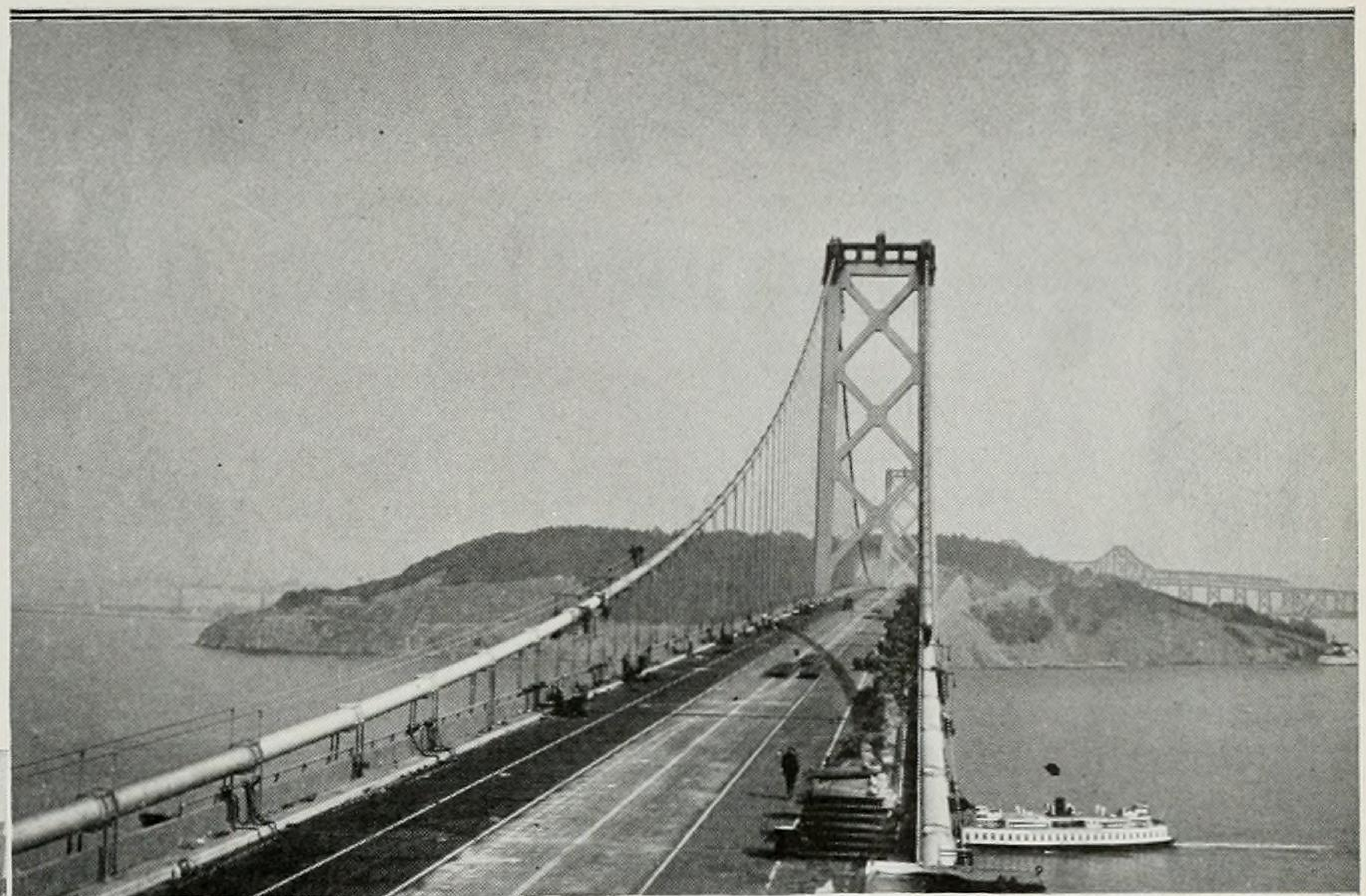
View of West Bay Crossing of San Francisco-Oakland Bay Bridge looking toward San Francisco showing paving laid on center lane.

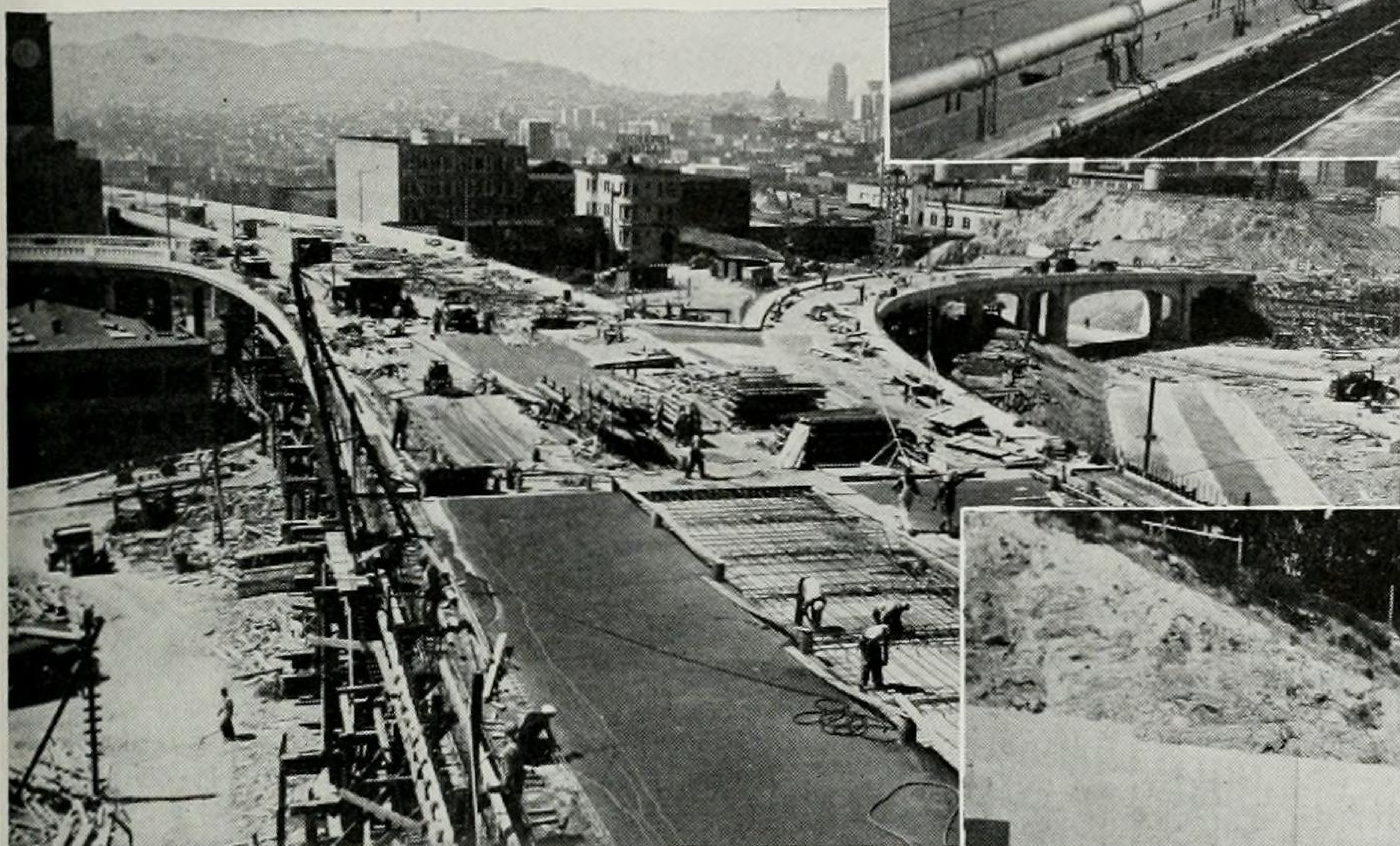
Col. Willard Chevalier, President of the American Road Builders Association, thumbs first ride over East Bay Crossing from Chief Engineer C. H. Purcell.

BAY BRIDGE FINISHING SCENES

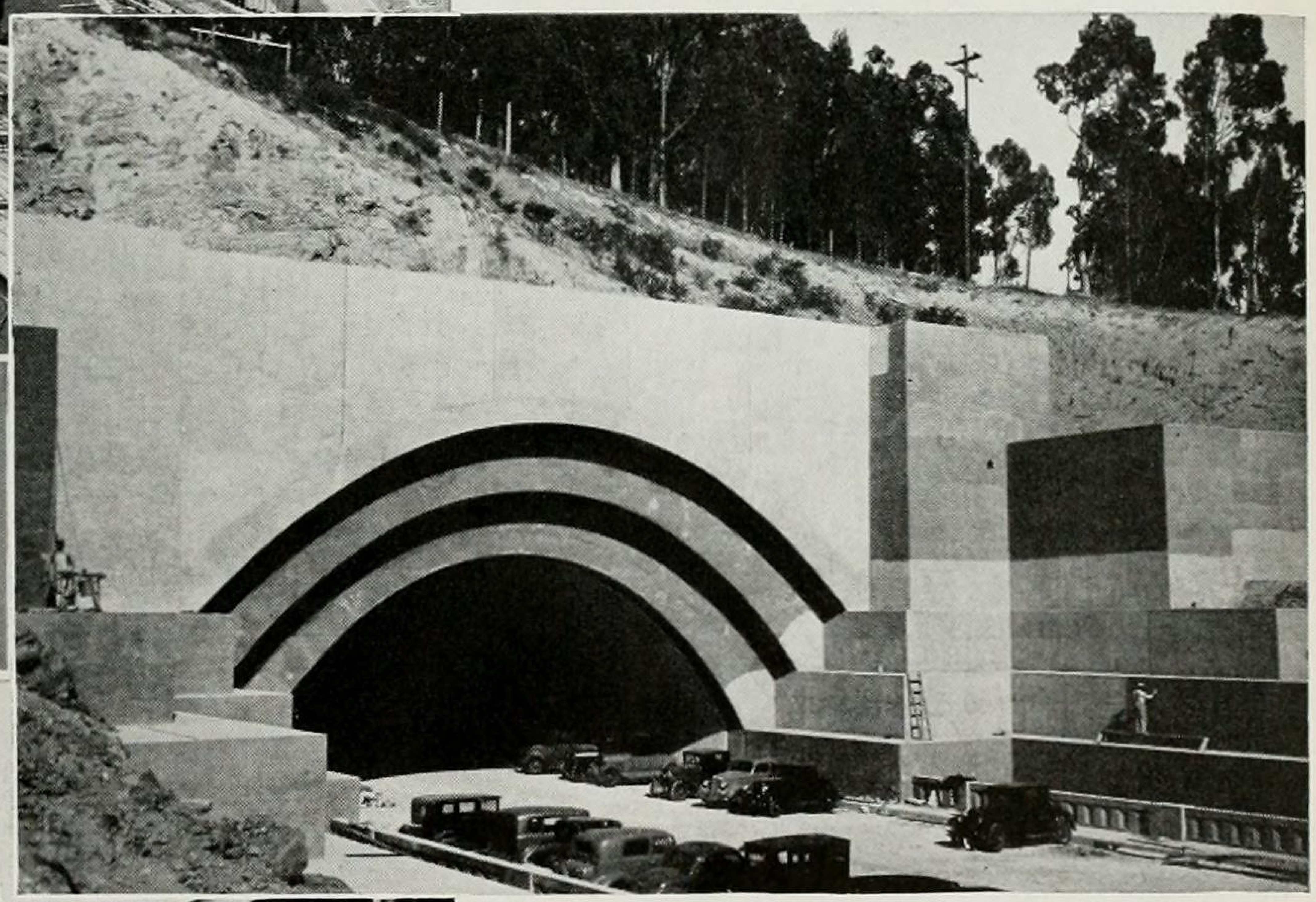
At right—View of upper deck of suspension span with its six traffic lanes completely paved.

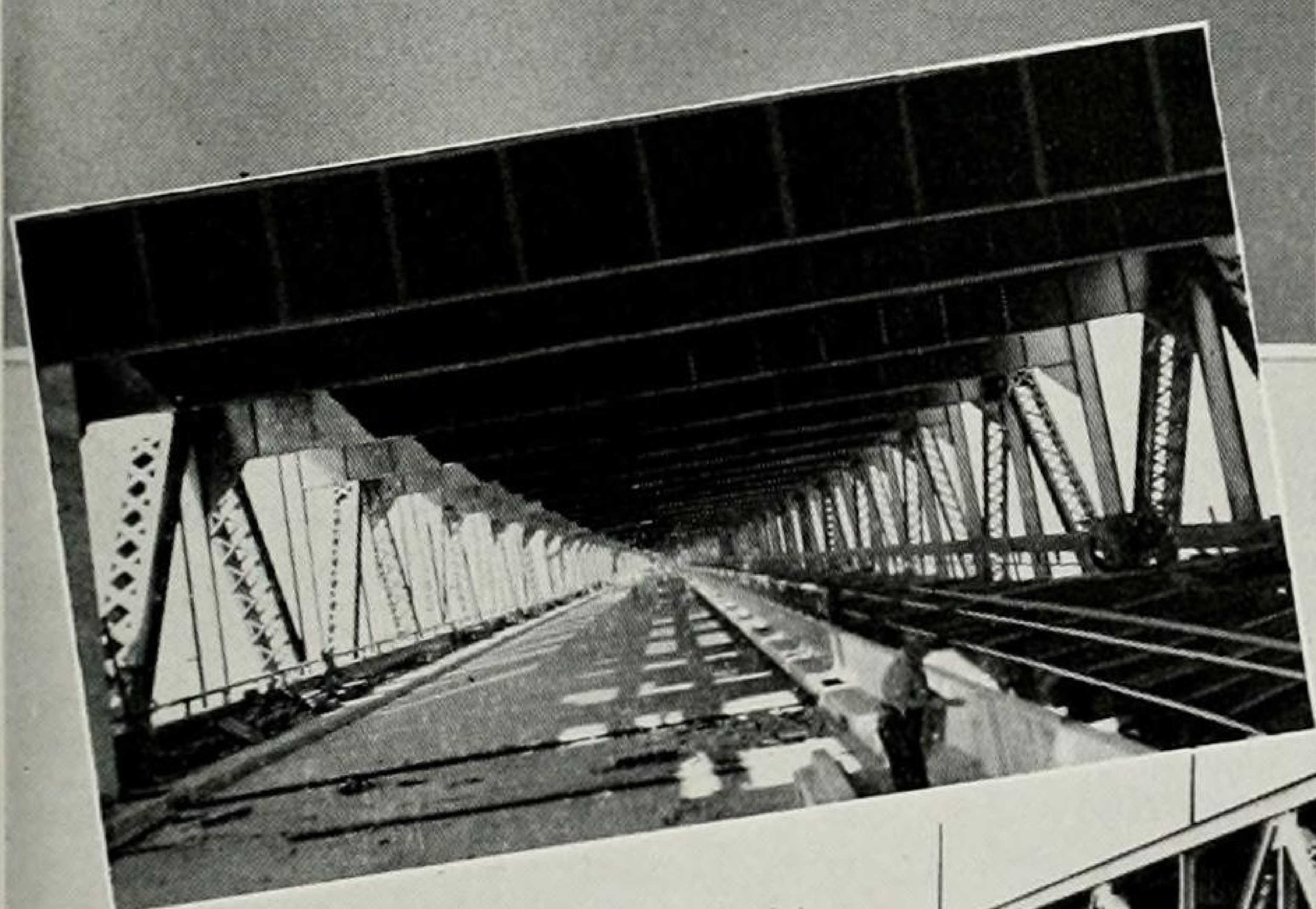
Below—San Francisco end of top deck showing main central approach to Fifth Street Plaza with off-ramp (right) to Clementina and First streets and on-ramp from Harrison and Fremont.

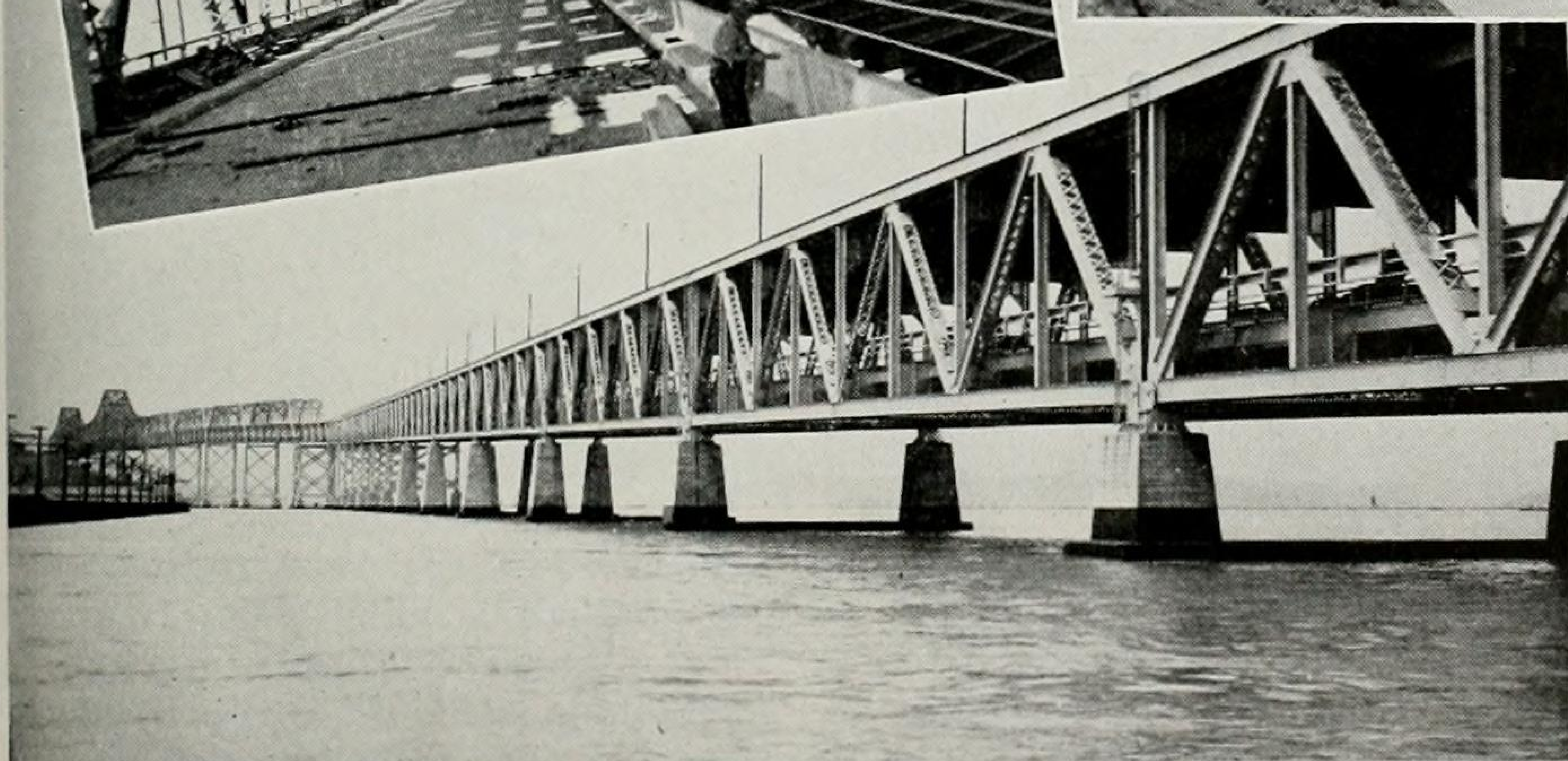




Below—View of top deck entrance to tunnel through Yerba Buena Island.







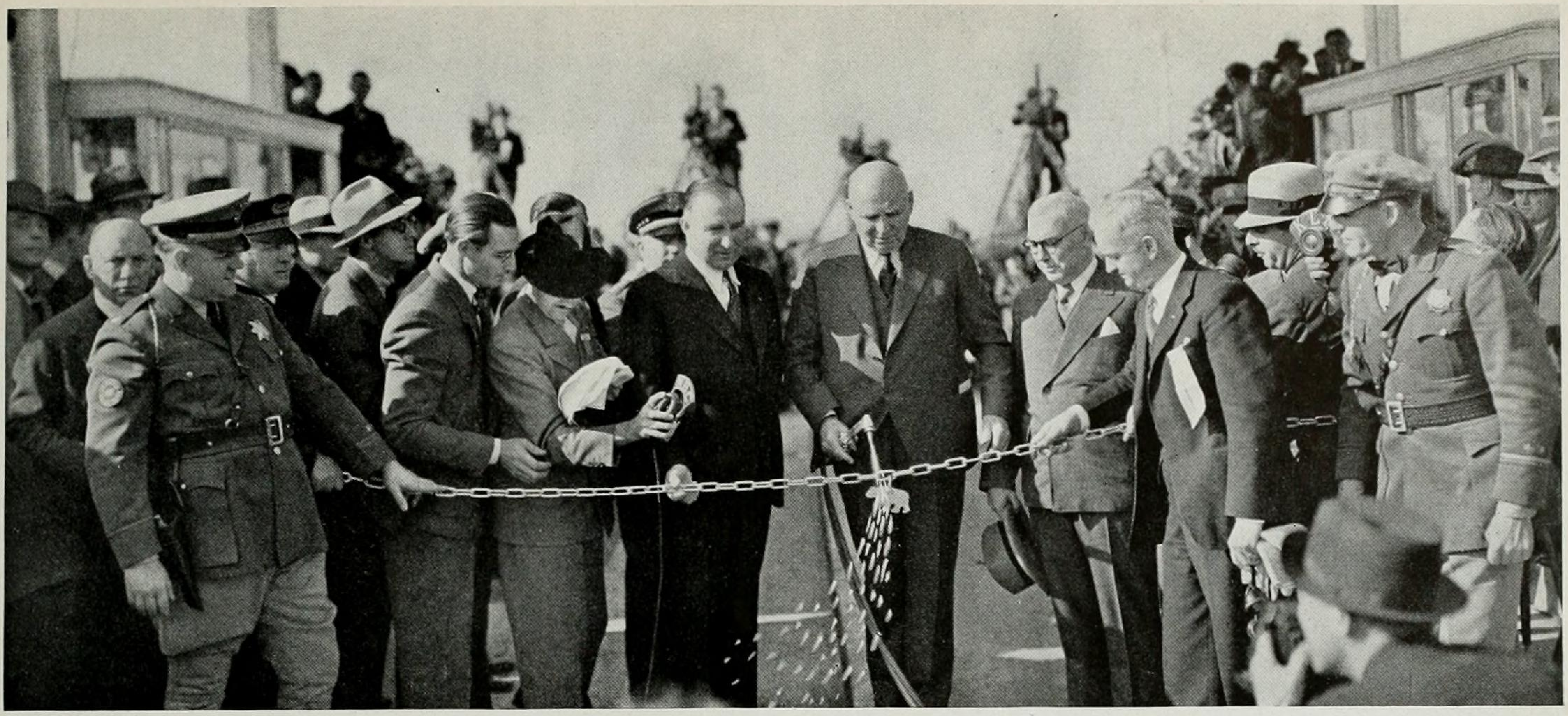
At left—Views of the lower bridge deck with its three-lane paved roadway for trucks and two tracks for railway cars.

CALIFORNIA
HIGHWAYS AND PUBLIC WORKS

San Francisco-Oakland Bay Bridge
Dedication Number
November 1936

Official Journal of the Department of Public Works

Cantilever Span and East Bay Approach Structure as Seen from Yerba Buena Island



Flanked by Earl Lee Kelly, Director of Public Works (left) and Chief Engineer C. H. Purcell (right), Governor Frank F. Merriam burns first barrier on Oakland side of Bay Bridge.

Burning Barriers, Governor Merriam Opens San Francisco-Oakland Bay Bridge

AN ACETYLENE torch in the hands of Governor Frank F. Merriam burned asunder a heavy chain barrier; an electric button pressed by President Roosevelt in the White House in Washington flashed the green "Go" signal and three columns of whirring automobiles sped from each shore of San Francisco Bay over six lanes of the world's greatest aerial highway—the San Francisco-Oakland Bay Bridge—a half hour after noon on November 12, 1936.

Cannons roared, bombs burst in air, sirens and whistles shrieked and massed thousands of enthusiastic citizens at the east and west approaches to the great structure blasted the welkin with their cheers.

California's long dreamed of bridge across the bay of San Francisco had become a reality.

With the formal opening of the huge span to automobile and truck traffic, the curtain rose on the highway drama of wheels over San Francisco Bay that will present a continuous performance to be enjoyed by future generations down through the centuries.

During the first 108 hours of its operation as a State Highway this record breaking bridge broke all traffic and safety records by carrying more than 250,000 autos, buses and trucks and approximately one million persons without one serious accident. Traffic experts have figured that for each 100,000 cars traveling at highway speed there are three fatal accidents in each cycle of twenty-four hours. The only mishaps were bent fenders and bumpers.

The setting of this remarkable record was attributed to the bridge's six traffic lanes, its unsurpassed night lighting system, the segregation of truck and auto traffic on different decks and efficient handling of an unprecedented traffic situation by the California Highway Patrol.

This safety record climaxed a day of thrilling events on land and sea beginning with impressively staged dedication ceremonies at both the Oakland and San Francisco plazas marked by stirring speeches by noted state and national figures, the cheering of jubilant throngs, a spectacular air show by fifteen squadrons of navy planes, a colorful marine parade by scores of gaily decorated yachts and motor boats, and roaring salutes from the big guns of the United States battle fleet anchored just south of the bridge.

San Francisco and the East Bay district celebrated the opening of the bridge with a four-day festival unequalled in the history of the state. Oakland set the pace on Armistice Day with parades, a regatta on Lake Merritt, fireworks and a great military and naval ball, curtain raiser for the long-awaited opening of the structure on November 12 and the parades, pageants and festivities that were to follow in San Francisco.

STARTED AT OAKLAND END

Official dedication ceremonies began at 10 o'clock on the morning of November 12 at the toll plaza at the eastern terminus of the bridge. Here were gathered thousands of men, women and children, many of whom had passed most of the night in their automobiles in order to be among the first to cross the bridge when it was formally thrown open. They came to hear the speeches of prominent officials, leading citizens and the builders of the huge transbay struc-

Taken from water level, this photograph shows the majestic sweep of the Bay Bridge suspension spans between San Francisco and Yerba Buena Island.

ture themselves, and to see Governor Merriam cut the chain barrier that stretched across the traffic lanes soon to be opened to them.

In front of the crowd, vividly remindful of pioneer California days and slower modes of travel were an ox-drawn cart from Sacramento, a stage coach from Auburn, a prairie schooner from Woodland, an Indian with squaw and papoose on a drag from Oroville and prospectors and their burros from Placerville.

Presiding on a speakers' platform filled with notables, Harrison S. Robinson of Oakland, president of the Financial Advisory Committee, officially started the dedication ceremonies.

''This bridge,'' he said, ''is an inspiring example of the great things which can be accomplished when men work together—a modern miracle—a supreme achievement of human endeavor.''

Mayor William J. McCracken of Oakland marvelled at what the bridge engineers had achieved.

ANOTHER WORLD WONDER

''What they have produced,'' he said, ''is a world-wonder, significant in its economic, human and spiritual advantages to all of California.''

''It is the greatest engineering feat of modern times,'' declared William J. Hamilton, chairman of the Alameda County board of supervisors.

Mayor E. N. Ament of Berkeley and W. J. Buchanan, chairman of the Contra Costa County Board of supervisors expressed themselves in similar vein and were followed by former Governor C. C. Young, under whose administration preliminary steps toward the building of the bridge were taken.

''Feeling that privately owned bridges had no proper place in a great publicly owned state highway system,'' Mr. Young said, ''we laid in 1929 the legislative foundation upon which this magnificent structure has been built. A policy of public toll bridges was inaugurated. The present Toll Bridge Authority was created and given the specific task of projecting a bridge between San Francisco and Alameda counties.''

MEEK'S VISIT TO WASHINGTON

Mr. Young told of the visit B. B. Meek, then Director of the Department of Public Works, made to President Hoover in Washington in the summer of 1929 and of the cooperation he obtained from the federal government in the creation of the joint State and Federal Bridge Commission.

''The commission met and organized in my office in Sacramento, October 7, 1929,'' Mr. Young concluded. ''With the assistance of State Highway Engineer C. H. Purcell and the Department of Public Works within a year the commission had completed its study and made its report. The site had been selected. The design had been adopted. The finished product is before us.

''Hearty congratulations are due to the present State administration, which has brought this great work to so successful a conclusion. I know how happy they must be to present it to the people of California and I rejoice with them in its completion. This is a great day for all of us.''

TRIBUTE TO WORKERS

The man who built the bridge, Charles H. Purcell, Chief Engineer and State Highway Engineer, followed Mr. Young. He declared that the completion of the bridge ahead of schedule and below estimated cost is ''a tribute to the intelligence of the American working man, which can not be equalled by any other nation.''*

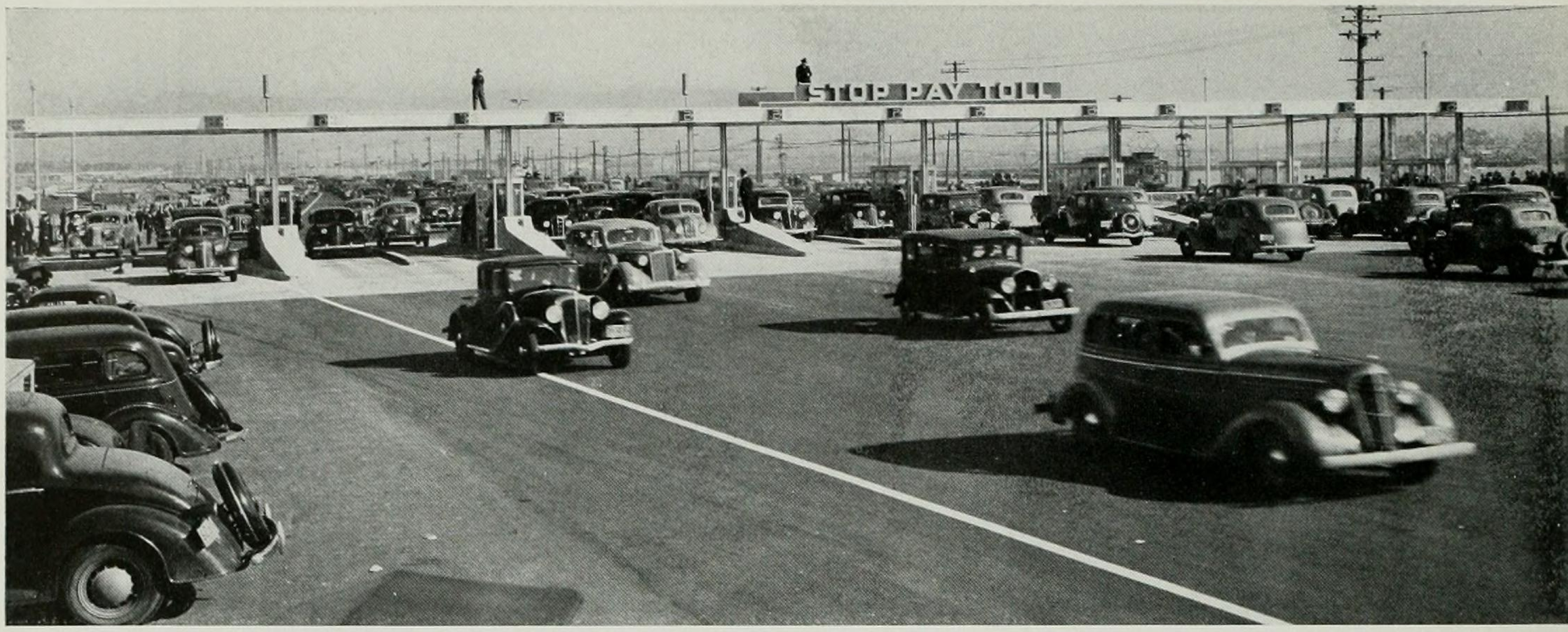
''The opening of this bridge,'' said Earl Lee Kelly, Director of the Department of Public Works, ''is the first step in eliminating the isolation of San Francisco. This isolation never will be entirely done away with until the bridge is toll free and I predict that it will be toll free in not to exceed twenty years.

''This bridge today becomes a part of our State highway system, a highway system that is equalled by none in the world. It will do much to help

* Mr. Purcell's speech in full on page 22.

Photo by Courtesy of San Francisco Examiner

Wheels over San Francisco Bay. Six traffic lanes on new bridge filled with autos. View from Yerba Buena Island to San Francisco.



The San Francisco-Oakland Bay Bridge is open for business! Photograph shows automobiles leaving toll station on Oakland side and machines from San Francisco arriving there shortly after President Roosevelt in Washington flashed by wire the "Go" signal on November 12.

the great exposition San Francisco is planning for 1939. It will bring the cities of the bay district into closer union and on this day of its dedication I am proud to sit with the Governor and distinguished guests gathered for its opening."

NO LABOR TROUBLE

Director Kelly paid a tribute to Walter Gaines, bridge foreman, for his untiring zeal and the hazardous chances he took with his men during construction of the bridge.

"I also want to express my appreciation of labor's treatment of us," said Director Kelly. "There were no labor troubles. For that I express the appreciation of the Governor and myself. Labor has been more than fair to us and I hope that we have been fair to them.

"This bridge was constructed by your highway engineers, the men who work on your highways. They are the State men who built your bridge. We did not have to employ outside engineers except in one or two instances in an advisory capacity.

"I want to express my appreciation of the untiring cooperation and wise counsel which the Governor has given to us. And I wish to thank the financial interests of San Francisco and the East Bay and the public generally for their encouragement and support."

Director Kelly expressed regret that illness prevented B. B. Meek, former Director of Public Works, from attending the dedication of the bridge "which was started under his jurisdiction."

SOUNDLY FINANCED AND BUILT

Charles Henderson, Director of the Reconstruction Finance Corporation, which loaned the money for the bridge, declared that the structure is "soundly financed and soundly built."

"Great and magnificent as this structure is," he said "it will not convey to the men, women and children crossing on its decks the unseen obstacles encountered in its building.

"Those whose engineering skill and science have created this bridge, and the men far above the water who have done the work, deserve the highest praise. It is not only a monument to the genius of Charles H. Purcell, the engineer in charge, it is a symbol of the unlimited capacity of modern men, working together through government, to unify the physical world around them.

"It is a symbol as challenging to those of us who are not scientists as the China Clipper that flies above it. Twelve minutes from San Francisco to Oakland—eighteen hours from Oakland to Honolulu.

"May we all work with equal success to unify, not alone the physical world around us, but the hearts and the goodwill of men."

High praise of the men who actually built the San Francisco-Oakland Bay Bridge was extended by former President Herbert Hoover who took an active interest in the project.

FORMER PRESIDENT SPEAKS

"I have taken great pride," said Mr. Hoover, "as a modest link in this bridge. Some 12 years ago while Secretary of Commerce I received the report of an investigation by Government engineers of this route for a bridge. They thought unfavorably of it because of military reasons. But later, as President, I was able to take up the problem again in cooperation with Governor Young and Commissioner Meek.

"Our joint commission, whose members were Mark Requa, George Cameron, Admirals Gregory and Standley, Colonels Pillsbury and Daly, Senator Breed, Professor Marx and Chief Engineer Charles Purcell, gave first favorable and practicable report on this bridge.

"Then arose the problem of the financing of such a daring project. I used this bridge and other projects as an illustration of what we could do to help unemployment during the depression and urged the Federal Government lending money for this kind of reproductive public works. Congress gave that authority to the RFC in 1932 and the financing of the bridge became a practicality.

DEVOTED WORK REQUIRED

"But let no one think these things are as easy to do as to say them. The devoted work of scores of citizens is required to make such great enterprise. I have perhaps had more opportunity than most to observe that service. The work of your finance committee, Mr. Leland Cutler, Mr. Robinson, Mr. Cameron and Mr. Knowland, the backing by Governors Young, Rolph and Merriam, by Lieutenant Governor Hatfield, by Earl Kelly, by Mayors of all the municipalities, all stand out.

"That this is the greatest bridge yet constructed in the world requires no repetition by me. Its construction also spans the whole advance in industrial civilization—our discoveries in science, our inventions, our increasing skill. It is the product of hundreds of years of cumulative knowledge.

DAILY RISKED LIVES

"But above them all are the engineers and workmen right here who combined all those centuries of knowledge with courage and imagination—your own chief engineer, Charles Purcell and his able assistants, Charles Andrew and Glenn Woodruff, are men whose courage and whose knowledge combine not only the product of these generations of ideas but from their own genius designed and built this bridge.

"Deserving high credit with them are the manufacturers, the contractors. But not the least was the part of these courageous men who daily risked their lives in its construction."

Governor Merriam concluded the speech making. As he took his place before the michrophone on the speaker's stand, a thousand pigeons were released from cages back of the platform and soared into the air with a din of drumming wings.

The Governor said it should be a matter of gratification that the bridge was constructed for less than the estimated cost and completed far ahead of schedule.

"This bridge," the Governor said, "belongs to this generation. We built it and we shall pay for it. But in a broader sense it belongs to the generations that are to come. When the youths of today become the citizens of tomorrow they will use it without cost. Accordingly we dedicate it today to our own use and to theirs, hoping that they will receive it as a legacy of great worth and an indication of our desire to serve."

The Governor concluded his dedicatory speech by reading a poem by Evelyn Simms lauding the builders of the bridges of the world.*

When the State's Chief Executive concluded, he left the platform and with Director Kelly and Chief Engineer Purcell crossed the plaza to the toll stations where, stretched across the lanes of traffic was a heavy golden chain.

CHAIN BARRIER SEVERED

An acetylene torch was handed to the Governor who applied its searing flame to the center links of the chain. Overhead, two hundred navy planes in perfect mass formation roared by, huge bombs burst high in the sky releasing parachutes with American flags, sirens and whistles in Oakland and the East Bay cities added to the bedlam of noise, and the chain barrier fell apart.

The eastern end of the bridge was open to the traffic that soon was to flood over it to San Francisco.

Hastening to automobiles, the Governor and his official party sped across the bridge to the San Francisco approach, where another chain barred their way.

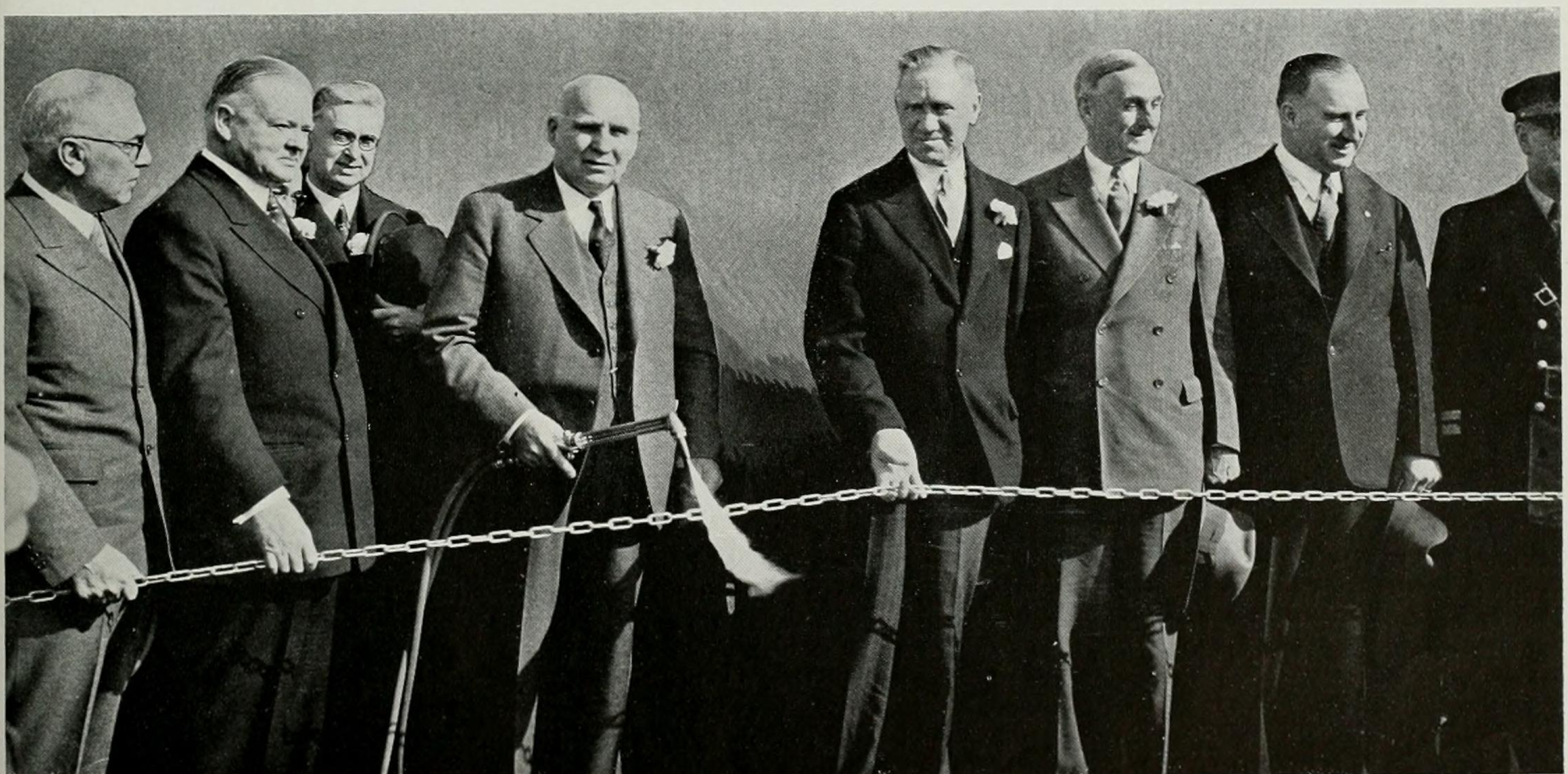
The Governor alighted from his car and surrounded by his party again wielded a blow torch, severing this second golden chain.

IMPRESSIVE MARINE PARADE

In the bay, far below the center towers of the bridge, several hundred yachts, fishing boats and other water craft, brilliantly beribboned and with flags flying, were passing in the greatest marine parade San Francisco ever has witnessed.

* See Governor's speech in full on page 14.

(Continued on page 9)



While notables who participated in the dedication ceremonies look on, Governor Frank F. Merriam severs the golden chain barrier at the San Francisco end of the San Francisco-Oakland Bay Bridge. Left to right: Charles H. Purcell, Chief Engineer; former President Herbert Hoover; Mayor W. J. McCracken of Oakland; the Governor; Charles Henderson, Director of Reconstruction Finance Corporation; Senator William G. McAdoo, and Earl Lee Kelly, Director of Public Works.

Chief Engineer Purcell Tells Construction Story of the Bridge

BY C. H. PURCELL
Chief Engineer and State Highway Engineer

FOR 85 years San Franciscans dreamed of a great bridge that would bring closer to them the East Bay Empire and the vast and wealthy hinterland which speeded the progress and development of the prosperous cities of Oakland, Berkeley and Alameda.

Long ago men of brains and money joined with a madman "Emperor" Norton in visioning a giant structure across their beloved bay.

It was William Walker, a militant San Francisco newspaper editor, who, as early as 1850, proposed the construction of a causeway from his city to Contra Costa County. He had in mind as a precedent the famous 2000 foot Clay Street wharf, some of whose foundations reached a depth of 40 feet.

SHERMAN REVIVED IDEA

His plan was received with enthusiasm, but nothing came of it. Six years later, General William Tecumseh Sherman of Civil War fame, then a youthful banker in San Francisco, revived the idea.

In 1869 when the continent was spanned by the Central Pacific and Union Pacific railroads Leland Stanford, later United States Senator from California, joined San Franciscans in urging his railway associates to do something about bridging the bay.

These bridge proponents were practical men, but even before some of them gave serious thought to the great idea, the mad "Emperor" Norton, worshipped for his eccentricities by fun-loving San Franciscans, had demanded of the Central Pacific that it build a suspension bridge from San Francisco to his "summer capital" in Oakland.

TUBE PLAN CONSIDERED

It was not until 1921 that definite plans for a San Francisco-Oakland Bay Bridge began to take form. In that year the San Francisco Motor Car Dealers Association contributed money to defray the cost of an engineering report on the feasibility of building a combined tube and concrete causeway which would connect the City by the Golden Gate with its East Bay neighbors.

Seven years later the Board of Supervisors of San Francisco had before it thirty-five proposals for different kinds of bridges and tubes submitted by corporations and individuals. In 1928 a bill was introduced in Congress authorizing San Francisco to construct a bridge across the bay and delegations from San Francisco and the East Bay cities headed by James Rolph Jr., then mayor of San Francisco, went to Washington to urge passage of the measure.

ARMY AND NAVY OBJECTED

Objections raised by Army and Navy officials defeated the plan.

It became apparent that the bridge would have to be built by the State of California and in 1929 the legislature created the California Toll Bridge Authority. In June, 1932, Congressional approval of a loan from the Reconstruction Finance Corporation to the State was obtained and thirteen months later actual construction of the San Francisco-Oakland Bay Bridge began.

On July 9, 1933, first ground was broken for the bridge.

On November 12, 1936, the structure was opened to automobile and truck traffic.

The three years and five months intervening were full of intensive and interesting work for all of us who have had the honor to be connected with the construction of this gigantic span.

The project on the whole progressed smoothly according to schedule and without serious delay.

For example, on July 6, 1935, spinning was started on the first strands of the north and south cables of the West Bay Crossing. The steel arch girders of the tunnel were being placed, while on the East section steel work was in process of erection only as far as E-33 to E-23.

SEVENTEEN MONTHS RECORD

This means that in seventeen months the cables were spun, the steel erected, paving placed, and the structure painted for the two miles of the West Bay Crossing on two decks; the tunnel, largest bore ever attempted, was lined with concrete, excavated, the flooring of the decks placed, and the upper deck roofing relined with tile; while on the East side the cantilever span, unequaled in length by any in the United States, was erected; and the entire East side paved and painted.

Simultaneously the San Francisco approaches and all of the East Bay approaches were completed from University Avenue on the north to Cypress Avenue and Seventh on the south and 38th Avenue and Market Street on the East.

It was a gigantic task, and one necessarily coordinated to have brought about the completion of this bridge at the designated time. For this thanks are due to the cooperation of Governor Frank F. Merriam, chairman of the California Toll Bridge Authority; State Director of Public Works Earl Lee Kelly; Bridge Engineer Charles E. Andrew; Design Engineer Glenn B. Woodruff; our fine engineering staff; and our contractors and their able workmen.

TWO CAISSONS TIPPED

Aside from the tipping of the caissons W-6 and W-4 in the earlier stages of the work in constructing the foundations, we had no mishaps that caused delay other than those provided for in our schedule.

Picture of Chief Engineer C. H. Purcell reproduced through courtesy of California Magazine of Pacific Business.

Probably the only other one occurred in September, 1935, when the 23d cable strand of the south cable became twisted and had to be respun.

Toward the middle of October, 1935, the spinning of the north cable of the West Suspension spans (between the San Francisco and Center Anchorages) was completed. On the following week spinning of the south cable was completed (October 16, at 8.30 p.m.) and equipment erected at the Yerba Buena Anchorage for work on the East Suspension Spans.

In the same week all of the steel girders of the tunnel were erected and the last concrete of the roof was poured.

A HAZARDOUS TASK

Meanwhile work was progressing on the East and West cantilever arms of the East Bay Crossing, with the hazardous task of erecting the 1400-foot cantilever span itself imminent.

Scarcely one month after the spinning of the cables had been completed on the west suspension spans, the cables of this section were squeezed and bound every three feet. That same week work started on the spinning of the mile long cables on the east suspension spans from the Center Anchorage to Yerba Buena Island.

Actual starting time of the spinning of the south cable of this section was at 8 a.m., November 12, 1935, exactly one year from the time the bridge is open to traffic.

Six days later the entire core of the great tunnel had been excavated.

On December 9, 1935, the Folger Avenue Underpass was completed, one of the features of the Berkeley approach to the bridge.

FIRST SUSPENDERS PLACED

On December 16, 1935, the first of the suspended cables was placed and lifting struts were rigged up preparatory to erecting the deck steel.

Four days after the New Year (January 5, 1936) the first of the deck steel was erected for the suspension spans. In the same week the second panel of the East cantilever arm was placed.

At 10 o'clock, the morning of January 20, 1936, the spinning wheel made its last trip over the north cable of the east suspension spans, completing all spinning six and one-half months after operations were first started. In this time 17,464 wires had been placed in each cable, having a total length of 70,815 miles.

On March 2, 1936, cable wrapping first started at a point between the San Francisco Anchorage and Pier W-1, while on the East Bay Crossing the gap between the east and west arms of the cantilever span was slowly lessening.

The last main unit of the deck steel between Pier W-1 and the Center Anchorage was erected on March 10, 1936, approximately four months after the first truss was lifted in this section.

CANTILEVER SPAN CLOSED

Early on the morning of March 21, commuters were startled to see tiny spider-like figures dangling on the suspender rope, hundreds of feet above the Bay. These were painters applying the first coat to the suspenders at spans W-1 and W-2.

On that same morning only two panels remained to be erected on the East Bay Crossing before the cantilever span would be closed.

On March 25, 1936, at 4.30 p.m., the cantilever span was closed, although to the public the first eyebar thrown across the gap early Monday morning on March 24 achieved the purpose.

Next to the sinking and anchoring of the caissons, the closing of the cantilever was probably the most ticklish job in the construction of this world's largest bridge.

First, it was the longest cantilever to be suspended and the heaviest; 1400 feet in its total length; it weighed 21,000 tons. Second, changing weather and tidal conditions made the closing of the gap difficult to calculate to a nicety.

DIFFERENCE OF FOUR INCHES

At one time during the closing, for instance, with a cold wind blowing through the Golden Gate on the west and a warm sun on the east, one side of the structure was as much as four inches longer than the other.

From Tower E-2 near Yerba Buena Island and from Tower E-2 east of it, traveling derricks had moved slowly toward each other, lifting steel members from barges approximately 195 feet below. Week after week bridgemen fitted these steel members and bolted them into place until 625 feet of steel, weighing around 10,000 tons, were suspended from each tower. It remained then to close the gap of 96 feet.

It was the eyebars of the lower chord that were slipped into place early one morning which the commuters considered closed the gap, but not so spectacular but even more exciting to engineers and certainly more exacting was the completion of the final closure.

Following the placing of the lower eyebars and steel members (such as horizontals), sufficient to give the structure support but the minimum weight, four steel pins—about one-half ton in weight and three feet in length—were to be driven and the upper chords placed and bolted.

BRIDGE MOVED BY JACKS

Here eight giant hydraulic jacks, each exerting a "push" of 500 tons, which had been temporarily installed for just this purpose, came into play. Four of these jacks were located at the top of the split steel bent on Tower E. With these it was possible to push or pull an entire half of the bridge east or west. It was these horizontal jacks, 1200 feet away, that jockeyed the eyebars into position so that the steel pins could be driven through, thus securely fastening the lower chords.

The four remaining jacks with a longitudinal action had been placed at each end of the upper chords of the cantilever arms.

It was now necessary to bring these into operation to adjust the arms of the cantilever so that the upper chord could be slipped into place and bolted. This was done just as we had calculated, and not until then was the bridge closed.

Operations during the entire procedure were directed by engineers stationed with a full view of the project through telephonic communication to operators on the jacks several hundred feet away.

WORK PROGRESSED STEADILY

After the closing of the cantilever, work continued there with the erection of additional steel members and the winding up of all riveting on the East Bay Crossing. Meanwhile, the placing of paving on both decks had been under way for some weeks over that area which had been completed east of the Island and west of the bridge head.

Work progressed on the West Bay Crossing steadily but less sensation-

This night photograph shows the excellent visibility afforded under all weather conditions by the new sodium vapor lighting system.

ally as the lifting of deck trusses continued. At the same time construction of the San Francisco viaduct was nearing completion while work elsewhere was continuing at the San Francisco anchorage, Yerba Buena anchorage and viaduct, the Yerba Buena spans, East Portal of the tunnel and the San Pablo Underpass, arterial of one of the three principal East Bay approaches.

First light standards were erected as early as April 18, 1936, when poles were placed on the north and south railings of the San Francisco approach.

Erection of major steel for the continuous spans on the West Bay Crossing was completed April 14, 1936.

At two o'clock Monday afternoon, April 20, the last of the main units of the stiffening trusses of the suspension spans was lifted, carrying its American flag, symbol of work completed.

On May 27 the first machine was driven across the lower deck of the East Bay Crossing, with the curing of the last concrete to be poured in that section.

Last concrete of the entire East Bay Crossing was placed on the upper deck on June 1, approximately three months after the closing of the cantilever.

First concrete of the upper deck of the suspension spans of the West Bay Crossing was poured just after sunrise on June 18, two weeks after the completion of concreting operations, on the east side.

CONCRETE RECORD SET

This work continued rapidly, with a new record for concrete pouring established on August 20, when 750 feet of paving was placed in one day.

On August 28, the last steel floor beam of the west bridge was erected at the west end of the San Francisco anchorage, completing all major steel work.

The last batch of concrete on the entire structure was placed in the lining of the upper deck of the Yerba Buena tunnel. The bridge was ready to take care of vehicular traffic on November 12.

There remains only the installation of electric railway facilities and the erection of the terminal in San Francisco for train traffic. This in itself is a mammoth task, which we expect to finish in the spring of 1938.

The engineers and those connected with the construction of this great bridge have worked long and hard during these past three years. We now turn the structure over to the people for their use.

President Roosevelt Switches on Signal Starting Traffic

(Continued from page 5)

Meanwhile, the great siren on the Ferry Building and hundreds of factory whistles throughout San Francisco were adding to the chorus of thousands of cheering San Franciscans gathered at the Fifth Street plaza between Harrison and Bryant streets.

The ceremony of severing the second barrier finished, Governor Merriam led his party to a speaker's platform erected at the western end of the plaza.

Here Leland Cutler, president of the Golden Gate International Exposition of 1939 and vice president of the Finance Advisory Committee, presided and, after an invocation delivered by Monsignor Ramm, introduced Mayor Angelo Rossi of San Francisco.

SYMBOL OF PROGRESS

"This bridge," said Mayor Rossi, "is a sample of the West to come, a signal for renewed civic effort, a proof that the pioneer spirit of San Francisco still lives. This magnificent structure will serve to unite us more closely with our friendly neighbors across the bay and means progress for all of us."

Lieutenant Governor George J. Hatfield said that to him the great structure looming up majestically before him is "the greatest triumph in bridge engineering the world has ever seen—an opening gateway to a new Manhattan of the Pacific—a splendid, miraculous realization of the California of today."

And United States Senator William Gibbs McAdoo said:

"This bridge is a bridge of national implications—an imposing tribute to the genius of our people and the progress of our times — a great miracle."

REMEMBER MARTYR WORKERS

Walter Gaines, assistant bridge foreman and worker, wearing the steel helmet which he wore daily during the years the bridge was under construction, urged San Franciscans not to forget the men who died in the performance of their duty while engaged in work on the great span.

"Regard this bridge as a tribute to the American working man, both skilled and unskilled," he said.

Other speakers, including Governor Merriam, Director of Public Works Kelly and Chief Engineer Purcell, cut their speeches on the San Francisco side short due to the imminence of the moment when President Roosevelt would press the electric button in Washington which would throw open the bridge to the public.

The Governor read a number of telegrams from prominent national labor leaders in which the latter sent their felicitations and expressed their pleasure over the amicable relations which existed between labor and the bridge builders throughout the period of construction.

Statistical Facts of Piers, Towers, Spans and Cables

San Francisco-Oakland Bay Bridge has:

Two west bay towers of 474 feet and two of 519 feet.

Six west bay piers of 100 to 240 feet depth, and 22 east bay piers of 50 to 242 feet depth.

Two 2310-foot center suspension spans and two 1160-foot side spans in the west bay crossing.

Center anchorage 300 feet high.

Vertical clearances of 200 feet at center span and 216 feet at anchorage.

Two $28\frac{3}{4}$-inch cables, each containing 17,464 wires.

Cantilever span of 1400 feet in the east bay crossing.

Two decks—a six-lane upper deck for fast traffic; a lower deck of three truck lanes and two interurban track lines.

Tunnel carrying the decks through Yerba Buena Island, 76 feet wide by 58 feet high.

DRAMATIC ACT BY PRESIDENT

With one eye on his watch, Governor Merriam concluded his remarks with these words:

"At this minute the President of the United States is seated at his desk in the White House. In a few seconds he will press an electric switch. Turn around all of you and look at the signal tower. Soon the red light will turn to orange and then to green. Ah! There it goes. I now declare the San Francisco-Oakland Bay Bridge officially opened."

It was a dramatic moment. A dramatic, stirring scene. As the light on the signal tower flashed from orange to green cheers from thousands of throats swelled into the air, whistles and sirens screeched and down on navy row big guns boomed a salute.

Governor Merriam and his party hastened from the platform, crossed the plaza to their waiting cars on the western approach, where Chief E. Raymond Cato of the California Highway Patrol, and Captain Charles Goff of the San Francisco police traffic department and their men were holding back the eager motorists who wished to make their first bridge crossing.

AN UNFORGETTABLE SIGHT

The Governor and his party entered their cars and flashed away toward Oakland, followed by a stream of cars that steadily throughout the day and night mounted into the thousands.

On the Oakland side a similar flood of machines at that identical moment was sweeping over the eastern approaches, headed for San Francisco.

It was an unforgettable sight when the two streams of automobiles met and passed on their respective lanes in the middle of the giant structure that is the San Francisco-Oakland Bay Bridge.

Governor Merriam and party proceeded from the eastern terminus to the Hotel Oakland where they were guests at luncheon of the City of Oakland under the auspices of the Junior Chamber of Commerce.

BRIDGE BATHED IN LIGHT

The night of November 12 in San Francisco ever will be a memorable one.

When darkness fell the huge bay bridge that had loomed up in the dusk as a great silvery span across the bay suddenly became aflame with light as the sodium vapor lamps spaced along the upper deck from the Oakland plaza to the curving ramps of the San Francisco approaches burst into fire.

(Continued on page 2")

Construction Records Made by Perfect Coordination

BY CHARLES E. ANDREW, Bridge Engineer
San Francisco - Oakland Bay Bridge

THE FIRST and major stage of construction of the San Francisco-Oakland Bay Bridge is now a reality. More than 200,000 automobiles passed over its roadway during the first 84 hours of operation in orderly fashion and without mishap.

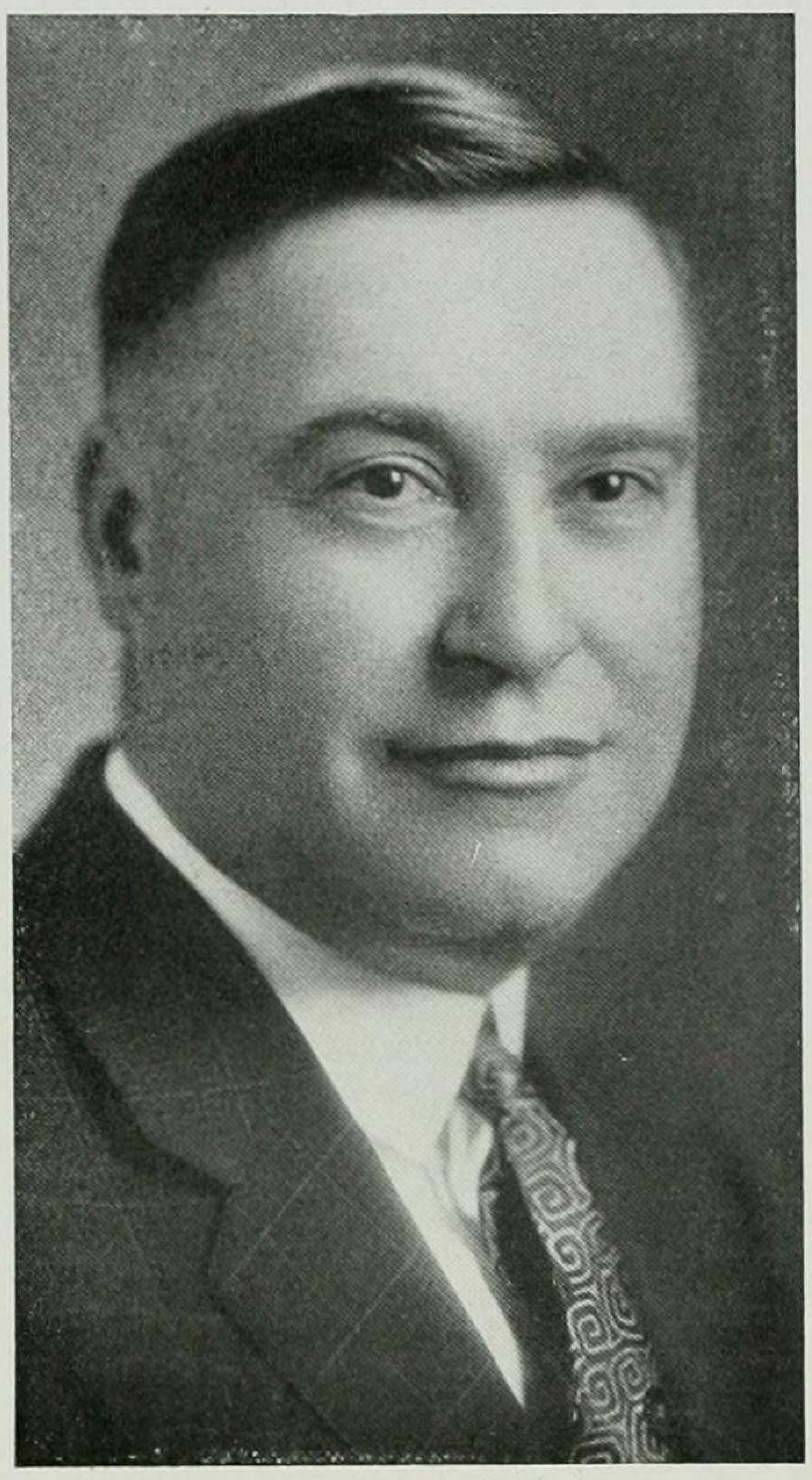
It is a wonderful satisfaction to the engineers and contractors who have toiled with untiring energy for several years to bring this great project to completion at a cost well within the first estimates made in 1929, and several months ahead of contract schedules.

The general public can not possibly realize the great amount of detail, hard work and long hours necessary in the planning and execution of such a structure.

We are proud of the fact that the world's greatest bridge has been wholly designed and constructed under the supervision and direction of employees of the Department of Public Works of the State of California. No finer or more efficient organization has ever been assembled. Too much credit can not be given to every member of the staff. All have worked long hours when necessary and have given their best.

They have (so to speak) been out in the front line trenches. Coordination of effort, both on the part of engineers and contractors has been the secret of success. Engineers have constantly exhorted and assisted contractors to keep their work planned to the minutest detail and the contractors have responded with the finest equipment and skill ever before assembled on a bridge project.

Some 15 major contracts have been so synchronized that each one has been completed in such unison as to cause practically no delay to the succeeding contract.



C. E. ANDREW

Such proper sequence is only arrived at by careful scheduling of contract dates and correct estimation of time required followed by almost exact performance on the part of contractors.

The bridge as it stands today is evidence of almost perfect performance on the part of all engineers and contractors.

Mabel—Do you think it is right to kiss a boy friend goodnight?

Marie—It is if there isn't any other way to get rid of him.

Mrs. Gabber—I've had such a cold I was unable to speak for three whole days.

Mrs. Blabber—Why you poor dear. How you must have suffered.

First Batter-leg Towers on Major Suspension Spans

ADDING a new chapter to the history of bridge construction, the towers supporting the double suspension span forming the San Francisco-Yerba Buena section of the Bay Bridge are the first "batter-leg" towers ever used in a major suspension bridge.

Each tower leg inclines inward toward the other and tapers toward the top. In designing them, the engineers were faced with the problem of flexibility. Under extreme load conditions, there will be a longitudinal movement of the bridge—either east or west—of six feet, six inches at the top of tower W-2, near the western end of the bridge. With such movement, a flexible tower was required.

WALL CELLS IN TOWERS

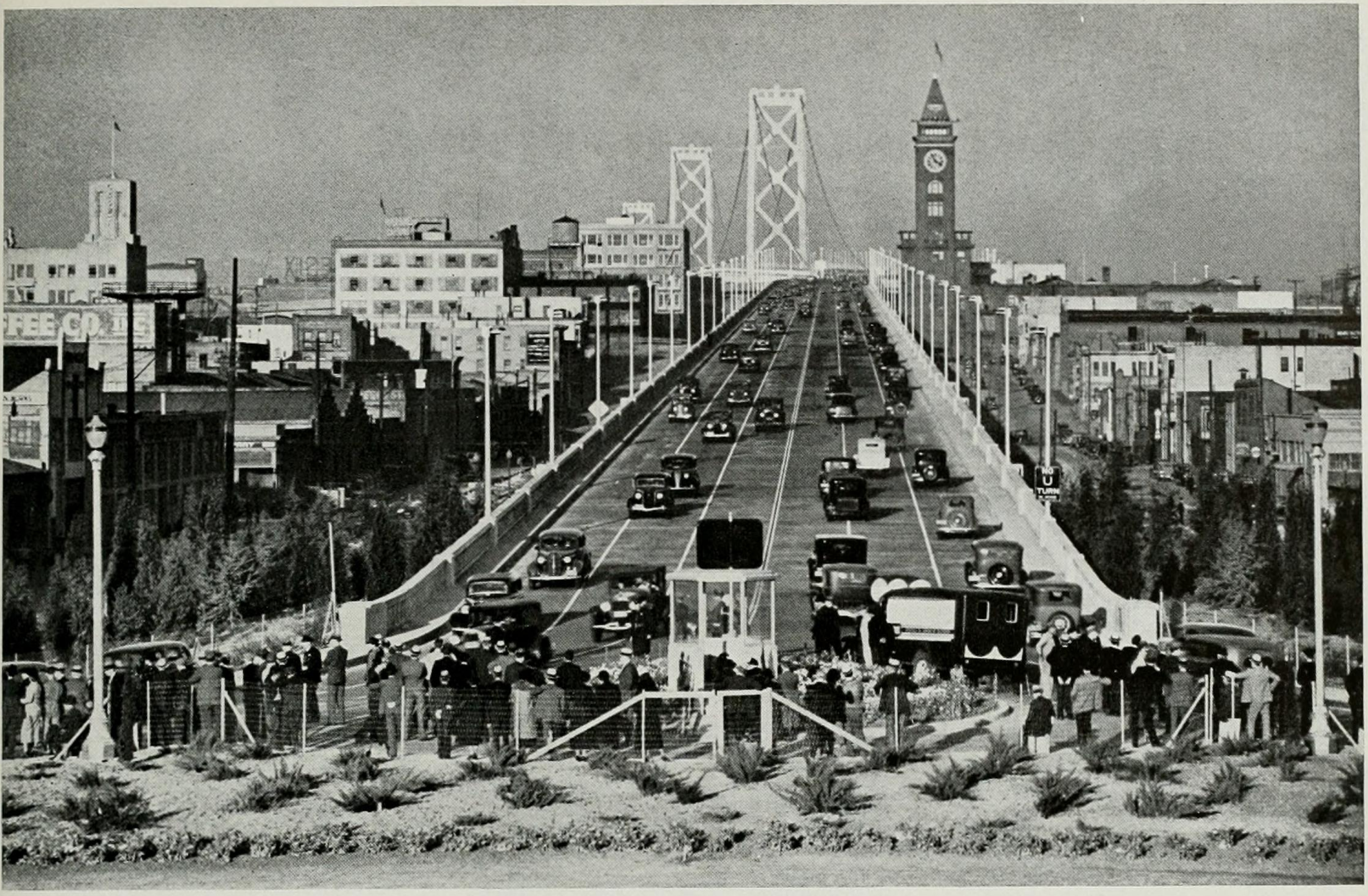
As designed and built, the towers consist of two columns joined by diagonal bracing. They are 109 feet wide at the base, tapering up to 78 feet in width at the top. Each tower leg covers a cross-shaped area of 32 by 19 feet at the base, and contains 21 small wall cells, or rooms, separated by silicon steel plate. The number of cells is reduced to nine just below the top.

Stresses in the towers were calculated for transverse loading, from a 90-mile-an-hour wind and from earthquake. Transverse stresses from earthquakes are comparatively small in a suspension bridge. Experts have said there is no need for fear that the bridge ever will be seriously damaged by earthquake.

ALLOWANCE FOR SWAY

The roadways over the truss spans of the bridge are attached to the towers by means of anchor arms, allowing for the required play. A rectangular slot in the lower roadway strut in each tower provides for a wind resistance connection to the span.

The two outer towers, those proximate to Rincon Hill in San Francisco and Yerba Buena Island, rise 474 feet from the top of their concrete piers, which in turn are 40 feet above the bay waters. The inner towers, on either side of the great center anchorage, are 519 feet high.



This view looking east on the bridge from the Fifth Street Plaza in San Francisco shows auto traffic coming and going over main western approach.

TRAFFIC DISTRIBUTION IN SAN FRANCISCO NOW CENTERING AT FIFTH STREET PLAZA

NOT THE least of the problems confronting the builders of the San Francisco-Oakland Bay Bridge was that of getting traffic on-to and off the structure on the San Francisco side.

Western approaches had to be constructed through a large industrial district and the building of "on" and "off" ramps was a big task in itself. Projected rights of way were occupied by many types of buildings, from frame dwellings to four-story concrete and brick buildings. All had to be demolished and the property upon which they stood acquired. In all two hundred and sixteen separate parcels of real estate had to be purchased, and the acquisition of some of them required litigation.

A number of streets had to be realigned, Rincon Hill was razed, railroad and street car tracks moved and viaducts built.

The San Francisco distribution center is in a plaza embracing an area of 121,000 square feet at Fifth Street, between Harrison and Bryant streets. All of it will be landscaped, sixty-four thousand feet of it being planted to grass.

Two roadways lead to the bridge, one diagonally to the main roadway from the corner of Fifth and Bryant streets, and the other completing a triangle from Fifth and Harrison, with Fifth Street as the base.

The main approach is a single-deck structure on a 3.6 per cent grade from ground level to bridge level and consists of a series of 51 concrete two-girder spans, varying in length from 50 feet on Rincon Hill to 93 feet over Second, Third and Fourth streets. The roadway width is 58 feet throughout.

An "on" ramp and an "off" ramp constitute two branches from the main approach for vehicular traffic.

The "on" ramp leaves ground level on Fremont street just south of Harrison, its 20-foot roadway curving on easy grades upward on twenty-one 45-foot spans to a juncture with the main approach approximately at Sterling Street.

Leaving the main approach at span 46, or Rincon Street, the "off" ramp curves downward to First and Clementina streets.

Bridge a Mighty Symbol of California Genius and Vision

BY EARL LEE KELLY, State Director of Public Works

TO ME the San Francisco-Oakland Bay Bridge is a mighty symbol of California achievement and a great State's faith in its splendid future.

It has been a tremendous project, unequaled by anything of its kind in the world and its successful completion is due to the combined efforts of the communities of San Francisco, and the East Bay, the State of California and the Federal Government.

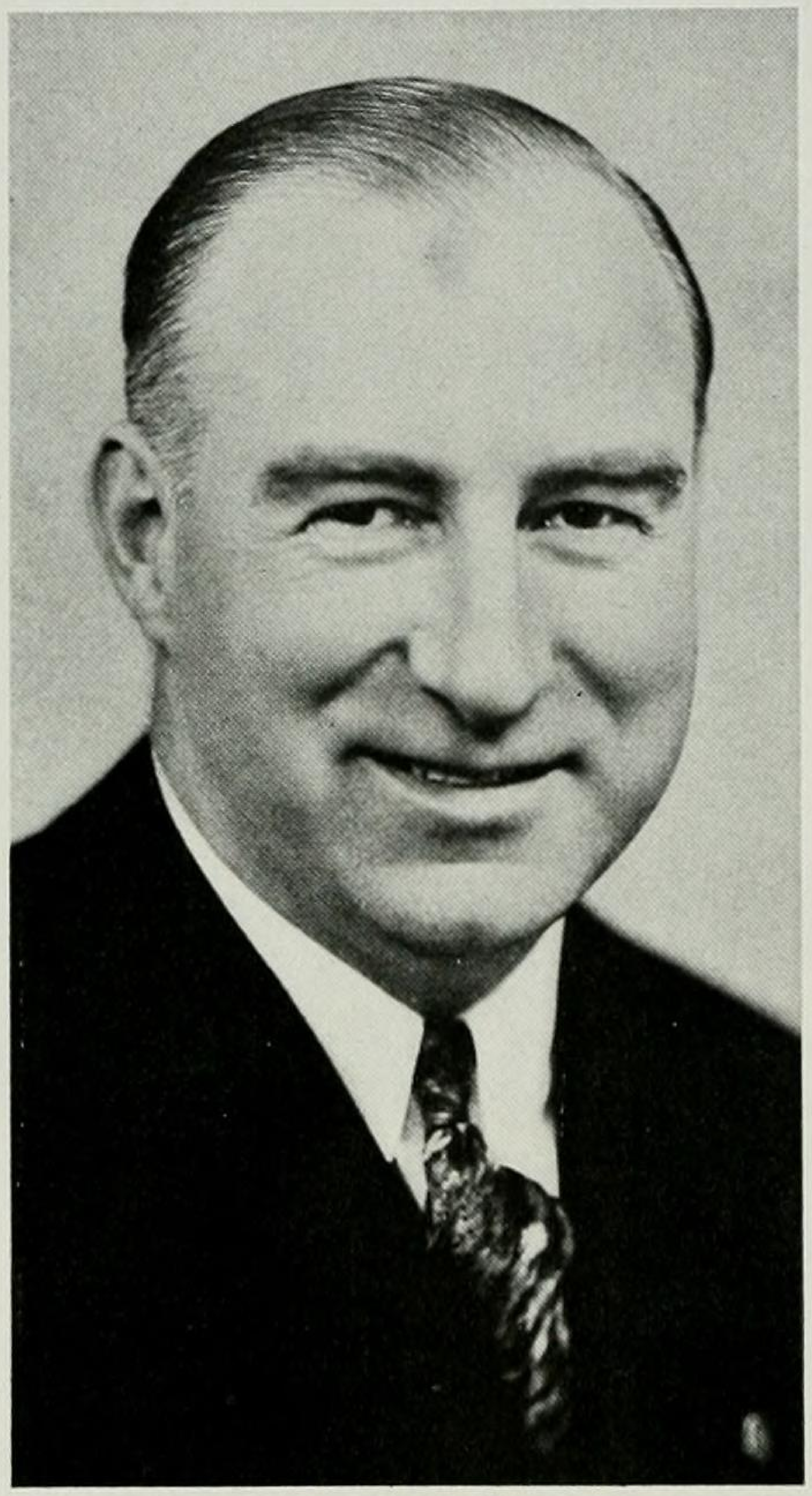
The whole State, I am sure, feels as much pride in this great bridge as do the cities of the Bay area, for it must be regarded as an important part of our State's highway system and as such is of paramount interest to every citizen; particularly because it is built without one dollar of cost to the taxpayers.

VAST PUBLIC PROJECT

While the proposition of spanning the Bay was discussed long before any of us can remember, nothing much was ever done about it because it was naturally a public project, too big to be handled by any private interests. Yet when the possibility of its construction began to crystallize into definite form a few years ago, we had about thirty-five propositions from private corporations and individuals who wanted franchises, but it was realized that none of them could successfully carry out such a vast undertaking.

So the big job was laid in the lap of the State and became a problem of the Department of Public Works and while we are rejoicing that the broad expanse of San Francisco Bay has at last been bridged, let us look back briefly at some of the historical events that led to this epochal accomplishment.

While the idea of bridging the Bay seems to have been a topic of conversation among San Franciscans ever since the city existed, it was not until the spring of 1929 when the State legislature created the California Toll Bridge Authority Act "to authorize and direct the Department of Public Works to build, purchase, condemn, or otherwise acquire for the State of California, toll bridges, toll highways, crossings and approaches thereto across waters within the State * * *" that California as a whole became a party to the project.



EARL LEE KELLY

JOINT COMMITTEE APPOINTED

The passage of this act was followed by the appointment of a joint Federal-State committee in the fall of the same year, which reported after intensive study that a bridge could be built at a cost not too great to be paid off by tolls with interest over a period of twenty years.

This committee, known also as the Hoover-Young commission, recommended the general design, specifications and route of the bridge. These have been altered somewhat in the completed plans of the present bridge but they provided a very definite basis upon which to proceed.

The cities of San Francisco and Oakland appropriated money toward test borings; the Army and Navy withdrew objections to the bridge as a bar to navigation and a menace to defense; and on February 20, 1931, Congress granted the State of California the right to construct a bridge from Rincon Hill, San Francisco, to Yerba Buena Island to Oakland.

ROLPH SIGNED APPROPRIATION

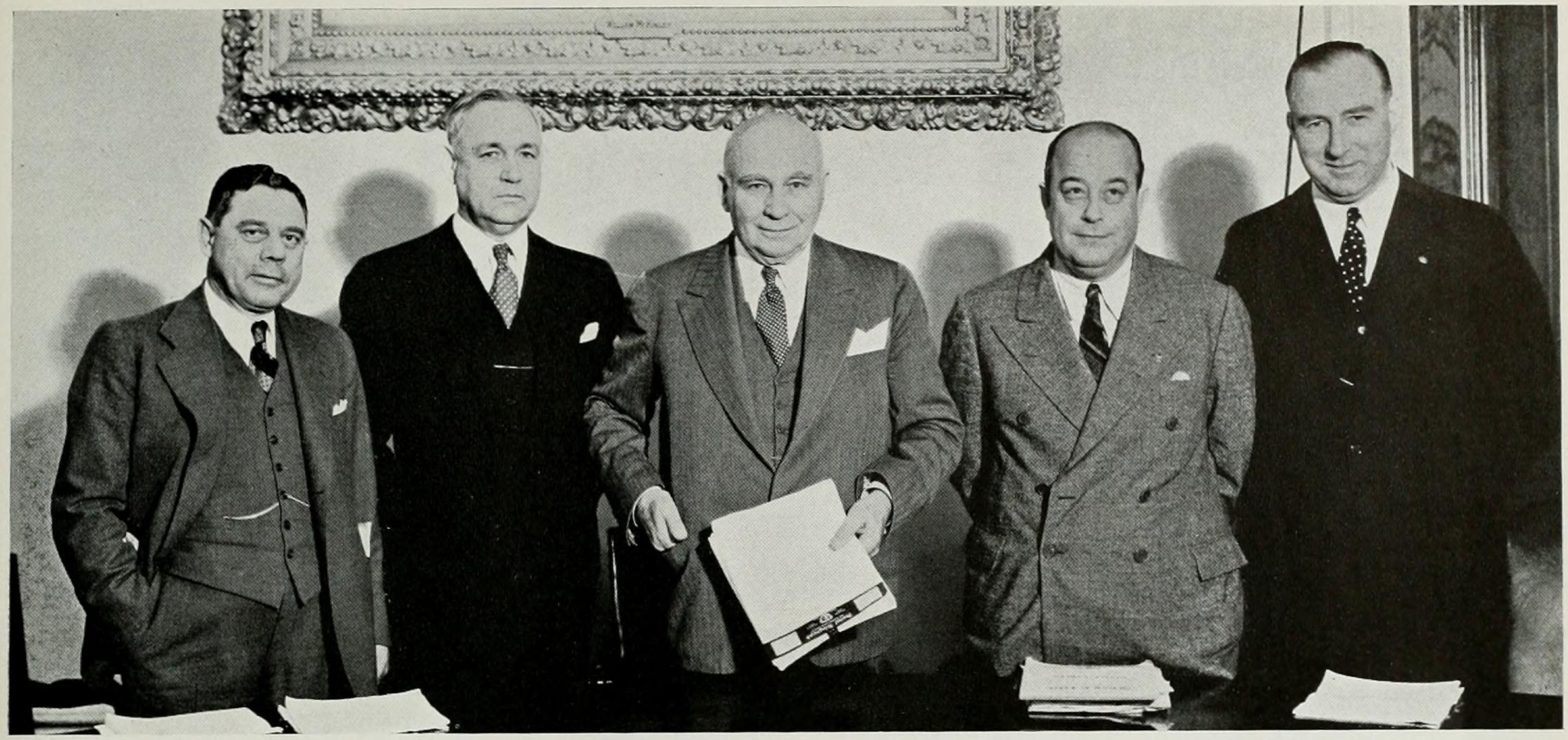
Governor James Rolph, Jr., signed amendments to the California Toll Bridge Authority Act to provide for the financing of state-owned bridges by revenue bonds on May 25, 1931, and simultaneously signed an appropriation of $650,000 for the creation of the San Francisco-Oakland Bay Bridge Division of the State Department of Public Works.

This division got down to business on September 15, 1931, when it opened offices at No. 500 Sansome Street, San Francisco, which its staff after over five years of hard and anxious labor will vacate when their work is accomplished.

Charles H. Purcell, state highway engineer, was appointed chief engineer of the bridge, and to Mr. Purcell and his fine work, sincere tribute must be paid.

NAVY GRANTS DEED

Next of importance was the permit to cross Yerba Buena Island granted the State in January, 1932, by the secretaries of War, Navy and Commerce, and the presentation of a deed to the right of way to Governor Rolph by Rear Admiral William Carey Cole, on February 25.



These men as members of the California Toll Bridge Authority, direct the affairs of the Bay Bridge. Left to right: Harry A. Hopkins, chairman California Highway Commission; Arlin E. Stockburger, State Finance Director; Governor Frank F. Merriam; Lieutenant Governor George J. Hatfield; Earl Lee Kelly, Director of Public Works.

Our next problem was the old one —money. The private bond market was gloomy, because the depression had dealt it a bad blow. After much negotiation with the Reconstruction Finance Corporation it agreed on October 10, 1932, to purchase $61,-400,000 of California Toll Bridge Authority bonds for the construction of the bridge proper, providing that the State would maintain the bridge and build the approaches.

Bids for the first contract were opened on February 28, 1933, by Governor Rolph in Sacramento. The R. F .C. announced the money available on April 27, 1933, and ground was broken on July 9, 1933.

AMAZING CONSTRUCTION PROGRESS

Thus in three years and five months the world's greatest bridge has been built and, considering the magnitude of the task and the engineering pioneering required, its quiet, steady progress has been indeed amazing.

It can not be said that the bridge is entirely completed because the electric railway system and the terminal have yet to be finished. This work will be ready by March, 1938, it is estimated.

The bridge will have an automobile capacity of 16,000 vehicles an hour without congestion. More than 30,000,000 passenger cars and trucks can pass over it a year without straining its capacity to handle traffic. The engineers have designed the bridge to accomodate a traffic volume of motor vehicles and interurban trains and passengers far beyond the estimated requirements in 1975.

65,000,000 PASSENGERS IN 1950

By 1950 we estimate the bridge will be carrying 12,600,000 automobiles and trucks, 25,000,000 motor vehicle passengers and 40,000,000 interurban train passengers.

It will save the interurban train passengers at least 15 minutes a trip, and automobile passengers a half hour or more. This time saving alone would make the bridge worth while. Figure out the amount of time saved by a commuter, multiply it by the number of passengers a year, and then try to figure out the total amount of time saved in a year. The result will be almost an astronomical figure.

Yes, the bridge will be a great break for the commuter from the time standpoint, and that alone would make it worth while. Surely the Bay commuters deserve this break.

Time saving is not the only advantage the commuter will eventually reap from the bridge, however. There is the financial advantage. It will save commuters and motorists hundreds of thousand dollars in lower fares and tolls. Keep this fact also in mind as supremely important—the bridge is being built without one dollar of cost to the taxpayers. It will be paid for out of revenue only.

The flat rate toll has been fixed at 65 cents per car and 5 passengers. This, however, may be adjusted according to revenues. A larger volume of traffic than we anticipate would most likely result in lower toll charges.

But according to our most careful estimates, the bridge should pay for itself in about 20 years.

After that it will become a FREE BRIDGE!

When I say that its construction will not cost the taxpayer a dollar, I am, of course, referring to the bridge proper; the approaches will be paid for out of northern California's share of the State gasoline tax allotment. But this amounts to only $6,600,000 and will be repaid out of bridge revenues.

The importance of this great new bridge unit as a connecting link of our State Highway System is emphasized by a glance at the map re-

(Continued on page 20)

Governor Merriam at Dedication Pays Tribute to Workers and Looks Forward to a Free Toll Bridge

Two addresses were delivered by Governor Frank F. Merriam in the dedication exercises, the first at the Oakland terminus and the second at the San Francisco end.

In his Oakland address, the Governor paid tribute to the civic leaders, government and State officials and the army of workers who made the bridge possible. He looked forward to the time when the great structure will be owned by the people of California and be toll free.

The Governor in San Francisco emphasized the great strides made in the development of California and expressed his gratification that the bridge had been constructed for less than the estimated cost and ahead of schedule.

Governor Cites Ideals In San Francisco Speech

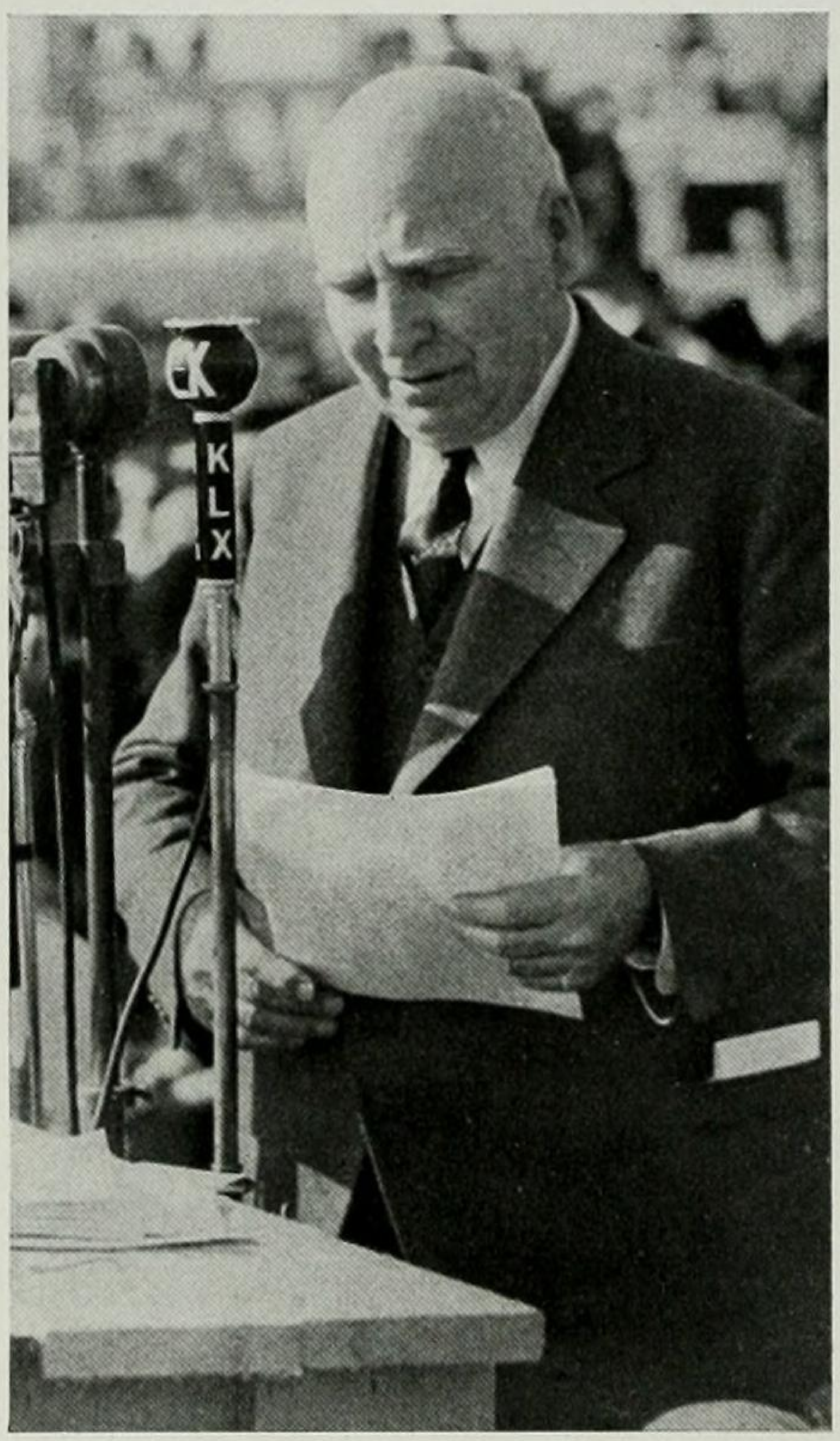
Governor Merriam said in San Francisco:

We have assembled upon this occasion to celebrate the completion of this great bridge. In so doing, we are following a custom that has marked the progress of highway construction throughout the Nation. The building of bridges has always stimulated the interest and aroused the enthusiasm of our people. But never had any group a greater incentive for celebration than have we because we are dedicating a bridge of stupendous construction, magnificent design, marvelous beauty, amazing strength and, withal, a capacity for unlimited service.

Our meeting today will do more than celebrate the completion of this project. In a broader sense, we must recognize this as a day of commencement rather than a day of attainment. In the past we have been interested in its construction, in the future we shall be interested in its use.

HARD WORK STRESSED

For more than three years engineers, construction corporations and workmen all under the Department of Public Works of the State of California, have been working together in this building program. This gigantic structure required the best thought and concentrated effort of some of the leading engineers of our State and Nation. It involved the formation of fiscal policies that demanded the highest ingenuity of outstanding financial leaders. Moreover, it required the devoted service of thousands of men who labored daily in placing the materials and in operating the machinery.



GOVERNOR FRANK F. MERRIAM

This, then, is a monument to the combined efforts of governmental authorities, construction experts, architectural engineers, skillful workmen and a cooperative people. It is the result of the broad vision and the heroic efforts of courageous men.

TWO THEORIES CITED

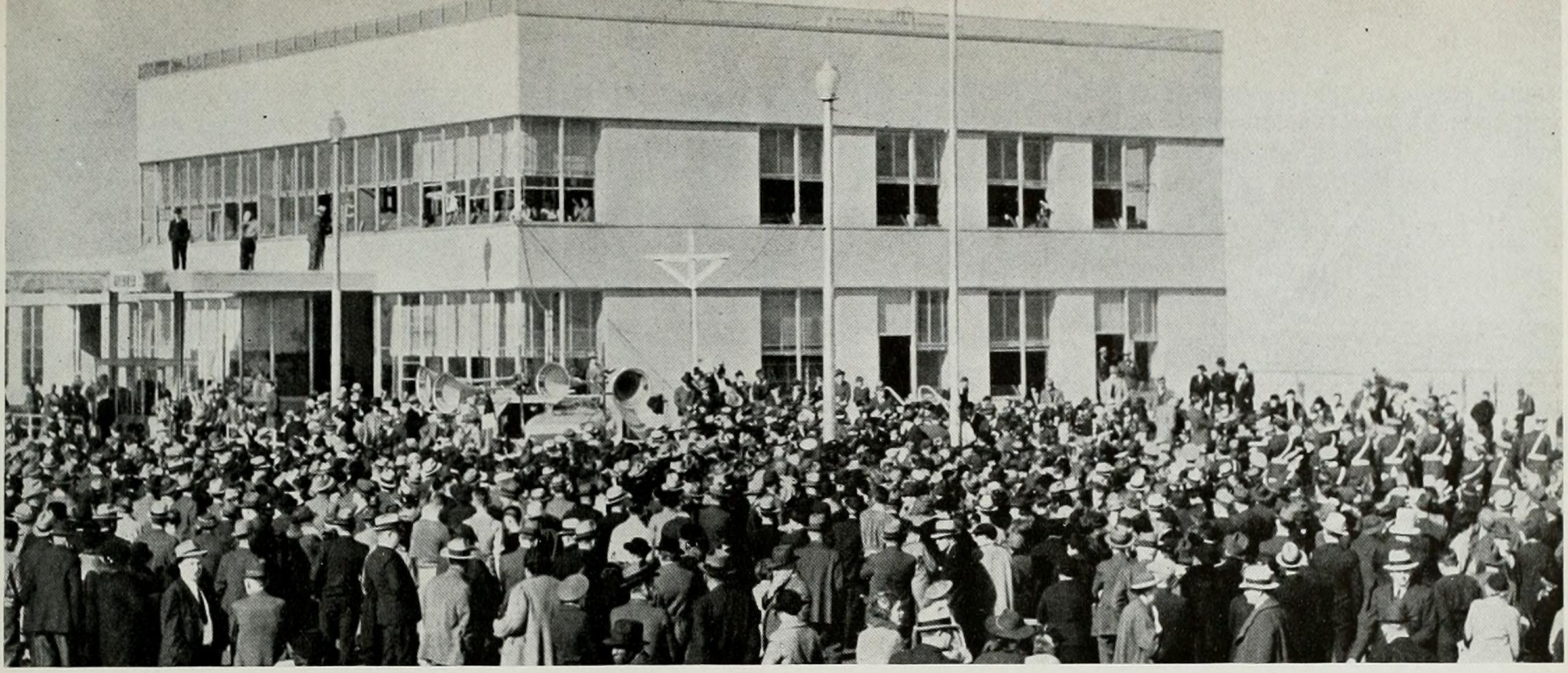
We can not dedicate this bridge without noting the remarkable advancement of the last 300 years. In reviewing that history we discover that our progress has evolved out of the common struggles of men. In the records covering these few centuries we find two threads of philosophy that run through the whole fabric of American life. The one expounds the theory of isolation, the other extols the ideal of cooperation.

In the formation of one of the early communities on the Atlantic Coast, the local government assumed the responsibility of providing every person with a musket, one pound of powder, twenty bullets and two fathoms of match, with sword and rest and bandoliers. This was in a period when the rivers, marshes and mountains served as barriers of protection and security. Throughout the centuries they had stimulated the organization of the clan, the tribe or the village.

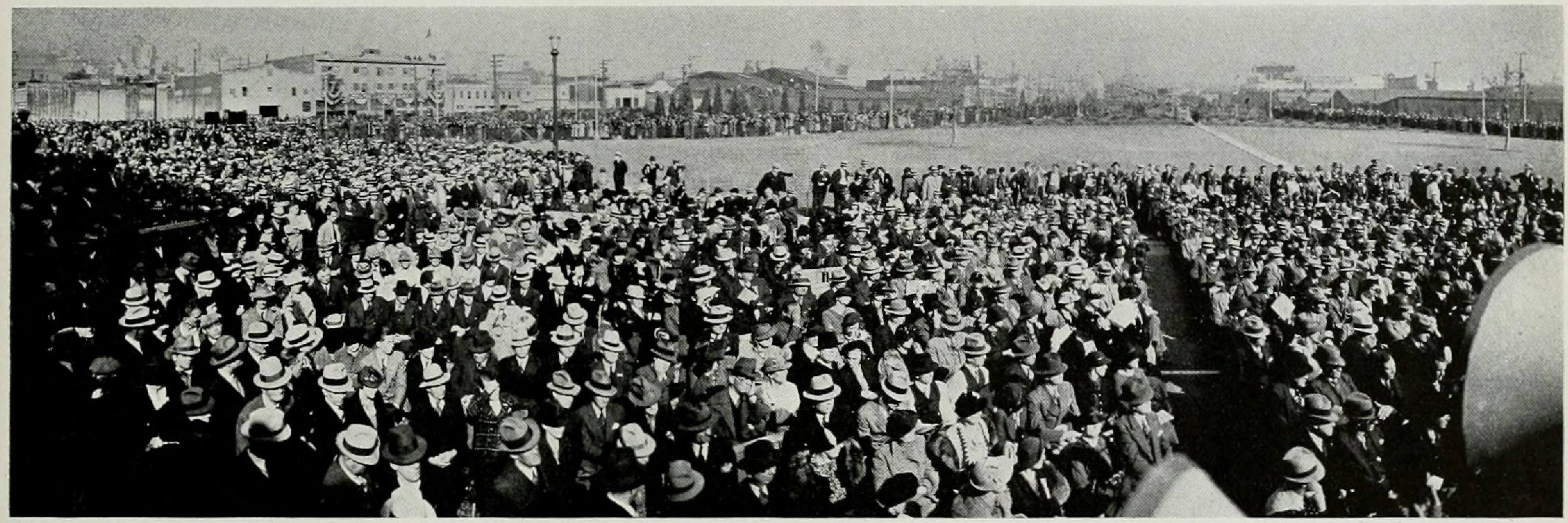
CREEDS BECOME STATIC

Obviously people living under such circumstances were deprived of the stimulus that comes from contact with other people and other races. This ideal of isolation prevented the extension of knowledge and the development of the spirit of service. Creeds, customs and conventions became static. Even habits of thought and the expression of ideas became stilted and circumscribed.

In striking contrast to that type of civilization we survey our own. In analyzing the qualities and characteristics of this great bay area we discover many factors that create common interest among the residents. They are held together by bonds of education, religion, government and



Section of huge crowd attending Bay Bridge dedication ceremonies on Oakland side, with Administration Building in background.



Scene at Fifth Street Plaza in San Francisco where thousands of enthusiastic persons gathered to hear dedication speakers.

Speakers platform in Fifth Street Plaza on dedication day. Lieutenant Governor George J. Hatfield is addressing throng of citizens.

social service. They share the advantages of great community enterprises, projected and maintained through public leadership and the use of public funds. This bridge which we dedicate today stands as a symbol of cooperative achievement for the residents of this local community, the State and the Nation. We have learned that isolation stimulates fear while cooperation inspires confidence. Isolation never advances commerce, business, industry and culture. It curtails rather than impels a feeling of community consideration.

EMBLEM OF FRIENDSHIP

Accordingly we dedicate this great structure as a part of the highway system of California to the use of the people in an emblem of friendship and neighborly association—an ideal which is beautifully and emphatically portrayed in the words of the poet when he said:

'I like a bridge—
'It cries "Come on
'I'll take you there from here and here from there.
'And save you time and toil."
'I like a bridge—
'It breathes romance;
'There's new adventure on the further side
'And I will help you cross.
'I like a bridge—
'It makes me think
'That when a worry comes, my mind will find
'Somewhere a friendly bridge.

Workers, Engineers Are Praised In Oakland Talk

Governor Merriam, in his speech at the Oakland end of the bridge, said:

We are privileged today to celebrate the completion of the greatest bridge yet constructed and to place it at the disposal of the multitudes who will cross and recross it as the years come and go. Never in the events of recorded years has such a bridge been built to span so great a stretch of water. The secrets of Nature, the science of their use, the art of construction and the inventive genius of man, have all contributed to this tremendous enterprise. San Francisco, Oakland, the adjoining communities, California, and the Nation may well be proud of this world renowned structure.

This bridge is not the product of a day. In the early years men gazed out upon the waters separating the peninsula from the mainland and advocated building a bridge upon which traffic might pass at will, successively a dream, a vision, a subject of scientific research, the definite engineering plans, governmental approval and financing, and finally the builders, realization—we are assembled here to inaugurate its service to mankind who may travel this way.

MANY TOOK PART

Nor has the bridge resulted from the activities of a single individual. A myriad of thinkers and workers have, through their individual and combined efforts, carried their share of the responsibility and have added their part to this great undertaking. Without the earnest cooperation of many minds and hands, this magnificent structure would not stand, at once, as the result and the instrument of modern progress.

PRESIDENTS PRAISED

Presidents Hoover and Roosevelt generally contributed to the enterprise; President Hoover in the initiation of planning and financing, and President Roosevelt in the support and aid which made possible its completion.

Governors Young and Rolph worked without reserve in promoting the enterprise—Governor Young in approving the act establishing the Toll Bridge Authority, the organization which has had immediate charge of the financing and supervision of its construction and Governor Rolph in enthusiastically carrying forward the executive activity during his term of office.

COMMISSIONS LAUDED

Two commissions, one appointed by President Hoover, the other by Governor Rolph, rendered splendid service. The first special committee, usually designated as the Hoover-Young Commission, was named to select a site, determine the route and to negotiate with the war department regarding these and other important items. The second, known as the Financial Advisory Committee, was instrumental in financing and convincing the Reconstruction Finance Corporation of the soundness of such an investment and in arranging for the sale of the revenue bonds. Both of these commissions gave generously and gratuitously of their time and ability in the advancement of the project.

Many others should be commended. Everyone, in any way connected with the work, was most zealous in his effort to be helpful. The contractors, the workmen who labored with their hands and those who operated the machinery, must all be commended for their skill and diligence. Director of Public Works Earl Lee Kelly and Chief Engineer Charles H. Purcell, rendered outstanding service in their particular lines of activity, as did their associates.

These bridge builders have looked forward with enthusiastic anticipation to this hour. In all of the processes of construction they followed a plan that had been inspired by the commanding ideal of service.

They now enjoy the results of their handiwork. Through the authority vested in the state they offer it today to the public as a masterpiece of architectural and engineering skill, a roadway between two great communities.

FINANCING CITED

While we extol the achievement of its building, and sing the praise of those who have accomplished its completion, the ulitarian and practical features which induced investors to finance the project should not be passed unnoticed. It was this decision which finally insured success.

The financing of the undertaking is as bold in the field of investment as is the project in engineering and construction. Self-liquidating, the $55,000,000 in bonds, already issued, and the $15,000,000 or $20,000,000 additional necessary to provide interurban electric car service over the bridge, are guaranteed, only by the revenues derived from its operation. The receipts and income must pay the indebtedness incurred. The taxes and credit of the cities, counties and even the State are in no wise pledged for the satisfaction of the bridge obligations. When the bonds and indebtedness have all been paid, the bridge becomes the property of the state, to be operated toll free as part of the highway system.

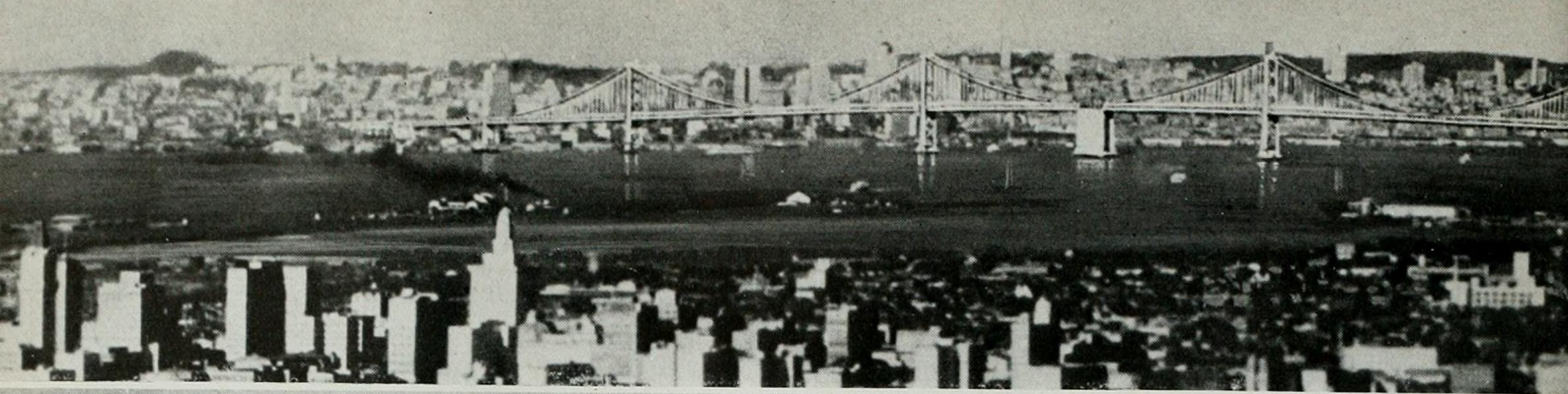
COST IS REDUCED

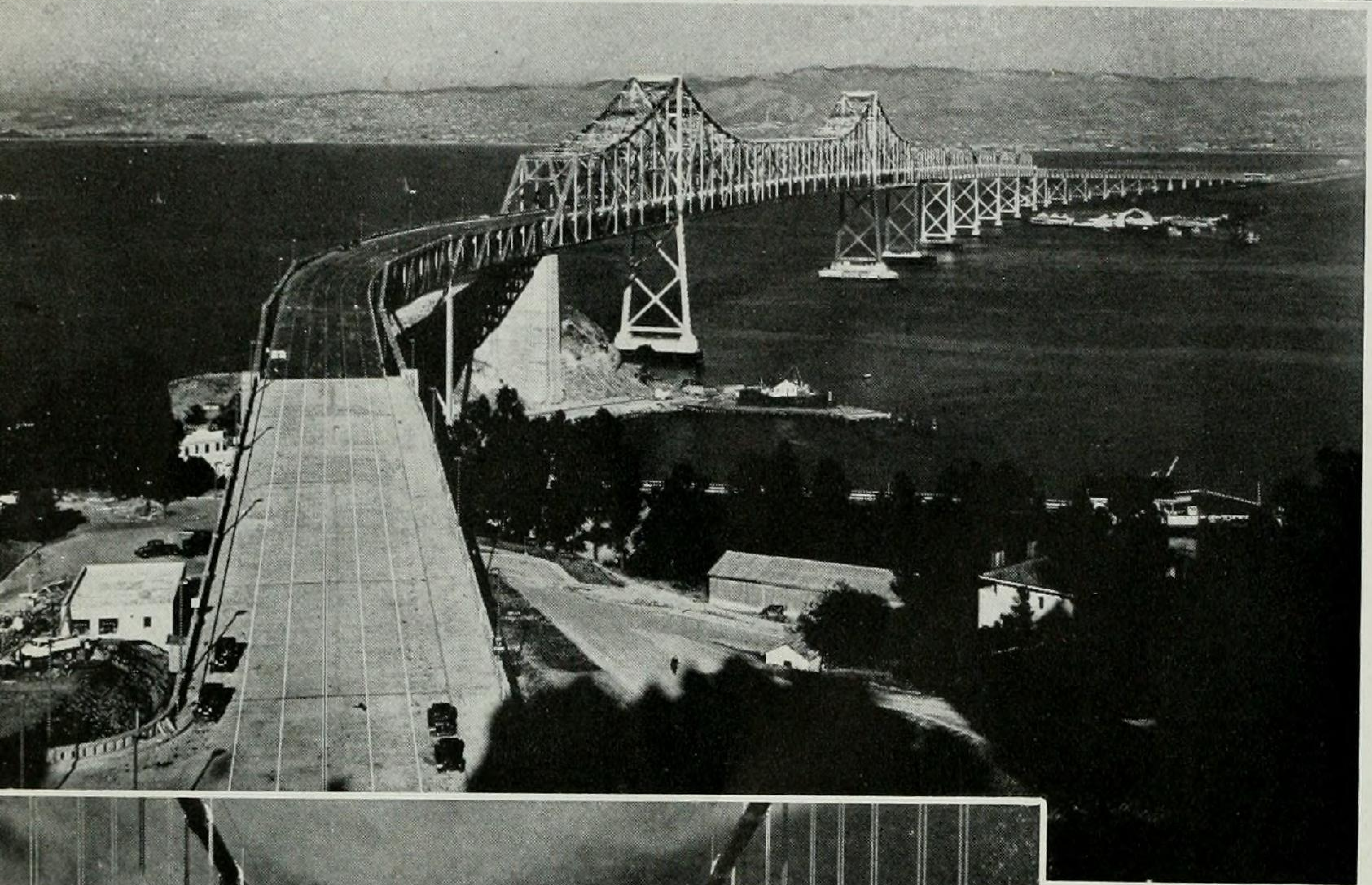
It is a matter of gratification that the bridge has been constructed for less than the estimated cost and completed in less than the time allotted under the contract.

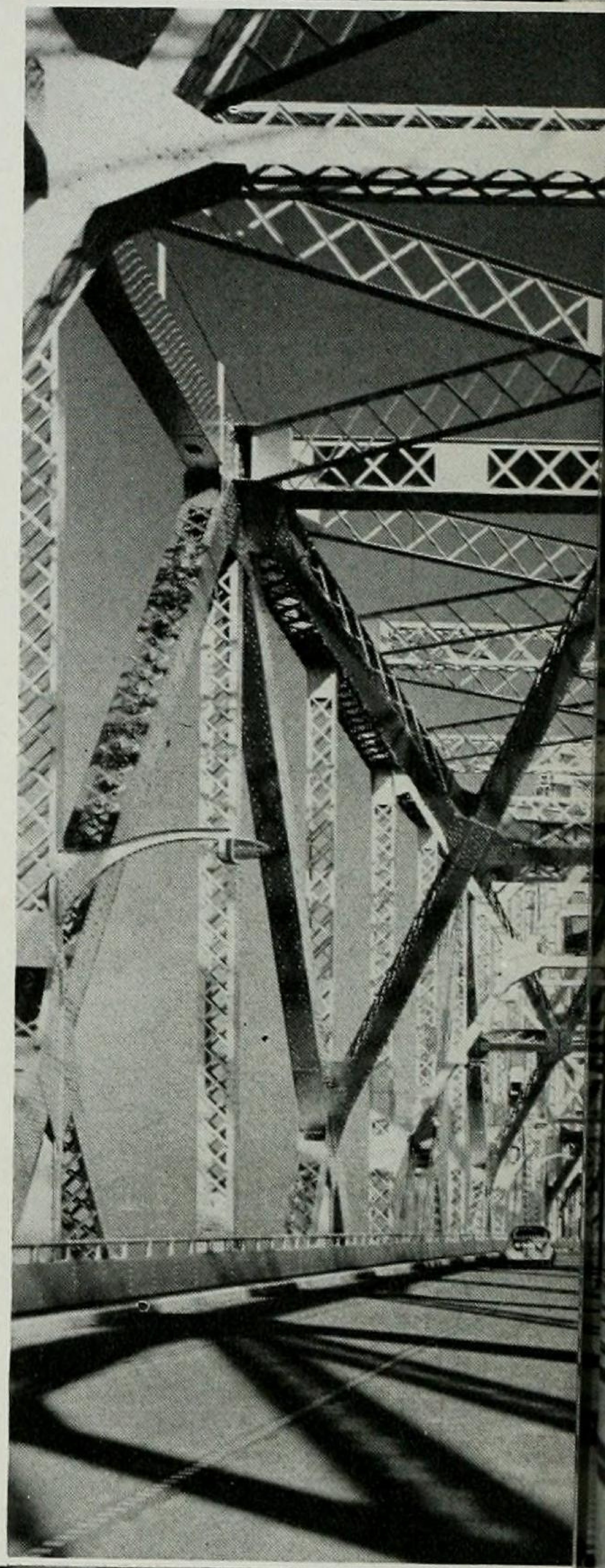
This bridge was designed and has been constructed to improve transportation facilities, to make travel less expensive, to save time and to provide convenience, safety, and com-

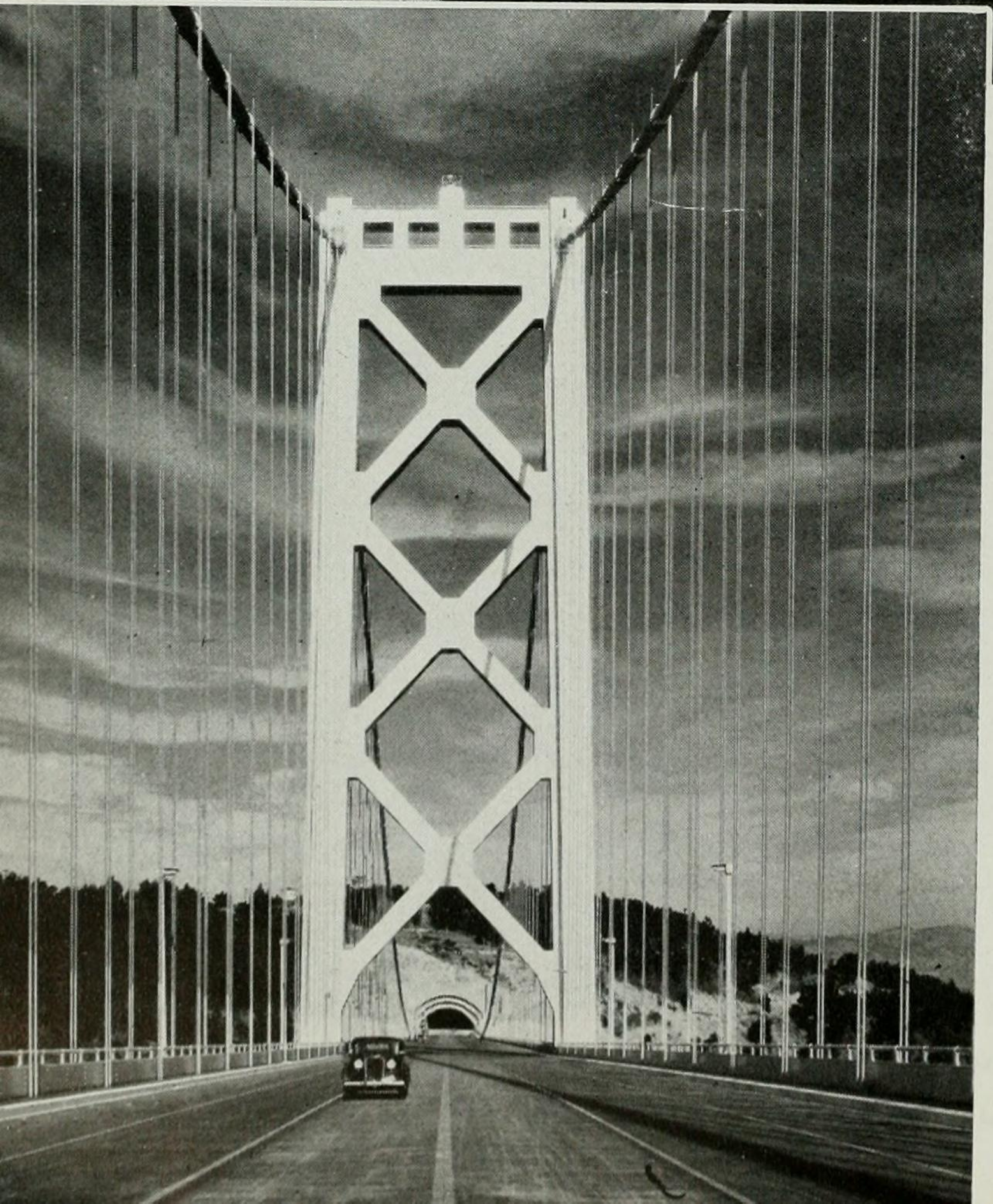
(Continued on page 23)

Entrancing view of Bay Bridge showing majestic lines of structure, with San Francisco in background.



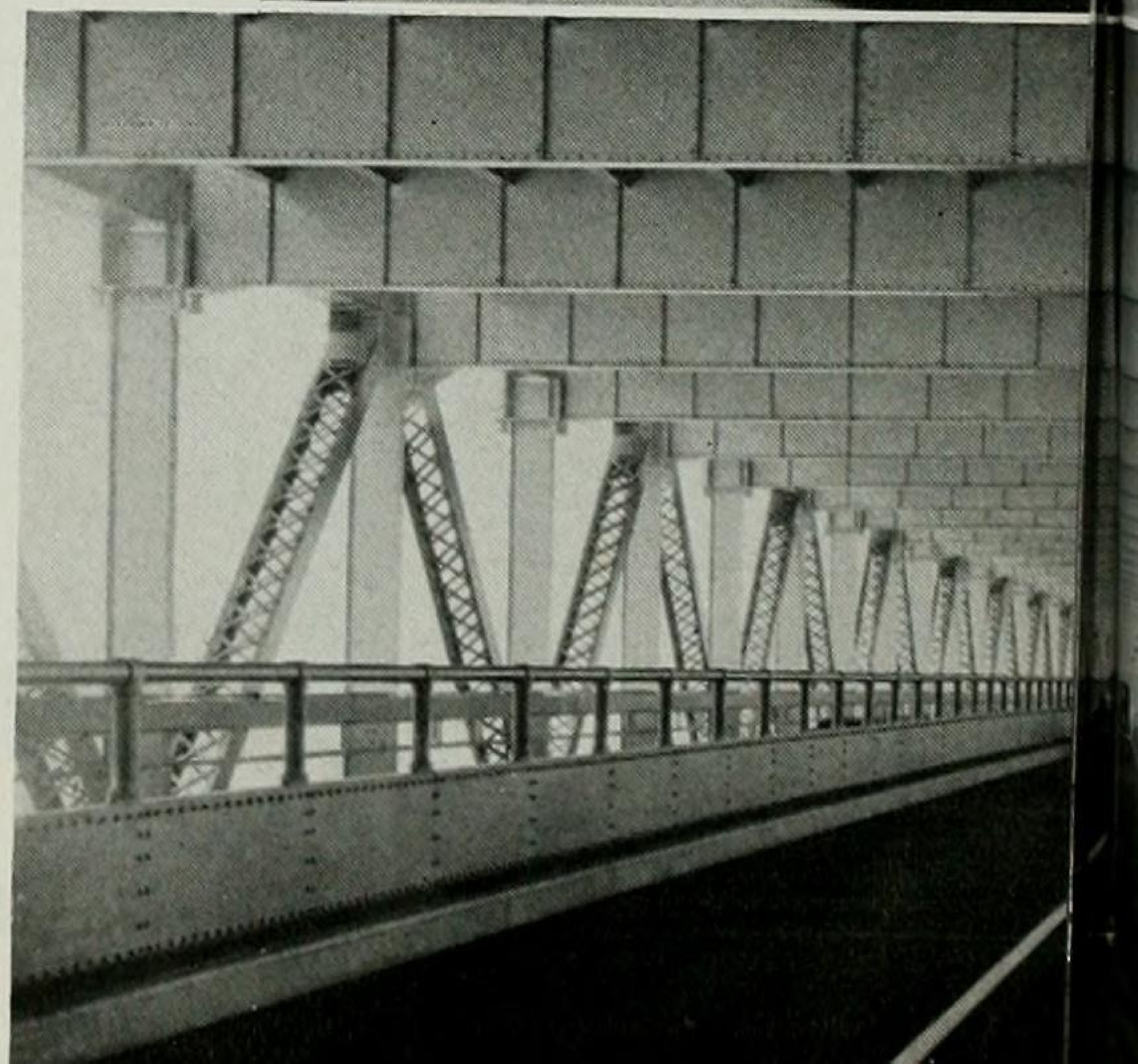




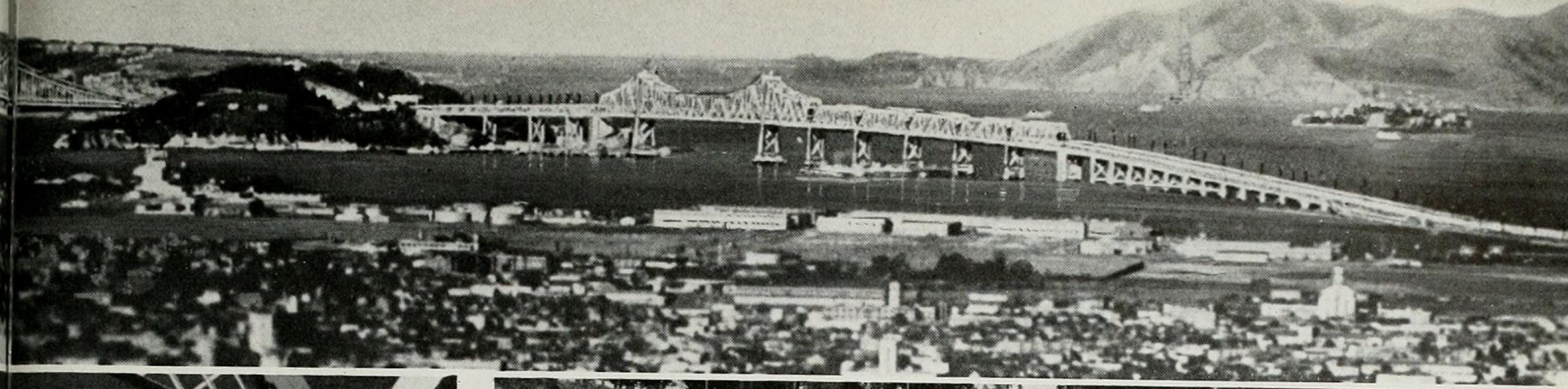


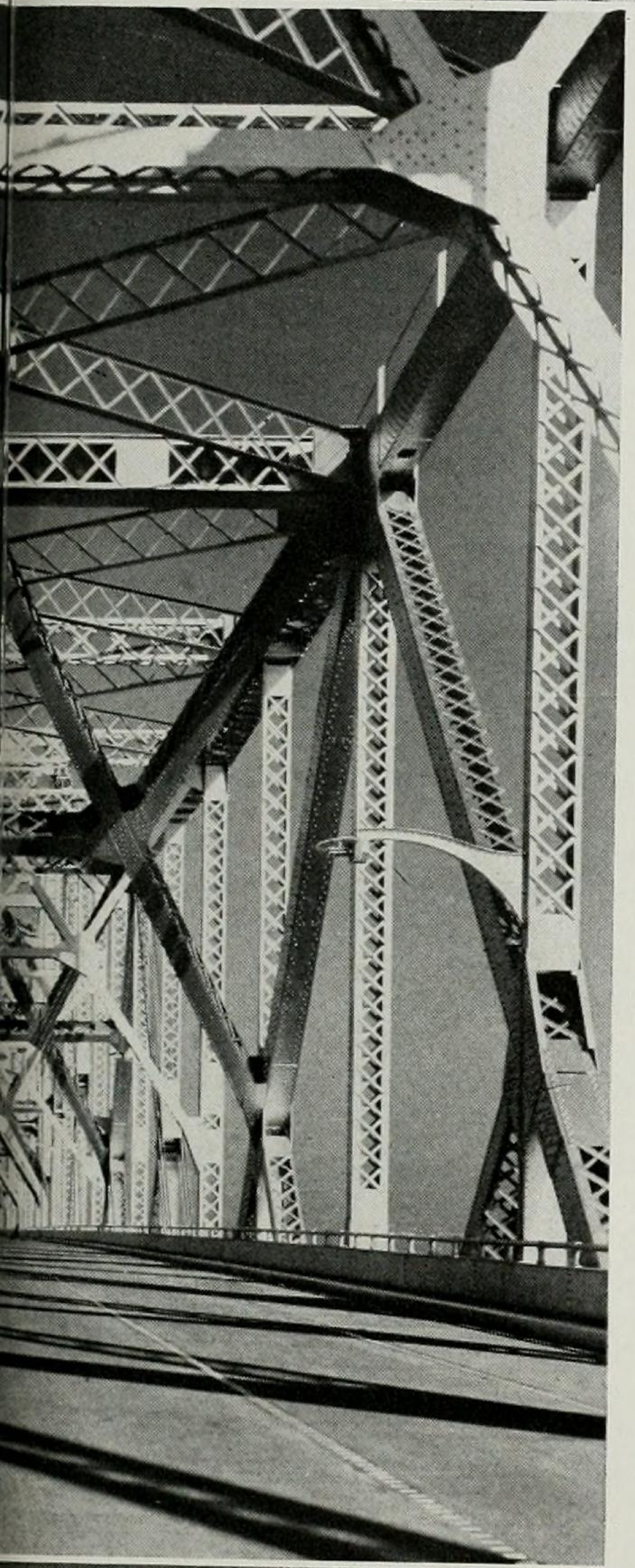
AT TOP
Panorama of entire bridge from Berkeley looking toward Golden Gate.

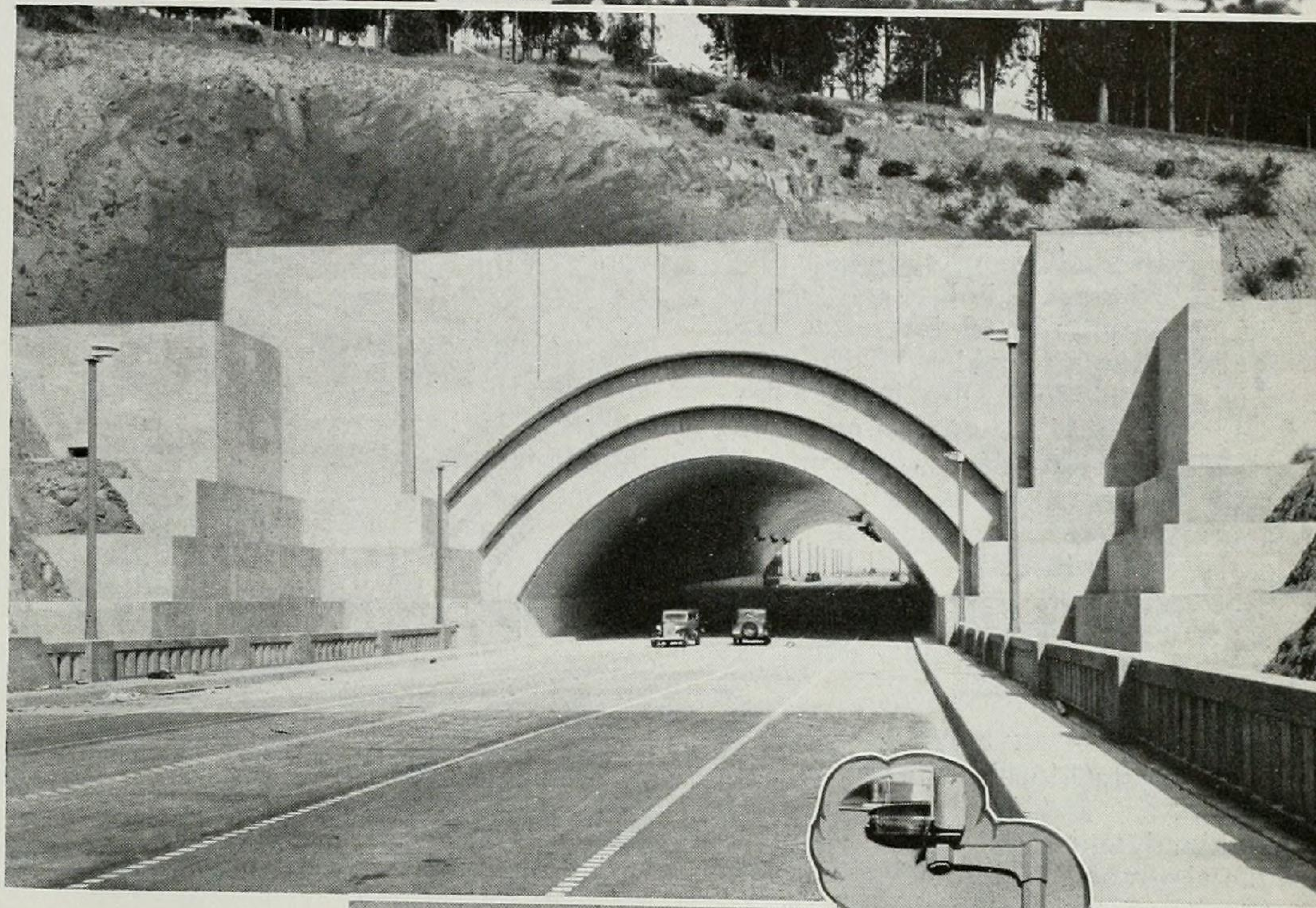
AT LEFT
Cantilever span and approaches and below, east suspension span approaching Yerba Buena Tunnel.



AT RIGHT
View of lower deck showing three truck lanes.

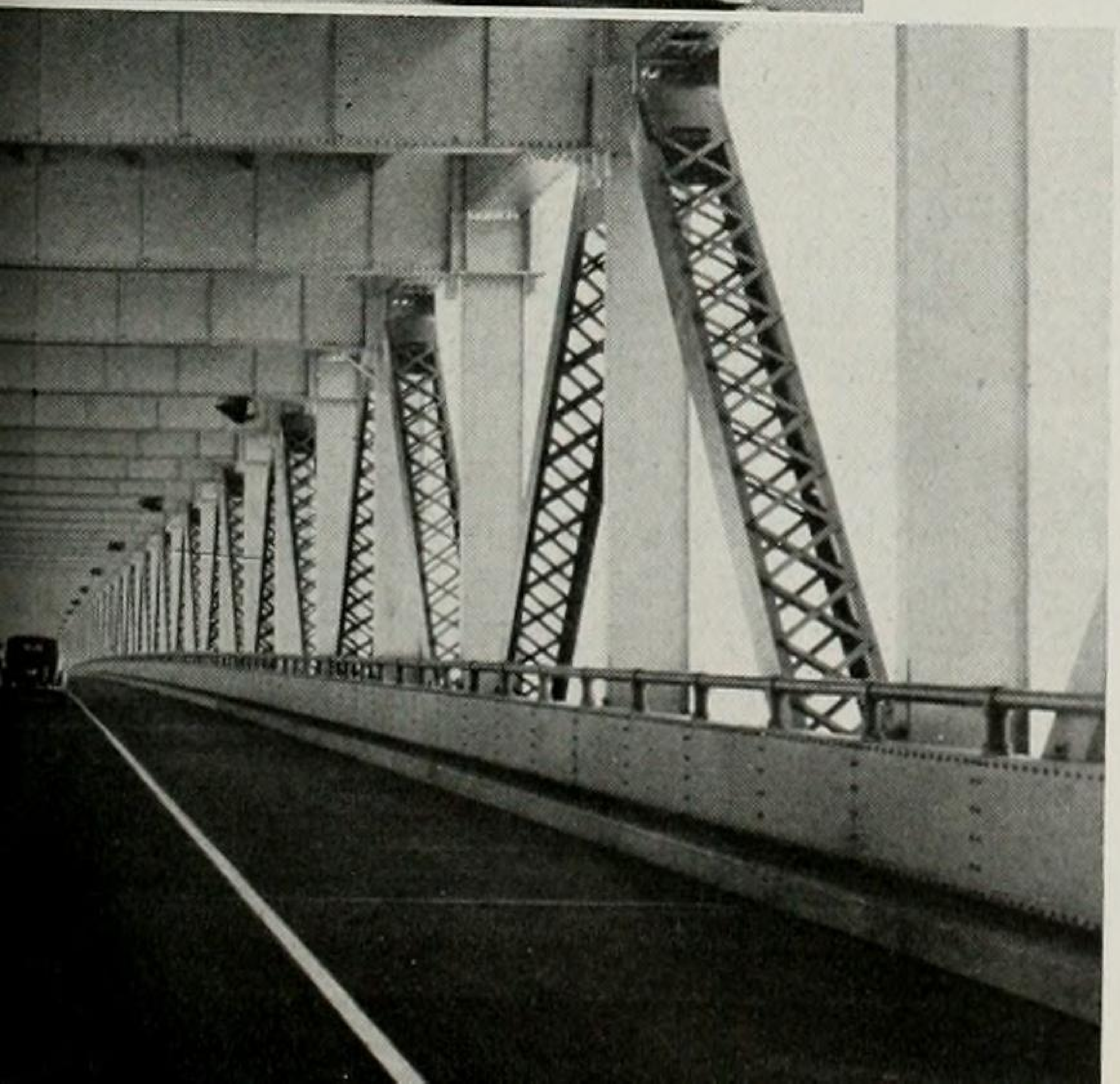






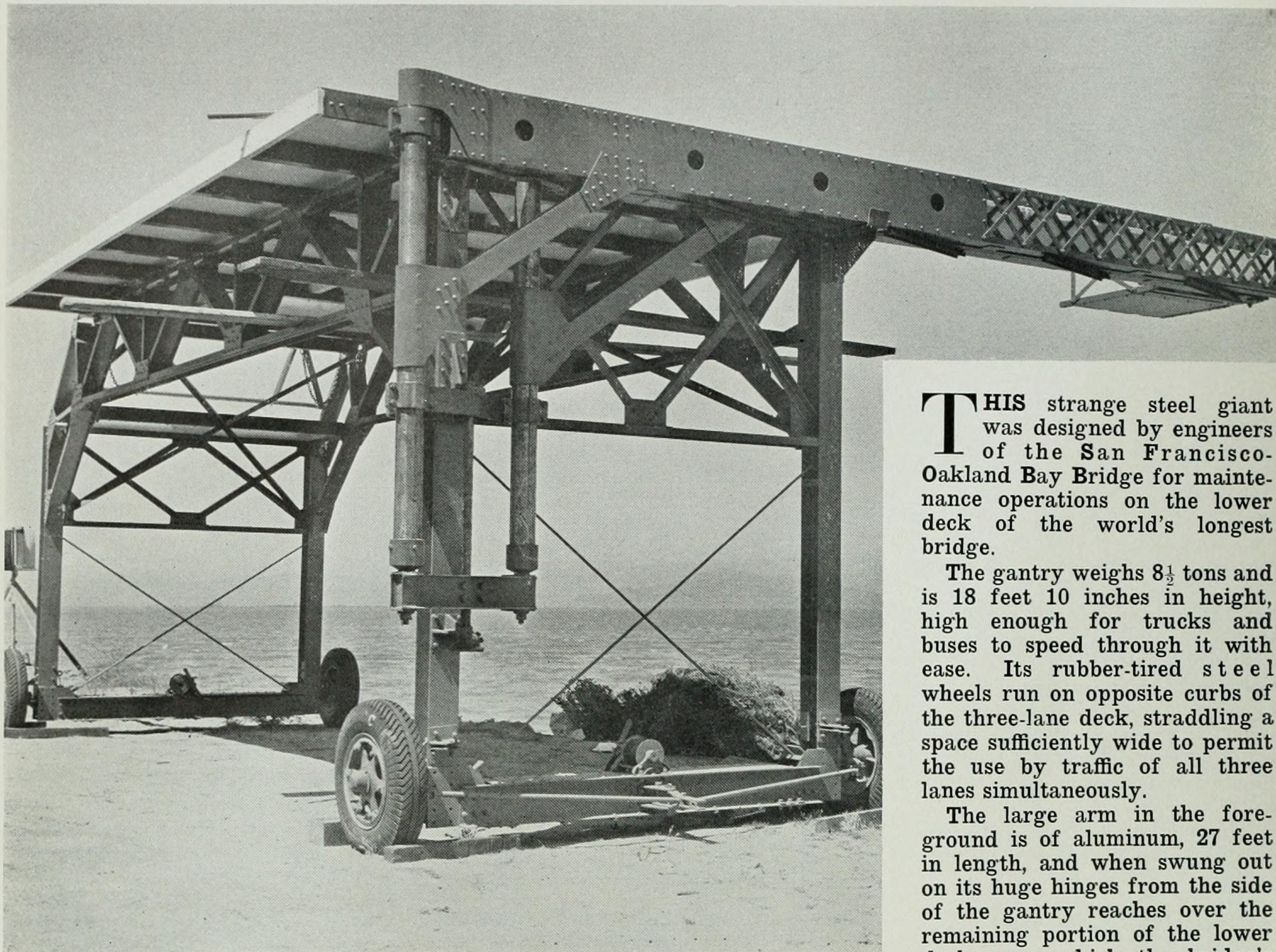
IN CENTER
Auto traffic passes through an arch of steel on top deck of cantilever spans.

AT RIGHT, ABOVE
View of upper deck through the Yerba Buena Tunnel.



AT RIGHT
Close up of main cable of east suspension span showing suspender cables and Fresnel light standard and lamp.

Engineers Design Huge Gantry for Bridge



THIS strange steel giant was designed by engineers of the San Francisco-Oakland Bay Bridge for maintenance operations on the lower deck of the world's longest bridge.

The gantry weighs 8½ tons and is 18 feet 10 inches in height, high enough for trucks and buses to speed through it with ease. Its rubber-tired steel wheels run on opposite curbs of the three-lane deck, straddling a space sufficiently wide to permit the use by traffic of all three lanes simultaneously.

The large arm in the foreground is of aluminum, 27 feet in length, and when swung out on its huge hinges from the side of the gantry reaches over the remaining portion of the lower deck, over which the bridge's electric railway system will soon be operating.

This aluminum arm, or cantilever, is designed to clear the catenary of the electric trains so that schedules can be kept uninterrupted by painting or other maintenance operations.

To swing the cantilever out above the catenary, it is first raised to the position shown in the illustration, sufficiently high to clear the trolleys. From this position it can be swung through 90 degrees. Floor boards are then placed in position, forming a safe working platform.

Number of Vehicles Using Bay Bridge Passes 8 Million Mark

A TOTAL of 705,704 vehicles crossed the San Francisco-Oakland Bay Bridge during September, bringing the entire number of vehicles to cross the span during the ten months since it opened to 8,283,231, according to Earl Lee Kelly, State Director of Public Works.

High point of the month was Saturday, September 25, when 31,762 vehicles crossed the bridge, stimulated by the University of California-St. Mary's football game at Berkeley, Mr. Kelly said. Low point was Tuesday, September 28, with a total of 19,949 vehicles.

Daily average for the month was 23,523, bringing a total income for September of $377,344.65.

Comparative figures of August and September traffic over the Bay Bridge, as reported by State Highway Engineer C. H. Purcell, were announced by Mr. Kelly as follows:

	Passenger Autos	Auto Trailers	Motor-cycles	Tri-cars	Trucks
Total Aug.__	807,670	2,460	3,691	780	27,737
Total Sept.__	663,520	1,689	2,994	772	25,993

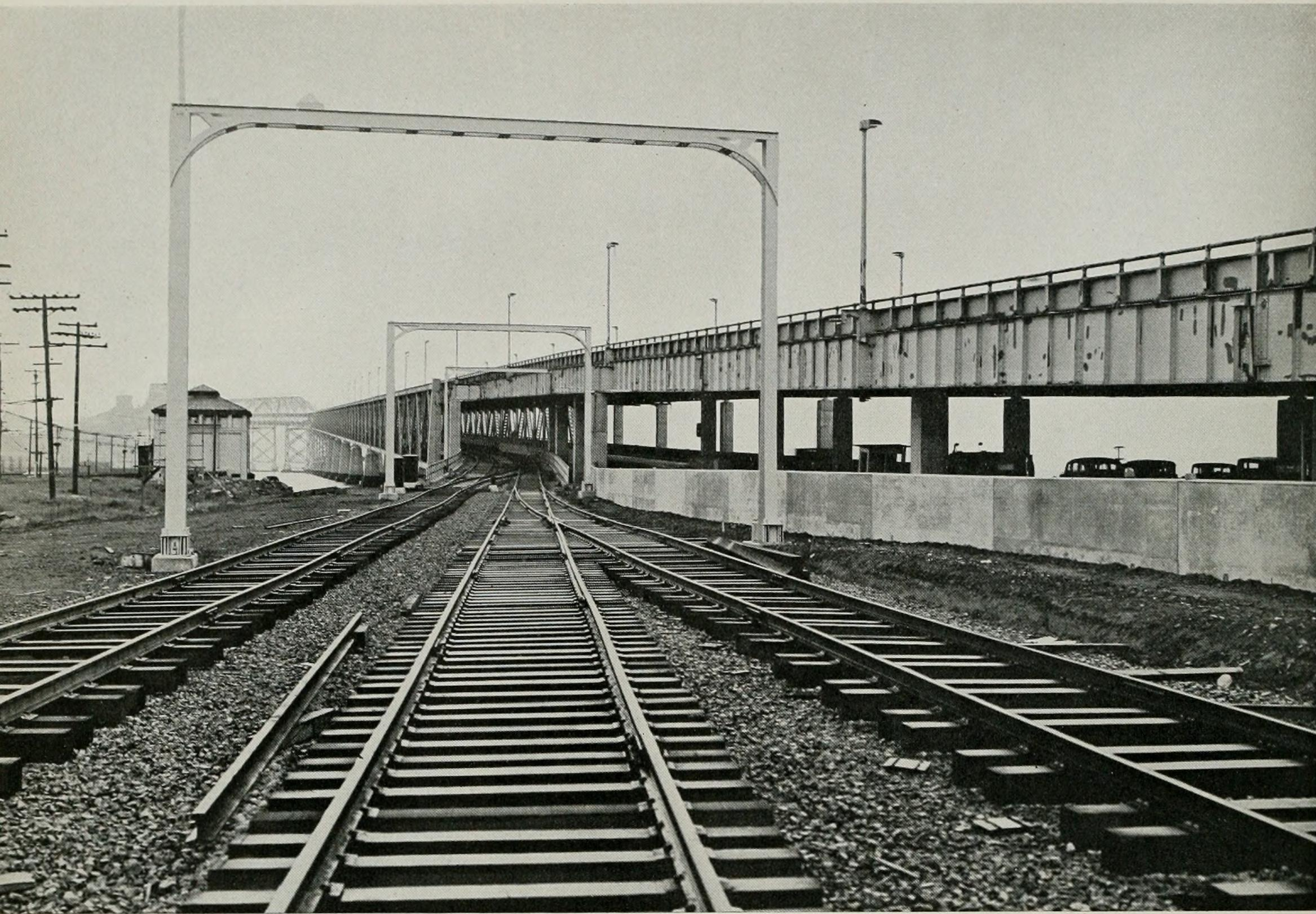
	Truck Trailers	Buses	Total Vehicles	Extra Passengers	Freight Lbs.
Total Aug.	1,408	9,833	853,579	209,620	69,082.335
Total Sept.	1,274	9,462	705,704	173,144	64,446,664

The Lady Remarketh: "Hobo, did you notice that pile of wood in the yard?"

"Yes'm, I seen it."

"You should mind your grammar. You mean you saw it."

"No'm. You saw me see it, but you ain't seen me saw it."



Where Bay Bridge trains will enter and leave the easterly end of the span.

BUILDING BAY BRIDGE RAILROAD

BY THE early part of 1939 a three-quarter century old custom around San Francisco Bay will have been altered.

For the picturesque ferry boats which for decades have carried passengers between metropolitan Oakland and San Francisco will be replaced by smooth running electric trains plying across the San Francisco Bay Bridge.

Both Key System and Interurban Electric (Southern Pacific) will operate trains across the span at an average saving to passengers of 15 minutes.

Trains will operate directly from Alameda, Berkeley and Oakland to the terminal in San Francisco.

This structure, facing Mission Street and extending within the vicinity of Beale and Second Streets, will be longer than the Ferry Building, and will bring 50 per cent of the daily commuter traffic to within walking distance of their destination in San Francisco.

REINFORCED CONCRETE TERMINAL

Street cars will loop in front of the terminal over an elevated ramp. The ramp will have three tracks, with a capacity of four cars each.

The terminal is a reinforced concrete structure to be faced with granite. To date, all structural concrete in the building units has been placed up to and including the track floor, the highest floor elevation in the project.

Above the track floor the side walls and roof slab are within 20 per cent of completion. All steel framing over the train shed, with the exception of the east unit, has been erected, and the only steel construction for the viaduct remaining to be placed is that over South First and South Fremont streets.

TRAINS 63 SECONDS APART

Because the Bay Bridge railroad will of necessity handle as many as 17,000 passengers one way at a twenty minute period over one track, close headway schedules will be required. Ten-car trains will run as

close as 63 seconds apart. By way of comparison, New York subway trains have a 90-second headway.

To assure maximum safety and efficiency, the most complete automatic interlocking and signal system has been designed.

Replacing the old system of manually operated levers will be a trim control board, six and a half feet long and four feet and three inches high, designed so that the operator may sit before it as he would at a high-topped desk. Engraved on the face of the board is a track diagram with a signal knob or button placed at the entrance of each "route."

To "set up a route" the operator has only to press the signal knob at the entrance to the route and the completion knob at the exit to the route.

CONTROL BOARDS

Such a control board will be installed in the San Francisco Terminal. The design on this board will show the six tracks over which bridge trains will roll to discharge and pick up passengers. On it will be indicated the 36 track switches and 40 wayside signals which comprise the interlocking plants of the terminal and viaduct.

A similar board will be placed in the high signal tower now completed in the Oakland yards situated just opposite the Toll Plaza. It will differ only in respect to its diagram which will show a design of the yards comprising the storage tracks and the mainline tracks. The Oakland interlocking plant controls 36 track switches and 62 wayside signals.

Each train has its corresponding numeral or letter (numeral for Interurban Electric; letter for Key System) identified on the board. When the train leaves either terminus the operator presses the proper button identifying the train to the operator at the other terminus.

TERMINAL NOISE ELIMINATED

Trains will loop into the San Francisco Terminal from the bridge over a viaduct, so insulated as to eliminate noise to the greatest possible degree.

The trains will leave and enter the lower deck of the bridge at a point west of and paralleling the truck and "off" vehicular ramps.

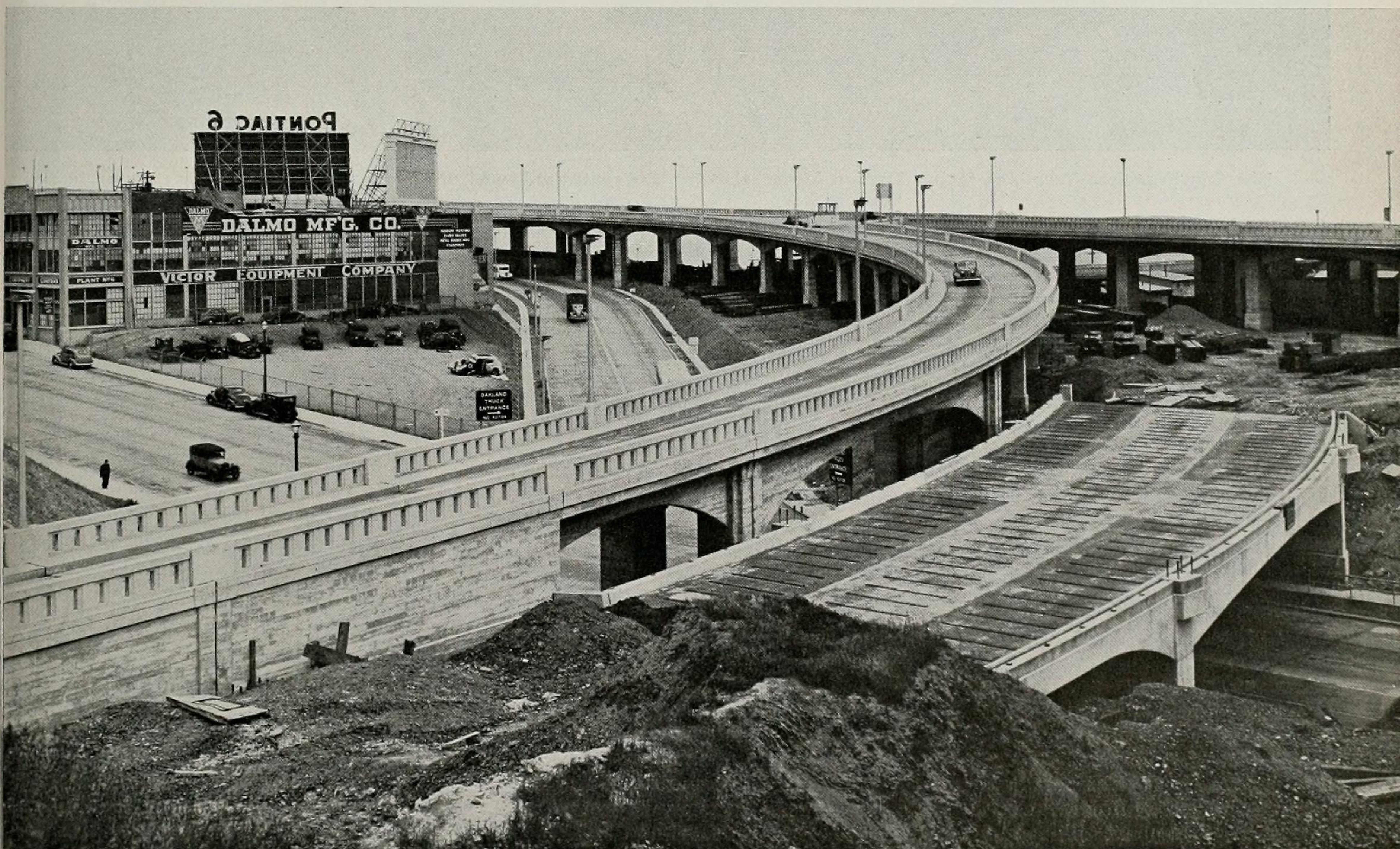
East and westbound trains will share a common viaduct between the bridge and Clementina street at which point the viaduct separates to form a gigantic loop which will encompass the approximate equivalent of seven city blocks. San Francisco-bound trains from this connection take an easterly to westerly curve into the Terminal.

All foundations for the viaduct are practically completed, as is the neat work on the piers. The concrete crossing over Harrison is finished, and other crossings are rapidly nearing completion.

On the bridge proper, the trains will ply over two tracks on the south side of the lower deck, paralleling the truck lanes.

105,000 RAILROAD TIES

California redwood has been selected for the ties. On the bridge proper the ties are laid directly on the stringers, after the steel had received two coats of inertol.



Trains will leave the westerly end of the bridge over a viaduct paralleling the truck and "off" vehicular ramps.

Trains will roll in the San Francisco Terminal over six tracks arranged in pairs. This view of the elevated track level also shows the roof steel just erected.

This view looking down the East Bay Crossing shows ties and tracks in place.

Governor Merriam Pilots First Train Across Bay Bridge

WEARING a brand-new trainman's cap, Governor Frank F. Merriam, chairman of the California Toll Bridge Authority, piloted the first electric train across the San Francisco-Oakland Bay Bridge Friday morning, September 23.

A Key System two-unit streamliner, the train started at 40th and Hollis Street and proceeded to the easterly foot of the bridge, where Governor Merriam boarded with his party. The Governor was accompanied by Chief Engineer C. H. Purcell, Bridge Engineer Charles E. Andrew, Engineer of Design Glenn B. Woodruff, Florence M. McAuliffe and Lloyd W. Dinkelspiel, counsel for the California Toll Bridge Authority.

Railroad officials, who, with newspapermen, were other occupants of the train, included: W. A. Worthington; C. R. Harding; A. T. Mercier; L. B. McDonald, vice presidents of the Southern Pacific; W. H. Kirkbride, chief Engineer; E. E. Mayo, assistant chief engineer; G. E. Gaylord, superintendent; F. E. Sullivan, train master, and E. J. Foulds, attorney, all of the Southern Pacific.

Key System officials were Alfred J. Lundberg, president; vice presidents William P. St. Sure, C. N. Anderson, Chester C. Vargas, S. G. Culver, Bruce Campbell; Frank Richards, general counsel, Andrew T. Haas, architect. I. S. Shattuck, traffic engineer for the Golden Gate International Exposition was also an observer.

The Governor was originally scheduled only to start the train as a ceremonious gesture. However, after a few brief instructions by Vice President C. N. Anderson in charge of operations for the Key System, the State's chief executive proved himself an able trainman and remained at the controls to guide the train and its 80 some passengers across the bay—the first time in history that a train ever crossed under its own power directly between San Francisco and the East Bay.

The trip proved the success of the bridge railroad constructed by the State Department of Public Works. Unanimous opinion of railroad experts and newspapermen was that the roadbed provided smooth and quiet operation; that the automatic cab control system was highly efficient and that the view from the train windows was unsurpassed.

Chief Engineer C. H. Purcell tersely summed up his inspection following the first test run. He reported: "The cab signal for the run indicated a permissible speed of 35 miles per hour and the train proceeded across the bridge in accordance with this prescribed signal indication. All facilities and equipment operated as intended."

It required approximately an hour to make the round trip over the bridge on the train's first run. This was due to frequent stops for inspection of expansion rails, and to permit newspapermen to photograph the train on the bridge.

It will require approximately 10 minutes after trains are in actual operation, to cross from the center of the San Francisco Bridge Terminal building to the easterly foot of the span.

Bay Bridge Traffic Shows Increase Over September 1937

A FIVE per cent increase in San Francisco-Oakland Bay Bridge traffic over that of a year ago was revealed yesterday by Director of Public Works Earl Lee Kelly from the September traffic report filed by State Highway Engineer C. H. Purcell. A total number of 740,622 vehicles crossed the bridge during last month, as compared to a total of 705,704 for the same period in 1937.

Due to changes in rate parities between the ferries and the bridge since the time of the bridge opening, this is the first time that a parallel comparison could be made between 1937 and 1938 and those for the current year. Other classifications of traffic also showed an increase over last year. Freight pounds were up 67 per cent, with a total of 107,886,750 pounds for September, 1938, as against 64,352,834 for the same month in the previous year. The number of trucks increased approximately 51 per cent with the comparitive figures of 37,684 for September, 1938, and 25,031 for September, 1937. Buses increased 39 per cent with 13,153 buses crossing the span last month and 9462 in September of last year. Traffic for September, 1938, averaged 24,687 vehicles a day—a drop of 389 vehicles from August.

	Total September	*Total August*	*Total since opening*
Auto Trailers	1,473	1,848	27,772
Passenger Autos	657,611	693,297	15,571,167
Motorcycles	2,806	2,994	58,396
Tricars	1,003	1,167	18,293
Buses	13,153	13,432	207,185
Trucks	37,684	39,863	600,912
Truck Trailers	1,637	1,768	34,576
Toll Vehicles	715,367	754,369	16,518,301
Auto Passes	23,245	21,089	231,345
Truck Passes	2,010	1,905	22,315
Total Vehicles	740,622	777,363	16,771,961
Extra Passengers	233,561	244,728	4,027,469
Freight Pounds	107,886,750	111,016,500	1,482,654,409

High point of the month was on Saturday, September 24, when 33,762 vehicles crossed the bridge. This increase was due to the St. Mary's football game in Berkeley.

After a few minutes of instruction, Governor Frank F. Merriam took over the controls, started the motor, and piloted across the San Francisco-Oakland Bay Bridge the first train in history to cross under its own power from Oakland to San Francisco. The Key System two-unit stream line is shown with Governor Merriam at the throttle and below, shaking hands with the Governor are railroad workers: (left to right) Martin Coyne, John Armstead and Fred Welsh.

Scene at official opening and dedication of San Francisco-Oakland Bay Bridge Electric Railway Terminal Building in San Francisco.

Bay Bridge Terminal Dedicated

WITH a few formal words uttered at the dedication ceremonies held in San Francisco January 14, Director of Public Works Frank W. Clark turned over to Lieutenant Governor Ellis E. Patterson, representing Governor Culbert L. Olson, the State-owned Bay Bridge and State-built Bay Bridge terminal building and electric railway, the first railway ever to operate directly between Sacramento, Alameda County and San Francisco.

Director Clark said,

"Lieutenant Governor Patterson, I, as State Director of Public Works, declare the San Francisco-Oakland Bay Bridge rail facilities completed for train operation and recommend acceptance by the California Toll Bridge Authority."

Lieutenant Governor Patterson, representing Governor Olson, who is Chairman of the California Toll Bridge Authority, accepted the completed facilities for the Authority and turned the use of them over to the railroads for operation. Mr. Patterson said,

"On behalf of Governor Culbert L. Olson, Chairman of the California Toll Bridge Authority and member of the Authority, your recommendation is accepted and the California Toll Bridge Authority hereby assumes possession."

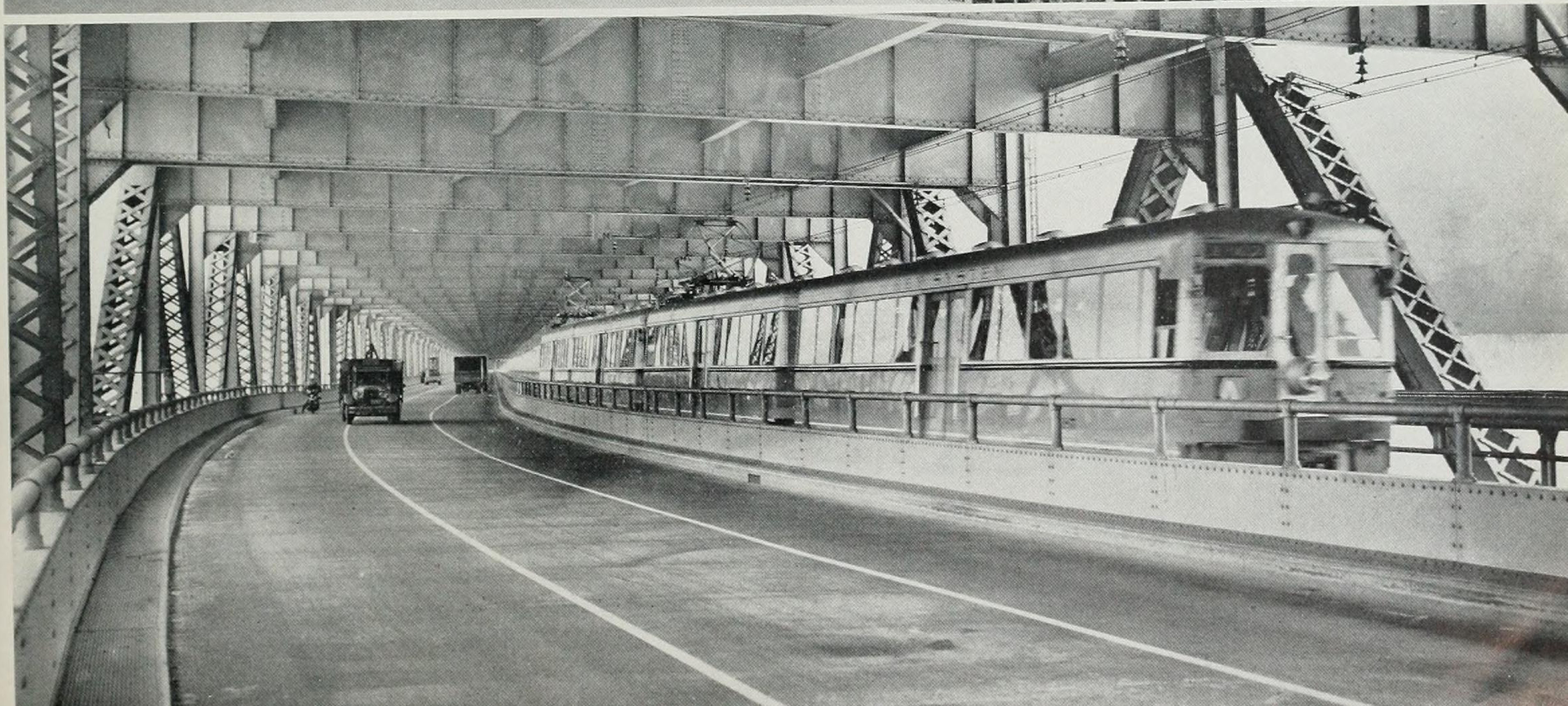
To the strains of "The Star Spangled Banner," and "I Love You, California," the National and Bear flags were then raised by the California Highway Patrol.

In completion of the formal steps necessary to the occasion Lieutenant Governor Patterson then turned to the railroad representatives present and said:

"In accordance with the agreement between the California Toll Bridge Authority and Interurban Electric, Key System, and Sacramento-Northern, I formally place the use of these railway facilities in the hands of representatives of the railroads here today. I am certain, gentlemen, that it will be your policy to operate these facilities to the best interest of the public."

A. T. Mercier, president of Interurban Electric; Alfred J. Lundberg,

At Top—One of four passenger platforms on upper terminal level where trains on six tracks load and unload passengers. Center—Mezzanine concourse entered from street car ramp and ground floor waiting rooms. Bottom—Lower Bridge deck carrying train and truck traffic.



president of Key System, and H. A. Mitchell, president of Sacramento-Northern, then formally accepted the use of the facilities for their companies.

The ceremonies were held in front of the newly completed terminal building facing Mission Street in San Francisco with more than 1500 dignitaries from cities of northern California, Alameda and San Francisco counties participating before a great throng of citizens who came to witness the epochal event.

The legal and essential formalities concluded, the program continued with a number of notable speakers.

"C. H. Purcell, Chief Engineer of the Bay Bridge and its railway facilities, was introduced by Supervisor John Ratto of San Francisco, chairman of the San Francisco citizen committee for the celebration, acting as chairman of the day. Mr. Purcell was described by Mr. Ratto as "a man who has probably accomplished more for the San Francisco Bay Region as a whole in a shorter period of time than any single person" and "a man who has quietly shouldered tremendous responsibilities and who has executed these responsibilities with great skill and amazing success."

Mr. Purcell said, "Into this project have gone the skill and experience of the engineering profession—civil, electrical and mechanical. Great praise is due the staff of engineers employed by the State Department of Public Works on design and in the field. Also to Bridge Engineer Charles E. Andrew and to Engineer of Design Glenn B. Woodruff, who worked faithfully, conscientiously, and ably, special praise is due.

"Appreciation is also due the fine cooperation given by the American workmen employed on the project; by the contractors engaged in the construction of the facilities and by the railroads who will operate the system.

"To the Federal Government, through the Reconstruction Finance Corporation, and to city and county governments thanks are given for the invaluable aid given us."

Mayor Angelo J. Rossi of San Francisco welcomed the visiting Mayors. Among those who spoke briefly were Mayor T. B. Monk of Sacramento; Dr. William McCracken, Mayor of Oakland; Edward N. Ament, Mayor of Berkeley; Henry A. Weichart, Mayor of Alameda; Oliver Ellsworth, Mayor of Piedmont; Earl Derry, Mayor of San Leandro.

Florence M. McAuliffe, special counsel for the California Toll Bridge Authority, read a telegram of regret from Jesse F. Jones, chairman of the Reconstruction Finance Corporation. The telegram, addressed to Charles H. Purcell, said:

FRANK W. CLARK
Director of Public Works

"I very much wish I could be present at the dedicatory ceremonies starting interurban service on the San Francisco-Oakland Bay Bridge. Again I am reminded that the design and construction of this bridge is one of the outstanding engineering feats of our generation. It is beautiful as well as being of great service and will stand a credit to all who had part in the great achievement. I extend hearty congratulations to San Francisco, Oakland and California."

Howard J. Klossner, a director of the Reconstruction Finance Corporation, spoke for the Corporation; and H. R. Judah, chairman of the State Highway Commission and member of the California Toll Bridge Authority, gave a brief but impressive talk.

Frank C. MacDonald, general president of the State Building and Construction Trades Council of California, who was introduced by Director Clark, spoke on behalf of labor.

The 1500 guests had been brought to the ceremonies by Key System and Sacramento-Northern trains. Two six unit Key System trains left 22d and Broadway in Oakland at 10:30 a.m., traveling smoothly over the bridge and arriving at the San Francisco Terminal for the ceremonies at 11:15 o'clock. Labor representatives, contractors' representatives, and civic officials of Alameda and San Francisco counties were present.

A Sacramento-Northern train, originating at Chico, carried mayors and distinguished guests of the Northern California towns along the route. Members of the State Legislature, who had been invited by Governor Olson to attend, were among the guests.

More than 5,000 persons gathered in the plaza before the handsome new Terminal to listen to the ceremonies. After completion of the dedication program the building was opened to the public for inspection. Thousands wandered through the modern structure during the day and evening.

Operation and maintenance of the Bridge Railway is now in the hands of the railways, a board of governors having been named by the railroads for management of the facilities. Named were R. E. Hallawell, General Manager of Interurban Electric; and William P. St. Sure, Vice President of the Key System. F. E. Sullivan was appointed Superintendent of the Bridge Railway and Orman Lutz was named Business Manager by the Board.

The construction chronology of the Bay Bridge Electric Railway facilities is as follows:

(Continued on page 28)

Terminal Plaza showing trolley car loop ramp to mezzanine level and street entrances for pedestrians and automobile passengers.

OFFICIAL GROUP—Left to right—Frank W. Clark, State Director of Public Works; Lieutenant Governor Ellis E. Patterson; Mayor William McCracken of Oakland; Mayor Angelo J. Rossi of San Francisco; John F. Hassler, City Manager of Oakland, and C. H. Purcell, Chief Engineer of Bay Bridge and its railway facilities.

California Toll Bridge Authority that adopted reduced rates on San Francisco-Oakland Bay Bridge. Left to right, seated, Lawrence Barrett, Chairman California State Highway Commission; Director of Public Works Frank W. Clark, Secretary, Toll Bridge Authority; Governor Culbert L. Olson, Chairman of the Board; Lieutenant Governor Ellis E. Patterson; Phil S. Gibson, Director of Finance. Standing, left to right, Charles H. Purcell, State Highway Engineer; Edward P. Murphy, Attorney for the Board; Hubert W. Erskine, Attorney for the Board; C. C. Carleton, Chief of the Division of Contracts and Rights of Way, Department of Public Works.

effect on or about the fifteenth of June.

It is interesting to note that in November of last year it was announced that it would be approximately three years before there could be any reduction in the tolls. Governor Olson, Mr. Clark, and the attorneys, Mr. Erskine and Mr. Murphy, are accordingly being congratulated upon this splendid achievement due entirely to the initiative and efforts of Governor Olson aided by the cooperation of Director Clark, and the attorneys for the Authority.

The people of the State of California, particularly those residing in the Bay area feel elated and are expressing their appreciation to the administration for the results so quickly and so efficiently obtained.

Following the action by the Toll Bridge Authority, Chairman Jesse H. Jones of the Reconstruction Finance Corporation announced the sale on June 7 of $71,000,000 of San Francisco-Oakland Bay Bridge bonds to a group of New York bankers. The bonds, known as 4 per cent revenue bonds, were sold at a price of 104 per cent of the face value plus accrued interest which, Jones said, represented a premium to the Reconstruction Finance Corporation of $2,840,000.

Another purchaser of the bonds was L. J. Mattox, State Industrial Accident Commissioner, who announced that the commission voted to invest $5,000,000 of the Workmen's Compensation Fund which now totals about $17,000,000.

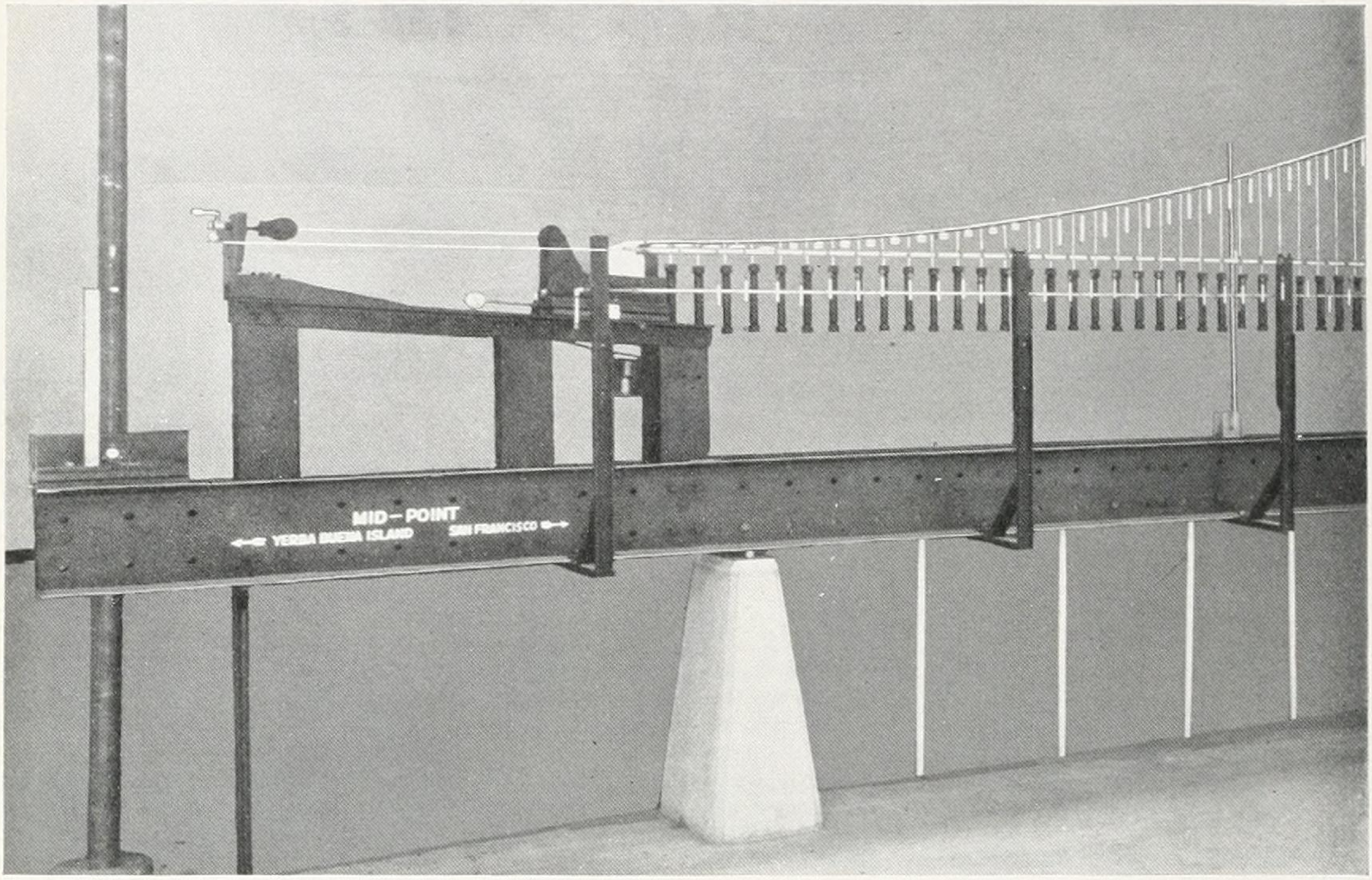
During the month of May, a total of 847,925 vehicles crossed the bridge, according to a traffic report submitted by Director Frank W. Clark to Governor Olson. This figure represents an increase of approximately 120,000 vehicles over the same period a year ago and brings the total number of vehicles to travel over the span since its opening November 12, 1936, to 23,081,127.

During the month a daily average of 27,352 vehicles used the bridge, which includes an increase over April of approximately 3,000 trucks. The total number of trucks using the

(Continued on page 5)

An aerial photo of San Francisco-Oakland Bay Bridge on the adjoining page shows the full 8¼ mile-length of the great structure, on which the toll for automobile with driver and four passengers has been reduced to forty cents. In the foreground may be seen the San Francisco end at Fifth Street Plaza and the bridge train terminal. At Yerba Buena Island in the middle ground a highway lateral and viaduct extends to Treasure Island shown at extreme left.

San Francisco-Oakland Bridge Model



HERE is the first photograph of the model bridge from which designs are being shaped for the mammoth $75,000,000 San Francisco-Oakland Bay Bridge.

Built to a scale of one-thousandth the actual size of the bridge to be erected, models have been constructed at the Engineering Department of the University of California at Berkeley by the State Engineers' Department, Professor Davis of the University and his classes.

These models have been put to a series of tests to determine strains and stresses and, from the results noted in these experiments, the engineers will determine upon the type of structure to span San Francisco Bay.

WORK HAS STARTED

Already work on the design of the real structure has started as a result of these experiments. Various plan layouts of that portion that will stretch between Yerba Buena Island and San Francisco are being made and estimates of cost compiled.

Two general plans are being considered; one consisting of two simple suspension spans with a central anchorage, the two main spans being approximately 2300 feet in length. The other, a single suspension span with a 3800-foot central span.

Preliminary figures indicate that the single suspension span with a 3800-foot central opening would be considerably more expensive and probably more flexible.

General layouts and estimates of these two types of structure are being intensively studied and will be in shape for a decision to be arrived at when the Consulting Board meets again.

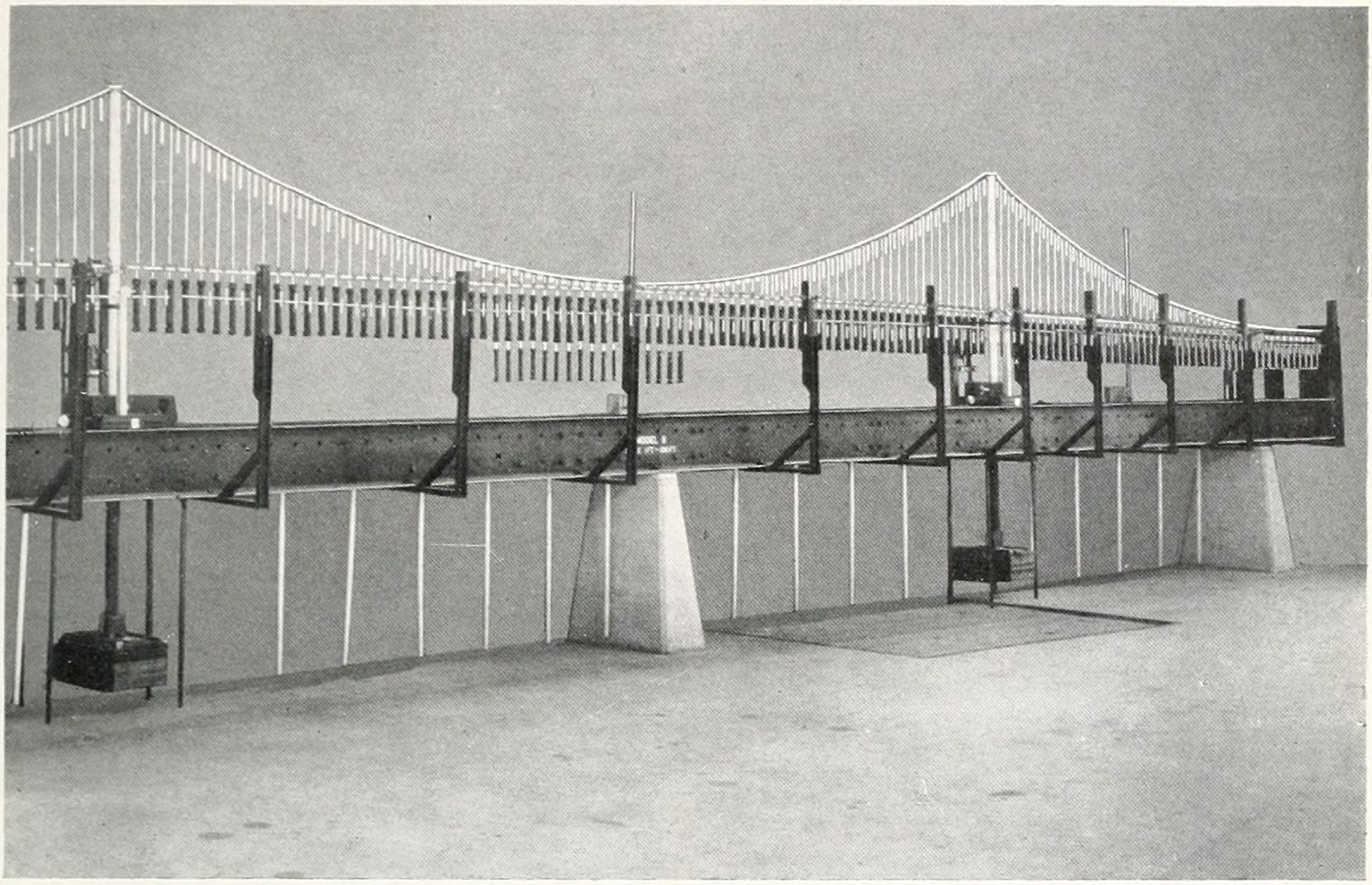
MAKING LOAD TESTS

The photograph above, taken by Lawton & McClure of San Francisco, represents one-half the bridge. The weights hanging from the top wires are used to test loads on the top cables. The vertical dotted line carries the roadways and breaks up distortions under load.

Next in order may be seen a string of horizontal black weights. These represent the weight of trusses and roadway. The little white weights at the bottom are hung from pulleys to represent "wind loads." In other

First Photograph of Test Set-up

(Continued from preceding page)



words the effect on the bridge of an 100-mile-an-hour gale has been tested by means of this model.

The heavy solid white verticals represent the towers of the bridge and at the bottom the white pillars may be noted two counter weights which represent the resistance the two towers would have against horizontal deflection at the top.

BORINGS COMPLETED

While these experiments have been taking place, very good progress has been made by the firm of Duncanson-Harrelson Co., in borings in the bay. Three holes have been put down at the second pier off Yerba Buena Island and rock has been encountered from 130 to 140 feet in depth.

Two diamond drill holes are nearly completed just east of the island for the first pier, where rock is encountered at 40 feet.

This work is being carried on as rapidly as possible, the contractor using three continuous shifts and with reasonable weather conditions the borings should be completed by the first of February.

Results of the borings to date indicate a slightly better foundation condition than was anticipated.

CAISSON WORK

It is hoped that the next meeting of the Consulting Board will be called early in January when designs and estimates will be advanced sufficiently, it is believed, to permit of final determination of the plan layouts.

The design and inspection forces now number slightly over fifty engineers who, with the exception of four, are citizens of the State of California.

CYCLIST WANTS TO PAY

A bicycle rider with a conscience so strong that he wants to pay a tax to the state for use of the public highways is reported by Russell Bevans, acting registrar of the Department of Motor Vehicles. C. G. J. Wolfe of Vallejo sent a check for $1 to Bevans with the explanation that it was "from one who wishes to pay his little bit for benefits received."

Unfortunately for Wolfe's conscience, however, there is no authority in the law to permit acceptance of fees from bicycle riders who use only leg power and Bevans returned the check to him.

CALIFORNIA HIGHWAYS AND PUBLIC WORKS

April 1933

Official Journal of the Department of Public Works
State of California

First Bay Bridge Steel Tower Now in Course of Construction on Pier II

ERECTION of steel began early this month on the first completed subaqueous pier of the San Francisco-Oakland Bay Bridge at the foot of Harrison Street, San Francisco, known as Bridge Pier No. 2. Upon this pier is being erected a 438-foot steel structure, the most westerly of the bridge towers, which with its concrete base will rise to the height of a 40-story building.

By the middle of the month nine huge segments of steel, weighing 1,500,000 pounds and rising 70 feet above the concrete pier had been placed in position.

The lower segments are hoisted into place and fitted on bolts protruding from the concrete. One segment for Tower No. 2 weighed 78 tons and necessitated a specially built steel frame car of heavy construction to transport it from the eastern mills where it was fabricated. This member is 7 feet square, 45 feet long and built of steel one inch thick.

RIVETING TO BEGIN

Each cellular segment fits into another and after several more have been erected riveting will begin. The start of the riveting process is expected by the end of this month, according to Chief Engineer C. H. Purcell.

This Bay Bridg tower consists of two legs of steel, joined and supported by cross bracing extending diagonally from one leg to another. The tower is erected in segments weighing more than 50 tons each. These segments of steel are divided into cells, the walls of which are $1\frac{1}{8}$ inch thick.

Erection of the tower is achieved by a derrick, the main post of which extends up through the cells of a leg of the tower. The height of the derrick is increased as the tower rises. These towers are left hollow and are fitted with ladders inside so that workmen may climb them at any time.

RIVETS VIA PNEUMATIC TUBE

Each segment of the tower has hundreds of holes drilled into it through which hot rivets will be placed to bind the units into a common mass.

The quantity of rivets utilized on the San Francisco-Oakland Bay Bridge will total 650,000 pounds.

The rivet is shot in a pneumatic tube while red hot up to a riveter who, with a pneumatic hammer, drives it into position and crushes the head into the material riveted so that it is virtually welded into place. An inspector follows the riveter and cuts out defective rivets.

LARGEST IN WEST

This will be the largest steel job the West has ever seen, and the $22,000,000 worth of steel purchased for this bridge was the largest steel order ever placed in the United States, according to W. A. Irvin, president of the United States Steel Company, who recently inspected the bridge work in company with Director of Public Works Kelly and Chief Engineer Purcell.

Another of the huge compressed-air, cylindrical dredging-well caissons has been towed into place at Bridge Pier 5, 3400 feet west of Yerba Buena Island, which completes the line of piers in construction in the West Bay channel.

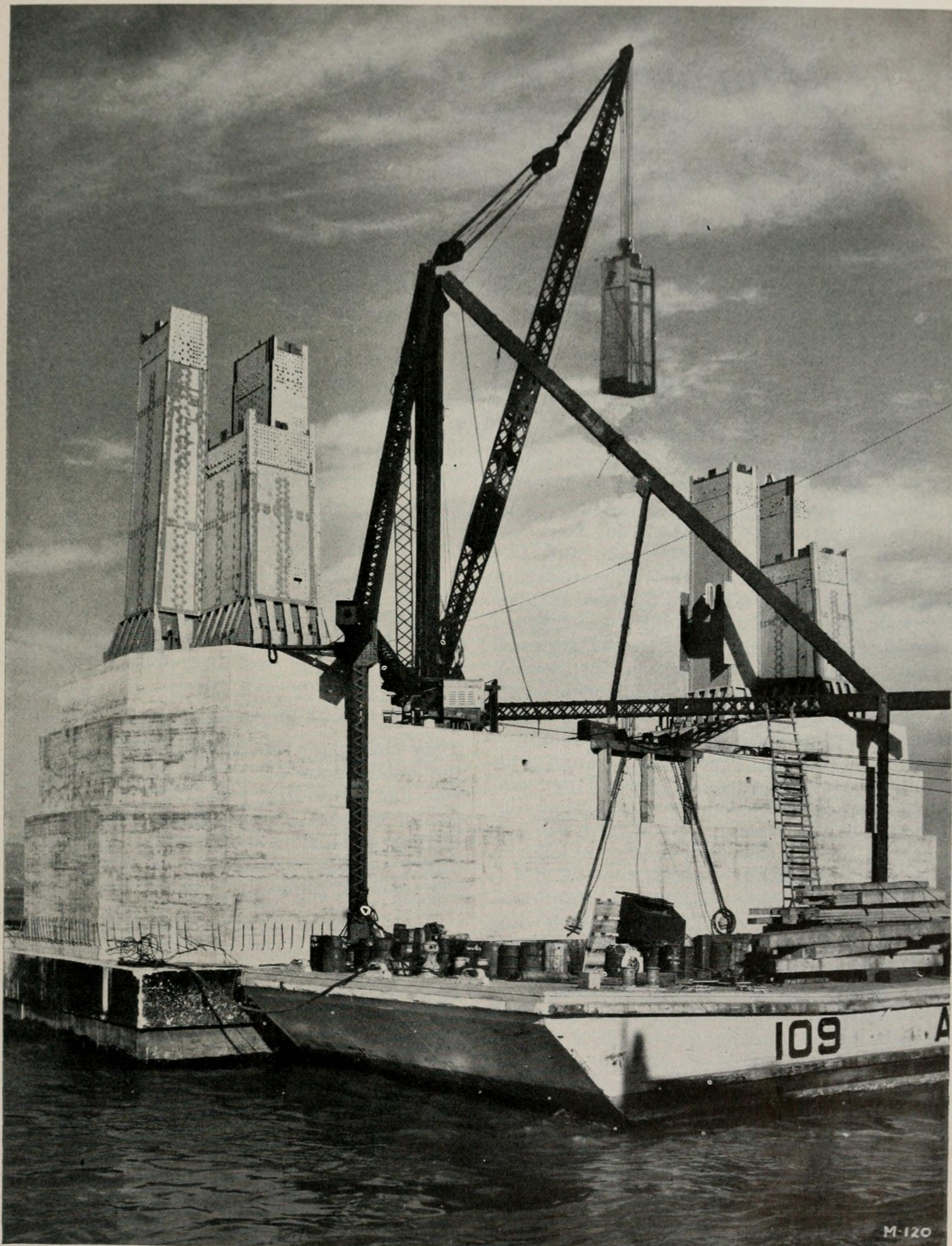
The West Bay crossing, according to the progress report filed with Governor James Rolph, Jr., chairman of the California Toll Bridge Authority, and State Director of Public Works Earl Lee Kelly by Chief Engineer Purcell, shows one subaqueous pier completed, one nearing completion, and three under construction.

BUILDING BIG FILL

The East Bay crossing, having a total of 39 subaqueous piers, now has one deep-water pier completed, two other deep-water piers under construction, four shallow-water piers, resting on piles, completed, and four shallow-water piers under construction.

In addition, work reports from District IV of the Division of Highways, under Colonel John H. Skeggs, show thousands of yards of sand and rock pumped and dumped respectively along the Key Route Mole on the Oakland tidelands to form the wide fill where both decks of the bridge will empty traffic onto a broad artery with 14 lanes of traffic at the toll houses.

A short answer seldom brings a long order—neither does a long-winded one.



UP IN THE AIR goes segment after segment of Tower No. 2 of the San Francisco-Oakland Bay Bridge as great derricks swing aloft the huge crate-like steel units and pile them up like blocks on top of each other. As they are dropped into the place they were made to fit, riveting crews soon fasten them together. Thus the tower is rising slowly and steadily to equal the height of a 40-story building. Nine segments weighing a total of 1,500,000 pounds and towering 70 feet above the concrete base off the foot of Harrison Street, San Francisco, had been placed by March 17.

Bay Bridge Six Months Ahead of Schedule Says First Annual Report

A YEAR has elapsed since ground was broken for the San Francisco-Oakland Bay Bridge on Yerba Buena Island, July 9, and in the first annual report on the bridge State Director of Public Works Earl Lee Kelly and Chief Engineer C. H. Purcell had the pleasure of reporting to Governor Frank F. Merriam that the bridge was six months ahead of schedule.

If this lead is maintained, Director Kelly informed Governor Merriam, the San Francisco-Oakland Bay Bridge will be opened to traffic by July, 1936.

The first anniversary of the bridge sees the completion of the first steel tower of the suspension sector and the beginning of erection of the second tower.

WEST BAY PIERS COMPLETE

During the year the contractors on the bridge have earned $11,500,000, or 31 per cent of the total amount of the major contracts.

At the end of the first year of the bridge all the piers of the West Bay crossing are either complete or nearing completion and, of the 22 major East Bay piers, only two are yet to be started.

Of the 51 piers beneath the entire bridge, 16 are complete, 18 are in construction, and the remaining 17 are small subpiers involving no unusual problems or quantities.

The San Francisco cable anchorage on Rincon Hill is now in its secondary stage of construction, containing more than 30,000 cubic yards of concrete, or half its final cubiture. No more concrete will be added to this monument at the west end of the bridge until the cables have been spun and tied to the giant steel eyebars projecting from this monolith, some time in 1935.

ANCHORAGES WELL ADVANCED

Work is now starting on the viaduct to carry the bridge west of the anchorage over Rincon Hill.

Piers to carry the bridge east of the anchorage on the San Francisco side are in construction.

On Yerba Buena Island the cable anchorage is well under way and the concrete center anchorage, midway between San Francisco and Yerba Buena Island, has its substructure in the final stage.

The two huge tunnels, large enough to drive a truck in (but not turn around), into which the two cables will be anchored to steel grillages and concreted, are complete and ready for setting the steel to which the cables will be anchored.

OPENING TUNNEL BORES

The huge vehicular tunnel that will carry two decks of traffic through the sandrock island is well under way with two headings due to go through by July 23, when Governor Merriam and the California Toll Bridge Authority will be escorted through by Director of Public Works Kelly and Chief Engineer Purcell.

The piers supporting the bridge viaduct on the east side of Yerba Buena Island are all practically complete, as is the huge anchor pier on Army Point for the west end of the anchor arm for the 1400-foot cantilever span.

OVER 7000 EMPLOYED

Inasmuch as the East Bay piers are in an advanced stage, erection of the steel superstructure at the east end of the bridge is expected to be started next month.

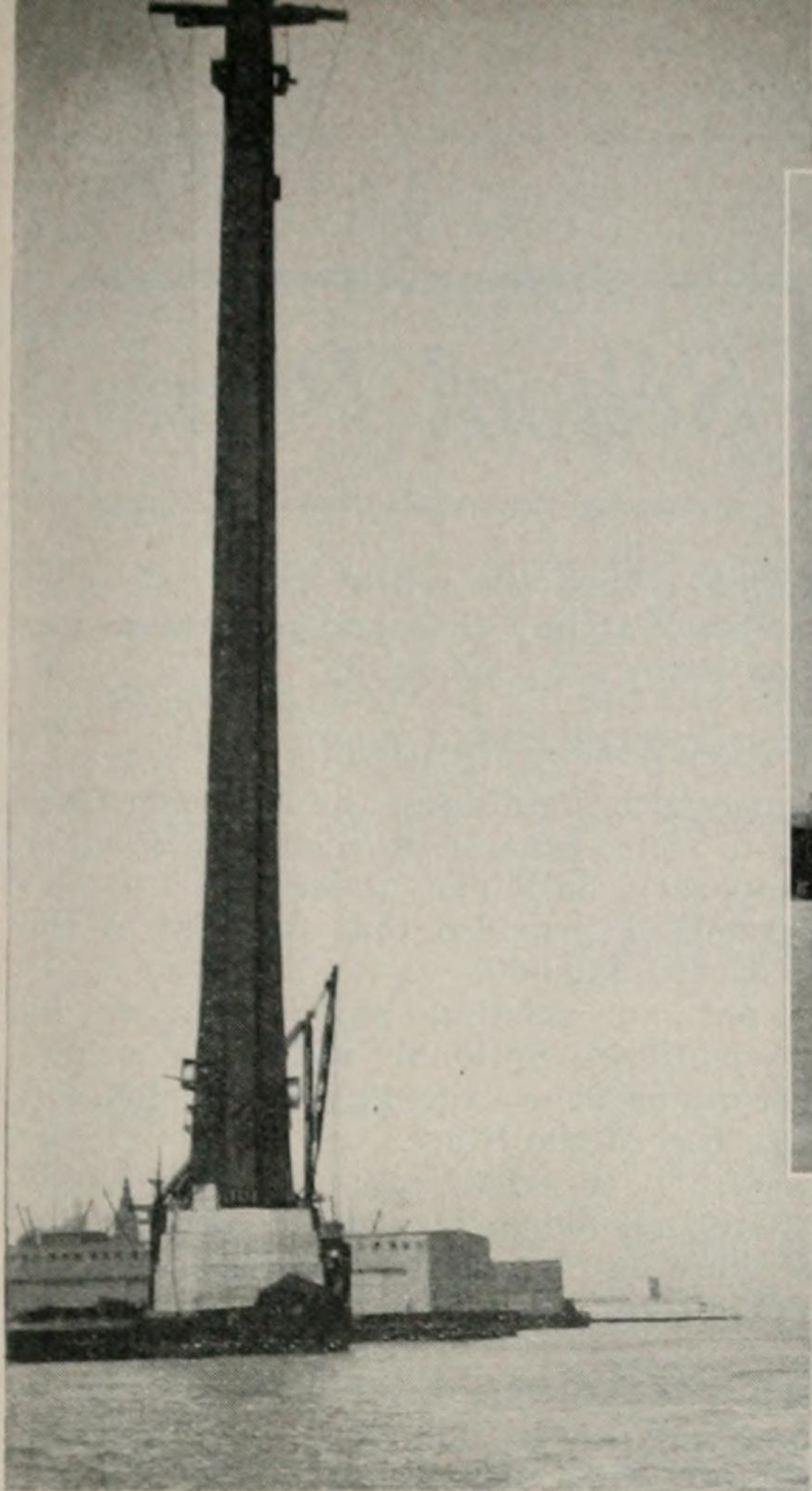
The sand fill, which is being pumped into place alongside the Key Route Mole, is well ahead of schedule and should be completed this year.

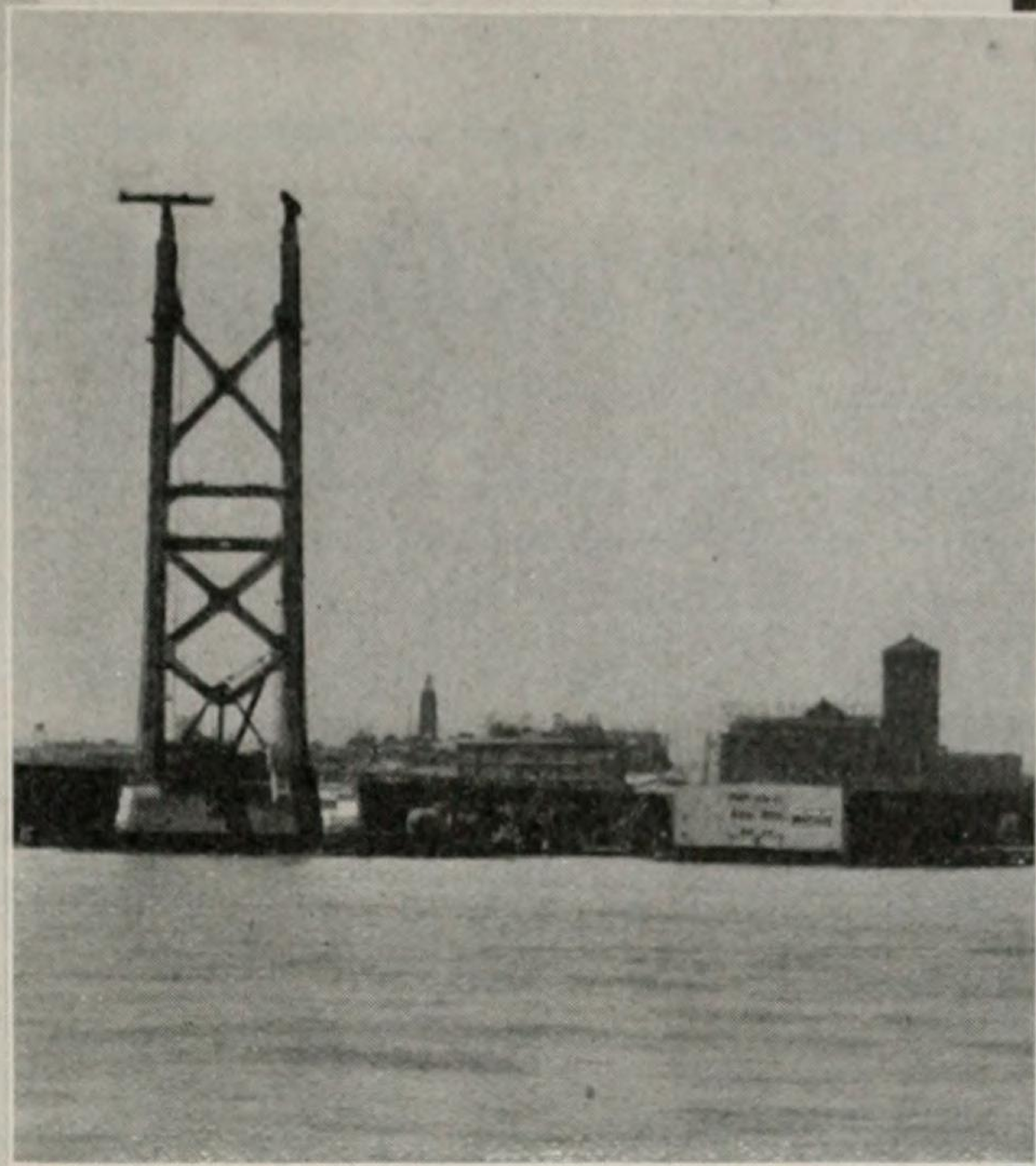
Employment on the bridge has now reached a total of 7238 men of which 4015 are employed fabricating materials, and the balance by the contractors on location.

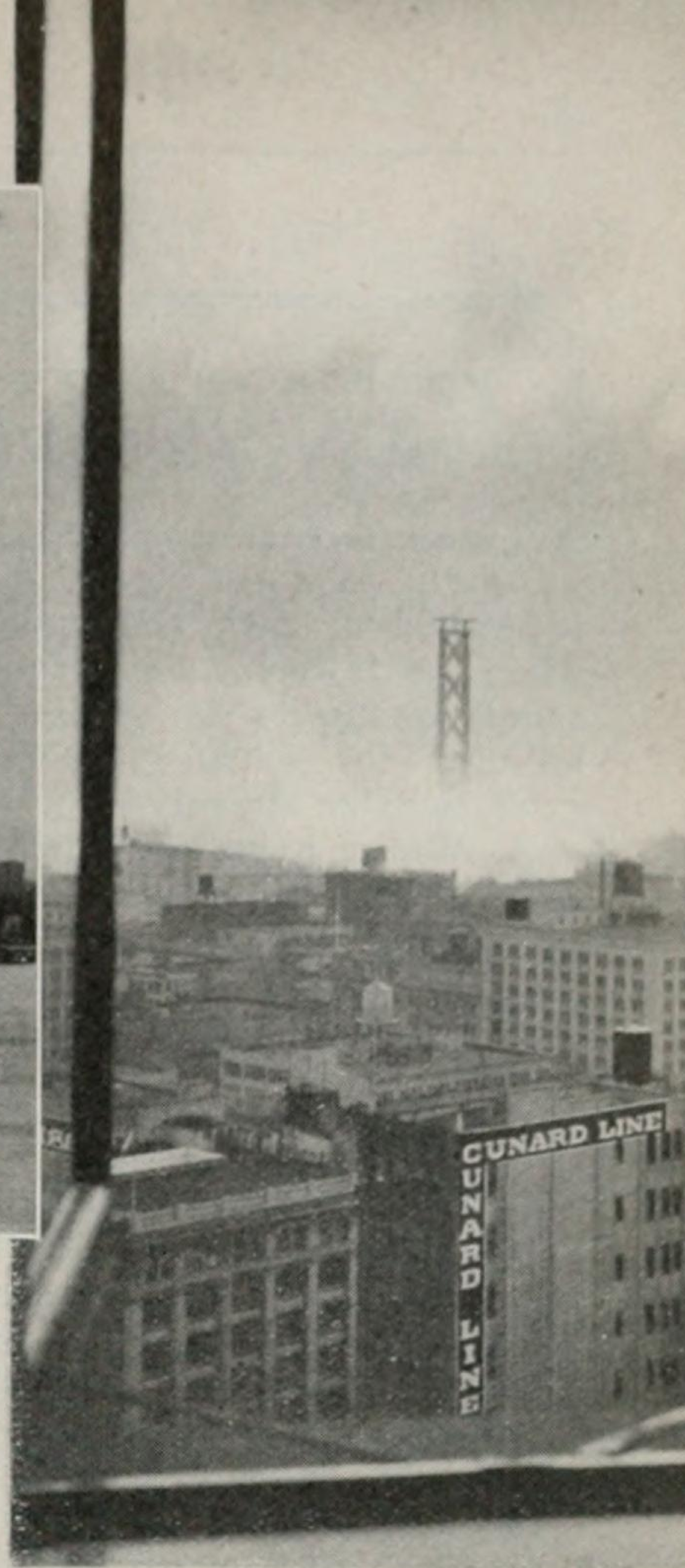
SURFACING COALINGA LATERAL

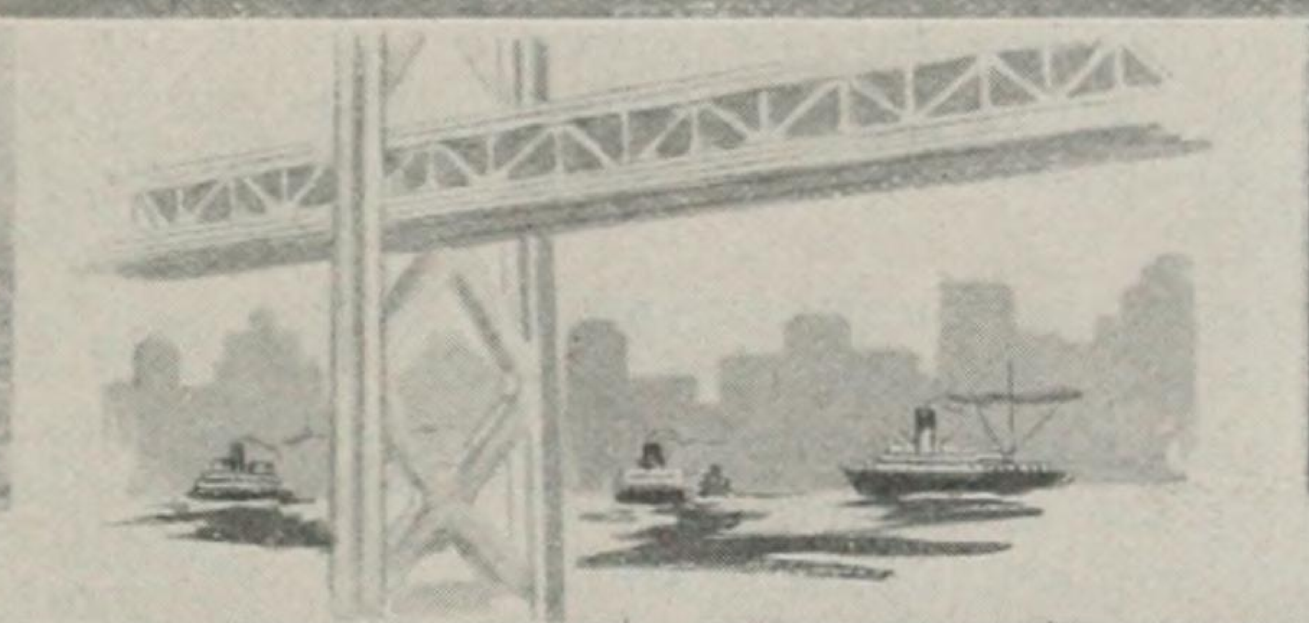
On the Coalinga lateral, between Mustang Ridge and Priest Valley, a distance of about 3.3 miles, the road is being constructed with a 24-foot graded roadbed and a 20-foot selected material surface. This project is financed under the National Industrial Recovery Act.

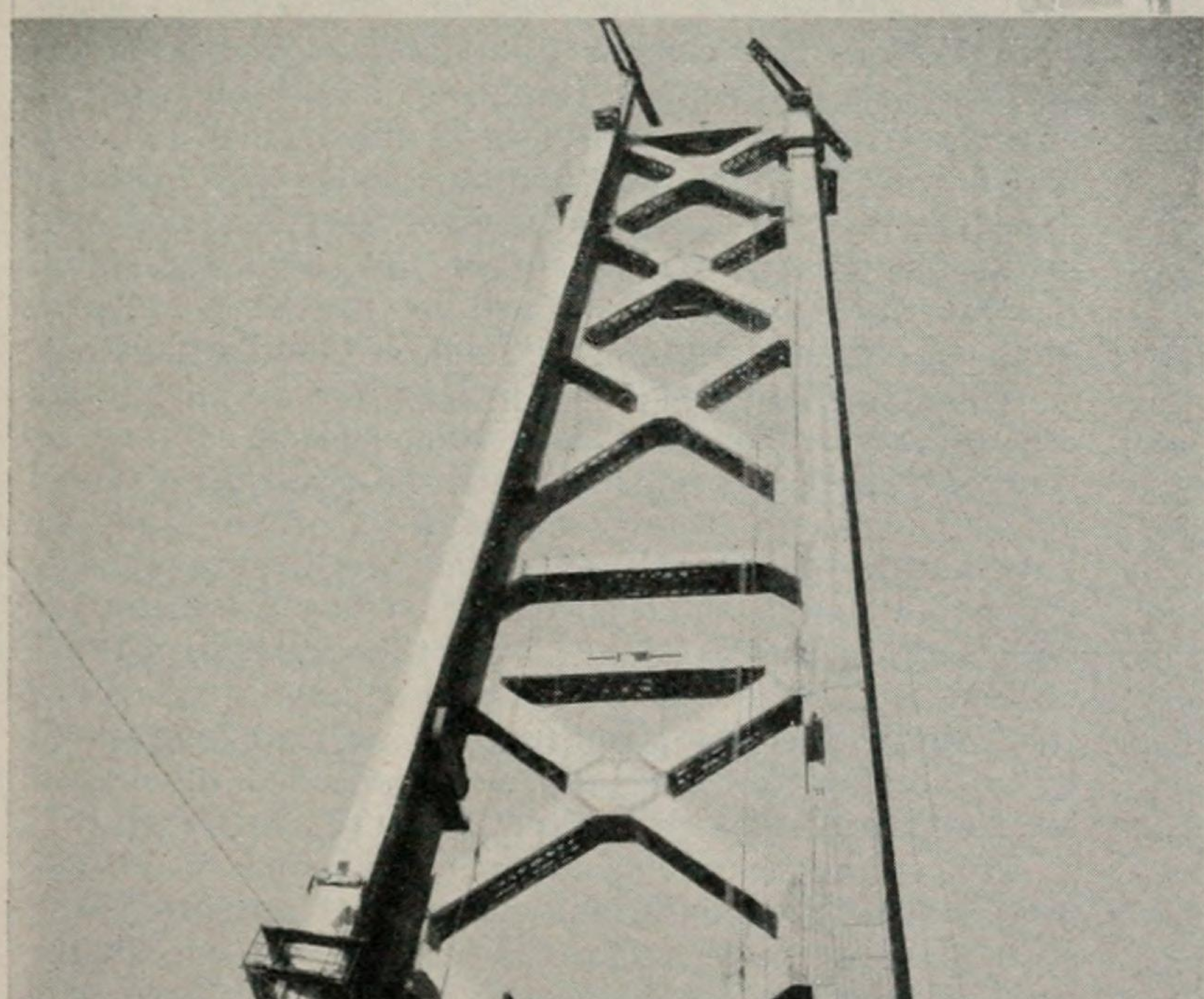
Gladys—What is your favorite sport?
Young Doctor—Sleighing.
Gladys—No, I mean apart from business.

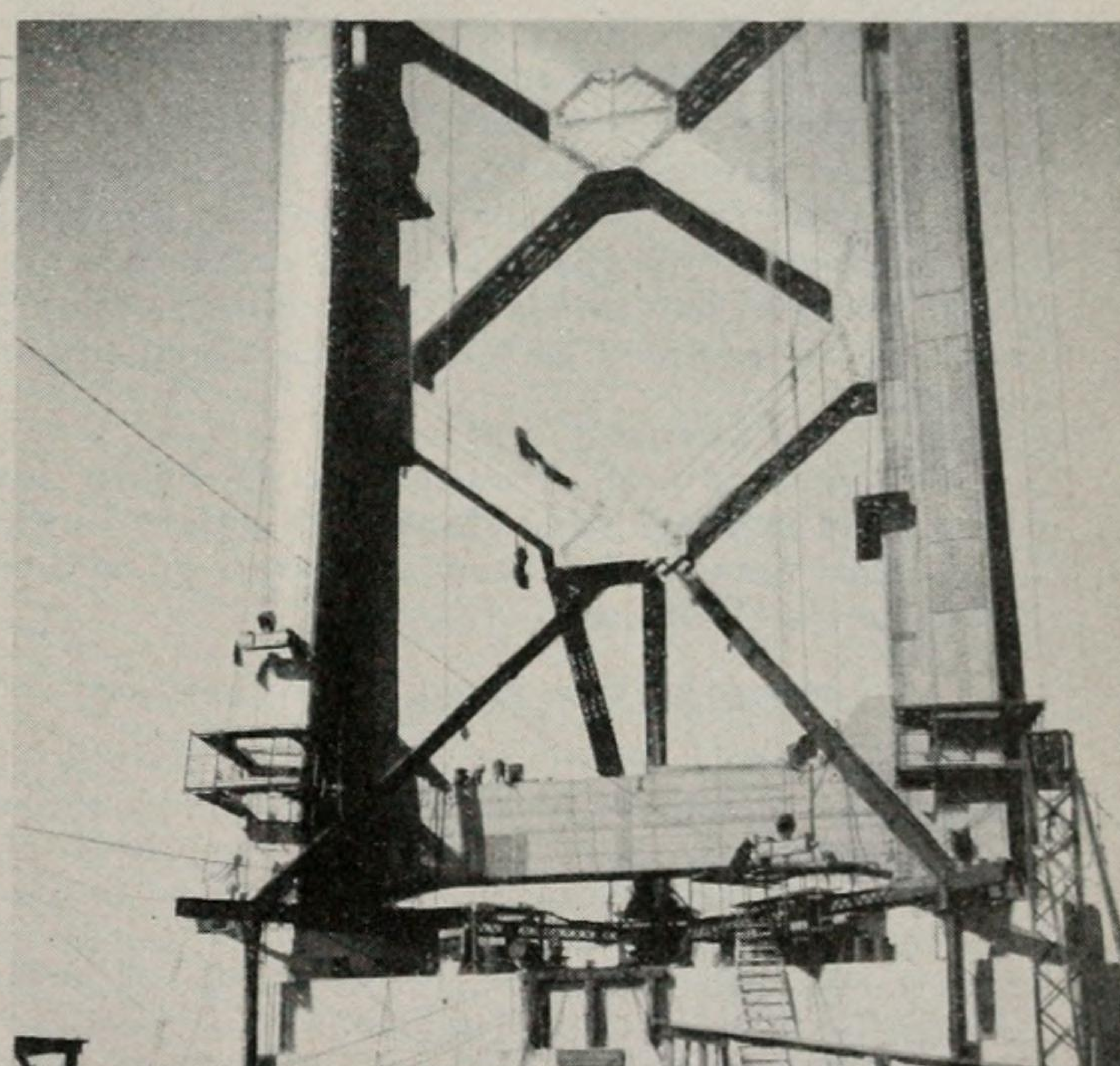












RISING SKYWARD above the city's shoreline, Tower W-2 of the San Francisco-Oakland Bay Bridge presents fascinating studies of majestic beauty and strength to the camera. A side view shows the slender, graceful silhouette tapering from the base to its top 474.35 feet above the water. A worm's eye view presents a vaulting pyramid of steel lattice work. Seen through a second story office window it dominates all the bay front structures, its top almost lost in the cloud vapors. A close-up reveals the massive size of the great steel girders.

Bay Bridge Construction Progress Reported With Schedule for 1935

By **C. H. PURCELL**, Chief Engineer, San Francisco-Oakland Bay Bridge

THE following is a report on the progress of construction of the San Francisco-Oakland Bay Bridge for the years 1933 and 1934, together with a schedule of expected construction for 1935 and filed with Governor Frank F. Merriam by State Director of Public Works Earl Lee Kelly:

Progress of Construction

FROM GROUND BREAKING, JULY 9, 1933, TO JANUARY 1, 1935

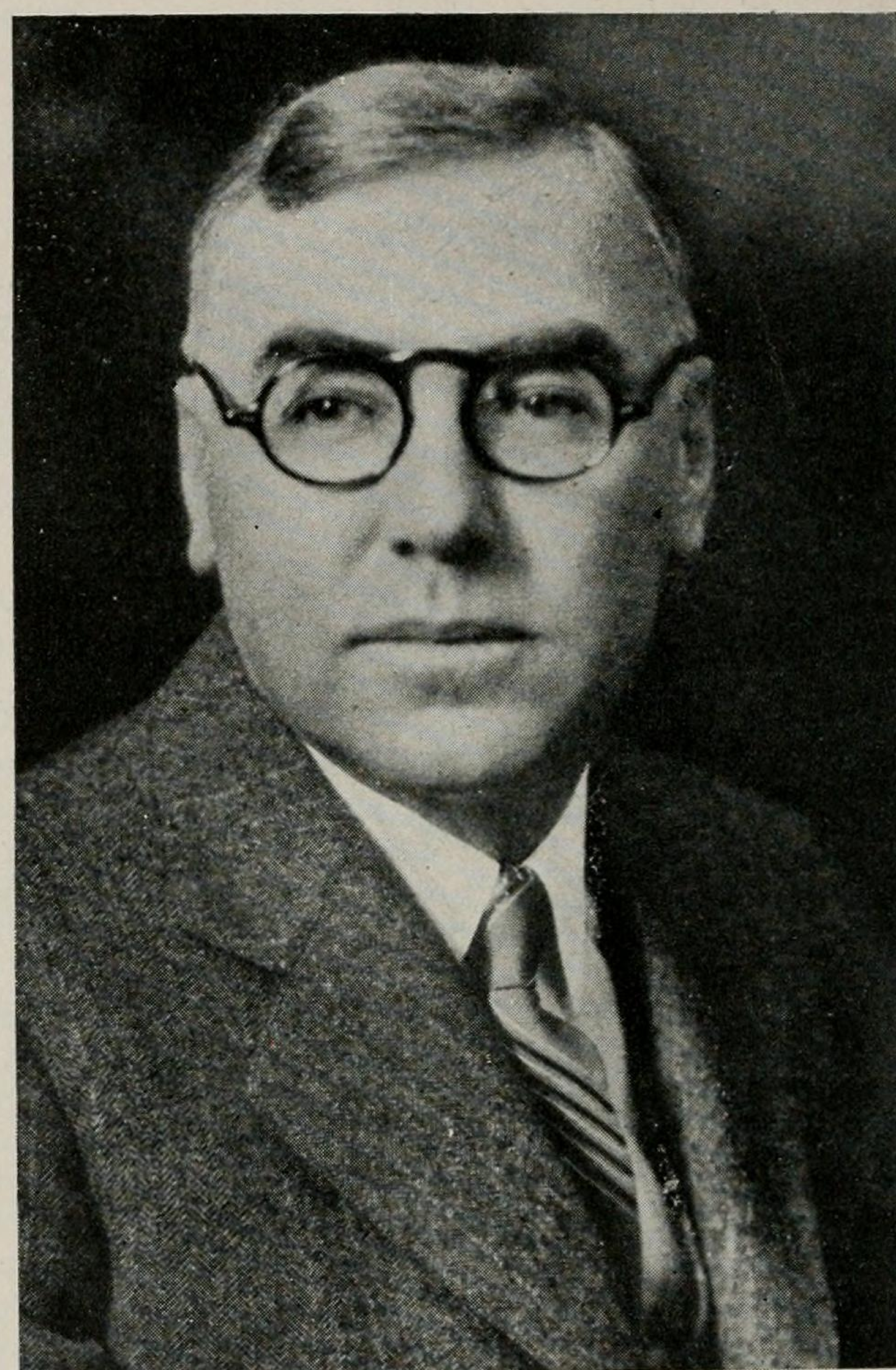
	July 9 to December 31, 1933	January 1 to December 31, 1934
Money spent in construction	$6,000,000	$16,500,000
Concrete placed	110,000 cubic yards	440,000 cubic yards
San Francisco cable anchorage (concrete)	25% completed	50% completed
Anchorage steel	50% fabricated	All fabricated and 86% erected
Steel, West Bay towers	Fabrication of two towers started	Fabrication complete
Cable wire	25% drawn	84% drawn 66% completed 65% delivered
East Bay steel superstructure		60% fabricated 52% delivered 25% erected
Peak of men at work	2100	5953
Piers	1 complete and 12 under construction	49 completed
Yerba Buena Island tunnel	Appoach excavations completed	Three pilot tunnels bored full length and outer walls raised to full height. Concrete wall lining started
Yerba Buena anchorage	Excavation completed	Concrete complete ready for erection of steel cable bents
West Bay tower erection		Towers W-2, W-3, and W-6 erected. Tower W-5 25% erected
Concrete center anchorage	Caisson anchored at site	Under water work complete and superstructure raised to 207 feet above water
East Bay substructure	Six piers started	All piers (43) complete
Erection, East Bay superstructure		Thirteen 288-foot spans and six towers erected
Yerba Buena Island superstructure		One span erected

Schedule of Construction for 1935

The following is the schedule for completion of work during the year 1935 on the San Francisco-Oakland Bay Bridge:

San Francisco automobile approach ramps—
- To be 65 per cent completed.

West Bay suspension bridge—
- Catwalk to be started March 1.
- Cable spinning to be started April 1.
- Suspended structure, San Francisco to center anchorage, 50 per cent placed.



C. H. PURCELL

Cable spinning completed for twin suspension bridges during 1935.

Vehicular tunnel through island to be completed.

Viaduct over east side of island to be completed.

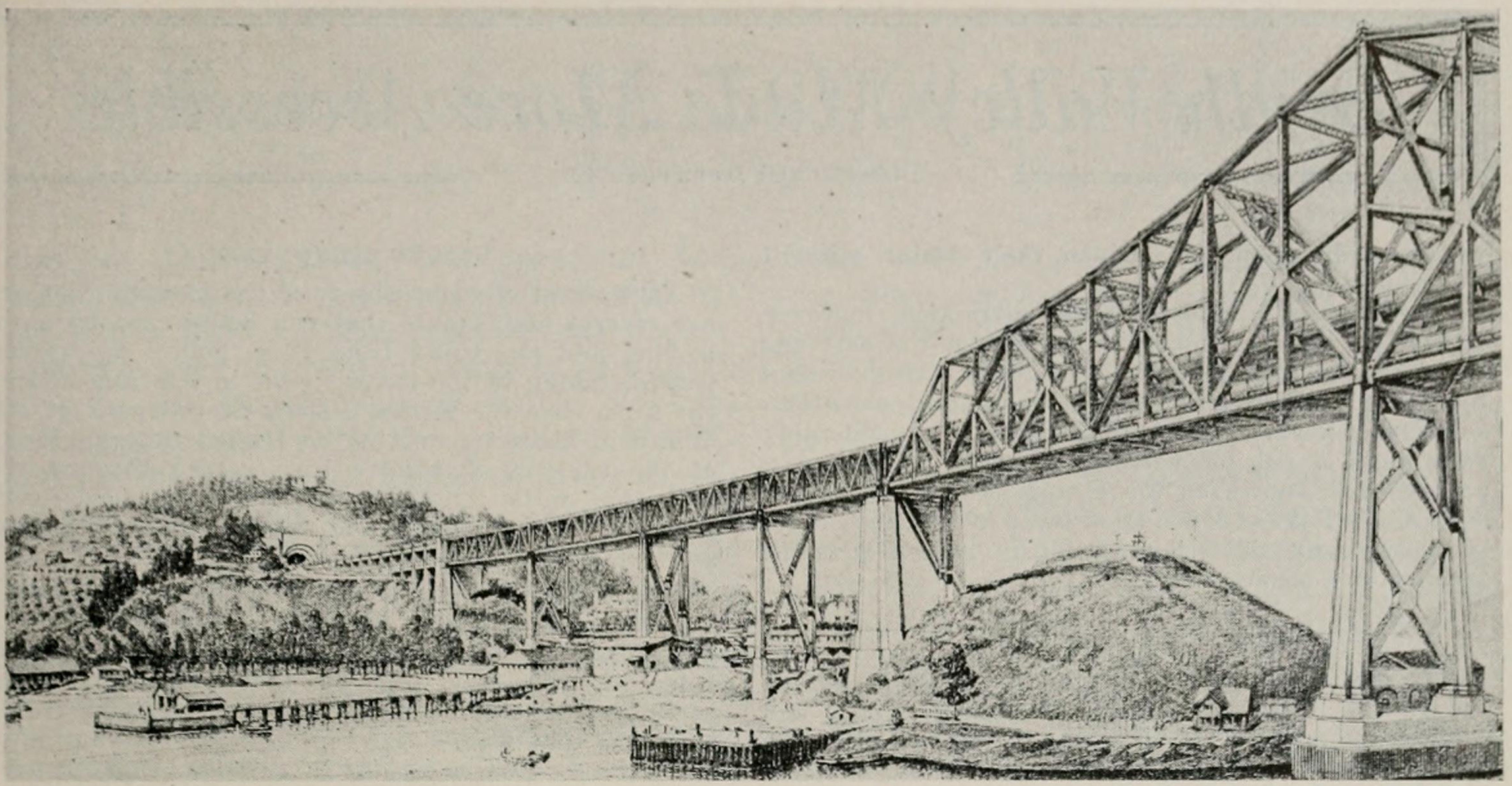
East Bay superstructure to be completed except for 576 feet of suspended span at center of 1400-foot cantilever span.

East Bay approaches to be 50 per cent completed.

Contracts to be let in 1935—
- East Bay automobile distribution structure ramps and viaducts.
- Cypress Street approach.
- San Pablo Avenue crossing and approach.
- Interurban Railway system construction.
- Administration Building and Toll Plaza.
- Bridge Lighting.

Son—Dad, did you ever meet a girl who combined the attributes of beauty, charm and intelligence?

Father—Yeah, but darn it, I sobered up the following morning.



AN IMPRESSIVE PREVIEW of a section of the San Francisco-Oakland Bay Bridge just east of Yerba Buena Island, to be built during the first half of 1935, is presented in this drawing by Artist Nusé. A concrete viaduct extends from the tunnel mouth to a large concrete pier YB-1. Steel truss spans connect this pier with the huge concrete Anchor Pier E-1, that holds the anchor arm for the heavy cantilever span that will extend easterly from Pier E-2 shown at extreme right of picture.

Highway from U.S. to Panama Feasible

A highway more than 3200 miles long, connecting the southern boundary of the United States with the Panama Canal Zone and traversing Mexico and Central America, is pictured in engineering and economic terms in an official government report just issued under the title, "The Proposed Inter-American Highway," by the Bureau of Public Roads, U. S. Department of Agriculture.

The termini of the Inter-American highway are Nuevo Laredo in Mexico, just across the Rio Grande from Laredo, Texas, and Panama City, Republic of Panama. While the report describes the highway as "proposed," it is in fact already well on the way to realization, for of its total length approximately 40 per cent. is now open to year-round traffic and an additional 27 per cent is good or fair in dry weather. To establish connections between the sections of road already built and to modernize existing highway where necessary is the task confronting the five Central American republics, Panama, and Mexico.

SURVEYED BY GOVERNMENT

The Bureau of Public Roads report is based upon a careful reconnaissance survey in Central America, during which the American engineers covered hundreds of miles of territory. Extensive aerial photography helped the engineers select the most practicable route. That a through highway between the United States and Panama is "entirely feasible from an engineering point of view" is the conclusion of the engineers.

Making a fool of ourselves is only giving nature an encore.

Water Authority Gives Hyatt Instructions

At a meeting of the Water Project Authority of California recently held in Sacramento, the following resolutions were unanimously adopted.

"That the Executive Officer of the Water Project Authority, Edward Hyatt, be instructed and directed to devote as much of his time and attention in Washington, D. C., and elsewhere, as he may determine to be necessary for the purpose of securing early Federal assistance in financing the Central Valley Project."

"That the Authority believes the Central Valley Project Act to be fundamentally sound and workable and recommends no amendments except those necessary to comply with Federal requirements."

150,000 ROAD SIGNS IN SOUTH

More than 150,000 sign markers guide motorists on roads in the southland, according to a report from the Automobile Club of Southern California. These include half a hundred types, warning drivers of road dips, curves, crossings or other hazards, and giving distances and directions to nearest towns and principal destinations along routes at every crossroad.

"Did you know that I had taken up story-writing as a career?"

"No. Sold anything yet?"

"Yes; my watch, my saxophone and my overcoat."
—*Barksdale News.*

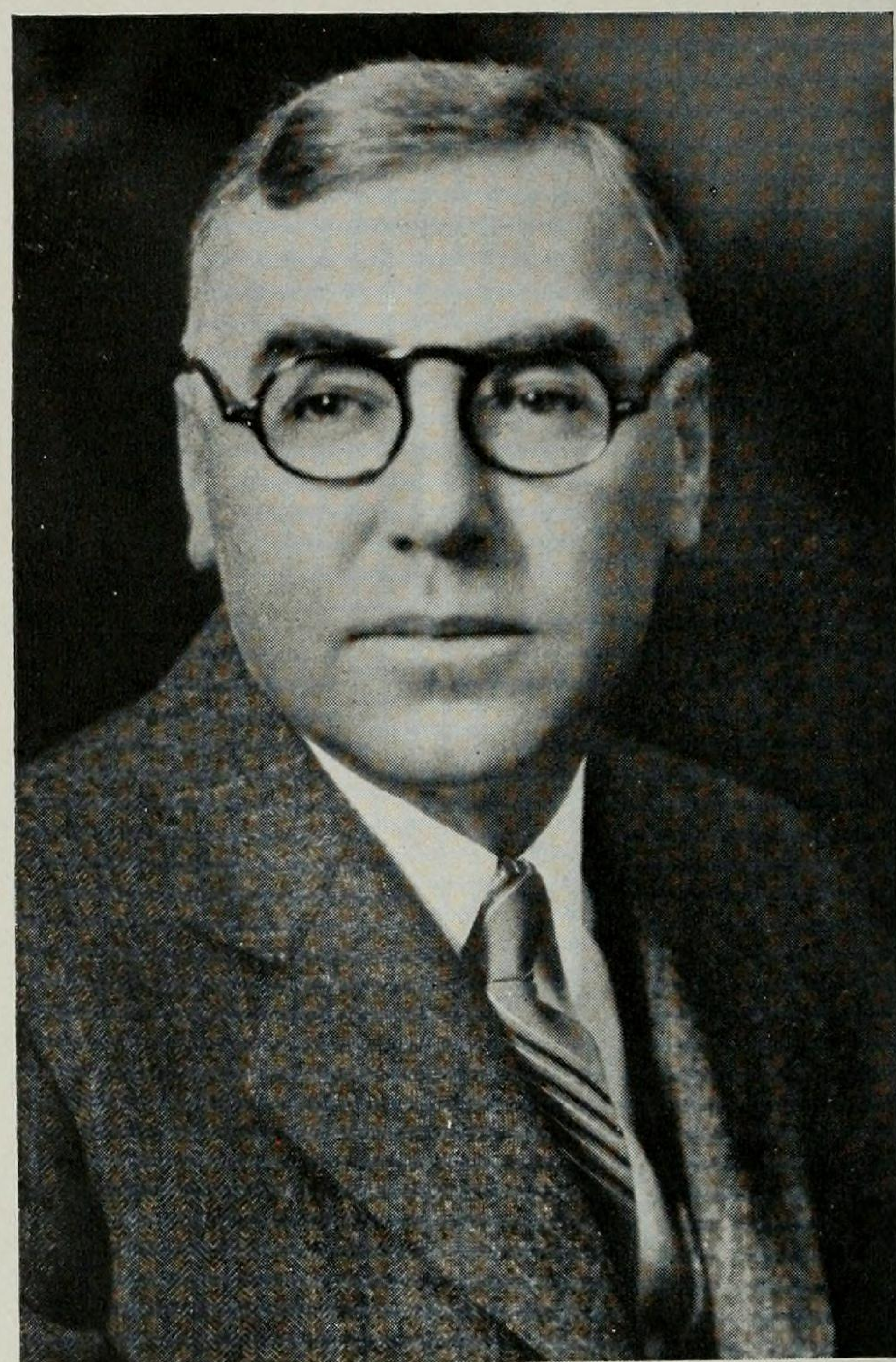
How Huge Steel Bridge Cables Will Be Spun Across San Francisco Bay

By **C. H. PURCELL**, Chief Engineer, San Francisco-Oakland Bay Bridge

BEFORE the suspension cables of the San Francisco-Oakland Bay Bridge can be spun, it is necessary to build walk ways which will follow the general line the cable is later to follow.

There will be two catwalks, each 10 feet wide, one under each of the two cables. The walks will hang from four 2¼ inch ropes, each rope having a strength of 480,000 pounds.

The surface of the walk will be made of two layers of wire mesh, the lower layer made of chain link fabric, and the upper of "hardware" cloth with mesh about ½ inch square. This mesh is laid on timber cross beams which are supported from the wire ropes at intervals of 10 feet. The walks will have handrails consisting of a single 9/16 inch wire cable.



C. H. PURCELL

CROSSWALK CONNECTIONS

The catwalks will be connected together by crosswalks, of which there will three in the center span and one in each of the side spans. These are for the purpose of bracing the two walks together and also to permit the workmen to cross from one catwalk to the other.

To add to the rigidity of the system, especially in times of storm, the storm cables are added. These consist of two one-inch lines in each span which are connected to the towers about 100 feet above the water, curve upwards, and are connected to the footwalk cables with wire hangers in such a way as to hold the footwalk cables in place.

Two cables for each footwalk have been placed between the San Francisco anchorage and Pier W-1 and two ropes for each walk between Towers W-2 and W-3. The next operation will be to raise the four ropes for each walk from Pier W-1 to Tower W-2, crossing the Embarcadero. Then the four ropes between the center anchorage and Tower W-3 will be placed. The final operations will be placing the last four ropes between Towers W-2 and W-3, and between the San Francisco anchorage and Pier W-1. With ropes all in place, the crosswalks will be erected.

CONSTRUCTING WIRE MESH

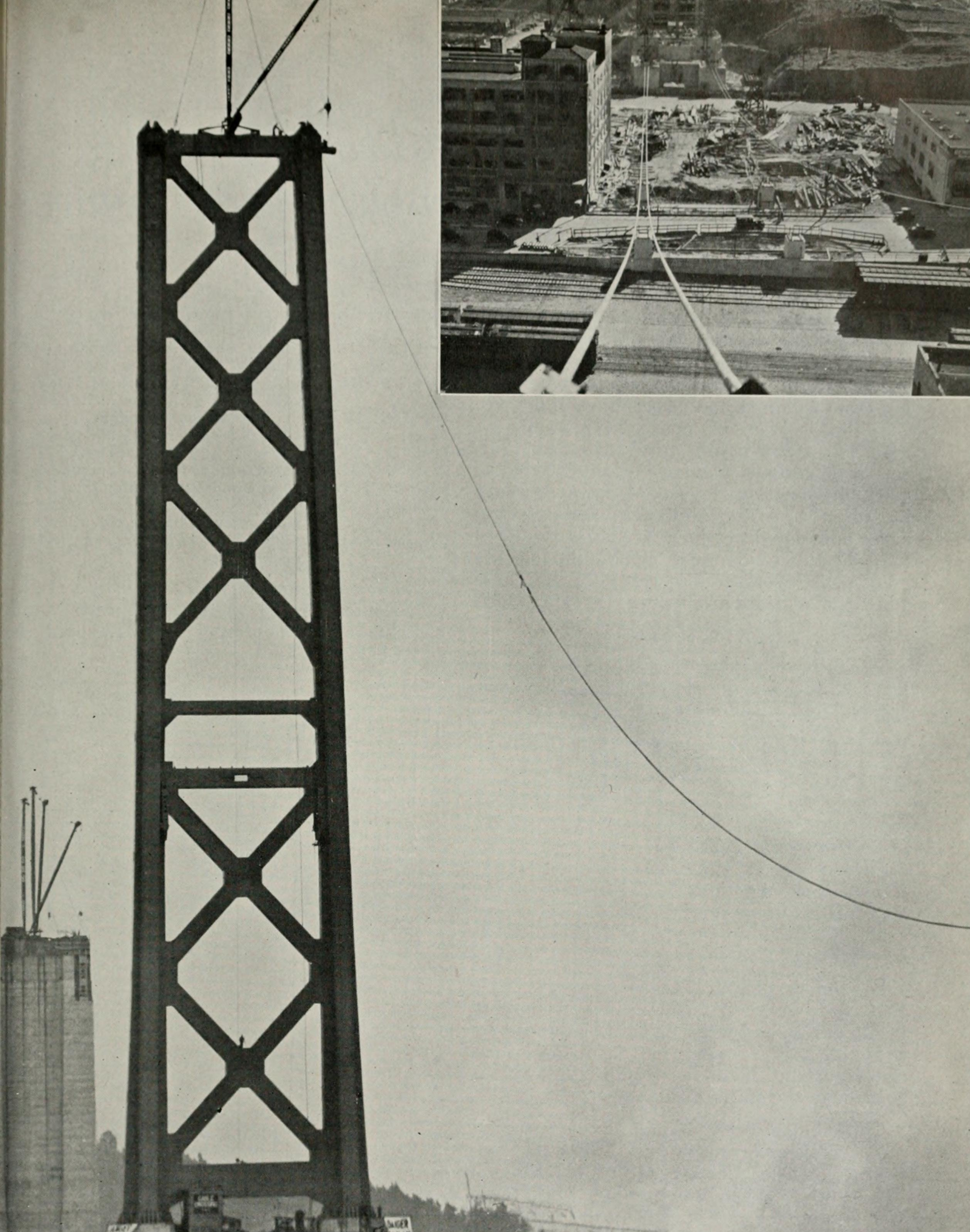
The next operation will consist in starting at Tower W-3 and putting the wire mesh construction simultaneously on each side of the tower from Tower W-3 to the center anchorage, and from Tower W-3 to the center of the 2310-foot span. These sections are erected to platforms near the top of the tower, connected to the cable, and then slid along the cable to the final position. Upon completion of this operation, these platforms will be transferred to Tower W-2 and the same operation repeated.

After the wire mesh is all in place, it will be tightened to reduce the "spring" in the wire as much as possible. The storm cables will then be placed, completing the catwalks.

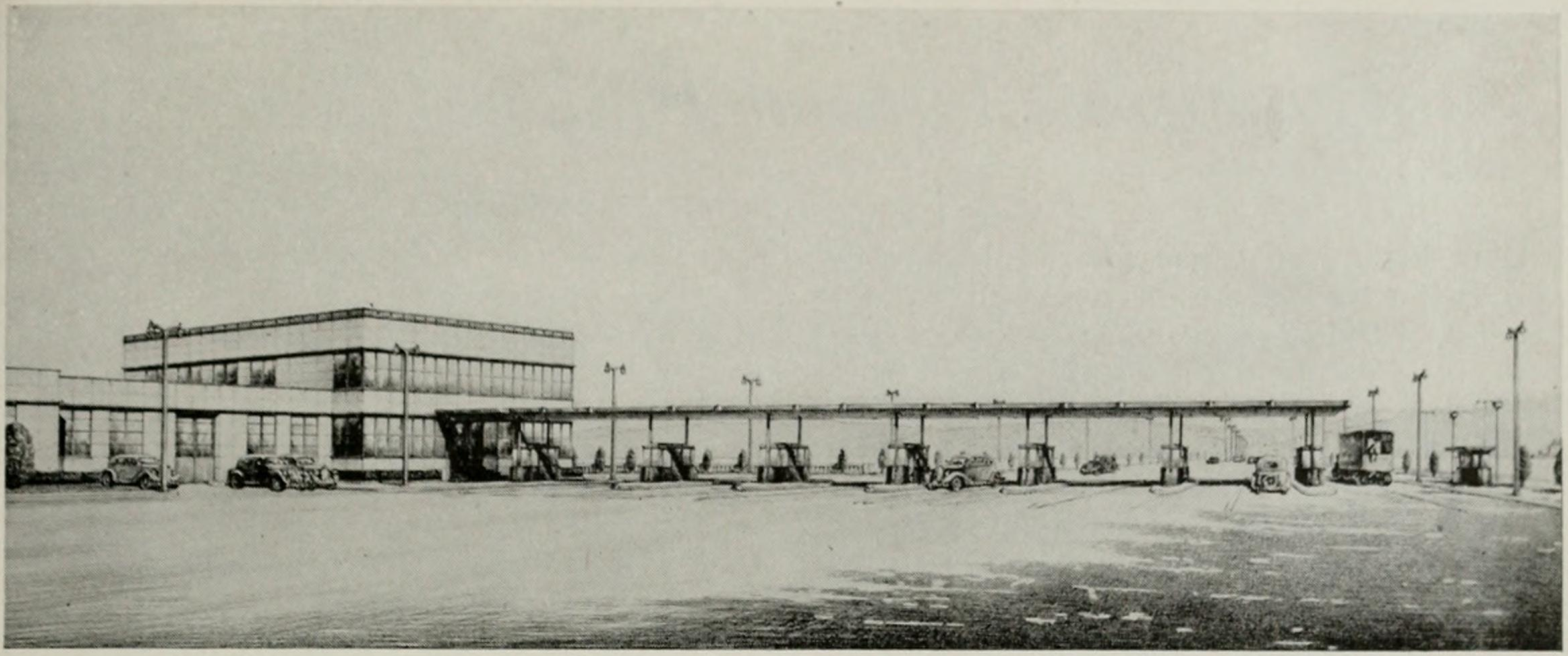
Following this, gallows frames will be erected. These consist of rectangular frames above each catwalk, at intervals of about 230 feet and at the towers, and to each are secured the haulage lines for the actual process of spinning the cable.

This haulage system consists in principle of an endless rope between the San Francisco

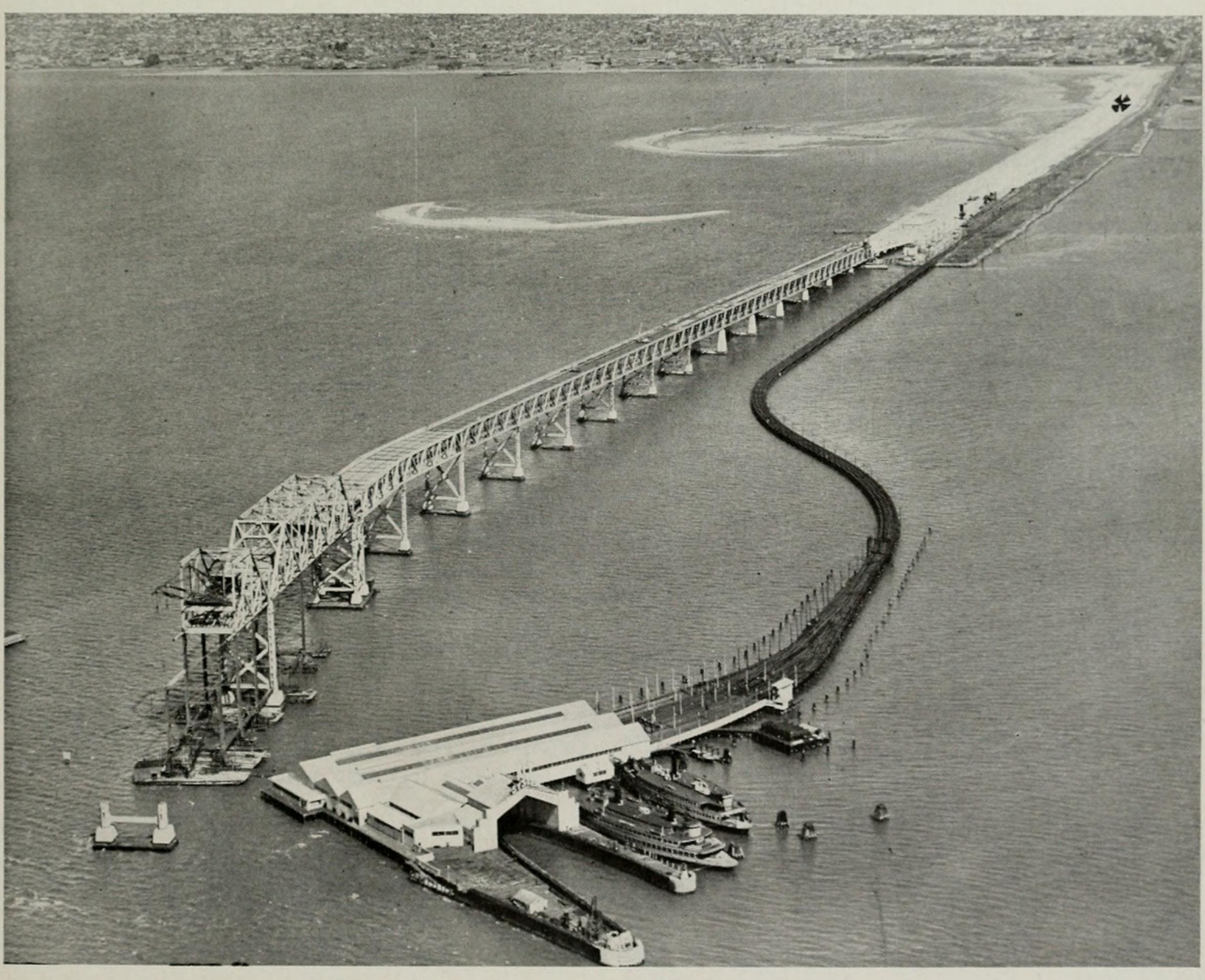
(Continued on page 15)



THE FIRST SAN FRANCISCO-OAKLAND BAY BRIDGE CABLE is seen being drawn across the waters of the bay on April 4th by a "messenger line" to Tower W-3 off the San Francisco shore. It is a 2¼ inch "catwalk rope," four of which will support a walkway for workmen during the big cable spinning job. Behind the tower, the camera has caught the great concrete mass of the Center Anchorage backgrounded by Yerba Buena Island and illusive tracings of the East Bay Superstructure making it appear almost completed. The inset shows four catwalk cables in place between Pier W-1 and the San Francisco Anchorage.



BAY BRIDGE TOLL HOUSES numbering 16 will be located beneath an overhead structure extending from the large operations building straight across the wide roadway at the Oakland end of the bridge. Traffic will be accommodated in 16 lanes, 14 for passenger vehicles and two for trucks. The operations building will contain a garage, machine shop, electric controls, police station and maintenance office.



AERIAL VIEW of the East Bay structure and the Oakland approach fill as constructed to date showing the fourteen 288 foot steel spans and Span E–8, the first of the five 500 foot cantilever spans already erected. A traveling derrick is erecting the second 500 foot Span E–7. The Maltese cross indicates the location where the 16 toll collection stations will be erected on the wide fill extending across the flats from the Oakland shoreline.

Wire Mesh Catwalks, Spool Brakes and Electric Spinning Control on Bay Bridge

THE FOOTBRIDGES completed for one mile over the San Francisco-Oakland Bay Bridge between Rincon Hill and the center anchorage, are the latest development in catwalks—fireproof and fallproof; and the spinning wheels thereon will have new safety controls never before used in suspension bridge building, it was revealed with the arrival of Curtis S. Garner and H. C. Hunter, Pennsylvania experts in suspension bridge construction, who will join forces with the contractors on the $22,000,000 superstructure of the bridge.

"Catwalks in the past have been made of lumber and easily caught fire," Garner explained. "The solid lumber catwalks were sails in the wind and their movement endangered workmen. By installing the wire mesh flooring catwalks, we have at once removed the fire hazard and the wind hazard. The steel mesh is, of course, impervious to fire, and lets the wind blow through without much swaying."

TWO SAFETY FEATURES

On his arrival from Pittsburgh, Garner went into conference with State Director of Public Works Earl Lee Kelly; Chief Engineer C. H. Purcell; Edward J. Schneider, contracting manager of the Columbia Steel Company; W. J. Ward, superintendent of erection; and E. E. McKeen, steel company resident engineer.

Two features will make spinning the cables of the San Francisco-Oakland Bay Bridge safer than any similar work undertaken previously. Those features are: (1) steel wire catwalks, which are fire and wind proof; (2) automatic, mechanical, and manual electrical control of the cable spinning operations.

One of the dangers of cable spinning in the past has been the jerking and jumping of the spinning wheel movement. The steel company and affiliated engineers believe they have eliminated this danger by means of a tower with a system of counter-balancing pulley wheels, working in cooperation with the reels of wire so that all slack is constantly kept out of the spinning wire.

BRAKES ON SPOOLS

By mechanical devices it is provided that any slack is immediately taken up by brakes applied to the huge spools of cable wire. In addition to this mechanical control of slack, an electrical system of switches is provided at 250-foot intervals over the entire catwalk so that in case of accident or a snarled wire all movement can be immediately shut down by the workmen witnessing the accident.

In the past, spinning wheels becoming snarled in the wire continued jumping and plunging until the reel workers at the ends of the bridge could be notified by telephone or signal cords to shut down operations. Peril to workmen resulted because of these unchecked snarls.

The spinning wheel arms will carry two wheels so that four wires can be laid in the cable simultaneously. The wheels will travel approximately seven miles an hour over the one-mile course.

DOUBLE SPINNING WHEELS

The features of the bay bridge cable spinning which are new to suspension bridge engineering are: (1) automatic brakes on the spools connecting to counter-balancing towers to take up wire slack; (2) wire mesh (or chain link) fireproof, windproof catwalks; (3) electrical control of operations from switches at either end, and at intervals of 250 feet over the catwalk; (4) a perfected form of two-sheave spinning wheel.

Arrangements are being made by State Director of Public Works Earl Lee Kelly for inspection of the bridge catwalks by Governor Frank F. Merriam.

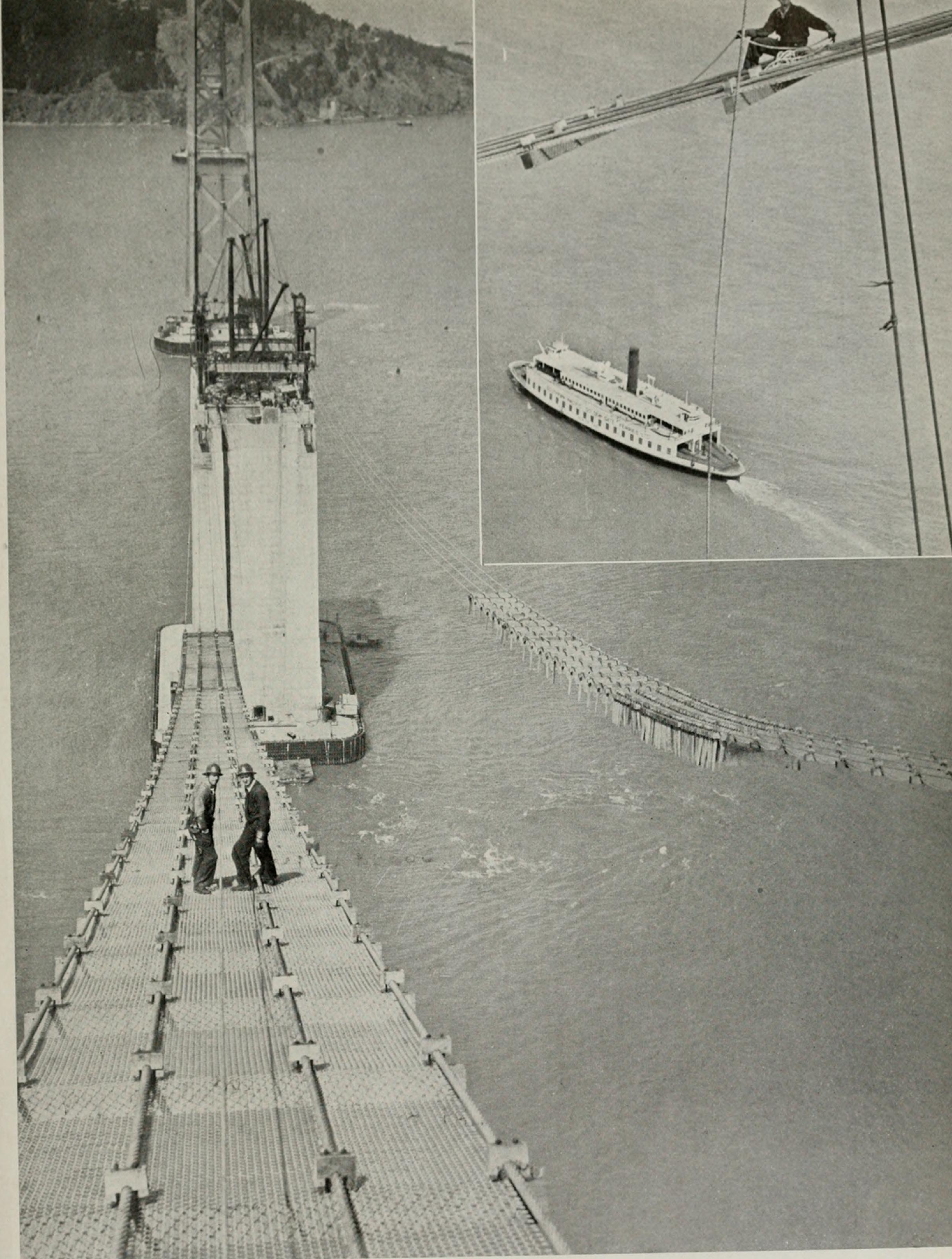
"Ish no use," sighed the drunk, as he staggered into the telephone pole for the third time. "I'm losht in an impen'trable fores'."

The Lady: "Hobo, did you notice that pile of wood in the yard?"

"Yes'm, I seen it."

"You should mind your grammar. You mean you saw it."

"No'm. You saw me see it, but you ain't seen me saw it."



A BOUNCING AERIAL WIRE TRAIL, ten feet wide, swinging high across the waters of San Francisco Bay, and no place for a promenade on a windy day, is a catwalk of the San Francisco-Oakland Bay Bridge. Built of steel mesh suggesting husky chicken wire, with mesh about a half inch square, and supported on timber cross-beams bolted to $2\frac{1}{4}$-inch cables at intervals of 10 feet, it affords a springy footing for the iron-nerved helmeted workers. Cable hand-rails will later be provided supported by posts seen hanging like a fringe from the right catwalk. The inset affords an idea of the dizzy height of the walks in comparison with the ferryboat below.

Governor Merriam Starts First Cable Spinning Operations on the Bay Bridge

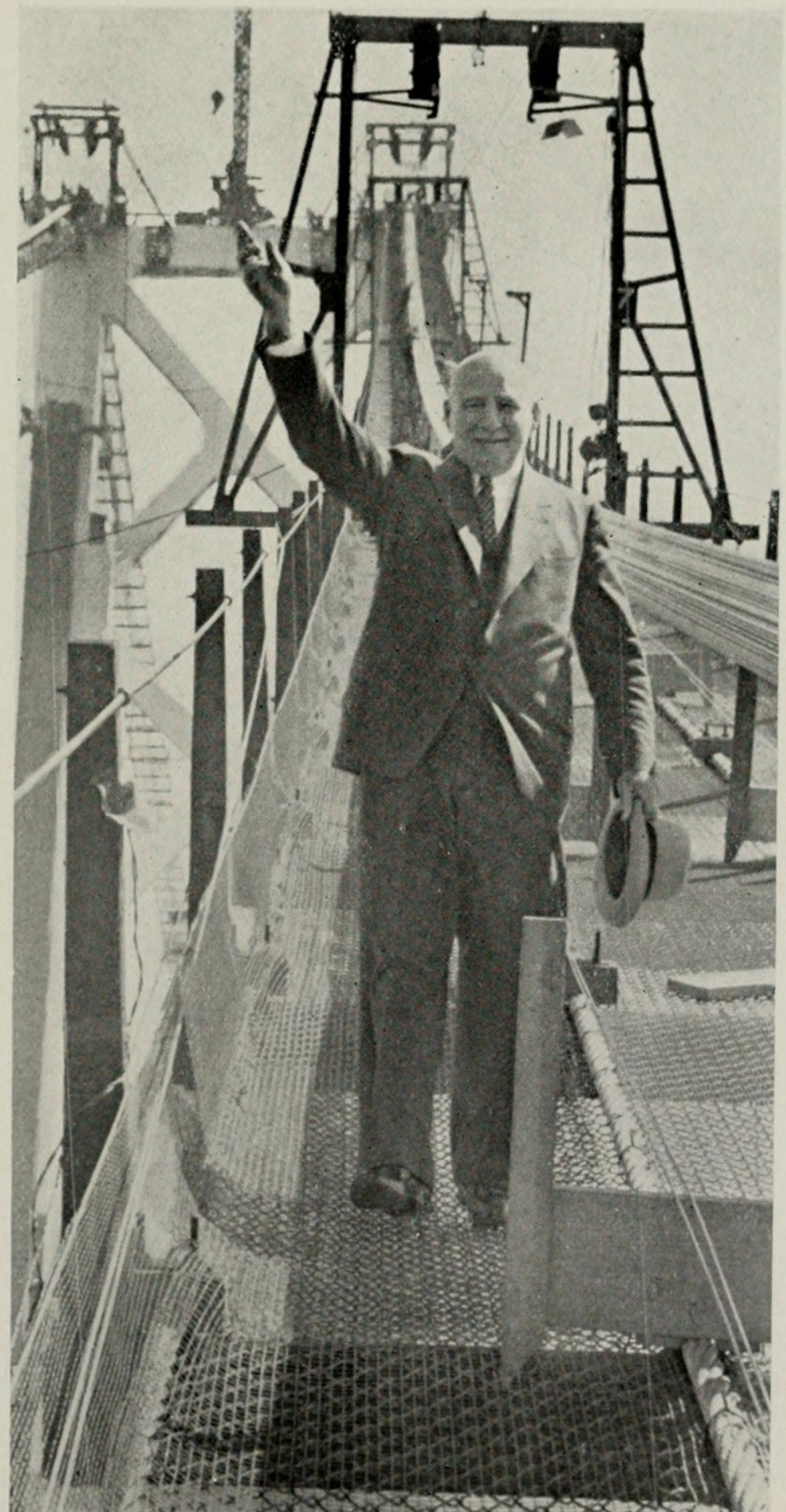
Chief Executive Makes Adventurous Inspection Tour Over Wire Mesh Catwalk Swung at Dizzy Height Above Water to Talk With Workers on Job

"IF IT IS safe enough for our workmen, it is safe enough for me."

With this declaration, Governor Frank F. Merriam walked out over one of the steel mesh catwalks that rise to dizzy heights over the San Francisco Bay on the first mile of the San Francisco-Oakland Bay Bridge, after he had started cable spinning operations by placing the first loop of wire on the spinning wheel on June 15 last.

With the Governor were State Director of Public Works Earl Lee Kelly, Chief Engineer C. H. Purcell, and Ambrose N. Diehl, president of the Columbia Steel Company, contractors.

After performing his official function, Governor Merriam expressed a desire to go out on the catwalks. Some of his advisors protested, but the Governor was adamant, and his advisors, timid or otherwise, were forced to trudge after the Governor up the steep incline of horizontal fence wire through which they could see the bay and huge ships far below.



GOVERNOR MERRIAM Promenades on Catwalk

Governor Merriam paused frequently to talk with the steel workers at their airy posts. On his first trip the contractors were still adjusting the cable spinning equipment, with frequent instances when the wire jumped off the spinning wheel. On the fifth of July, Governor Merriam again inspected the operations, when it was in full force with several hundred wires already laid in the cable.

As Governor Merriam and his party toiled up the steep incline of the catwalks, they would be warned by the tinkling of a cow bell fastened on the wheel, of the approach of the cable spinning apparatus dragging behind it a flopping steel wire.

The Governor and his party are the only persons, other than cable spinners and inspectors, who have been permitted on the catwalks during the spinning operations.

News reel camera men representing all the companies operating in America photographed the San Francisco-Oakland Bay Bridge on the occasion of the

Spinning Bridge Cables Across Bay

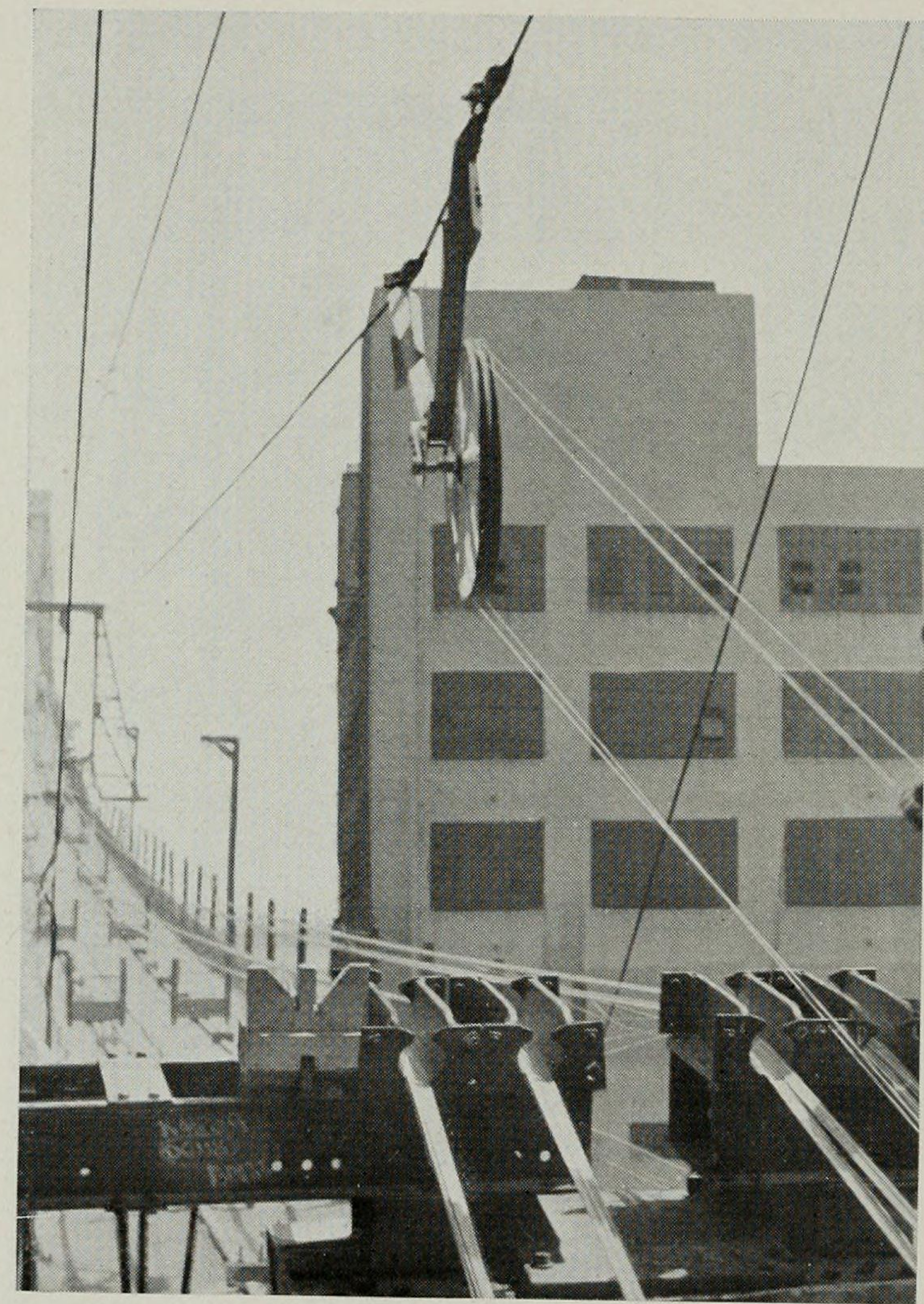
(Continued from preceding page)

Governor's second visit to the catwalks. The news reels represented were: Pathe, Hearst-Metrotone, Universal, Paramount, and Fox-Movietone. If these pictures of the cable spinning meet the standards of the Eastern editors, they will be disseminated throughout America before the end of July.

The spinning is now taking place on the most westerly of the twin suspension bridges. Two loops of the pencil-sized wire are carried in the two grooves of the wheel over the top of the towers and then to the center anchorage. Another spinning wheel returns with two loops of wire bound for the San Francisco anchorage simultaneously.

The spinning wheels are hung from an endless hauling cable similar to the pulley rope of a clothes line. Thus two spinning wheels are operating on each main cable, but in opposite directions.

Several hundred men of the cable spinning crew line the mile long catwalks seizing the wire as it comes along, and forcing it into grooves where its height is checked to a guide wire.



THE SPINNING WHEEL is 5 feet in diameter and carries two loops of the pencil size cable wire on each trip traveling 7 miles an hour.

The new safety catwalks have been found by Chief Engineer C. H. Purcell and his staff to be highly satisfactory. The open catwalk wire, bad for dizzy heads, is ideal for preventing wind swaying in these sky promenades.

With four strands completed in each of the cables of the western half of the suspension sector, preparations are under way for raising the catwalk ropes for the eastern sector from the center anchorage to the island.

Several days were spent adjusting to correct elevation the four strands completed on the south catwalk. Since the sags of the completed cable depend upon the correct adjustment of these first four strands, a high degree of precision is required in the position of the wire already spun.

Night and day crews of men, supervised by State bridge engineers, check the height of the cable wires and correct those out of position by mechanical leverage devices.

Spinning of the next four strands on the south walk were started while the adjustment of the four strands on the north walk was taking place.

By mechanical devices it is provided that any slack is immediately taken up by brakes applied to the huge spools of cable wire. In addition to this mechanical control of slack, an electrical system of switches is provided at 250-foot intervals over the entire catwalk so that in case of accident or a snarled wire all movement can be immediately shut down by the workmen witnessing the accident.

The wheels travel approximately seven miles an hour over the one mile course. Each cable strand contains 472 wires so that each strand requires 236 trips of the spinning wheel. Except for the center, or nineteenth strand, which is laid up by itself, the strands are spun in sets of four, each set being adjusted to correct elevation before starting succeeding strands. There will be 37 strands, or a total of 17,464 individual wires in each main cable, and the spinning will be completed this year.

TWIXT HEAVEN AND EARTH, suspended on a three-foot walkway between two catwalks of the San Francisco-Oakland Bay bridge, 350 feet above the bayshore, Governor Merriam and his official party inspected the cable spinning and posed for photographers. With the Governor in upper picture is Director of Public Works Earl Lee Kelly. Below, left to right, are W. G. Swanson; James Ward, American Bridge Co.; E. J. Schneider, President A. M. Diehl and Jack Fox of Columbia Steel Co.; Assistant Director of Public Works Justus F. Craemer; Governor Merriam, Director Kelly and Chief Engineer C. H. Purcell.

CALIFORNIA

HIGHWAYS AND PUBLIC WORKS

Nocturne of San Francisco-Oakland Bay Bridge With Catwalks Lighted for Cable Spinning

Official Journal of the Department of Public Works

AUGUST • 1935

Bay Bridge Center Anchorage Makes Largest "Pin-hole" Camera in World

ODDITIES of the great San Francisco-Oakland Bay Bridge which test the lay imagination vie with the structure's unusual engineering features and its illumined beauty by night in attracting attention to this marvelous construction undertaking.

Perhaps the strangest of these is the existence of a mammoth "box camera," creation of which was entirely unforeseen by the bridge engineers, in the huge concrete hollow of the central anchorage which "takes" a photograph 50 feet high.

"The world's largest camera," as the Anchorage Block now is called, was discovered by Chief Engineer C. H. Purcell.

INVERTED MOVING PICTURES

Descending the stairs in the anchorage, he observed in bright orange an inverted image of one of the bridge towers on the center wall of the anchorage. He was further amazed to see a ferry boat passing upside down across the wall.

Investigation disclosed that four rectangular apertures, each one by two feet in size, two on each side of the anchorage, constituted the "pin holes" or openings corresponding to the lens of a camera.

The plate upon which the images are thrown is the concrete diaphragm running vertically through the middle of the anchorage thus making the latter a combination of four pin-hole cameras set in a box 235 feet high, 197 feet long and 92 feet wide. The apertures are in walls which are about six feet thick and 207 feet above the waters of San Francisco bay.

"PIN-HOLE" CAMERAS

The images, as is the case in all pin-hole cameras, are thrown upside down on the concrete diaphragm in the center of the anchorage. The images are made by the slanting light rays. Those striking the top of the tower continue down to the "pin hole" and through to a point 50 feet below the level of the opening. The light rays that strike, or are reflected from the base of the tower, travel in an ascending slant through the "pin hole" and on to a point above the hole on the opposite wall.

When the sun is shining on the east face of Tower W-3, west of the anchorage camera, a color photo of the tower upside down is visible on the "plate." When the sun is in the west Tower W-3 is photographed in black and white. Similarly, when the sun is in the west, shining on the west face of Tower W-5, east of the camera, the image is in color, and when the sun is to the east of Tower W-5, it is reproduced in black and white on the wall inside the anchorage. The camera photographs passing ships clearly.

Another odd feature causes observant persons on ferryboats passing the East Bay section of the huge bridge to wonder at what appear to be wide cracks in several of the massive tower legs supporting the structure. Close inspection shows that the cracks go through the entire bridge, including the lower and top decks.

SPLIT TOWERS EXPLAINED

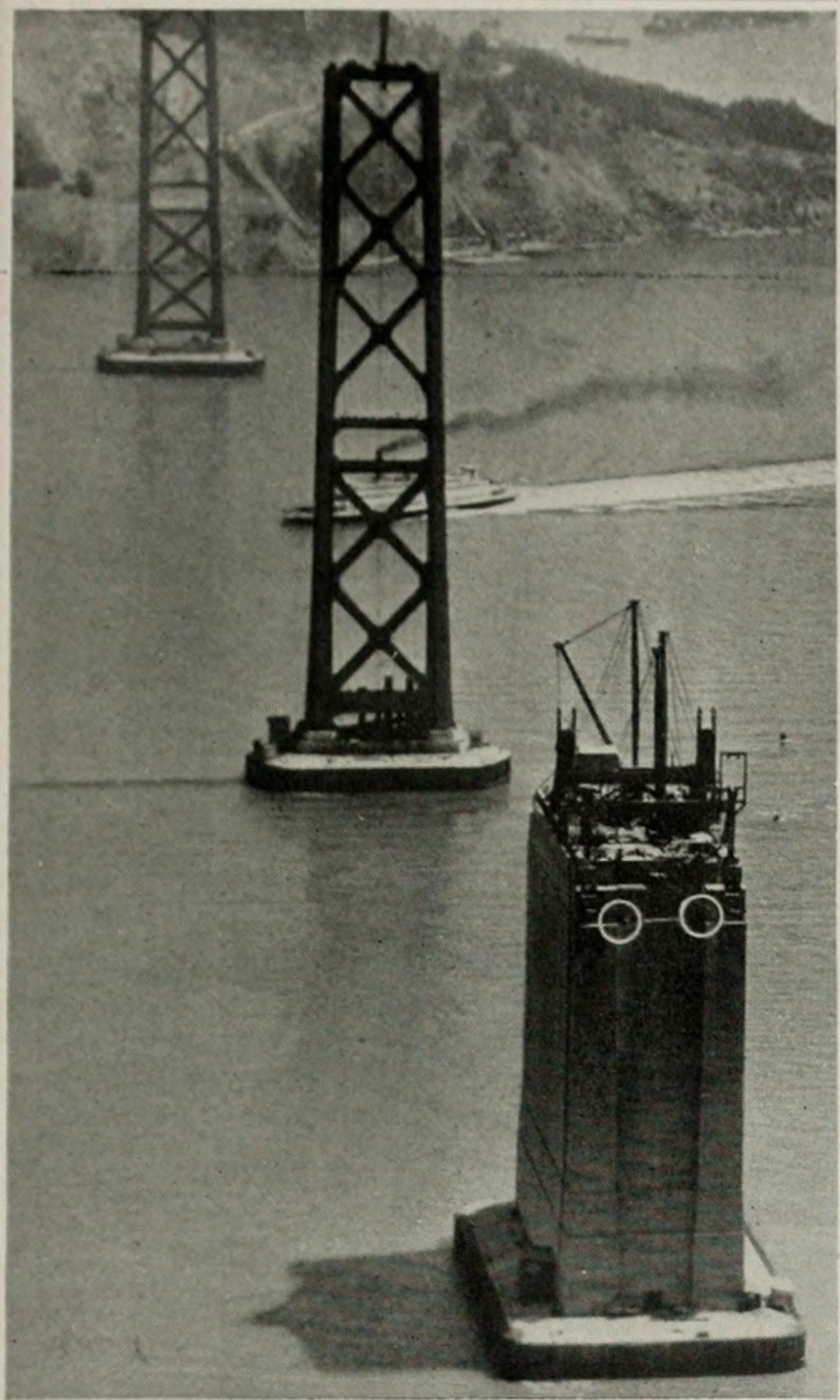
These are expansion joints designed by Chief Engineer Purcell and his staff to permit the bridge spans to lengthen and contract under the influence of heat, cold and load. The split towers make it possible for the spans to be pulled apart nine inches at this point when the spans contract.

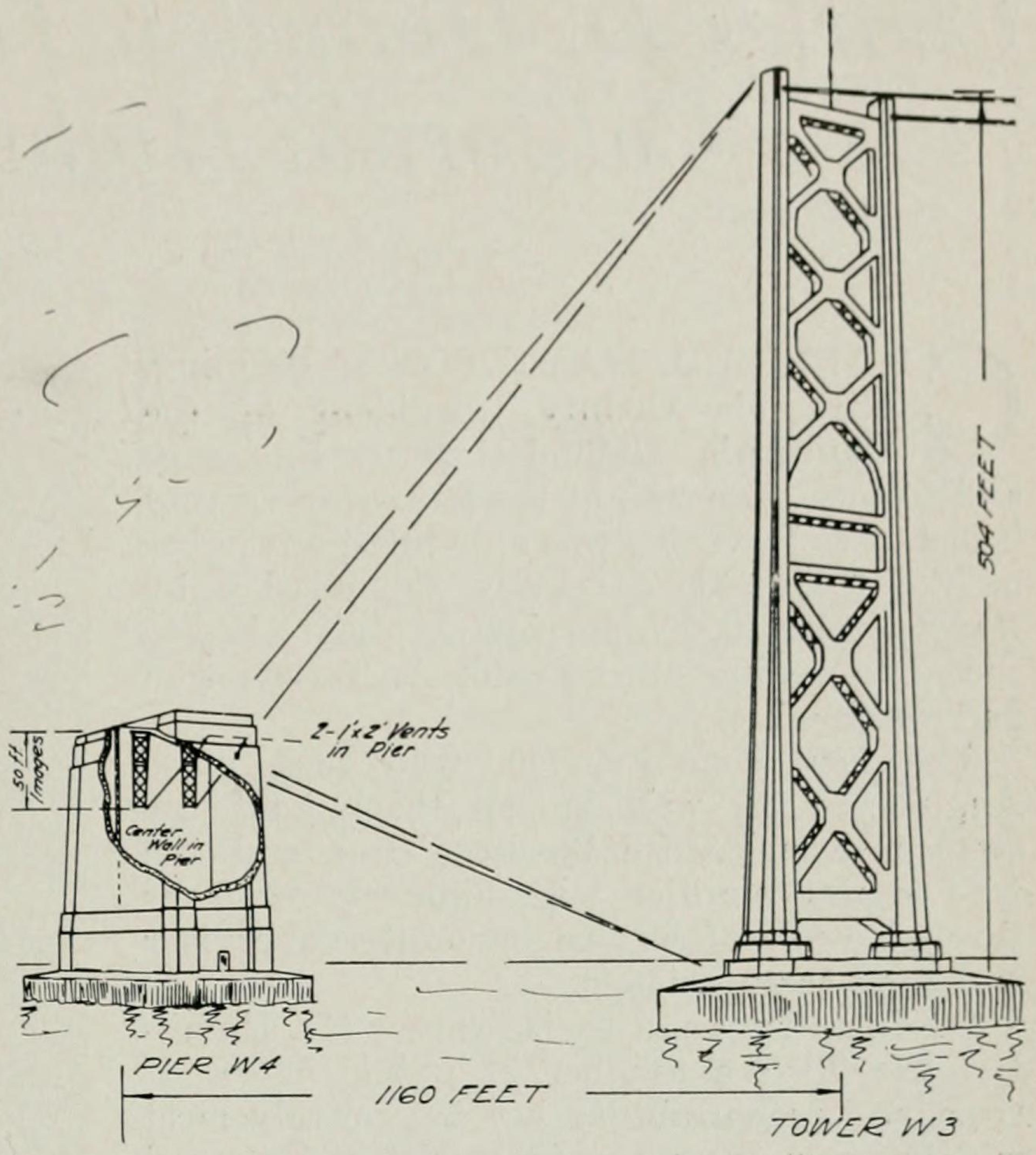
The spans are anchored securely to piers several span lengths away and all of the foreshortening, or change in length of the spans, is taken care of by flexing the two parts of this split tower. In the accompanying photograph it will be noted that even the diagonal bracings between the legs of the towers are also in separate units.

Reminiscent to San Franciscans of the beautiful lighting effects of the Panama Pacific International Exposition of 1915 is the night illumination of the bay bridge. Two long ribbons of light are suspended along the catwalks of the structure, high above the bay waters, to aid night workers in the perilous task of "spinning" the 70,000 miles of steel cable wire which will support the bridge.

Ferryboat commuters and visitors entering San Francisco Bay are afforded an unforgettable sight after dark when the bridge illumination is turned on.

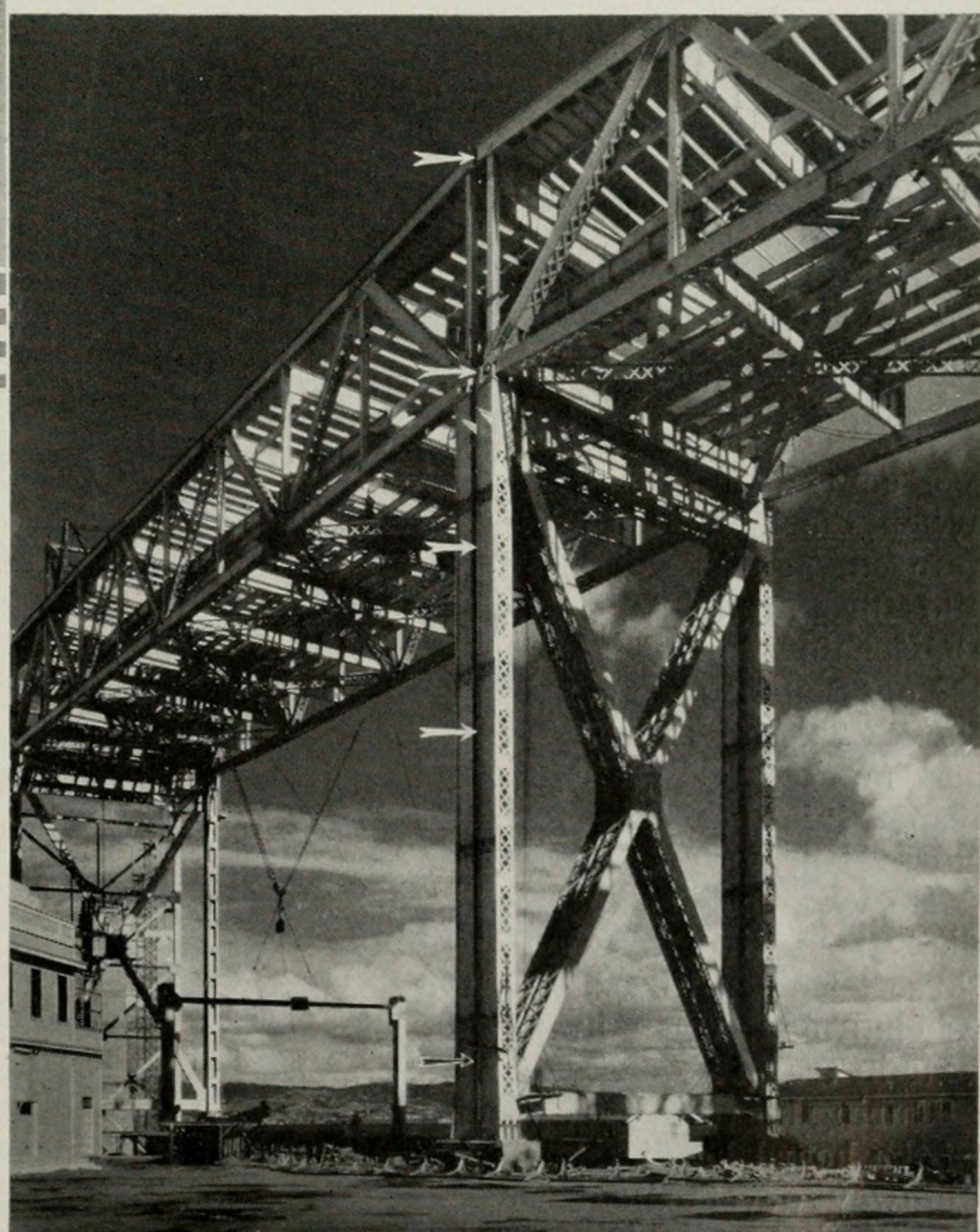
(Continued on page 29)





A FREAK OF BUILDING CONSTRUCTION has produced the world's largest pinhole box camera in the huge Central Anchorage of the San Francisco-Oakland Bay Bridge which makes a picture 50 feet high on the great central diaphragm wall in the interior of a "box" 235 feet high, 197 feet long and 92 feet wide. The pictures are due to 1 x 2 foot apertures in the top of the anchorage walls through which images of passing boats and bridge towers are reflected on the great concrete "plate" upside down as shown in the above diagram.

At lower right is shown one of the steel piers of the East Bay truss span structure which seems to be entirely split by a great "crack" that causes the layman to wonder. The "crack" is an expansion joint that permits the spans to be pulled apart 9 inches by heat expansion.



Bay Bridge Cables Get a Squeeze; All Channel Piers to Have Bells On

ONE of the most interesting tasks involved in the construction of the San Francisco-Oakland Bay Bridge now is being accomplished by the builders of the gigantic structure.

This job is the "squeezing" together of 17,464 wires into a compact, unbreakable cable. Two of these huge cables will cross from San Francisco to Yerba Buena Island and will carry the suspended weight of the bridge itself.

Each of these cables will be made up of 37 strands of 472 wires each, held together by soft sheet metal bands making a total of 17,464 wires to a cable.

SQUEEZED BY RADIAL JACK

Work of compressing the north cable extending from the west shore to the Center Anchorage will be undertaken first, to be followed by the "squeezing" of the south cable.

Upon the loosely laid wires spun from the shore to the Anchorage, a compacting machine travels, "squeezing" as it moves along. This machine, known as a radial jack, brings to bear on the 37 strands of wires the pressure of six 75-ton jacks which form a circle about the cable.

The chain drive of these six jacks compresses the 37 strands into a tightly compacted cable 28¾ inches in diameter.

The present cable has a somewhat hexagonal shape and is about 29 inches in width and 34 inches thick. The first compacting began this week from the top of Tower W-2. Six 75-ton jacks in each compacting machine, driven by air motors, will squeeze the cable, and temporary seizings or short spiral wrappings will hold the cable in its compacted form.

FOUR SUSPENDER ROPES

After the entire cable has been squeezed to size, and seized at intervals, and cable bands bolted on to supply grooves for the hanging of the suspender ropes, the compacting machines will be taken off.

The next operation will be to disengage the four 2¼-inch suspender ropes from the catwalks, leaving the catwalks supported by the main cables. The four ropes, of wrist thickness, which will be taken down will be cut up into lengths already marked off, and dropped over the main suspension cable in grooves provided in the cable bands.

To the ends of these suspender ropes, ranging in length from six feet to 230 feet, will be attached the trusses, or the decks, of the bridge. These trusses will be hoisted up by hoisting equipment suspended from the cables. The sections of trusses will be barged into position underneath the cable and from there lifted and secured to the suspenders.

WRAPPING FINAL JOB

After the decks, or the stiffening trusses, of the bridge have been suspended by means of the former catwalk ropes, paving will then be placed on the upper deck and on the truck lane. Thereafter when the bridge is fully loaded, the business of wrapping the cable will begin.

The cable is not wrapped until the total dead load is applied because only then has all the stretch been taken out of it.

Immediately before wrapping, a red lead paste will be applied to the cable. Then the cable is completely wrapped with steel wire except beneath the cable bands where the cable has been previously treated with red lead paste before the bands are bolted on.

CATWALKS REMOVED LAST

At the anchorages, huge splay castings will be applied to the cables before the wrapping, which will graduate the size of the cable from its fan-shaped spread at the eyebars to its closely compacted load-carrying size. After being spirally wrapped with wire, the cable will be given four coats of paint.

Almost the last operation of the bridge will be the removal of the catwalks along the cables.

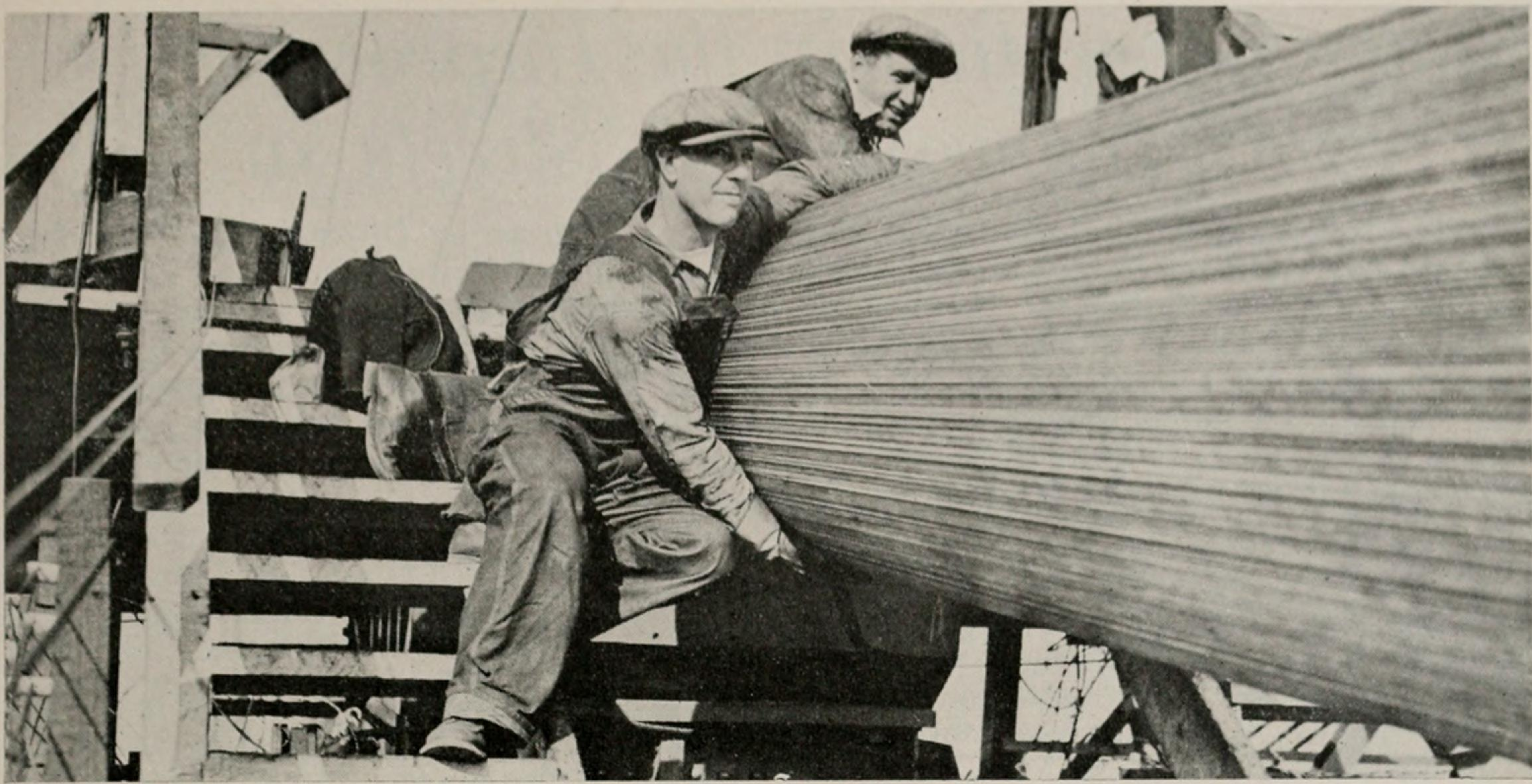
Work on the bridge is well ahead of schedule, according to Chief Engineer C. H. Purcell, and the transfer of cable spinning equipment from the western to the eastern catwalks was started a week ago.

BELLS ON THE BRIDGE

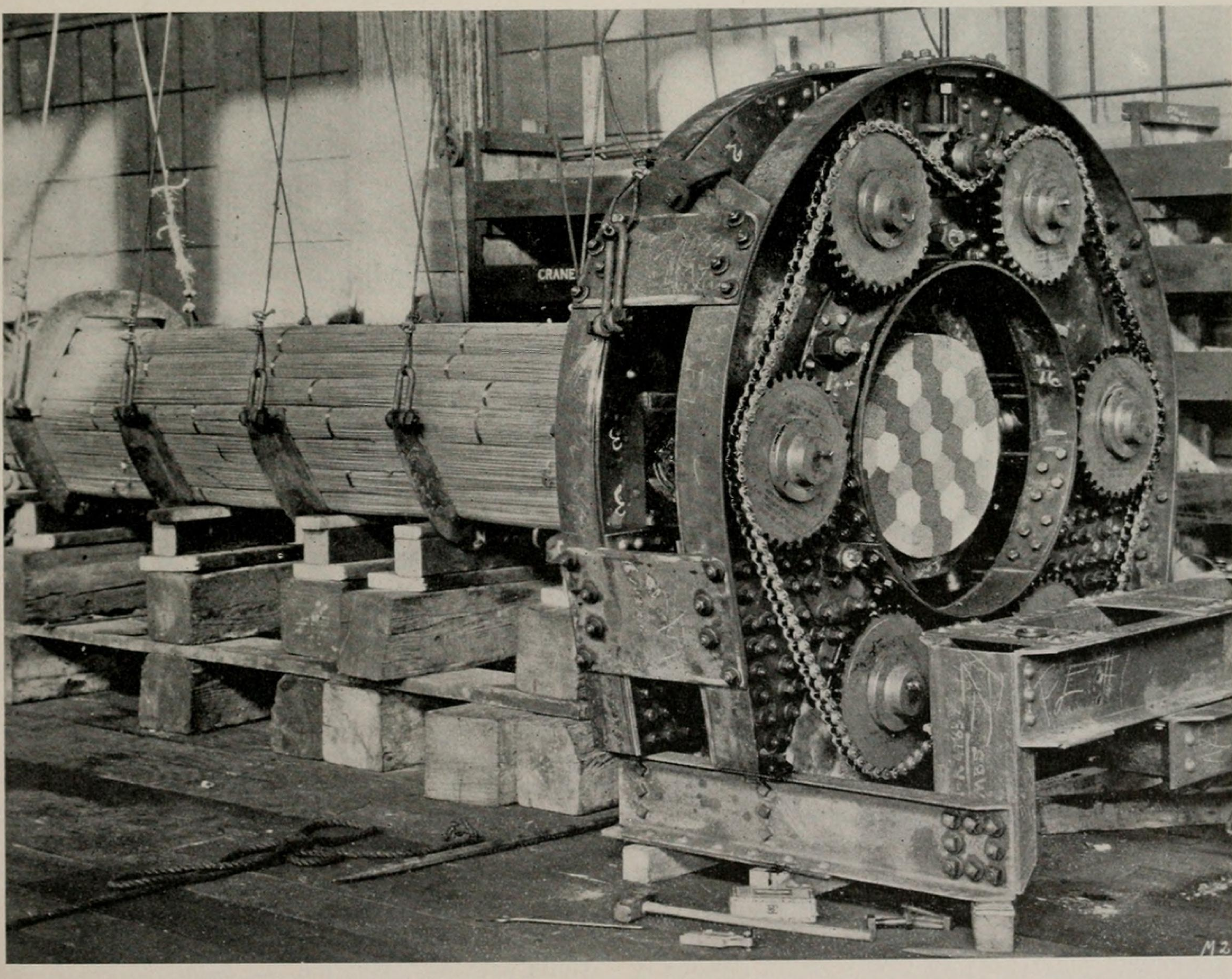
When cable spinning on the eastern catwalks is completed, compacting of the giant cables from the Center Anchorage to Yerba Buena Island will begin.

Another interesting feature of the bridge equipment is a set of five huge bells which

(Continued on page 29)



SO BIG! The two Bay Bridge workers are obligingly hugging one of the big cables to give an idea of its size before the compacting machine comes along and gives it a big squeeze.
Photo courtesy of San Francisco Examiner.



JACK THE SQUEEZER. After the 17,464 wires making up the 37 strands are in place the cable has a somewhat hexagonal shape 29 inches in width and 34 inches thick. The radial jack compacting machine squeezes the cable to a circular form 28¾ inches in diameter.

San Francisco-Oakland Bay Bridge Will be Opened to Traffic in 11 Months

ONLY eleven months more and the construction of the world's largest bridge will be California history.

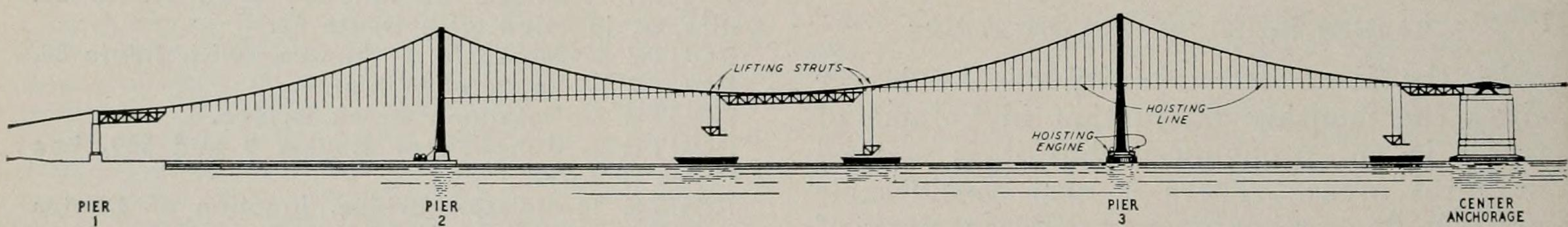
This is the essence of the 1936 New Year's Day report to Governor Frank F. Merriam, chairman of the California Toll Bridge Authority, by State Director of Public Works Earl Lee Kelly.

Despite the pace of the 30-hour week and the obstacles which nature places in the way when man seeks to set new engineering frontiers in defiance to the hazards of deep water and dizzy heights, the world's largest bridge will finish ahead of schedule. By November, 1936, Chief Engineer C. H. Purcell expects to have finished the paved decks so that the bridge may be opened to traffic during November.

these great bridges and California is the special beneficiary.

''The engineering wonders of these two record-breaking structures have turned the eyes of the world on America, on California, and on San Francisco Bay—just as Boulder Dam has turned the spotlight on Los Angeles. The State Department of Public Works is proud to present to California this San Francisco-Oakland Bay Bridge, which, eminent authorities have said, will hold its place as the greatest bridge in the world for one thousand years.

''During its first year we expect the bridge to carry 6,000,000 vehicles, and full prosperity only needs to return to give the bridge an annual passenger traffic of 50,000,000 persons.''



FERRIED ON BARGES roadway trusses for the Bay Bridge are lifted from midbay into position and fastened to suspender cables as shown in sketch.

$40,000,000 EXPENDED TO DATE

Thus far approximately $40,000,000 has been expended on bridge and approaches. During 1936, the bridge and its approaches—representing $62,600,000 at present estimates—will have been completed and the remaining $15,000,000 worth of work which represents the cost of the interurban railway on the bridge will, if present negotiations with the railroads and RFC are successful, be well under way. The railway portion will not be completed until after the highway decks have been opened to the traveling public.

''The building of this world's greatest $77,-600,000 bridge between San Francisco and Oakland,'' Director of Public Works Kelly said, ''and its sister bridge, the $35,000,000 Golden Gate Structure, sets in motion the tidal wave of public interest in California which is to produce a tremendous exposition on a specially made island in San Francisco Bay in 1938. The entire west is tributary to

PROGRESS SCHEDULE FOR 1936

The report to Governor Merriam set forth the following schedules for completion of units of the San Francisco-Oakland Bay Bridge in 1936:

BERKELEY UNDERPASS—now complete.

EAST BAY DISTRIBUTION VIADUCTS—complete April 1.

MAINTENANCE BUILDINGS IN OAKLAND TIDELANDS—complete July 1.

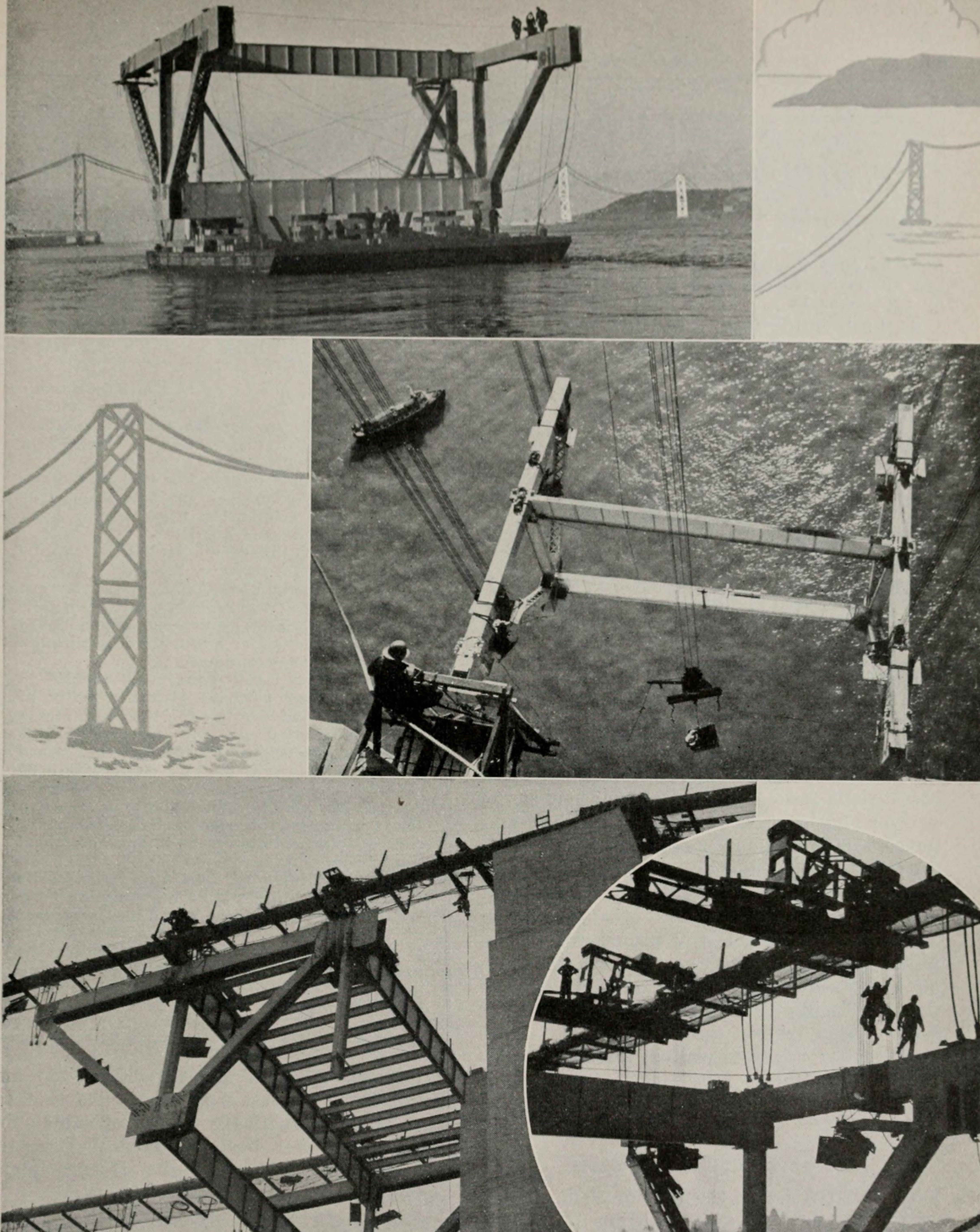
EAST BAY BRIDGE—cantilever closed March 7.

PAVING EAST BAY—complete May 7.

YERBA BUENA ISLAND—upper deck of tunnel and all island work, including the tunnel—complete June 1.

WEST BAY BRIDGE—(The twin suspension bridges, East Bridge and West Bridge, over the West Bay Channel, between San Francisco and Yerba Buena Island)—The west bridge will be completed first, with all of its spans hung from the cables by March 15, and the steel floor in by April 15. The East Bridge, between the concrete center anchorage and the island, 28¾ inch cables for which are now being spun, will have its decks

(Continued on page 20)



FROM THE WATER UP go steel sections of the San Francisco-Oakland Bay Bridge roadway to be hung in position on suspender cables. These sections consist of about 90 feet of truss measuring the full 66-foot width of the bridge and weighing as much as 210 tons. They are ferried out to the bridge on barges as shown in the top photo and lifted into position by steel lifting lines operated by engines at the base of the towers as seen in the center picture. At bottom is shown one section just six feet below final position 250 feet above the Bay and in inset workmen are sliding down from the main cables to attach socketed suspender cables, four of which can be seen dangling over each end of the truss.

A BRILLIANT NECKLACE OF LIGHTS is suggested by the arching, looping ropes of big incandescent lamps that at night illuminate the San Francisco Bay Bridge catwalks extending from the Golden Gate metropolis to Yerba Buena Island. Beneath them the third shift works all through the hours of darkness.

Banner Year for Construction Work

THIS YEAR promises to be a banner one in the construction industry in southern California in the opinion of Frank Connolly, manager of the Southern California Chapter Associated General Contractors.

He bases his optimism largely upon the extensive 1936 highway building program undertaken by the State Department of Public Works.

During 1935, Connolly points out, southern California enjoyed the unique distinction of having a proportionately larger volume of contracting business than any other section of the country due to reconstruction of schools, public buildings and other structures made necessary by the 1933 earthquake, construction of the Colorado River aqueduct, and the large state highway program in which the regular state expenditures were augmented by emergency relief appropriations.

"The number of highway projects offered for bids during the latter part of 1935," said Connolly, "almost overtaxed the facilities of the industry but in most cases there was satisfactory competition and a large volume of this construction now is under contract. The work of our highway engineers and contractors has been so excellent that it has attracted the attention of everybody using our roads.

"Motorists marvel at the fine broad highways, easy grades and curves and the wonderful bridges which have been constructed by this group. Most of the emergency funds for highways have been obligated, but the ordinary budget still provides for approximately $1,000,000 per month in highway construction for the next 18 months."

Green: "You must be keen on the talkies, old boy, to go twice a week."

Howarth: "It's not that exactly. You see, if I don't go regularly I can't understand what my children are saying."—*Toronto Globe.*

CALIFORNIA

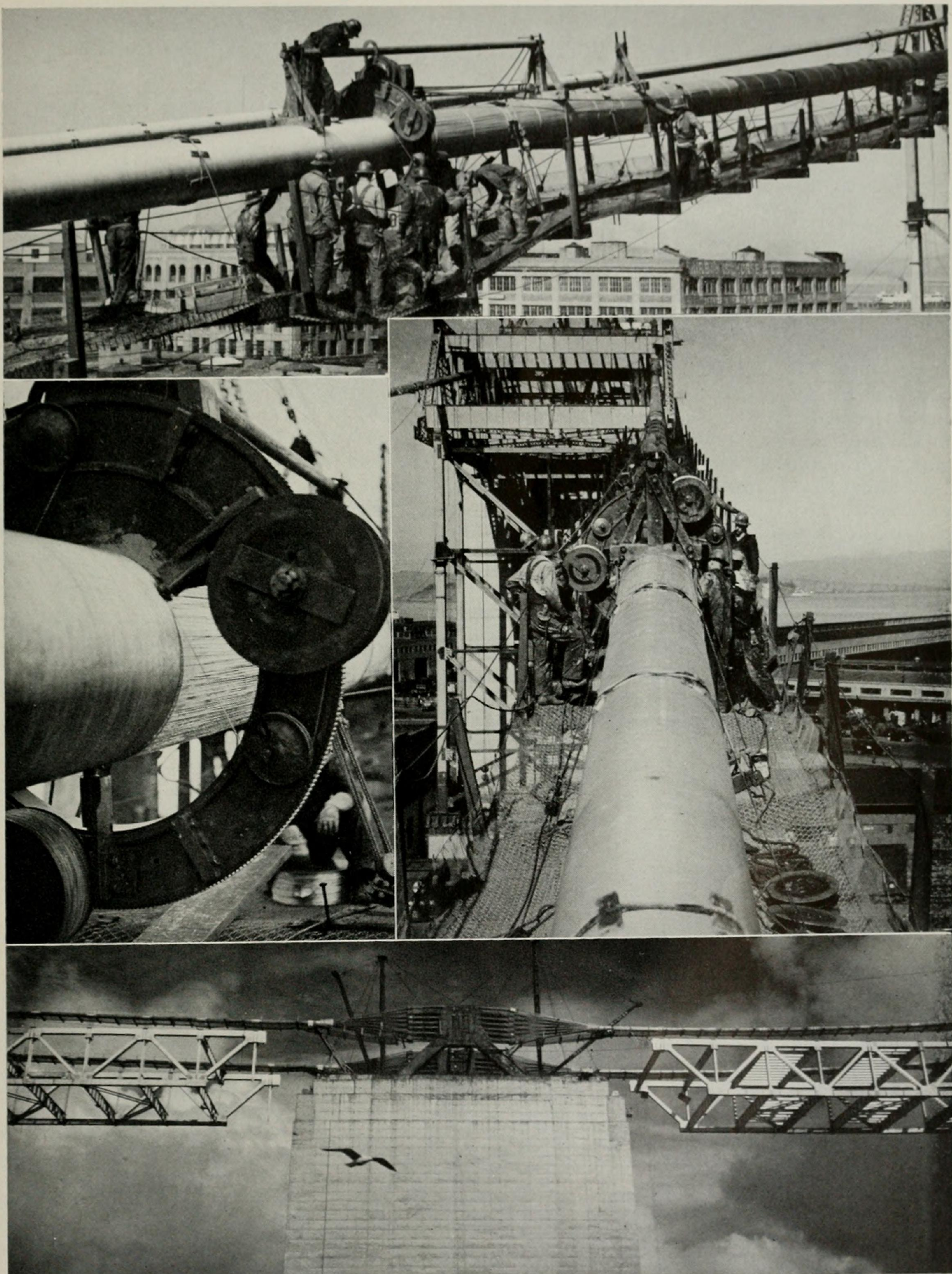
HIGHWAYS AND PUBLIC WORKS

Cal
Highway Dept

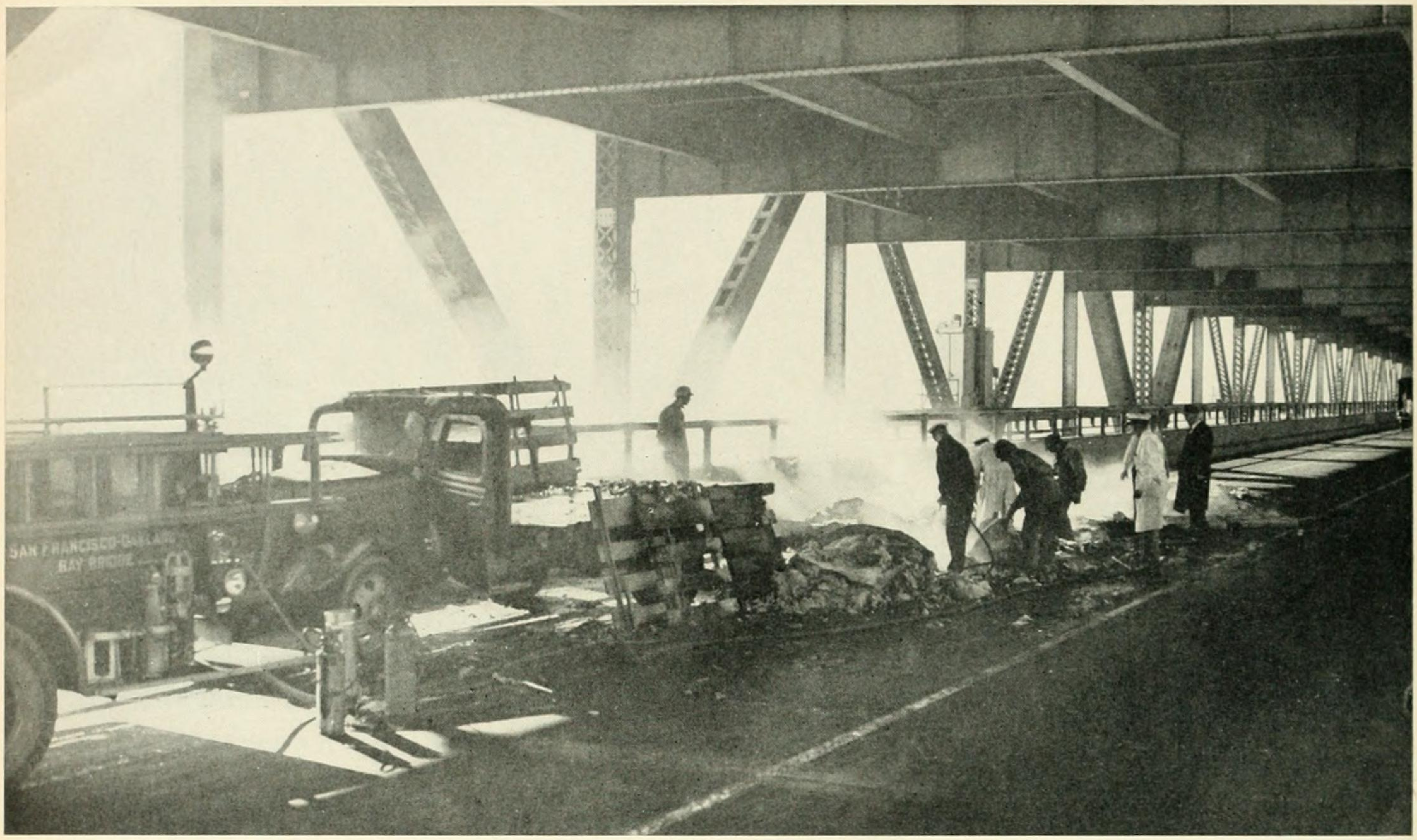
Spans across the Bay Join San Francisco and Oakland

Official Journal of the Department of Public Works

JUNE 1936



CABLE WRAPPING on the San Francisco-Oakland Bay Bridge is done by means of a steel ring 5 feet in diameter operated by an electric motor on top of the machine. The ring carries three 18-inch spools each containing 500 pounds of galvanized wire. The bottom picture shows the A-frame anchorage atop the central anchorage pier for cables of the twin suspension bridges of the West Bay crossing.



This photograph shows what happened on the Bay Bridge when a cigarette was carelessly thrown into a truck load of mattresses

Bay Bridge Maintains Fire Department

By C. S. HAMILTON, Associate Bridge Engineer

CONSIDERING the current popularity of radio quiz programs, we offer as the $64 question, "What does a fire department do on a steel and concrete bridge?"

While such a question may have no particular meaning when applied to the ordinary river crossing, it is quite pertinent on the huge San Francisco-Oakland Bay Bridge. On this structure fire is of sufficient potential hazard to bridge property and the public as to warrant the employment of a permanent fire department as a unit of the bridge maintenance forces. Nor is this hazard merely a theoretical one. The history of the bridge since the opening day in November, 1936, to date, has amply justified the assignment of men, equipment, and material to this fire-fighting function. It could well be that the continued use of the bridge by its many patrons is due in no small part to the constant vigilance and ready availability of the bridge fire department.

The main bridge fire equipment is centrally located for speed in action. The fire station is housed at Yerba Buena Island at the approximate center of the bridge. Roadway connections at this point provide ready access to the upper and lower decks of the structure in either direction. Permanently stationed at this location is a modern fire truck equipped to cope with the particular fire situations that may arise on the bridge. From this central point the fire truck can respond in a few minutes to any point on the 12½ miles of bridge and approach roadway and 4½ miles of bridge railway under the jurisdiction of the San Francisco-Oakland Bay Bridge unit.

The fire truck is an American-La France unit on a G.M.C. chassis and carries the following equipment:

1 300-gal. water tank connected to a Byron-Jackson 2-stage centrifugal pump delivering 120 g.p.m. at 130 pounds pressure.

700 feet of 2½-inch and 1½-inch hose for the above unit for hydrant pumping and 150 feet of ¾-inch chemical hose.

40-gal. Foamite tank operated by compressed nitrogen and equipped with 200 feet of ¾-inch hose and shut-off nozzle.

1 running-board-mounted Model 10 Foamite generator with 100 feet of 1½-inch hose and nozzle. Six 50-pound cans of Foamite compound are carried on the truck to serve the generator unit.

10 portable extinguishers made up by three 2½-gallon Foamite units, two 1-gallon carbon tetrachloride units, two 15-pound carbon dioxide units, two 1-quart Pyrene units, and one 2½-gallon plain water unit.

ADDITIONAL EQUIPMENT AVAILABLE

Auxiliary bridge fire-fighting equipment has been provided by installing small gasoline-engine-driven centrifugal pumps and hose on two 580-gallon truck-mounted water tanks normally used by the bridge painting crew for preliminary cleaning operations, and by installing a pump and pertinent equipment on the bridge maintenance boat *Active* for possible use on certain bridge piers having a timber protection fender. The *Active* is a 14-ton launch of 42-foot length and 12-foot beam powered by a 3-cylinder, 50 H.P. Corliss marine engine. The boat was used by bridge engineers during construction and on completion of that operation was assigned to the bridge maintenance forces. The fire-fighting equipment mounted on the boat consists of a Chrysler-Hale auxiliary fire pump of 500 g.p.m. rated capacity, 200 feet of 2½-inch and 1½-inch hose and a monitor nozzle mounted atop the pilot house. At the rated capacity the pump readily develops 125 pounds pressure.

All maintenance automotive equipment assigned to the bridge carries hand extinguishers which have been of frequent use in suppressing incipient fires without the necessity of calling for the larger units.

A 10-inch water main from San Francisco to Yerba Buena Island is installed on the West Bay crossing of the bridge. Fire hydrants at frequent intervals on this line provide ample water supply in case the portable supply should prove insufficient. A 12-inch water main now under construction from Oakland to Yerba Buena Island will shortly provide similar facilities on the East Bay crossing.

Harbor piers on the San Francisco waterfront, immediately adjacent to the bridge, are equipped with automatic sprinkler systems for bridge fire protection. These systems were installed by the bridge and are maintained by bridge forces.

COMMUNICATION SYSTEM

Reporting into the firehouse are the 54 fire alarm boxes distributed at intervals along the bridge and approach roadways for the use of the public and bridge employees. A terminal receiving instrument permanently records date, time, and location of all alarms transmitted on the system and, by the action of the fireman in resetting the box, records the same information for the response to a call.

The alarm system also reports each call and reset into the administration office of the bridge, located at the toll plaza. Auxiliary boxes at each end of the bridge connect the bridge system with San Francisco and Oakland systems so that the fire departments of these cities may be called if the bridge fire department needs outside assistance. A mutual aid arrangement has been agreed on with the Navy Fire Department at the Treasure Island Base, adjacent to Yerba Buena Island, thus providing another source of outside help on specific call.

Bridge maintenance phones provide additional communication into the firehouse and augment the coverage of the bridge alarm system.

The fire fighting forces are a part of the bridge maintenance and emer-

Maintenance boat "Active" throws a stream of water onto Bay Bridge during fire drill

Cal.

CALIFORNIA
HIGHWAYS AND PUBLIC WORKS

September — October, 1951

Highway Dept

1883 *Charles Henry Purcell* 1951

Artist's sketch superimposed on aerial photograph shows the three ramp connections between the upper deck of the San Francisco-Oakland Bay Bridge and Yerba Buena and Treasure Islands which will be improved to provide easier turns. A connection on the lower deck will also be improved.

California Highways and Public Works
DIVISION OF HIGHWAYS
P. O. Box 1499
SACRAMENTO, CALIFORNIA

World famous San Francisco-Oakland Bay Bridge in color. Aerial photo by Merritt R. Nickerson, Chief, Photographic Section, Department of Public Works

Bay Bridge Reconstruction

By E. R. FOLEY, Chief Engineer, Division of Bay Toll Crossings

The reconstruction of the San Francisco–Oakland Bay Bridge to provide five lanes of one-way traffic on each deck has been the subject of two previous articles in *California Highways and Public Works*. They appeared in the July-August 1960 and January-February 1962 issues.

This article describes the final phase of structural modifications before one-way traffic movements could be instituted. It covers strengthening of the upper deck on the East Bay spans; construction of refuge bays; resurfacing of the upper deck; additional reconstruction on the approaches; lower deck lighting; and signs.

Upper Deck Strengthening

The upper deck of the Bay Bridge was originally designed to carry passenger automobiles and light commercial vehicles on six traffic lanes, three in each direction. In the East Bay spans, defined as that portion of the bridge east of Yerba Buena Island, the floor system consisted of a reinforced lightweight concrete roadway slab six inches in depth and 58 feet wide. This was supported on transverse joists at six-foot centers which in turn rested on four longitudinal stringers spaced at 16-foot centers. These longitudinal stringers were framed into floor beams having variable spacings as indicated in the following tabulation:

Type of span	*Spacing, feet*
288-foot and 292-foot deck trusses	36
504-foot through trusses	42
Cantilever—anchor arm	48
Cantilever—cantilever arm	55
Cantilever—suspended span	58

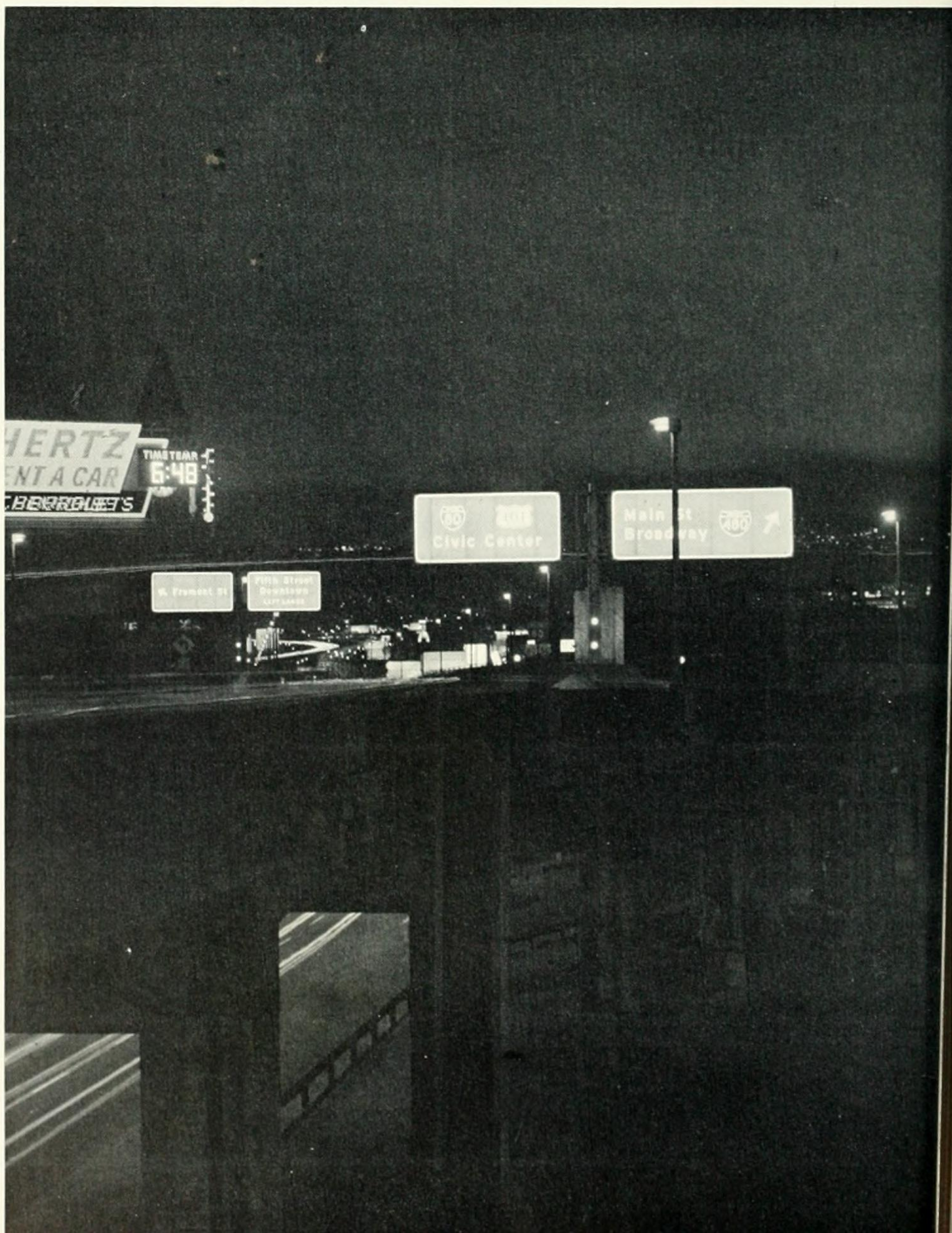
Analysis of this floor system indicated that all of its elements, that is, the roadway slab and its supporting structural steel members were inadequate to carry the heavier live load that would be imposed when unidirectional traffic movements were put into operation. A strengthening method had to be devised which would not interfere with passage of the more than 110,000 vehicles using the bridge each day. After consideration of many different plans and alternatives, the upper deck floor system of the East Bay spans was strengthened in the manner described in the following paragraphs.

Roadway Slab and Transverse Joists

To reduce the span of the roadway slab and the load carried by each of the existing joints, intermediate joists were installed at six-foot centers midway between the existing joists. The new joists are 10WF sections of A440 high-strength steel.

The rolled sections were threaded in one piece through the space between the existing longitudinal stringers and the concrete slab. The joists were preloaded at the third points of the spans between

These internally lighted directional signs on the San Francisco end of the bridge have proven quite effective for nighttime visibility. The color scheme used corresponds to that established by interstate highway standards.



stringers and at the ends of the joists to insure their full participation in carrying the live loads. High-strength bolts were used to connect each joist to the top flange of the stringer. The void between the joist and slab, varying between one-half to one inch, was filled with a 1:3 grout mixture, applied as air-blown mortar. The grout contained an admixture to prevent shrinkage.

Stringer Strengthening

The load-carrying capacity of the existing longitudinal stringers was increased by the addition of understringers. Both rolled and welded sections were used.

Sections were fabricated in such a manner that either their natural camber or a specified camber could be erected upwards.

The understringers were lifted and clamped into position. Then, using the predrilled holes in the understringer as a template, holes were drilled through the bottom flange of the original stringers. High-strength bolts, ⅞-inch in diameter, were installed and tightened in a sequence progressing from the ends of the understringer towards the center to complete erection.

Floor Beam Strengthening

The floor beams of the East Bay spans were strengthened in the same manner as those on the West Bay spans. A high-strength steel plate was bolted to the bottom flange of each beam after the plate had been stressed to a predetermined amount. Using this method of strengthening, the tensioned cover plate induces an initial compressive force on the bottom flange, thereby reducing the existing dead load tensile stresses. Thus, a greater portion of the strength of the original section is made available to carry increased live load.

The procedure for installing these cover plates was similar to that described in the article of January-February 1962.

Minimum Traffic Interference

In the preparation of construction contracts, serious consideration was given to details which would offer the least interference to the movement of bridge traffic. On the East Bay work, the State's traveling scaffolds were available for use by the contractor. These were augmented by his own scaffolds. Also, the contractor was permitted to use the south lane as a working area. This arrangement caused a minimum of inconvenience to traffic while reconstruction of the East Bay spans was accomplished.

As a result of strengthening the upper deck floor system in the East Bay spans the entire upper deck is now capable of carrying five lanes of H20-S16 traffic with maximum stresses not exceeding those allowable in the current edition of the American Association of State Highway Officials Standard Specifications for Bridges.

Refuge Bays

The capacity of a long structure, such as the San Francisco–Oakland Bay Bridge, is directly related to the continued movement of traffic. Thus any stalled or disabled vehicle reduces its capacity. To keep the large volume of traffic on the bridge moving, refuge bays have been constructed wherever possible. In the East Bay spans these were built in the curved sections of the bridge: first, in the area west of the cantilever span, and second, just east of the 504-foot truss spans. These refuge bays were built by moving the existing curb back and paving the area with lightweight conrcete.

Upper Deck Resurfacing

Resurfacing of the upper deck was considered necessary for two reasons. First, after nearly 27 years of use the concrete surface was beginning to show signs of wear, particularly in the curb lanes. The degree of deterioration was such that it was considered advisable to repair the deck before heavier loads were imposed upon it. Second, it was necessary to cover the 4″ x 4″ tiles which had been embedded in the concrete roadway to delineate the six traffic lanes.

Since the amount of dead load that could be added to the structure was limited, investigation was concerned with a lightweight material, that would provide a long, serviceable life. An epoxy coal tar compound met these requirements; it weighed 15 pounds per square yard at a ⅛-inch thickness, its serviceability was considered good, and it could be easily applied.

Resurfacing Operations

A total of 26 lane-miles of resurfacing was accomplished on the upper deck. The first step in the resurfacing process was to patch cracks and deteriorated areas wtih epoxy grout, followed by a sandblast cleaning of the deck. After this a special tank truck spread the epoxy coal tar compound

Hump Looks Good In Retrospect

Reprinted from the San Francisco *Examiner* of January 17, 1964

The new one-way traffic patterns on the Bay Bridge, in effect since mid-October, have more than proved in practice the expectations of the State Division of San Francisco Bay Toll Crossings.

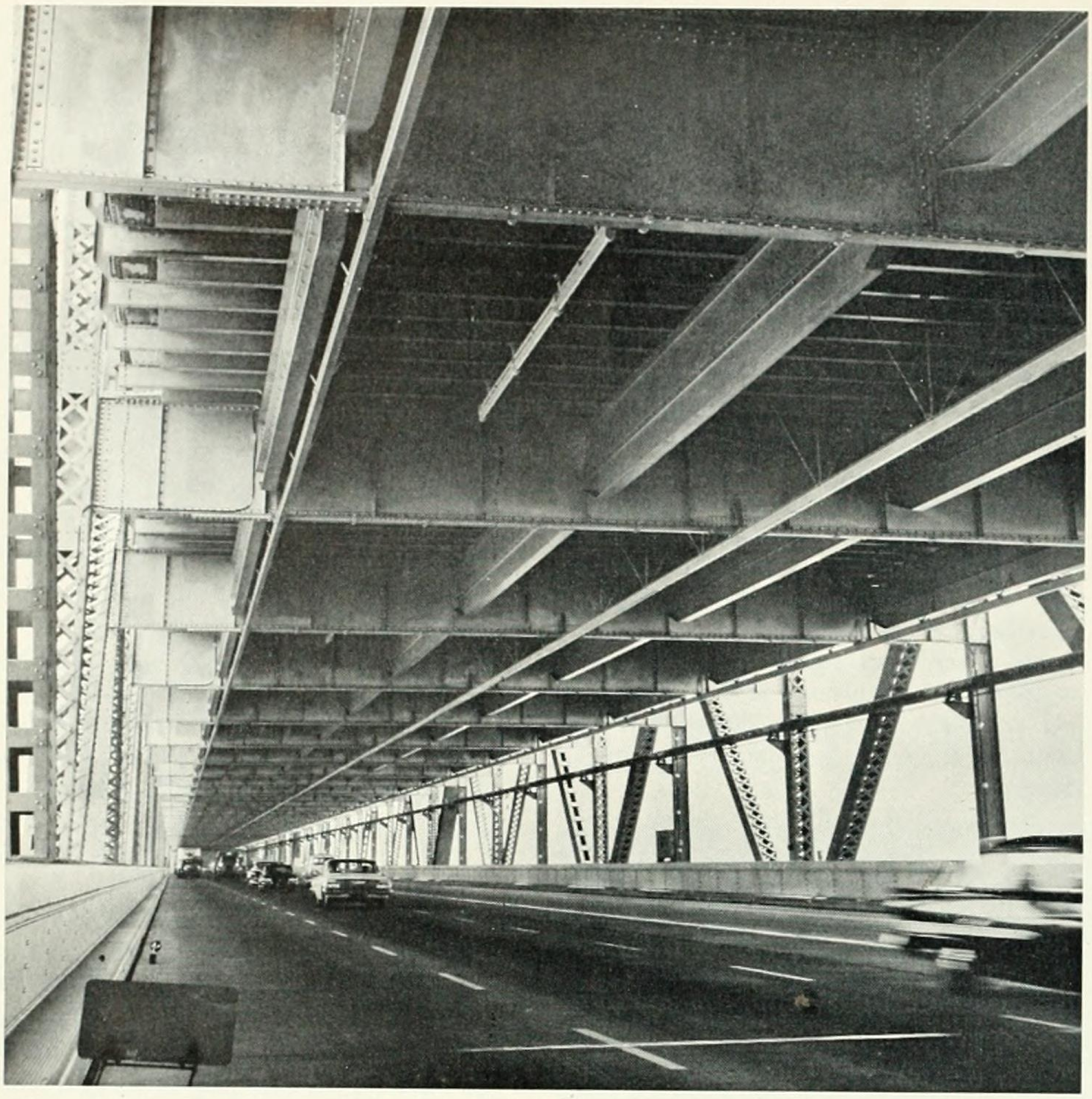
Traffic smoothed out quickly and flowed faster after the changeover, made possible by converting each deck to a one-way street. Notable, too, is the fact that no fatalities have occurred on the bridge since the changeover. Credit this to elimination of head-on collisions. The old two-way routing had a sanguine history.

All these facts stand out impressively against the background of abuse heaped on the division, and particularly on the division chief at the time, Norman C. Raab.

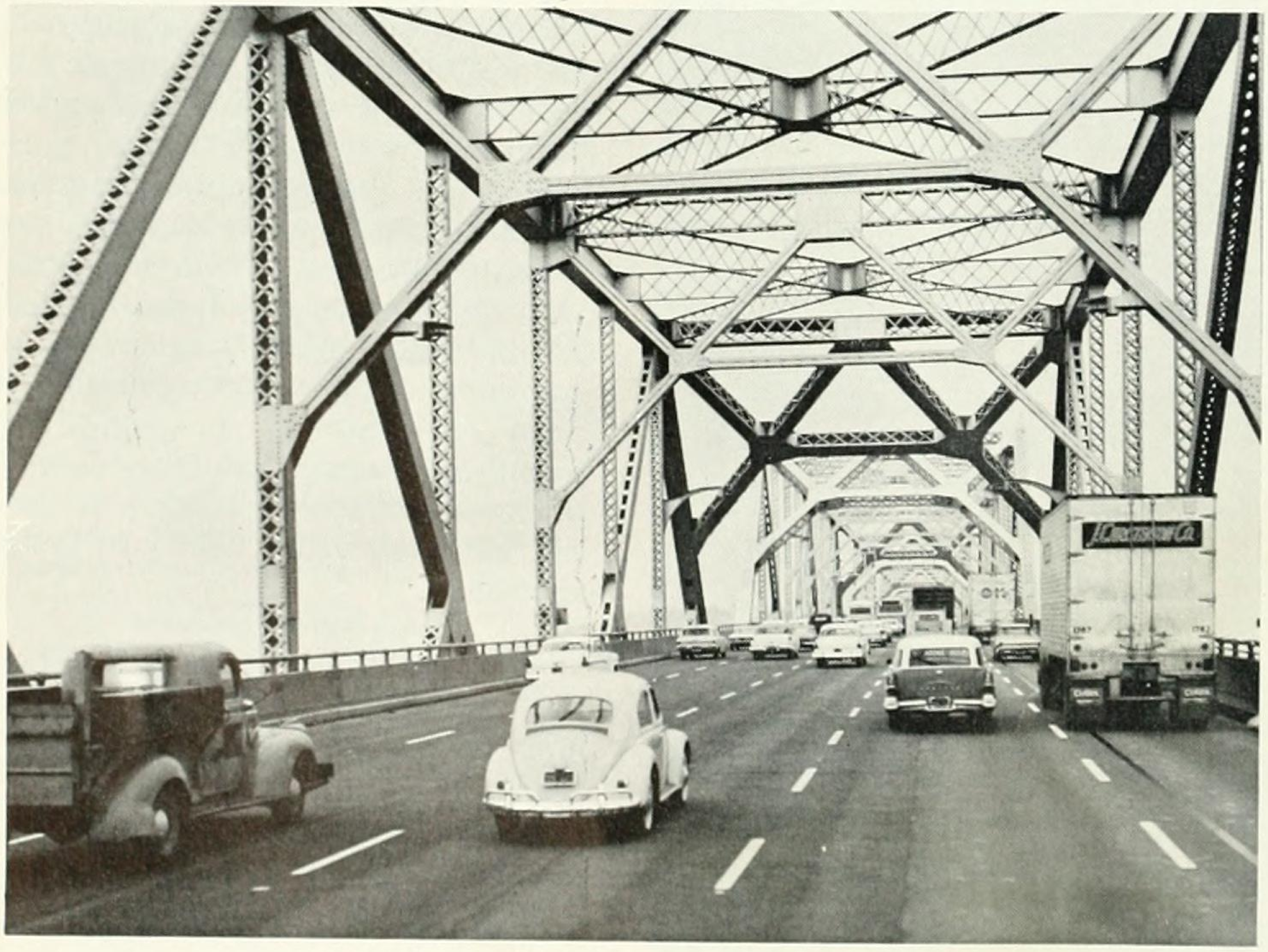
The beating Raab took from angry commuters and caustic critics during the days of "The Hump" seems in retrospect, and in the light of subsequent usefulness of the project, to have been of shallow substance. The Hump was necessary to permit raising of the upper deck to give adequate clearance to heavy vehicles. Commuters were discommoded. Construction delays were numerous. Tempers wore thin, as did public patience.

But disruption and inconvenience were unavoidable. The only alternative would have been to close the bridge.

We suspect a lot of people would like to take back the harsh things said about Norman Raab in connection with irritations caused by The Hump. Raab stepped down as division chief last July 31, after 40 years of state service, including many important contributions to California's system of bridges. The Hump was one of several thorns in his side accumulated over the years—the least deserved one, as experience with the one-way traffic on the Bay Bridge is proving every day.



The completed upper deck strengthening as seen from below on the lower deck showing the additional transverse joists, understringers, floor beam coverplate and typical lower deck lighting installation.



Upper deck traffic after change to one-way operation.

on the deck. The resin was filled immediately with a fine, hard, dust-free aggregate, which resulted in a nonskid surface. The aggregate was shoveled from trucks in the adjacent lane.

The distributor truck was provided with separate tanks to hold the two components of the epoxy coal tar compound. Volume and temperature controls were both critical. The distributor was especially designed to handle the mixture used.

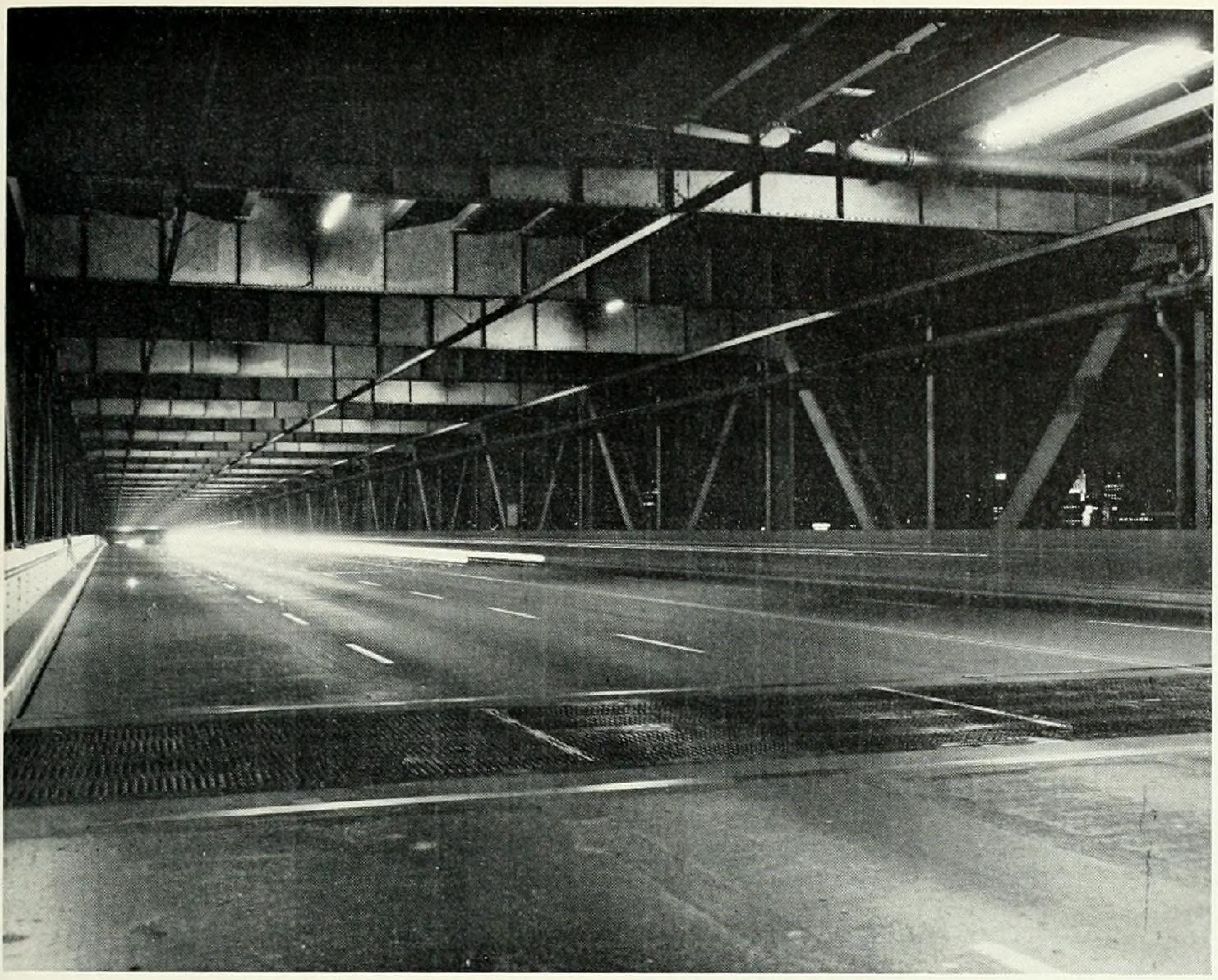
Traffic

As was the case in all other work performed on this project, disruption of the heavy Bay Bridge traffic was held to a minimum. To avoid hindrance to morning and evening peak hour movements, the contractor's operations were limited to the hours between 8.30 a.m. and 4 p.m. After the morning rush hour, the two lanes required for the contractor's operations were blocked off. Before the evening rush, all equipment was removed from the deck, with only that portion of the roadway surfaced that day closed to traffic. About one lane-mile of deck was surfaced each day. It required from 3 to 12 hours for the epoxy coal tar mixture to set, depending upon the temperature. The paved area was opened to traffic the next day, after the excess aggregate had been removed and temporary lane stripes installed. The resurfacing operations on the upper deck caused little inconvenience to the traveling public, and the resulting improvement will benefit the users for many years to come.

Lower Deck Lighting

The lower deck, as originally constructed, was divided for use by two different types of transportation. The northerly portion was surfaced for motor vehicles. The southerly portion carried railroad tracks for electric trains. Sodium vapor lights, similar to those on the upper deck, were in place on the northerly side. No lights were installed in the area where the electric trains operated.

Since the existing lighting was inadequate for the new traffic pattern, it was decided to install a modern highway lighting system that would complement the new lower deck roadway.



Lower deck lighting on the West Bay spans.

Fluorescent lighting was selected for the following reasons:

1. The existing sodium vapor lights and fixtures are obsolete and are no longer manufactured except on special orders and at premium prices.
2. Fluorescent lamps are economical with respect to (a) initial cost, (b) operating costs, and (c) lamp life (up to 10,000 hours).

The new lower deck lighting consists of two lines of fluorescent fixtures installed in alternate panels. In the West Bay spans the fixtures are attached to the stringers while in the East Bay spans they are fastened to the floor joists.

The new lighting on the lower deck of the Bay Bridge is in accordance with the latest practice for highway lighting. The average illumination is approximately three foot-candles as compared to 0.5 foot-candle on the upper deck.

Approaches

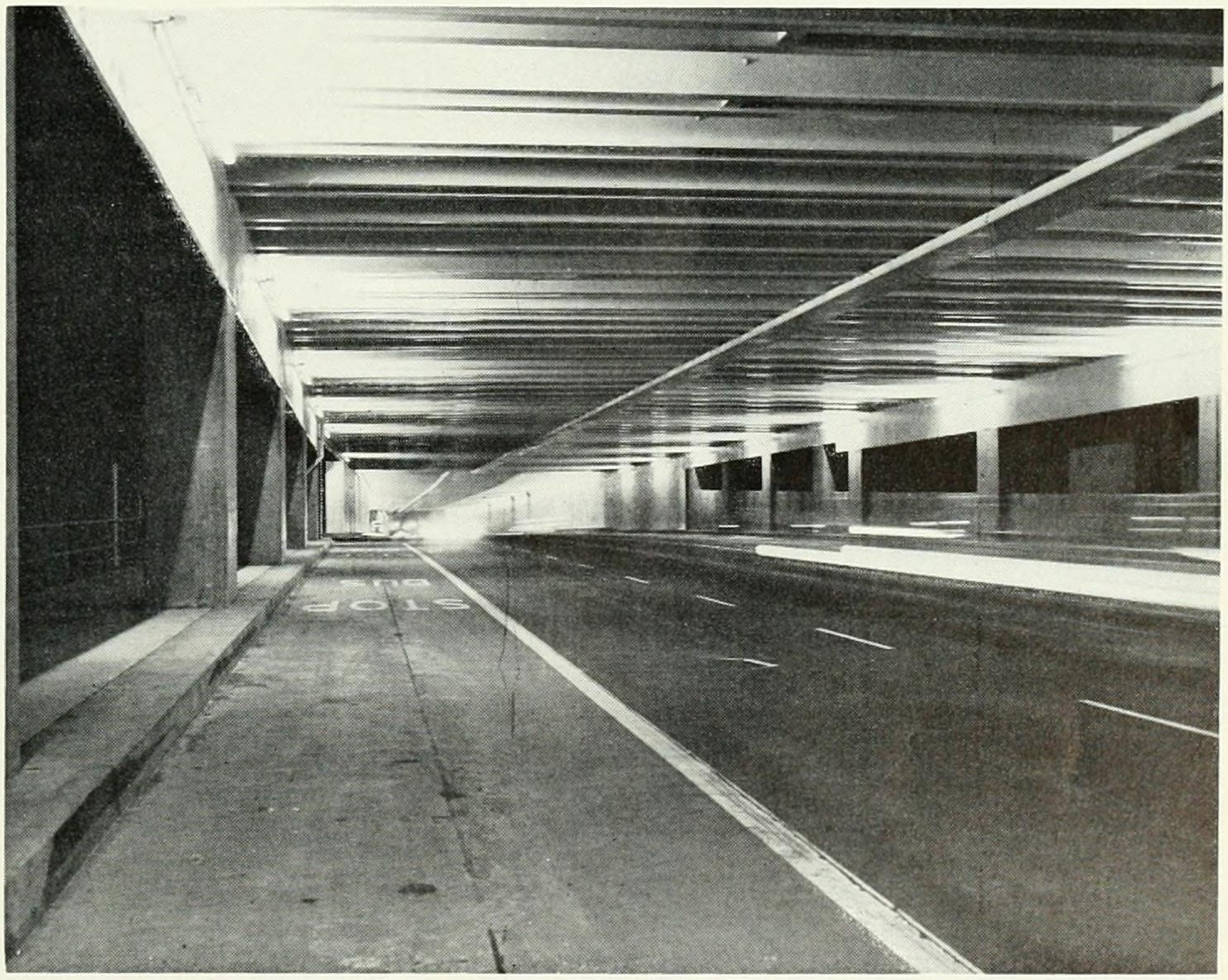
Before one-way traffic could be instituted it was necessary to provide some means for buses to reach the Transbay Transit Terminal from the upper deck of the bridge. This access was provided by raising the existing Fremont Street off-ramp to the same grade as the Terminal roadway.

To accomplish this required the demolition of a portion of the existing structure and construction of a ramp at the new elevation. It was extended to cross over First Street and terminates at Fremont Street. This change permitted traffic leaving the bridge to move into the one-way pattern on Fremont Street, which leads directly into San Francisco's financial and business districts. It also eliminates a traffic light on First Street, a cross-town, one-way artery.

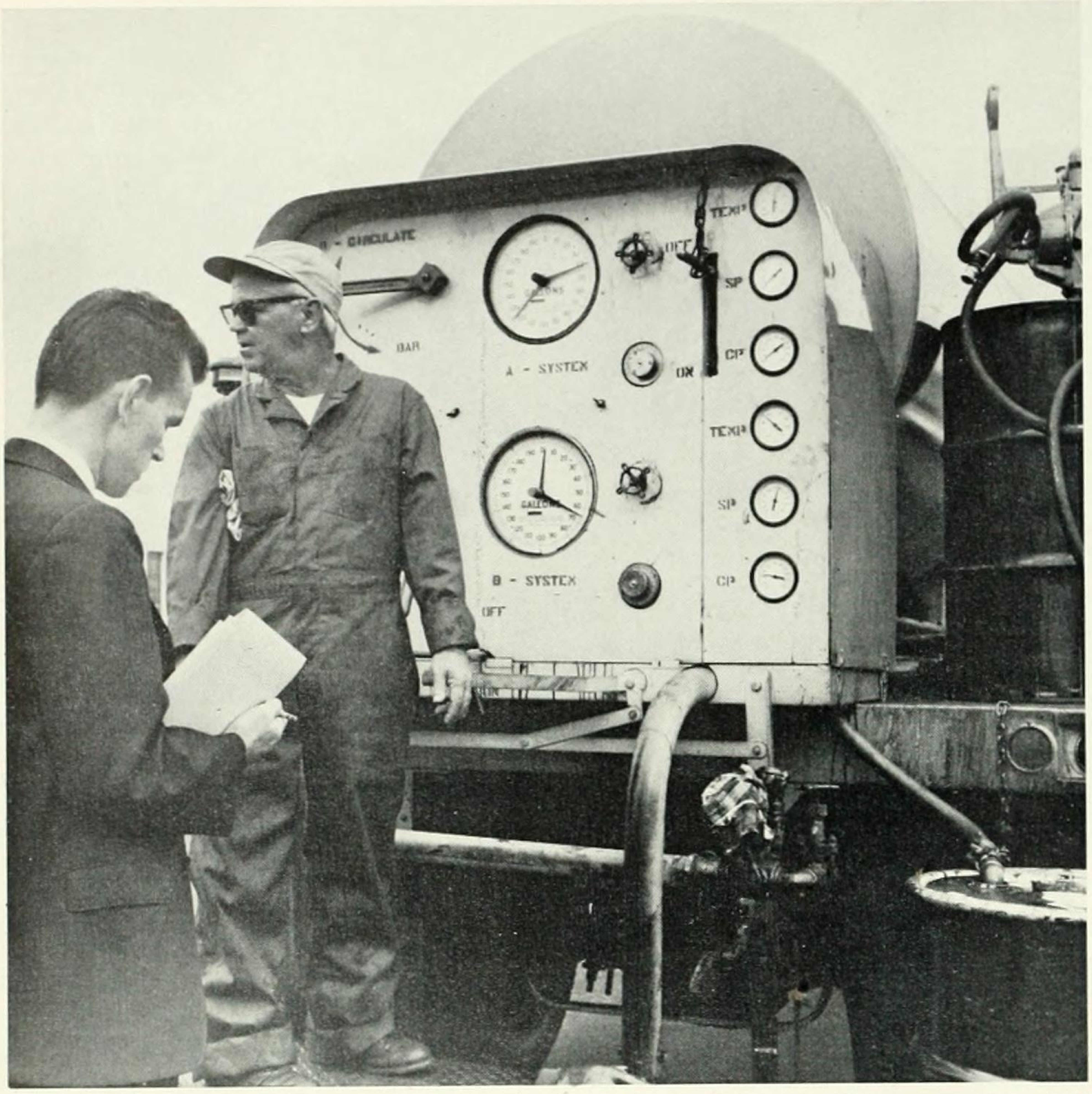
Yerba Buena Island Approaches

The existing approaches on the west side of Yerba Buena Island were constructed as a part of the access roads to the Golden Gate International Exposition, which was held on Treasure Island in 1939 and 1940. They were considered temporary and were to be removed at the conclusion of the Exposition.

With the advent of World War II and the establishment of the Navy base on Treasure Island, the approaches continued in use over the intervening years. However, these temporary approaches were inadequate for today's usage, particularly the ramp leading from the upper



Lower deck lighting on the viaduct section of the East Bay spans looking west toward the tunnel.



The control panel of a special truck for placing epoxy coal tar material. Gauges indicate pressures and temperatures of each mixture as well as the mixing chamber.

Equipment train for resurfacing the upper deck. The special truck for placing ⅛-inch-thick epoxy coal tar is in the lead followed by fine aggregate truck.

deck. A new steel structure with concrete deck was built to allow San Francisco-bound traffic to reach the upper deck. Access from the lower deck for eastbound traffic was constructed at grade.

Overhead Signs

The newly reconstructed bridge, with one-way traffic on each deck, required the installation of adequate signs to inform the motoring public. Internally illuminated overhead signs were chosen. Selection of the type of structural framework and the style of the signs was based primarily on aesthetic considerations. Colors used for the panels conform to standards for the interstate highway system.

Locations were carefully selected, particularly on the West Bay spans, where the effect on the view from the bridge into the City of San Francisco was of major importance. The internally illuminated signs present a pleasing addition to the bridge, especially at night.

One-way Traffic Instituted

On October 12, 1963, unidirectional traffic movements were put into effect. This was almost five years after the beginning of reconstruction on the San Francisco approaches, and one month less than 27 years following the opening of the bridge to vehicular traffic on November 12, 1936.

During the short period in which one-way movements have been in operation, there is ample evidence that motorists are now enjoying a faster and safer trip. The speed limit has been raised from 35 on the lower deck and 40 on the upper deck to 50 miles per hour, and traffic has been flowing evenly, secure in the knowledge that head-on collisions are no longer a major hazard on the bridge.

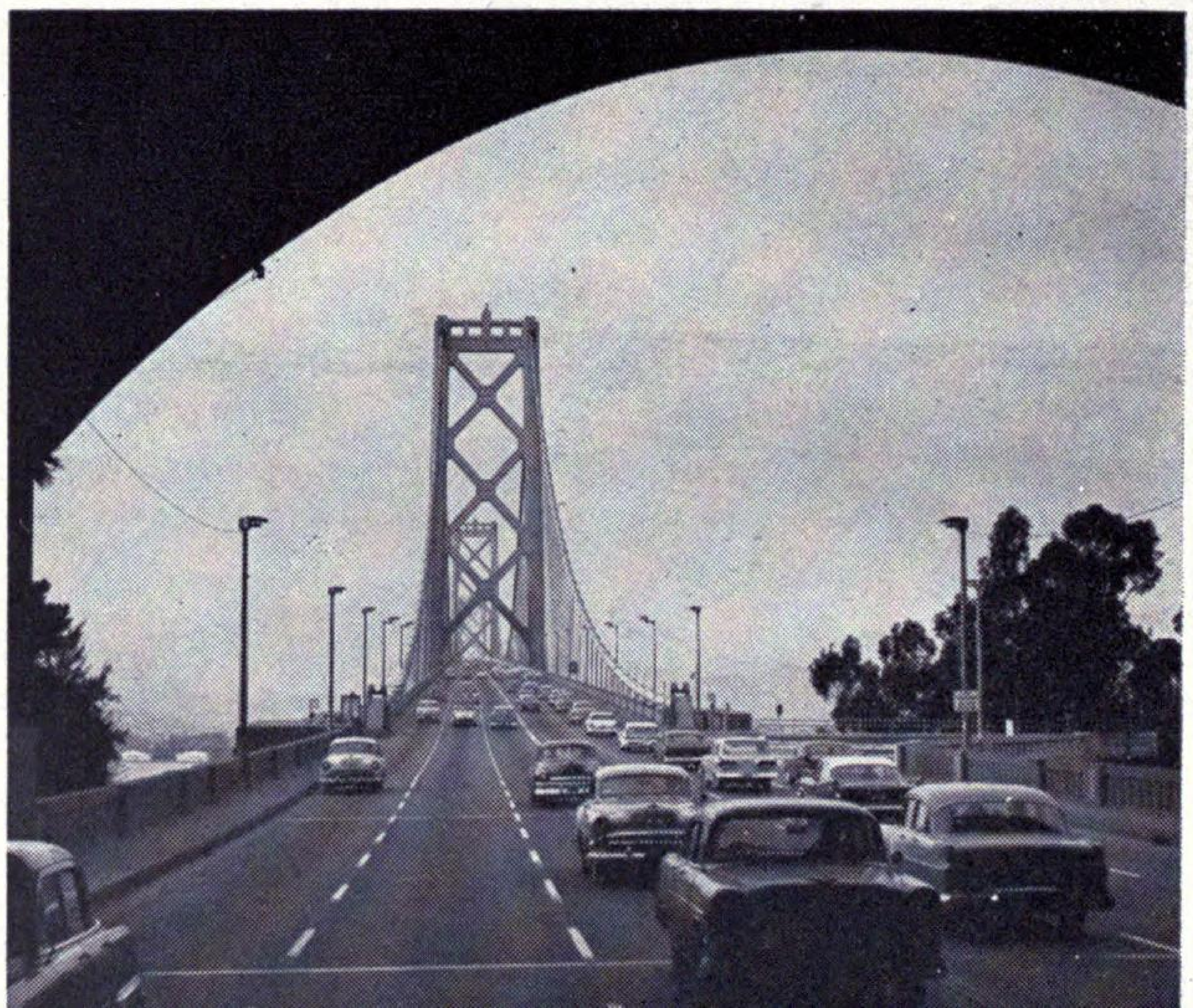
The California Highway Patrol recently issued a statement that statistics indicate that accidents have decreased by 32 percent, with 52 percent fewer injury accidents and no fatalities. Added to this is the comfort experienced in using the wider traffic lanes. The driver is relieved of the tension that was brought about by negotiating the narrow nine-foot eight-inch lanes that formerly existed on the upper deck.

. . . Continued on page 59

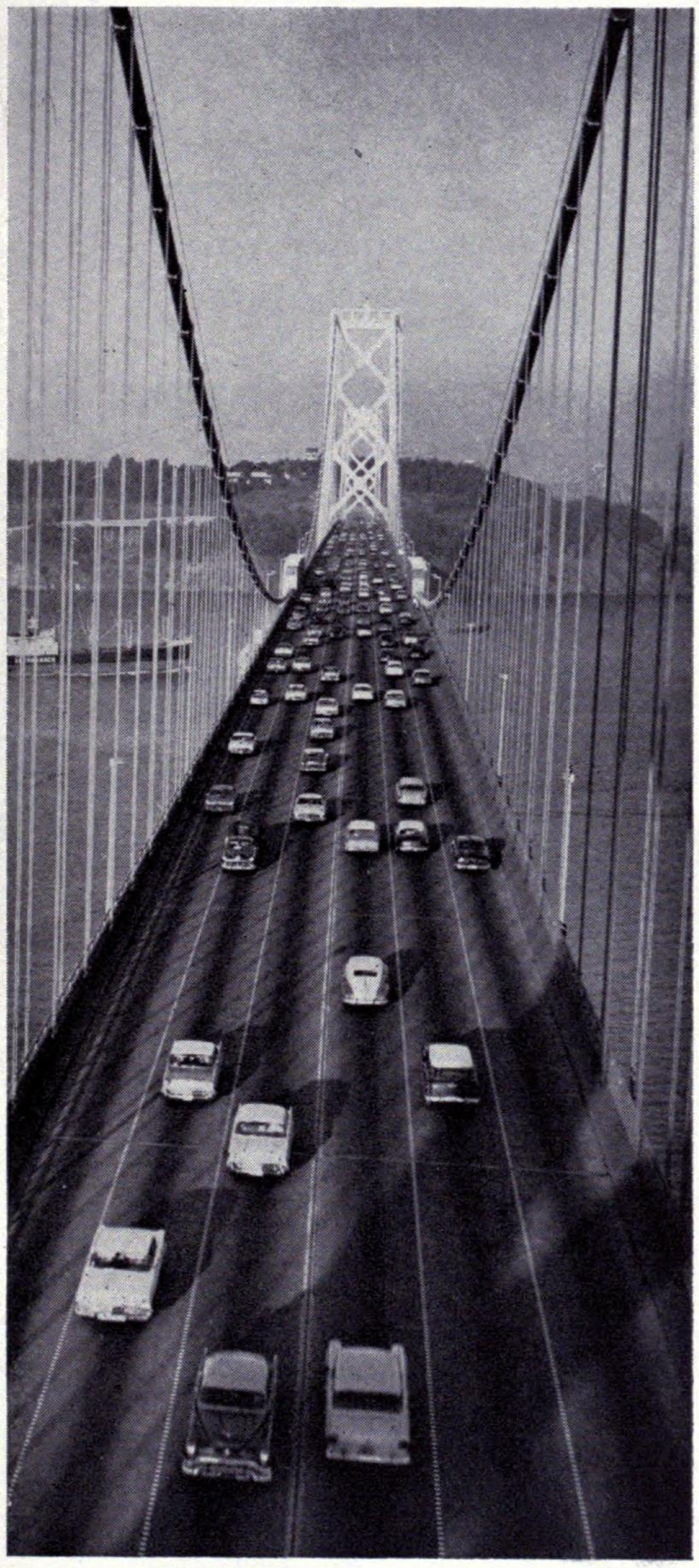
The Seventh Wonder

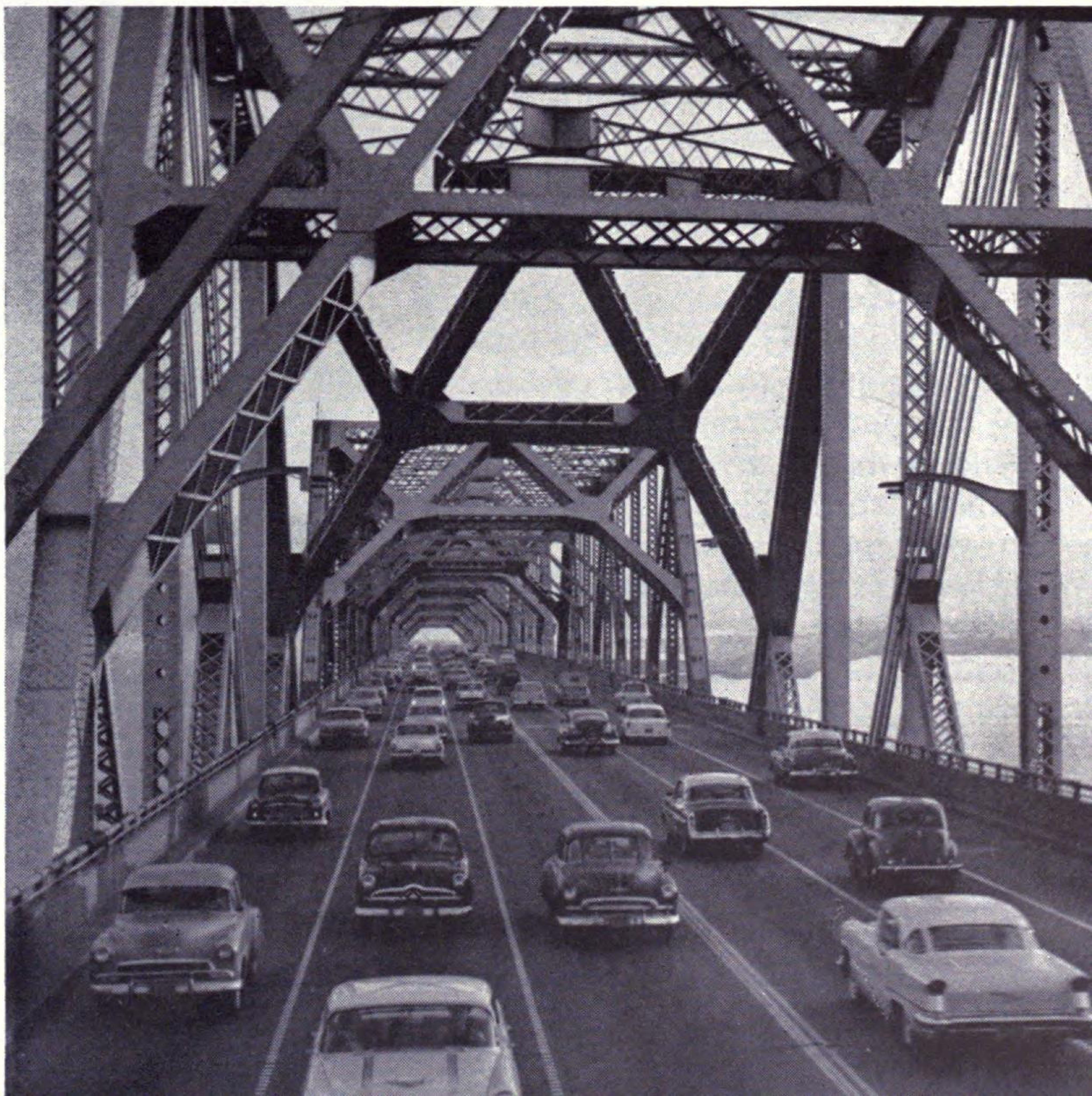
". . . its spans and foundations, the elevation of its towers, the dimensions of its cables and their composition are staggering . . . The assembly of these materials into this beautiful structure which contributes so much to human welfare is a civil engineering feat of the first magnitude."

—LOUIS R. HOWSON, National President of the American Society of Civil Engineers, San Francisco, March 17, 1958.



Included among the "seven civil engineering wonders of the United States" chosen by the American Society of Civil Engineers is California's own San Francisco-Oakland Bay Bridge. Here she is, captured in some of her moods over the past 22 years by Division of Highways cameramen.





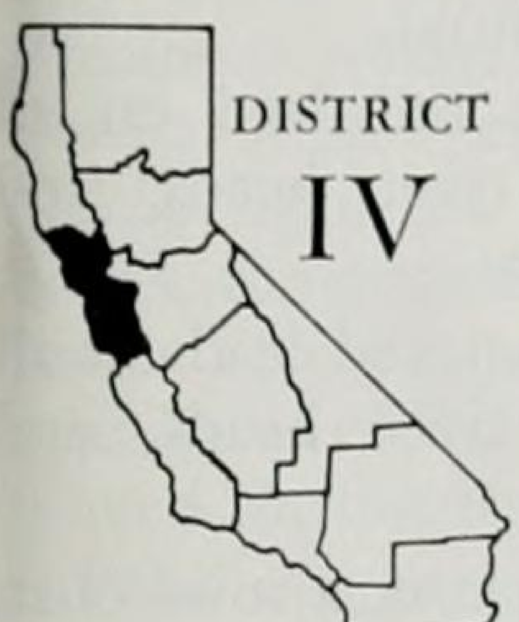
CALIFORNIA Highways and Public Works

JULY-AUGUST 1961

Painting the Bridge-1

Painted Surface Totals 370 Acres

By D. EWING MARSH, Maintenance Superintendent, San Francisco-Oakland Bay Bridge



CONSTRUCTION of the San Francisco-Oakland Bay Bridge was begun July 4, 1933. The bridge was completed and opened to motor vehicle traffic at noon on November 12, 1936. Interurban train operation commenced on January 15, 1939, and was discontinued April 20, 1958.

The steel structure is 4½ miles long, runs generally east and west, and extends from about six feet above high water to 530 feet above high water at the airway beacons on top of the suspension bridge towers. The entire West Bay section is above elevation 150 feet, except for the suspension bridge towers below the roadway. On the East Bay section of the bridge, the structure runs from elevation 390 at the tower tops down to a minimum of between six to eight feet at the east end of the bridge.

On most steel towers the lowest elevation of steel is on top of a concrete pedestal approximately 40 feet above high water. There are about 146,000 tons of steel which are painted for protection. This tonnage has about 370 acres of painted surface. 105,000 gallons of paint were required for the original paint job which was applied as three coats of red lead and a finish coat of aluminum.

Original Treatment

Original specifications called for the steel to be sandblasted after arrival in the San Francisco Bay Area and painted with two coats of red lead paint prior to erection. After erection there was a third coat of lead paint and a spot coat of lead paint on rivet heads, seams, and edges, followed by a finish coat of black. Sandblasting and priming were done at three locations. About 50 percent of the steel was sandblasted at Bethlehem Steel Company, Alameda yard, with either sand or steel grit. The suspension bridge trusses were sandblasted and painted at Harbor Pier 92, San Francisco. There was a third steel yard adjacent to the Oakland Mole at Asia Wharf just south of the passenger train terminal there.

The first coat of paint was a 28 pound per gallon red lead with raw linseed oil which was very slow drying. To improve the drying qualities, the formula was changed by the addition of mineral spirits reducing the weight of paint to 27.9 pounds. The second coat paint was a similar red lead with the addition of lamp black for coloring. The original second coat weighed 24.7 pounds to the gallon, and when modified to improve the drying qualities, weighed 24.5 pounds per gallon. The third coat was also a red lead, carbon black, raw linseed oil paint, which weighed 22 pounds per gallon. Before the finish coat was

Painting the aluminum finish coat on the upper chord eye bars on the East Bay cantilever structure. Treasure Island Naval Station is in the background.

applied to the bridge, changes were made from black because of civic pressure, and aluminum was used for the finish coat. The aluminum originally used was a long oil varnish using tung oil. Two and one-quarter pounds of aluminum paste were used per gallon of varnish.

Paint Policy Established

Maintenance began before the bridge was opened to traffic as an Extra Work Order on a construction contract by painting a portion of the upper-deck floor system from the contractor's traveling gantry. These surfaces had been subject to motor vehicle exhaust during construction and were also contaminated by wind off the salt water at the lower or east end of the bridge.

Permanent maintenance crews were established in October, 1937, about a year after the bridge was opened to traffic. A small crew of ten men and a foreman were put to work at the lower end of the East Bay portion of the bridge.

Our program of steam cleaning to eliminate inter-coat contamination and minimize sandblasting and our policy of preventive maintenance were established at this time by the late Carl S. Hamilton.

Rust removal then was done by hand methods using wire brushes and scrapers. Some experimental work was done with electric motor-driven wire cup brushes, with little success. Maintenance painting at this time consisted of two lead spot coats and a spot coat of aluminum.

System is Changed

It was soon found that this was not practical, and the system was changed to be a first spot coat of lead, a second spot coat of lead, and a solid coat of aluminum. This also was found to be impractical because of the mottled appearance of the finish in a few weeks after completion. Another change was made, making the first coat of lead a spot coat, the second coat a solid coat, and the finish coat a solid coat of aluminum. This gave a good appearing finish to the structure, and the solid coat of lead immediately before the finish coat of aluminum has been continued since late in 1939.

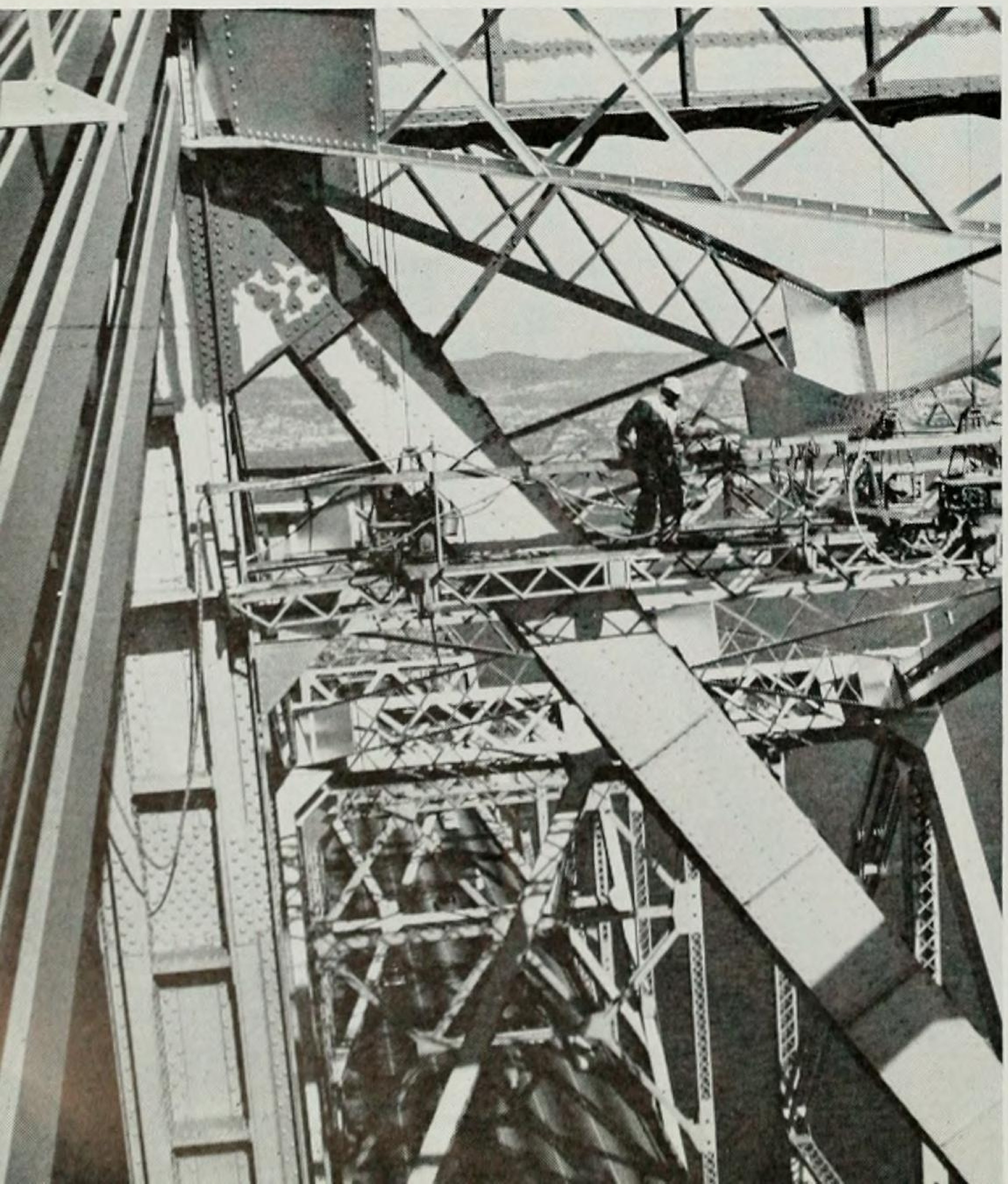
Our present routine is as follows:

1. Steam clean all surfaces that can be reached and where it does not interfere with traffic.
2. Rust removal, that is, spot sandblasting, power brush buffing, hand cleaning, and phosphoric acid crack treatment and caulking where required.
3. First spot coat red lead on all seams, edges, rivet heads, and sandblasted areas.
4. Second spot coat red lead on all seams, edges, rivet heads, and sandblasted areas.
5. Third coat red lead, a solid coat.
6. Finish coat aluminum.

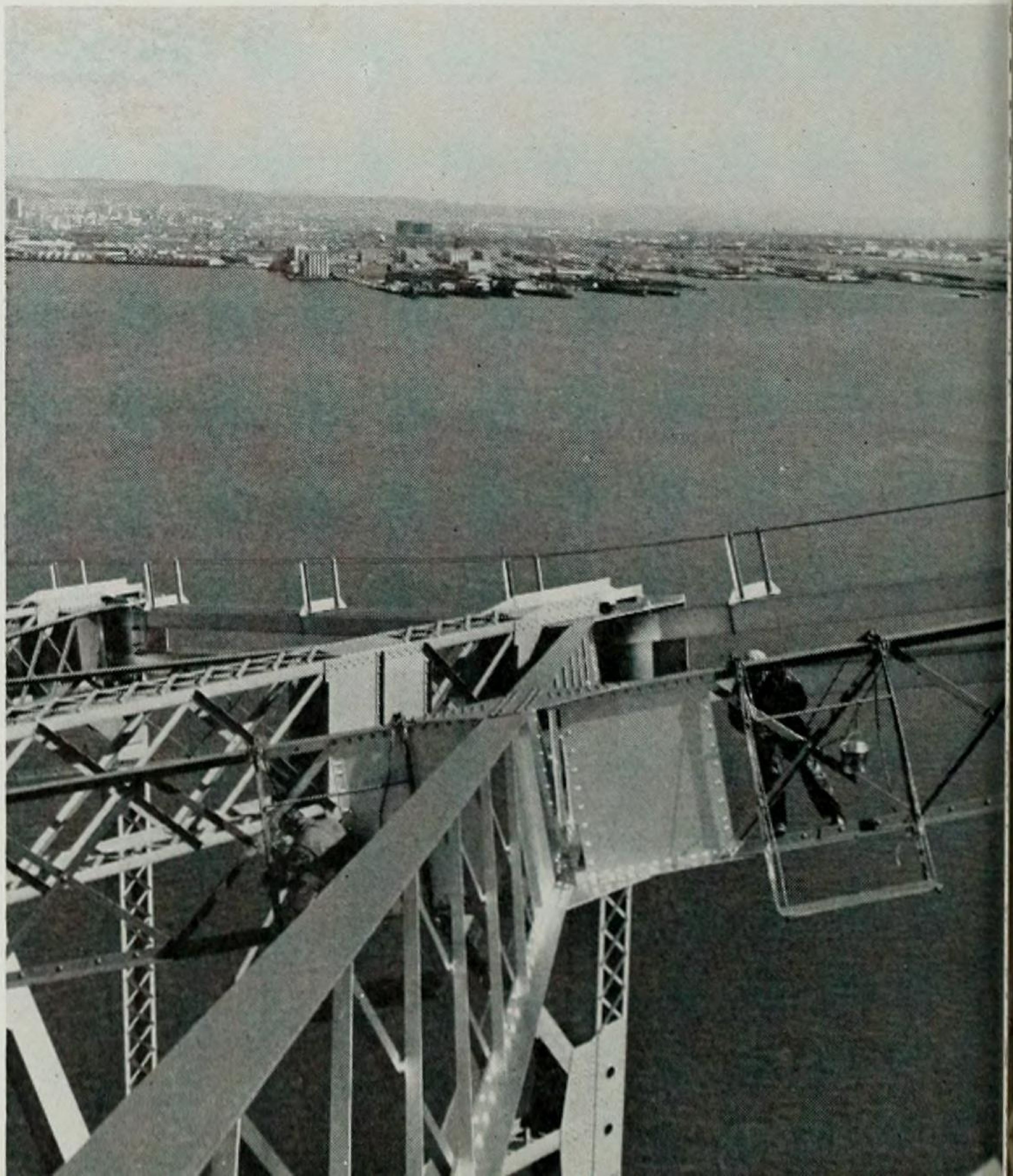
This treatment provides protection equal to the original paint job on all raw steel surfaces.

Surface Contaminants Studied

During these early days, some experimenting was done to determine the type of contaminants on the bridge steel. Distilled water wash samples were taken on areas of two square feet. The wash water was bottled and sent to the Division of High-



The first spot coat painting is applied on one of the towers of the East Bay cantilever section using air-powered hoists on trussed aluminum scaffolds designed by members of the Bay Bridge staff. The view is eastward with the Berkeley hills in the distance.



Painting the aluminum finish coat on top of the lateral bracing in the cantilever structure.

ways testing laboratory for analysis. A wind-powered air sampler was developed, which sucked the passing air in through a bottle of distilled water. These devices were mounted on the bridge, left for many months, and eventually the distilled water was sent to the laboratory for analysis. At this time there was a smelter on the San Francisco waterfront at the corner of Folsom and Spear Streets, only two blocks from the bridge, in a location where the prevailing winds blew the fumes across a portion of the bridge near Tower W-2. This smelter was removed during the war years.

Paint maintenance progressed westward from the east end of the bridge, the work being done principally on the lower-deck floor system until such time as scaffolding could be designed and installed for painting the upper-deck floor system. It was during this period that we learned from our distilled water samples that sea salt was to be found on the bridge surface as high as 400 feet above the water level. We also learned that on the upper-deck floor system (which is the bottom side of the upper deck, about 20 feet directly above the lower deck) we had heavy deposits from motor vehicle exhaust, soot, sulphurous acid deposits, and a certain amount of white formation which we believed to be aluminum hydroxide. It was after receiving these reports that we first decided to experiment with steam cleaning the bridge surfaces prior to painting. A used garage-type steam cleaner was purchased, adapted to portable use behind a tank truck, and thus began our program of steam cleaning which is continued to this day, although with improved equipment.

Dirty or old aluminum painted surfaces hold moisture, and in shady or poorly ventilated locations, the surface remains tacky or sticky to the touch until nearly noon. This condition is eliminated on steam cleaned surfaces, and they then become dry enough for painting at the regular starting time. We feel that by steam cleaning we gain a great deal by removing dirt, salt, acid, decomposed paint, and other contaminants, thereby providing a clean surface over which to paint, with better bond between coats and reduced inter-coat contamination.

The main cable scaffold runs on grooved wheels on handrail ropes. The deck is adjustable to keep it level. The wind curtains are rolled up, exposing the two working levels.

Size of Crews

The make-up of the paint crew through the years has been from the original 10 men in October, 1937, as follows: Late in 1938, separate crews were organized for the sections of the bridge east and west of Yerba Buena Island. The crew was gradually increased to 40 men by December, 1941, when the war started. During the war period, our crew dwindled from 40 men to 14 men at the Bay Bridge (and from 8 men to 2 men at the Carquinez Bridge). After the surrender, the Bay Bridge crew was built up to 50 men, at which time the Korean incident developed, and it dropped back again to between 35 and 40 men. Since the settlement of the Korean incident, we have attempted to limit the Bay Bridge paint crew to: 2 foremen, 6 leadmen, 60 painters, 2 laborers and 4 truck drivers. In our current budget, 1960-61, we have provided for 66 painters, which figure was also in the last previous budget, although we were unable to employ that many men because of our inability to recruit them.

Equipment and Tools

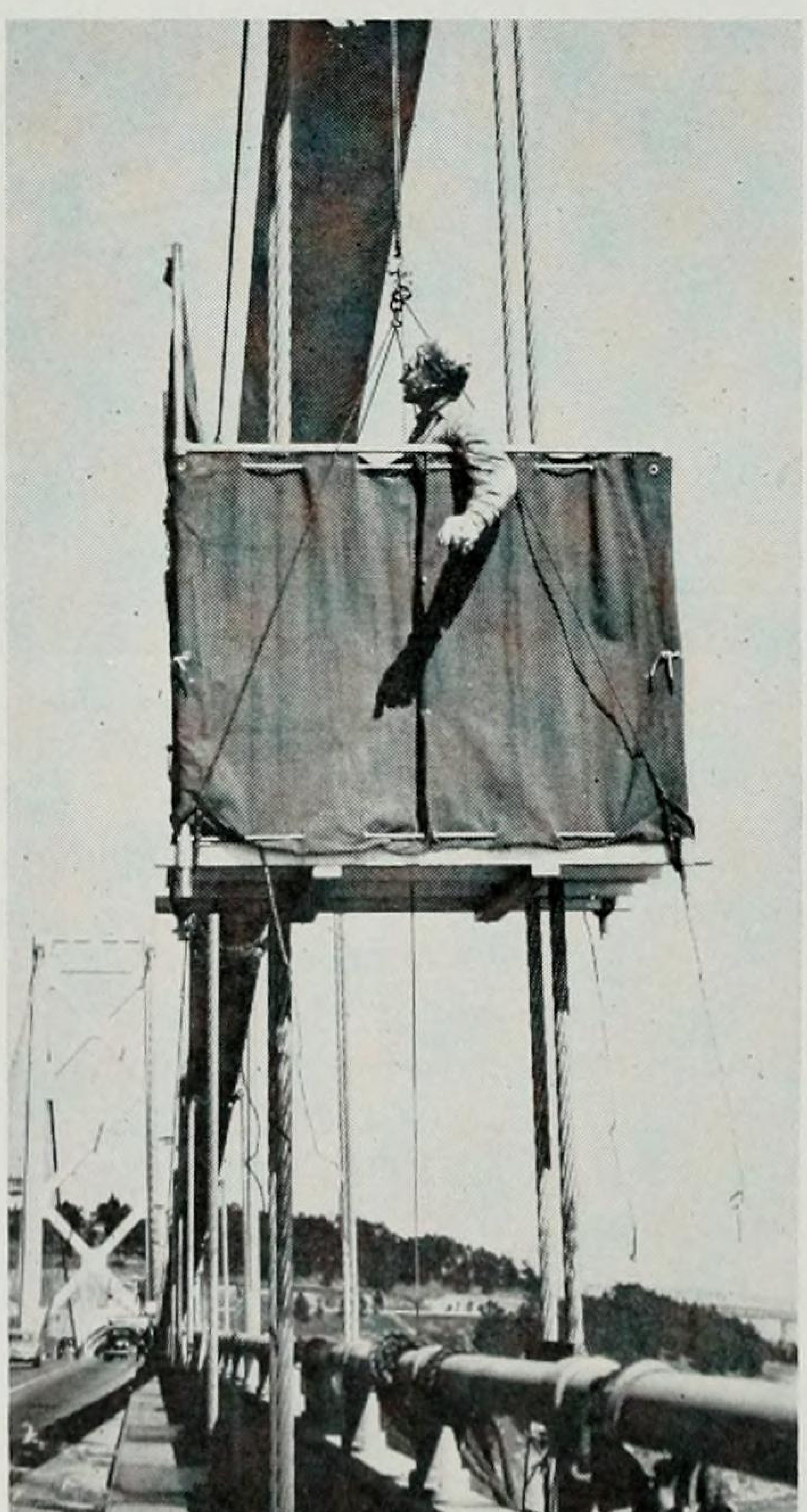
By December, 1938, we had developed three travelers (gantries riding the lower-deck curbs) for reaching the bottom of the upper deck. We also had eliminated the wire rope catenary or springboard rigging used underneath the lower deck and, late in 1939, installed three large suspended scaffolds 6 feet wide and 85 feet long. By this early date it was well determined that ease of accessibility was of the utmost importance for painting a major bridge. Our records had indicated that the conventional methods of rigging require too high a percentage (20%-30%) of the painters' time. We consider this as lost time which could be more profitably used in cleaning or painting the surfaces. From as early as 1938, we have endeavored to have as large as possible scaffold units operating on wheels or on a track and with power drive whenever practical. In some locations rigging time has thus been reduced to only 5 percent of the total.

Tools used at first were found to be inadequate, and we began using compressed-air, power-driven, rotary wire brushes, both cup and wheel type. It was found that 3-inch wheel brushes and up to 3¾ inch diameter cup brushes could be operated successfully on straight buffers or grinders operating at free speeds of 7,000 rpm for cutting rust. It took a lot of trial and error to determine which commercial brushes would stand the abuse given them on this type of work. On broad flat surfaces, we used a 6-inch wire cup brush on a tool operating at approximately 2,400 rpm. These we called salt brushes and used them to remove the general accumulation of dirt and the white formation off the broad faces of floor beams and large steel members.

Many Techniques Developed

Many techniques were developed to fit local conditions, one of which was the use of bottle brushes or as the trade calls them, tube brushes, for painting long slots left in the steel because of erection clearances. One place where these occur is at the 2,400 floor beam connections where they attach to the trusses. To illustrate this, these floor beams are from six to seven feet deep with an open slot or hole approximately ½″ x ¾″ at each end between the connection angles. Many of these were swabbed with these long-handled bottle brushes. Some were plugged at the bottom and poured full of paint. Others were swabbed first and plugged at both ends. Many anchor bolt holes were cleaned and filled with mastic. Some of these anchor bolts were set in pipes 10 to 15 feet deep in the concrete piers. It was necessary to clean these out with air jets, after which they were either swabbed with red lead and filled with mastic or filled with red lead paint, depending on which was the most convenient at the time and at the location.

Among the other special tools and brushes used is what we call a crack brush or a grainer, which is a pure bristle paint brush, three inches wide, two inches long, and approximately ⅛ inch thick. The use of these enables us to paint in narrow slots and cracks with the best application of paint and without the destruction or severe abuse to the large brushes normally used by a bridge painter. There are over 10,000 linear feet of one slot which is ¼ inch wide and ¾ inch deep.



A hoist behind the railing raises and lowers this suspender rope cage as much as 250 feet. Canvas curtains form a safety fence and protect passing cars from paint spatters.

Sealing of Cracks

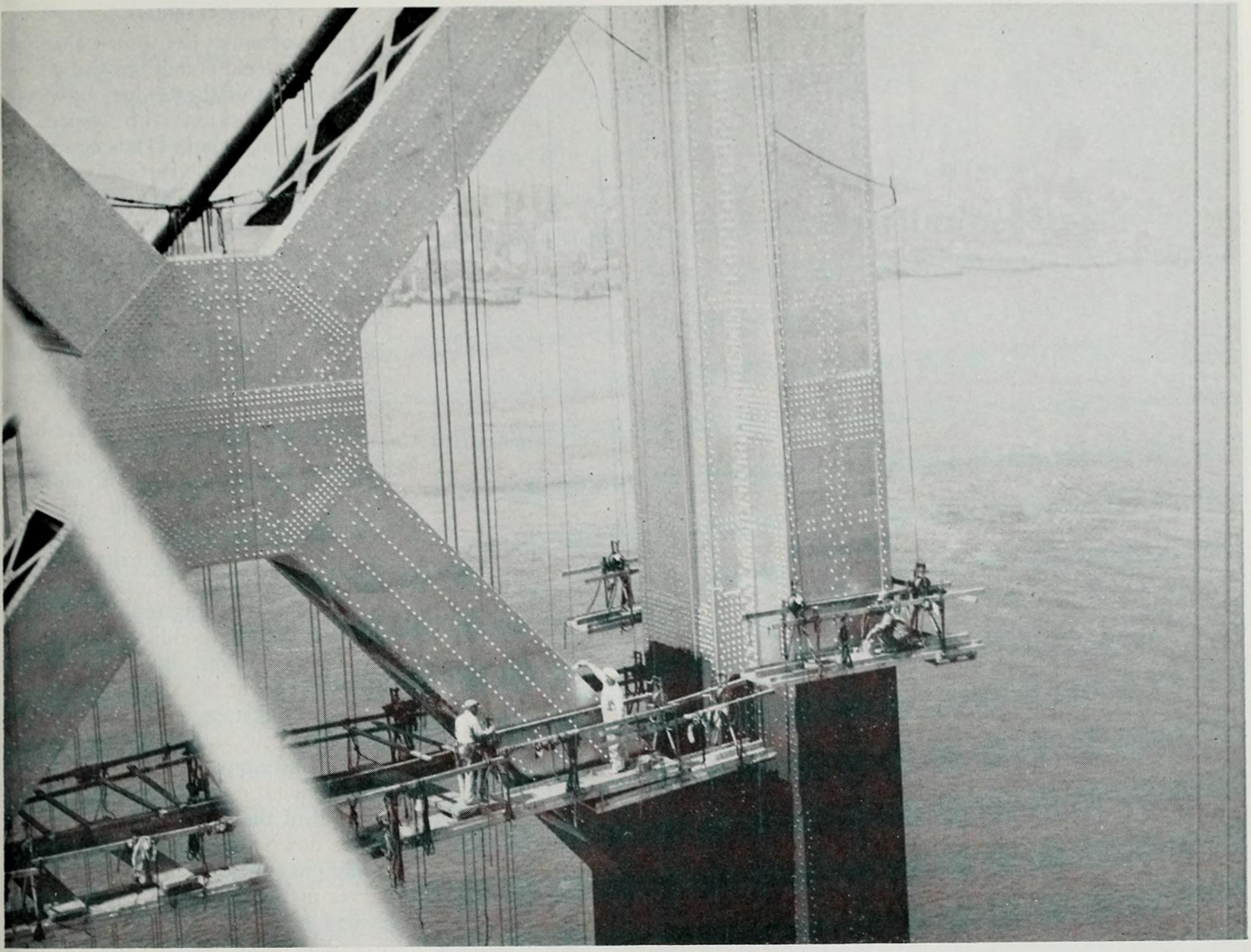
During the first two or three years of bridge painting, the greater percentage of the time was spent on sealing cracks and seams at similar locations to those mentioned above. One inch round sash tools were bought without handles. Handles from 18 inches to 20 feet long are applied for reaching into inaccessible places. Every man on the job is furnished with a size 35 (4 inch) stucco brush, made to our own specification or to an acceptable high quality commercial specification, and a two-inch oval brush, also made to our specification. Seven and nine inch paint rollers with extension handles from 18 inches to 4 feet long are used and are very effective.

Caulking guns were a source of trouble until we abandoned the use of guns having a friction grip to force the piston and insisted on a gun with a ratchet level mechanism for forcing the piston. In addition to the wire cup and wheel brushes and hand scratch brushes, a variety of hand tools have been used for rust removal. We have used the usual hook scrapers, old file scrapers, stiff blade two-inch-wide putty knives, and wire flue brushes. Wire flue brushes have been used both in ¾-inch-round form and in a ¾-inch-square form. This latter is very handy when reaching between two angles, back to back, with lacing bars in between.

Sandblasting Begins

With the crew reduced to 14 men during the war years and after having used several thousand of wire brushes, we began experimenting with sandblasting. This was necessary for three reasons:

1. To speed up the work.
2. Because of the shortage of manpower, maintenance on portions of the bridge was getting ahead of us.
3. We had found that in the San Francisco Bay Area after rust becomes four to six years old it is very difficult to remove with hand or power-driven wire



The main tower scaffold, which is supported by 26 hoists, is articulated and completely encircles the tower. The scaffold works from 40 to nearly 500 feet above the water level.

brushes. At this age, the composition of the rust is such that wire brushes do not scratch it off, but wear it down to a smooth polish or glaze and leave the active tubercules imbedded in hidden pits. This condition is probably related to the water content of the rust flakes. Since 1946, practically all rust removal has been done by sandblasting until very late 1959 when some power brush use was resumed.

Electric Railway

During 1938, the interurban electric railway was being installed on the bridge. When this was finished, we were confronted with bare wires carrying 1,200 volts and suspended 12 inches beneath the upper-deck floor beams. At the completion of railway construction and just before the current was put into this catenary, a coat of lead paint and a coat of aluminum were applied to the soffits of the upper-deck floor beam lower flanges in this area, because it was felt it would be too dangerous to attempt to do it under railway operating conditions.

At one location on six or eight floor beams, the entire beams were painted in this manner over the railway area. The paint on the bridge was only about three years old at this time. Although these extra coats of paint were put on to delay breakdown as long as possible, their true value was not determined for many years. In some places these areas were 20 years old before we were able to repaint them, and by then the advantage of the extra paint was very noticeable. Parts of the bridge, 20 years old without repainting, were found to have a minimum of rust, possibly not over 5 percent of the area involved.

The operation of the bridge railway created its own peculiar conditions and problems. During this period, while we were confronted with working adjacent to both a 1,200-volt overhead catenary system and a 600-volt third rail, and except for minor touches and sparks made by tools, we were very fortunate in having no injuries therefrom. Where the trains

All surfaces that can be washed without serious inconvenience to traffic are steam-cleaned before repainting.

slowed down or applied their brakes, a condition of brake shoe scale developed. This scale or grindings from the brake shoes were leaf-like grindings or scales which were slightly magnetic and which stood on edge and stuck in the paint film. This was very difficult to remove.

During steam cleaning, various types of detergents and softening agents were tried, with little success. Our best efforts were obtained by increasing the amount of wetting agent in our own steam cleaning compound, and in some cases, the use of a special wetting agent in addition to the regular compound. In spite of these additives, it was still always necessary to scrub and scrape the heaviest deposits of brake shoe scale. These deposits would build up in the corners where they were trapped, and in some places were as much as ⅜ inch deep. This created a condition of stain when dampness caused the scale to rust and stain good paint, thereby causing us to remove paint which would not otherwise have required removal.

Local Conditions

Our experience has shown that we have many local conditions caused by (1) elevation of the bridge above the water, (2) position with respect to the prevailing wind, (3) accessibility for rain to wash the surfaces, and (4) rapid temperature change.

Portions of the bridge which have the minimum service life of paint are the upper-deck floor system, exposed to direct vehicle exhaust from the vehicles on the lower deck, the lower-deck floor system, where the vehicle exhaust billows around and is blown underneath, the north face of the north stringer, and the back and bottom of the north sidewalk. These surfaces are not washed by rain, and the surface contaminants hold moisture which absorbs more contaminants from the air and vehicle exhaust while the resulting solutions gradually become more concentrated and active.

Another local condition is in the first 500 feet west of Yerba Buena Island where the salt spray laden wind blows up the steep surface of the hill leaving a salt and moisture deposit which causes rapid breakdown in that area. Similar conditions exist at the east end of the bridge where the steel comes down to sea level. Other local conditions are created at the two curves in the bridge where there is a change of angle with respect to the prevailing wind which causes a high throw down of moisture.

This is the first of two articles on painting the San Francisco-Oakland Bay Bridge. The concluding part will appear in the September-October issue of the magazine.

GUTHRIE AWARDED DOCTORATE

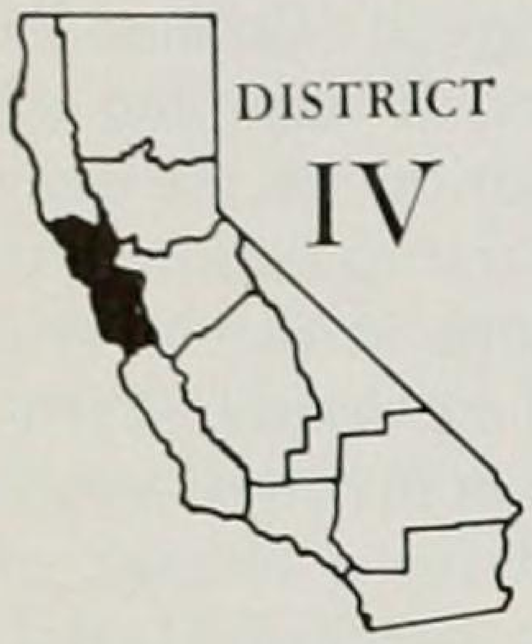
James A. Guthrie of San Bernardino, member of the California Highway Commission since 1943 and currently its vice-chairman, was awarded an honorary degree of Doctor of Humane Letters in June by the University of Redlands.

The degree was in recognition of Guthrie's contribution to the State and his community, both as newspaper publisher and civic leader.

Painting the Bridge—2

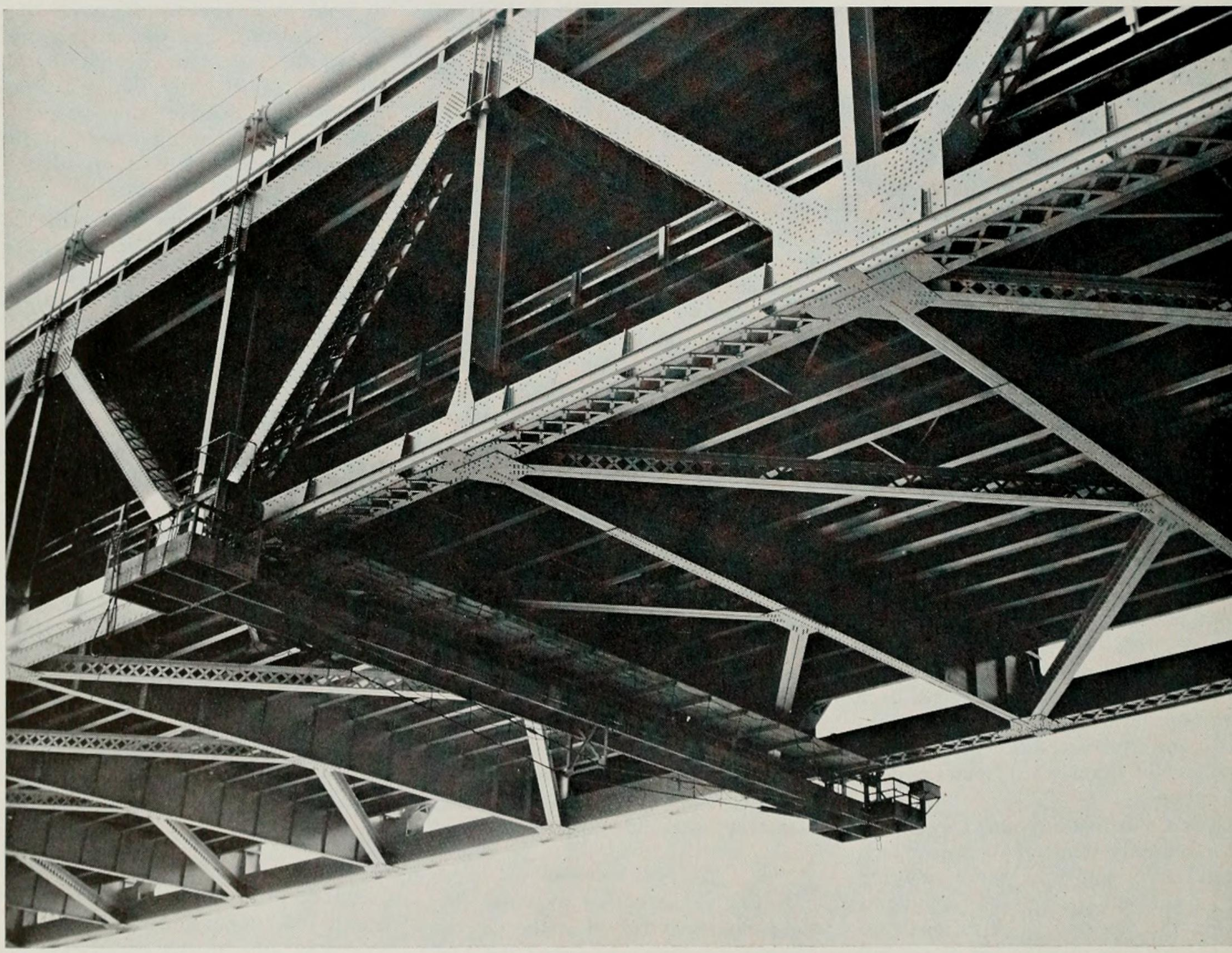
Gantries Aid Bridge Repair

By D. EWING MARSH, Maintenance Superintendent, San Francisco-Oakland Bay Bridge



ALTHOUGH the San Francisco-Oakland Bay Bridge is mostly built of heavy steel, there are locations such as the sidewalks and the overhead structure in the cantilever and 504-foot through truss spans where the steel is comparatively light and the steel temperature changes more rapidly than in other locations. This rapid temperature change causes a breakdown of the paint film on seams. In this portion of the bridge, we begin repainting at intervals of 3½ to 4 years. It is necessary to keep these seams well sealed because of their awkward position on the bridge directly above upper-deck traffic, and the fact that it would be extremely difficult to repair them if rust became extensive or heavy between the parts of built-up members.

The sidewalk and chord soffits on the bridge are what we call condensation surfaces. Walks are very light compared to other bridge steel, being only ⅜-inch plate, and flat on the bottom so that dew or condensation forms and hangs there. This cannot run off but remains in droplets absorbing contaminants from motor vehicle exhaust. Paint on these surfaces has a very short life. Sidewalks are non-stress carrying members and do not give too much concern. Various methods have



Inspection bridges such as the one in the photo were used originally as crossovers between catwalks during the cable spinning. Later 14-by-62-foot platforms were added so that they could be used in painting the floor system.

been tried on these walks to make the paint last longer, but the condition is so severe compared to other conditions on the bridge that nothing has proven completely effective in lengthening the life of the paint film to equal that on other portions of the bridge.

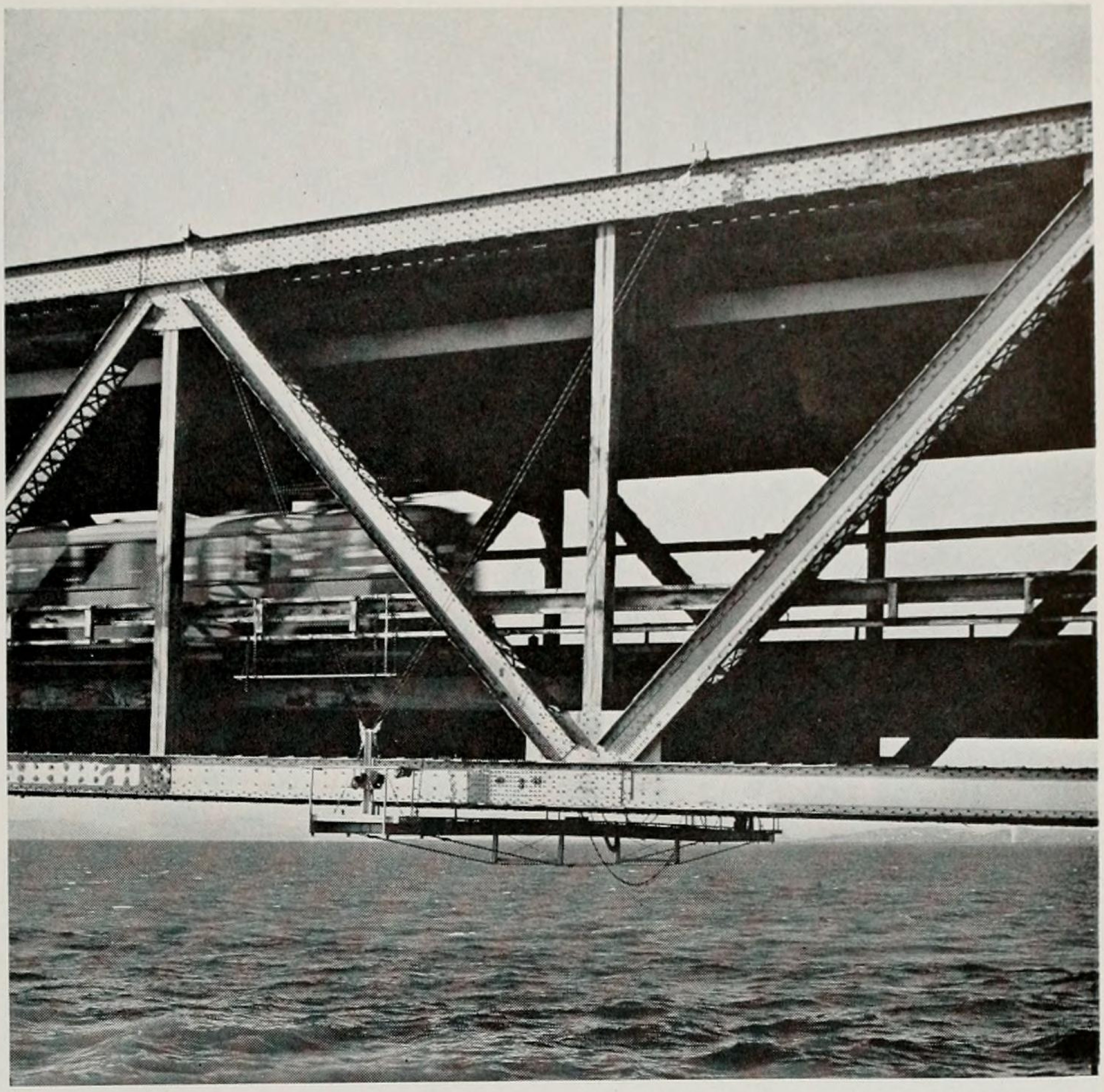
Effect of Rain

Surfaces on the bridge steel which receive rain and are washed clean have a minimum of rust, except as noted under "temperature change". Prevailing winds normally come from the northwest side of the bridge, but not in the rainy season. The heaviest rains come from the southwest, are not accompanied by high winds and consequently do little *good* beneath the decks. High velocity windstorms from the southeast accompanied by rain blow a large amount of water through the trusses on the south side of the bridge, and the effect of this water is very noticeable. The ends of floor beams, exposed to this rain water blowing in, will have little or no rust, while the opposite end of the same beams, subject to motor vehicle exhaust and generally unwashed, may have the entire surface rusted and require 100-percent sandblasting.

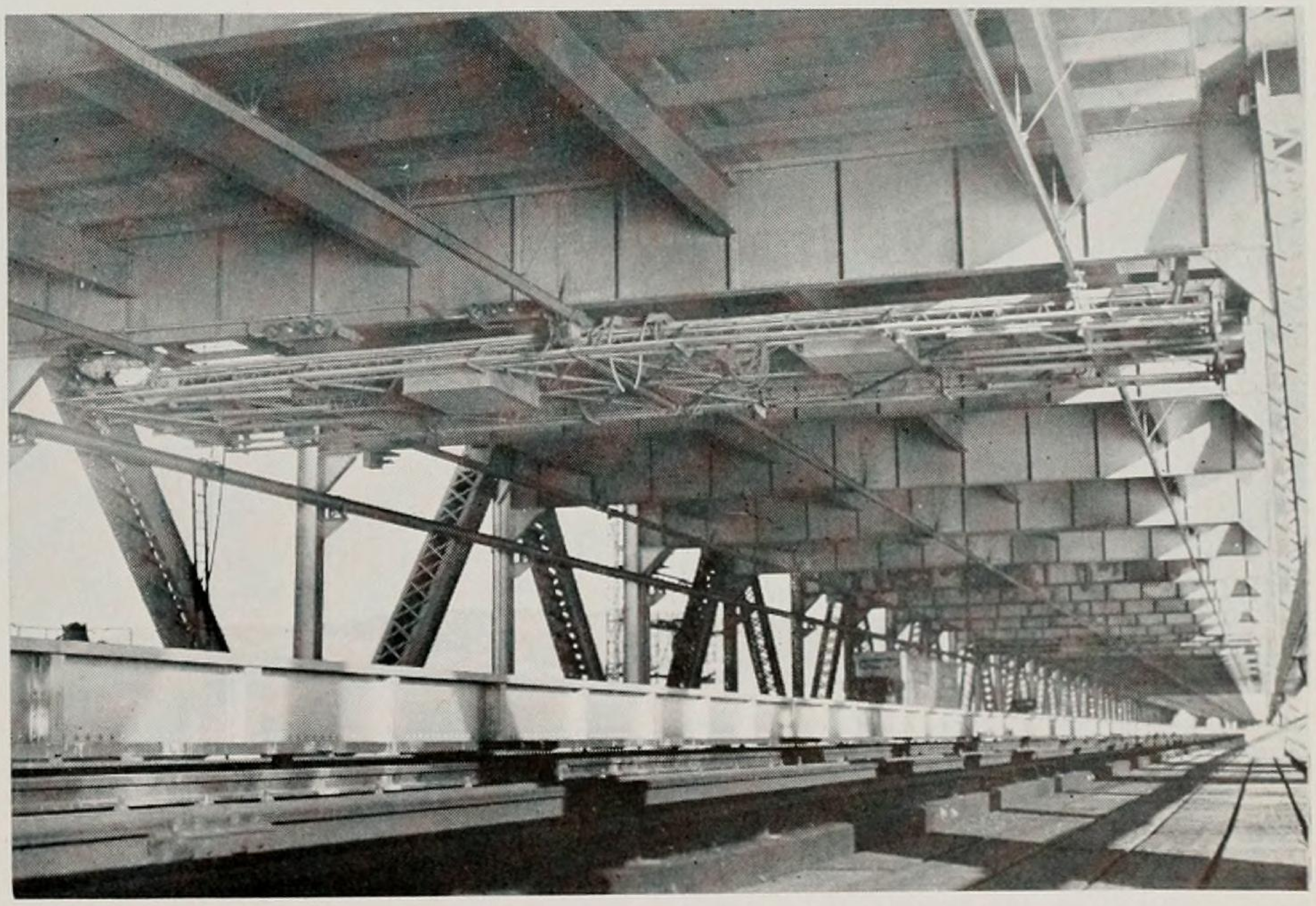
Paints in Use

Between 1940 and 1945, the formula for the aluminum vehicle was changed from a long tung oil varnish to a phenol formaldehyde type. The present varnish is known as California State Specification 58-I-04, and is a 100 percent phenol formaldehyde type. The resin used is CKR2432, or equal, corresponding to Federal Specification MIL-R-15189A. Aluminum paste used is Specification TT-A-468, Type II, Class B leafing type, except that nonvolatile is 74 percent minimum. Two pounds of this paste are used per gallon of aluminum vehicle.

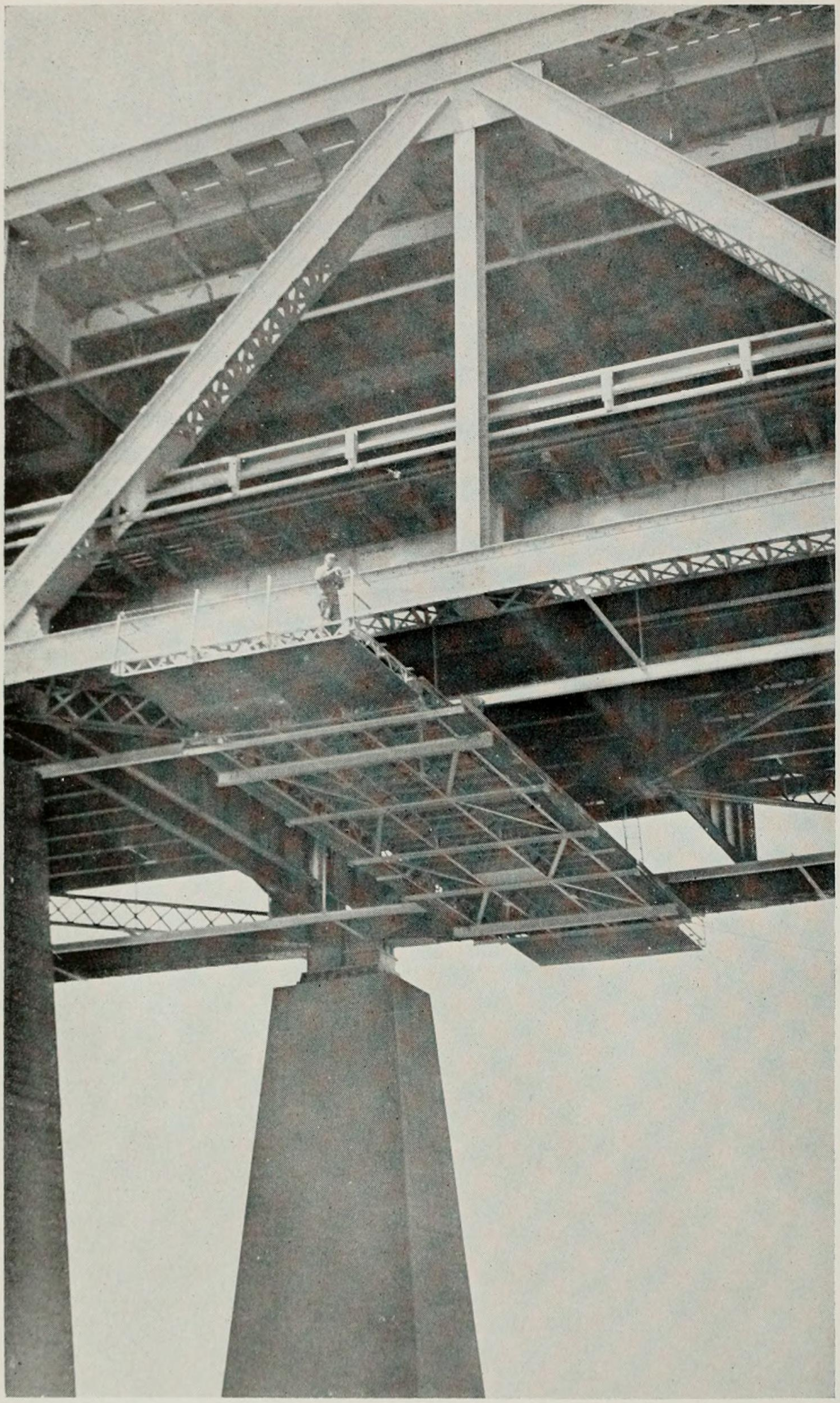
Several years ago, we began using a semi-quick drying red lead paint which weighs 21.7 pounds per gallon. This paint dries satisfactorily for recoating in 16 hours. We have not abandoned the use of slow drying paint, but use these quicker drying paints in locations where we can get at the surfaces for repainting more rapidly, thereby reducing contamination between coats during the repainting operation. Semi-quick drying paint



The Magic Carpets, 6 feet wide by 85 feet long, are suspended from the upper chord. For many years they have provided a platform for repainting the lower deck floor system. They are now being replaced with power-operated travelers (see photo next page).



The gantries or upper deck travelers run on a three-rail overhead track with air-powered drive. The working platform is 17 feet wide and 59 feet long.



Lower deck travelers used on the East Bay section provide a 19-by-73-foot platform for painting the lower deck floor system. They are hung from air motor-driven trolleys. Folding ends allow clearance when passing through the bridge piers. These are replacing the older Magic Carpets (see photo previous page).

is compatible with our linseed oil paints, and they are frequently mixed together in equal portions for color differences between coats, or some of this quick drying is added to the regular paints to speed the drying.

Another item of interest which is frequently used to our advantage is leafed metallic lead paste. This is added to the lead coats to reduce or speed the drying time and provide a better tooth or bond between coats. We add approximately 1½ pounds per gallon in our mixing tubs. It is not practical for us to buy paint with this mixed in at the factory. Our use is not continuous, but varies with the locations where we are working as well as with the weather conditions.

State Specification items used at San Francisco-Oakland Bay Bridge during 1960:

1. First coat paint
   a. Red lead linseed oil—27.8 lbs./gal. Specification 58-G-60
   b. Semi-quick drying red lead—21.7 lbs./gal. Specification 58-G-53
   c. Phosphoric acid wash (Mil-C-15328A) Specification 52-I-05
2. Second coat paint—24.4 lbs./gal. Specification 58-G-61
3. Aluminum finish coat—Specification 54-G-80
4. Steam cleaning compound—medium duty (Bay Bridge formula) Specification 59-A-77

Over the years, coal tar coatings have been used in some areas. The quantities have been small, but the results in these specific areas have been excellent.

The following quantities of our regular paints were used during the fiscal year ending June 30, 1960.

First coats	
Red lead linseed oil	1,472 gallons
Semi-quick drying red lead	4,945 gallons
Second coat red lead	2,890 gallons
Finish coat aluminum	5,945 gallons
Total	15,252 gallons

Everything practical is done to shorten the time between coats, thereby reducing contamination between coats. This is particularly important between the first and second coat. One coat of red lead paint has a very short life in our exposure and it is not satisfactory to leave unrecoated for more than two months and in some locations for only three weeks. At times, we have had two coats of red lead paint go for nearly a year with very few bad results. This was not done intentionally, but because of accidents where surfaces had to be left until access could be had at a later date.

Surface Preparation

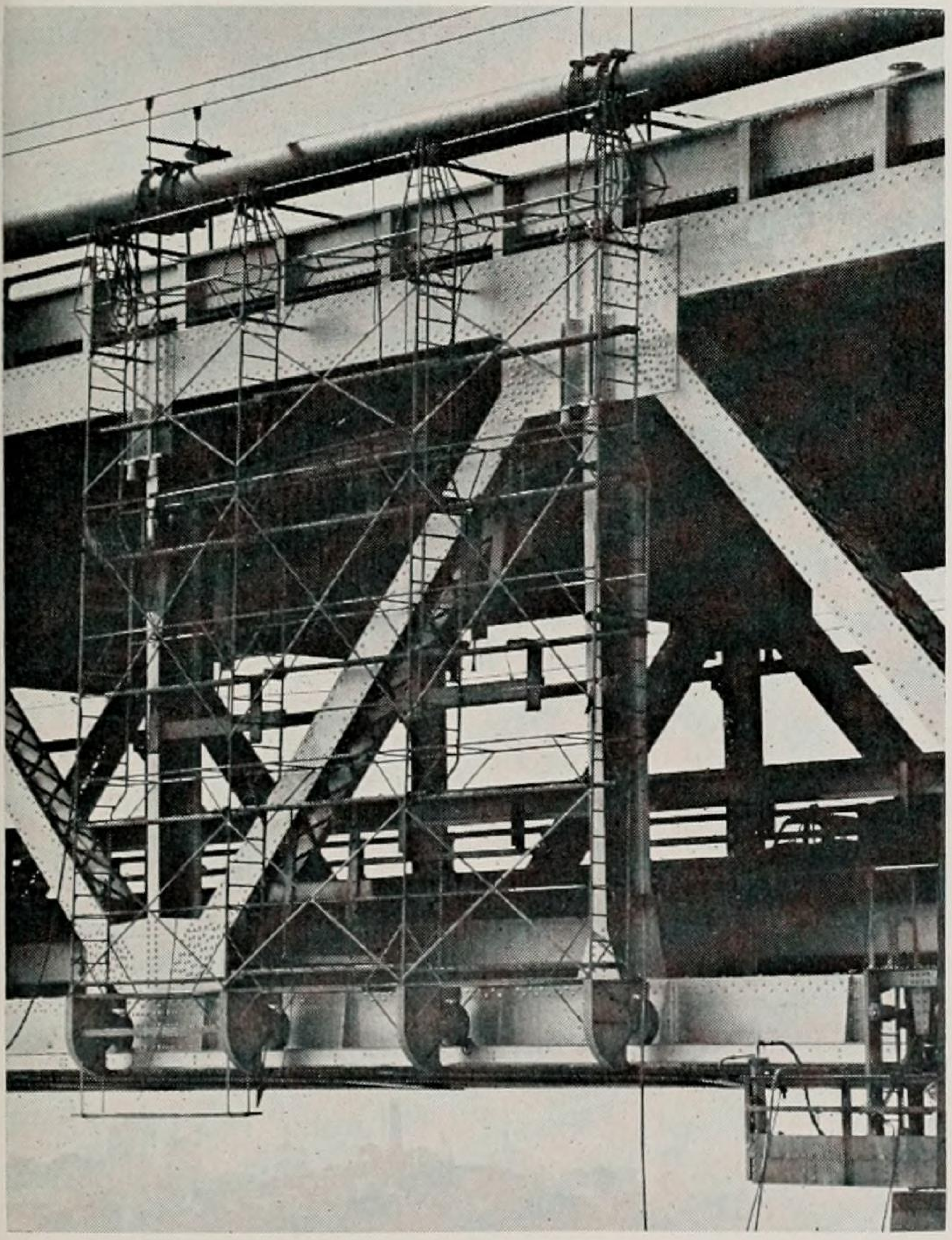
Our present policy is to steam clean all surfaces which can be cleaned without serious inconvenience to traffic. Under this plan, we have steam cleaned to the tops of the suspension bridge towers 275 feet above the upper deck with the steam cleaners on the lower deck of the bridge adjacent to the tower legs. This is followed by sandblasting to remove rust. The steam cleaning reduces the amount of sandblasting by removing dirt and other stains which might be mistaken for rust. Another advantage is the reduction in cost over that of blasting, and we do not wish to remove good paint unnecessarily.

We only do spot sandblasting except in rare instances, and no blasted surfaces are left overnight. They are all painted the same day they are blasted and receive two spot coats of lead paint, one of which is a spot coat on all seams, rivet heads, and edges in addition to the blasted areas. This is followed by a third coat of lead paint over the entire surface, which in turn is followed by the finish coat of aluminum. This brings all blasted surfaces to the same standard of protection which was originally used at the time of construction.

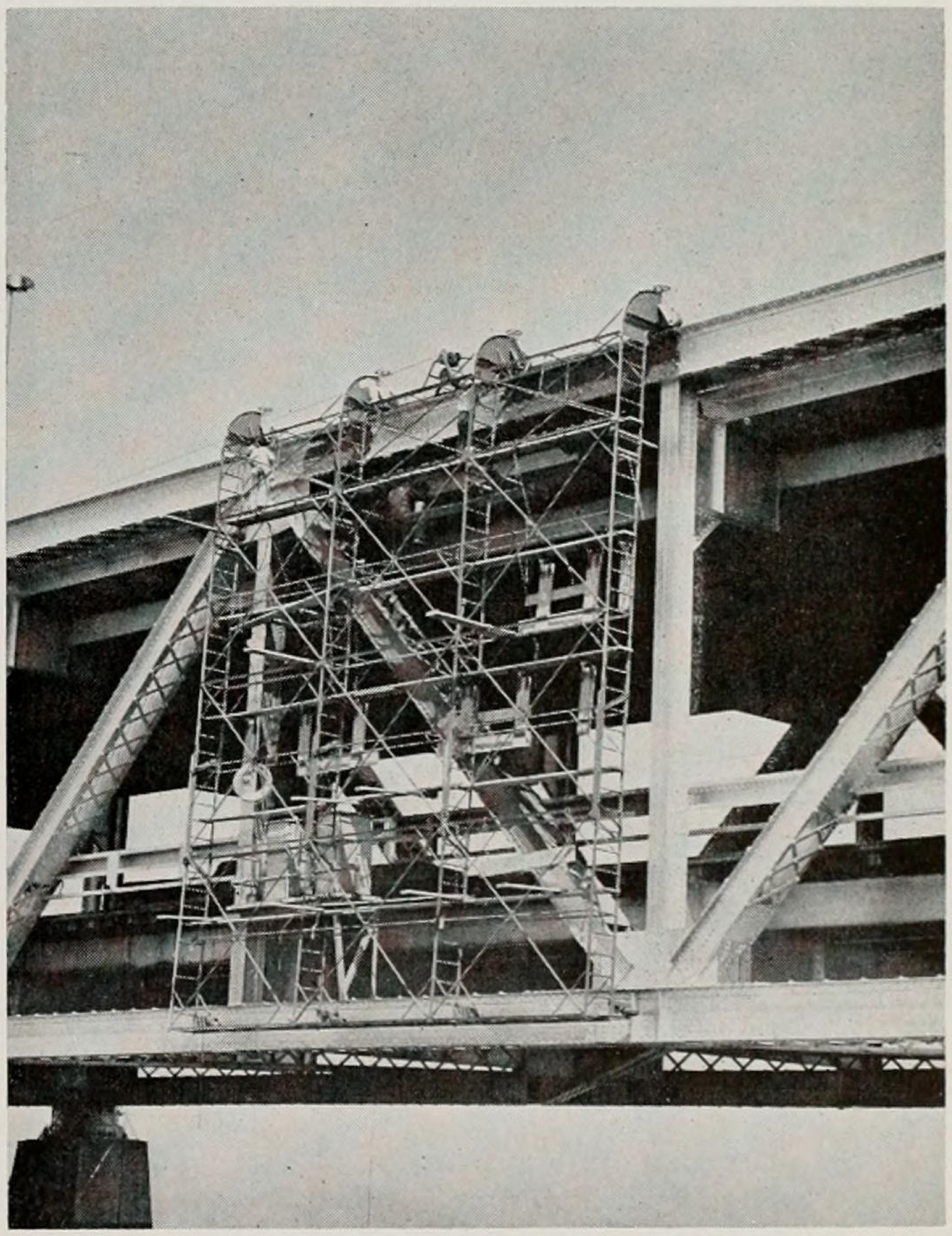
Another routine which we have adopted is that in many places where we are unable to clean out cracks which show indication of rust, we pour into that crack the phosphoric acid diluent of vinyl wash primer. This acid treatment is compatible with any water which may be in the crack, creates an inert surface on the steel it touches, and has a tendency to inhibit any rust which it touches or which absorbs it. After this has had a chance to dry, the open edge of the crack is given a treatment of a surface preparation oil, of which there are several on the market. These do not contain driers and are compatible with paint. Following this, the cracks are filled with caulking compound and sealed over with the usual several coats of paint.

Mechanized Scaffolds

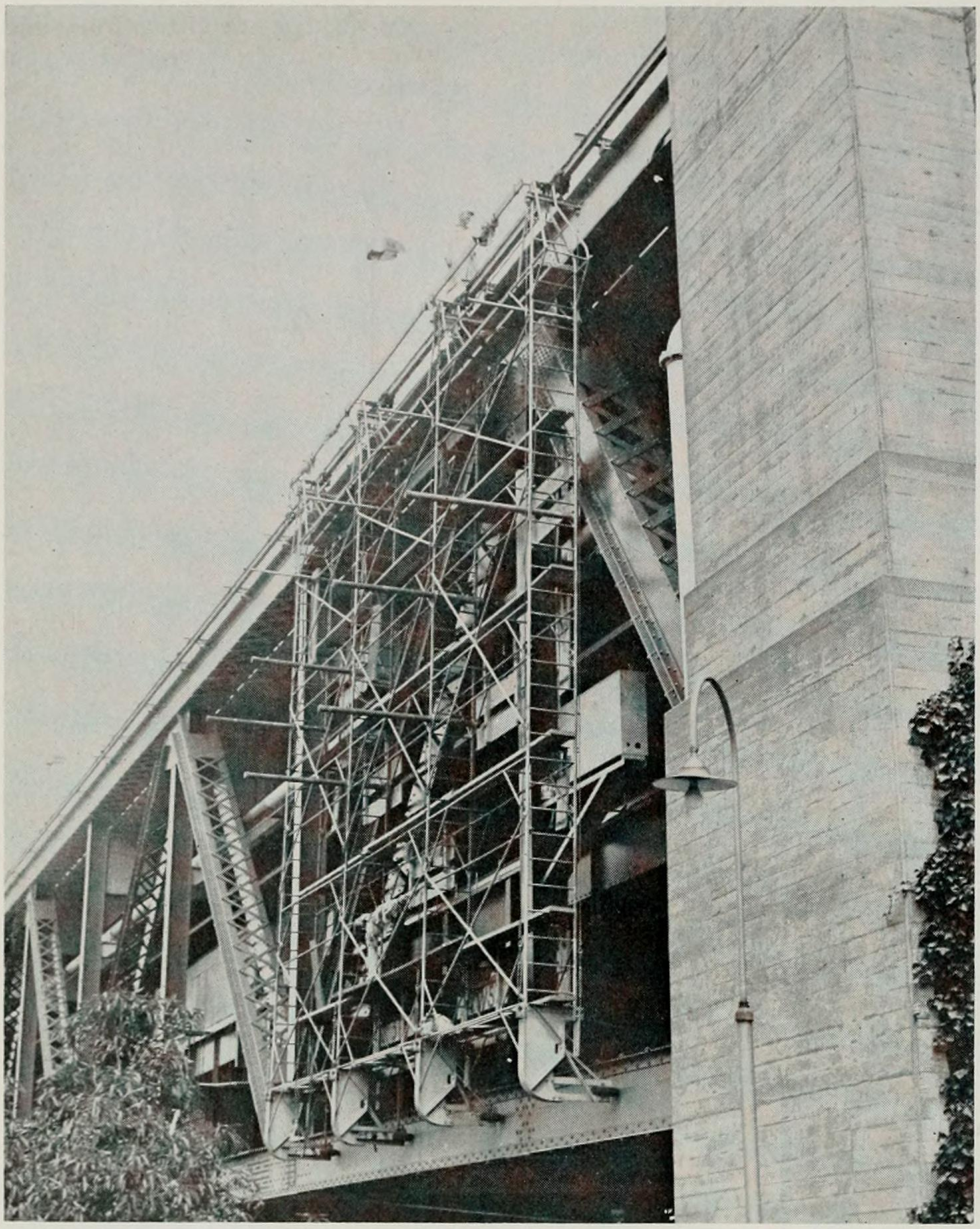
We attempt to have all our scaffolding in as large units as possible and mechanized to reduce human effort in moving the scaffold and thereby wasting time. At present, we have eight scaffolds covering an entire truss panel running on the outside of the bridge trusses for painting the truss web system. The first of these truss web scaffolds was built in our own shop in 1946 and others built to our design



The Bird Cages or truss web scaffolds on the West Bay suspension spans run on the inspection bridge track on the lower chord. These scaffolds are 40 feet high and 36 feet wide and support platforms for painting truss members. They are mounted outside the bridge to keep painters away from adjacent traffic.



The East Bay Bird Cage or truss web scaffold, also 40 feet high and 36 feet wide, is suspended from a portable truck on the top bridge chord. All Bird Cages have folding platforms providing access to truss diagonals sloping either to right or left.



This West Bay truss web scaffold was temporarily mounted on overhead track for work on the Yerba Buena Island Spans.

later that year. Two covering a half a panel were erected at the curved spans in February, 1961. These enable the men to paint the trusses without being on the narrow sidewalk adjacent to the highway and increase safety by keeping the men as far as possible away from traffic. There are currently five travelers running underneath the upper deck suspended on overhead rails.

These platforms are approximately 15′ x 60′ and cover half of a floor system panel providing easy access and a minimum amount of rigging time moving from panel to panel. In 1948, we built and erected the first of these and a half mile of track with our own crew. A new scaffold was installed in 1960 underneath the lower deck for painting approximately 3,000 feet of bridge on the east end. This platform is also approximately 15′ x 75′. Three more are in the design stage nearly ready for contract.

Run On Tracks

Seven inspection bridges running on track were provided with the bridge originally. These were 4 feet wide by 76 feet long, powered by hand, and were for inspecting the lower-deck floor system on the suspension bridge and the main span of the cantilever. Wider platforms, 14 to 15 feet wide, have been placed on these scaffolds and power drive has been installed.

Special scaffolds to run on the main cable hand ropes were built in 1947. These are adjustable so they may be kept level as the cable changes slope. Special elevator-type platforms are used for painting the suspender ropes. For painting the suspension bridge towers, an articulated scaffold was built in 1939 which completely encircled a tower. When not in use on the big towers, sections were used elsewhere. This was operated by hand-powered jack machines. It is now old and has deteriorated to such an extent that when the towers are painted again, we anticipate designing a new scaffold with power drive. For vertical transportation several different commercial makes of air-powered scaffold machines are used. We have learned that no one commercial machine answers all our problems, but that each type of machine which we have works better in some places than any of the others.

There is currently being installed on the Bay Bridge a 4-inch air line the full length of the bridge for conveying compressed air to working locations. Compressed air driven tools have proven to be the most adaptable to the variety of conditions encountered on this bridge. Originally, electric-driven tools were tried, but because of operating conditions, they were not satisfactory, although they might be on a bridge where power is more accessible and other conditions are different.

Areas Repainted

At the present time, January, 1961, the West Bay suspension bridge towers have been painted twice under maintenance at intervals of 12 years. The same applies to the main cables and suspender ropes. The suspension bridge trusses are now being painted for the second time under maintenance. The upper and lower-deck floor system painting is a continuous process which never ends and is carried on from the center of the suspension bridge toward the ends, or in other words, downhill from the center. This floor system has been painted at an average of eight-year intervals, although on the first time over portions went as long as 20 years.

On the East Bay as on the West Bay, painting of the floor system is a continuous process. The average time between coats being eight years, with portions on the East Bay having gone as long as 18 years. The trusses on the East Bay 288-foot truss spans are now being repainted for the second time under maintenance. All bents supporting the East Bay portion of the bridge are now being repainted for the third time. The 288-foot Yerba Buena Island spans have just been completed for the second time on the lower-deck floor system and the third time on the upper-deck floor system. The trusses are about to be repainted for the second time under maintenance.

Four-Year Intervals

In the 504-foot through truss spans and the cantilever section, which are roughly 2,500 feet long each, we find it necessary, because rapid temperature change causes paint failure on cracks and seams, to start a paint crew through the overhead structure (struts, bracing connecting the trusses, and the trusses themselves) at intervals not exceeding four years. Luminaire standards throughout the bridge have a very long life, the principal deterioration on them being abrasion caused by the use of the tower or ladder trucks.

Although large quantities of lead and aluminum paint are sprayed, it is a very small percentage of the total paint applied here. We have observed, however, that the speed gained is not always to our advantage, it having been found that paint which is applied to a surface with pressure, that is, by friction, is worked into the surface with a better bond and gives us a longer life and a better coat of paint. This undoubtedly is because any surface contaminants are worked up into the paint film and do not lie undisturbed between the old paint and the newly-applied coat.

The general order of painting is determined by:

1. Policy of preventive maintenance.
2. Anticipated life of paint coatings under local conditions on the structure.
3. Techniques required for specific locations.
4. Accessibility.

Routines vary between the suspension bridge between San Francisco to Yerba Buena Island and the cantilever and truss spans from the island east to Oakland. They are thus listed in the general order of their frequency. Groups are generally determined by the type of scaffold or rigging used.

West Bay Crossing

Parts of the suspension bridge done in units are:

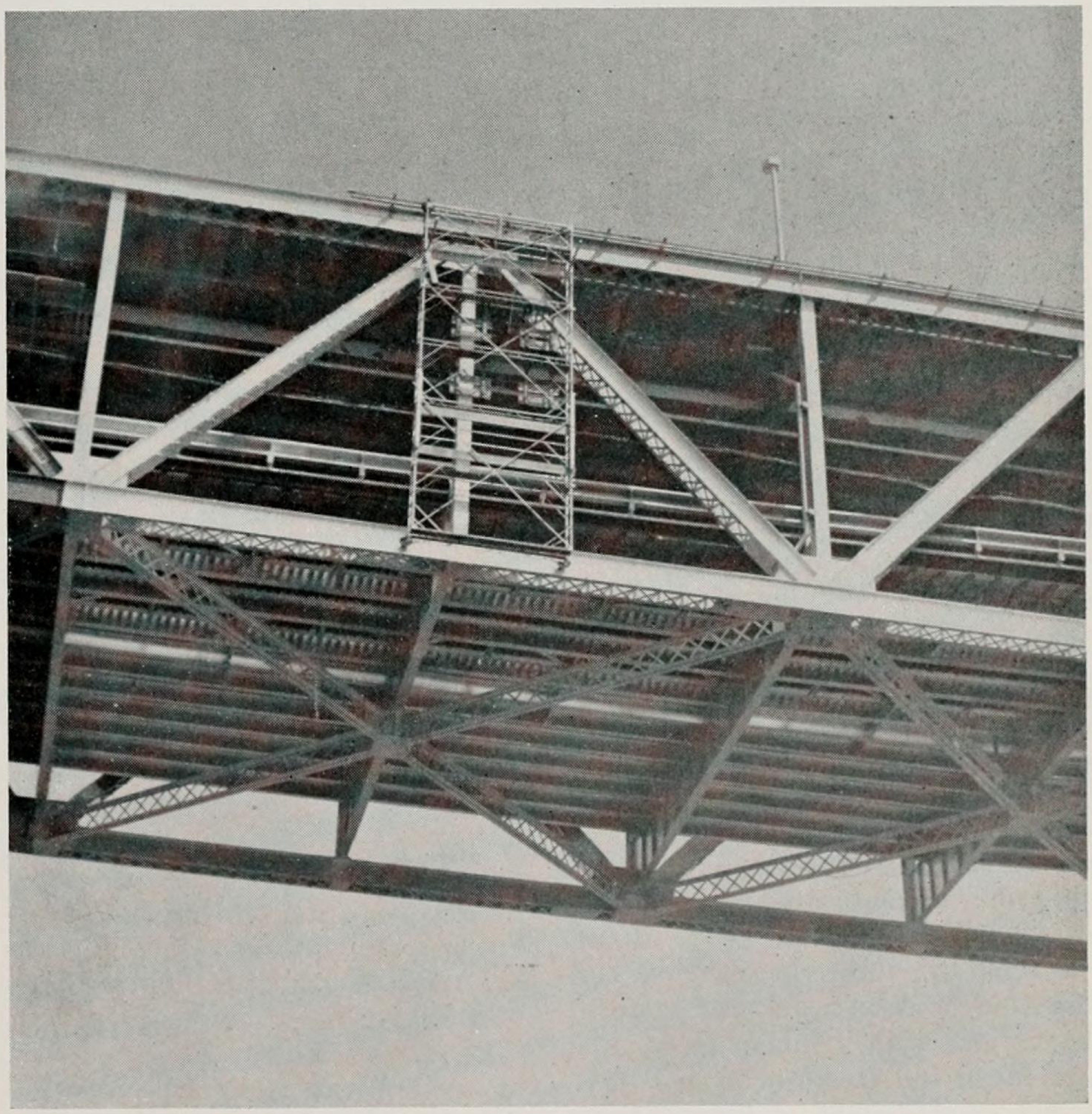
1. Floor systems—upper and lower deck.
2. Truss web members and rocker posts.
3. Tower and bent bases.
4. Towers and bents outside, suspender ropes, main cables.
5. Main cables in saddles and anchorage splays.
6. Roadway faces of walks and skid girders.
7. Bents and towers inside.

Truss web painting also includes inside the upper box chord, suspender rope connections and back of upper walks.

Inside the lower box chords and back of the lower deck walks are done with the lower-deck floor system. At this time, lower chord gusset pockets receive an extra treatment.

Upper-deck floor system includes the upper deck road strut and expansion details at the towers. Because of rapid paint failure on condensation surfaces, the bottom of the upper chord and the attached gusset pockets also receive an extra treatment.

Lower-deck road struts and expansion details on the main towers are painted from the lower tower scaffold.



A special narrow 15-foot wide Bird Cage mounted on overhead tracks is used on the curved spans on the East Bay section.

East Bay Crossing

Policy on this section of the bridge has been to maintain the many large connecting points separately because of the special tools and techniques necessary for working in such very inaccessible places. To keep scaffolding and gear at a minimum when painting the cantilever and 504-foot through truss spans above traffic, laterals, struts, portals, and sway frames are completed as the first operation; truss verticals and diagonals second; and top and batter chords last.

Parts of the East Bay structure done in units are:

1. Above decks or top side.
2. Upper-deck floor system.
3. Lower-deck floor system.
4. Truss web.
5. Bents and towers outside.
6. Large connecting points.
7. Inside of box chords, bents, and towers.
8. Roadway faces of walks and skid girders.

Conclusions

In drawing some very general conclusions based on our experience of painting the Bay Bridge since 1937, we feel that ease of accessibility which includes the use of large power-driven scaffold units is of primary importance. When we have had the opportunity to make suggestions to the designers of other bridges, we have recommended strongly that scaffolding or its supporting track, generous compressed air facilities and access walks be installed at the time of construction. We know from our own experience that film thickness of paint is the life of the job. Experiences also indicate that one or two additional coats of paint shortly after the completion of the original job gave us, with our exposure and under our other conditions, greatly extended life on the original paint job. It is probably not necessary to say that the detail work of sealing cracks, seams, crevices, and other construction details and erection clearances is done better and with a minimum of disagreement and argument by our own forces than it could be done under a contract. We are not implying that a contractor would not do it, but realize the great difficulties which would be encountered in writing a contract to cover the multitude of details and the methods of payment for handling them.

The San Francisco - Oakland Bay Bridge is the headquarters of the State-Owned Toll Bridges organization which is under the general direction of James E. McMahon, Assistant State Highway Engineer, Bridges.

Howard C. Wood, Bridge Engineer, State-Owned Toll Bridges, has direct supervision of the toll bridge organization and is assisted by Thomas J. Dunn, Supervising Bridge Engineer. Edwin F. Levy, Senior Bridge Engineer, is in direct charge of maintenance operations. D. Ewing Marsh is Maintenance Superintendent, Painting. He is assisted by Clair Gibson and Roy H. Proffer, Structural Steel Painter Foremen, who have been with the organization since 1937, and to whom much credit must be given for the establishment of many of our routines and for the successful conduct of our program of preventive maintenance.

Dwight Wonacott

Dwight Wonacott, 62, Highway Maintenance Superintendent for the State Division of Highways in Fresno, died of a heart attack on September 19 while on vacation in Long Beach with his wife Georgia Ann.

A veteran of over 42 years with the Division of Highways, Wonacott began his career as a truck driver for the division in his home town of Bishop. He was promoted to superintendent while in Bishop more than 30 years ago, and had been with the Fresno office nearly 20 years.

He was a member of the Inyo Masonic Lodge No. 221 in Independence, Inyo County, the Order of the Eastern Star, the California State Employees Association, and the Quarter Century Club.

Besides his widow, he is survived by his brother, A. W. Wonacott of Bishop, and a sister, Mrs. Evangeline Troxel of Livermore.

Interstate Funds Total $228 Million

Apportionment of Federal-Aid Interstate Highway funds to the states for the fiscal year 1962-63 as made in August by Secretary of Commerce Luther H. Hodges provides a total of $2,400,000,000 to continue the program. This is the full amount authorized for the period by the Federal-Aid Highway Act of 1961.

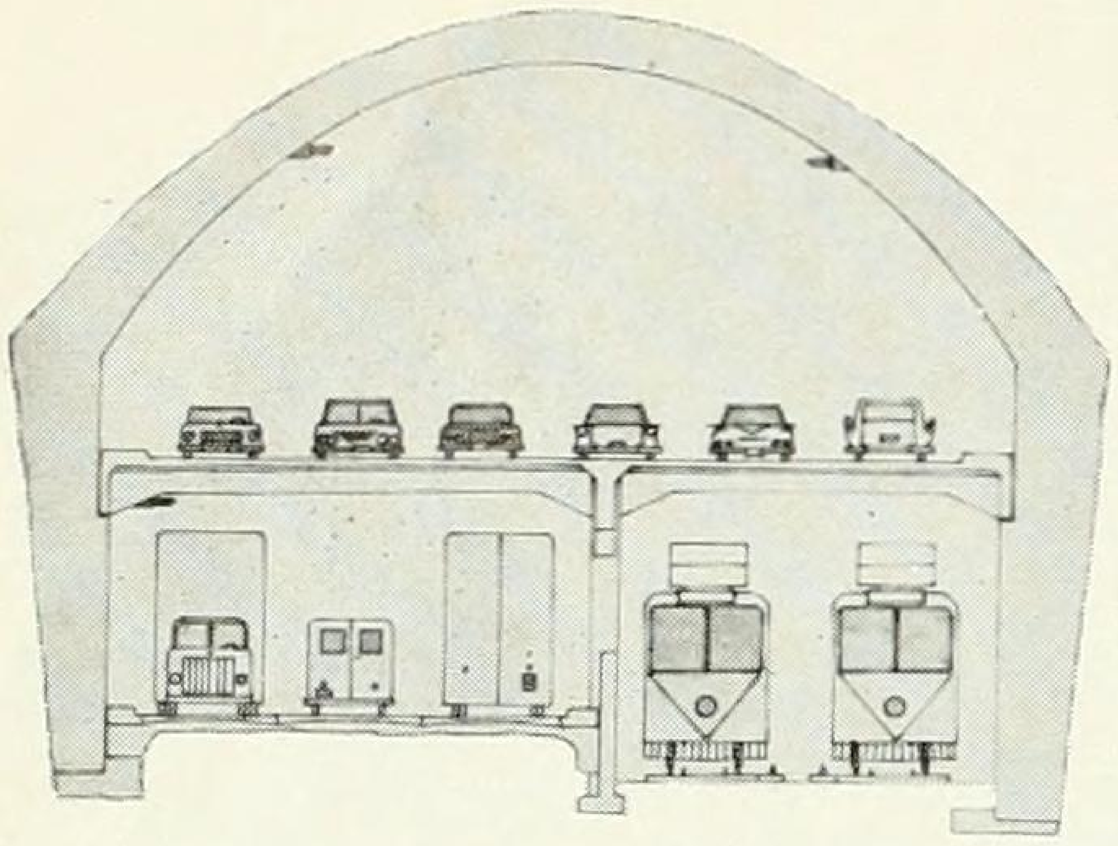
California's share is $228,847,200. Last year it was $220,070,812.

The Federal-Aid Highway Act of 1961 authorized the appropriation of additional amounts for the Interstate System through the fiscal year 1971. The total additional funds authorized over the entire period, compared to existing authorizations, amount to $11,560,000,000. No changes were made in the amounts authorized (and already apportioned) for the fiscal years through 1961-62.

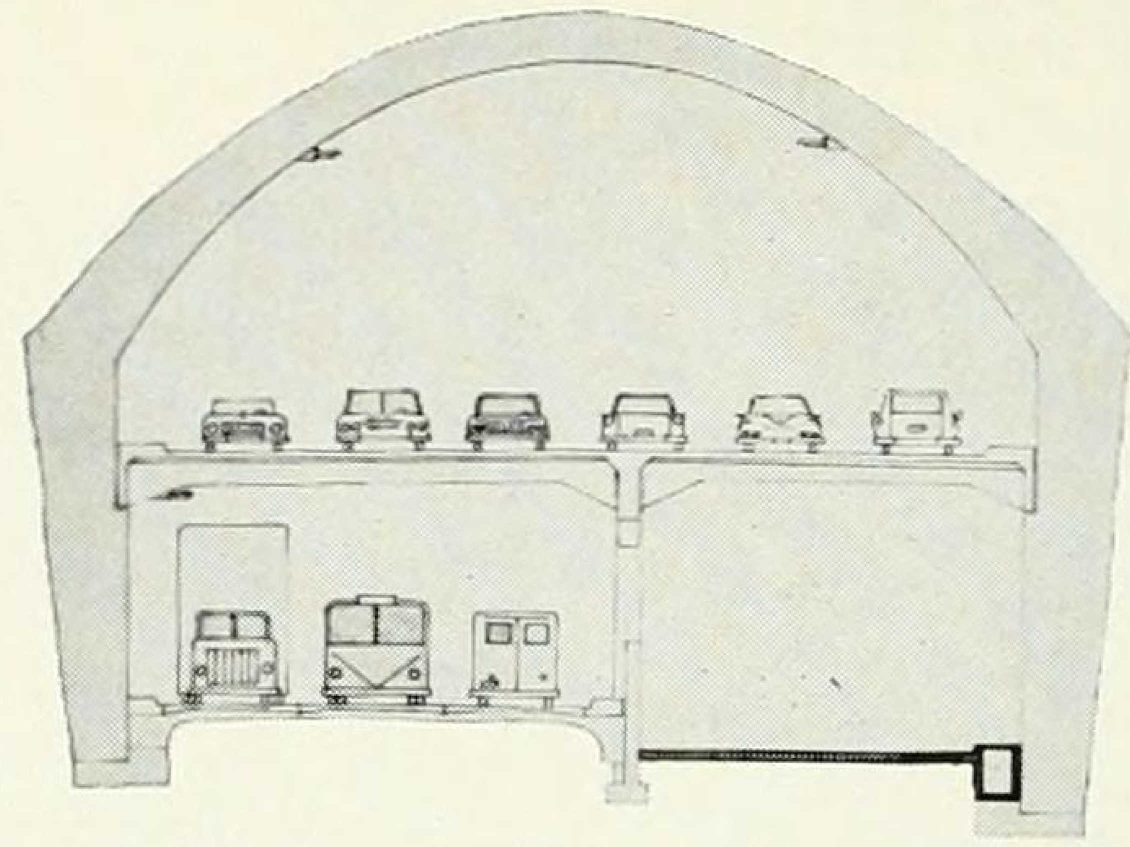
The latest cost estimate, approved by Section 102 of the 1961 Act, indicates that the total cost of completing the Interstate System will be $41,000,000,000, of which $37,000,000,000 is the estimated Federal share. This section increases the total amount authorized to be appropriated for this system from $25,440,000,000 to $37,000,000,000, adjusted to the fiscal years in which the estimated funds will be available in the Highway Trust Fund to cover the necessary disbursements. Under the present estimates, the amounts will be sufficient to complete the Interstate System by 1972.

Additional revenues were provided by the 1961 Act. A tax of 5 percent of the manufacturer's sales price of trucks, buses and trailers was increased to 10 percent, effective July 1, 1962. The tax on highway tires was raised from 8 cents to 10 cents per pound; on inner tubes from 9 cents per pound to 10 cents and on tread rubber from 3 cents per found to five cents.

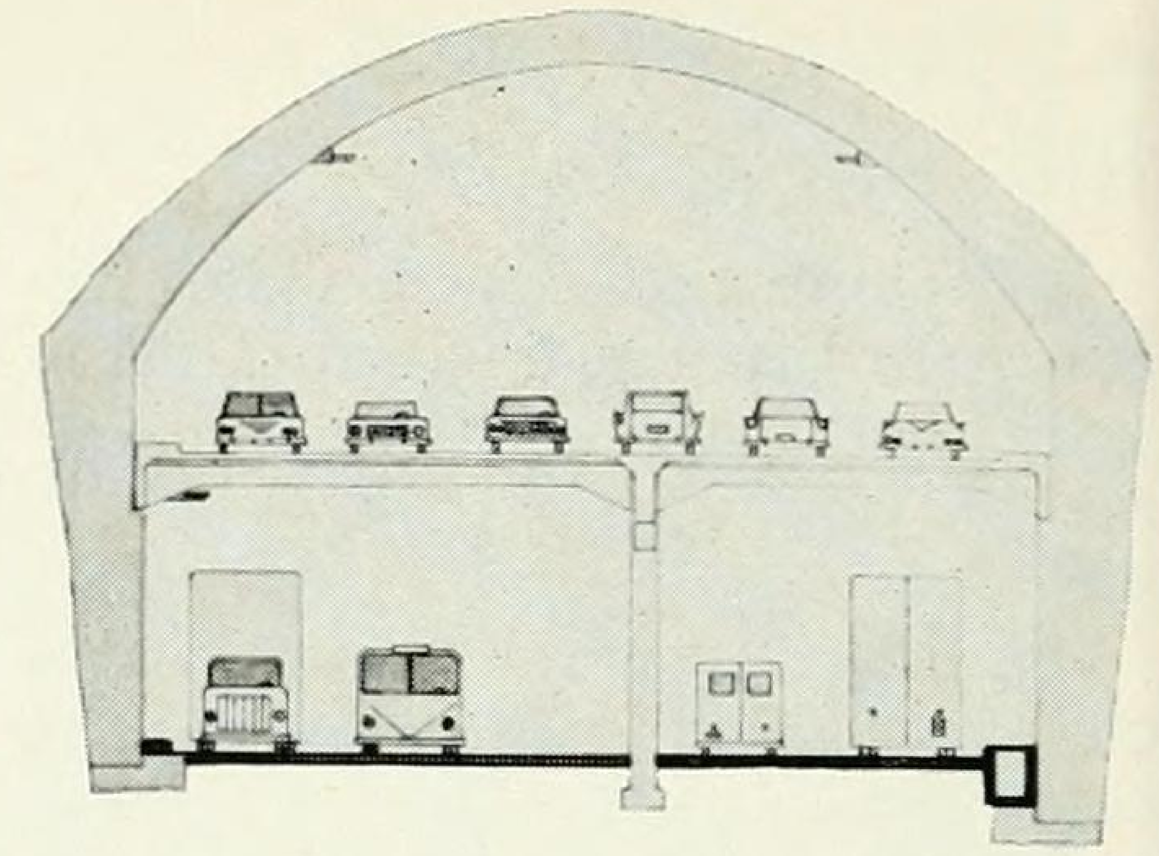
A truck use tax on vehicles over 26,000 pounds was increased from $1.50 per thousand pounds to $3. An excise tax of 5 percent of the manufacturer's sales price of autobobiles and automobile accessories was repealed effective July 1, 1961.



Cross section of Yerba Buena Island tunnel, San Francisco-Oakland Bay Bridge, looking east as originally constructed. Lower level right used by electric interurban lines, lower level left for commercial vehicles. Upper level six lanes of passenger car traffic.



When train service discontinued by Public Utilities Commission order; tracks were removed as first step in reconstruction, and area paved. As yet no change in motor vehicle traffic pattern.



Truck lanes lowered to level of of south lanes, and center wall between columns removed. Four lanes of traffic now available for lower level traffic. No change on upper deck at this stage.

Bay Bridge

Second Phase of Reconstruction Nearing Completion

By N. C. RAAB, Chief Projects Engineer,
Division of San Francisco Bay Toll Crossings

In the July-August 1960 issue of *California Highways and Public Works* magazine the first phase of the reconstruction of the San Francisco-Oakland Bay Bridge was described. That article dealt with the San Francisco approaches to the bridge, the conversion of the Transbay Transit Terminal from train to motor coach operation and the paving of the lower deck area over the West Bay crossing, formerly occupied by the bridge railway, for all vehicular use.

This article pertains to the paving of the East Bay crossing; the reconstruction of the roadways through the Yerba Buena Island Tunnel; the viaduct section on the Island; and the strengthening of the West Bay upper deck floor system to accommodate the heavier commercial vehicles.

110,000 Vehicles Daily

The planning for all contracts, in connection with the reconstruction of the bridge, provides for the more than 110,000 vehicles per day crossing the structure without serious delays. Specifications are so worded that construction is carried out on a calendar day basis, which calls for work to be performed outside the normal eight hour day and on weekends.

The present upper deck of the bridge has six 9′-8″ traffic lanes, three in each direction, for automobile traffic only. The lower deck originally had a 31-foot roadway, three 10′-4″ lanes for commercial vehicles. The remaining 27 foot width on the south side was occupied by the railroad.

Upper Deck Strengthening

The plan for strengthening the upper deck to accommodate five 11′-7¼″ one-way vehicular lanes for mixed traffic required the analysis of the present floor system to determine which members were deficient in strength and a practical means of reinforcing those parts not meeting specification requirements.

The completed portion of the lower deck, from San Francisco to Yerba Buena Island, was striped for five lanes. During the construction period it was operated as a four-lane roadway, two in each direction, with the fifth or south lane reserved for contractor's use.

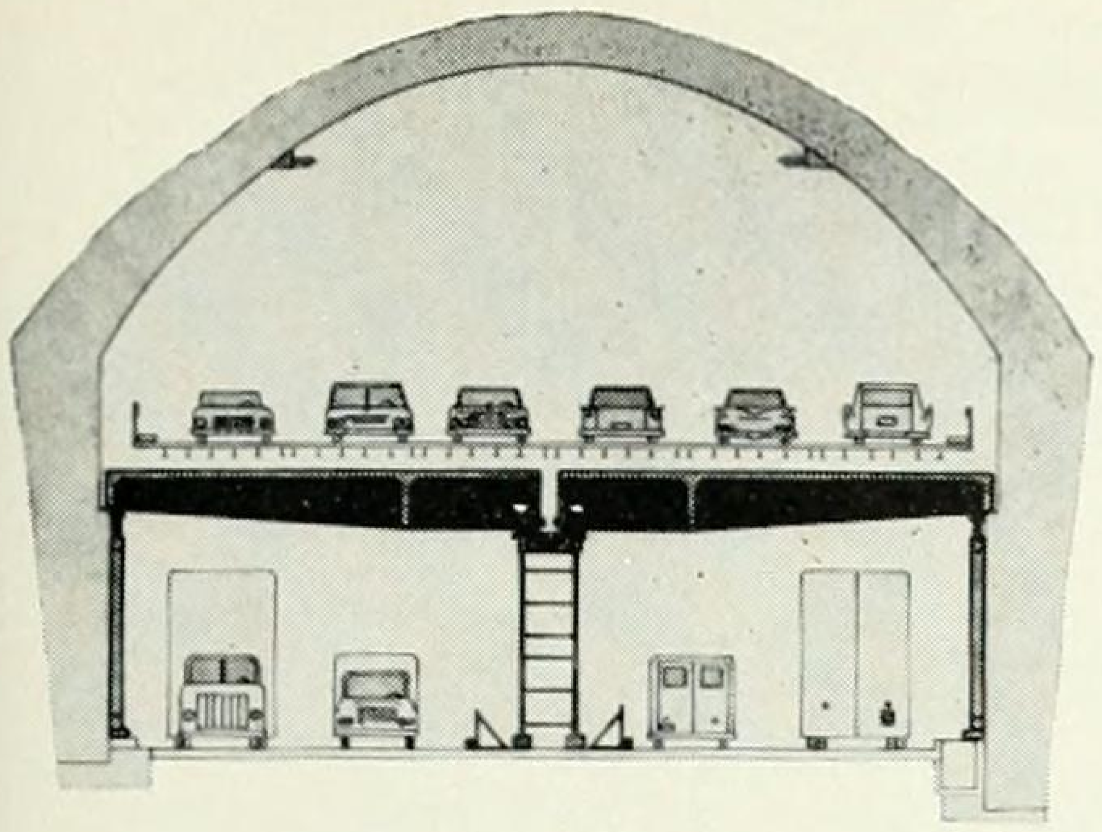
The upper deck floor system consisted of six-inch lightweight concrete slabs, 58 feet in width, supported on 13 longitudinal steel stringers, which in turn are framed into transverse steel floor beams on 30-foot centers.

Reinforce Floor Beams

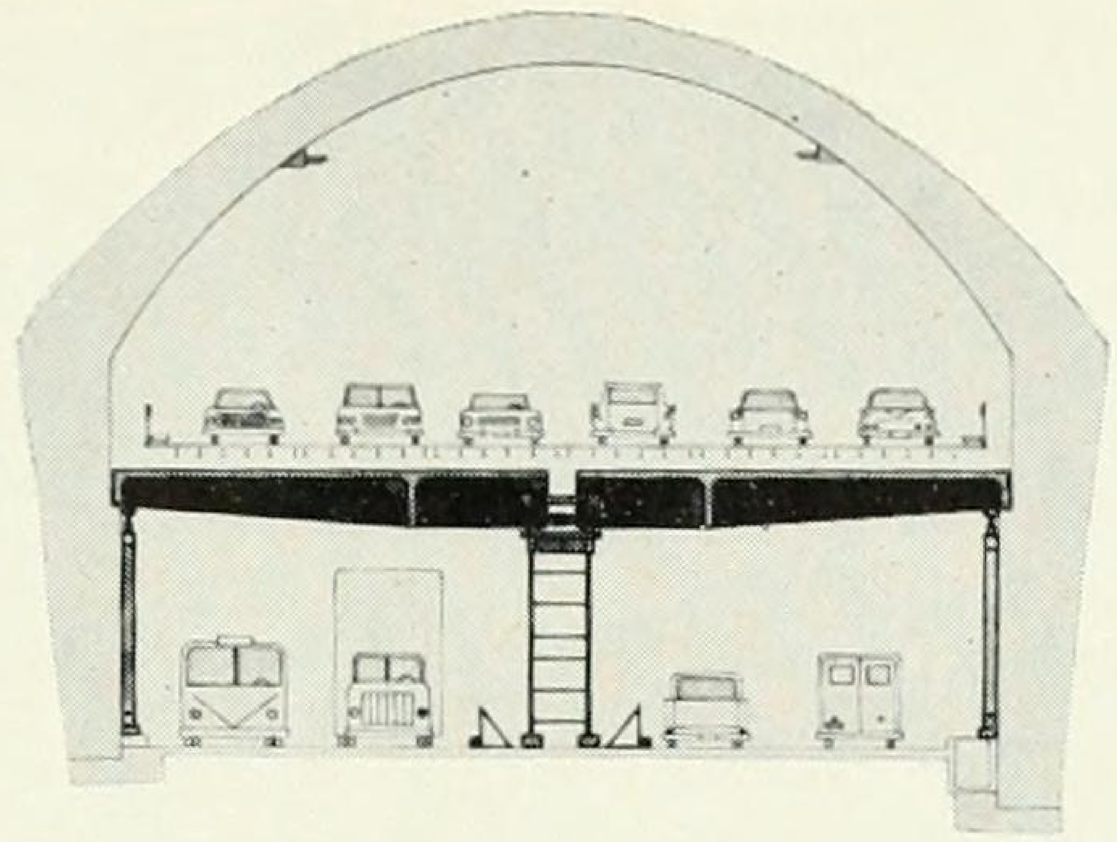
The theoretical analysis of the floor system revealed the adequacy of the concrete slab with its steel reinforcing to support the heavier commercial vehicles, and the same was true of the steel stringers. The floor beams were found to be deficient in strength and required reinforcing.

Due to the many assumptions that are applied in the theoretical analysis of a problem which could materially influence the results, it was decided to verify these findings by field tests using a loaded truck which imposed upon the concrete slab the legal loading concentrations.

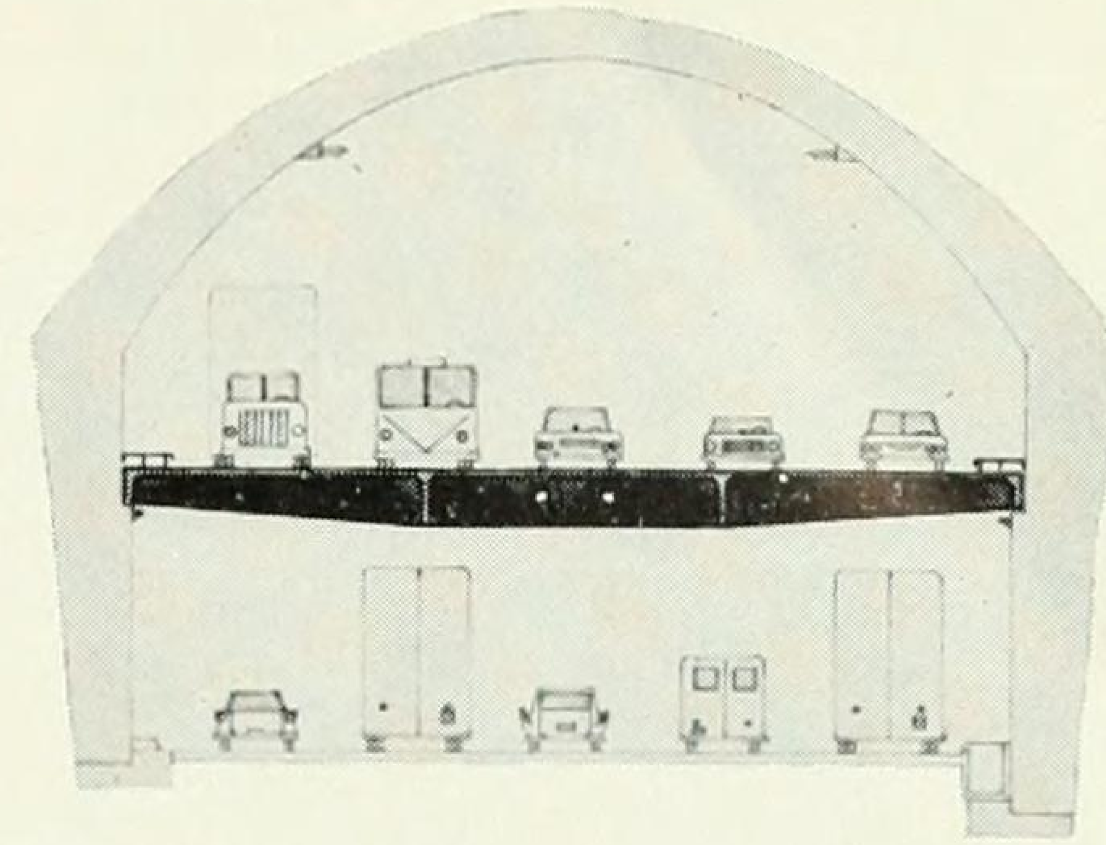
Four floor beams were selected for tests, each with different framing and loading characteristics. Instrument readings were taken of all floor mem-



Next step is lowering of upper deck roadway for better clearance in tunnel, and removal of center supports obstructing repaved lower roadway. Since upper deck must be replaced in sections, traffic moves over portion of upper roadway that is removed by means of a temporary bridge which is moved forward as new precast deck units are replaced in gap at lower elevation.



New deck units are put in position, one side at a time, while truck traffic is transferred to whichever alternate lanes not occupied by construction crews. After positioning, units are tensioned and center gap is filled with concrete.



When all units are in position, columns on lower level have been eliminated. Traffic pattern is now changed to five standard width lanes for mixed traffic; one-way, on each level. Lower level is eastbound, upper level is westbound.

bers before and after test loads were applied.

The results of the tests proved that existing conditions under actual loads were better than the results obtained by the theoretical calculations. It also demonstrated that the method of strengthening the deficient members was practicable and could be achieved under adverse working conditions.

The plan for strengthening the 357 floor beams required a high strength steel plate attached to the lower flange of the member after the plate was stressed to a predetermined amount. By tensioning the new cover plate a compressive stress was induced into the lower flange of the floor beam, resulting in a reduction of the dead load tensile stresses. The tensioning was sufficient to prevent an overstress of the composite flange under legal axle loading.

Traffic Continued

As this construction was done under traffic, the contractor was furnished three of the State's traveling scaffolds which are supported on tracks suspended from the upper deck. These were augmented by lighter platforms which the contractor fabricated and erected. The material was handled from the south lane provided for the contractor's use.

The operation in general consisted of drilling holes through the lower flange of the floor beam, bolting one end of the plate to the flange, stressing the free end of the plate by jacks, locking the stressing device, then drilling bolt holes through the lower flange using the stressed plate as a template, and then bolting.

High strength body bolts were inserted in the holes and the nuts tightened with a wrench to a specified torque. Stitch bolts were placed throughout the length of the plate to hold it in position.

Also included in this contract was the widening on both sides of the upper level roadway between the San Francisco Anchorage and Pier W-1 from 58 feet to 69 feet. This widened portion will eventually be incorporated into deceleration lanes and refuge bays for the "off" ramps on the north and south sides of the deck leading to Fremont Street in San Francisco, when the bridge becomes one way westbound.

On completion of the contract, the West Bay crossing will be completed and ready for five lanes of one-way mixed traffic on each deck when traffic is changed to this operation, starting the early part of 1963.

Yerba Buena Island Construction

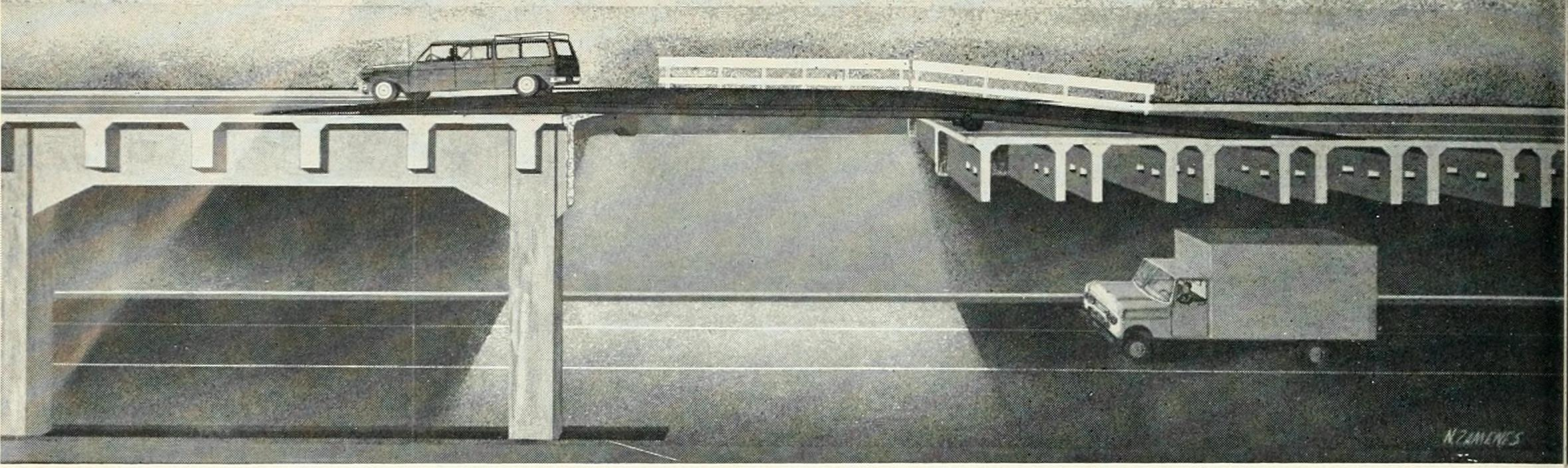
Probably the most exacting and difficult construction operation being completed is the work now in progress across Yerba Buena Island in connection with the San Francisco-Oakland Bay Bridge Reconstruction Project. The contract extends over a length of 1,786 feet which involves 826 feet of tunnel section and the remainder in a double decked concrete viaduct.

The reconstruction in general consisted of the following:

- 1. Remove the two tracks from the south side of the lower deck area.
- 2. Lower the grade and pave the area for two lanes of traffic.
- 3. Remove the present three north truck lanes, lower the grade three feet and repave.
- 4. Restripe the north and south roadways for two lanes in each direction.
- 5. A movable steel bridge with a span of 26 feet and a width of 58 feet which fitted between the curbs of the upper level roadway was placed on the upper deck.
- 6. The columns supporting the upper deck and sections of the deck under the movable bridge, 10 to 12 feet in width, were then removed.
- 7. Precast concrete deck units, 7′-8″ in width, replaced the removed section at a 16-inch lower level.
- 8. The bridge was advanced and the operation repeated.

The upper deck viaduct section to the east of the tunnel was strengthened by the addition of precast, post tensioned, concrete units prior to the removal of the center supporting columns.

Under the south roadway a continuous concrete utility tunnel was constructed to carry the various air, electric power, water, and communication lines across the Island, which



Cutaway section of Yerba Buena Island reconstruction, with movable steel bridge in position. Viewpoint is from south, with San Francisco to left. New deck units capable of accommodating the heavier commercial vehicles at right, old inadequate upper deck floor system before removal at left.

utilities extended to both ends of the bridge.

The 58-foot roadway constructed at ground level was lowered to maintain the 16 foot minimum vertical clearance between the two levels which accommodated both the deeper deck units and the 16 inch lowering of the upper level required for clearance at the tunnel portals.

Remove Concrete At Night

The removal of some of the concrete in the tunnel section was done at night to avoid the heavy traffic on the lower deck. The precast upper deck units were erected during the day by shifting traffic on either the south or north roadways. The new precast deck units rest on shelves of the tunnel which were used to support the original upper deck.

Forty-eight Hour Cycle

The tunnel units arrived at the site in two sections. Each section was raised and placed in position by an elevator hoist mounted on a truck. One end of the section rested on a shelf and the other on falsework struts along the center line of the tunnel. The units were post tensioned after connecting the high strength steel rods at the center and then jacking the two sections apart. The 1′-6″ gap between units is closed by a steel form, filled with concrete and then heat cured. The operation was based on a 48-hour cycle before traffic was allowed on the new roadway. Lightweight concrete was used in the units as well as the key forming the two parts into a single roadway section.

A sprinkler system with fusible metal plugs in the nozzles was suspended from the upper deck in the tunnel section for fire protection. A fire patrol station is automatically notified as soon as water starts flowing through the sprinklers.

Various island roadway connections to the bridge were necessitated to accommodate traffic during the construction period and for the final routing of unidirectional traffic on each level.

Also required by the change are passenger platforms for island personnel using public transportation to the mainland. The platforms are located opposite each other on the east side of the tunnel, one on the north side of the upper deck and the other on the south side of the lower level. The roadway has been widened to six lanes at the platforms which provides for a deceleration and acceleration lane for buses stopping at these stations.

Roadway Lighting

The roadway lighting for the upper and lower decks was a part of this contract and consisted of some rearrangement of the sodium vapor lights on the upper level where new roadway connections and passenger platforms require a change.

The lower level lighting was entirely new throughout the 1,786 foot length of the reconstruction which consisted of continuous lines of fluorescent fixtures on each wall of the tunnel section and separately spaced units on each side of the viaduct.

The lighting circuits are so arranged to have all the tunnel lights on during the daylight hours and half the number during the night. This light arrangement will be synchronized with the viaduct section.

Mechanical ventilation for the two roadway areas in the tunnel was considered during the reconstruction planning stages. The cross section area of 1,500 square feet of the upper level is large compared to vehicular tunnel or tubes where artificial ventilation must be considered for the comfort of the users. There has never been any noticeable or disagreeable effects from motor fumes on the upper level through the tunnel, probably due to the short (540 foot) length and favorable scavenging action of the air currents.

Lower Level Vented

The lower level has a cross sectional area of 1,000 square feet, two-thirds that of the upper area. The lower section does not have a free flow of air, and there could be some ill effects due to this. Provisions for the release of any accumulated fumes was considered in the planning and vents are placed at 7′-8″ centers under the sidewalk. The free flowing air through the upper section should siphon most of the gasses from the lower roadway.

If this does not prove to be an effective means of clearing the vitiated air, after one-way traffic is established, it has been planned to use the utility duct to convey and release fresh air along the lower roadway. Automatically operated electrical blower equipment would be housed in an existing vault at the east end of the tunnel.

Lower Deck Paving—East Bay

The removing of the railroad rails and paving of the area occupied by trains along with other reconstruction work on the East Bay crossing of the San Francisco-Oakland Bay Bridge was performed under another contract.

The decking operation consisted mainly of the following:

- 1. Removing of tracks and appurtenant material.
- 2. Saw cutting the concrete and removing approximately one foot of the truck pavement in the south truck lane to the center of the first highway stringer.
- 3. Remove the center steel barrier to the south truss of the bridge.
- 4. The various utility facilities were hung on the back wall of the barrier.
- 5. The railroad stringer bracing which was no longer required for the highway construction was removed.
- 6. New steel maintenance platforms were hung from the south truss at the lower deck level at specified locations with steel ladders leading to the upper deck.
- 7. Precast roadway deck units were placed, fastened to railroad stringers and joined by a concrete fill.

Tracks Removed

All track material was removed over the existing railroad, segregated and then stored in the proper bins or stacks in the East Bay storage yard. The material was held for disposal through contracted sales.

A one foot width of the lower deck adjacent to the center barrier was notched with a concrete saw. The concrete was broken out to the center of the highway stringer which provided a seat for one of the four lightweight concrete slabs that were placed in each panel.

The longitudinal steel bracing between the railroad stringers was removed to reduce the dead load and the maintenance painting of these parts. The converted railroad stringers are now braced by the continuous concrete deck slab which the stringers support.

The new deck units, approximately six feet in width and with lengths to fit the various panels were trucked to the site, lowered into position on the railroad stringers and then joined together by high early strength concrete.

Before the innermost panel was placed, the steel barrier which is composed of a curb and wall was skidded over the railroad area to its new position along the south truss of the bridge. After adapting and fastening, the salvaged barrier became the new south curb and rail for the 58-foot roadway.

Utility Facilities

The various utility facilities which consisted mainly of a four-inch pipe for compressed air and another for water, primary and secondary electric power cables, and a communication line were hung on the outboard side of the rail.

Salvaged and additional working platforms were suspended from the south truss at about 300-foot intervals which provides the maintenance personnel with a safe working space for the attachment to the outlets of the various utility lines. A steel ladder leads to the upper deck from each platform for easy access to these outlets. These facilities are in turn connected to the traveling painting scaffolds at or near each platform by flexible hoses and conduits. Communication to each end of the bridge can be obtained with a plug-in headset.

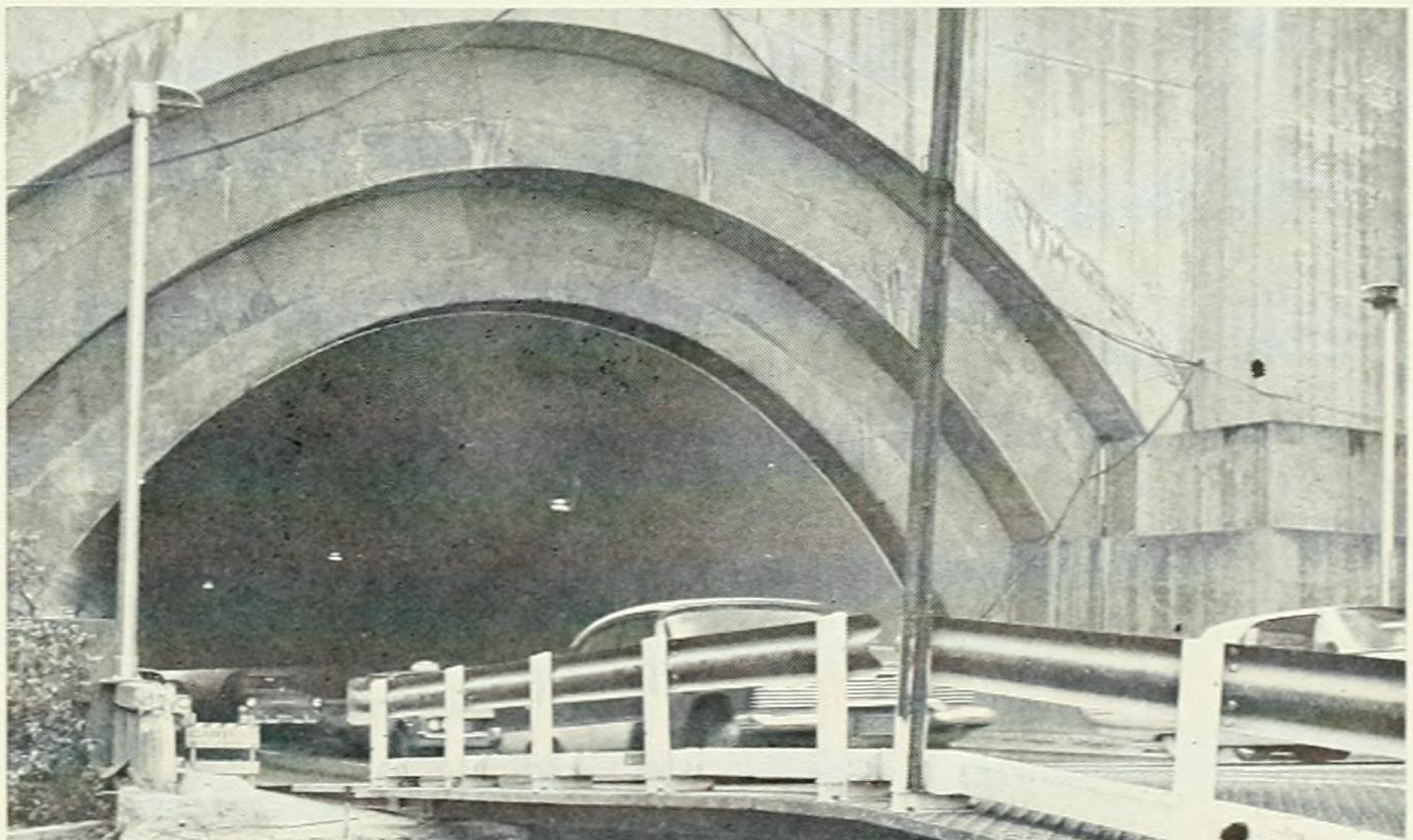
Precast Concrete Units

It was decided to precast the lightweight concrete deck units, transport them to the space vacated by the tracks, then set and join them together at each stringer with a high early strength concrete for the following reasons:

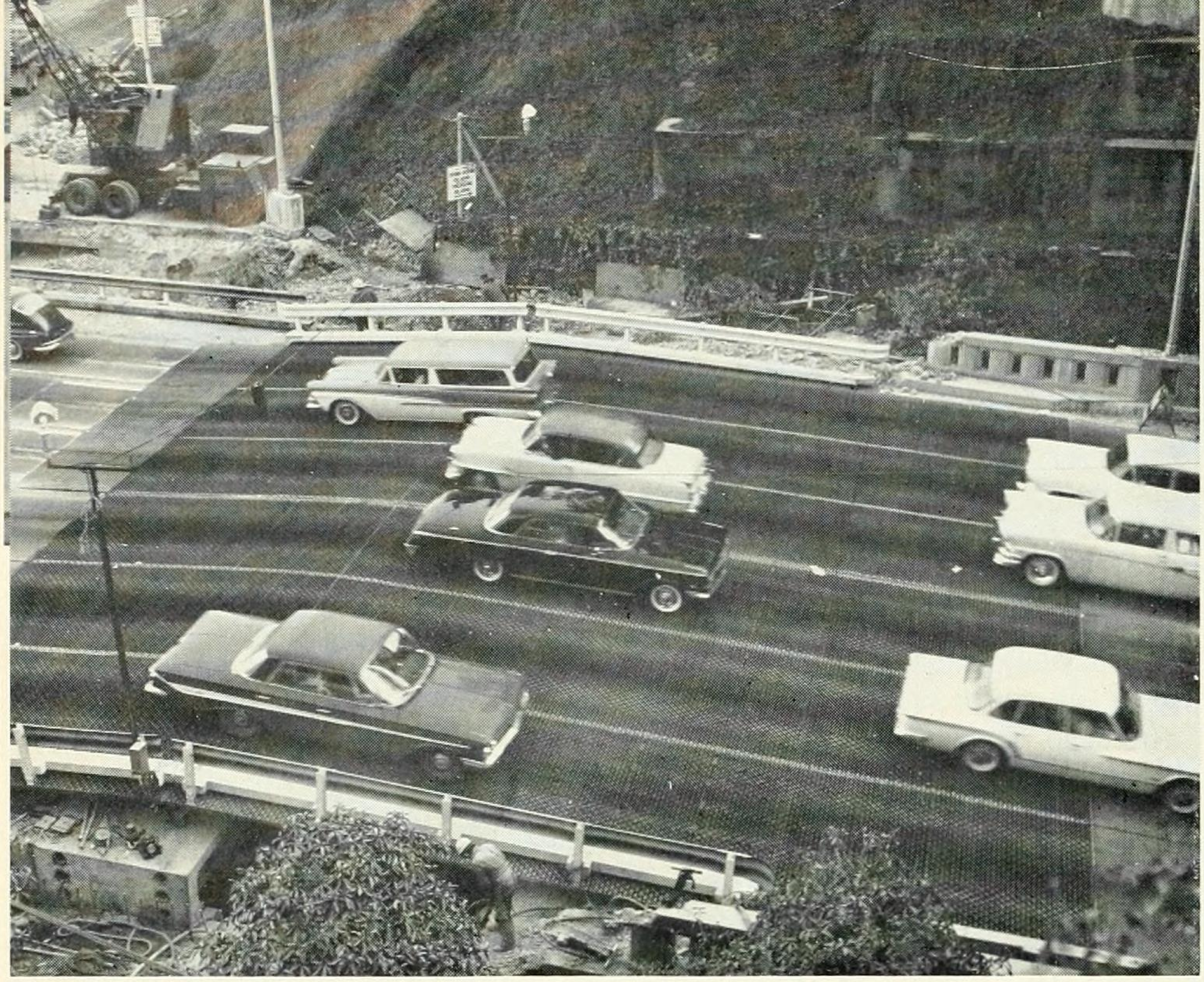
- 1. A poured-in-place slab would have required the inboard truck lane during the pouring and curing stages, thus cutting the lower deck roadway to two lanes.
- 2. There would be some doubt as to the strength of the concrete in certain areas of the bridge due to the excessive vibration of the structure.
- 3. The high early strength concrete used to connect the units together along the stringers does not require the strength that is needed in the slab.

East End of Bridge

The east end of the bridge presented several problems which resulted from the location of the columns supporting the upper floor system, and the separation of the railroad structure from the highway ramp where they

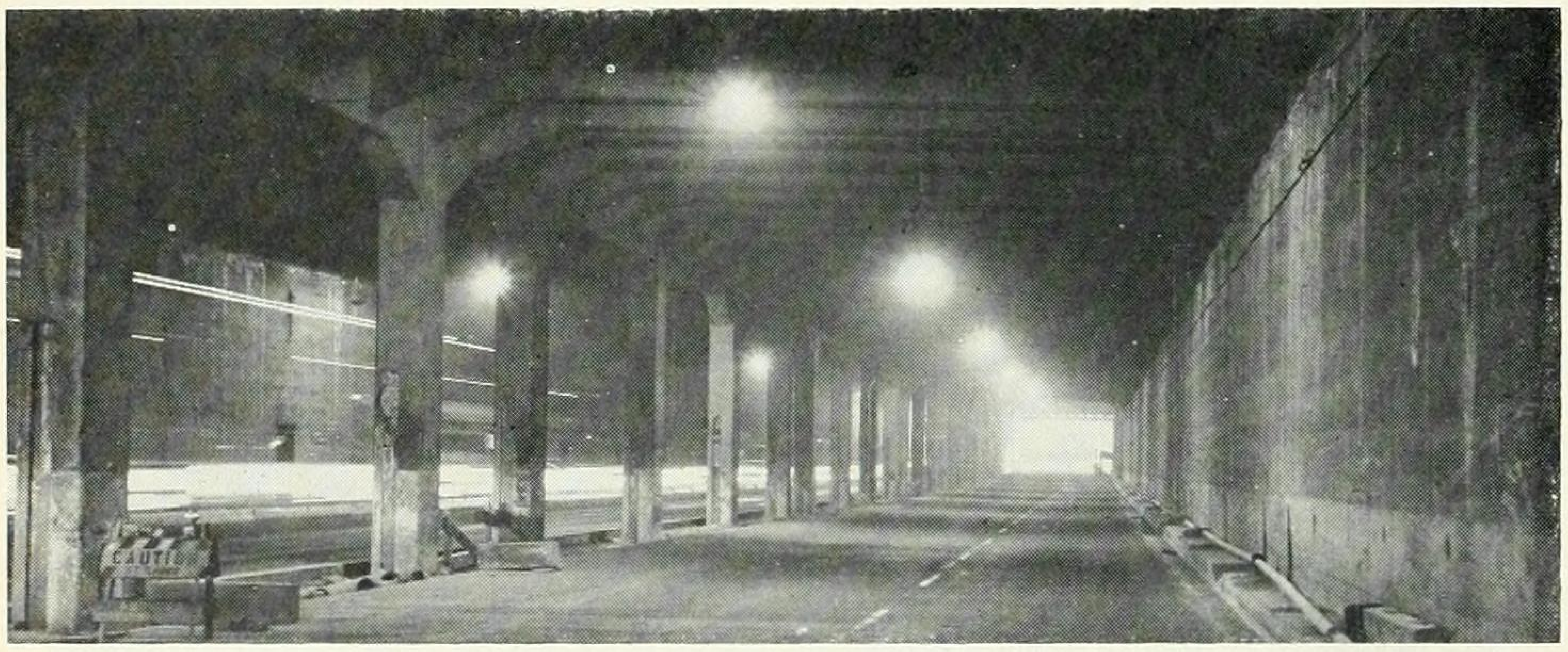


Photograph of movable bridge from viewpoint on same side of bridge as cutaway section of tunnel reconstruction. Outer ends of new deck units are seen in right foreground. The prefabricated, prestressed units fit neatly together, and no additional decking is necessary.



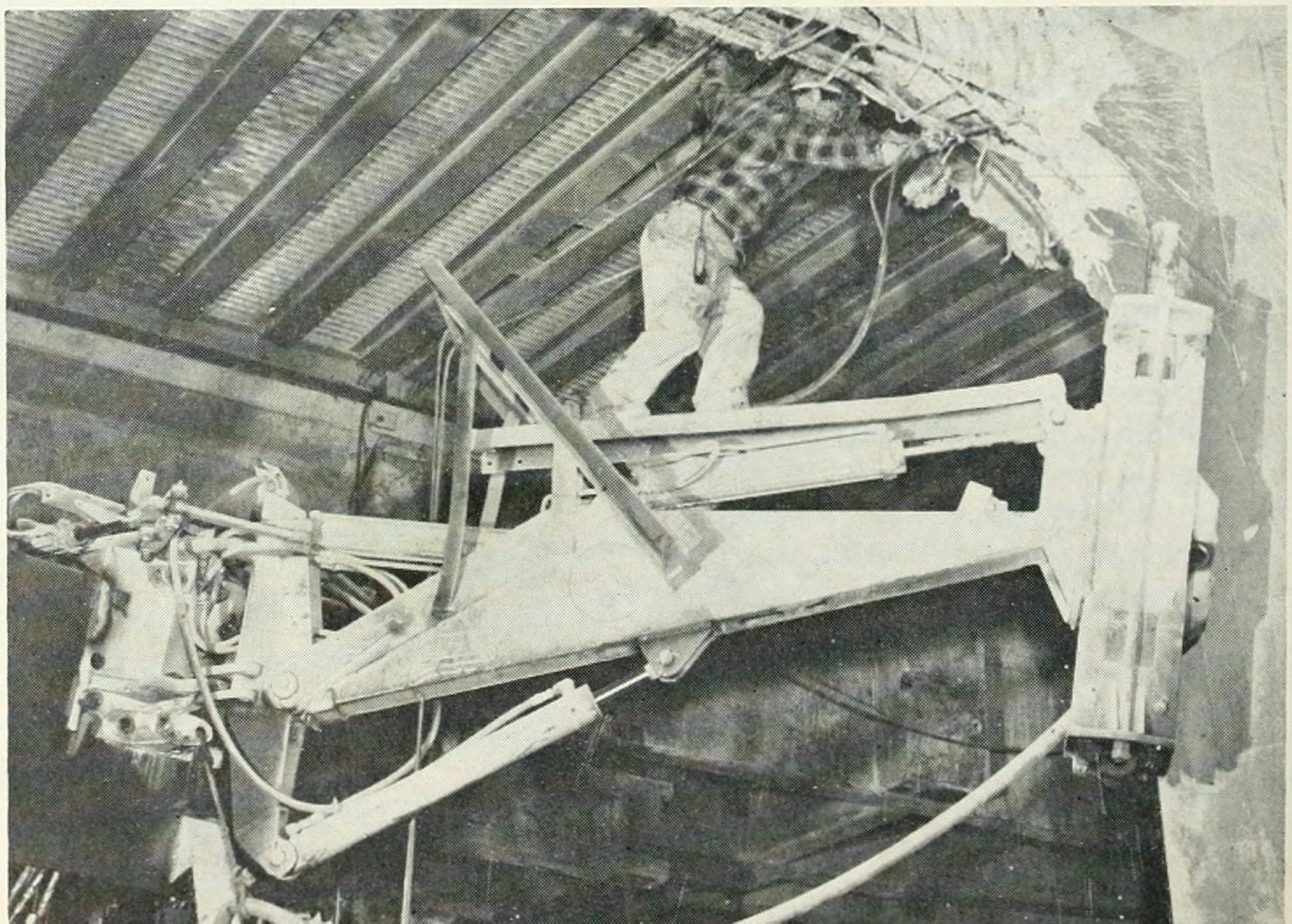
Above: Looking down from slopes at east entrance to tunnel, Yerba Buena Island, showing traffic crossing movable steel bridge. Many caution signals were posted and speed limit across movable bridge was reduced to 15 mph.

Beneath 90,000 Cars a Day

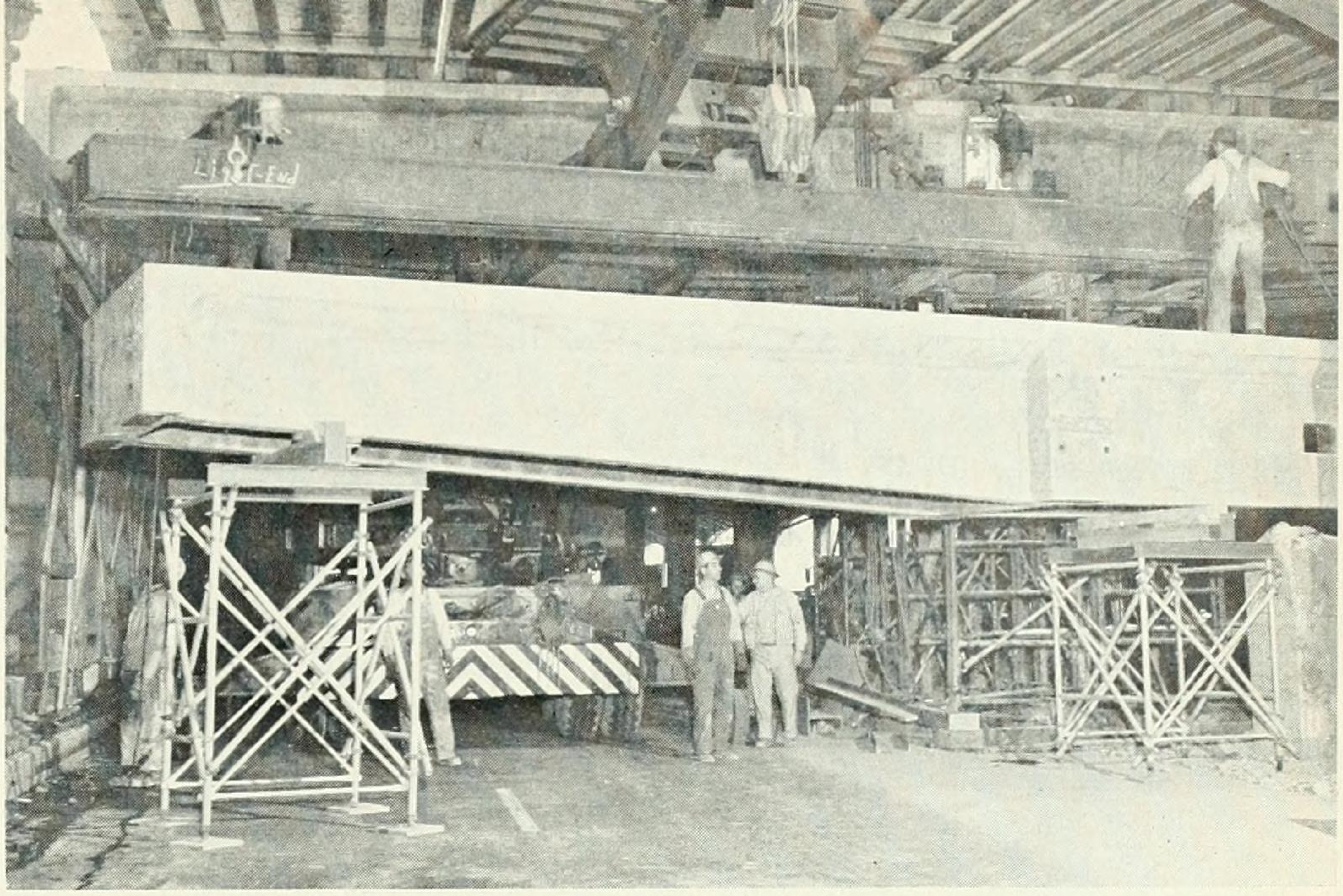


Left: View through lower level of tunnel, showing center columns to be removed. Construction crews are working in back of camera. Light lines far side of columns are lights of vehicles moving through tunnel over paved area which was once occupied by railroad.

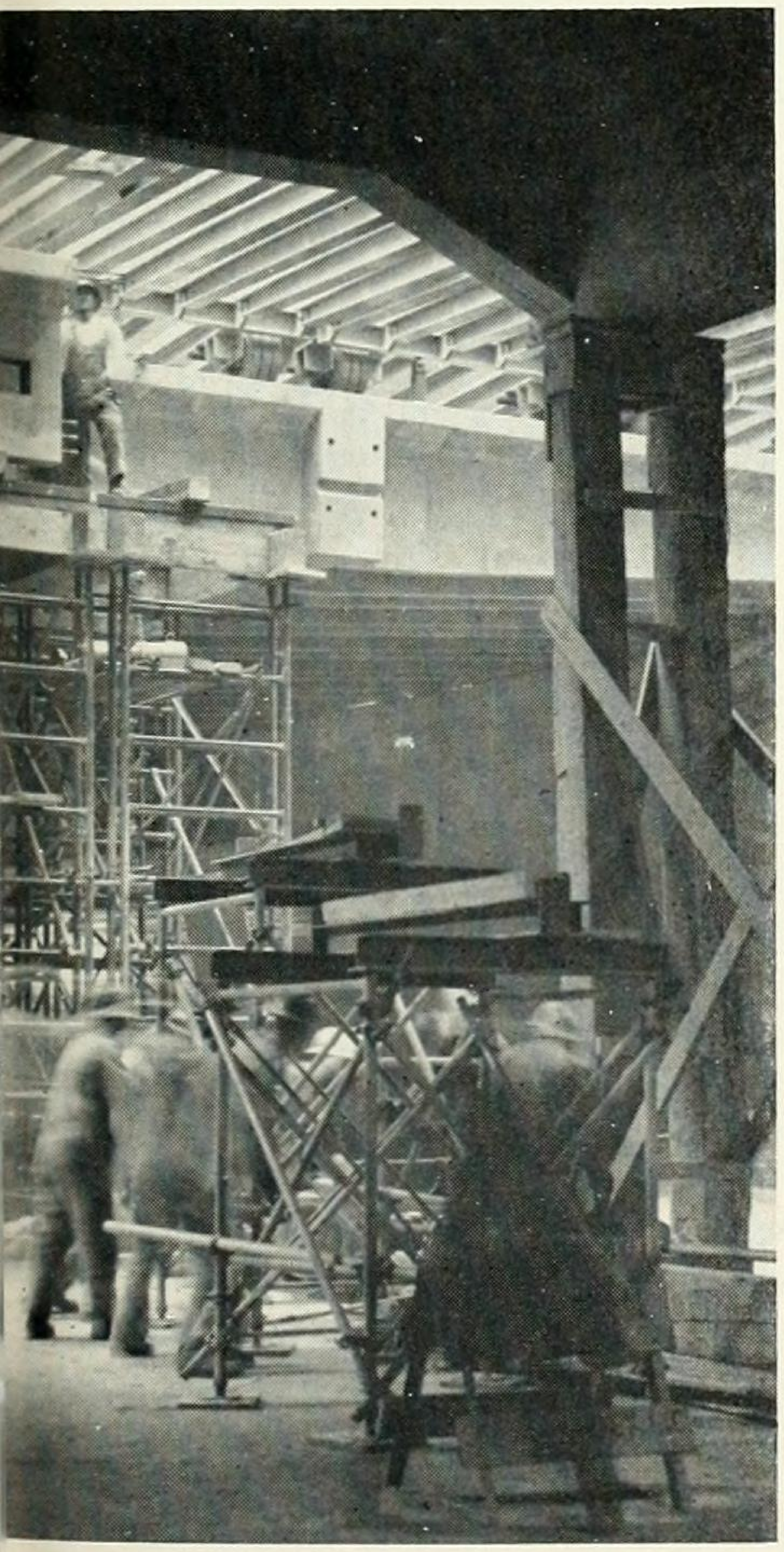
Double mounted air hammers, one vertical and the other horizontal for breaking out upper deck and columns. View shows movable steel bridge left and old reinforcing right. Workman is cutting away reinforcing steel with torch.



Huge precast concrete unit removed from truck and placed on temporary staging before lifting into position. After steel strongback is removed, crane in background places boom with special lifting platform beneath unit and positions unit in place. Men in background, upper right, are joining two previously placed right and left units.

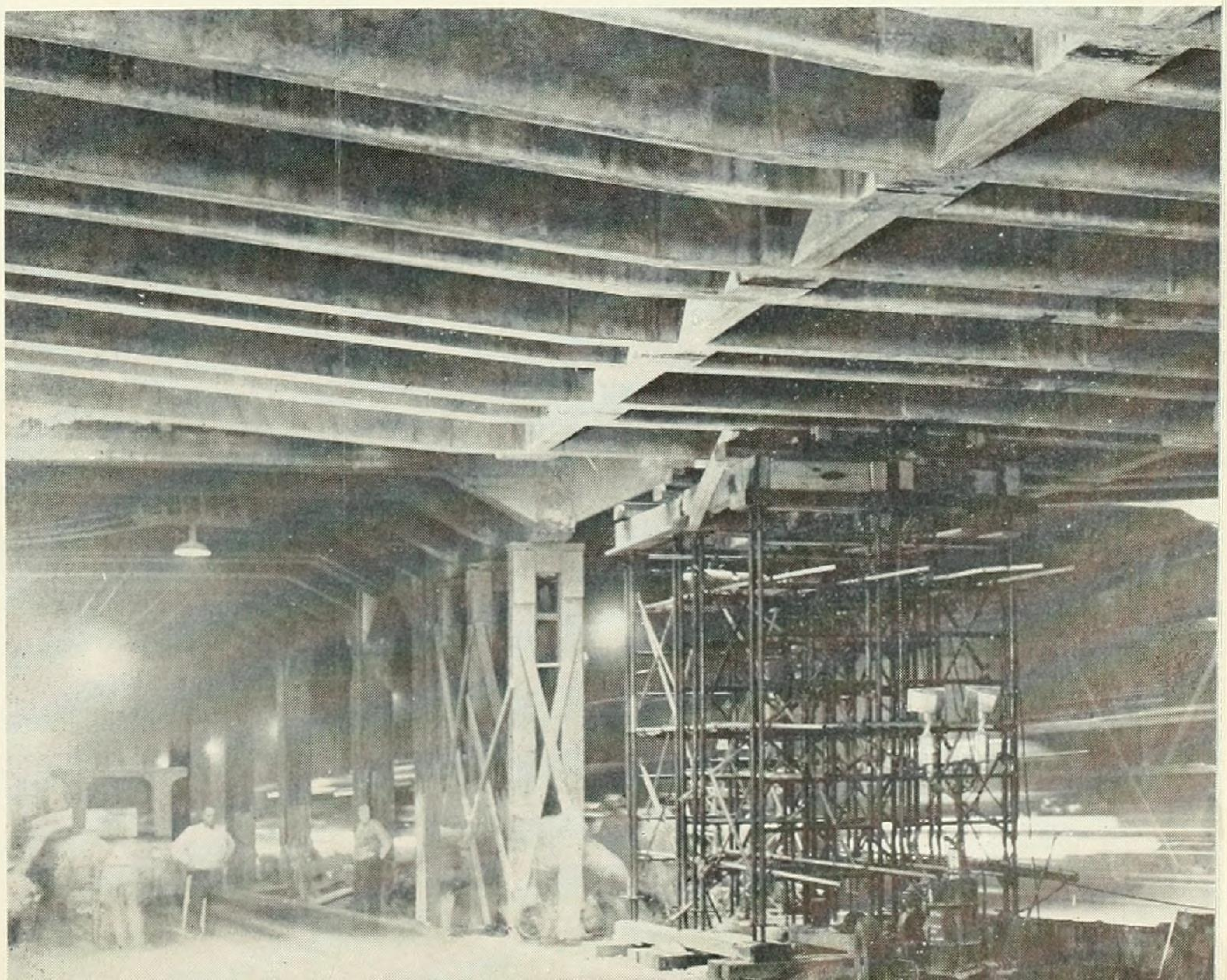


A 48-hour cycle



Above: With unit in position on falsework, workmen rapidly clear lanes of equipment preparatory to shifting traffic. Movable steel bridge is seen above head of workman on falsework. Rectangular hole in legs of unit are for jacking struts. Ends of three high strength steel rods are protruding from end of unit.

Below: Camera facing in other direction, shows truck backing into position with another unit, traffic now moving in other lanes. In upper part of photo is seen a number of units completed, with falsework removed.



both connect to the East Bay mole at the end of the structure. It was thought advisable under this contract to strengthen the upper deck run off spans between E23 and E39, a distance of 645 feet together with the 250 feet of concrete approach, as traffic could be shifted quite readily on the lower deck roadway during this construction period.

The eastbound two-lane highway structure was connected with the railroad ramp by decking between the two roadways. Additional stringers were required to support the slab and when completed formed the five lanes that are required for Oakland-bound traffic on the south side of the mole.

Several columns that were spaced between these two roadways had to be removed which in turn required the lengthening of the upper deck transverse steel floor beams and the strengthening of these members by an additional beam. Other columns had to be constructed on the south side of the piers to support these lengthened members.

Upper Deck Adequate

The present lightweight concrete upper deck with its steel reinforcing together with the stringers supporting the deck proved adequate to accommodate the heavier vehicles.

The reinforcing for the floor beams was accomplished by a unique method of connecting a high strength steel plate girder section to the lower flange of the floor beam. The beams were fabricated with a predetermined camber, as they were of different lengths, and then placed under the floor beams. The two ends were jacked into position, causing the reverse camber of the auxiliary beam to relieve the floor beam of its dead load stress. After the new member was brought into position, the two flanges were bolted together starting from the center.

Settlement Surveys

Settlement surveys have been periodically made of the overwater piers using the permanent bench marks established in the early 1930's during the construction of the bridge. At that time the only settlement occurred during the erection of the steel superstructure, and since then the movement in the piers have been so small that it is difficult to detect with the delicate instruments required for this type of work.

The mole highway on the east end of the bridge was constructed by a hydraulically placed sand fill which was pumped into an excavated area between the bridgehead and the shore. On this fill are located the toll plaza, mole highway approach to the bridge, and a concrete cellular approach structure which has settled with the fill and piles on which it is supported.

This structure was raised by progressively jacking the end of each span a small amount and then blocking. The operation was repeated until the deck was raised to its original grade line. The traveling public was not aware of this operation.

The work under this contract started at Yerba Buena Island and progressed eastward toward the mole; however, some of the subcontracted work such as the structural steel, the electrical and mechanical construction, and other miscellaneous work was carried on in less congested areas.

Curved Sections

There are two curved sections in the east bay crossing having center radii of 1,600 and 2,000 which made the paving operation more difficult than the same work required for the West Bay crossing. There were also two curved runoff spans for the lower deck on the east end of the bridge.

This curved alignment required some specially cast deck slab units and also the addition of extra stringers to support the slab. The steel curbs and rails were replaced as chords and the roadway lanes followed the curve. The space between the south lane stripe and curb is now utilized as refuge bays.

As the deck sections were completed, the 58-foot roadway was striped for five lanes of traffic, with the south lane barricaded for the contractor's use in strengthening the upper deck for the East Bay crossing.

The remaining four lanes were used for two-way traffic during the remainder of the construction.

Electrical and Mechanical Work

A great amount of electrical and mechanical work was required during the lower deck paving contract which consisted in general of the following new construction:

- 1. Change the bridge's main power supply from 5 to 12 KV.
- 2. Provide a four-inch water line across the bridge.
- 3. Install three compressor stations to supply air for bridge maintenance purposes.
- 4. Provide low voltage electrical energy at convenient locations for maintenance forces.
- 5. Communications, control and supervisory system cables installed for more efficient bridge operation.

As the rate for electrical energy is paid on a demand basis at the point of supply, it was thought advisable to provide a service connection in San Francisco at Sterling and Harrison Streets and another in Oakland at the maintenance warehouse on the East Bay mole. A failure in either incoming service will cause the automatic power throwover in the Yerba Buena Island Substation to connect to the energized line.

The bridge's electrical requirements had about reached the capacity of the old 5 KV line and a new and better 12 KV facility distribution was needed.

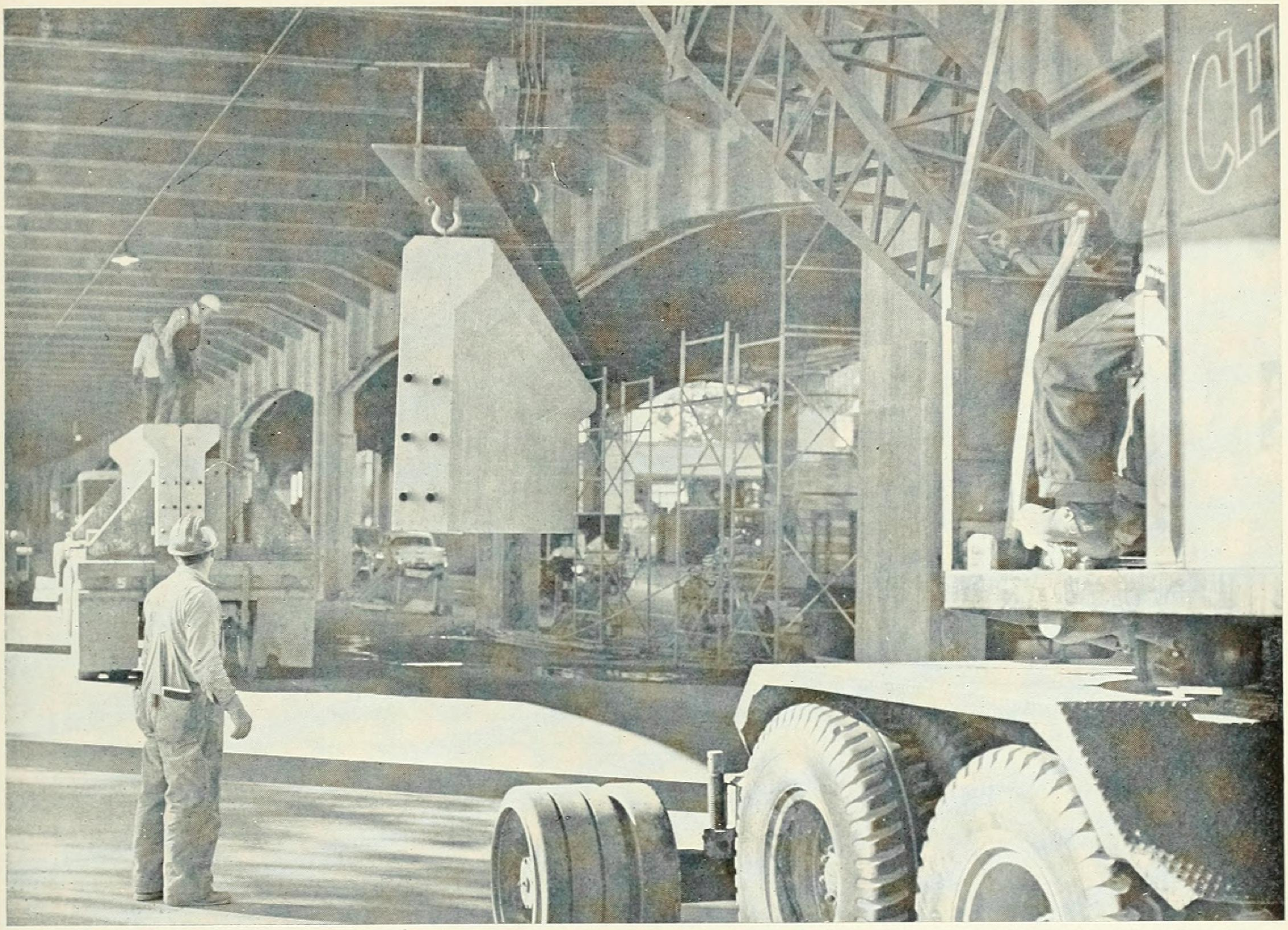
Water Lines Provided

Water is required for various purposes on and at each end of the bridge. Normally the quantity is small; however, the demand could be great in an emergency. To meet the latter requirement, a four-inch water line with a metered source of supply on Yerba Buena Island extends to both ends of the bridge.

A four-inch pipe for the conveyance of compressed air was installed parallel to the water line along the lower deck railing on the south side of the bridge. Valves are provided for hose connections at each of the service platforms suspended at 240- to 300-foot intervals.

Automatic Air Supply

Air is supplied to this continuous line from the Sterling Street Substation in San Francisco, from the substation on Yerba Buena Island, and



Moving precast, prestressed concrete girders into position preparatory to strengthening upper deck supports on section of bridge east of Yerba Buena Island. Units used in tunnel are inverted-U in section, compared to this simple beam section.

the one on the end of the East Bay mole. A drop in air pressure at any of the stations automatically starts one or more of the compressors to renew the supply. The compressors in each substation are so cycled that the last to shut off will be the last in sequence to start again.

There is available at each service platform a terminal box from which 110, 220, and 440 voltages are available for the operation of maintenance and repair equipment.

One large communication cable and one multiconductor control cable run the entire length of the bridge on the south side along with the other maintenance facilities. There is available at each platform, facilities for plugging in portable telephone headset for communication with the person on duty at the administration building.

Communications and Telltales

These cables, with some of the other existing multiconductor cables extending across the bridge and connecting to an indicator board at the toll plaza, will receive the calls from persons in stalled vehicles and signals from five alarm stations. There will also be installed a supervisory system which will indicate by visual, audible and recorded means the malfunctioning of any mehcanical and electrical apparatus. Also a control system whereby various operational functions, such as lighting and signals, are remotely controlled, and a monitoring system indicating their functioning behavior.

Besides the three substations previously mentioned, there are two additional stations on the bridge, one at Center Anchorage Pier W-4 and another on the East Bay spans at Pier E-9 where transformers are installed to reduce the 12 KV voltage to the various voltages needed in the bridge operation and also the necessary switchgear to distribute the electrical energy.

The longitudinal expansion and contraction of the bridge due to temperature changes, the vertical and horizontal movements from wind, and loading conditions are provided for at various pier locations. The continuous runs of pipes have articulated joints to provide for the universal movements at these locations and the electrical and communications cables were so draped to minimize the effect of these movements.

The third and last article on the reconstruction of the San Francisco-Oakland Bay Bridge will be published at the completion of this work.