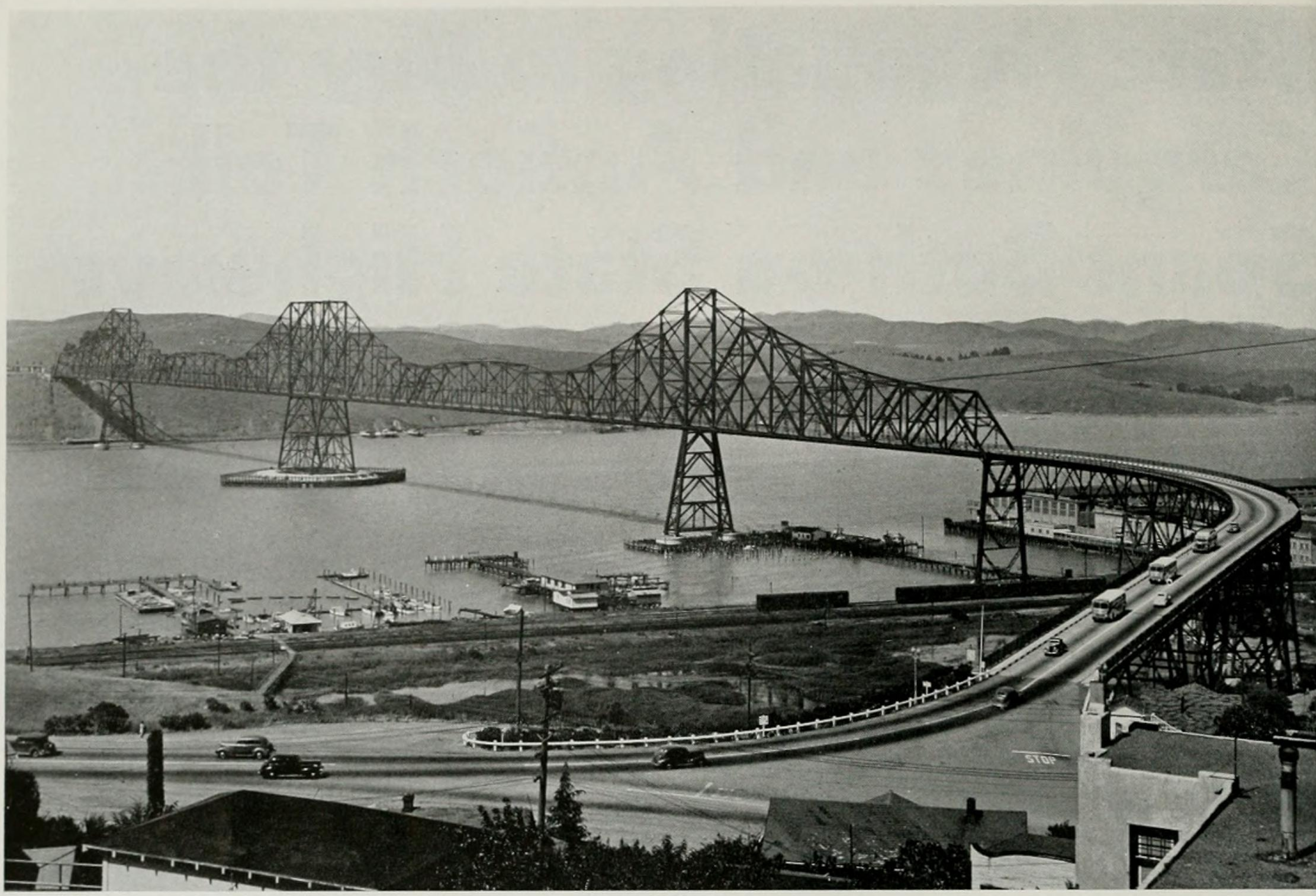

Privately owned Carquinez Toll Bridge across the Straits of Carquinez on State Highway Route 7, U. S. 40.

convinced that the cost of the bridges will be amortized and paid and the structures made toll-free highways within approximately the same period of time as would be the case under the existing franchises held by the American Toll Bridge Company.

IN THE PUBLIC INTEREST

It is my considered judgment that public interest and necessity require the immediate purchase of these bridges by the State. Following the action of the Toll Bridge Authority in directing me to enter into negotiations with the American Toll Bridge Company, two questions having to do with State ownership of the bridges and which required investigation were raised. On May 21, officials of Contra Costa, Solano and Sacramento counties, meeting with me in Sacramento, requested an opinion as to whether the State, in the event it purchased the bridges, would continue to pay to the three counties until 1948 the taxes they now receive annually from the American Toll Bridge Company under their franchise rights.

The proposal to acquire the properties of the American Toll Bridge Company contemplates the setting aside of $44,000 a year from bridge revenues for payment of taxes to the three counties involved for the remaining life of the franchises, provided the State is legally bound to pay these taxes.

QUESTION OF PROPERTY RIGHT

It is the view of the Legal Division of the Department of Public Works that the property right of the American Toll Bridge Company in the Carquinez Bridge is not ownership of the physical structure, i.e., the bridge, itself, but rather the right to take tolls for the remaining period of the franchise, that is, until March 7, 1948.

I have asked Attorney General Earl Warren for a ruling on the question of whether the State will, in the event it buys the Carquinez and Antioch bridges, be legally obligated to continue tax payments to Contra Costa, Solano and Sacramento counties.

On May 26, I met in Martinez with officials of that city and of Benicia and Contra Costa and Solano counties to discuss the question of the future of the Martinez-Benicia Ferry following State purchase of the American Toll Bridge Company properties.

WANT FERRY CONTINUED

Citizens and civic groups of Martinez, Crockett, Benicia, Vallejo, and of Contra Costa and Solano counties had requested assurances from Governor Olson, the Toll Bridge Authority and myself that the ferry service would not be abandoned if the State acquired the bridges and the ferry.

In order to determine what action the State should take with respect to the Martinez-Benicia ferry, I directed the Division of Highways to institute on May 28 a traffic count on the Martinez-Benicia Ferry to ascertain the origin, destination and amount of traffic using the ferry. This count was made over a seven-day period. Our analysis of the survey will assist us in determining whether continu-


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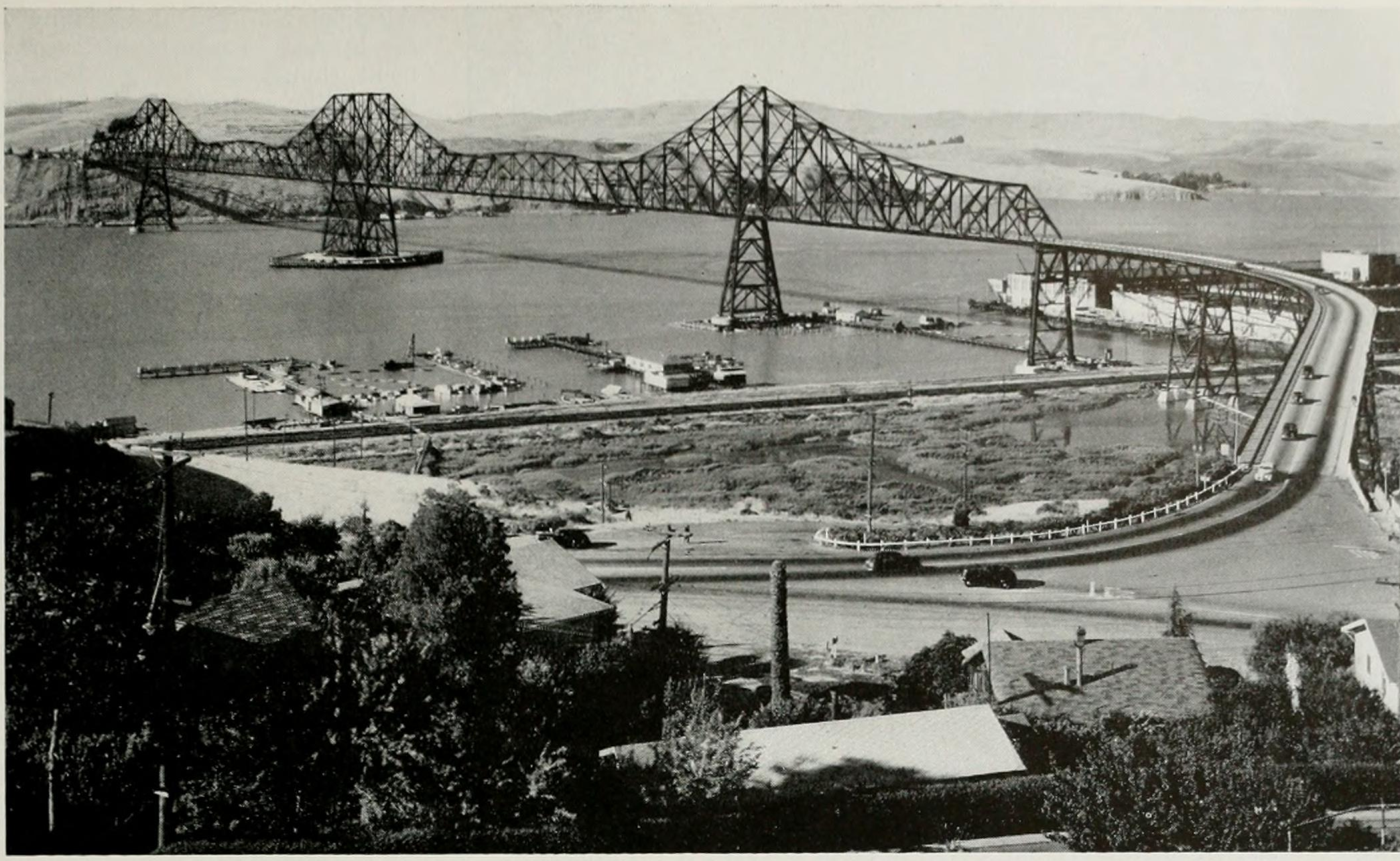
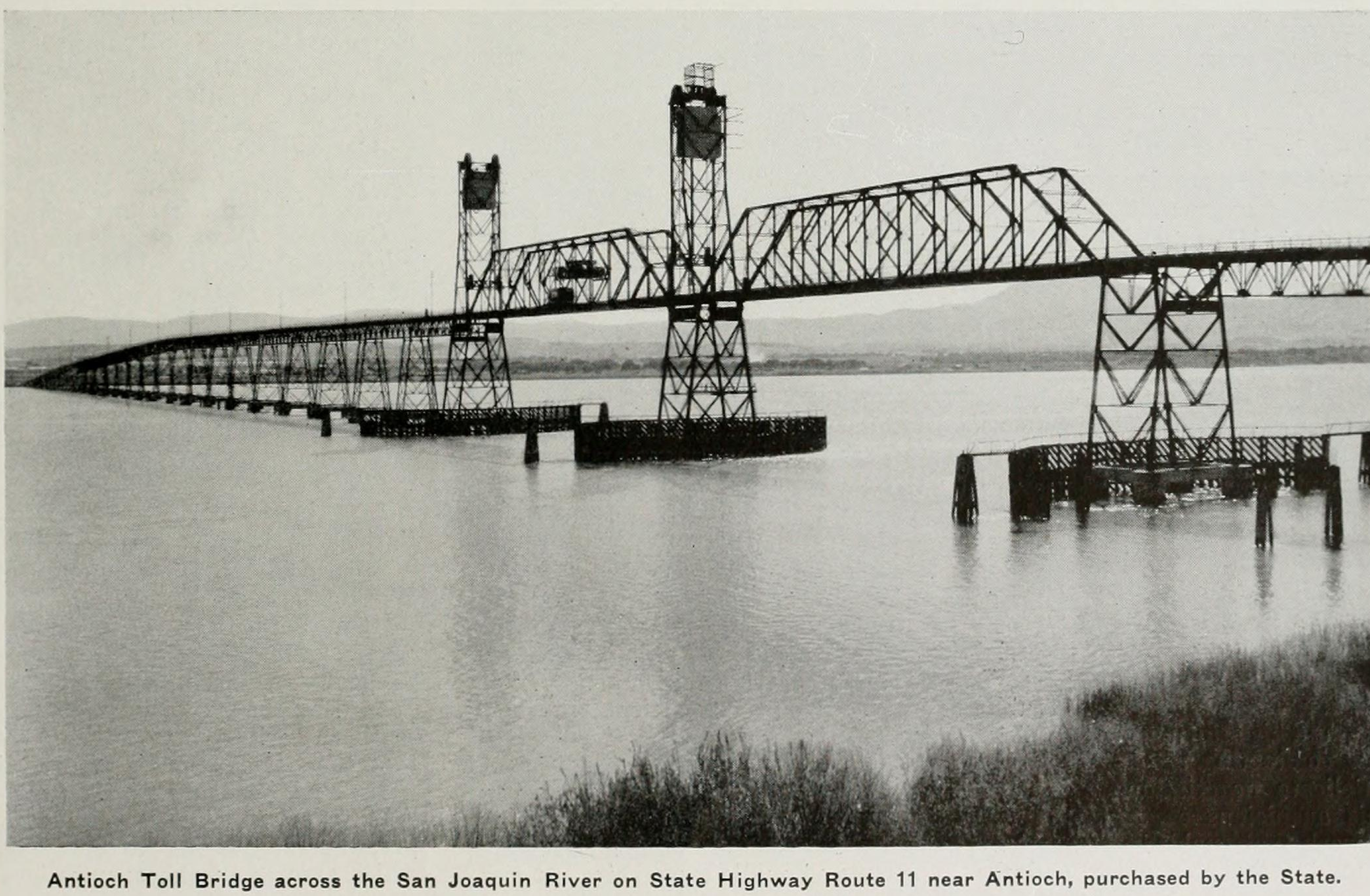
CALIFORNIA
HIGHWAYS AND PUBLIC WORKS
CARQUINEZ TOLL BRIDGE, ACROSS STRAITS OF CARQUINEZ
ON U. S. 40, PURCHASED BY STATE
(SEE ARTICLE IN THIS ISSUE)
SEPTEMBER
1940



Carquinez Toll Bridge across the Straits of Carquinez on U. S. 40 (State Highway Route 7) purchased by the State.



Antioch Toll Bridge across the San Joaquin River on State Highway Route 11 near Antioch, purchased by the State.

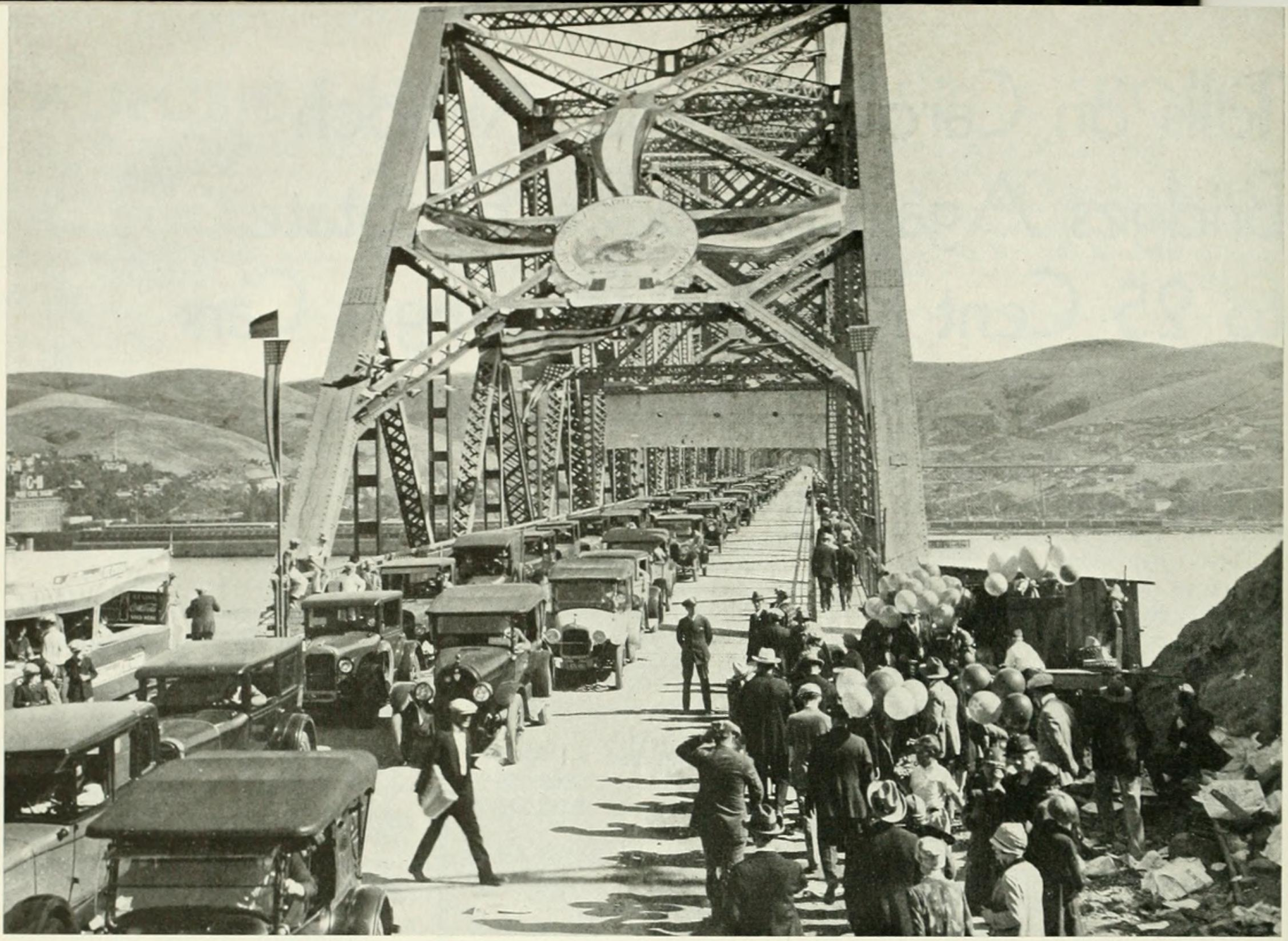


Photo Courtesy of Sacramento Union

Photo of Carquinez Bridge on May 21, 1927 when President Coolidge pressed a button in Washington and opened it to 50,000 cars of the vintage of sixteen years ago and prior which crossed it that day

provides that the members shall consist of the Governor, Lieutenant Governor, Director of the Department of Public Works, Director of the Department of Finance, and the Chairman of the Highway Commission.

The first act of this new agency was to launch construction of the San Francisco-Oakland Bay Bridge, which was completed and opened to traffic on October 12, 1936.

As late as January 1939, when Governor Olson took office, a toll of 50 cents per car was being charged on the Bay Bridge. The legal constituency of the Toll Bridge Authority places this agency under control of the Governor immediately upon his inauguration.

GOVERNOR ACTED TO CUT TOLLS

In May of 1939, less than five months after he became Governor and Chairman of the Authority, Governor Olson consulted with Jesse Jones, chairman of the Federal Reconstruction Finance Corporation, in an effort to arrange for reductions of tolls on the San Francisco Bay Bridge.

After correspondence and telephone conversations with Jones, Governor Olson dispatched Director of Public Works Clark to Washington to follow up the negotiations. These were so successful that on June 15th, of the same year, tolls for automobiles were reduced from 50 to 40 cents.

The reduction of tolls had an immediate effect on the stimulation of traffic, which in turn made possible further cuts. On January 1, 1940, tolls were established at 35 cents. On May 25th of the same year, they were cut to 30 cents, and only shortly thereafter, on July 1st, were reduced to the present charge of 25 cents. Not only have toll costs to motorists been cut, but other charges for the use of the bridge, including freight rates, have been materially decreased.

Despite the fact that the Legislature, in passing the Toll Bridge Authority Act in 1929, had declared it to be the policy of the State to own all toll bridges located on its highways, and that same body in 1937 had given specific approval to the acquisition, by purchase or by eminent domain of the Carquinez and Antioch bridges, no effective steps had been taken by the previous administration toward that end.

Extortionate tolls on these bridges had for years discouraged traffic over important highways. Prior to 1938 the toll charged on the Carquinez span had been 60 cents per car plus 10 cents per passenger. In that year, the State Railroad Commission had on its own motion investigated and ordered a reduction in charges to 45 cents per car and 5 cents per passenger.

The Toll Bridge Authority, under the leadership of Governor Olson,

(Continued on page 15)

Parallel Bridge Across Carquinez

By C. H. DARBY,
Senior Bridge Engineer

Legislature and Governor Provide for New Strait Span

GOVERNOR GOODWIN J. KNIGHT on June 16th signed Senate Bill No. 1450 providing for construction of an additional Carquinez Strait Bridge and a bridge between Benicia and Martinez as toll facilities and promptly called a meeting of the California Toll Bridge Authority, of which he is chairman, to set in motion legalities for the issuance of revenue bonds, to finance the projects.

The estimated cost of the bridges is $73,000,000 including the cost of bond financing. The Senate bill, introduced by Senator Luther E. Gibson of Vallejo, includes more than eight miles of Carquinez Bridge approaches on US 40. Construction of the parallel Carquinez Bridge will start as soon as bond financing by the California Toll Bridge Authority can be arranged under the terms of the legislation.

Depending on the speed with which these financing arrangements can be completed, actual construction on the Carquinez project can begin this fall. Completion of the new bridge and sufficient approaches for the start of toll collections would be scheduled for some time in 1958.

Plans Advance Rapidly

Plans for the Benicia-Martinez structure are being advanced rapidly with the aim of opening that bridge to the public in 1959.

Construction plans are already well advanced on the new Carquinez Bridge and the south approach. The object is to open that portion of the facility to traffic as early as possible for two important reasons: relief from the congestion which is particularly serious on the present south approach as well as on the existing bridge itself; and assurance of an early start on repayment of the bonds from toll collections, which is expected to encourage more favorable interest rates on the bonds.

The expected order of work on the Carquinez project is as follows:

Award contract and begin construction of the bridge substructure.

Award contract for the superstructure, so that fabrication of steel can get under way in the mills while the substructure is being placed.

Start the grading for the south approach so that the very deep and wide cuts through the Valona Hills will have time to stabilize before paving is undertaken.

In the meantime, approach construction through Vallejo will be expedited, although operation of the new bridge is not dependent on that portion of the work in view of the existing multilane divided highway.

Existing Structure Inadequate

A look at the map reveals how the waterway formed by San Francisco Bay, Carquinez Strait, and the San Joaquin River effectively cuts California in two and blocks north-south motor vehicle travel for nearly half the width of the State. For 90 miles from Stockton to the Golden Gate, the waterway is bridged at only two places by highway spans. In 1927 the present bridge across Carquinez Strait provided a long-needed access across this barrier at one of these locations. The Carquinez Bridge was one of the engineering marvels of its day and its double spans still merit recognition as the fifth longest cantilever spans in the world.

Modern traffic and California's phenomenal growth have taken their toll of the old structure, however, and now its three-lane roadway is inadequate for the thousands of vehicles which daily crowd across it. Once

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BRIDGE RESOLUTION

Now, therefore, be it resolved by the California Toll Bridge Authority, as follows:

1. The California Toll Bridge Authority hereby determines that, if financially feasible, it is for the best interests of the public highways of the State of California that the above-mentioned facilities be constructed, and the existing Carquinez Bridge be modified and improved, all under the provisions of the California Toll Bridge Authority Act.

2. The Director of Public Works is hereby authorized and directed to cause the Department of Public Works to complete all necessary engineering, traffic, revenue, financing, and legal studies, and to prepare and submit to the California Toll Bridge Authority the recommendations of the Director of Public Works, together with the preliminary estimates of the cost of construction of all of said facilities, and estimates of the amount required to be raised for that purpose by the issuance of revenue bonds. * * *

3. The Director of Public Works, in preparing his recommendations and in considering the form of any bond resolution, is requested, if found legally and practically feasible, to provide for the reimbursement of the State Highway Fund of any advancements made therefrom from and after the effective date of Chapter 960, Statutes of 1955, for the purchase of rights of way required for the ultimate completion of the facilities mentioned in said Chapter 960.

4. In the event the Director of Public Works determines that he will recommend to this authority that revenue bonds be issued for the construction of the facilities mentioned in Chapter 960, Statutes of 1955, the department is authorized to advertise for construction bids at such time and in such manner as to permit the execution of construction contracts simultaneously with the delivery of, and receipt of proceeds from, revenue bonds to be issued by this authority.

again Carquinez Strait has become a bottleneck to north-south travel.

This problem did not come suddenly.

Long ago it became obvious that something was going to have to be done to increase the capacity at Carquinez. The old bridge has only a 30-foot roadway—really too narrow for the three lanes which now use it. This inadequacy is not the fault of the structure itself. The traffic has jumped from less than 1,000,000 vehicles per year, when the bridge was first opened, to over 10,000,000 at the present time.

As a logical first step, the old bridge was examined to see if revisions could

be made to increase its capacity. One of the first ideas was to double-deck the old structure to provide three lanes in each direction. However, even as these studies were being made, the traffic reached a figure of 18,000 vehicles per day crossing the structure. It was obvious that three lanes in each direction would not be adequate as an ultimate solution.

Only Logical Solution

Next a temporary solution was sought by hanging additional lanes on brackets on the outside of the trusses. This would have provided a solution only for a short time and the bridge would have been overcrowded almost before the repairs could be completed. From all of these studies the present plan emerged as the only logical solution.

The new design for which plans have been prepared will provide for a new four-lane parallel bridge about 200 feet upstream from the present one. Traffic will travel north on the new bridge and south on the old. Remodeling of the present bridge, utilizing an outrigger lane on each side, would provide an ultimate four lanes on that structure.

There will be very little interference with traffic during construction. While the new bridge is being built, traffic will be maintained as usual on the old structure.

All Possible Crossings Studied

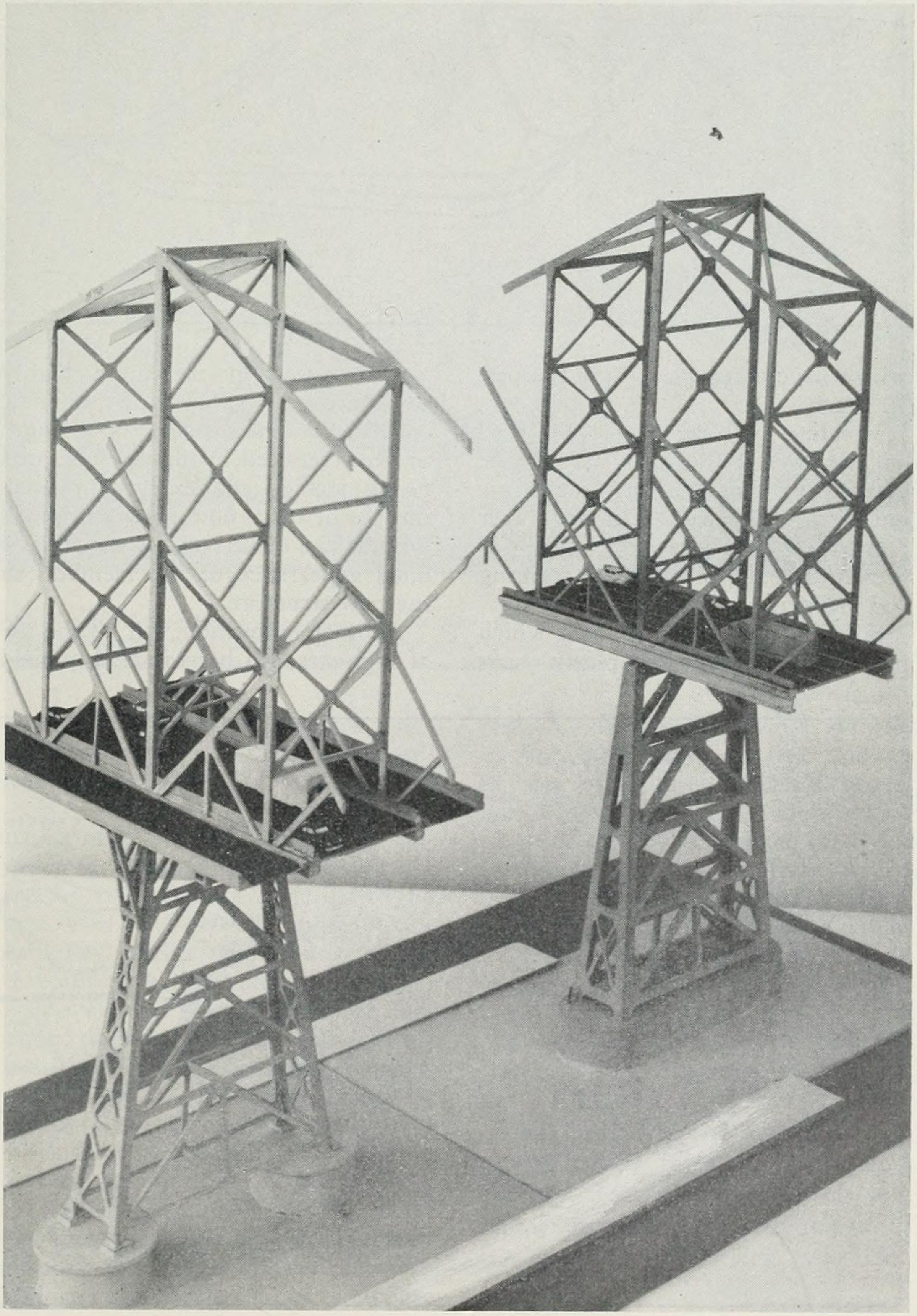
Before settling on a final design which provided for the construction of a parallel bridge, all of the possible crossings of Carquinez Strait from Selby Point to Dillon Point were considered. Along this three-mile stretch of the strait, the Carquinez Bridge location is the best for a number of different reasons. The cost of the approach highway construction through the rough country on each side of the strait east of Crockett ruled out a bridge in that location. Sites to the west also were studied but they likewise proved to be more expensive.

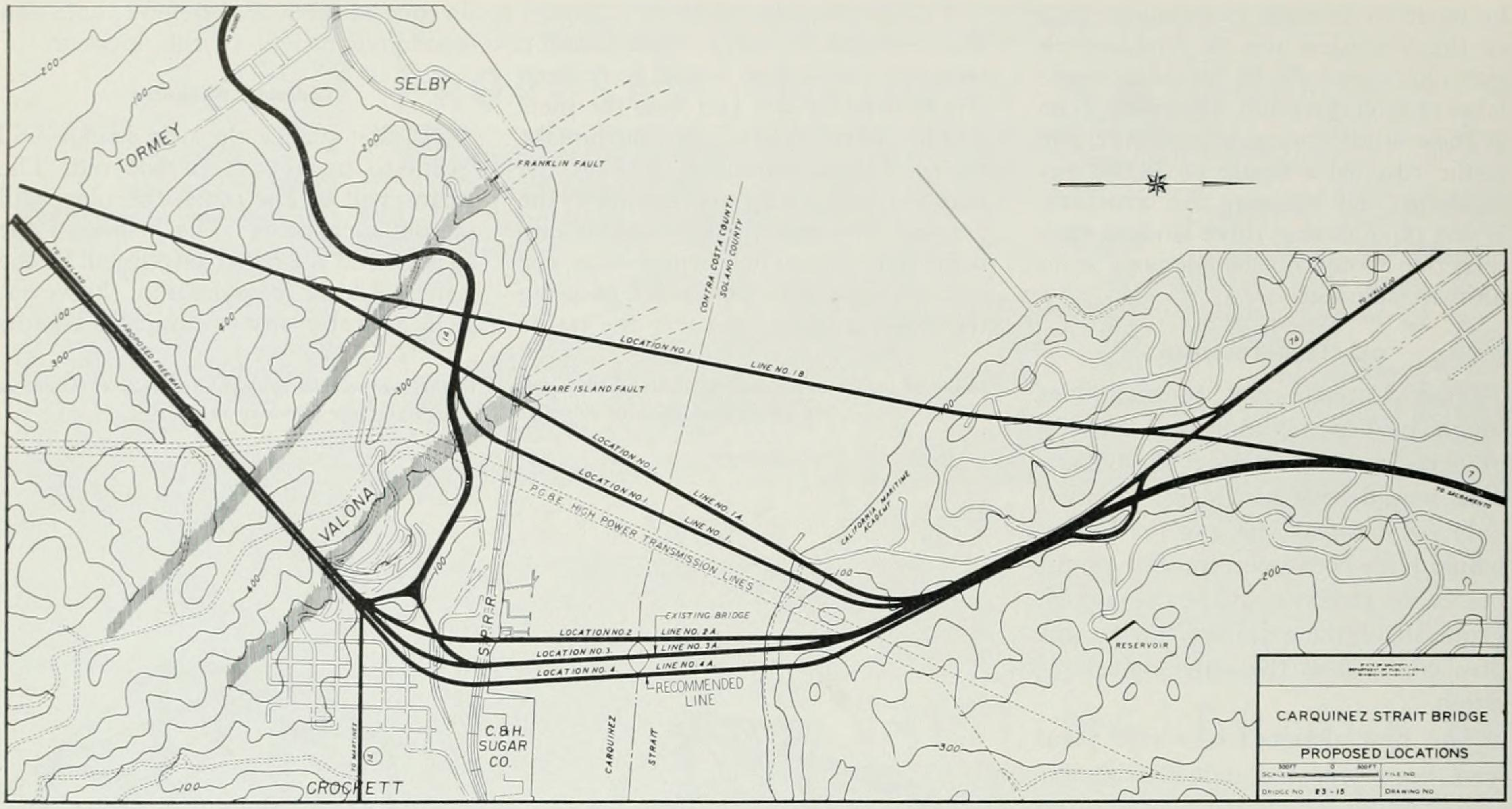
Two earthquake faults run through this area and the only other location seriously considered would have been jeopardized by the fact that the piers would have fallen on earthquake faults. The economy as well as the feasibility of getting approaches to the existing structure finally made it evident that a parallel bridge was the best solution. The possibility of using the existing bridge to carry the traffic in one direction also gave quite an economic benefit to this location.

Technical Advances

At first glance the new bridge will seem to be a twin of the old. The spans will be the same, the piers will adjoin each other. The height of the trusses and the panel length will be the same. Closer examination, however, will reveal many technical advances

Model of trusses and towers for ultimate development of the two parallel bridges at Carquinez Strait. At left, ultimate roadway of existing bridge; at right, new four-lane structure.



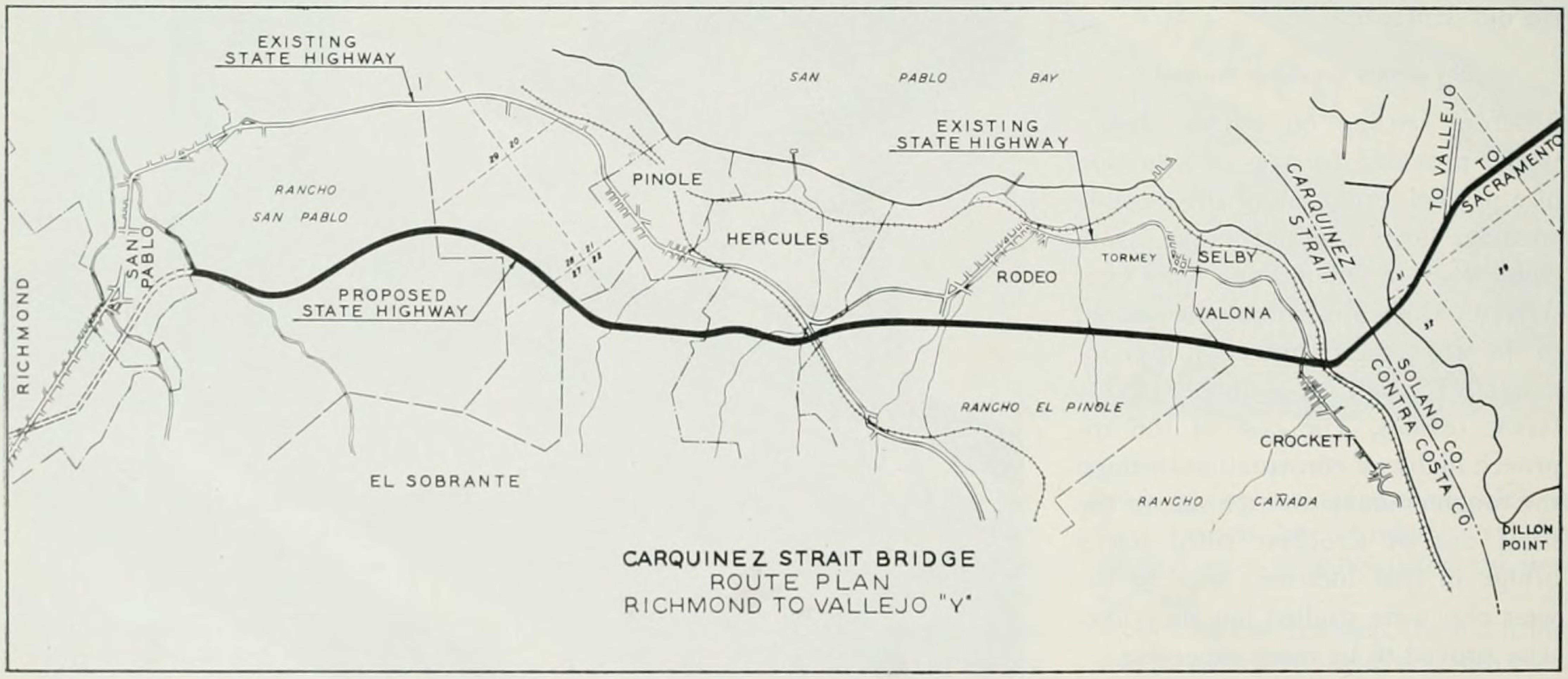


which have taken place over the past 30 years.

Welding will be extensively used and as a result the members will be cleaner and simpler than those in the old truss. This will make for easier fabrication and erection and will greatly ease the problems of painting and maintenance.

Some of the new alloy steels which have been developed in recent years will be used in the more highly stressed members. Some of these new steels have almost twice the strength of the steel used in the old structure. Easily welded and easily fabricated, the use of these new alloy steels will do much to make possible the streamlined appearance of the members in the new structure.

Another innovation will be the use of high strength bolts instead of field rivets. High strength bolts have proved their economy and usefulness and are being used more and more, especially for field connections of steel structures. The high strength bolts require less labor to place than rivets and the resulting connection is more rigid. After installation the bolts can be checked for the load they are carrying and a group can be evenly adjusted to spread the stress over the



CARQUINEZ STRAIT BRIDGE
ROUTE PLAN
RICHMOND TO VALLEJO "Y"

Legislators who sponsored Carquinez Bridge bill view sketch of parallel Carquinez Bridge in Governor Knight's office just prior to signing by the Governor of the act. LEFT TO RIGHT—Director of Public Works Frank B. Durkee, Senator Luther E. Gibson, Vallejo; Senator George Miller, Jr., Richmond; Governor Knight, Assemblyman S. C. Masterson, El Cerrito; Assemblyman Donald D. Doyle, Lafayette, and Assemblyman Samuel R. Geddes, Napa.

entire connection. This completely eliminates the necessity of cutting out and redriving rivets which have been poorly driven or which have loosened after driving.

The increased strength of the new steel alloy makes it possible to reduce the number of pieces required to make up truss members. Whereas the existing truss members were made up of many plates and angles, requiring as many as 5 to 14 separate pieces, the members in the new design will be made up of three to five heavy plates in an H or a welded box section. The use of smaller members, because of the high strength steel, also is effective in reducing the secondary stresses in some of the larger cantilever members. The use of this alloy steel avoids a sort of vicious circle whereby heavier members cause greater secondary stresses which in turn require still heavier members.

Large Concrete Caissons

Three large concrete caissons, 53 feet by 102 feet in plan, similar to the type used on the San Francisco-Oakland Bay Bridge will be used at the three piers in the water. A new and heavy fender system has been designed to protect the piers in the channel. This fender is designed so that it can be put in place before the new piers are constructed, and used as a working platform during the locating and the sinking of the caissons.

One of the more difficult problems has been the location of the highway through the Valona Hills at the south end of the bridge. The hills are rugged, cut by many ravines, and the country is unstable so that a large number of slides and slipouts occur. These hills form a rather high barrier south of the bridge and are the cause of the present poor alignment. In order to achieve a satisfactory approach to the bridge from the south, it would be necessary to either tunnel through these hills or make some massive open cuts. Present plans call for an open cut up to 300 feet deep where the freeway passes through the highest part of the hills.

Because the approach to the south of the bridge takes off across new country, nearly four miles of new highway must be included as part of the over-all project. This will carry

. . . Continued on page 22

Pedestrian Crosswalks Near Schools Will Be Repainted Yellow

All pedestrian crosswalks on state highways in the vicinity of schools will be repainted yellow as a result of a bill passed by the 1955 Legislature and signed into law by Governor Goodwin J. Knight, the Division of Highways has announced.

At present school crosswalks are painted white like other traffic markings.

The new law further specifies that the words "SLOW–SCHOOL–XING" must be painted, also in yellow, in traffic lanes leading to school crosswalks.

Most of the repainting of the crosswalks will be done by the Division of Highways, except that on state highways through cities, where maintenance is by agreement performed by the cities, local authorities are being requested to apply the yellow color. The repainting is scheduled for completion this fall.

The division plans to obliterate the existing white markings by sandblasting to prevent a confusing mottled yellow and white effect which would otherwise arise after the new paint has worn a little.

PARALLEL CARQUINEZ BRIDGE

Continued from page 5 . . .

the freeway south of the Hercules junction, just north of Pinole.

In the four miles south of Carquinez Bridge there will be interchanges, with connections to the local crossroads, and nearby towns. Design is now under way on all of these structures.

North of the bridge, the present route through Vallejo will be converted to a full freeway with no intersections at grade. Separation structures are planned for all of the important cross streets and highway intersections.

MEXICO AND MOTOR VEHICLES

Mexico had 438,250 motor vehicles in 1953, reports the National Automobile Club.

California Wins Fifth Consecutive Traffic Award

For the fifth consecutive year, California has been awarded a first prize for outstanding performance in the field of traffic engineering by the Institute of Traffic Engineers. The award was announced by the board of directors of the institute at its meeting in Atlanta on June 10th.

This year, as last, California shares, first place honors with the State of Michigan in the group of states with the most traffic and population.

Two California cities also received awards. Pasadena won first place in the 100,000 to 200,000 population class among cities throughout the Nation; Los Angeles shared a second place award with Detroit in the 1,000,000 and over group, in which first place went to Chicago.

The committee of judges, all members of the Institute of Traffic Engineers, was made up of six nationally known experts in the traffic and transportation fields.

Awards were based on the annual inventory of traffic safety activities conducted by the National Safety Council and other technical and educational organizations.

Harry Porter, Jr., Institute President and Senior Traffic Engineer for the National Safety Council, announced the awards and complimented the states and cities selected for their accomplishments.

Subsequently, on July 28th, Joe E. Havenner of the Auto Club of Southern California and a director of ITE presented a plaque in recognition of California's first place award at a ceremony in the Governor's Office in the State Building, Los Angeles.

Governor Goodwin J. Knight accepted the plaque and in turn presented it to George M. Webb, Traffic Engineer for the California Division of Highways, who represented Director of Public Works Frank B. Durkee and State Highway Engineer G. T. McCoy.

For the past five years, California has competed in a special group of the Nation's most thickly populated, heavily trafficked states which also includes New York, Pennsylvania, Ohio, Indiana, Illinois, Michigan and Texas.

New Assistant State Architect Is Appointed

Earl W. Hampton of the State Division of Architecture has been appointed Assistant State Architect, Administrative, by Anson Boyd, State Architect. Hampton has been acting in this capacity since the retirement of his predecessor, W. K. Daniels, Sr., last January.

Boyd said Hampton will have administrative responsibility for fiscal and budgetary matters pertaining to the Division of Architecture. Broadly, Boyd added, his job will be to administer and manage all construction contracts, supervise divisional cost controls and operating budgets, and administer and maintain cost controls of construction budgets. Most housekeeping activities of the division will come under the control of Hampton's office. Hampton is a native son of Sacramento County.

Civil Engineer's Society Honors Californians

Raymond J. Ivy, a supervising bridge engineer for the State Division of Highways, and Stewart Mitchell, who retired recently as a principal bridge engineer for the division, have been honored by the American Society of Civil Engineers.

They and four other Californians received the society's Arthur M. Wellington prize for 1955 for a technical paper entitled "Live Loading for Long Span Highway Bridges."

The other recipients are C. F. Scheffey and T. Y. Lin of the University of California faculty and N. C. Raab and V. J. Richey of the State Division of San Francisco Bay Toll Crossings.

Carquinez Project

Revenue Bonds Sold and Major Contracts Awarded

By LEONARD C. HOLLISTER, Projects Engineer—Carquinez

On June 15, 1955, Governor Goodwin J. Knight signed Senate Bill 1450 authorizing the Department of Public Works to "lay out, acquire and construct" two new bridges across Carquinez Strait. One bridge was to be located adjacent to the existing Carquinez Bridge and the other to be located about six miles upstream, between Benicia and Martinez. The bill also authorized the California Toll Bridge Authority to issue revenue bonds and to reimpose tolls upon the existing Carquinez Bridge for the purpose of financing the construction of the two new bridges and their approaches.

Senate Bill 1450 was passed by the 1955 Session of the California State Legislature under the sponsorship of Senators Luther E. Gibson and George Miller, Jr., and Assemblymen Donald D. Doyle, Samuel R. Geddes and S. C. Masterson.

On June 16, 1955, Frank B. Durkee, Director of Public Works, assigned the work contemplated under this legislation to George T. McCoy, State Highway Engineer. Exactly four months later four major contracts were advertised for bids involving a large portion of the construction work in connection with the new parallel Carquinez Bridge and its Contra Costa County approach.

Revenue Bonds Sold

On December 13, 1955, the California Toll Bridge Authority sold $46,000,000 worth of Series A Bonds in accordance with the Resolution dated October 4, 1955, authorizing Carquinez Strait Bridges Toll Bridge Revenue Bonds. The interest rate called for is 3¾ percent payable semiannually. Later, as plans progress, an additional issue of Series B Bonds can be sold for financing work on the Benicia-Martinez Bridge and the remaining freeway work through Vallejo.

Because these first four contracts were large and involved types of construction work not frequently encountered in the usual highway contracts, prospective bidders were given a full six weeks' time to study the projects and make up their bids.

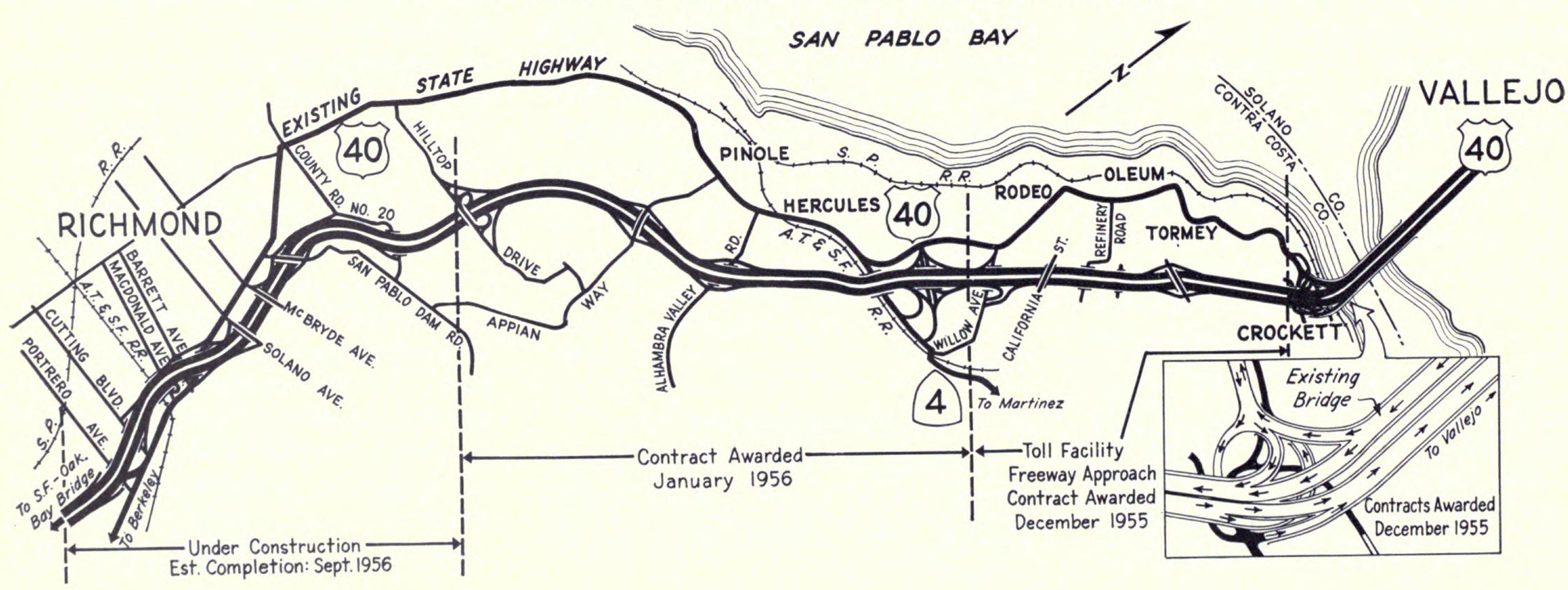
The first four contracts to be advertised and awarded include the following work: (1) Two and nine-tenths miles of freeway work in Contra Costa County extending from just north of the city limits of Hercules to the beginning of the bridge approach at Crockett; (2) The deep pier foundation work for the main bridge across Carquinez Strait; (3) The superstructure work, including the fabrication and erection of large steel double cantilever truss spans of the main bridge; and (4) The construction of the south approach and connecting interchange ramp spans through Crockett.

Contra Costa County Freeway Approach

The freeway project from Hercules to Crockett is exceptional not only because of the amount of money in-

Map showing the relation of the Carquinez Bridge and the Benicia-Martinez Bridge to the general San Francisco Bay area. →

This map shows how approximately 12½ miles of US 40 between Richmond and the Carquinez Bridge will be relocated and constructed to full freeway standards by mid-1958 when the parallel Carquinez Bridge is expected to be completed. This section of US 40 now runs on congested San Pablo Avenue and takes a tortuous route through several communities of northern Contra Costa County. One contract is now under way and five others have been awarded. Now under construction and scheduled for completion in September, 1956, is a six-lane divided freeway between slightly south of Potrero Avenue in Richmond and south of Hilltop Drive, east of San Pablo, at a contract cost of $5,107,922.




CARQUINEZ BRIDGE
BENICIA-MARTINEZ BRIDGE
NAPA COUNTY
SONOMA
SAN PABLO BAY
VALLEJO
RICHMOND
EL CERRITO
ALBANY
BERKELEY
OAKLAND
SAN FRANCISCO COUNTY
SAN FRANCISCO BAY
SUISUN BAY
SAN PABLO RES
PIEDMONT
MARTINEZ
CONCORD
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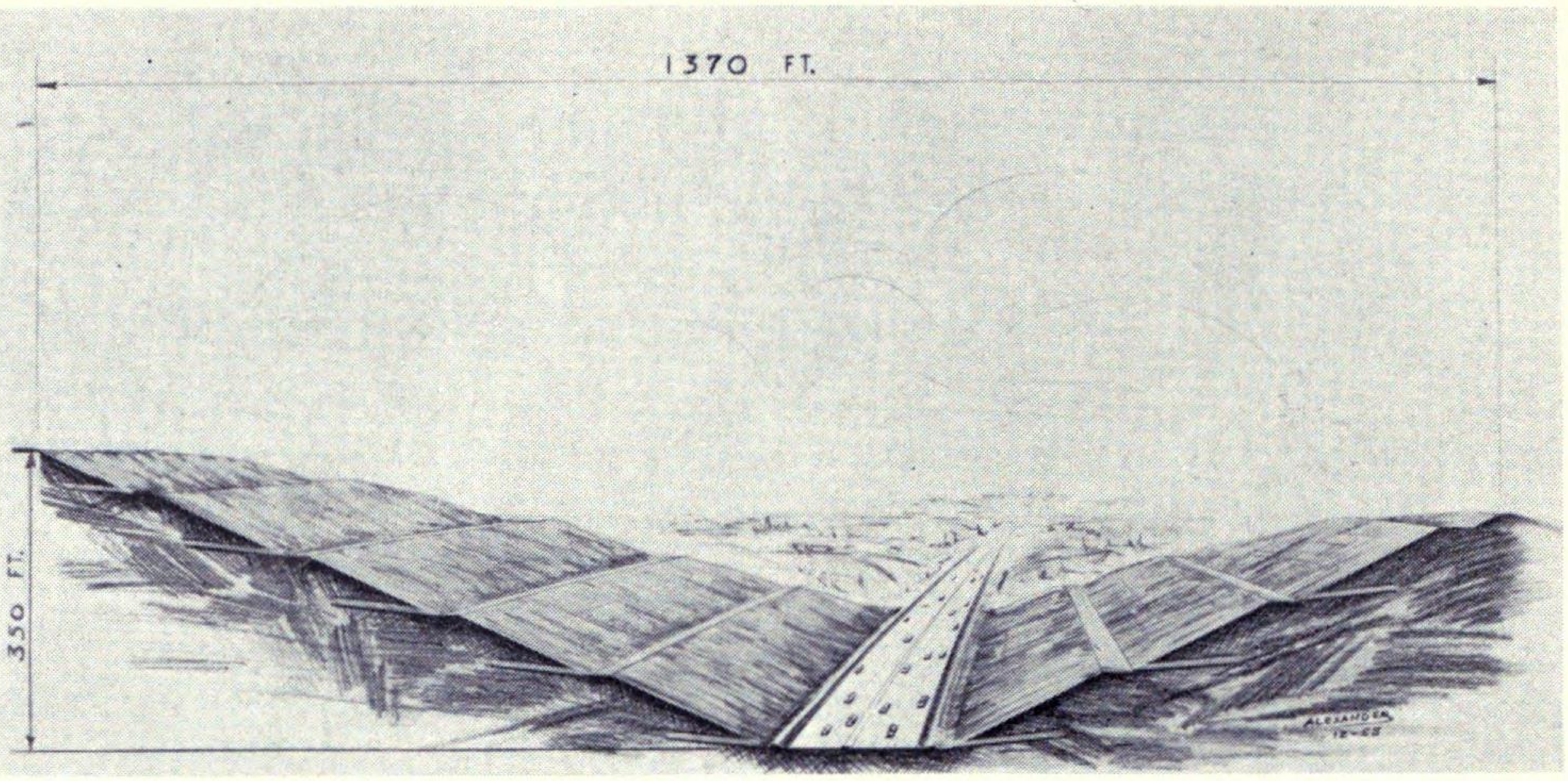
volved but because it includes the largest cut ever undertaken by the Division of Highways. The project includes 11,200,000 cubic yards of excavation and involves 455,000,000 station yards of overhaul.

Eight and one-half million cubic yards of this total excavation are to be taken from the big hill at the top of Crockett which has often been referred to as the "Big Cut." The depth at the largest section of this cut varies from 245 feet at the centerline of roadway to 350 feet at the high point to the side. The width at the top is 1,370 feet (about four average city blocks), and the total length is 3,000 feet.



Architectural sketch of the "Big Cut" which helps to give one the feeling of immensity that will be gained on driving through

Huge Excavation Job

To complete this 11,200,000 cubic yards of excavation on schedule the contractor must plan to excavate, haul and place about 30,000 cubic yards of excavation each working day. This is at a faster rate than called for in any of the contracts so far let by the Division of Highways.

It will be interesting to watch the contractor move in with his many pieces of heavy earth-moving equipment. The clockwork efficiency of his organization and equipment will pay big dividends for as can be seen a reduction in cost of as little as one cent a cubic yard will net a total saving to him of $112,000. The contractor's bid price for this roadway excavation was 25.6 cents per cubic yard.

Because of the size of this cut, preliminary studies included consideration of a tunnel. Geological conditions and economy of construction however, indicated considerable advantage to the open cut.

The "Big Cut"

To maintain structural stability the "Big Cut" will have two-to-one side slopes and horizontal benches 30 feet wide placed each 60 feet of depth. In addition, immediately following the excavation from top down to the first 30-foot wide bench, horizontal drains will be placed to drain underground water away and keep the sides of the cut dry, reducing the possibility of slides to a minimum. The drains will extend back into the sides of the cut for a distance of approximately 150 feet. This process of benching and draining will continue as excavation progresses from the top of cut on down to the final grade of the roadway. It is estimated that 20,000 lineal feet of these drains will be required.

Ten bids were received on this freeway job and Ferry Bros., John M. Ferry, Peter L. Ferry, L. A. and R. S. Crow, a joint venture of Glendale, California, contractors were the low bidders at $7,098,690.20.

Substructure Contract

The construction of the foundations for the main bridge across Carquinez Strait just 200 feet upstream from the existing bridge will require special skills and equipment for the deep water piers not often encountered in the usual highway contract.

The most spectacular operation in the construction of these foundations will be the sinking of large concrete caissons to bed rock approximately 135 feet below the surface of the water.

The lower portion of these piers, which measure 53 feet wide by 102 feet 6 inches long (about the size of a good city lot), will be precast at some location not far from the site of the bridge, launched into the waters of the bay and floated to the bridge site. At the bottom of these precast caissons will be a heavy fabricated steel cutting edge made from thick steel plates.

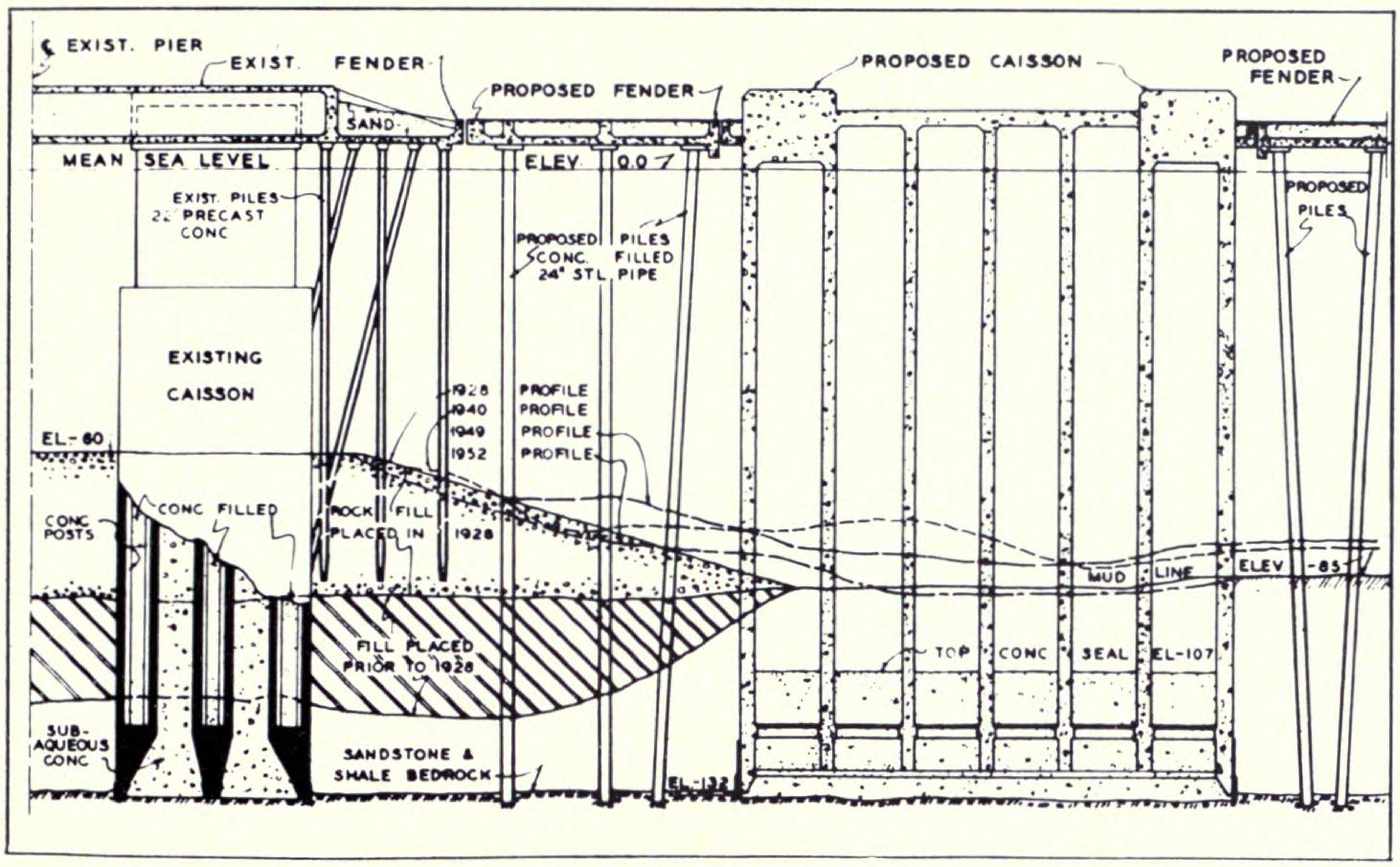
Positioning of Caissons

After being carefully positioned by heavy anchorages and guide towers, additional sections will be added and the caissons will be lowered through the water and overburden to bedrock. The caissons will be lowered through the mud, sand and gravel by excavating material out from the bottom through 18 precast wells built into the caissons. In addition to excavation through these wells, provision will be made so that powerful streams of water can jet up from the sides of the cutting edges at the bottom if found necessary. These jets can cut away material from the sides and will reduce friction as the huge mass of concrete is gradually lowered to its final position on bedrock at the bottom.

During this sinking operation, which will take several months, great care must be exercised to keep the caisson from tipping or lowering too fast on one side or one corner. If it should get out of vertical then it must be righted by a carefully planned sequence of excavation and jetting.

Over half of the work in the foundation contract lies in these three caisson piers which will cost a little more than $1,000,000 each. Other work will include the construction of two shore piers and one water pier 50 feet wide by 113 feet long founded on 260 steel bearing piles driven to bedrock.

As can be seen in the picture of the bridge, the center tower will have an extensive pier protection or fender system which will be founded on large steel pipe piles 24 inches in diam-



This sketch shows a section of the foundation work at the center tower of the bridge. To the right the section of the large concrete caisson is shown at its final resting place on bedrock at the bottom. To the left can be seen a half section of the existing caisson. The new and the old will be connected with one big fender protection system supported on the 24-inch-in-diameter 150-foot-long concrete-filled steel cylinder piles.

eter and 150 feet long, driven to bedrock and then filled with concrete. On top of these pipe piles will be placed large reinforced concrete girders and slabs surrounding the center tower and offering protection against navigation.

Five bids were received on the work involved in this contract. Mason and Hanger, Silas Mason Co., Inc. and F. S. Rolandi, Jr., Inc., a joint venture, were the low bidders at $5,454,694.16.

Superstructure Contract

The fabrication and erection of the superstructure of the main bridge across Carquinez Strait will also require special skills and equipment not usually encountered in normal highway construction.

There will be approximately 14,000 tons of steel to be erected 146 feet above the waters of Carquinez Strait. Because of the height, the depth and current of the water, and navigation requirements, most of this steel will be erected by cantilevering out from the piers to avoid the use of falsework. Each of the main spans of the double cantilever construction will be 1,100 feet long, with two side spans each 500 feet long and a central tower 150 feet in width.

The design of the new parallel bridge will be similar in span length and shape to the existing bridge but otherwise the two designs will be quite different because the new design will have a wider roadway and will incorporate several recent developments in modern bridge design.

Four Lanes of Traffic

The new structure will provide for four lanes of traffic on a 52-foot clear roadway supported by two trusses 60 feet apart. This will call for much heavier construction than the existing structure, which is 42 feet center to center of trusses and provides for only three lanes of traffic.

The new design features which make use of recent developments in bridge construction are: (1) the use of high strength bolts instead of rivets for field connections at the truss joints; (2) fabrication of the heavy truss members and floor beams by use of welding rather than riveting; and, (3) the use of a new high strength weldable steel nearly three times as strong as the ordinary structural steel used in bridge construction.

Bolted field connections were chosen in preference to rivets because the designers believe that field bolts will do their work with more assurance than the field driven rivets. In addition they feel that there is a good possibility that field bolts will show economy over field rivets on truss connections of this magnitude. These bolts are ⅞ inch, 1 inch and 1¼ inch in diameter. The smaller bolts are used for secondary bracing member connections, the 1-inch bolts are used in the main truss joints, and the large size bolts are used for the exceptionally heavy center tower joints. One average truss joint will require approximately 600 of these 1-inch bolts. The whole job will require 570,000 pounds of bolts or six freight car loads.

Welded Fabrication of Trusses

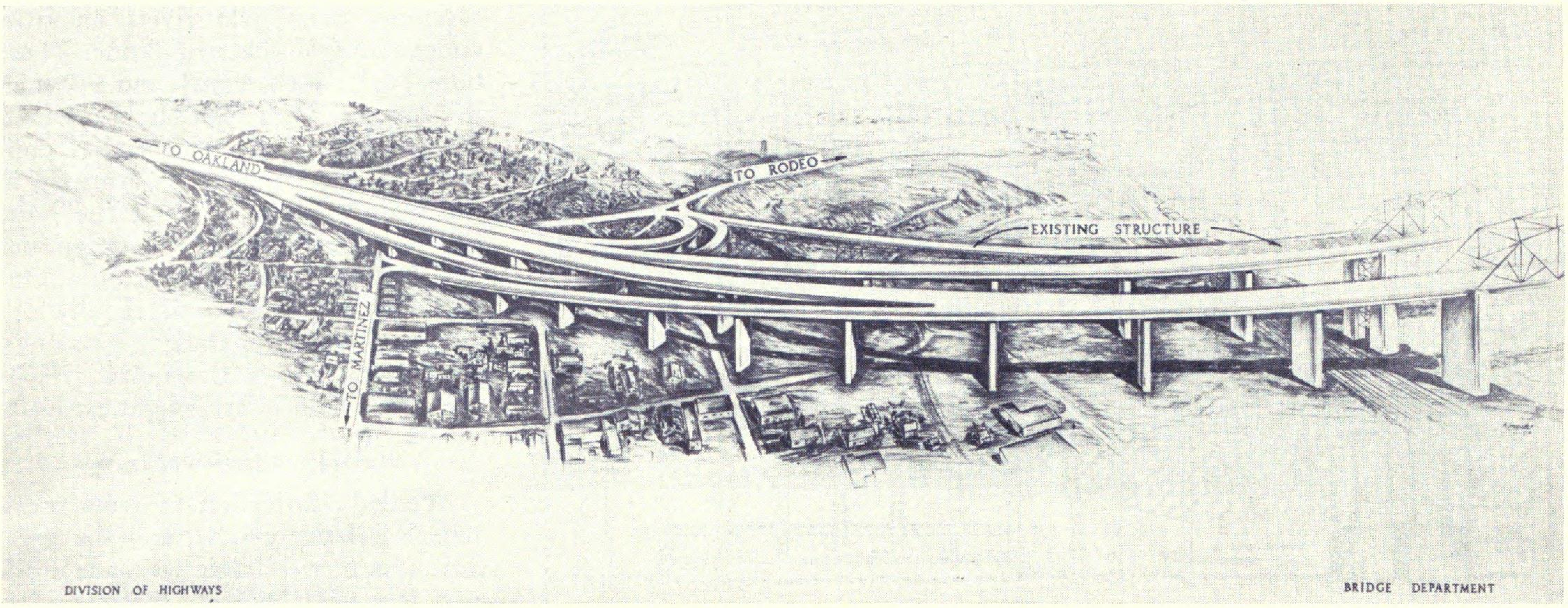
Welded fabrication of truss members is relatively new, and the great advances that welding has made in the past few years indicate that considerable economy can be realized by fabricating the heavy truss members by this method. It reduces the number of parts to be fastened together and simplifies and speeds up both design room time and shop work. As an example there are 29,440,000 pounds of steel to be fabricated and the low bid for this steel was $8,091,776 which is an average of 27.49 cents per pound. If through simplified shop work the fabricating costs can be reduced by as much as one-half cent per pound, it will result in a saving of $147,000 for the superstructure contract.

Three types of steel were used in the design of these trusses, they were: (1) structural steel known as A7, (2) a somewhat higher strength low alloy steel known as A242, and (3) a recently developed extra high strength steel with good weldable qualities known as T1.

High Strength Steel

The use of this new extra high strength steel T1 capable of resisting 90,000 pounds per square inch when placed under tension, indicated a saving of approximately $800,000 according to design computations. This large saving in cost was made in spite of the fact that the base price for the new steel was approximately 5.7 cents per pound more than regular structural steel.

This extra high strength steel was used in only the very heavily stressed members of the trusses. Because the heavily stressed members require such large sections of steel they become



Architectural sketch of the Crockett Interchange structure showing the approaches to the new and old bridge and the on and off ramps for use of traffic originating in the Crockett area

very stiff and when bent to conform to the large deflection of the 1,100 foot truss span, high internal bending stresses are set up. The vertical deflection of the trusses due to the dead weight of these long spans will be as much as 27 inches. The smaller these individual members are the less resistance they offer to the trusses conforming to this 27-inch deflection and therefore the smaller will be their stress due to bending. As an example the weight of one of these heavily stressed members would be 748 pounds per foot when designed of low alloy steel and only 400 pounds per foot when designed of this extra high strength steel. The high strength steels therefore made it possible to reduce the size of these heavily stressed members an appreciable amount and resulted in a considerable savings in the final cost.

Four bids were received on this project, which is the largest contract let to date by the Division of Highways. The low bidder was the United States Steel Corporation who submitted a bid of $9,489,126. This is the same firm that fabricated and erected the steel superstructure for the existing Carquinez Bridge and the San Francisco-Oakland Bay Bridge.

Crockett Interchange Structure

The south end of the main bridge structure will connect to a series of approach girder spans and ramp connections known as the Crockett Interchange Structure.

Traffic headed south from Sacramento and wishing to turn off at Crockett will use the existing bridge and the existing approach spans as an off ramp.

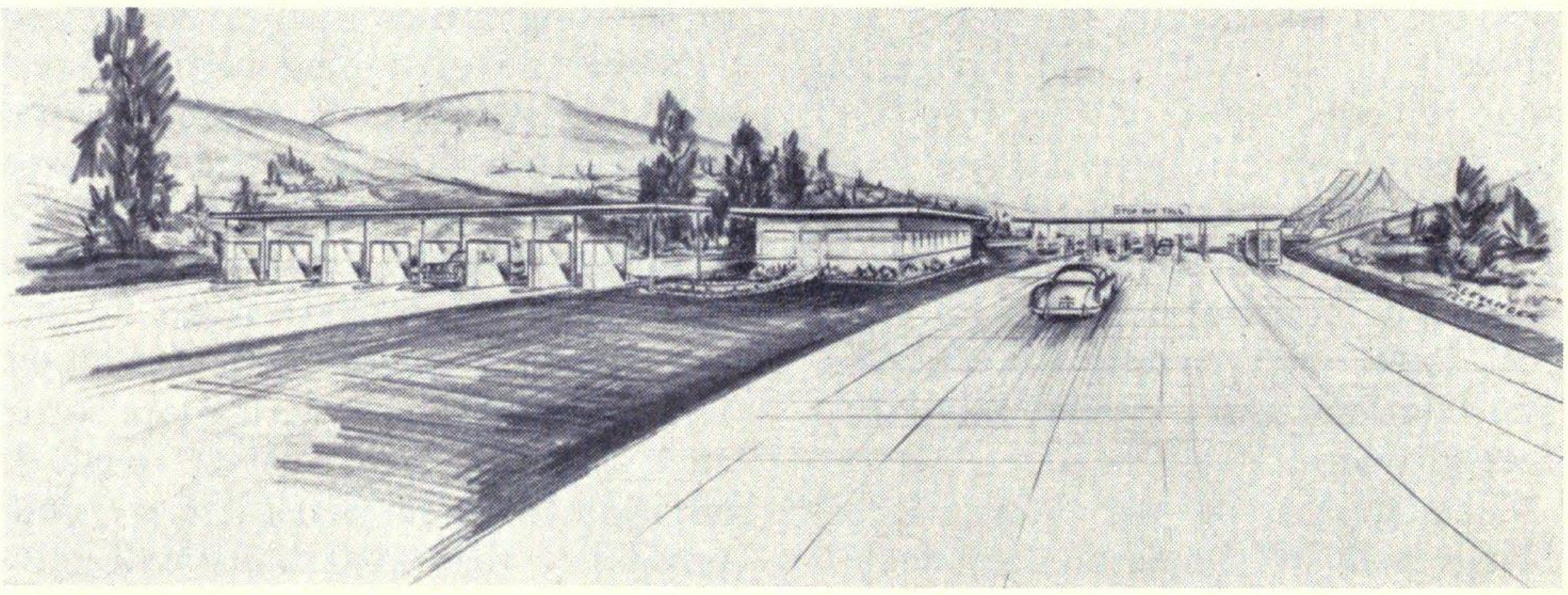
Traffic heading north from San Francisco and wishing to turn off at Crockett will be provided with a ramp taking off from the end of the "Big Cut" and swinging down under the approach spans and entering Crockett near the present intersection of Pomona Street and the existing highway. Crockett traffic headed for San Francisco will take off at this same intersection by use of a southbound on ramp. Crockett traffic headed toward Sacramento will take off from Pomona Street near Seventh Avenue and turn north by use of an on ramp. All of these connections will provide this area an easy access to the freeway and when completed will, figuratively speaking, place Crockett and vicinity at the front door to the San Francisco Bay area.

48 Girder Spans

The plans for this interchange structure call for the construction of approximately 48 girder spans ranging in length from 120 feet to 180 feet. These girder spans will require the fabrication of 4,250 tons of structural steel and the placing of 25,000 cubic yards of concrete.

In addition to this structural work there will be considerable grading and paving for the relocation of city streets. Approximately 300,000 square feet of new pavement will be placed in Crockett.

Architectural sketch showing how the Toll Plaza will appear on the Vallejo end approaching the bridge



Unfortunately the construction work in this area will make it necessary for more than 70 families living in the Crockett vicinity to find new dwellings. As is often the case with improvements that benefit all of the people, a few are sometimes temporarily inconvenienced.

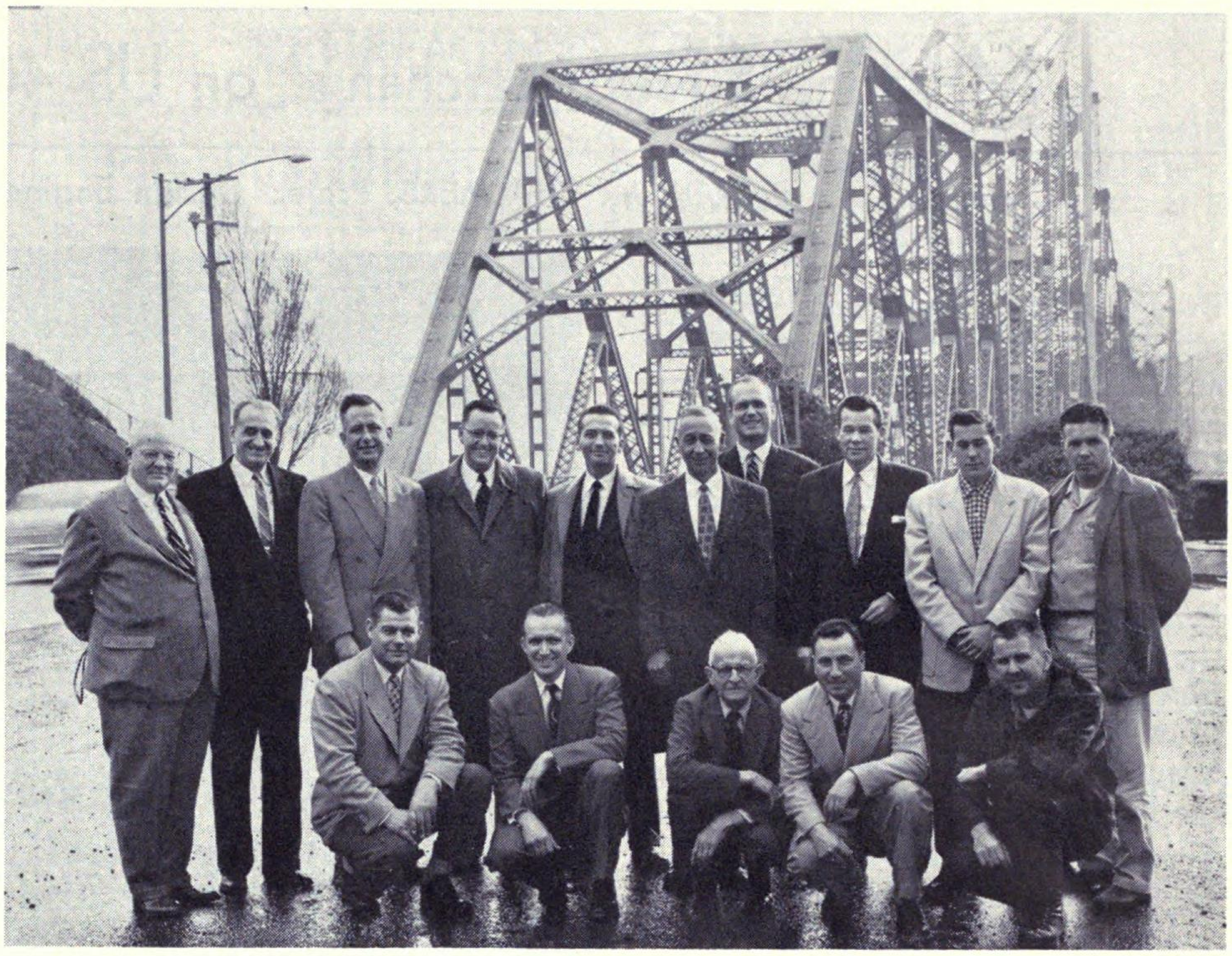
Because of the sudden nature and rapid development of this Carquinez Bridge project since the last session of the State Legislature, families whose property is required for the construction of the interchange and the relocation of the city streets, have not had sufficient time to adequately provide for new homes. In order to relieve this situation, the State has provided that families may remain in their dwellings if necessary until July 1, 1956. In any event the relocation of this many families in a very small community like Crockett does involve hardships. The people of Crockett have faced this situation courageously and in a spirit of cooperation. We are sure that all who will benefit from this project appreciate this spirit of cooperation.

Eleven bids were received on the work involved in the construction of this interchange structure and local road improvements. Peter Kiewit Sons Company was the low bidder at $4,661,462.

Future Contracts

In addition to these four contracts to be financed by Series A bonds there remains to be let a contract for the work from the north end of the bridge to a point about 0.2 miles north of the existing Vallejo Wye. This contract will include the construction of the Toll Plaza and Administration Building, and the widening of the Vallejo Wye. In order to adequately handle traffic with a minimum of delay it is planned to have 16 on-side toll booths for the initial construction with provision for four additional booths as traffic increases. This work is scheduled for advertisement in May of 1956.

A small mechanical and electrical contract is also to be advertised early in the spring of 1956. This work will provide for electrical power for beacon and navigation lights, and supply compressed air for maintenance operations of the two bridges.



Contractors and resident engineers gathered at the site of parallel Carquinez Bridge to discuss start of project.

TOP ROW, LEFT TO RIGHT: Russell G. Cone, Vice President, Mason and Hanger, and Project Manager for the substructure contract of the Main Bridge with Mason and Hanger, Silas Mason Co., Inc., and F. S. Rolandi, Jr., Inc.; E. E. McKeen, Erecting Manager for the steel work on the superstructure of the Main Bridge with United States Steel Corporation; F. S. Rolandi, Jr., Contractor on the substructure contract with Mason and Hanger, Silas Mason Co., Inc., and F. S. Rolandi, Jr., Inc., joint venture; Homer Olsen, Job Superintendent on the Crockett Interchange structure with Peter Kiewit Sons' Co.; L. G. "Bud" Waigand, Job Sponsor on the Crockett Interchange Structure with Peter Kiewit Sons' Co.; R. C. "Dick" Philbert, Superintendent of earth moving operations on the "big cut" job with Ferry Bros., John M. Ferry, Peter L. Ferry and Sons, and L. A. and R. S. Crow; Robert Hoyt, Superintendent of excavation on the Crockett Interchange structure with Peter Kiewit Sons' Co.; J. L. "Jim" Ferry, Contractor on the freeway contract including the "big cut" with Ferry Bros., John M. Ferry, Peter L. Ferry and Sons and L. A. and R. S. Crow, a joint venture; P. R. "Pat" Ferry, Contractor on the freeway contract including the "big cut"; Albert Lindquist, Superintendent bridge construction on the freeway contract.

LOWER ROW, LEFT TO RIGHT: Oscar Johnson, Senior Bridge Engineer, representative of the Division of Highways on the substructure and superstructure contracts for the Main Bridge and the Crockett Interchange contract; Wallace H. Ames, Associate Bridge Engineer, assistant resident engineer on the three-bridge structure contracts; Francis Donaldson, Vice President, Mason and Hanger Co. here from his New York office to look over the job on the foundation work for the Main Bridge; V. O. Smith, Senior Highway Engineer, representative of the Division of Highways on two large freeway contracts to the south of the bridge, one of which includes the contract for the "big cut" job; C. P. Sweet, Resident Engineer on the freeway contract including the "big cut."

Following the completion of the new bridge late in 1958 all traffic on the existing bridge will be stopped and routed temporarily over the new structure. This will be necessary in order to make the connections between the old bridge and the new approaches and ramps in Crockett. In addition the curbs on the old structure will be rebuilt and the roadway resurfaced to provide for 34 feet 4 inches between curbs, making the structure safer for the three lanes of traffic than is now provided by the 30-foot roadway width.

Completion in 1958

This work will be timed for advertisement in the summer of 1957 so that the contractor will have ample time to get his materials purchased and structural steel fabricated and be ready to start construction immediately after opening the new bridge to traffic. This will reduce to a minimum the period that traffic in both directions will be required to use the four lanes of the new bridge. Upon completion of this contract all southbound traffic will be switched back to the old bridge and

. . . Continued on page 66

Carquinez Bridge

Seven Million Pounds of Caisson Placed in Strait

By LEONARD C. HOLLISTER, Projects Engineer, Carquinez

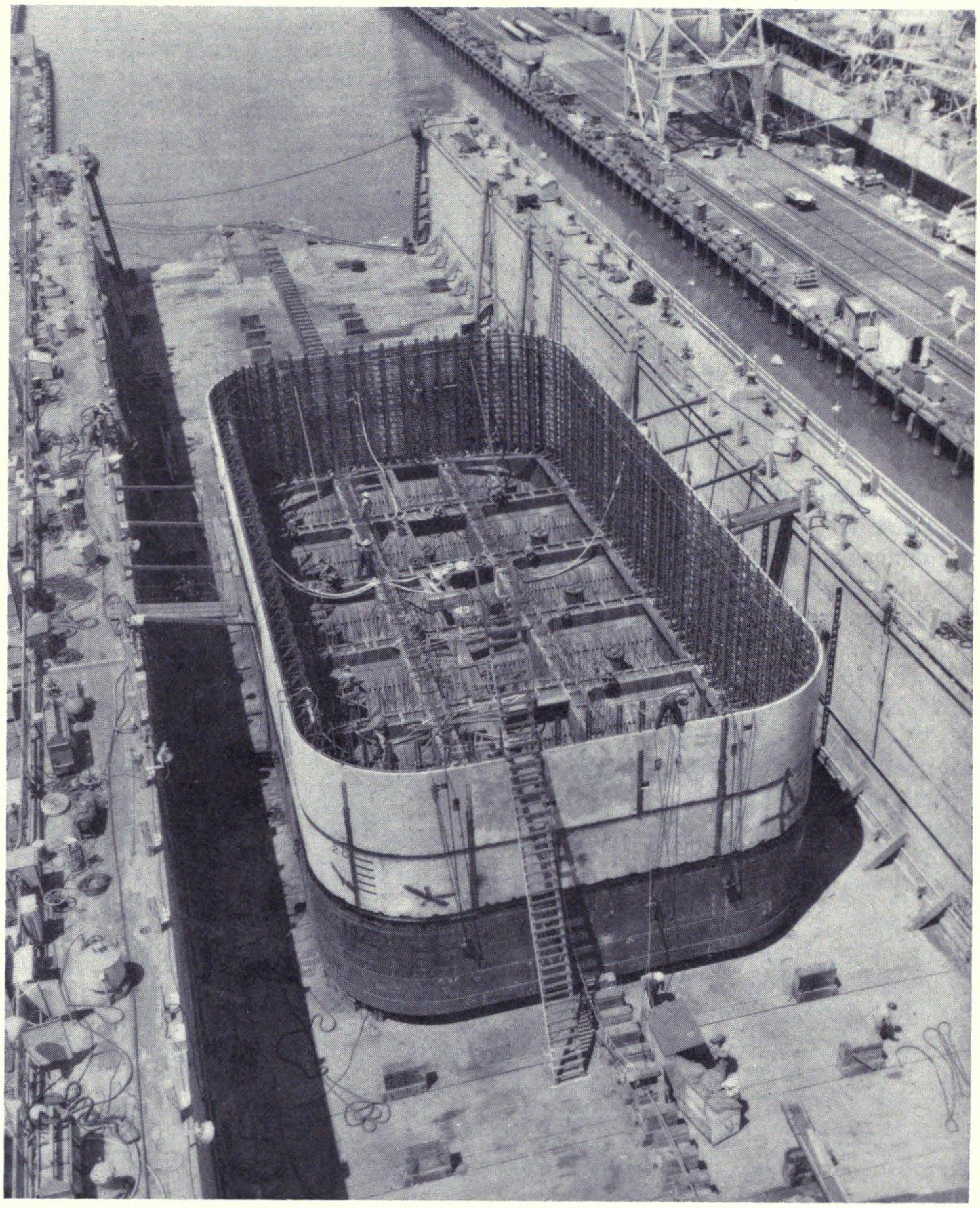
ON MONDAY MORNING, July 16, 1956, at exactly 8.30 a.m., Contractors Mason and Hanger and F. S. Rolandi, Jr., jockeyed into position the 7,000,000-pound bottom 39-foot section of the caisson for Pier No. 2 on the new parallel Carquinez Bridge project.

The hour of 8.30 in the morning was selected after considerable study of the tides and currents of the Carquinez Strait. At this time on this date there began an exceptionally long period of slack tide during which time the currents of both the ebb and flood tide of Carquinez Strait were at a minimum. This provided the contractor with a long period of slow moving currents in which to position the caisson and get it anchored to the 16 anchors which will hold the caisson rigidly in position during the sinking operations.

Huge Caisson

This reinforced concrete caisson will be 53 feet wide by 102 feet 6 inches long, the area of a moderately sized city lot large enough on which to build a six-room house, two-car garage, a patio, barbecue, flower garden and lawn. When completed the pier will be 149 feet high approximately the height of a 13- or 14-story office building. The caisson is divided into 18 open dredging wells each about 14 feet square. The contractor has been carefully planning the operations in connection with the sinking of these caissons for several months since the beginning of the contract which officially started on December 28, 1955.

The first operation in connection with the construction of one of these caissons was the fabrication and erection of the 400,000-pound structural steel cutting edges which were fabricated and erected at the Bethlehem Pacific Coast Steel Shipyards in San Francisco. These steel "cutting edges" are so called because they protect the bottom 13 feet of the reinforced concrete walls and partitions of the caisson. Their sharp edges at the bottom assist in cutting through the mud, sand and gravel during their downward path to bedrock at the bottom.

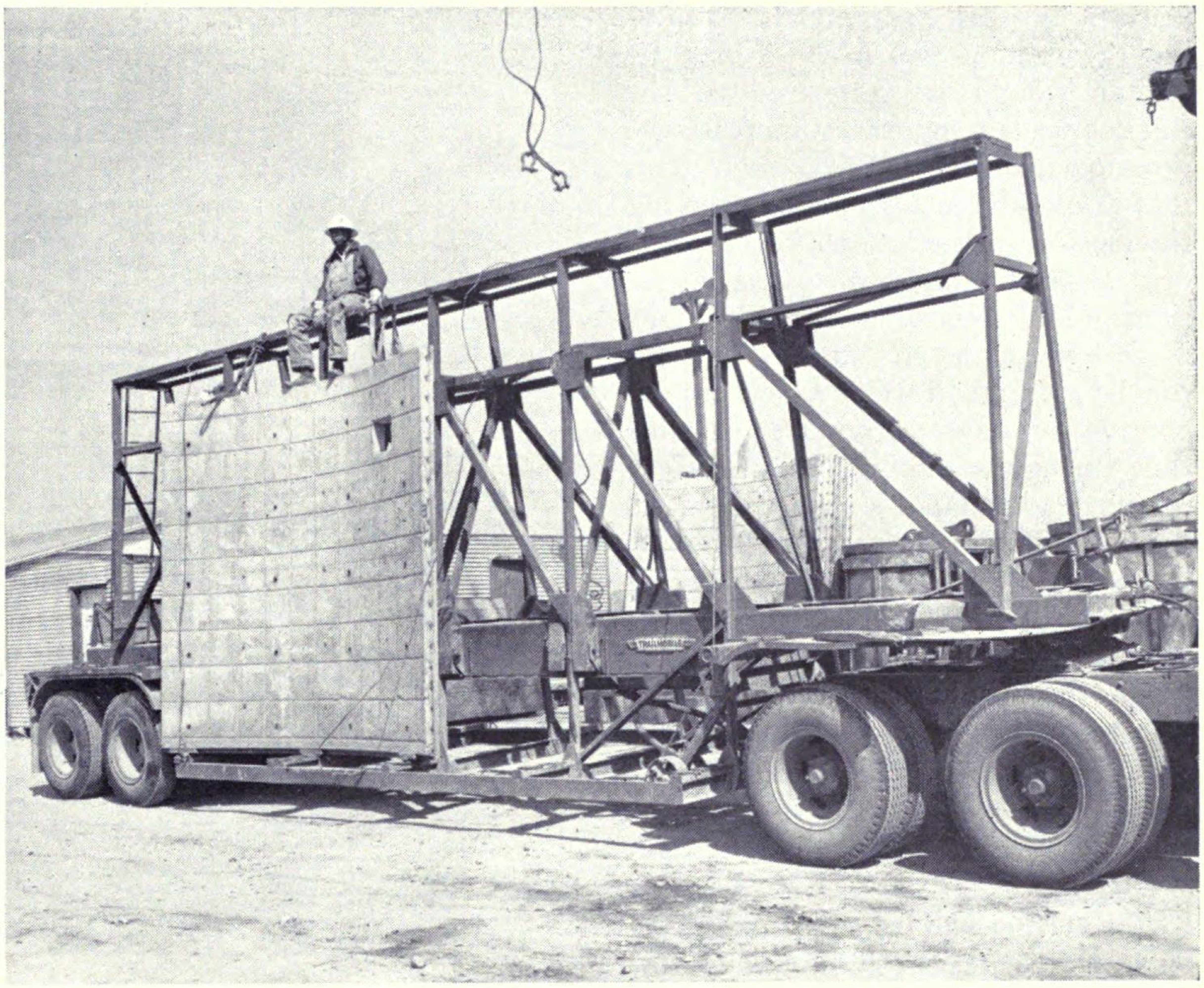


Erection of the 53-foot x 102-foot 6-inch caisson at the Bethlehem Pacific Coast Shipbuilding drydock. "False bottoms" for each of the 18 dredging wells can be seen, also the reinforcing trusses and 4-inch precast exterior slab can be seen above the darker shaded steel cutting edge.

Steel Cutting Edges

These steel cutting edges were then assembled on one of the shipbuilding yards huge drydocks. After assembly of the steel cutting edges which are approximately 13 feet deep, the contractor added the bottom 30-foot section of the reinforced concrete caisson securely anchoring it to the steel cutting edges. The caisson was then rigged up and made ready for flota-

tion by sealing of the 14-foot-square openings of each of the open dredging wells by the use of large dome-shaped timbers. These timber seals at the bottoms of the wells are called "false bottoms" because they are not a permanent part of the pier and because they are later removed after flotation is no longer necessary. After making the caisson seaworthy the drydock was then lowered into the water under the caisson and the caisson made to float. The caisson was then carefully examined for leaks and after determining it satisfactory was christened the *Arnold* after Arnold Hanger, president of Mason and Hanger. It was then floated to Vallejo where it was moored until the date for its positioning and the start of its journey to the bottom of Carquinez Strait where it will rest on bedrock 132 feet below the water level.

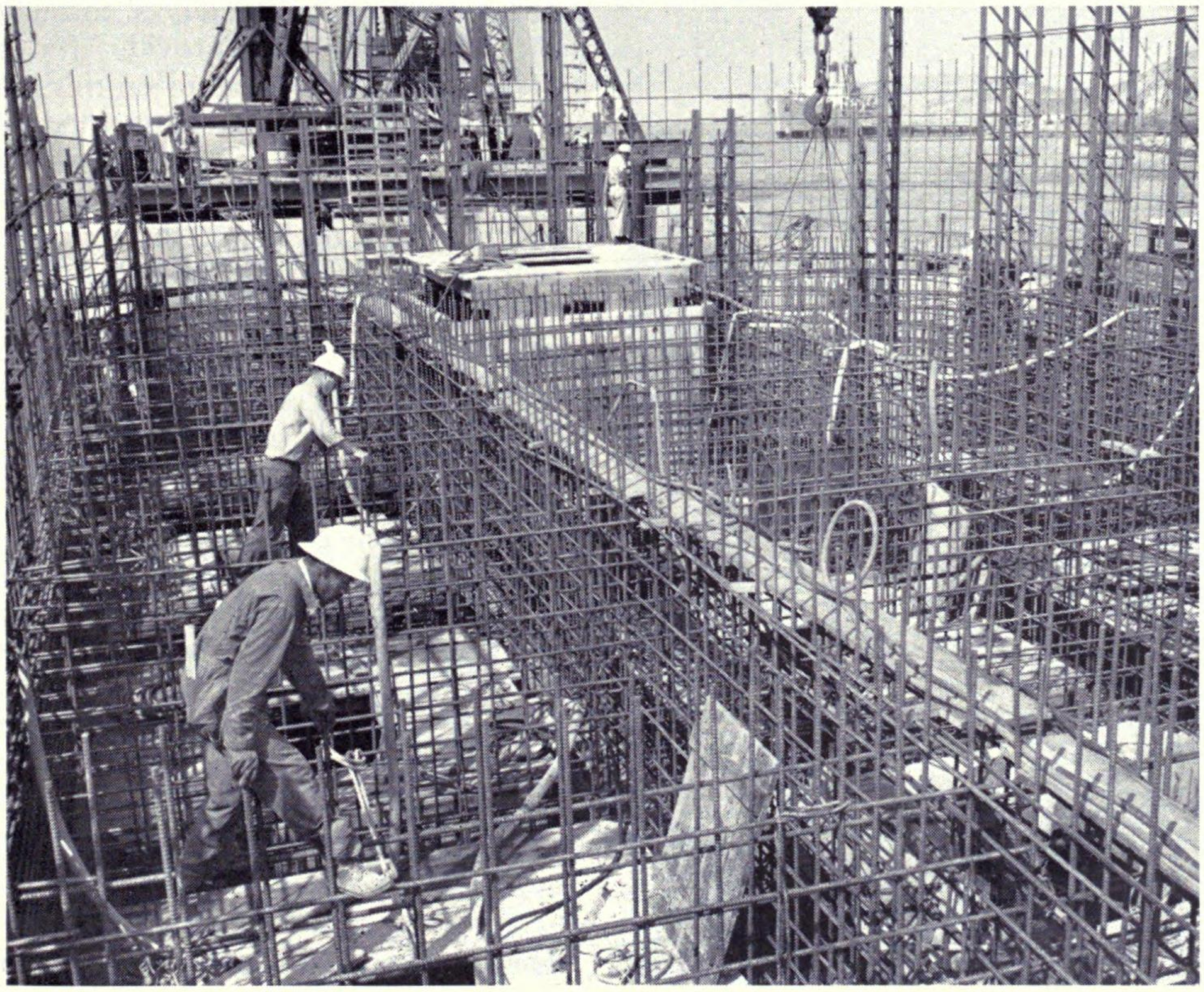


One of the rounded corner sections of the 4-inch precast slabs being unloaded at the contractor's dock where it will be transported to the pier by a barge

Not New, But Difficult

The work involved in constructing and sinking this caisson which will cost slightly more than $1,000,000 is not new in bridge construction history. For instance, deepwater caissons were used in the construction of the San Francisco-Oakland Bay Bridge, the Golden Gate Bridge, the Tacoma Narrows Bridge and on many other large bridge projects throughout the United States. Regardless of this, the sinking of these caissons always involves a certain amount of risk and contractors are continually searching for safer and more economical methods of sinking them to bedrock at the bottom. The contractor for the foundation work on the Carquinez Bridge plans some new construction methods and sinking operations which have not been used on any previous deepwater caisson construction work.

Inside the caisson. Placing reinforcing steel and setting forms preparatory to the next 10-foot lift of concrete to be placed on the caisson.

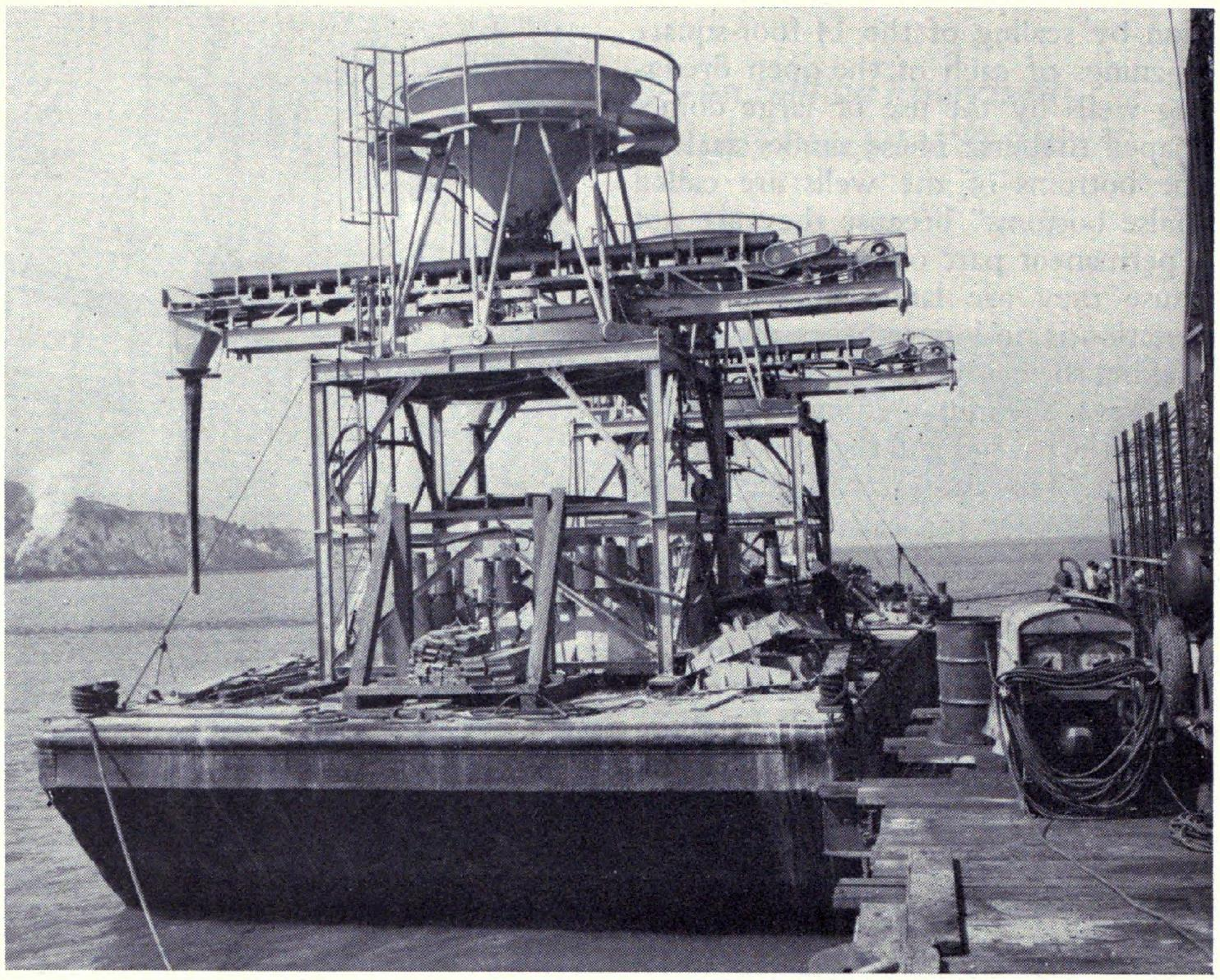


One of these features is the use of 4-inch reinforced concrete precast slabs which will be used around the exterior surface of the whole caisson. These 4-inch slabs will become an integral part of the 3-foot-thick reinforced concrete outside walls. They will be supported by small steel trusses cantilevered up from the 3-foot-thick wall which has been placed at the bottom.

Precast Slabs

These precast slabs have several advantages: (1) They form a 4-inch

watertight shell completely enclosing the caisson and because of their lighter weight as compared to the thicker walls temporarily increase the flotation qualities of the caisson. This is of considerable advantage in towing the caisson to the site and during the critical positioning and sinking operations. (2) It has a further advantage in that it acts as an outside form for the 3-foot caisson walls which are expensive to erect and requires valuable time during the sinking operations. (3) A third advantage is that there will be no formwork to remove from the outside and no finishing and patching to the exterior walls which will again save valuable time. The contractor hopes that these features will allow him to lower the caisson through the water and mud at the rate of 10 feet per day.

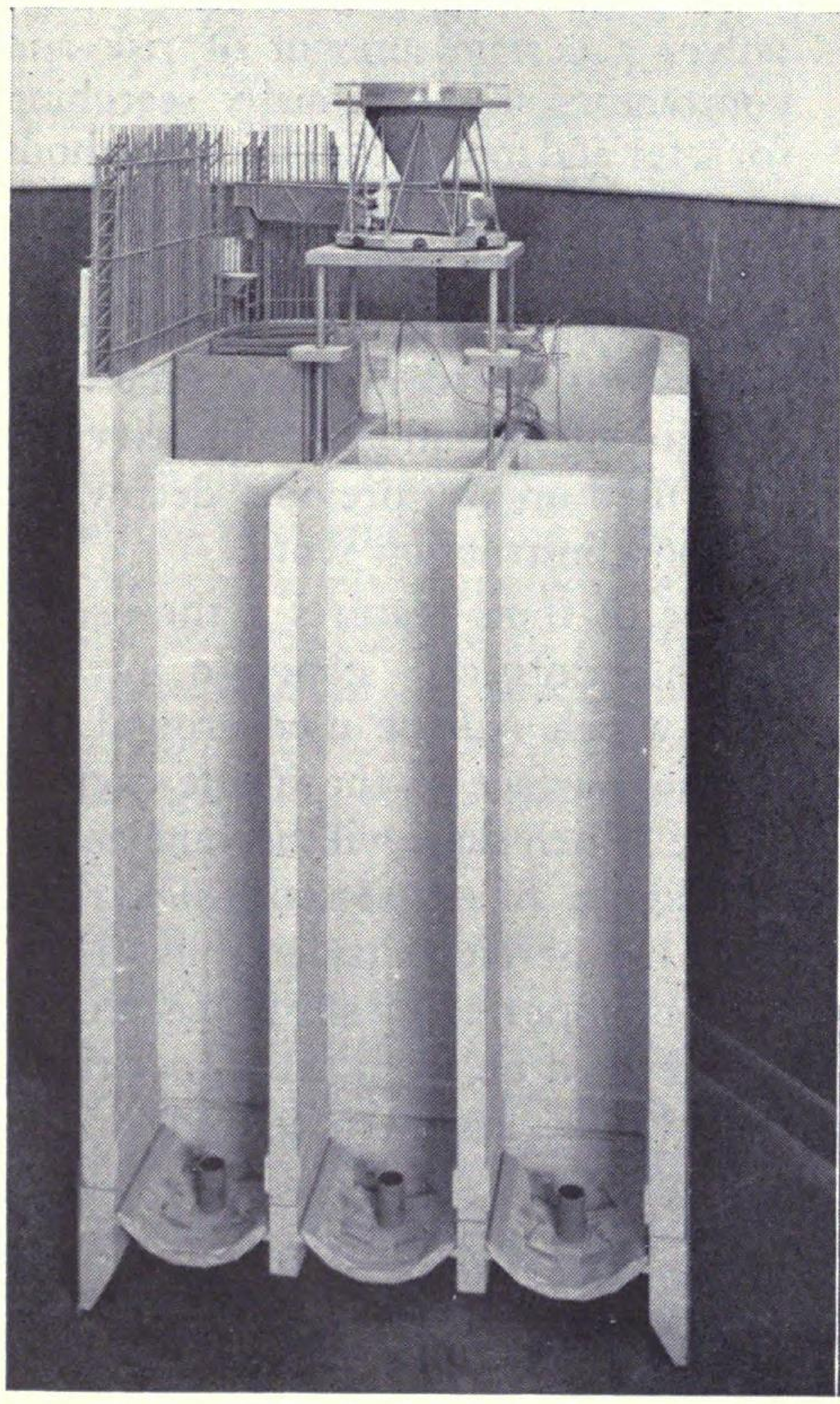


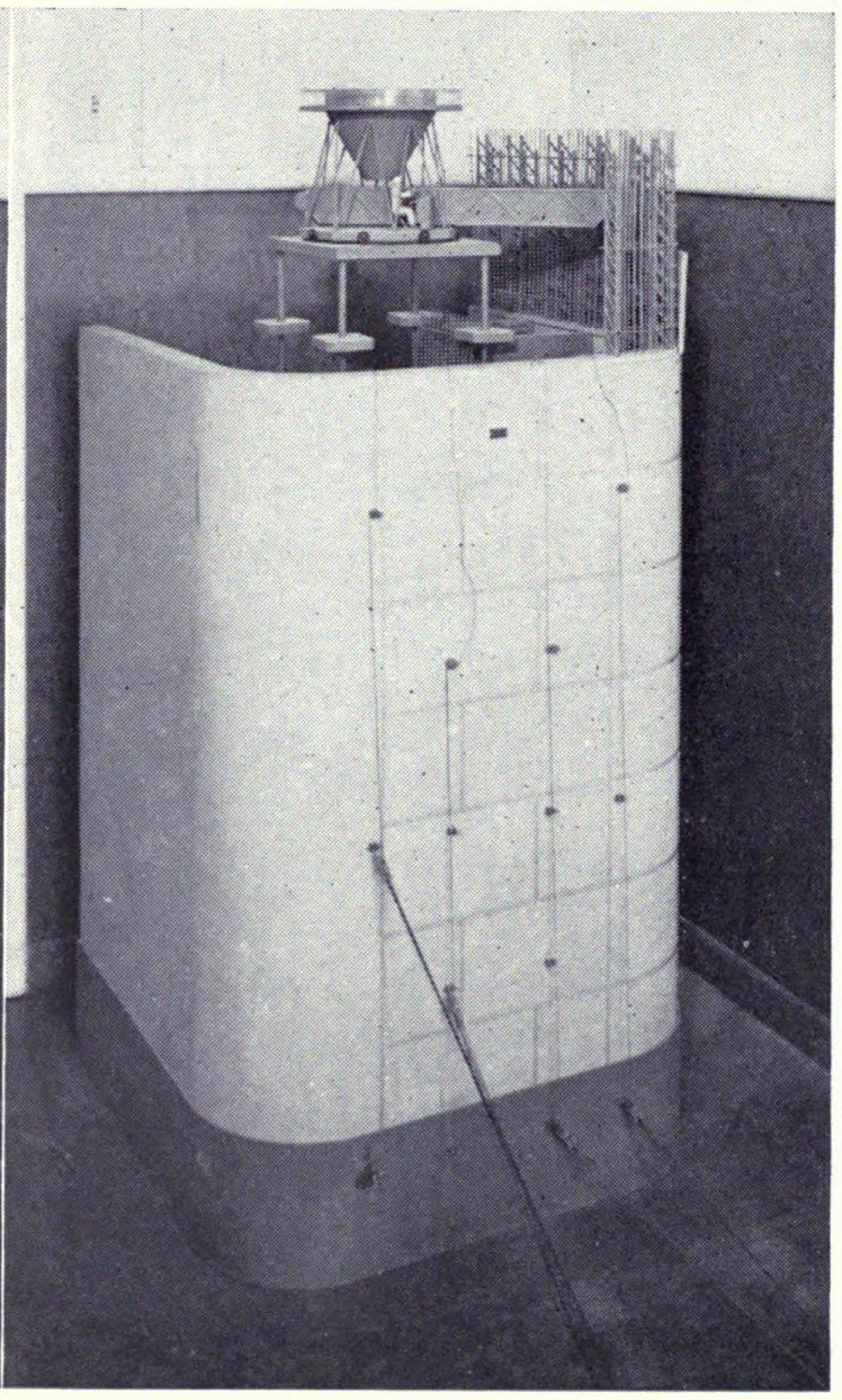
Concrete hoppers and traveling belts. Between concrete pours the concrete hoppers and frames are lifted from the caisson by large cranes and temporarily stored on a barge adjacent to the caisson.

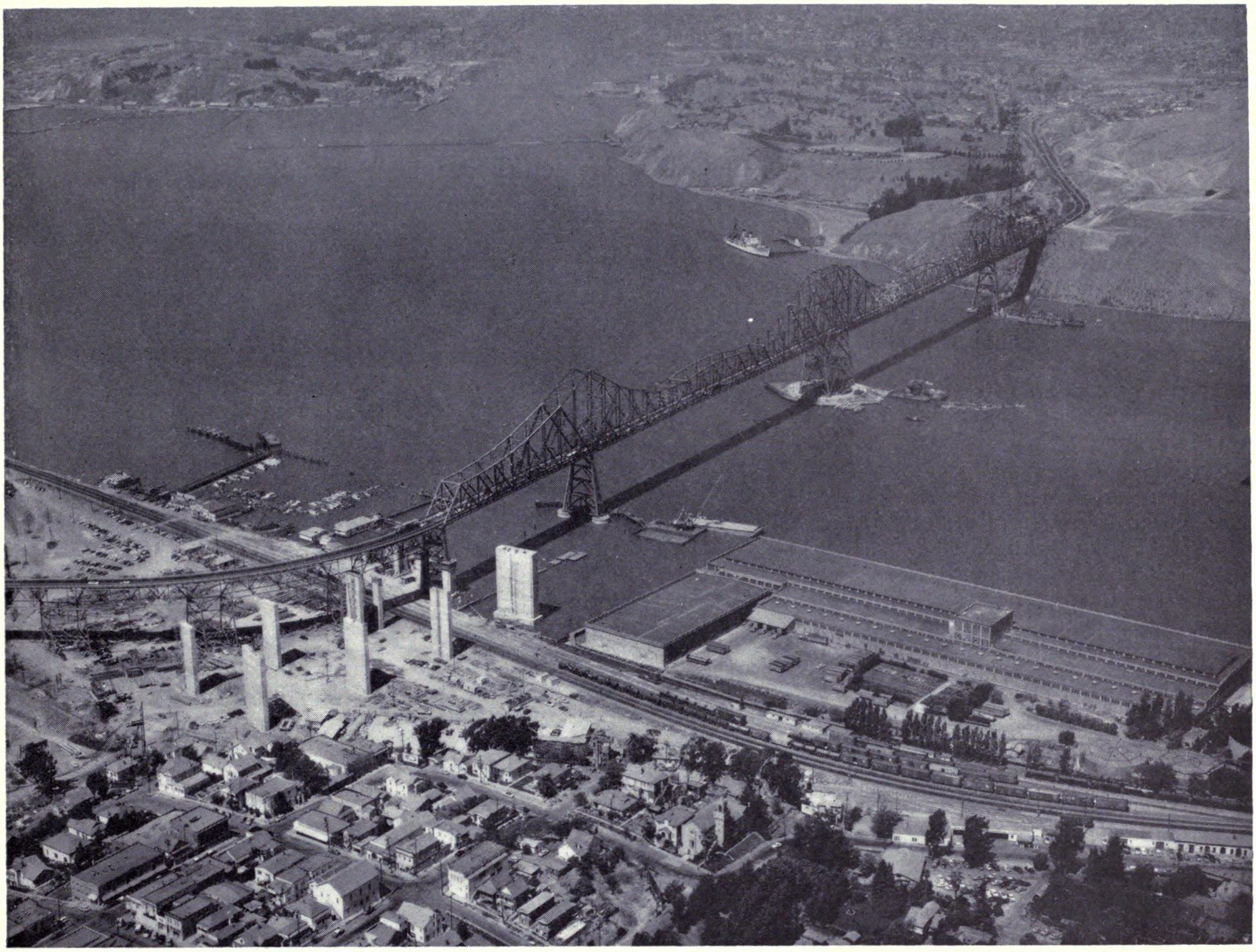
Sinking Caisson

The caisson will have approximately 90 feet of water through which to be lowered, at which point it will start on its path through about 42 feet of mud, sand, and gravel. Once the caisson is founded in the mud the usual method of sinking is to excavate the bottom from under the caisson with clamshell buckets through the 18 dredging wells provided for in the design. The contractor on this job plans an entirely different method of excavation. Instead of the clamshell bucket method of excavation the contractor plans to lower through the four center dredging wells powerful "Chicksan Intelli-Giant Jets." These jets can be operated at pressures from 30 to 300 pounds per square inch and their manufacturer claims that they can shoot a jet through 40 feet of water and cut clay at that distance. The plan then is to use these powerful jets to cut the bottom from under the caisson and pump the mud, sand, and gravel to the top where it will be discharged into barges and taken to the predetermined disposal area in the bay. These jets will be rigged up so that they can be lowered or raised to any position, can turn in any direction horizontally, and can be pointed up or down in any direction vertically. This method of excavation should

LEFT—Contractors sectional model of the caisson showing the timber "false bottoms," the concrete hopper and traveling belt that delivers concrete to any place on the caisson. There are two hoppers for each caisson. RIGHT—Caisson model used by the contractor in studying method of attaching anchorage gear to caisson. There are four anchorage lines on each side of caisson which are attached to concrete anchors buried in the bed of the stream. These anchors hold the caisson in position against the strong Carquinez Strait currents.







Foundation work in progress at the Carquinez Bridge. Caisson sinking is in progress at Pier No. 2 adjacent to far bank. Construction at each of the other piers is also under way. New piers for the Crockett Interchange can be seen at lower left.

greatly speed up excavation operations and allow the contractor to maintain his 10-foot-per-day schedule for lowering the caisson.

When the caisson reaches bedrock at the bottom the area underneath the caisson will be thoroughly cleaned of all loose materials and sediment, the timber false bottoms released, and the bottom 25 feet of the caisson's open dredging wells will then be filled with concrete. This will provide a foundation base 25 feet thick over the entire area of the pier.

For Completion in 1957

The remaining work will then consist of capping the pier with reinforced concrete and setting the huge anchor bolts for the commencement of erection of the steel towers for the superstructure of the bridge. The work on this pier is scheduled for completion May 1, 1957.

The total foundation contract for this project consists of an anchorage abutment set in the bluffs on the Solano side of the Carquinez Strait, three caisson piers as described above, one deepwater pier founded on 240 steel bearing piles, each capable of supporting a load of 28 tons, and an anchorage pier on the Crockett side 125 feet high. This contract was awarded to Mason and Hanger, Silas Mason Co., Inc., and F. S. Rolandi, Jr., for $5,454,694.16. Oscar Johnson is Bridge Department representative for the three bridge construction contracts and Reed Neff is the resident engineer on the foundation contract. This contract is part of the work authorized by the Legislature and the California Toll Bridge Authority for the construction of two new bridges across the Carquinez Strait. The work of these projects is under the jurisdiction of California Division of Highways, G. T. McCoy, State Highway Engineer.

VEHICLES ENTERING CALIFORNIA

A total of 579,354 vehicles entered California during July, 1956, an increase of 27,937 over the vehicles that entered during July, 1955. This total included 541,847 automobiles, 32,683 trucks, and 4,824 busses.

Now Read This

Carquinez Bridge Project Tests Ingenuity of Engineers

By LEONARD C. HOLLISTER, Projects Engineer, Carquinez*

THE SUBSTRUCTURE work for the main bridge across Carquinez Strait involves the construction of an anchorage abutment set in a shale and sandstone cliff at the north end of the bridge to support the 500-foot anchor arm of the truss span, three caisson piers founded on bedrock about 132 feet below water line, one cofferdam type pier supported on 240 80-ton steel bearing piles, and an anchorage pier 125 feet high located at the south end of the bridge. This foundation work is under contract to Mason & Honger, Silas Mason Inc. & F. S. Rolandi Jr. Inc., at an approximate cost of $5,500,000.

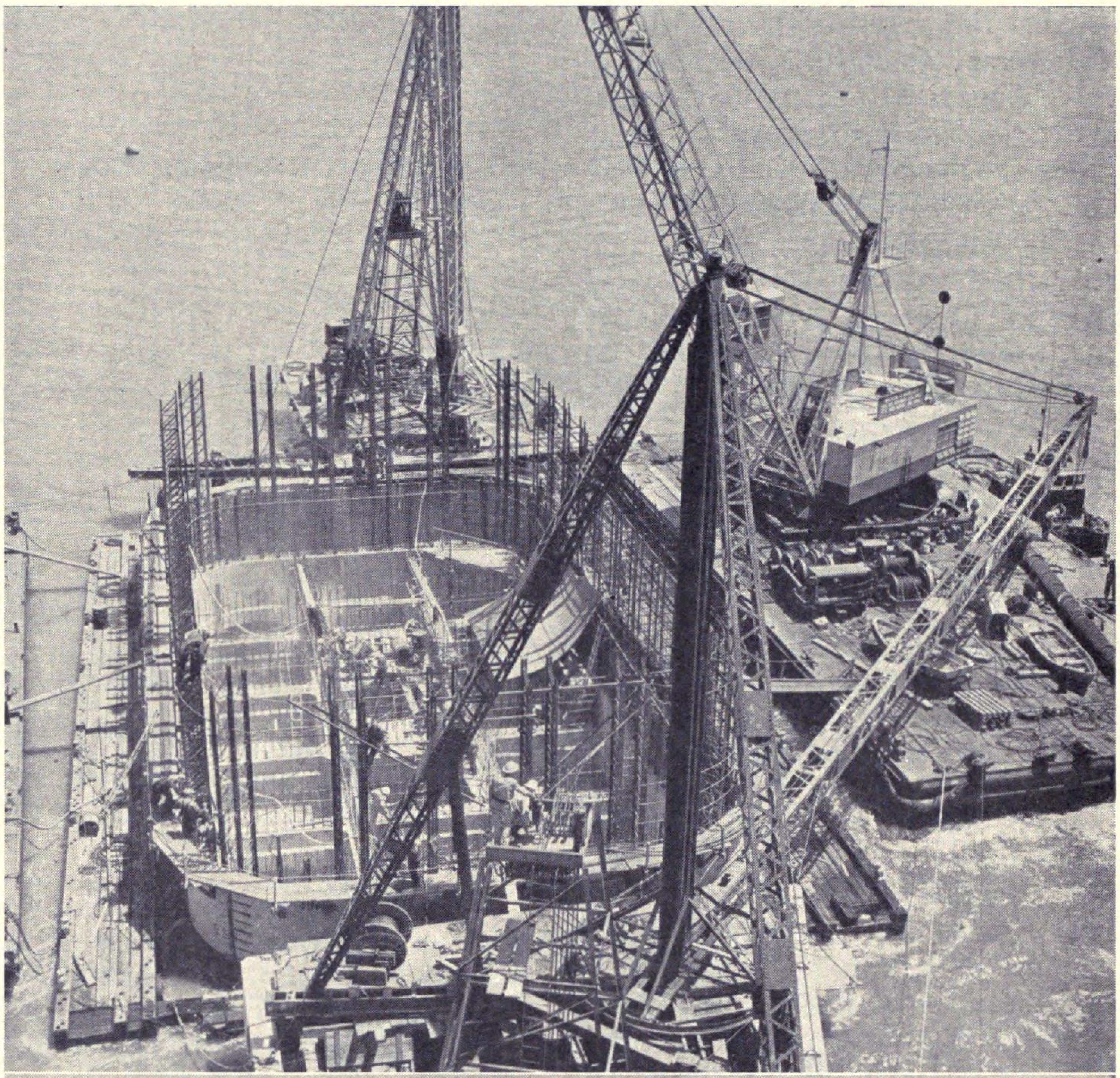
The three deep water caissons are identical in design being 53 feet wide by 102 feet 6 inches long. They are of reinforced concrete construction with outer walls 3 feet in thickness and inner walls 2 feet 6 inches in thickness. Each caisson is divided into 18 dredging wells approximately 14 feet square. The four corners of the caisson are rounded to a 12-foot radius to reduce pressures during sinking operations from high velocity currents. The bottom 13 feet of the concrete walls are protected by structural steel cutting edges fabricated by welding from ⅜-inch, ½-inch and ¾-inch steel plates.

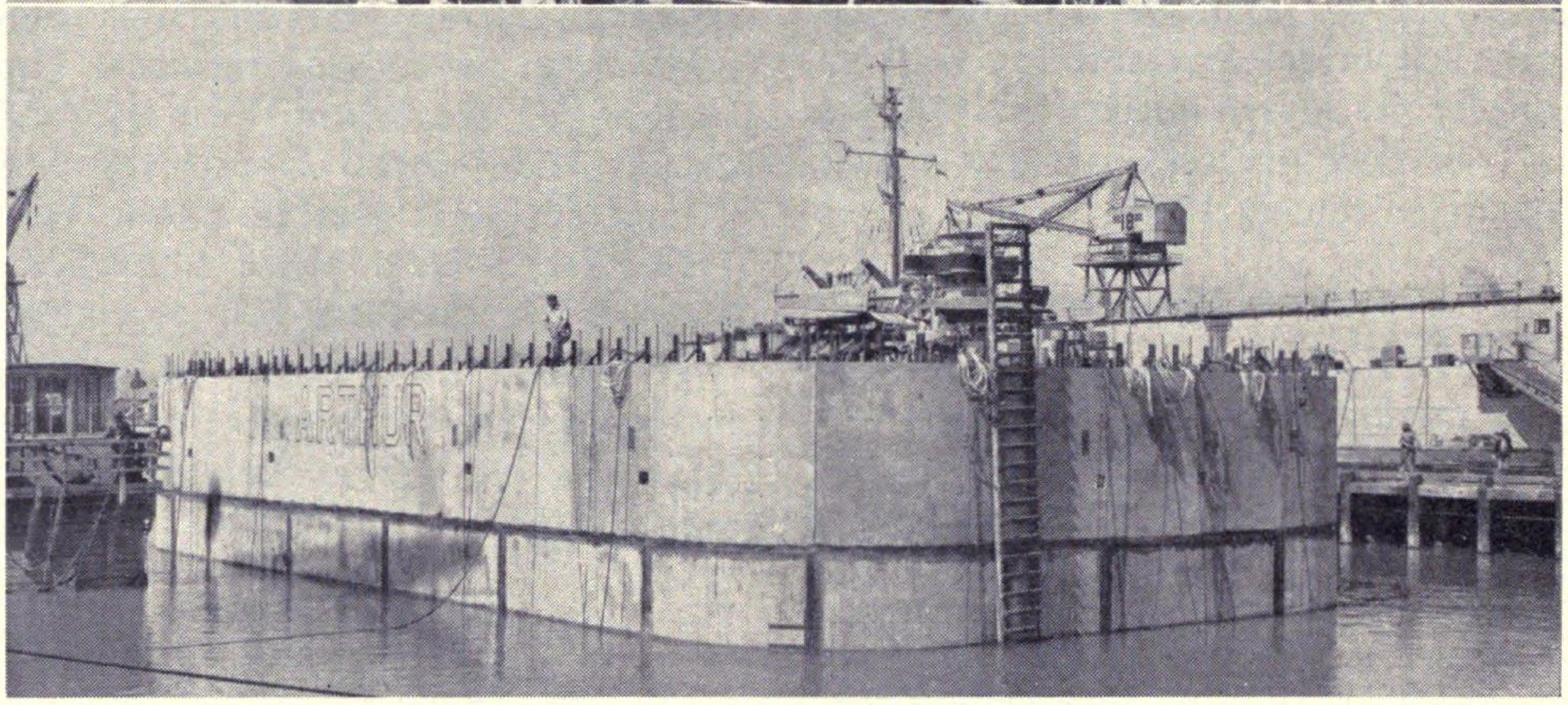
These steel cutting edges each weighing about 400,000 pounds per caisson were fabricated at the Bethlehem Pacific Coast Steel Shipbuilding Yards approximately 32 miles from the bridge site. Cutting edges were fabricated in sections pre-assembled in the fabricating yard for fit and then assembled on a shipbuilding dry dock and welded together.

New Precast Slabs

Following this assembly on the drydock the cutting edges were filled with concrete and the outside walls of the caisson were extended to a total height of 31 feet by placing four-inch precast slabs around the periphery of the caisson.

The use of these four-inch precast slabs is a new innovation designed by the contractor for use in reinforced





UPPER—Picture shows work being done on one of the caisson piers. Here heavy equipment is setting forms preparatory to placing a 10-foot lift of concrete in the side walls and partitions. LOWER—Picture shows one of the caisson piers floating at the Bethlehem Pacific Coast Steel Company's shipyard. After it has been thoroughly tested for flotation it will be towed to the bridge site.

* This is the second of two articles on Carquinez Bridge Project by Mr. Hollister—*Ed.*

concrete caisson construction. The slabs become an integral part of the three-foot thick outside wall when the caisson is completed. They were precast at the Basalt Rock Company plant and transported 39 miles by barge to the drydock and later about nine miles by truck to the bridge site.

The slabs were cast in sections 10 feet high by 16 feet long, and reinforced at center of slab with three-eighths-inch vertical bars 11-inch centers and three-eighths-inch horizontal bars six-inch centers. Outside surface was cast smooth and inside surface roughened and keyed for bonding to the poured-in-place section of the outside wall.

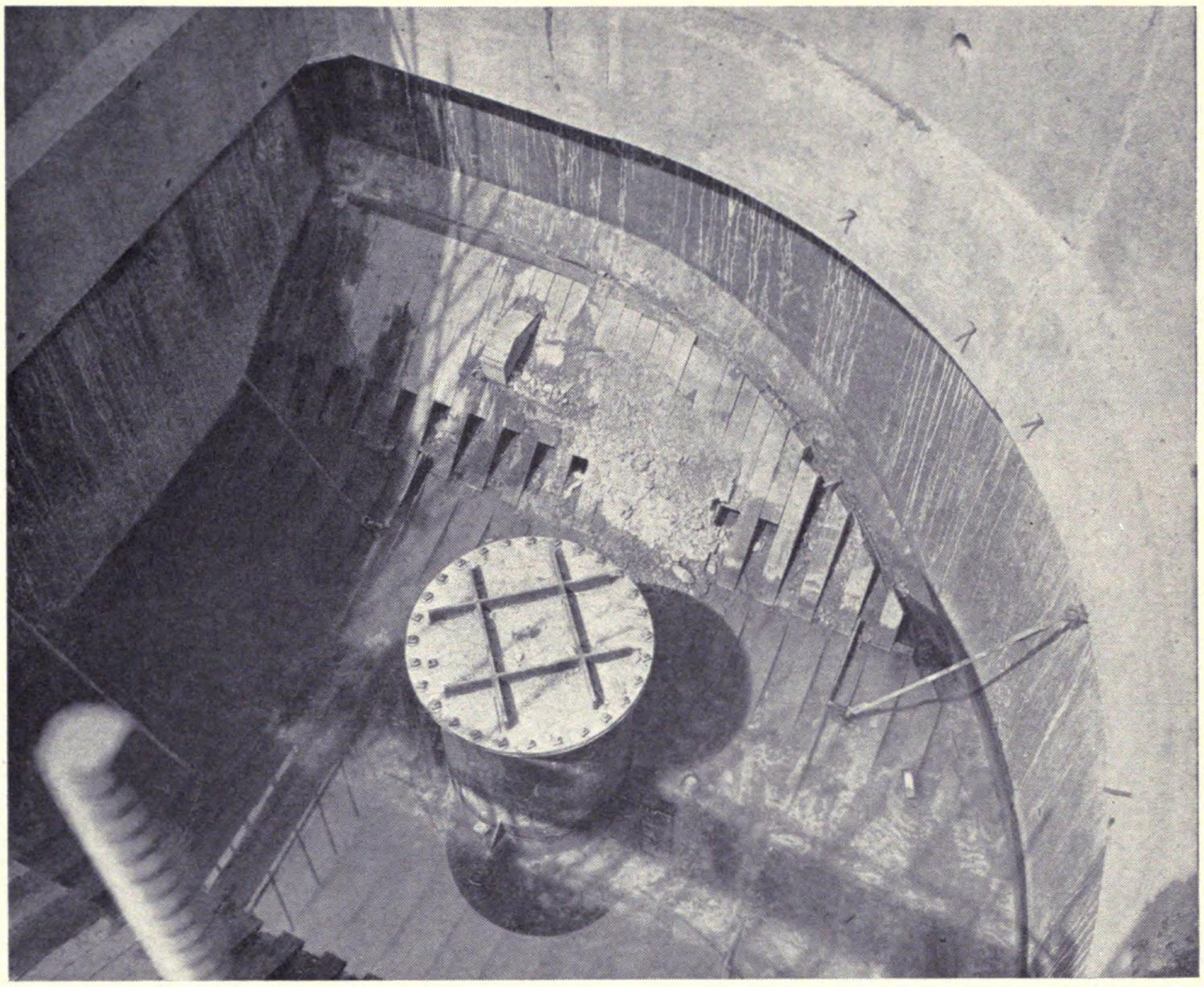
Support for Slabs

To support the slabs small vertical steel trusses 25½ inches deep were fabricated and cantilevered up from the top of the concrete and steel cutting edge below. The slabs were then secured to these trusses and the horizontal reinforcing slab bars welded at the joints between slabs. After erection there remained in the vertical joints a clear opening of one-eighth to one-fourth inch, at horizontal joints slab edges were seated on each other and there was no clear opening. To seal these joints and make them water tight the contractor used a commercial application of fiberglas fabric and fiberglas sealing compounds.

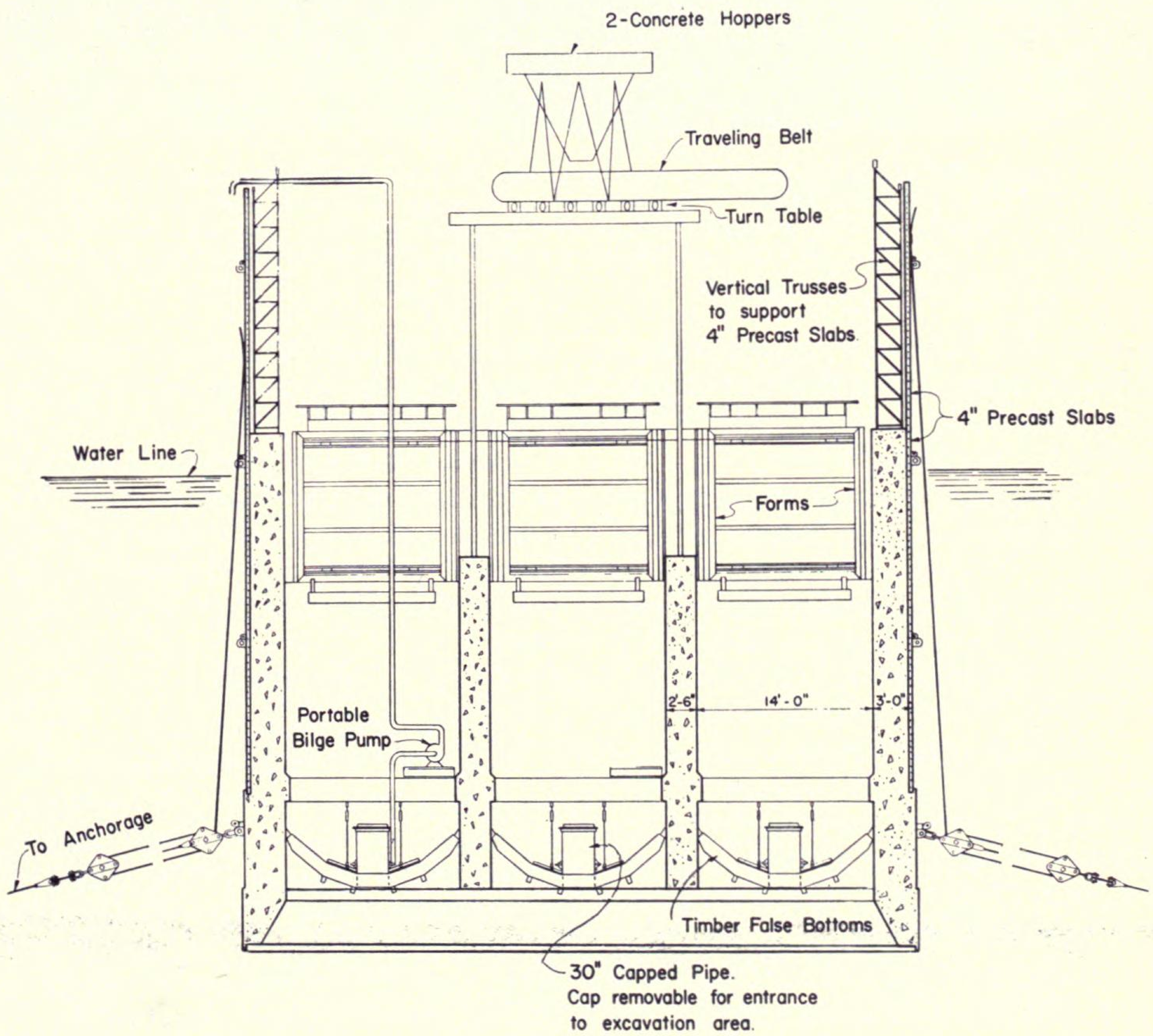
There are several advantages to this type of construction. It greatly increases the flotation qualities of the caisson by making the top 20-foot portion of the outside wall four inches thick as compared to 36 inches, thereby reducing total weight considerably. The precast slabs save the time and expense of placing and removing outside form work. This tends to speed up construction at bridge site during sinking operation. There is also provided an additional safety factor, since slabs can be placed quickly, and joints sealed to provide additional freeboard and bouyancy should the need arise.

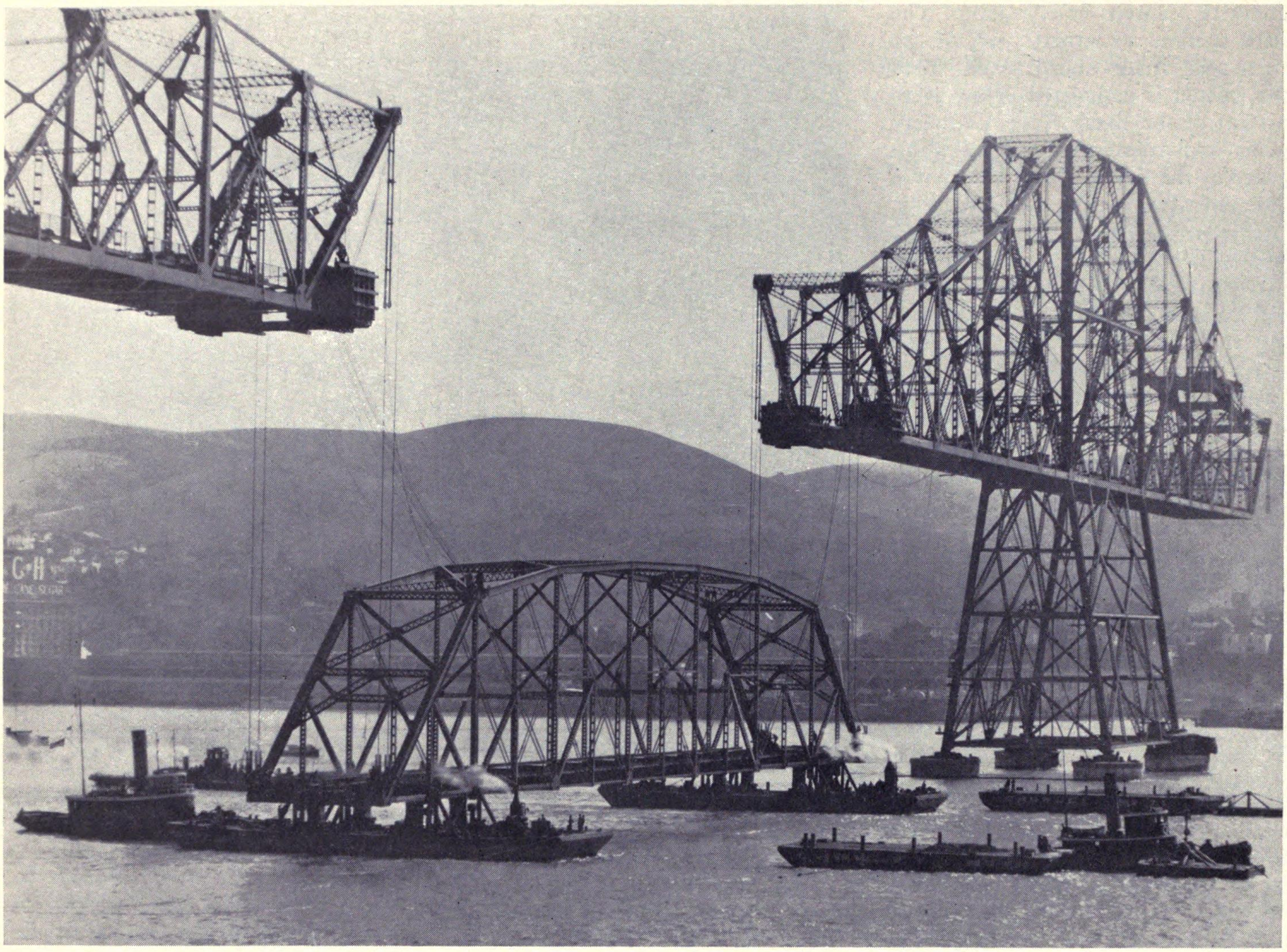
Dredging Wells Sealed

Bottoms of dredging wells were sealed with "false bottoms" fabricated from heavy timbers. Through each of the "false bottoms" there is placed a short section of 30-inch steel pipe. In-



UPPER—Picture shows the bottom of one of the corner caisson walls. Timber false bottom can be seen. The 30-inch capped pipe provides the contractor with access to underside of caisson. Jets and pumps can be lowered through 30-inch pipe and the bottom pumped out from under caisson allowing it to sink until it reaches bedrock. LOWER—Sketch showing equipment used in sinking the three caissons to bedrock. Jets and pumps can be lowered through any of the 30-inch pipes located at center of each dredging well. Contractor can also remove the whole bottom of any well and excavate by using a clamshell bucket if necessary.





Picture taken in 1927 during erection of the existing bridge. The same contractor (American Bridge Division of United States Steel Corporation) will erect the new bridge but will use a different method. This time contractor proposes to erect the center suspended span by cantilevering each half out to the center then bolting the two halves together with high-strength steel bolts. In this picture the center suspended span has been erected on barges and is being raised into position by counter weights much the same as an elevator moves up and down.

side of this there is a supplementary "false bottom" in the form of a concrete plug which can be removed and replaced whenever desired.

The purpose of these 30-inch steel pipe entrances to the bottom of the caisson is twofold. It makes access to the excavation area under the caisson possible for inspection purposes. This will be desirable in case of excavation difficulties during sinking operations and for final inspection when the caisson comes to rest on bedrock at the bottom. The other purpose is to provide access for lowering high-pressure jets and pumps into the excavation area below the caisson.

Here again the contractor has developed a new method of sinking the caissons through the mud, sand and gravel material overlaying the bedrock foundations.

Instead of the conventional method of excavating the material from beneath the caisson by clamshell buckets lowered through the dredging wells, the contractor proposes to jet and pump.

Use of Sets

This is being accomplished by extending the 30-inch steel pipes and lowering through the four center dredging wells four Chicksan Intelli-Giant Jets. These jets can be operated at pressures from 30 to 300 psi per square inch. They are so rigged that they can be lowered or raised vertically, turned in any direction horizontally, or positioned at various vertical angles. These jets are sufficiently powerful to cut loose the overburden after which it is pumped to the surface where it is discharged into barges and transported to a predetermined disposal area.

The contractor has predredged the area under each caisson to about 100 feet below water surface which leaves remaining about 32 feet of mud, sand and gravel through which each pier must be lowered. Pier No. 2 has now been sunk to bedrock at about elevation −132. The "false bottoms" were removed when north edge of caisson rested on rock at elevation −129. It was necessary to blast out along north edge for about 2 to 2½ feet in order

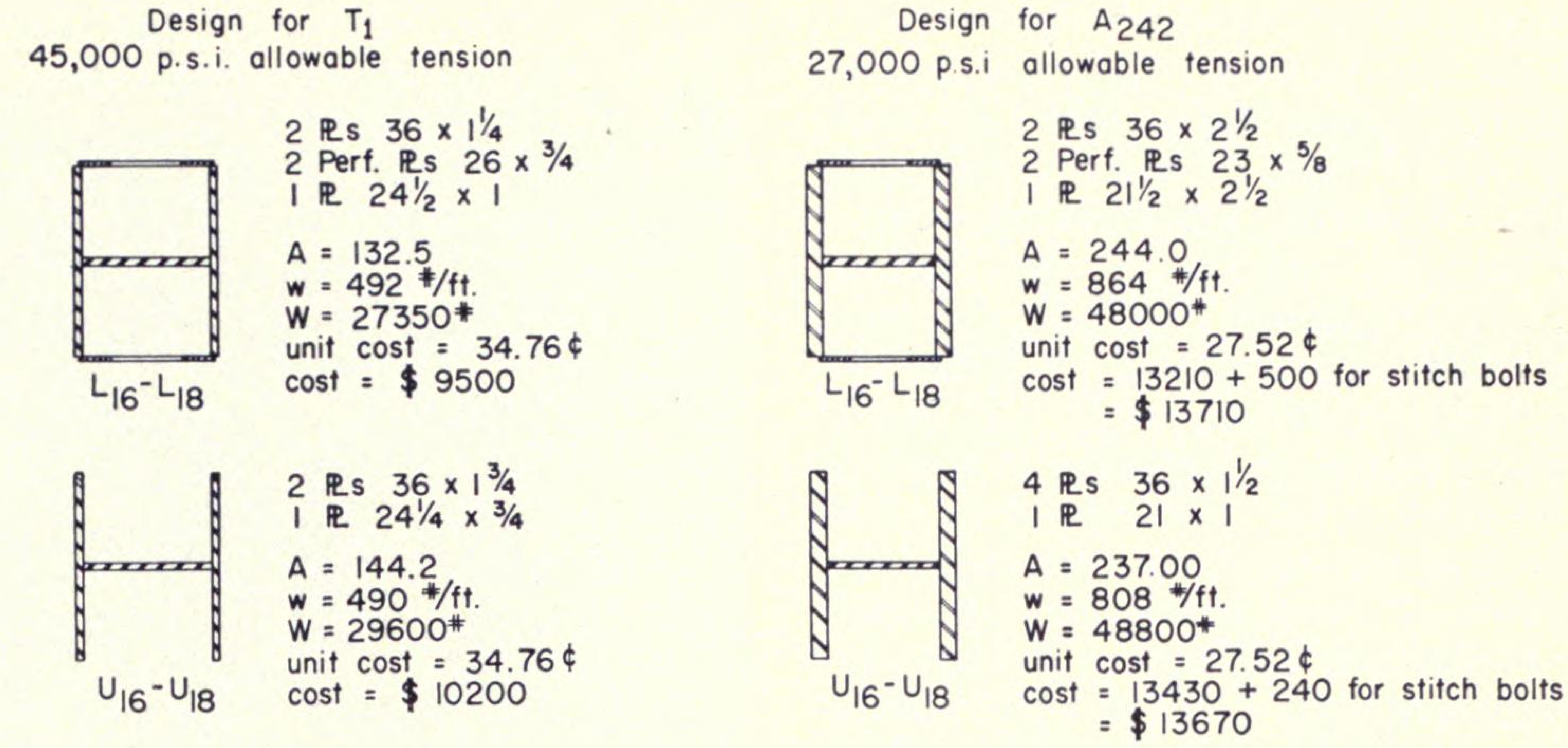
to level the bottom of caisson within specification requirements. Bottom of Pier No. 2 is now ready to be sealed with 25 feet of concrete.

Land-based Concrete Plant

For concreting the contractor has constructed a land-based concrete plant on the south shore. This plant has a capacity of about 120 cubic yards per hour. Concrete is discharged into six-cubic-yard buckets and barged to the piers in three specially constructed barges capable of carrying eight buckets each. About 20 minutes are required from the time barge leaves mixing plant until cranes pick up buckets for unloading into concrete hoppers at the pier.

For placing concrete in pier walls and partitions two concrete hoppers are set one at the center of each half pier. The hoppers discharge onto traveling belts which can be turned and extended to discharge at any point on the half pier. One 10-foot section of pier can be poured in one day. About four days are required to allow concrete to set, move forms and place reinforcing for the next 10-foot section, making sinking operations at the rate of about 10 feet per week.

The pier protection fender system is of reinforced concrete slabs and girders supported by 150-foot steel pipe piles 24 inches in diameter and filled with concrete. The steel pipe piles were fabricated from one-half inch steel plate and were put in place by jetting. When piles reach bedrock a spud was used to break up shale and sandstone which was pumped to the surface while the pile was being driven about three feet into the bedrock to form a key. Once the pile was located in the driver and jets rigged up it required only about 20 minutes to jet and drive the steel shell pile into bedrock.



Sketch showing comparison between the new type strength steel and the regular moderality high strength steel. These studies were made to determine the most satisfactory and economical type of steel to use in the makeup of the heavily stressed truss members for the 1,100-foot-long cantilever spans.

Superstructure Contract

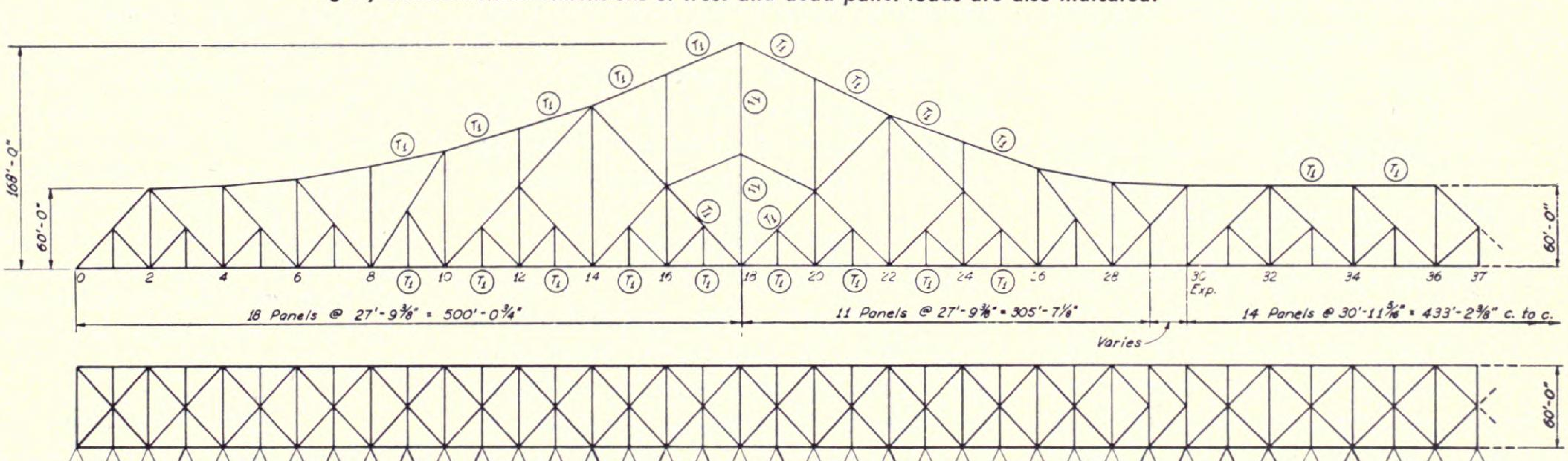
The main portion of the Carquinez Bridge superstructure consists of double cantilever truss spans with a central tower of 150 feet. The two end anchor arms are each 500 feet with two central spans each 1100 feet making the total length of main structure 3300 feet. The two suspended spans are each 433 feet 2⅜ inches long. This work is under contract to American Bridge Division of the U. S. Steel Corp. at an approximate cost of $9,500,000.

Trusses are 60 feet center to center and support a 52-foot concrete roadway with two 1-foot 10½-inch steel curbs. The roadway slab for the two anchor arms is to be of standard weight concrete while the slab for the remaining portion of the structure is to be light weight concrete at 100 pounds per cubic foot.

Three types of steel were used in the design of the superstructure. They were A7, A242 and T1 and the allowable unit tensile stresses were as follows:

A7—18,000 psi—all thicknesses
A242—27,000 psi—less than ¾ inch
A242—24,000 psi—¾ inch—1½ inches
T1—45,000 psi—all thicknesses

Sketch showing outline of truss with members fabricated from T1 steel indicated. Most other truss members are fabricated from A242 steel except for those very lightly stressed. Main dimensions of truss and dead panel loads are also indicated.



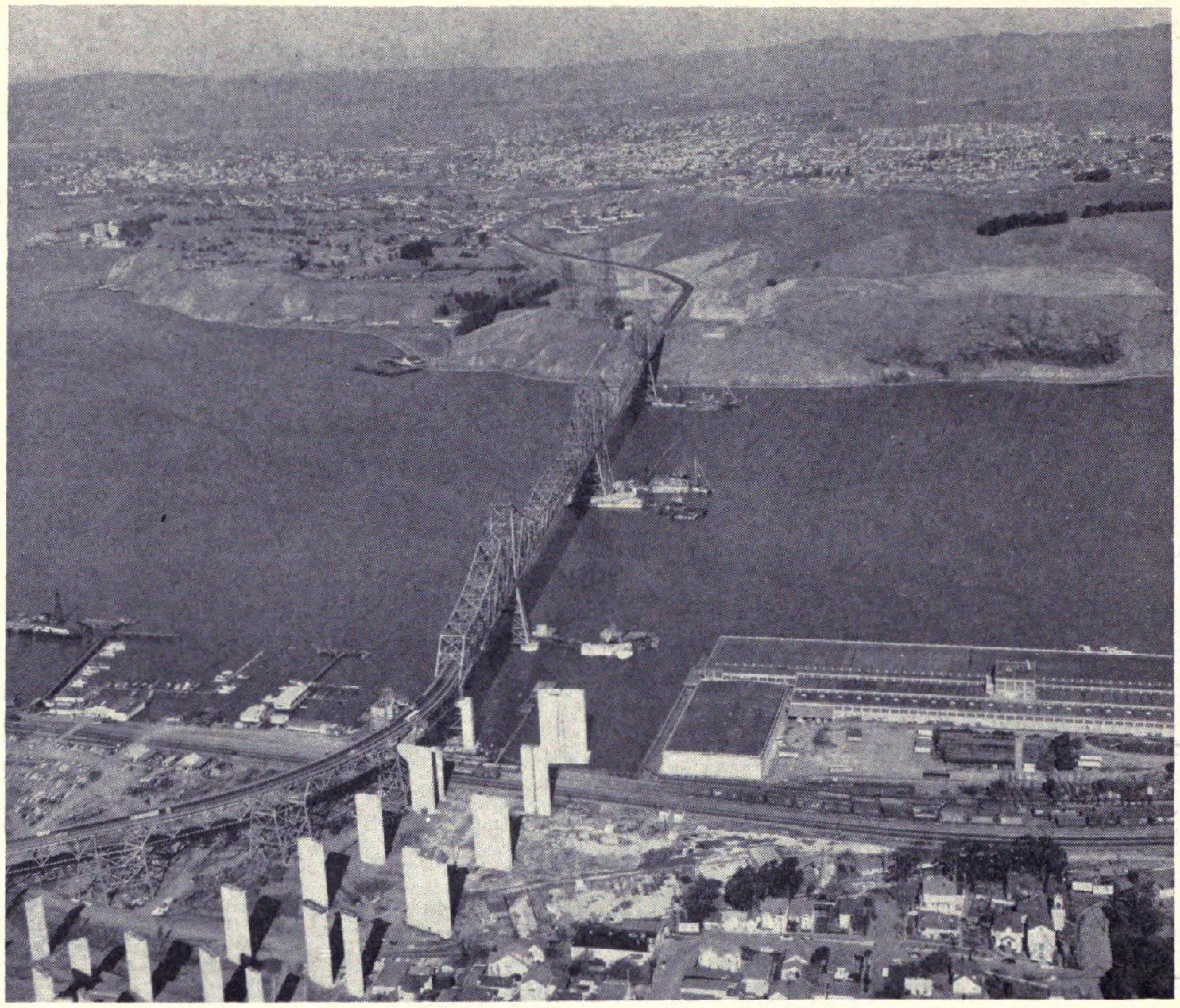
PANEL LOADS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Weight of Steel	36.8	69.5	91.6	49.3	102.2	50.4	108.4	55.1	94.5	55.9	131.6	56.1	138.8	51.2	160.4	51.8	174.9	75.4	363.6
Curb & Rail	1.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Conc. Rdwy. Slab	33.0	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1	60.1
UTILITIES	3.2	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
TOTAL	74.5	144.4	166.5	124.2	177.1	125.3	183.3	130.0	169.4	130.8	206.5	131.0	213.7	126.1	235.3	126.7	249.8	150.3	429.8

PANEL LOADS	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Weight of Steel	73.5	171.9	49.0	157.3	48.2	133.2	53.8	121.6	58.6	98.3	62.9	122.3	66.2	102.1	52.0	100.7	50.5	98.9	52.9
Curb & Rail	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.4	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Conc. Rdwy. Slab	45.6	45.6	45.6	45.6	45.6	45.6	45.6	45.6	45.6	45.6	45.6	48.3	51.0	51.0	51.0	51.0	51.0	51.0	51.0
UTILITIES	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	6.1	6.2	6.2	6.2	6.2	6.2	6.2	6.2
TOTAL	127.9	226.3	103.4	211.7	102.6	187.6	108.2	176.0	113.0	152.7	117.3	180.1	127.0	162.9	112.8	161.5	111.3	159.7	113.7

Design of Cantilever Trusses

In the design of cantilever trusses of this length, supporting four lanes of traffic with a concrete floor slab, one of the big problems has always been the makeup of the heavily stressed members in the area of supporting towers. These members frequently contain so many thick heavy plates that their resistance to bending between joints produces high secondary stresses, sometimes greater than the primary stresses. In the past some of this difficulty with high secondary stresses has been overcome by the use of pinned connected eye bars and pin connected compression members. The reliability of the pin connected compression member to relieve secondary stresses has been somewhat questionable, since the moment required to produce rotation in the pin may be as large as the moment induced by the secondary stress.

In any event the use of a high strength steel which would allow the makeup of members to retain reasonable flexibility appears to be the best answer in this case to the problem of secondary stresses.



Picture shows foundation work in progress for the main bridge. Caisson Pier No. 2 in water at far side of Carquinez Strait has now been sunk to bedrock. Caisson Pier 3A at center is now being lowered.

Comparative Designs

Comparative designs between the use of A242 and T1 for these critical members gave the following approximate figures:

	A242	T1
Maximum deadload truss deflection	100%	130%
Moment of inertia L16 L18	51,900 in-4	17,700 in-4
Bending stress L16 L18	19,200 psi	2,900 psi
Ratio secondary stress to primary stress L16 L18	110%	10%

From these comparative figures it can be seen that the high strength steel has a considerable advantage from a design standpoint and also indicates greater economy.

Using the unit bid prices for A242 and T1 received from the low bidder the total saving made by the use of T1 for the critical members was estimated to be approximately $800,000.

Before deciding on the use of this steel the California Division of Highways Testing Laboratory ran extensive tests on the parent metal and butt welded joints made from ½-inch, 1-inch and 1½-inch sample T1 steel plates. The butt weld samples were made by using a semiautomatic shielded arc, automatic submerged arc, and three types of manual low hydrogen processes.

The averaged test results for the parent T1 steel indicated a yield strength of 111,000 per square inch, ultimate strength of 120,000 per square inch, and an endurance limit of 55,000 per square inch. The steel exhibited excellent ductility.

The welded joints provided joint efficiencies from 87 percent to 100 percent of the ultimate strength of the parent metal and endurance ratios of 27 percent to 45 percent of the ultimate strengths of the corresponding welded joints. The welds exhibited moderate ductility and some porosity.

Butt Welded Joints

It was necessary to give considerable attention to butt welded joints of T1 steel because rolling limits will not permit full length plates for member makeup. Advantage was taken of this however by increasing plate thickness near joints to compensate for loss of net section due to holes for truss joint connections.

Experience gained by the California Division of Highways on the design and fabrication of thousands of tons of steel girders in the past few years prompted the consideration of steel truss members fabricated by welding in lieu of the customary stitch rivets.

This appeared to have considerable advantage such as: (1) the number of member shapes could be reduced to three for H sections, four for box sections, and five for box sections with interior webb; (2) makeup of all members can be made from plates only, eliminating the use of connecting angles; (3) shop fabrication has a good opportunity to be greatly simplified with a corresponding reduction in cost, because all stitch riveting and fitting is replaced by four continuous fillet welds; (4) maintenance, always a costly item near coastal waters, should be made easier by the smooth surfaces which are free from rivet heads, lacing bars and other small vulnerable details which are costly to clean and paint.

High Strength Bolts

Design plans call for field connections at truss joints to be made by high strength bolts with the contractor having an option between

rivets and high strength bolts for shop connections. Shop plans now being prepared by the fabricator, which is the American Bridge Division of the United States Steel Corporation, indicate that high strength bolts have been chosen for shop connections. High strength bolts for field connections were decided on for several reasons. First, it was the opinion of designers that the numerous past tests have indicated that the average high strength field bolt is superior to the average field-driven rivet in performing the fastening job that it is designed to do. The field inspection for a good high strength bolt is more positive than the inspection for a satisfactory field-driven rivet. The development and training of an efficient bolting crew is much easier than the development of an efficient riveting crew.

For these reasons designers felt that high strength bolts have an excellent opportunity to make possible more reliable field joints at reduced costs.

Field erection of the superstructure is to start in April, 1957.

Toll Plaza

The toll plaza will consist of an administration building and 16 onside modern barrier-type toll booths, with provision for four additional toll booths should future traffic demand require them.

Each toll booth will be equipped with automatic axle counters and photoelectric vehicle counters.

There is to be a nominal fee of 25 cents for passenger cars; trucks will be charged by the axle rather than by weight. Administration of the toll collection will be under the jurisdiction of the Division of Highways and will be operated by the same staff now being used to operate the San Francisco-Oakland Bay Bridge, the Richmond-San Rafael Bridge, San Mateo-Hayward, and Dumbarton Toll Bridges.

The Carquinez Bridge Project should be completed by October or November, 1958. All of the work in connection with these projects has been assigned to the Division of Highways by the California Toll Bridge Authority.

BRIDGES

Continued from page 39 . . .

higher cost is the emergence of a situation of relatively reduced competition resulting from the currently expanded programs of heavy construction.

The rise in construction costs is a part of the general price rise occurring throughout all phases of the economy. A majority of economists are of the opinion that the inflationary trends are the pattern of the current economy. In support of this thesis they cite: (1) The government's active intervention in the field of monetary controls; (2) The labor-management contracts whereby labor rates are either determined by official cost indexes or by long term contracts which call for annual wage increases; (3) The increasing trend on the part of many heretofore "backward" nations toward industrialization and the consequently increased competition for the world's rigidly limited supply of raw materials. These factors, the economists contend, inevitably lead to a creeping type of inflation on the order of 3-5 percent per year.

The situation insofar as California bridge construction costs are concerned is analagous to that of the broader economic pattern. Price advances are sometimes more dramatic but the long term trend is in the direction of an upward creep of about 5 percent, an increase which stems directly from the existing pattern of annual wage increases and the concomitant price increases of all cost elements associated with the industry.

In view of these circumstances it may be assumed that the California Bridge Department Cost Index will very likely reach a value of 285 during 1957, or a value which is about 5 percent greater than the value of 273 for the fourth quarter of 1956.

THE WORST TYPES

If you're a speeder, lane jumper, or bumper rider, you have the dishonor of being one of the three worst types of problem drivers in the United States today.

That, according to the National Automobile Club, is the opinion of 33 honored cabbies who have driven a total of 834 years and about 22,000,000 miles with nary an accident.

Common courtesy, the cabbies agree, would eliminate some 65 percent of all traffic accidents.

In Memoriam

A. D. EDMONSTON

A. D. Edmonston, 70, who retired as State Engineer in November, 1955, died on February 22d in Stanford Lane Hospital, San Francisco, where he had been under treatment three weeks.

Edmonston had 31 years of state service. Beginning as a hyldraulic engineer in 1924, he served for many years as one of the original collaborators on plans for the Central Valley Project. From 1937 through 1945 he was chief hydraulic engineer in charge of formulating the California Water Plan. In 1945 he became assistant state engineer under the late Edward Hyatt, and succeeded him as state engineer and chief of the Division of Water Resources upon Hyatt's retirement in 1950.

The position of State Engineer was the chief water planning job until the organization last year of the new State Department of Water Resources.

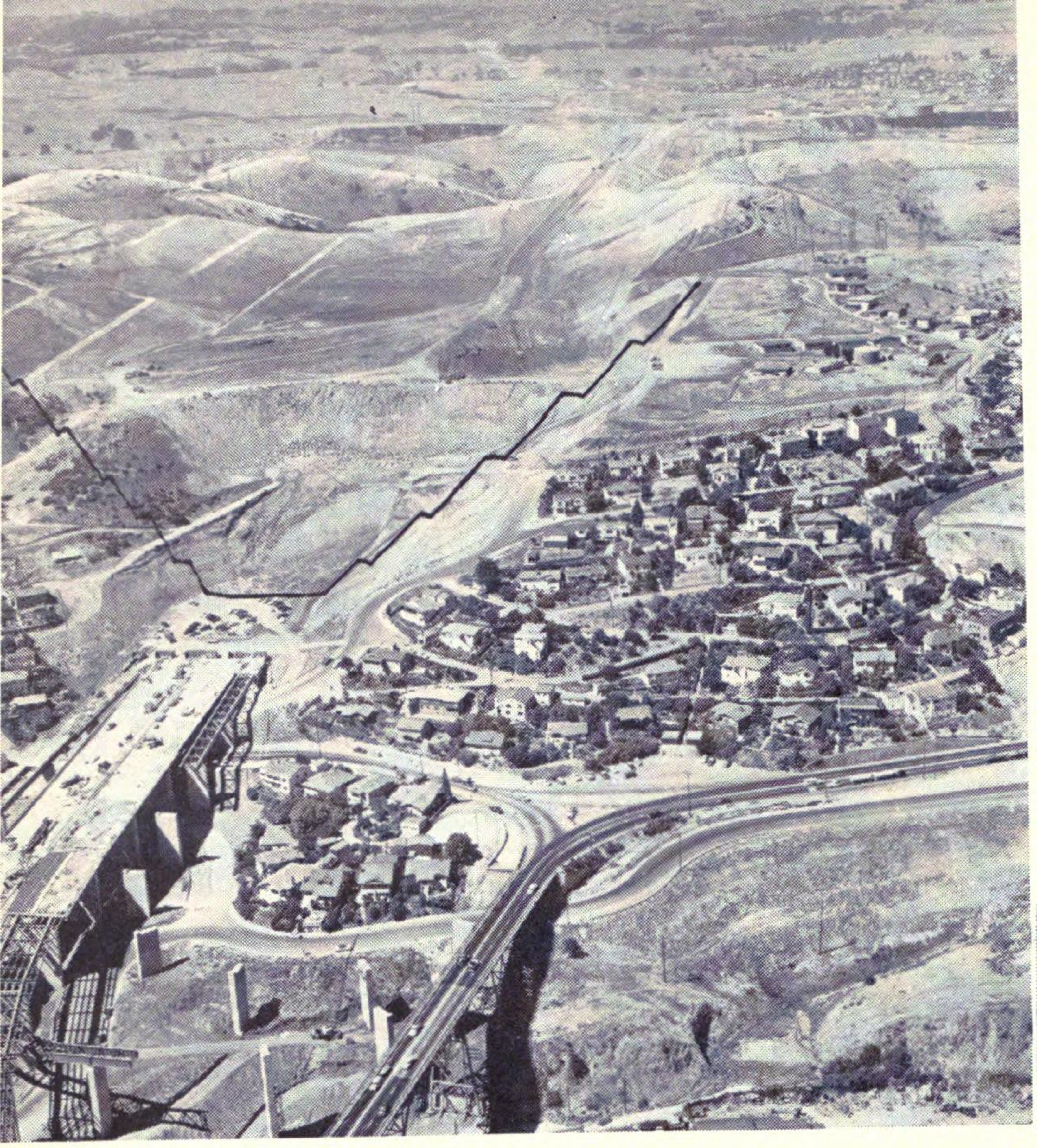
Edmonston directed most of the original studies on the Feather River Project and the California Water Plan, both plans now pending before the current session of the State Legislature.

Edmonston was born November 12, 1886, in Ferndale, Humboldt County, California. He was graduated from Stanford University in 1910. He served in World War I as a lieutenant with the Army Corps of Engineers.

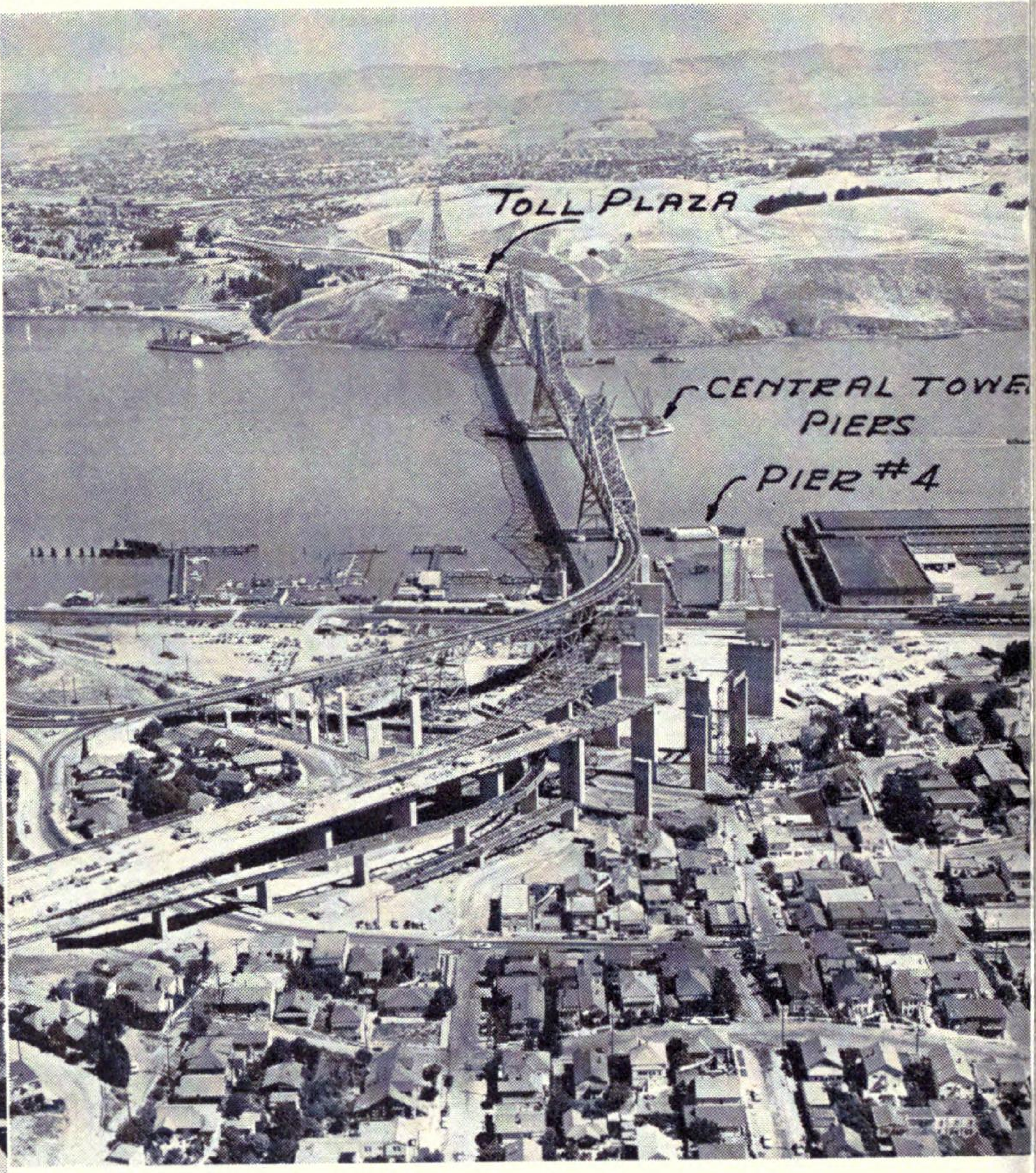
He was a member of the American Society of Civil Engineers, the Commonwealth Club, the American Deophysical Union, and Tau Beta Pi engineering fraternity.

He is survived by his wife, Dell, of Sacramento; his sons, Donald, a graduate student at University of California, and Robert, an engineer with the Department of Water Resources, Los Angeles office; a sister, Emma Edmonston of Palo Alto, and a brother, John Edmonston.

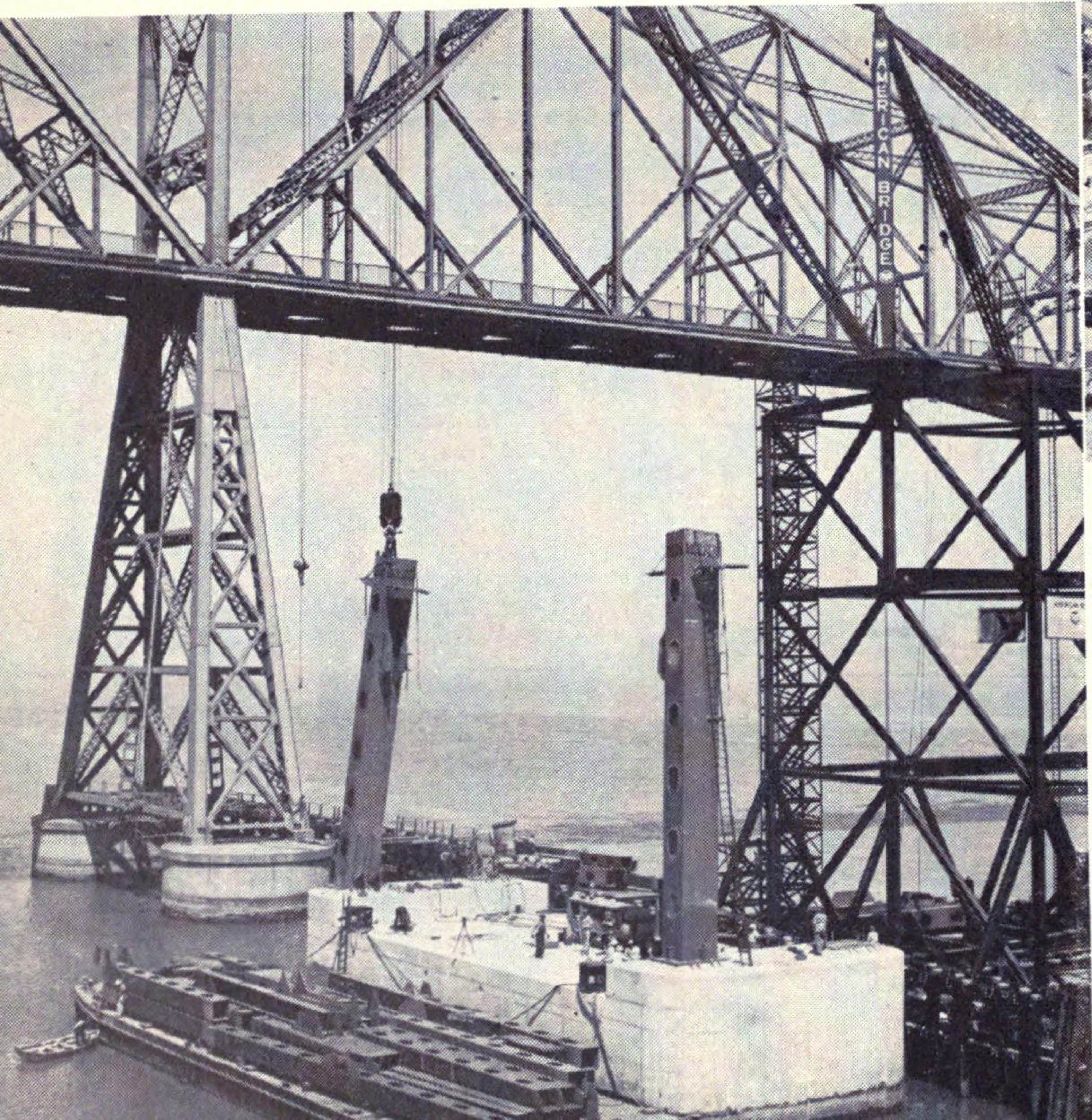
Carquinez Bri



LEFT—Work on the "big cut" to the south of the main bridge approach is in progress. This picture shows the approximate outline of the "big cut" as it will look when completed. This cut contains over 9,000,000 cubic yards of earth, and the contractor, Ferry & Crow, has now removed approximately 5,500,000 cubic yards at the rate of about 25,000 cubic yards per day. Work on the Crockett Interchange can also be seen in the foreground. Peter Kiewit Sons, Inc., the contractor, has a major por-



RIGHT—General view of the work at the Carquinez Bridge. Approach roadwork on the far side toward Vallejo is nearly completed. The administration building and 16 toll collection booths are well under way in the area of the toll plaza. This picture was taken shortly before steel erection started at Pier 4.



LEFT—The bottom section of two of the four legs to this steel tower on the Crockett side at Pier 4 are seen in place. This steel tower when completed will be similar to the tower of the existing bridge seen in the background, but, as can be seen, it will be much heavier in section.

...ge Project

...tion of the welded steel girders erected and is following closely with the placing of the reinforced concrete roadway slab.

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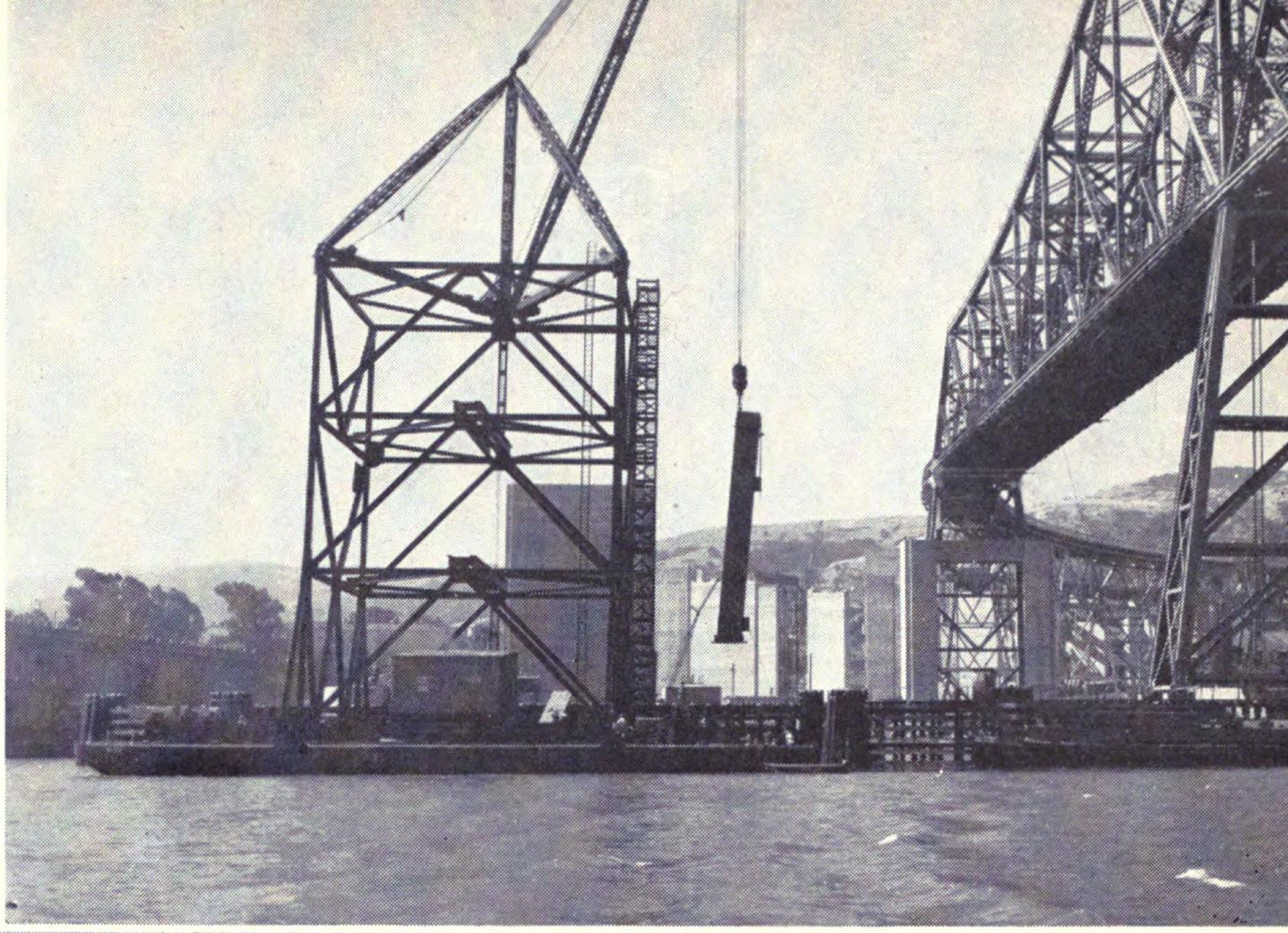
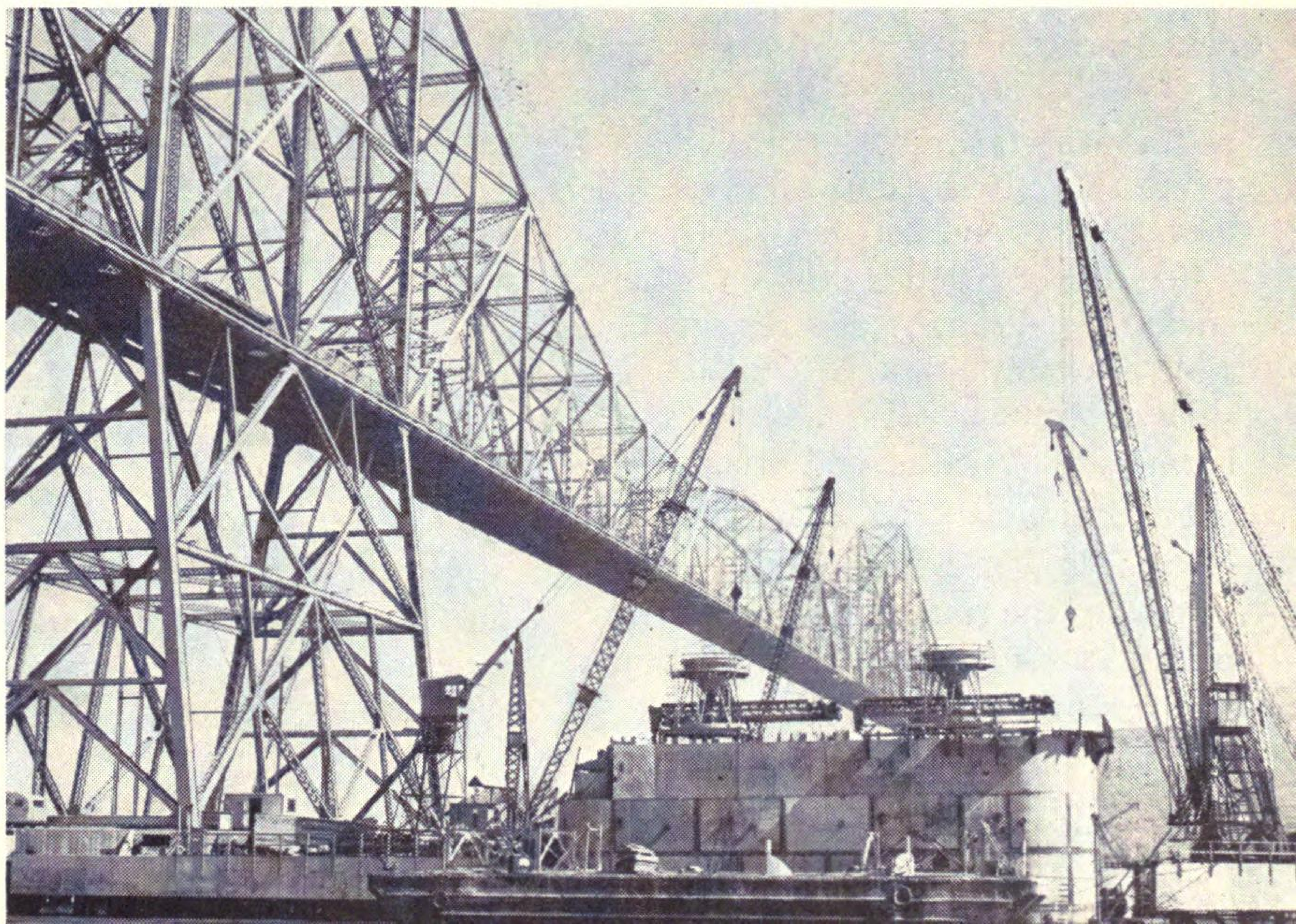


RIGHT—On June 27, 1957, steel erection on the main span was started by the American Bridge Division of the United States Steel Corporation at Pier 4. Their huge crane with a capacity of 100 tons is seen lifting the first piece of one of the main steel supporting towers into place. This single piece weighs 37 tons.

LEFT—Foundation work at the center tower is in progress by Contractors Mason & Hanger, Silas Mason and F. S. Rolandi, Jr. There are two large caissons at this point which will support the main center tower. One of these caissons has been founded on bedrock 132 feet below water, while the one seen in background has about 12 more feet to go before it comes to rest on the bottom. When these piers are sunk and the top cap with steel grillage for tower legs are placed, they will then be ready for the start of steel erection at the center tower.



RIGHT—This picture shows another view of the 53-foot by 102-foot, 6-inch reinforced concrete caisson at the center tower being lowered to bedrock 132 feet below water. The two hoppers on top the pier are used to receive and distribute concrete to the various walls and partitions of the caisson. As weight is added and mud from the bottom removed, the caisson sinks until it comes to rest on bedrock at the bottom. The surface of the bedrock is then thoroughly cleaned after which a solid footing of concrete 25 feet thick is placed under water forming the foundation for caisson and the main central tower for the bridge.

zation during 1956-57. Road closures due to storms and other disruptions, such as forest fires and earthquakes, were held to a minimum. The total expenditure for maintenance work during the year was $27,240,234.

Equipment

Equipment maintained by the Division of Highways ranges from passenger cars and highway striping devices to motor graders and a fleet of 40 rotary snowplow units mounted on four-wheel-drive trucks.

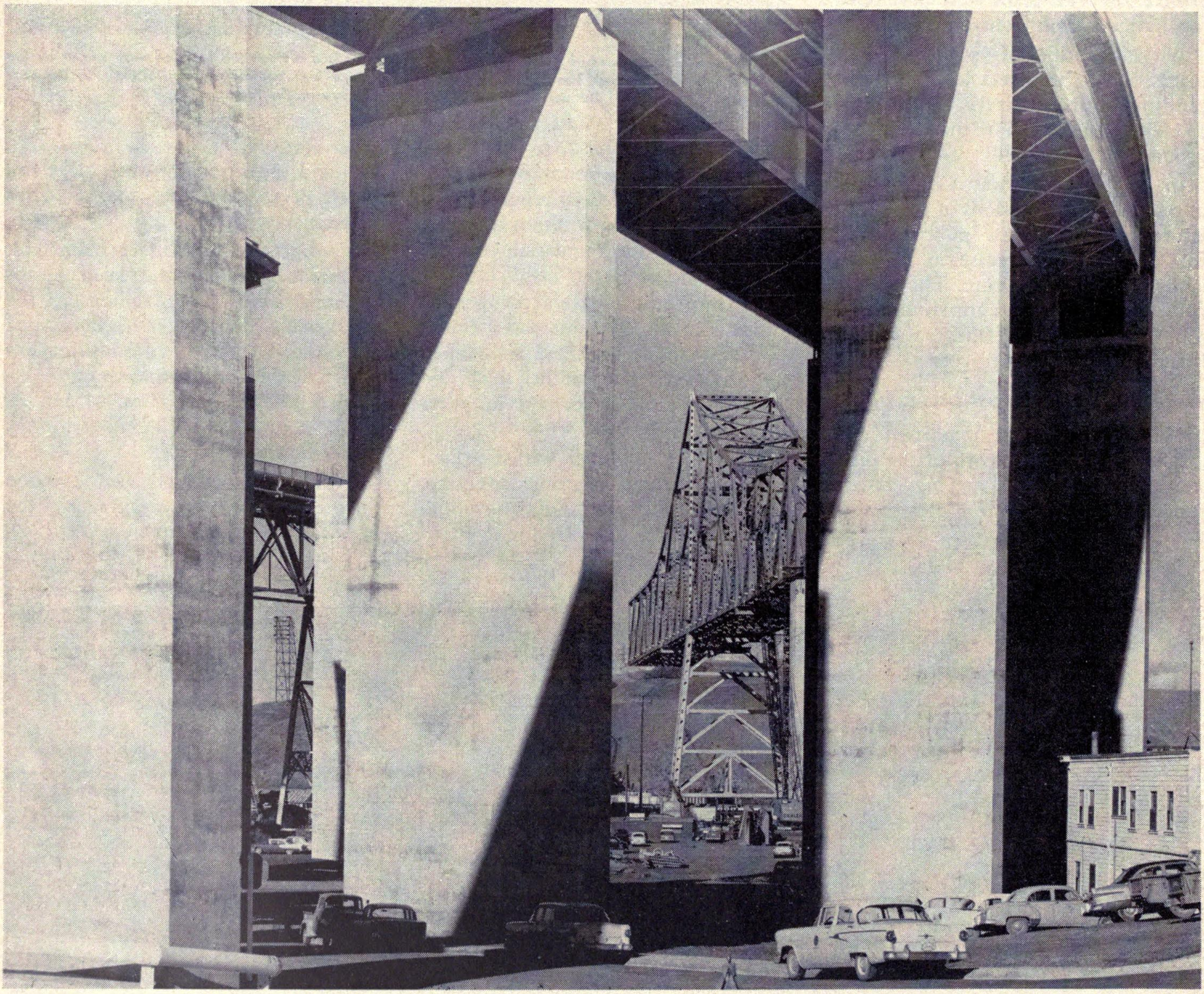
The accelerated highway program has resulted in increases in the Equipment Department's regular activities involving the procurement, repair and administration of major equipment used for highway maintenance. It also has meant increases in other activities such as the construction of experimental equipment to fill special needs and the modification of standard units to better meet specific requirements.

Most of the district shops have been enlarged in the past five years, and new shops, incorporating modern repair facilities, were completed during the fiscal year in Bishop, Fresno, and San Luis Obispo. Improvements also were made at the Eureka and San Diego shops.

Materials and Research

Two of the principal phases of Materials and Research Department activity are the testing of materials to be used in highway construction, and research aimed at developing improved use of materials and better construction methods.

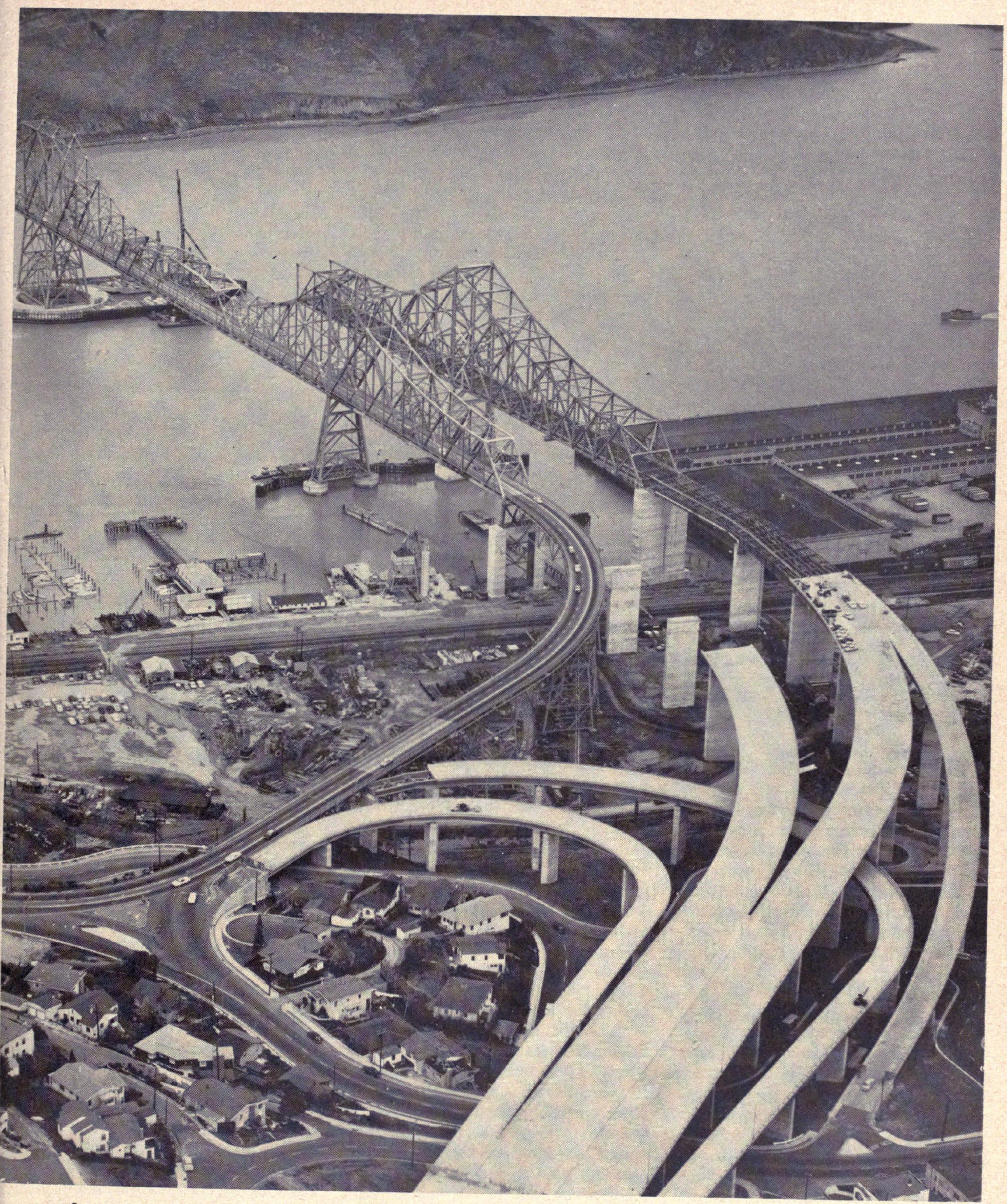
This work is divided between the Headquarters Laboratory in Sacramento, four branch laboratories located in Los Angeles, Berkeley, Santa Maria and Bakersfield, and individual laboratories in each of the 11 state highway districts.



Construction is progressing on the parallel Carquinez Bridge which will connect with freeway sections now being built on US Highway 40 northeast of Oakland and through Vallejo. The bridge is one of several major projects which are under construction or budgeted on this interstate route between Oakland and the Nevada State Line. In view (center) between the giant piers which support approach roadways is a portion of the superstructure of the new bridge.

CALIFORNIA
HIGHWAYS AND PUBLIC WORKS

MARCH-APRIL
1958



Construction on the new parallel Carquinez Bridge looking north from above the Big Cut. Crockett Interchange is in the foreground.

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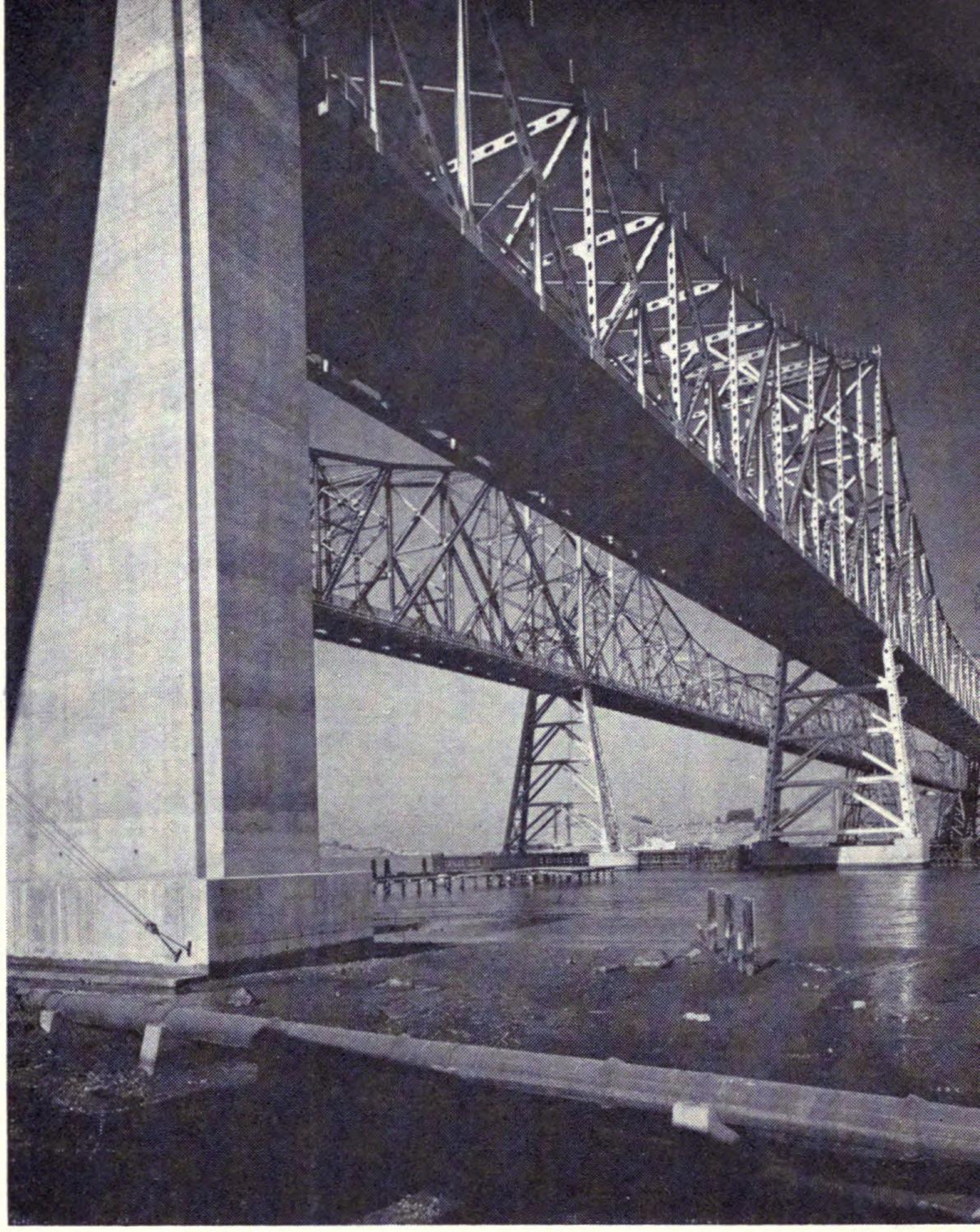


By L. C. HOLLISTER
Projects Engineer—Carquinez

On November 25, 1958, the new parallel Carquinez Bridge was open to traffic, breaking one of California's most critical highway bottlenecks. It also marked the culmination of many years of effort by Senators Luther E. Gibson, George Miller, Jr., and Assemblymen Donald D. Doyle, Samuel R. Geddes and S. C. Masterson and others who sponsored the necessary legislation making this very noteworthy project possible.

Appropriate ceremonies were conducted by the Contra Costa Development Association in which then Lieutenant Governor Harold J. Powers officially cut the chain opening the bridge to traffic. Since the chain cutting ceremonies thousands of cars each day have passed through the tollgates and over the new structure. On the Sunday following Thanksgiving 45,305 vehicles used the new bridge and its modern six-lane freeway approaches.

The new parallel Carquinez Bridge glistens in the sunlight while her drabber sister, some 31 years her senior, stands in the background.

There are several design and construction features in connection with the Carquinez Bridge and freeway approaches that have attracted a great deal of interest among highway and bridge engineers throughout the Country.

As for example the "Big Cut" involving the largest highway cut in history; the use of slip-form construction for the erection of the 120-foot-high piers for the complicated interchange and approach structure; the sinking of caissons to 132 feet below water with the difficulties and hazards encountered; the use of welded steel fabrication for the two 1,100-foot double cantilever spans; the use of high-strength bolts and a new very high-strength structural steel known as T-1. Some of these features are new developments and because they are progressive steps forward in highway construction have attracted the attention and interest of many engineers throughout the Country.

Stability Required

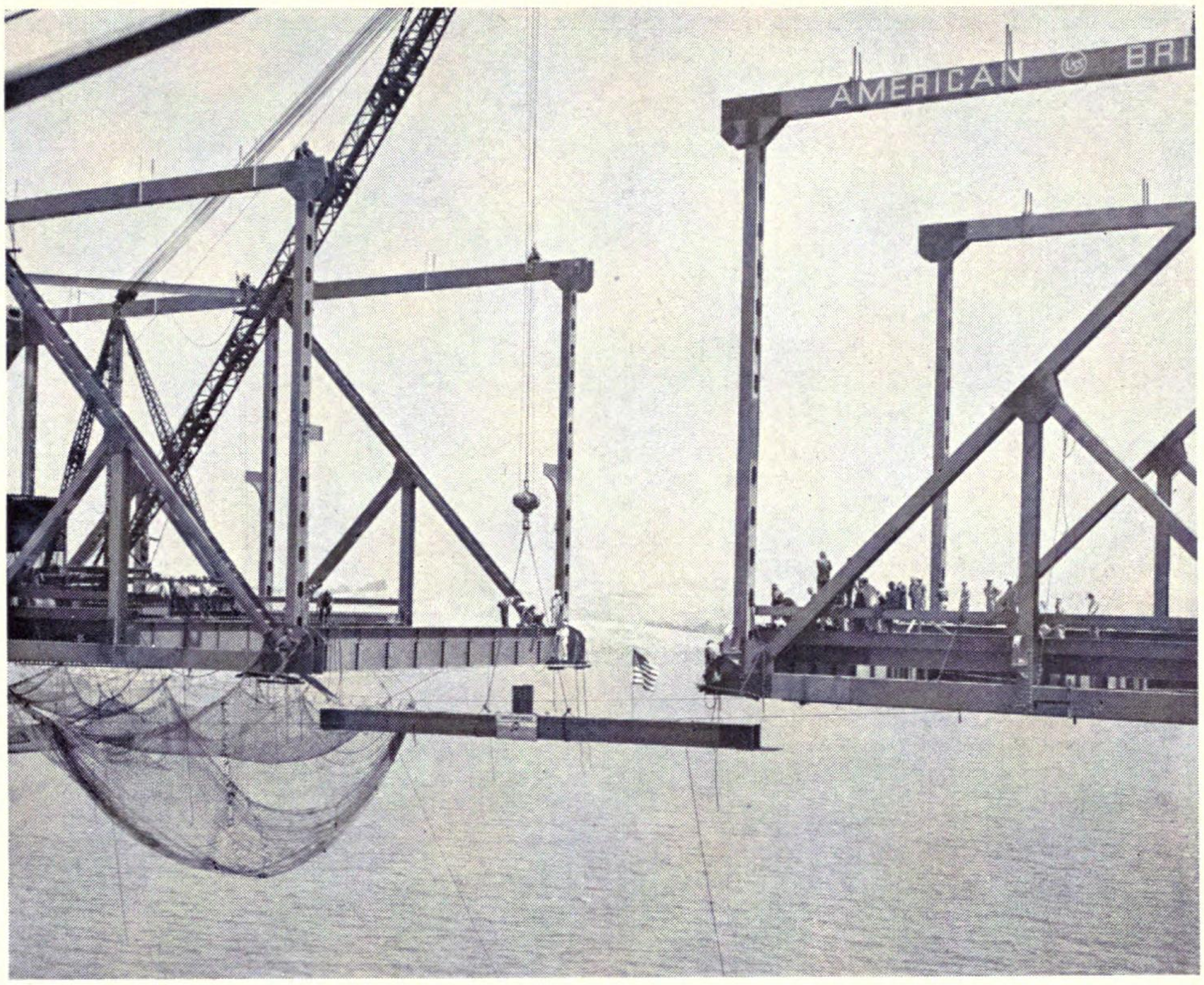
The "Big Cut" located immediately south of the bridge is approximately 2,500 feet long, 1,370 feet wide and nearly 300 feet deep at the deepest point. The elevation of the profile was controlled by the location of the bridge grades. To provide the degree of stability required in the type of formation encountered, the design provided for 2:1 cut slopes with a 30-foot-wide bench every 60 feet in elevation. A debris trough 40 feet wide was provided between the edge of the shoulder and the toe of the cut to allow room for maintenance to clear any sloughing that might occur without closing the traveled way. Initial construction provided three lanes in each direction and provision was made for an ultimate paved section of four lanes in each direction with a 12-foot division strip. This means that the total width of the cut from toe to toe is 204 feet and 1,370 feet from top of cut to top of cut at the widest point. At this location there were two stations that contained a million cubic yards per station. There were 8,800,000 cubic yards in the "Big Cut." The two other cuts on the three-mile project contained approximately 1,700,000 cubic yards, making a total of 10,500,-

with the exception of minor cracking of huge boulders. Many nests of these boulders averaging 8 to 10 feet in diameter were encountered at different elevations throughout the cut. These were pushed into piles, drilled and broken with powder to a small enough size that they could be loaded. They were then hauled to and incorporated in the fills.

Rains Cause Slide

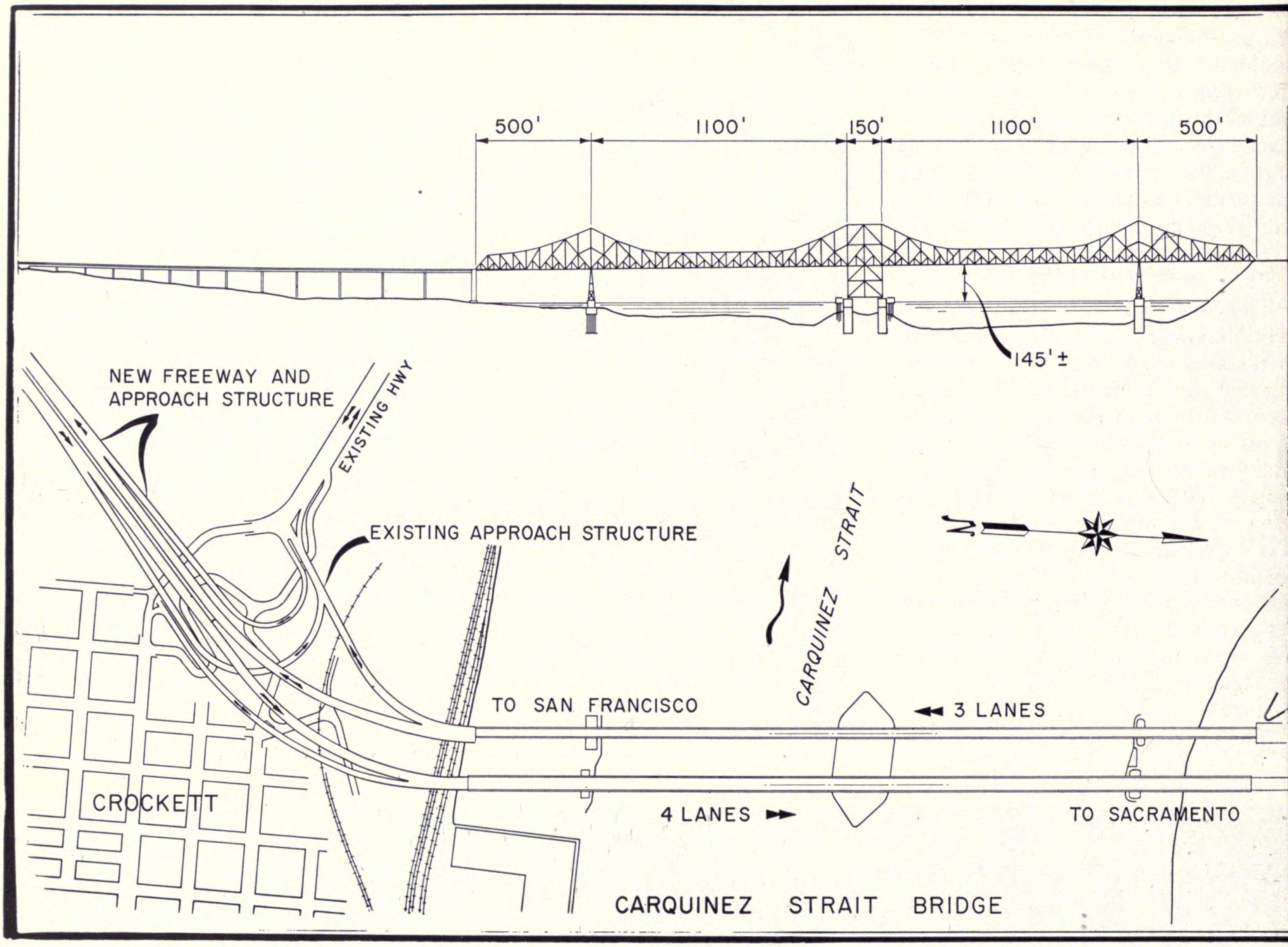
The "Big Cut" was nearly 10 percent complete prior to the heavy rains in the winter of 1957-1958. Considering the fact these were the heaviest recorded rains in 80 years, the slopes stood up remarkably well. Only one slide occurred, amounting to approximately 100,000 cubic yards. This took place at the top bench elevation and was approximately 60 feet deep. Unfortunately, it occurred in the only developed area bordering the cut and resulted in the removal of four homes. The remainder of the cut showed little signs of distress with only minor surface sloughing occurring.

The Crockett Interchange serves as a connecting viaduct between the



Starting the final closure between the two cantilever arms with the American Flag flying in the traditional custom of bridge builders throughout the Country. To make the final closure at this point six 500-ton jacks were used to jockey the suspended span into position so that bolting the final joints would be possible.

Lieutenant Governor Harold J. Powers is about to cut the chain starting the flow of 30,000 vehicles per day across the new Carquinez Bridge and its freeway approaches. Left to right are Assemblyman S. C. Masterson, Supervisor Mel Nielson, H. W. Saunders, Jo Ellen Fisher (Miss Contra Costa County), Senator George Miller, Jr., Lieutenant Governor Powers, Senator Luther E. Gibson, Wanda Kealty (Miss Solano County), Assemblymen Donald D. Doyle and Samuel R. Geddes.



General plan of the Carquinez Bridge showing principal dimensions. The old structure will carry three lanes of southbound traffic and the new bridge will carry four lanes of northbound traffic.

"Big Cut" and the south end of the main bridge. It also acts as an interchange structure providing on and off ramps for the town of Crockett.

This interchange structure is of conventional steel girder design, varying in span lengths from 120 feet to 205 feet. Girders are supported on 47 reinforced concrete piers. These piers vary in plan from 6-foot by 22-foot solid shaft to 20-foot by 76-foot boxed section shaft and in height from 20 feet to 123.5 feet, with the average height about 70 feet.

New Slip-Form Method

The piers were all designed without batter or offset so that slip-form construction could be used by the contractor if desired.

The contractor, Peter Kiewit Son's Company, investigated this method of construction for the piers and decided to proceed with slip-forms.

Slip-forms have been used before in the United States but they have been of the manually operated screw jack type. These have been cumbersome to keep level and troublesome to keep moving at a constant rate at all points.

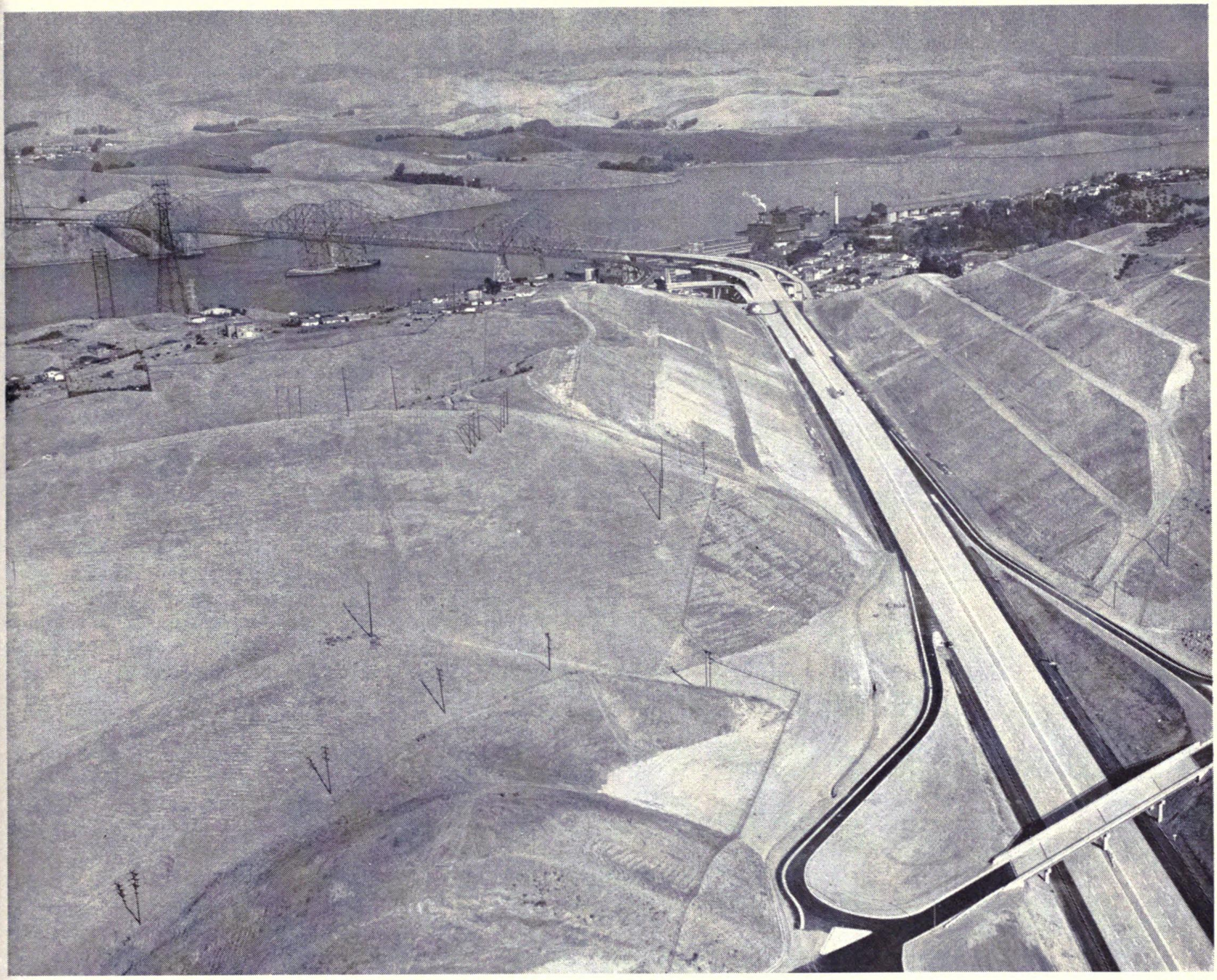
The development of an automatic controller for operating the hydraulic ratchet jacks has greatly simplified this procedure.

These hydraulic ratchet jacks are supported about seven-foot centers by one-inch diameter high-strength steel rods. Each rod has a three-foot section of metal sleeve which protects the rod from bonding with the green concrete making it possible to salvage them after the last pour on the pier has been made.

At the start of each pier after forms have been carefully set on pier footings, the four-foot-deep forms are filled in layers of about eight inches. As soon as concrete in bottom has set sufficiently, which may be in about three hours, the jacking operations are started. Once the jacking operations are under way the forms are slipped up at the rate of 5 to 14 inches per hour with the average being about 10 inches per hour. Rate of slipping is dependent on rate of curing which changes with the ambient temperature and wind velocity. An experienced operator determines the pace at which forms are slipped by pushing a thin steel rod down into the concrete.

Forms Tapered

The forms are constructed so that the outside form of the wall is vertical,



Picture showing the "Big Cut" completed with the Carquinez Bridge in the background. To the right can be seen the 30-foot benches spaced every 60 feet in elevation going up the side of the cut. Slope of cut between benches is 2:1; that is one foot up for every two feet horizontal.

while the inside form is battered about three-eighths inch in the four feet. This makes the form three-sixteenths narrower at top and three-sixteenths larger at bottom than the nominal thickness of wall.

Comparative costs between slip forms and conventional forms are not available; however, on a job with a reasonable number of piers 40 feet and over in height there appears to be an excellent opportunity for economy. Other advantages are safety and speed of operation. Therefore, where time is of importance there is considerable advantage. Their simplicity and safety also appear to give them an advantage over the conventional methods on high piers.

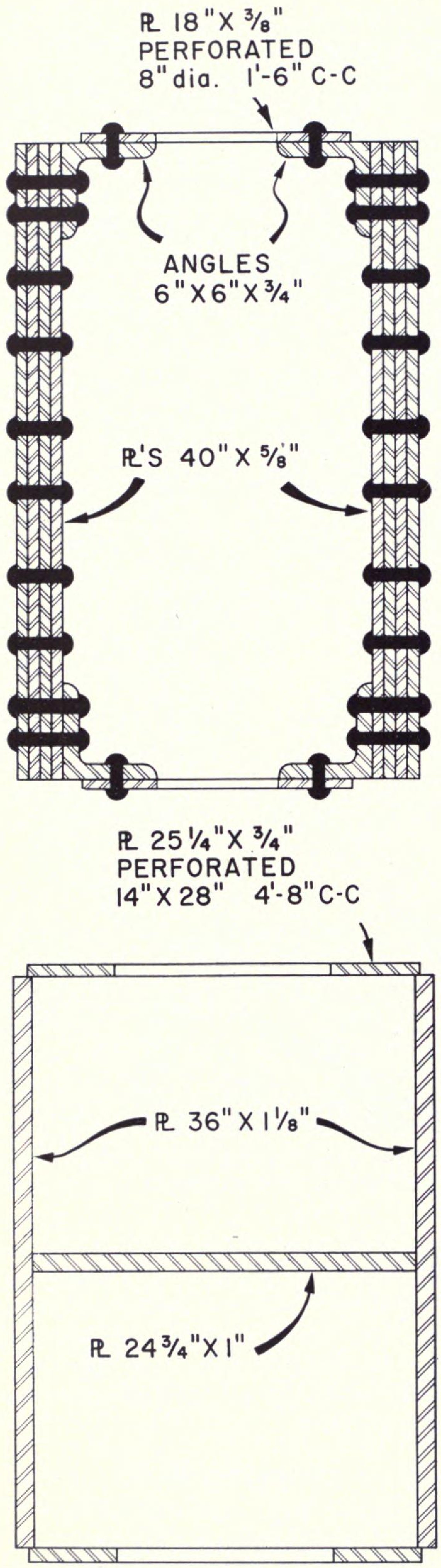
The Crockett approach structure involved the welding of over 8,500,000 pounds of structural steel for the girder spans. These spans ranged in length from 120 feet to 205 feet. The larger spans were made up of 144- by ¾-inch web plates with 24-inch flange plates top and bottom. The flange plates varied in thickness from 2½ inches at the center to one inch at the ends. Field splices were made by welding the heavy flanges and bolting the web plates with high-strength bolts.

The substructure for the main bridge consisted of four deepwater piers and two anchor piers or abutments. Three of the deepwater piers were of the caisson type lowered to bedrock 132 feet below the water surface. The other deepwater pier was of the conventional steel sheet pile cofferdam type founded on 260 heavy steel bearing piles.

Construction Hazards

Caisson pier construction is certainly not new but it is a type, nevertheless, which is not frequently used and requires special construction skills involving risks of the most hazardous type.

The Contractor Mason & Hanger, Silas Mason, Inc. & F. S. Rolandi, Jr., Inc., sunk the caissons by means of



Sketch showing comparison between the same member of the new and old structure giving a visual picture of the advantages of the new welded T-1 steel design over the old riveted silicon steel design.

UPPER—The old (A-94 steel, 840 pounds per foot) was made up of 14 component parts stitched together with over 1,000 rivets. It is 40 inches deep and required large pin connections at each end to overcome large secondary stresses.

LOWER—The new (T-1 steel, 470 pounds per foot) is made up of five plates fastened together by 340 feet of 3/8-inch fillet welds. It is only 36 inches deep and avoided the use of expensive pin connections at the ends to overcome secondary stresses. The new weighs almost half as much as the old, making transportation and erection much simpler.

jets, air lift pumps and clamshell dredging.

There were 18 dredging wells all of which were sealed at the bottom with arched laminated timbers. Through each of the timber "false bottoms" a 30-inch-diameter capped steel pipe was placed through which could be lowered a 6-inch-diameter jet pipe and a 10-inch-diameter air lift pump.

After predredging in the area of the piers to about elevation —100.00, there remained approximately 35 feet of overburden through which each pier was lowered. This overburden consisted mostly of fine sand and gravel and was removed for the most part by use of the jets and air lift pumps.

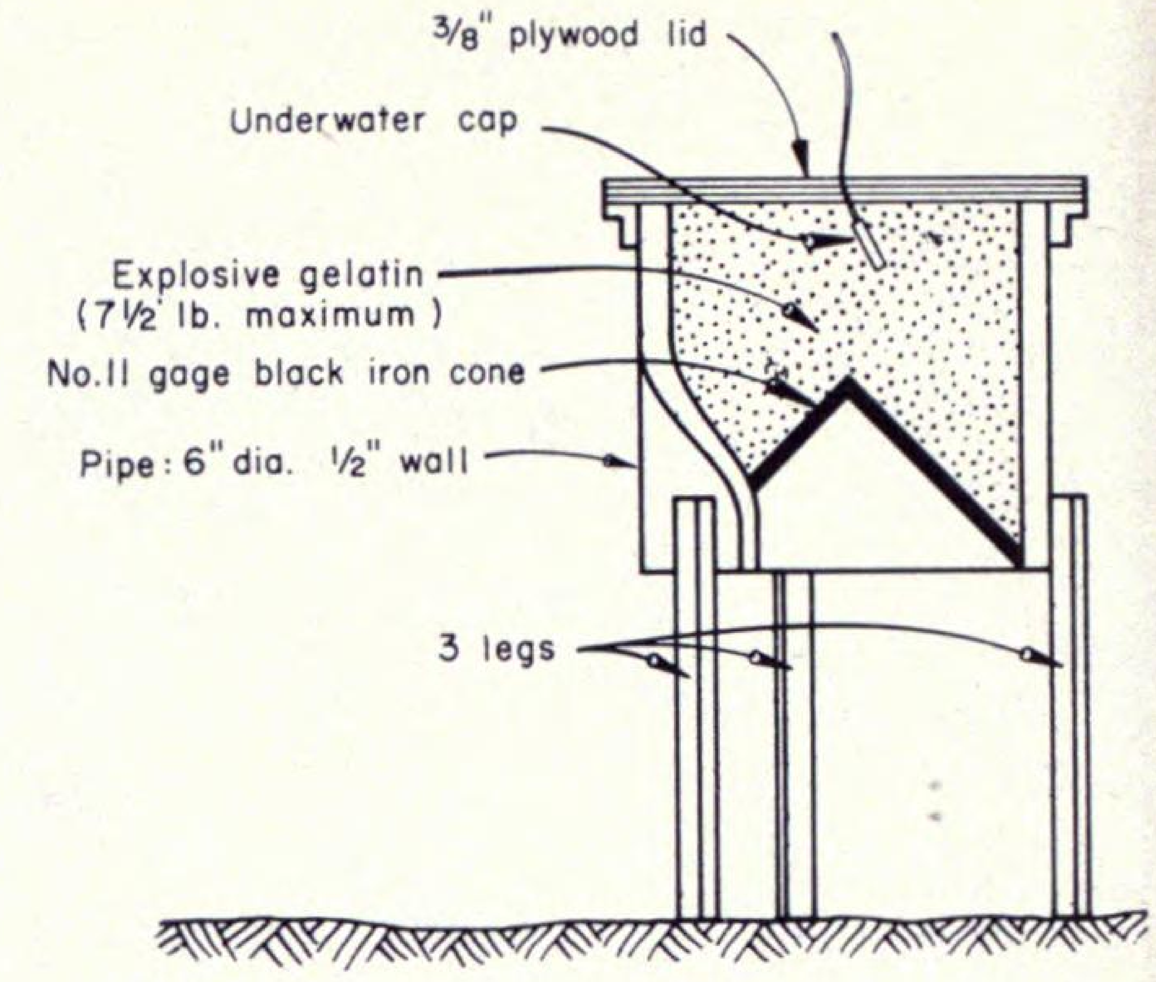
The jets and pumps were operated from the four center cells only; however, all the cells were equipped with the 30-inch capped pipes through which the jets and air lift pumps could be lowered if necessary. The jets loosened and churned up the sand and gravel permitting it to be pumped out by the 10-inch air lift pumps.

The jets were raised or lowered vertically by a work derrick. Rotation of jets was controlled by levers operated manually and movement of the nozzle was controlled manually by cables.

Shale Encountered

The bedrock at the bottom consisted of upturned layers of shale and sandstone with considerable variation in hardness. Pier No. 2 was located close to the north bank which forms a steep cliff with the layers of shale and sandstone exposed on the side wall of the cliff.

The nearness of this pier to the steep slope of the bedrock rising up to form the cliff provided very strong evidence that the plane of the bedrock on which Pier No. 2 was to rest would in all probabilities not be level.



Sketch showing shaped charges used to remove bedrock at botton of Pier 2 caisson. The charges were placed by divers at the bottom of caisson 132 feet below water.

The caisson did reach bedrock on the cliff side about three feet higher than bedrock on the opposite side. The specifications required that the pier must not be out of plumb more than 1 in 100. It was therefore necessary that the high side of the caisson cutting edge be lowered through the bedrock about three feet.

The contractor chose to use blasting methods to break away the rock under the north cutting edge. Because of the depth of water about 45 minutes was the maximum time for a diver to stay at the bottom. For this reason, the contractor discarded the idea of drilling and blasting in favor of shaped charges. The shaped charges could all be placed during one trip of the diver.

The contractor was aware that one of the big problems in connection with underwater blasting was to design the charge of sufficient size to fracture the rock without causing any damage to the caisson walls or steel facing for the cutting edges.

Scant Information

The contractor found that there was very little published information on the forces exerted by blasting within a closed caisson at various distances away from the charge.

The caisson was designed for rather heavy forces directed from the outside toward the inside, but was not heavily reinforced for forces and impacts directed from the inside out.

The contractor prepared a table showing the maximum safe charge plotted against the distance from the caisson walls. This table was prepared from information secured in the book "The Effects of Atomic Weapons" prepared by the Los Alamos Scientific Laboratory. Another book with information on blasting is "The Science of High Explosives" by Melvin A. Cook, director of the Explosives Research Group at the University of Utah, and published by Reinhold Publishing Corp.

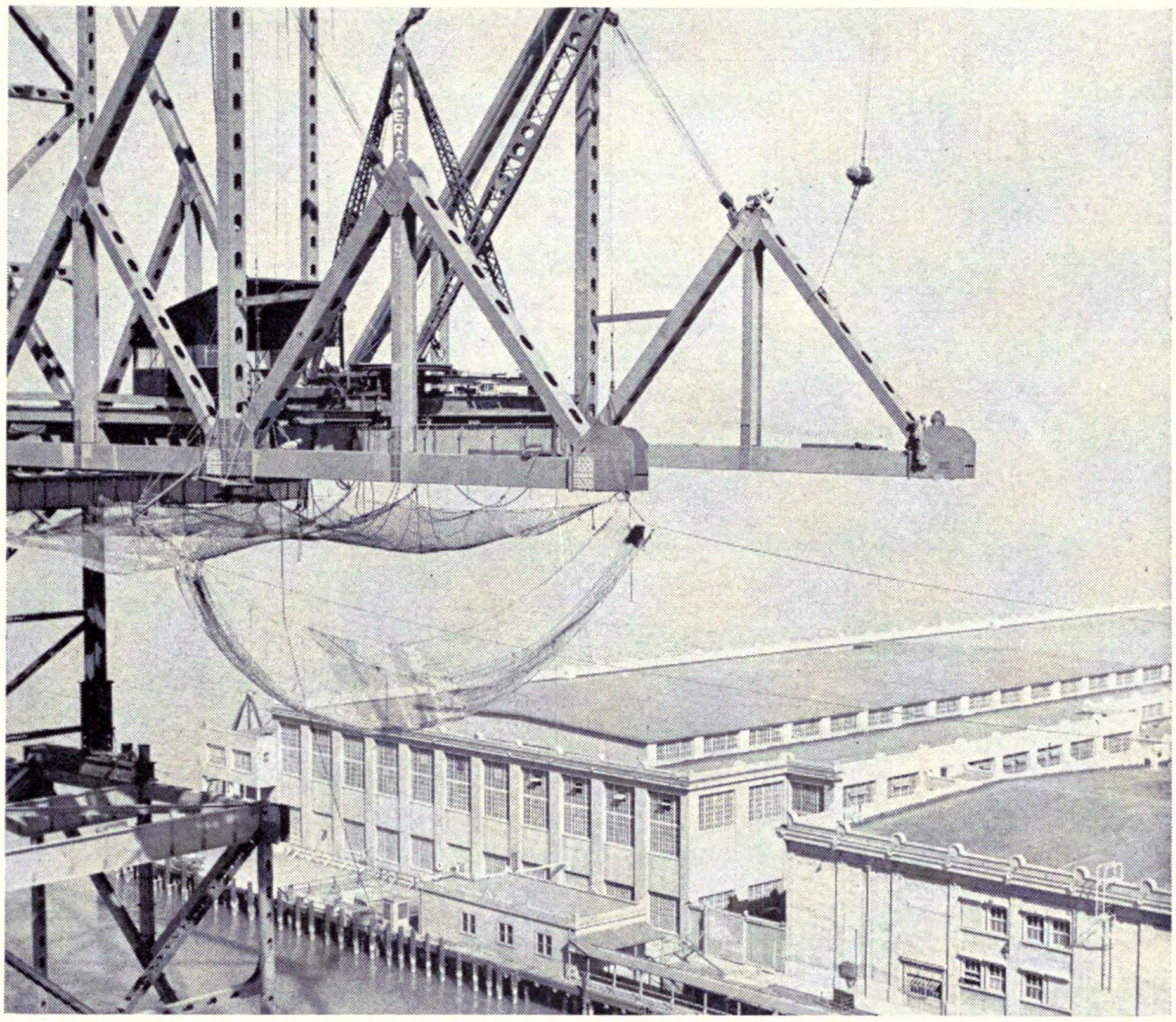
On the basis of the available literature and discussions with various people in the high-explosive field it appears that the science of underwater explosives has not yet been advanced to the point where accurate predictions as to forces exerted can be made.

We know that there is a certain amount of energy released with any particular blast, which can be determined with reasonable accuracy. The energy released is absorbed by: (1) breaking up the foundation bedrock, which is the sole purpose of the blast; (2) by raising the temperature of the water and rock, (3) by raising the elevation of the water surface and (4) by distorting or rupturing the caisson walls. The ideal condition would therefore be to have nearly all the energy of each blast absorbed by breaking up or shattering the foundation bedrock, with little or none remaining for distortion or damage to the walls.

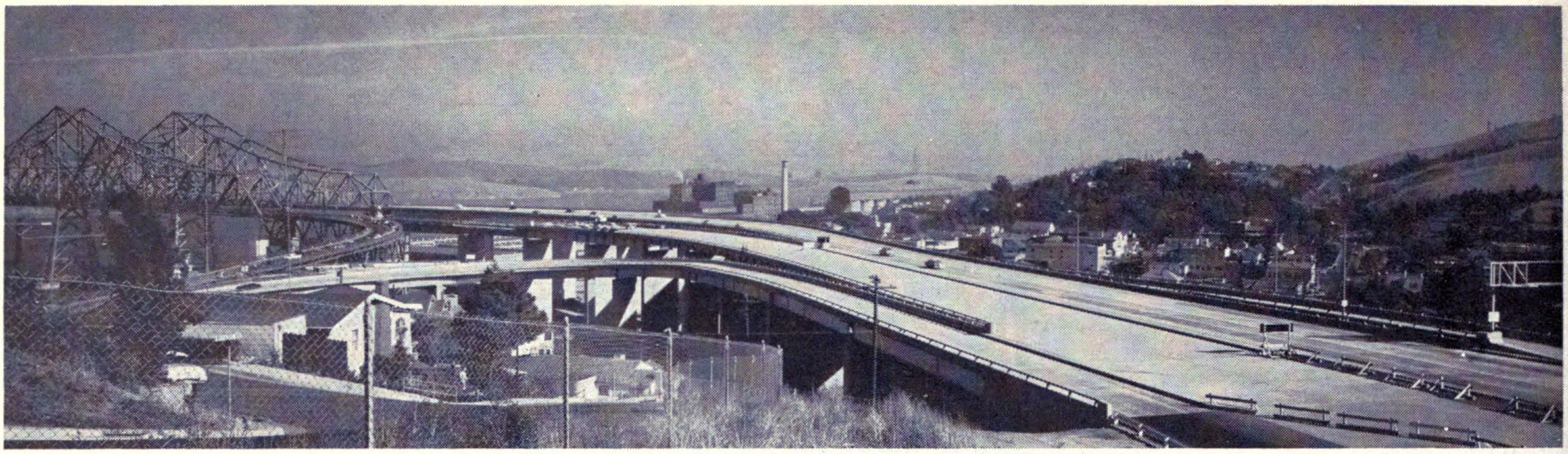
Drill Blasting Safer

This therefore points out the advantage and safety of using drilled hole blasting methods as opposed to shaped charges. The drilled-hole method can be counted on to absorb most of the energy released by shattering the bedrock foundations. The shaped charges on the other hand will release a much greater part of their energies for distortion or even rupture of the caisson walls.

The Carquinez Strait bridge caissons were 102′-6″ long by 53′-0″ wide and divided into six cells lengthwise and three cells crosswise. The 102′-6″ north side of the caisson was lowered through about three feet of bedrock to make it level with the south side. The shaped charges used were



UPPER—For erection of the south anchor arm, steel was brought to the site by water from the Richmond assembly yard on barges. It was lifted into place by a 146-ton tower derrick mounted on two barges and assisted by stiff leg skid travelers. Most of the steel members were erected by cantilevering out; however, near each of the end towers eight panels of the suspended span were temporarily used as falsework, a portion of which can be seen in the lower left hand corner of the picture. LOWER—The bridge grows piece by piece to join with the other half of the cantilever span 145 feet above the waters below.



This photo of the southern end of the twin bridges gives some idea of the broad sweep of line incorporated into the design of the main and approach ramps.

spaced about seven feet centers along the wall and back from the wall about four feet.

The shaped charges consisted of about six to seven pounds of explosive gelatin. The explosive charge is shaped by a sheet metal cone placed in the bottom of a six-inch steel pipe. The explosive wave of the shaped charge forms a direct jet that concentrates its force on the rock below. Short legs hold the entire assembly up about six inches from the rock for better effect.

The average crater made by each blast was approximately four feet in diameter by about two feet deep, probably approaching a half sphere in shape, and containing approximately one-half cubic yard of material. It is estimated that about 10 pounds of explosives were used for each cubic yard of material removed and there were about 40 cubic yards removed in all. This large amount of explosives is evidence that only 10 to 15 percent of the available energy went into breaking up the rock.

One of the heavy box section compression members being welded by the submerged arc process at one of the American Bridge fabricating plants.

Some Damage Caused

The maximum charge for any one blast was six 7½-pound charges located along the north wall of the caisson. A total of 10 charges placed at various locations along the wall and in various sizes from 1½ pounds per shaped charge to 7½ pounds.

In spite of the precautions used subsequent inspection disclosed that considerable damage had been done. Divers were sent down where they found some large cracks at the junction of the interior 2′-6″ walls with the outside 3′-0″ walls. There was also evidence that the steel plate cutting edge which encased the bottom 13 feet of the walls was ruptured at one point.

The evidence of rupture was so strong in the six northerly cells that repairs and strengthening were necessary to remove any doubt of structural stability. The bottom 25 feet of the caisson cells were to be filled with tremie concrete in accordance with the original plans. This portion of the caisson was considered satisfactory after placing of this bottom seal. To repair the six northerly cells from the top of the concrete seal upward, it was decided to fill them with concrete to a height where there was little or no damage. The two corner cells were filled to elevation 35 feet below sea level which is 76.5 feet above the seal, and the four center wells along the north edge to elevation 60 feet below sea level which is 46.5 feet above the seal course. This required a total of 2,350 cubic yards of class A concrete to be added to this caisson.

The other two caissons were lowered into position without any of the difficulties encountered at Pier No. 2.

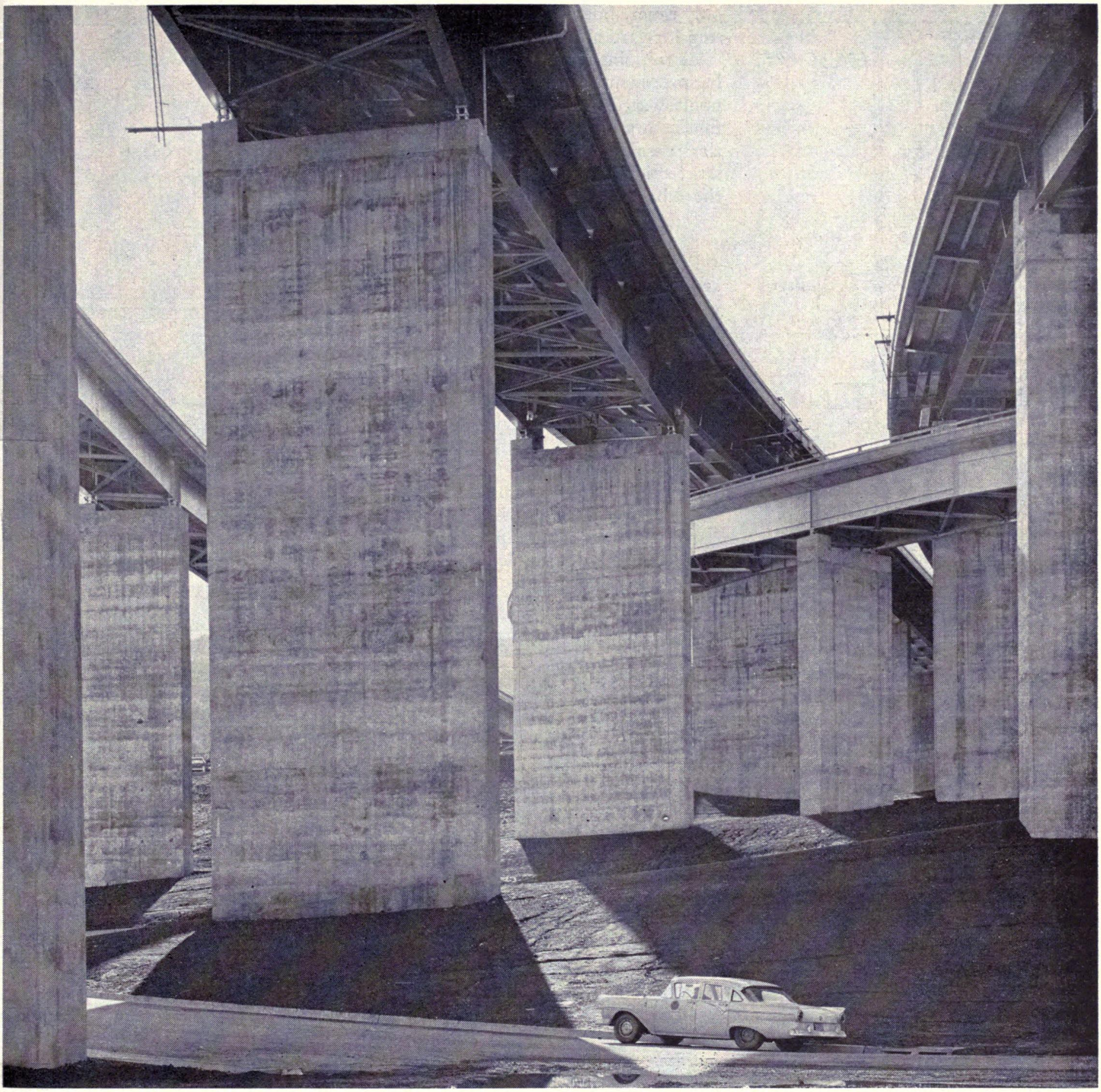
All of this points to the fact that bridge construction of the size of the Carquinez Bridge, particularly the deepwater foundations, is not accomplished without facing many problems and many hazards.

Welding Causes Interest

The design and fabrication of the two 1,100-foot cantilever spans by the use of welding rather than the conventional riveting method have attracted much interest among bridge engineers throughout the Country.

Welded fabrication of girders and beams has become a fairly well accepted practice in many states in the past few years. California, for instance, has completed over 240 all-welded steel bridge structures and has many more either under construction or ready to go to contract. These steel structures have involved the use of over 110,000 tons of welded steel fabrication. These structures have proven themselves to be completely satisfactory from a structural standpoint, they have shown considerable economy in the amount of structural steel required, their smooth surfaces have made maintenance much easier, and their smooth, clean lines have added much to the sharp, trim appearance of these bridge structures.

Because of this very favorable experience with the welded girder type of structure it was only natural that consideration be given to extending

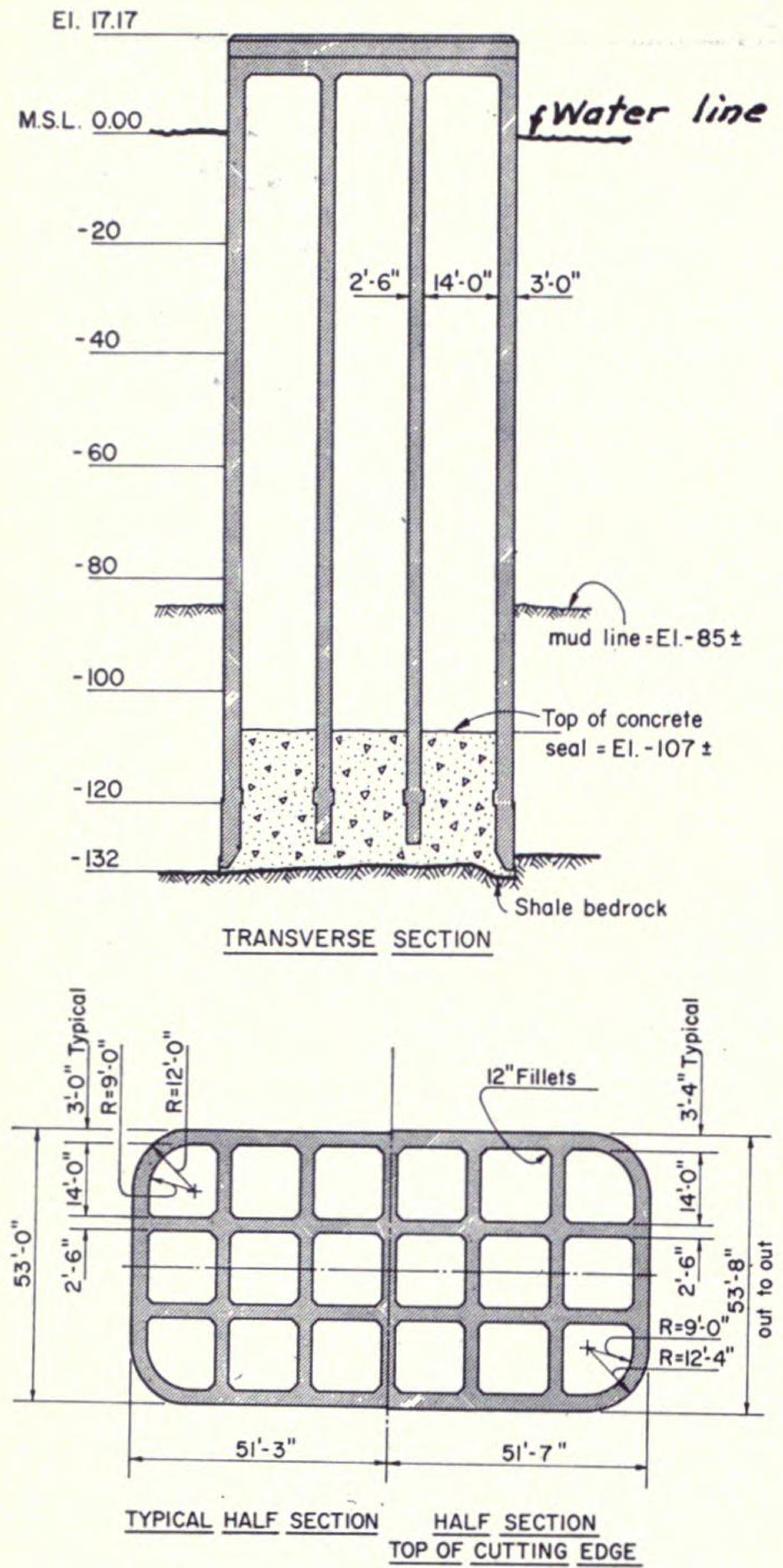


The interchange structure as seen from the streets of Crockett. Each of these pier shafts took only one week to construct. Slip-forms and modern bridge construction techniques made this speed possible.

the use of welding to the truss type of structure and thus gain these same advantages in this area of bridge construction.

Pros and Cons Weighed

There were, of course, arguments both favorable and unfavorable to such a move. In addition to the points already mentioned in favor of this move were these facts. Steel fabricating shops, over the past few years, have been continually improving their quality and efficiency in connection with their welded fabrication; our testing laboratory has done much in the past few years to standardize testing and shop inspection procedures; and one of the most important points in favor of welded fabrication for heavy bridge construction such as the Carquinez Bridge was the fact that it made possible the use of a very high-strength T-1 steel. The use of T-1 steel in itself accounted for a savings of over 4,200,000 pounds of structural steel and dead load to be carried on the bridge.



Sketch showing elevation and section of one of the three caissons. The use of explosives was necessary at Pier 2 caisson. Shaped charges were used along the north edge to remove bedrock and make this side of the caisson level with the opposite side, as seen in sketch.

On the unfavorable side were these arguments:

(1) This change from riveted to welded construction was a very definite break with past precedent, since trusses of this type and size of bridge structure had never before been fabricated by welding in this Country.

(2) There was no well established engineering precedence for member makeup or standardization of details as has been worked out for riveted fabrication over the past 50 years.

(3) Some welded structures in the past have failed including ships, tanks, and bridges.

Regarding (1) there is no question but that this was a strong break with past precedent. But the outstanding advancements made in the past 10 years in the knowledge and techniques of welding made this step now appear not only timely but also a very progressive step forward in bridge construction.

As to point (2) regarding engineering precedent for member makeup this point was discussed with the leading fabricators of the Country and practical details were worked out to the satisfaction of both the engineer and the fabricator.

Close Check Necessary

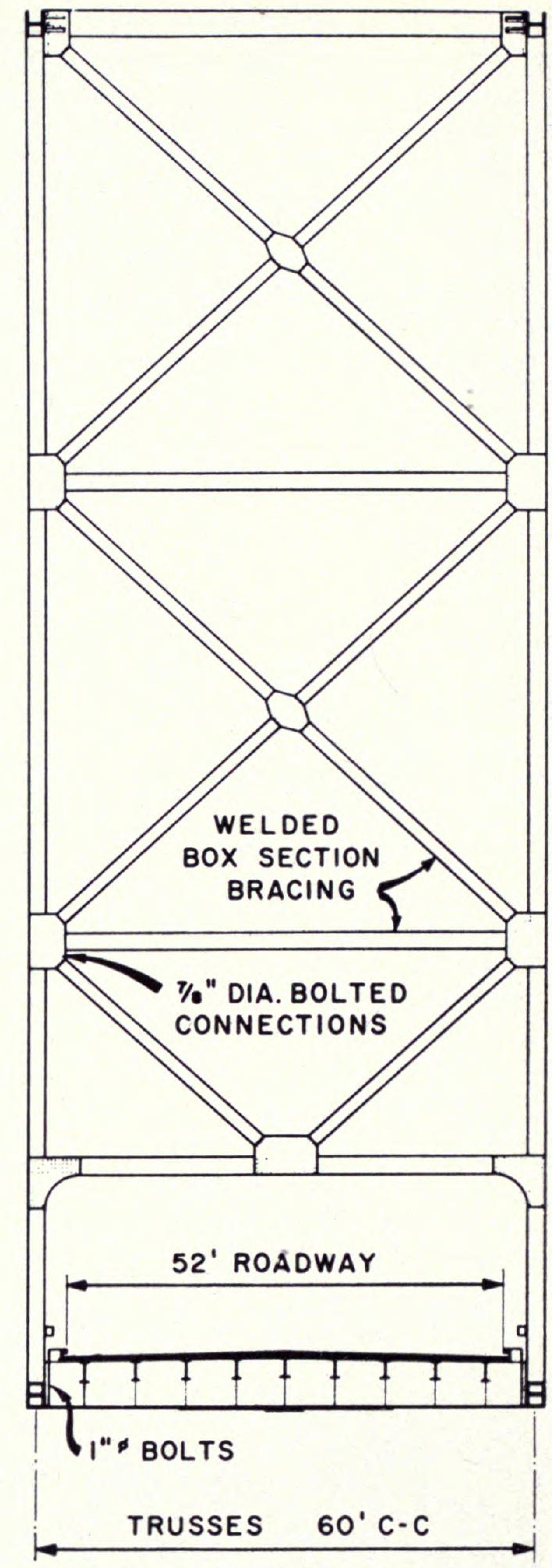
Point (3) was definitely a strong argument but there is no question that welding engineers and metallurgists throughout the Country have made such exhaustive studies sparked by the failure of a few welded ships that they now know how to overcome these past difficulties. The chemistry, particularly the carbon content of the steels to be used, would be closely checked and controlled. Truss members would be relatively small in cross section compared to ships and tanks. Members would be straight, simple in design and free from any geometric notches. Further, fatigue, rates of application of load, and operating temperatures would be very favorable. This last point in regard to operating temperatures is quite important. The lowest recorded temperature at the Carquinez Bridge site is +19 degrees Fahrenheit. This is well above the temperature at which any of the steel used on this job show any tendency toward brittleness.

These facts gave reasonable assurance that welded fabrication of truss members would be structurally reliable and therefore constitute a progressive step forward in bridge construction.

While the welded design and fabrication along with the types of steel used proved very satisfactory in every respect, the job was not completed without learning some lessons.

Damaged Plates Studied

During the latter part of April, the erection crews, due to a cable sling failure, dropped one of the heavy tension diagonals into Carquinez Strait. The member landed with the gusset plate end down, penetrating into the mud, sand and gravel for several feet. Upon recovery of the member from the bay, the gusset plates were found to be sufficiently bent to require replacement. It was decided



Sketch showing typical section of the new structure at one of the 168-foot towers. Floor beams are 66" x ½" web welded to 16" and 18" flanges. The concrete slab is 6¾" thick. Lightweight concrete was used on cantilever arms and suspended span, regular concrete on the two anchor spans.

that both the butt welds and fillet welds should be checked since the member had been subjected to severe impact. The butt welds were in perfect condition but inspection of the fillet welds revealed an occasional very fine transverse crack in the fillet weld metal.

These fine cracks were at first thought to be very minor surface cracks but further investigation re-

vealed that some of them extended through the full section of weld. Further it was determined that the cracks had occurred before the shop coat of vinyl wash had been applied.

This eliminated the possibility that the cracks had occurred during shipping or handling. And it strongly indicated that something had gone wrong with the welding procedure during at least a part of the fabrication.

Immediately the contractor started checking for flaws in the fillet welds of other members. As a final result of this check, a total of 56 H section tension members were repaired. None of the compression box section members were found with any faulty fillet welds.

All Crack Traces Removed

Repairs consisted of removing fillet welds flush to the plate surfaces with a slight trace of the fillet toe remaining to aid the repair welders in making the right size weld. If any cracks remained it was necessary to penetrate the depth of the weld fusion zone to remove all crack traces.

The fillets were removed with an Arcair gouging tool, and were made in intermittent lengths of five feet in the interior portion of beam and about 1½ feet near the beam ends.

In all there were 56 members that required repairs out of a total of more than 1,100 truss members which represented about 3 percent of the total fabrication for the job. This has led to an investigation by both the State Division of Highways Materials and Research Laboratory and the research department of the American Bridge Division to determine the cause.

These studies have not yet been completed. Possible sources of trouble which are being investigated are: (1) hydrogen entering the weld through moisture in the flux or from free moisture in the joint; (2) surging of the amperage or voltage. Neither of these factors so far has been isolated as the single source of the difficulties; (3) there is some evidence produced from other fields of fabrication that the difficulty may stem from the critical nature of the chemical and physical characteristics of the welding wire and flux. This factor or any combination of these three general factors could have been the source of the difficulties, but the crack-producing combination has not yet been singled out by these investigations. In any case all of this points to a re-emphasis of the fact that fabrication by welding of structural members from either T-1 or A242 steel is much more critical than for members of structural carbon steel such as A7 and A373.

In any event our laboratory is completely confident that such deviations from the required rigid controls can and will be detected on future jobs of this nature and corrections made on the spot.

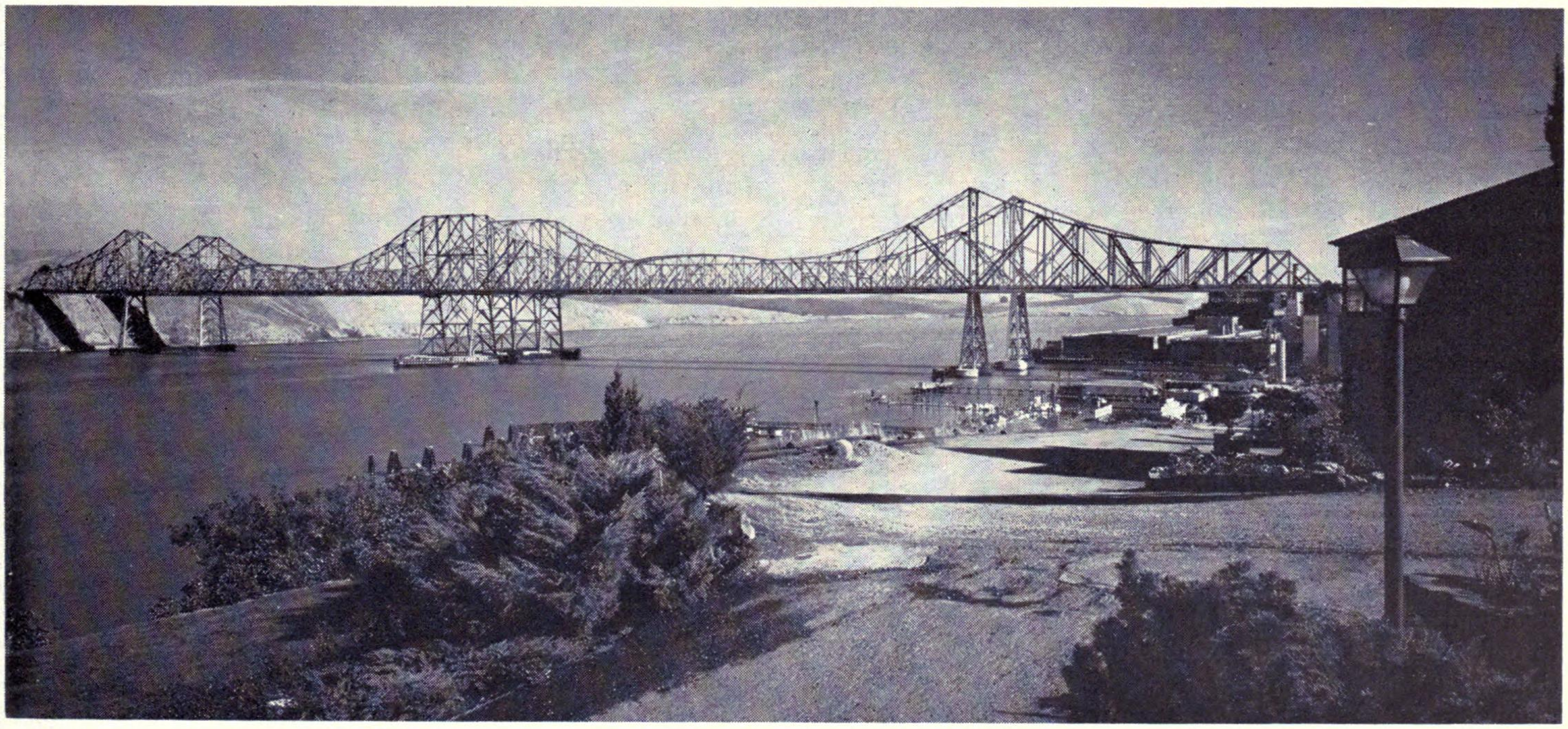
Due to the complete co-operation of the American Bridge Division of United States Steel Corporation, repairs were made to the complete satisfaction of the engineers and the job completed one month ahead of schedule.

New T-1 Steel Used

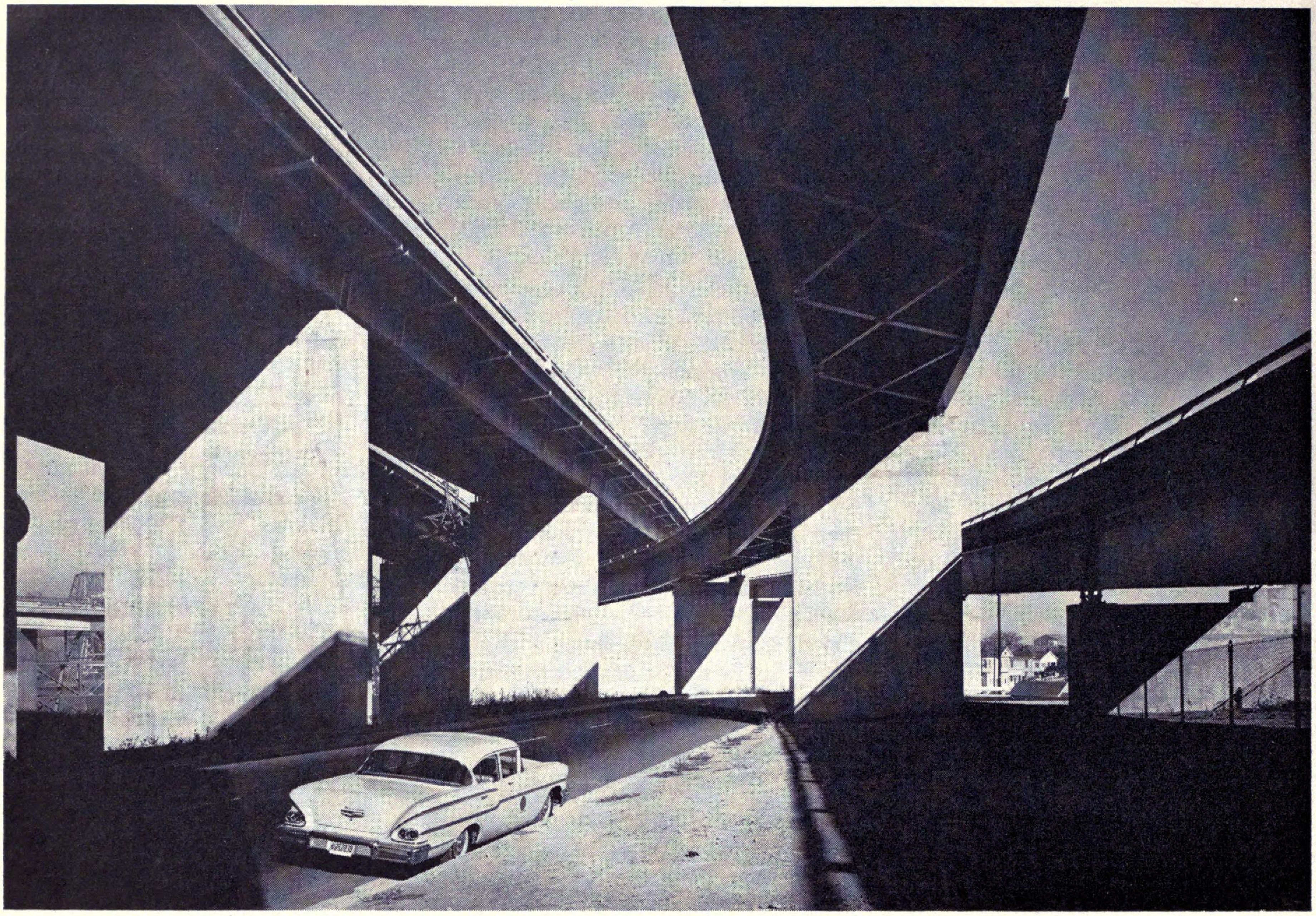
Early preliminary designs using A7-A373 and A242 steel and limiting plate thickness to 2½″ indicated that the required depth for the heavily stressed members would be 40 inches. This depth of member produced rather high secondary stresses.

A steel with a higher allowable working stress was therefore considered because it would facilitate a reduction in member depth and at the same time keep plate thicknesses for most members to 2½ inches without multiple side plates.

The new quenched-and-tempered T-1 steel was therefore considered. With the minimum yield strength of T-1 steel at 90,000 psi, a conservative



This view eastward shows the similarity of the outlines of the twin Carquinez Bridges, constructed 31 years apart. The old bridge is nearer the camera.



An interesting camera study of the southern approach ramps to the twin bridges taken from one of the city streets in Crockett.

working stress of 45,000 psi in tension and comparable working stresses in compression were used in trial designs. The resulting trial member makeup for the heavily stressed members indicated they could be kept to a 36-inch depth which resulted in reducing secondary stresses considerably. In addition there was a large reduction in tonnage of steel required which amounted to 4,255,000 pounds of steel.

As a further example of the savings in steel made the weight per foot for L16L18 was reduced from 864 ppf to 492 ppf when changed from A242 steel to T-1 steel.

It was therefore decided that T-1 steel had sufficient potential qualities to make worthwhile a thorough investigation of its use for welded truss members. Our testing laboratory therefore ran extensive tests on the welding and physical qualities from 3,000 pounds of T-1 steel plates.

Several Methods Tried

From these plates, numerous specimens of butt-weld joints were made and tested from ½-, 1- and 1½-inch plates. The welds were prepared using semiautomatic shielded arc, automatic submerged arc, and three types of manual low-hydrogen processes. The conclusions of the report on these tests were that T-1 steel could be satisfactorily welded into truss members but that narrow tolerances in the operating procedure were necessary. The full report outlined the precautions that must be taken.

The allowable working stresses used for A7, A373 and A242 were the same as those used in the A.A.S.H.O. Bridge Specifications. For T-1 steel members the allowable working stress for tension members was 45,000 psi and for compression $36{,}000 - 1.75\ (L/4)^2$. The A.A.S.H.O. Bridge Committee is now considering the inclusion of working stresses for T-1 steel in the bridge specifications.

All bracing and truss joints were fastened by use of high strength steel bolts. Bracing bolts were ⅞ inch and truss joint bolts were 1 inch and 1¼ inches.

Bolts were furnished and installed in accordance with the "Specifications for Assembly of Structural Joints Using High Strength Steel Bolts" approved February 27, 1954, by Research Council of Riveted and Bolted Structural Joints of the Engineering Foundation. The specifications called for field joints to be bolted and gave the contractor the option of riveted or bolted shop joints. The American

. . . Continued on page 63

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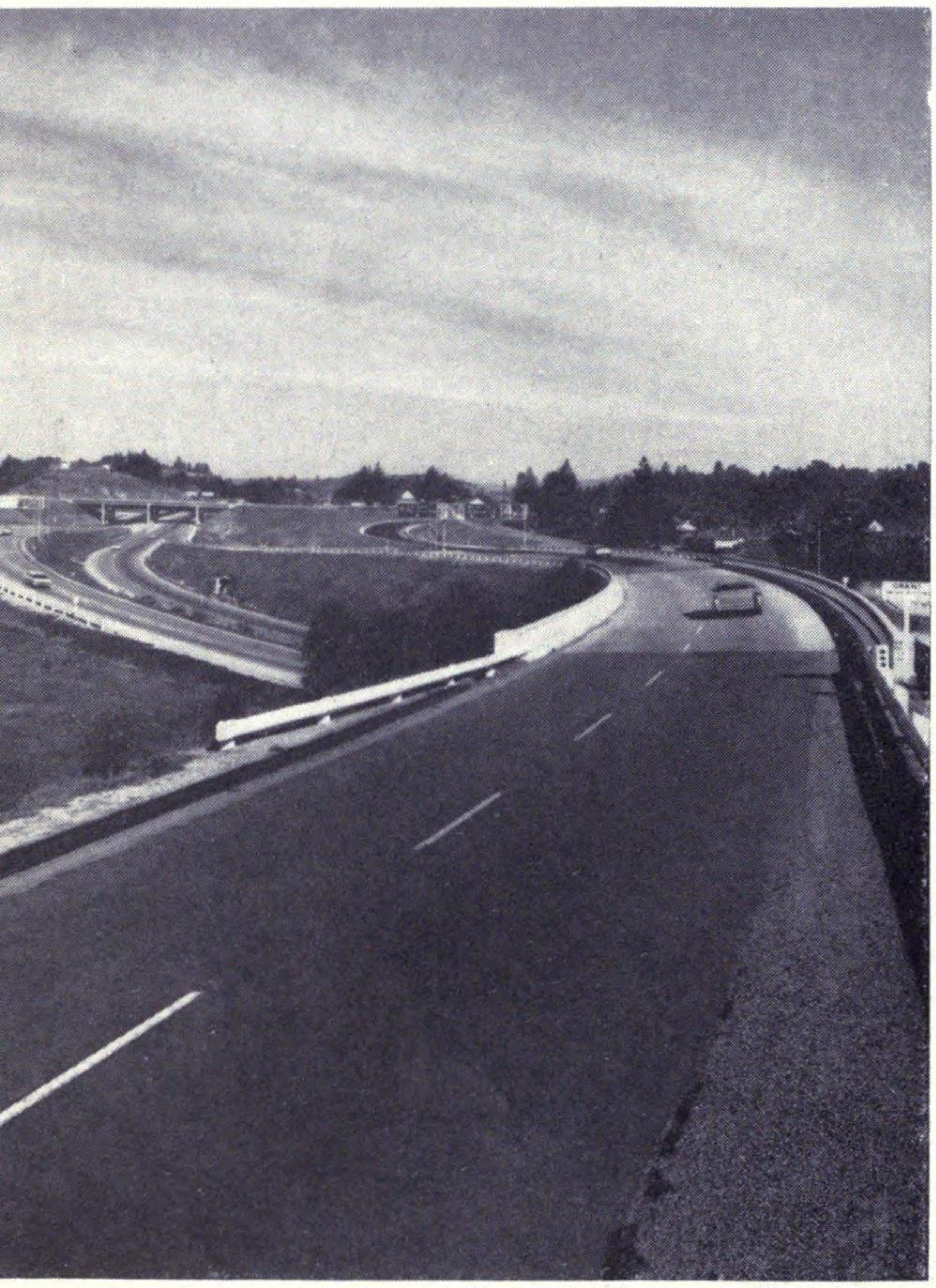

FRONT COVER

The junction of Sign Route 1 and Sign Route 17 in Santa Cruz, with its overcrossings and undercrossings, large directional signs, graceful connecting ramps and multilane, divided roadways, is typical of modern freeway interchanges.

—Photo by William R. Chaney

BACK COVER

All traffic is being routed over the new parallel Carquinez Bridge (right) until the work of widening the old bridge (left) can be completed after which time all southbound vehicles will use the old span and northbound the new one.

—Photo by William R. Chaney

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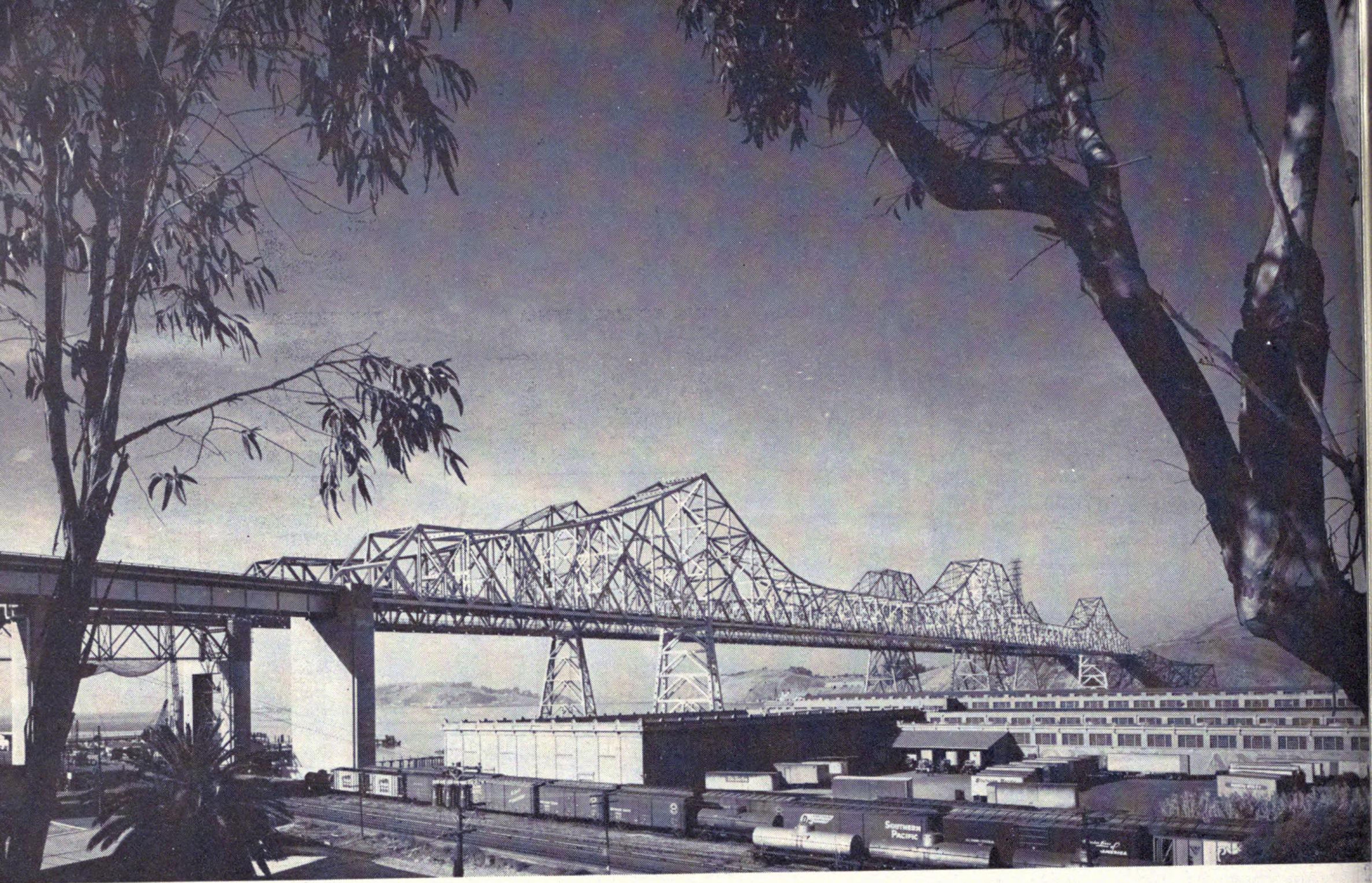
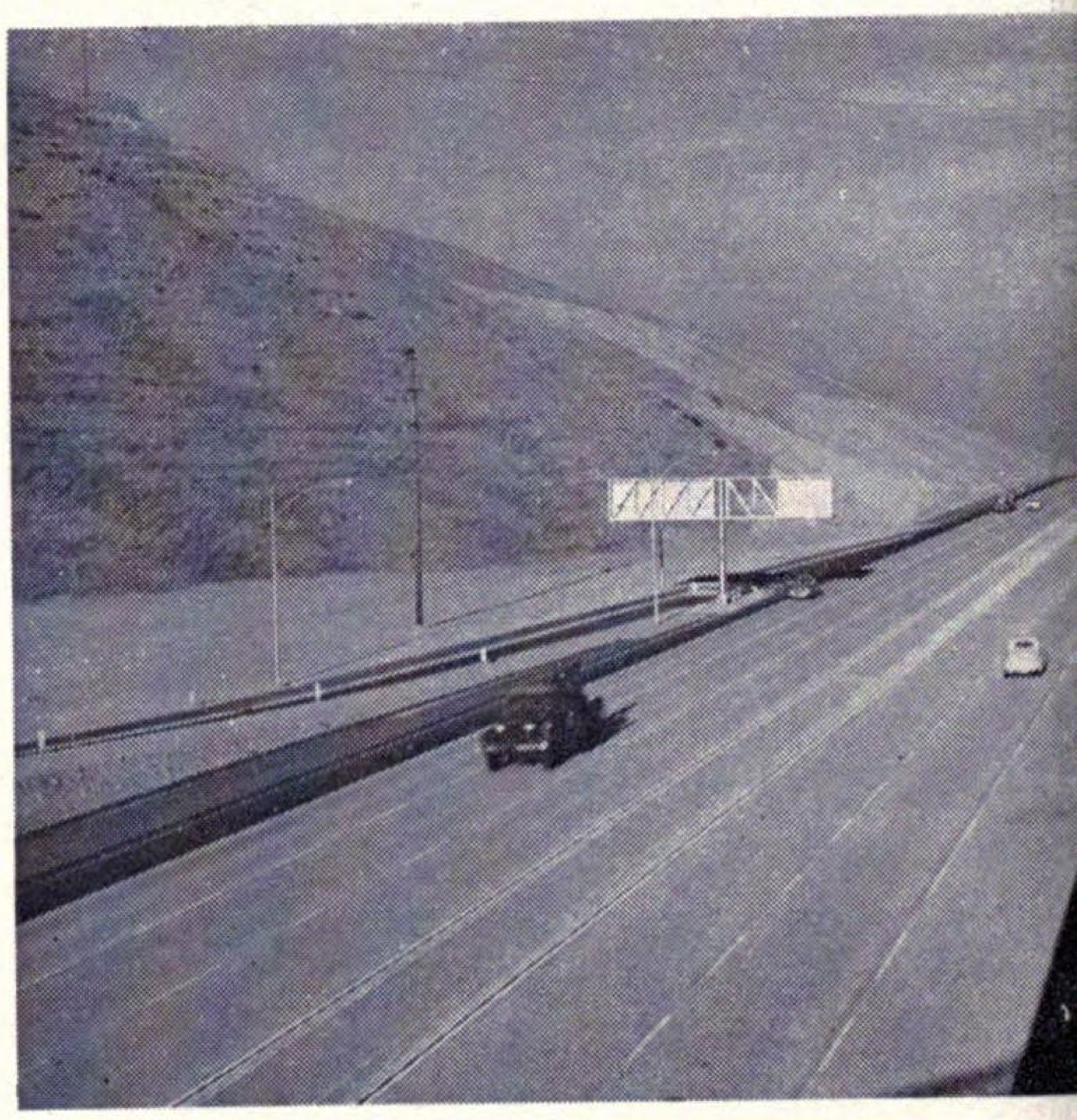
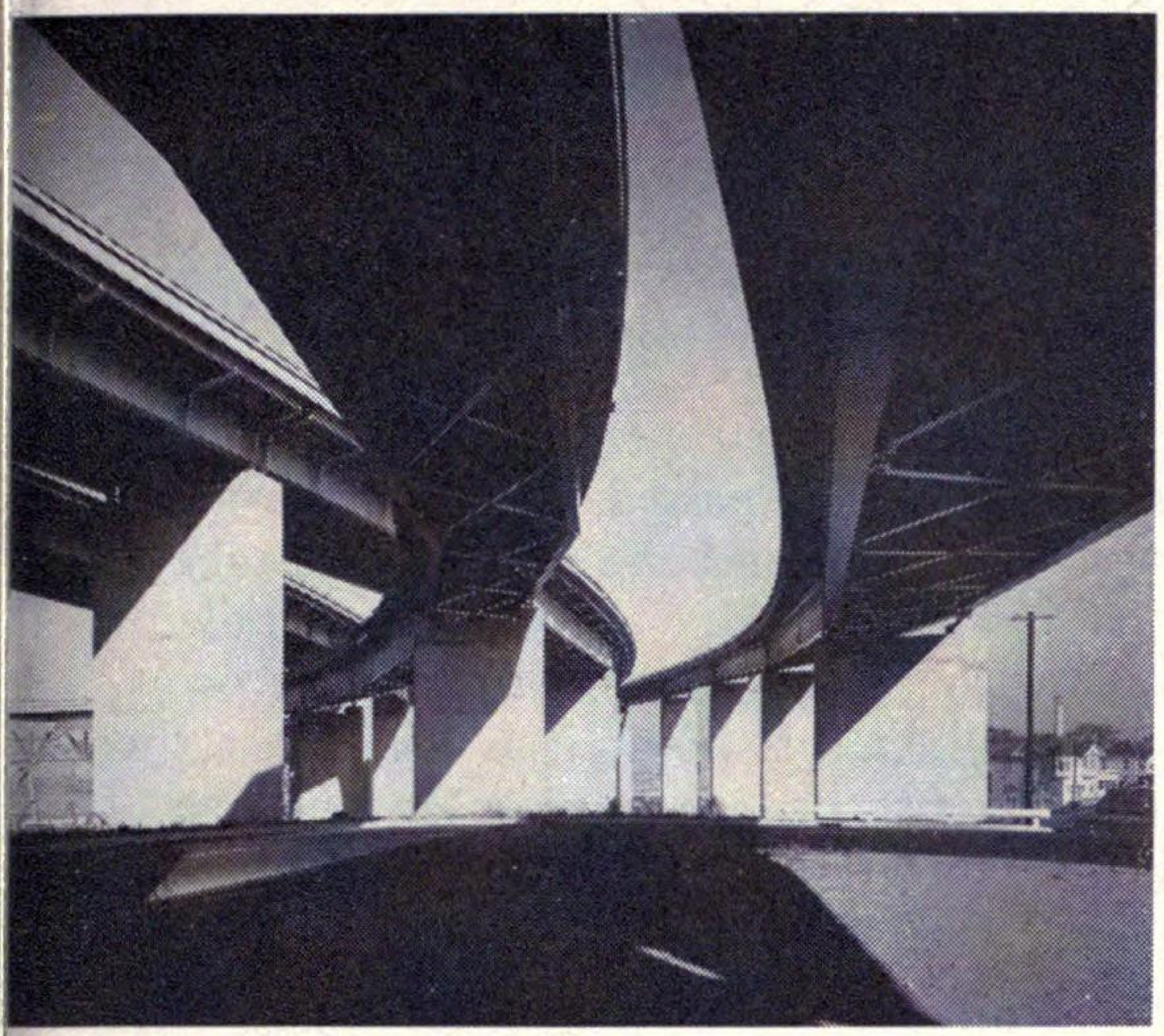


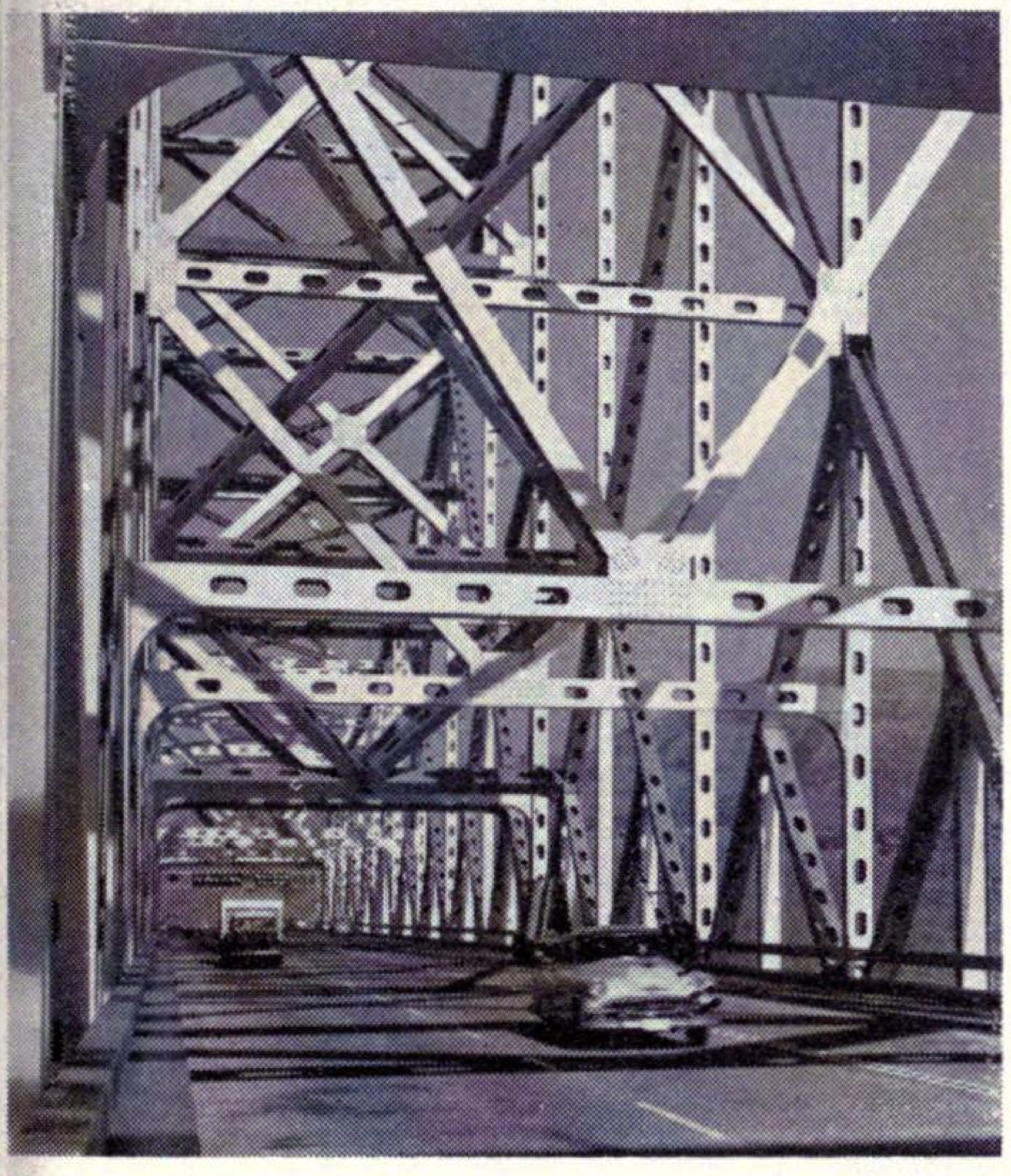
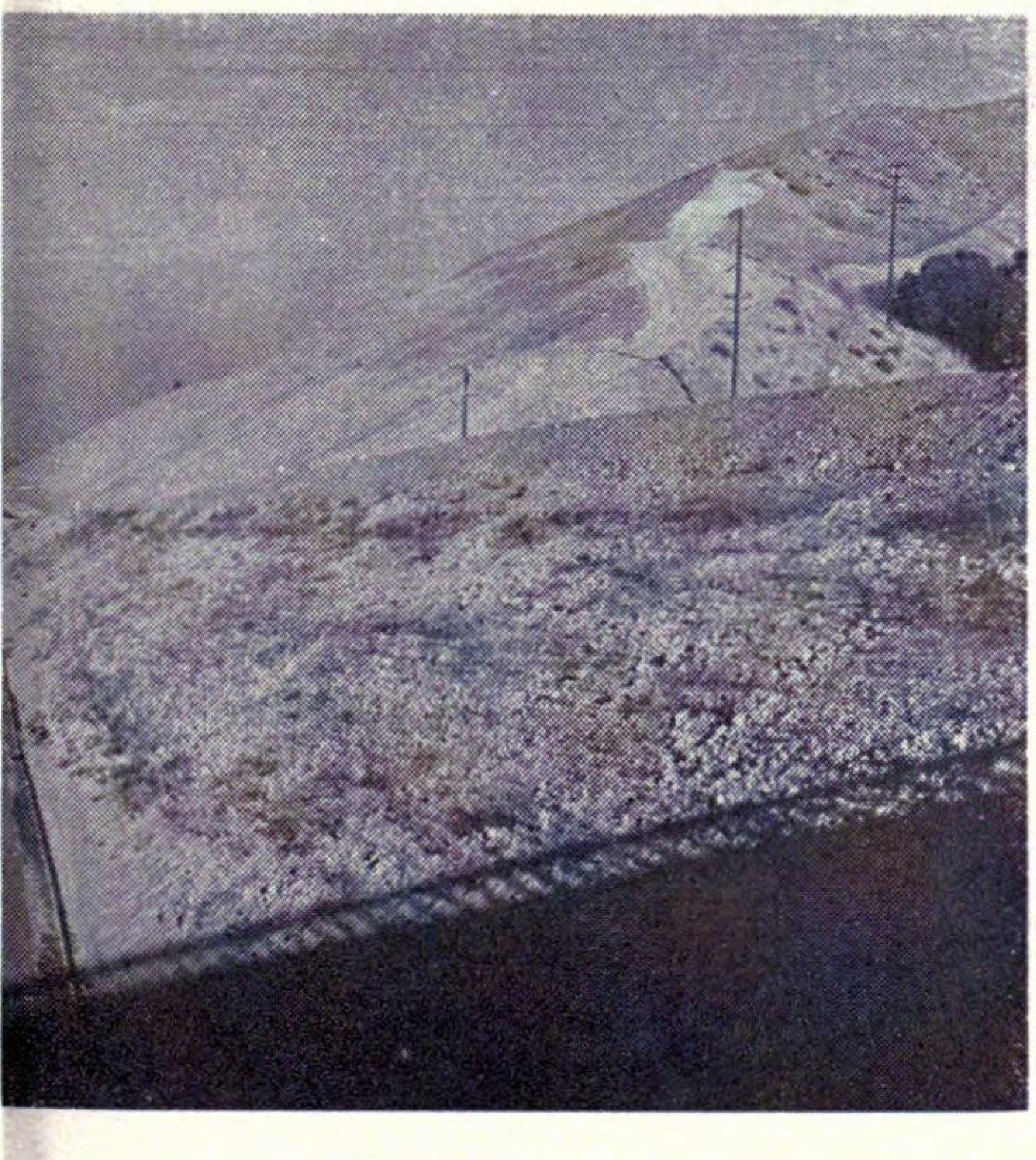
Carquinez Bridge

"Among the year's accomplishments, perhap the most impressive was the completion of th additional Carquinez Bridge. While the proje is spectacular in its own right—the structur duplicating the existing one, the graceful curve of interchange ramps and the monumental c running south through the hills—the most in pressive feature is the saving of lives, time an miles between Vallejo and the San Francisc Oakland Bay Bridge."

—Report From District IV *(see page*



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Hewes Award

Bridge Department's Roger Sunbury, Lab's Paul Jonas Are 1962 Winners

Roger D. Sunbury, Senior Bridge Engineer, and Paul G. Jonas, Senior Engineer Welding Technologist, are the winners of the 1962 Dr. L. I. Hewes Award, according to an announcement by the Western Association of State Highway Officials. Both men are career employees with the California Division of Highways.

The award, which was established in 1951, honors the memory of Dr. Hewes, the late Western Regional Chief of the U.S. Bureau of Public Roads. It is presented annually for outstanding contributions to western highway development and carries with it a cash prize of $500. The 1962 award was announced on June 13 at the WASHO conference in Seattle.

The team of Sunbury and Jonas received a joint nomination for their contributions to the design and use of high-strength steel in large highway bridges and the development of the arc welding process to a position as an accepted and valuable tool in the structural engineer's field.

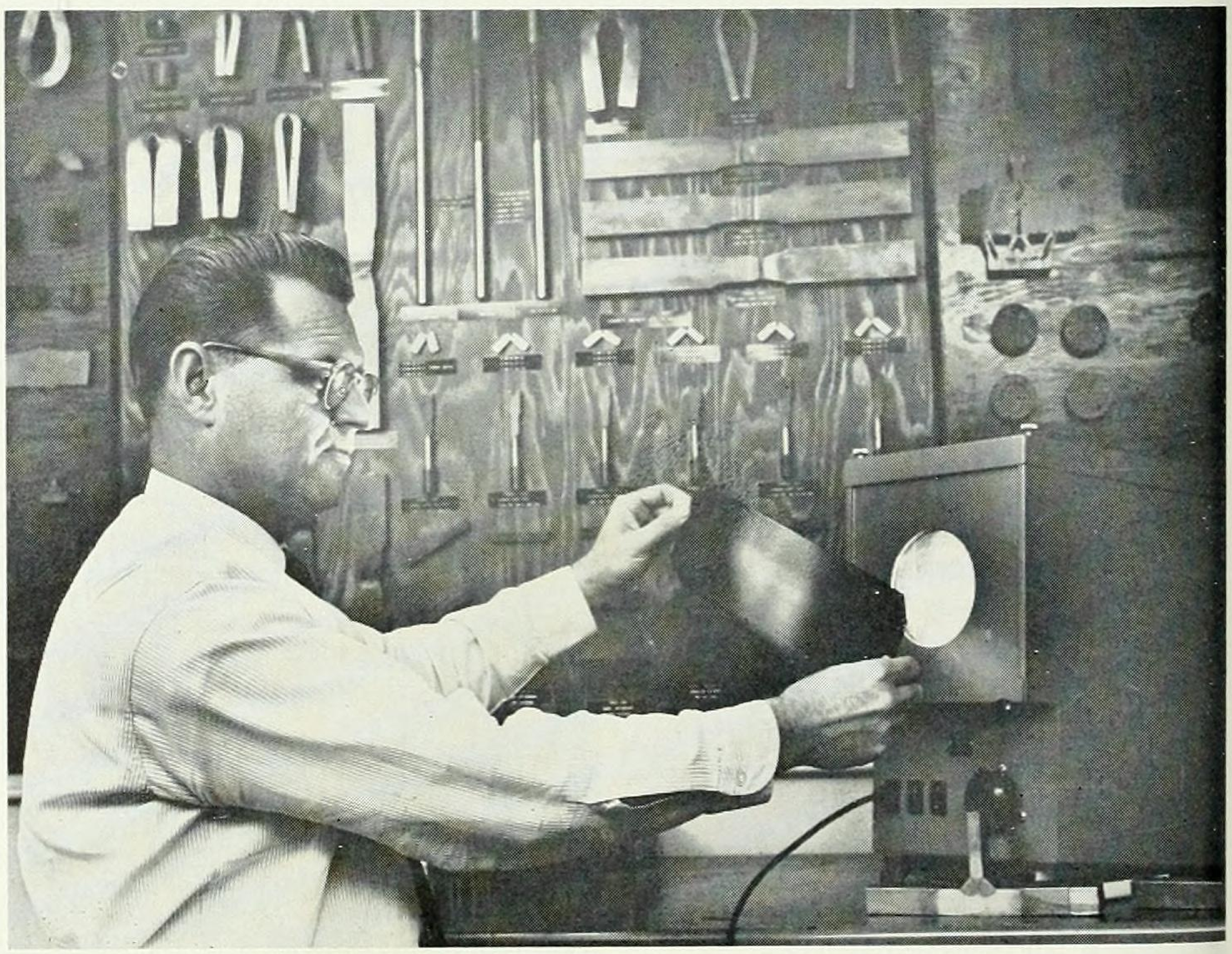
Sunbury's work was primarily in the field of the planning and design of structures utilizing high-strength steel members fabricated by welding. Jonas has done outstanding work in advancing and standardizing the technological aspects of welding to make the use of these high-strength steels practical and economical.

In his letter recommending Sunbury and Jonas for the award, State Highway Engineer J. C. Womack said that it was largely through their efforts that California has been able to establish precedents in the use of high-strength steel in major long-span highway structures, and has, at the same time, been able to confirm welding as the most satisfactory and economical method of fabricating steel members.

Steels Are Combined

According to Womack, steels ranging from ordinary structural steel to the newest high-strength steels have been combined by Sunbury into structures with both marked economy and

Robert L. Byrne, editor of Western Construction Magazine, presents certificates and $250 checks for Dr. L. I. Hewes awards to Paul G. Jonas (center) and Roger D. Sunbury, California Division of Highways Engineer.



Paul Jonas, Senior Engineer Welding Technologist, examines a radiograph of one of the steel plates used in constructing the new span of the Carquinez Bridge. Jonas was responsible for perfecting many of the techniques used in welding together the various types of steel used in the structure.

improved appearance. These new adaptations of different steels are now being duplicated across the country.

The standards for welding procedure and inspection developed by Jonas have been widely adopted by many welding organizations and states, and the California Test Method 601 which he developed is recognized as the best and most comprehensive weld testing procedure available.

To qualify for the Dr. L. I. Hewes Award, a highway engineer must be recommended by the head of one of the 14 state highway departments in WASHO. Persons nominated must be highway engineers of the western states, must have made an outstanding contribution to highway development, and must not be chief engineers or members of the chief engineer's principal staff.

In addition, the engineer nominated must be engaged in planning, design, construction, maintenance, bridge, materials and research, or traffic engineering.

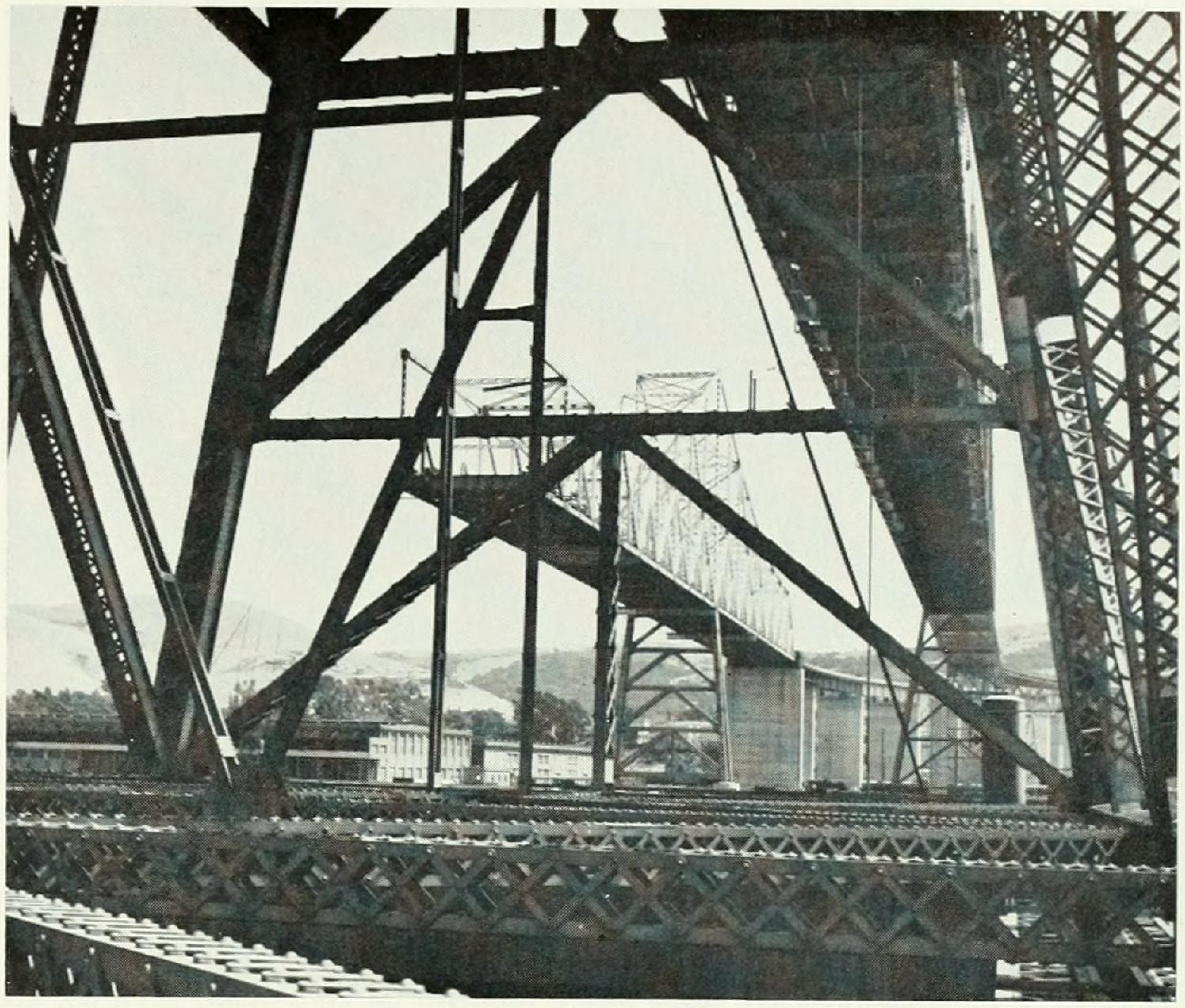
Final selection is made by the Executive Committee of WASHO.

Sunbury and Jonas are the third and fourth California Division of Highways employees to win this award. Previous winners were James T. McWilliam (co-winner—1952) and Arnold H. Carver (winner—1954).

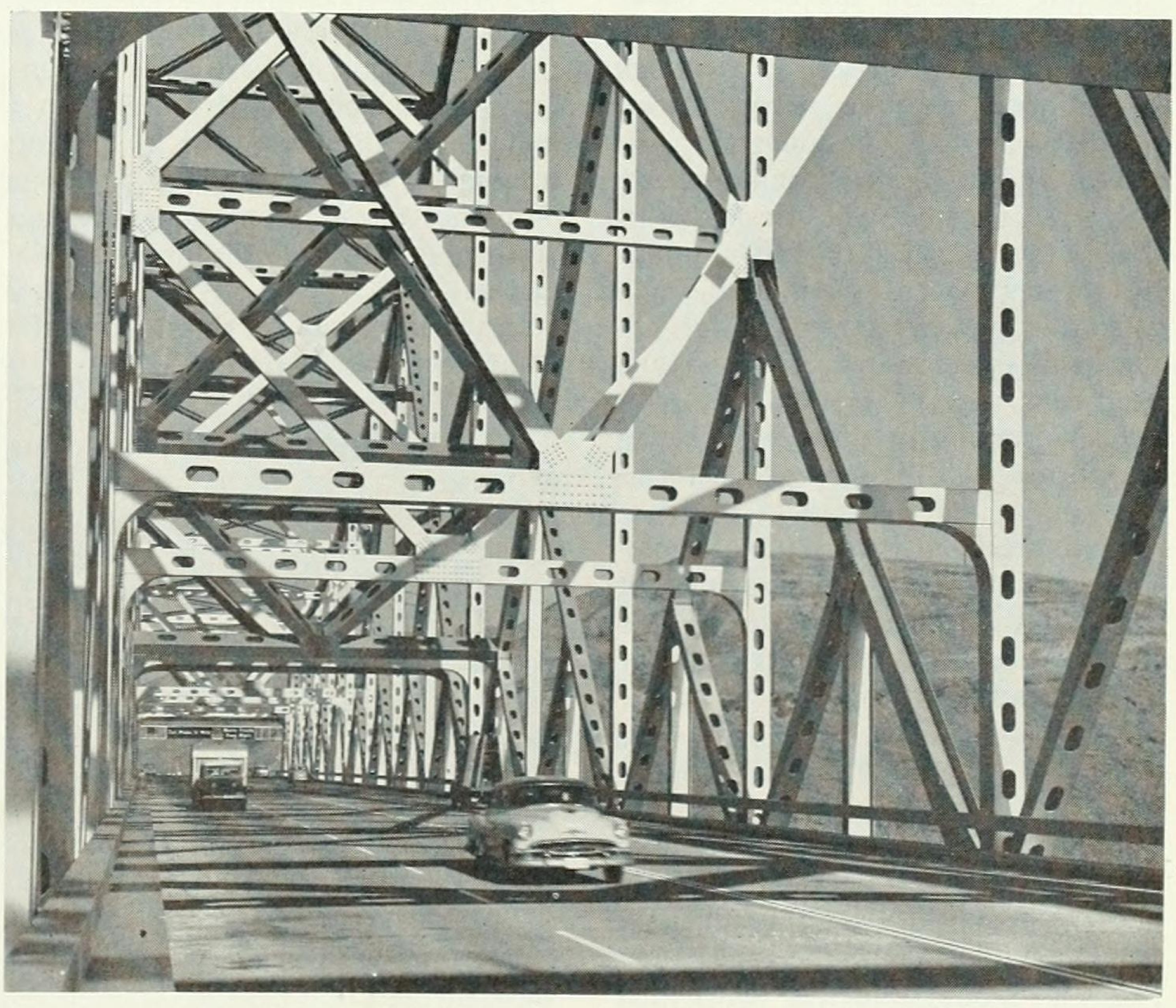
Sunbury Bridge Designer

A native of Ohio, Sunbury graduated from Ohio State University in 1941 with a bachelor's degree in Civil Engineering. He went to work for the American Bridge Company in 1941 and served as an engineering draftsman and field engineer for the company on the Trans-Isthmian Highway in Panama, and on the Alcan Highway in Alaska and Canada. In 1944, he was commissioned as an ensign in the naval reserve and called to active duty in the Pacific.

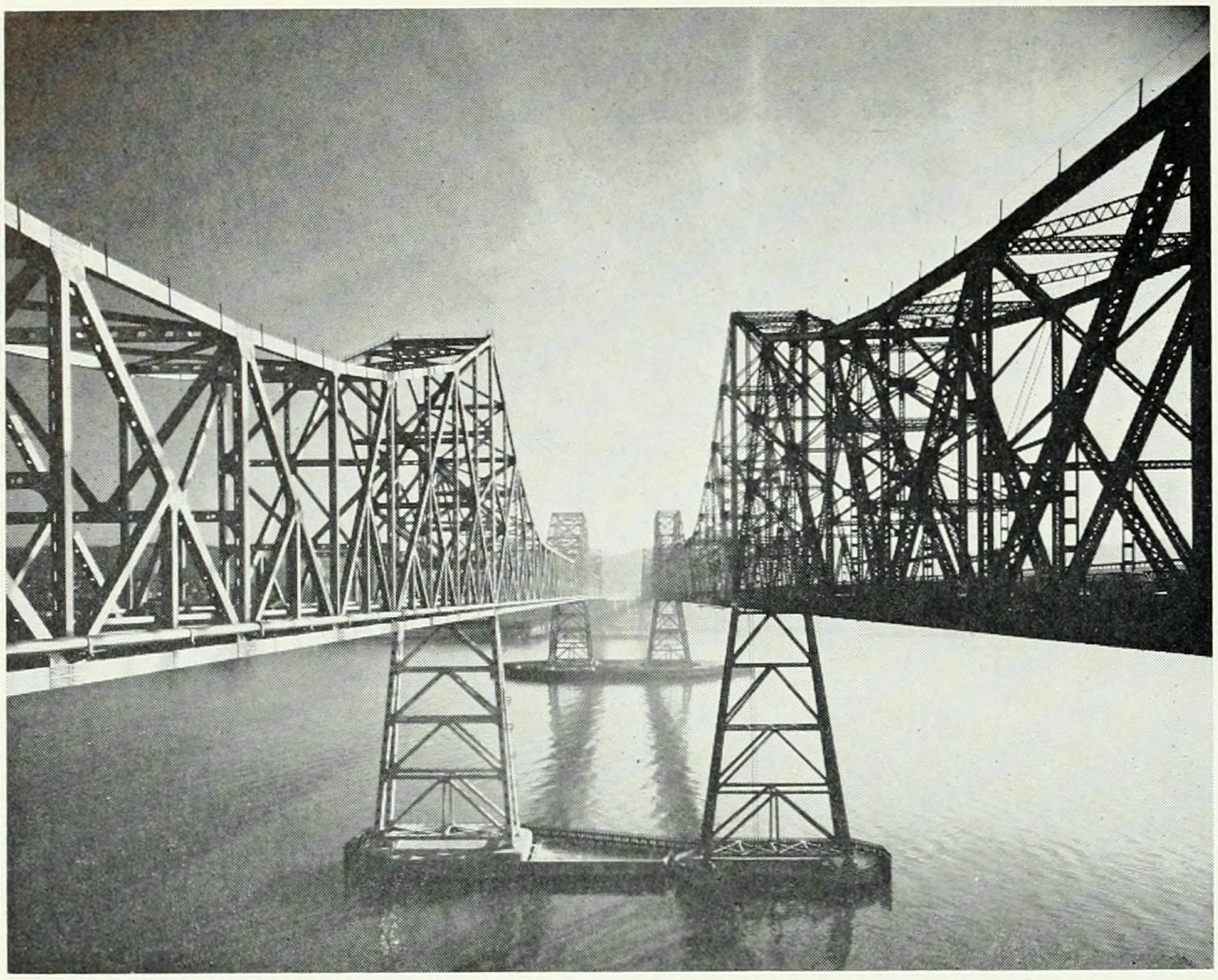
Upon return to civilian life in 1946, Sunbury was employed as a construction engineer with the American Bridge Company until 1947, when he joined the California Division of Highways. His initial assignments were in construction and estimating, but since 1949, he has been active in the field of bridge design.



An idea of the extensive riveting involved in creating the "lacework" on the older Carquinez Bridge is given in this photo taken during the construction of the new span (in background). The use of welded perforated box girders has virtually eliminated the use of riveting on such structures.



The extensive use of perforated box girders in the new Carquinez Bridge presents a smoother, more eye-pleasing appearance while at the same time making maintenance and inspection faster, easier and more effective.



This view of the twin Carquinez Bridges shows the simple, more eye-pleasing structure made possible by the use of high-strength steels and modern welding techniques. The new structure, on the left, was built at a savings of $800,000 by using these materials and techniques.

Sunbury brought his broad background in engineering to bear on the subject of bridge design at a savings to California taxpayers of more than $1,000,000 to date. Following up his earlier studies on the combining of high-strength steels, he was able to effect a saving of $800,000 by combining three types of steel in a single structure—the Carquinez Bridge. A new high standard for clean, uncluttered truss design was established with the construction of this double cantilever bridge with its all-welded members and bolted joints. Use of high-strength steels allowed slimmer members and afforded great savings of weight in members previously required to be heavy in order to carry large secondary stresses.

Many refinements of design were worked out on the Carquinez Bridge, the Benicia-Martinez Bridge, and the Whiskey Creek Bridge. Different types of steel were successfully combined to save bridge weight and at the same time improve bridge appearance. Plates were butt welded so that higher strength compensated for bolt holes and no increase in section was necessary. Box and H-sections were widely used to simplify the fabrication.

On the Whiskey Creek Bridge Sunbury carried plate girder design to a high degree of perfection by placing the higher strength steels in positions of higher stress, thereby maintaining uniform sections throughout the girder. All of these details are now being widely copied throughout the country.

Jonas Welding Expert

A native of Michigan, Jonas came to California with his family in 1923. He attended grade and high school in Antioch. He then completed a four-year night school vocational trade course in electric arc and oxyacetylene welding, layout, and machine shop practice.

Jonas has completed home study courses and night school courses in advanced welding, in metallurgy, and in teaching. He has had seven years teaching experience at Sacramento City College.

Prior to coming to work for the Division of Highways in 1946, Jonas worked in paper manufacturing, steel milling, ship building and repair, steel fabricating, constructing road building equipment, and inspecting and doing research in welding. From 1944 until 1946 he served with the U. S. Navy in a ship repair unit.

With the California Division of Highways for more than 15 years, Jonas has spent five years with the Headquarters Shops and more than 10 years with the Materials and Research Department. He joined state service as a fusion welder and has served as Assistant Steel Inspector and Associate Steel Inspector. He is at present Senior Welding Technologist.

Starting at a time when structural welding was in its infancy, Jonas developed tests, test methods, and qualification procedures which established welding as a reliable method to be used in many types of structural work.

His California Test Method 601 and his development and interpretation of radiographic inspection results have been widely adopted and copied throughout the country. According to State Highway Engineer J. C. Womack, Jonas' work with the fabricators in developing procedures and inspection techniques and qualifying welders has done much to make welding a practical, dependable, usable shop tool.

Major projects on which he has worked or with which he has been affiliated include the all-welded Skyway in San Francisco, the Oakland Distribution Structure, the Carquinez Bridge, the Benicia-Martinez Bridge, the Whiskey Creek Bridge and the West Branch of the Feather River Bridge.

R.M. Monahan Named B.H.I.F. Executive

Appointment of Robert M. Monahan as executive director of the Better Highways Information Foundation was announced in June by H. D. Anderson, chairman of the BHIF executive committee.

Monahan, who is a former special assistant to the Federal Highway Administrator, succeeds Ellis L. Armstrong, who had been executive head of the foundation since shortly after it was established in 1960.

Armstrong is a former U. S. Commissioner of Public Roads and Chief Highway Engineer of Utah.