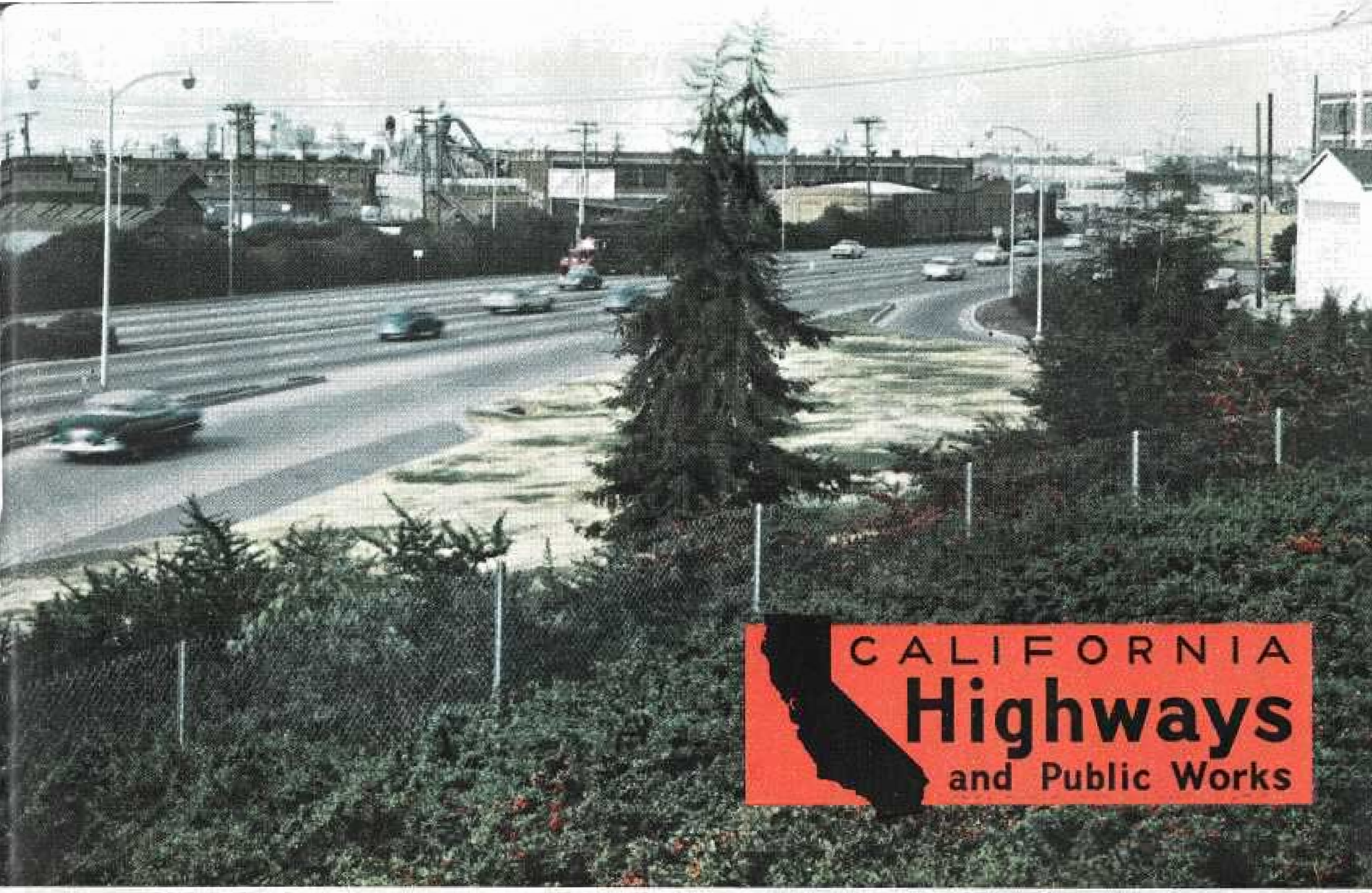
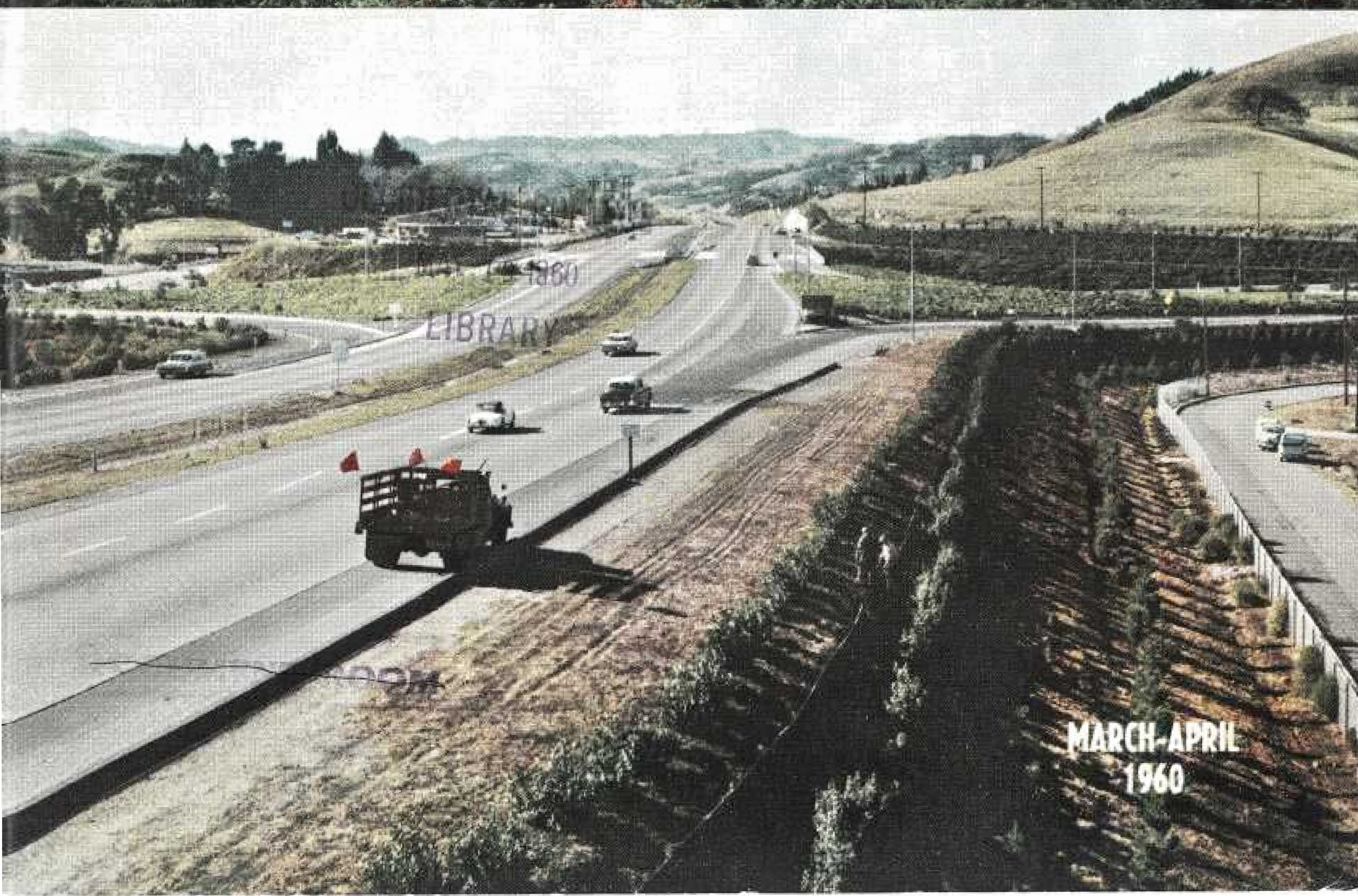


CALIFORNIA Highways and Public Works



MARCH-APRIL
1960

Traffic moving from State Sign Route 89, lower left, into Squaw Valley in February during Winter Olympics of 1960. Squaw Peak is peak farthest left, KT-22 is to the left and below it. Two sections of Navy's compacted snow parking area are nearly filled with cars, another at right center about half filled. Games area is concentrated beyond parking spaces. Road along right side of valley is for official cars and local residents—cars are entering at left on compacted snow road.
See story on Olympics traffic on page 35.

California Highways and Public Works

Official Journal of the Division of Highways, Department of Public Works, State of California

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FRONT COVER

UPPER—A landscaped portion of the Nimitz Freeway through an industrialized area in the City of Oakland. Foreground is planted with pyracantha and redwoods.

LOWER—Landscaping at the Pleasant Hill Road interchange on State Sign Route 24 between Oakland and Walnut Creek. Rows of plants in the foreground are Monterey pines and California holly which will form both an attractive and effective traffic noise deterrent screen.

Photos above and below by Jack Meyerpeter.

BACK COVER

Installation of new large-size directional signs on the Walnut Creek Freeway Bypass. For a description of this newly completed bypass see "Freeways in District IV" beginning on page 13 of this issue.

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State Growth

Governor's Conference Studies Urban Area Traffic Outlook

CITY and county planning officials, administrative officers, highway engineers and others participated in the Governor's Conference on California's Urban Areas and the State Highway System in Sacramento February 23 and 24. They undertook to study current problems of exploding urban growth and motor vehicle use and to explore an approach to future problems of a state expected to have more than 31 million people and more than 17 million motor vehicles in 1980.

The conference, held in the Eaglet Theater, dealt with the problems under these major headings:

1. Present and future growth, planning and development in urban areas and the California highway system.
2. The growing inter-relationships of governmental agencies in future urban development.
3. Goals for 1980 and beyond in urban growth and expansion of the state highway system.

Governor Edmund G. Brown paused to chat with Ira J. Chrisman (seated), Mayor of Visalia and President of the League of California Cities, as he left the rostrum after addressing delegates to the Governor's Conference on California's Urban Areas and the State Highway System held in the Eaglet Theater, Sacramento, February 23 and 24. At the right is Robert B. Bradford, Director of the State Department of Public Works, who was general chairman of the conference.

Governor Speaks

"Clearly, we have work to do," said Governor Edmund G. Brown in welcoming the approximately 200 delegates. "And," he said, "if projections about the future are valid, the task is monumental. How shall we proceed?

"First, our transportation plans must embrace more than highways and freeways.

"Second, we must recognize that our efforts to cope with the movement of large groups of people as they go about their work and play necessarily impinges on all phases of a community's life. As we come into an area with a network of concrete, what we do will very likely influence the future of that area for decades to come. This is true not only of an area but of the State as a whole.

"Finally, we must understand that our highways and other mass transit systems are more than links between the present points of origin and the present destinations of multitudinous individuals; they influence what our *future* points of origin and destination will be. They are, in other words, a positive conditioning force in shaping the pattern of our lives. To say this is to say that we must be sure we are looking at the whole picture as we plan our transportation facilities.

"Also, we must never forget that, in this dynamic, growing State, looking ahead takes on a new dimension; it is virtually a condition of survival."

Problems Outlined

Governor Brown told the delegates that in calling the conference he had in mind three basic problems:

First, the problem of relating metropolitan freeways to other systems of transportation;

Second, the problem of reconciling state and local jurisdictions in the area of highway planning;

Third, the problem of relating highway planning to other aspects of community life, both at the state and local levels.

In regard to the reconciliation of state and local jurisdictions in the area of highway planning, Governor Brown said that the State Division of Highways had recognized that today's highway systems are bound to have a profound impact on local areas, and that local interests must be consulted.

"I know that the heads of our highway division are ready and willing to co-operate with local jurisdictions," he said, "but I am convinced that still more can be achieved. I am sure that conferences such as this will further the already good day-to-day working relationships that prevail."

Bradford Is Chairman

Robert B. Bradford, Director of Public Works, was general chairman of the conference, but each discussion panel had its own chairman.

Ira J. Chrisman, president of the League of California Cities and mayor of Visalia, was the opening speaker following the Governor's address of welcome. Chrisman told the conference:

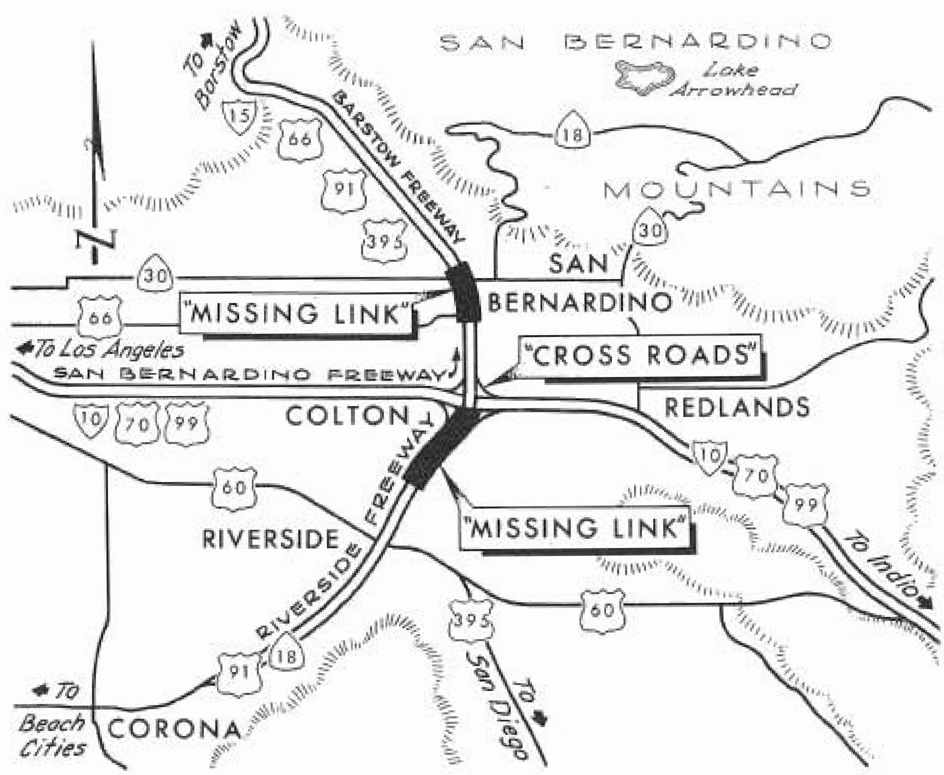
"The vast scope of highway construction under way and contem-

. . . Continued on page 66

Crossroads

Completion of Two Major Connections Joins Riverside, San Bernardino Freeways

By LOREN BARNETT, District Construction Engineer



RESIDENT Engineer calling Barricade Crews—Open Freeway!"

Flowers falling on Resident Engineer Tom Borman's car from the dedication ceremony on the overcrossing above were his signal to radio the standby crews to open the "missing link" of the San Bernardino Freeway.

The flowers were dropped at the climax of a double ceremony that started earlier in the day when a "missing link" in the Riverside Freeway was also dedicated.

It was appropriate that these freeways should be dedicated jointly as, in addition to each being a "missing link" within its own freeway, the main San Bernardino and Riverside Freeways were also linked together (at the "crossroads" interchange just east of Colton).

These freeways were connected at night a few months before with two cranes hoisting prestressed concrete girders in place over existing traffic. During this operation, the light predawn highway traffic was interrupted less than 30 minutes at any one time. The railroad was bridged with no delay to train traffic.

Railroad Conflict

This smooth operation was in sharp contrast to an important traffic connection in 1883 when the California Southern Railroad (now Santa Fe) was bringing its line up from San Diego and attempting to cross the pioneer S.P.R.R. at Colton.

A tussle ensued between the two railroads. The S.P. placed a heavy engine at the point of crossing, but was finally compelled to move the locomotive to save it from demolition. (Records indicate the S.P. finally aided in laying the disputed tracks.)

From this initial crossing grew an intolerable entanglement of railroad and highway traffic. Over 70 years later, a tremendously increased volume of cross-country and local traffic was still trying to cross near the same point.

The final phase to the solution of this entanglement was realized with the completion of the big three-level "crossroads" interchange.

This massive interchange has been appropriately referred to as the "Crossroads of the West," since the following main highways converge at this location:

- U.S. Highway 395, San Diego to Canada
- US 99, Calexico to Canada
- US 91, Long Beach to Canada by way of Las Vegas and Great Falls
- US 70, North Carolina to the Pacific Ocean
- State Highway 18, Long Beach to Victorville via the San Bernardino Mountains and the Mojave Desert

Southward Extension

From this "crossroads," the newly completed link of the Riverside Freeway heads south, bridges the main Southern Pacific Railroad line, and extends out across the historic Cooley Ranch—one of the few rural farmlands remaining in this area. It slices through the high bluff of Grand Terrace, passes under the Santa Fe and Union Pacific Railroads, and, at the Riverside county line, ties into the previously constructed portion of the Riverside Expressway that carries the traffic on into Riverside.

This freeway is a typical rural freeway design with widespread interchanges, each covering considerable acreage.

An unusual problem was encountered on this project in providing protection for an existing utility. The planned freeway passed over an old water tunnel which was first con-

Dedication ceremony on the Ninth Street Overcrossing. Left to right are: Millie Askew, who is Miss San Bernardino; Mrs. Davida Godfrey, San Bernardino pioneer; and James A. Guthrie, member of the California Highway Commission.

structed in the 1870's as part of a system for transporting irrigation water to the Riverside area. The tunnel was still in use and it was questionable how long the lining would last, considering its age and makeshift construction.

The tunnel was originally supported with 6-inch by 8-inch redwood roof timbers resting on brick piers. It was lined with two-inch redwood planks on the ceiling, four inches of concrete between piers on the walls, and three inches of concrete on the floor. In the 1920's, concrete mortar was pasted over the entire walls and ceiling.

The problem was to provide a new support to 530 feet of this tunnel without reducing the water-carrying capacity. The solution was an arched corrugated metal tunnel liner with pressure grout filling the voids between the liner and old walls, and air-blown mortar placed on the inside of the liner to provide a smoother flow.

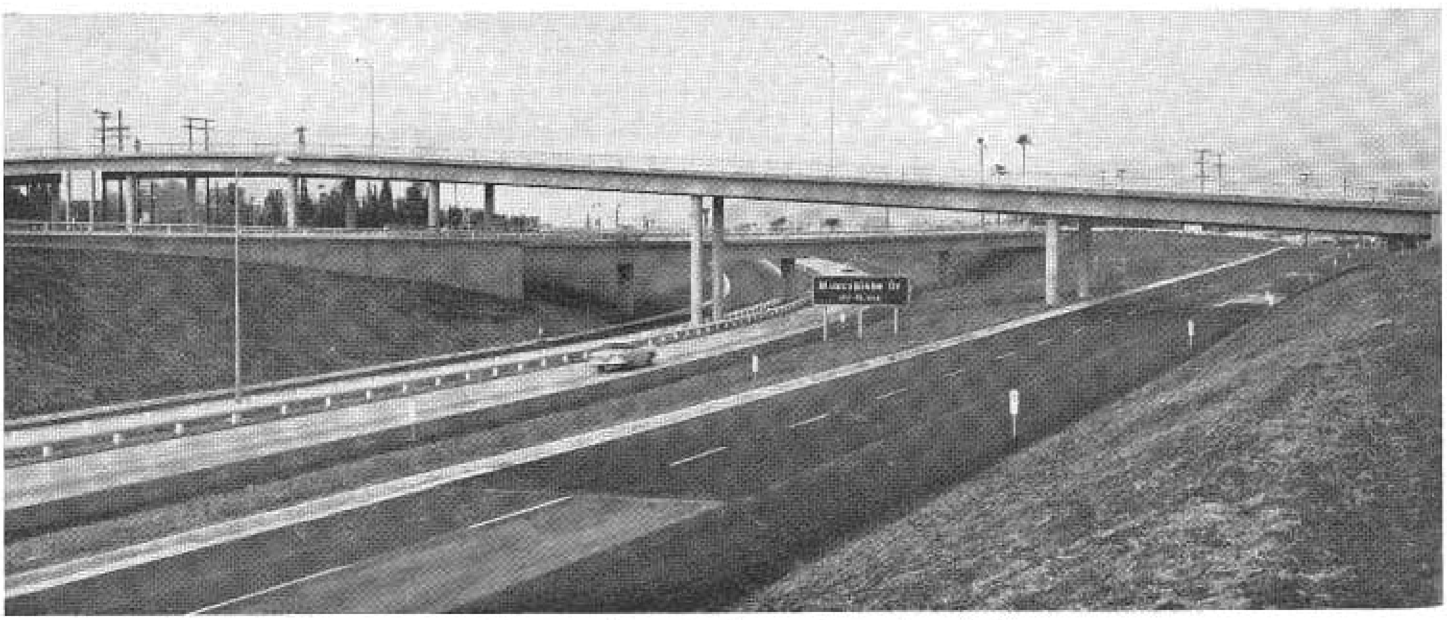
Not Much Headroom

Placing the tunnel liner and concrete with only approximately four and one-half feet of headroom posed a problem that could not be solved with normal construction methods and equipment.

The contractor for this work, N. M. Saliba Company, tried several methods of getting the concrete back into the tunnel, including wheeling it by hand "buggies," by pumping, and by the use of a hopper mounted on a monorail and propelled with a five-horsepower engine.

The powered monorail unit was found to be the most practical method in transporting the concrete long distances into the tunnel. It was also used to remove old concrete and to carry the liner plate into the tunnel.

After the metal liner was bolted into place, grout was forced in be-



Looking north from the 16th Street Interchange on the San Bernardino Freeway.

A southward view from the 16th Street Interchange on the San Bernardino Freeway.

tween the old and new linings with a pumping unit set up in the tunnel.

Air-blown mortar was applied to the inside of the corrugated liner with conventional pressure grouting equipment located outside of the tunnel pumping dry sand and cement through hoses to the site of the work in the tunnel, where it was uniformly mixed with water just prior to application.

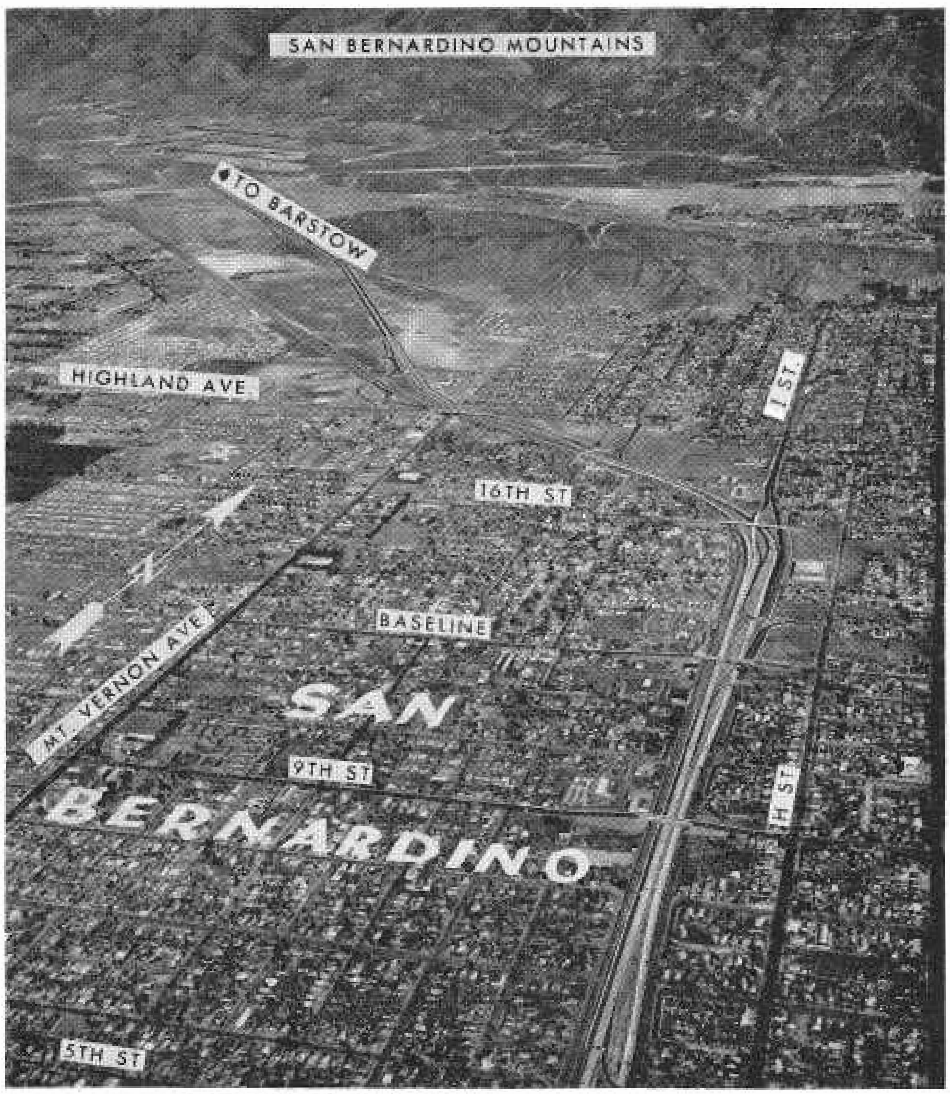
With this new smooth lining—even though reduced in section—the tunnel can now carry the same volume of water as it did with the old rough lining and with assurance that the tunnel will not collapse under the freeway.

Freeway Connection

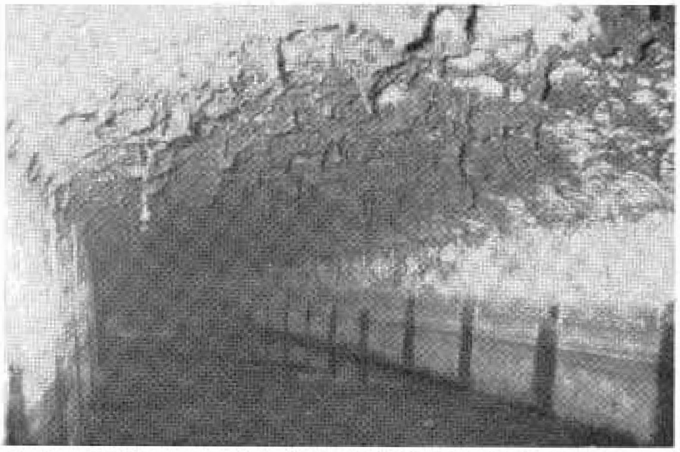
The other "missing link" is north of the "crossroads" interchange. It is part of the San Bernardino Freeway and extends from the center of San Bernardino to the northerly city limits, where it ties onto the Barstow Freeway.

It was also necessary to co-ordinate the freeway with an existing railroad. Here, portions of two mainlines of the Santa Fe tracks were shifted to ease sharp curvature to accommodate minimum standards of a parallel freeway alongside.

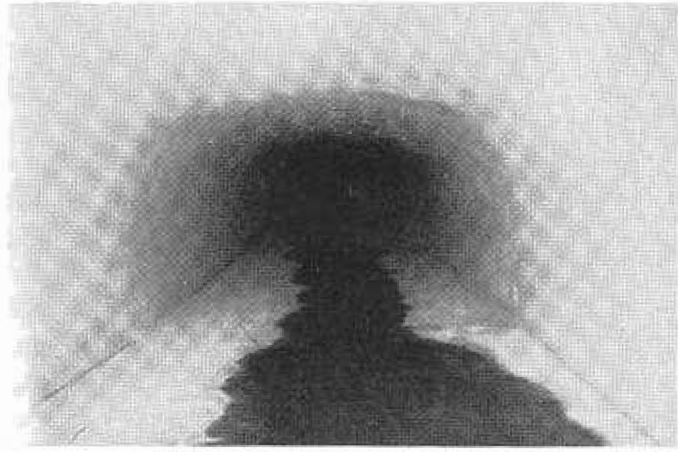
This freeway, in contrast to the Riverside link, is of urban-type development with more compact interchanges that utilize and tie into the city street system.



An aerial view of the newly completed section of the San Bernardino Freeway.



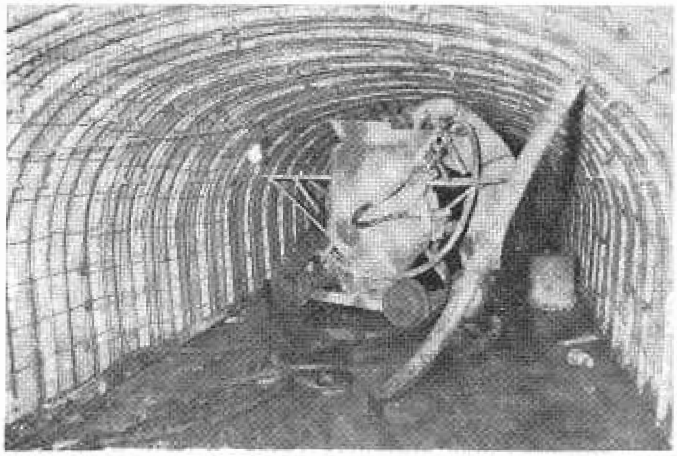
The tunnel before construction. Note the brick piers in the walls. The ceiling is covered with dirt-encrusted cobwebs.



The tunnel after it had been reconstructed.

Pouring the floor slab with a monorail unit.

A crew placing the tunnel liner.



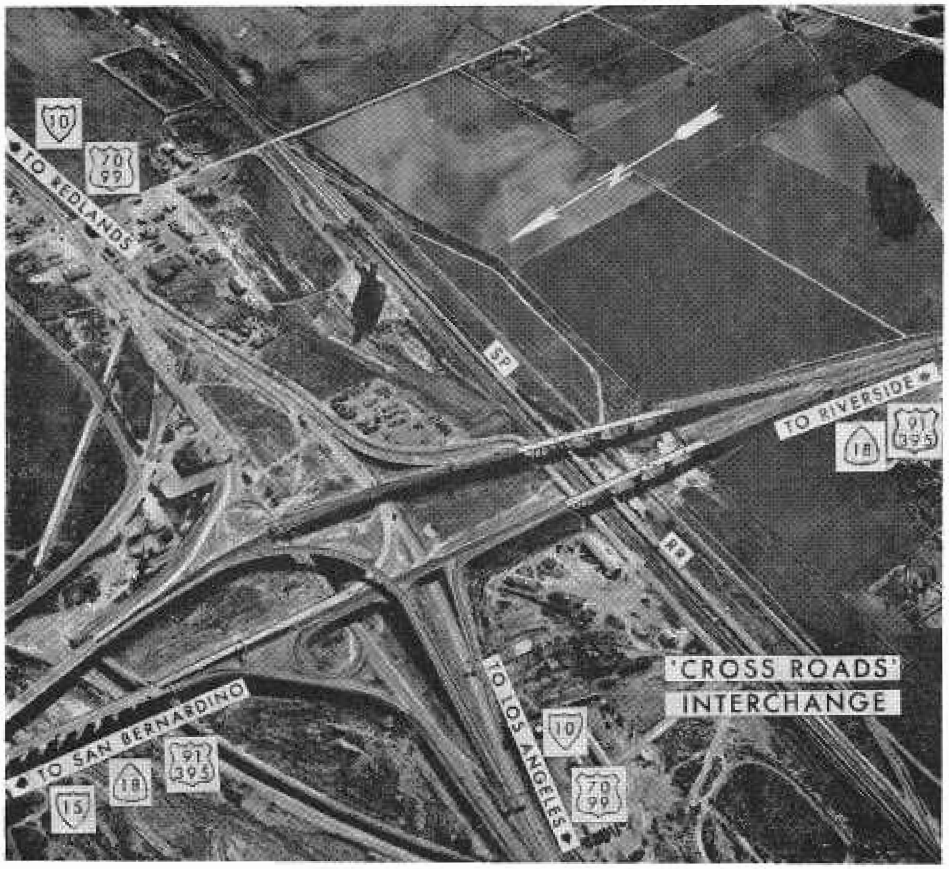
Forcing grout between the new and old tunnel lining.

Applying air-blown mortar to the inside of the new tunnel lining.

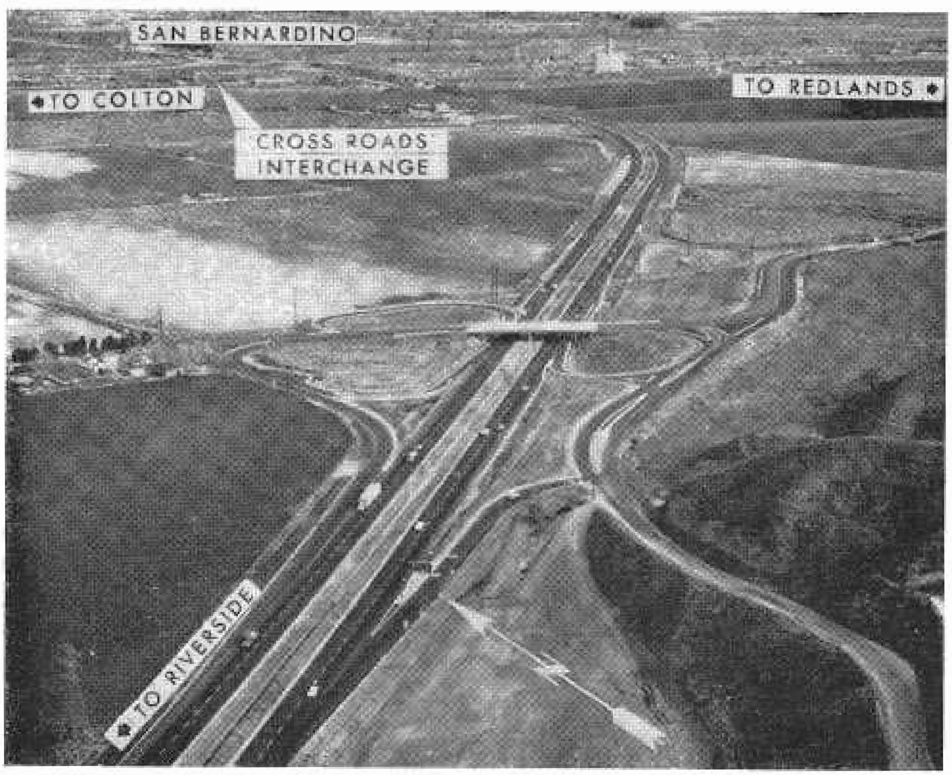
An example of compactness is illustrated by the condensed interchange at the 16th Street area, where the railroads, both freeway roadbeds, and three ramps all blend together, with the 16th Street Overcrossing spanning the whole network (see picture).

With the freeway and railroads lying adjacent, special consideration had to be given to the design of the ramps. The solution resulted in all but one ramp entering or leaving the freeway from one side. It was possible to provide separation from local traffic for both the freeway and railroad with single overcrossings.

A most effective method was used in blending these freeways into the surrounding terrain by the transplanting of existing ornamental trees. On the San Bernardino Freeway, a group of old olive trees were transplanted on a curve between the railroad and freeway. These trees served the dual purpose of landscaping and providing a shield from train headlight glare. On both of these freeway units, many



An aerial view of the "Cross Roads" Interchange east of Colton.



The north portion of the newly completed section of the Riverside Freeway.

"specimen" palm trees—some about 100 feet high—were transplanted into suitable settings at the interchanges.

During construction of the San Bernardino link, a native pioneer lady, Mrs. Grace Clark English, approached the resident engineer and told him of having carried water to a very small palm tree when she was a little girl. It had been brought to their place from Palm Canyon (near Palm Springs) in about 1884.

With the development of the freeway, Mrs. English moved to a new location adjacent to the freeway, but the palm tree had been left in the path of construction. She said she hoped her palm tree could be saved.

An ideal setting for this palm tree developed at the Orange Street On-Ramp. It is now visible to the passing motorist as well as from the window of Mrs. English's new home. She is again carrying water to help get her palm re-established.

The San Bernardino Freeway is now complete as a divided highway, permitting a 125-mile nonstop trip from Los Angeles to Barstow.

The Riverside Freeway is now complete as a divided highway, permitting a 100-mile nonstop trip from Corona to Barstow.

The dedication ceremonies celebrating the completion of these freeways were planned co-operatively by the San Bernardino, Riverside, and Colton Chambers of Commerce. Under the general chairmanship of George W. Savage, the celebration was completed with a large reception and dinner at the National Orange Show. Many dignitaries attended the ceremonies, including the Director of Public Works, Robert B. Bradford; Governor Lic. Braulio Maldonado of Baja California; Highway Commissioners James A. Guthrie and A. T. Luddy; Representative Harry R. Sheppard; U.S. Senator Thomas H. Kuchel; and State Senator Stanford C. Shaw.

With the completion of the "missing links" in the San Bernardino and Riverside Freeways, the giant "Crossroads of the West" interchange is now rapidly and efficiently sorting a mixture of intercity, interstate, and intercontinental traffic, and is discharging a much happier motorist.

US 50 Freeway

State Begins Construction on MacArthur Freeway in Oakland

By L. M. PETERSEN, Design Engineer, District IV

After many years of planning and right-of-way activity, including two district public meetings and two California Highway Commission hearings, the construction of U.S. Route 50, Interstate Route 5W, in Alameda County between the San Francisco-Oakland Bay Bridge and Castro Valley is under way. It is expected that sufficient funds will be provided on this section of interstate freeway to permit continued construction until completion.

This 15.3-mile section of US 50 is unofficially called MacArthur Freeway since it roughly parallels MacArthur Boulevard through much of its course. The route was adopted between the Bay Bridge distribution structure and Route 228 at Castro Valley in three units; in January 1955, May 1957 and June 1957, respectively. Freeway agreements covering this section were negotiated with the several local authorities involved between November 1956 and December 1958.

A total of $23,000,000 has now been budgeted for construction.

The 1959-60 budget includes $10,000,000 for construction from the distribution structure to Market Street and from Webster Street to Grand Avenue in Oakland. Bids have been opened on the first of these units and the second has been advertised.

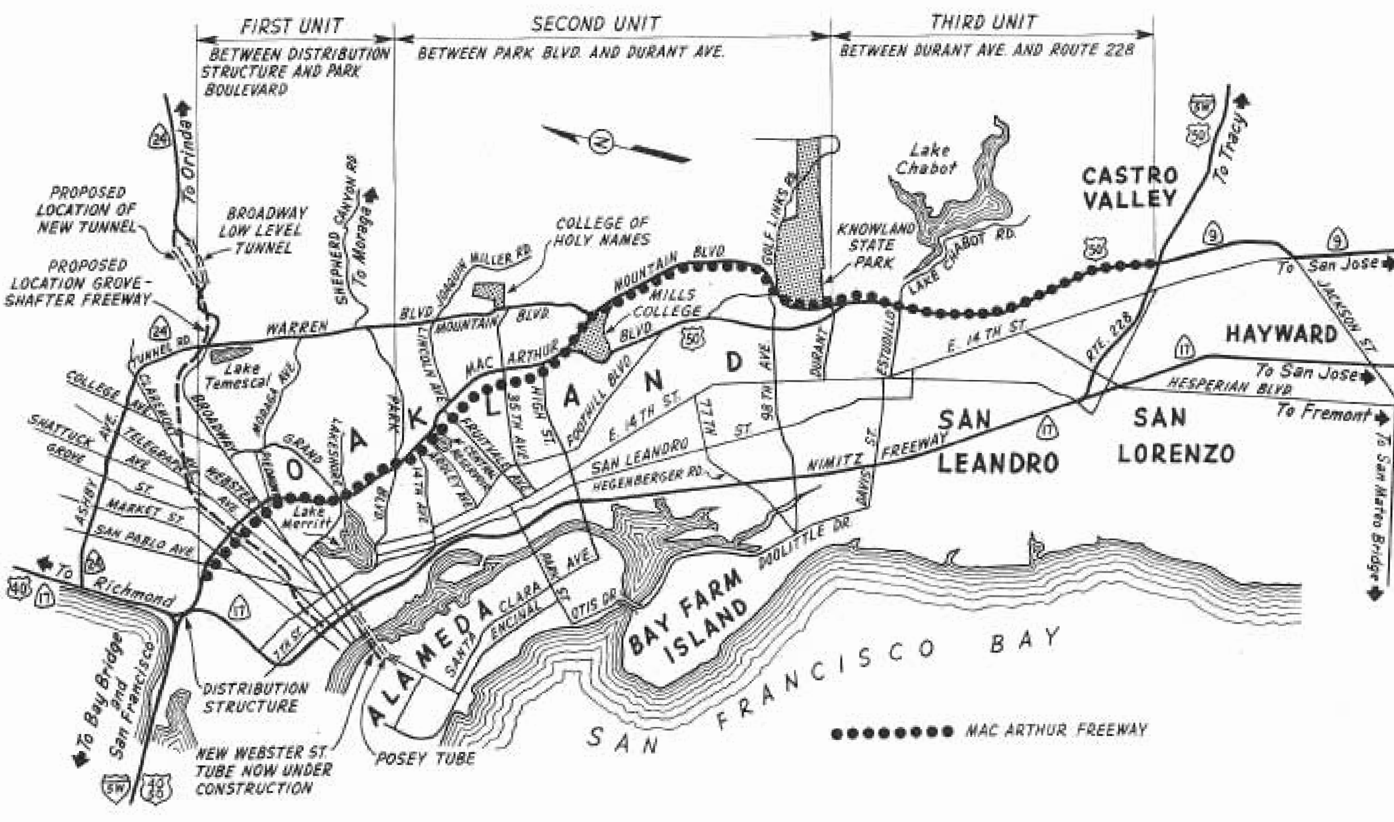
Will Close Gap

The 1960-61 Budget includes $13,000,000 for construction on two projects, the first to close the gap between the two projects financed in the 1959-60 Budget and the second to provide construction between Grand Avenue and 14th Avenue. It is expected both these projects will be advertised during 1960. These four projects will provide an eight-lane freeway between the Bay Bridge distribution structure and 14th Avenue for a length of about 3.9 miles.

The area traversed is nearly fully developed and improved. Most of the parcels required are residential in nature although many of them are multiple units. There are many other types of properties involved, however, such as churches, mortuaries, a burlesque theater, a soft drink producer, retail stores, service stations, cafes, motels and trailer courts.

The total cost for the entire 15.3-mile section is estimated to be about $100,000,000, about evenly divided

MAC ARTHUR FREEWAY



between construction and right-of-way.

Right-of-way purchases began soon after the first section was adopted in 1955. Over $34,000,000 has been spent to date on right-of-way with an additional $9,400,000 budgeted. Out of some 2,100 parcels required, about 1,600 have now been purchased. Funds now programed are sufficient to purchase right-of-way for nearly all the remaining parcels required for the full 15.3-mile section.

BORROW, EXCAVATION WORK COMBINED; SAVINGS RESULT

The result of co-ordinated planning among several departments has been evident since work was started February 11, 1960, on the first unit of the MacArthur Freeway. The contractor, C. K. Moseman and Son, is excavating at the east portal site of the future third Broadway Tunnel bore. This excess material will considerably reduce the cost of constructing freeway embankments in the metropolitan area between the distribution structure and Market Street in Oakland.

This borrow operation will continue through the next three contracts to provide the 350,000 cubic yards of embankment needed between separation structures extending to Broadway. Material is hauled through the existing tunnel and on the state highway during off-peak traffic periods. Subsequent contracts, beginning at 14th Street, will contain sufficient excavation to balance the grading beyond Broadway.

Looking westerly across Oakland residential area from vicinity of Grand Avenue, showing right of way clearance for proposed MacArthur Freeway.

Most Parcels Acquired

Nearly all the parcels have been purchased on the portion for which construction funds are now budgeted between the distribution structure and 14th Avenue, and about 90 percent of this section has been cleared. Easterly of 14th Avenue right-of-way negotiations are well advanced and clearing is under way. Slightly less than half the improvements cleared to date have been moved and the remainder demolished. Because of the advanced age of many of the buildings and scarcity of vacant properties in the area, it has been difficult to salvage even that amount. Some enterprising contractors have moved houses down to the bay and barged them up the San Joaquin River to the Stockton area.

The right-of-way purchase and clearance activities have been spread over several years to permit orderly readjustment of residents and businesses.

In selecting the route for this freeway, an attempt was made to effect a minimum of disruption to public facilities such as schools, parks, etc. In spite of this, the route crosses a portion of the City of Oakland's Lakeshore Park and Knowland State Arboretum and Park and requires some revision of playground facilities of the Lakeshore School on Grand Avenue in Oakland. A small portion of an EBMUD reservoir near Ardley Avenue will have to be cut off and rebuilt. At all of these locations, an attempt is being made to provide a minimum of disruption and a pleasing finished facility consistent with proper freeway standards.

On National System

Since this freeway is on the national system of interstate and defense highways, interstate design standards are being maintained. Eight lanes are to be constructed throughout with 60-mile-per-hour design speed pro-

. . . Continued on page 68

Conference

Collier, Backstrand, Armstrong Keynote Road Meet at U.C.L.A.

ROAD BUILDING is the world's second oldest profession, and like the world's oldest profession, it suffers greatly from the criticism of the amteurs who think they are better qualified than the professionals."

When Senator Randolph Collier made this statement in his speech to the opening session of the 12th California Street and Highway Conference in Los Angeles January 28, he received a delighted outburst of applause from the audience of city, county, and state engineers and other officials gathered in Schoenberg Hall at the University of California at Los Angeles.


RANDOLPH COLLIER

The Senator, who heads the Senate Transportation Committee, pointed out the many difficulties which arise in allocating highway funds in California, and discussed the great task confronting the engineers to make the highways safer. He said the annual death toll on the highways of the United States would make a line of hearses from Los Angeles to Salt Lake City.

Backstrand Stresses Safety

Assemblyman Lee Backstrand of Riverside County, who is chairman of the Assembly Transportation and Commerce Committee, spoke the same morning in the same vein.


LEE BACKSTRAND

"Based on a projection of present trends," Backstrand said, "700,000 more persons will have lost their lives in traffic by 1975, 25 million more will have been injured, and the total cost of motor vehicle accidents to the people of the United States between 1958 and 1975 will exceed $120 billion."

Speaking of future problems, Backstrand pointed out that "three-fourths of all adults in the United States are now licensed to operate motor vehicles, and safe highway transportation has consequently become a universal need close to the heart of the nation's welfare."

Co-operation Stressed

Keynote speaker for the opening day program was Ellis L. Armstrong, Commissioner of Public Roads, U.S. Department of Commerce. Armstrong devoted the major part of his speech to the problem of financing the interstate program, and the many organizations which must co-operate to make the program a success.

"In stressing the big and varied task that lies ahead," Armstrong said, "I want to emphasize both the array of talent and the professional skills that are found in our state highway departments and the counterparts in the local highway fraternity. You make up a very special elite—competent experts of high integrity and ability and perseverance dedicated to the public service.


ELLIS L. ARMSTRONG

"I know you by personal contact and by reputation. Suppose we also let the record speak. The vastly increased scope of the federal workload is implicit in dollar and mileage figures for the interstate and other federal aid systems—planning, construction, and completions are entirely up to expectations.

"Since the passage of the 1956 Highway Act over 100,000 miles of highways, including 20,000 bridges, have been constructed across America on the federal aid system, at a cost of about $8 billion. This includes nearly 5,800 miles of high-standard interstate system roads and the remainder on the regular primary, secondary, and urban systems. In addition, construction is now underway on 23,000 miles of highways and 8,800 bridges. Of this total, 4,300 miles is of interstate roads, the rest is the regular ABC work."

Air Car Described

At the general session which closed the conference on Saturday morning, January 30, the group was addressed by Minard W. Stout, Vice President for Research and Development, Curtiss-Wright Corporation. Stout spoke on the potential of the air-cushion car and showed a motion picture film of progressive experimental models developed by his firm. The company claims its production model, soon to be available, is already perfected enough to travel on conventional highways, and that wide use of the machines for travel will eliminate the need for bridges over water, and all but the most rudimentary type of road surfacing.

During the Saturday morning session, addresses were made by State Director of Public Works Robert B. Bradford, ex-Director C. M. Gilliss, now Executive Director, Los Angeles Metropolitan Transit Authority, and Keneth M. Hoover, chief engineer, San Francisco Bay Area Rapid Transit District.

Bradford spoke on the subject "Transportation Planning Calls for Team Effort." As one example, he cited "the relationship that has existed for more than 40 years between the United States Bureau of Public Roads and the various states, especially the California Division of Highways. We have all taken for granted how smoothly the accelerated Federal Interstate Highway Program has gone into effect and how rapidly it has progressed—yet very few of us have stopped to think what a struggle it could have been if we had not had a long-established foundation of close teamwork to build on. No wonder the writers of political science textbooks point to the federal highway

. . . Continued on page 64

Webster St. Tube

Work Starts on New Facility Under Estuary

By P. E. PARKER, Senior Bridge Engineer and
H. J. WHITLOCK, Senior Electrical Engineer

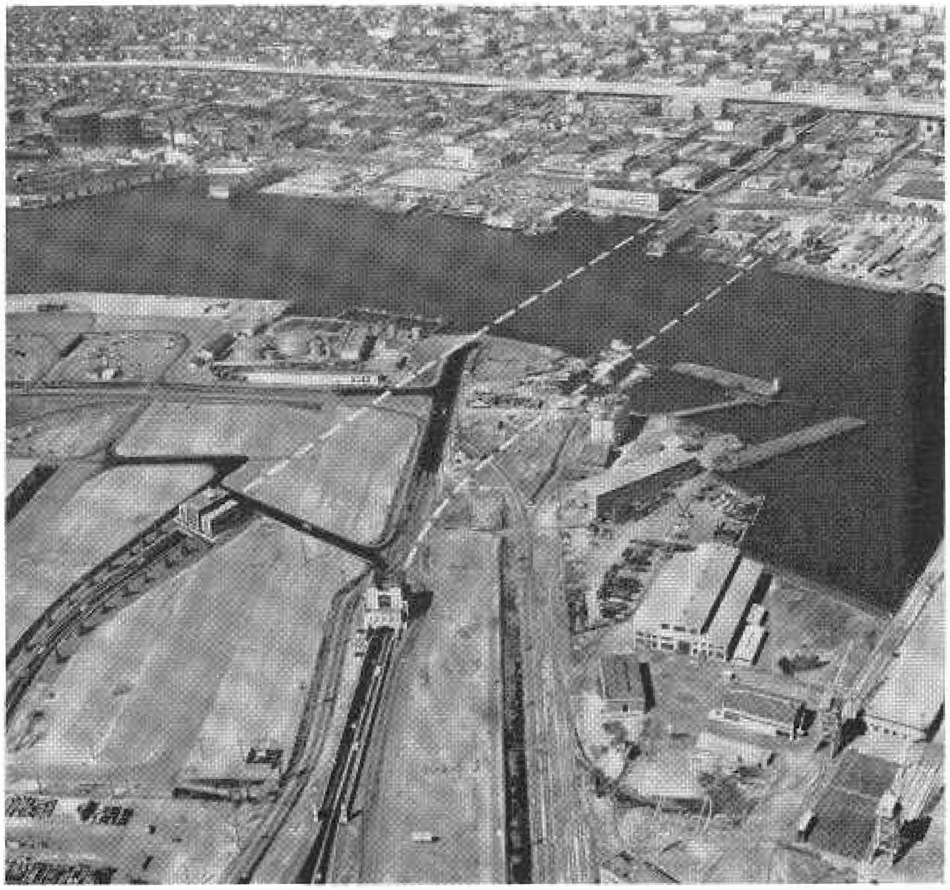
CONSTRUCTION of the new underwater tunnel between Oakland and Alameda is now under way. The Contractors are Pomeroy-Bates & Rogers-Gerwick and the contract amount is $16,641,000. Work began on October 12, 1959, and is expected to extend over a three-year period. George A. Greene is the resident engineer.

This tunnel, now known as the Webster Street Tube, will be roughly parallel to, and about 500 feet westerly of, the existing Posey Tube.

When completed, the new tube will carry two lanes of one-way traffic to Alameda and the two lane Posey Tube will become one way to Oakland.

Both tubes will be operated as one unit and all operating controls for both tubes will be housed in the Oakland Portal Building of the Posey Tube.

The project consists of the construction of "boat section" approaches in both Alameda and Oakland, a "portal building" at each end of the tunnel for ventilating and electrical equipment, 12 precast tube segments each 200 feet long, a cast-in-place portion of tunnel 783 feet long, temporary bridges, a permanent bridge, waterfront and street work together with mechanical and electrical work and equipment. There are 153 items of work in the contract.



Retouched aerial photograph of project site. Dotted line on left shows location of Webster Street Tube. Existing Posey Tube is indicated by dotted line on right.

Old Method Described

Prior to the Posey Tube, which was completed in 1928, nearly all underwater vehicular tunnels were constructed using the "shield" method which involved underground tunneling and use of compressed air. The Posey Tube was constructed by sinking precast tunnel segments in a dredged trench, aligning them accurately and connecting them underwater. This so-called "trench" system proved to be so much more economical, that since that time, this method has been used whenever practicable.

In general the "trench" type of construction is feasible if:

(a) Cost of R/W for approaches is relatively low.
(b) Water is reasonably quiet to permit accurate landing of tunnel segments.
(c) Material within the project limits can be readily excavated without necessity of underwater blasting.
(d) Sufficient water depth exists to permit floating of segments.

The precast segments are circular in cross section, have an outside diameter of 37 feet, are 200 feet long and have a shell thickness of 2′-6″. They are constructed entirely of reinforced concrete.

Segments Are Precast

It is understood that the contractor will construct the 12 precast segments two at a time in a basin which he will construct on the Alameda side of the Estuary about a mile from the tunnel site. Temporary watertight bulkheads will be placed in the ends of these segments to permit them to be floated. The scheme is to construct a segment, float it out of the basin, replace the head gate or dam, pump out the basin and construct the next segment.

The specifications have been written to ensure that the concrete for the tube will be as watertight as possible. In addition, the exterior of the tube shell will be covered with membrane waterproofing. The waterproofing for the precast segments will be covered with timber lagging to protect them during the floating and placing operations.

Segment draft, buoyancy and stability must be carefully considered for all phases of the work. The weight of the tube shell, roadway slab and temporary bulkheads as constructed in drydock is approximately 5,500 tons and the buoyancy is approximately 7,100 tons. When floated, the segment will have a draft of approximately 30 feet. In order to sink a segment at the site it will be necessary to add at least 1,600 tons of ballast. This can be done by filling the space beneath the roadway slab with water and placing sand on the roadway slab. In addition, enough extra ballast must be added to ensure that the segment will stay in position when sunk. Segments of this size are very sensitive to changes in specific gravity of the water. A change, for example, from 1.00 to 1.02 would increase the buoyancy by nearly 150 tons. Such a change could be easily caused by muddiness resulting from the placing operation.

Masts Show Location

Alignment masts will be erected at each end of each precast segment. These masts will project above the water when the segment is in final position and permit its exact location to be known at all times by usual survey methods.

Divers working in depths of water up to 90 feet with attendant muddiness must rely to a great extent on sense of touch only. For this reason, the method of connecting the precast segments has been made as automatic as possible. It is planned to rest one end of each segment on the preceding one. The other end will rest on piles previously placed to exact line and grade. Thus the divers need only be sure that each section is landed properly. The final few feet of lowering of the section forces a rubber sealing ring around a tapered projection which makes possible the complete encasement of the joint with tremie concrete.

After the segment is placed in position, sand backfill is placed under and around it to a level at least seven feet above the bottom of the barrel. This sand is thoroughly compacted by jetting, sluicing or other means. Additional ballast is then added to the segment until the downward force is at least 600 tons. The piles supporting the segment initially are designed to fail under this downward force thereby transferring the loading to the sand bed.

Placing of Segments

Placing of precast tube segments will begin at the Alameda Portal Building and continue across the Estuary to Oakland. The cast-in-place portion of the tube will be completed after all precast sections are in place.

The tunnel interior will be completed by entering one end, removing temporary bulkheads and pumping out ballast water and water trapped between bulkheads at each joint.

In addition to the rubber seal and tremie concrete seal at each joint, there is a grout seal and a seal obtaining by welding a continuous steel plate across the joint.

The tube will have a 24-foot roadway, a minimum vertical clearance of 15 feet 1⅜ inches, tiled ceiling and walls down to the roadway level and two lines of continuous fluorescent lighting. A PMS roadway surface has been specified to help reduce the

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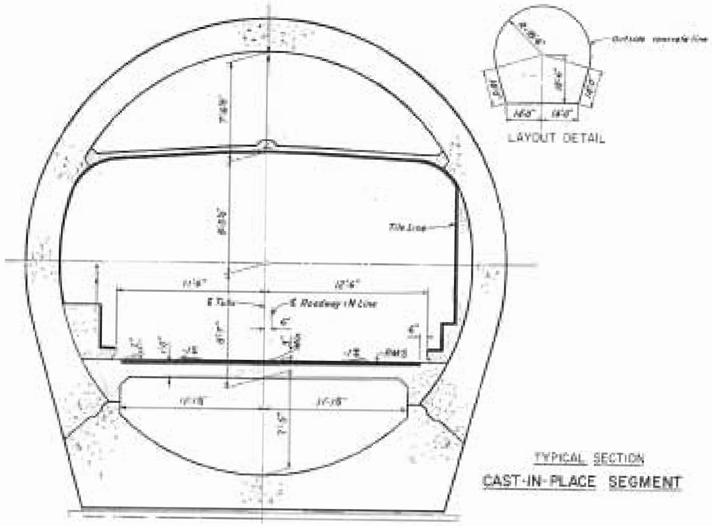
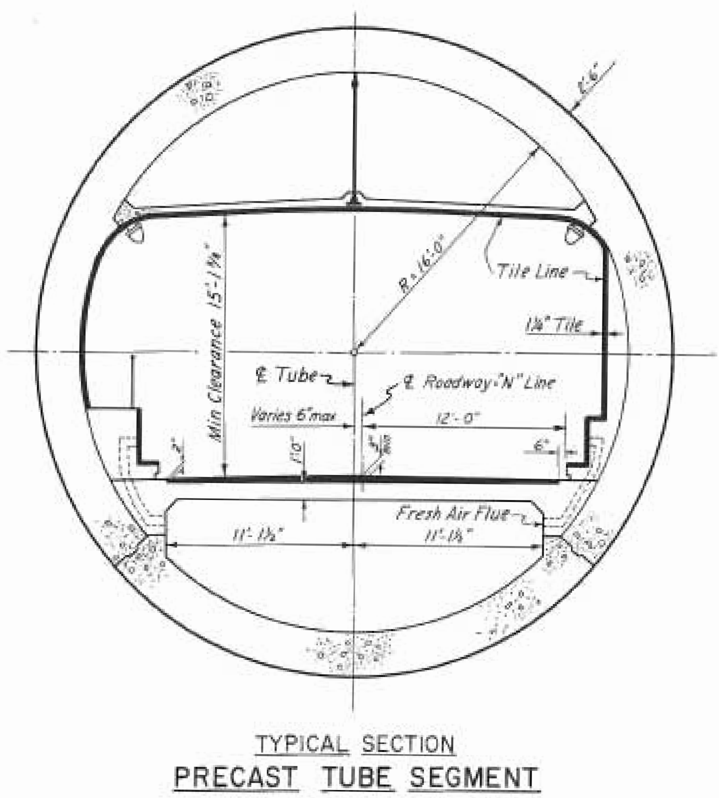


Horseshoe-shaped section is used to simplify placing of forms and concrete for portion of tunnel constructed in place in open trench.



Circular section is used for the 12 precast tube segments for maximum buoyancy.

Freeways in District IV

By J. P. SINCLAIR, Assistant State Highway Engineer

THE "FABULUOUS FIFTIES" have brought great advancements in modern freeway construction in the San Francisco Bay area. During the decade, a total of 300 miles of freeway have been completed in the nine counties comprising District IV.


J. P. SINCLAIR

However, the fifties have also seen a tremendous growth in population and vehicle registration. In 1950, the nine counties had a population of 2,643,000 with 1,102,000 vehicles. At the end of 1959, the population had grown to 3,648,000, an increase of over a million people. Vehicle registration has spurted to 1,786,000. Traffic throughout the district has nearly doubled.

Some of the comparative average daily vehicle counts are as follows:

Location	Number of Vehicles 1950	1960
Eastshore (Ashby Avenue)	46,000	83,000
S.F.-Oakland Bay Bridge	80,000	104,000
Golden Gate Bridge	26,000	50,000
Bayshore (South San Francisco)	29,000	75,000
US 50 (Dublin)	8,000	17,000

The total expenditures on freeways in District IV in the last 10 years is approximately $600,000,000. The district's total construction and right-of-way budget was $19,000,000 in 1950 and has increased to $80,000,000 this past year. This is a measure of the acceleration in the freeway program.

During this 10-year period, the Nimitz Freeway from Oakland to San Jose has been completed.

Sign Route 17 Freeway from San Jose to Los Gatos will be finished this summer.

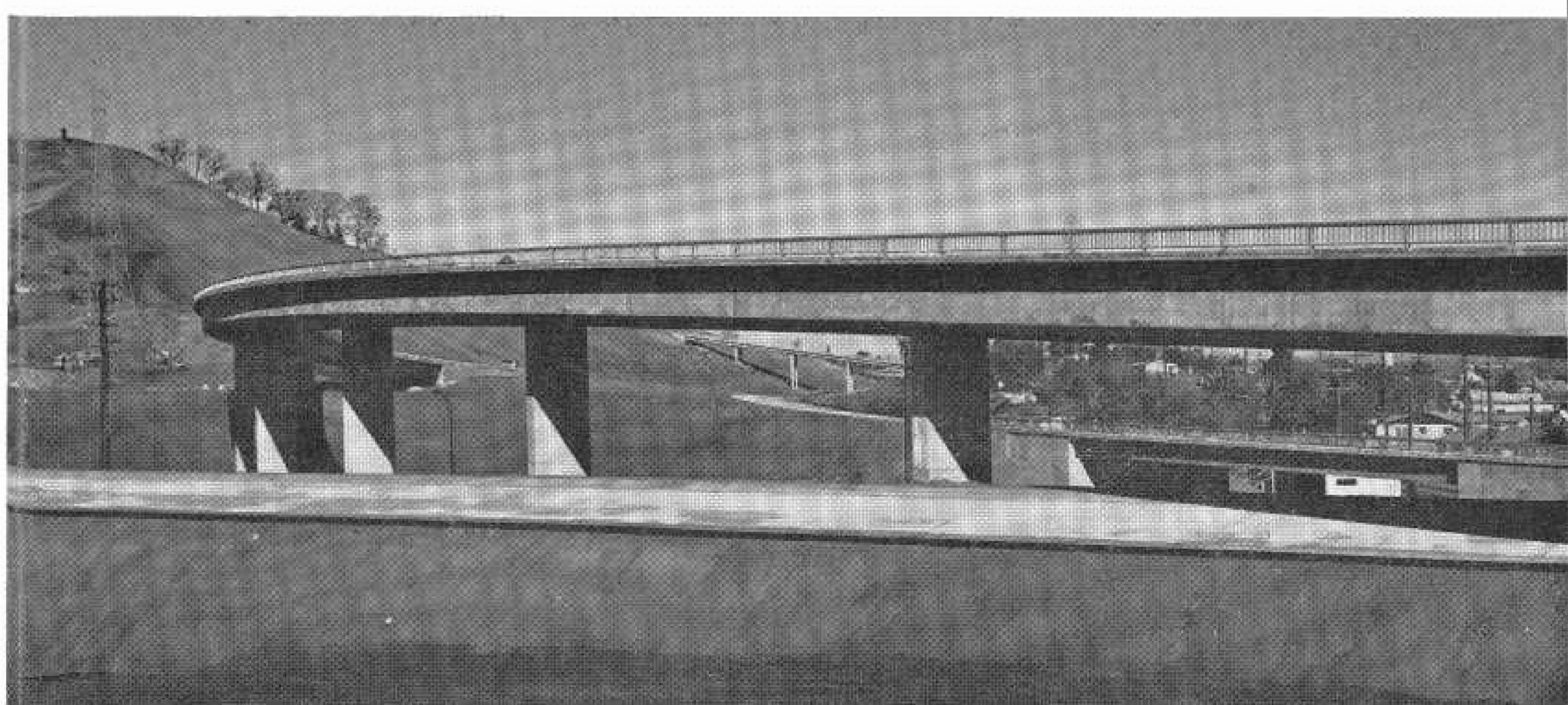
US 40, the interstate route from the Bay Bridge to Carquinez, is all full freeway except the one link from El Cerrito Overhead to Richmond, which is under construction and scheduled for completion this spring.

The last unit of the freeway on Sign Route 24 between Orinda and the Monument will be completed this spring while the project east of Orinda through Charles Hill to the Lafayette Bypass was opened to traffic last November.

This year, the last two projects to make the Bayshore a continuous freeway from San Jose to San Francisco are being advertised.

US 101 north of the Golden Gate Bridge is a divided highway through Santa Rosa, with the section to San Rafael completed as a full freeway last summer. Design is under way for converting the expressway to full freeway from San Rafael to Petaluma, and the first construction project at Freitas Parkway has commenced. Other projects are being constructed or budgeted for a full freeway on the Healdsburg Bypass and a section from Santa Rosa to Windsor. Planning activities have

Photo below—Ground view of the Walnut Creek "Y" Interchange. Branch connection structure from SSR 24 to SSR 21 in immediate foreground.



resulted in the adoption of the last unit of a freeway route north of Lytton which provides a freeway location all the way from San Francisco to the Mendocino county line.

Design work has started on the Junipero Serra Freeway, an interstate route from San Bruno to San Jose, and three fourths of the cities have signed freeway agreements. Routes have been determined for all other sections of the interstate system in the district except the portion in San Francisco and Daly City. Planning activities have started on several of the new freeway locations designated in Senate Bill No. 480.

A more detailed review of construction highlights and future plans for freeway development in District IV follows:

US 40—San Francisco to Carquinez Bridge

A 2.3-mile project presently under construction between south of El Cerrito Overhead and Jefferson Avenue is the last link of freeway on US 40 between San Francisco and Vallejo. Estimated to cost approximately $5,-583,000, it is being performed as a joint venture by Piombo Construction Company, M&K Corporation and Connolly Pacific Company. Completion in June of this year is anticipated for this six-lane freeway project which includes three interchanges: a direct connection at Hoffman Boulevard to State Sign Route 17, and diamonds at Central Avenue and Carlson Boulevard. A more detailed account of this project will appear in the May-June issue of *California Highways and Public Works.*

An eight-lane freeway is already in operation from the distribution structure at the east end of the San Francisco-Oakland Bay Bridge to the El Cerrito Overhead. Also previously completed is a six-lane freeway to the Carquinez Bridge which included the eight and one-half million cubic yard "Big Cut" which is approximately 0.6 mile long, a quarter mile wide at the top, and 300 feet deep. Three contracts completed the approaches to and erection of the parallel Carquinez Bridge, opened to traffic in November 1958.

Temporary connections were provided at each end of the new bridge to permit two-way traffic so that the old bridge could be modified and the Crockett approach ramp could be constructed. This project, costing approximately $1,315,000, was completed in April of 1959 and provides for three lanes of southbound traffic on the old bridge and four lanes northbound on the new. Rothschild, Raffin and Weirick performed this work.

Construction of US 40 north of Arnold Industrial Highway (State Sign Route 4) was financed from revenue bonds as part of the Carquinez Bridge project. Another major US 40 project being financed by toll bridge funds is the reconstruction of the approach ramps to the double-decked Bay Bridge so that five lanes of one-way westbound traffic will be carried on the upper level with eastbound traffic on the lower deck. This work is being administered by the Division of San Francisco Bay Toll Crossings. Toll bridge funds also provide for the widening of the south side of the Bay Bridge Toll Plaza. This work, expected to start shortly, will be done in conjunction with remodeling and increasing the number of the toll booths. Faster collection for Oakland-bound traffic will be made from the driver's side of the vehicle and truck tolls by weight will be superseded by axle count tolls to save time.

During 1959, landscaping was completed on the constructed portions of the freeway south of El Cerrito Overhead and north of San Pablo Avenue to Ridge Road. Funds in the amount of $280,000 have been provided in the 1960-61 fiscal year budget for landscaping between 0.3 mile south of El Cerrito Overhead to 0.3 mile south of Jefferson Avenue which will be advertised for bids this spring. An additional $130,000 has been provided for landscaping on which work is now starting from the Port of Oakland Overhead on the San Francisco-Oakland Bay Bridge approaches to the distribution structure. A small planting project is underway between Ridge Road and Crockett.

US 50—Bay Bridge to Castro Valley

Work has started on the first unit of the MacArthur Freeway which will ultimately provide an eight-lane interstate facility from the Bay Bridge Distribution Structure in Oakland to Castro Valley. A total of $23,000,000 has been included in the 1959-60 and the 1960-61 budgets for the construction of four projects comprising the 3.9-mile section between the distribution structure and 14th Avenue in Oakland. Right-of-way is nearly all acquired.

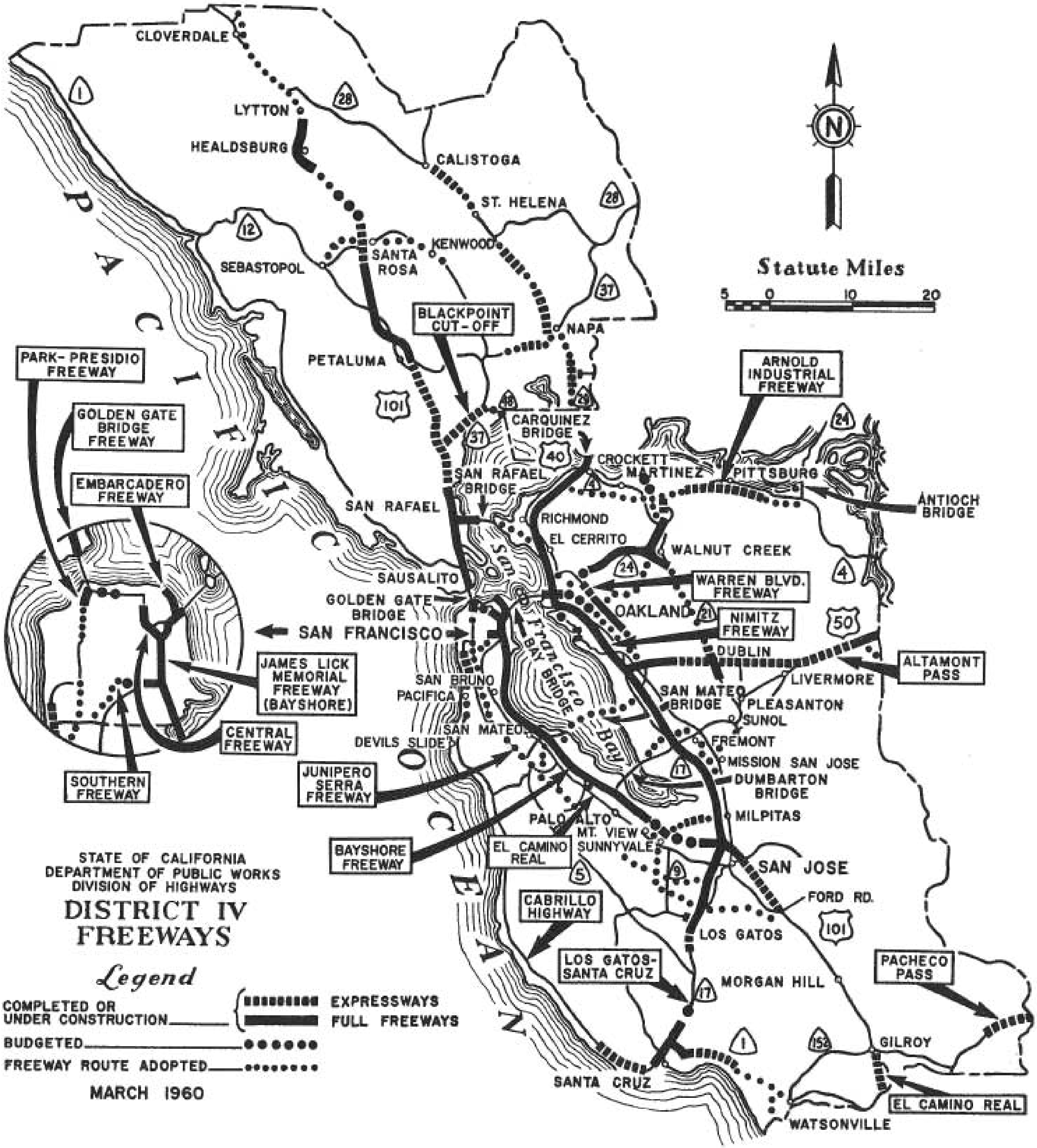
The usual design problems occasioned by intersecting freeways have been further complicated at the intersection of the MacArthur and Grove-Shafter Freeways by the recently proposed inclusion of the rapid transit facilities in the Grove-Shafter median. Studies by the Bay Area Rapid Transit Commission are not yet complete, nor is financing certain. However, bridge superstructures will be deferred and construction staged so that the much-needed MacArthur projects will get underway on schedule and will include all features necessary to the proper handling of US 50 traffic. These alterations will avoid extensive revisions to accommodate possible rapid transit requirements in the Grove-Shafter Freeway.

A more detailed article covering the planning, design and right-of-way aspects of the MacArthur Freeway, as well as the limits and funds of budgeted projects, is contained elsewhere in this issue.

US 50—Castro Valley to San Joaquin County Line

Portions of the Nimitz Freeway (State Sign Route 17), Route 228 easterly to Castro Valley and US 50 easterly have provided a continuous freeway from Oakland to Dublin, since the 1957 completion of a four-lane facility between Castro Valley and 2.3 miles west of Dublin. To the east of Dublin, US 50 is presently an expressway with a controlled number of intersections at grade.

Construction activities in this area during the past year have been limited to landscaping, resurfacing, and minor projects. Among these is a landscaping project to be completed soon between Center Street in Castro Valley and the Nimitz Freeway, and a seven-mile resurfacing project east of Livermore which was completed in July of 1959. The latter work was



done by A. Teichert and Son at a cost of $135,400.

Studies have continued for the development of the existing expressway east of Dublin to full freeway standards. Aerial mapping is underway for preparation of plans for an initial six-lane, ultimate eight-lane freeway between Dublin and Greenville. Planning studies are being made on the portion of this route between Greenville and 1.5 miles east of the Alameda-San Joaquin County Line to meet Federal Interstate requirements.

US 101—Golden Gate Bridge to San Rafael

The year 1959 saw continued progress towards the development of a full freeway on the Redwood Highway (US 101) north of the Golden Gate Bridge.

Prior construction provided a six-lane freeway from the bridge to Greenbrae. A northbound freeway structure and ramps at the Greenbrae Interchange were completed last October at a cost of $1,780,000.

Bids on the final stage of construction at Greenbrae Interchange are scheduled to be opened late in April. It is estimated to cost approximately $1,240,000 and will create a three level separation providing both left and right turn ramps for northbound freeway traffic. The old bridge with a lift span across Corte Madera Creek will be removed.

Previous projects northerly completed a six-lane freeway to the San Rafael Viaduct.

Funds in the amount of $54,500 were provided in the 1959-60 budget for landscaping US 101 between the Richardson Bay Bridge and Corte Madera Creek. This work which includes the planting of redwood trees is presently underway.

Studies are now in progress for expansion to an eight-lane freeway from San Quentin Wye to Porto Suello Hill, north of San Rafael, including expansion of the present four-lane San Rafael Viaduct.

US 101—San Rafael to Petaluma

This section had been previously developed as an expressway with intersections at grade. The first project to convert to six-lane full freeway standards at the Freitas Parkway intersection was awarded to Frederickson and Watson Construction Company. The $1,250,000 contract scheduled for completion in November includes a trumpet type interchange, frontage roads and a partial interchange at San Pedro Road near the new Marin County Civic Center.

Design studies are proceeding on a six-lane, freeway from 0.6 mile north of Forbes Overhead to north of Atherton Avenue in Novato. Future construction projects will include a partial interchange at Miller Creek Road, an added northbound uphill lane to relieve congestion on a sustained grade, and an interchange at Ignacio Wye at the intersection of US 101 and State Sign Route 37 as soon as construction funds are made available.

US 101—Petaluma to Mendocino County Line

An 18.5-mile section of freeway from south of Petaluma to the southerly city limits of Santa Rosa was completed in 1957 after a series of five construction projects. Design studies are underway for a $3,000,000 conversion of the existing expressway through the City of Santa Rosa to the initial four lanes of an ultimate six-lane freeway.

Funds have been provided in the 1960-61 construction program for a 9.2-mile four-lane freeway northerly from Mendocino Avenue in Santa Rosa to Grant Creek. This $5,200,000 project which includes five interchanges, provides for construction of the freeway between Santa Rosa and Windsor and for grading between Windsor and Grant Creek. Design is nearly completed for drainage, bridges, base and surfacing on the latter portion although this estimated $3,800,000 project has not yet been budgeted for construction.

North of Grant School, a 1.2-mile portion of the Healdsburg Bypass south of the city was completed in May of 1959. This $1,629,000 project also included twin bridges over the Russian River, partial construction of interchanges at Grant Avenue and South Healdsburg, and accomplished 3.7 miles of rough grading for the freeway to the north.

The current phase of construction which will complete the bypass to a connection with the existing highway at Lytton was awarded to Guy F. Atkinson. This 4.1-mile $2,700,000 project includes interchanges at Dry Creek and Guerneville Roads as well as three other bridges and undercrossings. It is expected that construction will be completed late this summer.

From Lytton to Mendocino county line, the route has been adopted and a four-lane expressway providing for development to a six-lane freeway is being designed.

Planting of redwood trees on portions of the freeway between the Petaluma Creek Bridge and Santa Rosa was accomplished last year. This work, costing approximately $14,500, was performed by Shawn Company. The 1960-61 construction program provides $100,000 for landscaping on 0.8-mile portion of the freeway between Lynch Creek and the south city limits of Petaluma. Bids will probably be advertised this summer.

US 101 (Bypass)—San Francisco to Palo Alto

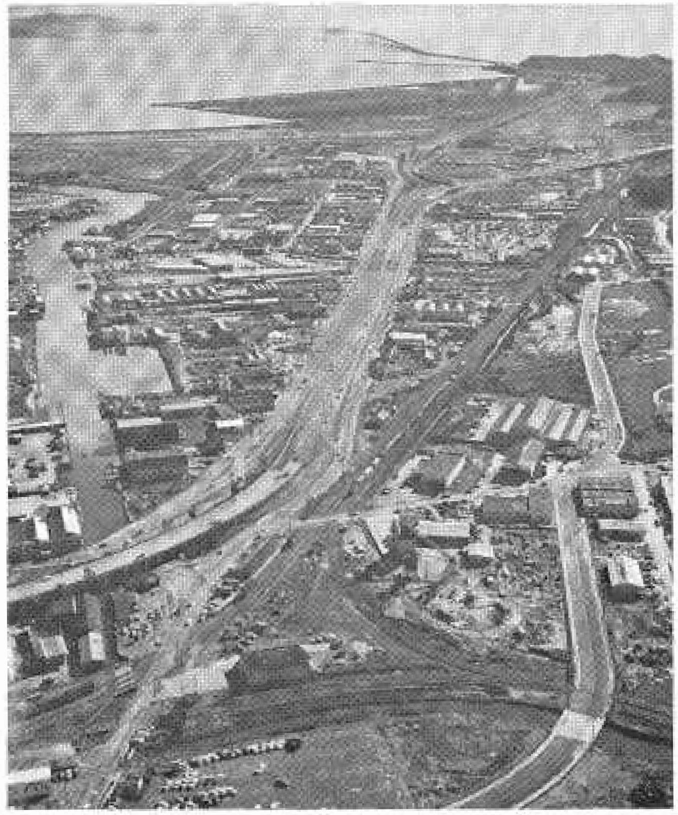
Previous projects on the Bayshore have provided a continuous six-lane freeway from the south city limits of San Francisco to Palo Alto, a total distance of 26 miles. Included in these projects were four contracts totaling $7,710,000 for the "open water fill" across an arm of the San Francisco Bay, between Sierra Point and Candlestick Point. This section saved 0.4-mile distance and reduced commute hour travel time by approximately 20 minutes.

Heavy, congested traffic on this freeway near the San Francisco International Airport led to the inclusion of $1,900,000 in the 1959-60 budget for widening the freeway to eight lanes from Broadway in Burlingame to San Bruno Avenue in San Bruno. This 7.5-mile project, to be advertised this spring, will include the addition of a direct right-turn ramp to the southbound freeway lanes and improvement of other ramp outlets at the Millbrae Avenue Interchange. An additional northbound lane is included between Broadway and Peninsular Avenue. A double metal beam barrier will be provided between the opposing traffic lanes through these areas.

Improvements north of Palo Alto during the past year have included landscaping and minor interchange revision. A 2.2-mile, $82,000 landscaping project between Peninsular Avenue and 16th Avenue in San Mateo was completed in April of 1959, and consisted of planting trees, shrubs, and ground cover. Also completed in April was the Norfolk Street connection to the East Hillsdale Boulevard Interchange at a cost of approximately $59,700.

Presently under way is a $220,000 landscaping project at Willow Road and University Avenue Interchanges. Included in the 1960-61 budget is $180,000 for landscaping the completed freeway between 16th Avenue in San Mateo and Harbor Boulevard.

Greenbrea Interchange in Marin County on US 101 at Corte Madera Creek, looking south. Corte Madera Interchange structure in upper left background.



Looking southeast along US 101 in San Rafael. San Quentin Wye Overcrossing connection to Sign Route 17 Freeway and Richmond-San Rafael Bridge in upper portion. US 101 curves to right at overcrossing.

Yountville Bypass project on SSR 29 in Napa County. Looking northwesterly from the beginning of project, California Drive Interchange in center.

Atherton Avenue Interchange at Black Point on SSR 37, looking east. Petaluma Creek Bridge at upper left.

Looking southwest over the Crockett Interchange from the Carquinez Bridge, through the "big cut."

US 101 (Bypass)—Palo Alto to San Jose

Funds in the 1959-60 and 1960-61 budgets provide for construction of the last two links in the continuous Bayshore Freeway between San Francisco and San Jose. Several other contracts are currently under way and an important interchange was completed this past year.

The interchange at the intersection of Bayshore Freeway and Sign Route 9 was completed in July. This $1,257,000 project, including an overpass carrying Mountain View-Alviso traffic over the Bayshore and short sections of six- and four-lane freeway, was constructed by Dan Caputo and M.J.B. Construction Company as a joint venture.

Virtually completed is the 4.4-mile freeway extension from the San Mateo county line to Stierlin Road. This six-lane facilitiy is being constructed by L. C. Smith and Concar Ranch and Enterprises at a cost of approximately $3,465,000. It will provide interchanges at Embarcadero and San Antonio Roads and a partial interchange at Middlefield Road.

In San Jose a 4.1-mile freeway section from Brokaw Road to Taylor Street is under construction. This project includes four interchanges and a total of 13 structures. A major interchange is provided at the intersection of Nimitz, Bayshore and Sign Route 17 Freeways. Also included in this $4,315,000 project is the extension of State Sign Route 17 as a freeway to First Street in San Jose.

One of the two remaining gaps in the freeway is scheduled for advertisement this spring and will extend Bayshore Freeway from Charleston Road in Mountain View to the Guadalupe River near San Jose. This $5,050,000 project also includes work on the Mountain View-Alviso Road (State Sign Route 9) from Bayshore to 0.2 mile east of Borregas Avenue. Another feature is the alteration of existing channel facilities of the Santa Clara County Flood Control District including the Guadalupe River realignment. The Flood Control District is participating in the cost of the project.

The last remaining section of the freeway between Brokaw Road in San Jose and Morse Avenue in Sunnyvale is included in the 1960-61 budget. This 6.1-mile project will consist of a four-lane facility between Brokaw Road and Guadalupe Parkway, and six lanes from there to Morse Avenue. Cloverleaf interchanges will be provided at Fair Oaks Avenue, Lawrence Station Road, San Tomas Aquinas Boulevard and De La Cruz Boulevard. This project will complete the freeway between San Francisco and San Jose, costing approximately $5,760,000, and it is expected to be advertised this spring.

US 101 (Bypass)—San Jose to US 101 at Ford Road

Design studies are underway for conversion of the existing expressway to freeway standards from Santa Clara Street to Ford Road. The expressway has been in operation since 1947.

North of Santa Clara Street the last three-lane portion of this route was eliminated in 1957 by the completion of 1.3 miles of freeway to north of Taylor Street in San Jose.

Funds in the amount of $100,000 are in the 1960-61 budget for landscaping this section.

US 101—Ford Road to San Benito County Line

Studies have been completed and a public meeting will be held in the near future on the proposed freeway routing between Ford Road and south of Gilroy. These studies are the culmination of several years of work by the division and the Santa Clara County Planning Department.

South of Gilroy, 5.8 miles of expressway have been in operation to the San Benito county line since 1951. Full freeway development within these limits is dependent upon traffic requirements and availability of funds.

A $119,200 resurfacing project between Llagas Creek and Gilroy was completed in August. Drainage improvements were constructed in Morgan Hill as a co-operative project with that city.

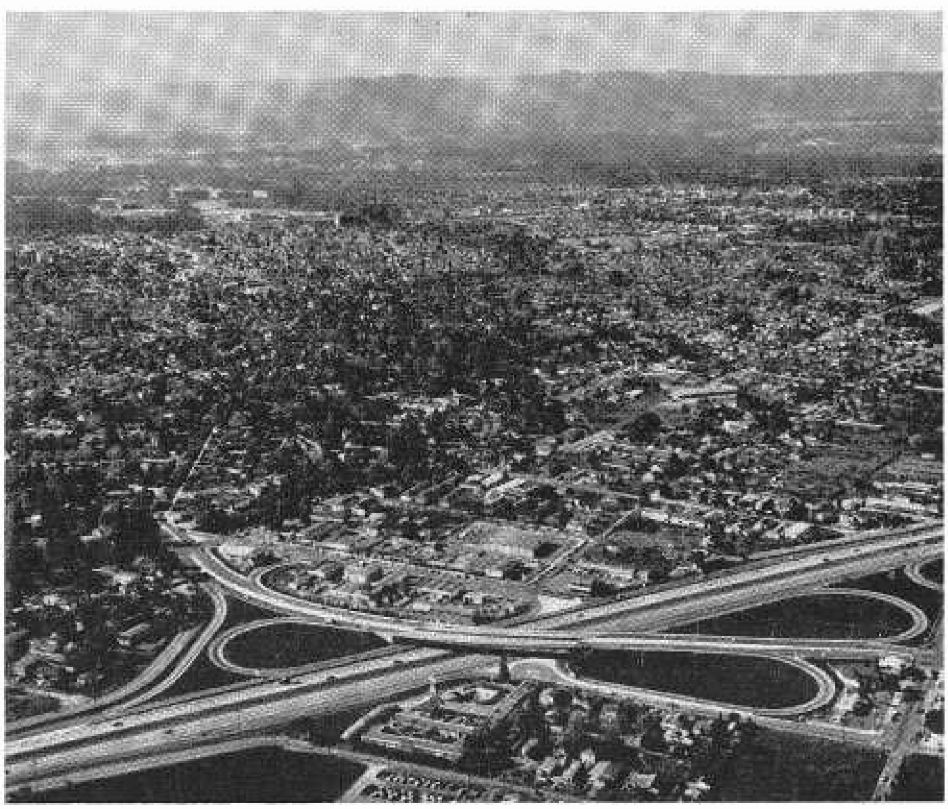
US 101—El Camino Real

Although not a freeway, this historic route plays an important role in serving the communities of the Peninsula between San Jose and San Francisco. Major portions have been and are being widened to four and six lanes with some median separation. In co-operation with the many cities, traffic signal and channelization projects have been completed and others are being planned.

A $1,345,000 project was completed in 1959 which provided 3.9 miles of divided highway between San Tomas Aquinas Creek in Santa Clara and State Sign Route 9 in Sunnyvale. The Santa Clara County Flood Control District participated.

Design studies are underway for widening El Camino Real to a six-

Bayshore Freeway along peninsula south of San Francisco. Willow Road Interchange in Palo Alto in center foreground with University Avenue Overcrossing in upper left; looking south.



Looking westerly across the University Avenue Interchange on Bayshore Freeway in the City of Palo Alto.

Looking southerly at the site of construction for interchange facilities between Sign Route 17 and US 101 Bypass (Bayshore) near San Jose. Old Bayshore Highway intersection in foreground, new Nimitz-Bayshore interchange in center.

lane divided highway between Taylor Boulevard in Millbrae and Old Mission Road in Colma. Similar projects are being studied in Palo Alto between University Avenue and Matadero Creek, and a four-lane divided arterial is under design study between Ford Road and South Tully Road.

The widening to an ultimate six-lane divided section of the portion of El Camino Real between Palo Alto and San Jose is under study, and public hearings have recently been held to discuss the plan.

US 101 in San Francisco

Nearing completion is the first unit of the Southern Freeway. This construction will provide a direct connection interchange for the intersection of the Southern and James Lick Memorial Freeways at Alemany Boulevard. In addition to the interchange connections, the project required relocation of Bayshore Boulevard, reconstruction of ramp facilities at the Alemany Boulevard interchange on James Lick Memorial Freeway, and rough grading for a portion of the eight-lane Southern Freeway. This work by the Guy F. Atkinson Company scheduled for completion this spring will cost approximately $8,100,000, and of this amount, $1,450,000 has been contributed by the City of San Francisco.

To be advertised probably this summer is the second unit of this freeway, for which $4,995,000 has been included in the 1959-60 budget. This 1.4-mile project provides for building six lanes of the ultimate eight-lane freeway from the James Lick Memorial interchange westerly to Milton Avenue.

Design studies for the next 1.3-mile portion between Ocean Avenue and Mission Street are well advanced. Right-of-way acquisition is nearly completed and $6,000,000 has been provided in the 1960-61 budget for construction. The route for the Southern Freeway has been adopted as far as Orizaba Avenue near the south city limits of San Francisco.

The full value of the Southern Freeway will be greatly enhanced when its extension easterly and northerly to the Embarcadero Freeway is completed. This connection was added to the State Highway System in 1959 as Route 253. A section has been adopted and construction may proceed as soon as right-of-way is acquired by the city under terms of the legislative act adding this new route to the system.

James Lick Memorial Freeway (US 101)

A six- and eight-lane freeway has been in service since 1956 from the county line near Third Street to the San Francisco-Oakland Bay Bridge. This skyway is used by approximately 125,000 vehicles daily and affords motorists a panoramic view of San Francisco. Work in the past few years, except for the revisions necessitated by construction of the direct connections to the Southern Freeway, has consisted of landscaping, erosion control, and installation of barriers to prevent disastrous median crossing accidents.

The Chicago Fence and Equipment Company is presently constructing a median barrier on portions of the section between south of Third Street and Army Street. This 1.4-mile installation consists of back-to-back steel guard rails and will cost approximately $74,000. It extends the barrier completed in 1958 between 17th Street and Army Street. Since the first installation, there have been no median crossing accidents and the number and severity of all accidents in this area have declined noticeably.

The gap left in the present barrier contract, within the limits of the interchange project now under way, will be closed by a separate contract.

A landscaping project between Fifth Street and 17th Street was completed during the past year by Watkins and Sibbald at a cost of $38,000.

Central Freeway

In April of 1959, the second unit of this distributor facility to the Civic Center area of San Francisco was opened to traffic. It extends the elevated six-lane section of divided freeway between the James Lick Memorial Freeway and South Van Ness Avenue by means of a two-level elevated structure to Turk Street.

The extension provides off ramps to the intersections of Fell and Laguna Streets and to Franklin and Golden Gate. On ramps were provided for traffic from Oak and Laguna and Turk and Gough. The viaduct, carrying southbound traffic on the upper deck and northbound traffic on the lower deck, leaves the city streets below free to handle the heavy cross-traffic movements. The contractor on this $7,800,000 project was Peter Kiewit Sons' Company.

Approximately $450,000 has been provided in the 1960-61 budget for landscaping and paving parking areas along the Central and James Lick Memorial Freeways. Presently there are two such projects in progress; a $46,000 contract being performed at nine locations on the Central, James Lick and Embarcadero Freeways by Charles L. Harney, Inc., and a $72,000 project for paving parking lots between Mission Street and Turk Street. The contractor on the latter project is O. C. Jones and Sons.

Embarcadero Freeway

This 1.5-mile elevated facility providing traffic service from the Bay Bridge and James Lick Memorial Freeway was constructed in three projects starting in April of 1955. The last project was completed in March of 1959 at a cost of approximately $7,627,000 for 1.2 miles of double-deck elevated viaduct. Ramps were provided at Broadway. Extensive reconstruction work was required to relocate portions of the Southern Pacific Railroad and State Belt tracks under the freeway along the Embarcadero. A $12,000 landscaping project between Front and Sansome Streets is underway.

Studies are now underway for the location of Route 253 which was added to the state highway system by the 1959 Session of the Legislature. This will provide an extension of the Embarcadero Freeway southerly to the vicinity of Army Street and thence westerly to a connection with the Southern Freeway at James Lick Memorial Freeway. A Hunter's Point leg connecting near Army Street will extend southerly to the Bayshore Freeway near the south city limits. Public meetings will be held upon completion of the studies.

Looking east along Sign Route 24 toward Mt. Diablo with Acalanes Valley Road Interchange in foreground.

Sign Route 17

This highway links the metropolitan communities of the Bay area with the recreational facilities of the Santa Cruz area. Two projects presently under construction, estimated for July completion, will provide 75 miles of continuous freeway via Sign Route 17 from south of Los Gatos to Oakland, thence along US 40 to Vallejo.

One of these projects, two and one-half miles of initial four-lane, ultimate six-lane freeway, is being constructed between Bascom Avenue and North Fourth Street in San Jose at a cost of $3,117,000. This work, scheduled for completion in August, is being performed as a joint venture by Gordon H. Ball, Gordon H. Ball, Inc., Ball and Simpson, and Lew Jones Construction Company. Interchanges will be provided at Bascom Avenue, El Camino Real, Coleman Street, and North First Street. A separation structure at Laurel Street and a bridge over the Guadalupe River are also included. (The second project connecting this work with the Bayshore and Nimitz Freeways, also scheduled for completion in August, is discussed more fully under US 101 Bypass.)

Additional signal and minor contracts were completed during the past year and $175,000 has been provided in the 1960-61 budget for 5.5 miles of landscaping between Roberts Road and Danta Street.

North from the recently landscaped freeway entrance to the City of Santa Cruz, the freeway is being extended by 3.3 miles of four-lane expressway, to Carbonera Creek near Glen Canyon Road. This work, scheduled for completion in May being performed by Frederickson and Watson, is virtually complete. The $1,650,000 contract includes interchange facilities at Pasatiempo and an underpass structure at Beulah Park Drive. Frontage roads are provided along most of the expressway.

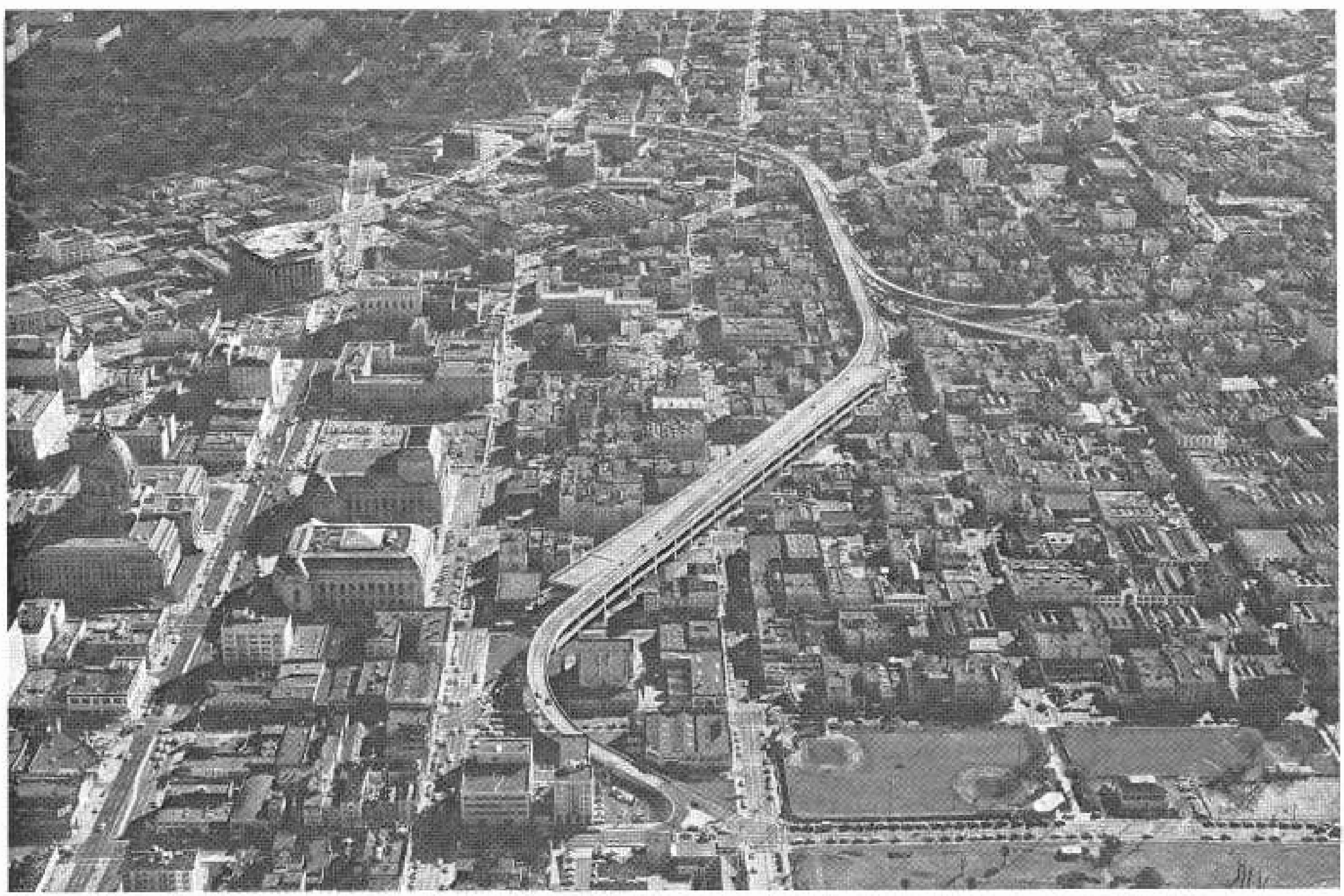
Immediately to the north, construction is starting on the 3-mile section from Glen Canyon Road to 0.6 mile north of Granite Creek Road. This $1,500,000 four-lane expressway includes interchanges at Granite Creek and Glen Canyon and an overcrossing at Scott Valley. The elimination of the three-lane highway through Scott Valley will provide a continuous freeway-expressway from Sign Route 1 in Santa Cruz to Santa's Village.

A major realignment along this route was completed in April 1959, when the 8.8-mile section of freeway between the junction of the Saratoga-Los Gatos Highway in Los Gatos and Bascom Avenue in San Jose was opened to traffic. This $5,835,000 project included 20 structures. Interchanges were provided at Saratoga Avenue, Lark Avenue, Camden Avenue, Hamilton Avenue, Stevens Creek Road, and Bascom Avenue.

A landscaping project at the Saratoga Avenue Interchange in Los Gatos is being completed at a cost of $49,000. Planting on the remainder of the freeway between Los Gatos and Bascom was completed in January, costing $87,500.

San Jose to Oakland (Nimitz Freeway)

Although the last gap in the continuous freeway between San Jose and Oakland was completed in 1958, planning continues on this important arterial. It was originally constructed as a four-lane freeway from San Jose



Central Freeway in San Francisco, looking southeast from Turk Street and Gough Street terminus. City Hall at extreme left center facing the Civic Center Opera House and Veterans Memorial Buildings. Ramps to Oak and Fell Street at right center.

James Lick Memorial (Bayshore) Freeway in San Francisco at the site of construction for the Southern Freeway Interchange. Alemany Interchange in foreground; looking south.

to High Street in Oakland, but increased flows of traffic have indicated the need for additional lanes. The first such widening project was completed in 1956 between Washington Avenue in San Leandro and High Street in Oakland to handle the increased traffic resulting from completion of the four-lane freeway between US 50 and the Nimitz Freeway.

Funds in the amount of $4,800,000 have been provided in the 1960-61 budget for additional widening to eight lanes between Hegenberger Road and Fallon Street in Oakland and will be advertised this summer. This 5.6-mile project will include median barrier installation from High Street to Fallon Street. Studies for an additional two lanes of widening to provide an eight-lane freeway as far south as Route 228 in San Leandro are proceeding and a six-lane facility from there to Route 105 in Hayward are under way.

Funds have been provided in the 1959-60 budget for construction of the Floresta Drive Overcrossing over Nimitz Freeway in San Leandro which will be advertised for kids this spring. Jointly financed by the City of San Leandro, this project will cost $283,000, of which $160,000 is being provided by the State.

Presently under construction is 6.8 miles of median barrier installation between Washington Avenue and High Street at a cost of $214,000. Chain-link

A view northerly along Sign Route 24 at the Oak Park Boulevard Interchange. Hookston Road Interchange in background.

fence and cable barrier is being installed on the southerly portion of the project to 98th Avenue in Oakland, while blocked-out guard rail is being placed from 98th Avenue to High Street. In November, a 2.1-mile landscaping project costing $84,000, between Tennyson Road and Jackson Street, was completed. Also, a $56,800 landscaping project was completed in August 1959 from the distribution structure to north of Market Street. Thirty-five thousand dollars has been included in the 1960-61 budget for the 1.5-mile landscaping project between Fifth Avenue Overhead and Linden Street.

US 40 to US 101 (Sign Route 17)

Design studies are under way for the construction of a six-lane freeway between El Cerrito Overhead and 32d Street in Richmond with provisions for a future eight lanes between 32d Street and Marine Street, at the east end of the Richmond-San Rafael Bridge. This 5.8-mile section is estimated to cost $11,850,000 and is not yet programed for construction. In the interim, as in the past, numerous projects including drainage improvements and channelizations of various intersections along Hoffman Boulevard have been completed to allow more efficient use of the existing facilities. One such project is presently under construction at the intersection of Hoffman Boulevard and 47th Street in Richmond. The work, including traffic signals, highway lighting and channelization, is being performed by Lee J. Immel and will cost approximately $88,800.

A western approach from US 101 in Marin County to the Richmond-San Rafael Bridge was constructed to freeway standards in two projects. The first contract was between Tiburon Street and Point San Quentin. The other unit was completed in August of last year and provides continuous freeway between US 101 and the bridge. This two-mile freeway section cost $767,000. Financing for these approaches was provided by Division of Highways funds while the San Rafael-Richmond Bridge and its eastern approaches were constructed through bonds issued by the Division of Bay Toll Crossings.

Sign Route 21—Warm Springs to Dublin

From Warm Springs to two miles north of Mission San Jose, this portion of the interstate route location lies to the west of existing state highway. North of Mission San Jose, the route has been adopted generally along the existing route with substantial reductions in the grade rate over Mission Pass. Design studies are under way for a freeway on both of these portions which will complete the facility to Sunol. North of Sunol to the intersection with US 50 to Dublin, public meetings and a Highway Commission hearing have been held and it is expected that a route will be adopted shortly on this 11.1-mile portion.

Sign Route 21—Dublin to Martinez

The initial two lanes of the future freeway between US 50 and the Contra Costa county line, a distance of 1.8 miles, was constructed in 1955. Included in this work was the interchange with US 50.

North of the county line to Walnut Creek, design studies are well advanced for the two projects comprising this 12.2 miles of freeway facility. Rights-of-way are being acquired for an initial four-lane, ultimate six-lane freeway which is expected to cost approximately $15,000,000.

In the vicinity of Walnut Creek, an $8,546,000 contract is nearing completion for construction of a 4.2-mile four- and six-lane facility between Rudgear Road and the junction with Sign Route 24 near Oakland Boulevard. This contract also includes the portion of State Sign Route 24 from the completed freeway near Lafayette to Walnut Creek. Sixteen major structures and five major interchanges are included in this contract which was started in June of 1957. The work is being performed by Charles L. Harney.

North of Oakland Boulevard, a 2.9-mile section of freeway to Monument has been in operation since January of 1957. The route for the future freeway between Monument and the Martinez-Benicia Bridge has been adopted. Financing of this facility to Escobar Street in Martinez will be from federal and state participation in the interstate program. Construction northerly of this point, including the bridge itself, will be financed through revenue bonds in conjunction with the toll bridge project authorized by the Legislature in 1952. The bridge is presently under construction and is expected to be completed in the summer of 1962. A high level structure, west of the existing Southern Pacific Railroad Bridge, will cost approximately $14,240,000. To be advertised this summer are the approaches between the bridge and Arnold Industrial Highway (State Sign Route 4).

Funds in the amount of $350,000 have been provided in the 1960-61 Budget for landscaping the project presently under construction near Walnut Creek.

Sign Route 24

Beginning at Ashby Avenue Interchange on US 40 (Eastshore Freeway) in Berkeley, Sign Route 24 proceeds easterly through the Broadway Tunnel to Walnut Creek, Concord, Antioch and northerly points via the Antioch Bridge.

$10,000,000 is provided in the 1960-61 budget for an additional two-lane bore to be constructed to the north of the two existing two-lane tunnels. Completion of this project for which bids will be advertised this summer will allow four-lane operation in one direction during peak hours and permit tunnel maintenance without restricting traffic flow during off peak hours. Easterly of the east portal to the completed freeway near Orinda, design is under way for an eight-lane freeway. This 1.6-mile section is expected to cost approximately $5,000,000.

Orinda to Arnold Industrial Freeway

East of the Orinda interchange which has been in service since 1955, a 2.1-mile project was recently completed. This $4,380,000 contract provides a six-lane freeway between Orinda Road to 0.8 miles east of Sunnybrook Drive. The work, performed as a joint venture by Gordon H. Ball, Gordon Ball, Inc. and Ball and Simpson includes a diamond interchange at Charles Hill Road and a four-quadrant cloverleaf at Acalanes Valley Road. It involved co-operative work with Contra Costa County and the Central Contra Costa Sanitary District.

This project connects to the Lafayette Bypass which was completed in 1957. Immediately to the east of the Bypass is the Pleasant Hill Interchange which serves as a connection between this major freeway and an important county expressway to the north; it will in the future provide a southerly connection to Oakland via the Shepherd Canyon Freeway. The remaining portions of freeway required to provide a continuous freeway from west of Orinda to north of Monument near Concord are under construction and has been discussed under Sign Route 21.

Watkin and Sibbald are the contractors on a $28,700 landscaping project between Sunnybrook Drive and Hodges Road which should be completed shortly. $125,000 has been provided in the 1960-61 budget for landscaping the project between Orinda Road and Sunnybrook Drive. Additional funds are provided in the same budget for landscaping the remaining portion near Walnut Creek.

Concord to the Sacramento County Line

Between the westerly portion north of Concord and Neroly Road east of Antioch, Sign Routes 24 and 4 are identical. A major portion of the route between Willow Pass Road and A Street was completed to freeway standards in 1952. South of Sign Route 4 to Concord and north of A Street in Antioch to the bridge, the route has been adopted and design studies are in an advanced stage.

Junipero Serra Freeway

From San Bruno Avenue north to its present intersection with Sign Route 1 in Daly City, the existing Junipero Serra expressway is known as State Highway Route 237. Constructed by Joint Highway District 10, it was taken into the state highway system when that district was dissolved in July of 1956. In this area, numerous studies have been made in connection with the development of other freeways in the vicinity for pos-

Looking north along Sign Route 17 Freeway at Stevens Creek Road Interchange in San Jose. Bascom Avenue Interchange at upper right.

sible relocation between San Bruno Avenue and the San Francisco county line. Public meetings were held in January 1960.

South of San Bruno Avenue this important interstate route was designated by the 1957 Legislature as State Highway Route 239. The route has now been entirely adopted between US 101 south of Ford Road in Santa Clara County to San Bruno Avenue in San Mateo County. Survey control and aerial mapping has been completed. Design studies are under way on over 50 miles of this facility. Including rights-of-way, the cost of the initial development is estimated to be approximately $74,000,000. Freeway agreements have been executed with most of the local governmental bodies and detailed designs are being made preparatory to right-of-way acquisition.

Sign Route 1

South of San Francisco, this facility is known as the Cabrillo Highway. The route has been adopted for a freeway bypass at Watsonville and preliminary project studies are well advanced for conversion to full freeway from Watsonville to Rob Roy Junction. North of Rob Roy Junction to Santa Cruz, an expressway has been in operation for several years and design studies are well advanced for development of this 6.5-mile section of full freeway.

In the vicinity of Santa Cruz, two projects have been completed to freeway standards. The most recent of these was the 2.1-mile freeway between the junction of Sign Route 17 and 0.3 mile east of Morrissey Avenue. This work was completed in November of 1958. Also completed about this time was the initial two lanes of a future four-lane expressway on new alignment between Swift Street in Santa Cruz and Wilder Creek. This project was jointly financed with Joint Highway District No. 9.

From Wilder Creek to 4.0 miles south of Davenport, a 3.1-mile section of expressway is under construction. Initially two lanes are being constructed with four lanes being built at locations where the terrain restricts sight distance. This work, expected to cost $940,000, is being jointly financed with Joint Highway District No. 9 which contributed $240,000. Also under construction is 2.1 miles between New Years Creek near the Santa Cruz county line and 0.2 mile south of Whitehouse Creek. This work involves reconstruction, realignment, and widening and completes the first-stage improvement financed jointly by the State and JHD No. 9. Since the district's organization in 1927, it has contributed approximately $3,883,000 to the improvement of the 68 miles of Sign Route 1 between Santa Cruz and San Francisco including the $240,000 being contributed to this $417,000 project. Funds in the amount of $150,000 have been provided in the 1960-61 budget for the base and surfacing of a portion of Sign Route 1 between San Gregorio Creek and one mile north of Tunitas Creek in San Mateo County.

Route studies are under way between Canada Verde Creek south of Half Moon Bay and Pedro Valley. Preliminary conferences have been held and geologic and materials studies are about complete for the portion covering the proposed relocation in the Devils Slide area. Public meetings are anticipated in the near future.

Between Pedro Creek and 0.4 mile north of Manor Drive, freeway design studies are under way. The portion north of Manor Drive was completed in 1958 as a four-lane expressway between Manor Drive and Skyline Boulevard in Daly City. Design studies are progressing for its development to a six-lane freeway with additional separation structures.

From Skyline Boulevard near Edgemar Road in Daly City, Sign Route 1 has been developed as an expressway to 19th Avenue in San Francisco. This portion has been in service since 1956.

North of San Francisco, planning studies for relocation of Sign Route 1 between one mile north of Golden Gate Bridge and Point Reyes Station are almost completed. Public meetings will be held soon on the route determination. Funds in the amount of $120,000 have been provided in the 1960-61 budget for drainage and paving projects at various locations on the Marin coast. $230,000 has been provided for work on portions between 0.4 mile south of the Marin county line and Bodega Bay.

Route 105—San Mateo and Alameda Counties

Design is under way and rights-of-way are being acquired for a freeway between El Camino Real and the Hayward-San Mateo Bridge and westerly to Junipero Serra Freeway.

The freeway route for the portion in San Mateo County (19th Avenue Freeway) from Sign Route 5 (Skyline Boulevard) to the Alameda county line, a distance of 7.2 miles, was adopted in 1957 by the State Highway Commission. That portion of the route in Alameda County between the county line and Nimitz Freeway was adopted in 1952, and preliminary design has been started.

Preliminary studies have been completed for the widening of the San Mateo Bridge to four lanes and for converting its approaches to freeway standards. These were made by the Division of San Francisco Bay Toll Crossings.

East of the Nimitz Freeway, design studies are well advanced for the interim improvement of this route as a four-lane divided conventional highway along Jackson Street in the City of Hayward.

Stevens Creek Freeway

Design studies are underway and rights-of-way are being acquired for an eight-mile section of this important cross-country facility from Sign Route 17 in Los Gatos to the Bayshore Freeway near Mountain View. From Azule south of Junipero Serra Freeway, the route will be developed as an initial six-lane freeway. The portion from Junipero Serra Freeway to Bayshore Freeway (US 101 Bypass) will be developed as an initial four-lane freeway. Design studies have also been started on the portion of this route between Sign Route 17 and Azule.

Funds have also been provided in the 1960-61 budget for an interim improvement within Sunnyvale pending completion of the future freeway. This project, estimated to cost approximately $220,000, will provide a four-lane divided arterial along Mathilda Avenue between the Southern Pacific Railroad east of El Camino Real in Sunnyvale to Bayshore Freeway. Rights-of-way are being acquired by the City of Sunnyvale.

Mountain View-Milpitas Area

Approximately one mile of initial four-lane development on Sign Route 9 between Bayshore and 0.2 mile east of Borregas Avenue is included in the $4,760,000 contract which will be advertised shortly for completion of US 101 Bypass (Bayshore Freeway) in Mountain View.

Major construction in this area during the past year was the completion of the interchange at the intersection of Bayshore Freeway and Mountain View-Alviso Road. This $1,257,000 contract completed in July is covered previously in this article in connection with the discussion of US 101 Bypass.

Design studies are in progress for the portion of this route between US 101 and Nimitz Freeway. Development is planned as an initial four-lane freeway with provisions for a future six lanes. This route was adopted in 1954. Since 1957 two lanes of the future Alviso Bypass Freeway have been in operation between Lawrence Station Road and the San Jose-Alviso Road.

Between El Camino Real and Bayshore Boulevard the route was adopted in September of 1958. An initial four-lane freeway is planned for this 2.5-mile section.

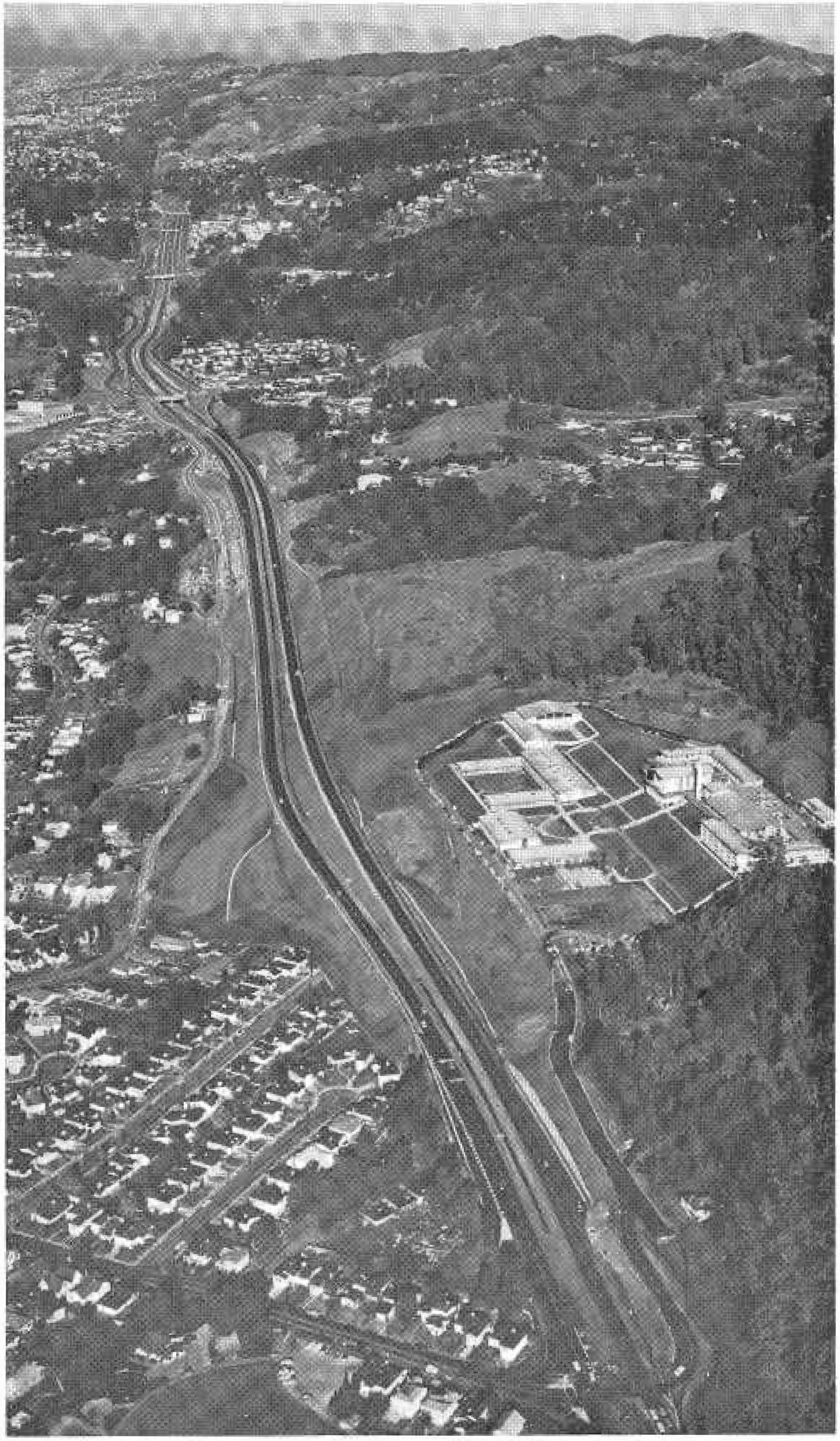
Route 228—Nimitz Freeway to US 50

Additional landscaping has just been planted in a $90,500 contract between Center Street in Castro Valley on US 50 and the Nimitz Freeway. This work supplements planting placed under a previous contract.

This important freeway connection between Sign Route 17 and US 50 was completed in September of 1956, providing continuous freeway and expressway between the Bay Bridge and Tracy in San Joaquin County.

Webster Street Tube

A $20,000,000 contract is presently under way for the construction of a parallel two-lane tube and approaches between Oakland and Alameda. The new underwater tube will be 3,350 feet long from portal to portal and the all-tiled interior of the tube will be illuminated by continuous fluorescent lighting. An extensive ventilation system to supply nearly a million cubic feet of fresh air per minute inside the tube will be installed.



New section of Warren Boulevard in Oakland looking north from Redwood Road to Lincoln Avenue.

The portion of the tube between First and Fourth Streets in Oakland will be built in place in a trench and then backfilled. The remainder of the tube will be constructed by sinking precast sections in a dredged trench

South Main Street Interchange on SSR 24 in Walnut Creek, with new Walnut Creek "Y" Interchange in upper left.

and backfilling with a sand blanket in the underwater area. Twelve tube sections, each 200 feet long and 37 feet in diameter will be built in dry dock, floated to the proper location, sunk and connected in final location at depths up to 90 feet. This is the 12th underwater vehicular tube to be constructed by this method throughout the world. The adjacent Posey Tube, which was completed in 1928, was the first.

Included in the work is the proposed Fourth Street Overcrossing adjacent to the Eastern Portal building and temporary structure for the support of the main line Western and Southern Pacific Railroads. Temporary structures are also required for support of major utilities, including sewers, during construction. This work is being performed as a joint venture by Pomeroy-Bates and Roger T. Gerwick and is expected to be completed late in 1962.

Upon completion of the new tube, the existing Posey Tube will be closed for rehabilitation and inter-connecting work under another project. At the completion of this work, the two tubes will be operated as one-way facilities.

Several other contracts were required to relocate U.S. Government facilities and replace in kind, storage areas purchased from the Departments of Army and Navy for tube construction. The first of such contracts was completed in 1958 providing a paved storage area for the Naval Air Station in Alameda. A major relocation contract was completed in 1959 by Arntz Brothers at a cost of $287,000. This work consisted of partly dismantling and relocating a 600-foot by 150-foot metal hangar from within the required right-of-way to a new location within the Naval Air Station. The hangar was reconstructed as a 300-foot by 300-foot building. Additional contracts will be required to relocate the railroad marshaling yards adjacent to the U.S. Army depot; reconstructing the existing sewer outfall from the service installations and providing additional paved storage areas.

Warren Boulevard (Mountain Boulevard)

Another unit of this route, being developed jointly by the State, County of Alameda, and the City of Oakland, was recently completed providing a continuous freeway between Broadway Terrace and Redwood Road in Oakland. This route from State Sign Route 24 near Lake Temescal to a connection with the future MacArthur Freeway (US 50) at Calaveras Street near Mills College was originally established by Joint Highway District No. 26. Although this district was dissolved by the Legislature in July of 1954, the City of Oakland and Alameda County have agreed to continue to provide a total of $300,000 per year until 1961 for completion of this initial four-lane, future six-lane freeway.

Between Broadway Terrace and Lincoln Avenue, the freeway has been in operation since August of 1958. The 1.6-mile portion recently completed from Lincoln Avenue to Redwood Road was constructed as a joint venture by Frederickson and Watson and Ransome Company and cost an estimated $1,088,500. Also completed during the past year was a landscaping contract between Park Boulevard and Lincoln Avenue at a cost of $19,000.

Design studies are well advanced for the remaining portions of this freeway between the end of the completed project and MacArthur Freeway.

Shepherd Canyon Freeway

Freeway agreements have been executed and design studies are proceeding for the development of this 10.3-mile route as an initial four-lane, ultimate six-lane freeway. Beginning at Warren Boulevard at the Park Boulevard Interchange, the route adopted in December 1956 follows Shepherd Canyon adjacent to the abandoned Sacramento Northern Railroad. A tunnel, approximately 1,400 feet long, will be required through the Oakland Hills. Crossing Moraga Valley just north of the present townsite, the freeway will terminate at Sign Route 24 at Pleasant Hill Interchange.

Route 107—Dumbarton Bridge to Niles

The route for this 5.7-mile section between Dumbarton Road and Sign Route 9 at Niles has been adopted and surveys are under way. An initial four-lane, future six-lane facility is to be developed on new alignment north of the existing highway. Some rights-of-way are being acquired.

Route 108—Sunol to Livermore

A public hearing was held by the Highway Commission on September 25, 1959, concerning a freeway routing for a 10-mile section of Highway Route 108 between Sunol and US 50 near Livermore, but further action toward adoption of a route is being deferred pending studies of an extension of Route 108 to the north of US 50. This extension was added to the state highway system by the Legislature in 1959.

Arnold Industrial Freeway (Sign Route 4)

Design studies are well advanced for portions of this route from US 40 near Hercules to Willow Pass Road northeast of Concord. The freeway route for this section was adopted in October, 1958. A short relocation and the interchange with US 40 was constructed in conjunction with the construction of US 40.

From Willow Pass Road to Neroly Road east of Antioch, the route is covered in this article under Sign Route 24 since within these limits

Healdsburg Bypass, looking east from intersection of new construction with existing highway at Grant. City of Healdsburg in background. Russian River in center with bridge crossings (left to right) at freeway, old highway and NWP Railroad.

both routes are identical. Presently under way within these limits is a $33,250 landscaping project at Railroad Avenue Interchange in Pittsburg.

Grove Shafter Freeway

Rights-of-way are being acquired and design studies are well advanced on this important link between the Nimitz Freeway and the Broadway Tunnel. An eight-lane freeway is planned. Footings for the future interchange connections with MacArthur Freeway will be placed as a part of a 1960-61 budget contract on MacArthur Freeway. Detailed plans for this important interchange are pending as a result of the rapid transit studies in this area.

Sign Route 12

A freeway route 17 miles long was adopted in January 1957 between Sebastopol and Kenwood. Design studies are under way and some rights-of-way are being acquired. On the 13.8-mile section of Sign Route 12 between Kenwood and Schellville, preliminary planning studies are in progress.

Sign Route 37 (Black Point Cutoff)

In June of 1959, 6.7 miles of initial four-lane expressway were completed between US 101 at Ignacio Wye and Sears Point. One million eight hundred sixty thousand dollars was spent in constructing two additional lanes, the Atherton Avenue Interchange, and approaches to the new Petaluma Creek high level structure completed in 1958. This was the second stage construction within these limits.

From Sears Point to the Napa county line, planning studies are under way for a future six-lane freeway.

In 1955, the initial two lanes of a future four-lane freeway were constructed from a point two miles east of the Napa county line to 2.2 miles east of Carneros School. Design studies are under way for portions of an initial two-lane expressway, which will ultimately be developed to a six-lane freeway between the Sonoma county line and Imola Avenue in Napa. East of Napa, planning studies are being made for possible relocation and future improvement.

Sign Route 29

Funds have been provided in the 1960-61 budget for the first unit of a 3.25-mile initial four-lane freeway between Imola Avenue and Union Station in Napa County. Included in the first contract will be construction of the Old Sonoma Road Overcrossing and frontage roads between Imola Avenue and Sonoma Road. North of Napa, 2.3 miles of four-lane expressway between Union Station and Orchard Avenue were completed in 1957. From Orchard Avenue to the newly completed Yountville Bypass, rights-of-way are being acquired and design studies are in progress for a four-lane expressway.

Two lanes of the future four-lane expressway bypassing Yountville were completed in July of last year. Work on this 2.9-mile section included construction of the California Drive Undercrossing. The route has been adopted in its entirety between Napa and Rutherford and design studies are proceeding on the remaining portion. Public meetings have been held on the portion of the future four-lane freeway between Rutherford and St. Helena. North of St. Helena, 3.8 miles of two-lane, future four-lane expressway between St. Helena and Calistoga have been in service since 1956.

South of Napa, studies are being made for right-of-way acquisition for a future six-lane freeway between Imola Avenue and the Solano county line. These sections of Sign Route 12 and 29 have been operating for many years as a four-lane expressway.

Pasatiempo Interchange, looking south towards Santa Cruz on Sign Route 17.

Summation

Signs of prodigious postwar growth in the Bay area may be seen on every hand superimposed upon the unique but unchanging face of the bay and its surrounding hills and valleys. Not the least of these changes is evident in the hundreds of miles of freeways constructed since 1947.

The freeways, because of their inherent long-range planning based on

STATUS OF DISTRICT IV FREEWAY AND EXPRESSWAY PROJECTS

March 1960

Description	Total miles	Completed projects: Miles	Completed projects: Construction cost	Under contract: Miles	Under contract: Construction cost	Budgeted: Miles	Budgeted: Construction cost	Right of Way expended and budgeted
US 101 and 101 Bypass								
Bayshore and James Lick Memorial Freeway								
US 101 Bypass, Southern Freeway in San Francisco to Ford Road South of San Jose	52.9	38.7	$39,716,000	5.6	$6,609,000	8.6	¶$12,323,000	$23,389,000
Southern Freeway	4.7				**8,930,000	2.3	11,025,000	18,109,000
James Lick Memorial Freeway	3.0	3.0	11,427,000				10,000	12,870,000
Central Freeway	1.8	1.8	11,862,000		66,000		100,000	8,552,000
Golden Gate Freeway	1.1					1.1	5,100,000	889,000
Ford Road South of San Jose to San Benito County Line (portions)	5.8	5.8	1,093,000					546,000
Redwood Freeway; Golden Gate Bridge to Mendocino County Line	84.3	51.9	*37,226,000	3.7	3,641,000	9.2	6,630,000	13,736,000
US40; San Francisco to Carquinez Bridge (portions)	18.2	15.9	§56,517,000	2.3	5,583,000		435,000	13,292,000
US 50								
MacArthur Freeway; distribution structure to Castro Valley	15.3			1.5	10,000,000	2.7	13,000,000	43,470,000
Castro Valley to San Joaquin County Line	31.4	31.4	11,662,000					6,370,000
Sign Route 17								
Nimitz Freeway, distribution structure to Bayshore Freeway at San Jose	41.3	41.3	55,123,000		215,000		4,995,000	21,681,000
Santa Cruz to San Jose (portions)	19.9	10.6	9,288,000	7.1	6,266,000	2.2	1,775,000	9,849,000
US 40 near Albany to US 101 near San Rafael (portions)	9.9	2.4	1,973,000					1,805,000
Sign Route 9 and 21								
Warm Springs to US 50 (portions)	9.7							578,000
US 50 to Walnut Creek	16.0	2.1	550,000	1.4	2,360,000		150,000	7,320,000
Walnut Creek to Monument	3.4	2.0	2,868,000	1.4	6,236,000		200,000	6,801,000
Monument to Solano County Line	7.4					3.2	†6,833,000	3,022,000
Sign Route 9 North of Route 21 in Fremont	2.2							
Grove-Shafter Freeway and Sign Route 24								
Sign Route 17 in Oakland to Warren Boulevard	4.8							2,988,000
Warren Boulevard to Walnut Creek	11.0	6.8	9,561,000		39,000	0.8	10,125,000	5,584,000
North of Monument to Sign Route 4, Concord	3.4		226,000					867,000
Embarcadero Freeway	1.5	1.5	14,764,000					12,285,000
Park—Presidio Freeway, Golden Gate Bridge to Fulton Street	2.1	1.2	1,448,000					3,000
Junipero Serra Freeway								
US 101 South of San Jose to Sign Route 17	10.0							335,000
Sign Route 17 to San Francisco County Line	43.9							6,448,000
Cabrillo Highway								
San Pedro Creek to Lake Merced Boulevard in San Francisco	10.0	5.4	2,766,000					2,012,000
Watsonville to 4 miles South of Davenport (portions)	22.8	12.4	6,299,000	3.1	631,000			2,879,000
Junipero Serra Freeway to Nimitz Freeway								
19th Avenue Freeway, Junipero Serra Freeway to Alameda County Line at San Mateo Bridge (portions)	8.0							3,301,000
San Mateo County Line to Nimitz Freeway	6.8							25,000
Pacheco Pass: 1 Mile East of Bell's Station to Merced County Line	5.3	5.3	1,285,000					12,000
West of US 101 to Bypass US 101 in Redwood City (Route 214)	1.1							500,000
Stevens Creek Freeway, Sign Route 17 to Bayshore Freeway at Mountain View	13.6							2,989,000
Mountain View—Alviso Freeway—El Camino Real to Eastshore Freeway	10.5	2.1	1,006,000			1.1	850,000	699,000
Freeway Connection from Nimitz Freeway to US 50 (Route 228)	2.2	2.2	2,803,000					2,467,000
Bay Farm Island Bridge and Approaches	0.6	0.6	2,062,000					165,000
Webster Street Tube	1.1		203,000	1.1	17,363,000			3,073,000

STATUS OF DISTRICT IV FREEWAY AND EXPRESSWAY PROJECTS—Continued

March 1960

Description	Total miles	Completed projects		Under contract		Budgeted		Right of Way expended and budgeted
		Miles	Construction cost	Miles	Construction cost	Miles	Construction cost	
Warren Boulevard Freeway: Sign Route 24 near Lake Temescal to MacArthur Freeway	5.6	4.1	‡5,612,000	------	------	------	------	1,735,000
Tracy Triangle: (Route 110) US 50 to San Joaquin County Line	0.4	------	------	------	------	------	------	------
Shepherd Canyon Freeway; Warren Boulevard Freeway to Sign Route 24	10.3	------	------	------	------	------	------	450,000
2.6 Miles East of Dumbarton Bridge to Sign Route 9 at Niles	5.7	------	------	------	------	------	------	50,000
Arnold Industrial Freeway; (Sign Routes 4 and 24) Hercules to Antioch Bridge	34.1	14.7	4,694,000	------	------	------	------	1,610,000
Sign Route 12; Sebastopol to Kenwood	17.7	------	------	------	------	------	------	2,672,000
Sign Route 29; Solano County Line to Calistoga (portions)	35.7	22.2	3,472,000	------	------	0.5	400,000	3,664,000
Sign Route 48; Sign Route 37 to Solano County Line	2.3	------	------	------	------	------	------	------
Sign Route 37; from Redwood Freeway at Ignacio to Napa	13.4	7.2	5,900,000	------	------	------	------	832,000
Totals	612.2	292.6	$301,406,000	27.2	$67,939,000	31.7	$73,951,000	$249,924,000

* Includes total of $5,000,000 by Golden Gate Bridge and Highway District.
** Includes total of $1,600,000 by City of San Francisco.
† $8,833,000 from Toll Bridge Funds.
‡ City of Oakland and Alameda County contributions included in this figure.
§ $29,117,000 Toll Bridge Funds in this amount.
¶ Includes $300,000 contributed by co-operating agencies.

comprehensive traffic, population and economic projections, have been in the forefront of regional development during the past 10 years.

Symptomatic of mounting awareness of transportation's role on the national, state and local scenes are the Federal Highway Act; the Highway Commission's policy placing more emphasis on local participation in highway matters; Senate Concurrent Resolution No. 26 and its resultant freeway and expressway legislation (which added 266 miles of state highways in District IV); the current Senate Concurrent Resolution No. 62 deficiency studies on city streets and county roads; the resurgence of Bay area rapid transit studies; the formation of the Golden Gate Authority Commission; and studies by local associations to arrive at staggered working hours in an effort to spread peak-hour congestion.

A part of the kaleidoscopic scene stems from efforts to reduce pressures built up by geographical limitations; the new Richmond-San Rafael Bridge; a parallel Carquinez Bridge; present construction of the Martinez-Benicia Bridge and the Webster Street Tube; proposed parallel construction of the San Mateo Bridge and further modifications to the Golden Gate Bridge; contemplated construction of a Southern Crossing and rapid transit tube; current revamping of the San Francisco-Oakland Bay Bridge; and a soon-to-be-constructed parallel tunnel through the Oakland hills.

Over and above the immediate problem of providing for commuter and other traffic is increased emphasis on landscaping and aesthetic blending of transport facilities, and the contemplation of a leisurely, scenic Skyline National Parkway from the Golden Gate to Monterey Bay.

The tempo of change, past and present, indicates portentous years ahead. Governor Edmund G. Brown recently expressed the shape of things to come thusly: "Freeways should be more than a way of moving motor traffic rapidly. They can and must be related to other aspects of a community's life: its historic landmarks, its parks and residences, its plans for urban renewal, its natural beauty."

Commission Allocates Contingency Funds

At its March meeting the California Highway Commission allocated $12,590,000 for major highway projects in 11 counties. The projects were added to the 1960-61 State Highway Budget.

State Director of Public Works Robert B. Bradford, commission chairman, said the allocations were from contingency reserves and from savings accumulated from favorable bids on construction projects.

Hatchet Mountain

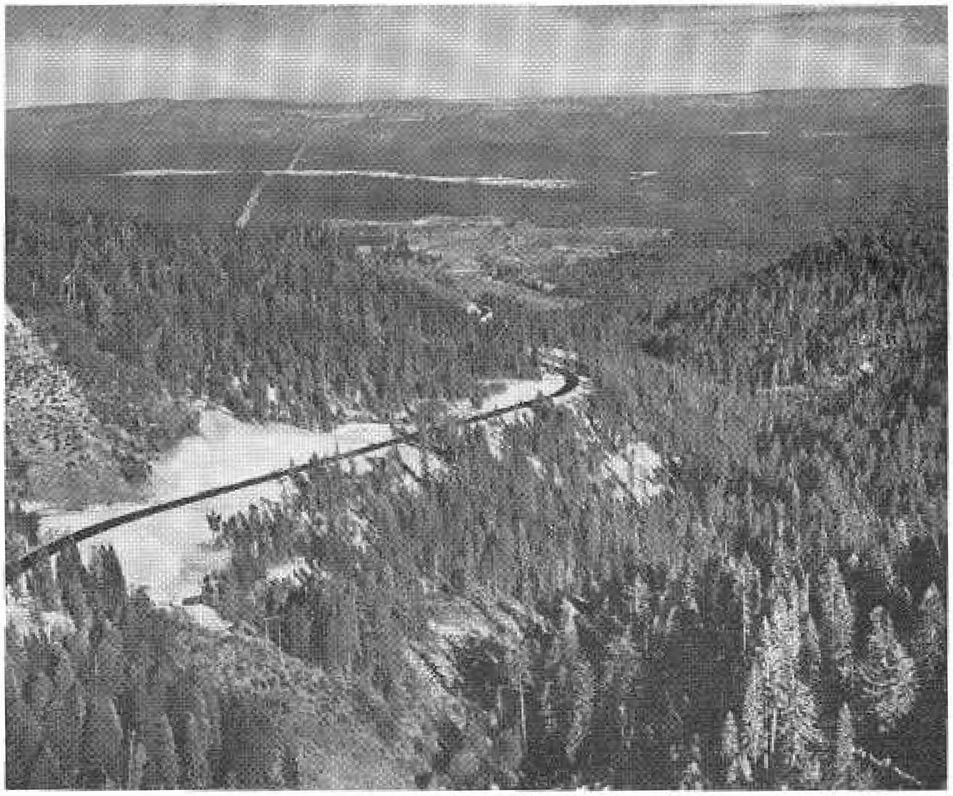
Modern Highway Replaces Tortuous Mountain Road

By ROBERT J. FELTON, District Construction Engineer and
WESLEY W. JONES, Resident Engineer

On December 10, 1959, construction was completed on the final unit of U.S. Highway 299E between Montgomery Creek and Burney Valley in Shasta County. The section now consists of 15 miles of modern two-lane highway traversing rugged mountainous terrain constructed at a cost of $3,181,488, partly financed by federal aid funds administered by the Bureau of Public Roads.

In 1950 the route consisted of 16 miles of tortuous mountain road. There were 159 curves for an average of one curve for every 533 feet of road. Minimum radius of curvature was 50 feet.

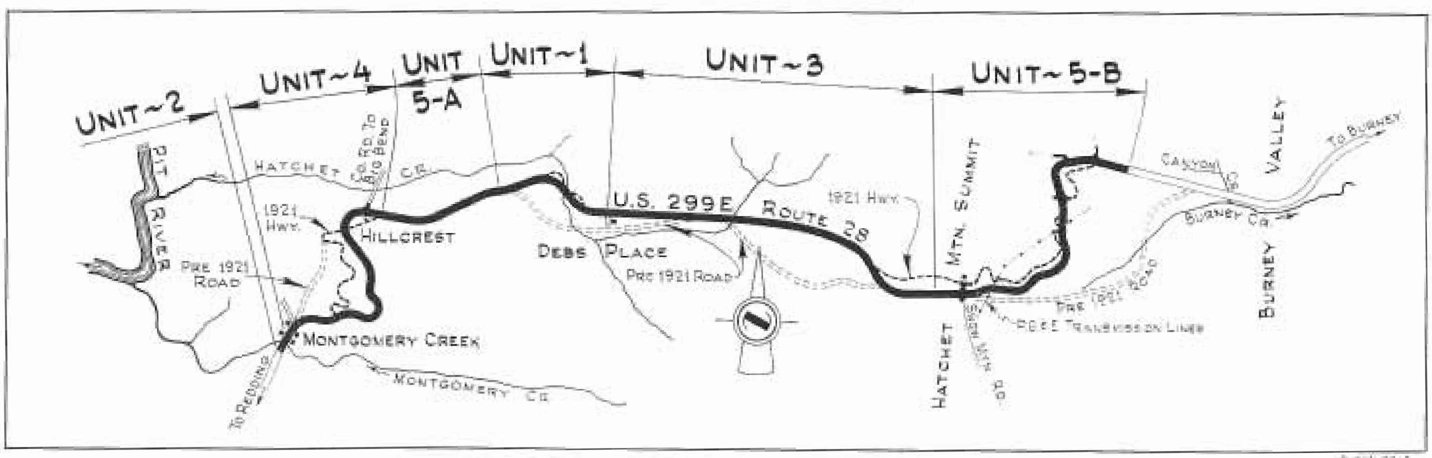
U.S. Highway 299E is the connecting line between U.S. Highway 99 at Redding, and U.S. Highway 395 at Alturas approximately 140 miles to the east. The section rises from elevation 2,136 feet at Montgomery Creek to elevation 4,366 feet at Hatchet Mountain Summit and descends to elevation 3,279 feet at Burney Valley. Snow packs of four feet are common at the summit with a maximum pack of 12 feet. The use of chains is frequently mandatory on the entire section during the winter storms.



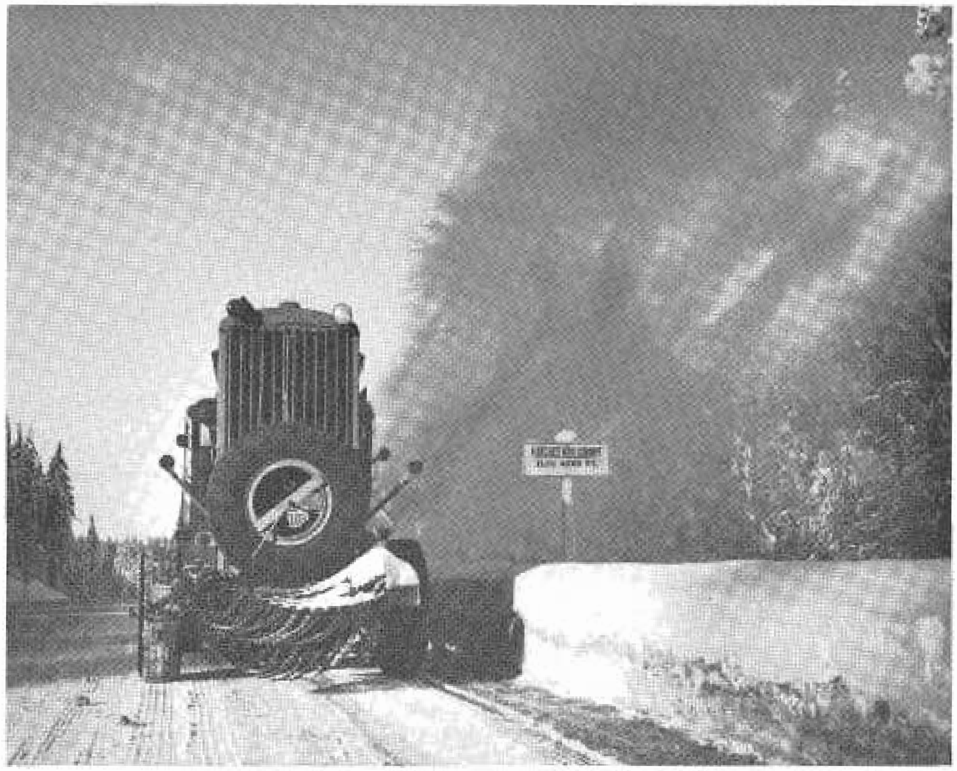
East from Hatchet Mountain Summit showing completed road (Burney Valley in background).

Curves Reduced

Reconstruction of the section has reduced the number of curves to 35 and increased the minimum radius to 600 feet. Maximum gradient is now 7 percent as compared to a maximum



Relocation of U.S. Highway 299E over Hatchet Mountain Summit was started in 1950 and completed in 1959. The new highway has eliminated 124 curves and shortened the distance by one mile over the original route.



Snow removal operations at the summit.

Normal winter snow conditions between Montgomery Creek and Burney Valley. Auto is ascending east slope of Hatchet Mountain near summit on recently completed alignment.

of 6.5 percent on the former alignment. The increase in maximum gradient on the new alignment was necessary due to the reduction in length of the section.

Improvement of the section was accomplished in five construction units as indicated on the vicinity sketch.

Unit No. 1 consisted of replacing Hatchet Creek Bridge with a 16-foot concrete arch culvert and constructing 1.61 miles of roadway. The work was done by Eaton and Smith Construction Company between October 1950 and November 1951, at a cost of $355,776.

Unit No. 2 consisted of constructing a new bridge across Montgomery Creek and constructing 0.35 mile of roadway approaches. The work was done during 1952-53 by B. S. McElderry Company at a cost of $98,324.

Unit No. 3 consisted of constructing 4.93 miles of roadway terminating at Hatchet Mountain Summit. The work was done by Fredrickson and Watson Construction Company between May 1955 and July 1956 at a cost of $646,097.

Unit No. 4 consisted of constructing 3.56 miles of roadway at the Montgomery Creek end of the section. The work was done by Eaton and Smith Construction Company between May 1955 and December 1956 at a cost of $659,604.

Metal Underdrains Used

A considerable amount of work was done on subsurface drainage in excavation areas on this unit. Perforated metal pipe underdrains were placed beneath the roadbed and two-inch steel pipe horizontal drains were drilled into cut faces to dewater unstable slide areas.

In December 1957 a crack appeared along the centerline of the pavement in the center of a 70-foot embankment 1.2 miles east of Montgomery Creek. The slide continued until the southerly half of the roadbed was 15 feet lower than the northerly half. At this point, the entire roadbed began to settle resulting in complete failure.

Investigation revealed that unstable material located a minimum of 15 feet below original ground had become saturated and lost its ability to support the embankment. As the embankment settled, the original ground rose over a comparable area approximately 100 feet from the toe of the embankment.

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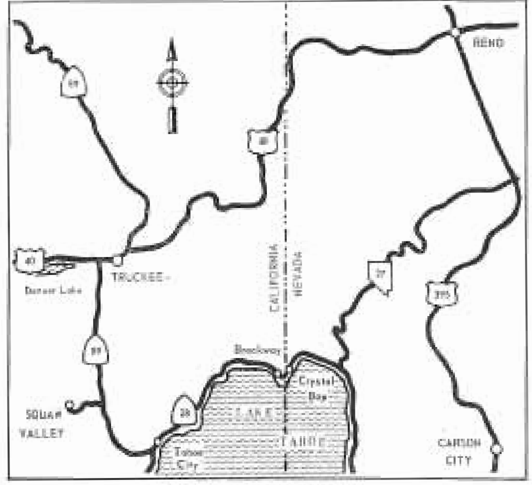
OLYMPICS TRAFFIC

By ALAN S. HART, District Engineer, District III



SERIOUS planning for handling the traffic during the Winter Olympics at Squaw Valley in 1960 started four years before with the official announcement of the Squaw Valley choice at the games in Italy. A transportation committee to study the problem was formed of representatives of the Olympic Commission, the California Division of Highways, the Highway Patrol, and other concerned activities, and it immediately went to work. The Division of Highways representative was State Highway Engineer J. C. Womack, then Assistant State Highway Engineer (Planning).

The Squaw Valley site is a beautiful one, but the absence of a closeby city was a subject of concern for the planners. With Reno, 44 miles away, the nearest sizable city, and virtually no facilities for food and lodging within the valley itself, considerable work had to be done to make it feasible for the public to visit the games.

There was no way to provide any appreciable amount of additional lodging for such a short period, so obviously visitors must be transported in on a day-by-day basis. For the majority of the visitors, this meant in typical American fashion—behind the wheels of their own cars. Traffic would be a problem, requiring adequate roads and tremendous parking areas.

The biggest worry was the weather. Donner Pass and Donner Lake, only a dozen miles from Squaw Valley, are named for the ill-fated Donner Party of pioneer days. Caught just east of the pass in a severe snowstorm, they were trapped and completely immobilized by succeeding storms. Many of the party starved to death.

Storms can come up rapidly in this part of the Sierra Nevada, and snowfalls of six to eight inches an hour are not uncommon. What would happen if such a storm came up while the games were in progress?

The highway maintenance men knew that keeping a lightly traveled highway open in a snowstorm is not difficult except under the worst blizzard conditions, but that the trouble almost invariably starts when a truck jackknifes, or a pair of cars lock bumpers, or several are involved in a skidding accident. Then the plows are stymied, the snow starts piling up, and "the road is lost."

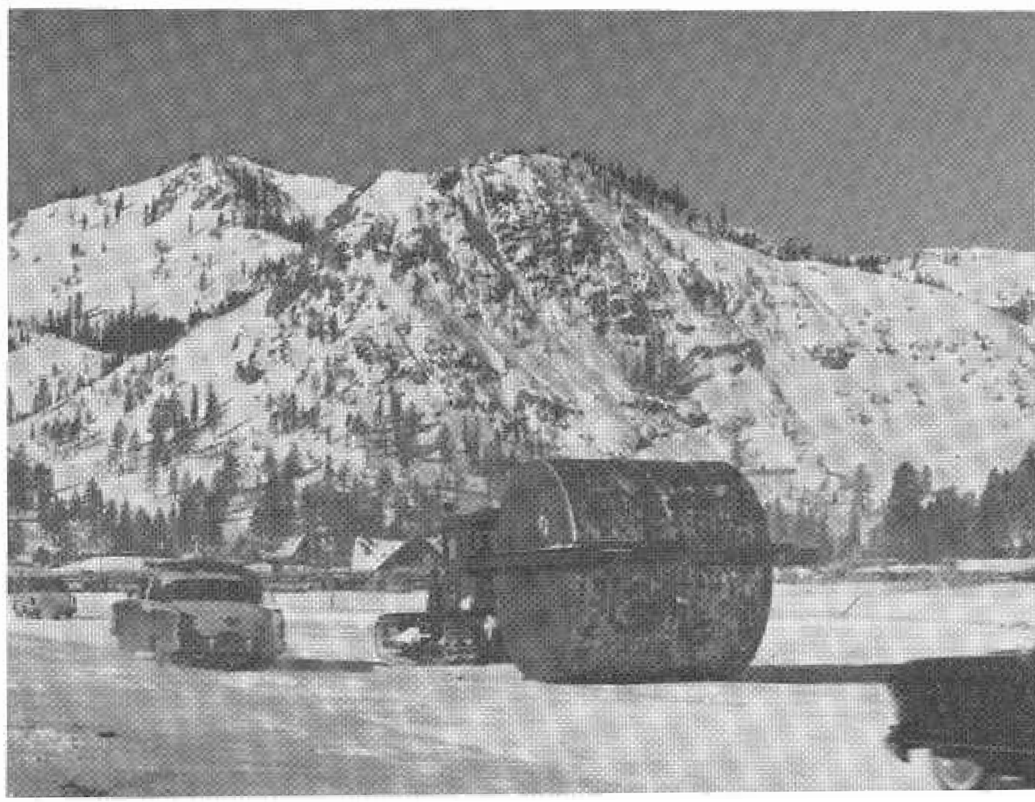
If the worst happened, and such a sudden storm struck, a mass evacuation of the valley might result in a disaster which would make headlines in every newspaper in the world. Nervous, worried motorists were virtually certain to get into accidents, the plows would be immobilized, and literally thousands of people would be trapped.

This was the biggest worry. Another was if "chaining up" should become necessary. Virtually all the traffic would originate in the snow-free lowlands, and none of the cars would start for the mountains with skid chains on their wheels. This is a routine problem to the Division of Highways maintenance superintendent in a mountain area—he sets up and removes chain control points many times each winter month.

Olympic visitors might be required to put on chains at some point on the way up, or a snowfall during the day might make chains necessary to get back down to the valley that evening. If on the way up, there was the prospect of thousands of cars stopped on US 40 in the dim light of dawn, their drivers cold, irritated, and many of them inexperienced at putting on chains. If chaining should be required before departure from the valley there was the worse prospect of complete chaos as 10,000 motorists, jammed together on the big parking apron, tried to maneuver on to their chains. If this occurred coincident with a storm, no doubt thousands would have to be evacuated in buses.

The third worry was parking. In a city parking lot, 225 square feet per car is considered adequate. In the mountains it was felt twice that would

Navy roller towed by small tractor continues work on compacted snow entrance road while traffic enters parking lot.



Parking lot at Squaw Valley on a weekend with attendance about 25,000 (7,000 cars in lot). Composite photo made f

be needed, which would dictate a main parking lot of at least 100 acres. This would allow heavy equipment to operate in and through the lot, provide overflow space for buses, and give the motorists room to maneuver under difficult conditions.

There was not nearly this much parking space in the valley. The cost of buying, grading and paving such a space would be enormous, with no hope of getting it back in one short, 10-day season. It also would be an eyesore in the valley which was to be a state park, and it would ruin some excellent summer pasture land.

The Navy suggested it might be able to provide parking space by the snow compaction method it had been experimenting with for Arctic air fields, if Congress would appropriate the money. The money was appropriated, and the Navy's plan was accepted—not without misgivings in some quarters. The idea was revolutionary and untried, but the Navy insisted it was practicable. Navy Sea Bees did some experimental work in Squaw Valley in 1958, and then compacted a large parking area in 1959.

The major route to Squaw Valley, both from the east and the west, is US 40, which connects San Francisco to Reno, and continues east to the Atlantic seaboard. This route has been designated part of the US Interstate System, so it ultimately must be improved and realigned over almost every one of its 3,000 miles.

Whenever possible, the Highway Commission authorized expenditures on the modernization of US 40, with the result that all but 36 of its miles between San Francisco and the Nevada state line was four-laned by the time the 1960 Olympics opened. Much of it was full freeway to interstate standards. Between June 1958 and January 1960, 48.7 full-freeway miles of this route between Sacramento and Nevada state line were completed at a cost of $42,685,000.

State Sign Route 89, connecting US 40 with Lake Tahoe and the final access highway from both directions to Squaw Valley, was widened and resurfaced. There was some concern because a narrow, two-lane underpass beneath the Southern Pacific Railroad on State Sign Route 89 was not improved, but this was deemed too expensive and difficult an undertaking at the time. As an alternate plan, a county road, River Street extension, which leads into Truckee and US 40 by a slightly roundabout route, was improved at nominal cost as an overflow road, and as an emergency route in case of evacuation.

In February 1959 the North American Ski Championship competition was held in Squaw Valley, giving everyone a chance for a dress rehearsal—Navy, Highway Patrol, and Division of Highways.

The competition was held on the three-day Washington's Birthday weekend—Saturday the 21st through Monday the 23d—and on the following weekend. On the 18th torrential rains softened the Navy's parking pad so it was unusable, and the cars of 10,000 visitors had to be parked wherever possible in the valley, on the access roads, and along State Sign Route 89 outside the valley entrance. However, the temperature dropped on Sunday, and by Monday the parking pad could be used. Although about a foot of snow fell each day between Tuesday and Friday, the following Saturday dawned clear and cold. The weekend's crowds were handled without difficulty.

Applying the lessons learned from the North American Championships, all the agencies modified and refined their planning as the time for the Olympic Games approached. A new system of drainage was installed in the parking area. The Highway Patrol arranged to take over Truckee High School as headquarters and barracks. On February 1, 1960, they moved in bunks, cooks, a large force of patrolmen, and patrol cars. Cooks were instructed to feed a minimum 3,600 calories a day cold weather diet.

Special destination signs were installed by the Division of Highways.

e from three photographs by William Chaney, Division of Highways photographer. View is generally south across valley.

Some new rotary plows and other equipment had already been purchased for the higher altitude maintenance stations, and additional equipment was moved in from other districts on a short term loan basis. Maintenance Superintendent Frank B. Fox of the Truckee territory assumed responsibility for maintaining the access road into Squaw Valley to the Administration Building, under financial agreement with Placer County and the Olympics Commission. Headquarters Maintenance Communications Section included the Squaw Valley weather forecast in its daily road condition report.

Convertible overhead signs were placed at several points on State Sign Route 89, so that the route could readily be converted to three lanes in one direction and one in the other, at any time. A special communications network, both teletype and radio, connected the various highway and Highway Patrol units with each other and with their respective Sacramento headquarters. A number of trailers were brought in, and permanent liaison groups from several agencies were assigned in Squaw Valley itself for the duration of the games.

In January and February 1960, just prior to the opening of the games, a series of storms swept across California. The first storms were cold, and several feet of snow fell in the mountains. Then tropical air masses moved in from the Pacific, and rain fell at high altitudes.

On February 6 a slide closed US 40 east of Monte Vista, so that the previously constructed Alta detour had to be used, but this slide was cleared in two days. A more serious slide started at the new Whitmore Maintenance Station above Baxter. Beginning near the old highway, it gradually broke back across the wide slope area between the two roadways, until it undermined the fill of the recently completed section. Before it stopped moving, about 200 feet of paving was lost, and traffic was diverted to the old route for several days until a temporary "shoofly" detour could be built.

On the eighth of February more than five inches of rain fell in a few hours in Squaw Valley, flooding the entire valley floor, and nearly washing out the entrance road bridge over Squaw Creek. Sign Route 89 was closed three times on this one day by fallen trees. The compacted snow parking pad in the valley seemed hopelessly ruined. With the Olympics just 10 days away, it was necessary to make emergency plans.

On the 9th and 10th there was heavy snow and wind. All except official vehicles and those of residents were barred from the valley so that the maintenance crews could clear the roads.

The parking pad was still usable by the 11th, and traffic from sightseers and skiers was increasing. But cars were allowed to enter the valley again on the 11th, and 625 were parked along the wide section of the entrance road that day, 650 the next.

The dedicated Navy crews were working hard all this time, and the new snow helped. They hoped to have part of the lot back in shape by Saturday, the 13th, to handle a part of the weekend sightseer and skier traffic.

The Division of Highways crews in the meantime worked most of the night getting signs ready to direct traffic to parking on an old section of US 40 near Truckee. The Greyhound Bus Company got some of the large resorts in the State Line area at Lake Tahoe to clear their parking lots for car storage so Squaw Valley travelers could take the shuttle buses from there. Officers from both Nevada and California Highway Patrols visited every motel and lodge at the north end of the lake, telling people to leave their cars at the motel and take the shuttle buses.

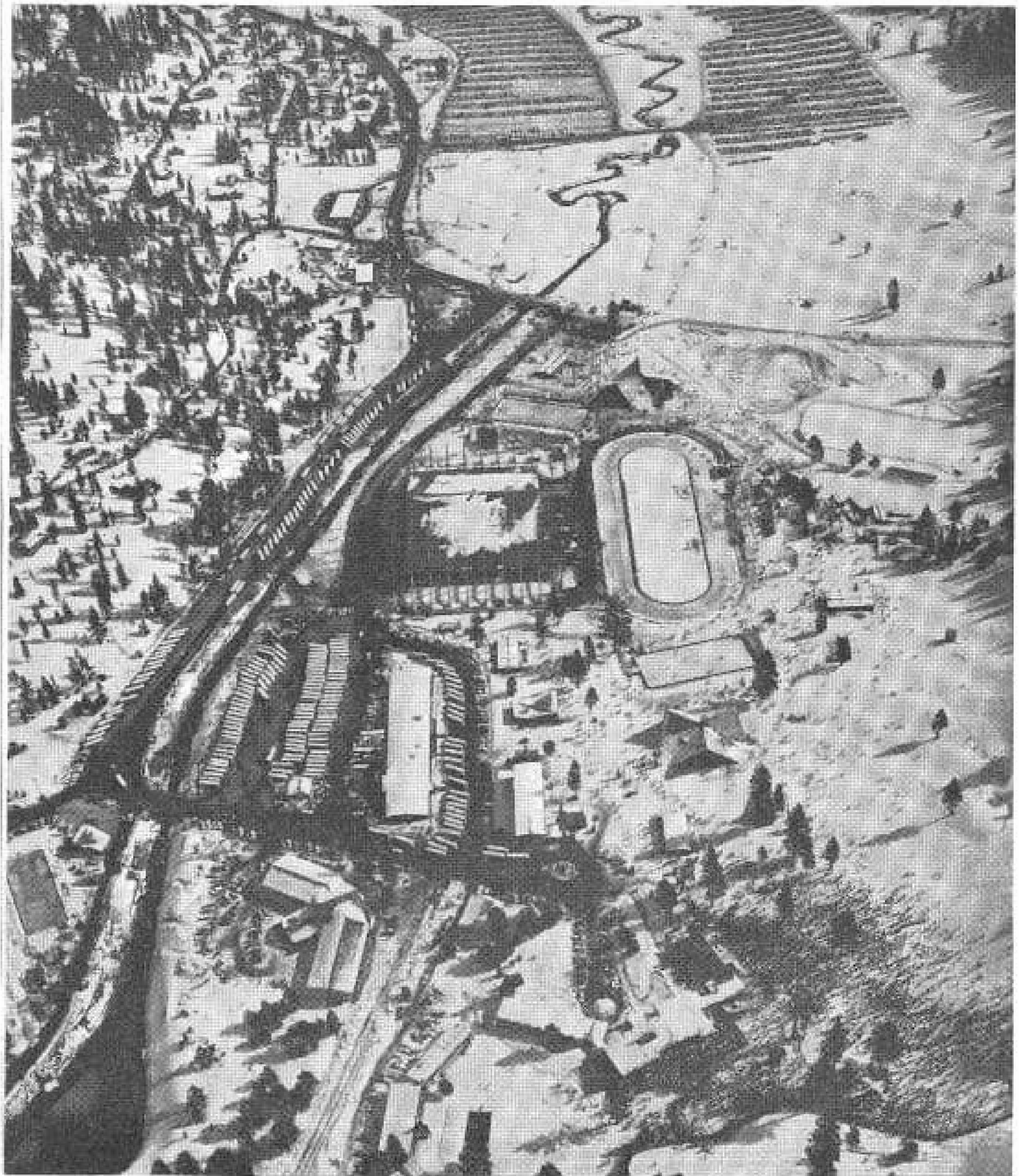
At this time the situation seemed to be that the shaky parking lot would be continued in use until about 11 or 12 o'clock, and if the influx of cars continued heavy, then parking would be shifted to the already designated areas near Truckee. Crews were at work placing signs that morning with bolts so they could be reversed when desired, when the word came at 9.30—"The pad just went." Highway patrolmen immediately began diverting traffic, and the crews finished the signing virtually on the run, not bolting, but nailing the signs in place.

There were just two lanes available in the old section of US 40, with high snow banks on either side. Cars entered at one end of the six-mile loop, and parked in progression one behind the other, filling one lane. The shuttle buses entered at the other end of the loop, using the remaining lane to move forward and load. This system worked admirably, except that there was a delay in getting enough drivers immediately for the shuttle buses, both at Truckee and at Lake Tahoe.

The emergency parking area at Truckee proved unusable, however, in the afternoon, when passengers returned on the buses to their cars. Whereas parking in the morning had been progressive along the area as it filled, the buses naturally were loaded at random in the evening. Cars continuously pulled out from the parking lane at many points and blocked the buses. This problem had been anticipated to some extent, so that the buses in the afternoon reversed their morning direction and moved with the traffic, but they still were immobilized.

At an emergency meeting between Division of Highways and Highway Patrolmen that afternoon, it was decided to use the outside shoulders of the new freeway sections of US 40 for emergency parking—both east and west of Truckee. To facilitate the movement of the shuttle buses on their return from the valley that next afternoon (Sunday), the Division of Highways crews worked all night making zone signs for the parking areas. They also posted 13 miles of highway with burlap-covered 25 miles per hour signs, which could be uncovered when parking, loading and unloading was in progress. The Highway Patrol administrative section was meanwhile working on instruction leaflets for parkers, explaining how the zone system worked. Maintenance crews worked all night clearing the snow from the shoulders in the designated parking area.

Main Olympic Games area on the biggest attendance day, showing most of the 310 special buses in central parking area. Compacted snow parking area at top. At lower right, crowds watching ski races.



Essentially, the plan was to have each driver keep his leaflet, and to write his zone code on it. When he was ready to return from the valley on the shuttle bus that afternoon, he and his car group would board the bus marked for his zone.

The plan was never needed. That night the temperature dropped almost to zero. The hard working Navy crews had continued to work on the parking pad, and the cold solidified it.

At 0730 hours on the 14th the Navy reported, "Compacted area officially open," and at 0742 hours "Pad looks good." At 1046 hours, the Patrol reported "Pad is holding up good. Temperature favorable—will probably hold 1000 or 2000 vehicles if nothing happens. Six hundred to 700 parked at this time."

Nothing did happen, and at 1326 hours the patrol reported the peak seemed to have been reached. The parking lot had handled between 1200 and 1300 cars at the peak without incident. During the games it handled many thousands more than this on several days.

Handling the traffic for the Olympic games themselves was almost an anticlimax. Minor problems arose, of course, but in general, things went very smoothly. There was no rain and only two light snowstorms during the days the games were on. Nights continued cool—close to and sometimes below zero and the pad functioned perfectly.

On the 21st, which was Sunday and the middle day of a three-day weekend, the weather in the valley was

... Continued on page 64

Data Processing

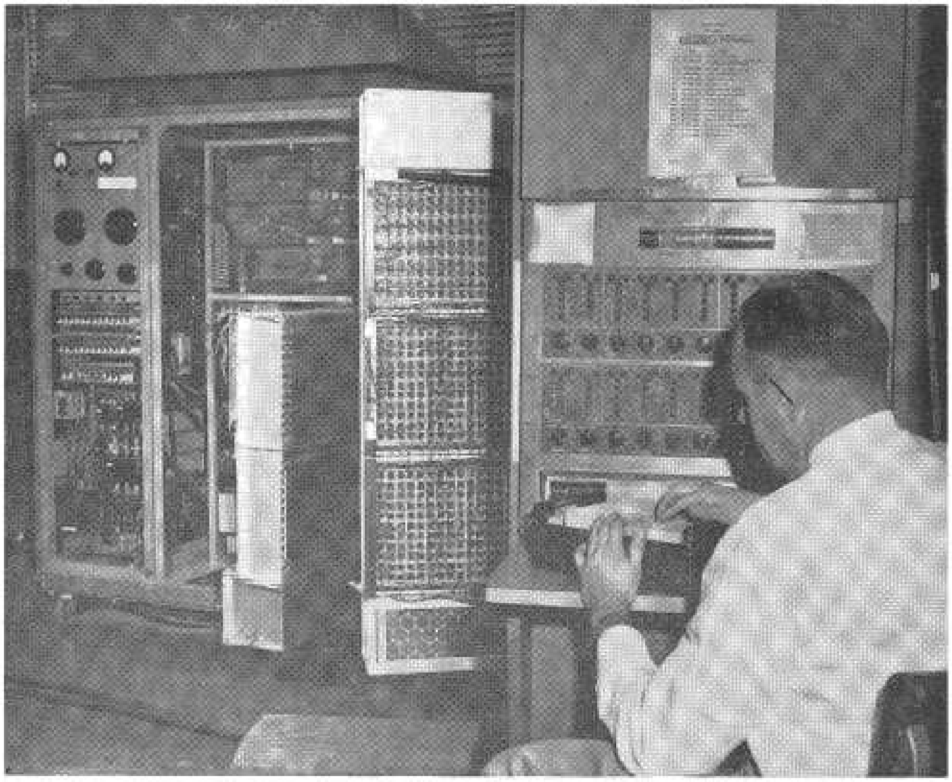
New Tabulating Methods Speed Design Calculations

By F. M. REYNOLDS, Highway Planning Survey Engineer

DATA FOR administrative decision and for the location and detailed design of modern highways are being processed at an ever-increasing rate in the tabulating and data processing section of the Headquarters Highway Planning Survey.

The division's present activity and capacity in the field of data processing is the modern result of early beginnings made in the thirties. The punched card approach to statistical and research problems was started at a time when tabulating equipment was slow and relatively unsophisticated. Origin and destination data and similar tabulations useful for planning and for traffic engineering were among the first reports prepared.

Early in 1955 extensive efforts were started in order to produce a system of calculation to serve the design and construction engineer. Since that time the major portion of the processing volume has been concerned with traverse solutions earthwork quantity calculations, and vertical alignment problems. Other services which are being utilized by the engineer include structural analysis and design computations, traffic assignment, geodimeter traverses, and miscellaneous quantity calculations.



John A. Haller, Senior Research Technician, selects cards prior to processing. The IBM 650 console and power unit have the covers removed to show the intricate circuitry.

Advantages Cited

Some of the basic advantages frequently cited as resulting from the use of machine computations are savings in man-hours and money, increased accuracy, and neatly tabulated results. Probably the most important benefit, however, is the potential saving in engineering time, and this was the original primary objective when the feasibility of using tabulating equipment for engineering computations was first investigated. The extent to which these services have been used to reduce the number of repetitious calculations performed by the engineer, thereby leaving him more time for decisions requiring engineering judgment, would be a good measure of the effectiveness of the program.

The fact that at the present time over 300 miles of earthwork calculations, 125,000 traverse courses and numerous calculations involving vertical alignment data, structural design and analysis, traffic analysis, etc., are processed each month, provides some indication that this primary objective has been achieved.

As an aid toward promoting more efficient use of these services throughout the division, several districts have appointed engineers who act as coordinators for machine computations. These co-ordinators maintain contact with the Headquarters Design Section and Planning Survey and provide a readily available source of information to operating personnel in their respective districts. Being well versed in the capabilities and limitations of the various programs, the liaison man can be of valuable service to the district personnel in immediately resolving most problems concerning procedure. In this connection periodic visits by the co-ordinators and any other interested users of the service are welcomed by Headquarters Office personnel who are available to demonstrate the procedures and equipment and offer consultation in any matters regarding the data processing system.

Vertical Alignment

The most recent major service to be placed in production is the Profile Grade and Grid Elevation Computation Program. A service to calculate profile grade elevations only was placed in operation in 1957 and the capability of obtaining grid elevations was introduced early in 1959.

This service consists of the determination of profile grade data or the computation of roadbed elevations anywhere on successive cross sections by combining profile grade, superelevation transition, and cross section data. In addition, the program can determine, as a separate problem, the transverse location of specified contour elevations on successive cross sections.

This computer service is used by design and construction engineers for the following applications:

1. To obtain profile grade line information.
2. To obtain elevations along pavement and shoulder edges.
3. To determine the location of, and the elevation of, sags and summits for drainage studies.
4. To obtain tabulations of specified contour elevations for plotting bridge deck contour maps or proposed roadway contour layouts.

These grid elevations determined by the electronic computer are forwarded to the engineer in neatly printed tabulations which he can use directly in the field or office. The listing is arranged in the conventional cross section note manner.

The program is being modified so that the output cards can be used directly as input roadbed template data to be combined with terrain data for the computation of earthwork quantities without the necessity of copying data by the engineer or repunching cards by the key punch operators.

Traverse Computations

The traverse solution program was the first of the various services to be offered to the districts on a production basis and it has proved to be the most widely accepted, as evidenced by comments from district personnel and by the fact that it is utilized by a greater number of operating units than any of the other programs.

One of the reasons for the popularity of this program is that the engineer is able to convert to the format used in submitting data for machine computation with little change from conventional manual traverse calculation methods. Another reason is that traverses are calculated and results mailed back to the district on the same day the problems are received at Headquarters Office. This will still result in some delay, however, and rearrangement of work schedules is sometimes necessary in order to utilize the service to the best advantage. The effect of this waiting period has been minimized with the introduction of interdependency between traverses which was made possible by the acquisition of computing equipment with greater capacity. This feature allows the engineer to call for and use results of the calculations of a particular traverse in a subsequent traverse without the necessity of waiting for the initial solution to be mailed back before submittal of the dependent traverse.

Real Traverses Few

Relatively few courses submitted are traverses per se. Most traverses submitted for solutions of unknowns are a variety of geometric problems such as are encountered in interchange areas for solving intersections of skewed structure bents with centerline or location of ramp noses. Traverses are used as a matter of convenience in lieu of the more cumbersome academic methods.

At present the following types of problems can be processed:

1. All sides and bearings known.
2. Any problem with two unknowns. These unknowns may be two distances, two bearings, or one distance and one bearing in either the same course or in different courses.
3. Traverse adjustment by either the compass or transit rules; and
4. Any of the problem types listed under 1, 2, and 3 above plus the enclosed area.

The final tabulation includes the following:

1. The original data;
2. The missing data for unknown courses;
3. The latitude and departure for each course;
4. The co-ordinates for each course;
5. The error of closure; and
6. When requested, the area enclosed by the traverse in square feet and acres.

Early in 1959 the program was refined and expanded, resulting in the following additional computer capabilities:

1. Descriptive data consisting of 14 alphabetical and/or numerical characters can be submitted and will be reproduced on the output tabulation;
2. Curve alignment consisting of either the radial bearing when when stationing is known, or stationing when the radial bearing is known, can be computed;
3. Dependency within the same traverse problem is possible;
4. Complete interdependency is possible regardless of the number of solutions;
5. Dependency between traverse and curve alignment problems is allowed; and,
6. Rotation of bearings up to 360 degrees in either direction can be accomplished.

Earthwork Quantity

In terms of tabulating man-hours and card volume, the earthwork program has been the major engineering computation project undertaken by the Planning Survey. This is due to a number of factors among which are inherently large amounts of input data, extensive preparatory card handling, a great deal of special handling, and the necessity for procedure writing in order to process district requests for manipulation of original data.

Shortly after the inception of the program late in 1955, it was realized that more powerful computing equipment would be necessary to handle the volume of work which could be anticipated at that time. Accordingly, an IBM type 650 computer was acquired by the Planning Survey. This change made it possible to obtain in one pass of the cards through the computer the same results which previously required over 60 card-handling steps. A great deal of input card handling is still necessary, with the result that earthwork calculations take considerably more time than any of the other services. It may take from 8 to 15 working days following receipt of data to process a complete earthwork project. The length of time is dependent upon the amount of special handling required, coupled with the incidence of questionable data and upon existing workload in the tabulating section.

Notes Transmitted

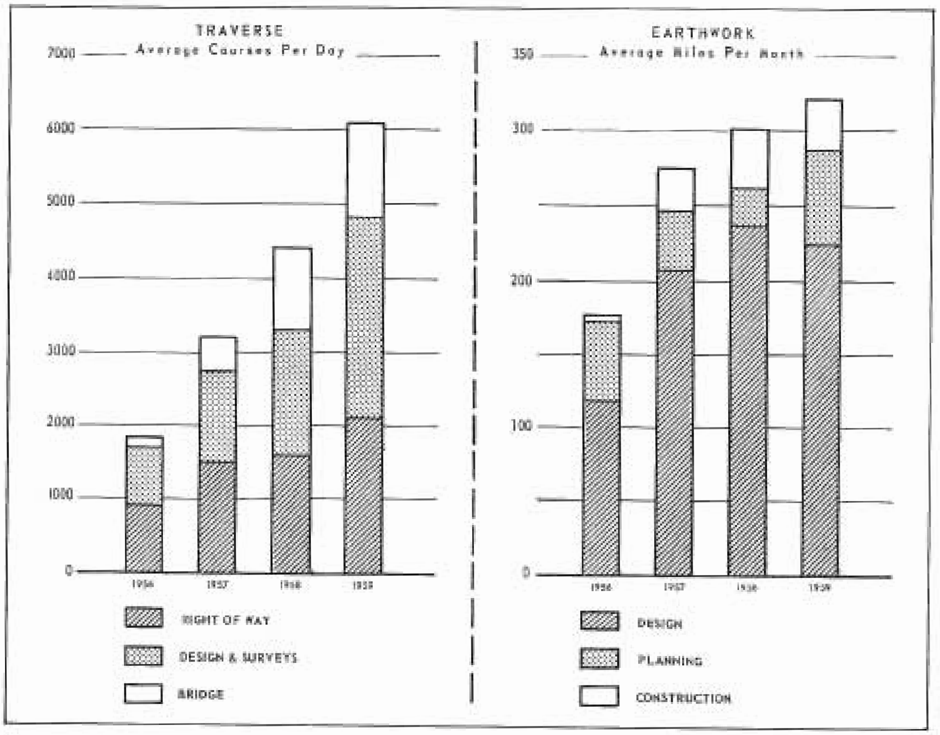
Under the present system, terrain notes are transmitted to the Planning Survey as they are written in the field or prepared from contour maps. Notes can be submitted in the form of true elevations, rod readings, or as differences from elevation at centerline or an offset point. Roadbed notes are submitted similarly. Cards are punched for roadbed and terrain notes separately, and each deck of cards is put in sequence and mechanically merged by station before processing through the computer.

The engineer is furnished with the following tabulated results:

1. A list of reduced terrain and roadbed notes;
2. A quantity sheet showing stationing, end areas in square feet, excavation and embankment quantities in cubic yards, grading factors and mass diagram ordinates by station; and,
3. A list of calculated slope stake points and side-slopes by station.

In addition to performing the basic quantity calculations using original notes, the data can be reused and manipulated in various ways without rekeypunching. Examples are horizontal and vertical grade shifts which can be performed mechanically upon receipt from the engineer of grade differences, or offset distances. Another example is the use of computing equipment to make terrain adjustments according to the method described by L. L. Funk in his paper published in *Highway Research Board Bulletin 228*, National Research Council, 1959, entitled "Terrain Data for Earthwork Quantities." The adjustment consists of raising or lowering the entire terrain at each cross section by an amount equal to the error at centerline. This operation can be performed upon the original terrain elevations provided the tabulating section is furnished with a list of adjustments.

The greatest saving in engineering manpower and money results from the



Traverse and earthwork computations processed by the Highway Planning Survey for the calendar years 1956 to 1959.

use of mechanical methods to shift grades and from the reduction or elimination of cross section plotting and subsequent planimetering.

A recent innovation is the preparation of terrain notes from contour maps as described by Index Nos. 6-433.7 to 6-433.10 of the Planning Manual. This method utilizes either strips cut from a print of a map which includes photogrammetric cross sections (spot elevations) or a strip of transparent grid overlay which is placed over the contour map for entry of distances and elevations. Keypunching of terrain notes can then be performed directly from the strips by utilizing a special holder. The use of this method results in a savings of approximately two cents per point, which is roughly half the cost of transcribing notes by conventional methods.

Other Services

Another program available to the engineer is entitled "four-factor computation." This service will perform four types of algebraic manipulation involving four factors of six digits and will summate the results of any number of these separate calculations. The program is commonly used for clearing and grubbing computations, and for computing and summarizing construction estimate items.

The bridge design engineer may choose one of several tools for design and analysis work. Prominent among these tools is the column analysis program which will analyze any rectangular steel and concrete column for biaxial bending. The data submitted for this program consist of biaxial load, size of column, and position and size of reinforcing bars.

Another useful program designs a composite action steel and concrete girder from minimal data of span, spring, structure depth, and steel stress desired. This program also has the interesting feature of allowing the engineer to specify more than the minimum conformation so that individual requirements and decisions may override the standards built into the program.

Distribution Technique

Analyses of frames are made using a moment distribution technique. In this case, the computer is able to study many patterns in a comparatively short time by using iterative methods which are especially well accomplished by a computer. The multistory general frame analysis program computes final frame moments for a given set of loadings. Influence lines for single story frames, including as many as five spans, can also be computed. The Bridge Department has taken advantage of a synthetic computer language (Fortransit) to write single-use computer programs for the solution of special problems, such as tidal flow in Guadalupe Lagoon, and final design of the San Pedro-Terminal Island Bridge.

Other programs which have been written by the Bridge Department and which are in use by them, involve calculations for obtaining total settlement of bridge approach fills, volumes of excavation for bridge abutments and piers, and prestressed concrete girder design, including all properties of the section, plus the required prestressing force and resulting concrete stresses. A suspension bridge analysis program developed by the State of Washington was used in the design of the San Pedro Bridge.

Amounts of reinforcing steel in terms of length and weight are grouped by standard bar sizes, extended and summarized by means of another calculation service.

The Geodimeter program reduces Geodimeter Model 3 readings, checks for errors, applies necessary physical correction constants, and computes slopes and vertical and horizontal distances.

Traffic Problems

The IBM equipment is used extensively in the processing of rural and metropolitan origin and destination studies and in other traffic problems.

The conventional equipment is used to expand the sample interview data, whether it be roadside interviews or home interviews, to trips on an average weekday. The trip information is then processed to obtain the total transfer of trips between pairs of zones.

Proposed freeway bypasses in the rural areas or major city street and freeway networks in the urban areas are laid out on maps by the engineers. Trip volumes derived from the origin and destination studies are then routed over the bypass or freeway and city street network to determine the traffic profiles on the proposed roads and to obtain the turning movement for freeway access points.

The routing between pairs of zones has in the past been done manually. A method of routing trips mechanically selecting the route which is either the shortest in time or distance or some other criteria by use of the computer is being developed. This method will be made available for use as soon as it is fully checked, if it is found to be reliable. This would relieve the engineer of the tedious work involved in manual routings.

User Benefits Determined

The Freeway Assignment Program gives the necessary information to determine the user benefits if the bypass or network were placed in operation. This analysis is made for current-year traffic and generally estimates of traffic in the design year are made and traffic profiles and user benefits are determined for this year also. More than one design year and more than one freeway system may be studied for comparative purposes.

The estimated trips between zones for any future year are predicted by one of three methods now in use by Highway Planning Survey.

A multiple regression analysis develops the coefficients for the several components in each zone that have an effect on the volume of traffic. The coefficients developed for each zone are then used to predict traffic in the design year based on estimates of the predicting factors in the design year.

A second method, developed by personnel in District XI and called the Friction Factor Method, is used to estimate future trips between zones based on current trip ends per zone and estimated future trip ends per zone and the deterring factor of the distance between zones.

The third method, commonly known as the Frator Method, is based on current trip ends per zone and expected trip ends per zone in the design year, applying a method of successive approximation to distribute these trip ends from the subject zone to all other zones.

The computers and the other equipment are also used in the computation of average daily traffic figures from the annual and monthly count information, and to prepare the monthly traffic trend figures.

Annual tables summarizing traffic accidents by various categories are prepared for the Traffic Engineer.

A matrix solution service is available to solve simultaneous equations of 40th order or less.

The solution of various degree curves of best fit to a set of data is accomplished by use of a polynomial approximation program.

Multiple regression analysis is used for traffic studies and for materials and research laboratory problems. This service computes means, standard deviations, simple correlation coefficients, partial correlation coefficients and the residuals between observed and calculated values.

Time series trend equations are being solved for linear, semilog, and exponential values of Y (dependent variable) for years of trend plus desired years in the future, together with the standard error of estimate.

Extensive machine processing techniques are applied to data which are collected at various truck-weighing stations throughout the State. The information is gathered by Planning Survey field crews and includes truck weights by axle, commodities carried, vehicle dimensions, body types and age, and truck origins and destinations.

These data are checked for consistency, and grouped and summarized by tabulating equipment for aid in analysis. Annual tables are prepared from tabulations for the Bureau of Public Roads and include statistical summaries of axle frequencies, gross weights, number of trucks weighed and counted, numbers of trucks loaded and empty, percentages of trucks by type and percentages of each type occurring in the population which was sampled. By use of the computer, an annual table is obtained which summarizes the results of comparing various axle weight combinations against both state and AASHO overweight standards.

A monthly advance planning report and a weekly design section report are prepared for the Bridge Department.

Kern County

Two Freeways Completed Under County FAS Program

By WILLIAM CANESSA, Deputy Road Commissioner, Kern County

KERN COUNTY has recently completed two freeways. The first, on Federal-aid Secondary Route 887, was the Manor Street project, a 2.3-mile four-lane divided combination freeway and expressway connection between the northeast Bakersfield urban area and the unincorporated area of Oildale. This project starts at Union Avenue and the western end of Panorama Drive in Bakersfield on the bluffs overlooking the Kern River, and crosses the Kern River, its flood plain, two canals and connects with a four-lane divided highway at its temporary termini in Oildale. It eventually will be pushed to the north and west to connect with State Routes 142 and 129.

> "Kern County's planning for the future growth of the area adjacent to Bakersfield will help to avoid the costly and disruptive reconstruction usually associated with urbanization."
>
> J. C. WOMACK
> State Highway Engineer

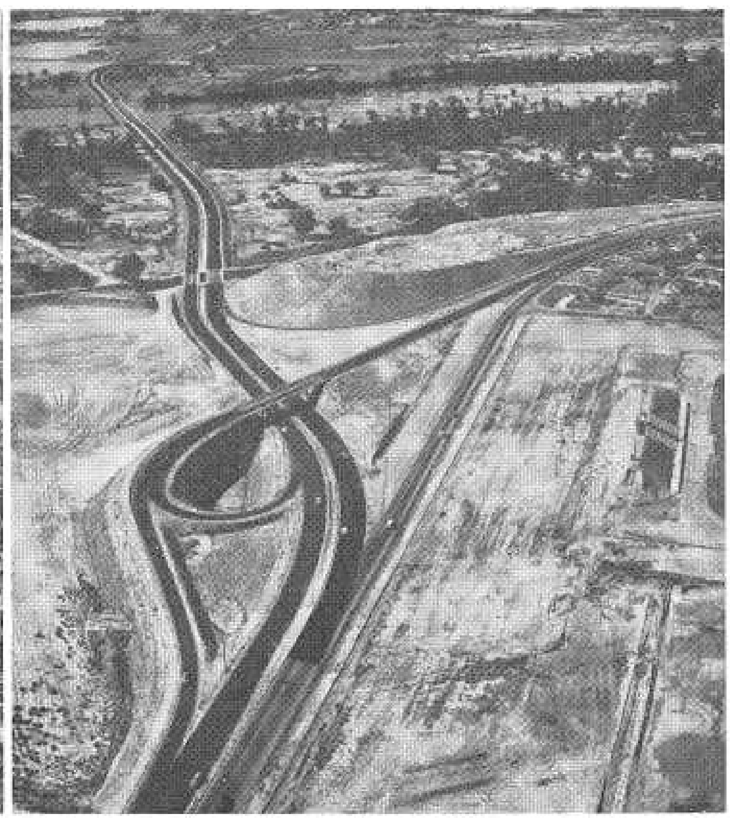
The second freeway, on FAS Route 885, the Alfred Harrell Highway, begins at the eastern end of Panorama Drive in Bakersfield at the top of the same bluff on the south bank of the Kern River and proceeds up the river in a northeasterly direction for five miles. The work as completed to date has been constructed in two contracts. There will most likely be two and possibly three additional contracts let to complete this freeway from its present terminus to State Sign Route 178 approximately seven miles to the southeast.

Serves Recreation Area

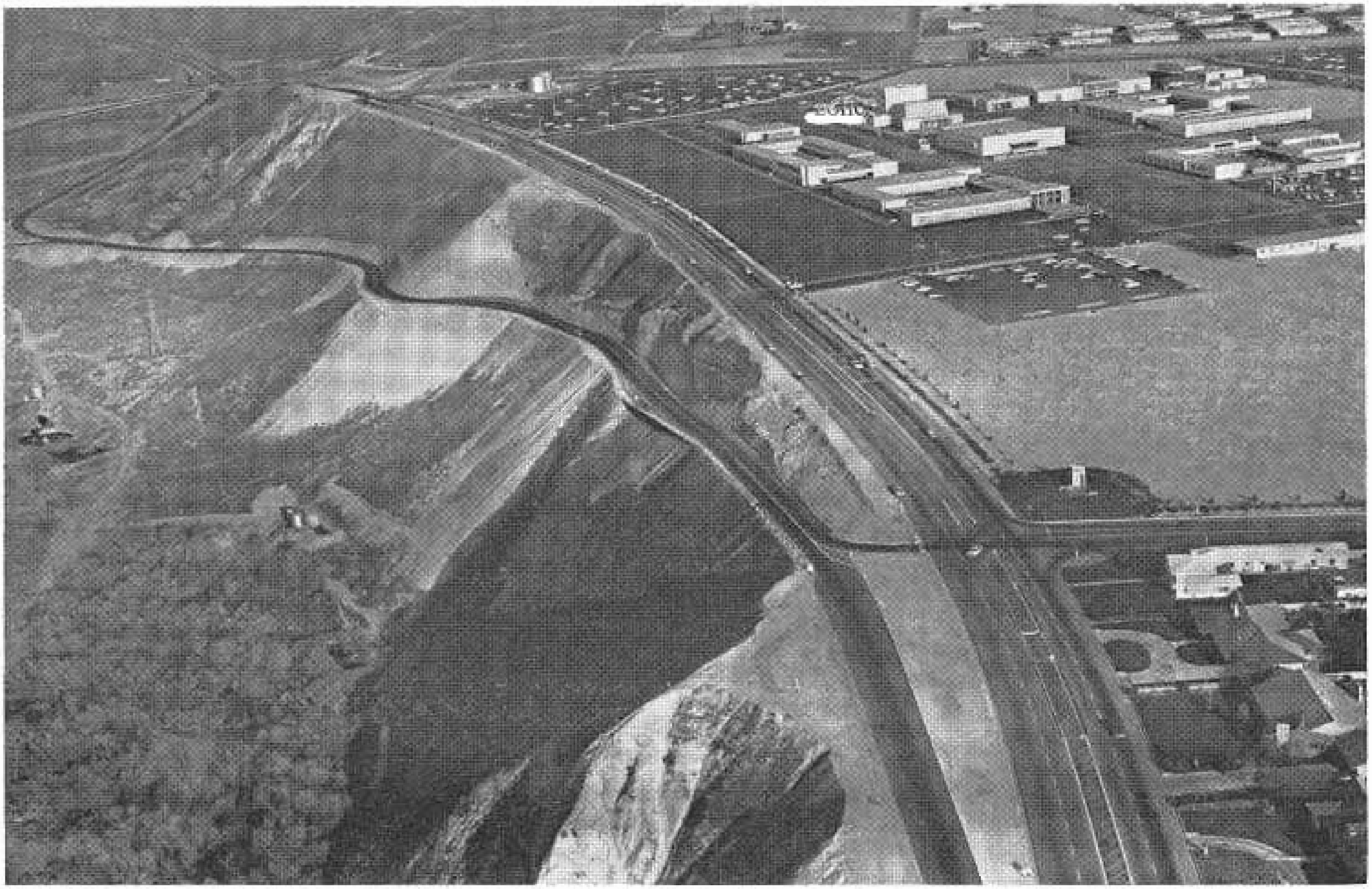
This freeway serves as the only route to Kern County's largest recreational area, which includes an 18-hole golf course, a new 107-acre boating lake and Hart Memorial Park. Traffic counts are well in the thousands with weekend counts of over 15,000 and with proposed additional facilities and the natural expansion in that area even higher counts are expected.

The Manor Street project was completed under five separate contracts. The first was advertised in May 1954

Looking south at expressway portion of FAS Route 887 on Manor Street in Oildale, Kern County.



Interchange connecting Union Avenue (foreground) and Panorama Drive (right) in Bakersfield with Kern County's FAS Freeway to Oildale across Kern River (in distance).



Looking east toward end of Panorama Drive opposite Bakersfield College. Westbound traffic from Hart Memorial Park, destined for Bakersfield, travels Kern County's Alfred Harrell Freeway in distance at left and utilizes the old China Grade Loop Road to climb the Kern River Bluffs in foreground. The new down ramp for eastbound traffic is partly hidden by a bend in the bluff.

A "diamond" interchange on the Alfred Harrell Highway between Bakersfield and Hart Memorial Park.

and the last one completed in July 1958.

The first contract was the concrete pile-supported reinforced concrete "T" beam bridge 616 feet long spanning the Kern River. A second contract covered two smaller bridges and the roadwork. In November 1956 with the completion of the third contract which was the interchange on the south end, the road was opened to traffic as a two-lane highway. The traffic count on this road two weeks after opening was over 7,000 vehicles per day.

First Prestressed Bridge

The fourth contract covering structures for the northbound lanes included what is believed to be the first prestressed concrete bridge constructed in Kern County. The parallel structure for the southbound lanes was a composite steel beam with con-

. . . Continued on page 50

Oregon Trail

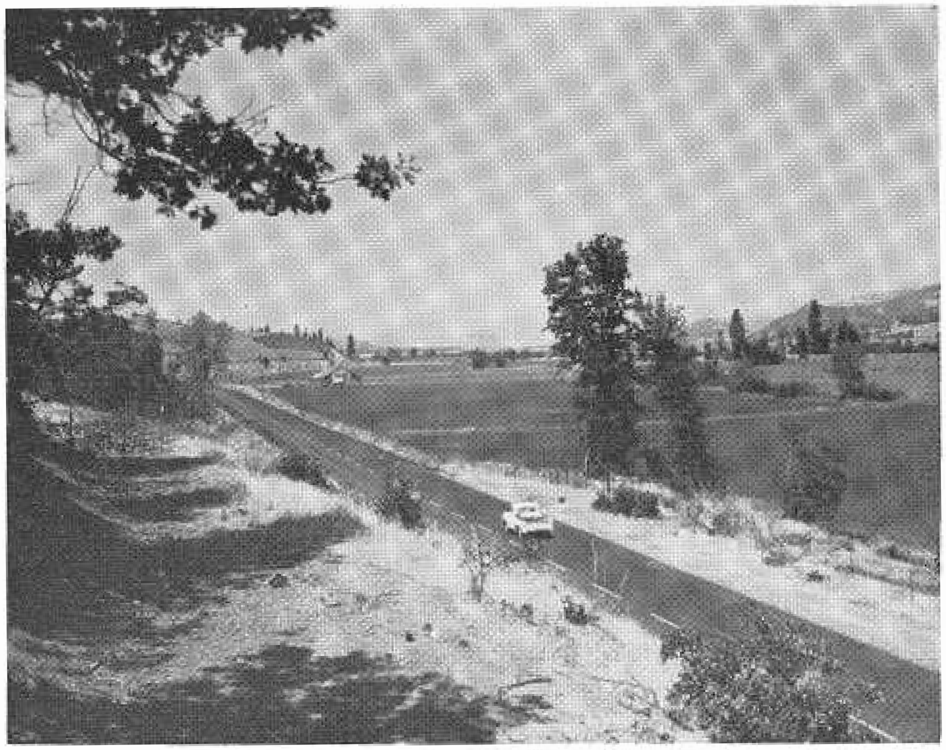
State's Longest FAS Route Is Being Relocated, Improved

By MELVIN E. DALE, Trinity County Road Commissioner and
A. A. POWERS, Siskiyou County Road Commissioner

Construction of the Trinity Dam northeast of Weaverville in Trinity County has provided a welcome stimulus to much needed road construction on Federal-aid Secondary County Route 1089. This route is the only direct north-south connection between Weaverville, the county seat of Trinity County, and Siskiyou County points, measuring 124 miles, it is the longest continuous Federal-Aid County Route in the State.

This route has a long if somewhat obscure history. It is, in part, the historic "California-Oregon Trail" which extended from Shasta, the early day metropolis of Northern California, through French Gulch and Trinity Center, thence north into Scott Valley and Yreka. Over it passed the first north and south stage travel, which was greatly increased after 1849 by the discovery of gold.

With the exception of necessary maintenance, little construction was done on this route prior to the beginning of the Federal-Aid Secondary Program in 1945. Under this program 14 contracts, comprising work by 12 different contractors, have been completed. These contracts have provided 40 miles of road, graded and surfaced to modern standards, and the replacement of eight obsolete bridges.



A recently improved Section on FAS 1089 at the south end of Scott Valley in Siskiyou County.

Further Progress Made

Through the combined efforts of the U.S. Bureau of Reclamation and Trinity County, further strides are being made in the reconstruction of the southern portion of this highway. The U.S. Bureau of Reclamation is constructing new portions of Route 1089 around the west side of Trinity Lake to replace roads which will be inundated by the construction of Trinity Dam. Trinity County is reconstructing intervening portions.

Construction in Trinity County, including surfacing, is scheduled for completion as far Carrville at the upper end of Trinity Lake by 1961. A stretch of 40 miles of modern highway from Weaverville north will then be ready for use by the traveling public. From Carrville to the Trinity-Siskiyou County line near Scott Mountain, construction will be somewhat slower due to the very rugged terrain and the bridges required to span the many mountain streams emptying into the Trinity River. This remaining 18 miles of road in Trinity County is unimproved, with a number of sharp curves and steep grades. In general, it is wide enough for two lanes of traffic and readily traversable except in the winter months.

Road Crosses Pass

At the Trinity-Siskiyou County line the road crosses through a pass near the summit of Scott Mountain at an elevation of 5,350 feet and descends to the floor of Scott Valley near Callahan at an elevation of approximately 3,000 feet. This section of road is also unimproved and comparable to the section on the Trinity County side of the pass.

From Callahan to State Highway Route 82 at Etna, a distance of about 14 miles, four FAS projects have been completed and one is now under contract. Upon its completion in 1960, the entire section of FAS Route 1089 between Callahan and Etna will have been graded and realigned to modern standards with bituminous surfacing throughout.

Between Etna and Fort Jones, traffic follows State Route 82 along the westerly side of the valley eight miles to Greenview, from where it crosses the valley to Fort Jones about six miles away.

A project for reconstruction of FAS Route 1089 between Fort Jones and six miles northwesterly was completed several years ago. The remaining 24 miles, which follows closely the Scott River to connect with the Klamath River Highway near Scott Bar, is unimproved but easily traversable except in bad weather.

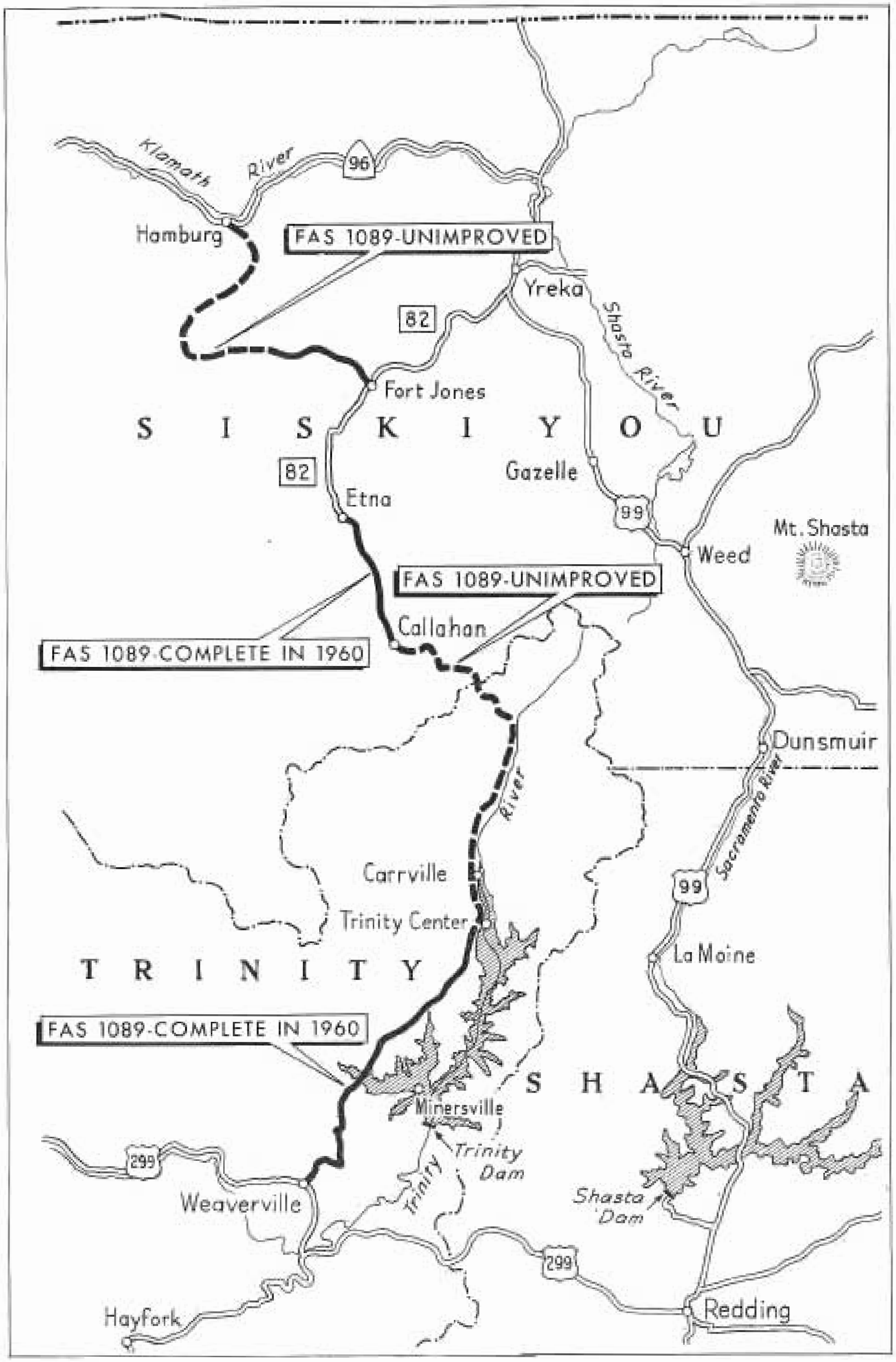
Many Attractions

This increasingly popular route will hold many attractions for the motorist. A short side trip will take the traveler to the site of the Trinity Dam. This dam, scheduled for completion in 1961, will be the highest earthfill dam in the world, rising almost 500 feet above streambed. The mountain lake formed by the dam will have a surface area of approximately 25 square miles. From about 10 miles north of Weaverville to Carrville the relocated FAS Route 1089 will be, in general, a lakeshore road skirting the wooded shoreline of the lake for many miles and affording many scenic views of lake and mountains.

All of the mileage in Trinity County is in mountainous country, cutting through the heart of the beautiful Trinity Alps, and giving access to vast primitive recreational areas. West of the road the Salmon Trinity Alps Wilderness area lies ready for exploration by the more hardy and adventurous. To the east lies a vast stretch of mountains threaded with many streams and dotted with numerous lakes all of which are capable of affording excellent sport for the fisherman. Public camps are positioned along the road and can be used as a base of operations for jeep or hiking trips into the mountains.

Vast Forest Areas

Cattle ranching and farming are the main pursuits in Scott Valley in Siskiyou County. West of Scott Valley vast areas of federal forest are beginning to supply timber to lumber mills in Scott Valley, Yreka and Weed. It is estimated that the annual cut will amount to over 50 million board feet in the near future. In the area southwest of Callahan beyond Cecilville approximately 3.5 billion feet of prime timber is available, all of which will



The above map shows the present status of improvements to Federal-aid Secondary Highway Route 1089 consisting of Trinity and Siskiyou County roads connecting with state highways at Weaverville, Fort Jones and the Klamath River. The portion between Carrville and Callahan follows the original "California-Oregon Trail." The route between Weaverville and Yreka conforms in general to the legislative description of a route in the future California Freeway System.

be transported over county and state roads.

North of Fort Jones, Route 1089 parallels the scenic Scott River noted for its fine trout and steelhead fishing. West of this section the Marble Mountain Wilderness area, one of the nation's largest unspoiled primitive areas, is available for pack trips, hiking, fishing, and hunting.

The increasing importance of this

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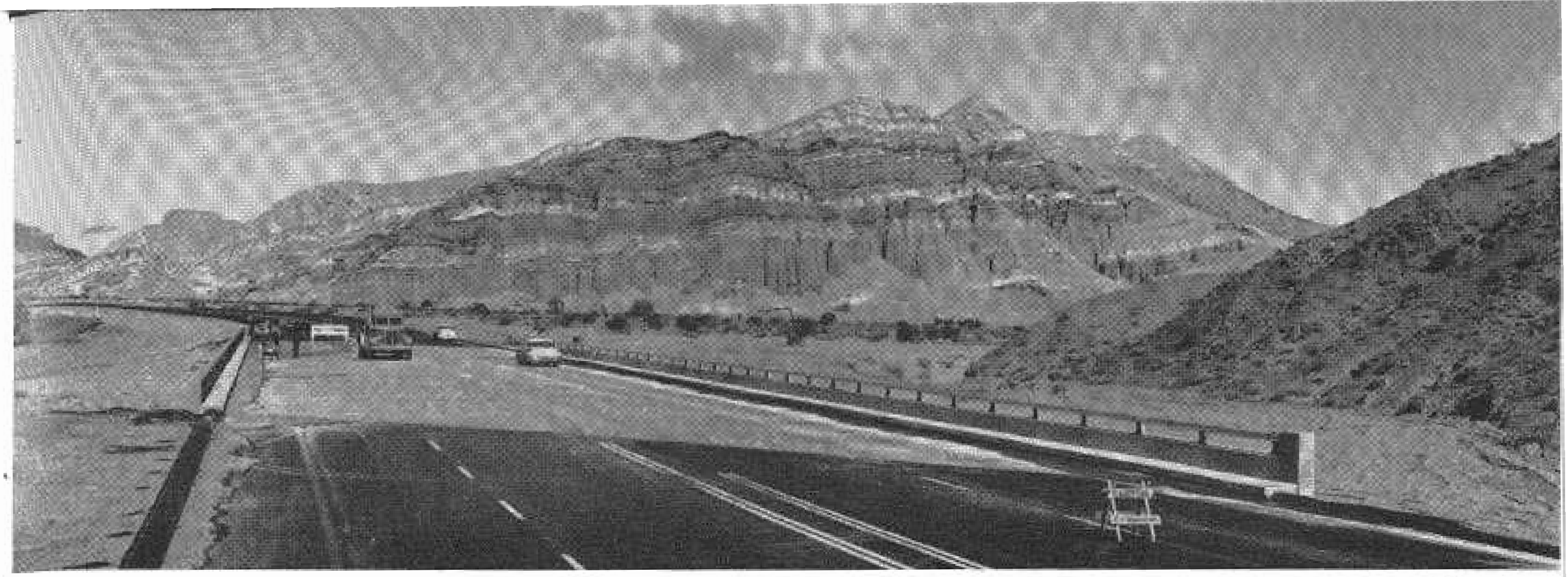


Deck grinding operation on new 394-foot bridge across main wash of Red Rock Canyon. Striped cliffs in background are site of annual Easter sunrise services.

Red Rock Canyon

Two-year Reconstruction On US 6 Is Completed

By C. E. FORBES, Resident Engineer

Completion of the second major contract in two years on U.S. Route 6, in Red Rock Canyon, concludes the elimination of a historic "bottleneck" between Southern California and the "High Sierra" area.

Red Rock Canyon, located approximately 25 miles north of Mojave, California, has been the scene of numerous destructive flash floods resulting in complete road closures for short periods, and one-way traffic for as long as two months. The watershed area of the canyon consists of approximately 47 square miles of steep terrain almost bare of any vegetation. During the last major flood, in October 1945, a momentary peak flow of 16,000 second-feet was realized. This same flood resulted in a complete road closure for 48 hours and one-way traffic for two months. To bypass Red Rock Canyon a detour of some 50 miles via US 395 and US 466 is necessary, since the only other through route in the area is via a county road which also crosses the wash.

Parallels Wash

The original highway paralleled the main wash for about three miles and crossed it via dip sections at three locations. Numerous lesser washes also contributed to the flooding problem.

Aside from vulnerability to washouts the original route contained many severe sight restrictions, both vertical and horizontal, which, coupled with steep grades and 15 percent truck traffic, made a slow and dangerous stretch in an otherwise high-speed highway.

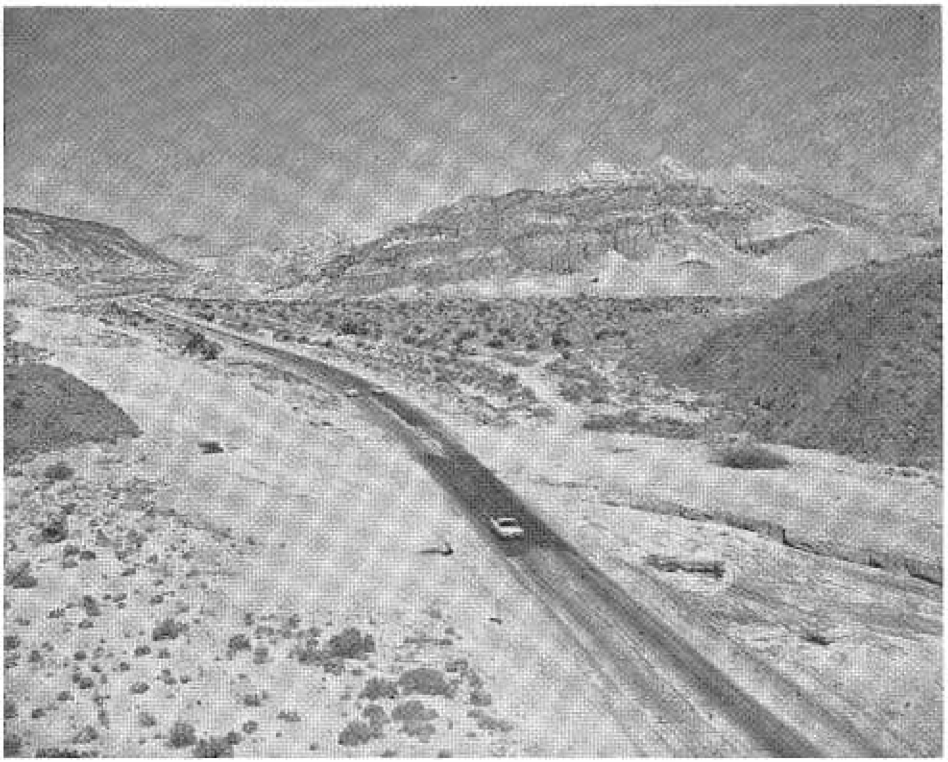
U. S. Route 6 is the shortest route between Southern California and the Rocky Mountain areas, as well as the recreational facilities of the eastern Sierra region. It is also an important outlet for the U.S. Naval Ordnance Test Station at China Lake near Ridgecrest, and for chemical installations in and near Trona and the Searles Lake area. An ever-increasing amount of truck traffic follows US 6 to Bishop then US 395 to the Pacific Northwest.

The bond issue of 1919 provided for the completion of a highway from Bishop to Los Angeles, and the existing route was taken into the state highway system in 1925. It was not until 1930, however, when a 15-mile contract was let to George Herz & Co., from Cinco to seven miles north of Ricardo through Red Rock Canyon that this vital link in the highway system was completed.

Scenic Beauty

The Red Rock Canyon area is in itself a tourist attraction for its scenic beauty and is somewhat of a "paradise" for "rock hounds," photographers, and amateur prospectors. Many campsites are available, and campers are seen even in the hot summer months. The area is also well known for its use as an outdoor studio in countless western movies and TV shows.

The first of the two recent contracts consisted of reconstruction generally along the existing alignment through the narrowest part of the wash. This project extended from the mouth of the canyon for approximately one mile north with a temporary connection at the north end. To provide adequate sight distance a 60-foot all-paved section was constructed with minor relocations to provide for 60-mph alignment. The widening and realigning from the original winding two-lane road necessitated extensive channel changes which accounted for the bulk of the grading and over half the cost of this contract.



Old highway crossing of the main wash of Red Rock Canyon in dip section where flash floods frequently closed the road. This is site of new 13-span, four-lane concrete bridge.

New bridge across main wash of Red Rock Canyon during construction. Note sand fill used instead of conventional falsework for deck slab.

During construction it was found that the fractured rock in the channel cuts was unstable on the planned ½:1 slopes and several slides occurred, making it necessary to flatten these slopes to ¾:1. The ditch and channel excavation along with roadway excavation provided material for the roadway embankment and the excess was stockpiled for use as untreated base and mineral aggregate for plant-mixed surfacing on this and the second contract.

Embankment Protected

To protect the embankment adjacent to the realigned channel, grouted rock slope protection was placed to within about five feet of the finished shoulder. The grouted rock was placed in a mat two feet thick measured normal to the slope.

The placing of rock slope protection preparatory to grouting was completed on September 5, 1958, and on September 6, 1958, a flood occurred in the channel which washed out a section of the ungrouted rock and washed sand and mud into the remainder of the rock for heights varying from 4 to 12 feet. This delayed the start of grouting operations by five weeks.

A second flood occurred on October 24, 1958, after most of the grouting was completed and damage was confined to a short section of ungrouted rock and to washing out the concrete batch plant.

This contract was completed on November 24, 1958, by Stecker & Scott & Spirite & Conn at a cost of approximately $460,000. D. A. Crane was resident engineer for the State.

Complete Relocation

Work on the second contract got under way in April 1959 and except for the two ends was a complete relocation primarily to the east of the old highway. This section picked up where the other ended continuing the 60-foot all-paved section across the main wash on a 394-foot reinforced concrete slab bridge consisting of 13 spans supported on concrete pile bents. After crossing the wash the roadway transitions into District IX's first full divided highway with a 22-foot median. The new alignment avoids recrossing the main wash, remaining to the east with the aid of extensive channel excavating for approximately one mile before swinging completely out of the main wash area. The divided highway runs for two miles before it transitions back into two lanes for the last mile tying into the existing road about 4½ miles north of the mouth of the canyon.

After leaving the main wash area the new alignment crosses one of the major tributaries to Red Rock Canyon at three locations. This wash drains an area of some 16 square miles, and has an estimated maximum flow of 830 second-feet; 556 lineal feet of 108-inch field assembled plate culvert were used in these three crossings.

Use Wooden Forms

All work on the bridge was completed on the job site. The contractor set up a pile casting yard and cast the 6,150 lineal feet of concrete piling using wooden forms. The usual procedure was to cast 8 to 10 piles per day, stripping and reforming for the next pour the following morning; 142 piles were poured in this manner. Pile driving was accomplished with a combination of jetting and driving with a diesel hammer.

In lieu of conventional falsework for the bridge deck, the contractor used a sand fill placed by rubber tired scrapers and dozers after pile driving was completed. The sand fill was fine-graded by hand and one-fourth inch plywood nailed to 2 x 4 sills was used to form the soffit for the deck slab. The sand fill was removed by skip loaders after waiting vainly several weeks for a flood to come along and wash it out.

Upon removal of the sand blanket, used in curing the deck concrete, it was found that the finished deck did not meet the smoothness requirements. The contractor elected grinding as a corrective measure.

Deck Is Smoothed

A Concut Bump Cutter was obtained to plane the entire deck thereby improving both the appearance and the riding quality of the bridge and bringing the work within the permissible tolerance for smoothness.

Grouted imported rock protection was also used on this project with the rock being placed with a "Gradall" which eliminated the need for all but very little hand labor. Grouted rock slope protection was used on the embankments adjacent to the wash, at each side of the south bridge abutment, and at the inlets and outlets of the 108-inch field assembled plate culverts.

Due to limited headroom and close spacing of piles it was impractical to place rock and grout beneath the bridge at the south abutment. Here slope protection was provided by placing a four-inch mat of Gunite reinforced with 4″ x 4″ steel mesh to a depth of 12 feet below channel grade.

The second contract was completed on February 3, 1960, by R. R. Hensler, Inc., at a cost of approximately $700,000. C. E. Forbes and M. D. Tetrick were resident engineers on this contract. An interesting note is the fact that both jobs were supervised for different contractors by the same superintendent, Mr. Ray Mason.

When coupled with a previous project to the south, completion of this work gives the district its longest continuous four-lane highway, seven miles. The two contracts combined, consisted of 735,700 cubic yards of ditch and channel and roadway excavation and 26,400 cubic yards of grouted rock slope protection.

All work was under the general supervision of District Construction Engineer J. R. Jarvis and District Engineer E. R. Foley.

New realigned four-lane section climbing out of main wash of Red Rock Canyon. The grouted rock slope protection extends 12 feet below the interception channel.

US 101 in Ventura Will Be Six-laned

The State Department of Public Works today has awarded an $8,209,756 contract to Griffith Company, Los Angeles, for grading and surfacing 4.6 miles of six-lane freeway on US 101 between Telephone Road and Palm Street in and near Ventura.

Ten structures will be built, including traffic separation bridges, a pedestrian overcrossing, and railroad grade separation structures.

Resident Engineer in District XI Retires

William T. Rhodes, long-time Resident Engineer for the California State Division of Highways in the San Diego area, retired on February 1. Rhodes, who was employed by the State for 39 years, acted as the State's representative on numerous construction projects both in the central as well as the southern portion of the

William T. Rhodes (right) with E. E. Wallace, retired District Engineer of District XI.

State. During his career, he developed a number of aids to the field of Highway Engineering. Among them the "Rhodes Arc," which rapidly calculates the relationship of Horizontal to Slope distance for surveyors, is the widest used. Other innovations have been "Rhodes Ready Reckoner" for determining pavement depth during construction, and "Rhodes Temporary Striping" consisting of white painted tar paper which is glued to new paving with asphalt binder to delineate traffic lanes through new construction.

Rhodes participated in highway development and growth during its greatest period of change and has supervised construction projects ranging from two-lane desert highways to the complex US 80 Freeway between Grossmont Summit east of La Mesa to Chase Avenue in El Cajon.

On retirement, Rhodes and his wife, Marguerite, plan an extended trailer tour. They will maintain their residence in San Diego.

KERN COUNTY

Continued from page 44 . . .

crete deck, but due to a steel shortage it was decided to use the prestressed concrete channel type for the second structure.

The fifth and final contract to complete the four-lane divided road was accepted in July 1958.

The total cost of the 2.3-mile Manor Street Freeway-expressway, not including expenditures for right-of-way or engineering, was approximately $971,600. The roadway is plant-mixed surfacing over eight inches of Class "C" cement-treated base with curbs and gutters for drainage and traffic control. The roadbed was constructed with a core consisting of sand from the Kern River and the outside 12 feet and top 2.5 feet with a select material obtained from a borrow pit adjacent to the south end of the job. The reason for this is evident since the sand was in the middle of the project and next to the road, which made the sand borrow economical. The facing material was necessary since the embankment would be subject to washing or scouring when the Kern River overflows into the flood plain.

South End Interchange

Another interesting feature of this project was the construction of the interchange at the south end. This interchange was constructed in an abandoned borrow pit where 80-foot cuts were involved and, 150 feet away, 44-foot fills were required.

The Alfred Harrell Highway freeway begins on top of the bluffs and consists of a one-way down ramp and a one-way up ramp that are separarated by a vertical distance of about 350 feet. The west ends of the two-ramp are one-half mile apart but are connected at the bottom by an interchange. The old two-way China grade serves as the one-way up ramp.

The continuation of this freeway to the west entrance of Hart Park was completed in August of 1959. This last contract was four miles long and had two complete interchanges with necessary frontage roads for access to all properties. The total cost of the work done to date on this project, not including engineering or right-of-way, is $1,024,000 for about five miles of freeway. This roadway is three inches of plant-mixed surfacing over 6 inches of cement treated base with curbs and gutters at interchanges for drainage and traffic control.

The proposed freeway extension will include at least three additional interchanges and possibly four. There are three interchanges on the completed portion.

State Awards Contracts

As required under the federal-aid secondary highway program all contracts were awarded by the State Department of Public Works. Federal funds were provided through the U.S. Bureau of Public Roads and the State Division of Highways. A portion of the matching moneys consisted of state highway funds which, along with the federal funds were apportioned to Kern County in accordance with state statutes. A substantial portion of the matching funds were provided by the county.

The resident engineer on all the contracts except the first bridge contract on Manor Street was Charles M. Call. The resident on the first bridge contract was George J. Hummel. These projects were designed, engineered, and inspected with county personnel all under the general direction of Vernon G. Smith, Road Commissioner. The Kern County Board of Supervisors co-operated with the planning and financing of these projects.

La Forge Honored by County Engineer

At the California County Engineers Association annual dinner this year in Los Angeles, California Division of Highways Principal Engineer Harold B. La Forge was honored in a surprise ceremony. La Forge, who has been in charge of the Division's Federal Secondary Roads program since 1945, was presented with a gift subscribed to by the entire membership. Association President R. P. O'Neill of Butte County praised the Division of Highways engineer for the excellent relationships he has maintained during his 15 years on the job.

Profilograph—2

History of Measuring Devices In California Is Described

By FRANCIS N. HVEEM, Materials and Research Engineer

THE CALIFORNIA DIVISION OF HIGHWAYS became interested in means for evaluating road roughness more than 30 years ago, and for many years construction forces, resident engineers and contractors were "kept on their toes" by the fact that pavements would be evaluated for roughness at the completion of the contract. The devices used were of the type de-

> This article is the second of two describing the development of use of devices for measuring the roughness of pavement. This material was also presented before the Highway Research Board at its 39th Annual Meeting in Washington, D.C., January 11 to 15.

scribed previously in the form of a mechanically operated counter actuated by the movements of the front axle of a car. (Figs. 16, 17, 18.) In 1950, the mechanical difficulties of the car-mounted Roughometer were overcome by the development of an electronic device, but differences between cars still affect the readings.

A novel instrument developed by E. L. Seitz, Resident Engineer of the California Division of Highways,[1] is the Bumpograph (Fig. 19) which was intended solely for use during the construction of asphaltic concrete pavements. When wheeled by hand over a section of pavement, the Bumpograph would mark all of the high spots with white chalk. The machine was light in weight, weighing only about 30 pounds and had a wheelbase of approximately eight feet.

While serving as a resident engineer on a paving contract, the author developed a simple profile measuring device which it now appears was identical in principle to the original Viagraph ascribed to Mr. Brown of Belfast 40 years earlier. The mech-

[1] *California Highways and Public Works*, February 1937, page 26.

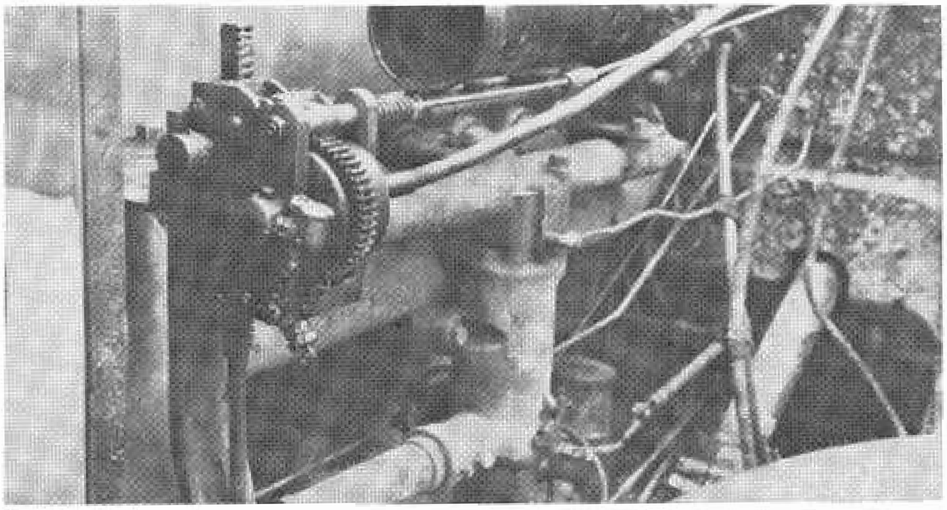


FIGURE 16—Shown above is the method of mounting the Roughometer rack and roller on an automobile.

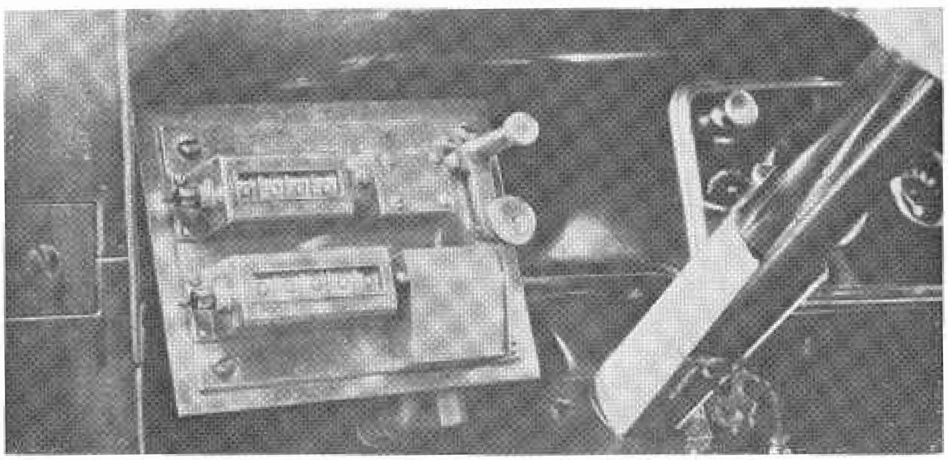


FIGURE 17—The Roughometer shown mounted on the instrument board of an auto.

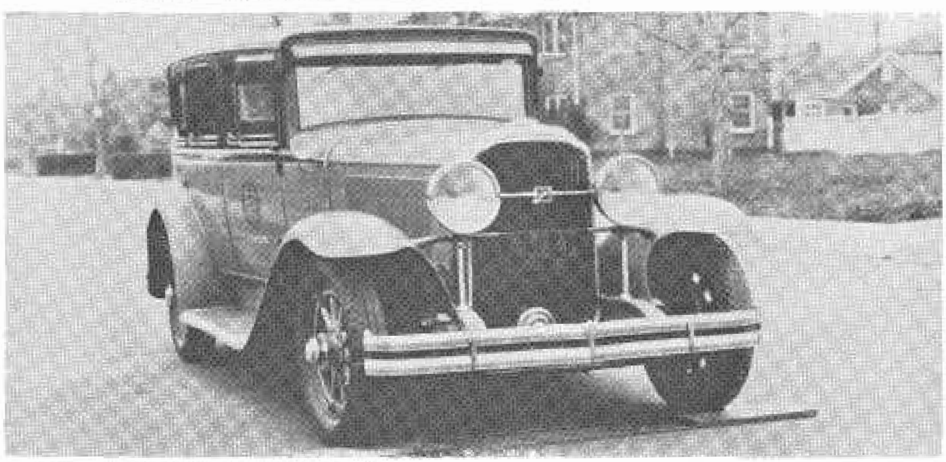


FIGURE 18—Testing the Roughometer with one-inch boards—1931.

anism used, however, was much less involved than that shown for Brown's Viagraph. The straightedge was constructed of two pieces of 1" x 6" lumber 10' in length. The paper feed roller was driven by a small rubber-tired wheel and the mechanism taken from a small hand-operated churn served as a reduction gear. The stylus was a common lead pencil and the platen supporting the paper was an empty tomato can. Graph records were quite accurate and reproducible. However, the unit was somewhat noisy in operation and dragging the "sled" for any appreciable distance became a little wearing.

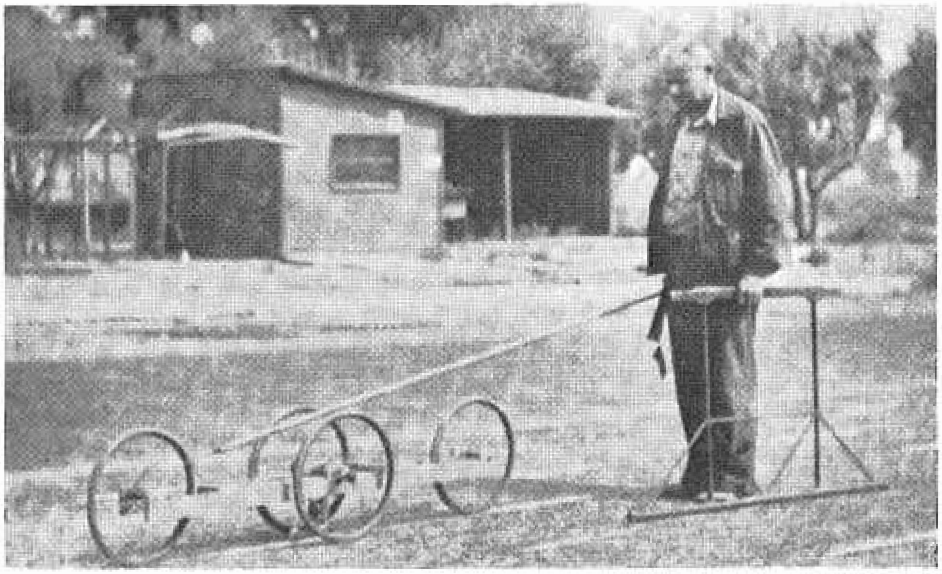


FIGURE 19—The Bumpograph, shown above, was constructed by E. L. Seitz, of the California Division of Highways, for detecting bumps during construction of asphaltic pavement.

First in California

In 1940, after becoming associated with the Materials and Research Department, a more elaborate device was constructed (Fig. 20), which consisted of a frame 10 feet in length supported upon multiple wheels at either end. The important feature of this first California profilograph [2] is the fact that the frame could be broken down into relatively small pieces for ready transportation in a pickup or in the tonneau of a small sedan. The selection of a 10-foot length of frame was due to the fact that California specifications for pavement finish referred to the amount of departure from a 10-foot straightedge placed on the surface. Profilograms obtained with this profilograph were compared with profiles plotted from level notes at five-foot intervals and also comparisons were made over sections of pavement by stretching a steel piano wire and measuring ordinates with a steel scale (Fig. 21). Agreement appeared to be sufficiently close for all practical purposes but unanswered questions always persisted as to the exact shape of the bumps in the pavement.

[2] California Highways and Public Works, March-April 1944, pp. 6-9.

Longer Base Needed

With the general increase in the speed of traffic and trend toward vehicles with a longer wheelbase, it was concluded that an improved profilograph should have a longer frame and a 25-foot length was selected more or less arbitrarily. Experience in operating the hand-propelled profilograph on pavements subjected to high speed traffic has shown that this is definitely a hazardous occupation. Therefore steps were taken to develop a unit capable of more rapid operation and which would offer reasonable protection to the operator. In order to accomplish both purposes a profilograph mechanism was incorporated into a two-ton truck. The frame of the truck was lengthened and became the principal "beam" member. The truck was equipped with a series of small bogie wheels in the front and rear making a total of 10 wheels in line. Figure 22 shows this truck with the operator carried by an independently supported frame pushed ahead of the truck; this position enables him to get a close view of any cracks or defects which are registered on the profilogram by manually pressing appropriate buttons on the console. Figure 23 shows the unit with the driver in an elevated position back of the cab. This position is used whenever it is not necessary to mark cracks or joints on the profilogram. The vertical movement of the extra bogie wheels is mechanically integrated and then electrically integrated with the movement of the truck frame in order to produce a datum representing the mean elevation of the high or low spots of the pavement which are in contact with the 10 wheels.

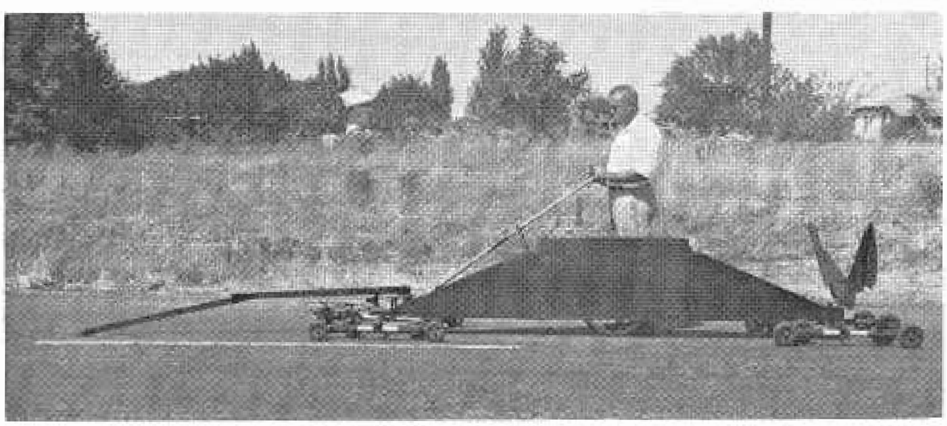


FIGURE 20—The multiwheel profilograph with 10-foot base length developed by the California Division of Highways.

Vertical Motion Recorded

The "profile" is recorded from the vertical movement of a wheel attached

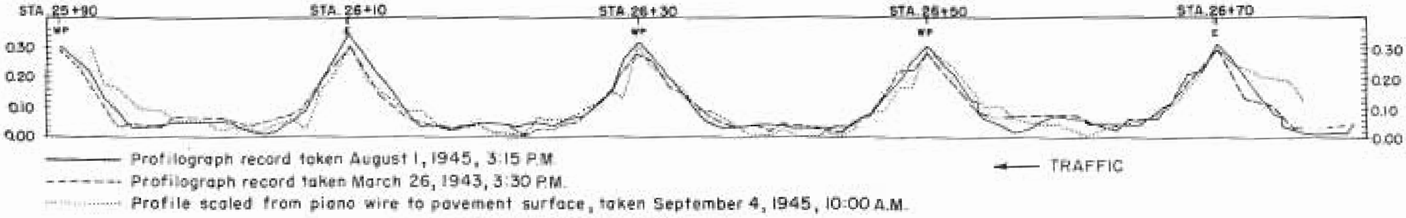


FIGURE 21—The above graph shows the relative accuracy of profilograph records compared with a profile obtained by stretching a piano wire and scaling off set to pavement surface. The pavement shown is a badly curved or warped concrete pavement.

to the truck frame at the midpoint and is always with reference to the mean elevation of 10 points of contact with the road surface. This self-powered mobile profilograph was constructed in 1955 and has been operated over the length and breadth of California and was sent on one trip to Colorado to record the riding qualities produced with a slip form type of paver. This truck model has proved to be eminently satisfactory and has given little or no trouble in operation and has enabled us to make records over many miles of existing highways. This unit has been duplicated with some modifications in the State of Michigan and reported by William S. Housel and Olaf L. Stokstad in a paper entitled "Pavement Profile Surveys to Correlate Michigan Design Practice With Service Behavior." [3] It has permitted setting up of a tentative scale for evaluating pavement roughness and relating this scale to the so-called riding qualities or the reactions to road roughness of drivers and passengers in motor vehicles.

[3] Proceedings of the 38th Annual Meeting of the Highway Research Board, Vol. 38 (1959).

While the truck-mounted profilograph is invaluable for securing measurements over many miles of an existing highway system and for following the changes that take place with time and traffic, it is, of course, not suitable for use on jobs under construction. The truck is obviously too heavy for safe application on a newly constructed concrete pavement. Therefore, there is a need for a lightweight profilograph and a new model has been constructed using the same wheelbase as the truck unit and which produces a graph record by mechanical means that is virtually identical.

Unit Too Light

There had been some complaint from operators using the original small plywood unit that crosswinds at times created problems in operating the machine. Therefore, a 25-foot unit using a tubular aluminum frame was constructed in an attempt to meet this objection (Fig. 24). While satisfactory so far as operation and ability to knock down and reassemble the tubular frame, this material and type of construction proved to be relatively expensive and so in 1957 another hand-propelled model was designed using a plywood frame constructed in five sections for ready knockdown and transportation (Fig. 25). This model, constructed of plywood, appears to be superior in most respects considering rigidity, ability to nest units for conservation of space in a transporting vehicle, enclosing of the operating mechanism for protection against damage and above all the lowest initial cost of construction. This instrument is intended primarily for use to check the surface roughness of newly constructed pavements. The profile of the finished pavement is recorded on a graph record or profilogram to a horizontal scale of one inch equals 25 feet and a vertical scale of one inch equals one inch which is the same as the scale established for the mobile truck-mounted unit.

Number System Evolved

Since the first roughness measurement devices were constructed, there has been an instinctive and virtually automatic move on the part of en-

FIGURE 22—A mobile profilograph constructed by the California Division of Highways in 1955 showing the operator in position to record cracks and joints.

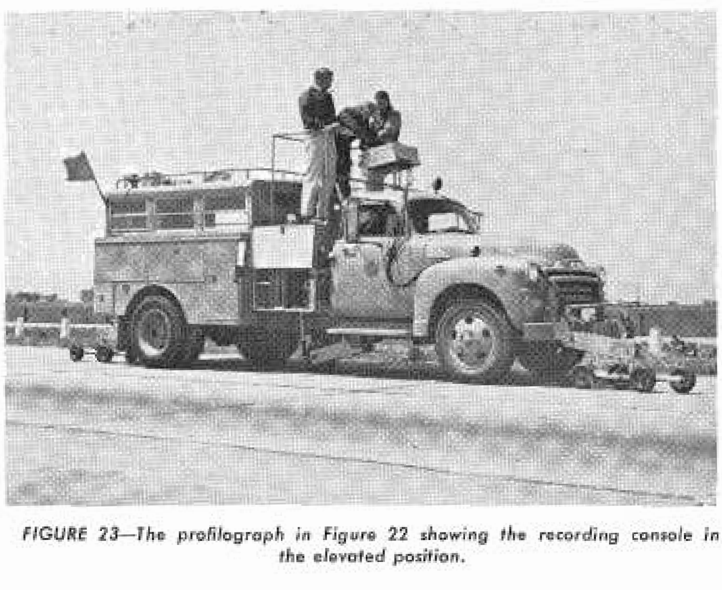


FIGURE 23—The profilograph in Figure 22 showing the recording console in the elevated position.

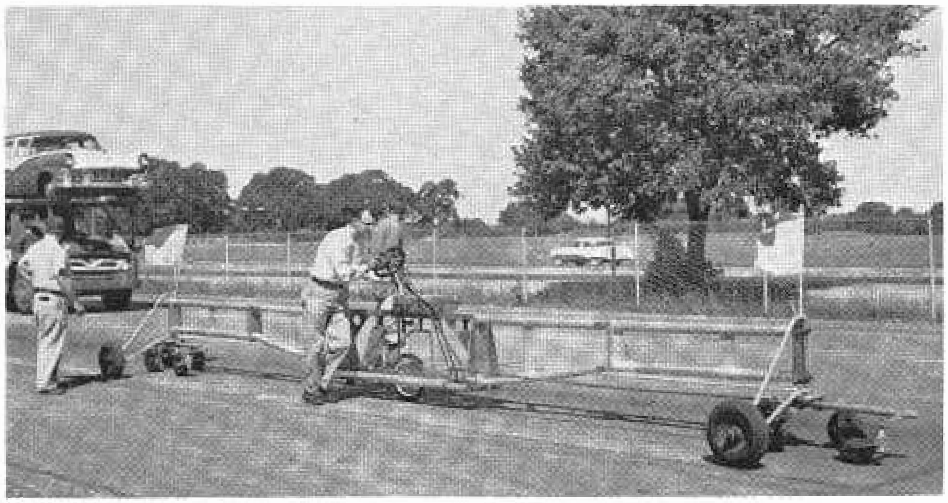


FIGURE 24—A hand-propelled profilograph with unitized frame for rapid knockdown.

FIGURE 25—The most recent model of a hand-propelled recording profilograph intended primarily for construction control.

gineers to reduce the data to a number. For example, in the report of Mr. Brown's Viagraph it is shown that he recorded a profilogram and he also expressed road roughness in terms of feet per mile. It is previously noted that he thought that 15 feet of roughness per mile represented a very satisfactory road! Throughout the years, engineers have converted the readings of roughometers, profilometers, etc., to numbers, thus California employed a unit of inches per mile to express results of a 'bumpmeter" mounted in an automobile.

The Bureau of Public Roads device has means for integrating the results, and Professor Housel has added a mechanism for accumulating the total distance involved in the vertical excursions of the recording stylus to develop a "roughness index." It is true, of course, that these numbers are convenient, but unfortunately often represent an oversimplification and no simple numerical scale has been devised to distinguish between large numbers of small asperities on the pavement surface as compared to a few larger and distinct bumps. The British machine uses a number of different counters but the results are not expressed by a single number. It appears that there is no substitute for a careful examination of the graph record if an engineer wishes to know what is going on during construction of a pavement or to study the nature of changes which are taking place with time and traffic. However, the use of a roughness "number" becomes less objectionable and is more justifiable as a means for specifying the surface finish to be obtained during construction.

New Index Made

Therefore, California has developed a new index which has been called the "profile index" to indicate that it is derived from the recorded profile or profilogram record. Appendix I, attached herewith, is taken from a report by Mr. Bailey Tremper describing in some detail how the profile index was derived. No claim is made that the roughness or riding quality of a pavement is directly or completely reflected by the profile index. It should again be emphasized that strictly speaking the devices reported herein do not furnish a direct index to "riding qualities." The most elaborate attempt to actually evaluate the response of a passenger is an elaborate instrument developed in Kentucky.[4] California duplicated the Kentucky machine and instrumentation but we were unable to interpret the results to give consistent or meaningful indices to rideability of a road surface. However, as a practical matter, it can be shown that if the profile index is very low the pavements are usually considered to be smooth and to have good riding qualities. At the present time California has established a profile index of seven which means that the contractor is permitted deviations outside of the 0.2 in. band which will not total over seven inches per mile or in proportion for shorter distances. A copy of our current specifications appears at the end of this article as Appendix II.

Cannot Differentiate

While the profile index appears to be reasonably satisfactory for use in specifications, it fails to differentiate between bumps or irregularities of different shape and of different length and this numerical expression does not adequately emphasive the annoyance in terms of riding qualities generated by badly faulted concrete pavement, for example. A somewhat more elaborate system of deriving a numerical index will be necessary if it becomes important to assign num-

[4] "Triaxial Acceleration Analysis Applied to the Evaluation of Pavement Riding Qualities," Gregg, L. E. and Foy, W. S., Kentucky Department of Highways.

bers to existing highways or airfields. It is to be doubted that there will ever be any adequate substitute for careful visual examination of the recorded profiles which convey information on the frequency, magnitude and shape of the inequalities, and it seems unlikely that all of these factors can be adequately identified by any simple numerical expression even tho the numbers are produced by feeding the profile record into one of the modern electronic calculators or data reduction "mechanical brains."

In order to illustrate some of the relationships and information which may be derived from pavement surface profilograms, several examples are shown. Figure 26 represents three profiles taken of the same stretch of pavement plotted by different means. Profile (a) was developed from level notes with rod readings taken at $2\frac{1}{2}$-foot intervals. The readings were adjusted to eliminate any effects of pavement grade or grade changes. Profile (b) is the same surface as recorded with a truckmounted profilometer (Fig. 22, 23). Profile (c) is recorded with a hand-propelled model illustrated in Figure 24. Figure 26 and Figure 21 both demonstrate the relative accuracy of these profilograms compared to other methods of measurement.

Some Variation

It will be obvious, of course, that the inequalities in the pavement are recorded with reference to the datum furnished by a 25-foot beam supported on multiple wheels at either end. In order to illustrate the effects of varying the length of the wheel base, Figure 27 shows a stretch of concrete pavement with marked faulting at most of the joints as recorded by the 25-foot truckprofilograph. The succeeding profiles represent the same stretch of pavement recorded with hand-propelled units in which the length of wheel base has been changed successively from 25 feet to 20 feet, 15 feet and 10 feet respectively.

It will be evident that while there is not much difference between a 20-foot and 25-foot length, the 10-foot wheel base does introduce some departures in the recorded profile. It will be noted, however, that the principal features are shown on all records, especially the magnitude of faulting at the joints. Figure 28 is included to illustrate some of the changes in surface roughness which may develop in a pavement over a period of time. Here are shown three stages in the life of a concrete pavement; namely, after four months, one year and three years. Figure 29 illustrates the improvement in riding qualities that develop from placing successive layers of construction. The lower graph is the surface of a cement treated base. The second is the surface of the first layer or leveling course of asphaltic concrete. Third represents the second layer of dense graded asphaltic mixture and the fourth or upper profile represents the finished surface of an open-graded wearing course. It will be observed that while most of the initial bumps were eliminated in the top course, nevertheless, the principal one which is shown is apparently the reflection of a bump in the base course.

Faulting Detected

One valuable attribute of the profilograph is the ability to detect incipient faulting. If the instrument is adjusted to give the proper sensitivity, it is possible to estimate faulting to the nearest 0.01 inch. Periodic measurements make it possible to follow the increase in faulting if it occurs. Faulting can be detected on a profilogram before it is apparent from an inspection of the pavement. Profilograms provide a convenient method for recording the location of cracks and also for determining whether there is any relationship between the high or low points in the profile and the location of joints or cracks in the pavement. Profilograms have been used to measure the warping or curling of slabs as affected by variables such as the maximum size of aggregate or nature of the cement. For example, Figure 30 shows several profiles taken from the Topeka test road illustrating some of these effects. (Note that the numerical values for roughness represent a total range from high to low points and on this chart do not correspond to the profile index scale.) Profilograms have made it possible to visualize the wide variations in curling of concrete slabs that often develop between early morning and late afternoon. They have also demonstrated that California pavement slabs as a rule are curled upward at the ends and it is only on warm afternoons that the slabs approach a condition of flatness. Very few examples have been found of pavements that assume a downward curl with the joints being low.

Profilograms furnish an invaluable means for recording the initial roughness of pavements as constructed and for following up and analyzing the changes which take place during the years following construction. It is axiomatic that if an engineer is to take steps to correct any deficiency he must understand the nature and cause of the thing he is trying to correct.

Acknowledgments

I wish to acknowledge the contributions of many individuals who have furnished information and material used in this paper and to those who have assisted in the development and use of the profilograph units constructed in this State.

Among those who have furnished helpful information are:

Mr. H. Petersen, Road Research Institute, Technical University, Hanover, Germany.

Mr. R. Peltier, Director of Research and Tests, Laboratoire Central des Ponts et Chaussees, Paris, France.

Mr. A. C. Whiffen, Head of Special Problems Section, Road Research Laboratory, Harmondsworth, Middlesex, England.

Mr. J. D. Lindsay, Engineer of Materials, Division of Highways, Springfield, Illinois.

Mr. W. N. Carey, Jr., Chief Engineer for Research, and Mr. A. C. Benkelman, Flexible Pavement Research Engineer, AASHO Road Test, Ottawa, Illinois.

Professor Ralph A. Moyer, University of California, Berkeley, California.

Among those who have made contributions to the work in this State are:

Mr. Bailey Tremper, Supervising Materials and Research Engineer; Mr. George Pomeroy and Mr. R. E. Wil-

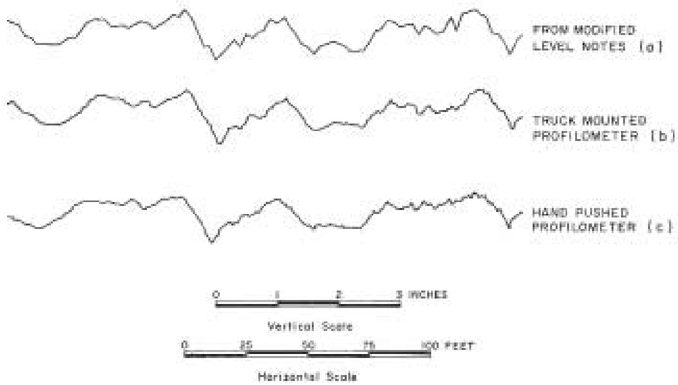


FIGURE 26—A comparison between three different methods of recording pavement roughness.

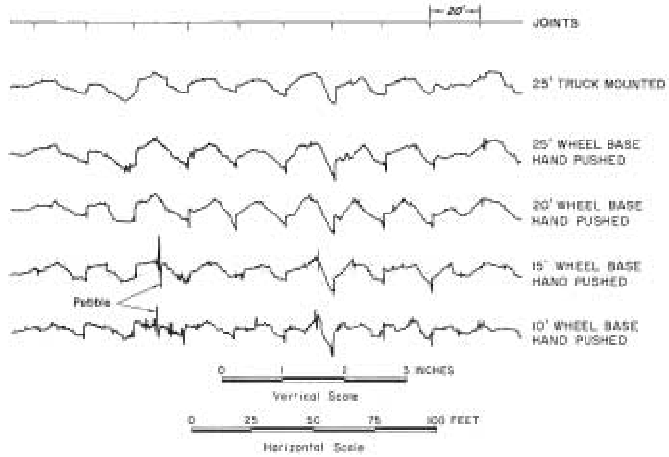


FIGURE 27—Profiles of a faulted concrete pavement showing influence of varying the length of wheelbase on the profilograph.

helmy, Chief Instrumentmakers; Mr. J. L. Beatty, Mr. Charles W. Clawson and Mr. Douglas Howard who have operated the profilographs over many miles of road.

Mr. J. E. Barton, who suggested the electrical circuits making possible the compensating device on the truck-mounted profilograph, and Mr. Robert Field, who worked out the mechanical and electrical circuits for this unit.

Mr. Don Spellman, who developed the profile index.

Appendix I

MEASURING PAVEMENT ROUGHNESS FROM PROFILOGRAMS

During the spring and summer of 1956, profilograms of selected pavements in the nine districts were recorded with the new truck-mounted profilograph. These pavements were selected by the districts in response to a request for examples of "smooth" and "rough riding" pavements, of both portland cement concrete and bituminous types. The profiles covered 60 miles in all representing 17 sections of each type. Some sections were two-lane and others four-lane and since profiles were nearly always made of the two outer lanes, the lengths given above are only about one-half the total profiles obtained. All profiles represent the outer wheel track, about 30 inches from the edge of the pavement, recorded in the direction of traffic. From this group, 15 sections of portland cement concrete pavement and 11 sections of bituminous pavement were selected for study.

At the time the profiles were made, the operators recorded their personal observations as to relative roughness when driving over the roadway in a car. Disagreement in terms of personal impressions was found with only a few of the district ratings. Such disagreement, however, was only to be expected since the profilograph operators were making comparisons on a statewide basis, while the districts were presumably comparing roads within their own areas. It is believed that the observations made by the headquarters profilograph operators should be more consistent on a statewide basis and for this reason they are used in the discussion that follows.

The classification as to riding comfort must necessarily be broad because in addition to the factor of personal reactions, speed and type of vehicle are other prominent variables. Nevertheless, among the pavements selected, examples were found that could be classified as distinctly either rough or smooth without much likelihood of

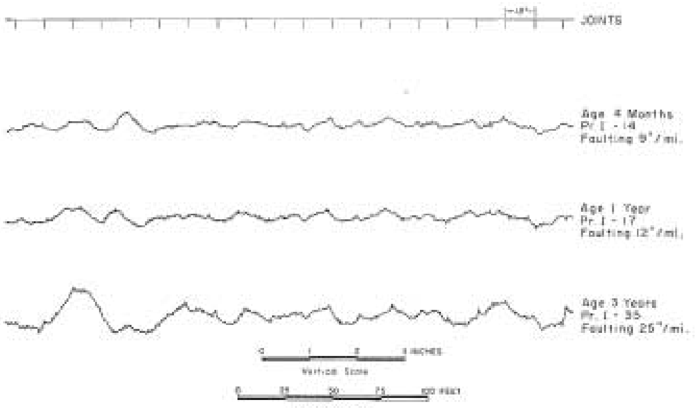


FIGURE 28—The three recorded lines above show the progressive roughening of a concrete pavement.

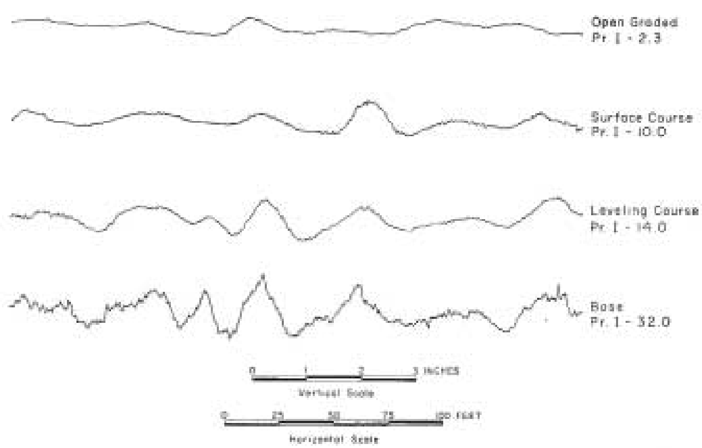


FIGURE 29—A comparative chart showing the improvement in riding qualities (reading bottom to top) as successive layers of pavement are placed over a base.

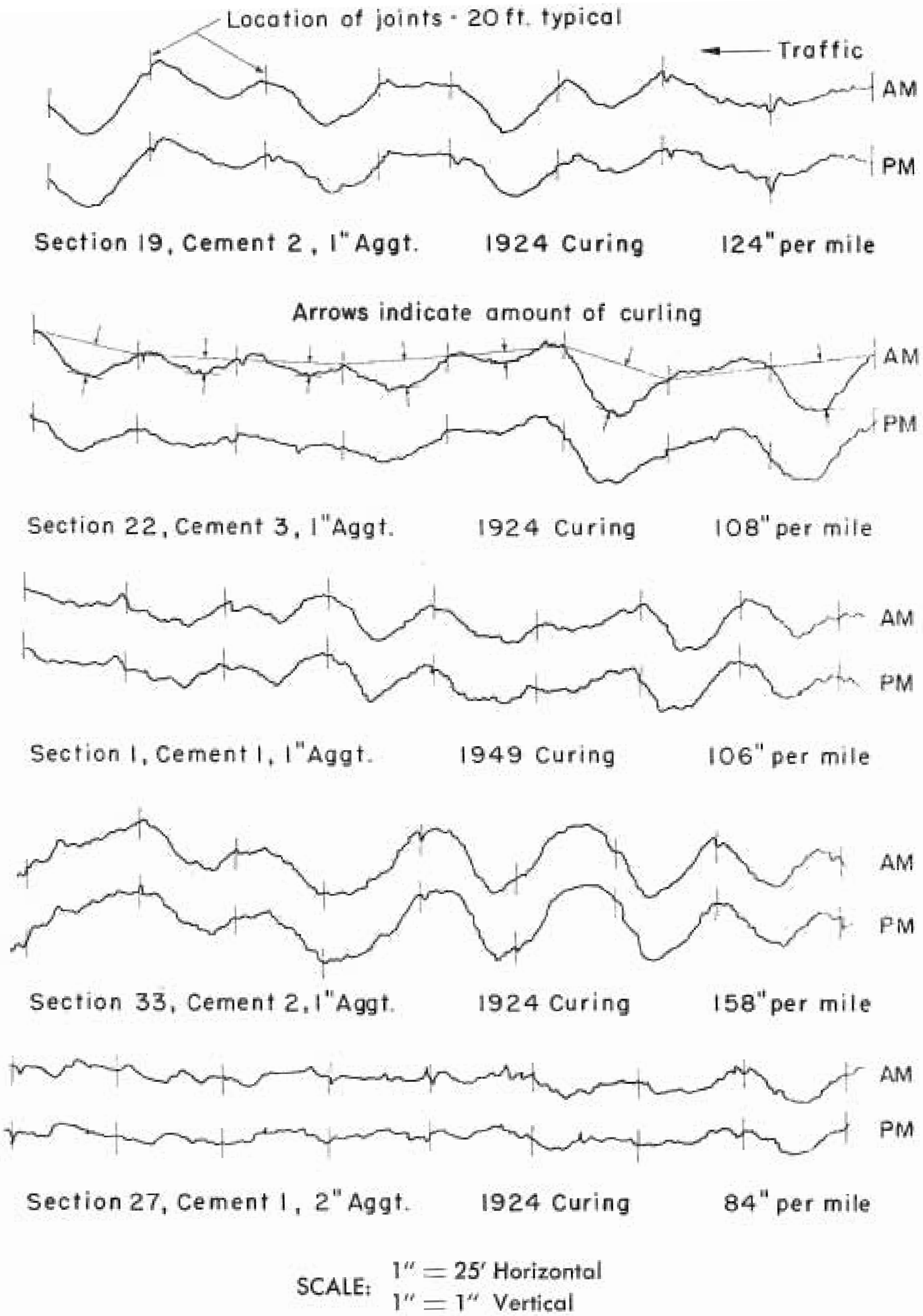


FIGURE 30—A profilogram record of the Topeka road test showing warping or curling of pavement slabs.

disagreement. In the intermediate zone it is not unlikely that there would be some difference of opinion as to which pavements are smoother than others.

Profile Analysis

Various expedients were tried seeking to convert the profilogram records to a numerical scale that would correlate with the jury classification.

To speed up the evaluation and make use of the fact that rough roads showed short waves or "scallops" having ordinates over three-eighths inch, Mr. Don Spellman conceived the idea of evaluating roads on the basis of vertical deviations only after blanking out those portions of the profile showing only minor inequalities which apparently cause little discomfort to the passengers in a motor vehicle. A "blanking" band of 0.2 inch was arbitrarily selected and a summarization of the measurements of the peaks and low points exceeding that amount were made on several profiles by selecting one-mile sections that were typical of the job.

It was found that a minimum of one mile of profile was needed to obtain a reasonably representative section of road. Even then some profiles exhibit wide differences in appearance from one end to the other and cannot well be represented as "average." This is one distinct advantage of the profilogram record in that such varying areas can readily be seen on the graph and located on the road. The entire profile could be used in an analysis but of course this would lengthen the time required. The counts or total number of inches deviation obtained by this method varied from two inches to over 90 inches per mile. To avoid confusion with previously established usage, the term "inches per mile" in excess of 0.2 inch will be given another name, to indicate that these values are derived from the profile. This term "profile index (0.2 in.)," leaves room for other terms which may correlate better with "riding quality." A profile index (0.2 inch) of 2 inches to 10 inches on a portland cement concrete pavement appears to be typical of new pavements and old ones in good condition. Counts of 40 or over would be considered rough. Other methods yet to be devised may better describe roughness or may better express "riding qualities."

Appendix II

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT CONCRETE PAVEMENT

40-1.10. Final Finishing.—After the preliminary finishing has been completed, the edges of an initial pavement lane shall be rounded with an edging tool having a 0.04-foot radius. Transverse contact joints, expansion joints, and joints adjacent to an existing pavement shall be rounded with an edging tool having a 0.02-foot radius.

When a straightedge 10 feet long is laid on the finished pavement surface, and parallel with the centerline of the highway, the surface shall not vary more than 0.01 foot from the lower edge of the straightedge. Upon completion of the pavement, if any high

. . . Continued on page 71

'Tempus Fugit' Corner

Twenty-five years ago. The following items appeared in the March and April 1935 issues of *California Highways and Public Works.*

FIRST FREEWAY

The State Legislature designated the Arroyo Seco Parkway as a secondary highway in the state highway system, thus making the project eligible to receive allotments from the city's share of the gasoline tax in the Cities of Los Angeles, South Pasadena, and Pasadena for starting work on surveys, plans, and acquisition of rights-of-way on California's *first freeway.*

CATWALKS FOR CABLE SPINNING

A wire rope was drawn across a mile of water between San Francisco and the concrete center anchorage of the San Francisco-Oakland Bay Bridge midway to Yerba Buena Island. It was then raised to the tops of Towers W-2 and W-3 for the first support of the first of the two catwalks built over the bridge tower tops preparatory to spinning the cable of the first of the twin suspension bridges between San Francisco and Yerba Buena Island.

RETALIATION

On March 26, Grizzly Dome, towering 1,000 feet above the North Fork of the Feather River 35 miles east of Oroville, struck back at the river for ages of cutting deeper and deeper through the canyon, and without warning dropped 75,000 cubic yards of rock into the North Fork along the line of the proposed state highway. Work on the highway had not yet reached the vicinity of the slide. George M. Webb was resident engineer on the job.

SNIP WENT ANOTHER BOTTLENECK

The transformed American River Bridge on 16th Street on the northerly approach to Sacramento was dedicated on March 24. Constructed 20 years previously as a two-lane structure, it was widened to four lanes with five-foot sidewalks on either side.

NEW SIGNS HELP MOTORISTS CHECK SPEEDOMETERS

Participating in the unveiling of the new speedometer check signs on the Bayshore Freeway were (right to left): Assemblyman Charles W. Meyers of San Francisco, Captain John Kennedy, in charge of the San Mateo unit of the California Highway Patrol, and Assistant State Highway Engineer J. P. Sinclair of District IV.

Following the adoption of Assembly Resolution No. 394 in the last session of the Legislature, new signs to assist motorists in checking speedometers have been installed at various locations on state highways.

The complete installation in each test location consists of black-on-white enamel signs showing: Speedometer Check Ahead, Mile 0, Mile 1, etc., and a final signpost with both Ending Mileage and End of Check. Signs are installed along the shoulder areas on both sides of a relatively straight, level section of highway. By noting the speedometer reading at the time of passing the Mile 0 sign and again upon reaching the last Mile sign, motorists will have a check on the accuracy of their speedometers in measuring distance traveled.

The first unit for use in the San Francisco Bay area, a two-mile interval, was installed along the open water portion of the Bayshore Freeway in San Mateo County near the south city limits of San Francisco. In company with Division of Highways representatives in District IV, Assemblyman Charles W. Meyers of San Francisco, author of the resolution providing for use of the signs, participated in the introduction of the signs along this first unit on February 25, 1960.

Two additional locations have been selected for similar installations in the Bay area and signs are now in process of installation: the Nimitz Freeway in Fremont near the Alameda-Santa Clara county line and US 101 between Cotati and Santa Rosa in Sonoma County.

BEAUTIFICATION PROJECT

In Santa Monica on US 101 Alternate along the famous Santa Monica Bluffs, the use of SERA workers furnished the labor for this most difficult of beautification projects, the State furnishing the materials and supervision.

Bridge Costs

Continued Decline Shown In Price Survey for 1959

By H. K. MAUZY, Senior Bridge Engineer and
W. J. YUSAVAGE, Assistant Research Technician

THE YEAR 1959 was the second consecutive year in which bridge construction costs were lower than those of the preceding year. The cost data maintained by the Bridge Department shows that the year 1957 represented

> This article is the eighth of an annual series dealing with California bridge construction costs. The seventh article appeared in the March-April 1959 issue.

the high point of costs with an index value of 283. During 1958 the index dropped to a value of 267, or to a level 5.7 percent below that of 1957. During 1959 the index dropped still further, to a value of 260 or to a level 2.6 percent below that of 1958. Since the budget expenditures by the Bridge Department were roughly $65.1 million and $44.3 million for the years 1958 and 1959, respectively, real savings relative to the cost level of 1957 were roughly $4 million and $3.7 million for the corresponding years. (The 1959 figures do not include those for the Webster Street Tube and the Benicia-Martinez Bridge. The corresponding totals for the two projects were $15,513,365 and $14,238,485.)

The level of costs for successive periods is presented graphically in an accompanying chart which summarizes the course of California bridge construction costs since 1934.

Construction Activity

Due to the curtailment of funds for the Interstate Highway Program, the value of bridge work let to contract during 1959 was less than that for any year since 1953. The index of value, the measure of construction activity in terms of current dollars, dropped to a value of 860 or to 33 percent less than the 1958 value of 1,287. Coincidentally, the index of volume, the measure of construction activity in terms of 1939-40 dollars, dropped to

INDEX RELATING TO CALIFORNIA BRIDGE CONSTRUCTION AND PERIODIC DOLLAR VALUES OF LOW BIDS ON CALIFORNIA BRIDGE CONSTRUCTION

I Year	II Quarter	III Index of the cost of California bridge construction (1939-1940—100)	IV Index of the value of California bridge construction (1939-1940—100)	V Index of the volume of California bridge construction (1939-1940—100)	VI Index of the bids on California bridge construction (in millions of dollars)
1934	..	94	*60	*64	3.1
1935	..	88	*138	*157	7.1
1936	..	98	*72	*73	3.7
1937	..	114	*60	*53	3.1
1938	..	99	*78	*79	4.0
1939	..	101	*99	*98	5.1
1940	..	99	*101	*102	5.2
1941	..	122	*78	*64	4.0
1942	..	158	*80	*50	4.1
1943	..	165	*16	*9	.8
1944	..	153	*29	*19	1.5
1945	..	167	*109	*65	5.6
1946	..	182	*247	*133	12.7
1947	..	215	*443	*202	22.8
1948	..	229	*307	*134	15.8
1949	..	201	*233	*117	12.0
1950	..	202	*269	*129	13.5
1951	..	248	*617	*247	31.8
1952	..	235	*561	*237	28.9
1953	..	229	*522	*227	26.9
1954	1st	221	691	313	8.9
1954	2d	217	1,196	551	15.4
1954	3d	*219 220	*870 1,002	*399 455	44.8 12.9
1954	4th	213	590	277	7.6
1955	1st	217	1,039	477	13.3
1955	2d	237	500	211	6.4
1955	3d	*228 228	*930 1,047	*408 461	47.9 13.4
1955	4th	237	1,148	484	14.7
1956	1st	245	833	340	10.7
1956	2d	284	1,083	381	13.9
1956	3d	*265 260	*1,117 604	*422 232	57.5 7.8
1956	4th	273	1,952	715	25.1
1957	1st	292	680	232	8.8
1957	2d	283	2,007	709	25.8
1957	3d	*283 275	*972 460	*343 167	48.0 5.9
1957	4th	281	740	263	9.5
1958	1st	259	1,219	471	15.1
1958	2d	268	1,841	687	23.7
1958	3d	*267 268	*1,287 1,468	*482 548	65.1 18.9
1958	4th	259	528	204	6.8
1959	1st	244 †260	1,437	589	18.5
1959	2d	309	396	128	5.1
1959	3d	*260 292 †262	*860 163	*331 .56	44.3 2.1
1959	4th	253	1,445	571	18.6

* Average annual index.
† Adjusted index due to insufficient quarterly data.

a value of 331 from the 1958 value of 482. The reduction, in terms of current dollars, amounted to about $20,000,000 less than the amount expended during 1958.

The construction activity indexes are designated as indexes of value and volume in the accompanying charts where the values are given for all periods since 1954.

Bidder Activity

The tendency of construction costs to fall during a period when costs in other sectors of the economy were either stable or were drifting upward is a clear indication of the strength of competition which prevailed during 1959. Competition involving bridge work was especially evident during this period; the average number of bidders for each of 115 projects let to contract during 1959 was 8.8 with 39, or 35 percent of the projects, each drawing 10 or more bidders. Bidding on projects let to contract during January 1960 is on a level with that of 1959, indicating that the competition which was generated in the past year is being carried into 1960.

Average Unit Prices

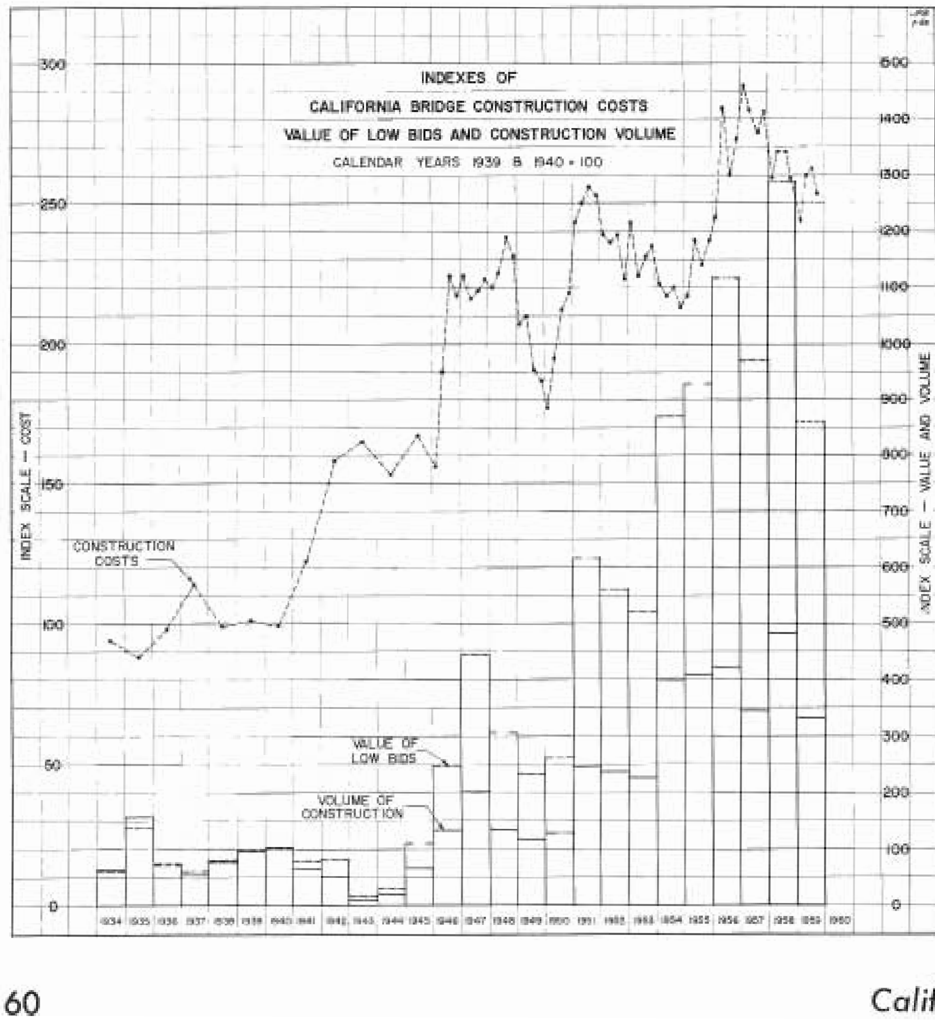
Unit prices for various bridge items declined further from the high levels of 1957. The costs of the three most significant bridge construction items have developed trends which are described as follows:

Class A portland cement concrete (structures) cost an average of $58 per cubic yard in 1957, dropped to $55 per cubic yard in 1958, and during 1959 declined again, to an average price of $52 per cubic yard or to a level 10 percent below that of the average price of 1957.

Structural steel (plate girder) cost an average of $0.205 per pound in 1957, dropped to $0.164 per pound in 1958, and now averages $0.163 per pound, a reduction of 20 percent from 1957 prices.

Bar reinforcing steel which cost an average of $0.123 per pound in 1957 and $0.124 in 1958, dropped to an average of $0.113 per pound in 1959, a reduction of about 9 percent from 1957 prices. In a significant number of projects the price of bar reinforcing steel has been reduced to about $0.10 per pound. The reduction of cost to this level is impressive, especially in view of the fact that a reduction of $0.01 per pound represents a saving of about $1,000,000 in annual construction costs.

An interesting development in connection with the pattern of unit prices is that there seems to be a growing tendency toward less variation among the different sectors of the State. Thus it is not too uncommon today to receive a price quotation of about $55 per cubic yard of Class A portland cement concrete for a project in some remote area such as the Whiskey Creek Bridge, northwest of Redding, where not so long ago such a price would have been entirely unlikely. This tendency to narrow the pattern of cost differentials is apparently due to the increasing industrialization of the state together with much improved accessibility to formerly remote areas.



Summary

Bridge construction costs began to decline during the second quarter of 1957 in conjunction with the then developing period of general recession. The general decline of construction costs continued into 1958 and was continuing at the close of the period of general recession. The persistent depression of construction costs may be ascribed to a significant curtailment in the outlays for the Interstate Highway Program as well as to sizeable reductions in other sectors of heavy construction.

The prospects for increased construction during 1960 are considerable; prominent among such outlays will be those for missile sites, reclamation and flood control projects by the federal government; outlays for industrial construction are likely to be increased, and the outlays for the Interstate Highway Program will also be increased although by smaller amounts than were anticipated several years ago.

The cost of producing steel will be higher but economic writers in gen-

. . . Continued on page 71

Pack Mules

Age-old Transportation Methods Prove Most Practical on Fence Job

By M. T. TRESIDDER, Resident Engineer

THE construction of freeway fence (Type BW) on State Sign Route 190 (Contract 59-6VC19, Terminus Dam Relocation) is now nearly complete. Due to the steep and rocky terrain in this portion of eastern Tulare County, it has proved to be a very difficult job.

The special provisions required that before any operation involving actual roadway excavation, except construction of pioneer and haul roads, were begun, property fencing on the south side of the right-of-way for the full length of the project was to be constructed; provided, however, that when any one parcel of property had thus been fenced, actual grading operations within the limits of the cross fences could proceed. To comply with this provision and in order to maintain a continuous operation on the fence work it was necessary to construct the fence at various locations in advance of construction of any pioneer and haul road construction.

Use Metal Posts

Components for the construction of the fence consisted of galvanized metal line posts 7 feet in length weighing approximately 22 pounds each and 8-foot tubular steel pipe posts weighing approximately 25 pounds each were required for end and corner posts. In addition to concreting the

The photos above were taken on the job to show some of the operations and the conditions under which they were performed. Supplies and equipment had to be brought up to the work site on mules.

end, corner and pull posts the special provisions required that when rock was encountered the line posts were to be placed in drilled holes and concreted therein. The latter proved to be the rule rather than the exception in many areas. This requirement necessitated the use of pneumatic drills and 500 feet of air hose was required to gain access to the fence line from vantage points where a compressor could be situated.

The major problem that arose during the construction of the fence was the matter of getting the construction materials up to the work area. During the first month of operations materials were taken as close to the work area as possible by means of a four-wheeled-drive vehicle and then were transported manually from that point. Each man was able to carry only two posts at a time and this method proved to be very slow and costly. This work was being undertaken in the middle of summer when the temperature was often in excess of 100 degrees, and to say the least it was a back-breaking job to carry this material to the fence line.

Mules Are Hired

When it became evident that the work areas were getting farther from locations that were accessible to a vehicle a packer with horses and mules was hired to transport the materials to the work areas. This method was very satisfactory and the production of fence construction gained accordingly. For the purpose of carrying posts outriggers were affixed to the pack saddles and the posts were tied to them. Each mule or horse was able to carry eight posts or about 175 pounds. The packer experienced some difficulty with his animals in the first few days while transporting posts but gradually they accepted their work without any outward signs of hostility.

Canvas side packs (kyacks) were attached to the packsaddles and were used to transport all the ingredients for the concrete, including mixing water in five-gallon cans, rolls of barbed wire, and many other minor items that were required for fence construction.

On the average one saddle horse and two packmules were utilized over a period of about three and one-half months.

Isbell Construction Company of Reno, Nevada, is the prime contractor on the project and the fence work is being done under a subcontract to Anchor Fence Div., Anchor Post Products Inc., of Sacramento.

LATHROP RECEIVES 'ENGINEER OF YEAR' AWARD

Scott H. Lathrop, Principal Engineer for Division of Highways, receives the Engineer of the Year Award of the Engineering Council of Sacramento from John Davis, president of Chapman College in Orange County. (Lathrop is a member of the college's Board of Governors.) The presentation, which was made at the annual awards dinner, was for Lathrop's "gift of time and talent in the enrichment of his community as President of the Sacramento Council of Churches" during 1959. Lathrop has been with the Division of Highways since 1931 and is Director of Personnel and Public Information functions.

Road Building Crew Finds Indian Site

Highway construction and archaeology joined hands on the Terminus Reservoir highway rerouting when workers found an extensive Indian dwelling site and burial ground while removing materials from a borrow pit.

Operations were suspended in the area where skeletons and artifacts were found and Jay von Werlhof, College of the Sequoias instructor and archaeologist for the University of California archaeological survey, was summoned to the scene by project workers. He confirmed that the burials were those of Indians and spent two days making a study of the area.

He said that there were some 20 burials, including several of children, in the doubled-up position traditional with Yokuts and Western Mono burials. Artifacts found included a portable stone mortar, pestles, a round game stone a little smaller than a baseball, obsidian chips, a disk of abalone shell drilled through the middle and other items. Von Werlhof said that the burials could be hundreds of years old. Much of the material was salvaged by von Werlhof for the COS collection although several of the burials were disturbed by curiosity seekers between his visits to the site and some material was lost.

Employees of the Isbell Construction Company and M. T. Tressider, resident engineer for the Division of Highways, co-operated with von Werlhof in the preservation of the artifacts which they had located.

CONSTRUCTION VOLUME

During February the department advertised for bids on 57 highway projects with an estimated value of $65,792,100, and awarded 17 contracts with a value of $21,586,800. During the same period 25 contracts with a value of $2,558,700 were completed. On March 1, 202 contracts with a total value of $344,847,700 were under way.

Bridge Engineer J. W. Green Retires

John W. Green, Supervising Bridge Engineer, Division of Highways, retired on March 1 after 30 years of service with the State. A dinner was given in his honor on March 2 at the Roger Young Auditorium in Los Angeles.

JOHN W. GREEN

Green was born near Jefferson City, Tennessee, on July 13, 1892. He moved to Crawfordsville, Oregon, where he received his early education. He completed his engineering training at Oregon State College, receiving his bachelor of science degree in civil engineering in 1916.

After graduation he worked in steam and hydroelectric powerplant design for the Fargo Engineering Company of Jackson, Michigan, design and construction of mine buildings as plant engineer for the New Cornelia Copper Company at Ajo, Arizona, as engineer with the Pennsylvania Railroad in Pittsburgh, highway engineer with the Michigan Highway Department, and with the U.S. Geological Survey in the Rocky Mountain area of Montana.

After returning from service with the Army in World War I, he worked as assistant bridge engineer for the State of Washington. In 1927 he joined the U.S. Bureau of Public Roads as associate highway bridge engineer in their district and regional offices in San Francisco.

He began his career with the Division of Highways in 1930 when he was employed by the State Bridge Department on preliminary studies, investigations and reports on the San Francisco-Oakland Bay Bridge. Material developed in connection with these studies was incorporated in the report of the Hoover-Young San Francisco Bay Bridge Commission.

When work on the Bay Bridge entered the design stage, Green was placed in active charge of the design, preparation of plans, and specifications for all of the substructure and approaches for the bridge. This included the design of the record-depth caissons used in the construction of the piers.

In 1939, following the completion of the Bay Bridge, he was placed in charge of all Bridge Department work in the southern area of the State.

For the past several years, as a representative of Headquarters office of the Bridge Department, Green has worked exclusively on studies and reports requested by the State Legislature in connection with proposed major bridges in Southern California. These include the San Diego-Coronado Crossing and the San Pedro-Terminal Island project which is now in final design stage.

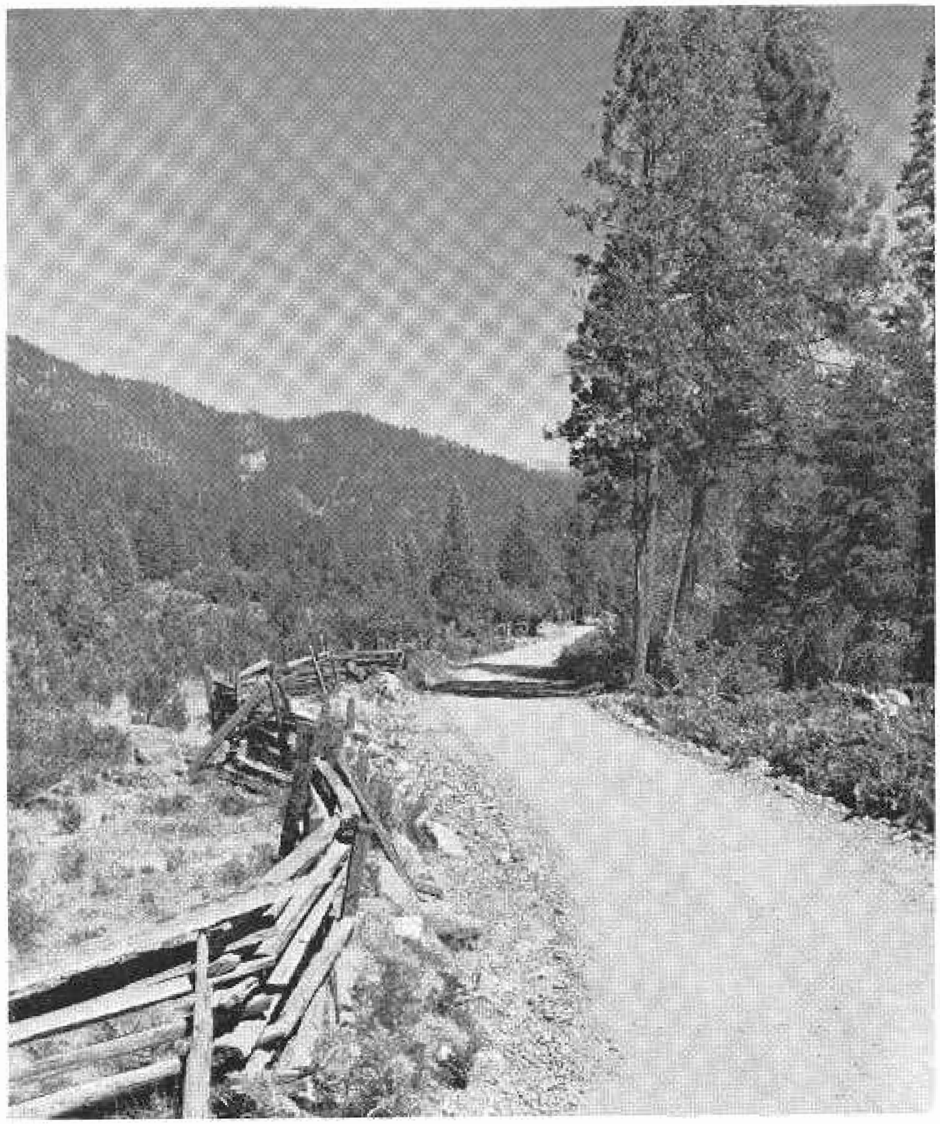
Green is a registered civil and structural engineer in California and a Fellow of the American Society of Civil Engineers. He was married to Meryle Nelson Green, who died in 1959.

Green lives in Glendora. His retirement plans include golf, photography, and extensive travel.

OREGON TRAIL

Continued from page 46 . . .

route both for recreational and commercial purposes is becoming more evident every day, and it is the resolve of Trinity and Siskiyou Counties to expend every effort toward continuing the work on this road until the entire route is constructed to modern standards.



This view of FAS 1089 south of Carrville in Trinity County is typical of the unimproved sections of the road which are being replaced by modern two-lane highway.

CONFERENCE

Continued from page 10 . . .

program as an outstanding example of federal-state co-operation."

Speaking of state-county relationships in road programs in California, Bradford said these "are acknowledged nationally as wonderful. A Chicago magazine featuring county road problems considered it nationally newsworthy last year that a California county had named a new F.A.S. road after an engineer working for the State Division of Highways." (This was Aramayo Way in Tehama County named by the county after Luis Aramayo, Assistant District Engineer of District II.)

During the special group sessions on Thursday afternoon and on Friday, several Division of Highways engineers delivered papers.

Maintenance Engineer Frank E. Baxter gave a paper on "Road Surface Maintenance" in which he pointed out the average motorist is probably more concerned with the condition of the traveled way surface than with any other visible part of the road, and then discussed how the Division of Highways maintains the various surfaces. In this connection, he said that the California State Highway System includes "approximately 1,700 miles of Portland cement concrete pavement, 10,500 miles of bituminous surface, 1,700 miles of oiled gravel, and even, believe it or not, approximately 100 miles of unimproved, primitive, earth roads."

Assistant State Traffic Engineer R. J. Israel spoke of speed zoning in relation to the 1959 law. Because of the new speed limit, he said, it has been necessary to establish 267 new restricted-speed zones extending over 360 miles of highway.

New Signal Patterns

Assistant Traffic Engineer R. W. Matthews discussed some of the new developments in multiphase traffic signal systems, and explained how they can be best used. "For many years," Matthews cited as an example, "we believed there was only one way to phase a signal with a left-turn lane and that is, Phase A for through traffic, Phase B for left-turn traffic, and Phase C for cross-street traffic. This enabled the through motorist on the highway to look at the side street signal with the knowledge that when it went yellow he should be ready to start. . . ."

New developments, Matthews explained, now offer three ways to phase this same left-turn signal. First, because many intersections handle an uneven amount of traffic in different directions at different times of the day, the original left-turn signal was refined to allow through traffic to continue in one direction if no vehicles were waiting to turn left.

This device speeded up traffic flow, but failed in its purpose if even one car entered the low volume left-turn lane. A new refinement now shortens the cycle in either of the left-turn lanes when traffic demand is light.

Aluminum Alloys Developed

Supervising Bridge Engineer W. C. Kiedaisch gave a paper on "Recent Developments in Small Bridge Design." In conclusion, he said, "The future in bridge design appears as promising as the past. Designs with aluminum alloys have been developed on an experimental basis. The use of high stress large-size reinforcing steel bars together with stronger concretes is probable in the immediate future. Concrete waffle and steel battle decks are being studied by the designers and, together with glued timber stringers (treated and fireproofed), have their economical applications.

"Economy is the primary justification for new design developments but it is surprising how often economy and attractive appearance go together. Fancy railings and exotic portals that used to be the fashion with the bridge designers added nothing to the appearance of the structure, but a lot to its cost. Improvements in bridge design, details, and materials will continue to be necessary if structure costs are to be kept down in a time of rising prices."

More than 500 engineers from California and nearby states attended the conference, which was under the sponsorship of the Institute of Transportation and Traffic Engineering, University of California. This annual conference was set up to provide a means whereby California road men might benefit by briefings on new techniques and other developments and by discussion of their current problems.

OLYMPIC TRAFFIC

Continued from page 38 . . .

ideal. The temperature was slightly above freezing and the sky a brilliant blue. Some 54,000 people visited the valley that day, arriving in 10,000 cars and 310 buses. The only problem was that of traffic jams because the cars just could not be admitted into the valley rapidly enough. This was not serious, as the jams were cleared in an hour or two, and everyone who wanted to enter the valley did so with only slight delay.

Although the operation was definitely blessed with good luck, its success was by no means attributable just to luck. Almost every day of the games, traffic equivalent to that of a rush hour cycle in a major city was handled smoothly and efficiently despite very difficult terrain and driving conditions. The many, many hours of meticulous planning paid off in a well-nigh perfect action, and certainly everyone connected with it added considerably to his experience as well.

James Lick Freeway Extension Adopted

The California Highway Commission has adopted a routing for approximately one mile of the Southern Freeway Extension (State Highway Route 253) in San Francisco between the James Lick Memorial Freeway (Bayshore Freeway) near Alemany Boulevard and Evans Avenue.

The adopted route follows a routing which had been adopted by the City and County of San Francisco before Route 253 was added to the State Highway System by the Legislature in 1959. The San Francisco Board of Supervisors, by resolution dated December 10, 1956, adopted the routing as a freeway. The commission announced in February that it was considering the adoption of a freeway routing and the San Francisco Board of Supervisors was asked if it wished the commission to hold a public hearing on the matter before taking further action to adopt a routing.

Division Announces Recent Retirements

Headquarters Office

George A. Karsten, Highway Equipment Operator-Laborer, 33

George W. Sloan, Highway Equipment Operator-Laborer, 28

Clarence T. Todd, Assistant Highway Engineer, 27

District II

Frank V. Day, Highway Leadingman, 31

District III

Joseph C. Havey, Highway Leadingman, 30

Matthew E. Ryan, Assistant Highway Engineer, 32

District IV

William Kane, Assistant Highway Engineer, 30

District V

Russell A. Adams, Highway Equipment Operator-Laborer, 25

Harold J. Wilkinson, Associate Highway Engineer, 31

District VI

Emil Hokanson, Associate Highway Engineer, 22

District VII

William V. Brady, Associate Highway Engineer, 23

Rex C. Farmer, Highway Foreman, 28

William W. Hollis, Highway Leadingman, 22

Leo A. Penney, Highway Leadingman, 33

Ralph E. Schott, Assistant Highway Engineer, 26

District VIII

Gilbert E. Malkson, Senior Highway Engineer, 31

District IX

Dorothy J. Bright, Assistant Highway Engineer, 15

District X

Elbert B. Clary, Drawbridge Operator, 7

John L. Oneto, Highway Leadingman, 28

Donald T. Wade, Laborer, 26

District XI

Raymond L. Potts, Laborer, 25

William T. Rhodes, Associate Highway Engineer, 38

Headquarters Shop

Harold H. Hamlin, Automobile Mechanic, 28

Shop 11

Horace S. Berry, Automobile Mechanic, 31

Transport Minister Visits District VII

Greater London is a teeming metropolis of 10 million Englishmen, 94 percent of whom use public transportation and the remaining 6 percent automobiles.

This constitutes a serious traffic problem, according to Ernest Marples, British Minister of Transport,

Assistant State Highway Engineer E. T. Telford (left) discusses the Los Angeles Metropolitan Freeway System with Ernest Marples, British Minister of Transport.

who visited Los Angeles early this year to study local freeway and traffic conditions.

In an interview with Edward T. Telford, Assistant State Highway Engineer in charge of District VII, and members of his staff, Marples expressed amazement at the great changes that have taken place in population, economic and industrial expansion, and motor vehicle registration in the City of Los Angeles and California.

In comparing London's transportation problems with those of Los Angeles, the Minister stressed the lack of space in his own city and the attendant difficulties of improving existing traffic facilities and constructing new ones.

Telford outlined the state freeway system in greater Los Angeles and explained results achieved and aimed for in the future to cope with increasing traffic and population. He said that present freeway planning was based on predicated needs over a 20-year period, and that planners were developing broad frameworks with an eye to providing "room for maneuvering" for future planners. He declared that the planning program was a dynamic thing geared to progress and expansion.

Minister Marples questioned the utility of a freeway system within London because of crowded conditions, but was urged by Telford not to discount this avenue of development. "We should strive for solutions today, keeping in mind that a perfect transportation system is next to impossible to achieve. We can at least provide liveable solutions," Telford said.

The Minister's party included John Garlick, secretary; H. Gamble, British consul general; and Sam Taylor, general manager, Los Angeles City Traffic Department. Also present at the interview from the District VII staff were District Engineers A. L. Himelhoch and Lyman R. Gillis.

IN MEMORIAM

District II

Joseph Becker, Highway Foreman.

District III

Earl L. Wortell, Assistant Highway Engineer.

District VIII

John L. Gardner, Highway Engineering Technician.

Mary R. Clifford, Intermediate Stenographer-clerk.

STATE GROWTH

Continued from page 2 . . .

plated in this State provides a unique opportunity to revamp much of our urban environment on a substantial scale in the interests of better living and safer, freer movement. The highway program will not only provide indispensable traffic service; it can, in many situations, help mold desirable land use arrangements. It can help to preserve homogeneous areas on the one hand, and on the other, to divide residential sections from industrial sections, or to effect desirable separation of other dissimilar land uses.

"It can also be a powerful stimulus to urban renewal. With proper co-ordination, the highway system and the land use plan can complement each other."

Catherine Bauer Wurster, Department of City and Regional Planning, University of California, told the conference:

"In shaping the future, no professions have a more significant role than the transportation experts and the urban planners, and their new 'togetherness'—exemplified in this conference—is a fine and hopeful sign. They deal with interrelated aspects of the environment: communication and land use. Their responsibilities are also intertwined, and it is more and more recognized that land use decisions determine future communications requirements, while the location and design of a freeway will in turn greatly influence the future development pattern."

City-County Planning

Hugh R. Pomeroy, director of the Westchester County Department of Planning, White Plains, New York, and a former California legislator and Los Angeles planner, gave a summation in which he suggested that intercity and intercounty planning on a regional basis is needed. He said it would provide a basis for comprehensive area plans to which highway plans could most effectively be related.

As a general comment, Pomeroy said:

"One of the beginnings of wisdom in planning is a recognition of our own fallibility as we attempt to forecast the future and to predict future needs. I am convinced that planning adequately means simply planning considerably beyond what, at any given time, we think we may need in the future.

"When it comes to determining how amply a thoroughfare should be provided for or how much land will be needed for public purposes in the future, it is certain that if the answer can be obtained from a slide rule or a calculating machine, it will not be enough.

"Statistical projections are subject to so many variables when they get more than a short distance into the future that they are seriously misleading unless judgment begins to condition them not very far out and then to take over not so far beyond that. It is too easy to build calculated shortsightedness into what we do.

"Except for some isolated freak situation, have we ever provided too much right-of-way for our thoroughfares, acquired too much park land, built too many playgrounds, provided too much automobile parking space? In the face of an almost universal record of inadequacy and shortsightedness, we should somehow have enough sense to realize that if we must err—and err we shall—we should do it on the side of amplitude—in other words, in the direction in which we must inevitably go. Any error in that direction will be only temporary."

Nineteen speakers and panel members took part in the conference. They included State Senator Randolph Collier, chairman of the Senate Committee on Transportation, Assemblyman Lee M. Backstrand, chairman of the Assembly Interim Committee on Transportation and Commerce, and Assemblyman Ernest R. Geddes. Max S. Wehrly, executive director of the Urban Land Institute, Washington, D.C., was one of the out-of-state speakers.

STATE FURNISHES TREES

More than 150,000 pine and eucalyptus seedlings, all grown in state-owned nurseries, will be planted along nine miles of US 40 in San Pablo and Crockett under a landscaping contract awarded by the State Department of Public Works.

NEILSON W. REESE

Neilson W. Reese, retired engineer of the Division of Highways, died March 14 after a short illness.

Reese retired in January 1955 from the position of assistant district engineer of the Division of Highways in Los Angeles, which he had held since October 1947. He was traffic engineer with District VII from March 1940 to October 1947. His service with the State dated from October 1931, when he was employed as senior bridge engineer, design and construction, on the construction of the San Francisco-Oakland Bay Bridge.

Prior to entering state service, Reese in April 1919 was employed as construction engineer with the Oregon State Highway Department; in 1923 he was design and construction engineer bridge consultant with Dr. Gustav Lindenthal; and in 1928 went into consulting practice in design and construction of dams and powerhouses.

Reese was born in Cleveland, Ohio, in 1894. He attended grade school at Lakewood, Ohio, and high school at Cleveland, and was graduated with a B.S.C.E. degree from the University of Illinois in 1920. He came to California from Oregon in 1930.

He was an Army veteran of World War I.

Reese is survived by his wife, Ruth J., and one son, Jack, who is employed by the Standard Oil Company in the San Francisco Bay area.

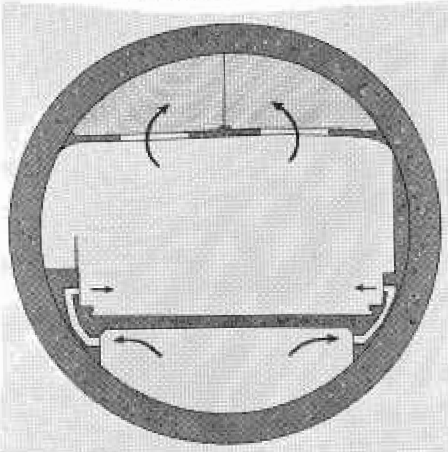
Traffic Slows After Speed Signs Posted

Motorists are reducing their speeds, at least temporarily, following installation of the new 65-mile maximum speed limit signs on highways in open country, a Division of Highways speed check has indicated.

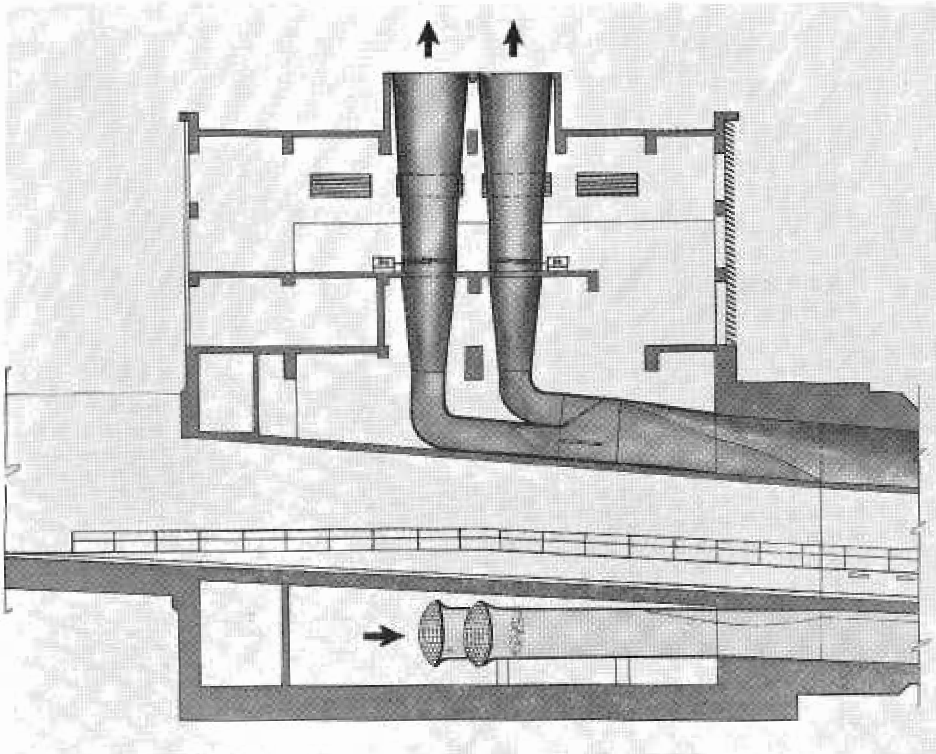
The speed checks were made at locations on US 91-66 north of Victorville, on US 66 southeast of Barstow, and on US 91-466 northeast of Barstow. After the signs were posted, average speeds were from three to five miles an hour slower.

WEBSTER ST. TUBE

Continued from page 12 . . .



Arrows indicate movement of air typical of "Transverse" ventilation system.



Longitudinal cross section of portal building showing arrangement of fresh air intakes and exhaust stacks.

noise level. There is a three-foot walkway on the west side for pedestrians and tube personnel. The tunnel is 3,350 feet long from portal to portal.

The entire area below the roadway slab is used for fresh air supply and the area above the ceiling is used to exhaust air. Air is fed from the supply duct through flues spaced at nine-foot centers along both sides of the roadway and near the roadway level. Air is exhausted through ports in the ceiling spaced at approximately 14-foot centers. This method of ventilation is known as the "transverse" system since there is a minimum longitudinal movement of air in the traveled portion of the tunnel. With this system, smoke and fumes from possible vehicle fires are localized. There are four blower fans and four exhaust fans in each portal building capable of handling nearly a million cubic feet of air each minute.

Has Two Sections

A transverse wall in both the fresh air duct and exhaust air duct divides the tunnel into two sections for ventilating purposes. These walls are placed nearer the Alameda end from the center of the tunnel. This makes it possible to supply more air in the upgrade portion of the tunnel where more vehicle exhaust gases are generated.

The amount of air supplied to the tunnel can be controlled manually or automatically by a vehicle counting device that adds the vehicles entering the tunnel and subtracts those leaving. In this way the amount of air supplied will depend upon the number of vehicles actually in the tunnel. Modern carbon monoxide recorders will keep a continuous record of carbon monoxide content and ensure that reasonable levels are maintained at all times.

Separate high-voltage electrical services will be installed in each portal building to supply power for all operating needs. There will be a tie cable between the buildings and all power will normally be taken from one source. In case of failure of that source, the load will be automatically transferred to the other source for such length of time as may be necessary.

Protective System Installed

The tunnel has a complete and up-to-date police and fire warning and protective system.

Consideration was given to the communication problem during construction and a private automatic telephone system is included in the contract. This will make it possible to make adjustments in the number and placing of telephone instruments as the needs of the work dictate with the contractor's own forces. As the work nears completion the system will be installed in permanent form for use by the operating and maintenance forces.

Several temporary bridges must be built to permit construction of the tube. A S.P. Co. spur track in Alameda will be carried across the dredged area on a temporary trestle. This trestle will have a removable span to permit the precast segments to be floated past it into position. On the Oakland side, three S.P. Co. tracks at First Street, one W.P.R.R. track at Third Street, a 105-inch interceptor sewer and a 48-inch sewer must be carried across the trench in which the cast-in-place portion of the tunnel will be built. Since this trench varies in depth from about 70 feet to 45 feet, the construction problem can be readily appreciated.

Upon completion of the Webster Street Tube it is planned to close the Posey Tube temporarily and modernize its interior to match the new tube.

When completed both tunnels will be among the most modern in the world.

U.S. 50 FREEWAY

Continued from page 9 . . .

A view showing area cleared for the MacArthur Freeway, looking westerly toward the Bay. Distribution structure at upper left. Present MacArthur Boulevard through Oakland shown at upper right, and again at extreme lower right at the intersection with Harrison Street.

vided. The minimum curve radius on the freeway will be 1,150 feet and the maximum grade will be 4 percent. The freeway will have 10-foot shoulders on the outside with 8-foot shoulders on the inside within a 22-foot median. Shoulders will be provided on structures as well as on graded sections. It is planned to use the new-type cable chain link barrier in the median on the portion now budgeted.

The most complicated and difficult design problems encountered have been where other freeways cross. This occurs at two locations: near the westerly end where the proposed Grove-Shafter Freeway crosses the proposed MacArthur Freeway between Grove Street and Telegraph Avenue and at the easterly end where US 50 intersects Route 228.

The design of the interchange with Grove-Shafter has been completed, and the one with Route 228 has just begun. The interchange with the Grove-Shafter Freeway provides a minimum radius of 600 feet for all freeway movements. It provides for all possible movements between the freeways and also for many local movements from streets in the vicinity. Because this interchange is near the downtown area and in a heavily populated section, there is a large demand for local service at and near the interchange. To properly provide this local service and also a high standard freeway interchange was difficult and costly to accomplish.

Freeway Is Planned

This freeway is planned to be constructed on graded sections, with structures only at grade separations. Retaining walls will be used to save improvements in some areas where economically feasible. It is planned to landscape the freeway to blend in with the surrounding area.

The technical staffs of the cities and counties involved have been very cooperative during the design study stages. The state and local officials all realize that careful planning of freeway connections to local streets is necessary to provide proper traffic service without disruption to freeway or local traffic.

The public is looking forward to the many benefits that will be provided by this freeway. The overloaded Nimitz Freeway along the shore of the bay will be relieved after this freeway is complete. Motorists using Highway 50 will, of course, benefit by timesaving and the increased safety of the new facility. Those who cross the present facility will also benefit. The grade separation features of the new freeway will make it much easier and safer for cross traffic and pedestrians to cross this main arterial. The merchants along existing MacArthur Boulevard will also benefit because of decreased traffic congestion. This will make it much easier for their customers to drive and to park along the existing street. Now that construction is starting, it will not be long until some of these benefits will be realized.

FREEWAYS IN SAN DIEGO

Among recent call for bids by the Division of Highways is a $3,650,000 freeway job on US 80 in El Cajon, San Diego County. This project, along with other current or budgeted jobs, will provide 17 miles of continuous full freeway between Taylor Street in San Diego and Third Street in East El Cajon.

HATCHET MOUNTAIN

Continued from page 34 . . .

As a result of this one failure, a 700-foot section of the embankment had to be removed and stockpiled while the original ground was excavated to a depth of 35 feet for the placing of perforated metal pipe underdrains and pervious material in order to de-water and stabilize the area. The repairs required the handling of 343,500 cubic yards of material, including stockpiling and replacing. By comparison, this amounted to 77 percent of the earthwork required for constructing the entire 3.56 miles of Unit No. 4. Cost of the restoration work was $280,000.

Traffic Used Old Route

A two-mile section of Unit 4 was closed for several months and traffic was carried on the old route during repair work. Experience gained from this development was utilized in the design of the subsequent unit. It is now standard practice to investigate the quality of material underlying all large embankments, to a greater extent than was possible in former years. The district employs mobile drilling equipment capable of penetrating to depths of 150 feet below the surface of the ground. Determination of subsurface water with concurrent unstable soils is of primary importance in the investigation of the embankment foundations.

Unit No. 5 consisted of constructing 5.28 miles of roadway at two locations and terminating at Burney Valley three miles west of the town of Burney. The work was done by M. W. Brown between July 1958 and December 1959 at a cost of $1,421,685. Location "B," between Hatchet Mountain Summit, and Burney Valley, proved to be the wettest area of the entire section. Water was encountered in every cut on the project and each required perforated pipe underdrains. Embankment areas were wet too.

Drains Are Installed

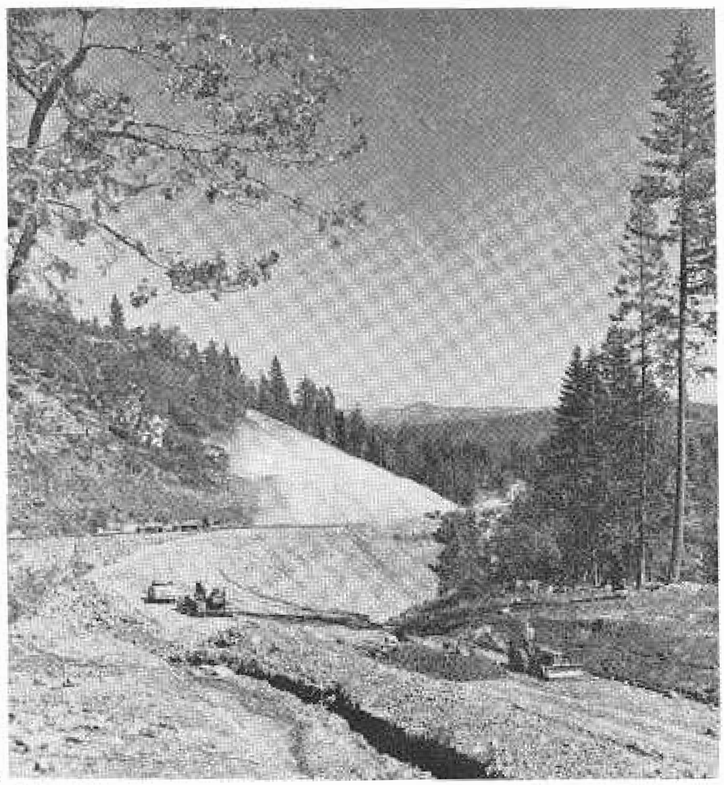
Stabilization trenches similar to the restoration work performed below original ground on Unit 4 were constructed under three embankment areas. A series of vertical drainwells 70 feet deep were installed under an embankment area that would not economically lend itself to the construction of a stabilization trench. The vertical drainwells consisted of 24-inch diameter holes with 8-inch perforated pipe in the center and backfilled with pervious material. The drainwells are designed to act as vertical collector pipes and were placed on 20-foot centers. Two-inch horizontal drains were drilled in to intercept the lower portion of the drainwells and provide an outlet for the system.

All five units have been constructed to a 32-foot roadbed with three inches of bituminous surfacing. Six inches of cement-treated base was used on all but Unit 1 which was 6 inches of untreated base. Imported subbase material or selected material varied in depth from 6 inches to 15 inches as required by the variable basement soil quality.

Units 3, 4, and 5-B are limited access expressway.

Improvement of the section has reduced the distance by one mile, but of greater significence is the 15-minute reduction in average driving time for the 15-mile trip.

West from Burney Valley showing nearly completed expressway.



During construction, east side of Hatchet Mountain, rough grade completed. Trenches are for perforated pipe underdrains. Old road appears in left background.

Bridge Department

McMahon Succeeds Panhorst; Downing, Dunn Appointed

FREDERICK W. PANHORST, the State's Chief Bridge Engineer for the past 29 years, retired April 1 after a long career of public service, most of it with the California Division of Highways.

Panhorst was Assistant State Highway Engineer—Bridges and headed the division's extensive Bridge Department, which handles about $140,000,000 in structure work annually.


F. W. PANHORST

State Highway Engineer J. C. Womack appointed James E. McMahon to succeed Panhorst. McMahon was formerly in charge of the department's branch office in Los Angeles where he served as Bridge Engineer—Southern Area.

Dale F. Downing, Assistant Bridge Engineer—State-owned Toll Bridges, was promoted to replace McMahon as Bridge Engineer—Southern Area.

Promoted to fill the position of Assistant Bridge Engineer—State-owned Toll Bridges was Thomas J. Dunn, Sacramento area construction supervisor.

Saw Staff Grow

During his 33 years with the Division of Highways Panhorst saw the division grow from a staff of 115 to nearly 1,000. During the same period the allocations for bridge construction also grew, starting at $3,250,000 and culminating in today's $140,000,000. Panhorst saw his own responsibilities grow rapidly with the increase in the need for more and better bridges for the State of California.

Before joining the Division of Highways he had worked as an engineer in such areas as naval architecture, plant design and railroad bridge construction. Three years after joining Division of Highways he was promoted to the position of Acting Bridge Engineer, replacing Charles E. Andrew who had been assigned to the San Francisco-Oakland Bay Bridge project. In 1936 Panhorst became permanent Bridge Engineer and in 1947 he attained the civil service rating of Assistant State Highway Engineer—Bridges.

Billion Dollar Total

During his 29 years as department head, Panhorst was responsible for the planning, design, construction and maintenance of what he modestly refers to as "maybe $1 billion" in bridge and tunnel projects, including hundreds of separation and interchange structures for the State's expanding network of freeways. Such complex structures as the parallel Carquinez Bridge on US 40, the Webster Street Tube in Oakland, the Benicia-Martinez Bridge and all of the State's elevated freeway structures were planned and undertaken during Panhorst's tenure as Assistant State Highway Engineer—Bridges.

Work is soon to be started on yet another major bridge project, plans for which were prepared under Panhorst's supervision. This structure, the San Pedro-Terminal Island Bridge at Los Angeles Harbor, will be Southern California's first state toll bridge. Panhorst was also responsible for the operation and maintenance of the San Francisco-Oakland Bay Bridge as well as the other state-owned toll bridges in the San Francisco Bay area.

Praised By Legislature

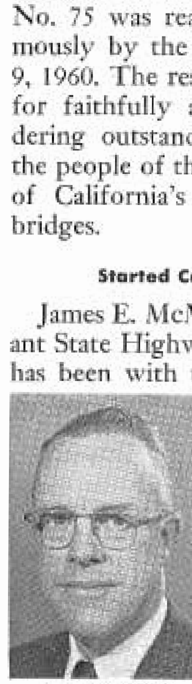
Born in Mexico, Missouri, Panhorst attended grade and high schools in Staunton, Illinois. He received his bachelor of engineering degree in 1915 and his professional degree in 1936 from the University of Illinois.

Panhorst is a past national director of the American Society of Civil Engineers, and a former president of the Sacramento section of that organization. He is a member of the Structural Engineers Association, the American Concrete Institute, the American Association of State Highway Officials, the American Roadbuilders Association, and the American Toll Bridge and Turnpike Association.

In recognition of his years of faithful and outstanding service to the State of California, House Resolution No. 75 was read and adopted unanimously by the Legislature on March 9, 1960. The resolution cited Panhorst for faithfully and energetically rendering outstanding public service to the people of the State and to all users of California's many highways and bridges.

Started Career in Riverside

James E. McMahon, the new Assistant State Highway Engineer—Bridges, has been with the Division of Highways continuously since 1931, except for five years active duty with the Navy during World War II. At present he is a captain in the reserve.


J. E. McMAHON

He began his career as a member of a highway maintenance crew in the Riverside-San Bernardino region, and later served as a junior highway engineer in the Redding area.

From 1933 to 1936 he worked on the San Francisco-Oakland Bay Bridge project. He returned to Southern California in 1936 as an assistant bridge engineer. In 1953, following a series of promotions, he was advanced to bridge engineer—Southern Area.

McMahon was born in Chebanse, Illinois, and went to high school in Kankakee. He attended Marquette University and received his civil engineering degree from the University of California at Berkeley in 1931. He is a registered civil engineer and a registered structural engineer. A member of the American Society of Civil Engineers, McMahon also is active in the Toastmasters Club.

Joined Division in 1941

Dale F. Downing, the new bridge engineer–Southern Area, has been with the Division of Highways since 1941 when he was assigned to the Bridge Department in Sacramento. Soon after reporting to work he was called to active duty in the Army and it was five years before he was able to settle down to peacetime engineering with the department. Still active in the reserve Downing now holds a commission as lieutenant colonel.

DALE DOWNING

A native Californian, Downing was born in Los Angeles. He attended grade school in Seattle, Washington and high school in Roseville. He studied at Sacramento Junior College and received his engineering degree from the University of California at Berkeley in 1938.

Before his assignment as bridge engineer–Southern Area, Downing was assistant bridge engineer–state-owned toll bridges.

Started as Draftsman

Thomas J. Dunn, newly appointed assistant bridge engineer–state-owned toll bridges, began his career with the Division of Highways in 1931 as a draftsman in the Fresno area. Five years later he became a junior engineer and in 1952, after several years spent as resident engineer on bridge projects, he was assigned duties as an area construction supervisor.

THOMAS J. DUNN

Another native Californian, Dunn was born in Fresno and he attended grammar, high school and Fresno State College all in his hometown. He is a registered civil engineer.

In his new position Dunn will assist Bridge Engineer Howard C. Wood in supervising the operation and maintenance of the five state-owned toll bridges in the San Francisco-Oakland Bay area.

PROFILOGRAPH—2

Continued from page 57 . . .

points are in excess of 0.01 foot, they shall be removed by abrasive means.

In addition to the requirements in the above paragraph, the pavement surface shall be tested by a profilograph in accordance with the methods in use by the Laboratory of the Division of Highways.

The profile index, as measured by the profilograph, for any one-tenth mile section shall not exceed the rate of 7.0 inches per mile along any line parallel to the edge of the pavement. Any deviations, which produce a profile index rate of more than 7.0 inches per mile in any one-tenth mile section, shall be reduced by abrasive means to provide the required profile index. Such abrasive means shall not produce a polished pavement surface. If the daily average of the profile indexes, measured along lines approximately 2.5 feet from the edges of each traffic lane, before grinding, exceeds the rate of 7.0 inches per mile for any three consecutive working days, the paving operations shall be discontinued until suitable equipment and methods are provided by the contractor and approved by the engineer.

Freeway Adopted on Feather River Route

The California Highway Commission has adopted a freeway routing for approximately 7.3 miles of US Highway 40 Alternate (Feather River Highway) between Sloat and 0.7 mile west of the Feather River Inn in Plumas County.

The adopted route generally follows the existing highway but provides some minor relocations to eliminate sharp curves and steep pitches. It was recommended by State Highway Engineer J. C. Womack.

Plans of the Division of Highways call for the construction of a modern two-lane highway, with access control, on the adopted route. Provision will be made for an ultimate four lanes. The estimated cost is approximately $2,275,000 for the initial two lanes, including rights of way for four lanes. Start of the construction will depend on the availability of future highway funds.

Sections Opened on Golden State Route

Two segments of the Golden State Freeway in downtown Los Angeles were opened to traffic March 18.

The two freeway construction projects representing a combined cost of over 10½ million dollars complete the Golden State Freeway from Sixth Street to Pasadena Avenue, a distance of approximately two and one-half miles. At the Pasadena Avenue end of the freeway temporary connections are provided by Avenues 19 and 20, one-way routes southbound and northbound, respectively, between Albion and Lacy Streets, and connecting with heavily traveled Riverside Drive and San Fernando Road. At the Sixth Street end of the freeway temporary connections are provided at Boyle Avenue. At various intermediate points along the freeway route are connections to east-west city streets, including interchange facilities with the San Bernardino Freeway.

The Golden State Freeway is now completed at two separate locations, between Sixth Street and Pasadena Avenue and between Glendale and Burbank Boulevards, together totaling some nine miles and a construction cost of more than 26 million dollars.

BRIDGE COSTS

Continued from page 60 . . .

eral foresee no increase in steel prices until after the 1960 election because of the political overtones which have become associated with an inflationary economic situation. Other industries will probably be urged to follow the course of the steel industry to keep prices constant.

The foregoing observation point to a year of general price stability. The improved situation in the field of heavy construction may, however, moderate the current competitive situation and thus open the way to higher construction prices.

EDMUND G. BROWN
Governor of California

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1912

The old photo shows U.S. Highway 101 in 1912 before it was a state highway. This section is just south of the Ventura-Santa Barbara county line. The point in the distance is Rincon Point.

Financed mainly by private contributions, the wooden viaduct was built by Ventura County about 1910. Before it was built, the only road was along the beach, often impassable because of the surf.

For its day, the viaduct was an ambitious project. Without mechanized road equipment, the cost of rock and earth fill sufficient to raise the roadbed above the surf would have been prohibitive, whereas lumber was cheap.

Although damaged by wave action many times, the viaduct was continued in use until 1924. With funds provided by the new gasoline tax law enacted the year before, a 20-foot high concrete seawall was constructed to hold a fill and protect a 40-foot roadbed.

In 1949 the right-of-way was widened to accommodate four lanes divided. The outer edge of the fill was protected this time by a riprap seawall of boulders weighing up to 10 tons brought from Riverside County by rail. Fill was carried beneath the railroad on a conveyor belt through a tunnel.

1959


Walnut
Creek
SOUTH