Opening Day at the Golden Gate Bridge 1937.

SAN FRANCISCO AND OAKLAND

BUILDINGS & TRANSPORT

FEATURING BAY AREA RAPID TRANSIT ENVIRONMENTAL CONTROL SYSTEM

BRIAN ROBERTS

COIT TOWER 1933

210 ft high, of reinforced concrete, even has an elevator.

VAN NESS AND MARKET CABLE CAR

The first line opened in 1873.

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BMR, Budleigh Salterton 2021.

SAN FRANCISCO BAY 1850

A forest of ship's masts, abandoned as hopeful prospectors joined the Gold Rush.

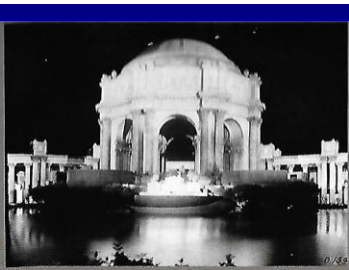
INTRODUCTION

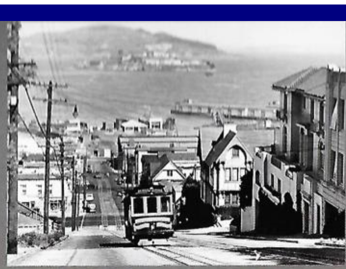
Two of the major Professional Organisations for Building Engineering Services are ASHRAE in the USA (which dates from 1894) and CIBSE in the UK (from 1897). For many years, both dealt mainly with those topics of interest to engineers in their own country. From the 1960s, this began to change and now both Organisations have Chapters and Groups in many other countries. The Heritage Group also researches and records historic on buildings and engineering services outside of the UK with representatives in Australia, France, Italy, the Netherlands and the United States.

This booklet, in the series on Architecture and Engineering Services in major cities of the USA, looks at two cities- San Francisco and Oakland, both in the Bay area, and in the 1970s linked by Mass Transit rail which included an immersed tube system carrying passenger trains under water, the story of which is featured in pages 34-43.

PICTURE PARADE 1861-1945

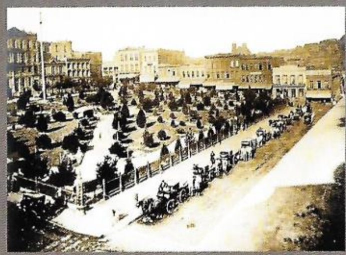

Golden Gate Bridge, 1935 p. 10


Palace of Fine Arts, 1915 p. 20

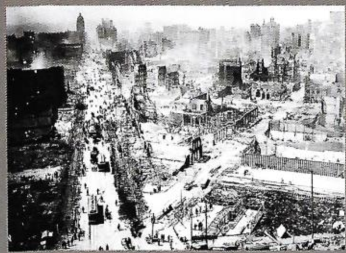

Cable Car on Hyde Street, 1945 p. 28

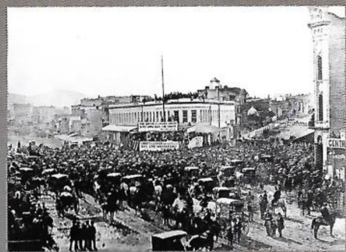

Telegraph Hill, 1865 p. 38

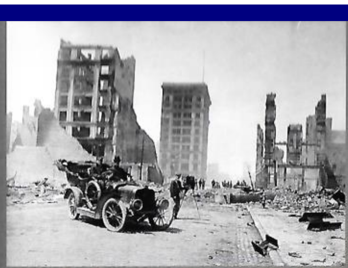

Fairmont Hotel, 1907 p. 60

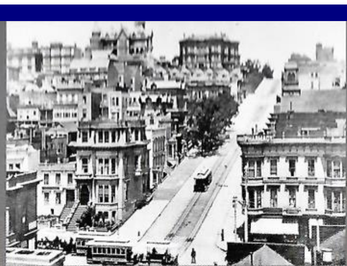

Portsmouth Square, 1865 p. 68

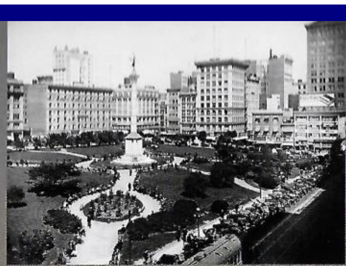

Ferry Building, 1880 p. 74


View from the Ferry Building, 1906 p. 76

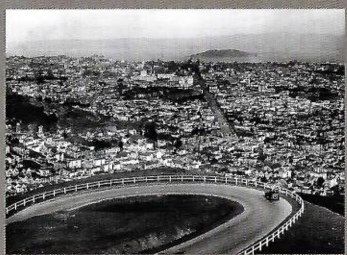

Union Rally, 1861 p. 88

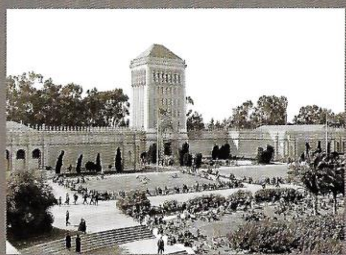

Grant Avenue at O'Farrell Street, 1906 p. 94

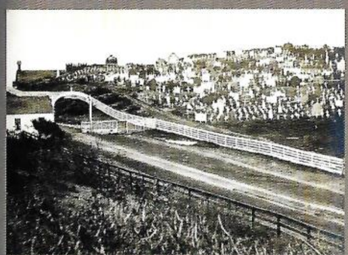

Powell Street, 1896 p. 96

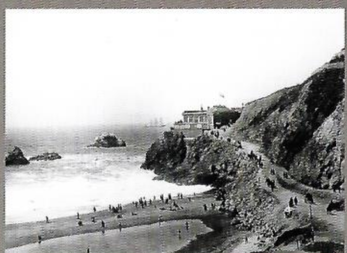

Union Square, c. 1910 p. 104


Painted Ladies on Alamo Square, 1906 p. 116


Twin Peaks Boulevard, c. 1930 p. 122

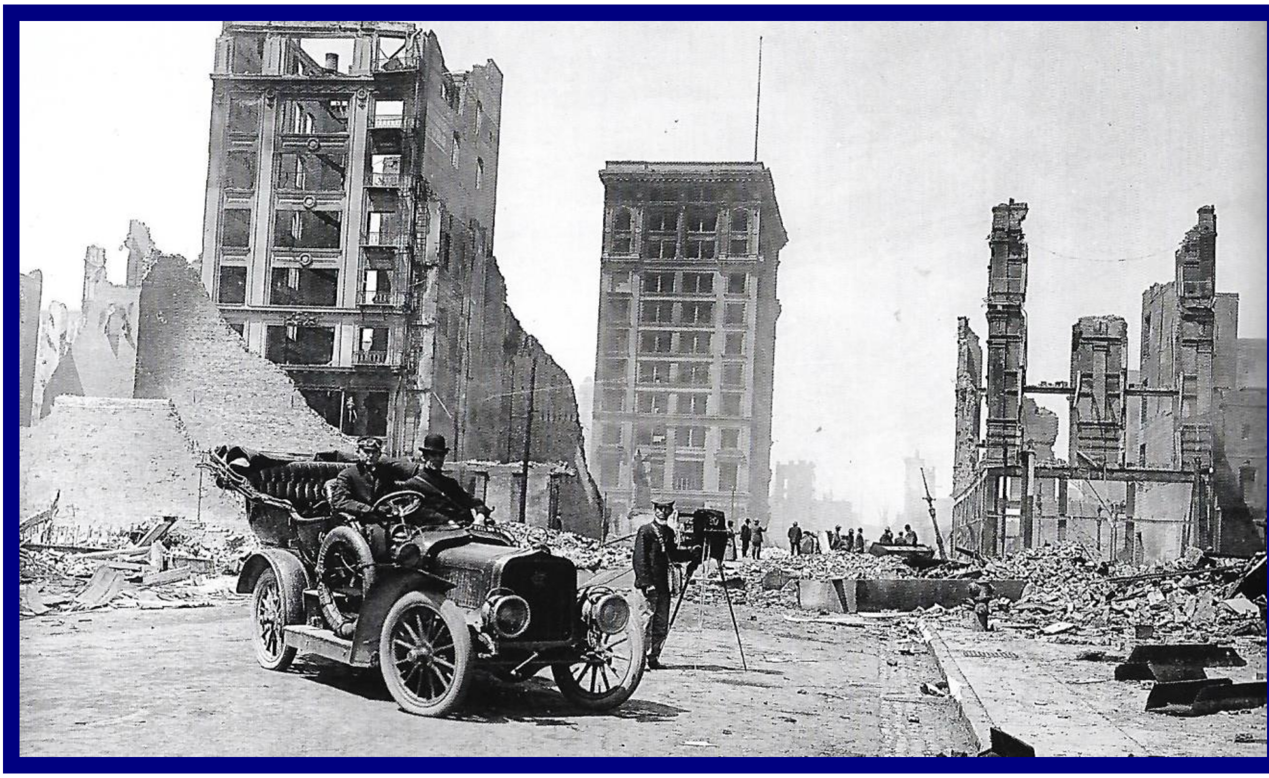

De Young Museum, c. 1930 p. 128


Point Lobos Road, 1865 p. 136


Cliff House, 1880 p. 140


Ocean Beach, c. 1920 p. 142

EARTHQUAKE & FIRE 1906

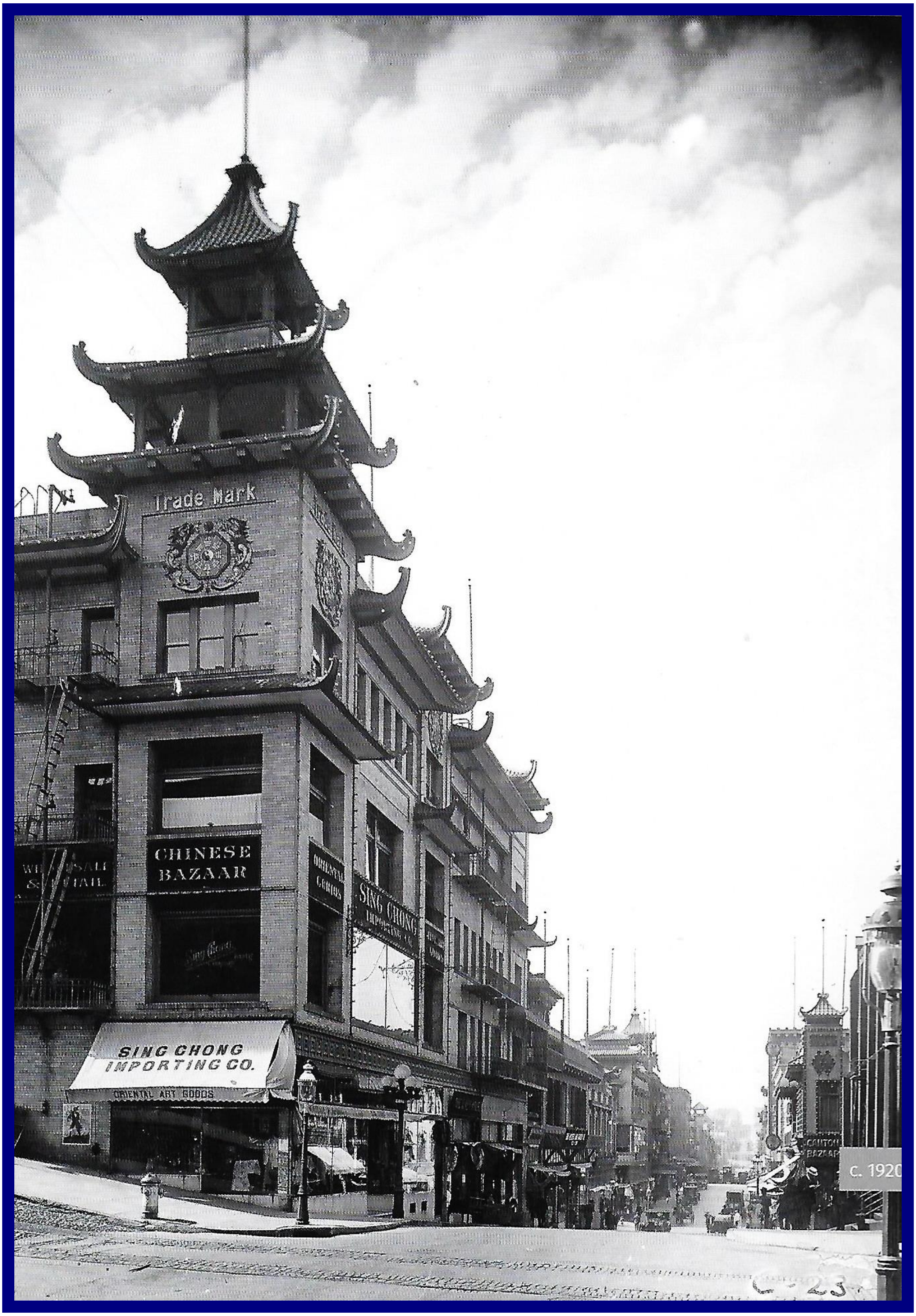


In Grant Avenue, documenting the destruction after earthquake and fire.

Devastation left by the earthquake and fire.

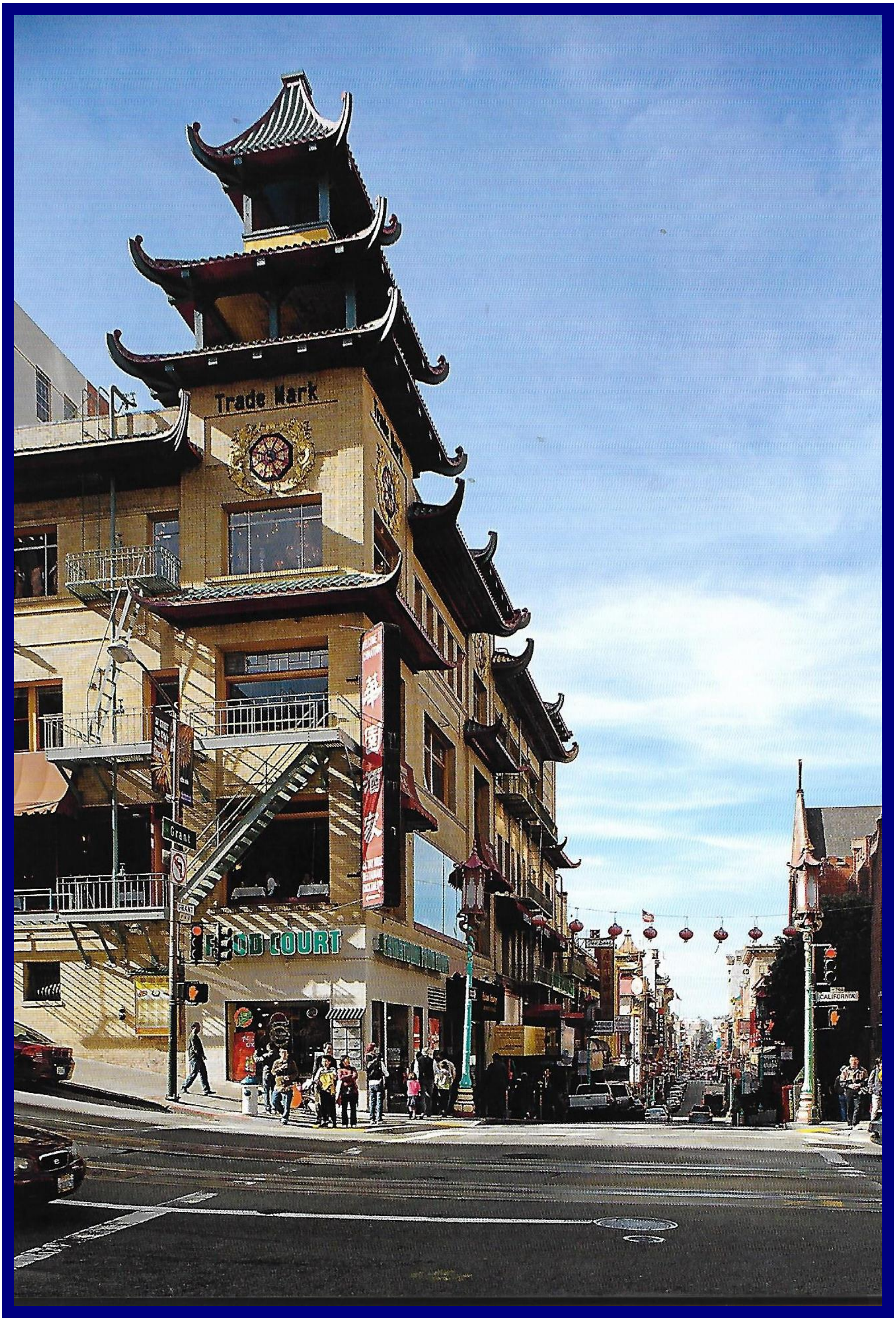
VICTORIAN PAINTED LADIES

CHINATOWN 1920



In 1894, this was the Chinatown Telephone Exchange with Chinese-speaking operators.

CHINATOWN



Now the Trade Mark Building, complete with Ground Floor Chinese Restaurant.

CITY HALL 1915

The Dome is larger than that of the US Capitol.

PALACE OF FINE ARTS 1915

Rebuilt 1964-74.

ALCATRAZ FEDERAL PRISON 1934-63

Originally a Military Prison.

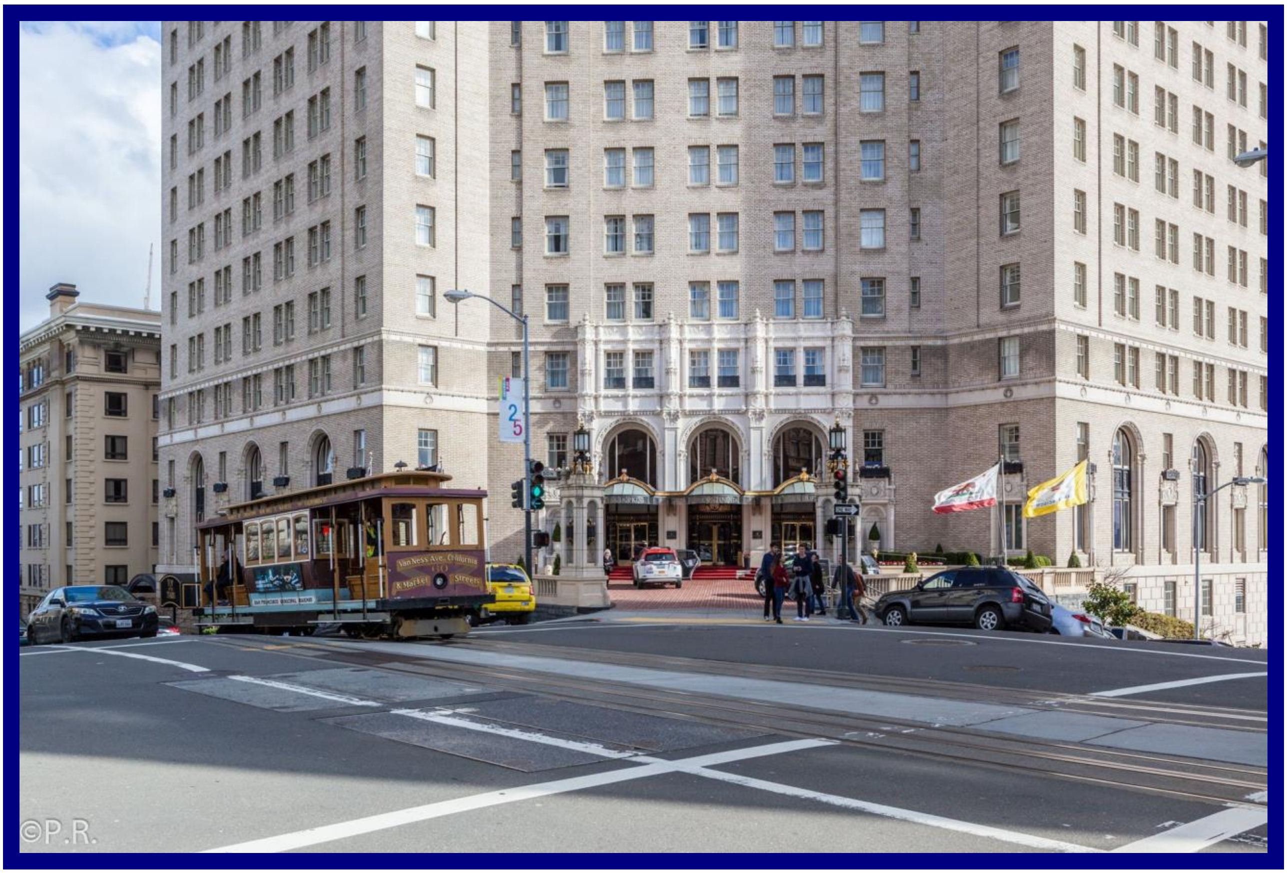
EMBARCADERO FERRY BUILDING 1898

Built on reclaimed land, the Clock Tower is 245 ft high.

FAIRMONT HOTEL 1903/7

Reopened after 1906 earthquake, 591 rooms.

MARK HOPKINS HOTEL 1926



19 floors, 380 rooms.

SIR FRANCIS DRAKE HOTEL 1928

Once 600 rooms, number now reduced.

THE SECOND PALACE HOTEL 1909

The first Hotel dates from 1875.

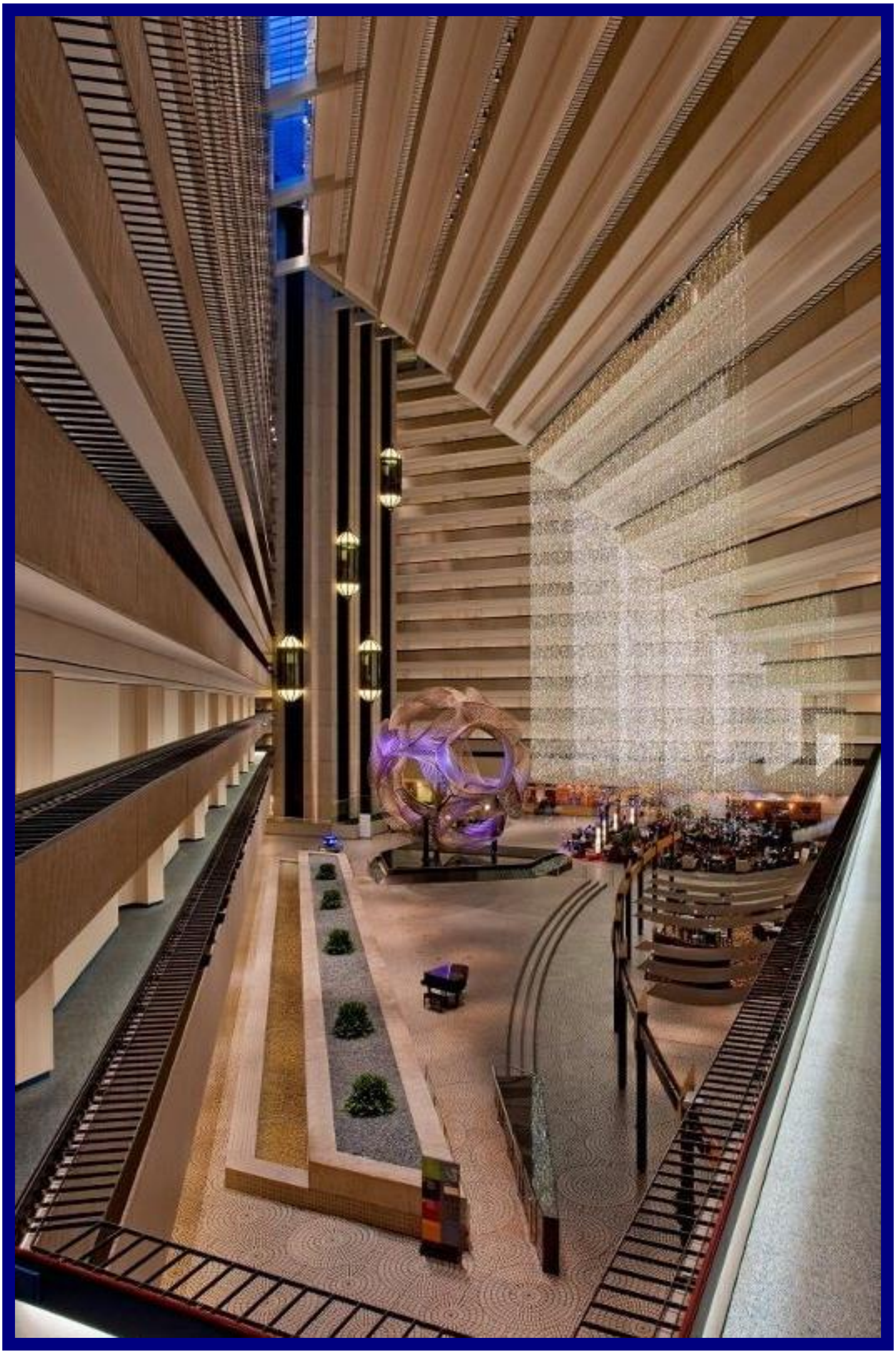
THE SECOND PALACE HOTEL 1909

568 rooms.

HYATT REGENCY HOTEL 1973

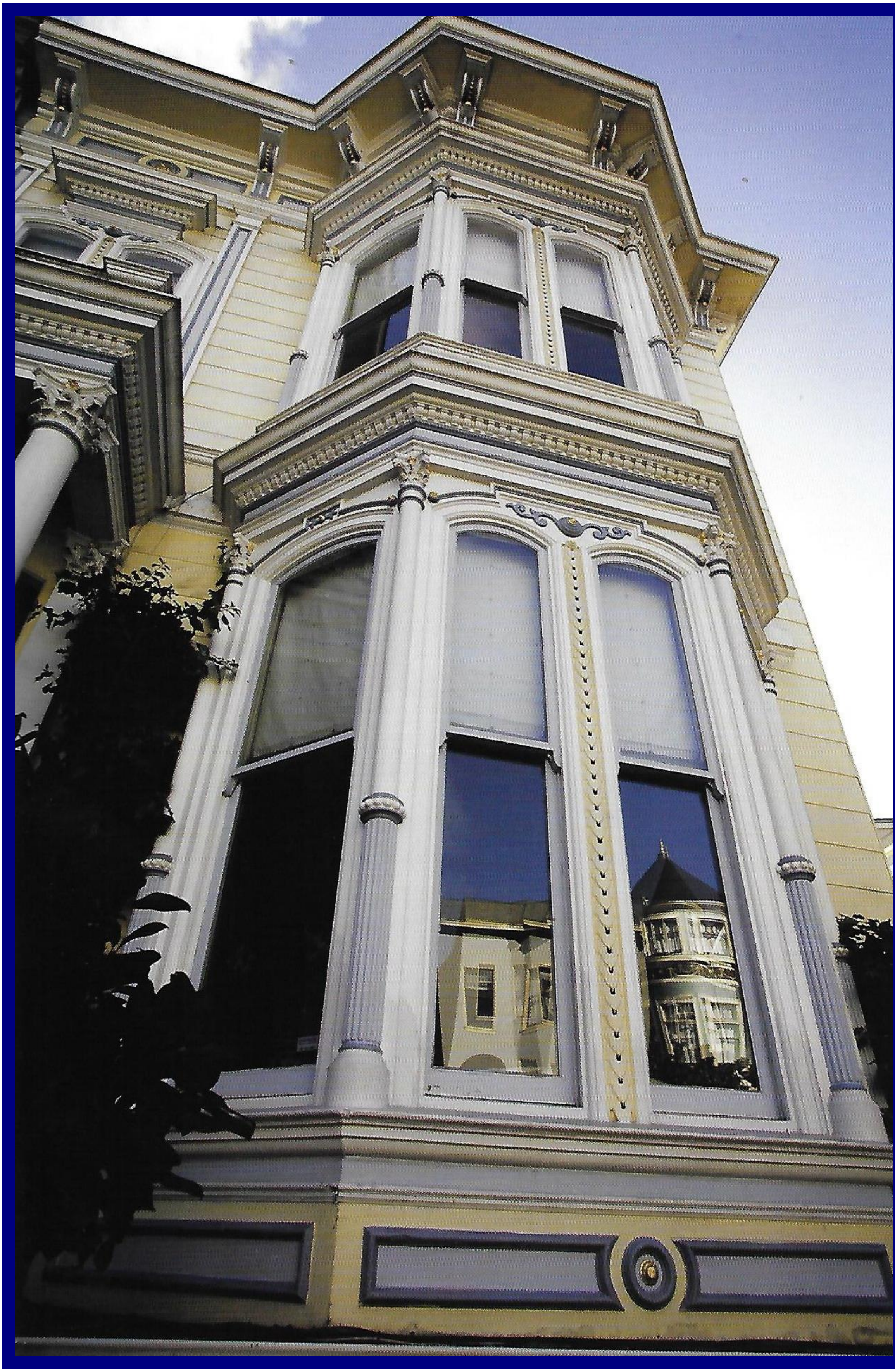
Originally a Holiday Inn.

HYATT REGENCY HOTEL

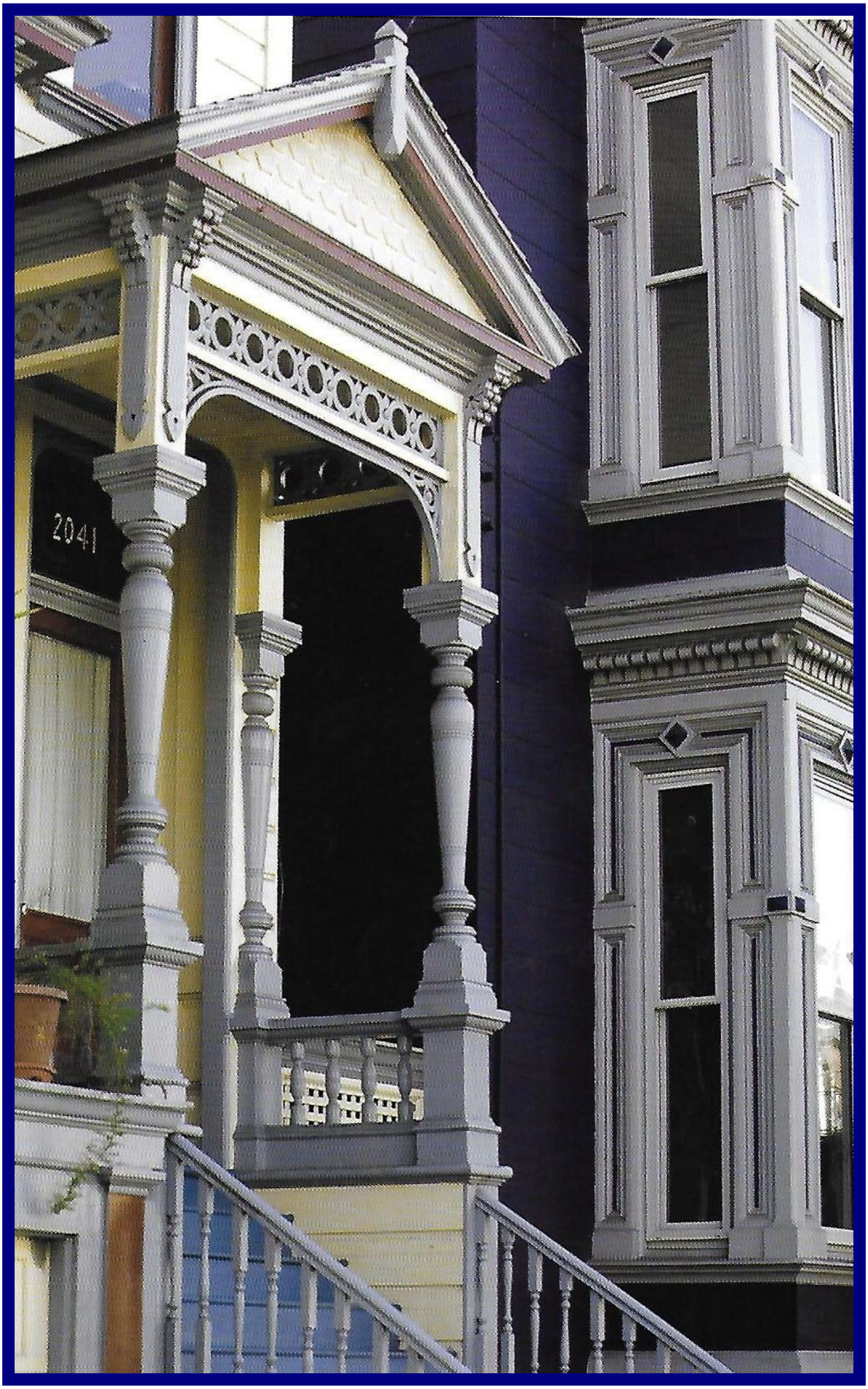


253 ft, 20 floors, 800 rooms, when opened the Atrium Lobby was the largest in the world.

VICTORIAN HOMES PAINTED LADIES

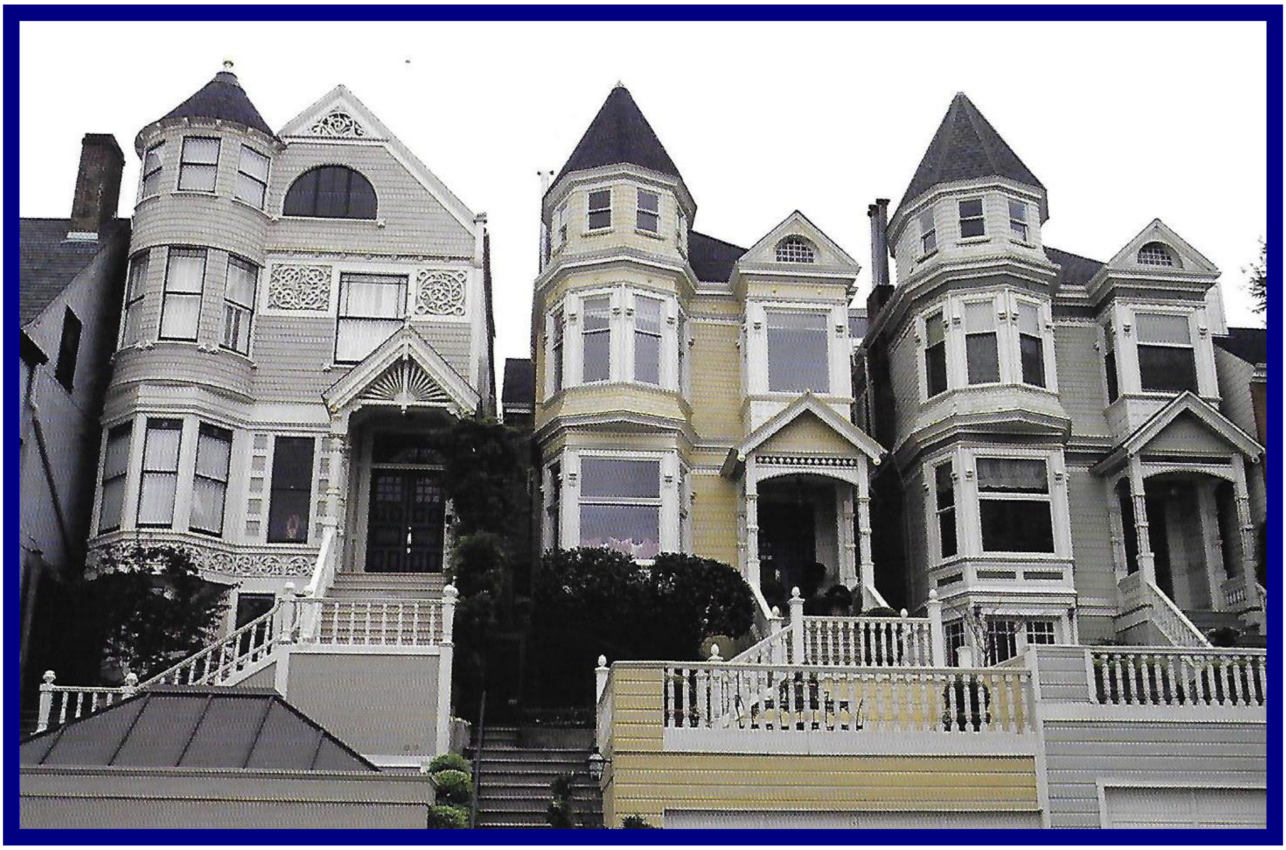


VICTORIAN HOMES PAINTED LADIES



VICTORIAN HOMES PAINTED LADIES

VICTORIAN HOMES PAINTED LADIES



VICTORIAN HOMES PAINTED LADIES

VICTORIAN HOMES PAINTED LADIES

SALESFORCE TOWER 2018

Offices, 1070 ft, 61 floors, tallest in San Francisco.

<25>

181 FREMONT 2017

Offices and Residential, 802 ft, 56 floors, third tallest in San Francisco.

555 CALIFORNIA STREET 1969

Offices, 779 ft, 52 floors. fourth tallest in San Francisco.

THE AVERY 2019

Residential, 618 ft, 56 floors, eighth tallest in San Francisco.

PARK TOWER AT TRANSBAY 2018

Offices, 605 ft, 43 floors, ninth tallest in San Francisco.

101 CALIFORNIA STREET 1982

Offices, 600 ft, 48 floors, joint tenth tallest in San Francisco.

OAKLAND CITYSCAPE

THE TRIBUNE TOWER 1906

Tower dates from 1923, 385 ft, 22 floors.

FEDERAL REALTY BUILDING 1913

Now known as the Cathedral Building, 160 ft, 14 floors, 2 elevators.

PARAMOUNT THEATRE 1931

No longer a Movie Theatre, but a Centre for the Performing Arts including Ballet and Symphony Concerts.

BART: BAY AREA RAPID TRANSIT

The Transbay Tube Route from San Francisco (right) to Oakland.

INTRODUCTION

In 1976, Drake & Scull in Hong Kong was commissioned to carry out a Design Study to identity the air conditioning and ventilation requirements of the stations and tunnels for the planned first phase of the Hong Kong subway passenger train system (known as the Modified Initial System). The writer, then General Manager of Mechanical Services in London, was seconded to lead the design team, which included PBQD (Parsons Brinkerhoff) the American Consulting Engineers. We looked at existing subway train systems in New York and Tokyo and the newly opened systems in Washington DC and that serving San Francisco and Oakland. I then worked for 6 weeks, in the New York office of PBQD at One Penn Plaza, using the Subway Environmental Simulation Computer Program, known as SES (an outline of which is given on pages 40-43). The SES was used to compute a variety of train operations over a computer model of the initial HK system and establish station air conditioning loads and the airflow in stations and tunnels caused by the "piston-effect" of moving trains.

The visit to the BART system was of particular interest because of the ventilation systems employed for the immersed tube/tunnel running 3.5 miles beneath the waters of the Bay (see pages 38-39) and at that time the longest underwater tunnel of that type in the world. Later, the HK initial system also featured an underwater tunnel connecting Hong Kong Island and Kowloon and has now been in operation since 1979. A similar concept is used in the Eurotunnel ("Chunnel") which runs beneath the English Channel and opened in 1994, having a total length of 31 miles including above water sections, connecting England and France.

BART: BAY AREA RAPID TRANSIT

Passenger cars have an aluminium body with air conditioning, each car powered by four 150 hp axle motors fed from a 1000-volt DC third rail system of 5' 6" track gauge.

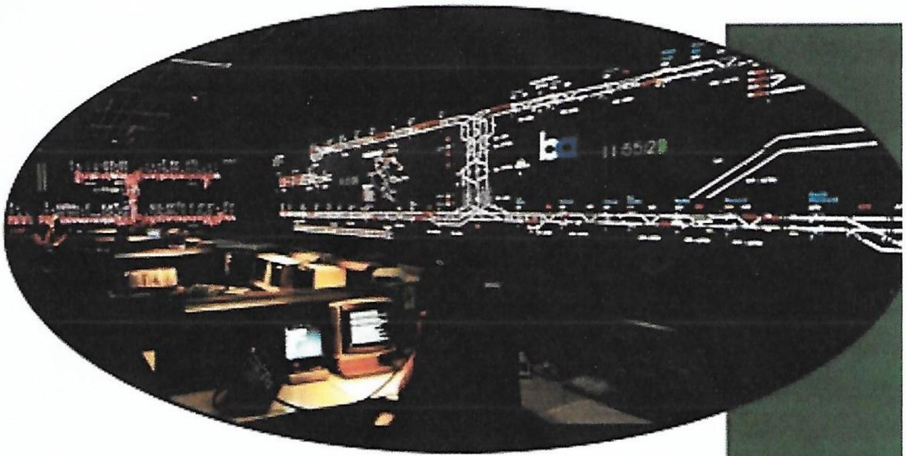
When visited in 1976 the original air-conditioned control room is said to have had the largest monitor display boards in the USA, showing electricity supply status at all points in the system, location and movement of trains and operation of ventilation fans. All now replaced by computer imaging and video projection.

BART: BAY AREA RAPID TRANSIT

BART

is the only rapid transit system to be deemed worthy of "National Landmark" status by the American Society of Mechanical Engineers International. The heart of BART is in its commitment to service and quality, and in its engineering and other design details. Every day, BART serves a complex geographical area with continuing attention to state-of-the-art technology, engineering and electrical innovation, and the utmost in professionalism.

San Francisco Bay Area Rapid Transit District



• control central - the nerve center of BART

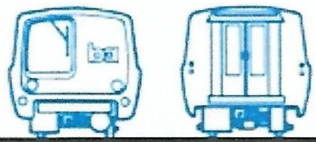
Tucked away in the Oakland building that houses the Bay Area Rapid Transit District's main offices is an unobtrusive door with a red light on the wall beside it. There is no sign on the door, and the hall is nondescript. All this understatement is fitting, because this is the nerve center of BART. Known as Operations Control Center, it is here that one can truly understand the depth, breadth and scope of the BART operation.

Upon entering the large room, one is faced with 65 feet of wall space displaying 96 miles of track and up to 56 trains in service at any one time throughout the system. Numerous schematic displays illustrate everything about the rapid transit system's operations. Colored lights denote electrified rails, moving and non-moving cars, location markers, ventilation settings in the Tube and tunnels, and scores of other tidbits of information.

The calm and hushed atmosphere in the room gives little hint of the organized flurry of activity taking place in the "real world" outside the symbolic one displayed on the walls of Operations Control Center — all geared to helping make BART transportation throughout four counties as smooth, efficient and comfortable as possible. Outside, 1.5 million trips each week are taken by the region's three million inhabitants.

1863	1900	1904	1907	
LondonUnderground opens	Paris Metro opens	New York City Subway system opens	Philadelphia rapid transit system opens	NO NEW SYSTEMS BUILT

BART: BAY AREA RAPID TRANSIT

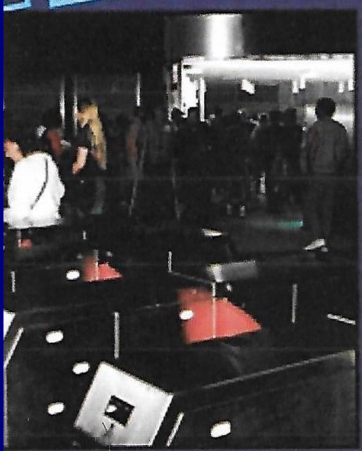


automatic train control

The nevre centre of the world's first fully automatic train control system is housed in Operations Control Center, a vast room that is dark save for the subdued desk lights of a baker's dozen of U-shaped workstations, including an elevated supervisor's pit. The centerpiece of everyone's attention is the wall display detailing the BART train operation in progress.

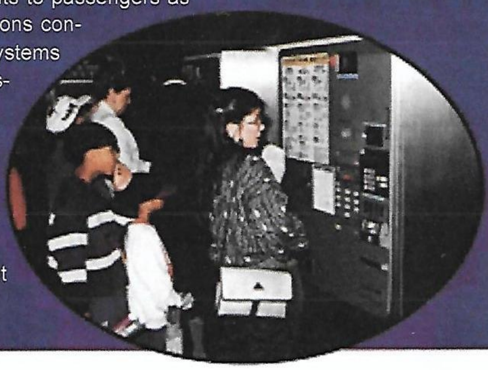
maintenance & service

A fleet of 670 train cars, 96 miles of track, and all other electrical and mechanical equipment are maintained and serviced by some 3,000 BART employees. Yards in Concord, Hayward, Daly City and Richmond provide efficient and convenient attention to the full spectrum of BART needs.



passenger stations

BART stations have won numerous awards for design and functionality. Purposefully airy and full of light, the 39 stations of the system feature electronic processing of tickets — introduced by BART to American rail transportation — and computer monitors and displays which beam information, entertainment and commercial announcements to passengers as they wait for trains. Many stations connect with other mass transit systems to yield an efficient flow of passenger transit throughout the busy Bay Area. An important BART system tenet is to foster integration of a variety of transportation entities in order to serve the ever-changing needs of a vital and spread out business and residential hub.



N AMERICA

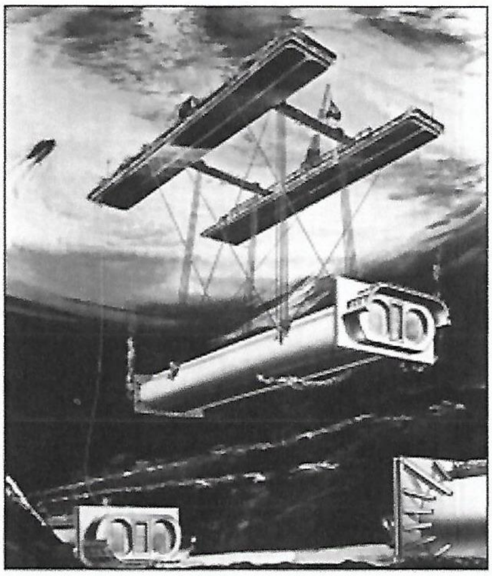
1964	1972	1995	1996	1996	1997
San Francisco Bay Area Rapid Transit System breaks ground for Diablo Test Track	BART opens first line, Fremont to MacArthur Station In Oakland	BART extension opens to North Concord	BART extension opens to Colma	BART extension opens to Pittsburg/Bay Point	BART extension opens to Dublin/Pleasanton

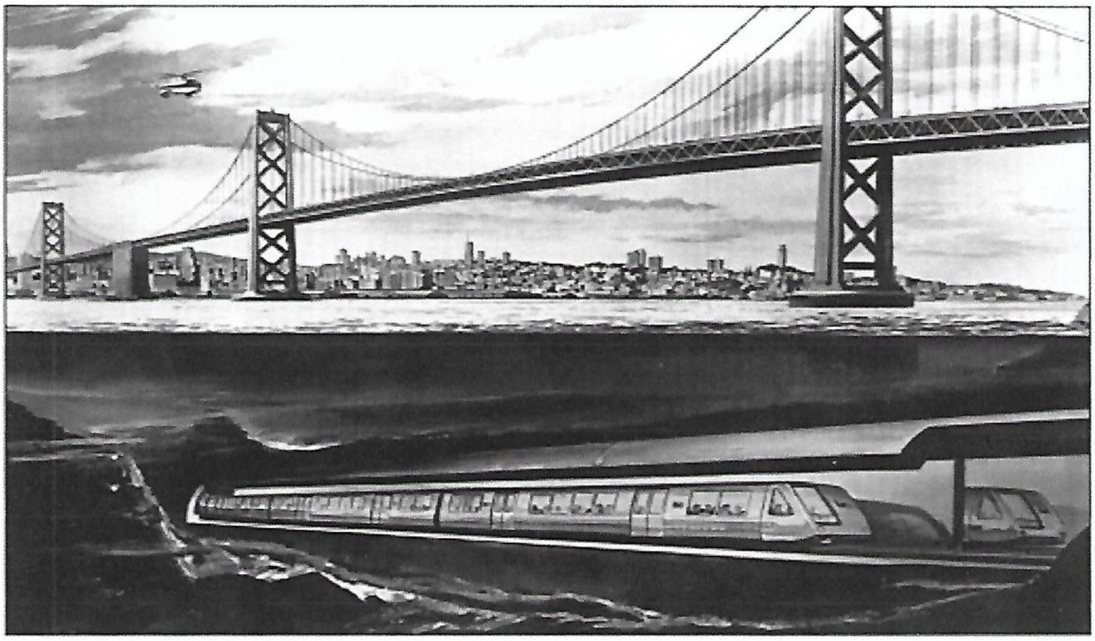
BART: BAY AREA RAPID TRANSIT

Innovations

The Transbay Tube

The BART Transbay Tube is the longest underwater tube of its kind in the world. It's ventilation system — pioneered by BART — has been adapted by other underwater systems throughout the world.





BART: BAY AREA RAPID TRANSIT

Tube Construction

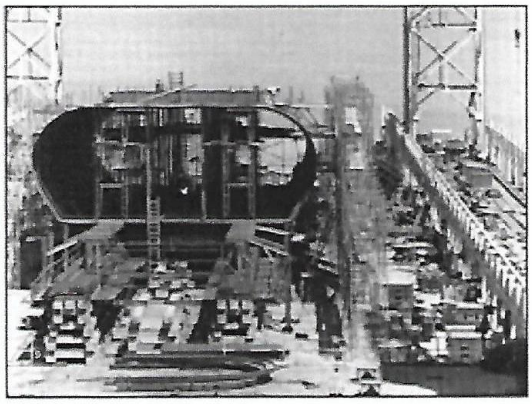
The BART Transbay Tube, opened in 1974, was a remarkable feat. At that time, it was the longest underwater tunnel of any kind in the world, and its design and construction were internationally lauded by engineers and other professionals.

Nestled in a man-made trench and traversing the floor of the Bay for 3.5 miles, the Transbay Tube is comprised of fifty-seven 350-foot exterior steel and concrete-lined sections. Sections were joined underwater using sophisticated mechanical engineering methods. The steel exterior is protected by 20 huge anodes placed in the water to control corrosion.

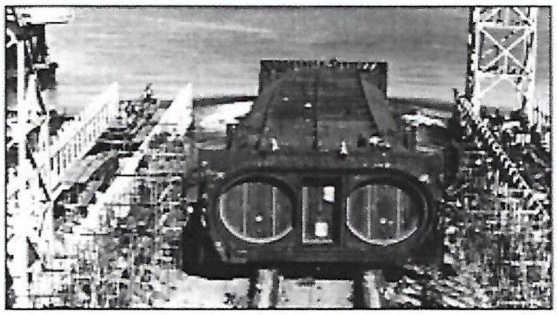
Some 130 feet below the Bay's surface, the tube structure connects San Francisco with Oakland. The structure includes two tunnels with tracks and a "gallery" area running the length of the tube between them. The gallery is divided into two chambers; one serves for maintenance access and the distribution of various electrical and safety systems, and the topmost chamber serves as an air duct for the ventilation system pioneered by BART.

Significantly, the Transbay Tube is considered by many as probably the safest place to be in an earthquake. Says 25-year BART veteran Mark Rubenaker, track department foreman, "The tube is where I want to be when the Big One hits!" The structure was designed to be flexible at each of its 57 sections, and the entire tube can flex naturally as much as 4-6 feet.

In 1989, BART withstood the powerful earthquake which devastated many of San Francisco's highways and bridges. In fact, the system was checked and back up and running within three hours of the record-setting earthquake — as the only fully operational means of transport in the Bay Area.



The BART Transbay Tube under construction.



Transbay Tube section being prepared for launch.

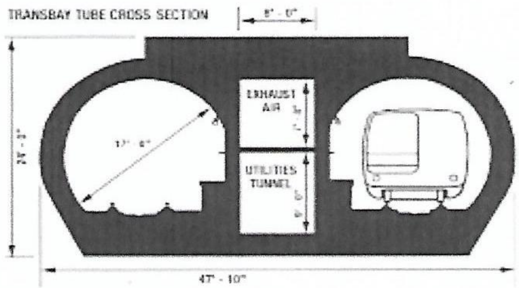
Ventilation System

Of special note is the BART system's ventilation system. Traditionally, tunnels of any type rely on the piston-like action of the vehicles passing through to vent air into and out of the tube.

BART designers specified the use of forced ventilation, made possible by power-driven propellers at every transit station, together with a system of dampers in the Tube which could be remotely controlled from Central consistent with the conditions at hand.

In the Transbay Tube, large blowers move 300,000 cubic feet of air per minute along a shaft located along the topmost duct-type chamber of the tube structure. Reversible 6'x12' louvers, each with a motor and controlled by Central, are located every second section of the 57 total sections.

In testimony to the lasting efficacy of BART designs, the England-to-France "Chunnel" (completed more than 20 years later) utilizes the same concept.



SUBWAY ENVIRONMENTAL CONTROL

Background

The control of environment in the underground portions of fixed guideway mass transit systems has in recent years come to the fore as a significant systemwide element. Today's generation of high-performance, air-conditioned rolling stock produces large quantities of heat which, if not properly dealt with, lead to patron discomfort and possibly even distress. The transit system proposed for Hong Kong presents factors which make proper engineering of the Environmental Control System (ECS) even more critical. Not only does Hong Kong experience severe temperature and humidity ambient conditions for many months of the year, but the urban railway is being designed to carry almost twice the maximum passenger loading of other comparable systems (Ref. 1).

The Hong Kong Mass Transit Railway Corporation (MTRC) recognised the potential consequences of an uncertain ECS, both in terms of reduced ridership and patron safety. This recognition led to the commissioning of Drake & Scull Engineering Ltd. in association with Parsons Brinckerhoff Quade and Douglas Inc. to undertake a study of ECS performance goals and alternative engineering solutions leading to positive recommendations on the most viable and economical concept for that portion of the Mass Transit Railway known as the Modified Initial System (MIS) (Ref. 2).

Implementation of this two-month Initial Design Study (IDS) was on a team basis, utilizing experienced professionals in the fields of subway environmental analysis, equipment design and performance, automated controls, and plant design and construction. Detailed, quantitative analyses of alternative ECS concepts were made possible by the use of latest state-of-the-art techniques as reflected in the Subway Environmental Design Handbook (Ref. 3) and the Subway Environment Simulation (SES) computer model (Ref. 4), developed and verified during an ambitious four year research program sponsored jointly by the United States Department of Transportaion and the the American Public Transit Association, which represents the operating transit agencies in North America.

The IDS comprised three distinct phases of work:

* **ECS Performance Goals,** including recommendations for air temperature, humidity and velocity criteria in the underground stations and tunnels during normal and emergency operating conditions.

Analysis of Alternative Engineering Solutions, including detailed performance analysis of three alternative ECS concepts under normal conditions and emergencies, and recommendation of the best concept.

* **Mechanical Systems Development,** including the development of preliminary functional specifications for major equipment required by the best ECS concept.

SUBWAY ENVIRONMENTAL CONTROL

Design Conditions

	Deg. Fdb	Deg. Fwb
Outside	90	82
Concourse	86	76
Platform	83	74
Train	80	71

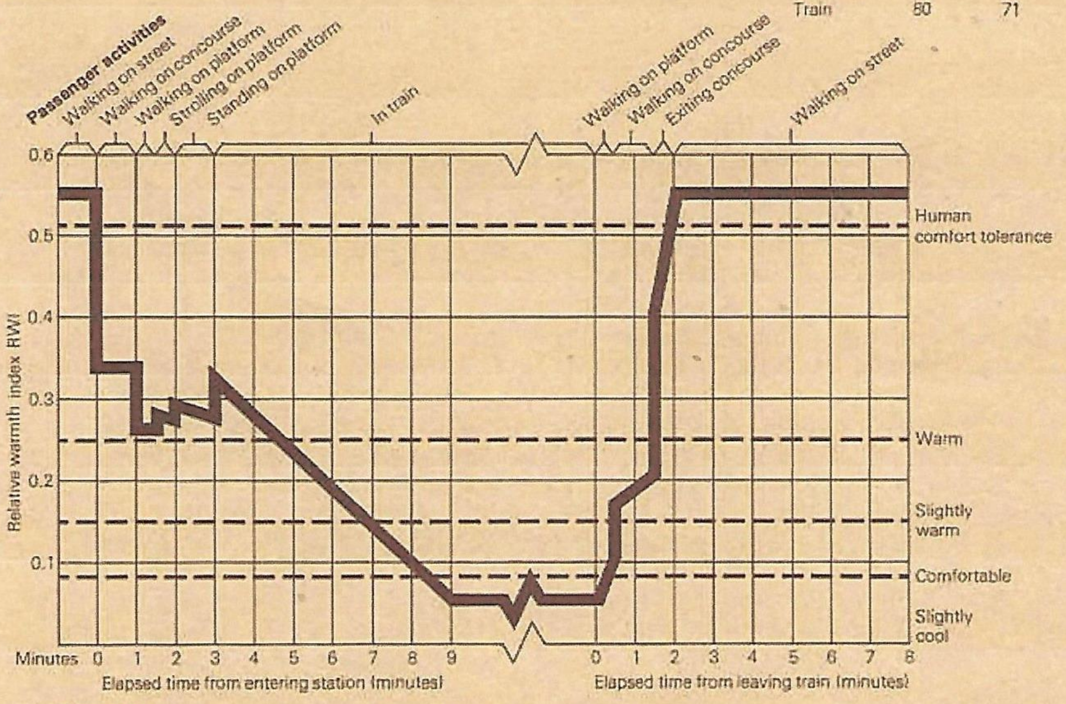


Figure 1
Relative warmth histogram in subway system: Evening rush period

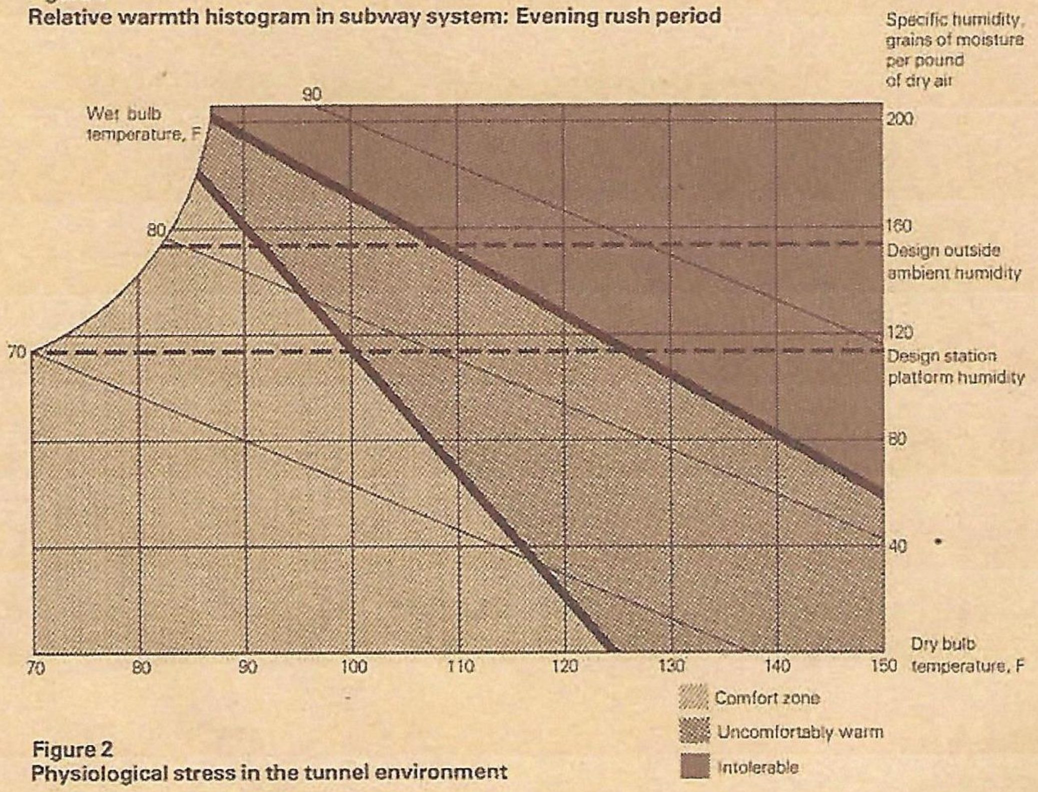


Figure 2
Physiological stress in the tunnel environment

SUBWAY ENVIRONMENTAL CONTROL

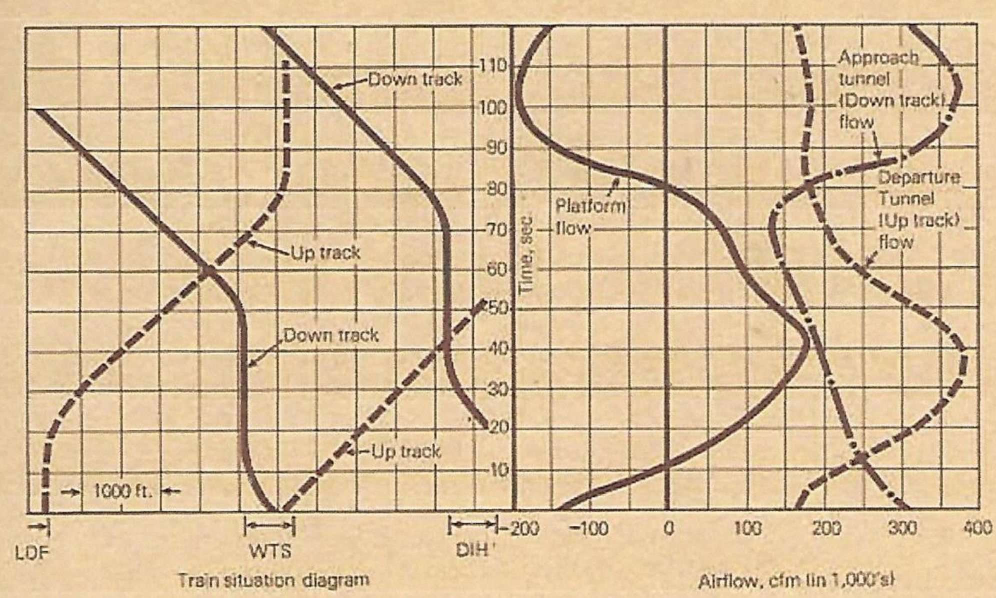


Figure 4
SES-Computed airflow at Wong Tai Sin Station: Closed system, normal operation

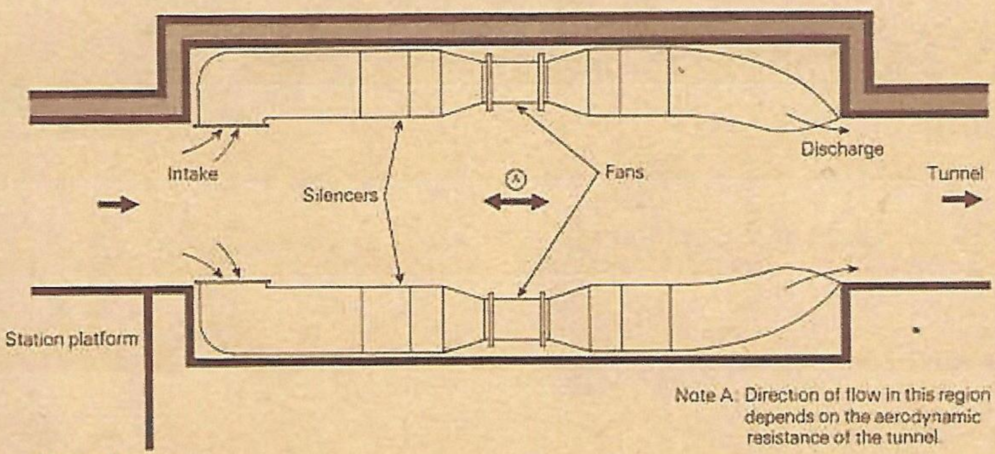


Figure 5
Impulse fan system schematic

SUBWAY ENVIRONMENTAL CONTROL

Conclusions

The Closed System ECS has been selected by the Mass Transit Railway Corporation for implementation in the underground portion of the Modified Initial System. Properly engineered and operated, this ECS will provide fully for the comfort and safety of patrons and the protection of equipment.

Although the Closed System is conceptually simple and straightforward, the overall performance of the ECS is tied closely to the coordinated functioning and interaction of all of the ECS components. These components are linked in the Closed System to a degree never before encountered in subway environmental control by the direct, unattenuated aerodynamic and thermodynamic communication among the stations and tunnels. As a consequence, such normally occuring phenomena as train-generated piston-action air flow and ground heat sink effect assume major roles in the ECS performance and can cause adverse cascading effects unless they are accurately anticipated and employed to advantage.

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PALACE HOTEL SAN FRANCISCO 1906

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