required train service. Basically, two alternatives are available. One is to supply controls and attendant's facilities on each end of all units which constitute the train. The second alternative involves the use of special end cars with controls and the train consist would be made up with these cars at each end of all trains. The second alternative is the least expensive. Since these end cars will be used at the train ends only, they can be given a distinctive appearance for aesthetic and functional purposes.

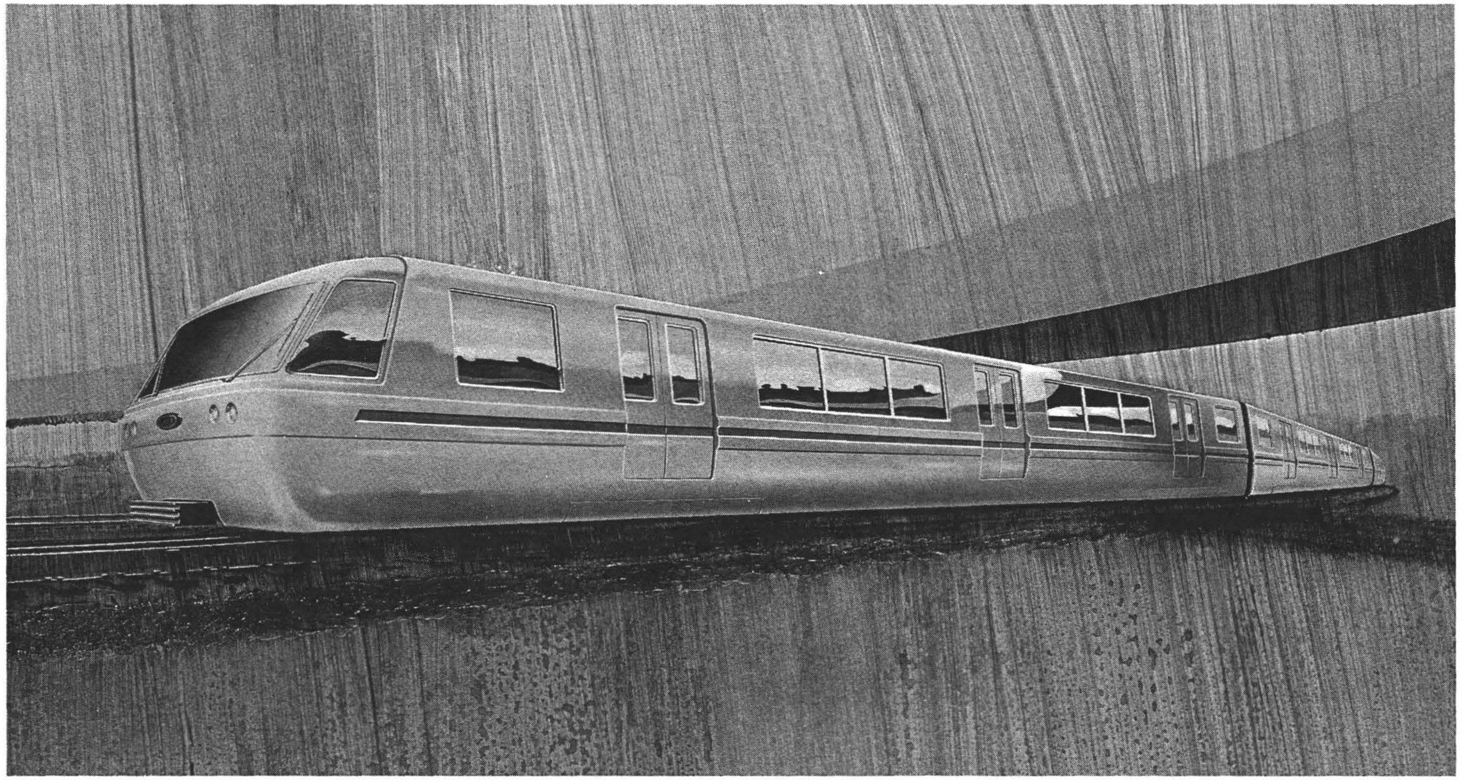
Utmost attention has been given to the convenience, dependability, and aesthetic features of the system. Each element of the vehicle has been carefully selected to enhance the design and to provide comfortable, convenient, and low-maintenance interiors. The end cars have been designed to reduce wind resistance and economize on the power requirements at the speeds demanded by the Los Angeles system.

DIMENSIONS

Train Length—To provide for the required normal capacity of 1,000 passengers per train, a maximum train length of 600 feet will be required.

Passenger Aisles—A rapid and free flow of passengers is extremely important throughout the system. One basic objective of the vehicle design is to reduce the time spent standing at stations, and an orderly flow of passengers is vital for an efficient loading and unloading process. A passenger aisle width of about 27 inches is considered the minimum efficient dimension and 30 inches is desirable. The SCRTD vehicle is designed to provide at least 30 inches of width in the longitudinal aisle of the transit vehicle.

Door Widths—A width of the door opening of a transit vehicle must be sufficient to permit rapid movement from both directions through the door. Door openings of 54 inch width



will permit two-way traffic, and this width will be used for side doors.

Number of Doors—Train door requirements have been determined based on the predicted passenger loading volumes. The maximum number of passengers entering and leaving a train at each station during the peak hours of travel has been used as a basis for this design. These calculations indicate that at least 22 doors will be required to accommodate the design load volumes. A uniform door spacing of 25 feet has been selected to provide 24 sets of doors along each side of a 600-foot train. This number of doors provides a ten percent allowance for non-uniform distribution.

Door arrangements which provide identical dimensions between doors throughout the length of the train have been used on the vehicle to simplify the problems of alignment of train doors with platform doors, if train screens are used. However, uniform door spacing is desirable even without train screens so that station structures can be designed with regular spacing to assure that the door locations would always be consistent.

Car Height—Overall height is an important dimension because of its effect on the diameter of the tunnels, and the resulting influence on cost. Three factors combine to establish the total height of the vehicle:

. The floor height, which is established by the sizes of the equipment to be mounted under the floor, the floor construction, space required for air distribution ducts, clearances for the wheels and trucks, and allowances for movement of the car body permitted by the suspension system. The critical element for the vehicle is the size of the equipment. Limiting equipment to 26 inches or less establishes a floor height of 40 inches above the top of the running rail.

. Head room inside the car has been established at 7 feet, 2 inches vertical clearance in the aisles.

. The thickness of the ceiling and roof construction of the car body will be limited to about 4 inches.

. The total of the floor, aisle and ceiling requirements results in a car height of 10 feet, 10 inches.

Car Width—This dimension, like the height of the car, must be controlled to avoid any unnecessary tunnel cost. Proportioning the width of the car to fit the geometry of rectangular and circular tunnel sections, and including provisions for the necessary walkways and third rails permits the optimum use of the tunnel area, and the selection of the optimum car width. This dimension is about 10 feet, 6 inches. This provides space for a 30-inch aisle, two 44 inch seats, and two 4 inch walls.

Car Length—Car length for the system is a multiple of the total train length of 600 feet. Vehicle lengths considered included a 75 foot and an 85 foot car. Car length has also been selected to provide the appropriate length of train required for off peak service. Other important factors which were considered in determining car length were system design questions involving the following principles:

1) Within limits, longer cars permit cost savings since there will be fewer items of equipment such as propulsion motors and trucks to buy and maintain. Also, the number of pieces of miscellaneous car equipment is reduced, and consequently unit weights are also favorably reduced.

2) Longer cars will require more clearance on curves for throw out.

3) Longer cars will result in higher axle loads (fewer axles), and aerial structures will require larger section modulus to accommodate this increased load.

4) The heavier load per axle requires increased motor capability per axle, and could result in an unacceptable space requirement for the propulsion motors.

An analysis of the first three elements results in minor savings for the longer car. However, no assurance could be obtained that propulsion equipment capable of satisfactory performance could be developed within the anticipated schedule of construction and system implementation. Therefore, the 75 foot vehicle has been selected for preliminary design.

Vehicle Weight—Studies indicated that a light-weight car weighing about 865 pounds per foot is technically possible, but the economic justification of reductions of weight to this extent is questionable since potential costs to reduce weight to this degree may exceed the value received in return. Therefore, the car weight of 865 pounds per foot has been established as the target weight, but system designs have been made on the basis of an allowance of up to 15% increase for contingencies.

CAR BODY DESIGN

Stainless steel and aluminum alloy are the basic construction materials for light-weight modern transit vehicles. The structural design should be a semi-monocoque design using all welded construction. The exterior surface of the vehicle will be either aluminum alloy or stainless steel in combination with nonmetallic materials which do not require painting.

Exposing unprotected metal surfaces to the atmosphere of the Los Angeles area has been investigated, and it has been determined that vehicles which are washed at least once each week may be constructed of aluminum alloy or stainless steel. These materials will provide adequate resistance to corrosion without additional surface treatment.

Impact resistance criterion for rapid transit vehicles have not been established as an industry standard. The practice is to modify the impact resistance requirements for rapid transit equipment to sustain the static and dynamic strains from routine operation of car coupling and the variations of tractive effort within the elastic range of the car body structure.

The nuisance damages caused by careless or even automated handling in the yards should be minimized by providing couplers with draft gear incorporating high energy absorbing characteristics so that low velocity impacts can be absorbed without damage. Therefore, the transit vehicle has been designed to withstand about 3 G s of static load applied at the ends before permanent deformations occur.

INTERIOR DESIGN FEATURES

The basic seating arrangement will be standard for all cars. The door location has been previously discussed. Two-and-two transverse seating will be used wherever possible to assure maximum comfort. The seats used in the vehicle are of modern design with upholstered cushions. A generous seat width of 44 inches is provided for a two-passenger seat, and an arm rest is located on the aisle and wall sides.

Since there will be standees during rush periods, safe and convenient supports have been provided for standing passengers throughout the car. Vertical posts have been placed at each side of each doorway vestibule and vertical posts have been provided at the back of each transverse seat. In addition, "assist" handles have been located adjacent to each door on the interior wall of the vehicle.

Windows have been provided to permit both standing and seated passengers comfortable visibility to the outside. These windows will also compliment the exterior appearance of the car. The windows are tinted safety glass to reduce the solar heat load on the air comfort system.

Floors of the vehicle will be carpeted. The use of resilient floor material has been traditional with rapid transit and bus vehicles in years past. However, carpet is becoming more commonly used in many public facilities. In addition to its advantages in appearance, the chance of slipping on a wet floor will be eliminated and the acoustics of the vehicle will be improved because of the sound absorptive qualities of the carpet. The cost of providing a carpeted floor is not significantly greater than that of a high quality resilient floor.

Lighting levels will be adequate to provide illumination for pleasant reading. The absence of glare and elimination of sharp contrast will contribute to rider comfort at night. The vehicle will be provided with about 35 footcandles at the reading plane. A high frequency fluorescent lighting system has been selected because of its size, weight, efficiency, and the quality of the light. An emergency lighting system is also provided by switching a portion of the regular lighting system into service under emergency power. The emergency lights will be battery powered in the event of a temporary outage of main power. In addition to the selected standard light fixtures recessed in the ceiling, several DC fixtures will be located strategically around the car to provide improved illumination under both routine and emergency conditions.

MECHANICAL EQUIPMENT

The power supply system propulsion and braking, automatic train control, and communication systems for the SCRTD vehicle are discussed in detail elsewhere in this report.

The truck, or undercarriage for the vehicle, is the assemblage of four wheels, two axles, traction equipment, the suspension systems, and the supporting frame. The wheels will be rigidly pressed onto axles and held in sets of 2 axles by the side frames of the truck. The lateral spacing of the wheels for the car will be at the standard railroad gauge of 4'– 8½". The longitudinal spacing of the axles for the vehicle has been established at 7 feet. The secondary suspension system for the vehicle will be air springs with or without steel coil springs. These air springs will include the load leveling equipment to maintain a constant floor level regardless of passenger load. The truck for the vehicle will be specified to meet actual physical limits of weight, and to provide specific ride characteristics. The truck may be manufactured of cast steel or fabricated metal.

Wheels play a vital role in the smoothness and quietness of the vehicle ride. The vehicle will use either a 28 inch or 30 inch wheel diameter with a tapered or cylindrical tread profile. The larger diameter wheel has improved wearing qualities and reduces maintenance costs. However, the smaller wheel will be lighter in weight and have a lower first cost. The final selection of the wheel diameter for the vehicle will be made at the time of final design.

Coupler and draft gear for the vehicle offers an opportunity to make use of new and improved designs. Couplers and draft gear, including the electrical portion of the coupler, perform three functions:

- Cushion impact between cars,
- Provide mechanical linkage between cars, and
- Connect cars electrically.

The impact resistance of the coupler and draft gear for the system will distribute forces received at the coupler face over a broader base of time by recoiling as much as 3 inches under the load. The energy absorption charactistics of this device must be adequate to absorb impacts between cars at 6 miles per hour without resulting in serious damage to the vehicle.

The mechanical portion of the coupler for the vehicle will be operable from both within the car and at the wayside. The electrical section of the coupler will make it possible to transmit the necessary control and communication signals throughout the train.

The auxiliary electrical system on the vehicle will supply low voltage power to the car-carried equipment. This system will consist of a battery, power supply/battery charger, an inverter for the car lighting system, and necessary controls and switches. It will also include an MG set or a static inverter to provide AC power for the air cooling equipment and other items.

CLIMATE CONTROL

Various combinations of temperature, humidity, and air movement appropriate for the Los Angeles area were utilized in determining the desired comfort level for the vehicle. A temperature differential of 10 to 20 degrees will be maintained between the vehicle and the outside temperature. Air supply will be introduced into the car through diffusers at the window sills. The air motion within the car will generally be between 25 and 35 feet per minute, with a maximum velocity of 65 feet per minute and a minimum of 10 feet per minute. Dirt, pollens and other atmospheric impurities will be removed by filtration of outside fresh air which will be supplied at a rate of about 10 cubic feet per minute per seated passenger.

SPECIAL FEATURES

Sound control features will be used as required on the vehicle to maintain sound levels which coincide with the required criteria. The desirable sound level is one which will provide a sufficiently low background noise to permit individual conversations to take place confortably without disturbing other passengers. The specified criteria will be:

	Speed	Maximum Criteria
In the vehicle	60 to 70 mph	NCA-65
In the vehicle	0 mph	NCA-55

A number of techniques in addition to normal car construction may be used to reduce the sound levels. These include:

. A deep skirt on the car to shroud the equipment, and coating the inside surfaces with sound absorptive material.

. Sound absorptive material installed over the trucks and in other areas where above average sound levels exist.

. Maintaining the running rail in good condition by grinding when necessary.

. Maintaining a smooth wheel tread by grinding when necessary.

. Rubber dampers in all connectors and couplings in the truck design.

. Resilient mountings for the floor structure.

. Effective seals at the doors.

. Sound absorptive material installed inside the car such as carpeting, upholstered seats, and perforated ceilings with absorptive material.

. Mufflers on air release sources such as brakes.

. Rubber stubbers or other devices to eliminate metal to metal contact wherever possible.

. Wheel damping or resilient wheels.

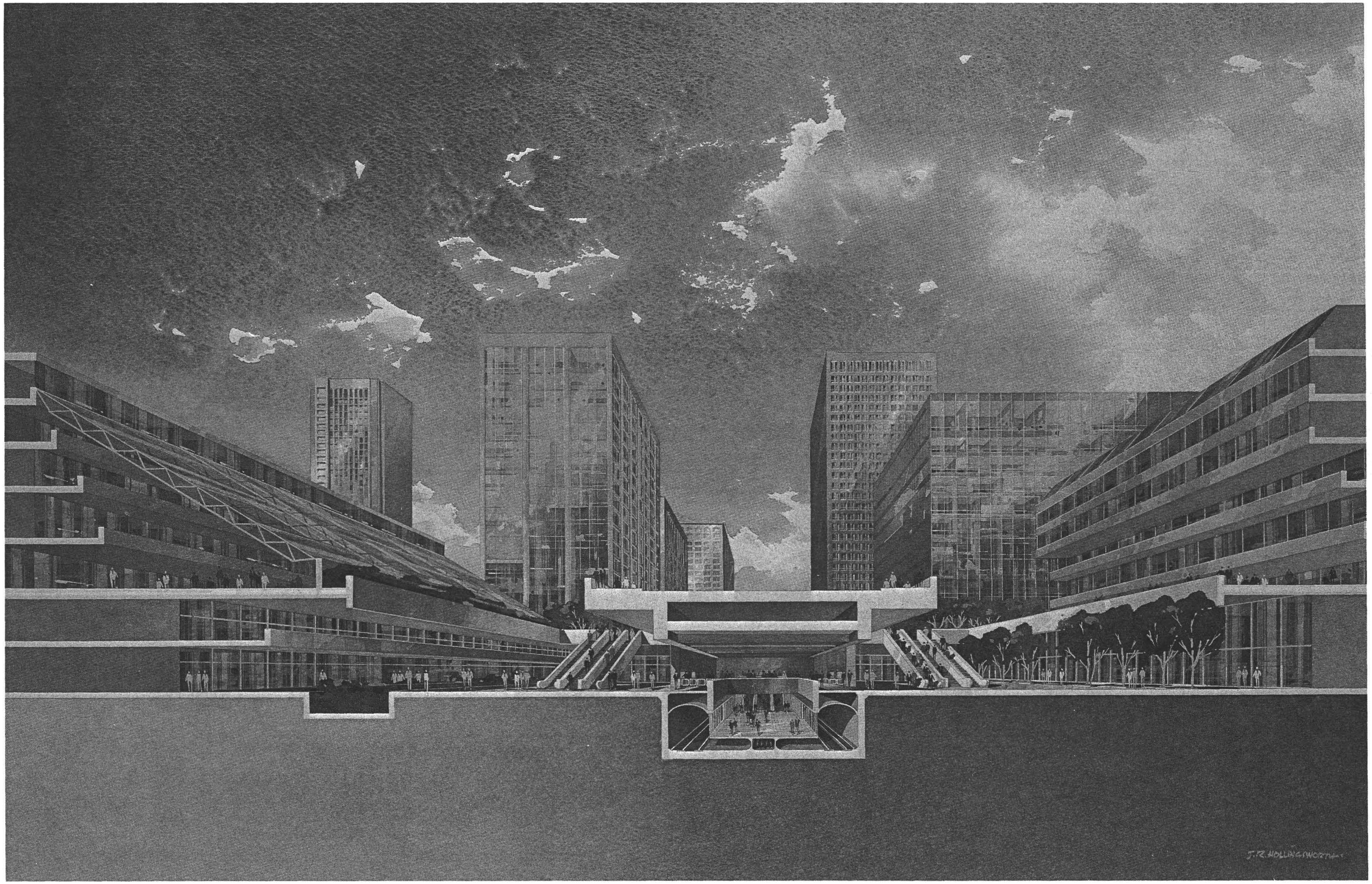
AIRPORT CORRIDOR CAR

The concept for the Airport Express operation and the type of vehicles to be employed has been developed and described in a report by Day and Zimmermann Inc., consultants to the District. The following descriptions have been abstracted from this report.

Initially, the proposed Airport Express will be made up of four cars. One end of the first passenger coach and one end of the baggage mail car will be equipped with front end controls to permit point to point operation. The baggage car will always be at the rear end of the train as it leaves the Metroport and at the head end of the train as it leaves the Airport.

The airport express vehicle will use the same car shell, propulsion, and control equipment as the regular transit vehicle. The interior arrangement will be considerably altered to provide an environment compatible with this high speed deluxe airport service. All passengers will be comfortably seated and each car will have fifty-six (56) seats. Carpeting and a public address system will be provided. Ample space is provided in the car for storing baggage for those passengers wishing to keep their luggage close to them.

The baggage-mail car would have essentially the same dimensions as the passenger vehicle, and would include front end controls. The ramainder of the car would be open, with no division between baggage and mail areas. The car floor would be equipped with ball transfer to facilitate the movement of containers in and out of the car.



J.R. HOLLINGSWORTH

ACOUSTICAL AND VIBRATION CONSIDERATIONS

Increasing attention has been focused on the mounting level of ambient noise in urban areas by urban planners and residents alike. Therefore, the preliminary design studies have included a special in-depth study of noise generation and attenuation. This study comprised investigation and analysis of the following acoustical aspects of the transit system:

- Noise levels from interaction of vehicles on roadway structures.
- Community ambient and tolerance levels.
- Vibration propagation in soils and buildings.

The purpose of these studies was to provide review and analysis of potential noise and vibration problems throughout the system, and to provide data for use as a guide in its design and development.

When discussing sound and noise, it is essential to point out that the human ear is not equally sensitive to all frequencies of sound, and it responds differently to different levels of sound. There are several methods or scales available for evaluating the loudness or annoyance of a sound. The studies conducted for this program have employed a measuring system which provides the best correlation to the subjective evaluation of a noise. These measurements are taken directly with a sound level meter which permits the convenient determination of community noise levels over long time periods without the necessity for laborious and time-consuming octave band analyses and calculations. The results obtained are an accurate measure of the subjective interpretation of noises.

TRANSIT TRAIN COMMUNITY NOISE LEVEL ESTIMATES

Data obtained at the BARTD Test Track in Concord, California, have provided the basis for estimates of the noise and vibration to be expected from the operation of the SCRTD transit trains. The laboratory cars used at the BARTD Test Track are modern design lightweight cars, and represent a close approximation of the anticipated system noise.

Figure 1 indicates the average wayside noise levels measured 50 feet horizontally from the track at different running speeds for a single transit car operating on a concrete and on a ballast roadbed. The levels are representative of results with a continuous welded rail. However, in actual operation, track maintenance will include grinding of the rail at regular intervals. This maintenance procedure had not been implemented on the test track and the rail was quite rough.

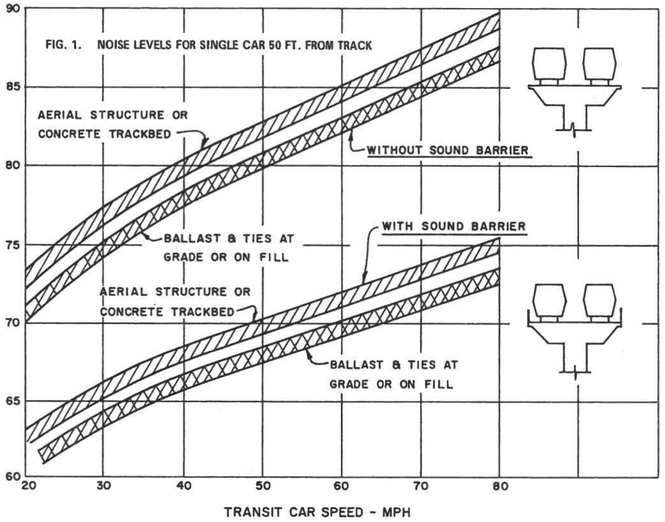


FIG. 1. NOISE LEVELS FOR SINGLE CAR 50 FT. FROM TRACK

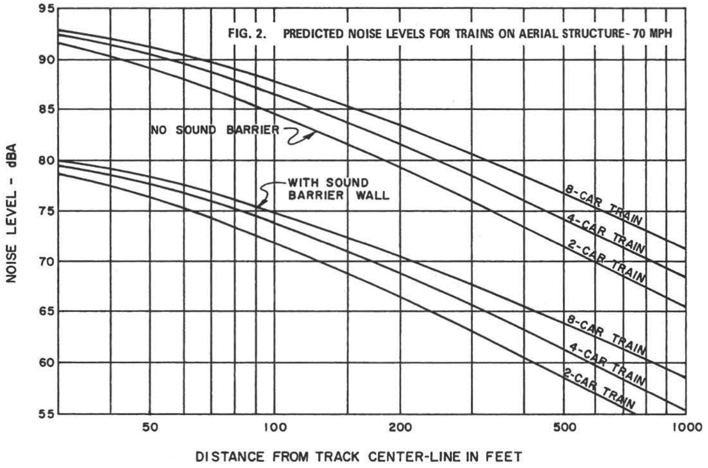


FIG. 2. PREDICTED NOISE LEVELS FOR TRAINS ON AERIAL STRUCTURE-70 MPH

It can be expected that a smooth, continous rail will give slightly lower noise levels. Further, new developments in noise control are anticipated with less noise generation than current measurements indicate.

One of the most significant results from the BARTD Test Track is also shown on Figure 1; i.e. the reduced wayside noise which results from the use of a sound barrier wall or parapet. The sound barrier consists of a vertical wall along the trackside next to the car, and extending from the roadbed to a height sufficient for the top of the wall to be above the bottom of the car side skirt at the wheels. For maximum effect, the wall should have sound absorbing material attached to the side facing the car. This type of sound barrier has the advantage of being able to reduce, by shadowing and absorption, the noise level from all the significant noise sources on a transit car including the wheel and rail, the traction system, and the auxiliary equipment.

The wayside noise reduction of the barrier wall is 12 to 13 dBA. A noise reduction of 10 dBA is generally considered to result in a noise "one-half as loud" subjectively. Thus, it is apparent that a sound barrier wall can reduce transit train noise at the wayside to less than one-half the loudness which would be experienced without a barrier.

Figure 2 shows the estimated noise level as a function of distance into the community for different lengths of train at 70 mph. This graph is for the unobstructed propagation of the noise in a horizontal direction through the community. The graph represents the worst case to be expected, since shadowing of buildings or other features of terrain would reduce the noise level rapidly as distances increased.

COMMUNITY NOISE LEVELS

In order to relate this technical data on noise to more familiar and recognizable terms, as well as to provide current information on the community noise levels present in the areas where the rapid transit routes are planned, noise measurements were made along the routes in each of the corridors. The principal background noise which is present in these communities is that created by vehicular traffic on the streets and highways.

Typical residential area background noise levels, without nearby street traffic, were found to be in the range of 50 to 60 dBA in the daytime, and 40 to 50 dBA at night. Noise levels measured in the transit corridor communities at residential building setback lines indicate that typical slow auto traffic creates noise levels in the range of 60 to 70 dBA.

Similarly, automobile traffic on busy boulevards creates levels in the range of 70 to 75 dBA at the residential building setback line. Trucks and buses create levels in the range of 75 to 85 dBA at the setback lines, and observations on commercial area sidewalks indicate frequent levels in the range of 80 to 90 dBA. In all of the above cited cases, the occasional vehicle with loud exhaust noise has been omitted. Existing noise levels observed along the proposed transit routes are summarized in the following table, and Figure 3 indicates these ranges superimposed upon the projected transit noise. Sidewalks along major boulevards are typically 35 to 50 feet from street centerline. From this figure, it is apparent that transit trains operating at 70mph at this same distance will produce comparable or lower sound levels than the buses which now operate on the streets. It is also evident that transit operating in the median of very wide streets such as Chandler and Sherman Way will also produce sound levels at the building line which are comparable to those presently experienced from automobiles alone.

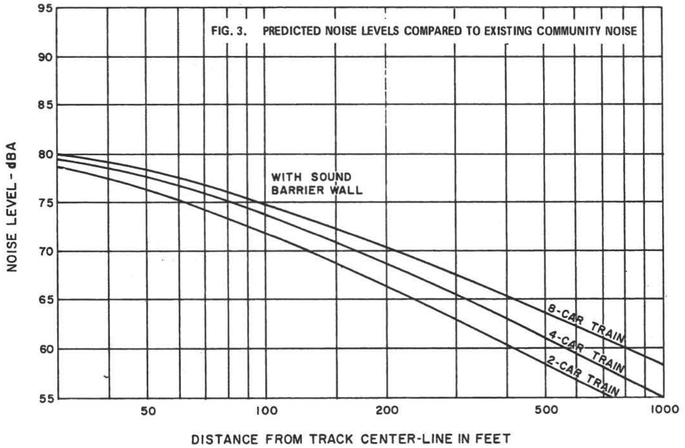


FIG. 3. PREDICTED NOISE LEVELS COMPARED TO EXISTING COMMUNITY NOISE

Typical Community Noise Levels Observed
Along SCRTD Corridor Routes:

Type of Area	Type of Noise	Noise level dBA
Residential removed from Freeways & Boulevards	Autos	60-70
	Trucks	70-80
	Airplanes	60-70
	Freight Trains	80-95
Residential near Flight Pattern	Airplanes	75-85
Residential-Commercial near Boulevards	Autos	65-75
	Trucks	70-80
	Buses	70-80
	Airplanes	70-80
Sidewalks of Commercial Area	Autos	70-80
	Buses & Trucks	80-90
Industrial	Background-Day	60-70
	Background-Night	50-60
	Autos	65-75
	Trucks	75-85

A major noise source in the Los Angeles area which contributes to the community background noise is the freeway system. Figure 4 shows typical freeway noises compared to projected rapid transit train noises. This graph is based on data obtained from those freeways which have fairly constant use day and night, such as the San Bernardino Freeway.

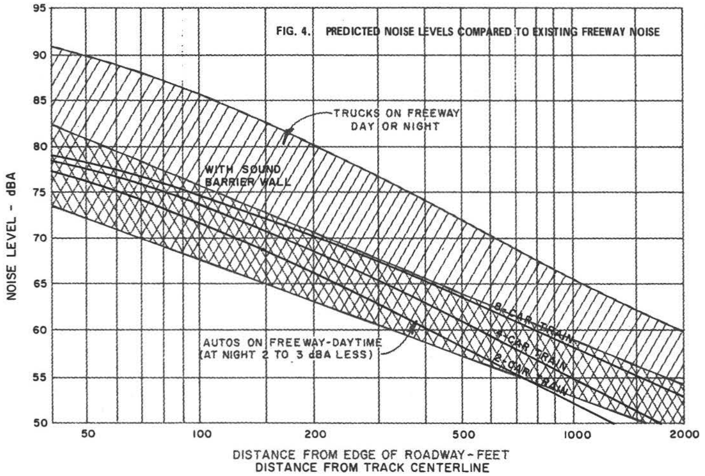


FIG. 4. PREDICTED NOISE LEVELS COMPARED TO EXISTING FREEWAY NOISE

VIBRATION STUDIES

While airborne vibrations in the form of sound waves are of paramount importance in aerial structure and other open configurations, they are of much less concern in the subway portions of the route. However, the factors generating these vibrations are still present, and under certain conditions could constitute an annoyance. Therefore, a detailed analysis of potential ground vibrations produced by rapid transit trains has been included in the acoustical studies.

There are three possible sources of annoyance due to tunnel operation of rapid transit trains. The first is perceptible vibration of the ground or adjacent building structures. The second is noise generated by the vibration of the building floors or walls. The third possibility is the transmission of airborne noise in the tunnel through the tunnel walls and ground or through vent shafts to adjacent occupied buildings.

VIBRATION LEVEL ANALYSIS

Figures 5 and 6 show the vibration perception criteria presented by Dyer. These criteria are the most frequently quoted in recent literature and represent the best now available. The threshold of vibration perception as presented by Koffman and Postlethwaite is also shown on the charts.

The vibration considerations apply primarily to vertical vibration since the sensitivity to horizontal vibration is only about 70% of that to vertical vibration. Also, it was found by a comparison of vibrations generated by the transit vehicle that the vertical vibration was between 2 to 4 times greater than the horizontal.

Figure 6 indicates that the sensitivity to vibration is approximately proportional to the vibration velocity over a relatively wide frequency range at levels near the threshold of

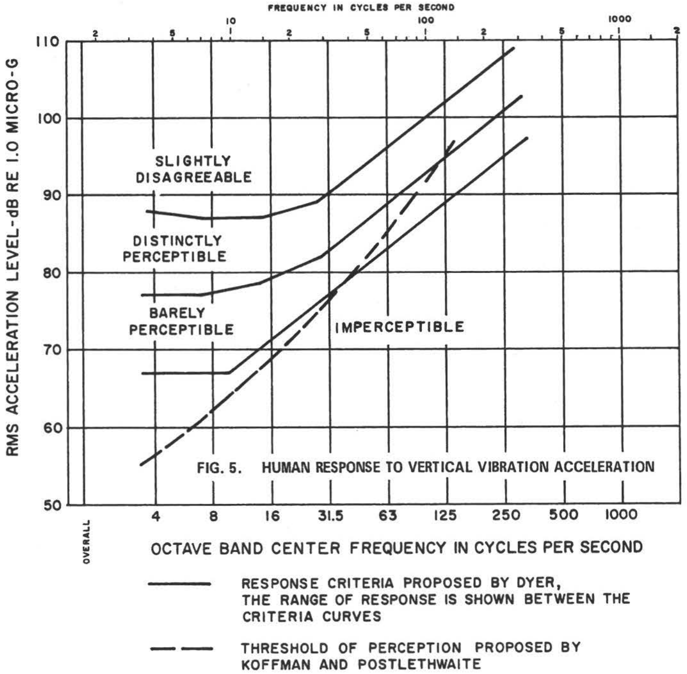


FIG. 5. HUMAN RESPONSE TO VERTICAL VIBRATION ACCELERATION

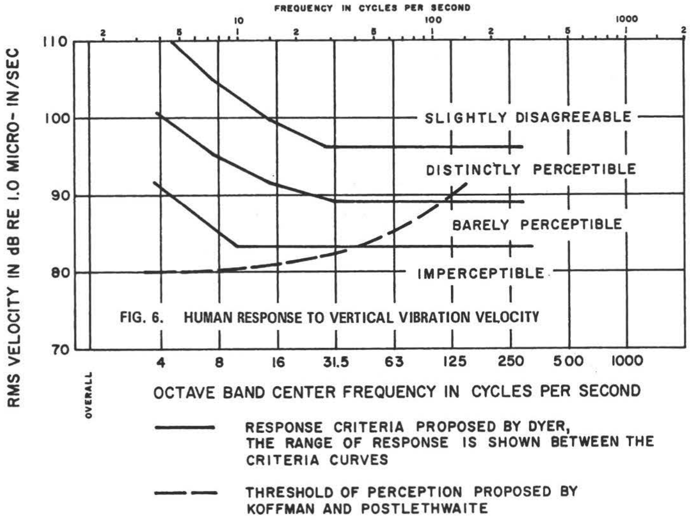


FIG. 6. HUMAN RESPONSE TO VERTICAL VIBRATION VELOCITY

perception. Since this frequency range covers the range of the principal vibration components from transit trains in tunnels, it is convenient to present the vibration data in terms of vibration velocity.

PREDICTED TRANSIT TRAIN VIBRATION LEVELS

Vibration data obtained at the BARTD Test Track in Concord, California, in conjunction with information and data obtained in a search of pertinent literature, have provided the basis for estimates of the ground vibration to be expected from the operation of SCRTD trains in tunnels.

To assist in predicting the expected vibration levels from tunnel operations, measurements were carried out at the BARTD Test Track in a location where the soil composition was relatively similar to that of the Wilshire Corridor areas. The soil conditions at the Test Track location would, if anything, provide better propagation of vibration than Wilshire Corridor locations, and result in conservative estimates.

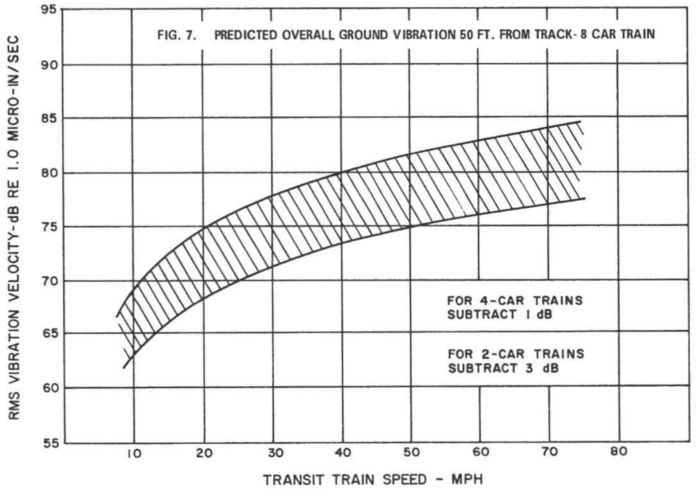


FIG. 7. PREDICTED OVERALL GROUND VIBRATION 50 FT. FROM TRACK- 8 CAR TRAIN

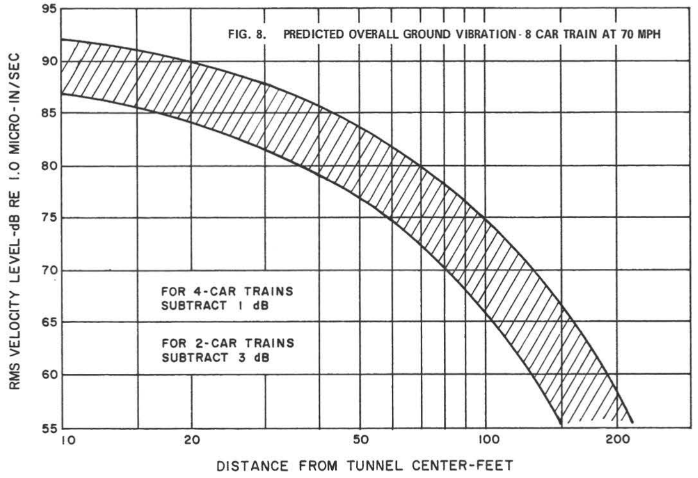


FIG. 8. PREDICTED OVERALL GROUND VIBRATION- 8 CAR TRAIN AT 70 MPH

The studies carried out at the Test Track were measurements of surface waves induced by a source on the surface. Using the Test Track data, estimates made of the ground vibration from a tunnel beneath the surface are comparable or greater in level than will actually occur because the amplitudes of body waves induced by a subsurface source are less than the amplitudes of surface waves induced by a source of similar energy on the surface. This also provides conservative estimates.

Figure 7 indicates the average ground vibration level expected at different passby speeds for an 8-car transit train as it would occur in the ground 50 ft. from the tunnel.

Figure 8 shows the estimated ground vibration level as a function of distance from the tunnel for an 8-car train at 70 mph. This graph is for the unobstructed propagation of the vibration in the ground. The presence of buildings or other man-made changes in the earth would modify the results.

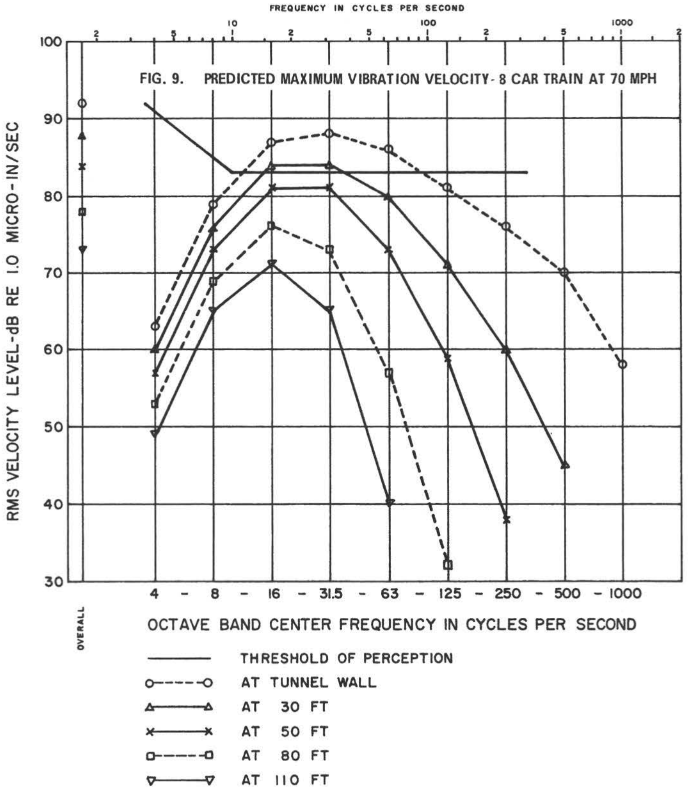


FIG. 9. PREDICTED MAXIMUM VIBRATION VELOCITY- 8 CAR TRAIN AT 70 MPH

Changes in the composition of the soil along the propagation path will have only minor effects on the transmitted vibration levels.

Figure 9 gives the octave band analysis of the maximum expected vibration levels for an 8-car train at 70 mph in the tunnel as observed at different locations. The spectrum shape is not expected to change significantly with speed and the spectra shown can be used for estimation of the vibration analysis at other speeds.

Vibration levels observed on existing subway installations, when corrected for the vibration reduction expected from continuous welded rail and the use of resilient rail fasteners, give results comparable to those obtained from the Test Track measurements.

As shown on Figure 9, the vibration levels expected from the trains are below the threshold of perception of vibration for most circumstances. The greatest vibration level would be created by an 8-car train at 70 mph in a single tunnel with the presence of ground water between or around the tunnel and the adjacent structure. Under these extreme conditions, the vibration level at distances less than 30 feet would be perceptible and for distances of 50 feet or more from the tunnel the vibration would be imperceptible. Because of the great attenuation of vibration and noise by ground, the vibration levels decrease rapidly with distance from the tunnel, and the range or distance an annoying level penetrates into the community is minimal.

During final design, further research on the vibration propagation characteristics of the soils surrounding the tunnel locations is needed to definitely determine the need for auxiliary vibration reduction features in the tunnels at critical locations. However, using the best available information, the ground vibration levels expected are below the threshold of perception for all types of buildings located more than 50 feet from the tunnels. For massive concrete buildings, the vibration will not be perceived as motion at separations of only 25 or 30 feet.

ESTIMATED SOUND LEVELS FROM TUNNEL OPERATED TRANSIT TRAINS

There are three means by which sound from a transit train passing by in a tunnel can reach an observer in an adjacent building. The first is by direct transmission of airborne sound in the tunnel through the tunnel wall, the earth, and into the building. The second is by generation of noise within the building due to the vibration of the tunnel. The third is by airborne noise transmission from tunnel vent exits.

The attenuation of higher frequencies by soil is so great that for buildings located more than 10 ft. from the tunnel wall, the airborne sound transmission would be much less than the noise generated by ground vibration. It is apparent that transmission of airborne noise from the tunnel is not a significant problem except under very exceptional circumstances.

Figure 10 shows the maximum predicted Sound Pressure Level generated by ground vibrations at various distances from the tunnel. The levels shown indicate that the building noise level generated by ground vibration should be acceptable in a commercial area for buildings located 50 feet or more from the transit tunnel. Actually, because of the nature of most commercial buildings, and particularly those along the Wilshire Corridor, the coupling loss from the ground to the building will probably be in the range of 5 to 10 dB, and the sound level should be acceptable for buildings located as close as 30 feet.

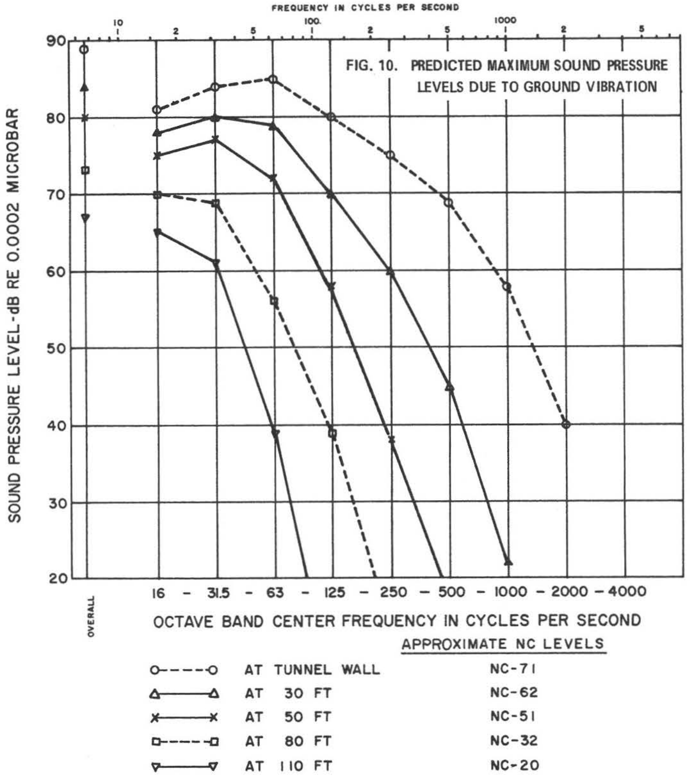


FIG. 10. PREDICTED MAXIMUM SOUND PRESSURE LEVELS DUE TO GROUND VIBRATION

Figure II shows the estimated Sound Pressure Level inside the tunnel for an 8-car train operating at 70 mph.

The greatest noise reduction required will be for vents with openings in or very near sidewalks. For such vents, noise reductions of 30 to 35 dB at 500 cps will be necessary. Such reduction will be accomplished through the use of glasswool lining and right-angle bends in the vent duct.

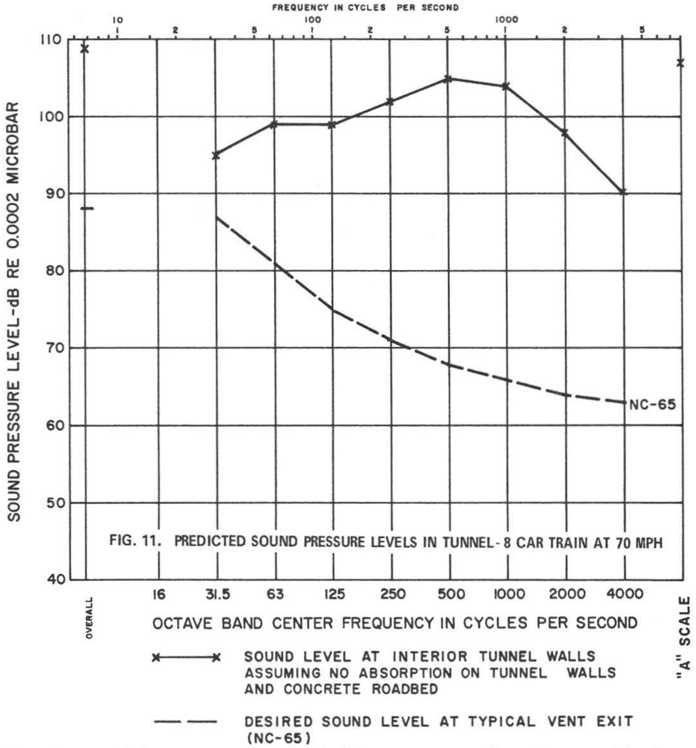


FIG. 11. PREDICTED SOUND PRESSURE LEVELS IN TUNNEL- 8 CAR TRAIN AT 70 MPH

A substantial attenuation of airborne tunnel noise could also be provided within the tunnel. For example, appropriately located sound absorptive material on the tunnel walls can reduce the airborne sound by 10 to 15 dB. Such noise reduction would have the additional benefit of reducing the sound level for transit passengers.

PROCEDURES FOR REDUCING VIBRATION AND NOISE FROM TRAINS IN TUNNELS

In those areas where tunnels must be located in close proximity to a building with activities sensitive to noise and vibration, there are techniques available for further reduction of the vibration and noise.

There have been many efforts made to provide greater vibration isolation for trains in tunnels than that which is attainable through the use of resilient rail pads. These efforts have generally produced little or minimal benefit. For those areas where vibration appears to be critical in the SCRTD System tunnels, a type of vibration isolation not previously employed in transit system tunnels is recommended.

The vibration reduction scheme suggested is the same as that used in buildings for the reduction of structural vibration due to rotating machinery. The excitation frequencies from typical machinery are in the range of 10 to 30 cps, the same range as the highest amplitudes from transit vehicles. The procedure is to provide a floating concrete slab floor, or in the case of transit tunnels, a floating concrete roadbed. Load-bearing glasswool pads are used as the flexibile support for the floating roadbed. Such a system is generally capable of reducing the low frequency vibration levels transmitted to adjacent structure, and has the advantages of providing vibration level reduction without reducing rail stability. The isolating pads could be inserted between the roadbed and tunnel structure in those areas where vibration is critical, and omitted at other locations. No other significant changes in the tunnel details should be necessary.

SUMMARY

The evaluation of the potential sound and vibration problem has been related to the various areas traversed by the proposed routes. General conclusions are as follows:

. The Wilshire and San Gabriel Valley Corridors present the least possibility of any acoustical problems due to the subway configuration in the Wilshire, and the extensive use of freeway median and rail rights-of-way in the San Gabriel.

. The selection of alignments in or adjacent to busy boulevards with very wide rights-of-way in the San Fernando Valley, northern portions of the Long Beach routes, and the Airport-Southwest routes, combined with the use of sound barriers on the aerial structure, will provide acceptable sound levels in these areas. In nearly all cases, sound generated by transit operations will be at or below existing sound levels generated by street traffic.

. The use of an open-cut configuration along Wilton Place in the San Fernando Valley Corridor will prevent transit noise from being transmitted any appreciable distance into the adjacent community and the subway sections through Hollywood will eliminate any possibility of noise in the community.

. Aerial transit way in rail rights-of-way in the Long Beach Corridor and Airport-Southwest Corridor routes, largely through industrial areas, will minimize noise problems in those areas. When routes are not in industrial areas, sound barriers on the structure will reduce noise levels well below those currently experienced from existing railroad operations.

. Ground vibrations generated by subway operations will be below the level of perception for most structures adjacent to the routes. More detailed studies at critical locations will be conducted during final design to determine the extent of any additional attenuation which may be necessary. At these critical locations, special techniques such as roadbed isolation will be incorporated to reduce vibrations below perceptual levels.

WAY STRUCTURES

The aesthetic considerations in connection with route configurations involve architectural design and landscape treatment previously discussed. The visual qualities, as well as the safety and economy of construction of the way structure and stations are largely a function of architectural and structural design. In the course of this program, extensive effort has been devoted to careful analysis of way structure types, their relationship to the community, and the physical conditions in each area traversed.

The basic transitway configurations considered include:

Aerial Structures
Surface or Existing Grade
Open Cut or Depressed Section
Subway

ALIGNMENT PARAMETERS

One basic consideration in achieving a desired high speed system involves the physical environment in which the trains operate. This includes providing adequate horizontal curvature and profile grade limitations to assure high performance throughout the system.

The alignment parameters for the SCRTD system are based on maximum train velocity of 75 mph. This has been determined from an analysis of station spacing. Alignment factors based on this criteria are briefly summarized as follows:

. Curvature is designed to sustain velocity within limits of track superelevation and economic restraints of right-of-way. All curves will be provided with spiral easements for superelevation and horizontal transition to improve the comfort of passengers. Minimum curve radius will be 550 feet on main line trackage, and 275 feet in yard areas.

. Profiles are designed to adapt the transit route to the physical features through which the system passes. This involves economic considerations for subways in congested areas and landscaped cuts and aerial structures in suburban areas. The transition gradients are designed to offer least resistance to train movement. Maximum grades of 3.0% will be used for sustained lengths with 4.0% allowed for short ramps. Vertical curves are provided for safety and comfort at all gradient changes.

. Physical environment has been investigated to determine influence on transit alignment and cost. Elements which were covered in this study phase include topography, right-of-way, drainage channels and structures, substructures, utilities, railroads, and streets and freeways. Considerations for relocation of these elements has been included where required.

. Clearances for transit vehicles in structural configurations have been taken into account as required by the Public Utilities Commission of the State of California. These clearances have been adapted from regulations requested by and granted to the Bay Area Rapid Transit District for comparable system requirements. These consist of vertical and horizontal clearances from the vehicles to surfaces in subways, on aerial structures, and obstructions.

Within the parameters outlined above, preliminary alignment studies were completed consisting of investigation, evaluation and profile development for over 200 miles of alternate route segments.

STRUCTURAL DESIGN

Public safety is the primary consideration governing the design of all public facilities. Design for rapid transit system facilities must meet all safety requirements of conventional public facilities, and in addition, must include considerations for special design loads from the transit vehicle.

Structural design for such facilities in the Los Angeles area must also include special provisions for seismic disturbances. Past experience, scientific measurements and data, and current scientific theory indicate that there will be seismic disturbances in the future. Therefore, seismic design criteria for the way structures was based on the recommendations of the Structural Engineers Association of Southern California. Along with other members of the Structural Engineers Association in the State, the findings of this group form the basis for seismic design provisions in local and regional building codes.

Present-day technology permits accurate failure limit predictions, and it is therefore possible to design structures to a high degree of accuracy if the loads to be applied can be accurately determined. Thus, the primary factor in assuring safe design of the transit facilities is the determination of possible loadings to which the structure could be subjected. Factors of safety used are consistent with those provided for by conventional building codes. The following paragraphs discuss the various types of loads to be expected along with other design considerations.

GENERAL CRITERIA

Criteria established for design of the transit facilities meets or exceeds local code requirements and the Uniform Building Code (UBC). Further, special codes have been considered where applicable, such as for railroad or highway bridges.

The design criteria and test results of the Bay Area Rapid Transit District (BARTD) have been carefully reviewed, and information provided by the concrete and structural steel industries has also been considered in developing criteria and preliminary design.

In addition to the structural design criteria, aesthetic considerations of the structures, particularly the aerial structure, are of paramount importance in assuring that they will be visually acceptable in the area traversed, and also to insure that their construction or the structure itself will not create hazardous, disruptive effects. While keeping both first cost and maintenance cost as low as possible, the criteria and preliminary designs give foremost consideration to the safety and comfort of the public, as well as aesthetic value to the community.

MOVING CAR LOADS AND IMPACT LOADING

Aerial structures must safely support the rapid transit trains which may consist of from two to eight cars, and vary from 150 to 600 feet in length. Further, passenger load may vary widely from peak to off-peak volume. Thus, the magnitude and distribution of the moving car loads vary considerably at speeds up to 75 mph. While the suspension system for the cars will compensate for track irregularities, passenger imbalance, wind gusts, girder deflection and similar effects, the train movement will produce vertical and lateral acceleration which result in added forces in these directions. These are called impact forces and are expressed as a percentage of the total loading.

The American Railway Engineering Association (AREA) and American Association of State Highway Officials (AASHO) have impact effect formulae that are functions of span. The AREA formula varies from 28% at 80 feet to 23.5% at 110 feet, while the ASSHO formula varies from 25% at 75 feet to 20% at 125 feet. Results of impact measurement on the BARTD test track indicated that a factor of 25% independent of span would be appropriate. As the analysis of any coupled system is complicated and the results sensitive to assumptions and variations, any empirical approach should be verified by testing. Therefore based on the BARTD test track experience, and the ultimate necessity for specific component testing to confirm design, an impact factor of 25% has been used for preliminary design.

The preliminary design vehicle length was established at 75 feet with a truck spacing of 52 feet and a vehicle weight of 65,000 pounds. The maximum number of passengers was set at 267 which, at 150 pounds per passenger, produced an additional load of 40,000 pounds, for a total vehicle weight of 105,000 pounds. With two axles per truck, the resulting design axle load was 32,800 pounds including impact.

SEISMIC CONSIDERATIONS

Seismic design is basically in accordance with the current seismic code of the Structural Engineers Association of California. This requires design for a force $V=KCW$, where K is a constant dependent on the type of member or structure, C is a constant generally dependent on the natural period of the structure, T, and W is the total dead load on the structure. For the support columns, $C=0.05/\sqrt[3]{T}$.

For aerial girders and station platforms, a "K" value of I.0 is adequate, but for support columns that are cantilevered from the ground with essentially a lumped mass at the top, a "K" value of at least 2.0 is required. This results in a seismic design factor for support columns in the range of 10 to 16%, but which is dependent on span, height and column size.

In general, tunnels and similar underground construction have not experienced damage from earthquakes. Basically, such a structure simply moves with the earth for all practical purposes and therefore has the same movement period as the earth with little or no net resultant seismic force exerted on the structure.

Since none of the corridors cross an active fault or fault zone, or have any unique soil conditions, there are no special design considerations required. The structures designed for the Los Angeles area will be structurally and operationally safe under all anticipated loading conditions, including earthquakes.

WIND LOADING

The UBC criteria for wind pressure forces is presented on a map of the United States showing wind pressure areas. Based upon this criteria, the Los Angeles area required design for 15 psf up to 30 feet in height, 20 psf from 30 feet up to 50 feet and 25 psf from 50 feet up to 100 feet. The Los Angeles City Building Code requires design for a 15 psf wind load on those portions of structures up to 60 feet in height, and 20 psf on those portions at 60 feet and above.

A review of U. S. Weather Bureau published records for the Los Angeles area reveals a maximum recorded fastest mile gust of 62 mph (L.A. International Airport, March, 1952). The Bureau maintains, or has maintained these records for Civic Center, International Airport, Burbank Airport, and Long Beach Airport. A review of records of the Los Angeles County Air Pollution Control District (APCD), and those of Los Angeles State College, indicates velocities recorded at these stations are considerably below this 62 mph figure.

Based on the evaluation of available wind records, future year predicted winds and discussion with SEAOSC, as well as a review of BARTD criteria, wind loadings of 20 psf for those portions of structures up to 60 feet in height and 25 psf for those portions at 60 feet and above were selected as design criteria.

NATURAL FREQUENCY, DEFLECTION AND CAMBER

Based upon empirical analysis, BARTD established a mimimum of 2.5 cps for the first mode natural frequency of simple-span aerial girders, which is equivalent to a maximum static deflection of 2.0 inches. Also, no more than one span in any three consecutive spans could have a first mode natural frequency of less than 3.0 cps (or 1.4 inches maximum static deflection). The maximum specified natural vertical frequency of the BARTD vehicle suspension system is 1.5 cps. Since the BARTD test track results gave no indication of dynamic deflection or structural frequency, there appears to be 100% damping. Live load deflections were also considerably less than those calculated.

AASHO requires that live load deflection will not exceed L/800, where L is the girder span. Both BARTD and the SCRTD preliminary design criteria require camber for deflection due to dead load plus 3/4 of live load and impact, with horizontal and vertical curvature and creep also to be considered.

The SCRTD vehicle suspension system will also have a maximum natural vertical frequency of I.5 cps. A minimum first mode natural frequency of 2.0 cps (3.1" maximum static deflection) has been established as the SCRTD criteria for spans less than or equal to 120 feet, and 1.75 cps (4.0" deflection) for spans over 120 feet. Live load deflection has been limited to L/800 for 80% of maximum live load. This criteria recognizes the BARTD test track experience in particular, and the criteria has been reviewed and approved by the dynamics consultant to the Joint Venture.

SOILS INVESTIGATIONS

Preliminary soils investigation was conducted, and included the compilation of existing soils data supplemented with test borings as required. Preliminary design values used for foundations and underground structures were developed from this investigation.

Areas with special subsurface conditions such as the La Brea Tar Pits, rivers, and difficult construction areas due to ground water or soil conditions have received special consideration. No major problems were found to exist and all of these conditions can be handled satisfactorily.

The general description of foundation materials to be encountered along the system routes may be described as belonging to three major geologic groups: Recent alluvium, Pleistocene terrace deposits, and Tertiary marine sediments. The rock formation in the Santa Monica Mountains constitute a separate group. These strata are not encountered elsewhere along other corridors.

Recent alluvium consists primarily of silty sands, sands, and gravels. Layers of cobbles also may be encountered in some areas. Pleistocene terrace deposits comprise an older alluvium, consisting primarily of clays, silts, silty sands, and sands. In general, these soils are finer than the recent alluvial soils and are less compressible. Tertiary marine sediments consist of highly consolidated clayey silts and are variously referred to as either shales or siltstones. Although considered as bedrock, these deposits are easily excavated by conventional equipment and tunnelling machines.

Along the Wilshire Corridor, the soils from Union Railroad Station to Main Street are recent alluvial deposits consisting of sands, gravels, and cobbles. For the next mile to about Fourth Street, a relatively shallow depth of Pleistocene terrace deposits is found overlying the shales and siltstones, and these constitute the formations through which the tunnels will be driven. Along the remaining portion of the "downtown" area to about Flower Street, the coarse, recent alluvial soils are again encountered. Continuing westward to about Normandie Avenue, the terrace deposits overlie shales and siltstones. Bedrock is not again encountered within foundation depth along the rest of the corridor. From Normandie Avenue to La Cienega Boulevard the soils are described as terrace deposits, and among these are also the tar-saturated sands in the vicinity of the La Brea Tar Pits. West of La Cienega Boulevard to Barrington Avenue, the recent alluvium consisting of silts, silty sands, and sands is underlain by terrace deposits.

Along the San Gabriel Valley Corridor, the coarse recent alluvial deposits are found along the corridor from Union Railroad Station to the east bank of the Los Angeles River. Shale and siltstone occur either near the surface or at shallow depths to slightly beyond the Long Beach Freeway. Shallow Pleistocene terrace deposits occur where bedrock is not exposed. Continuing eastward to approximately San Gabriel Boulevard, terrace deposits predominate. Thereafter to the corridor terminus, recent alluvial deposits are encountered.

Along the San Fernando Valley Corridor, from the junction with the Wilshire Corridor to approximately Santa Monica Boulevard, the Pleistocene terrace deposits are found overlying shale and siltstone. Continuing along the corridor to the vicinity of Hollywood Boulevard, the tunnels will intercept recent alluvial soils. In tunnelling through the Santa Monica Mountains, various rock strata will be encountered including shales, siltstones, sandstones, conglomerates, basalts, and granites. North of the mountains to the corridor terminus, the soils consist primarily of recent alluvial deposits.

The soils along the entire Long Beach Corridor consist primarily of recent alluvial deposits which become somewhat finer in gradation going from north to south. No significant rock strata are known to occur along the corridor.

Recent alluvial deposits are encountered along the Airport-Southwest Corridor from Union Station to about Broadway consisting of sand, gravels, and cobbles. Pleistocene terrace deposits are found overlying Tertiary marine sediments to about Flower Street. A recent alluvial is then encountered from Flower Street to the vicinity of Crenshaw Boulevard and Florence Avenue. Along the remaining portions of the corridor, Pleistocene terrace deposits predominate except for approximately the last two miles along Aviation Boulevard where the soils consist primarily of dune sand.

Determination of the type of foundation required for structures was based on subsurface data obtained from the soils investigation. Generally, pile footings for aerial structures will be used throughout the system, and on-grade structures and subway stations will be supported on spread footings. Varying subsurface conditions have been identified for subway construction, and appropriate design values have been developed and used in the preliminary design of tunnel sections.

UNDERPINNING

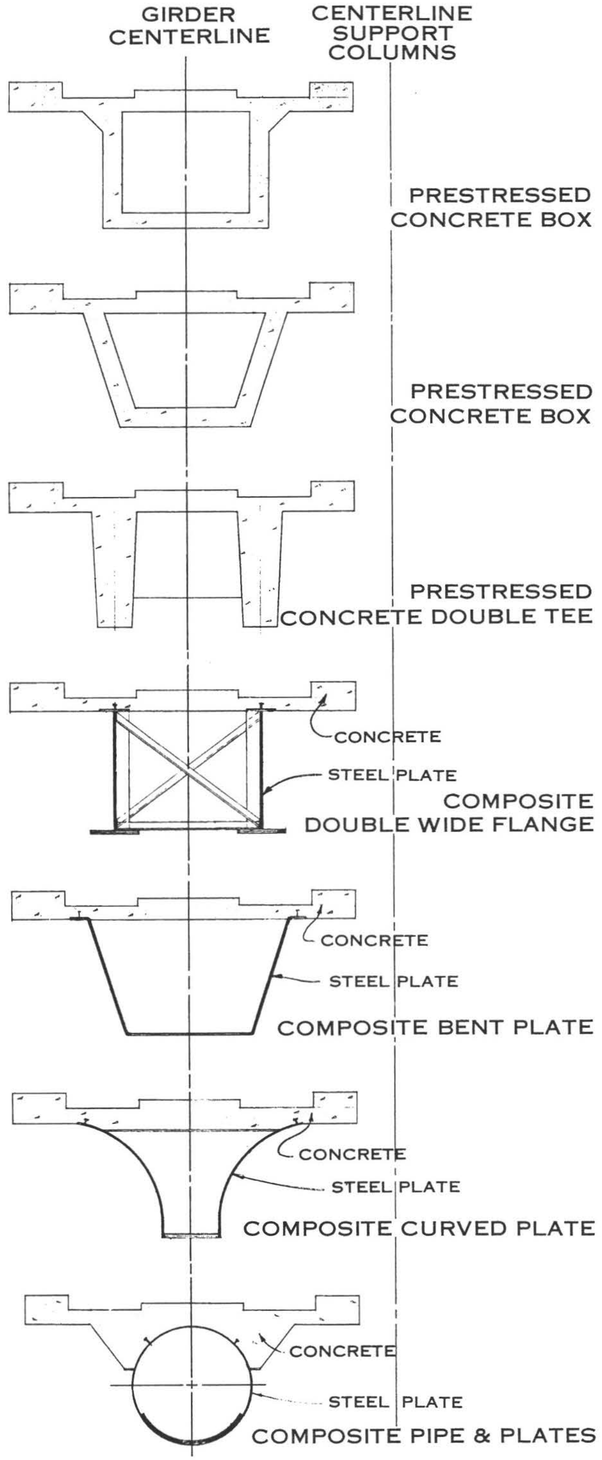
It will frequently be necessary to underpin or support the foundations where tunnels for rapid transit extend close to existing building foundations of four or more stories in height, or are located under existing buildings. Underpinning will be necessary if the zone of pressure from the foundations does not go below the tunnel spring line. Underpinning is generally required for all buildings at underground stations. If a tunnel is located under buildings three stories or less in height, except for special cases, no underpinning is required if the depth from the bottom of the existing foundations to the top of a tunnel is at least equal to the outside diameter of the tunnel.

AERIAL STRUCTURES

Spans (distance between supports) of aerial structure girders should be as long as practical, and still efficiently and safely support the moving car loads. However, they should not be so long as to result in an unreasonably deep girder. The spans should be of near uniform dimensions and be within a range that would allow economical construction and erection techniques. Further, the span should not be so large as to require a column size disproportionate to the girders and environment.

Continuity, obtained through continuous span over several supports, would generally allow greater length than a simple span. However, this method would sacrifice the economies of prefabricating techniques ideally suited to repetitive construction and erection. Detail analyses of spans for various segments of the system were made. It was determined that spans ranging from 70 feet to 110 feet were possible in 95% of the aerial system. The consideration of the width and depth of the girder, height of the structure above ground, and the size of the column were found to be in proper proportion to these spans. Thus, it was determined that this range of spans would provide an optimum aerial system which will combine visual attractiveness with practical construction techniques.

Numerous types and shapes of girders were developed and included different construction materials. Concept designs for each were carried out and thoroughly analyzed from the standpoint of proportion, aesthetics, quality of finish, constructability, maintenance, and cost. The basic sections considered in concrete were the rectangular box, trapezoidal box, and double tee. It was found that the box sections had superior structural characteristics in torsional resistance, lighter weight and pre-stressing. The basic composite sections using steel girders and concrete deck were steel pipe, curved web, box and double "I" girder sections. The box section was found to be the most feasible section, and in addition, it was similar in shape and dimension to the concrete box section. Thus, an identical section for two different materials would be



highly desirable to permit consideration of alternate materials for construction.

Of the sections studied, it was determined that the basic "box" section would embody more desired structural and aesthetic features than any other section. For the concrete "box" section, the pre-stressed precast method of construction was selected as best meeting requirements of cost, appearance, and aesthetic value, as well as other design criteria.

Prefabricated girders, when compared to reinforced concrete poured in place, have numerous advantages. Precast pre-stressed girders are readily adapted to economical mass production, and to proven construction and erection techniques. Finish, consistency and appearance can be more strictly maintained to produce a very pleasing structure requiring little maintenance. Construction is generally faster, and no special considerations must be made at locations where shoring could not be tolerated. However, some limitations on precast girders exist including the necessity to obtain special permits to transport and erect extremely long or heavy girders. In such special locations, either composite steel girders or poured-in-place reinforced concrete girders can be used.

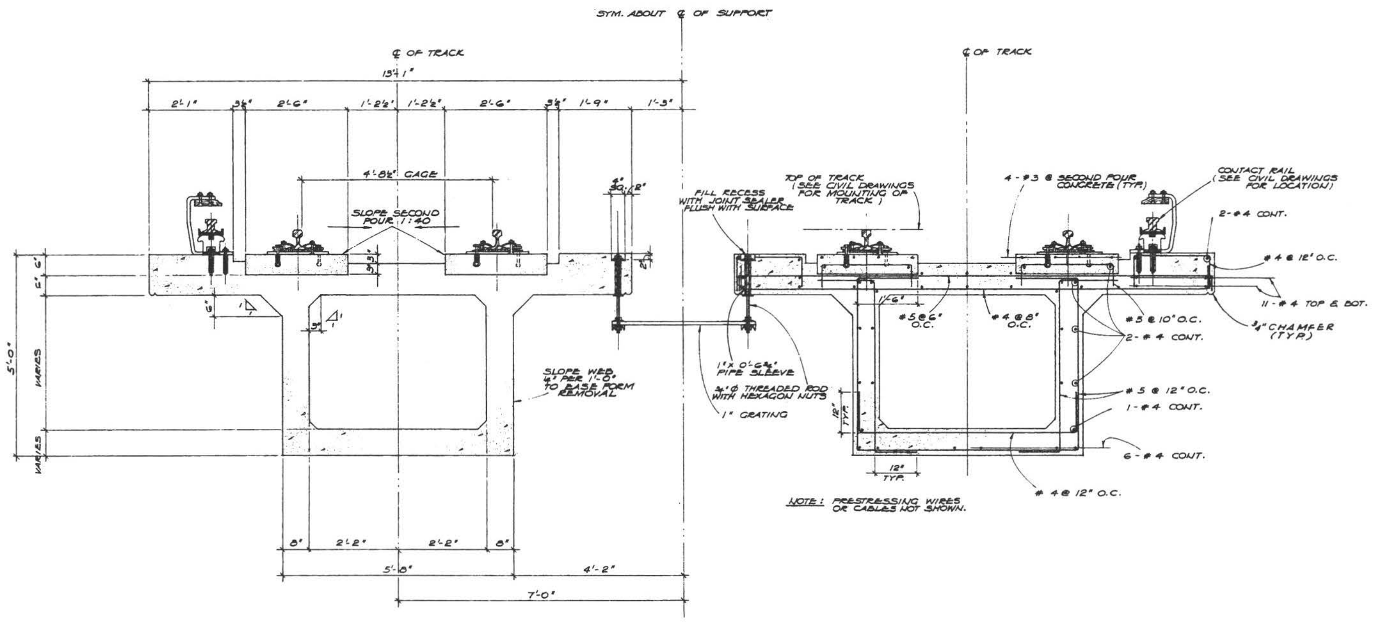
Composite girders of structural steel with a reinforced concrete top slab permit longer spans with less weight, but generally at a higher cost and more maintenance. For this report, the concrete section has been used throughout as the basic girder design, and as cost estimating basis. However, the selection of these sections does not rule out consideration of other designs during final design or construction stages. Advances in construction technique and/or economy in construction costs may also justify changes.

SINGLE COLUMN VERSUS MULTIPLE COLUMN

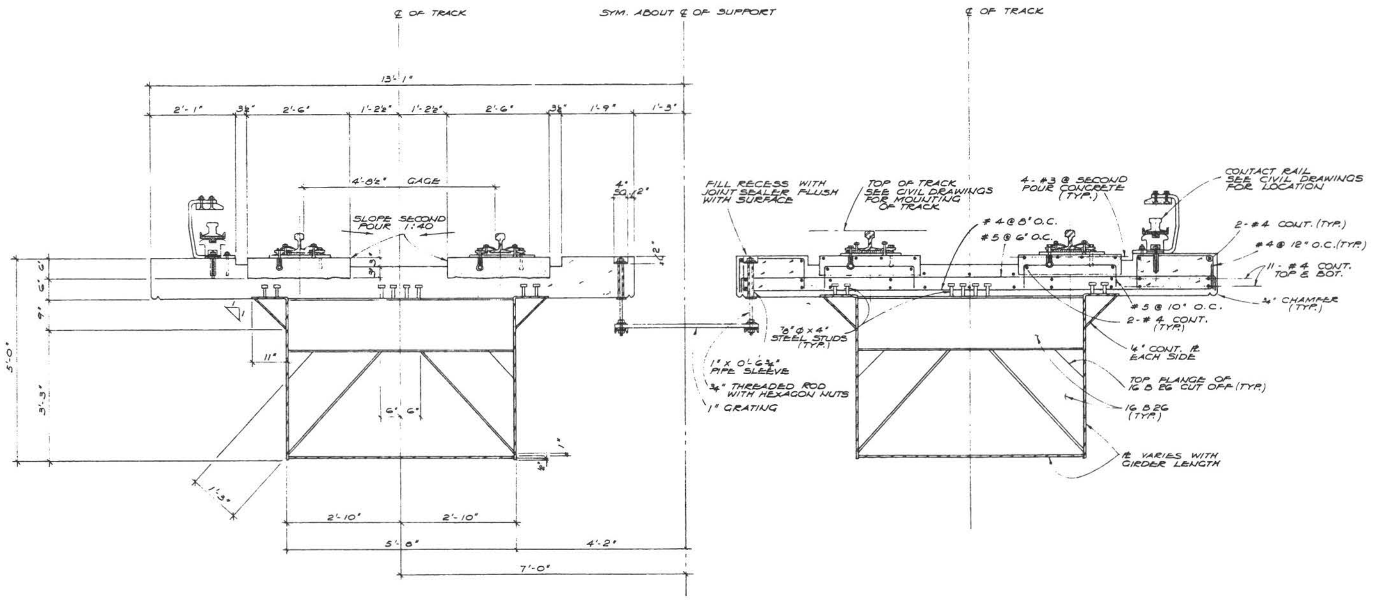
Way structures using a single column design to support aerial girders are generally more economical than multiple columns because duplication of loading and increased forming is eliminated. Further, it is not possible to use multiple columns where supports are located in a street median. In addition to the increased economy, a single line of columns is generally considered the more pleasing design. Therefore, the preliminary design of all aerial structures employs a single column concept.

SUPPORT COLUMNS AND ARMS - SIZE AND HEIGHT ABOVE GRADE

A column must be large enough to safely support the loads transmitted to it, yet not be out of proportion with the



TYPICAL SECTION THROUGH
PRESTRESSED AERIAL GIRDERS



TYPICAL SECTION THROUGH
COMPOSITE AERIAL GIRDERS

remainder of the structure and its environment. The height of the girders above grade should be as low as possible to minimize the column dimensions (and therefore costs), but must be high enough to allow surface vehicles to safely pass beneath. A minimum clearance of 16′-0″ has been established. This meets or slightly exceeds all existing street and highway requirements. When access to station concourse levels must be below the platform level and must cross adjacent streets, column heights have been increased accordingly.

Increasing the height of the girders for a given column size and span creates greater effective design bending moments proportional to the height, and thus requires more reinforcing steel and larger foundations. Column diameter also must increase when additional reinforcing steel cannot be effectively placed in column.

A basic column size of 5′-0″ in diameter for typical length of column and span was selected as meeting design requirements, and for very high columns and/or long spans, a column diameter of 5′-6″ is required.

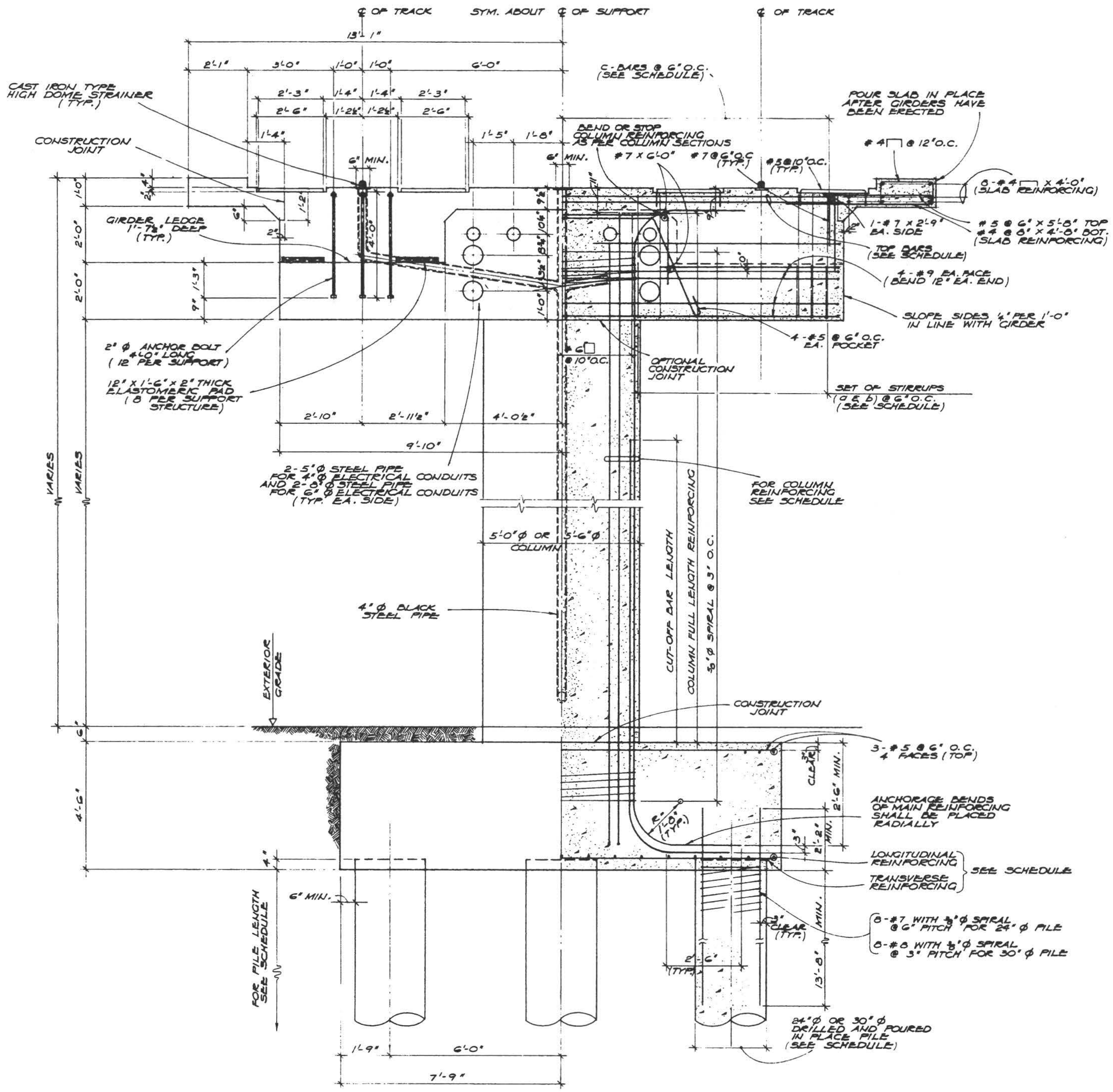
The support arm configuration is designed to match the girder outline to obtain a continuous longitudinal flow of the girder profile.

Preliminary design has been based on poured-in-place reinforced concrete columns and arms using metal forms for repetitive construction. However, this does not preclude consideration of structural steel for final design, and it is anticipated that these alternates will be designed and included as bidding options.

CUT AND COVER BOX SECTION AND SPECIAL UNDERGROUND CONSTRUCTION

Use of cut and cover construction in lieu of tunnelling is most economical when the construction is on private property with no utilities interference, where the depth is not excessive, and where access to the construction is not restricted. However, this construction method has limited application for typical way construction in those areas where subway is contemplated.

Cut and cover techniques are of necessity applied to station structures, intermediate vent shafts, underground turnback and crossover construction. In addition, cut and cover techniques must be employed where the rapid transit lines pass under large buildings, or where the orientation of two or more tracks is changing as is the case with the Wilshire/Long Beach Interchange.



TYPICAL SECTION THROUGH AERIAL SUPPORT STRUCTURE

0′ 1′ 2′ 3′ 4′ 5′

TUNNEL DESIGN

The selection of twin tunnel construction was based on the nature of soil encountered, economics, and potential construction problems. Subways can be constructed in different shapes, and with different materials. A tunnel section for two tracks can be of either single tunnel or twin tunnel construction. The shapes can be either circular or horseshoe. The tunnel lining can be either steel or concrete. The twin tunnel section was selected based on a detailed analysis of type of soil to be encountered, safety during construction, less cost, and certain operational advantage related to tunnel ventilation.

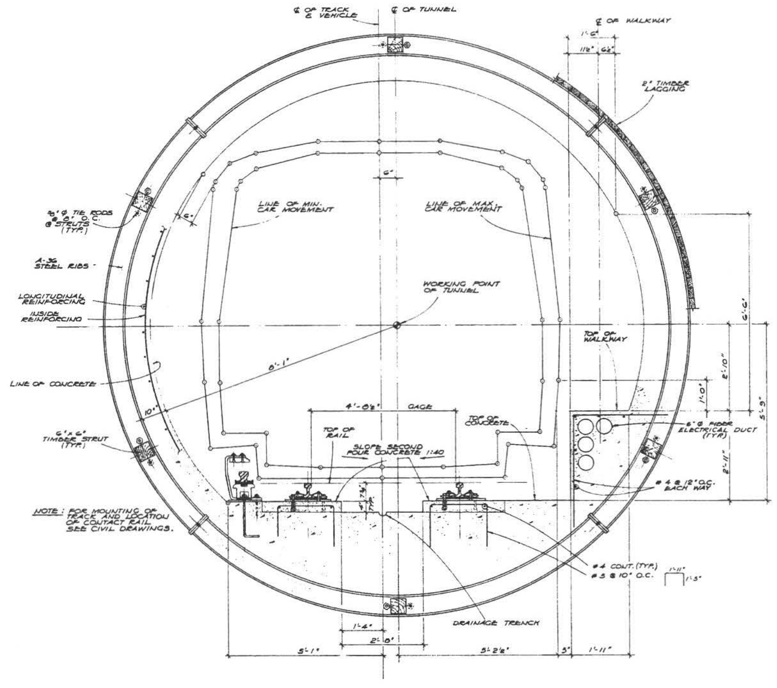
Based on a 75-foot long car, three sizes of tunnels were selected for use in the system. For tangent track, an internal diameter of 16′-4″ is adequate. For a minimum radius of 1000 feet, 17′-0″ is required, and for a radius of 600 feet, 17′-3″ is required.

The section of tunnel through the Hollywood Hills will be in rock. On the basis of information available concerning construction of a 6′-0″ diameter sewer tunnel located not far from the proposed rapid transit tunnels, this section was designed using structural steel rib sets with a concrete liner. The spacing of rib sets varies depending on the specific characteristics of rock encountered. Design vertical loads vary for these sections but have been established as a function of the outside diameter of the tunnel, while horizontal load is expressed as a percentage of the vertical load.

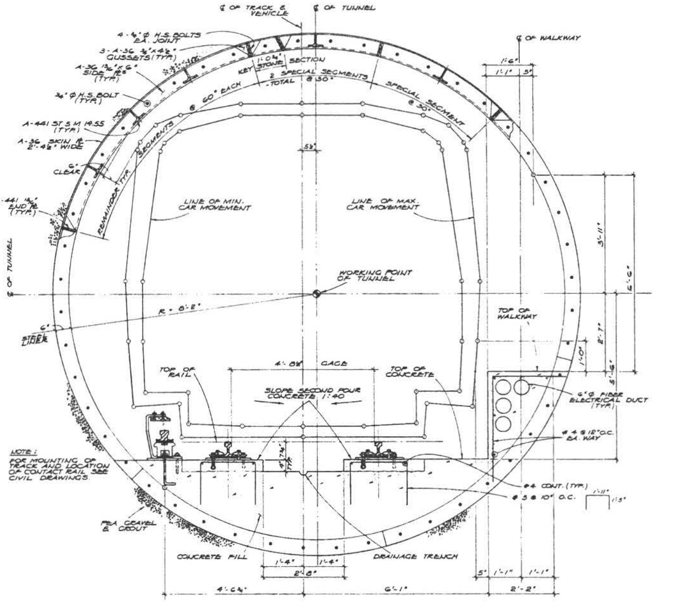
Soil characteristics encountered elsewhere in the system where tunnels will be used are such that temporary structural steel rib sets and permanent unreinforced concrete lining can be used. Design for these sections is for a vertical load equal to the effective soil weight above the crown and a horizontal load equal to one-half the effective soil weight at the spring line.

An alternate design employing steel liner plate sections can also be used. For this type section, it is assumed that the liner will distort and soil pressures will redistribute to produce radial loading equal to the equivalent weight of soil above the crown of the tunnel. For this loading and a radial displacement of ½″, using ASTM A-36 structural steel, the ring stresses do not exceed 22,000 psi; for a displacement of 1½″, the stresses do not exceed 36,000 psi (yield).

It is expected that use of steel liner plates will result in faster construction and cost will be comparable with concrete lining. Both designs should be included in the final design for bidding in addition to a horseshoe design.



TYPICAL SECTION OF
REINFORCED CONCRETE TUNNEL
TANGENT TRACK



TYPICAL SECTION OF
STEEL LINER PLATE TUNNEL
TANGENT TRACK

YARD AND SHOPS

A fundamental principle of a modern rapid transit system is first class maintenance to insure the operational integrity and visual appearance of operating units. Maximum attainable safety, dependability, and comfort are required to provide the high level of service demanded by today's transit patron. The proposed yard and shop facilities will satisfactorily meet these requirements with the functional elements described in the following paragraphs.

YARD FUNCTIONS

Typical daily operation includes varying the number of cars per train (train consist) to adjust to peak and off-peak patronage levels. The prime task of the yard operation is to make up the trains and insert the units into the system's automatic train control. Cars are stored convenient to the transfer area and brought to position under manual control. Transfer from manual to automatic train operation takes place between yard and mainline tracks and is accomplished through transfer tracks. When the dispatch includes trains bound in both mainline directions, the use of an additional staging area is required, called a dispatch track, which is under surveillance of the automatic train control. While not in passenger service, the transit cars will be stored in a location convenient to the transfer area so that cars can be readily brought into position for use. Automatic control of these storage yard functions is under development and may be included in final design of the systems become operationally and economically practical. However, for preliminary design, manual control is used. The service facilities including washing, cleaning, and daily maintenance activities should be accessible from the storage area. These functions are accomplished in each of the corridor storage yards. Yard locations are at or near the end of the line with the exception of the Wilshire Corridor where car storage is located in east Los Angeles near Macy Street. The following three classifications of vehicle maintenance operations are required:

1) Washing and cleaning, simple operational checks of equipment, minor servicing, and limited trouble shooting activity will be provided at corridor storage yards.
2) Servicing includes routine operational functions such as scheduled inspections, scheduled lubrication and steam cleaning service, periodic operational tests for vehicles and components, and the occasional exchange in certain types of equipment when inoperative. This may include simple repairs such as wheel grinding and electrical trouble-shooting.
3) Major repair includes overhaul, reconditioning, repairs and thorough testing. The overhaul may be for the complete vehicle or for certain components. Major modifications and wheel turning would be considered major repairs. New car acceptance tests would also be done at the repair shop.

Maintenance and repair of sophisticated equipment in automatic train control and air-conditioning systems, in addition to the routines for conventional vehicle components of body, trucks and traction motors covered in items 2 and 3, will be performed only at the Main Repair Yard in the Dominguez area on the Long Beach Corridor.

Non-vehicle maintenance functions such as wayside maintenance, automatic train control repairs and fare collection repairs are also provided for in the design of yards and shops facilities. A central receiving and storage area for all materials and supplies, including replacement parts, is provided.

FACILITIES

Transfer Tracks

As described earlier, the transfer tracks are those on which consist changes are made and trains are received and dispatched. Trains move from these tracks either into revenue service or into storage. Train lengths will vary from approximately 150 feet to 600 feet and will require approximately 650 feet of transfer track. A detailed analysis of train operating schedules will be necessary during final design to establish the number of tracks required in each yard. However, general analysis of the activities at the change track indicates a required time period of about nine minutes to change the consist of a train, and to prepare it for entry into revenue service. Therefore, three minute headways in the suburban areas will require four change tracks. One additional change track is provided for emergency substitutions. Platforms are to be provided for attendants to enter and leave trains. The tracks are spaced to provide ample room for activity between tracks. This may include the use of diagnostic test equipment and some off-track vehicular traffic. An alternating spacing of 20 feet and 16 feet is recommended.

The transfer tracks provide direct access to the mainline of the system, except where it will be necessary to enter or leave the mainline in either direction. In this case, dispatch tracks are required. In addition, grade separation of the access tracks and the mainline has been provided to avoid any potential conflict with mainline operation.

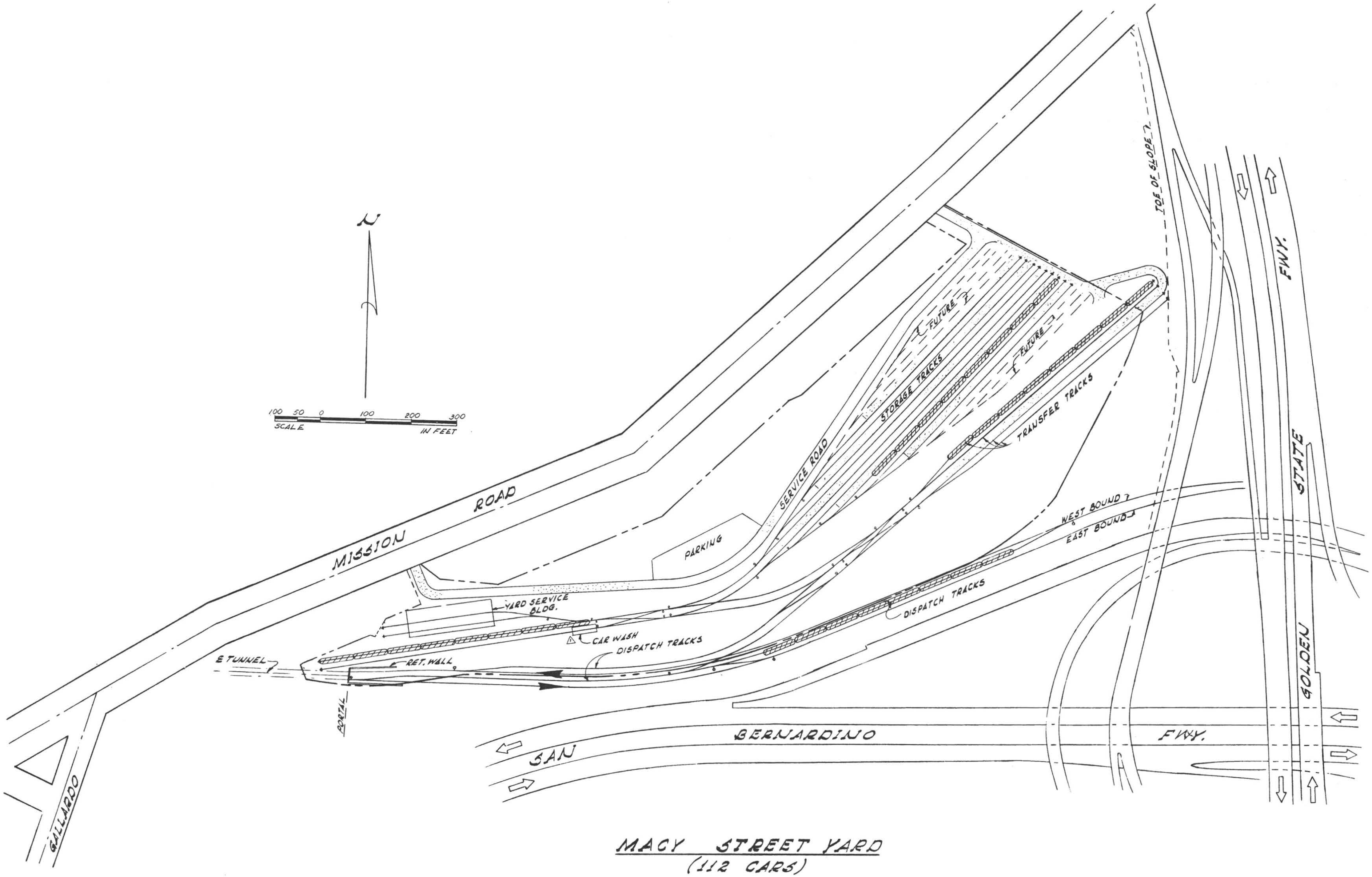
Storage Tracks

Each individual storage track will have its own power disconnect switch. The storage tracks should be utilized for the daily interior cleaning and adequate track spacing has been provided to permit easy access for the cleaning vehicles. Alternate spacing of 14 feet and 18 feet are used.

Initial property acquisition will include sufficient area for the ultimate capacity of the storage yard. The yard storage area will be provided with adequate light to permit work to proceed without auxiliary lighting facilities. The yard signal system will utilize dwarf signals with manual and remote operating facilities. Drainage will be provided and curbs utilized to protect the third rail from wheeled vehicular traffic. The entire yard area will be enclosed with a high security fence. Maximum speed in the yard will be limited to about ten miles per hour. The yard design will provide easy access from the storage tracks to the yard service facilities.

Yard Service Facilities

A Yard Service Building will be provided at all yards except the Dominquez Yard where the Main Repair Shop is located. The Yard Service Building will provide facilities for simple equipment operational checks and limited trouble-shooting



MACY STREET YARD
(112 CARS)

activity. Any repairs accomplished at the yard service facility will be by component exchange rather than direct repair. All routine scheduled service work and all extensive repair work will be done at the Main Repair Shop.

The Yard Service Building will be available to the transition track area and the storage area. It contains two tracks running through the building 20 feet apart with a two car length pit under one track. The total area of the building has been established as 12,000 square feet. About 700 square feet of storage space adjacent to the building is needed for wayside maintenance equipment and supplies. The facility will serve as a base for car cleaners and supervision.

Main Repair Facilities

The Main Repair Shop will house inspection facilities for routine inspection and lubrication, and the main repair and overhaul facilities for the entire fleet of vehicles.

The inspection portion of the building will contain inspection facilities large enough to house about 2% of the total car fleet. The service and inspection facilities should be available during all operating hours. The inspection facility contains about 60,000 square feet. Three tracks will run through the building and the DC rail will terminate approximately 70 feet away from the building. Jumper connections to a protected power supply are provided for shifting vehicles inside of the building. A service pit extends the entire length of one track and under parts of the other two tracks. The pits will be supplied with air, water, vacuum, electricity, light and an oil sump. Storage for parts will be minimum for vehicle repair items, since component exchange procedures will be used. The building has been provided with vehicular truck access for supplies and a vehicular parking lot for rubber tired work vehicles. Roofed maintenance- of-way equipment storage will also be provided. Although very little cleaning activity will be performed in the building, storage facilities for the car cleaning equipment has been provided and is similar to those in the yard service facilities. Transit vehicle entry into the building will be through roll-up type doors at both ends. The building will be expandable to meet future needs.

Major Repair Shop

Shop repair work will fall into three categories: the vehicle, automatic train control, and fare collection. The repair work on the vehicle will include scheduled major overhauls, modifications, component and assembly overhauls, repairs to the car body, and repair and exchange of wheel assemblies. General types of repair activity required to support the shop activity include: welding, sheet metal work, carpentry, glass work, sign painting, upholstery repair, machine tool work, painting, electrical and electronic repairs, and others. The support activities will include shipping and receiving of parts and supplies. At least 2% of the operating fleet may be in the main shop at any one time and will require facilities containing about 100,000 square feet. Cars will be handled as single units in the shop. The building will be designed with tail tracks for the facilities, but access from both ends of the repair shop is not mandatory. The repair shop will have five tracks placed on 20 foot centers and will be served by hydraulic body lifts. One service pit will be provided. Required equipment will include hoists, cranes, jacks, turntables, and facilities for all of the special activities to be performed within the shop. Office space, storage areas, areas for drawings, catalogs and maintenance records, and locker and lunchroom facilities have been included. Work space for special functions has been provided including a truck service facility for steam cleaning and wheel turning. The facilities are designed to provide maximum flexibility to accommodate future requirements by either revising interior arrangements or by simple expansion of the building outline.

Washing Facilities

It is recommended that vehicles be washed at least every three to seven days. The wash facilities will be installed at each yard in a section of track which is readily accessible to the storage tracks and also available to cars returning from the mainline. This suggests that the wash area can be located on one of the yard leads. In this position, cars entering or leaving mainline service may be washed as necessary.

Control Tower

A control tower will be located in each yard so that all yard operations will be under visual observation. The tower should be close to the service facilities to permit the yard master or his representative to control train and car movements into the yard, and to supervise the dispatch of cars from the yard to the transfer track for entry into service.

Service

The main shop, inspection facilities, terminal facilities and the service buildings require toilet, locker, shower, and washroom facilities, as well as time clock and bulletin board areas, drinking fountains, lunchroom and vending machine areas, public telephones and communication facilities.

CIVIL DESIGN DETAILS

Way structure design includes small and large details, from track fastenings and drainage to control of right-of-way access and the right-of-way access is particularly critical at any point where the system is operated in an open cut configuration or at grade in a freeway median. In the open cut sections, fencing to prevent predestrian access is generally adequate while in freeway medians, the possibility of accidental automobile encroachment must also be eliminated. The following paragraphs discuss these various civil details, and they are also illustrated in drawings on the facing page.

MEDIAN BARRIERS

The available width of the right-of-way in the San Bernardino Freeway median is 50 feet. This section has been the subject of several discussions with the California Division of Highways, and it has been concluded that construction of a barrier guard rail at the transit right-of-way line, with a pedestrian chain link fence behind it to exclude pedestrians, would adequately meet requirements of both the highway and transit operations.

In other joint use situations such as the future Industrial Freeway, a greater right- of-way width is provided in the initial freeway design.

RIGHT—OF—WAY FENCING

Outside of freeway median locations, the use of metal chain link fencing will provide adequate protection for transit right-of-way. Security will be maintained along at-grade and open cut construction areas and storage yards through use of 7 foot high fencing with barrier arms. Areas under aerial structures will normally not be secured except at specific locations for control of maintenance problems. Gates will be provided at access points for maintenance vehicles and personnel.

TRACK AND ROADBED

Two types of trackage are used in the system. One type consists of rail fastened to concrete surfaces in subway and on aerial structures, and the second type consists of rail fastened to cross ties supported on ballast. The tie and ballast track will be used on at-grade mainline and in yard construction. Prestressed concrete ties will be used in mainlines and yard track construction will utilize wood ties.

Recent advances in track hardware provide improved riding quality and reduced maintenance of transit roadbeds. Resilient pads and spring clip fasteners have been developed which minimize shock and impact to both vehicles and roadbed.

Rail material and track construction have undergone steady improvements, while the physical section remains basically the same. Extensive use is now made of continuously welded rail which improves riding qualities, reduces maintenance and minimizes noise, but it requires more effective anchoring to counteract movement by thermal forces. Hardening of rail heads by a number of heat and chemical treatments has prolonged rail life and reduced the heat generated by wheel action at curves, switches and crossings.

Track for the SCRTD system will consist of elements outlined in the following description:

RAIL

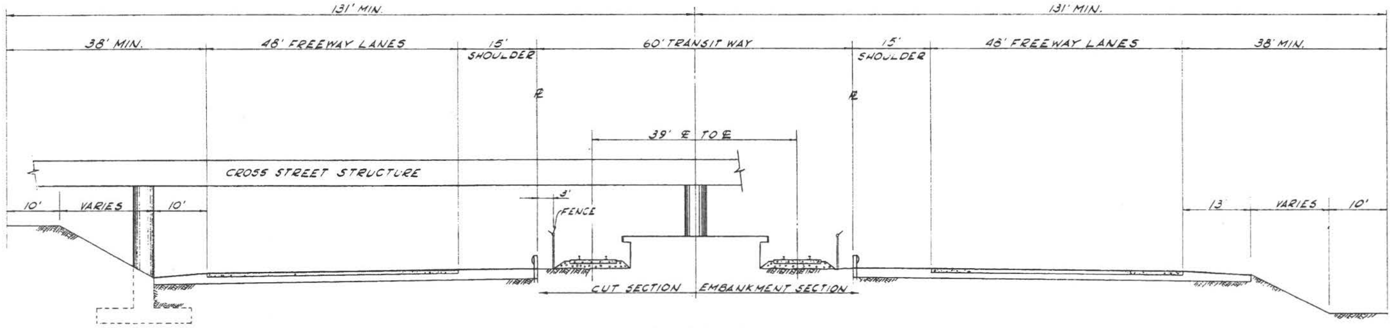
- Track rail will be 100 lb./yd. RE (AREA) section, continuously welded, control-cooled type treatment on tangent sections, surface heat- treated on curves between 1900 ft. and 950 ft. radius, and fully heat-treated on curves of less than 950 ft. radius.

TRACK CONSTRUCTION

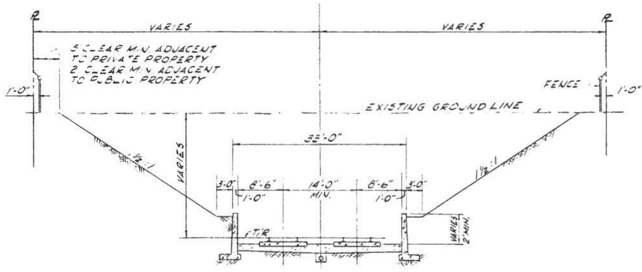
- Mainline subway and aerial structure track will consist of rail fastened to concrete surfaces at 3′-0″ centers by means of compression spring clips. The clips are fastened to metal base plates supported on resilient pads and are anchored to the structure with embedded inserts. Each fastener will provide an anchorage of 2000 lbs. minimum in restraint of thermal forces. Track will be set to line and grade by use of a "second-pour" concrete pad cast into slots on the floor of tunnels and aerial beams.

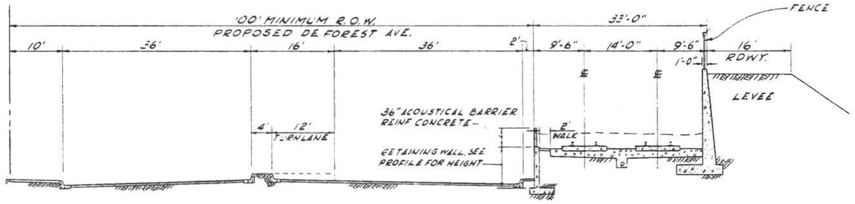
- Mainline at-grade track will consist of rail fastened to prestressed concrete ties by compression spring clips supported on resilient pads which are directly fixed to the concrete tie surface and anchored by embedded inserts. Each fastener will exert a restraining force of 2000 lbs. minimum in restraint of thermal forces. Ties will be supported on a minimum of 12 inches of crushed rock or slag ballast.

- Yard at-grade track will consist of rail fastened to wood ties with cut spikes supported on metal tie plates. Ties will be supported on on a minimum of 12 inches of ballast.



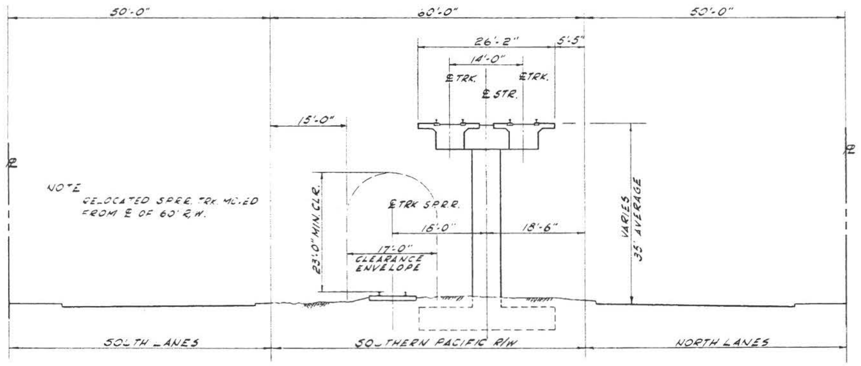
INDUSTRIAL FREEWAY MEDIAN

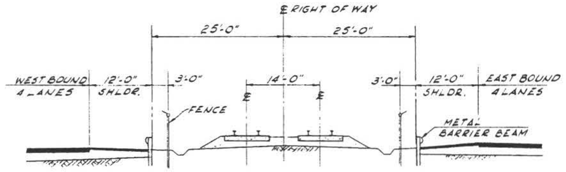




RETAINED CUT SLOPE

ADJACENT TO PROPOSED DE FOREST AVE.

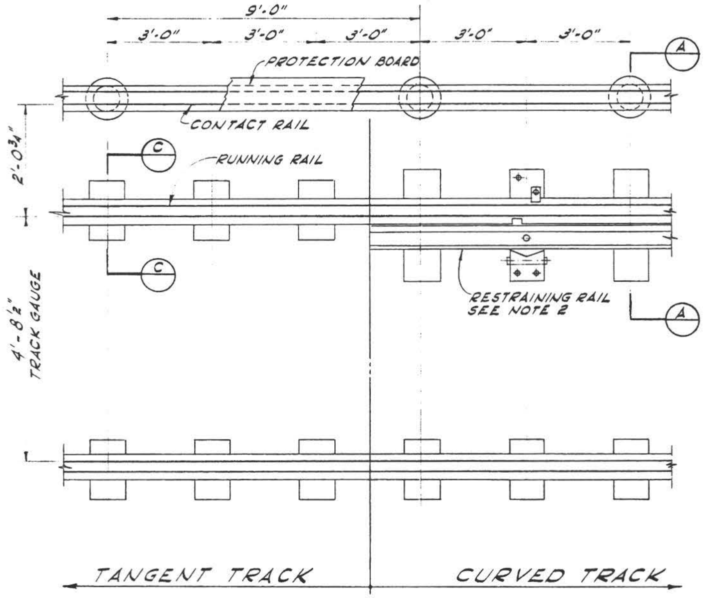




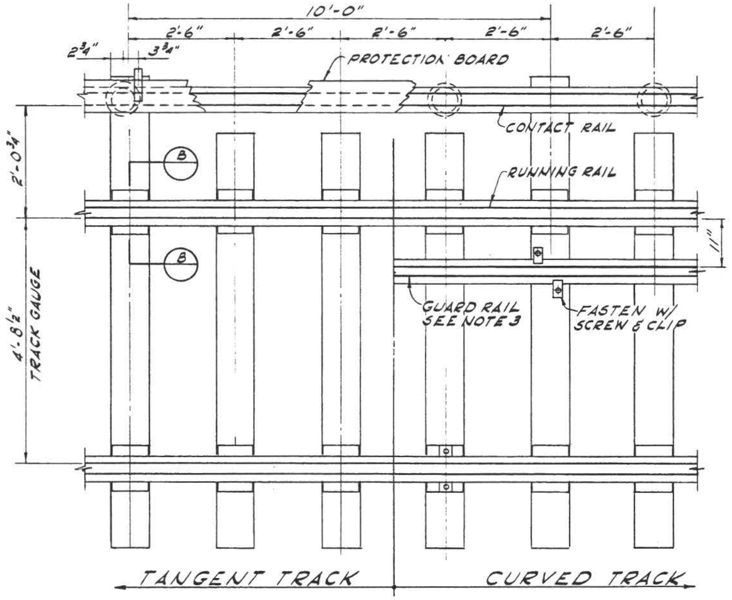
SAN BERNARDINO FREEWAY MEDIAN

CHANDLER BLVD. MEDIAN

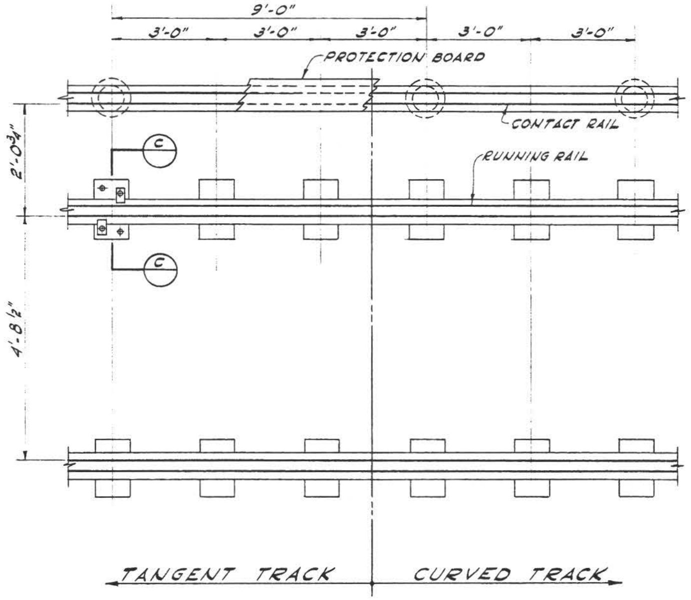
TYPICAL ALIGNMENT SECTIONS



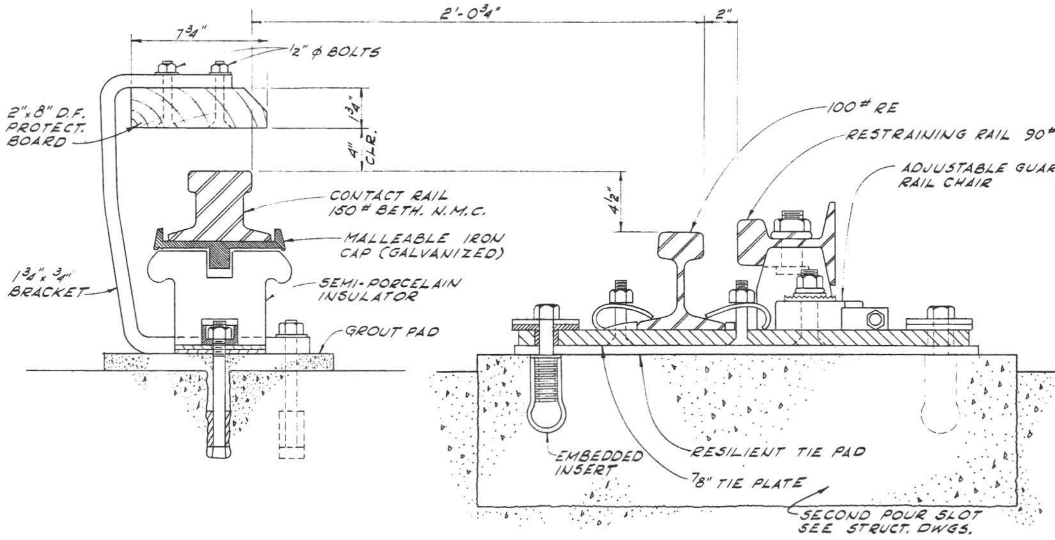
PLAN OF TRACK IN TUNNEL
NO SCALE



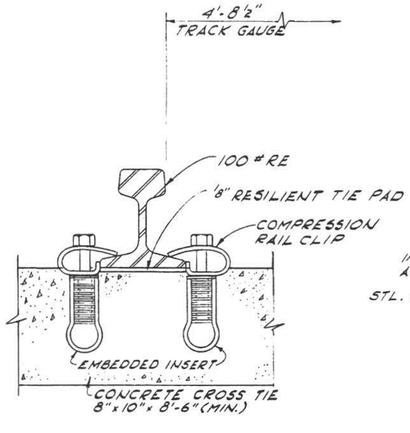
PLAN OF TRACK AT GRADE
NO SCALE



PLAN OF ELEVATED TRACK
NO SCALE



SECTION (A)
NO SCALE



SECTION (B)
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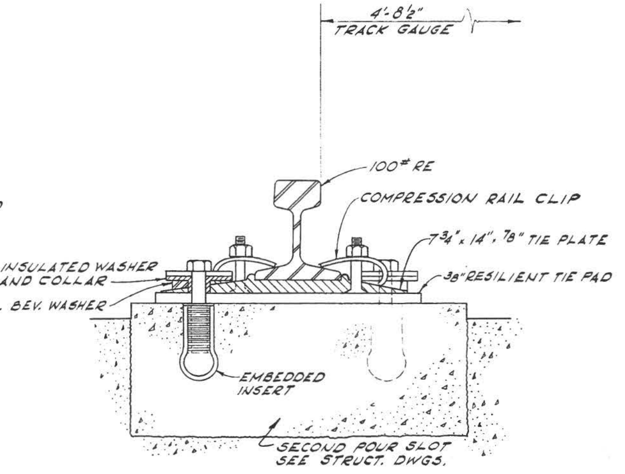


SECTION (C)
NO SCALE

NOTES

1. RUNNING AND CONTACT RAILS SHALL BE PROVIDED WITH CONTINUOUSLY WELDED JOINTS.
2. RESTRAINING RAILS SHALL BE PROVIDED IN TUNNELS ON INSIDE RAIL OF ALL CURVES OF LESS THAN 950' RADIUS, AND WITH BOLTED JOINTS.
3. GUARD RAIL SHALL BE PROVIDED ON AT-GRADE TRACK ON INSIDE RAIL OF ALL CURVES LESS THAN 950' RADIUS, AND WITH BOLTED JOINTS.

ELECTRIFICATION

DESIGN BASIS

Of the various methods available to propel rail guided vehicles, the one most widely used in rapid transit systems consists of vehicle mounted electrical motors supplied from an electrical conductor (contact rail) running parallel to the tracks. The most important reasons advanced for using this method for rapid transit are safety, reliability, and economy of operation.

The primary objective of a rapid transit system is to provide reliable transportation under any of the varying conditions which may be encountered. To meet this objective the propulsion power system must provide enough power for satisfactory rapid transit operation even when the power system is not fully operational. Rapid transit propulsion systems consist of several elements including a power source, transmission capability, power conversion equipment, a contact rail system, and vehicle propulsion and braking equipment. Total failure of any one of these elements would prohibit further train movement. Therefore, the components making up these elements must be arranged so that a component failure will not result in total element outage. For all elements except the contact rail system, this can be accomplished economically by providing multiple components. The contact rail system cannot be readily protected from outage by an alternate or spare installation and therefore must be constructed as ruggedly and reliably as is feasible. If component failure results in insufficient power, the trains will have to operate at reduced speed in the vicinity of the failure. If the power deficiency persists for more than a few minutes the transit system capacity will be reduced.

The propulsion power demand varies considerably throughout the operating day. During the commute periods it is four times the midday demand. Assuming the commute periods total only 20 hours out of a total of 140 operating hours per week, the full capacity of the propulsion system is required less than fifteen percent of the time, even though this is during the most important period. Since the probability of a prolonged component failure during the commute period is remote, the risk of reduced speed operation is low enough to permit the propulsion system design to be based on the following provisions:

- Normal operation at maximum demand for fully operational power system.
- Reduced speed operation at maximum demand with one component failure.
- Normal operation at off-peak demand with one component failure.

This concept results in a requirement for a dual path from at least two power sources to the contact rail system, so under any circumstances of two or more component failures the service objective could still be met.

The propulsion system design must also consider the effects of stray currents on existing subterranean metallic installations, electromagnetic radiation interference to wireless communication networks, and transient demands on power system voltage.

Propulsion power is by far the largest user of electricity in a transit system. However, the load represented by the total of all passenger stations, yards, shops, and the control center is sizeable. The objective of this facility power system is to provide normal service with fully operational components while allowing critical systems such as train control, communication, minimal lighting, and fare collection to remain in service with a single component failure.

SYSTEMS CONSIDERED

Evaluation of the individual propulsion power elements has been undertaken to arrive at an economical system that meets the service objectives of a rapid transit system. Alternate methods for each element were considered and evaluated not only on their individual merit, but as part of the entire system.

Analysis was made to determine the most desirable source of power, and the best method of transmitting it to the individual energy conversion units. Consideration included economics of buying or generating power, location of metering points for purchased power, and ownership of the transmission system as well as its voltage level.

For the short station spacings and high track density dictated by urban rapid transit, economic consideration favors transferring power from the wayside to the vehicles at the nominal propulsion voltage rather than operating the contact rail at a higher voltage and providing on-board transformation to the motor voltage. This requires power conversion equipment to alter the characteristics of the transmitted energy to suit the propulsion motors. The maximum demand on a power conversion unit occurs while a train is accelerating out of a passenger station; therefore, power conversion unit location at or near the passenger station would tend to minimize contact rail voltage drop.

The components making up an individual power conversion unit or substation include primary switchgear, transformers, and for direct current propulsion, rectifiers and direct current switchgear. Both fused disconnect switches and circuit breakers were considered for the primary switchgear. Substation location permits consideration of oil, askeral, and air as the primary cooling and insulating medium. Oil filled transformers were selected for this application due to their economy and reliability at the high primary voltage. Silicon diode rectifiers have replaced other AC to DC conversion devices in nearly all high power requirement applications. They are more reliable, less expensive and cheaper to operate than any of the devices they replaced. Air cooling of the diodes is recommended over water cooling because the dispersed location of the substations makes the operating expense of water cooling uneconomical.

Air brake drawout type switchgear was selected as the DC circuit protective and isolation device. Circuit protective device coordination was the primary reason for selecting a circuit breaker. Drawout construction selection was predicated on the need to change equipment quickly in the event of failure in order to restore the system to normal operating capability in the shortest possible time.

The contact rail system conducts power from the power conversion units to the vehicle propulsion motors. Its configuration is dependent upon the propulsion scheme used. For a direct current and single phase alternating current system, it can be a single conductor, using the track as the low potential return. For a three phase alternating current system, three conductors would be used, and the track would not be used as a return. Historically, two locations have been favored for the contact rail. One, positioned above the vehicle on the track centerline is referred to as a catenary, and the other, positioned slightly above and to one side of the track, is called a third rail. In practice, either of these positions could be used for direct current, single phase alternating current or three phase alternating current. Contact rail materials for the third rail position include low carbon steel, aluminum-alloy, and composition rails in which a steel contact surface is used in conjunction with a high conductivity aluminum alloy structural member.

Advanced propulsion power and braking equipment for high speed rapid transit operation is undergoing development. The system envisioned for SCRTD will require some departure from existing practice to take full advantage of the technological development which has occurred since existing systems were constructed. In particular, stepless propulsion motor control with automatic train control is needed to provide passenger comfort. Higher contact rail voltage, and hence higher voltage propulsion equipment, is desirable to maintain performance at high power levels while minimizing the total number of power conversion units required.

SYSTEM SELECTED

Not all propulsion power elements have been or need to be firm commitments at this phase of development to assure technical feasibility or to establish cost. While the source of power, method of transmission, location, and design of power conversion equipment are items requiring immediate decisions, the contact rail design and certain aspects of the propulsion motor control system are items that can be deferred without penalty.

The basic decision to use the local utility companies as the sole source of power is predicated on economics and reliability. The total transit system demand, and the low load factor exclude the possibility that even a single District owned and operated generating plant would be economical. Multiple units including spare capacity would have to be provided in order to achieve the service objective. This would further reduce the economic feasibility of District owned power sources. The cost of electricity has not escalated with the general economy. One reason for this is the increasing utilization of electricity and an improving load factor. A District owned generating system would be faced with a static load and low load factor. Rising labor and fuel costs would surely force the power cost to be sensitive to escalation of the general economy.

Connection points to electrical utility company bulk power stations have been selected to serve the entire propulsion power requirements of the rapid transit system. There are seven connection points required to serve the system. The decision to connect the transit load to these stations rather than to tie each power conversion unit or group of power conversion units to local distribution networks is based on the nature of the transit load. Provision for simultaneous train starting at stations and at groups of stations is necessary to maintain operating flexibility. Superimposing this type of transient load on the local power networks may cause undesirable voltage fluctuations to other users. Bulk station capacities are capable of absorbing the transit load without disturbance. The advantage of this arrangement to the District is that bulk power stations are a very reliable source of power. To make full use of this reliability, dual supply lines to the transit system are run from two bulk power station buses. Switching is provided to interconnect either bulk station bus with either supply cable. System design is based on supplying the full transit load on either supply cable.

The requirement to isolate the transit load from local networks forces the interconnection of the power conversion units through a distribution network paralleling the transit right-of-way. The need for a parallel distribution system was the deciding factor concerning distribution voltage. It also presented the opportunity to consider the possibility of bulk station interties through the distribution system which would further increase the reliability of the power source. The most desirable distribution system voltage was determined to be 34.5 kilovolts. It is a standard voltage in the area for transmitting power levels similar to those expected by the parallel feed arrangement. The redundancy established in the bulk station equipment and supply cables is carried through the 34.5 kilovolt distribution system. Each bulk station supplies a distinct group of power conversion units through an isolated supply and distribution system. Each of these isolated systems has essentially double its required capacity available when both cables are operational. Modifying the distribution cable sizes between the isolated systems and adding intertie circuit breakers provides for the contingency of one bulk power station being out of service.

Contact rail voltages of 600 and 900 volt DC were both considered. A comparative analysis based on providing similar propulsion performance and allowing for vehicle cost differentials revealed that the higher voltage system could save as much as 15 percent in capital cost. A contact rail system based on using a third rail rather than a catenary was chosen since the high currents anticipated, even at 900 volts, suggest a massive overhead structure which would be both unsightly and expensive.

The substation spacings allowed by the 900 volt contact rail system promotes stray leakage currents. Track leakage resistance must be maintained at a high level and design limits for rail voltage gradients must be set low to offset the deleterious effect of stray currents.

CONTINUING INVESTIGATION OF SINGLE PHASE ALTERNATING CURRENT

To date, alternating current propulsion systems have not been popular for rapid transit systems. The direct current series motor has nearly ideal performance characteristics for rapid transit service. The use of any other type of motor has always involved adding cost to the system and weight to the vehicles. The present interest in single phase alternating current stems from the ability of alternating current systems to provide reliable regenerative braking which would make two potential benefits attainable. The most likely and easily measurable benefit is a reduction in subway ventilation costs. The major source of heat in the subways is from dynamic braking of trains. If all of this heat were routed out of the subways for use elsewhere as electricity, the ventilation system could be simplified more than enough to offset the possible increased costs of the AC system. Less assured, particularly if total schedule flexibility is demanded, is the possibility of reducing the total power obtained from the electrical companies by distributing the regenerated power to accelerating trains.

The District is evaluating a propulsion power scheme based on providing a single phase contact rail system using the track as the return rail. The electrical utility companies are also considering the effects of the single phase load on their systems.

While an AC system has not been developed for final evaluation, certain tentative conclusions have been made. For instance, propulsion power transformers will be installed at each passenger station, and phase breaks will occur between passenger stations in a zone where the train would normally be coasting. The contact rail voltage will be 5000 volt, 60 hertz single phase. This is a departure from the principal of distributing along the contact rail at nominal motor voltage. A vehicle mounted transformer is considered necessary to improve the train power factor during acceleration. Once a transformer is required there is no additional penalty in raising the contact rail voltage as high as 5000 volts. Provision of adequate electrical clearances in subways prohibit consideration of a higher voltage.

The on-board propulsion equipment will consist of the aforementioned transformer and a control device to convert the alternating current to direct current. The controller will not only rectify the AC, but will control the direct current voltage level to regulate motor torque. During braking, the controller will convert and regulate the motor direct current output to full voltage AC.

The controller is basically a silicon controlled rectifier. In addition to the propulsion motor smoothing reactors, filters and a power supply for the motor fields will be required. Since the braking resistors would no longer be required and the auxiliary power system would be simplified, there may be no vehicle weight penalty. The propulsion motors themselves will have to be separately excited in order to regulate motor output voltage at all speeds during the regenerative brake mode.

Regenerative braking, using a three phase AC contact rail, has been successfully demonstrated; however, the added cost of the contact rail itself is more than the projected ventilation cost savings for SCRTD. Regenerative braking of direct current systems is possible but it is extremely sensitive to voltage regulation and therefore is considered too unreliable.

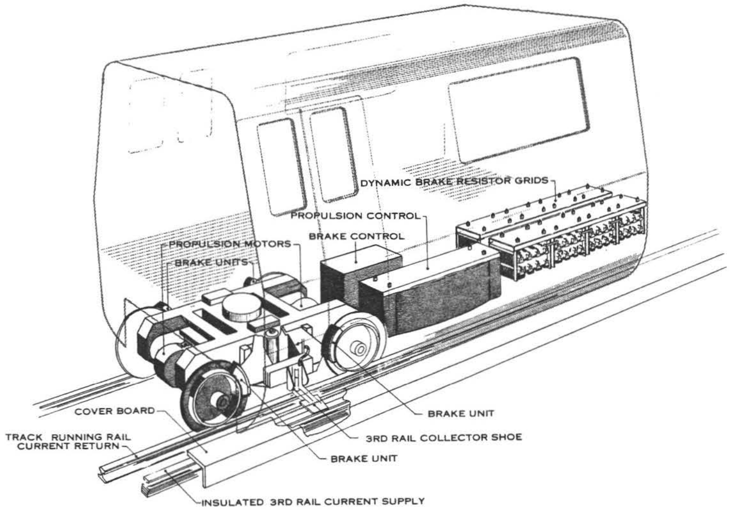
At present, the feasibility of the AC system under consideration is subject to the ability of the utility companies to absorb the unbalanced load economically.

PROPULSION POWER AND BRAKING

Each of the four axles on every vehicle has a propulsion motor capable of operation up to 75 miles per hour. Two types of motors have been developed for use in this application. The DC series motor has long been the industry standard. It is the only motor that has inherent speed-torque characteristics considered suitable for traction applications. A second type is a separately excited motor in which field control is used to maintain torque constant at various speeds. Simplicity and inherent reliability during dynamic braking are the major advantages of the series motor. The separately excited motor can be smaller and can have, through field regulation, greater torque at high speed than a comparable series motor. However it is dependent upon power from the wayside to maintain dynamic braking. Either of these propulsion motor designs is considered suitable for the SCRTD system.

As proposed, automatic train control demands that stepless tractive effort control be used. Two types of controller are under intensive development and both are considered suitable. The series chopper is essentially a direct current silicon controlled rectifier requiring forced commutations. The shunt chopper is an improvement on the conventional cam controller in which resistors are switched, but one resistor is shunted by a thyristor to maintain the stepless feature between switch points. The series chopper has demonstrated the need for considerable on-board filtering to assure contact rail voltage stability. The shunt chopper requires more power, and may still require the series parallel motor transition during acceleration. Fully developed, either of these devices appear suitable as a stepless controller.

Primary braking with the DC system will be dynamic. Car-borne thyristors will be used in conjunction with switches and resistors to provide stepless dynamic braking. Below about 10 miles per hour, dynamic braking will fade and a mechanical system will be used to complete the braking cycle. A brake blending control is required to make a smooth transition between the brake systems. Both tread and disc type mechanical brakes, pneumatically or hydraulically operated, are available. Tread brakes polish the wheels and improve the electrical conductivity. Under certain conditions, they improve the wheel to rail adhesion. Disc brakes have higher capacity. However, they preclude use of resilient wheels and add weight to the vehicle. While pneumatically applied brakes may have a longer delay time, the brake fluid (air) is readily obtainable. Hydraulic systems require periodic refilling and may be heavier. Any of these could be considered satisfactory brake system components.



PROPULSION AND BRAKING DIAGRAM

The size of the mechanical braking system is dependent on the motor type selected, the vehicle type, and the transit system configuration. In practice, whenever the braking requirement is greater than the dynamic braking system can furnish, the mechanical system completes the brake cycle unaided. Vehicles using separately excited motors thus can expect mechanical brake cycles at high speed more often than those using series motors. End cars, when operating in two car trains, can expect heavier braking loads since there are less cars to share any overload in the event one truck brake system is locked out; and finally, the mechanical brake system should be able to handle all braking from the farthest point of travel to the storage yard.

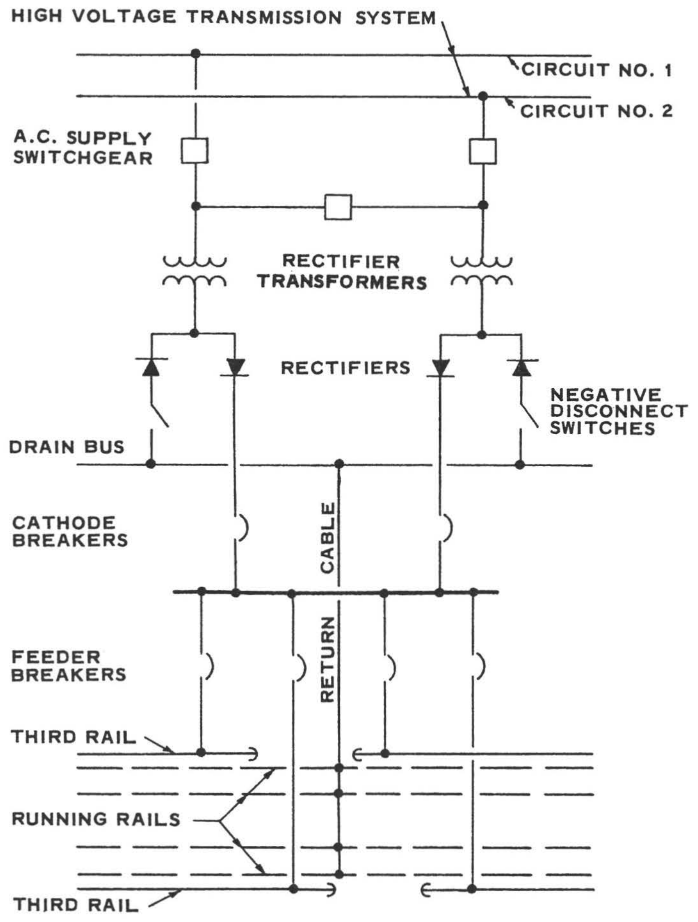
A wheel slip detection system is used on every truck to prevent wheel or rail damage caused by wheel spinning during acceleration and wheel slide during braking. The system measures the speed of each axle and its rate of change. If the rate of change of axle speed exceeds the design acceleration or deceleration limits, appropriate action is taken by the propulsion controller. If axle speeds are not within wheel diameter tolerance of being synchronized during acceleration, the propulsion power is reduced. If this occurs during braking, the dynamic brakes are released and the mechanical brakes are applied to all but the truck with the sliding axle.

SUBSTATION DESIGN

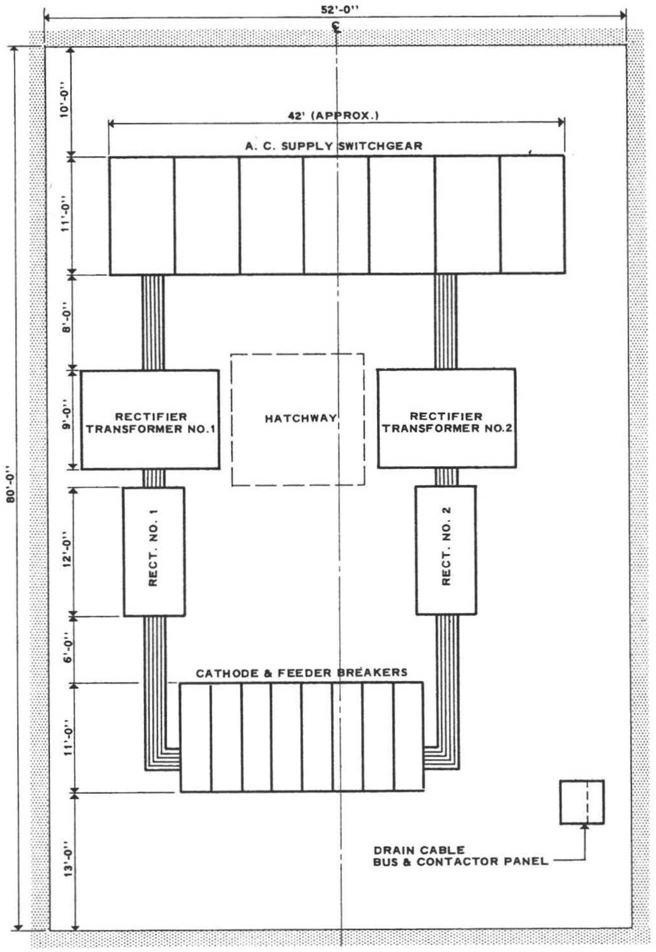
Rectifier substations are designed to take maximum advantage of the primary power dual circuit arrangement. The AC supply switchgear can transfer substation supply from either circuit to either of the two rectifier transformers. In normal operation one rectifier transformer is supplied from circuit No. 1 and the other from circuit No. 2. This procedure requires that both primary circuits be normally energized. The advantage of this procedure is that the operational availability of both circuits are known at all times. Failure of one primary circuit will cause automatic transfer of the rectifier transformer to the remaining energized circuit through the primary tie circuit breaker. Relaying is arranged so that each rectifier transformer is protected from overload and short circuit by either the primary incoming circuit breaker or the tie circuit breaker, depending upon which circuits are energized. Cable in conduit is used to connect the high voltage switchgear to the rectifier transformer.

Two transformer rectifiers are used in each substation to supply the maximum demand of a track section. Each rectifier transformer is sized to supply, at its continuous rating, the off-peak load beginning at 7:00 P.M. This allows a daily routine maintenance period of up to 10 hours for one of the two transformer-rectifier units. Oil insulated self-cooled transformers are used to convert the 34.5 kilovolt primary voltage to the desired voltage level for the rectifiers. The secondary windings in each transformer are arranged to provide an equivalent six phase supply to the rectifier. The secondary windings in the two transformers are rotated 30 degrees. This results in equivalent 12 phase rectification when the entire substation is in use. Each transformer is throat connected to its rectifier.

The rectifier consists of silicon diodes assembled on a fan cooled heat sink. A full wave bridge circuit arrangement is employed, paralleling bridges to achieve the rectifier rating. Rectifier design allows the substation to operate at 150 percent of its nameplate rating for two hours following 100 percent rating load. This overload rating capability is used to supply the morning and evening peak loads. Also allowed during the peak period is a superimposed cyclic overload consisting of five periods of 300 percent overload each one minute long, followed by one period of 450 percent for 15



SINGLE LINE DIAGRAM OF TYPICAL PROPULSION POWER SUBSTATION



TYPICAL INDOOR PROPULSION POWER SUBSTATION

seconds spaced equally throughout the two hour period. The rectifiers are air cooled and use internal fans to draw air from the substation room or vault. The air exhaust is ducted to the outside or track area. The rectifier assembly employs at least one extra bridge circuit so that failure of one bridge will not reduce the sub-station capacity below its rating. Each diode is connected in series with a current limiting fuse. Diode failure causes a short circuit which operate the fuse to isolate the failed diode from the circuit. This failure is noted at central control through the diode monitoring circuit. A second failure in the same bridge causes rectifier shutdown. High resistance frame grounding is used for the rectifiers. The rectifier frame is isolated from the floor and the transformer throat connection.

The higher potential output from the rectifiers is bused to the DC switchgear assembly. The low potential load is led to a ground bus in the substation through insulated cable. Switches located in the ground bus cubicle are used to disconnect the rectifier from ground bus.

The DC switchgear contains a cathode circuit breaker for each rectifier and single pole feeder breakers to connect power to the contact rail sections. The switchgear is metalclad using air break single pole drawout circuit breakers. The cathode breakers protect the rectifiers from reverse current, positive bus faults, and backs up the feeder circuit breakers. Overloads and fault currents down to the DC feeder breakers are cleared by the primary circuit breakers in coordination with the cathode breaker. The feeder circuit breakers protect the contact rail system from prolonged short circuits and are used to isolate track sections. All circuit breakers, both AC and DC, are arranged for remote operation from central control. Most passenger stations that do not have an initial requirement for a propulsion power substation have a room designated as space for a future substation. In each of these rooms, the primary distribution system cables are terminated for connection to the future substation. A gap breaker assembly is also located in the room. The assembly consists of four feeder circuit breakers arranged and connected to each other and the track, identical to a substation connection. The purpose of the gap breaker assembly is to equalize the power drain from adjacent substations through the contact rail.

PASSENGER STATIONS

Electrical service to passenger stations is divided into three levels of reliability.

- Normal service supplies all lighting and power load required for system operation.
- Failure of the normal supply results in transfer of critical loads to an alternate source.
- Finally, failure of all external electrical supply energizes battery powered emergency lighting adequate for safe evacuation of the system.

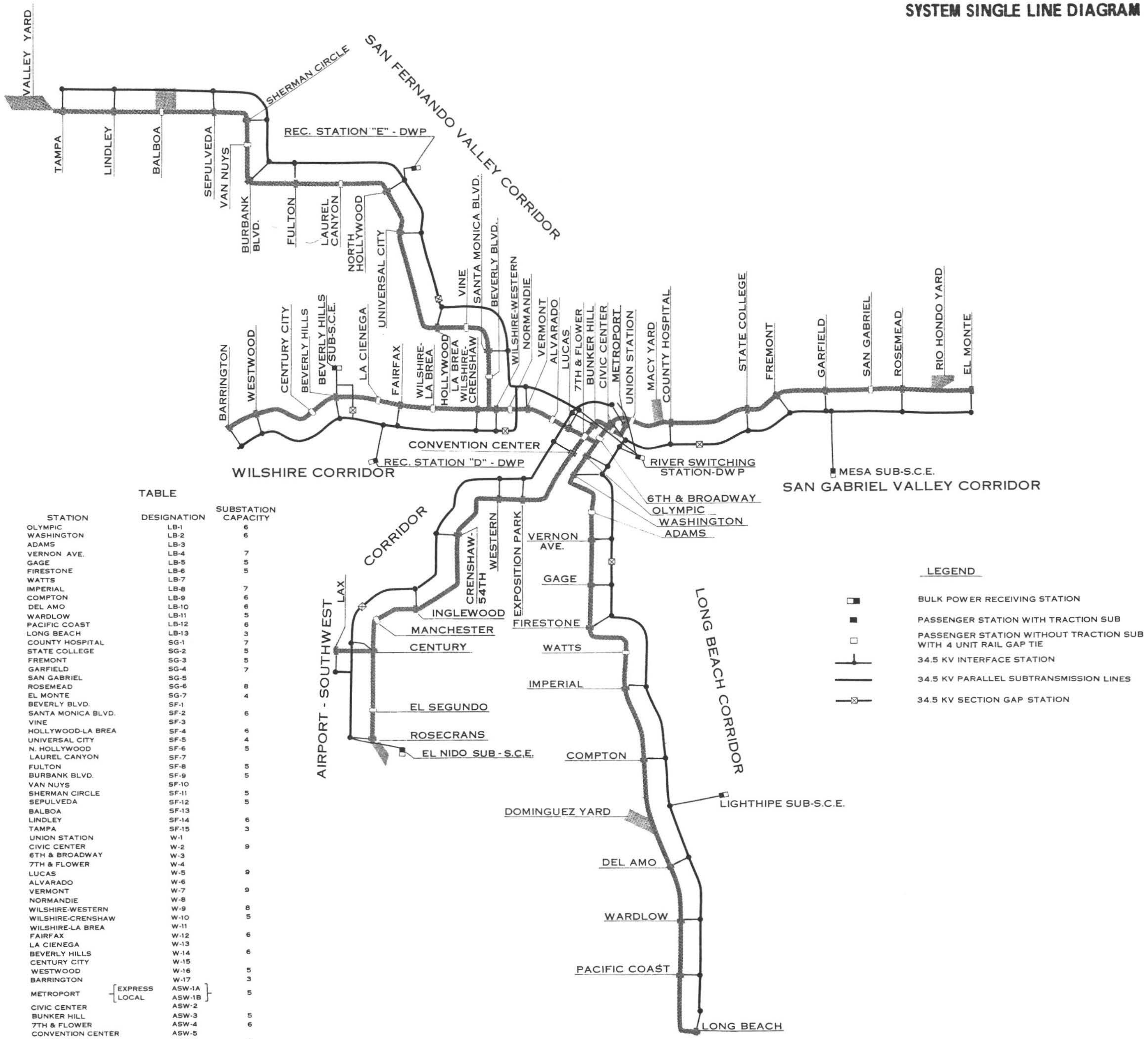
Critical loads are those necessary to maintain safe, although not necessarily comfortable, operation. The normal station power supply is obtained from the local electrical utility company network. The critical power supply is obtained from the propulsion power high voltage distribution system.

In those stations that do not have the high voltage distribution system available, two feeds are obtained from separate utility networks. The critical bus is still used, although transfer from normal to alternate feeder in this case tranfers both normal and critical loads.

Station platforms are provided with lighting intensity of not less than 25 footcandles. Ticket lobby and entry corridors are illuminated to not less than 40 footcandles intensity. Fixture brightness ratios for lighting and adjacent surfaces do not exceed 20 to 1. Street access stairs from subway stations are illuminated to a minimum of 100 footcandles intensity during daylight hours of operation. Emergency lighting in stations provides illumination in areas normally occupied by passengers to not less than 5 footcandles intensity.

A separate battery power supply for essential automatic train control and communication is provided which will allow train controls to function for at least two hours after failure of station power. Therefore, if there is a local power failure, train operation can proceed on a station run-through basis.

SYSTEM SINGLE LINE DIAGRAM



TABLE

STATION		DESIGNATION	SUBSTATION CAPACITY
OLYMPIC		LB-1	6
WASHINGTON		LB-2	6
ADAMS		LB-3	
VERNON AVE.		LB-4	7
GAGE		LB-5	5
FIRESTONE		LB-6	5
WATTS		LB-7	
IMPERIAL		LB-8	7
COMPTON		LB-9	6
DEL AMO		LB-10	6
WARDLOW		LB-11	5
PACIFIC COAST		LB-12	6
LONG BEACH		LB-13	3
COUNTY HOSPITAL		SG-1	7
STATE COLLEGE		SG-2	5
FREMONT		SG-3	5
GARFIELD		SG-4	7
SAN GABRIEL		SG-5	
ROSEMEAD		SG-6	8
EL MONTE		SG-7	4
BEVERLY BLVD.		SF-1	
SANTA MONICA BLVD.		SF-2	6
VINE		SF-3	
HOLLYWOOD-LA BREA		SF-4	6
UNIVERSAL CITY		SF-5	4
N. HOLLYWOOD		SF-6	5
LAUREL CANYON		SF-7	
FULTON		SF-8	5
BURBANK BLVD.		SF-9	5
VAN NUYS		SF-10	
SHERMAN CIRCLE		SF-11	5
SEPULVEDA		SF-12	5
BALBOA		SF-13	
LINDLEY		SF-14	6
TAMPA		SF-15	3
UNION STATION		W-1	
CIVIC CENTER		W-2	9
6TH & BROADWAY		W-3	
7TH & FLOWER		W-4	
LUCAS		W-5	9
ALVARADO		W-6	
VERMONT		W-7	9
NORMANDIE		W-8	
WILSHIRE-WESTERN		W-9	8
WILSHIRE-CRENSHAW		W-10	5
WILSHIRE-LA BREA		W-11	
FAIRFAX		W-12	6
LA CIENEGA		W-13	
BEVERLY HILLS		W-14	6
CENTURY CITY		W-15	
WESTWOOD		W-16	5
BARRINGTON		W-17	3
METROPORT	EXPRESS	ASW-1A	5
	LOCAL	ASW-1B	
CIVIC CENTER		ASW-2	
BUNKER HILL		ASW-3	5
7TH & FLOWER		ASW-4	6
CONVENTION CENTER		ASW-5	
EXPOSITION PARK		ASW-6	5
WESTERN		ASW-7	
CRENSHAW-54TH		ASW-8	5
INGLEWOOD		ASW-9	6
MANCHESTER		ASW-10	
LAX		ASW-11A	3
CENTURY		ASW-11B	6
EL SEGUNDO		ASW-12	4
ROSECRANS		ASW-13	3

CONTROL AND COMMUNICATION

Recommended control and communication methods and devices have been selected to best satisfy the requirements for high-speed, frequent service with total safety and smooth riding comfort. Both existing and newly-developed equipments have been analysed and evaluated on the basis of the degree to which they fulfill these demanding requirements, as well as their initial cost, useful life, reliability, and operating and maintenance costs.

The systems selected combine advanced, computerized control and communication equipment with improved versions of traditional train-safety equipment. The advanced equipments are the kinds that have successfully raised operating efficiencies in other expanding industries to higher levels than were formerly possible. The traditional equipments have demonstrated their dependability by enforcing operating safety in existing transit systems.

The recommended train control system employs a centrally located, process-control digital computer system which will supervise all transit operations.

A compact electronic computer on each train will regulate its operation according to continuous safety and control intelligence input from wayside transmitters.

High speed data channels will deliver train performance data to the central control system where a sophisticated digital computer system will permit Dispatchers and Supervisors to manage and coordinate movement of trains and buses throughout their entire routes. The integrated control and communication system will compare moment-to-moment positions and movements with schedules, conditions, and requirements.

The data transmission system will also deliver status and control information between the control center and widely dispersed, unattended installations such as electrical sub-stations and subway ventilation motors.

A high quality system-wide voice communication network will deliver information to passengers, and keep supervisory and maintenance people in constant contact with all offices and work areas to insure uninterrupted, safe, comfortable, reliable and coordinated service.

Specifications call for extensive use of solid-state modules and integrated circuitry which will make the control and communication equipment reliable, compact, and economical to operate and maintain.

AUTOMATIC TRAIN CONTROL

All operating elements of the transit system will be controlled by an integrated system consisting of three subsystems, each of which perform within an operational category.

. An automatic train operation subsystem will control the operation of every vehicle in passenger-carrying service.

. A safety subsystem will provide safety for patrons, employees and equipment.

. A central supervision subsystem will optimize and coordinate the movement of all trains, and the operation of all functional facilities on and adjacent to all routes.

AUTOMATIC TRAIN OPERATION

Systems analysis of train operation requirements, related to the need for safety at high speeds and close headways, proved automatic train operation (ATO) is decisively superior to manual operation. The analysis included an extensive study of four degrees of automation and led to the following conclusions:

. Minimum automation would provide illuminated signals in the train to show a motorman authorized speed information transmitted from the wayside. It would automatically stop the train if the operator failed to obey restrictive signals.

. The next degree of limited automation would automatically regulate running speed but leave starting, stopping, and door control to the motorman.

. The third degree of automation would require manual door operation and manual release before starting.

. The maximum degree would automate all train operation functions.

The systems analysis included a study of relative control precision, response time, and consistancy of automatic and manual operation. It also considered other functions that could be performed by personnel on a train and the relative time periods they would devote to such duties compared to automatic means. In addition, the analysis evaluated initial cost and recurring expenses for automatic versus manual operation.

Combined results of the systems analysis have led to the following overall conclusions regarding duties related to operation of trains and the optimized degree of automation for those duties.

1. Total automatic train operation is the only method which will safely fulfill the requirements for 70 miles per hour running speed with ninety-second headway. It achieves faster average interstation run time because control equipment suitable for manual or semi-automatic operation must transmit intelligence from the wayside to the operator. The operator must interpret this intelligence, and then initiate control actions such as acceleration and deceleration, whereas ATO equipment initiates control actions directly and instantaneously.
2. A motorman confined to the front end of a train under manual operation would be essentially ineffective in the performance of any routine and emergency duties related to onboard activity. With ATO, such duties could be assigned to an individual trained for train-attendant responsibilities because his attention would not be required for operational duties accomplished by ATO.
3. Train attendants can safely operate trains manually in yards and in the event of equipment malfunctions while in passenger service.
4. ATO will achieve tangible economic savings over the expected equipment life that will cumulatively amount to more than the incremental cost of the equipment.

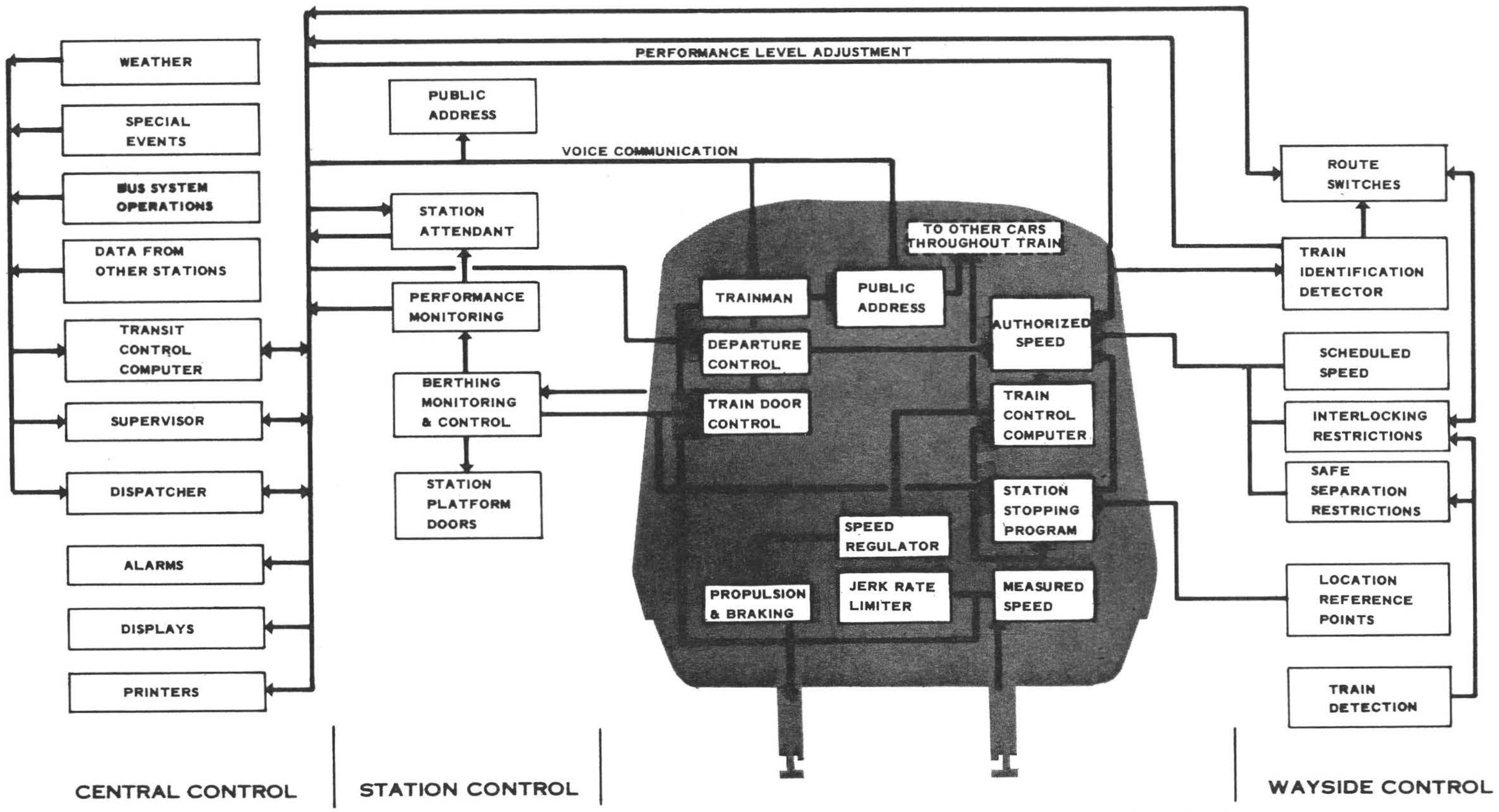
A train-control computer on each train will continuously regulate speed and minimize the difference between the train's autorized speed and its actual measured speed. As the schematic diagram illustrates, authorized speed will depend on scheduled speed as limited by safe separation and interlocking restrictions. Authorized speed will be further modified at times by a station stopping program, station departure control, and performance level adjustment data transmitted from central supervision.

Departure control will follow a scheduled program unless modified by the trainman, the station attendant, or by instructions from central supervision. It will also be interlocked with train door control which in turn will depend on stopping accuracy, station platform door position, and the trainman.

SAFETY

The safety subsystem will employ basic concepts which have proved dependable through long service in existing transit systems.

The full extent of all routes will be divided into individual zones ranging in length from one train-length to a maximum of five thousand feet. Presence of a vehicle within any zone will



AUTOMATIC TRAIN CONTROL FUNCTIONAL SCHEMATIC

be automatically detected and the detection intelligence transmitted to adjacent and nearby zones on a fail-safe basis. Alternating current, solid- state vehicle detection circuits will not prevent the use of running rails for propulsion current return as do earlier direct-current circuits.

Enforced safe separation between vehicles will be controlled by detection intelligence transmitted from wayside equipment to speed control equipment on the trains. The enforced safe separation will be equal to the train's maximum stopping distance plus a wide margin of safety.

Each train will proceed at full authorized speed only as long as it is separated from the train ahead by more than a safe distance. When the separation distance approaches the safe limit the following train will automatically reduce speed. If the following train reaches the safe-separation limit, which includes an added safety factor, it will be brought to a controlled stop automatically.

Precision station stopping will be accomplished by means of speed-distance programs that are stored within train control computers. Precise distance from the station berthing position ahead will be detected from wayside location points. If a train is unexpectedly delayed in the station ahead, the safety subsystem will enforce safe separation instead of programmed stopping.

The safety subsystem will also include route protection circuits which will make it impossible for a train to enter any route section not scheduled for that train. The circuits will detect positions of all track switches surrounding a route. Logic circuits will deduce route protection intelligence based on switch positions, detection intelligence, and elapsed time. Route protection intelligence will be transmitted to trains approaching the route only when:

- All track switches are firmly in their proper position.
- The route is completely clear.
- There are no approaching trains which present a route conflict.

If any part of the automatic control and communication equipment should malfunction, the remaining equipment, and the propulsion and braking equipment will automatically assume a safe operating status. A trainman can manually operate the train at a reduced speed in emergencies, and in storage and maintenance yards.

SAFE SEPARATION PROGRAM

Scene One of the diagram illustrates a condition where Train A enters a station as Train B follows more than two full zones behind. Train B is proceeding at full authorized speed. Train B would have automatically initiated a controlled speed reduction if it had entered the last separation zone, illustrated by the dashed outline, before Train A had moved all the way into the station.

Scene Two shows Train A completely within the station. Train B is proceeding at full authorized speed to the permissive zone.

In Scene Three, Train B automatically begins controlled deceleration when it reaches the permissive zone because Train A is still in the station. If Train A had cleared the station by that time as illustrated by the dashed outline, Train B would have continued at full authorized speed until it reached the point for starting its precision stopping program, illustrated by the vertical row of dots.

In Scene Four, Train A has cleared the station by the time Train B enters the optimum zone. Thus Train B will proceed at constant speed until it reaches the precision stopping program location for that speed, after which it will follow the program to the station berthing location.

The dashed outlines of Scene Five show where Train B would have come to a complete stop if Train A had been further delayed in the station.

COMFORT

By making all train movements smooth and gentle, automatic train control will greatly enhance passenger comfort. It will change speeds promptly enough to keep time in transit to a minimum—yet it will initiate and discontinue acceleration and braking actions very smoothly. Overly fast starts and sudden stops will be eliminated.

As a train moves between stations, its speed will change as illustrated by the adjacent speed- distance curve. The shape of this speed-distance curve is determined by three influences:

- Speed limits and restrictions imposed by alignment characteristics establish limitations within which the curve must be contained.
- Changes in speed, acceleration, and braking-rate will be limited to rates that insure smooth riding comfort. Rate of change of acceleration and deceleration (jerk rate) will never exceed one and one-half miles per hour per second.
- Operational delays will automatically reduce speeds of the following train.

On-board ATO equipment will regulate running speed within a range of plus-or-minus two and one-half percent of maximum speed. For maximum performance level operation, running speed will be maintained as close as possible to the upper limit.

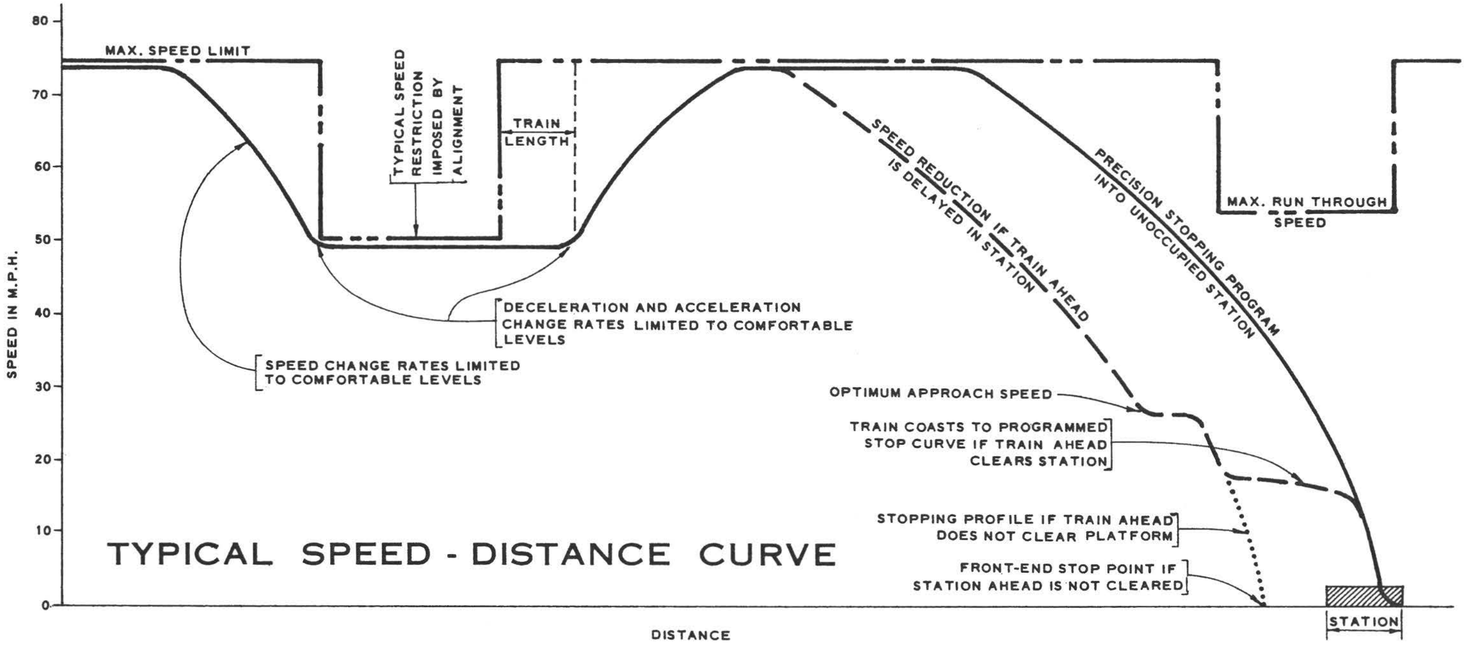
As the curve indicates, speed reduction for any speed restriction imposed by alignment will begin early enough to stay entirely within the outside limitation. The train will continue at the restricted speed until its entire length has passed into the higher speed-limit region. If the station ahead is unoccupied, the train continues at top speed until it reaches the excact point where it should begin to decelerate for its programmed stop, and for smooth, precise berthing.

However, if the station platform ahead is occupied by a train that has been delayed, controlled breaking will begin at a point which will maintain safe separation between trains. If the train ahead does not clear the station in the meantime, controlled breaking will continue until the speed has been reduced to an optimum approach speed.

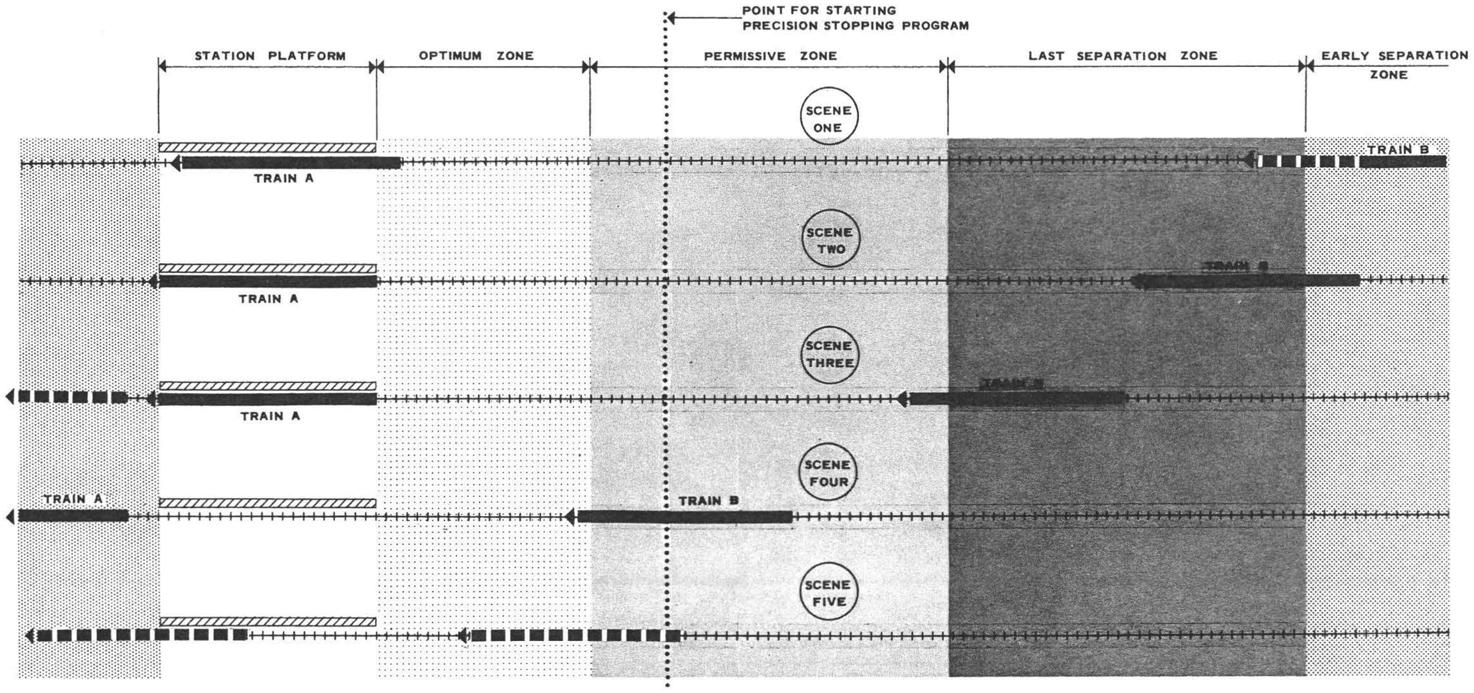
If the station is still occupied, full braking will begin. In the example illustrated by the curve, the train reduces its speed to about 20 miles per hour before the train ahead clears the station. The train then coasts to the programmed stopping curve, and decelerates to the precise berthing position. As the dashed curve shows, the train would have stopped a safe distance away if the preceding train had not departed.

CENTRAL SUPERVISION

At the transit control center, a central supervision facility will enable the transit system to provide coordinated service to match varying transportation needs. A process control digital computer will continuously receive real-time operating elements of the transit system. It will analyze the data and automatically determine which are to be recorded, displayed, or stored for subsequent processing, or that which requires special attention.



TYPICAL SPEED - DISTANCE CURVE



SAFE SEPARATION PROGRAM

The central supervision system will quickly recognize conditions which indicate a need for service not previously anticipated or scheduled. Regular schedules will be designed for different days of the week, different seasons of the year, and planned commercial, cultural, and sports activities. Nevertheless, passenger volume at station platforms can be expected to surge at times due to the grouping characteristics of public activities and other transportation modes.

A special computer program will enable the central supervision system to select the best strategies to compensate for unusual circumstances and to continually improve operating schedules.

A primary corrective strategy will advance or retard the performance level of selected trains. Advanced performance level will increase running speed between stations, retarded performance will reduce speed.

Complex strategies to be used to compensate for more severe variations in traffic flow include the following:

. Longer or shorter dwell times by selected trains at selected station platforms when appropriate.

. Scheduled routes may be altered.

. The order in which trains enter a merging route maybe revised.

. Lengths of trains entering service may be altered.

. Trains may be added to or withdrawn from service.

DIRECTION REVERSAL

Trains running under automatic train operation will be able to move in only one direction. Interlocking devices will make it impossible for the running direction to reverse except in special Direction-Reversing Zones, and by means of an exacting sequence of events involving both wayside and train equipment.

TRANSFER FROM MANUAL TO AUTOMATIC

Trains will normally be operated manually in storage yards and maintenance shops. Authorized trainmen will use a transfer switch and a special key to transfer from automatic to the manual operating mode. This transfer can be accomplished at any point in the system to accommodate any potential ATO malfunction, and yet permit the train to be run to the end of the line on manual operation.

Transfer from the manual to automatic operating mode will be possible only in designated zones located in the departure route of all yards, and only by means of a carefully controlled procedure. In the transfer procedure, trains will be required to pass a series of tests which will make sure that all parts are functioning satisfactorily.

VOICE COMMUNICATION SYSTEM

A voice communication system which blankets the entire transit system will enable performance of important functions in the rapid transit system under voice control. Supervisors will have equipment and channels available for them to talk to any station, yard, train, or shop without delay. Maintenance personnel will have provisions for communicating to and from virtually any location throughout the system.

Information important to the passenger's travel and comfort will be transmitted to them by voice messages in all trains and stations. Facilities will be provided for patrons and employees to ask questions or report conditions from all cars, stations and wayside locations.

A dial telephone system will interconnect all stations, yards, shops, and the control center by a network of shielded multi-conductor cable. Every conductor-pair will be conditioned to high quality transmission standards by the insertion of inductive loading coils and amplifying elements at optimum locations. These main communication cables will be pressurized with dehumidified air to protect against moisture. Quality characteristics of the voice communication channels will equal or exceed recognized transmission standards.

Smaller distribution cables will connect wayside call phones to nearby stations. Located every one-fourth mile and on both sides of subway routes, the call phones will serve two purposes. When a call phone handset is lifted from its hook, a switchboard operator will ask if there are any unusual conditions to report, or if special attention is needed at the offhook location.

Maintenance personnel will normally use the call phones differently. They will turn a selector switch to a position which will connect them to telephones in maintenance and equipment rooms in the nearest station.

The heart of the telephone system will be an automatic switching exchange located at the control center.

A manual switchboard will route calls from wayside call phones to the automatic exchange, and will also dispatch calls to and from public telephone companies throughout regions served by rapid transit routes. Pushbutton intercom arrangements at the control center and at each station, yard and shop will enable employees to use their dial telephones to communicate with other employees at the same facility.

Voice communications will be transmitted by radio to and from passenger trains. Main and standby antennas at central, high locations will handle messages to and from widely separated points throughout the transit system. Any locations that would be out of reach or shielded from the main station will be reached by separate radio repeater stations.

Subway repeater stations with special long antennas will relay voice messages to the trains when they are in subway portions of the system. The radio system will also include two-way voice communication equipment in maintenance vehicles, at yards, shops and stations, and in addition, portable units will be carried by certain maintenance personnel.

DATA COMMUNICATION SYSTEM

Three high-speed data communication channels will connect the control center with each passenger station, storage yard, and maintenance shop. Each channel will consist of a four-wire circuit suitable for duplex operation, simultaneous transmission in both directions.

At each station, yard, or shop data will be received and stored in a data storage buffer. Data in digital form will be fed directly into the buffer. Analog data will be first changed to digital form in analog-to-digital converters (not shown in the simplified block diagram).

A switching circuit will route different categories of data between the buffer and three modems (modulators and demodulators). Although all three channels will normally operate continuously, vital data can be handled by any two if one is out of service for repair or emergency.

Modulators will translate the data into a serialized code format that is designed for efficient error detection. The demodulators recognize almost any possible error that might be introduced into a code by channel noise or malfunction. Erroneous codes are rejected and replaced with retransmissions. Transmitters and receivers (T/R) will deliver modulated signal energy to and from the data channels.

At the control center, input-output switching devices will automatically route data to and from the various data processing, display, supervisory, and printing devices.

The data channels will be combined with voice communication channels in shielded, multi- conductor cable which will be pressurized with dehumidified air.

Quality characteristics of the data communication channels will equal or exceed recognized transmission standards.

High-quantity characteristics will be maintained by the insertion of dynamic conditioning equipment at selected intervals. The equipment will amplify the coded data signals, and equalize attenuation and delay.

All data used for train control central-supervision are transmitted to destination within approximately one second after they are ready in the transmit buffer. Other data reach their destination within about three seconds.

AIRPORT-SOUTHWEST CORRIDOR

Coordinated operation of airport express trains running on the same routes with local trains will pose some special control and communication complexities on the Airport-Southwest Corridor. However, analysis of those complexities has shown that all control and communication requirements can be completely satisfied with combinations of the same equipment selected for use on the other routes.

Express and local trains will be scheduled for carefully co-ordinated bypass at the Western Avenue station. Precise arrangements of wayside equipment, combined with the coordinated timing of automatic train control will prevent conflicts if scheduled express trains tend to overtake local trains. If uneven passenger requirements delay a train at any station, the close schedule will sometimes reflect that delay to one or more following trains. Without the coordinating influence of central supervision, simple delays could produce major delays.

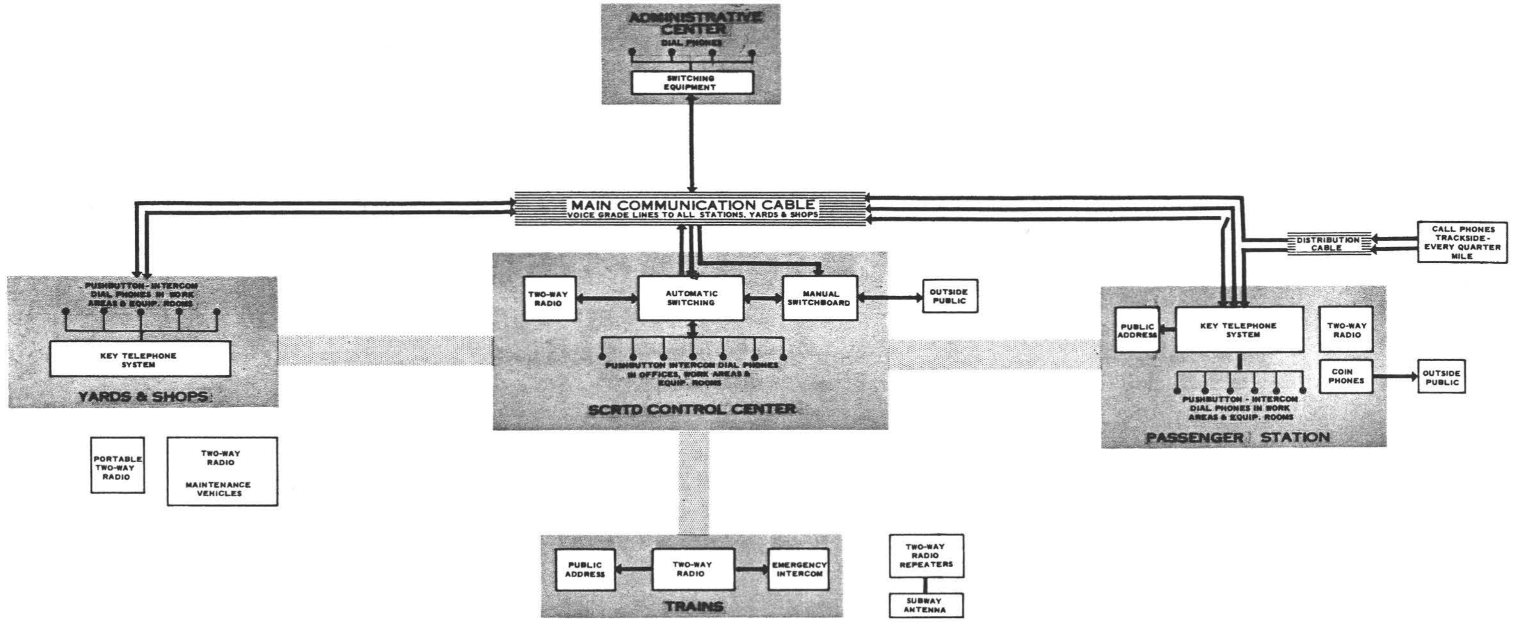
The communication system will report all off-schedule events to the control center within fractions of a second. The transit control computer will analyze these incoming data and within a few seconds select and implement corrective strategies which will minimize delays and their consequences throughout the corridor and the entire system.

As in all corridors, the safety subsystem will never allow control corrections to jeopardize safety in any way. Detection interlocking circuits, and devices will enforce safe separation and route protection to the same extent and with the same safety factors.

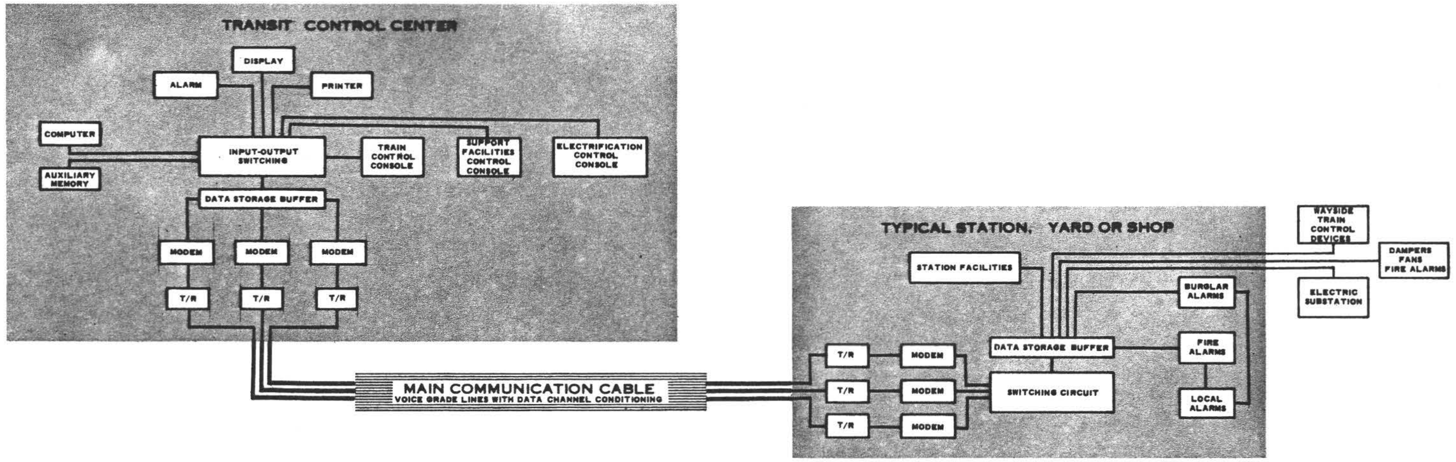
Airport express trains and local trains will be equipped with identical ATO equipment. They will respond identically to control itelligence from wayside equipment such as scheduled speed and location reference data. Stopping program equipment will stop both types of train with the same berthing precision. However each type will carry a unique coded indentification which wayside detectors will recognize. Detection of the unique identifications will automatically position track switches at merging and diverging route locations.

Similarly, ATO equipment on each type of train will automatically differentiate between stations at which they are scheduled to stop or bypass.

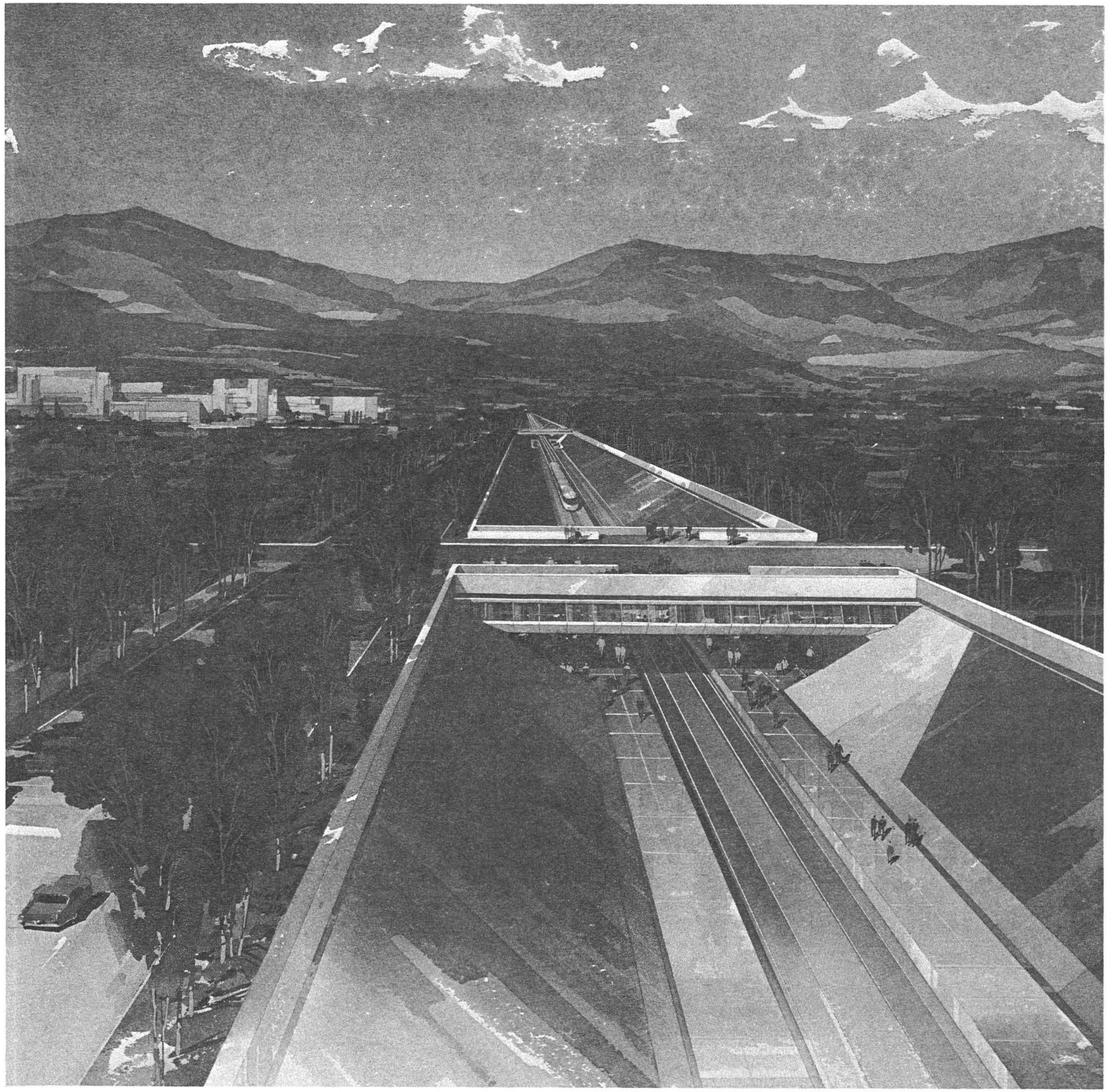
All trains will carry a full complement of voice communication equipment to deliver voice messages to and from passengers and trainmen in all cars.



VOICE COMMUNICATION SYSTEM



DATA COMMUNICATION SYSTEM



ROUTE PLANS AND PROFILES

WILSHIRE CORRIDOR

CORRIDOR DESCRIPTION

The Wilshire Corridor generally comprises that area surrounding Wilshire Boulevard from west of the Veterans Administration Complex to Union Station and includes the Los Angeles Central Business District. It is within the City of Los Angeles for most of its length; the only exceptions being a section through Beverly Hills and a short length through the unincorporated Veterans Administration area.

The major physical features are principally man-made and include the Los Angeles Central Business District and Civic Center, the Beverly Hills Central Business District, the Wilshire District from Hoover to Crenshaw, the Miracle Mile, Century City, U.C.L.A., and Veterans Administration Complex. The corridor contains the San Diego, Santa Monica, Hollywood, and Harbor Freeways as well as the future Beverly Hills, Laurel Canyon and Western Avenue Freeways. The Southern Pacific Company maintains an at grade rail line in Santa Monica Boulevard through Beverly Hills. The predominant natural feature is the Santa Monica Mountain Range paralleling the corridor on the north and northwest.

The residential development is generally medium to high density in character with large pockets of high quality single-family housing in the Hancock Park area, in Beverly Hills and west of Century City.

The commercial activity is very extensive in the Beverly Hills Central Business District, the Miracle Mile, the Wilshire District between Crenshaw and Hoover, Century City, and Westwood Village. The Los Angeles Central Business District, including the Civic Center area, is generally bounded by Pico Boulevard, the Harbor Freeway, Sunset Boulevard, and Main Street. It comprises headquarters and executive offices of various corporations, the financial center of the Pacific Southwest, the largest concentration of department and retail stores in the Los Angeles area, and a 25-building governmental office complex. This area also contains the Bunker Hill Urban Renewal District, an area that will experience vigorous building activity in the near future.

STATION LOCATIONS

The center of the Los Angeles Central Business District is at the intersection of Broadway and Sixth Street, and is a logical transit station location. The proximity of the SIXTH AND BROADWAY station to the "Y" interchange requires that it be designed as a "stacked" station consisting of three levels below the street. The concourse comprises the first level with the inbound and outbound transit lines arranged one above the other below the concourse.

The UNION STATION located in Macy Street provides service to the principal rail center in the region. The Macy Street location also provides for transition to the east through a large radius horizontal curve mostly in street right-of-way.

The CIVIC CENTER station serves the large and active Civic Center complex and north part of the commercial core. The SIXTH AND BROADWAY, OLYMPIC, and SEVENTH AND FLOWER stations serve the CBD core, the garment district, and the Bunker Hill Redevelopment Area. The LUCAS and ALVARADO transit stations serve the high density residential area in the MacArthur and Westlake Park Districts just west of the Los Angeles Central Business District.

Wilshire Boulevard from Hoover Street to the west city limits of Beverly Hills is the backbone of the Wilshire Corridor destination area. A large portion of the major stores and office buildings in the corridor are either on Wilshire Boulevard or very close to it. Therefore, Wilshire Boulevard is the most favorable location for the transit line through this area. The VERMONT, NORMANDIE, WILSHIRE-WESTERN, WILSHIRE-CRENSHAW, WILSHIRE-LA BREA, FAIRFAX, LA CIENEGA, and BEVERLY HILLS stations provide access to major destination areas through this reach of Wilshire Boulevard. In addition, they give good service to walk-in origin patronage from the medium to high density housing both north and south of Wilshire.

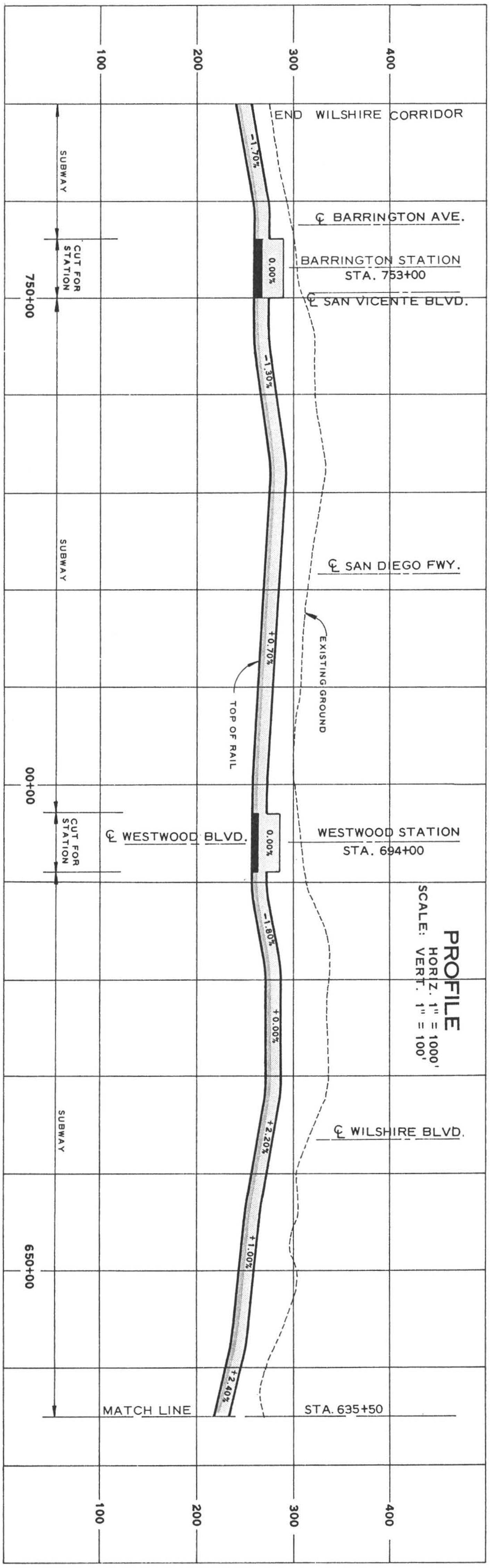
The CENTURY CITY station has good potential for both transit origins and destination because it is in an integrated commercial, office, and high-rise apartment complex. Since Constellation Boulevard is in the interior of that complex, it is a favorable location for a transit line with the station placed near the Avenue of the Stars intersection. Such a station would allow for patronage from all parts of Century City and from the 20th Century Fox Studio in the southwest quadrant of the complex.

West of Westholm Avenue, the WESTWOOD station at Wilshire and Westwood Boulevards is a desirable location providing service to Westwood Village and U.C.L.A.

The BARRINGTON station provides good access to the Barrington Towers area and the area west of the San Diego Freeway. The terminal station at this point also has good access to the San Diego Freeway. The station location north of Wilshire on Goshen Avenue will allow for a parking garage, and an easy future transition to the west when the transit line is extended to Santa Monica.

ROUTE DESCRIPTION

The route begins in a subway configuration at Union Station in Macy Street about 600 ft. east of Alameda Street. Leaving the station, the line turns southerly on a l600 ft. radius curve crossing under the Hollywood Freeway to enter Broadway. Proceeding southerly on Broadway, the line continues in subway to 6th Street, where it meets the Wilshire-Long Beach Interchange structure. The Wilshire-Long Beach Interchange structure is situated at the intersection of 7th Street and Broadway, and provides full interchange capability for trains proceeding west on Wilshire, east on San Gabriel Valley, and south on Long Beach Corridors. The structure occupies public and private property on 7th Street and Broadway. The Wilshire Corridor line continues west on 7th Street from the interchange, crosses under the Harbor Freeway and proceeds to a point at Carondelet Street where it turns northwesterly on a 3000 ft. radius reverse curve, entering private property in subsurface easement for the horizontal transition to Wilshire Blvd. Entering Wilshire Blvd. at Wilshire Place, the line continues westerly along Wilshire in subway to a point near Peck Dr. in Beverly Hills, where it turns southwesterly on a 2000 ft. radius curve to enter private property in subsurface easement for the transition to Young Street. Entering Young Street at about Lasky Drive the line proceeds westerly in subway to Moreno Drive where it enters and proceeds under the property of the Beverly Hills High School to a position in Constellation Blvd. at Century Park East. The alignment follows Constellation Blvd. to the westerly limit of Century City at Century Park West where it turns northerly on a 2000 ft. radius curve through subsurface easement to Thayer Avenue near Kinnard Avenue. Proceeding along Thayer Avenue, near Wilkins Avenue the line turns westerly along a 2000 ft. radius curve under private property in subsurface easement to Wilshire Blvd. near Westholm Avenue. Proceeding west along Wilshire Blvd., the line continues in subway to San Vicente Blvd., enters property of the Veterans Administration in subsurface easement to Goshen Street ending at a terminal station between Federal Avenue and Barrington Avenue. The route for the Four-Corridor System will follow the same alignment to the La Cienega Station which will be the termination of the Wilshire Corridor under that system.



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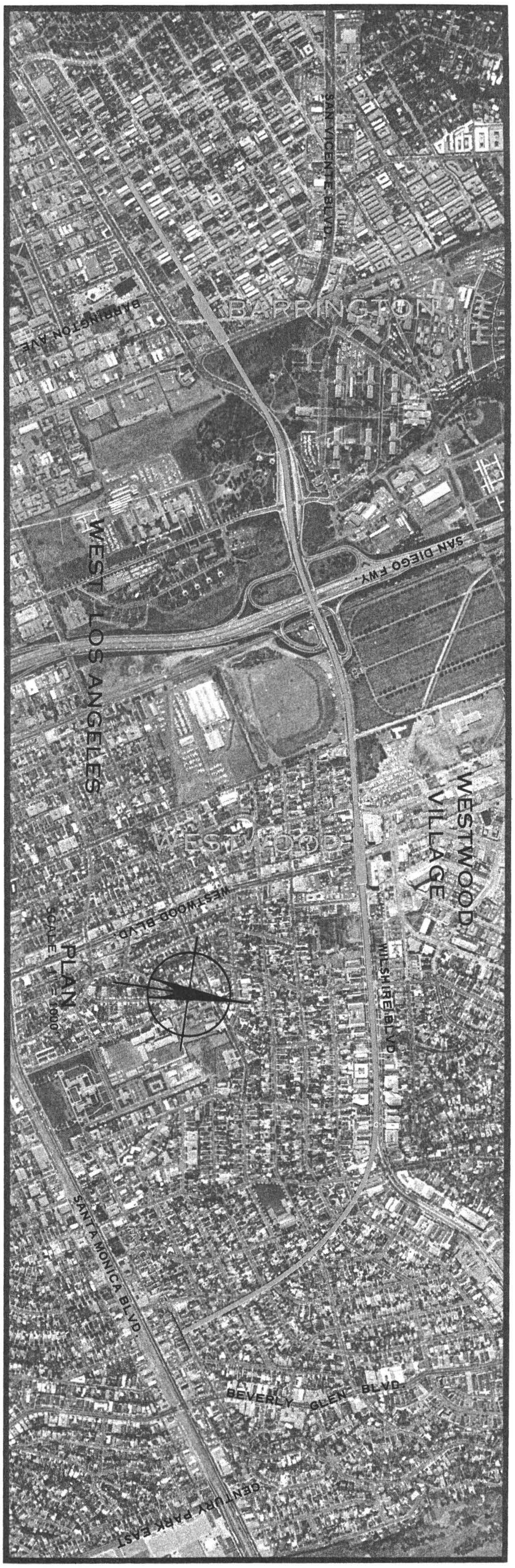
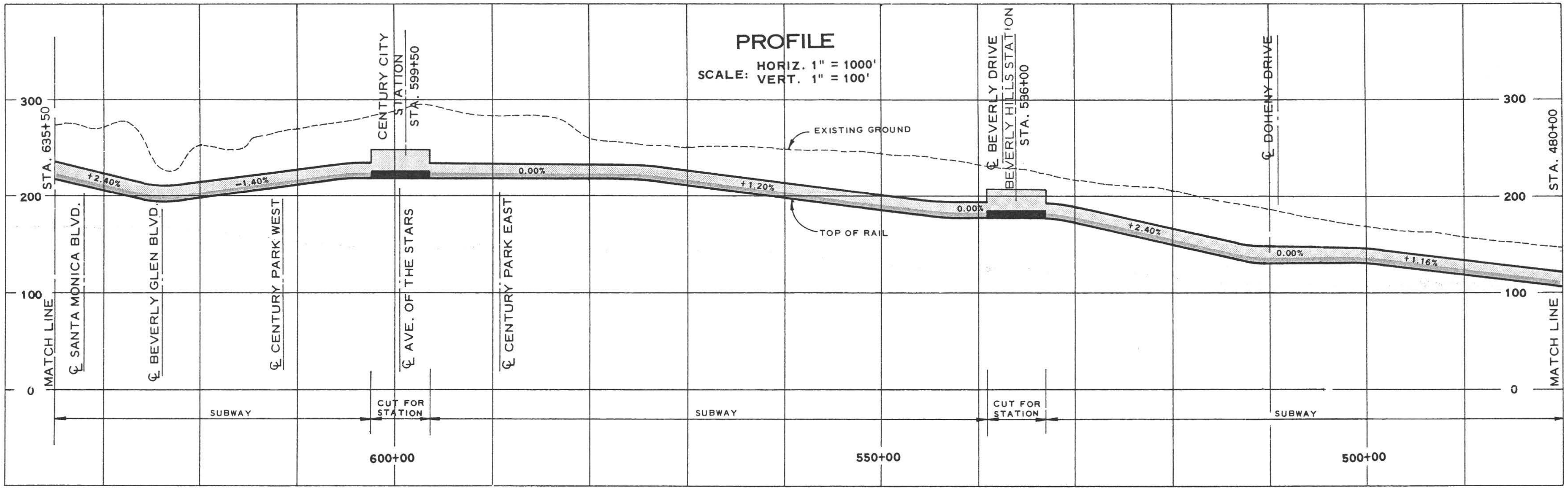
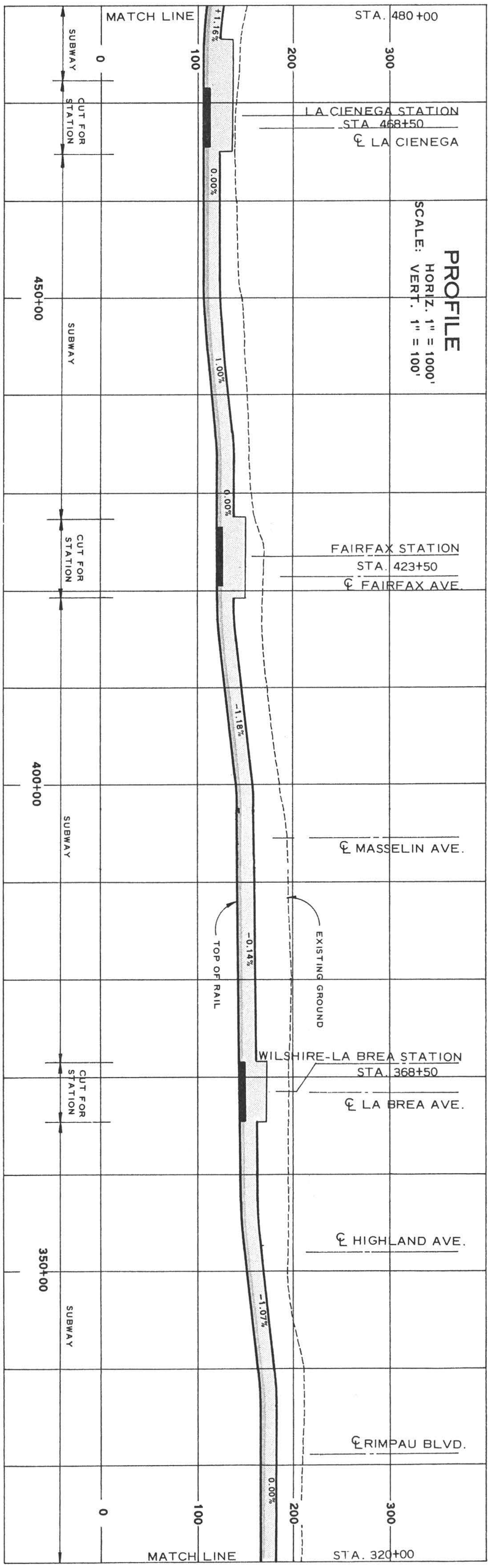
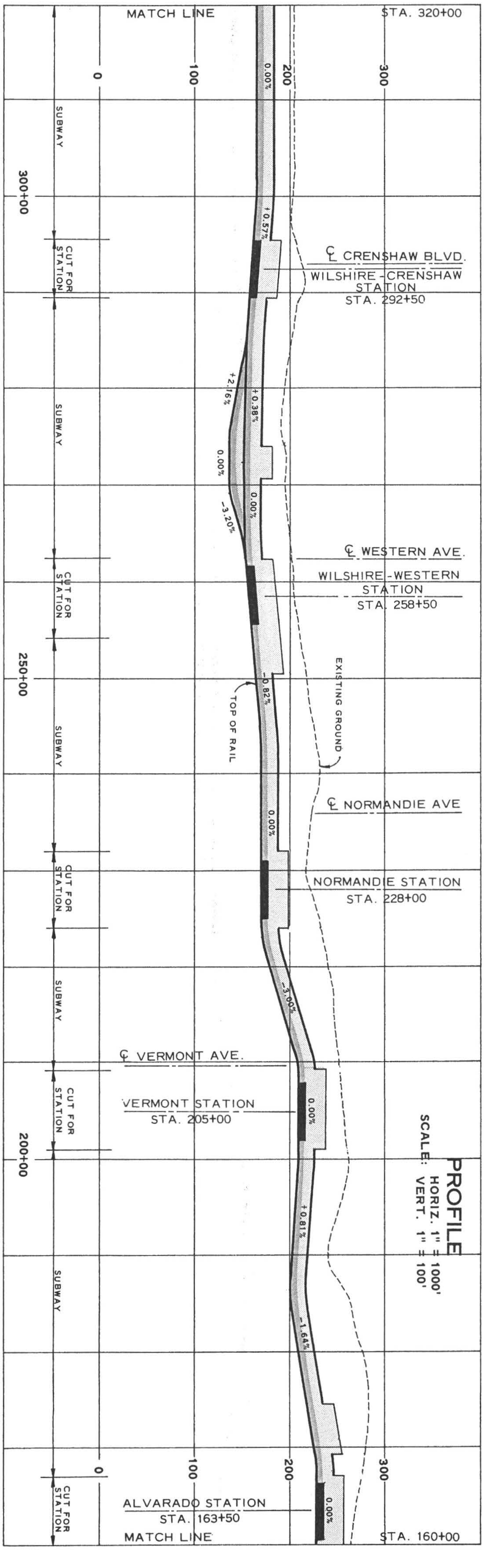



LOS ANGELES
COUNTRY CLUB
WILSHIRE BLVD.
SANTA MONICA BLVD.
BEVERLY GLEN BLVD.
MATCH LINE
CONSTELLATION BLVD.
AVE. OF THE STARS
CENTURY PARK EAST
CENTURY PARK WEST
20TH CENTURY FOX STUDIOS
LOS ANGELES
BEVERLY DRIVE
BEVERLY HILLS
DOHENY DRIVE
OLYMPIC BLVD.
MATCH LINE
LA CIENEGA BLVD.
PLAN
SCALE: 1" = 1000'


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
300
200
100
0
STA. 635+50
MATCH LINE
℄ SANTA MONICA BLVD.
℄ BEVERLY GLEN BLVD.
℄ CENTURY PARK WEST
CENTURY CITY STATION
STA. 599+50
℄ AVE. OF THE STARS
℄ CENTURY PARK EAST
EXISTING GROUND
TOP OF RAIL
℄ BEVERLY DRIVE
BEVERLY HILLS STATION
STA. 536+00
℄ DOHENY DRIVE
STA. 480+00
MATCH LINE
+2.40%
-1.40%
0.00%
+1.20%
0.00%
+2.40%
0.00%
+1.16%
SUBWAY
CUT FOR STATION
SUBWAY
CUT FOR STATION
SUBWAY
600+00
550+00
500+00


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
MATCH LINE
STA. 480+00
SUBWAY
CUT FOR STATION
LA CIENEGA STATION
STA. 468+50
℄ LA CIENEGA
450+00
FAIRFAX STATION
STA. 423+90
℄ FAIRFAX AVE.
400+00
℄ MASSELIN AVE.
TOP OF RAIL
EXISTING GROUND
WILSHIRE-LA BREA STATION
STA. 368+50
℄ LA BREA AVE.
350+00
℄ HIGHLAND AVE.
℄ RIMPAU BLVD.
MATCH LINE
STA. 320+00
0
100
200
300
+1.16%
0.00%
1.00%
0.00%
-1.18%
-0.14%
-1.07%
0.00%


PLAN
SCALE: 1" = 1000'
MATCH LINE
LA CIENEGA BLVD.
FAIRFAX AVE.
LOS ANGELES
MASSELIN AVE.
LA BREA AVE.
HIGHLAND AVE.
RIMPAU BLVD.
MATCH LINE



PROFILE
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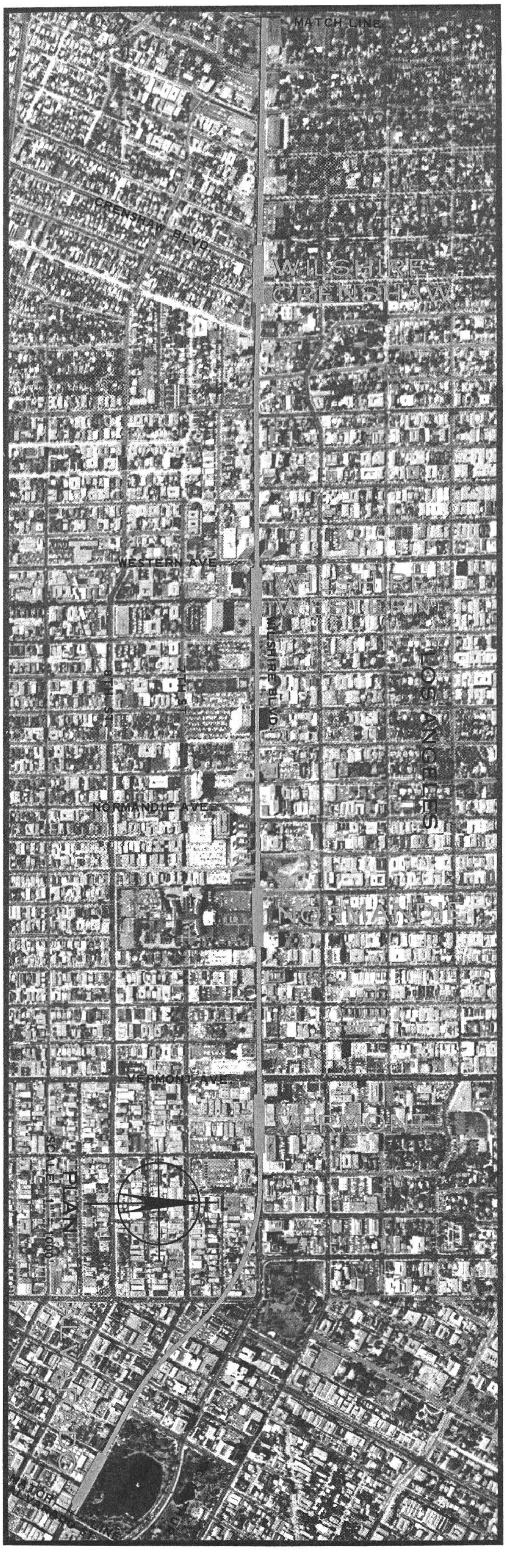
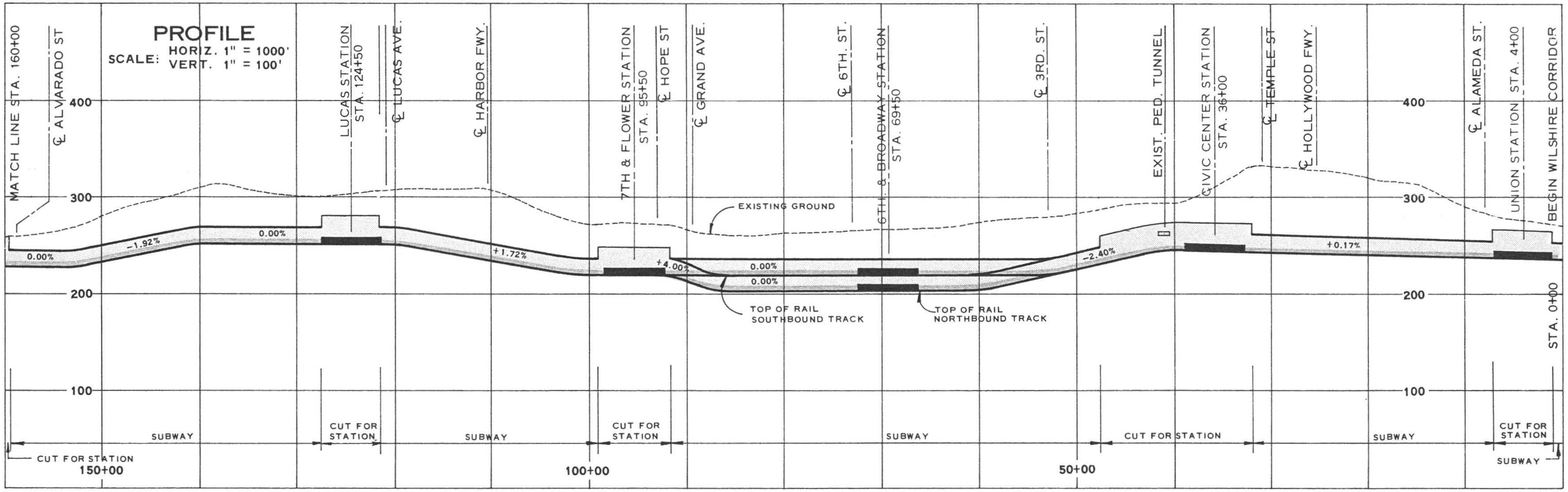
VERT. 1" = 100'



PLAN
SCALE 1" = 1000'


MC ARTHUR PARK
6TH ST.
WILSHIRE BLVD.
7TH ST.
8TH ST.
LOS ANGELES
HOOVER ST.
MATCH LINE
ALVARADO ST.
LUCAS AVE.
HARBOR FWY.
7TH & FLOWER
6TH & BROADWAY
HOPE ST.
GRAND AVE.
OLIVE ST.
HILL ST.
BROADWAY
SPRING ST.
MAIN ST.
CIVIC CENTER
HOLLYWOOD FWY.
TEMPLE ST.
UNION STATION
BEGIN WILSHIRE CORRIDOR
ALAMEDA ST.
PLAN
SCALE: 1" = 1000'


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
MATCH LINE STA. 160+00
℄ ALVARADO ST
LUCAS STATION
STA. 124+50
℄ LUCAS AVE.
℄ HARBOR FWY.
7TH & FLOWER STATION
STA. 95+50
℄ HOPE ST
℄ GRAND AVE.
℄ 6TH. ST.
6TH. & BROADWAY STATION
STA. 69+50
℄ 3RD. ST.
EXIST. PED. TUNNEL
CIVIC CENTER STATION
STA. 36+00
℄ TEMPLE ST
℄ HOLLYWOOD FWY.
℄ ALAMEDA ST.
UNION STATION STA. 4+00
BEGIN WILSHIRE CORRIDOR
STA. 0+00
EXISTING GROUND
TOP OF RAIL SOUTHBOUND TRACK
TOP OF RAIL NORTHBOUND TRACK
0.00%
-1.92%
0.00%
+1.72%
+4.00%
0.00%
0.00%
-2.40%
+0.17%
400
300
200
100
CUT FOR STATION
SUBWAY
CUT FOR STATION
SUBWAY
CUT FOR STATION
SUBWAY
CUT FOR STATION
SUBWAY
CUT FOR STATION
SUBWAY
150+00
100+00
50+00

SAN FERNANDO VALLEY CORRIDOR

CORRIDOR DESCRIPTION

The San Fernando Valley Corridor, south of the Santa Monica Mountains, includes Hollywood and takes in that area bounded by Wilshire Boulevard on the south, the Hollywood Freeway on the east, and Beverly Hills on the west. North of the Santa Monica Mountains, it passes through the center of the San Fernando Valley to the community of Reseda on the west. This corridor is entirely within the City of Los Angeles.

Some of the predominant physical features are the Santa Monica Mountains, which divide the corridor into two distinct parts; the Hollywood, Ventura, and San Diego Freeways; a branch line of the Southern Pacific Company, going west along Chandler Boulevard, Oxnard Street, and Victory Boulevard; the Van Nuys Airport west of the San Diego Freeway; and the Sepulveda Flood Control Basin, an area restricted to recreational use by its primary purpose of flood water retention during periods of heavy rainfall.

From a land-use standpoint, the corridor is split by the Santa Monica Mountains into two distinct and different developments. On the south side, there is the Hollywood area with a strong commercial core centered on Hollywood Boulevard and surrounded by medium to high density housing. North of the mountains, the San Fernando Valley is essentially single family residential with multi-family development along many arterial streets. The commercial activity in the Valley, with the exception of the Van Nuys Central Business District, is essentially in suburban shopping centers such as the Valley Plaza and Bullocks Fashion Square. Within the transit corridor, the major industry is concentrated around the Van Nuys Airport and along several branch lines of the Southern Pacific Company.

STATION LOCATION

From Wilshire Boulevard to the Hollywood Freeway, Wilton Place generally divides the multi-family residential on the east and the single family residential on the west. A transit line in this vicinity provides definition and a buffer between different types of land use without a visual barrier since the way configuration is a landscaped cut. The BEVERLY BOULEVARD and SANTA MONICA BOULEVARD stations provide excellent service to the surrounding residential areas and also are located at major east-west arterials providing convenient feeder bus access.

In the Hollywood District, Selma Avenue provides a location half-way between two major boulevards, Hollywood and Sunset, which are destination areas for intensive commercial and office developments. The VINE station west of Vine Street provides service to the eastern and central portions of Hollywood while the HOLLYWOOD-LA BREA station serves the western sections. The HOLLYWOOD-LA BREA station should also develop considerable walk-in patronage from the present and planned multi-family dwelling developments to the south, west, and north.

The UNIVERSAL CITY station is located at the north portal of the tunnel under the Santa Monica Mountains and provides access to a complex in Universal City which is rapidly developing, both as an employment area and a tourist attraction. The NORTH HOLLYWOOD station at Magnolia Boulevard provides access to major feeder routes from the east and northeast as well as the commercial area along Lankershim Boulevard.

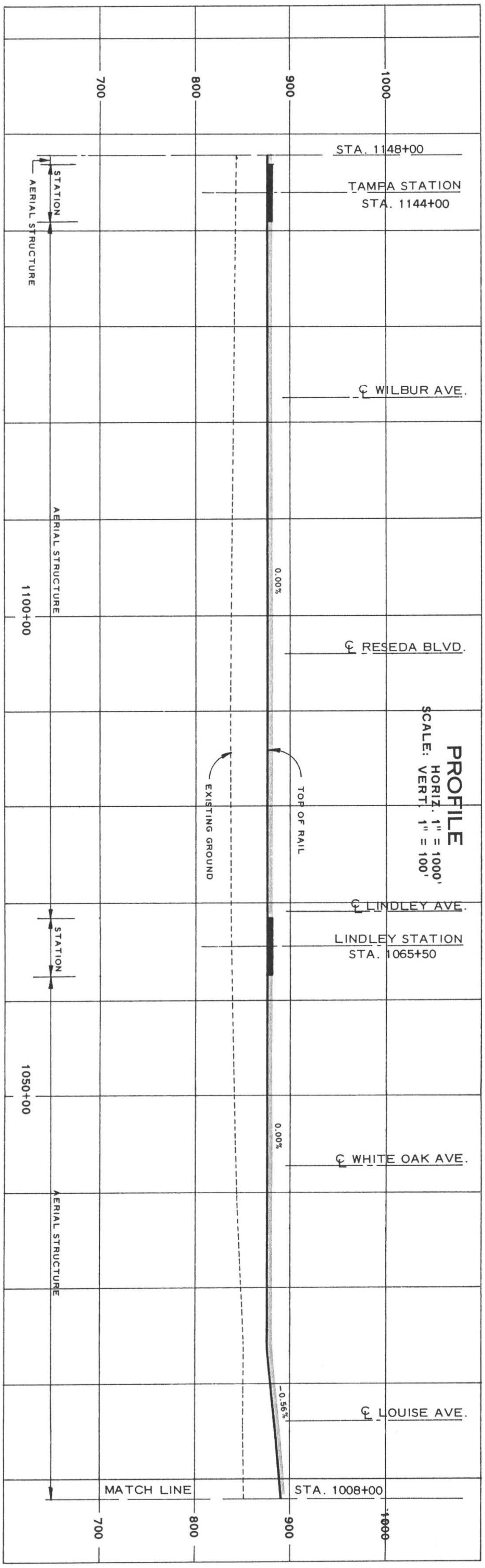
Chandler Boulevard is a wide arterial street leading directly west into the south end of the Van Nuys Central Business District. The LAUREL CANYON station affords excellent north-south feeder service and the FULTON station serves the Valley Junior College.

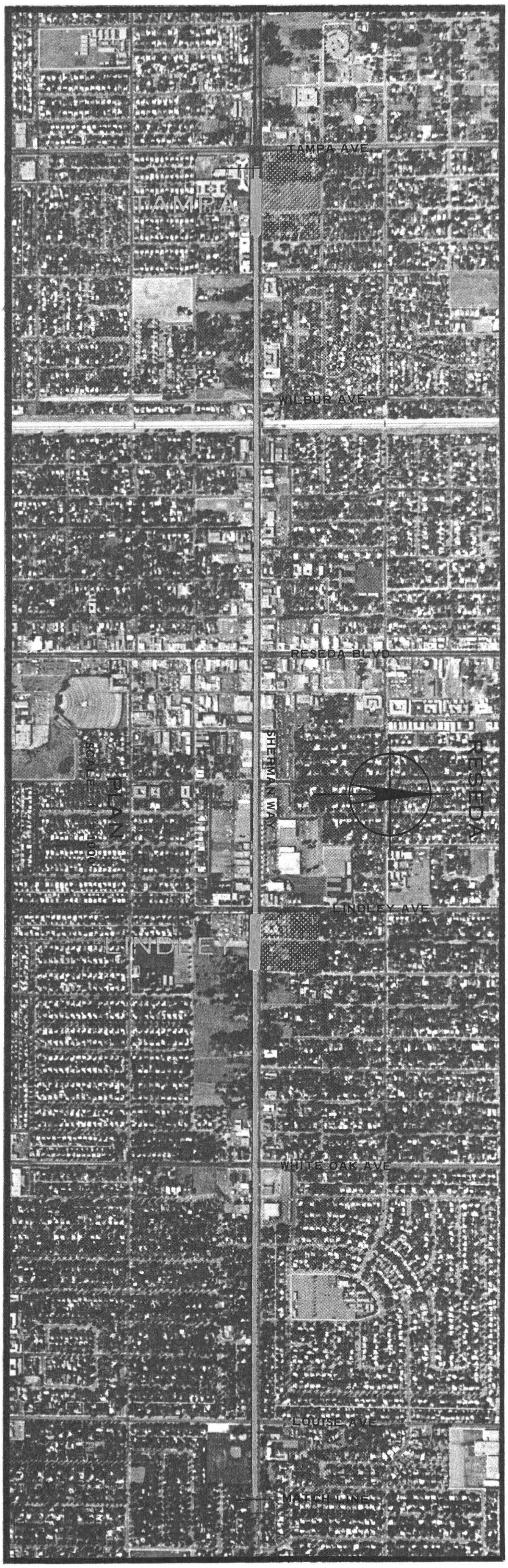
The Van Nuys Central Business District is a major shopping and business development and contains the principal governmental complex in the San Fernando Valley. Three stations are located within this length: BURBANK BOULEVARD serving areas to the south along Van Nuys Boulevard and residential areas to the south and west; VAN NUYS station at Erwin Street providing service to the Valley Civic Center and commercial centers at Van Nuys and Victory Boulevards; and the SHERMAN CIRCLE station where feeder service to the Panorama City area and other areas to the north and north-east is provided.

Sherman Way is similar to Chandler Boulevard in that it is wide enough to accommodate a transit line in its median without disturbing adjacent properties. The Los Angeles City Planning Commission has developed a plan for a multi-family dwelling complex along Sherman Way, and a transit line in the median with the SHERMAN CIRCLE and SEPULVEDA stations would complement the plan. The BALBOA station serves the Van Nuys Airport complex and, together with LINDLEY and TAMPA stations, affords excellent feeder service from the north and south. The terminal station at Tampa provides service to a major regional commercial center in Reseda as well as the residential areas in the western end of the Valley.

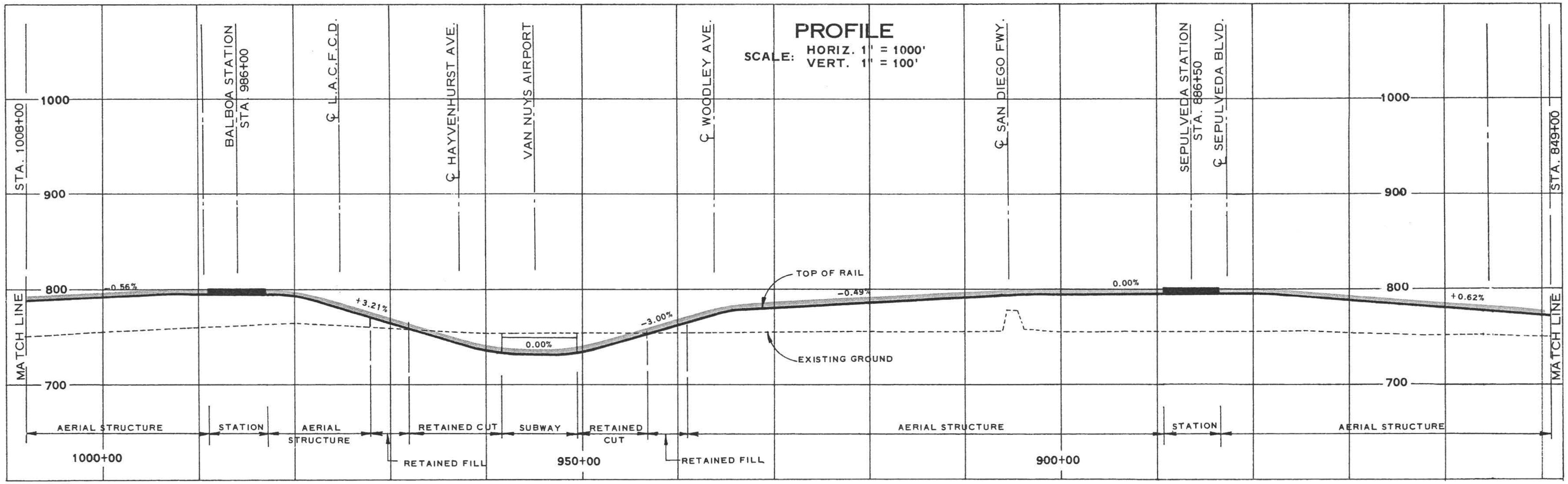
ROUTE DESCRIPTION

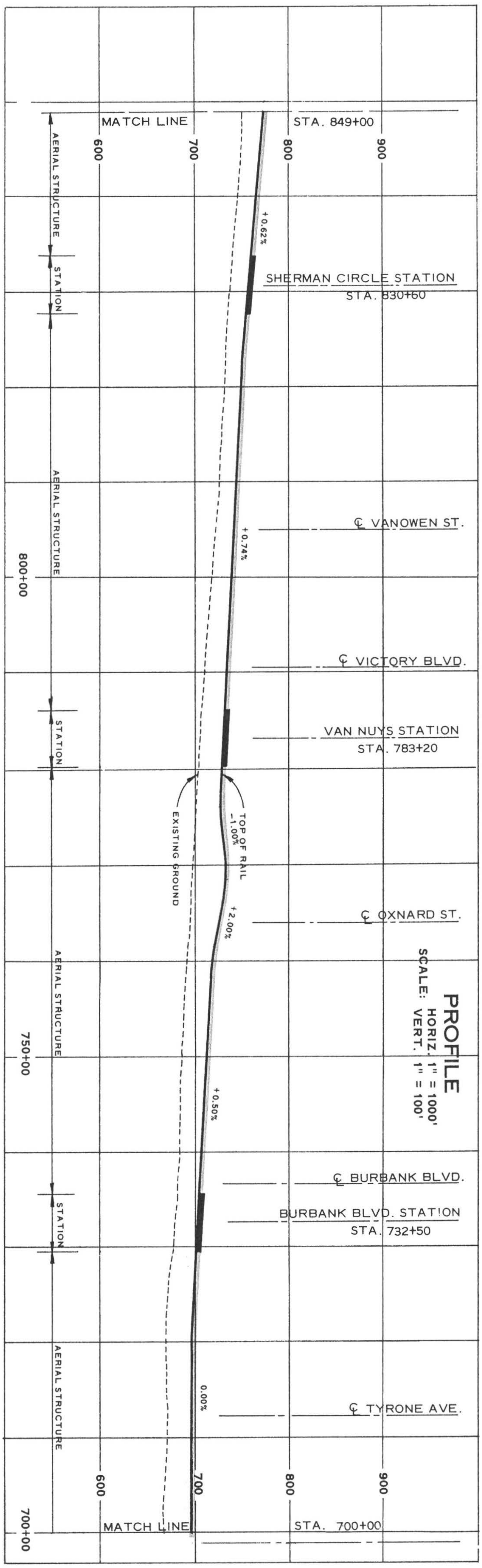
The route begins in a subway configuration at the Wilshire-San Fernando Valley Interchange on Wilshire Blvd. at Gramercy Place. The alignment turns northerly along a 600 ft. radius curve under private property in subsurface easement to Wilton Place at about 6th Street and proceeds northerly under Wilton Place to 2nd Street where it becomes an open cut section on private right-of-way east of Ridgewood Pl. The line continues northerly in open cut and returns to subway configuration at Fernwood Ave. It then turns west along a l500 ft. radius curve under private property in a subsurface easement to Selma Avenue at Gower Street. The line continues westerly under Selma Avenue to Highland Avenue and under the athletic field of Hollywood High School to Orange Drive, under private right-or-way to La Brea Avenue, under Hawthorne Avenue to Formosa Street, and then turns north on a 2000 ft. radius curve in a tunnel under the Hollywood Hills. The tunnel emerges about 400 ft. north of the Hollywood Freeway and west of Lankershim Blvd. where it becomes an aerial structure. The route continues across the Los Angeles River and enters private right-of-way east of Lankershim at Chiquita Street. The aerial structure parallels Lankershim Blvd. in private right-of-way to Magnolia Avenue and turns west on an 1800 ft. radius curve to the Southern Pacific Company's right-of-way in the median of Chandler Blvd. It then proceeds along Chandler in aerial easement within the median to Coldwater Canyon Blvd. where the Southern Pacific right-of-way diverges and the transit line continues in the Chandler median to Van Nuys Blvd. The aerial structure continues across Van Nuys Blvd. and crosses on private right-of-way to the west side of Vesper on 1000 ft. radius curves. The line continues north in private right-of-way parallel to Vesper, and crosses to the east side of Tobias Avenue north of Victory Blvd. It then continues to Gault Avenue where it turns west on a l200 ft. radius curve to enter the median of Sherman Way. The line proceeds west on an aerial structure to Van Nuys Airport, and changes to subway configuration under the runway through the existing north auto tunnel, which is to be replaced by a new auto tunnel immediately north. The line returns to aerial structure and continues westward in the median of Sherman Way, terminating at Tampa Avenue with a storage yard located west of Tampa. The Four-Corridor System terminates at a storage yard and terminal station at Balboa Blvd.


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
700
800
900
1000
STA. 1148+00
TAMPA STATION
STA. 1144+00
STATION
AERIAL STRUCTURE
℄ WILBUR AVE.
AERIAL STRUCTURE
1100+00
0.00%
℄ RESEDA BLVD.
TOP OF RAIL
EXISTING GROUND
℄ LINDLEY AVE.
LINDLEY STATION
STA. 1065+50
STATION
1050+00
0.00%
℄ WHITE OAK AVE.
AERIAL STRUCTURE
-0.56%
℄ LOUISE AVE.
MATCH LINE
STA. 1008+00
700
800
900
1000


PLAN
SCALE: 1" = 1000'
TAMPA AVE.
TAMPA
WILBUR AVE.
RESEDA BLVD.
SHERMAN WAY
RESEDA
LINDLEY AVE.
LINDLEY
WHITE OAK AVE.
LOUISE AVE.
MATCH LINE

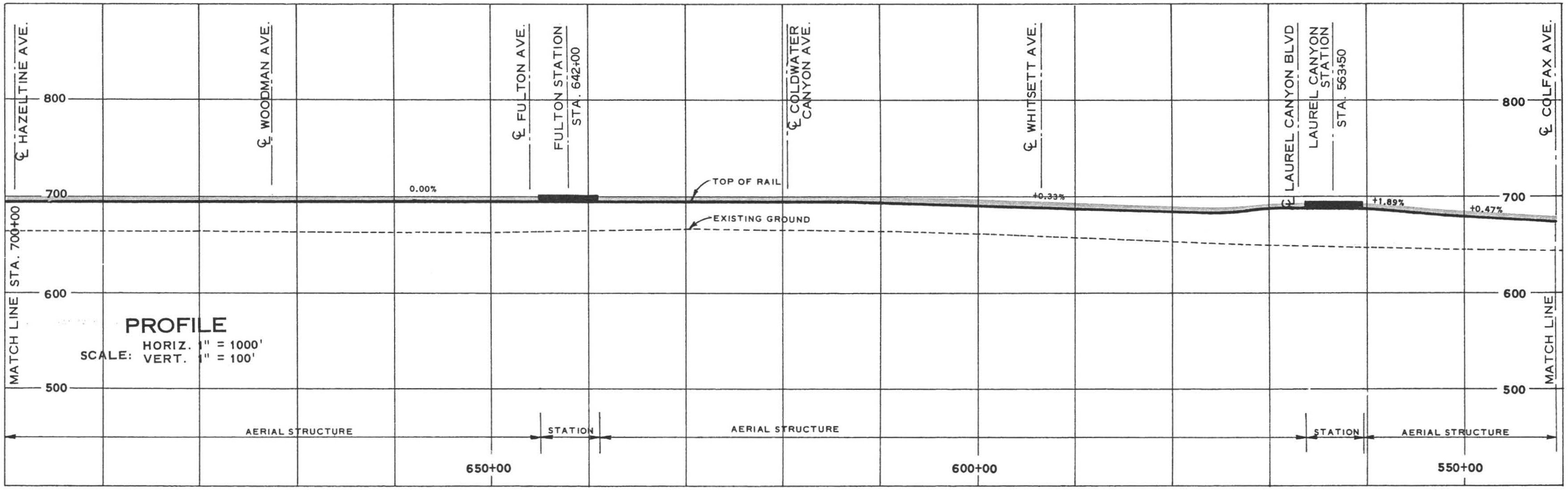

MATCH LINE
BALBOA BLVD.
L.A.C.F.C.D.
HAYVENHURST AVE.
VAN NUYS AIRPORT
WOODLEY AVE.
SAN DIEGO FWY.
SEPULVEDA BLVD.
KESTER AVE.
MATCH LINE
SHERMAN WAY
BALBOA
VAN NUYS
SEPULVEDA
PLAN
SCALE: 1" = 1000'

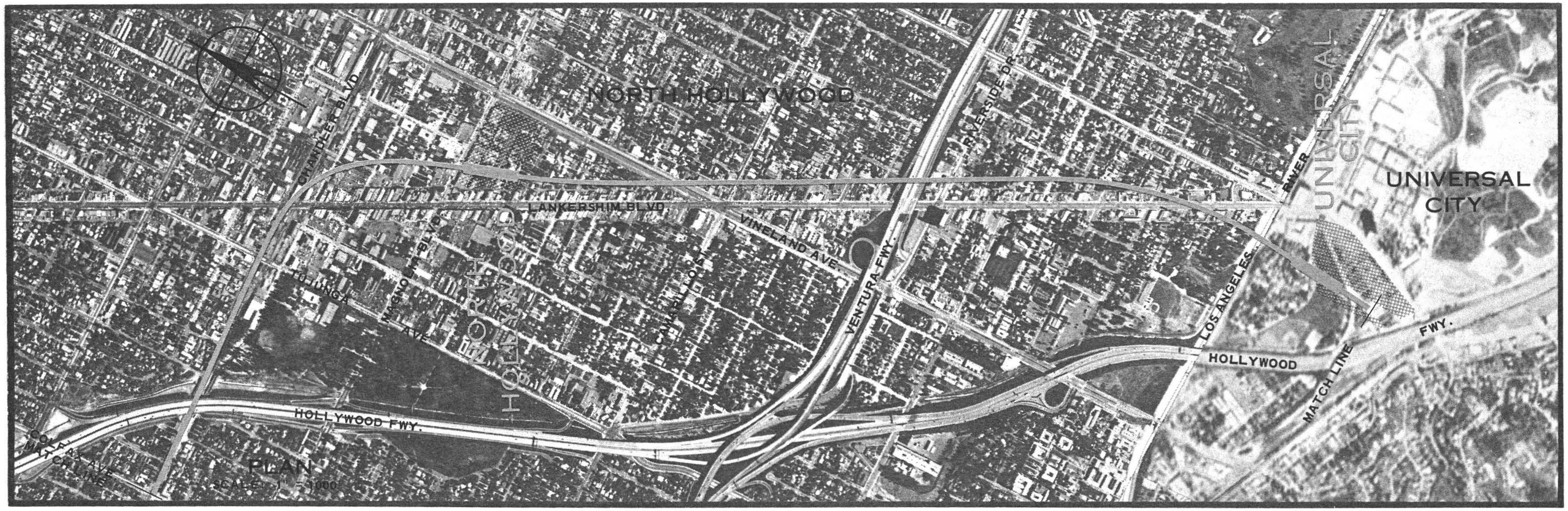

PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
STA. 1008+00
BALBOA STATION
STA. 986+00
℄ L.A.C.F.C.D.
℄ HAYVENHURST AVE.
VAN NUYS AIRPORT
℄ WOODLEY AVE.
℄ SAN DIEGO FWY.
SEPULVEDA STATION
STA. 886+50
℄ SEPULVEDA BLVD.
STA. 849+00
1000
900
800
700
MATCH LINE
-0.56%
+3.21%
0.00%
-3.00%
-0.49%
0.00%
+0.62%
TOP OF RAIL
EXISTING GROUND
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
RETAINED FILL
RETAINED CUT
SUBWAY
RETAINED CUT
RETAINED FILL
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
1000+00
950+00
900+00

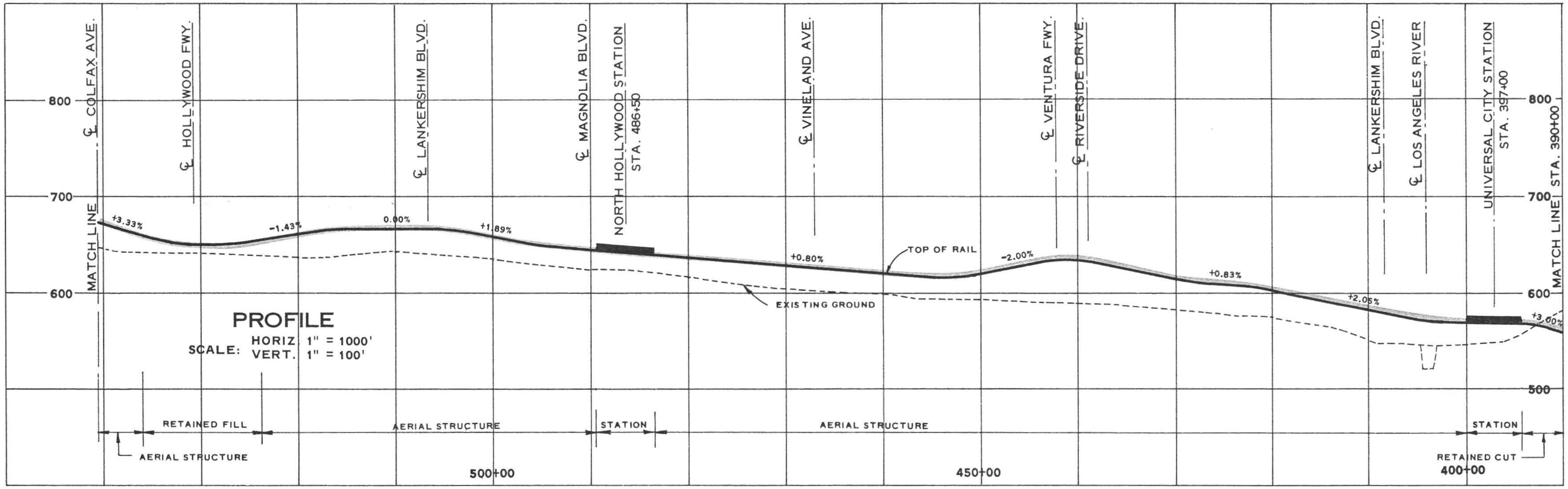

MATCH LINE
STA. 849+00
600
700
800
900
AERIAL STRUCTURE
+0.62%
STATION
SHERMAN CIRCLE STATION
STA. 830+60
AERIAL STRUCTURE
800+00
+0.74%
℄ VANOWEN ST.
℄ VICTORY BLVD.
STATION
VAN NUYS STATION
STA. 783+20
EXISTING GROUND
TOP OF RAIL
-1.00%
+2.00%
℄ OXNARD ST.
AERIAL STRUCTURE
750+00
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
+0.50%
℄ BURBANK BLVD.
STATION
BURBANK BLVD. STATION
STA. 732+50
AERIAL STRUCTURE
0.00%
℄ TYRONE AVE.
600
700
800
900
700+00
MATCH LINE
STA. 700+00

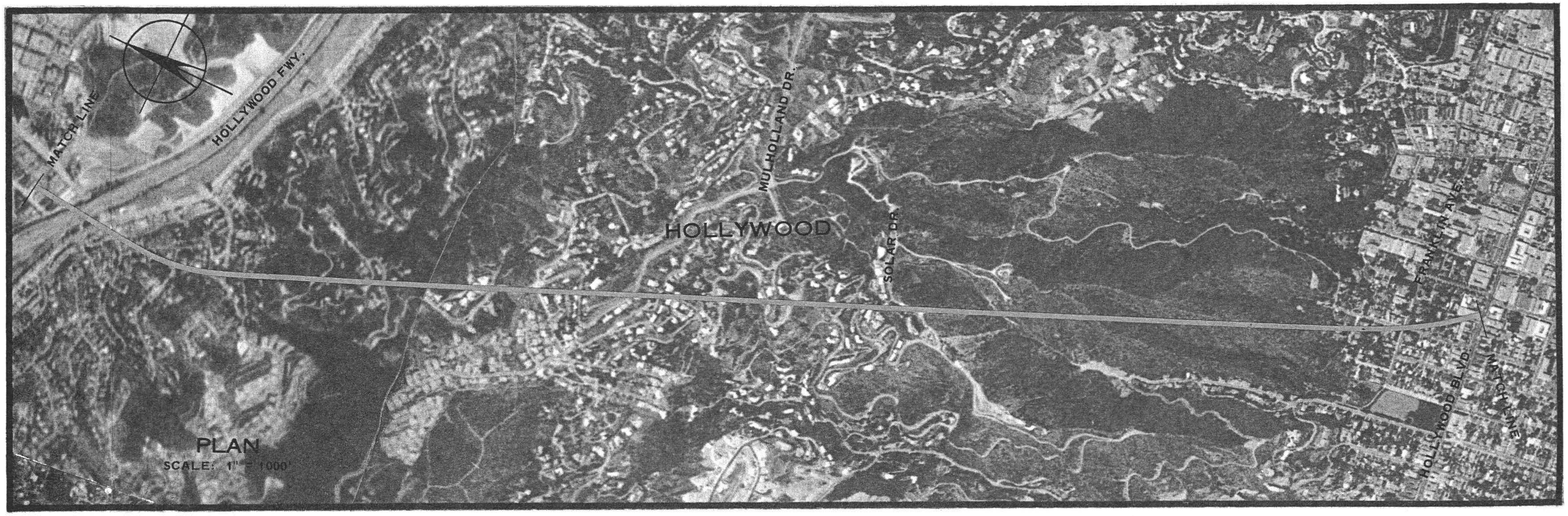

MATCH LINE
SHERMAN WAY
SHERMAN CIRCLE
VANOWEN ST.
VAN NUYS BLVD.
VICTORY BLVD.
CEDROS AVE.
VAN NUYS
VAN NUYS
OXNARD ST.
PLAN
SCALE 1" = 1000'
HAZELTINE AVE.
BURBANK BLVD.
BURBANK BLVD.
CHANDLER BLVD.
TYRONE AVE.
MATCH LINE
MAGNOLIA BLVD.


MATCH LINE
VALLEY COLLEGE
VAN NUYS
CHANDLER BLVD.
LAUREL CANYON
HAZELTINE AVE.
WOODMAN AVE.
FULTON AVE.
COLDWATER CANYON AVE.
WHITSETT AVE.
LAUREL CANYON BLVD.
MATCH LINE
PLAN
SCALE: 1" = 1000'

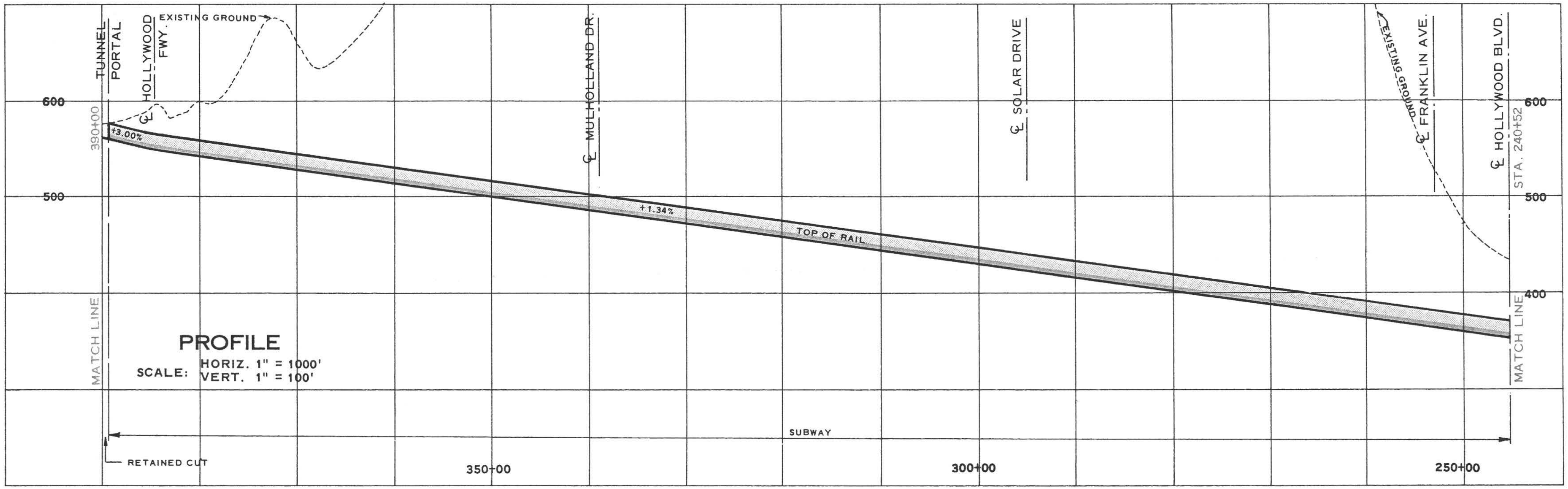

℄ HAZELTINE AVE.
℄ WOODMAN AVE.
℄ FULTON AVE.
FULTON STATION
STA. 642+00
℄ COLDWATER CANYON AVE.
℄ WHITSETT AVE.
℄ LAUREL CANYON BLVD
LAUREL CANYON STATION
STA. 563+50
℄ COLFAX AVE.
800
700
600
500
0.00%
+0.33%
+1.89%
+0.47%
TOP OF RAIL
EXISTING GROUND
MATCH LINE STA. 700+00
MATCH LINE
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
650+00
600+00
550+00


NORTH HOLLYWOOD
CHANDLER BLVD.
LANKERSHIM BLVD.
TUJUNGA AVE.
MAGNOLIA BLVD.
NORTH HOLLYWOOD
CAMARILLO ST.
VINELAND AVE.
VENTURA FWY.
RIVERSIDE DR.
LOS ANGELES RIVER
UNIVERSAL CITY
UNIVERSAL CITY
HOLLYWOOD FWY.
MATCH LINE
COLFAX AVE. MATCH LINE
HOLLYWOOD FWY.
PLAN
SCALE: 1" = 1000'

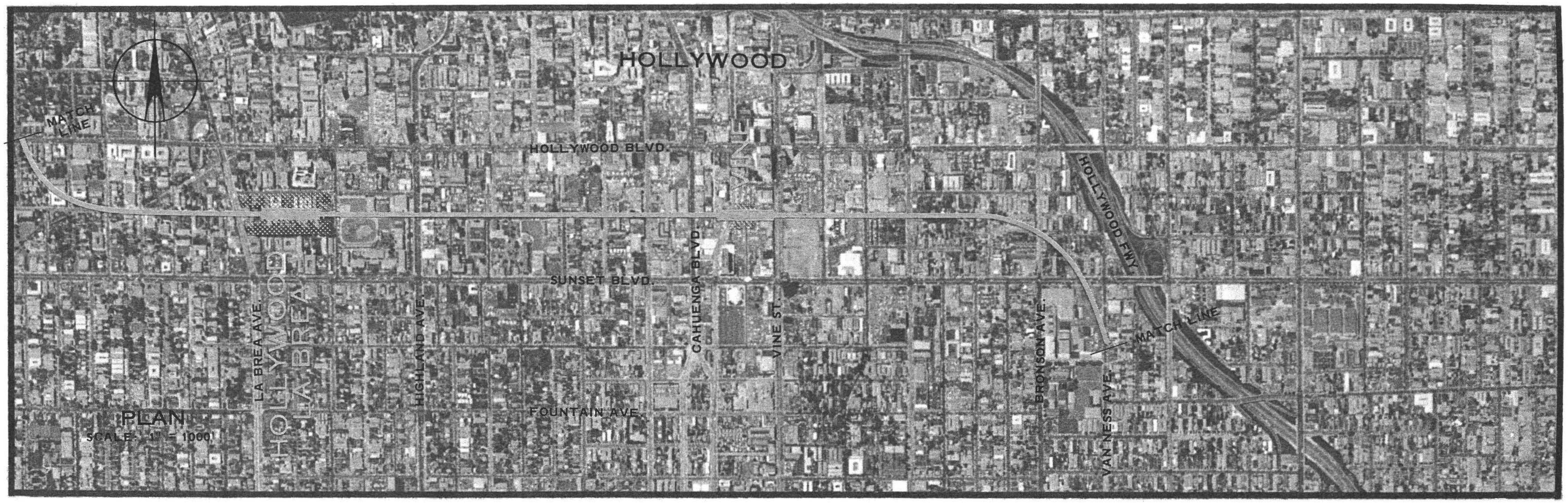

℄ COLFAX AVE.
℄ HOLLYWOOD FWY.
℄ LANKERSHIM BLVD.
℄ MAGNOLIA BLVD.
NORTH HOLLYWOOD STATION
STA. 486+50
℄ VINELAND AVE.
℄ VENTURA FWY.
℄ RIVERSIDE DRIVE.
℄ LANKERSHIM BLVD.
℄ LOS ANGELES RIVER
UNIVERSAL CITY STATION
STA. 397+00
MATCH LINE
MATCH LINE STA. 390+00
800
700
600
500
+3.33%
-1.43%
0.00%
+1.89%
+0.80%
-2.00%
+0.83%
+2.05%
+3.00%
TOP OF RAIL
EXISTING GROUND
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
RETAINED FILL
AERIAL STRUCTURE
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
STATION
RETAINED CUT
500+00
450+00
400+00

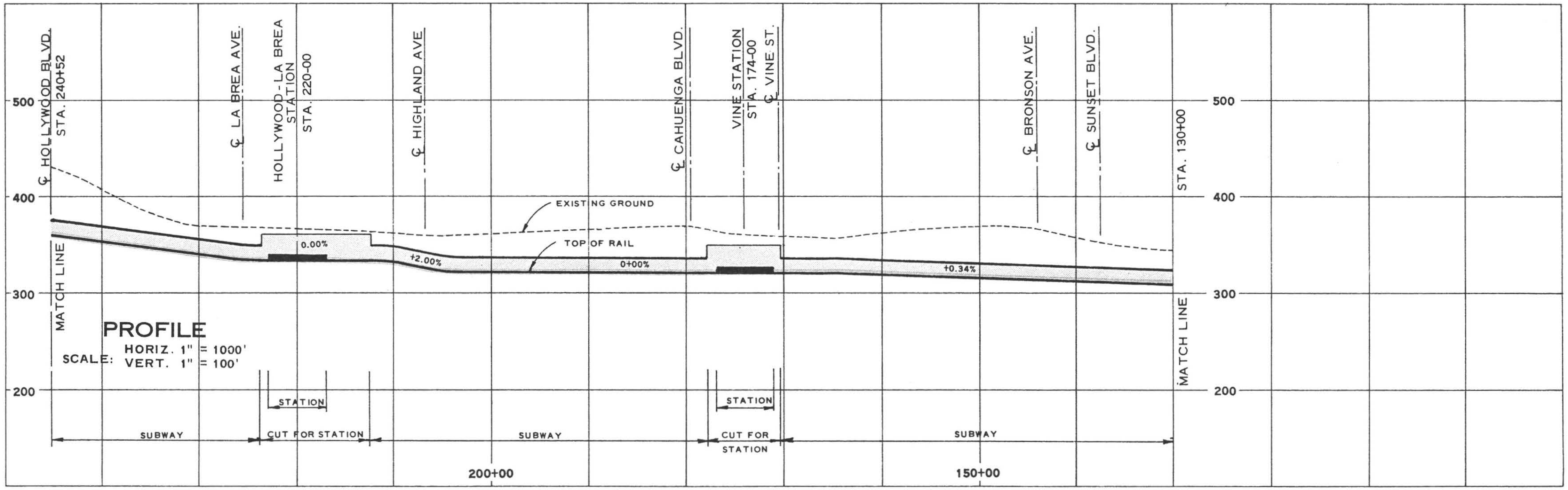


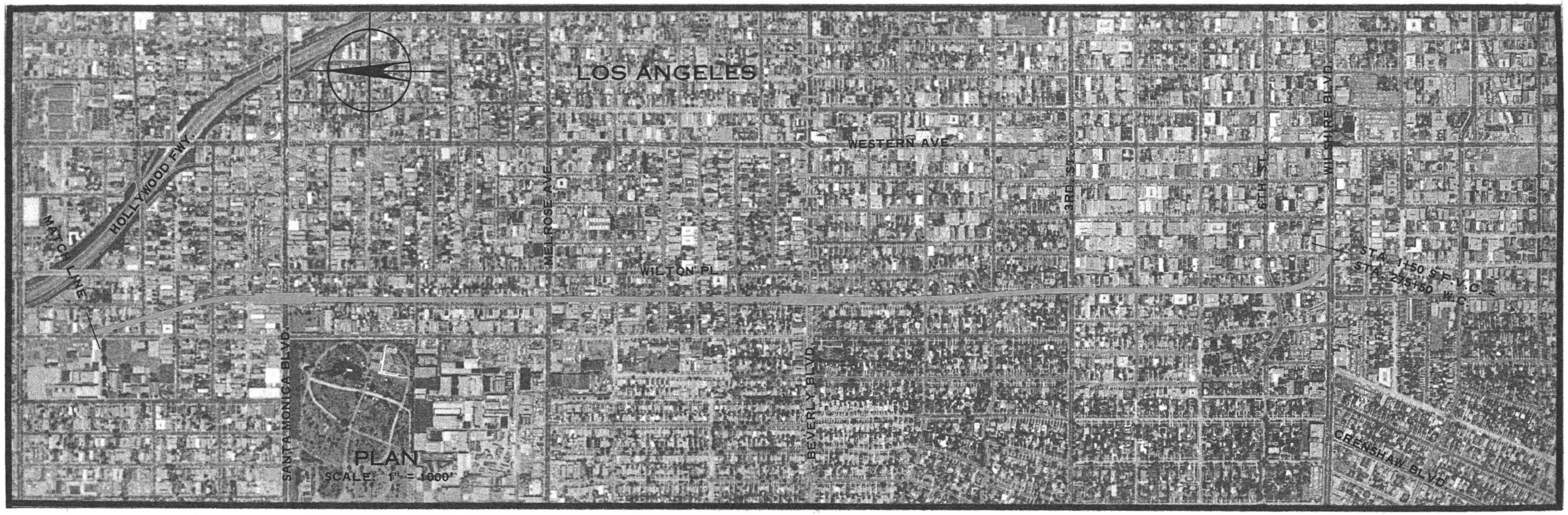
PLAN
SCALE: 1" = 1000'

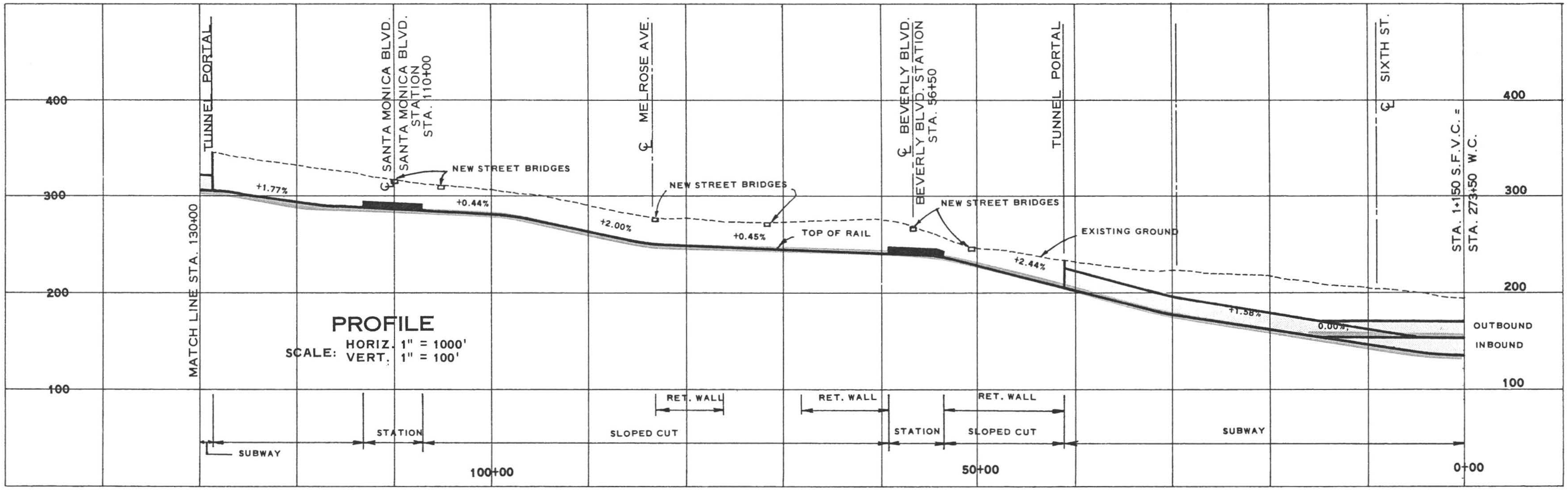


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'


PLAN
SCALE: 1" = 1000'
MATCH LINE
HOLLYWOOD
HOLLYWOOD BLVD.
HOLLYWOOD LA BREA
LA BREA AVE.
HIGHLAND AVE.
SUNSET BLVD.
FOUNTAIN AVE.
CAHUENGA BLVD.
VINE
VINE ST.
HOLLYWOOD FWY
BRONSON AVE.
VAN NESS AVE.
MATCH LINE


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
℄ HOLLYWOOD BLVD.
STA. 240+52
℄ LA BREA AVE.
HOLLYWOOD-LA BREA STATION
STA. 220-00
℄ HIGHLAND AVE
℄ CAHUENGA BLVD.
VINE STATION
STA. 174-00
℄ VINE ST.
℄ BRONSON AVE.
℄ SUNSET BLVD.
STA. 130+00
MATCH LINE
MATCH LINE
EXISTING GROUND
TOP OF RAIL
0.00%
+2.00%
0+00%
+0.34%
500
400
300
200
500
400
300
200
STATION
STATION
SUBWAY
CUT FOR STATION
SUBWAY
CUT FOR STATION
SUBWAY
200+00
150+00


PLAN
SCALE: 1" = 1000'


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'

SAN GABRIEL VALLEY CORRIDOR

CORRIDOR DESCRIPTION

The San Gabriel Valley Corridor comprises an area north and south of the San Bernardino Freeway extending to the San Gabriel River on the east, and to the Los Angeles River on the west. There are portions of six incorporated cities within the corridor; Los Angeles, Alhambra, San Gabriel, Monterey Park, Rosemead, and El Monte. Unincorporated areas include portions of East Los Angeles and South San Gabriel. Important physical features in this corridor include the San Bernardino and Long Beach Freeways, the Puente Hills, the Whittier Narrows Regional Recreation Area, and the Los Angeles, Rio Hondo, and San Gabriel Rivers. The Southern Pacific Company rail lines traverse the corridor in a general east-west direction.

The corridor is primarily single family residential in character with multi-family districts in Alhambra, Monterey Park, East Los Angeles and El Monte. The corridor is largely an orgin area for transit riders. Commercial activity in the corridor is centered in the community business districts in the several cities, the Montgomery Ward Shopping Center in Rosemead, and strip commercial development along Garvey Boulevard, Valley Boulevard, and other arterials. Industrial development is located in the City of Alhambra north of Mission Road, along Monterey Pass Road in Monterey Park, the Flair Industrial tract in Rosemead, and in several districts in El Monte. This corridor also contains two major institutional complexes, the County General Hospital and a California State College campus near Eastern Avenue.

STATION LOCATIONS

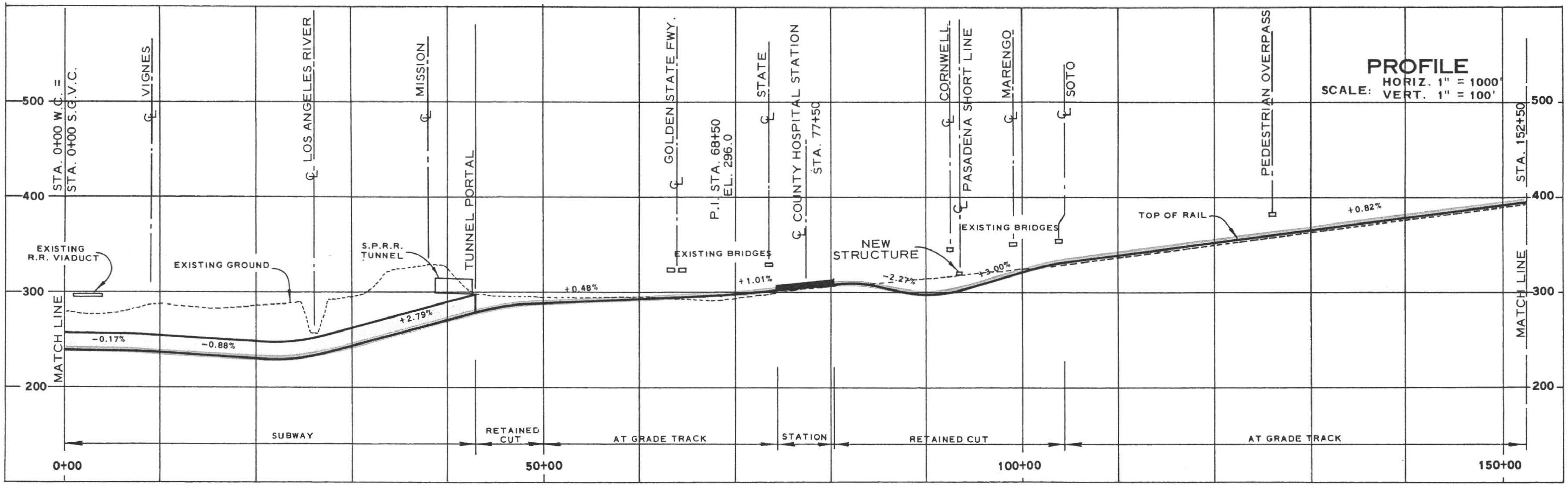
The COUNTY HOSPITAL and STATE COLLEGE transit stations both serve important public institutions in the corridor. The Los Angeles County Hospital is a 2800-bed facility with more than 6000 employees.California State College has 20,000 students with approximately 2,000 employees which is projected to increase to 33,000 students and 3,500 employees by 1975.

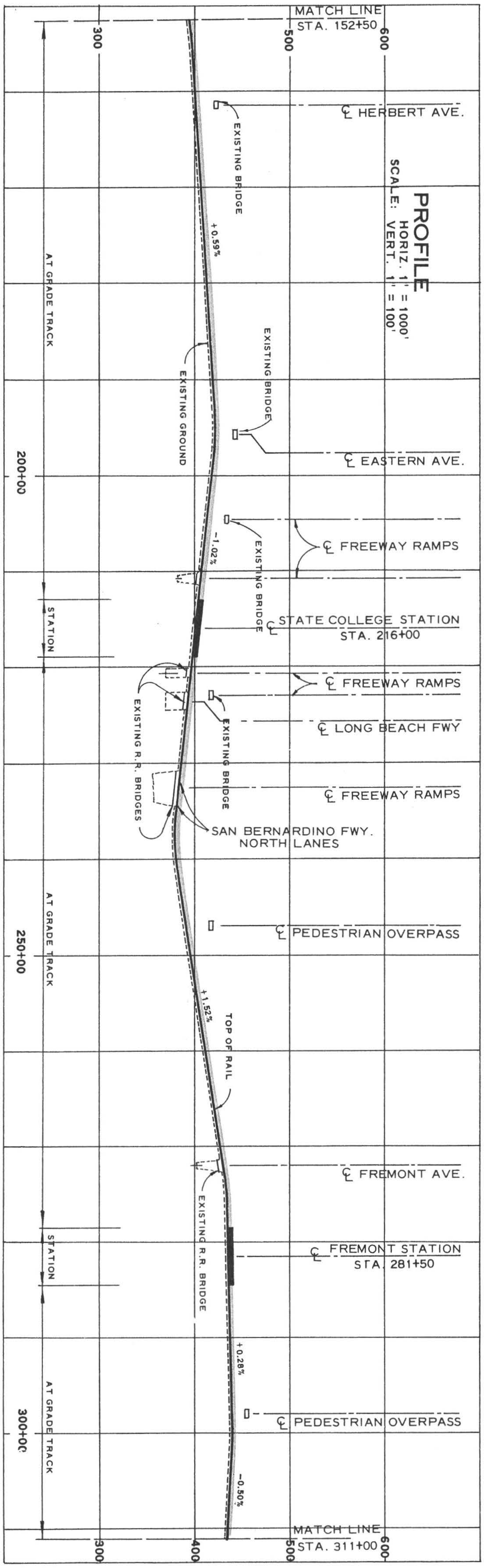
Traveling eastward, four stations, FREMONT, GARFIELD, SAN GABRIEL, and ROSEMEAD are an average of 1-1/2 miles apart and are easily accessible from the north-south arterial street system. The location of these stations reflects local community desires. The EL MONTE station is located to permit convenient access from the north, south and east via arterial streets and freeways. To facilitate freeway access, direct ramps are provided serving the parking area.

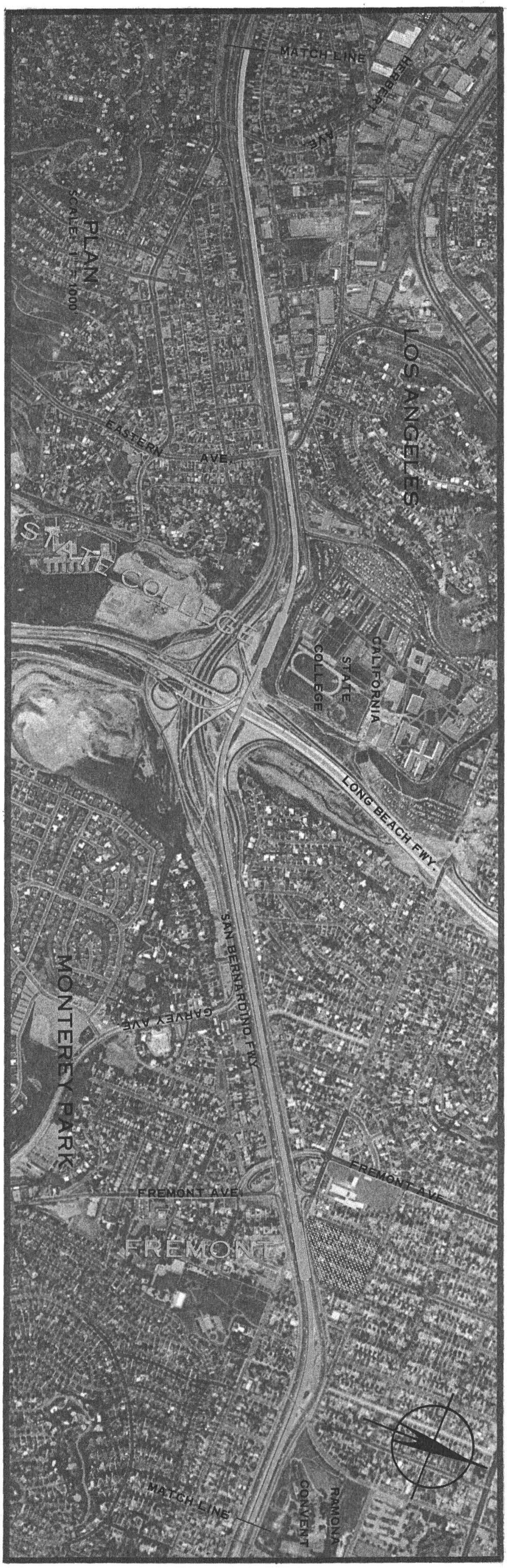
ROUTE DESCRIPTION

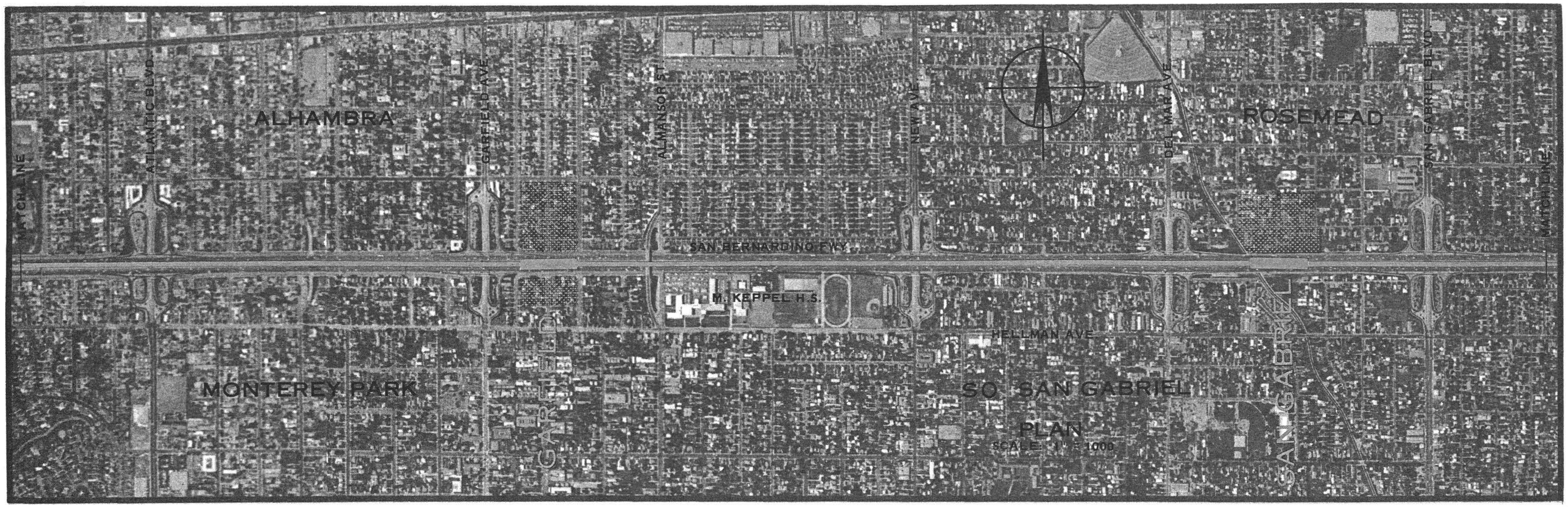
The alignment begins at the east end of Union Station about 600 ft. east of Alameda Street, and proceeds easterly in subway configuration along Macy Street to Lyon Street, where it diverges on a 3200 ft. radius curve in subsurface easement on a line under the Los Angeles River and Mission Road, and surfaces at a portal in the Southern Pacific Company's right-of-way at the District's Macy Yard. After the yard connection, the tracks run at-grade along the Southern Pacific right-of-way, in joint use with a Southern Pacific track to Cornwell Street, where the Southern Pacific line turns north over a grade separation structure. The transit tracks proceed easterly at-grade from Cornwell Street in the Southern Pacific right-of-way, then under existing grade separations for Soto Street, Herbert Street, Eastern Avenue, through the Long Beach Freeway interchange, and enter the median of the San Bernardino Freeway about 1000 ft. east of the interchange. The alignment proceeds at-grade in the Southern Pacific right-of-way in the freeway median, passing over existing street interchange structures at Fremont, Atlantic, Garfield, San Gabriel, Rosemead, and Walnut Grove Blvd. The right-of-way leaves the freeway median through Gibson overpass and continues easterly through the grade separation for the Rio Hondo Yard connection, crosses the Rio Hondo River on a bridge structure, changes to an aerial structure before reaching Hoyt Avenue, and terminates at El Monte Station. This route is identical under either the Recommended Five-Corridor System or the Four-Corridor System.

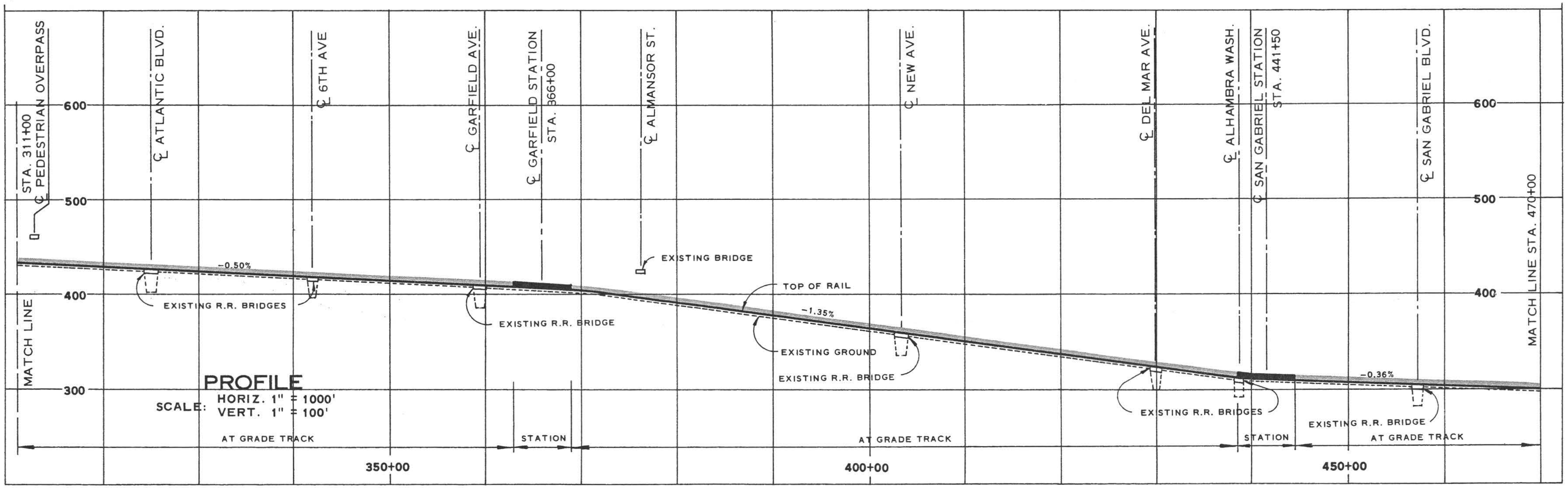

LOS ANGELES
COUNTY GENERAL HOSPITAL
ALAMEDA ST.
STA. 0+00
VIGNES ST.
LOS ANGELES RIVER
MISSION RD.
MACY ST.
SANTA ANA FWY.
GOLDEN STATE FWY.
STATE ST.
COUNTY HOSP.
MARENGO ST.
CORNWELL ST.
SOTO ST.
WABASH AVE.
SAN BERNARDINO FWY.
MATCH LINE
PLAN
SCALE: 1" = 1000'

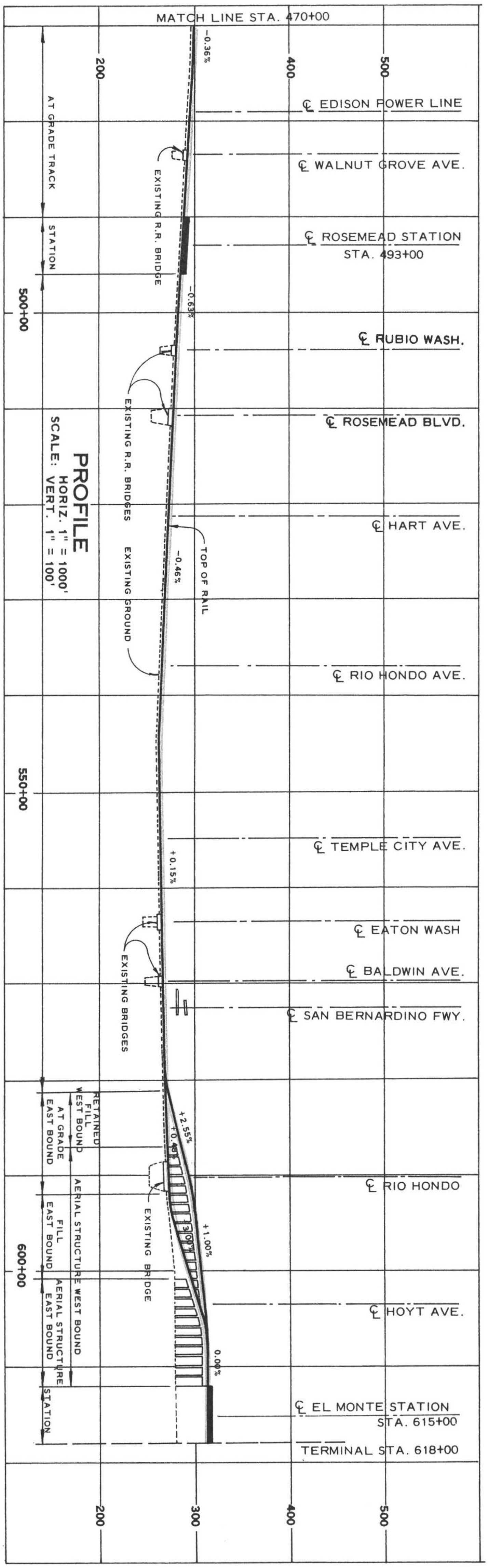

PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
500
400
300
200
STA. 0+00 W.C. =
STA. 0+00 S.G.V.C.
MATCH LINE
EXISTING R.R. VIADUCT
℄ VIGNES
EXISTING GROUND
℄ LOS ANGELES RIVER
S.P.R.R. TUNNEL
℄ MISSION
TUNNEL PORTAL
−0.17%
−0.88%
+2.79%
+0.48%
℄ GOLDEN STATE FWY.
P.I. STA. 68+50
EL. 296.0
EXISTING BRIDGES
+1.01%
℄ STATE
℄ COUNTY HOSPITAL STATION
STA. 77+50
NEW STRUCTURE
−2.27%
+3.00%
℄ CORNWELL
℄ PASADENA SHORT LINE
℄ MARENGO
EXISTING BRIDGES
℄ SOTO
TOP OF RAIL
℄ PEDESTRIAN OVERPASS
+0.82%
STA. 152+50
MATCH LINE
SUBWAY
RETAINED CUT
AT GRADE TRACK
STATION
RETAINED CUT
AT GRADE TRACK
0+00
50+00
100+00
150+00


MATCH LINE
STA. 152+50
300
500
600
℄ HERBERT AVE.
EXISTING BRIDGE
+0.59%
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
AT GRADE TRACK
EXISTING GROUND
EXISTING BRIDGE
℄ EASTERN AVE.
200+00
℄ FREEWAY RAMPS
-1.02%
EXISTING BRIDGE
STATION
℄ STATE COLLEGE STATION
STA. 216+00
℄ FREEWAY RAMPS
℄ LONG BEACH FWY
EXISTING R.R. BRIDGES
EXISTING BRIDGE
℄ FREEWAY RAMPS
SAN BERNARDINO FWY.
NORTH LANES
℄ PEDESTRIAN OVERPASS
AT GRADE TRACK
250+00
+1.52%
TOP OF RAIL
℄ FREMONT AVE.
EXISTING R.R. BRIDGE
STATION
℄ FREMONT STATION
STA. 281+50
+0.28%
AT GRADE TRACK
℄ PEDESTRIAN OVERPASS
300+00
-0.50%
MATCH LINE
STA. 311+00
300
400
500
600


MATCH LINE
HERBERT AVE
PLAN
SCALE: 1" = 1000'
LOS ANGELES
EASTERN AVE.
STATE COLLEGE
CALIFORNIA STATE COLLEGE
LONG BEACH FWY.
SAN BERNARDINO FWY
MONTEREY PARK
GARVEY AVE
FREMONT AVE.
FREMONT AVE.
FREMONT
RAMONA CONVENT
MATCH LINE


MATCH LINE
ATLANTIC BLVD.
ALHAMBRA
GARFIELD AVE.
ALMANSOR ST.
NEW AVE.
DEL MAR AVE.
ROSEMEAD
SAN GABRIEL BLVD.
MATCH LINE
SAN BERNARDINO FWY.
M. KEPPEL H.S.
HELLMAN AVE
GARFIELD
MONTEREY PARK
SO. SAN GABRIEL
SAN GABRIEL
PLAN
SCALE: 1" = 1000'


STA. 311+00
℄ PEDESTRIAN OVERPASS
℄ ATLANTIC BLVD.
℄ 6TH AVE
℄ GARFIELD AVE.
℄ GARFIELD STATION
STA. 366+00
℄ ALMANSOR ST.
℄ NEW AVE.
℄ DEL MAR AVE.
℄ ALHAMBRA WASH.
℄ SAN GABRIEL STATION
STA. 441+50
℄ SAN GABRIEL BLVD.
600
500
400
300
MATCH LINE
MATCH LINE STA. 470+00
-0.50%
EXISTING R.R. BRIDGES
EXISTING R.R. BRIDGE
EXISTING BRIDGE
TOP OF RAIL
-1.35%
EXISTING GROUND
EXISTING R.R. BRIDGE
EXISTING R.R. BRIDGES
-0.36%
EXISTING R.R. BRIDGE
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
AT GRADE TRACK
STATION
AT GRADE TRACK
STATION
AT GRADE TRACK
350+00
400+00
450+00


MATCH LINE STA. 470+00
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
200
300
400
500
500+00
550+00
600+00
-0.36%
-0.63%
-0.46%
+0.15%
+2.55%
+0.46%
+1.00%
3.00%
0.00%
AT GRADE TRACK
STATION
RETAINED FILL WEST BOUND
AT GRADE EAST BOUND
AERIAL STRUCTURE WEST BOUND
FILL EAST BOUND
AERIAL STRUCTURE EAST BOUND
EXISTING R.R. BRIDGE
EXISTING R.R. BRIDGES
EXISTING GROUND
TOP OF RAIL
EXISTING BRIDGES
EXISTING BRIDGE
℄ EDISON POWER LINE
℄ WALNUT GROVE AVE.
℄ ROSEMEAD STATION
STA. 493+00
℄ RUBIO WASH.
℄ ROSEMEAD BLVD.
℄ HART AVE.
℄ RIO HONDO AVE.
℄ TEMPLE CITY AVE.
℄ EATON WASH
℄ BALDWIN AVE.
℄ SAN BERNARDINO FWY.
℄ RIO HONDO
℄ HOYT AVE.
℄ EL MONTE STATION
STA. 615+00
TERMINAL STA. 618+00


EDISON POWER LINE
WALNUT GROVE AVE.
ROSEMEAD
ROSEMEAD BLVD.
ROSEMEAD
SAN BERNARDINO FWY.
RIO HONDO AVE.
TEMPLE CITY BLVD.
EATON WASH
BALDWIN AVE.
PLAN
SCALE: 1" = 1000'
RIO HONDO
EL MONTE
HOYT AVE.
EL MONTE
END OF TRACK

LONG BEACH CORRIDOR

CORRIDOR DESCRIPTION

The Long Beach Corridor extends from the Los Angeles Downtown area to the Ocean. Portions of nine incorporated cities are within the Long Beach Corridor: Vernon, Huntington Park, South Gate, Lynwood, Compton, Carson, Long Beach, Signal Hill and Los Angeles, as well as unincorporated areas of Los Angeles County.

The Santa Monica, Harbor, Long Beach, San Diego and Terminal Island Freeways pass through portions of the corridor. In addition, the Industrial Freeway is nearing route adoption extending the full length of the corridor. Also represented are main lines and branches of the Santa Fe, Union Pacific, and Southern Pacific Company railroads and extensive harbor facilities in the vicinity of Long Beach. The most prominent natural features in the corridor are Dominguez Hills, Signal Hill and the Los Angeles River.

The corridor is characterized by a mixture of residential, commercial and industrial uses. The northern portion of the corridor, comprising south- central Los Angeles, Huntington Park and Compton, has a relatively high residential density composed of mixed single family detached and multi-family dwellings. The most southerly portion of the corridor within the City of Long Beach also contains high density residential development. Lower density areas are found in South Gate, Lynwood and North Long Beach. Although the largest single concentration of commercial development in the corridor is in the Long Beach Central Business District, there are identifiable commercial districts located in Huntington Park and Compton. Commercial use in the corridor is also found along arterial streets. Industrial areas are intermingled throughout the corridor with major concentrations in the Vernon and Harbor areas and an emerging complex in the Dominguez area.

The remaining industrial development is situated in a narrow band adjacent to the Southern Pacific Railroad in Alameda Street or scattered through the corridor. Future industrial growth can be expected in the Dominguez Hills Area, where large acreages are undeveloped or under oil leases.

STATION LOCATIONS

The northern portions of this route traverse an area where increased public transportation is most needed.

The WASHINGTON station at Washington and Broadway, ADAMS near Adams and Central, and VERNON AVENUE, GAGE and FIRESTONE stations along Central Avenue serve a large low income area and provide good feeder route access to the east and west.

The joint use of right-of-way with the proposed Industrial Freeway is compatible with plans of the City of Los Angeles and the City of Compton. Stations along this portion of the route include the WATTS station located at 103rd Street, IMPERIAL at Imperial Highway, and COMPTON at Compton Boulevard. Several proposals are currently under consideration in the Watts area destined to provide higher intensity development. The 103rd Street location of the WATTS station compliments this general concept. The COMPTON station is directly related to proposed Civic Center developments and conforms to the adopted Compton General Plan.

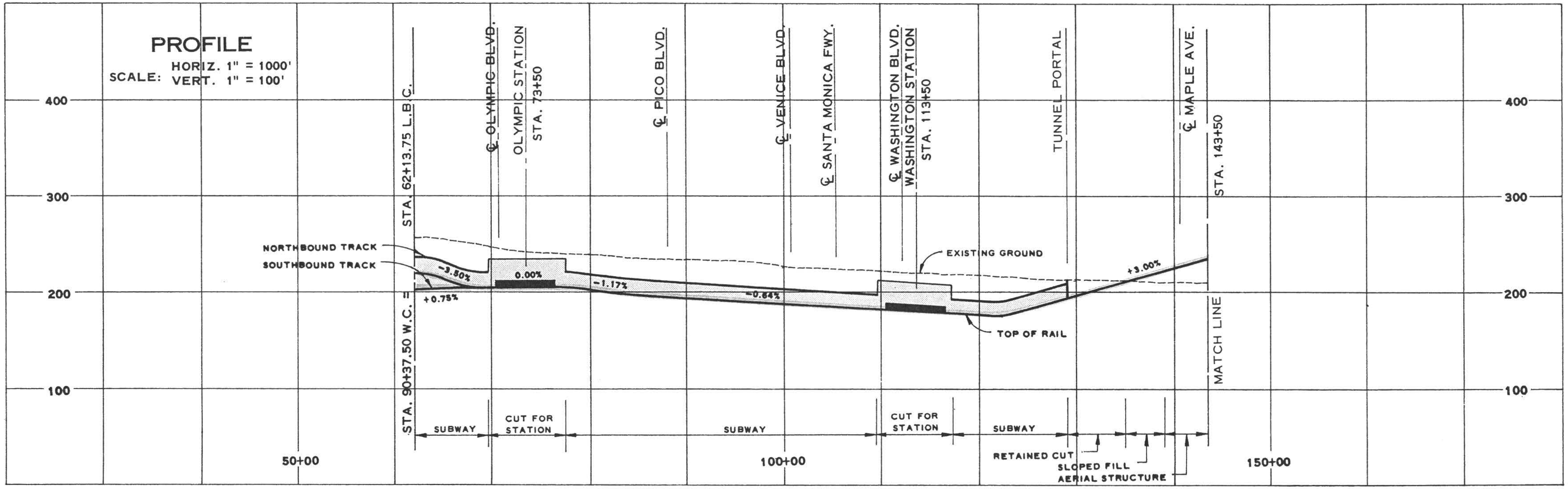
The Southern Pacific Company's right-of-way from Artesia Avenue to the Los Angeles River provides a direct connection between the proposed Industrial Freeway and the Los Angeles River and causes minimum disruption to land use patterns in the area. The DEL AMO station will serve future industrial developments and also allows a major east-west feeder route into North Long Beach.

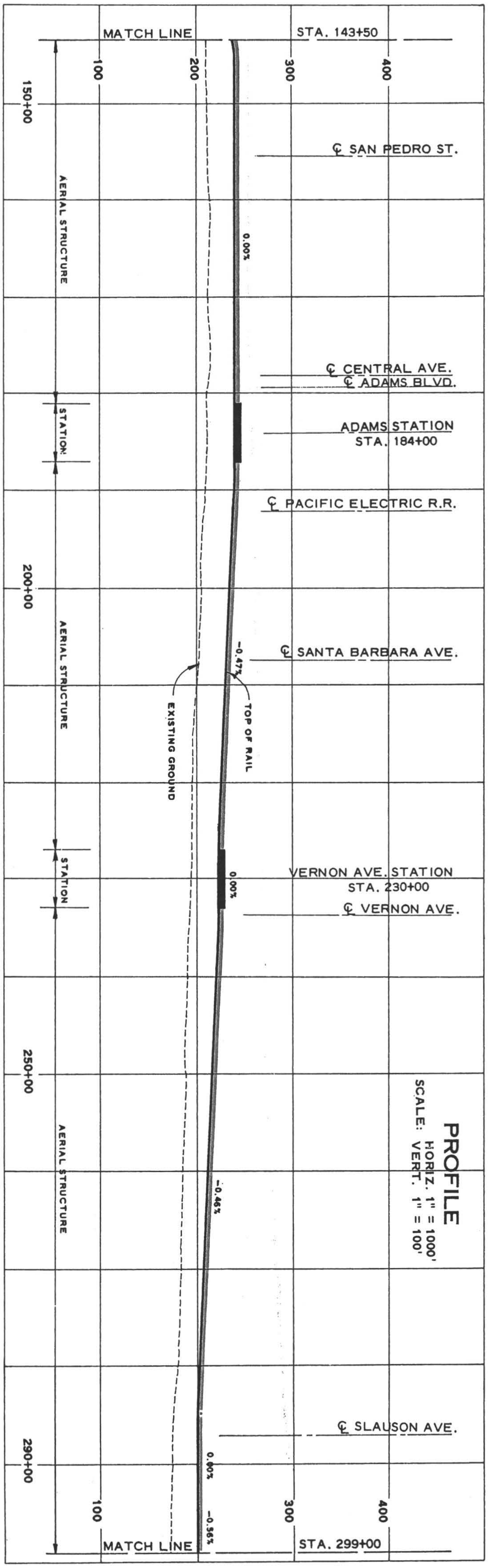
The residential districts in Long Beach will be served by the WARDLOW and PACIFIC COAST stations where major east-west feeder routes are also anticipated. The LONG BEACH station at Ocean Boulevard and Pine Avenue will be integrated into the proposed City of Long Beach Transportation Center serving the Long Beach Central Business District, convention and government centers and shoreline development.

ROUTE DESCRIPTION

The route begins in subway at the Wilshire-Long Beach interchange located at 7th and Broadway. The subway alignment proceeds southerly along Broadway from the end of the interchange near 9th Street to a point about 700 ft. beyond Washington Blvd. There it turns eastward on a 1600-ft radius curve to enter private property north of 25th Street and then surfaces to become an aerial structure. The aerial route continues parallel to 25th Street to Central Avenue, where it turns southward on a l000 ft. radius curve to private right-of-way parallel to, and east of Central Avenue. This alignment continues to Firestone Boulevard, turns eastward on a l300 ft. radius curve to follow private right-of-way north of 9lst Street to Elm Street. There it turns southward on a ll50 ft. radius curve, and changes from aerial structure to at-grade configuration, joining the median of the proposed Industrial Freeway at about 97th Street. Following the Industrial Freeway, the alignment proceeds south, parallel to Grape Street and Willowbrook Avenue, to Greenleaf Blvd. where it changes during a 2500 ft. radius reverse curve from freeway median at-grade to aerial easement over the Southern Pacific Company's right-of-way. The alignment then proceeds through the grade separation structure for the Dominguez Yard and Shops about l000 ft. south of Greenleaf Boulevard. Proceeding southeasterly on the Southern Pacific right-of-way on aerial structure from the Dominguez Yard, the line crosses the Los Angeles River and turns south to enter the Los Angeles County Flood Control District property on a 2500 foot radius curve. There it changes from an aerial structure to a retained embankment configuration. The alignment proceeds southerly along the Los Angeles River in Los Angeles County Flood Control District property to a point about 2000 ft. beyond the Long Beach Freeway interchange. It then turns eastward on a l250 ft. radius curve and becomes a subway configuration under the Long Beach Freeway and Ocean Avenue. Proceeding east along Ocean Avenue, the subway ends at the Long Beach terminal station at Ocean and Pine interconnecting with the proposed Transporation Center. This route is identical under either the Recommended Five-Corridor System or the Four-Corridor System.


PLAN
SCALE: 1" = 1000'
LOS ANGELES
7TH ST.
8TH ST.
9TH ST.
OLYMPIC BLVD.
OLYMPIC
PICO BLVD.
VENICE BLVD.
SANTA MONICA FWY.
WASHINGTON BLVD.
WASHINGTON
MATCH LINE
MAPLE ST.
SPRING ST.
BROADWAY
GRAND AVE.
HARBOR FWY.
FIGUEROA ST.

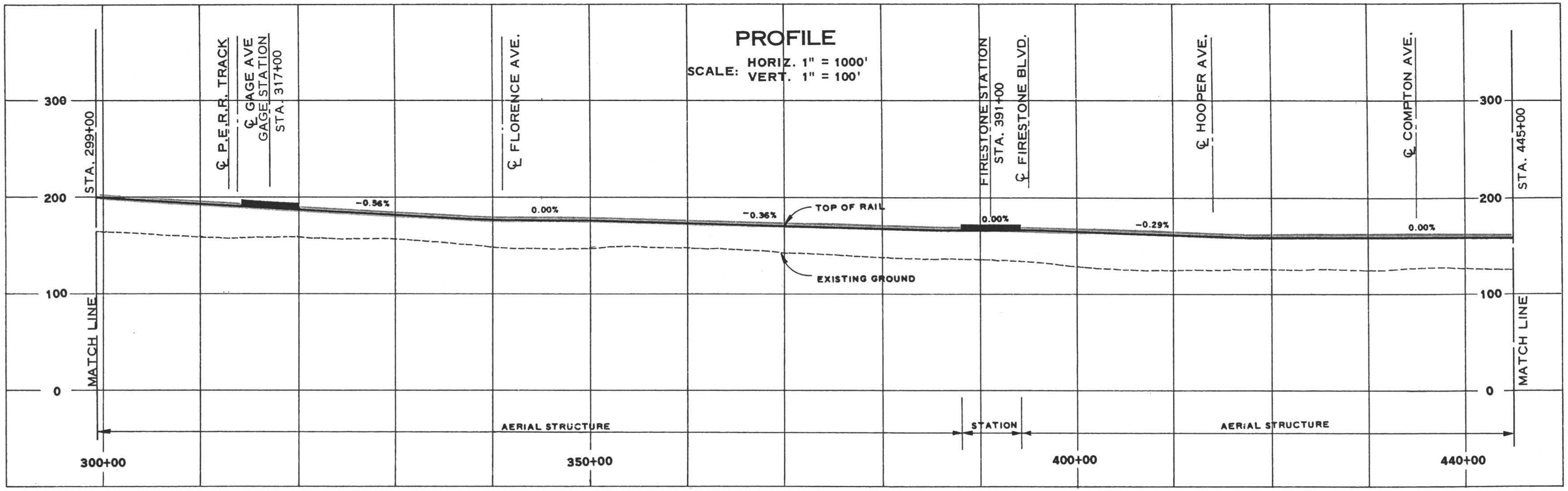

PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
400
300
200
100
50+00
100+00
150+00
STA. 90+37.50 W.C. =
STA. 62+13.75 L.B.C.
℄ OLYMPIC BLVD.
OLYMPIC STATION
STA. 73+50
℄ PICO BLVD.
℄ VENICE BLVD.
℄ SANTA MONICA FWY.
℄ WASHINGTON BLVD.
WASHINGTON STATION
STA. 113+50
TUNNEL PORTAL
℄ MAPLE AVE.
STA. 143+50
MATCH LINE
NORTHBOUND TRACK
SOUTHBOUND TRACK
EXISTING GROUND
TOP OF RAIL
+0.75%
-3.80%
0.00%
-1.17%
-0.64%
+3.00%
SUBWAY
CUT FOR STATION
SUBWAY
CUT FOR STATION
SUBWAY
RETAINED CUT
SLOPED FILL
AERIAL STRUCTURE

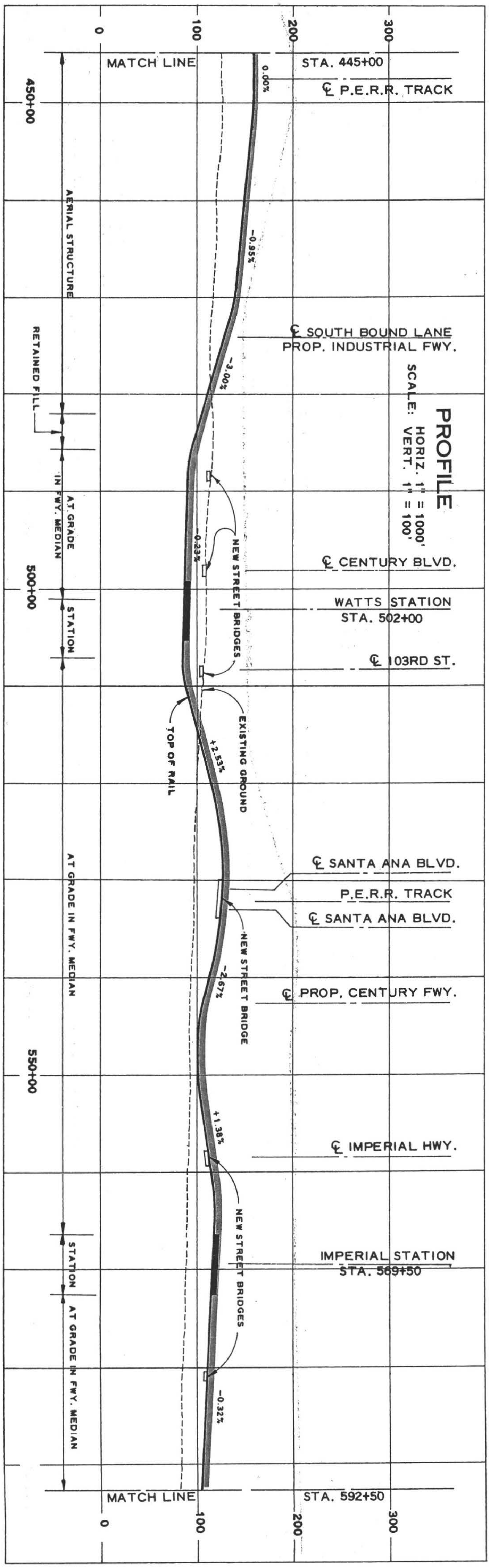


MATCH LINE
STA. 143+50
100
200
300
400
150+00
℄ SAN PEDRO ST.
AERIAL STRUCTURE
0.00%
℄ CENTRAL AVE.
℄ ADAMS BLVD.
STATION
ADAMS STATION
STA. 184+00
℄ PACIFIC ELECTRIC R.R.
200+00
AERIAL STRUCTURE
℄ SANTA BARBARA AVE.
-0.47%
EXISTING GROUND
TOP OF RAIL
STATION
VERNON AVE. STATION
STA. 230+00
0.00%
℄ VERNON AVE.
250+00
AERIAL STRUCTURE
-0.46%
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
℄ SLAUSON AVE.
0.00%
290+00
-0.56%
100
300
400
MATCH LINE
STA. 299+00

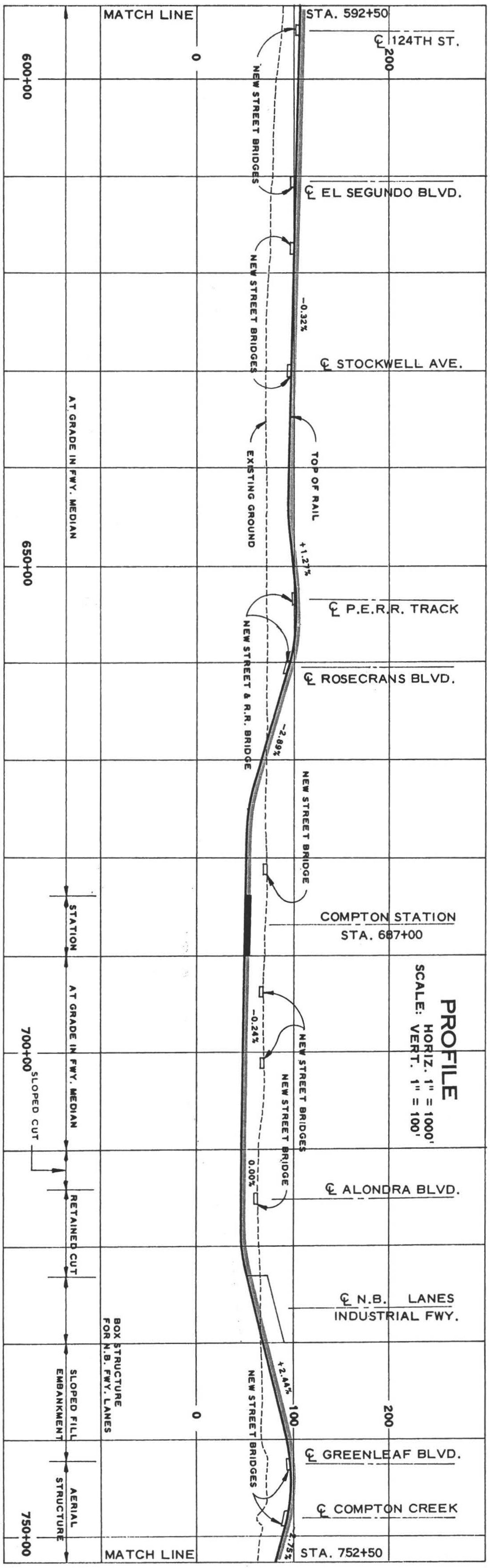
SANTA MONICA FWY.
ADAMS BLVD.
ADAMS
PACIFIC ELECTRIC R.R.
SANTA BARBARA AVE.
CENTRAL AVE.
LOS ANGELES
VERNON AVE
VERNON AVE.
PLAN
1000
SLAUSON AVE.
MATCH LINE


MATCH LINE
LOS ANGELES CO.
COMPTON AVE.
SLAUSON AVE.
MATCH LINE
P.E.R.R. TRACK
GAGE AVE.
GAGE
PLAN
SCALE: 1" = 1000'
FLORENCE AVE.
HOOPER AVE.
FIRESTONE
FIRESTONE BLVD.
CENTRAL AVE.


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
STA. 299+00
℄ P.E.R.R. TRACK
℄ GAGE AVE
GAGE STATION
STA. 317+00
℄ FLORENCE AVE.
FIRESTONE STATION
STA. 391+00
℄ FIRESTONE BLVD.
℄ HOOPER AVE.
℄ COMPTON AVE.
STA. 445+00
300
200
100
0
-0.56%
0.00%
-0.36%
TOP OF RAIL
0.00%
-0.29%
0.00%
EXISTING GROUND
MATCH LINE
MATCH LINE
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
300+00
350+00
400+00
440+00


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
MATCH LINE
STA. 445+00
℄ P.E.R.R. TRACK
℄ SOUTH BOUND LANE
PROP. INDUSTRIAL FWY.
℄ CENTURY BLVD.
WATTS STATION
STA. 502+00
℄ 103RD ST.
℄ SANTA ANA BLVD.
P.E.R.R. TRACK
℄ SANTA ANA BLVD.
℄ PROP. CENTURY FWY.
℄ IMPERIAL HWY.
IMPERIAL STATION
STA. 569+50
MATCH LINE
STA. 592+50
0
100
200
300
450+00
500+00
550+00
0.00%
-0.95%
-3.00%
-0.23%
+2.53%
-2.67%
+1.38%
-0.32%
AERIAL STRUCTURE
RETAINED FILL
AT GRADE IN FWY. MEDIAN
STATION
AT GRADE IN FWY. MEDIAN
STATION
AT GRADE IN FWY. MEDIAN
NEW STREET BRIDGES
EXISTING GROUND
TOP OF RAIL
NEW STREET BRIDGE
NEW STREET BRIDGES

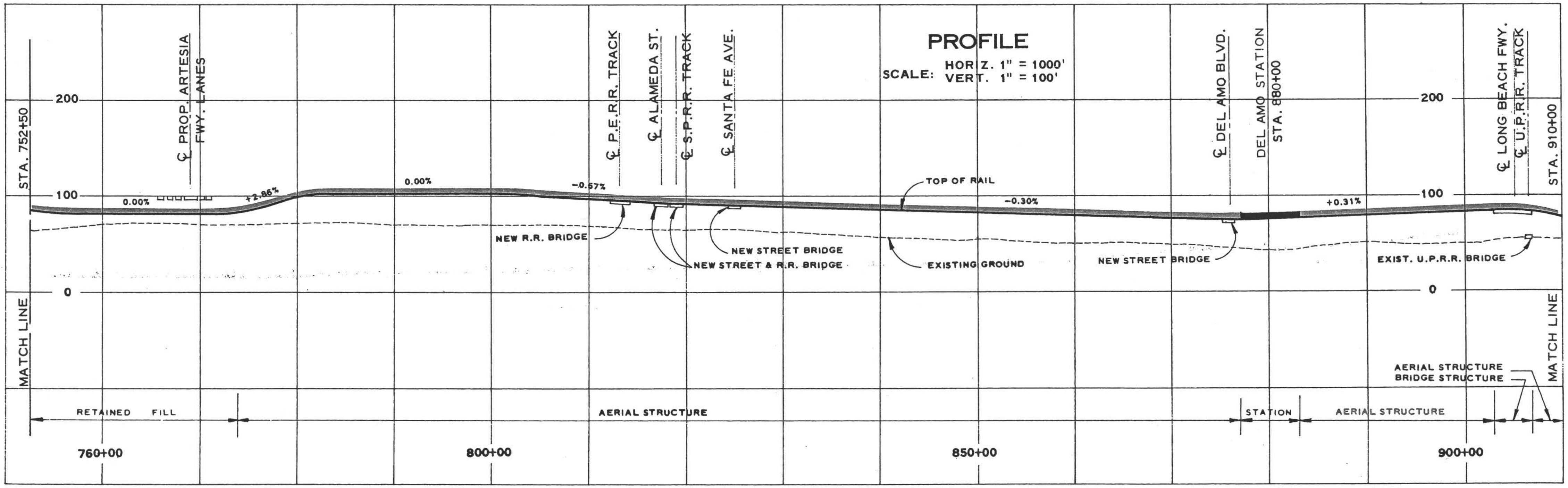

PLAN
SCALE: 1" = 1000'
LOS ANGELES CO.
P.E.R.R. TRACK
MATCH LINE
PROP. INDUSTRIAL FWY.
CENTURY BLVD.
WATTS
103RD ST.
WATTS DISTRICT
LOS ANGELES
P.E.R.R. TRACK
SANTA ANA BLVD.
SANTA ANA BLVD.
PROP.
CENTURY
FWY.
IMPERIAL HWY.
WILLOWBROOK AVE.
IMPERIAL
MATCH LINE

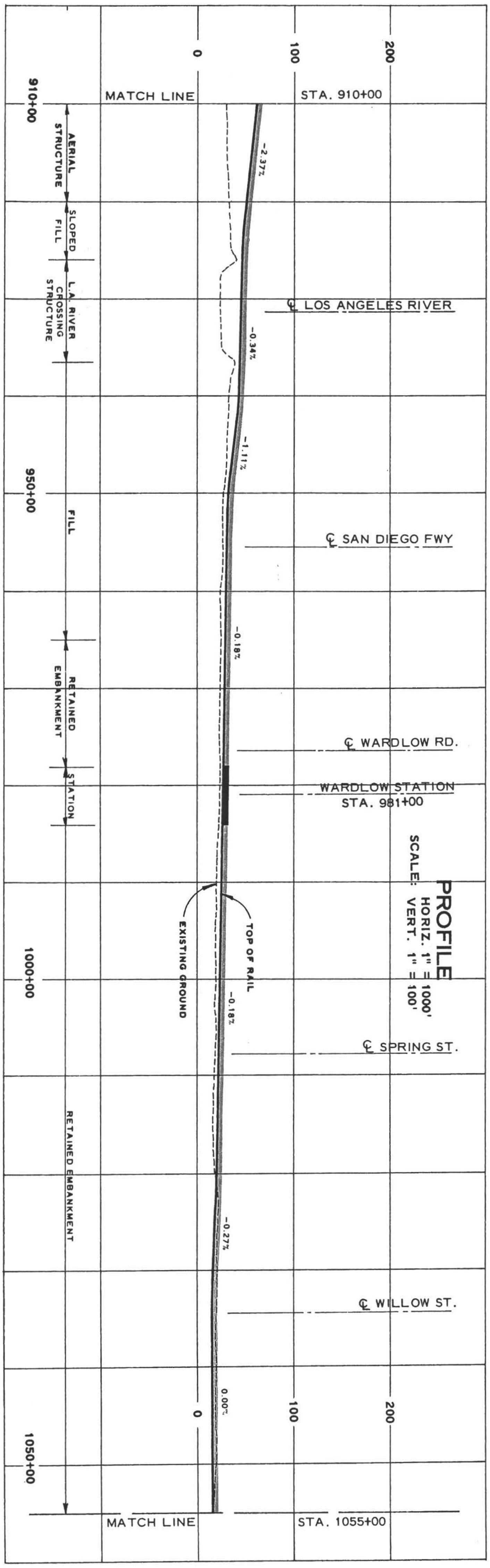


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'

PLAN
SCALE: 1" = 1000'

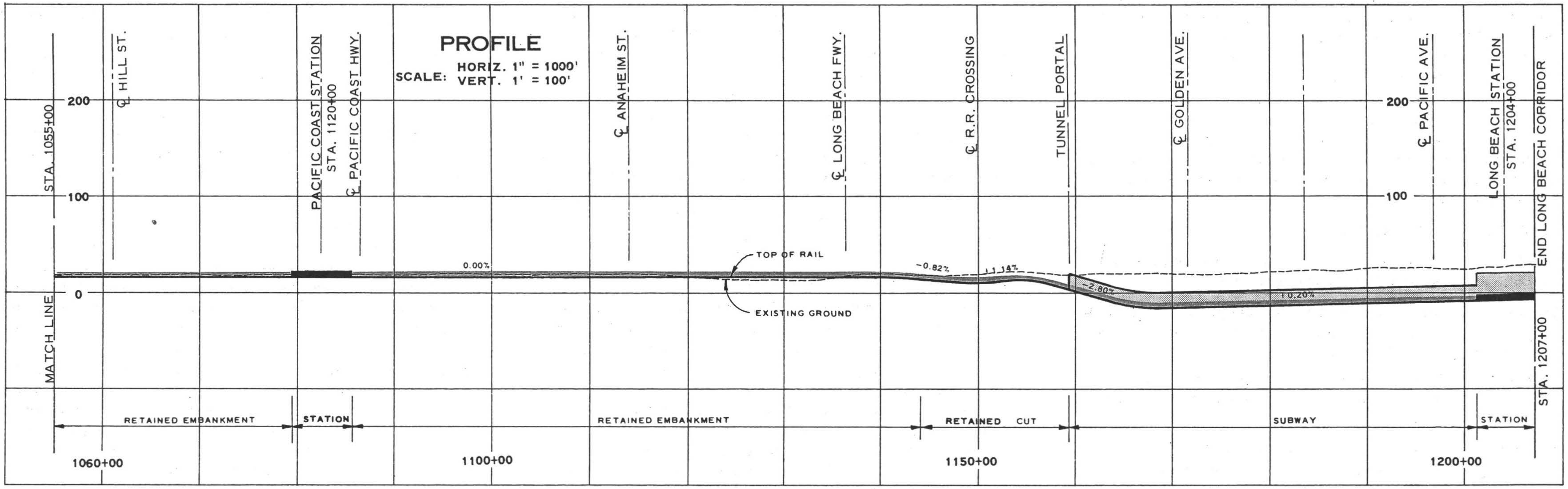

LOS ANGELES CO
LONG BEACH FWY.
MATCH LINE
U.P.R.R. TRACK
COMPTON CREEK
S.P.R.R. TRACK
SANTA FE AVE.
ALAMEDA ST.
DEL AMO BLVD
DEL AMO
ARTESIA FWY.
PROP.
DOMINGUEZ HILLS
MATCH LINE
PLAN
SCALE: 1" = 1000'


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
STA. 752+50
℄ PROP. ARTESIA FWY. LANES
℄ P.E.R.R. TRACK
℄ ALAMEDA ST.
℄ S.P.R.R. TRACK
℄ SANTA FE AVE.
℄ DEL AMO BLVD.
DEL AMO STATION
STA. 880+00
℄ LONG BEACH FWY.
℄ U.P.R.R. TRACK
STA. 910+00
200
100
0
0.00%
+2.86%
0.00%
-0.57%
-0.30%
+0.31%
TOP OF RAIL
NEW R.R. BRIDGE
NEW STREET BRIDGE
NEW STREET & R.R. BRIDGE
EXISTING GROUND
NEW STREET BRIDGE
EXIST. U.P.R.R. BRIDGE
MATCH LINE
AERIAL STRUCTURE
BRIDGE STRUCTURE
RETAINED FILL
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
760+00
800+00
850+00
900+00


0
100
200
MATCH LINE
STA. 910+00
910+00
AERIAL STRUCTURE
-2.37%
SLOPED FILL
L.A. RIVER CROSSING STRUCTURE
℄ LOS ANGELES RIVER
-0.34%
-1.11%
950+00
FILL
℄ SAN DIEGO FWY
-0.18%
RETAINED EMBANKMENT
℄ WARDLOW RD.
STATION
WARDLOW STATION
STA. 981+00
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
TOP OF RAIL
EXISTING GROUND
1000+00
-0.18%
℄ SPRING ST.
RETAINED EMBANKMENT
-0.27%
℄ WILLOW ST.
0.00%
0
100
200
1050+00
MATCH LINE
STA. 1055+00


U.P.R.R. TRACK
MATCH LINE
NORTH LONG BEACH
LONG BEACH FWY.
LONG BEACH
SAN DIEGO FWY.
WARDLOW
WARDLOW RD.
PLAN
SCALE: 1" = 1000'
SPRING STREET
LOS ANGELES RIVER
LONG BEACH
WILLOW ST.
MATCH LINE


PLAN
SCALE: 1" = 1000'
LONG BEACH
LONG BEACH BLVD.
PACIFIC AVE.
GOLDEN AVE.
R.R. TRACKS
ANAHEIM ST.
PACIFIC COAST HWY.
HILL ST.
MATCH LINE
LOS ANGELES RIVER
LONG BEACH FWY.


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1' = 100'
STA. 1055+00
MATCH LINE
℄ HILL ST.
PACIFIC COAST STATION
STA. 1120+00
℄ PACIFIC COAST HWY.
℄ ANAHEIM ST.
℄ LONG BEACH FWY.
℄ R.R. CROSSING
TUNNEL PORTAL
℄ GOLDEN AVE.
℄ PACIFIC AVE.
LONG BEACH STATION
STA. 1204+00
END LONG BEACH CORRIDOR
STA. 1207+00
200
100
0
0.00%
TOP OF RAIL
EXISTING GROUND
−0.82%
1.14%
−2.80%
0.20%
RETAINED EMBANKMENT
STATION
RETAINED EMBANKMENT
RETAINED CUT
SUBWAY
STATION
1060+00
1100+00
1150+00
1200+00

CONSTRUCTION PLANNING AND COST ESTIMATE

One of the primary objectives of this preliminary engineering program was to develop reliable estimates of construction cost to be used in establishing the bond issue amount. The construction of a totally new rapid transit system involves many design and construction considerations which are unique when compared to usual construction. Therefore, the investigations and studies conducted for the preliminary design of facilities and systems were carried to sufficient depth and detail to permit careful analysis of construction methods and techniques most feasible for this project. Alternate design, construction methods, materials, and construction plant and equipment were studies to determine the most feasible alternates for meeting design objectives and economy of construction. Preliminary drawings and outline specifications were prepared and used as the basis for quantity take-off and pricing of materials and equipment.

The construction of a project of the magnitude and complexity proposed, with its wide range of types of facilities and the extensive area covered, requires careful planning to complete it economically and within time objectives. The most favorable sequence of construction, contract size and content, construction schedule and construction methods were the objectives of the planning work. Consideration was given to needs for minimum disruption of public services during construction, for maintenance of an approximately level engineering and construction activity without high peaks, for division of the total project into appropriate construction contracts scheduled to minimize physical interference among contractors and permit early completion of operational segments of the system, and for the general need for efficiency and economy of construction.

SEQUENCE OF CONSTRUCTION

The sequence of construction to permit an orderly completion of the project has been established as follows:

Segment I - San Gabriel Valley Line and portion of Wilshire Line from Union Station to and including the 6th & Broadway station.

Segment II - Portion of the Long Beach Line from the interchange with the Wilshire Line to the Del Amo Station.

Segment III - Portion of Wilshire Line from 6th & Broadway Station to the junction with the SFV Line and the entire San Fernando Valley Line.

Segment IV - Remainder of Long Beach Line and portion of the Wilshire Line from the SFV junction to La Cienega Station.

Segment V - Remainder of the Wilshire Line and the entire Airport-Southwest Line.

The above sequence of construction will permit an orderly and logical completion of the system which will be operationally useful by segments. The completion of the San Gabriel Valley Line, together with the portion of the Wilshire Line from Union Station to 6th & Broadway Station, will provide transit service for San Gabriel Valley patrons directly to the heart of the CBD. This segment will be used for testing and checking out equipment and systems, and also for training operating personnel. The second segment will provide service to the south-central communities on the Long Beach Line and also provide access to the major repair and maintenance facilities located on this line. The third segment to be completed will be the extension of the Wilshire Line from 6th and Broadway to the junction with the San Fernando Line, and the entire San Fernando Valley Line. This segment will provide service to the San Fernando Valley, and expand the major destination areas of the system. The remaining segments will complete the Wilshire and Long Beach Lines and also the entire Airport-Southwest Line to make the total system operational.

The size, complexity and interrelated features of this system demand a sophisticated method for developing and controlling the work schedule from start to finish. This scheduling is planned to be developed in the form of the Critical Path Method (CPM) set up for use on a computer. Basic divisions or phases of this schedule should include field surveys and investigation, right-of-way acquisition, final design, preparation of contract documents, construction, and acceptance testing for equipment and operational systems. The computer program to be used will provide time scheduling, manpower, and cash flow requirements for both design and construction phases of the program.

CONTRACT SIZE AND CONTENT

The total project has been divided into contract packages of various sizes, large enough for efficient operations but small enough to create bidding competition. It is planned to call for bids on these packages singly or in combinations of two (2) or more, depending upon type of work involved. This method will permit a greater number of local contractors to participate in this program, and additionally, will interest large specialty contractors from other areas to participate, thus encouraging greater competition. Bids will then be awarded to the lowest qualified bidder or bidders depending on the most favorable combination. Certain types of work involving complete operating systems such as the automatic train control system, are planned as single contract packages with the option of purchasing some of the major equipment on one or more supply contracts, to obtain the most economical costs, and the undivided responsibility for the satisfactory performance of the system.

An overall schedule was prepared for bidding and completing construction of each contract in the sequence of construction as established. This is based on a program requiring large amounts of work to be performed at one time but within the capabilities of the construction industry and design profession. From this, it has been determined that the Four-Corridor System can be completed within six years, and the Recommended Five-Corridor System within seven years after award of the initial construction contract. Assuming that final engineering design can start in January 1969, and allowing one (1) full year to complete the engineering for the initial contract package, the Four-Corridor System can be completed by the end of 1975 and the Recommended Five-Corridor System, by the end of 1976.

CONSTRUCTION METHODS

The aerial way structures, the subways system, and the stations have been given special attention since the construction of these facilities will have a major impact on the community and the general public during the construction period. The design of these facilities was carefully analyzed to achieve the established design objectives with minimum disruption to the community during construction. This was accomplished by closely correlating the design with construction elements. This took into consideration subsurface conditions, interference with existing utilities, and interference with and disruption of existing surface improvements and their use.

For construction of aerial way structures, it was determined that the use of pre-cast concrete girders would offer favorable aesthetic and structural design features, and in addition, it would be the least disruptive to the community during construction. Girders would be fabricated in a central casting yard which would normally be located in an area zoned for heavy manufacturing. The pre-cast girders would then be transported by trucks to the construction site and quickly placed on the support columns. This method would drastically reduce the costly and unsightly construction of concrete forms and shoring, the disruption of smooth traffic flows in nearby streets, the inherent noise of construction operation, and the continuous flow of heavy trucks hauling concrete and reinforcing steel.

This method is considered to be the most efficient in terms of both cost and time of construction. However, steel girders may also be used in this same manner and consideration should be given to them on an alternate basis at the time of bidding.

Subway tunnels have been designed as a twin tube system which is the most suitable for the subsurface conditions encountered. For the soil conditions generally encountered in the Los Angeles Area, the use of tunneling shields or mining machines is a feasible, safe, and economical construction method. The smaller bore size, using twin tubes with individual tracks, is especially suited for this method of tunnel construction and has several advantages over a single large tunnel section with two tracks. A single tunnel section for two tracks would become so large that many structural difficulties and construction unknowns would be introduced which would result in higher cost than the twin tube system.

At the time of preparing bid documents each section of subway will be carefully analysed in further detail to determine the proper type of construction and design to be used in order to utilize the least expensive methods. In some cases, it may be advantageous to call for alternate bids for cut and cover versus tunnel; cast in place concrete lining versus steel liner plate; horseshoe versus circular tunnel section; or other similar variable construction methods.

In the construction of subway stations, the cut and cover method is the most feasible in the type of subsurface soil conditions to be encountered. The construction procedure to be used will consist of first excavating one-half of the longitudinal section of the station to a depth required to continue operating the equipment when the excavation is decked over. This will permit one-half of the street to be decked over at all times for maintaining traffic flow. When the second half has been excavated and decked over, the street will be opened to its full width except for an area required to operate surface construction equipment. By the use of this method, subway stations can be constructed with minimum disruption of traffic flow and business activities.

COST ESTIMATING

As was stated previously, the construction of a rapid transit system involves many unique construction elements. It also involves large quantities of repetitive items whose costs are influenced by subsurface conditions, location of existing utilities, and structures. These factors required the cost estimating process to be performed in a detailed manner which consisted of estimating materials, equipment, labor, and construction plants and equipment separately, in order to properly reflect varying site conditions and construction methods.

An allowance of fifteen percent (15%) of the estimated cost of construction and engineering has been added as a contingency to cover the unknown and unanticipated conditions of the work which are certain to develop as final detail studies and designs are completed.

Costs were based on labor rates, material prices, and construction industry practices in effect from June 1967 to June 1968. Some allowance must be made for an increase in prices of labor, material, etc., over the relatively long period required to complete the project. Such costs are very difficult to assess accurately, but after careful consideration the rate of 7% per annum compounded was finally selected as the most proper escalation allowance. The total system was divided into contract packages with complete estimates made for each package. Each contract package cost estimate was then identified to a particular time period following the established construction sequence. Based on a realistic completion time for construction, the total estimated expenditure for all contract packages occuring in each of the construction years was appropriately escalated. By the use of this estimating process, with appropriate allowances made for contingency and incidental expenses, it was possible to develop an accurate cash flow schedule as shown in the accompanying tables.

ESTIMATE OF COSTS
RECOMMENDED FIVE-CORRIDOR SYSTEM

(In Thousands of Dollars)

1.	Structures and Roadbeds	$ 465,264
2.	Stations	379,882
3.	Electrification	98,765
4.	Control and Communication	53,814
5.	Utility Relocation	23,314
6.	Underpinning	33,494
7.	Yards and Shops	15,801
8.	Project Management, Engineering, Construction Management and District Pre-Operating Expense	139,143
9.	Contingency	181,422
10.	Escalation on Construction	622,741
	Subtotal	$2,013,640
11.	Vehicles (Includes Controls and Escalation)	213,451
	TOTAL	**$2,227,091**

ESTIMATE OF COSTS
FOUR-CORRIDOR SYSTEM

(In Thousands of Dollars)

1.	Structures and Roadbeds	$ 301,993
2.	Stations	248,002
3.	Electrification	69,135
4.	Control and Communication	40,590
5.	Utility Relocation	14,521
6.	Underpinning	16,400
7.	Yards and Shops	13,644
8.	Project Management, Engineering, Construction Management and District Pre-Operating Expense	91,557
9.	Contingency	119,376
10.	Escalation on Construction	378,900
	Subtotal	$1,294,118
11.	Vehicles (Includes Controls and Escalation)	149,278
	TOTAL	**$1,443,396**

CASH FLOW SUMMARY
RECOMMENDED FIVE-CORRIDOR SYSTEM

(In Thousands of Dollars)

Period	Annual Expenditure	Accumulated Total
1-1-69/6-30-69	8,606	8,606
7-1-69/6-30-70	52,542	61,148
7-1-70/6-30-71	164,113	225,261
7-1-71/6-30-72	333,475	558,736
7-1-72/6-30-73	497,684	1,056,420
7-1-73/6-30-74	551,571	1,607,991
7-1-74/6-30-75	385,452	1,993,443
7-1-75/6-30-76	193,732	2,187,175
7-1-76/12-31-76	39,916	**2,227,091**

CASH FLOW SUMMARY
THE FOUR-CORRIDOR SYSTEM

(In Thousands of Dollars)

Period	Annual Expenditure	Accumulated Total
1-1-69/6-30-69	4,507	4,507
7-1-69/6-30-70	26,415	30,922
7-1-70/6-30-71	108,775	139,697
7-1-71/6-30-72	259,215	398,912
7-1-72/6-30-73	403,975	802,887
7-1-73/6-30-74	394,298	1,197,185
7-1-74/6-30-75	205,175	1,402,360
7-1-75/12-31-75	41,036	**1,443,396**

DESIGN
CONSTRUCTION
SURVEYS
APPRAISALS
ENGINEERING REPORTS
ECONOMIC STUDIES
CIVIL
STRUCTURAL
MECHANICAL
ARCHITECTURAL
ELECTRICAL

M. A. NISHKIAN & COMPANY
MEMBER A.S.M.E, C.E.A.C., A.C.I.
DESIGN ENGINEERS AND CONSULTANTS

3754 LONG BEACH BLVD.
LONG BEACH, CALIFORNIA 90807
TELEPHONES: 424-1627 AND 636-9351

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March 26, 1968

Kaiser Engineers and
Daniel, Mann, Johnson & Mendenhall
A Joint Venture
1060 South Broadway
Los Angeles, California 90015

Gentlemen:

Subject: Southern California Rapid Transit District.
Airport-Southwest Corridor

We are pleased to submit our engineering and planning report for the Airport-Southwest Corridor segment of the proposed Southern California Rapid Transit District network of initial routes. It is the intent of this report to provide plans and cost estimates for construction and operation of the selected route in sufficient detail to assure construction feasibility and reliability of the estimates of costs.

We gratefully acknowledge the cooperation and assistance of many agencies and individuals who have contributed information required for the completion of this report. It has been a sincere pleasure to have the privilege of participating in this major and important program.

Yours very truly,

M. A. NISHKIAN & CO.

M A Nishkian
M. A. Nishkian, President

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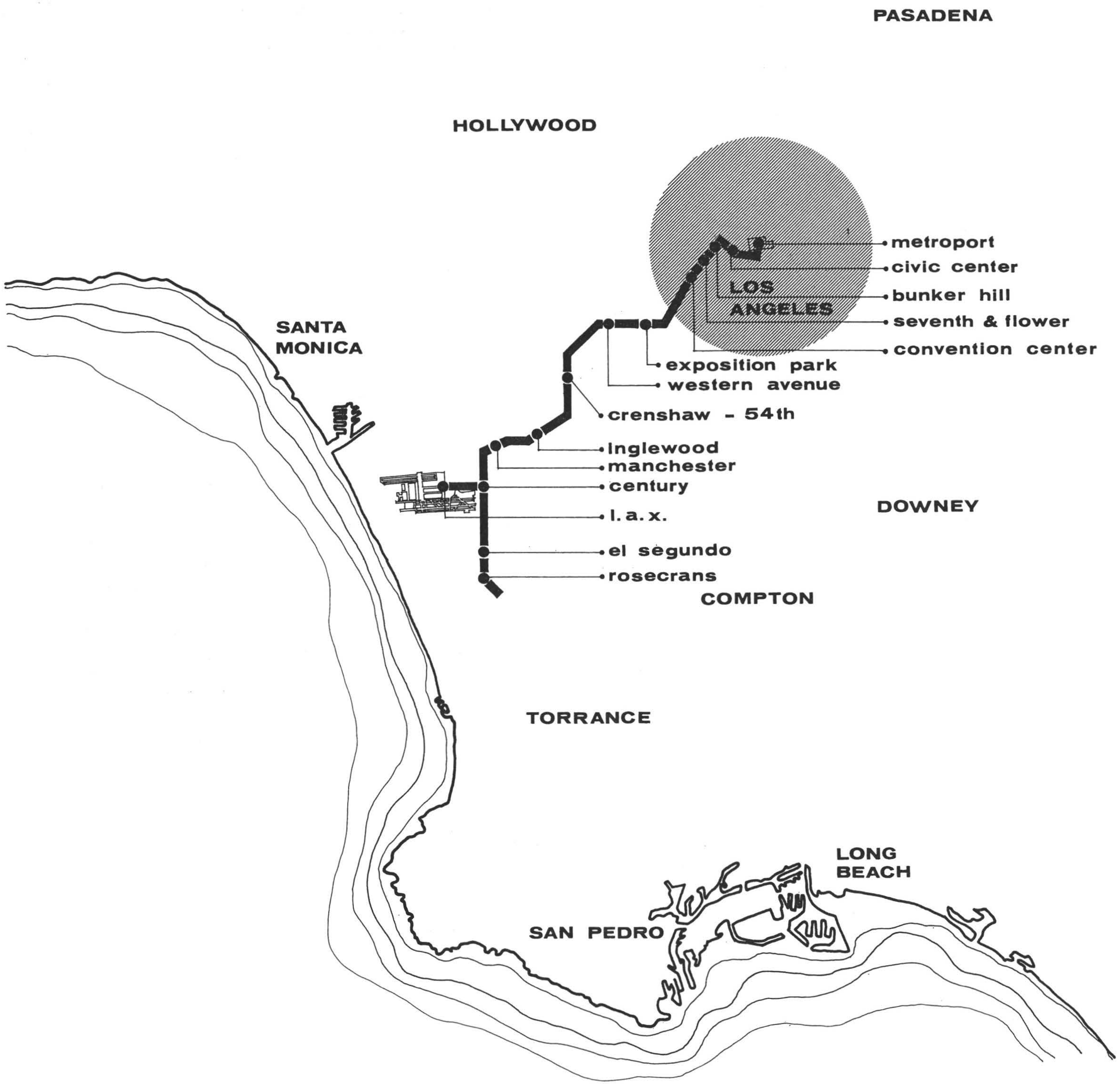
ENGINEERING CONTRACTOR, CLASS A, LIC. NO. 98556 - PROFESSIONAL ENGINEERS: CIVIL ENGINEER NO. 5777, MECHANICAL ENGINEER NO. 81, CHEMICAL ENGINEER NO. 560


PASADENA
HOLLYWOOD
LOS ANGELES
metroport
civic center
bunker hill
seventh & flower
convention center
SANTA MONICA
exposition park
western avenue
crenshaw - 54th
inglewood
manchester
century
l. a. x.
el segundo
rosecrans
DOWNEY
COMPTON
TORRANCE
LONG BEACH
SAN PEDRO

MAN
2

INTRODUCTION & SCOPE

It is apparent that metropolitan Los Angeles needs an integrated rapid transit system to effect mass movement of a population with the anticipated future growth. Evident also, is the existing need for a rapid transit system to move people to and from areas where the private citizen cannot afford personal transportation or when existing facilities, such as freeways, urban surface streets and parking lots are inadequate or unavailable to accommodate the demand.

The primary objective was the development of a rapid transit system for the Airport Southwest Corridor. This program is unique in design if compared to other proposed corridors as a result of the dual purpose transit service requirements. This system will provide express service from the Metroport and Central Business District to the Los Angeles International Airport (LAX). Integrated with the express service will be a local transit service commencing at the Metroport and terminating at Rosecrans Avenue and Aviation Boulevard. The total corridor will comprise approximately 18 route miles of transit system.

Standards used for planning and design of the facilities and the operational system of the Airport Southwest Corridor will provide the maximum service to the areas served, be aesthetically pleasing, and be the most advanced and modern possible by utilizing the latest technological developments consistent with economy so as to provide the maximum benefit to the public.

SCOPE

The scope of the work required preliminary planning and engineering, and preparation of preliminary estimates of cost for the designated route and station locations. This includes but is not limited to, stations, terminals, way structures, station access passageways, special passenger handling systems at terminal stations, electrical propulsion systems, and other facilities necessary to provide a complete and operable rapid transit service. The basic design criteria employed for preliminary engineering was that developed by the Joint Venture for the other corridors thereby insuring full coordination and compatibility of the entire rapid transit system. In addition, terminal stations at each end of the Airport Southwest Corridor's express service were related to special terminals for airline passengers now being planned by the Los Angeles Department of Airports.

Preliminary design consideration was directed towards aesthetic qualities, as well as the functional factors such as space allocation, passenger volumes and circulation, materials of construction, lighting, operation and maintenance, and economy to assure an optimum system design. Detailed consideration was also given to a designated alternate route through the Los Angeles Central Business District.

The route engineering aspect of this report includes, but is not limited to the following: route alignment investigation, field reconnaissance, utilities and structure research, and compilation of available soils data. The plan and profile study considered existing and future land use, topography, right-of-way and easement requirements, and access and traffic circulation.

Based on the general locations furnished by the Joint Venture, the most feasible station and facility locations were determined to provide maximum service to specified areas. These areas of service include the Metroport, Civic Center, Bunker Hill, Convention and Trade Center, Exposition Park, University of Southern California, Los Angeles International Airport, and industrial employment concentration areas. Designated station locations at 7th and Flower and the Civic Center have been coordinated to provide a compatible inter-corridor transfer connection.

Preliminary structural design and recommendations for way structures, tunnels, interchanges, bridges, retaining walls and underpinning of existing buildings were made.

The ventilating system preliminary concept includes the determination of size and location of vent shafts, blast shafts, ducts, fans and refrigeration equipment to provide the maximum passenger platform comfort and the desired compatibility with the other corridors of the system.

Transit facilities were designed to complement planning and engineering of the other corridors to insure ease of maintenance and operations with similar components of the total rapid transit system. Preliminary engineering of the power distribution system includes sizing and spacing of substations and method of providing traction power to the substations to obtain an optimum system.

DESIGN PARAMETERS

Basic criteria and general parameters for the system were provided and used as the basis for design of the Airport Southwest Corridor. The design of all fixed facilities and equipment will provide optimum service to accommodate projected passenger volumes.

Local service trains composed of a maximum of eight (8) 75-foot cars will be capable of moving 1,000 passengers (125 per car). The express service is planned for a maximum of eight-car trains, seven (7) of which will provide accommodations for 56 seated passengers and their baggage, or a total of 392 passengers per train. The eighth car of this express train will be utilized for transportation of mail and baggage between the Metroport and Los Angeles International Airport. With shared use of way structures, as well as the express service train schedule maintained at 15-minute intervals, the local service trains may be scheduled up to a maximum of 16 per hour. This system will be capable of providing the required capacity to transport the anticipated passenger volumes at maximum design speed.

As the study and preliminary design progressed, particular attention was given to the horizontal alignment to maintain passenger comfort and sustain design speed of the trains. The maximum radius for all horizontal curves, as well as the maximum length for spiral curves for transition from tangent alignment were used where possible. Appropriate super-elevation at curves is provided to maintain equilibrium at sustained velocity of the vehicles. Similarly, the vertical alignment provides for reasonable maximum grades and appropriate vertical curves to reduce any lifting effect of the vehicles

STRUCTURAL DESIGN

The structural design has been influenced by vehicle design criteria including dimensions, passenger loading and speed. Selection of span lengths, type of structure and materials of structures have involved consideration of aesthetics and costs.

The aerial structure for the proposed alignment is approximately 73,000 feet in length, essentially double track, with a single track structure planned for the express route, connecting the Los Angeles International Airport Station with the double-tracked main line. This does not include sections of the aerial structure that are within station limits and have received special design consideration. The aerial structure is carried on single vertical columns of reinforced concrete construction located at approximately 120-foot spacing.

As preliminary studies and design progressed, various systems were investigated, such as:

a. Pre-cast, pre-stressed, concrete girders with simple spans.

b. Composite steel and concrete girders with continuous and simple spans.

c. Poured-in-place concrete, box girders, with continuous spans.

Poured-in-place, concrete, box girders have some advantages for this type of construction, such as:

a. Continuous spans can reduce the total vertical deflections.

b. A single girder can be used for the support of the double-tracked road bed.

c. The girder can be curved to follow the horizontal and vertical alignment.

Pre-stressed, pre—cast concrete sections have been considered and offer some advantages such as:

a. Pre-cast pre-stressed girders are adaptable to economical mass production and acceptable construction and erection techniques.

b. The finish and consistency provides an aesthetic appearance which requires a minimum of maintenance.

c. Construction may proceed rapidly with less interference with street and railroad traffic.

Composite girders of structural steel and reinforced concrete permit long spans with less weight and a reduced vertical dimension. In many areas the additional cost of a composite structures does not justify its use.

For the purpose of this report, the pre-cast concrete section has been used as the basic girder design for preparation of the estimate. This preliminary selection does not preclude further consideration of other types of structure during the final design or construction stages. Advances in construction technique or costs may justify other selections. Final, detailed engineering will probably indicate that various types of structures will be used in different areas of the system to simplify construction and reduce costs to accommodate local conditions.

ELECTRICAL DESIGN

The criteria for electrical design of the Airport-Southwest Corridor is similar to the criteria for the other corridors. Power will be provided for a minimum number of metering and billing points conveniently located to the right-of-way and will be distributed to groups of traction substations. At the substations the AC power input will be rectified to provide 900-volt DC traction power to a contact rail. Capacity will be provided for a maximum train acceleration of 3.0 mphps. Uniform deceleration will be 2.6 mphps. Each car will have integral auxiliaries to provide power for air-conditioning, lighting and similar functions. Power supply for facilities such as tunnels, stations, parking lots, yards and other components, which are distinct from the train electrification, control and communication systems, will be supplied by the electrical utility which serves the particular area. A secondary power supply has been provided for critical functions in stations and other facility locations. Appropriate illumination intensity levels have been established for all areas.

STATION DESIGN

Passenger station studies and preliminary design were given careful consideration to assure comfort and safety. Space has been allocated to prevent undue congestion during peak traffic conditions. The minimum size station includes facilities for 900 passengers disembarking during a peak period of 20 minutes. Supporting facilities, such as escalators and auxiliary stairways, have been arranged and located to minimize congestion and to effectively channel opposing traffic.

The passenger traffic and flow pattern is planned to minimize delay of passengers by design of station facilities to accommodate movement through the station without exceeding a delay period of 30 seconds.

Appropriate shelter has been provided for access structures, ticketing areas and platforms for continuous protection of passengers. Platforms, at all stations, are 600 feet long with a minimum width to preserve passenger comfort and safety. The height and surface of the loading platforms has received careful consideration to reduce hazards and minimize accidents. Station areas can be effectively closed during periods when the transit system is not functioning.

Many suburban stations will include ground level parking areas adjacent to passenger entrances and exits. Normally, stations located in the Central Business District will not have provisions for parking since they primarily serve destination areas.

The Metroport Station is the only on-grade facility located in the Airport-Southwest Corridor and is also illustrated later in this report.

The stations located in the Airport-Southwest Corridor consist of three basic designs, subway, aerial and on-grade.

Of the fourteen (14) stations in this corridor, five (5) can be considered typical aerial stations, with minor variations to accommodate the site and passenger volume. These stations are: Rosecrans, El Segundo, Century, Manchester and Crenshaw-54th. Each is an aerial station with side loading platforms. The ticket lobby of Rosecrans station is under the platform, ongrade, while the other ticket lobbies are on-grade and detached to one side.

There are four other stations in the aerial category: Exposition Park, Inglewood, Western Avenue and LAX. Each has certain requirements which classify them as special. Exposition Park is a side loading platform station, with the ticket concourse elevated under the platforms. Access is from each end and opposite sides, at grade level. The Inglewood station has side loading platforms, with the ticket concourse elevated under the platform. Access to the concourse is from two street levels. The upper access is on the same level as the ticket concourse, adjacent to the business district, while the lower access is approximately twenty-three feet below and on the opposite side, adjacent to the parking facilities. Western Avenue and LAX stations are illustrated later in this report.

There are a total of four subway stations located in the Central Business District. The Convention Center and Civic Center are basic stations incorporating special features. Both have center loading platforms with the ticket concourse over and access from the surface streets above, to the center of the station. The Civic Center station differs in that this is an inter-corridor transfer station, providing direct access to the Wilshire Corridor. The Convention Center station differs in that it is designed for peak loads generated by the Convention and World Trade Center. Provisions also have been made to provide a future, direct passenger tunnel access to these facilities. Bunker Hill and 7th and Flower stations are illustrated later in this report.

COST ESTIMATE AND CASH FLOW

The estimate of costs is based on 1967 construction materials and labor prices. These costs are arranged in divisions including, but not limited to the following:

Structural and roadbed costs including tunnels, way structures, cuts, fills, street relocation, tunnel ventilation, trackage, landscaping, etc.

Station costs including subway, at-grade and aerial construction, site preparation, structures, parking areas, ticketing equipment, ventilation and air conditioning, escalators, landscaping and all other related construction.

Propulsion power costs including wiring, switchgear, transformers, third rail (necessary to supply power) in addition to all station, tunnel and yard lighting.

Utility relocation costs including removing, relocating, replacing, supporting and maintaining all utilities affected, except at subway stations.

Underpinning costs including protection and reinforcement of structures within the influence of construction.

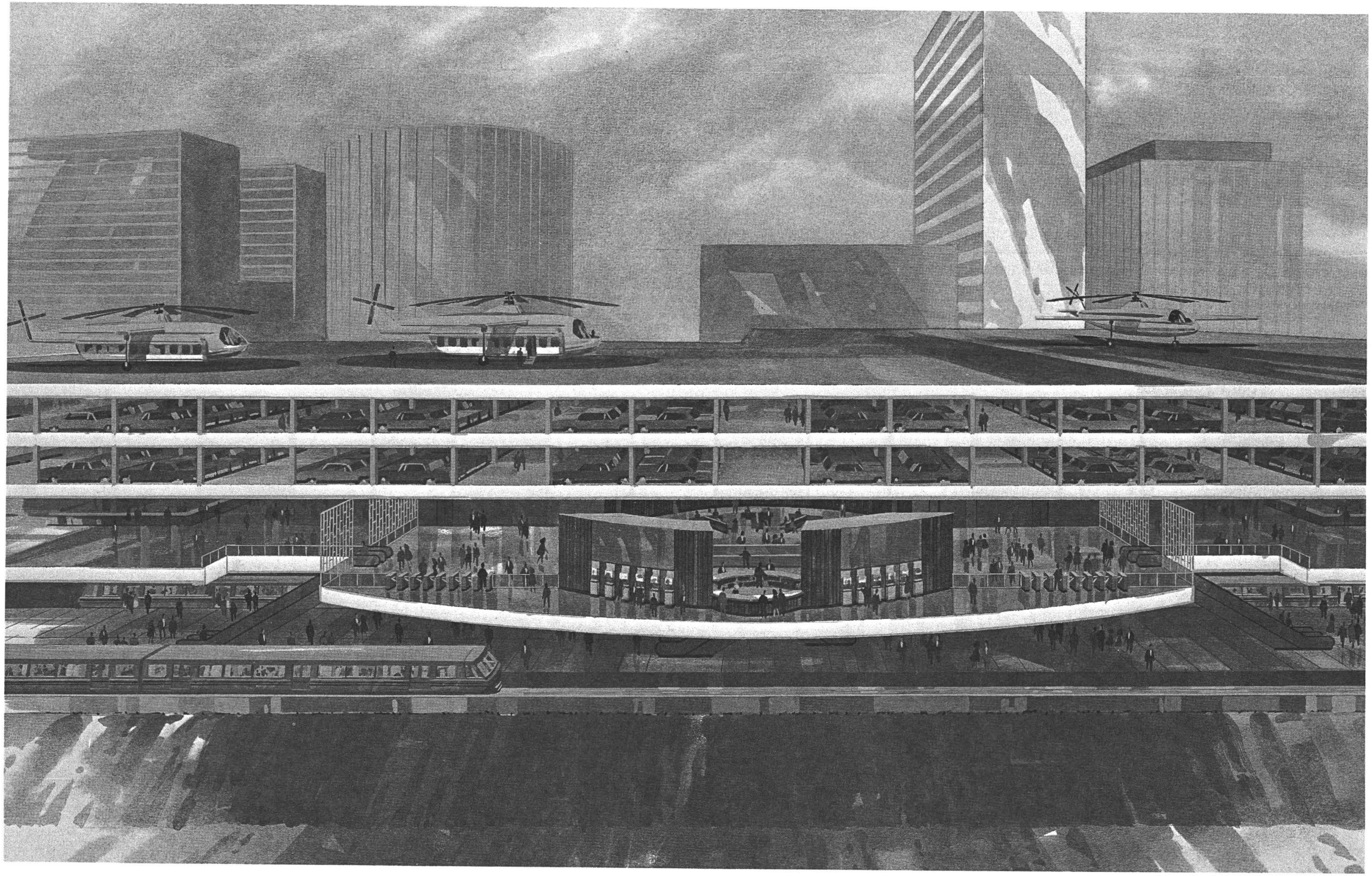
Yard and shop costs including service facilities, site preparation, trackage, maintenance equipment, etc.

A contingency sum equivalent to 15% of estimated construction costs is included in the total cost.

The escalation cost, 7% compounded per annum, is added to compensate for anticipated, wage, tax and price increases plus working conditions, rules and regulations that may change during the construction period.

The estimated cash flow is based upon a feasible construction schedule related to a specific time base. This schedule was established to provide a realistic engineering program that will permit design and construction of the Airport-Southwest Corridor to parallel each other after initial engineering is provided. This program is planned to be initiated later this year and be completed in the mid-seventies.

The estimate of-costs and cash flow schedule developed for the Airport-Southwest Corridor is incorporated into "Estimate of costs" and "Summary of cash flow" for the recommended five-corridor system presented in the Joint Venture's report.



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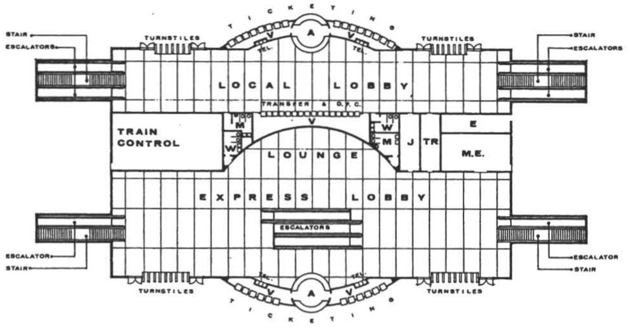
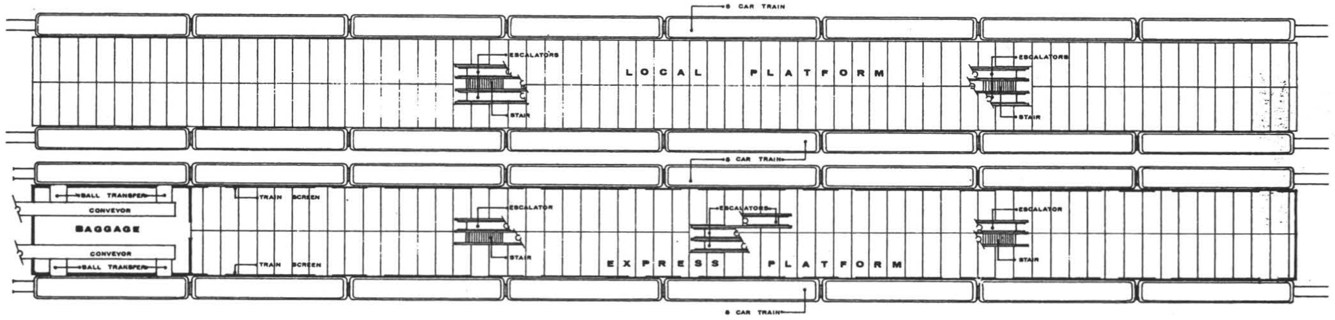
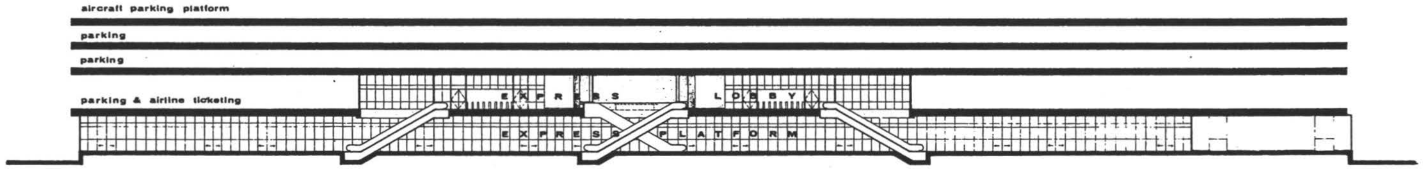
TICKET LOBBY PLAN



PLATFORM PLAN



LONGITUDINAL SECTION



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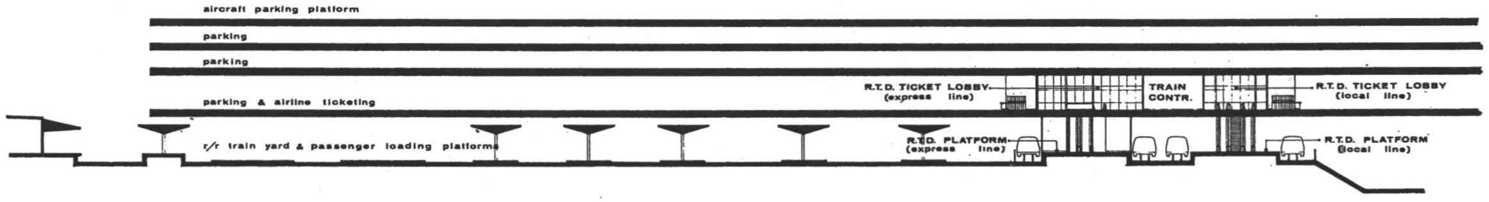
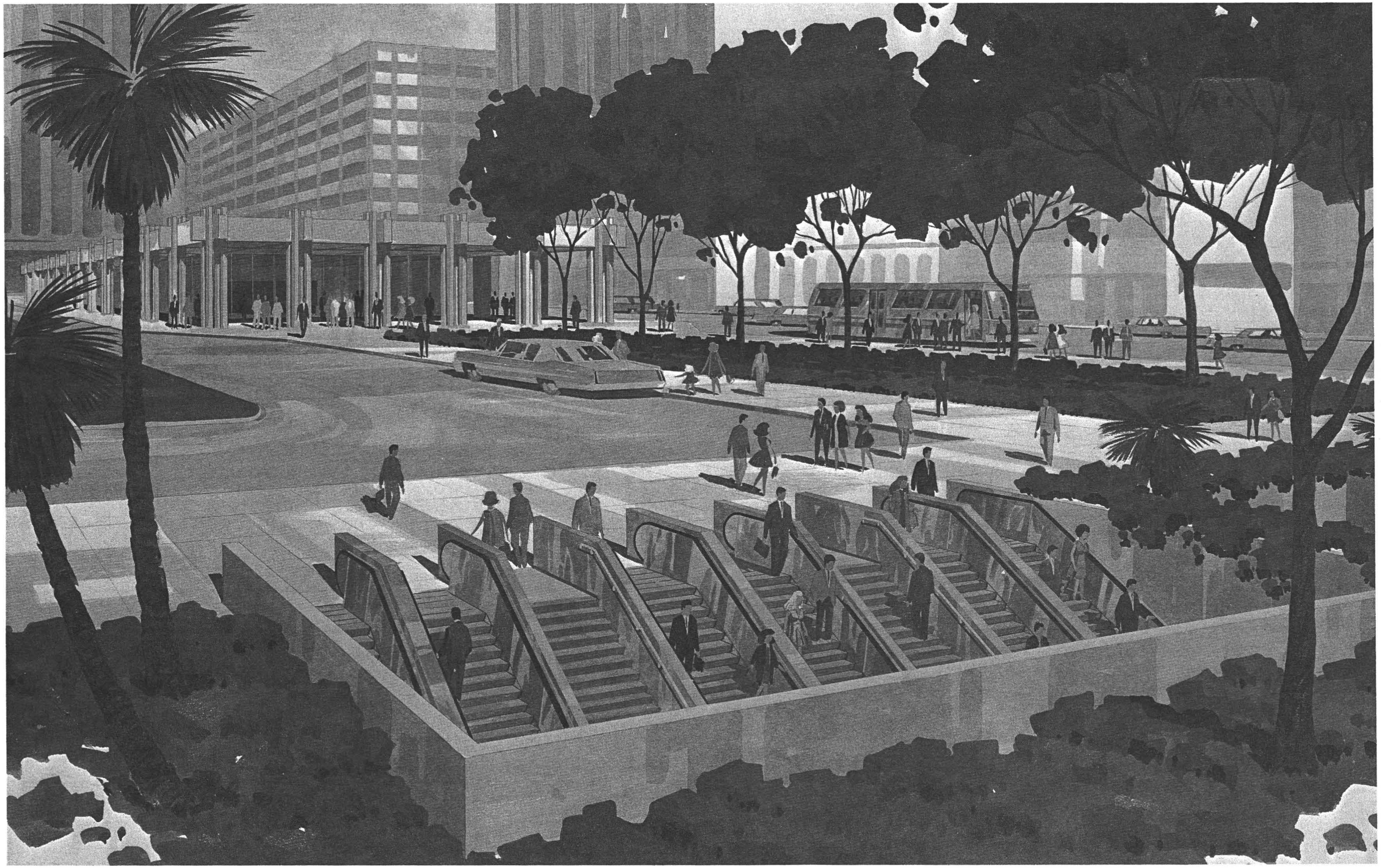
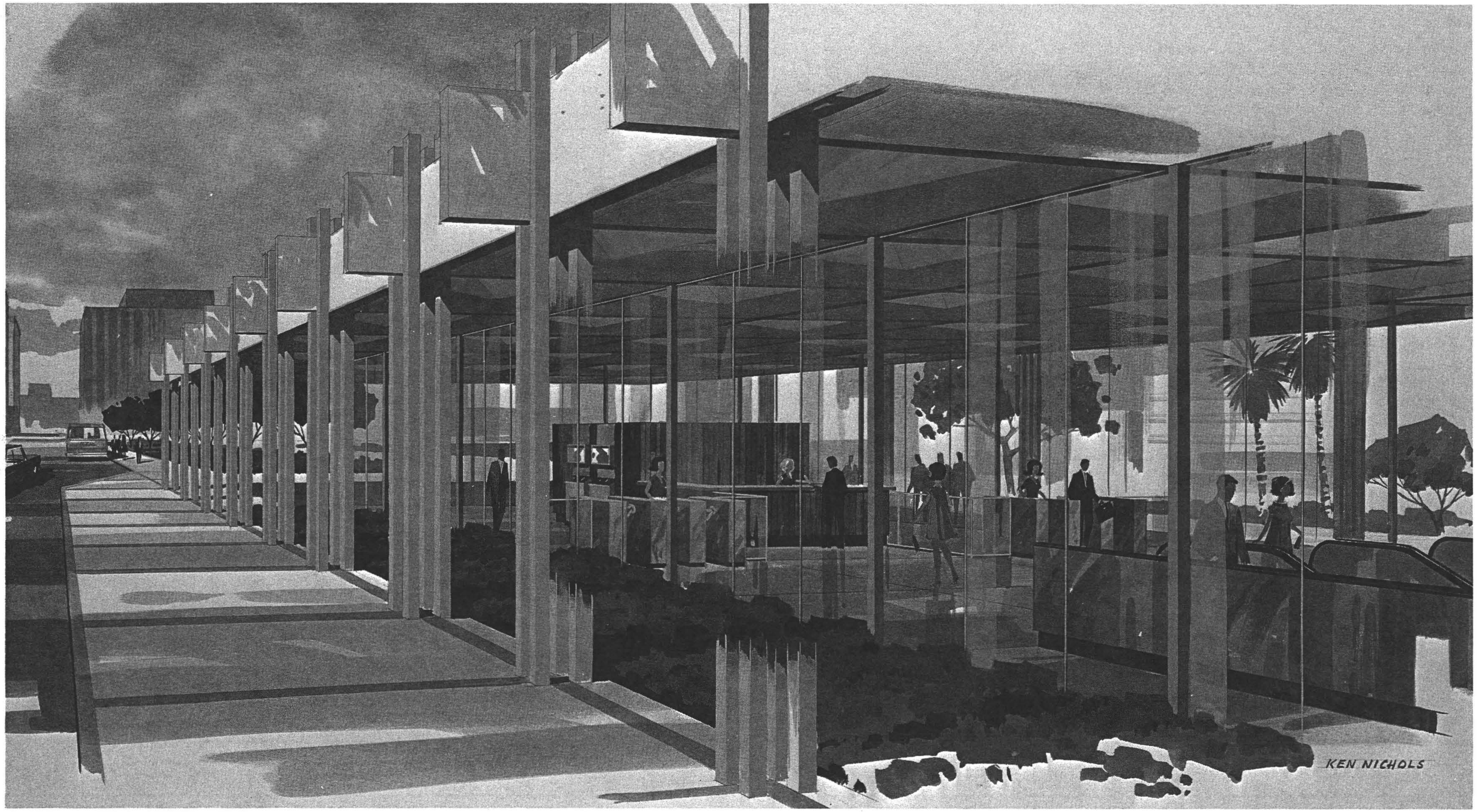
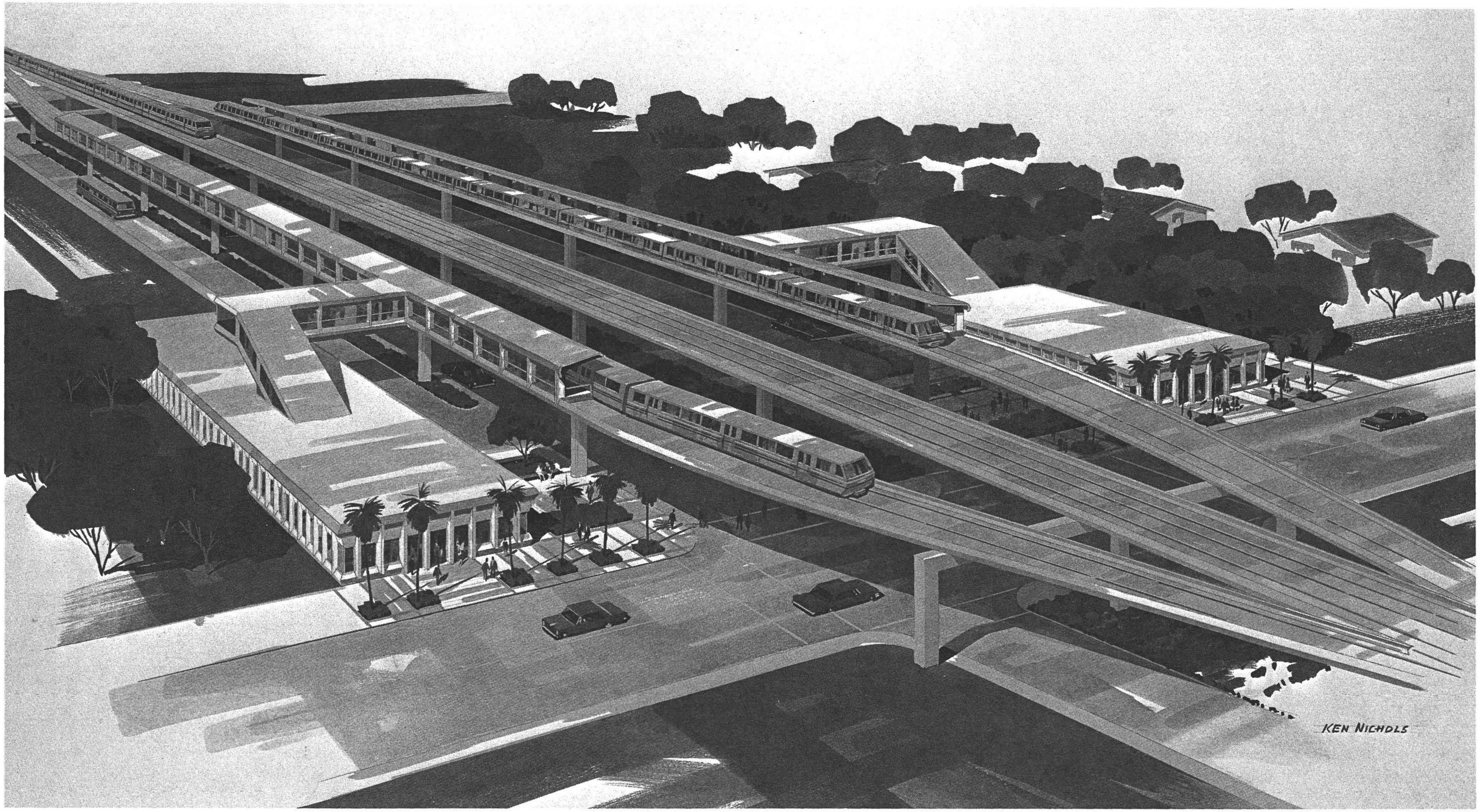


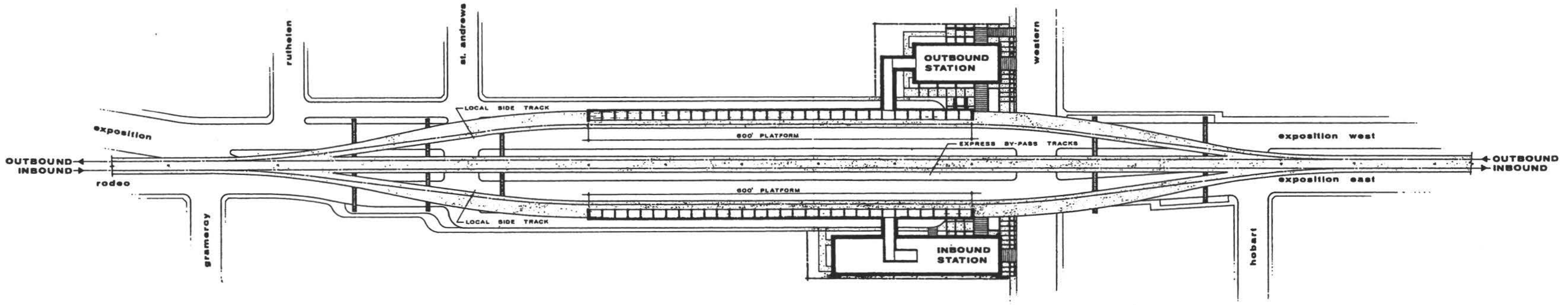


MAN
10


KEN NICHOLS



MAN
14



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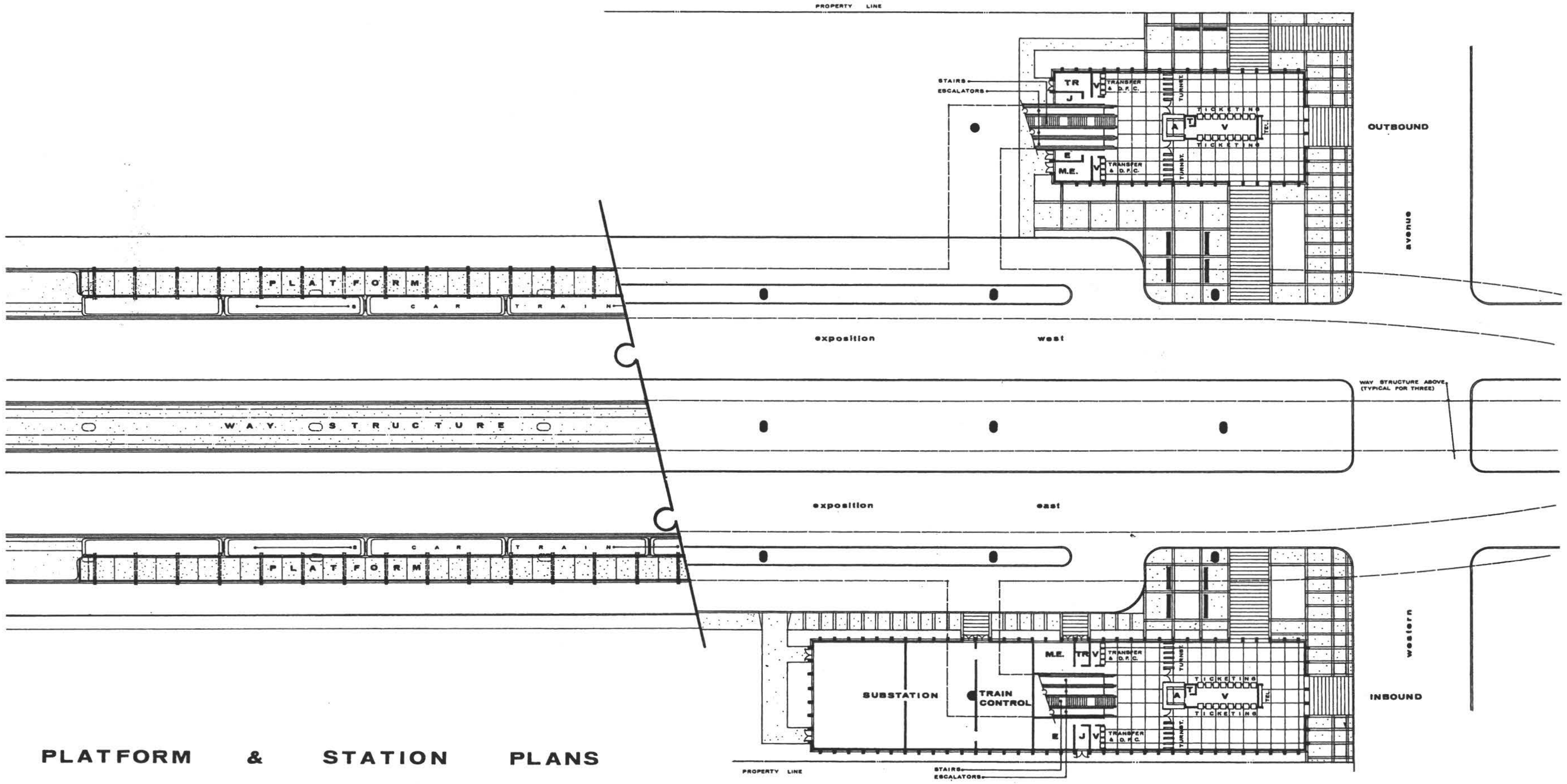
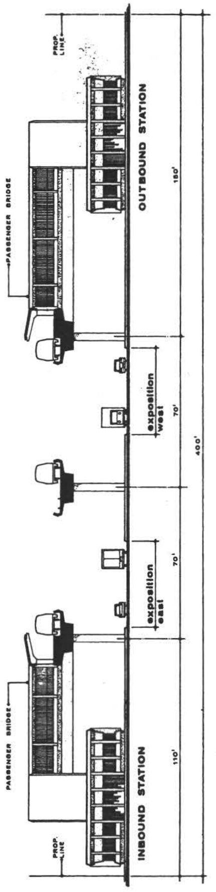
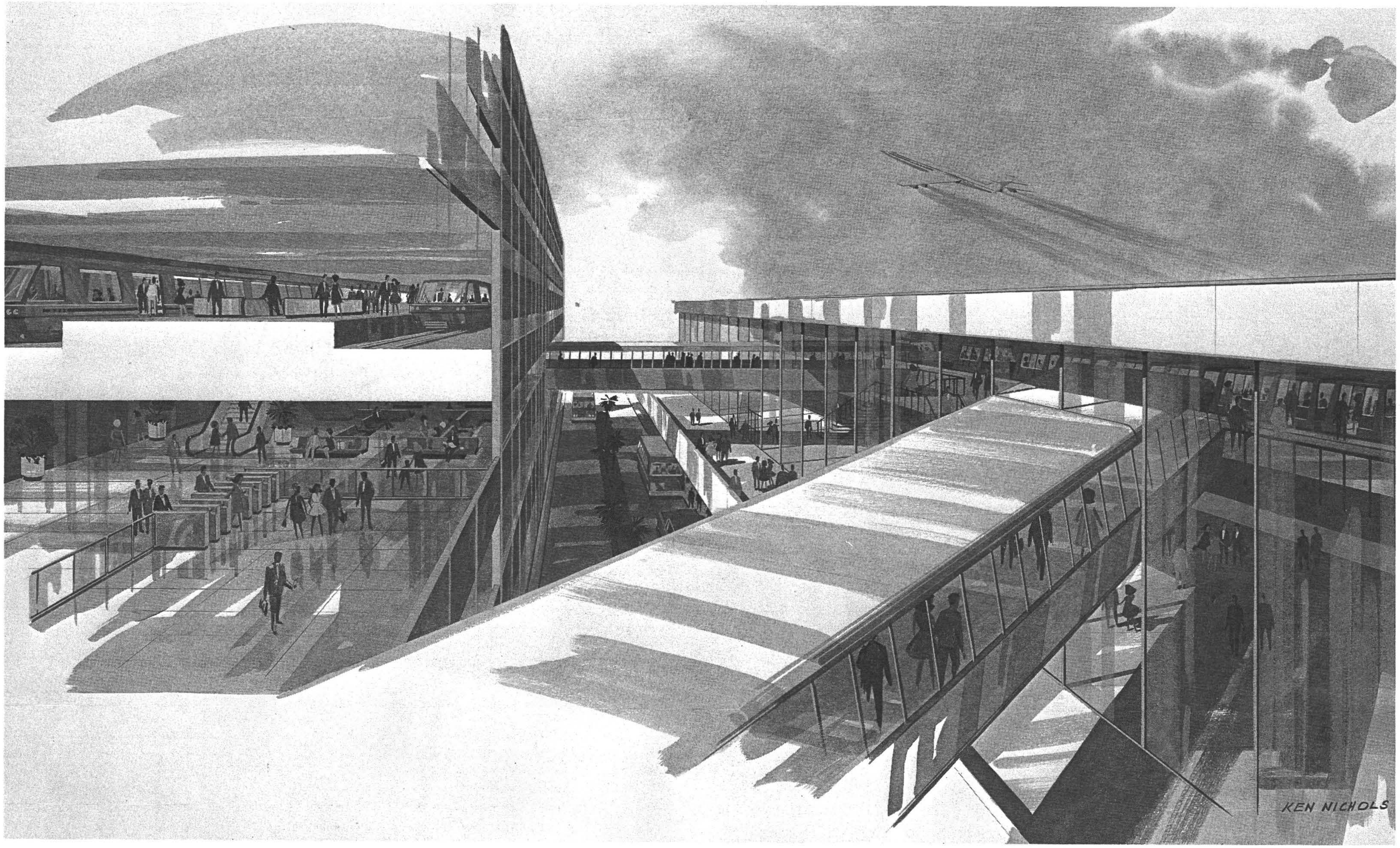
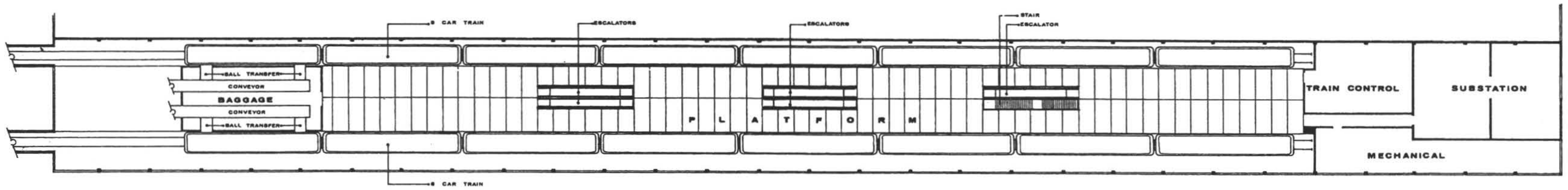


PLATFORM & STATION PLANS

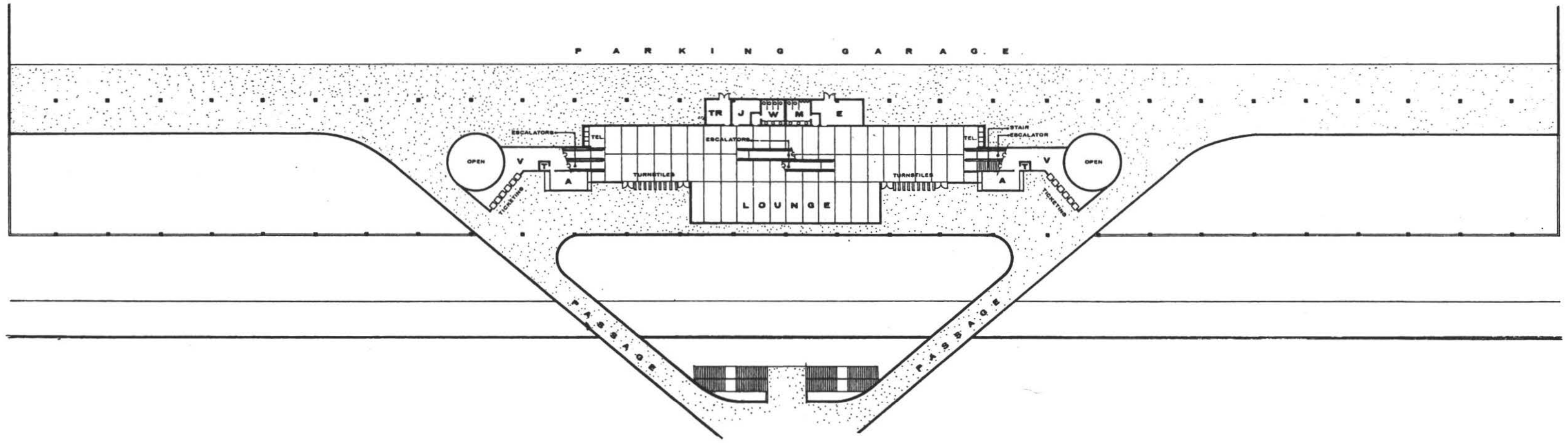


ELEVATION & SECTION

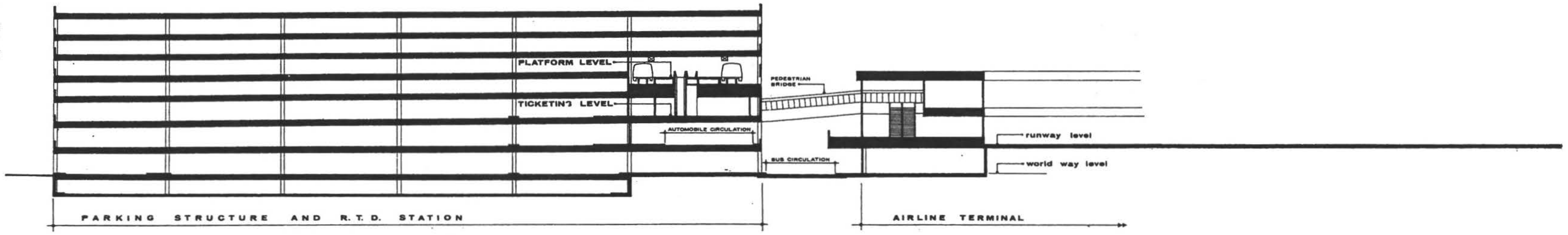

KEN NICHOLS



PLATFORM PLAN



TICKET LOBBY PLAN



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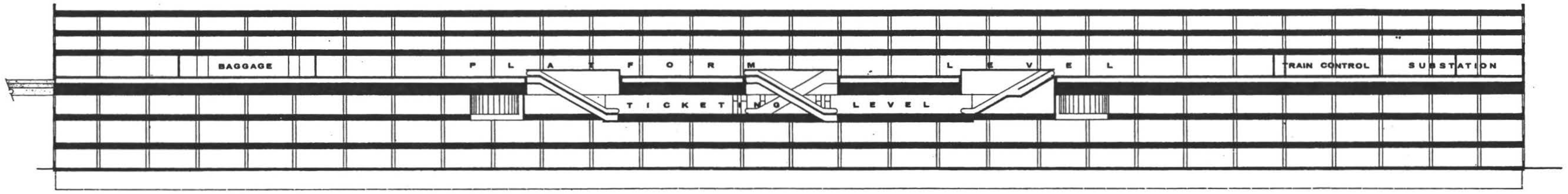

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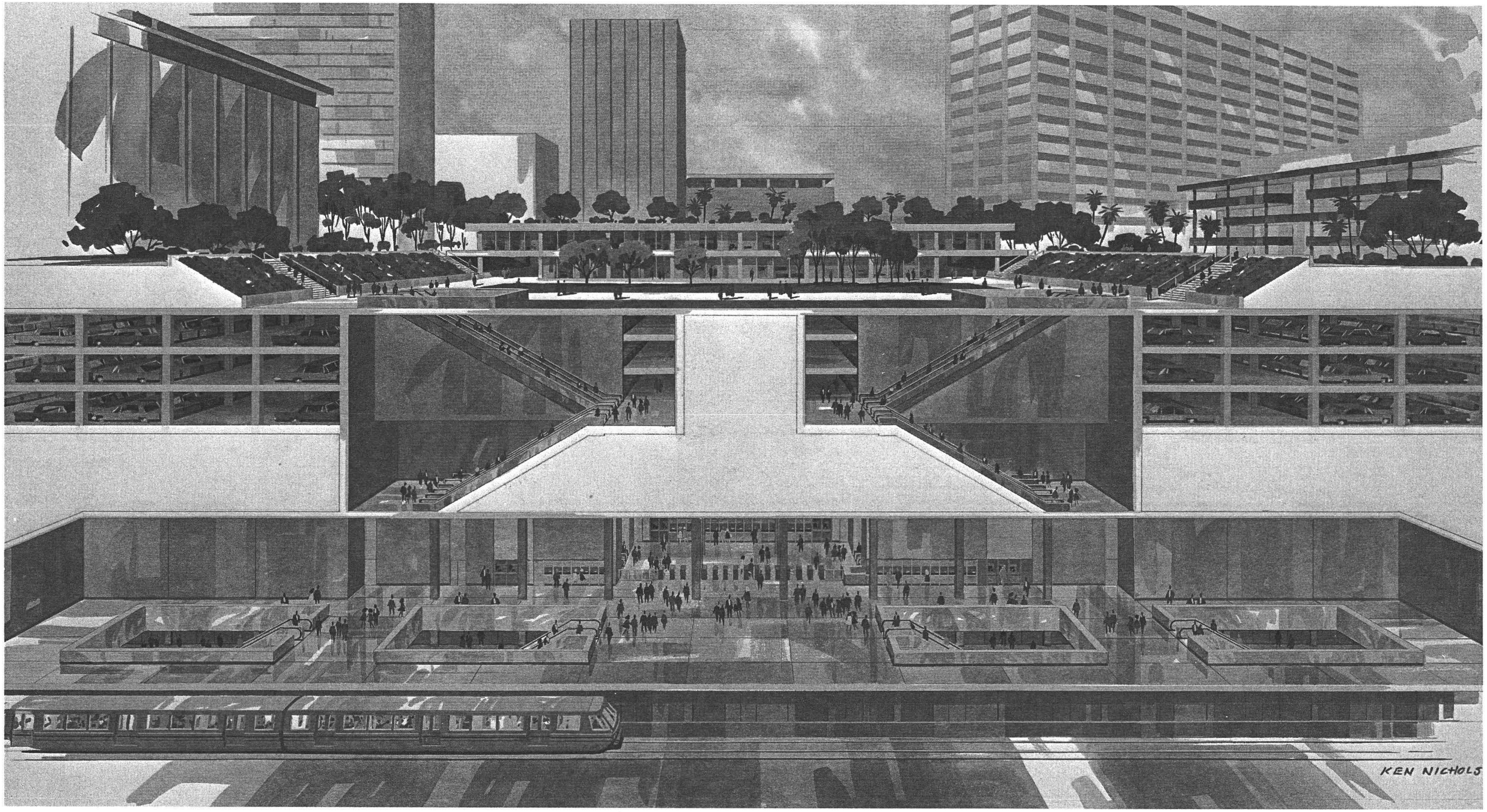

KEN NICHOLS

BUNKER HILL

This station is located in an area bounded by Hope, Grand, Second and Third Streets. The station has been designed to provide access of rapid transit service to the vast residential and office building complex being planned for the Bunker Hill Urban Renewal Project. The entire station is below ground, with the ticket lobby located above the trackage level and a center platform for passenger access to the cars. Passenger ingress and egress will be provided from a ground level plaza above the station and directly from the surrounding high-rise buildings.

AIRPORT SOUTHWEST CORRIDOR

CORRIDOR DESCRIPTION

The Airport-Southwest Corridor generally comprises those areas surrounding Flower Street, Exposition Boulevard, Florence Avenue and Aviation Boulevard, extended from Union Station to south of the Los Angeles International Airport. The corridor is essentially within the City of Los Angeles with its southerly portion traversing the City of Inglewood and extending into the cities of El Segundo and Hawthorne.

The major physical features of this corridor are principally man-made structures; including the Los Angeles Central Business District, the Civic Center Complex, the Bunker Hill Urban Renewal Project, the University of Southern California, Exposition Park, the Inglewood Central Business District, El Segundo's Industrial Park and the Los Angeles International Airport. The corridor contains portions of the San Diego, Santa Monica, Hollywood and Harbor Freeways.

With the exception of the Los Angeles Central Business District, the commercial activity is primarily located in the Crenshaw and Inglewood business districts. Industrial developments consist of numerous facilities in the vicinity of Aviation Boulevard from Century Avenue to Rosecrans Boulevard, as well as minor facilities located throughout this corridor.

The recreational and cultural facilities in this corridor are numerous and include the Music Center, County Fine Arts and Historical Museums, the Sports Arena and Coliseum, the Main Public Library, University of Southern California, The Forum and Hollywood Park in addition to many parks and theatres located in, and adjacent to, this corridor.

The Los Angeles Central Business District is the hub of the entire Los Angeles urban area. This business district has various corporation headquarters and executive offices, the financial center of the Pacific Southwest, governmental office complexes, the Civic Center area, and the largest concentration of department and retail stores in the Los Angeles area.

The construction, witnessed in the past few years, of the 40-story Union Bank Building, the Music Center complex, with other developments projected for early completion, such as the 42-story Crocker Citizens Building, clearly indicate that the Los Angeles Central Business District is expanding and developing a distinctive skyline. In the near future, the Bunker Hill Urban Renewal Project's objectives will be consummated, adding motels, hotels, high-rise apartments, major commercial and business complexes. Completion of the Convention and World Trade Center within the next several years will no doubt revitalize the southern portion of the Central Business District. These proposed developments and those already constructed within the Airport-Southwest Corridor will be linked with the Los Angeles International Airport and those areas of Metropolitan Los Angeles served by the other corridors of the rapid transit system.

STATION LOCATIONS

Various station locations were studied and discussed with regard to area needs, traffic projections and proximity to major areas of activity. After thorough consideration of all factors, locations were selected which have been refined and detailed in this report. Essentially, the stations will provide access to the rapid transit system for areas of highest residential, industrial, and commercial concentration in the corridor and special locations such as Bunker Hill, Convention Center and Exposition Park, as well as locations most beneficial to the populace. Consideration was also given to transfer of passengers from other corridors in the system and to connections with surface transportation, such as feeder buses and private vehicles. At all visible or above-ground structures, the architectural design has been directed toward an aesthetic blend with adjacent structures and development.

The major transit station for the Airport-Southwest Corridor has been located in the vicinity of Seventh and Flower Streets. This station location not only acts as the hub of both the express and local service, but also is a point of focus for the entire Los Angeles Central Business District. Each transit station located in the Central Business District is designated to serve a specific area. This combination of stations will efficiently serve the entire Central Business District.

The Metroport Station, express and local facilities provide service to the Union Station and future airport satellite and is the terminal station for both the express and local service.

The large and active Civic Center complex has service provided by the station located on First Street between Broadway and Main Streets.

The Bunker Hill and Convention Center stations are located to provide direct access to each of these proposed complexes.

The Exposition Park station serves the University of Southern California, the Sports Arena, the Coliseum, and the Los Angeles County Museum. This station is located in the Southern Pacific Railway right-of-way in Exposition Boulevard, east of Vermont Avenue, with access to both the north and south sides of Exposition Boulevard.

The station at Western Avenue provides two important functions: First, this station serves as a transfer point to the Feeder Bus System. Second, this station provides by-pass trackage required for the express train to pass the local train.

Crenshaw-54th, Inglewood, La Brea and Manchester stations provide service for surrounding business and residential areas in addition to providing convenient access to the Feeder Bus System.

The Century station provides local service for commercial and industrial developments located adjacent to the Los Angeles International Airport and along Century Boulevard.

The El Segundo and Rosecrans stations are similar in that they are adjacent to vast aero-space complexes. These stations also provide transit service for most of the beach cities to the south including Manhattan Beach, Hermosa Beach and Redondo Beach. The Rosecrans station will be the Airport-Southwest Corridor terminal station. The station has good access from the San Diego Freeway to its parking facilities and will allow future extension to the south.

The fourteenth station in the Airport Southwest Corridor is the only station which is limited to express transit service. This station is located at Los Angeles International Airport to provide high-speed transit service to and from the Metroport and the Los Angeles Central Business District.

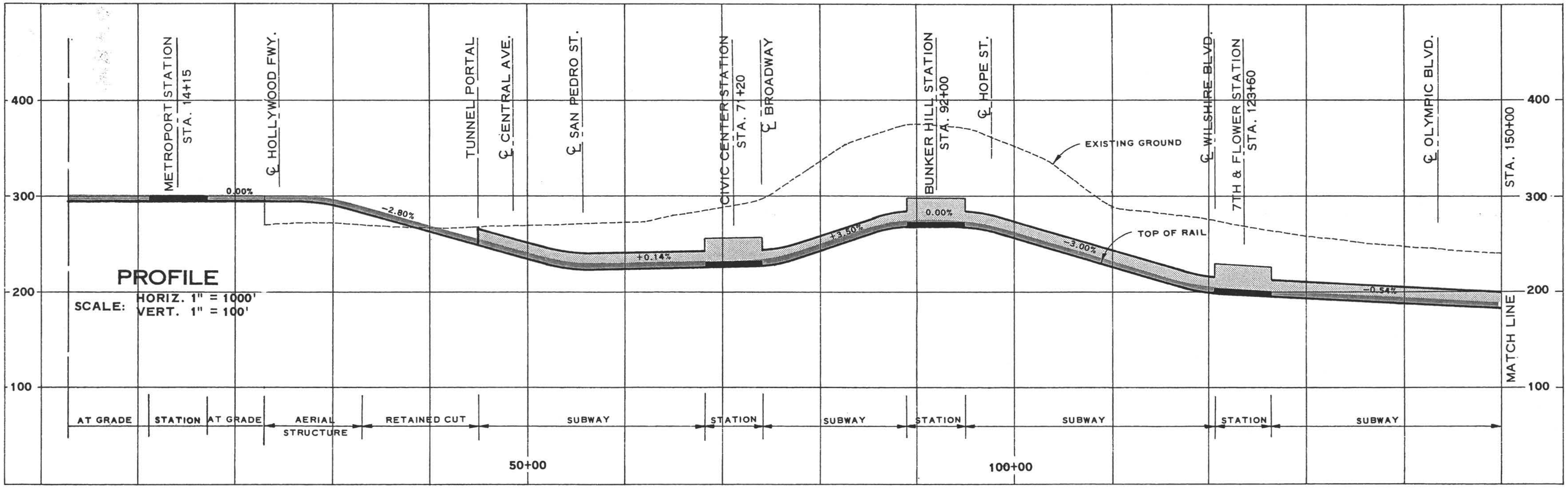
ROUTE DESCRIPTION—LOCAL ROUTE

The Airport-Southwest Corridor begins on grade at Union Station. The route proceeds southerly on grade, in private easement, to the Hollywood Freeway; transitions to aerial structure and continues southerly to a horizontal curve. At the northwest corner of Alameda Street and First Street, the route portals to a subway configuration and continues to a point in First Street, approximately 500 feet west of Alameda Street; then westerly to a horizontal curve north of Hill Street. The route continues in subsurface easement, southwesterly, through the Bunker Hill Urban Renewal Project to a horizontal curve, where it turns southerly in Flower Street at Fifth Street. The route continues southerly, in subway, under Flower Street, entering private property in a subsurface easement west of 28th Street and proceeds southerly to a portal near 30th Street. The route transitions into aerial structure and continues southerly, in private right-of-way, to a point near 35th Street, and traverses a 1,000 foot curve to the median of Exposition Boulevard. The aerial structure continues westerly in Exposition Boulevard, in aerial easement, jointly utilizing the railroad right-of-way to Gramercy Place. The route enters private right-of-way at the north side of Rodeo Road continuing to a point near Arlington Avenue, where it turns southerly on a 1,000 foot radius curve to the west side of Roxton Avenue. The route, in private right-of-way, continues southerly to a point 900 feet north of Santa Barbara Avenue, turns southwesterly on a 1,000 foot curve into the median of Leimert Boulevard and continues to 11th Avenue, where it traverses a 1,000 foot radius curve in Leimert to proceed southerly in the median of Crenshaw Boulevard to 66th Street. Turning westerly, the route enters the right-of-way of the Atchison, Topeka and Santa Fe Railroad west of Victoria Avenue, and continues southerly and westerly, in aerial structure, in joint use of the railroad right-of-way along Redondo Boulevard and Florence Avenue to a point near Portal Avenue. At this location the route enters private right-of-way west of the railroad right-of-way and proceeds southerly adjacent to Portal Avenue and Aviation Boulevard, transitioning to a cut and cover configuration south under the Los Angeles International Airport approach zone at 104th Street and returning to an aerial configuration south of Imperial Boulevard, to 139th Street. The route then turns southeasterly, through private right-of-way, terminating in a storage yard east of Aviation Boulevard and south of Rosecrans Boulevard.

AIRPORT EXPRESS ROUTE

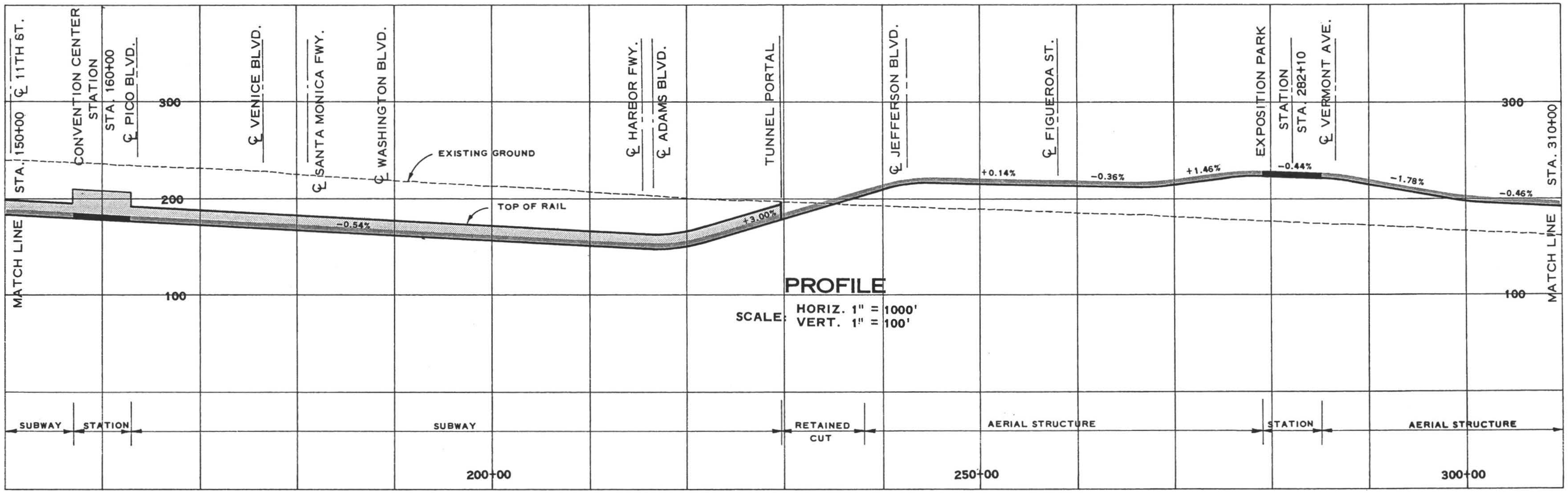
The Airport Express route, of the Airport-Southwest Corridor, is identical to the local route from the Metroport Station, adjacent to Union Station, to a point 650 feet north of Century Boulevard. At this point the express route turns westerly from the local route via an 800 foot radius curve and continues in aerial structure in the south side of Century Boulevard to a terminus within the Los Angeles International Airport.

PLAN
SCALE: 1" = 1000'

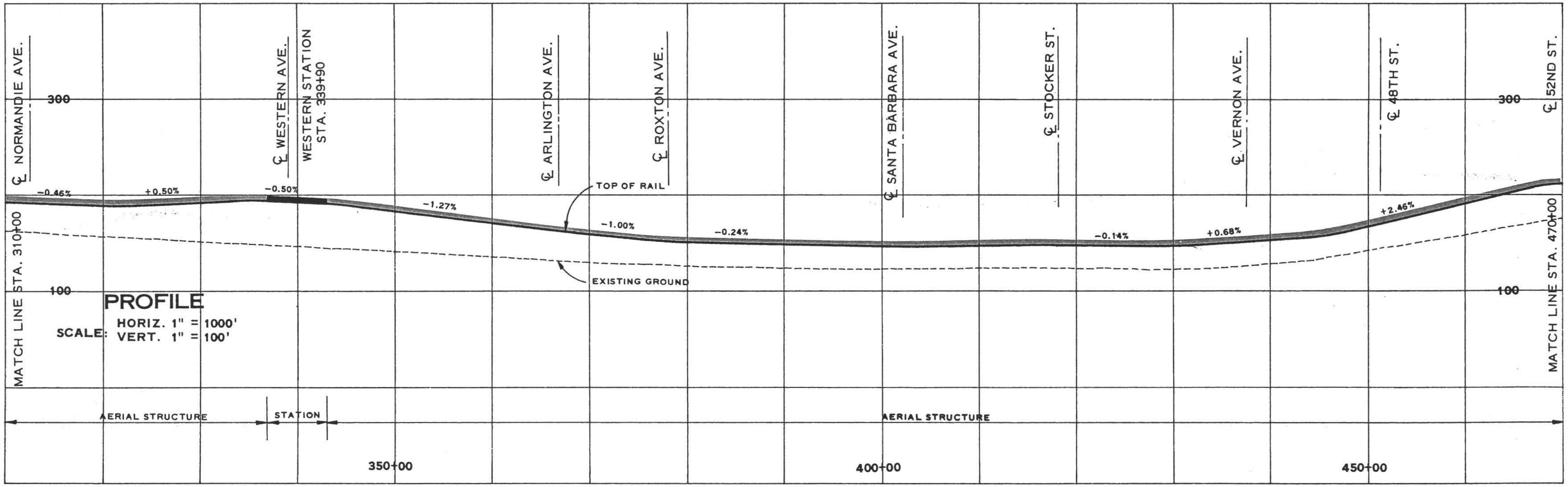


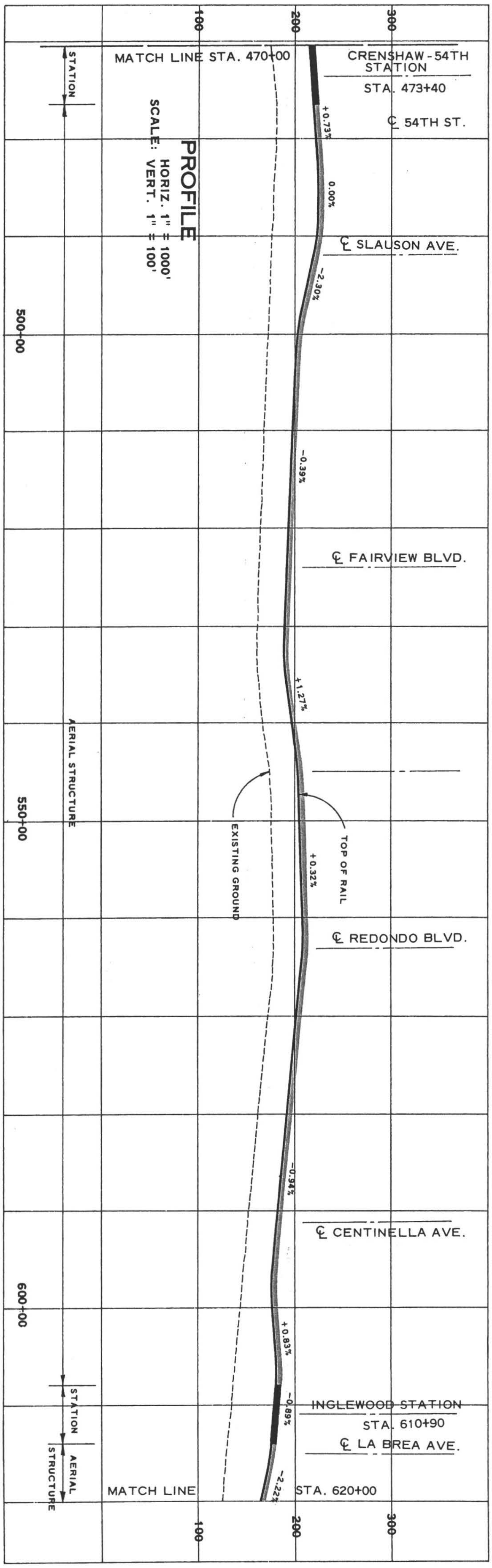
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'


MATCH LINE
PICO BLVD.
FLOWER ST.
FIGUEROA ST.
GRAND AVE.
VENICE BLVD.
SANTA MONICA FWY.
WASHINGTON BLVD.
HARBOR FWY.
HOPE ST.
ADAMS BLVD.
JEFFERSON BLVD.
SHRINE AUDITORIUM
HOOVER ST.
UNIVERSITY OF SOUTHERN CALIFORNIA
EXPOSITION PARK
EXPOSITION
VERMONT AVE.
MATCH LINE
PLAN
SCALE 1" = 1000'
LOS ANGELES


MATCH LINE
STA. 150+00
℄ 11TH ST.
CONVENTION CENTER STATION
STA. 160+00
℄ PICO BLVD.
℄ VENICE BLVD.
℄ SANTA MONICA FWY.
℄ WASHINGTON BLVD.
EXISTING GROUND
TOP OF RAIL
-0.54%
℄ HARBOR FWY.
℄ ADAMS BLVD.
TUNNEL PORTAL
+3.00%
℄ JEFFERSON BLVD.
+0.14%
℄ FIGUEROA ST.
-0.36%
+1.46%
EXPOSITION PARK STATION
STA. 282+10
-0.44%
℄ VERMONT AVE.
-1.78%
-0.46%
STA. 310+00
MATCH LINE
300
200
100
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
SUBWAY
STATION
SUBWAY
RETAINED CUT
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
200+00
250+00
300+00

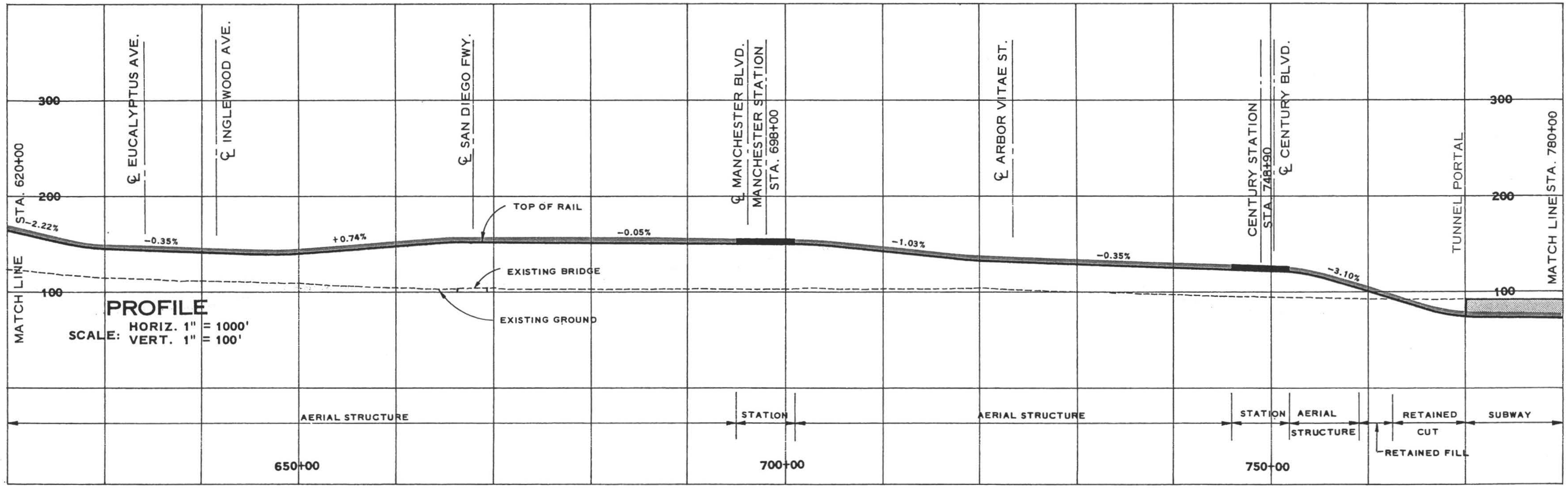

MATCH LINE
NORMANDIE AVE.
WESTERN AVE.
WESTERN
LOS ANGELES
SANTA BARBARA AVE.
ARLINGTON AVE.
ROXTON AVE.
RODEO RD.
VERNON AVE.
48TH ST.
CRENSHAW BLVD.
MATCH LINE
PLAN
SCALE: 1" = 1000'


℄ NORMANDIE AVE.
℄ WESTERN AVE.
WESTERN STATION
STA. 339+90
℄ ARLINGTON AVE.
℄ ROXTON AVE.
℄ SANTA BARBARA AVE.
℄ STOCKER ST.
℄ VERNON AVE.
℄ 48TH ST.
℄ 52ND ST.
300
300
100
100
-0.46%
+0.50%
-0.50%
-1.27%
-1.00%
-0.24%
-0.14%
+0.68%
+2.46%
TOP OF RAIL
EXISTING GROUND
MATCH LINE STA. 310+00
MATCH LINE STA. 470+00
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
350+00
400+00
450+00

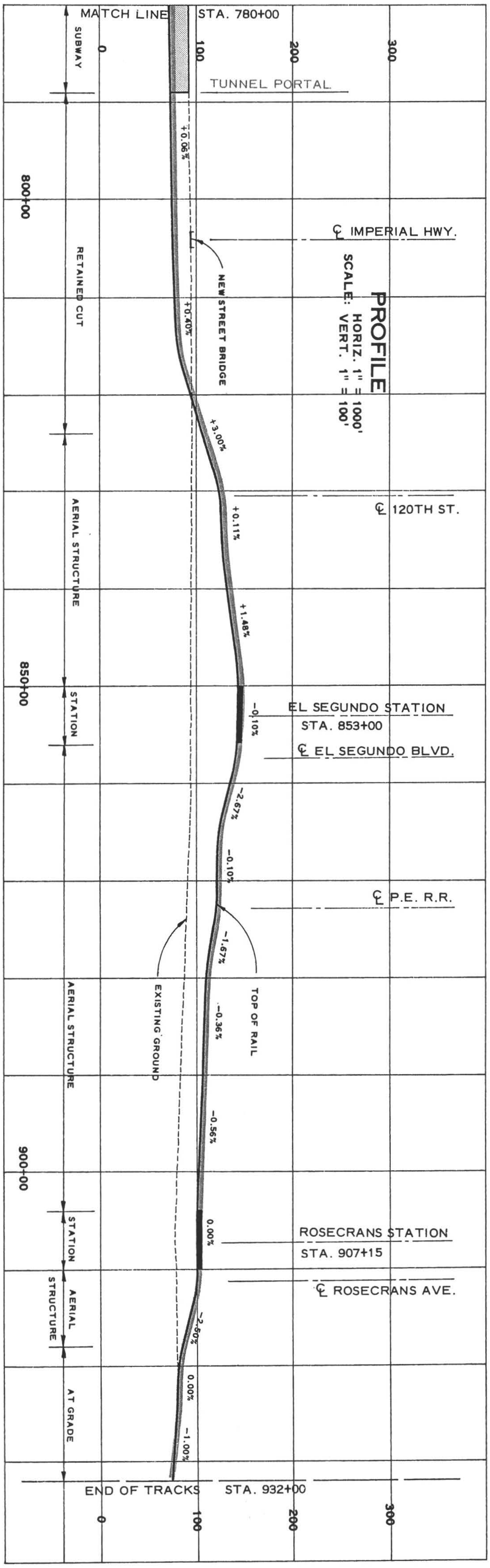

PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
MATCH LINE STA. 470+00
CRENSHAW-54TH STATION
STA. 473+40
℄ 54TH ST.
℄ SLAUSON AVE.
℄ FAIRVIEW BLVD.
℄ REDONDO BLVD.
℄ CENTINELLA AVE.
INGLEWOOD STATION
STA. 610+90
℄ LA BREA AVE.
MATCH LINE
STA. 620+00
STATION
AERIAL STRUCTURE
500+00
550+00
600+00
100
200
300
+0.73%
0.00%
-2.30%
-0.39%
+1.27%
+0.32%
-0.94%
+0.83%
-0.89%
-2.22%
EXISTING GROUND
TOP OF RAIL


PLAN
SCALE 1" = 1000'
CRENSHAW-54TH
MATCH LINE
54TH ST.
11TH ST.
SLAUSON AVE.
CRENSHAW BLVD.
FAIRVIEW BLVD.
LOS ANGELES
FLORENCE AVE.
CENTINELLA AVE.
PRAIRIE AVE.
HILLCREST BLVD.
LA BREA AVE.
MATCH LINE
INGLEWOOD


MATCH LINE
LOS ANGELES
FLORENCE AVE.
INGLEWOOD AVE.
SAN DIEGO FWY.
MANCHESTER BLVD.
MANCHESTER
ARBOR VITAE ST.
PORTAL AVE.
AVIATION BLVD.
CENTURY BLVD.
AVIATION BLVD.
MATCH LINE
PLAN
SCALE: 1" = 1000'

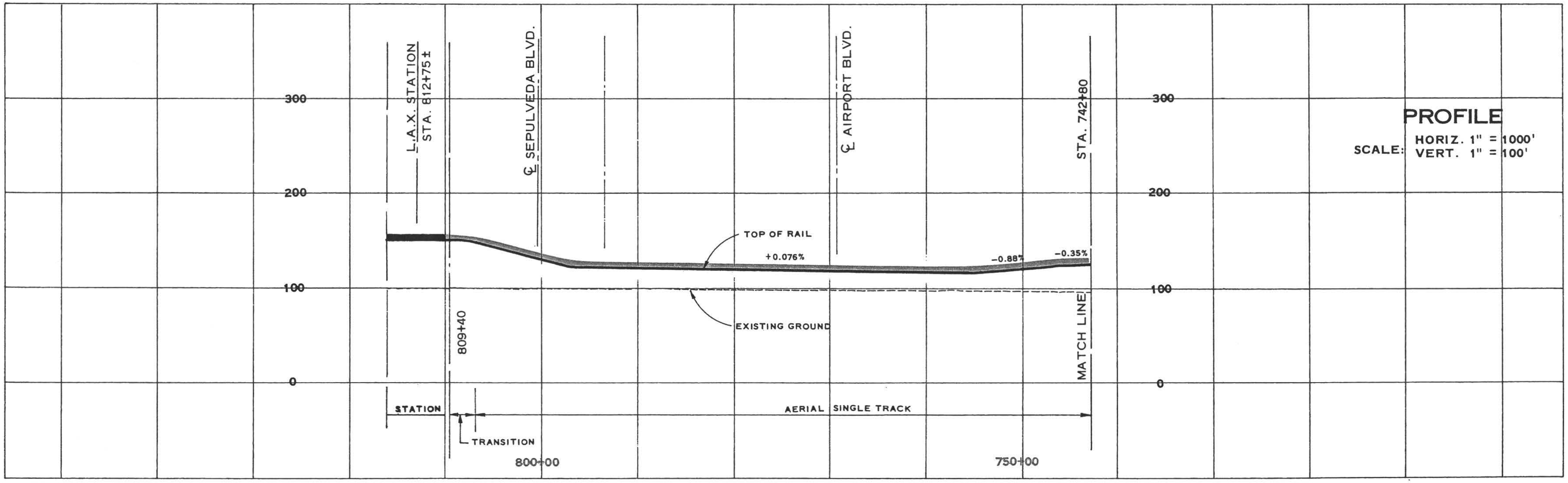

300
200
100
MATCH LINE
STA. 620+00
-2.22%
℄ EUCALYPTUS AVE.
-0.35%
℄ INGLEWOOD AVE.
+0.74%
℄ SAN DIEGO FWY.
TOP OF RAIL
EXISTING BRIDGE
EXISTING GROUND
-0.05%
℄ MANCHESTER BLVD.
MANCHESTER STATION
STA. 698+00
-1.03%
℄ ARBOR VITAE ST.
-0.35%
CENTURY STATION
STA. 748+90
℄ CENTURY BLVD.
-3.10%
TUNNEL PORTAL
MATCH LINE STA. 780+00
PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
STATION
AERIAL STRUCTURE
RETAINED CUT
RETAINED FILL
SUBWAY
650+00
700+00
750+00

MAN
30


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'
MATCH LINE
STA. 780+00
SUBWAY
TUNNEL PORTAL
0
100
200
300
+0.06%
800+00
℄ IMPERIAL HWY.
NEW STREET BRIDGE
RETAINED CUT
+0.40%
+3.00%
℄ 120TH ST.
AERIAL STRUCTURE
+0.11%
+1.48%
850+00
STATION
EL SEGUNDO STATION
STA. 853+00
-0.10%
℄ EL SEGUNDO BLVD.
-2.67%
-0.10%
℄ P.E. R.R.
-1.67%
EXISTING GROUND
TOP OF RAIL
-0.36%
AERIAL STRUCTURE
-0.56%
900+00
STATION
0.00%
ROSECRANS STATION
STA. 907+15
℄ ROSECRANS AVE.
AERIAL STRUCTURE
-2.50%
AT GRADE
0.00%
-1.00%
END OF TRACKS
STA. 932+00


PLAN
SCALE: 1" = 1000'
MATCH LINE
IMPERIAL HWY.
A.T. & S.F. R.R.
AVIATION BLVD.
LOS ANGELES
DOUGLAS ST.
EL SEGUNDO
EL SEGUNDO BLVD.
A.T. & S.F. R.R.
P.E. R.R.
SAN DIEGO FWY.
135TH ST.
A.T. & S.F. R.R.
ROSECRANS
ROSECRANS AVE.
MATCH LINE


PLAN
SCALE: 1" = 1000'


PROFILE
SCALE: HORIZ. 1" = 1000'
VERT. 1" = 100'