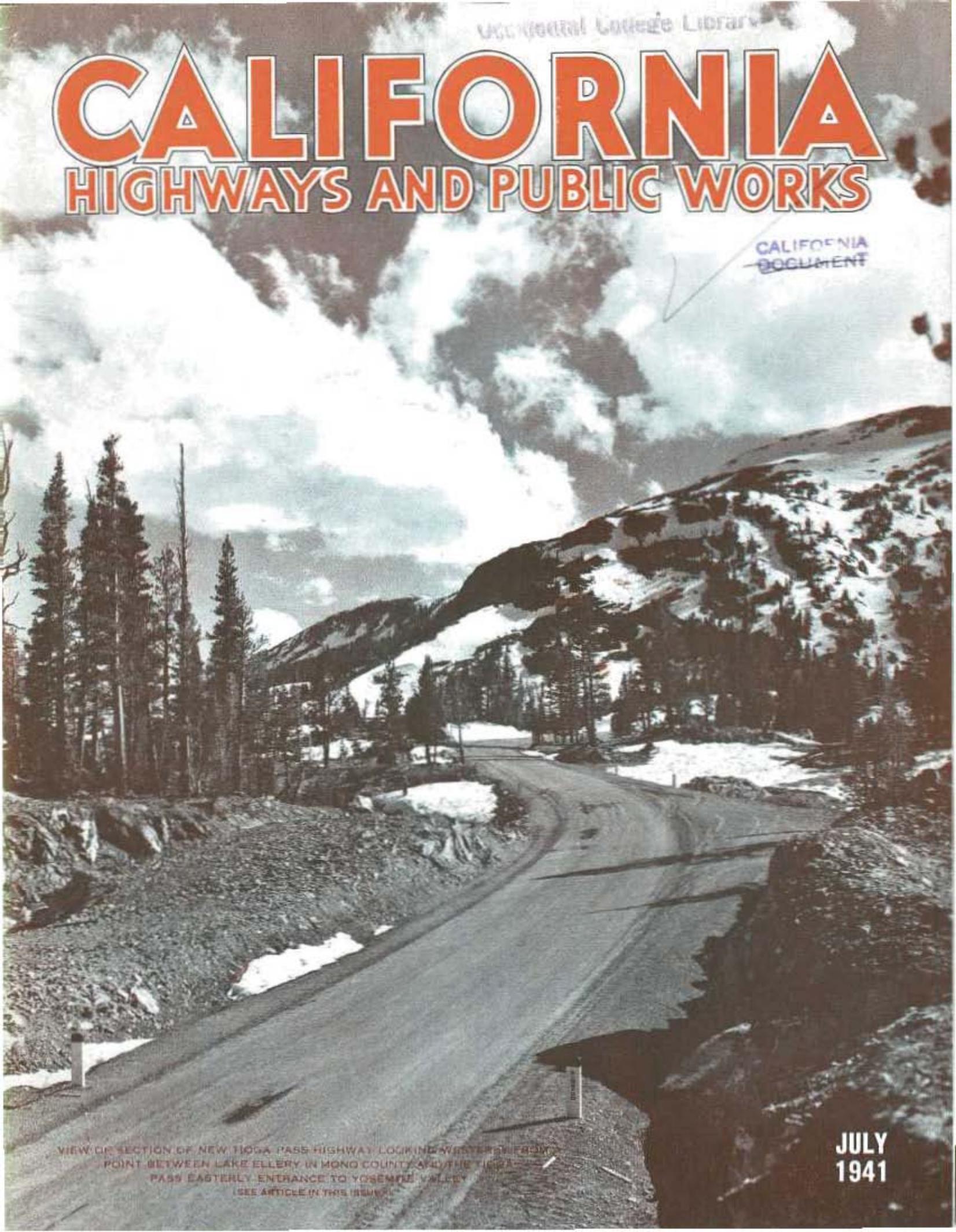


CALIFORNIA

HIGHWAYS AND PUBLIC WORKS

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VIEW OF SECTION OF NEW TIoga PASS HIGHWAY, LOOKING WESTERN FROM
POINT BETWEEN LAKE ELLERY IN MONO COUNTY AND THE TIoga
PASS EASTERLY ENTRANCE TO YOSEMITE VALLEY
(SEE ARTICLE IN THIS ISSUE)

JULY
1941

CALIFORNIA HIGHWAYS AND PUBLIC WORKS

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

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Slide Problem

STORMS DO COSTLY DAMAGE
ON STATE HIGHWAYS YEARLY

By T. H. DENNIS, Maintenance Engineer and R. J. ALLAN, District Materials Engineer, District VII

THE removal of slides and repair of storm damage are major phases of State highway maintenance work. In the 10 years since 1931, expenditures of \$13,780,000 or practically one-sixth of the total of \$82,656,000 required for maintenance has been used for this purpose. Some 9,000 miles of the system are located in rugged or rolling country or in the flood channel of large streams, and includes the portion of the system on which such damage occurs. The travel on this mileage represents two-thirds of the total travel for the entire rural State Highway System. In many sections, the closing or even partial closing of the road presents an emergency situation.

Naturally, the amount of expenditure from maintenance funds varies from year to year, depending on the severity of the particular season. This is shown by comparison of the proportion of total funds required for such work as indicated below:

Year	Percentage of Expenditures for Major Slides and Storm Damage to Total Maintenance Expenditures
1931-32	12.65
1932-33	7.91
1933-34	9.55
1934-35	9.56
1935-36	16.27
1936-37	13.89
1937-38	36.21
1938-39	11.44
1939-40	19.44
1940-41	18.46
Ten-year average	16.37

The influence of extreme conditions is evident for the 1937-38 season.

SLIDE REMOVAL PROBLEM

In modern highway work, the problem of slide removal, correction of fill foundations and protection from storm damage is of major importance from the standpoint of construction, as well as the maintenance cost. On two major projects, (1) the American Canyon on State Highway Route 7 in Solano County, on which grading was completed in 1935, and (2) the Cuesta Grade improvement on State High-

SALES TAX NOT VALID ON BORROW PIT MATERIAL

Under a ruling by the Attorney General, a sales tax is not payable on gravel or other excavated material used in highway construction and maintenance and purchased under the form of "borrow pit agreement" used by Division of Highways.

In the past, property holders who have disposed of such material have been assessed a sales tax based on the amount of money paid to them by the Division of Highways or its contractors and have added the tax to the price charged for the material.

In the opinion of the Attorney General, which has been accepted by the State Board of Equalization, transfer of gravel, dirt, rock or other excavated material under a written instrument wherein the State is "granted * * * the right of easement and privilege to enter upon * * * land and excavate and remove * * * materials, if and when and as needed by the State and in any amount or amounts up to and not exceeding the maximum amount specified as the State may deem necessary" does not constitute a sale of tangible personal property and, therefore, no sales tax is payable.

The opinion is in accordance with views heretofore held by attorneys for the Division of Highways.

way Route 2 in San Luis Obispo County, completed in 1937-38, for example, the removal of slides represented approximately 12 per cent of the total cost. During the past 10 years more and more attention has been given to design of slopes and to corrective work during construction.

Construction which involves cuts of 100 feet or more in depth, and fills of 50 feet or more in height, is certain to disturb the surface balance which nature has achieved over hundreds of years. Likewise the area of slopes subject to wash and weather is greatly increased for such work as compared to earlier designs. Equipment and methods for ascertaining subsurface conditions and materials have been developed, and more attention is being given constantly to the matter of design of slopes in cuts and of foundation for fills on all new construction projects. Even with the best equipment available, however, only limited information can be secured as to probable future developments once a grading project is completed.

SLIDES ARE EMERGENCIES

For through routes, particularly where the daily traffic averages from 10,000 to 20,000 or more vehicles, the partial or complete closing of the road by slides or slipouts becomes an emergency. This has been evidenced on the Bay Shore route when the road has been partially closed at Brisbane slide at times, and on Waldo approach to Golden Gate Bridge, which is closed for short periods once or twice each season. Roads available for detours at these two locations are inadequate, and confusion results immediately when the traffic flow is interrupted.

In the case of the Waldo approach, a special study was made of the slopes on completion of the regular grading work while the contractor's equipment was on the job, and some 300,000 cubic yards of additional material was removed, with the result that interference to traffic has been kept to a minimum on this important section. The present policy recognizes this advantage to traffic in planning slope and protective work as part of construction.

ON RURAL SYSTEM

For the rural State Highway System as a whole, charges for major slide removal or storm damage were made against 6,765 miles of road for the 1938-39 Winter season, and 6,896



These pictures show volume and force developed by a circular type slide, such as occurred at Kellogg Hills

miles for the 1939-40 season. In an extreme storm, two-thirds of the daily traffic on the entire system would be endangered or inconvenienced in some degree. From the traffic as well as cost of maintenance points of view, it is very desirable that the most thorough job of slide removal and protection work be carried out at the time of construction. From a strictly economic viewpoint, however, extreme measures may be difficult to justify. The final stabilization of a road may require years in time and necessarily involve heavy maintenance expenditures.

In general, landslides are of the following types:

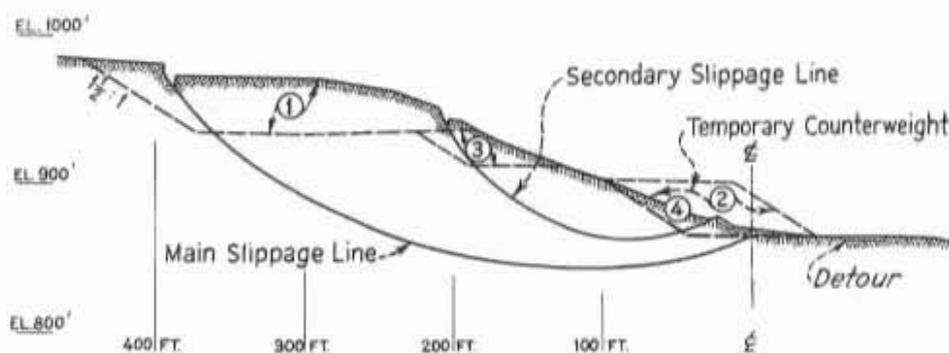
1. Slides due to weathering or erosion.

These may consist of broken masses of rock or earth, or of soil or silt washed from the face of a cut into the side ditches or onto the pavement, sometimes to a depth of several feet.
2. Slippage along defined planes which become lubricated by rain or springs.
3. Crushing of the underlying formations, which are not strong enough to withstand the load when the support is removed in excavating the road prism.

FILL SLIPOUTS

Slipouts refer, in general, to movement of fill material and may be due either to movement of the natural ground as a result of the fill load, or movement of material in the fill, which becomes saturated to the point where it flows under the existing load.

Stabilization of the face of cut slopes against ordinary erosion is a



- ORDER OF WORK
- | | |
|----------------------------------|-----------------------------|
| 1. Excavate upper bench | 3. Excavate secondary bench |
| 2. Build temporary counterweight | 4. Remove counterweight |

SECTION THROUGH KELLOGG SLIDE ON U. S. HIGHWAY 70—WEST OF POMONA

somewhat expensive process. The most desirable method is the establishment of natural vegetative cover. However, this requires fertile soil and soil moisture, and is not generally effective where slopes are steeper than $1\frac{1}{2}$ to 1, since the imported soil will wash away. Some success has been had by construction of terraces or digging holes in which fertile soil could be placed for support of plantings. For sandy soils, paving or oiling of slopes has been carried out in particular cases and, for mud flows, bridges have been constructed to carry the material under the roadway.

Weathering of cut slopes goes on continually, and slides from this cause may occur years after the original construction, even though all loose material had apparently been removed.

All slides are failures due to insufficient frictional resistance of the soil to resist the driving force caused by its weight. They are usually

caused by excess moisture in the soil, which not only increases its weight but also decreases its cohesive strength. Hydrostatic pressure developed by underground water may also contribute to the cause of earth failures.

Although every slide or slipout must be studied as an individual case, certain general principles of investigation and correction are usually applied. The study usually consists of a boring investigation, in some cases supplemented by a geological study, to determine the type of slide, the location of the sliding surface, and the presence of underground water.

Where a definite source of underground water can be located, provision should be made for intercepting the water and removing it from the slide area. In many cases, however, no definite source of moisture can be found, saturation having taken place by a more or less uniform percolation



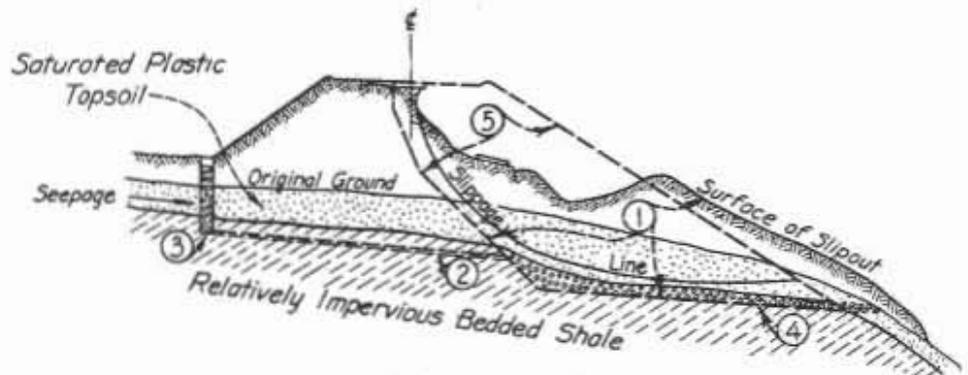
Views of slipout on Ridge Route Alternate, U. S. 99. Sketch shows method of correction

of surface waters. It is always advisable to look for shallow ponds or springs above the slide area and to drain any that may be found. In any case, diversion ditches should be constructed to keep surface water out of the slide cracks which have developed.

CIRCULAR TYPE SLIDES

In the correction of the circular type of slides, the forces acting upon the circular slide surface are first analyzed. Benches are then excavated in such a manner as to reduce the driving force as much as possible without reducing more than necessary the forces which tend to increase the friction on the sliding surface. This is usually accomplished by removing benches toward the upper portion of the sliding arc. This type of correction is illustrated in the accompanying sketch of the Kellogg slide. If the angle of internal friction and the cohesion of the soil can be determined by test methods, a reasonably accurate mathematical analysis of such slides may be made to determine the amount of material which must be removed in order to stop the movement. Where these properties of the soil can not be readily determined, they may be estimated in order to make an approximate analysis.

In the case of bedding plane or fault plane slides, the only possible corrective measures which can be applied are the interception of underground water which may be lubricating the slide plane and the removal of all of the loose material above the plane. In many cases where the dip of the strata is relatively flat, this type of slide is pro-



ORDER OF WORK

1. Remove slide material
2. Place perforated pipe in boring
3. Construct intercepting trench
4. Construct gravel subdrain
5. Rebuild fill

SECTION OF SLIPOUT SHOWING METHOD OF CORRECTION

gressive and enormous quantities of material must eventually be removed. In some extreme cases, it may even prove to be more economical to relocate a portion of the highway than to attempt the removal or correction of this type of slide.

SURFACE SOIL SLIDES

The correction of surface soil slides is similar to that which is applied to the bedding plane type.

Since most slipouts are caused by saturation of the foundation soil, it is obvious that drainage of the foundation is of major importance as a corrective measure. This is usually accomplished by the construction of a cut-off trench on the upper side of the fill to intercept the flow of underground water. An outlet for this trench is usually provided by means of a pipe installed through the fill, either by jacking the pipe, boring, or installing the pipe in a trench.

The slide material is excavated down to relatively dry impervious soil and either a gravel blanket placed or gravel and tile drains constructed in the foundation soil. After these drainage provisions have been completed, the fill is then reconstructed.

Where the topography is favorable, the waste material removed from the slipout may sometimes be used to advantage in the construction of a counterweight or bracing fill below the main fill.

This procedure is practicable only where the ground slope below the fill is relatively flat, or where the counterweight may be constructed across the bottom of the canyon to form a support against the opposite side. It is usually necessary to provide foundation subdrains under such counterweight fills, as well as under the main roadway fill.

(Continued on page 10)

Tioga Pass

HIGHWAY ENGINEERS ACHIEVE ANOTHER VICTORY OVER NATURE IN HIGH SIERRA

By J. N. STANLEY, Resident Engineer

WITH two and one-half miles of its precipitous roadway widened and realigned to eliminate grade curves, historic Tioga Pass highway, blanketed with snow since early last fall, was opened to summer traffic on June 20th.

This most recent improvement of Tioga road between the easterly boundary of Yosemite National Park and Lake Ellery in Mono County was completed toward the end of last year at a cost of \$78,600. The contractor started work on August 15, 1939, and finished the work on September 20, 1940, using well over a year to do a job that consisted principally of excavating less than 50,000 cubic yards of rock. However, in all of that time, the opposing elements of nature—tempestuous winds, snow storms and freezing temperatures—allowed the contractor only 165 working days and many of those were spent in drilling only, when snow was still too deep to permit full scale operations.

Tioga Pass highway is on State Sign Route 120, which after crossing the summit drops down the eastern slope of the Sierra Nevada range to Mono Lake and continues on to the Nevada State line near Tonopah. It

forms the eastern entrance to Yosemite. At the summit it connects with the highways of the park system.

HIGH ELEVATION

The project recently completed is situated on the highest section of road in the State Highway System. Beginning in Tioga Pass at an elevation of 9,941 feet above sea level, it curves easily downward past meadow, brook and peak to Lake Ellery, an elevation of 9,500 feet.

In the vicinity of this pass are found some of the most beautiful and interesting spots in all California and the completion of the improvement is regarded locally as one of the high lights in the 80 years of man's struggle against the barrier of the Sierra at this crossing.

To the motorist passing through this region for the first time, there comes a feeling of pioneering. It is impossible to escape the impression that this area has just been opened to travel or to escape a sensation of newness and freshness. A maze of treeless peaks, whose slopes are mantled with spotless snow fields, surround the wayfarer. The stones along the way are as clean as a dining table and may

be safely used as such. Crystal clear streams fed by the melting snow banks descend in foaming cataracts. The roadway seems to have been carved from the primeval rock only yesterday and the air seems fresher than any ever sensed before.

PIONEERS FACED PROBLEM

The impression of newness, however, arises, not from the fact that man has not previously invaded this territory, but from the fact that his puny efforts have been of little avail against the obstacles set in his path by Nature. Alaskan winters that close the pass from six to nine months of each year have kept him at arm's length. The efficiency of man, beast, and machine is so reduced by the effect of altitude that the most Herculean efforts, backed by careful planning and organization have left little more than faint evidences of the pains taken through four-fifths of a century.

The first pioneers to this region were the inevitable prospectors. Entering by horseback from the west and from the east the hard way, afoot, over the crags, their prying eyes and picks soon found reasons for staying.

(Continued on page 6)



Section of new Tioga Pass Highway looking easterly toward Camp Tioga. Left—Before and (right) after improvement



Views on new Tioga Pass Highway. Upper—Vista of Tioga Lake. Center—Looking easterly from Yosemite Park checking station
Bottom—Entrance to Yosemite Valley



Left—Section of old Tioga Pass road at Leevining Creek bridge. Right—Same section after improvement

(Continued from page 4)

The Shepherd Mine was located in 1860, and a small town, Bennettville, soon sprang up. This settlement was later renamed Tioga, and was located about two miles northerly from the present road on sparkling Mine Creek. The hardy souls inhabiting the now long vanished community managed without a road for over 20 years, surviving in some manner on the meager supplies that could be brought in over dim and tortuous pack trails.

TOUGH JOB FOR MINERS

The miners were caught on the horns of a dilemma: they could not afford to build a road until the mines could be made to produce the large sums required for such an undertaking; and, without the roads, machinery needed to develop the mines could not be brought in. After many years of hesitation and attempting various schemes, a plan was evolved whereby they might bring in the mining equipment without a road. They decided to take advantage of the chief impediment to the development of the whole region, namely the snow and ice of the long cold winter.

A lusty and booming mining town named Lundy grew up with the sudden vigor characteristic of such settlements on the shore of nearby Lundy Lake. This camp was less than 10 miles from Tioga as the crow flies but a good 3,000 feet lower in elevation. Lundy was connected to the outside world by good wagon trails leading through the then metropolis of Aurora, Nevada. The much needed machinery was shipped to Lundy, in the summer time, and the Tioga miners

settled down and waited for the arctic winter to freeze the mountain lakes into hard surfaced boulevards and for the deep snows to iron out minor irregularities of intervening talus slopes and boulder-choked gorges.

SLEDS HAULED OVER TIOGA

The winter that followed would seem to have been of a severity most pleasing to the furtherance of the transportation plan. From that winter's news in the Lundy Miners Index, edited and published by one "Lying Jim" Townsend, the following item, among others, has been preserved attesting to the gratifying depth of the snow:

"Our devil says that he doesn't mind carrying the paper around on snowshoes; that is great fun; but thinks his eyesight injured by smoke while calling down stove pipes and chimneys to people to look after their paper as he dropped it down."

When the snow was considered deep enough and the lakes frozen a foot thick, the goods destined for Tioga were loaded on especially prepared sledges and the moving job began. The heavy loads were towed slowly along by long ropes wound inch by inch onto capstans set up far ahead. When the capstans were reached they were dismantled and carried ahead another lap, and the ropes again attached and again wound slowly in. And so they proceeded, across the frozen lake, up the icy talus slopes, over cliffs rising hundreds of feet vertically. The loaded sledges broke through the snow again and again, wedging themselves crazily into draws and crevices, where they

were painfully pried out by pole and crow-bar, or block and tackle snubbed to scrub juniper or drill steel arduously set into the rock where no tree grew. Every ounce of propulsive effort was furnished by human muscle, and when the task was done it had cost three lives and many thousands of dollars.

ROAD BUILDING EXPENSIVE

Realizing that they could not afford to get rich by such transportation methods, the miners decided to build a road at any cost. In 1883, money was raised in Sonora for a road leading down the west side to that place. Work was started at once, and a road 14 feet wide was completed in 1884, from Carl Inn to Tioga. No figures as to the cost are at hand but it is understood that the road building exhausted the finances of all concerned. Internecine strife then broke out among the stockholders and the mines languished through years of court action. The new road fell into disuse and neglect and became impassable until taken over by the National Park Service many years later and developed into the sturdy mountain highway now serving the western approach to the pass.

In the meantime another mining combination, known as the Great Sierra Mining Company, came upon the scene and took over Tioga's mines. The long trek out to Sonora was discarded as an economic impossibility for their venture, so a much shorter road was built eastward down Leevining Canyon to the shipping and supply centers of the Mono Lake area. This road was little more

than a trail that clung most precariously to the gray granite walls of the great abyss below Lake Ellery, although it was known as "The Great Sierra Wagon Road." Its cost greatly exceeded all expectations and apparently depleted the resources of its builders as completely as had the road previously built toward Sonora.

STATE TACKLES PROBLEM

The Great Sierra Company hung on and tried to maintain the road, enlisting the aid of Mono County, but such funds that all interested parties were able to raise towards its maintenance and improvement were insufficient. The workable summer season seemed only long enough to clear away the previous winter's slides and then another winter was upon them, and another year had fled.

The California State Highway Commission became interested in the possibilities of this route across the Sierras and in August, 1914, a party of Commissioners attempted to inspect the road driving up the grade from Mono Lake. Half way to the summit, at "Blue Slide," progress was barred by a fallen rock and the trip abandoned. Under the circumstances, it is small wonder that the Commission should have felt reluctant to have the road taken into the State system, particularly since the Great Sierra Company was asking \$25,000 for its interest in the road.

In 1915, the situation took on a new complexion. Public spirited Stephen T. Mather, one of the outstanding figures of all time in the National Park Service, purchased the road

with his own and other donated private funds and turned it over to the public as a gift.

NOW MODERN HIGHWAY

The name "Great Sierra Wagon Road" is practically forgotten and can only be encountered in old records and the files of old newspapers. The route is now identified under the more descriptive title of "Tioga Pass Road." The State took over the road as a State highway many years ago and has gradually improved the entire length from Mono Lake to the summit. It has been widened throughout, and improvements continue year by year, shooting off a point here, building a wall there, providing safe and adequate bridges, all combining to produce a road of a quality far exceeding the wildest dreams of those dauntless men who braved the crags so long ago.

The little valley forming the eastern approach to the pass was carved from a solid block of hard rock by prehistoric glaciers which left dozens of little knolls and hillocks of solid rock, scattered without reference to pattern. These small ridges and humps consisted of the hardest knurls in the original rock mass, the type of rock that could, and did, stand up under the grinding of thousands of tons of ice made abrasive by included rock particles through a period of thousands of years. Scratches made on the surfaces of the rock masses by pebbles dragged across them in the grip of the grinding glaciers still show plainly, although winds and snows of some 50,000 years have sought to erase such evidence.

Most of the excavation on the project was encountered in cutting through these small hard-rock hills and, in spite of the fact that the contractor had equipped himself with the most modern equipment, his progress was slow in such material. Drilling was the major problem, as the rock was crystalline and broke up readily once the explosives were properly placed. Jackhammers scarcely dented the rock and were given up in favor of wagon drills except for use in plugging isolated boulders. Drill bits were used literally by the truck load, and a grinder was kept going steadily night and day. Water heads were installed and were comparatively successful, increasing the average hole drilled per bit from one inch to five inches. Cold weather prevented a complete change over to wet drills which could only be used when the temperature was above freezing.

The work was barely finished in 1940, and the road-mixed surfacing was laid out after the first fall of snow had already whitened the mountains.

The contract was performed by Isbell Construction Company, of Reno, Nevada.

TIOGA HIGHEST PASS IN STATE

Of 14 prominent mountain passes in California, Tioga is the highest with an elevation of 9,941 feet.

Sonora is 9,624; Ebbetts, 8,800; Carson, 8,650; Conway, 8,100; Echo, 7,365; and Donner, 7,135.

The other passes range from 4,315 to 6,350.



These are two more views of Tioga Pass Highway before and after realignment



Looking toward Davis from a point on realigned U. S. 40 Highway south of State Nursery

Improvement

NEW CONSTRUCTION PROGRESS ON U.S. 40 BETWEEN DAVIS AND DIXON

WORK is now under way on three projects between Dixon and Sacramento which are units in the development of this portion of U. S. Route 40 into a divided highway. This road is a part of the main east-west transcontinental highway terminating at the San Francisco Bay area and carries heavy traffic, both commercial and pleasure, throughout its entire length. Its development as a divided highway will enable it to serve the constantly increasing traffic with a greater degree of efficiency and safety.

Previous articles in "California Highways and Public Works" have discussed the contracts which provided for the grading and the construction of bridges and underpasses on new alignment between 1.3 miles

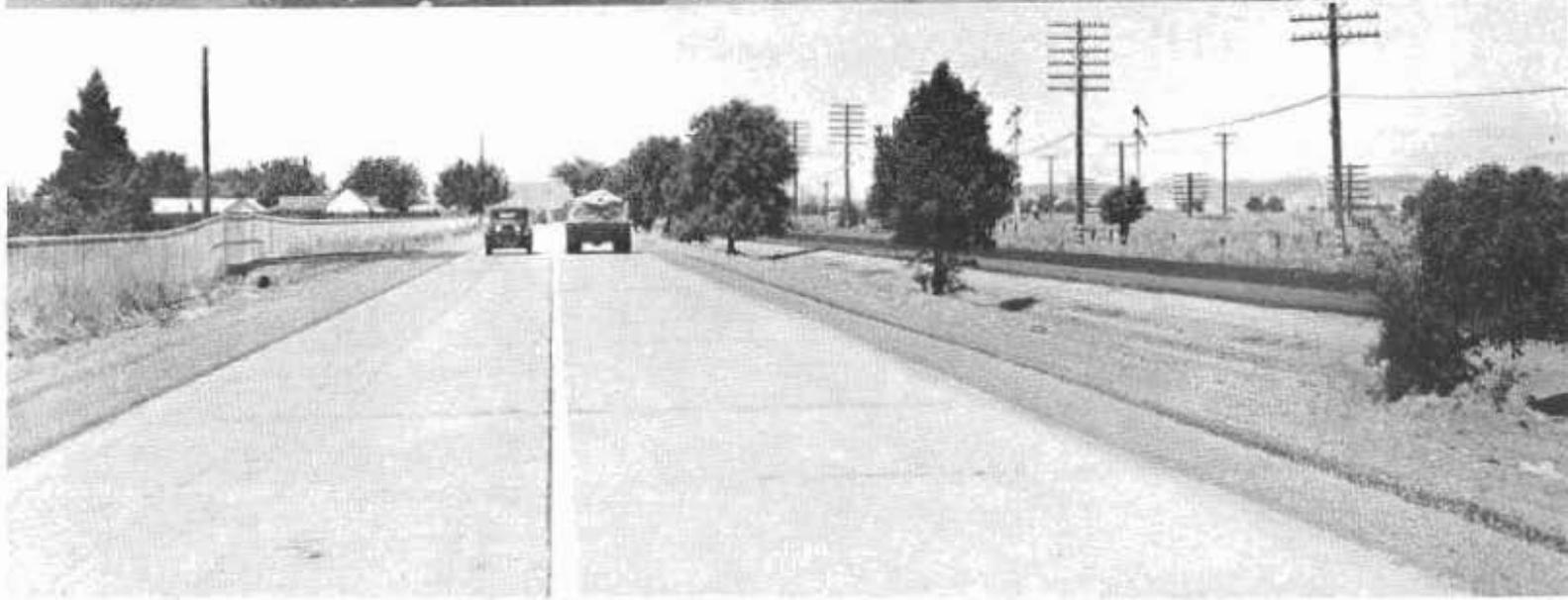
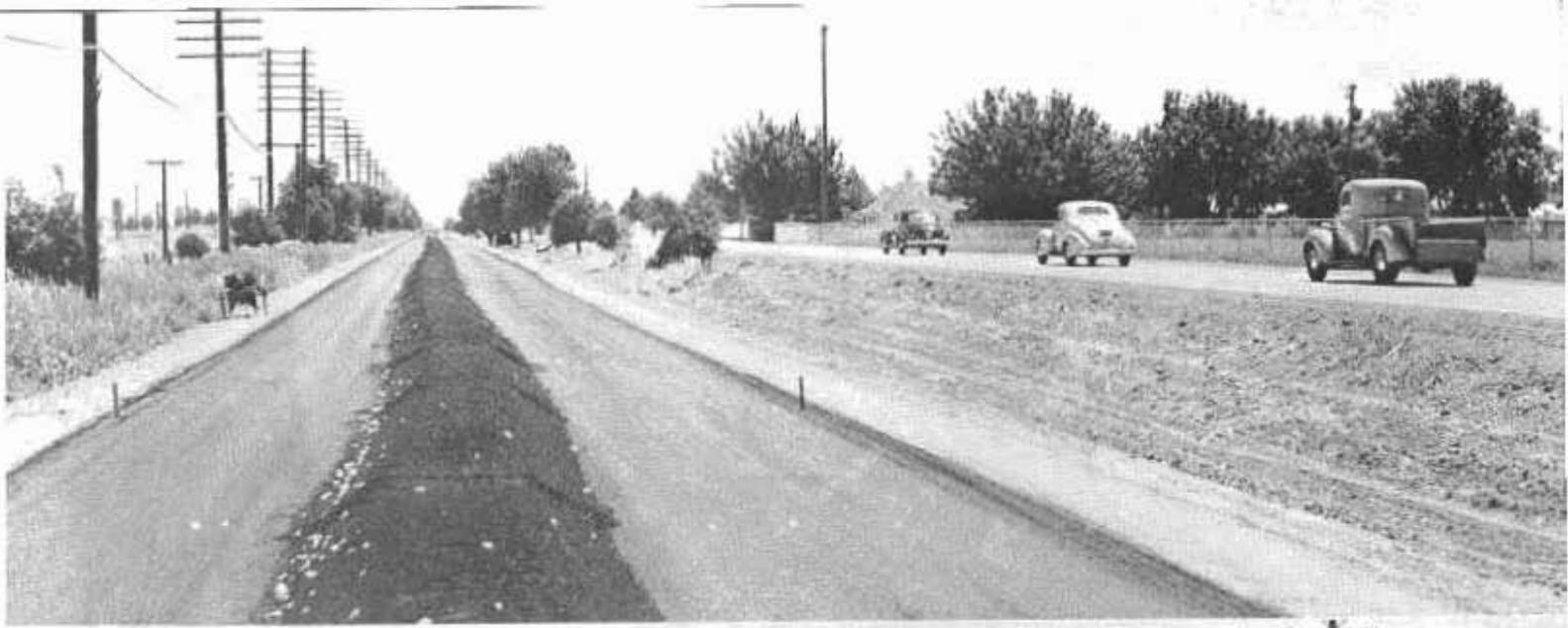
north of Dixon and 1.0 mile east of the Davis Subway. A contract has just been awarded providing for the placing of Portland cement concrete pavement on both lanes of the highway from the South Fork of Putah Creek to 1.0 mile east of the Davis Subway and on the new south lane between Swingle and the Yolo Causeway.

Between 1.0 mile east of Davis Subway and the Yolo Causeway, the same contractor is completing work on two contracts. The first contract covers the grading and surfacing with Portland cement concrete pavement of the new south lane of a divided highway and the resurfacing with plant-mixed surfacing of the existing highway, which will serve as the north lane. The limits of this work are from 1.0

mile east of the Davis Subway to Swingle. The second contract provides for grading a new south lane between Swingle and the Yolo Causeway.

The soil in the vicinity of all these projects, while suitable for certain types of agriculture, is, in general, not particularly well adapted to use in road construction, since it usually has a low bearing value and fairly high swell. After considerable investigation, sources were located from which sandy or gravelly material could be obtained for use in the upper part of the roadbed, but it was necessary for reasons of economy to use the poorer soil in the lower portions. In order to insure a proper moisture content in this material and prevent

(Continued on page 17)



Views of realigned U. S. 40 between Davis and Dixon in Yolo County. Upper—Looking toward Yolo Causeway and Sacramento from point near State Nursery, showing resurfacing material windrowed in center of old highway. Center—Looking toward Davis; State Nursery on left. Bottom—Fill and widening operations for divided highway at point directly south of Yolo Causeway



The upper three pictures show a slide in progress south of Topanga in Los Angeles County. Lower pictures show hazard and extent of typical slipouts. Sketch shows method of correction

Storms Do Costly Damage on Highways

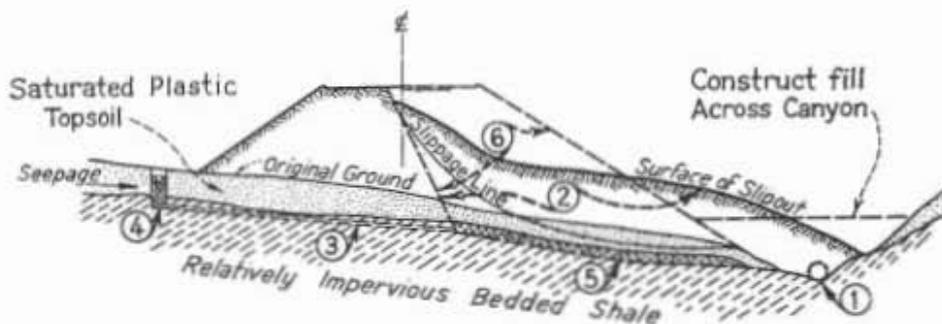
(Continued from page 5)

It will be readily seen that, before corrective designs for slipouts can be made intelligently, an investigation by means of borings to locate the saturated zones is absolutely necessary. Furthermore, great care must be taken during construction to verify the information disclosed by the borings and to be sure that the stripping operations are carried down to relatively dry and stable material, before the foundation drains are installed and the fill reconstructed.

Failure to remove all of the plastic soil, or to place the drains sufficiently deep before reconstructing the fill, may result in complete failure of the corrective measures and consequent loss of all of the work performed. For this reason, inadequate preliminary investigation or lack of inspection of the work during its progress, may prove to be very costly.

SATURATION

For several years past the rainfall in the Los Angeles area has been well in excess of the normal. During the past rainy season, for instance, an all-time record was established



ORDER OF WORK

- | | |
|------------------------------------|----------------------------------|
| 1. Place pipe in creek bed | 4. Construct intercepting trench |
| 2. Remove slide material | 5. Construct gravel subdrains |
| 3. Place perforated pipe in boring | 6. Rebuild fill |

SECTION OF SLIPOUT SHOWING METHOD OF CORRECTION

when the precipitation was more than double the normal amount. The cumulative effect of this series of excessively wet seasons is being shown in the large number of serious slides and slipouts which have occurred this year. In many instances, cuts and fills which had previously shown no indication of instability have failed because of the high degree of saturation which has been accumulating.

The Kellogg slide is located on Garvey Avenue (U. S. 70) near the Kellogg Ranch, a few miles west of Pomona, on a section originally completed in 1933.

As may be seen from the accompanying diagram, this is a very good example of the circular arc slide and serves well to illustrate the method of correction applied to this type. It will be noted that this actually consists of two slides, one within the other. The lower or secondary slide was the first to be noticed. Soon afterward the pavement started to bulge and the upper slide crack was discovered. The movement was gradual but during one period amounted to several feet a day and the pavement was uplifted as much as 15

(Continued on page 22)

Supreme Court Upholds Authority of Public Works to Require Relocation of Pipe Line Placed in Highway Under State Franchise

By FRANK B. DURKEE, Attorney, Division of Contracts and Rights of Way

AUTHORITY of the Department of Public Works to require the owner of a pipe line to move the same, at the cost and expense of such owner, to a different location within the highway, "whenever necessary to insure the safety of the traveling public or to permit of the improvement of the highway," as provided by Section 680 of the Streets and Highways Code, has been upheld by the Supreme Court in the case of *State of California vs. Marin Municipal Water District*, decided April 2, 1941, and modified in certain particulars on May 1, 1941. (101 Pac. (2d) 1112; 111 Pac. (2d) 651; 3 Cal. Dec. 152, 631.) The decision is now final.

The pipe line, subject of the litigation, was placed in what was previously a county highway of the County of Marin by the predecessor in interest of the defendant Water District pursuant to a permit granted by the Board of Supervisors in 1909. Upon establishment of the State Highway System, the highway in question was taken over and incorporated into the right of way of the State highway (Road IV-Mrn-1-C).

JUDGMENT FOR STATE

The section of pipe line required to be moved was located in an area which had been originally a mud flat along the shore of Richardson Bay. Building of the Waldo Approach to the Golden Gate Bridge required placing of a considerable fill over a portion of the area. Engineers of District IV were of the opinion that the fill would cause such a subsidence of the ground as would result in rupture of the pipe line, with consequent destruction of the fill and hazard to life and property.

A formal demand, in writing, as contemplated by the code, was served upon the water district directing it to relocate its pipe line from within the area within which the fill was to be made. The district declined to act, whereupon the department had the

necessary work performed by the State's contractor. The action in the superior court was brought pursuant to Section 722 of the code to recover the amount paid the contractor under the extra work order.

Upon trial, it was shown that removal and relocation of the pipe line was necessary, not only to insure safety of the traveling public, but, also, to permit improvement of the highway. Judgment was for the State, and the water district appealed.

DISTRICT APPEALS

The defendant district contended that, under the language of Section 19 of the Municipal Water District Act, it had a grant from the State which gave it a vested right to occupy the highway with its pipe line; that to require it to assume the cost of relocating the main would violate constitutional provisions against the impairment of the obligation of contracts and the taking or damaging of property without due process of law; that, in any event, Section 680 of the Streets and Highways Code was not applicable to the situation, on the ground, among others, that a water district is a subdivision of the State.

In affirming the judgment, the Supreme Court held that the right of a district, organized under the Municipal Water District Act, to maintain water mains along a public highway must be considered a "franchise" (which was the position of the department), whether regarded as derived from the district's acquisition of the assets and property of the private corporation, its predecessor in interest, the act under which the district was organized (Stat. 1911, p. 1290), or the general provisions of the several statutes conferring upon municipalities the right to construct water mains along the highways. (Stat. 1911, p. 852; Stat. 1923, p. 147.)

In modifying its opinion, subsequent to filing of a petition for a rehearing, which was denied, the court

specifically held that the defendant water district derived its "franchise" by virtue of its existence as a subdivision of the State from the Statutes of 1911 and 1923 granting to municipalities certain rights to occupy highways. These statutes, the court said, conferred upon the district the right to maintain a pipe line along the highways of the State only "in such manner as to afford security for life and property."

AUTHORITY GIVEN

Section 680 of the Streets and Highways Code, the court pointed out, gives the Department of Public Works the authority to require removal of a pipe line at the owner's expense when "necessary to insure the safety of the traveling public or to permit of the improvement of the highway."

"It is clear," the court went on to say, "that neither defendant nor any other municipal water district has the authority to maintain pipes on the highway in a position which does not afford security for life or property, and therefore that the application of Section 680 to municipal water districts would not result in a limitation upon their otherwise valid power, but would operate only to prevent them from exercising their franchises in a manner contrary to law."

In other words, the section in question is "clearly within that residuary power of the State * * * known as the 'police power'."

Further, the court held, relocation of defendant's pipe line would not deprive it of its franchise; "it has simply been required to bear the expense of removing its mains to a location on the highway consonant with public welfare. The benefit to the public as a whole * * * clearly outweighs the burden imposed upon defendant, and the legislation (Section 680) is therefore valid."

(Continued on page 24)

Central Valley Project Will Serve

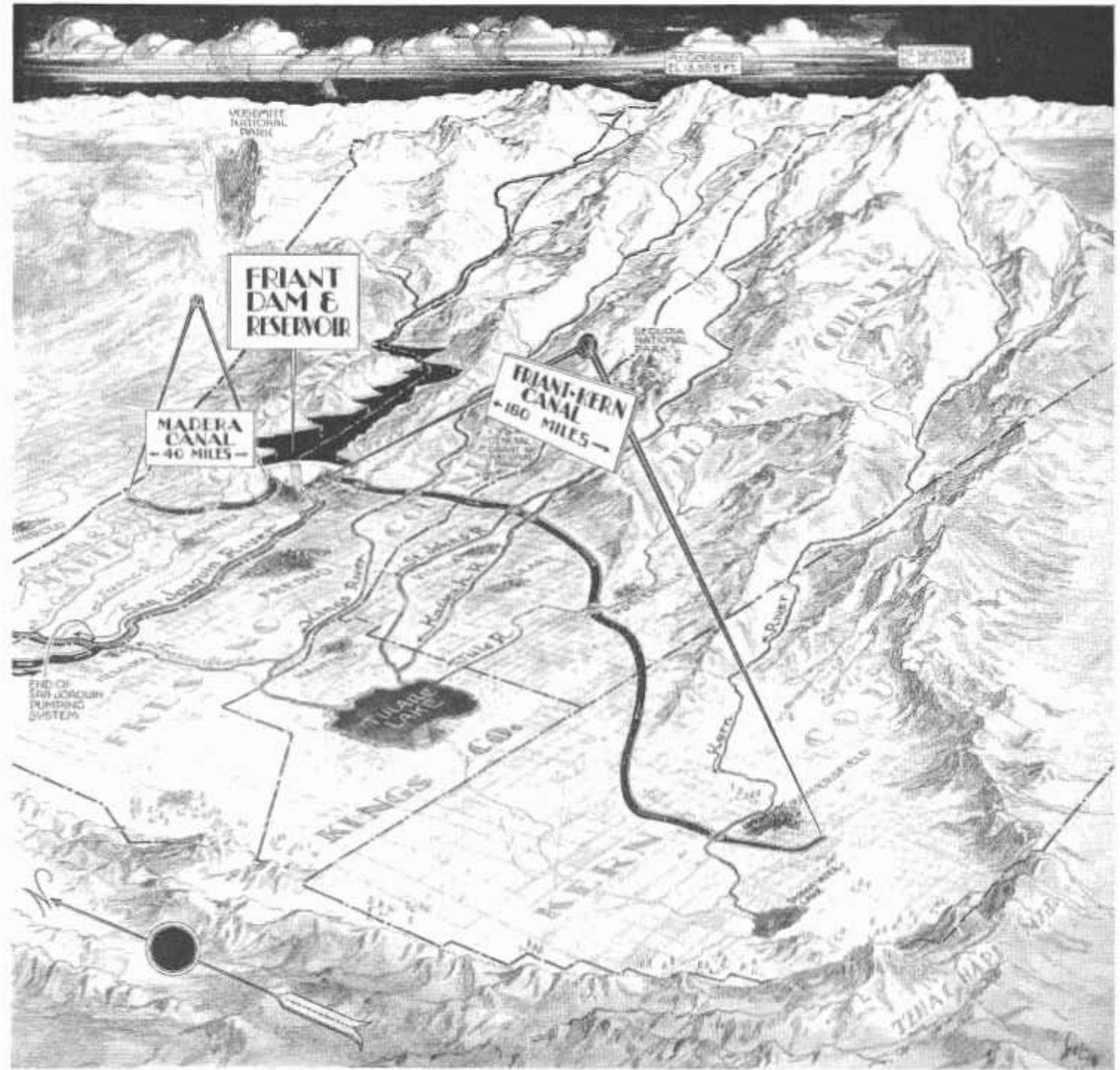
CONSTRUCTION work on the first 8½-mile section of the Madera Canal is reaching an advanced stage. This shows one of three large siphons being built. The siphon will be 600 feet long and will have a barrel about 12 feet in diameter. The Madera Canal will extend from Friant Dam on the San Joaquin River 40 miles north to the Chowchilla River and bring a new water supply to lands in Madera County.



U. S. Bureau of Reclamation photo.

Vast San Joaquin Valley Acreage

FRIANT DAM, now more than half completed, will impound the San Joaquin River to furnish a supplemental water supply for 1,250,000 acres of land in Madera, Fresno, Tulare, Kings and Kern Counties. This artist's perspective drawing shows the 200-mile long canal system which will carry irrigation water from Friant Reservoir as far south as Bakersfield and north almost to the Merced County line.



Future Roads

HIGHWAYS OF TOMORROW TAX INGENUITY OF BUILDERS

By CONDE B. McCULLOUGH, Assistant Oregon State Highway Engineer

Conde B. McCullough, Assistant State Highway Engineer of the State of Oregon, in an address before the highway section of the Institute of Government recently held in Sacramento, discussed "highways of tomorrow," in which he reduced certain fundamentals of economic highway planning to mathematical formulas. Excerpts from his paper are presented in the following article. Mr. McCullough bears the titles of Professor of Engineering, Doctor of Laws and Honorary Doctor of Engineering.

THE formulation of highway improvement programs has always been somewhat of an administrative "headache" but the development of the future highway plan is quite likely to aggravate this condition into a malady of major dimensions. It is true, of course, that throughout the States the nucleal systems have already been selected but transport necessities are developing at such a rate as to produce demands for betterments and extensions hitherto unpredictable—for a transportation plant designed for heavier loads, higher speeds, and unprecedented traffic densities.

How is this new plant to take shape? Out of the myriad needs how are the priorities to be established? All too frequently, in the past, improvement programs have been dictated by pressure rather than reason, by expediency rather than logic, resulting in a badly balanced growth.

THREE ESSENTIAL FACTORS

These early errors have already occasioned large economic waste, have necessitated extensive reconstruction costs. If this condition is not to be repeated it is essential that the highway transport plant of tomorrow be planned along sound lines and that there be developed a suitable criterion or "yard stick" for the measurement of economic priorities.

Basically, the problem is simple enough. It comprehends but three essential ingredients: (1) costs, (2) revenues, and (3) benefits, and the ratio in which they are interrelated. Revenues must be sufficient to balance costs, otherwise eventual bankruptcy is inevitable. Revenues must

also be backed up by corresponding benefits, else the setup will collapse for lack of economic support.

These, the above, are the cardinal principles of all construction economics; and, like all good engineers who have gone before us, let us see if we can't "say it in the form of an algebraic expression."

If we let

C. represent the total annual cost of any proposed project inclusive of every item of expense involved in its financing, maintenance and operation;

I. represent its probable net annual revenue expectancy; and

B. represent the annual benefits to be derived from its utilization,

we may develop two criteria in the form of quotient or ratio values, as follows:

A so-called *solvency quotient* " Q_s ," measuring the financial soundness of the project, and a *benefit quotient* " Q_b ," measuring its economic justification.

We may then write:

$$Q_s = I/C, \text{ and } Q_b = B/C.$$

Here, then, are our "yard sticks" in algebraic form. If Q_s is less than unity the project is not self-liquidating and can only be built by subsidy. If Q_b is less than unity the project has no justification and should not be built at all. If Q_b is especially high the project may merit consideration even though it may need subsidy (provided, of course, that surplus revenues are available).

In the field of highway economics the formulas are not quite as simple as above stated for the reason that a portion of the benefits (fuel savings) operates to deplete resulting

income values so that the two quotients become interrelated. Moreover, a correction is necessary to take care of that portion of the annual income derived from traffic "drained" or diverted to the new improvement from other portions of the system. Methods for applying these corrections were developed by the Oregon Highway Department and published in 1938 as Technical Bulletin No. 7.*

WHAT FORMULAS ACCOMPLISH

Let us get back to our formulas. It is true that they are somewhat crude and inexact. It is also true that the problem postulated (the development along sound economic lines of a highway plant to meet future needs) is not one which is susceptible of exact mathematical analysis since in the end the selection of both design standards and priority schedules must be tempered by human judgment and an understanding of individual conditions and needs. What good, then, are the formulas? What do they accomplish? What have we done so far?

So far we have accomplished this—we have taken our problem apart and put it together again in logical form. We have determined what we need to know. We now have a reference frame into which we may fit our experimental data. Some of our ingredient factors (costs, revenues and benefits) involve complexities which render them hopelessly difficult of exact evaluation but at least we are on the right track. We know the direction that our future research must take.

* The Economics of Highway Planning.

Let us, then, proceed to consider in turn each of the economic factors involved (C_a , I_a , and B_a). Let us see what we now know about them and what we have yet to learn.

THE COST FACTOR

This factor may be written:

$$C_a = C_{ac} + C_{am} + C_{ao}$$

where C_{ac} represents the annual cost of capital, C_{am} the annual cost for maintenance, and C_{ao} the annual cost for operation.

The first item (C_{ac}) comprehends all expense which accrues by virtue of the use or provision of funds for the project considered, and may be broken down into two components: (1) an annual charge in the nature of a fixed rental (interest) for the use of the funds involved; and (2) an annual provision for amortizing the first cost of the project during its service-life expectancy. The sum of these two may be represented by the formula

$$C_{ac} = C \left\{ r + \frac{r}{(1+r)^n - 1} \right\} \dots (1)$$

where " C_{ac} " represents the annual capital cost; " C " the total first cost; " r " the interest rate; and " n " the service life in years.

The second item (C_{am}) involves the maintenance expense and may be broken down into: (1) maintenance of pavement and roadway surfaces; (b) maintenance of roadbed, shoulders, and right of way; (c) maintenance of structures; (d) miscellaneous general maintenance; and (f) maintenance administration expense.

OPERATION COSTS DEFINED

The third item "operation costs" includes the expense of all of those functions and necessities which are incident to furnishing highway transportation to the public and which can not be classified either as maintenance or as capital expense. Among the various activities embraced under this designation are (a) the operation of travel and information bureaus, (b) traffic control, and such policing of highways as is required to be performed from highway funds, (c) the operation of lighting systems for roadways, bridges, tunnels, etc., (d) the development and operation of parks and recreational facilities, and (e) any other activity concerned with transportation and required to be

done by the highway organization, which is not properly chargeable to either construction or maintenance.

In general the cost factor C_{ac} is susceptible of evaluation with fair accuracy once the first cost is determined, although we need to know a great deal more about service-life expectancies for the various construction components in order correctly to evaluate the term " n ." The first cost element " C " (in Formula 1) will depend upon the design types necessitated by the future and here we must launch out into uncharted seas. The road of today must be designed for tomorrow, for every tomorrow during its service-life expectancy. During this period what top speeds will it be necessary and possible to provide for? What traffic densities, maximum loads, lane widths? What pavement thicknesses shall we employ? How should bridge standards be modified? To what degree will channelization, signalization, and grade separations be warranted?

In every case the answer is indicated, though highly involved. Design standards can be raised if and only if the tax structure base is or can be

adjusted to meet the costs incurred. In other words, if and only if it is possible to maintain an average value of the solvency quotient " Q_s " at or above unity; and this tax structure base, in turn, can be maintained only if the benefits are sufficient to warrant.

And so our problem shifts to the other factor groups.

HIGHWAY REVENUES

The second ingredient factor, I_a , is obviously compounded from the annual traffic (in gross ton miles) and the unit net income, segregated by vehicular types. Table I hereinbelow indicates the segregation adopted by the Oregon Department, and Table II the unit net income values developed by the Oregon Highway Planning Survey.

Table II is for the highest type of roadway surface. For lower surface type standards the unit net income values will be slightly higher because of the greater fuel consumption.

The table data are of course applicable only to Oregon highways and to the Oregon Highway Tax Structure, but the various highway planning

TABLE I
ANNUAL ROAD EARNINGS

Type of Traffic	Gross Tons Per Annum	Gross Ton Miles Per Annum	Unit Net Income Per Ton Mile	Total Annual Revenue
Passenger Cars (Oregon)			\$-----	\$-----
Passenger Cars (Foreign)				
Trucks (Light)				
Trucks (Medium)				
Trucks (Heavy)				
Trucks with Semi-Trailer				
Trucks with Trailer				
Busses (School)				
Busses (Other)				
Other Traffic				
Total annual net income				\$-----

TABLE II
GROUP 1—HIGHWAYS (Highest Type)

Type of Vehicle	Net Revenues Per Gross Ton Mile From			Total Net Revenues
	Registration License Fees	Motor Transportation Fees	Fuel Taxes	
Passenger cars (Oregon)	\$0.000422		\$0.001645	\$0.002067
Passenger cars (foreign)			0.001797	0.001797
Trucks—light	0.000563	\$0.000127	0.001097	0.001787
Trucks—medium	0.000394	0.000517	0.000833	0.001744
Trucks—heavy	0.000286	0.000517	0.000658	0.001461
Trucks with semi-trailer	0.000332	0.000517	0.000559	0.001408
Trucks with full trailer	0.000426	0.000517	0.000426	0.001369
Busses (school)				
Busses (other)	0.000125	0.000517	0.000723	0.001365

surveys have rendered it possible to assemble similar data for practically every State in the Union.

The annual income factor, I_a , employed in the economic equations must obviously be the average annual income during the service life of the improvement projected, so that it becomes necessary not only to determine present traffic income values but also to forecast future expectancies.

Our future highway plan is vitally dependent, therefore, upon the most careful study of traffic developments and traffic trends. Too much emphasis can not be placed upon this necessity. If our designing is to be adequate, if our systems are to remain solvent, if our growth is to be directed along sound economic lines, we must devote great thought to this phase of highway research.

HIGHWAY BENEFITS

The third ingredient, " B_s ," is the most difficult of evaluation. Our economic equations concern themselves particularly with motorized transport benefits, although general community benefits and special land service benefits must be considered in any study of highway tax structures. Motorized transport benefits are generally broken down into (1) the "mileage element," group and (2) the "time element" group.

The mileage-element group includes, in general, those benefits which are functions of the cost of fuel, lubricants, tires, and tubes, vehicular maintenance and a pro rata of general vehicular depreciation. In general these benefits are calculated by means of a comparison of the estimated mileage-element operating cost over the improved facilities, with similar data for the facilities existing between the same termini prior to the improvement. In general, mileage-element benefits are derived from (a) a reduction in distance between termini, (b) an improvement in roadway surface, (c) a reduction in rise and fall, (d) an improvement in gradients, (e) an improved alignment, (f) the elimination of traffic stops and congestion.

(Note—Dr. McCullough here quoted extensively from Bulletin No. 10 of the Oregon Highway Department, entitled "An Analysis of the Highway-tax Structure in Oregon," describing the methods for the evaluation of each of the above benefit items and the method employed in evaluating time-element benefits.)

The basic economic equations applicable to the planning of long-range

June Traffic on State Toll Bridges Shows Heavy Increase

THE records for June indicate a continuation of the large volume of traffic which has for some time been characteristic of the three State-owned toll bridges. For the San Francisco-Oakland Bay Bridge the daily average during the month was 52,573 representing an increase of 16 per cent over June, 1940.

On the Carquinez Bridge the traffic was 88 per cent above that of the same month of 1940. This large in-

crease appears to have been caused principally by the reduction in bridge tolls and the continued intense activity at Vallejo and Mare Island Navy Yard.

The traffic using the Antioch Bridge was much less than on the other two bridges, but showed, nevertheless, a substantial gain over the previous year.

June vehicular traffic on the San Francisco-Oakland Bay Bridge and the Carquinez and Antioch bridges is shown in the following tabulation:

	San Francisco-Oakland Bay Bridge	Carquinez Bridge	Antioch Bridge
Passenger autos and auto trailers	1,431,226	370,802	21,510
Motorcycles and tricars	4,193	1,145	56
Buses	30,235	5,241	181
Trucks and truck trailers	80,485	27,354	3,318
Others	31,039	238	115
Total vehicles	1,577,178	404,780	25,180

programs may also be employed for the more detailed problems of type selection for bridges, pavements, and similar property units. This method of economic analysis applied to short-span suspension bridges is discussed in Oregon Highway Department Technical Bulletin No. 11.* Space, however, will not permit of further discussion of this point.

The above is but a most sketchy outline of the economic problems involved in the development of the future highway plan. Its purpose, as previously stated, is merely to postulate the problem, to list the data needed to fill out the frame, to point the need for further work.

MUCH DATA NEEDED

The work remaining to be done is formidable indeed. The problems are many. Among the data needed may be mentioned:

- Further and more accurate knowledge of service life expectancies for bridges and surface types.
- Additional cost data for highway maintenance and operation.
- A Nation-wide study of transport economics, looking toward the standardization of weight, length,

and speed restrictions so that design types may be standardized without fear of untimely obsolescence. These restrictions can not be arbitrarily imposed. They must find economic justification and this again means a balancing of resultant costs, revenues, and benefits.

- Further data to aid in forecasting traffic trends, including a study of the various factors of influence, to the end that income expectancies may be more accurately predicted.
- Further data looking toward a more accurate evaluation of distance savings, reductions in gradients, and reductions in rise and fall.
- A more accurate determination of the value of time savings to operators, passengers, and recipients of motor transport.
- The effect on vehicular operating costs of surface types, lane widths, and alignment.
- Highway capacity studies, including the effect of channelization, signalization, and speed zoning, to the end that the economic benefits thereof may be evaluated and segregated.
- Accident prevention, including an economic evaluation of the various safety measures, such as grade separations, signalizations, etc.
- A study of future design requirements for highways, with special regard to maximum vehicular speeds, weights, and dimensions, and the extent to which additional first-cost expenditure finds economic justification.

* The Economic Analysis of Short Span Suspension Bridges.

Gas Tax AS APPORTIONED TO CALIFORNIA COUNTIES DURING THE 91st AND 92d FISCAL YEARS

GASOLINE tax apportionments to the counties of California for the fiscal year July 1, 1940, to June 30, 1941, will make the counties' share of gas tax funds for the present biennium total \$33,962,279.75.

During the Ninety-first Fiscal Year which ended June 30, 1940, the coun-

ties received \$16,652,561.22. During the Ninety-second Fiscal Year ending June 30, 1941, they will receive \$17,309,718.53, an increase of \$657,157.31.

In apportioning gas tax moneys to the counties, each such political subdivision first receives a minimum of \$7,500. The remainder is allocated in the proportion that the registration

of motor vehicles in each of such counties bears to the total number of vehicles registered in the State.

California's motor vehicle registration as of April, 1941, on which was based the apportionment to counties for the present fiscal year was 2,775,635.

Apportionments were as follows:

County	Ninety-first Fiscal Year July 1, 1939, June 30, 1940	Ninety-second Fiscal Year July 1, 1940, June 30, 1941	Totals Ninety-first and Ninety-second Fiscal Years	County	Ninety-first Fiscal Year July 1, 1939, June 30, 1940	Ninety-second Fiscal Year July 1, 1940, June 30, 1941	Totals Ninety-first and Ninety-second Fiscal Years
Alameda	\$1,058,666.98	\$1,100,600.39	\$2,159,267.37	Placer	97,297.99	98,155.88	195,453.87
Alpine	30,814.58	30,806.13	61,620.71	Plumas	52,022.44	54,161.03	106,183.47
Amador	49,814.59	50,176.98	99,991.57	Riverside	267,877.80	272,426.74	540,304.54
Butte	138,919.29	140,079.11	278,998.40	Sacramento	415,162.90	432,415.32	847,578.22
Calaveras	50,680.97	51,118.25	101,799.22	San Benito	60,006.36	60,011.43	120,017.79
Colusa	58,542.26	57,513.18	116,055.44	San Bernardino	382,138.77	394,146.98	776,285.75
Contra Costa	241,188.16	258,374.25	499,562.41	San Diego	622,967.53	673,477.92	1,296,445.45
Del Norte	41,111.35	41,114.99	82,226.34	San Francisco	1,045,712.07	1,073,522.29	2,119,234.36
El Dorado	58,902.06	59,789.08	118,691.14	San Joaquin	325,746.72	332,681.27	658,427.99
Fresno	453,583.68	469,658.15	923,241.83	San Luis Obispo	114,092.70	119,096.49	233,189.19
Glenn	63,717.23	63,770.32	127,487.55	San Mateo	257,616.44	275,570.83	533,187.27
Humboldt	130,903.21	132,474.06	263,377.27	Santa Barbara	204,802.28	206,377.63	411,179.91
Imperial	170,281.23	170,514.05	340,795.28	Santa Clara	448,354.81	457,896.99	906,251.80
Inyo	49,118.93	49,940.26	99,059.19	Santa Cruz	143,051.92	143,272.77	286,324.69
Kern	350,714.36	366,364.88	717,079.24	Shasta	96,367.51	104,632.73	201,000.24
Kings	114,451.07	119,975.05	234,426.12	Sierra	36,579.55	36,221.34	72,800.89
Lake	52,741.44	52,819.42	105,560.86	Siskiyou	91,875.30	94,579.60	186,454.90
Lassen	60,249.66	63,212.41	123,462.07	Solano	132,779.32	142,924.73	275,704.05
Los Angeles	6,114,103.59	6,429,486.64	12,543,590.23	Sonoma	207,359.61	209,830.07	417,189.68
Madera	84,939.39	87,777.03	172,716.42	Stanislaus	219,380.00	222,759.55	442,139.55
Marin	123,804.94	128,498.32	252,303.26	Sutter	75,744.64	77,002.49	152,747.13
Mariposa	43,488.95	43,227.02	86,715.97	Tehama	67,319.44	66,874.92	134,194.36
Mendocino	84,738.93	85,711.70	170,450.63	Trinity	38,367.39	38,655.82	77,023.21
Merced	137,038.83	142,668.37	279,707.20	Tulare	272,713.40	281,825.80	554,539.20
Modoc	49,320.92	50,540.24	99,861.16	Tuolumne	55,710.70	56,317.77	112,028.47
Mono	34,899.51	34,946.11	69,845.62	Ventura	183,021.04	186,753.62	369,774.66
Monterey	195,742.42	209,832.81	405,575.23	Yolo	99,189.27	100,016.10	199,205.37
Napa	91,108.01	94,882.06	185,990.07	Yuba	72,928.65	75,553.81	148,482.46
Nevada	70,732.14	71,635.16	142,367.30				
Orange	362,055.99	365,050.19	727,106.18	Total	\$16,652,561.22	\$17,309,718.53	\$33,962,279.75

Pan-American Highway Will Be Discussed in Mexico City

The fourth Pan-American Highway Congress, meeting in Mexico City September 15th to 24th, will have as one of its important topics for discussion the subject of the development of the Inter-American Highway System. Delegations from each country represented will report on the status of construction and the program for future activities.

A permanent organization of Pan-American Road Congresses will be

effected. The delegates will discuss connecting points of the Pan-American Highway at international borders, the financing of the highway and the extension of the system for insular republics.

The Inter-American Federation of Automobile Clubs will discuss cooperation in the development of international traffic and special signs and markers.

Construction Progress on U.S. 40

(Continued from page 5)

future swelling, with the accompanying distortion of the pavement, a clause is included in the new contract

requirements providing for the wetting of the lower quality material underlying the gravel sub-base until the upper two-foot portion has a moisture content between 17 per cent and 25 per cent.

The completion of the work now under contract will provide a divided four-lane highway from the South Fork of Putah Creek to the Yolo Causeway. Plans are now being made to develop other sections of this road between Dixon and Sacramento to the same standards as rapidly as funds become available.

Fredericksen and Westbrook are the contractors on the work and J. W. Corvin is the resident engineer.

Coast Road

GRADING PROJECT, WATSONVILLE
TO ROB ROY, IS NEAR COMPLETION

By A. WALSH, Resident Engineer

THE LEGISLATIVE act of 1933, added to the State Highway System that portion of the Coast Road between Santa Cruz and Watsonville in Santa Cruz County.

This section of two-lane concrete pavement has developed a heavy traffic flow in excess of the safe capacity of the road.

To relieve this traffic burden a major construction project has been under study for several years.

The State Highway Budget for the Ninety-first-Ninety-second Fiscal Years provided funds for stage construction of a portion of this road which is now under contract.

This contract, 6.2 miles in length, connecting with the City of Watsonville on the east, consists, in general, of constructing a 47-foot graded roadbed sufficient for a three-lane pavement and seven-foot shoulders, widened to a 64-foot roadbed over summits where sight distance is limited.

The work was let to contractors N. M. Ball Sons, of Berkeley, in December, 1940.

The new location lies between the present road and the coast line and crosses several old tidal channels which have filled up with alluvial waste and vegetable matter in the form of peat land. The peat formation in these areas vary in depth of from 10 to 43 feet.

These areas required special foundation treatment to support the superimposed loads placed thereon by the highway fills. Test borings were made to determine the character and depth of the peat formation and it was decided to stabilize the foundations at Harkins and Watsonville Sloughs by constructing vertical sand drains to permit the escape of ground water as pressure was applied to the surface by placing the fill. These drains were constructed by drilling wells 20 inches in diameter through the peat formation, varying in depth from 10 to 43 feet, spaced on 13-foot centers parallel to center line and on

11-foot centers at right angle to center line.

To insure the wells being free of sediment before backfilling, clear water was injected into the well and removed by a suction pump which carried away the silt and sediment. This process was continued until the water ran clear, after which the wells were backfilled with a clear graded sand.

A three-foot sand blanket is being placed over the entire area to provide a drainage outlet from the sand drains.

To determine the rate of settlement and side pressures being developed by placing the fill and the safe rate at which the load can be placed, pressure gauges connected with well points placed at the bottom of the peat formation are located at the sides of the fill and settlement platforms are installed at intervals beneath the fills.

From these platforms one-inch pipe is extended vertically as the fills are constructed, and level readings taken thereon to determine the amount and rate of settlement.

From this data the rate at which the fills may be constructed without causing undesirable displacement of the foundation material is determined.

Some 70,000 cubic yards of material will be required for the 35-foot fill at Harkins Slough and is the larger of the two being treated with vertical sand drains.

At several other crossings of peat land formation overloading of the foundation by increasing the height of the fill is being done. The largest of these is at Struve Slough where 84,000 cubic yards of fill material will be placed, 35,000 cubic yards of which is provided for subsidence and displacement of the peat land foundation.

The peat at this location has a maximum depth of 35 feet. The height of the grade line above the natural ground is 35 feet.

Results secured from these alternate methods of hastening settlement and ultimate stabilization of the roadway will be interesting and valuable.

The northwesterly section of the new location is through rolling hills with vistas of the coast line and Monterey Bay in the distance and will unquestionably develop as potential home sites.

Throughout the project cut slopes have been flattened to $1\frac{1}{2}$ to 1 and will be covered with six inches of top soil sown with grass seed to retard erosion.

Some of the major contract items on this job are:

- 1,225,000 cubic yards roadway excavation.
- 16,190 lin. ft. of 20" diameter drilled wells for fill stabilization at slough crossings.
- 9,000 lin. ft. of corrugated metal pipe of various diameters.
- 490 cubic yards concrete.
- 60,000 lbs. reinforcing steel.
- 10,000,000 sta. yds. overhaul.
- Contract cost \$285,481.00.

The project is being financed from both State and Federal aid funds.

Approach roads on the project are held to a minimum and are restricted to locations consistent with safety.

The grading is being done by means of seven 18 cubic yard carryalls powered with RD8 tractors; three 12 cubic yard Turnapulls; and one 14 cubic yard Euclid. The Turnapulls and Euclid units are relatively new on highway construction. They are self-powered, have a short turning radius, and have a speed of approximately 20 miles per hour.

The terrain which the road traverses contains many springs and ground water which are being treated by constructing trenches through the water bearing strata and backfilling same with drain rock.

(Continued on page 24)



Construction on new Rob Roy-Watsonville Highway is proceeding rapidly. Upper—Truck loading with tractor pushing. In right foreground, Bulldozer in operation and in background, two Turnapulls hauling to fill. Lower—Huge fill being made

on any batter up to the one in four maximum and in both of the required directions.

Despite the low cost per square foot of deck area, this structure designed to care for modern transportation demands, is less than one-half mile long and contains sufficient concrete to build over 11 miles of the type and width of concrete road that adequately served the needs of this region some 20 years ago.

The creek draining a large area of the city runs directly under and follows the line of the viaduct for a distance of about 1,200 feet. To properly control the flow through this channel it will be rebuilt directly down the centerline of the structure where storm waters can flow between the columns without danger to the viaduct substructure. New concrete culverts are required under each of four major city streets.

CONSTRUCTION PROBLEMS

It is customary to think of a bridge as something to span across a creek but certainly somewhat unusual for a structure to be located directly over a creek for a distance of 1,200 feet. This feature caused many construction problems during the rainy season due to flood waters flowing through the foundation excavations. After each heavy rain, the footing excavations would be refilled with mud and debris for a depth of six to eight feet and it was necessary to again excavate them. Some of the excavations were cleaned out as many as ten times in an effort to keep the job progress from falling too far behind schedule.

The relatively short periods of fair weather occurring during the rainy season would not permit the placing of large sections of formwork where concrete could be poured before excessive weathering ruined the forms and it was decided to pour the supporting columns up to ground line only and return after the seasonal torrents to complete the work. This proved to be a fortunate change as it permitted at least some of the work to be carried on at times when the entire project would have been completely stopped under any other plan.

The plans for highway reconstruction near the south end of the viaduct called for traffic from the south destined for San Rafael to be routed over the old Irwin Street entrance

to the city. In order to complete these plans, it was part of the work embraced by the viaduct contract to construct a triangular shaped bridge at the San Rafael Harbor crossing. While working on this structure it was noted that the adjacent Irwin Street bridge was in very poor condition and that heavy loads being hauled over it made immediate replacement desirable. Discussions were started with city officials relative to replacing the existing bridge. The city welcomed such an improvement and with its participation a new two-span concrete bridge supported on concrete piling was built and the old unsafe wooden bridge removed.

TIME SAVED

The San Rafael viaduct will allow the Redwood Highway to assume an even more important role in the economic and social welfare of the northern coastal area than it has in the past, as it is essentially a time saver.

Time saved is an important and definite economic factor where there is heavy commercial traffic such as there is on this arterial, and it has a definite monetary value to both the industry whose time is directly saved and to society at large.

Less tangible perhaps but equally important in the long range view, is the time saved by countless pleasure cars and the lessened wear and tear on the human system when driving over a modern highway as compared with the older roads with their lower standards of curvature, grades and widths; and the never ending succession of restricted speed zones and other obstacles to free traffic flow.

With the Nation's major efforts now concentrated upon problems of National defense and with present day military units almost completely mechanized, rapid transportation facilities between strategic points becomes a matter of primary importance in case of war.

During recently observed practice maneuvers, troop movements were considerably hampered by using the present route through San Rafael and local traffic was completely disrupted.

Completion of the new skyway will eliminate San Rafael as an obstacle to rapid military transportation through this region.

Pit River Bridge Agreement With U. S. Is Signed

On behalf of the State of California, Director of Public Works, Frank W. Clark, has signed an agreement with the United States under which the Division of Highways and the Southern Pacific Railroad Company jointly will maintain and operate the five million dollar Pit River Bridge the world's highest double-deck span which is being constructed by the United States Bureau of Reclamation to reroute the Pacific Highway and the railroad around the Shasta reservoir.

The contract signed by Clark has been under negotiation between the Federal and State Governments and the railroad company for approximately two years. Title to the bridge is to remain permanently in the United States. It will be maintained by the State and railroad company at their expense, the State receiving from the Federal Government a perpetual easement for the exclusive highway facilities.

The agreement provides in detail for the method of determining the cost of maintenance and the items which shall be included in computing the same, as well as liability and indemnification of the respective parties in connection with the maintenance. The agreement also provides for the accommodation on the bridge of certain distribution and communication lines of Pacific Telephone and Telegraph Company, Western Union Telegraph Company, Postal Telegraph-Cable Company and Pacific Gas and Electric Company.

Edith: "Dick, dear, your office is in State Street, isn't it?"

Dick: "Yes; why?"

Edith: "That's what I told Dad. He made such a funny mistake about you yesterday. He said he'd been looking you up in Bradstreet."

A girl was discovered crying bitterly the other day. Her mother asked her what was the matter.

Little Girl (wailing)—Boo boo! My new shoes hurt me!

Mother—Well, no wonder. You have them on the wrong feet.

Little Girl (protesting)—I haven't any other feet.

Yearly Storms Do Costly Damage to the State Highways System

(Continued from page 10)

feet before corrective measures could be started.

HUGE EARTH MOVEMENT

It is estimated that approximately one-quarter million cubic yards of earth are in motion, and it is hoped that the removal of between 50,000 and 80,000 cubic yards, in the form of benches as illustrated in the diagram, will be sufficient to stop the movement. This is not certain, however, and it may be necessary to remove more material from the upper bench in order to bring the slide completely under control.

The removal of the lower bench, marked (3) on the diagram, is for the purpose of stabilizing the lower or secondary slide. Since it was necessary, in any case, to move some of the material twice, it was decided to place this material in a form of a temporary counterweight (2) in order to slow up the movement pending the completion of the bench excavation. The removal of this temporary counterweight will be the last operation to be performed.

It is believed that the moisture which caused this slide resulted from percolation of surface waters, since no evidence of underground sources of water was apparent. This cut had never caused trouble previously and would probably have remained stable indefinitely under normal conditions of rainfall.

RAINY SEASON BAD

In an 18-mile section between Castaic and Alamos Creek, which was completed in 1933, 15 slides and slipouts have developed during the past rainy season. Several of these are shown in the accompanying photos, and diagrams of typical cases show the proposed method of correction.

The immediate cause of these failures was the excessively heavy rainfall during the past winter. Unfavorable geological conditions in this area were a contributing cause, since the formations encountered consist largely of soft clay shales which weather to considerable depths and become soft and plastic when saturated. These materials also are difficult to compact in embankments. In some portions of this area compara-

tively hard sandstones occur, but these are invariably interbedded with thin shale strata which become plastic and slippery when wet and thus induce slides along the bedding planes where the strata dip toward the roadway.

This was one of the first projects to be constructed on a high standard of grade and alignment through rugged mountainous country. It was built during a cycle of dry years when adverse subsurface moisture conditions were not apparent, and at a time when little was known about modern soil mechanics and its application to foundation and stability studies in connection with highway construction. Much has since been learned about the stability of cuts and fills, and about methods of anticipating and preventing them.

CORRECTION MEASURES

The general methods of correcting the more serious slipouts are shown in the accompanying diagrams.

For some of the smaller slipouts and some of the fills which are showing the first signs of instability, the corrective measures proposed will consist of drainage by means of perforated pipes installed in borings which are made by means of a horizontal power auger. These borings can be made at comparatively low cost, and it is believed that such drainage measures will reduce the moisture content and lower the ground water sufficiently to stabilize these fills which are showing the first signs of failure.

There is considerable evidence that much of the water which is saturating the fills is coming from seepage in cut sections which drains down-grade into the adjoining fills. In some cases a considerable flow of water has been found traveling under the concrete pavement. An extensive program is contemplated to eliminate this source of water by constructing longitudinal subdrains along the gutter line in cut sections with transverse drains across the highway at the ends of the cuts.

The three major slides on the Ridge Route which are shown in the photographs involve an estimated total of approximately 200,000 cubic yards.

In addition to this amount, it is estimated that minor slides on this route will total 67,000 cubic yards.

The following is a rough estimate of the total quantities involved in the correction of the slides and slipouts described for the two locations.

The cost of this work will be approximately \$330,000.

	Ridge Route	Kellogg Slide	Total
Excavation (cu. yds.)	490,000	80,000	570,000
Horizontal Borings (lin. ft.)	6,300		
Division Trenches (lin. ft.)	38,000		
Gravel for porous drains (cu. yds.)	5,000		
24-inch culvert pipe (lin. ft.)	280		
72-inch culvert pipe (lin. ft.)	200		
Bituminous Surfacing (tons)	800	1,100	1,900

In the preliminary investigation of proposed construction projects, the soil survey and foundation investigation is becoming increasingly important. The location of the highway should be influenced to a considerable extent by conditions disclosed by geological studies and boring investigations, in order, where possible, to avoid cuts in unstable soils or in stratified rocks where the dip is unfavorable. Cut slopes should be designed sufficiently flat or should be benched to avoid major slides, and fill foundations should be adequately drained, especially where the cross-slope of the ground is appreciable. A thousand dollars spent on the preparation of a fill foundation may prevent a slipout which would cost from 10 to 30 times that amount to correct.

California Leads

With California leading all the States in the Union, the third largest annual increase in registration of motor vehicles since the depression occurred in 1940, the Public Roads Administration of the Federal Works Agency announces.

Public, private and commercial motor vehicles registered in California last year totaled 2,810,566. New York State was in second place with a registration of 2,778,312. Pennsylvania was third with 2,169,702 vehicles. Six States, Illinois, Indiana, Michigan, New Jersey, Ohio and Texas exceeded 1,000,000 registrations each.

Highway Bids and Awards for June, 1941

CALAVERAS COUNTY—Between Ames and South Fork of Mokelumne River, about 3.6 miles in length to be graded and surfaced with road-mixed surfacing on a base of imported borrow. District X, Feeder route. Claude C. Wood, Lodi, \$118,038; Harms Bros., Sacramento, \$123,371; Johnston Rock Co., Inc., Stockton, \$125,254; A. Teichert & Son, Inc., Sacramento, \$134,422. Contract awarded to Elmer J. Warner, Stockton, \$117,160.

CONTRA COSTA COUNTY—A toll plaza for the Antioch Bridge at its south approach, consisting of a toll booth, reinforced concrete scale pit, scales, concrete roadway widening and appurtenances thereto. District IV, Route 11, Section A. Underground Construction Co., Oakland, \$19,971; D. W. Nicholson Corp., San Leandro, \$21,005; Albert H. Siemer and John Carcano, San Anselmo, \$21,211. Contract awarded to M. A. Jenkins, Sacramento, \$17,673.

FRESNO COUNTY—Between White Deer Road and Sequoia Forest Boundary, about 3.1 miles, bituminous surface treatment to be applied to the existing roadbed. District VI, Route 41, Section T. Geo. E. France, Visalia, \$13,245. Contract awarded to Oilfields Trucking Co., Bakersfield, \$12,786.

HUMBOLDT COUNTY—Across Eureka Slough at Eureka, a bridge having an overall length of 849 feet 6 inches consisting of two steel truss spans and 17 reinforced concrete girder spans to be constructed and approaches about 0.7 mile in length to be graded and surfaced with plant-mixed surfacing on a gravel base. District I, Route 1, Sections Eur.&H. A. Soda & Son, Oakland, \$304,678; C. W. Caletti & Co., San Rafael, \$306,514. Contract awarded to Ralph A. Bell, San Marino, \$289,478.

KERN COUNTY—Between Levee Canal and S. P. railroad crossing at Oildale, about 1.2 miles to be graded and surfaced with asphalt concrete. District VI, Route 142, Section A. Piazza & Huntley, San Jose, \$105,325; A. Teichert & Son, Inc., Sacramento, \$113,021. Contract awarded to Griffith Co., Los Angeles, \$94,951.35.

LOS ANGELES COUNTY—On Bellflower Boulevard between 0.3 mile south of South Street and Artesia Avenue, about 1.3 miles, to be graded and surfaced with plant-mixed surfacing. District VII, Route 169, Sections A.L.Bch. Nick Perscallo, Los Angeles, \$37,888; Griffith Co., Los Angeles, \$38,857; Vido Kovacevich, South Gate, \$39,435; Oswald Bros., Los Angeles, \$42,722; Sully Miller Contracting Co., Long Beach, \$44,603. Contract awarded to J. E. Haddock, Ltd., Pasadena, \$35,942.

LOS ANGELES COUNTY—At Topanga Creek near Santa Monica, a reinforced concrete girder bridge to be constructed and about 0.27 mile to be graded and surfaced with plant-mixed surfacing and bituminous surface treatment applied to shoulders. District VII, Route 156, Section A. J. S. Metzger & Son, Los Angeles, \$77,629; The Contracting Engineers Co., Los Angeles, \$81,797. Contract awarded to J. E. Haddock, Ltd., Pasadena, \$61,241.

LOS ANGELES COUNTY—Between Cypress Avenue and Big Dalton Wash, about 0.6 mile to be graded and surfaced with plant-mixed surfacing. District VII, Route 62, Section D. Wm. C. Horn Co., Pomona, \$13,840. Contract awarded to J. E. Haddock, Ltd., Pasadena, \$11,116.

MENDOCINO-HUMBOLDT COUNTIES—Between Ridgewood Ranch and one mile north of Dyerville, about 5.9 miles to be surfaced with imported borrow and road-mixed

surfacing. District I, Route 1, Sections DH,BD. Contract awarded to Claude C. Wood, Lodi, \$27,900.

MERCED COUNTY—At points between 12 and 18 miles east of Los Banos, 7 bridges to be widened and approaches thereto to be widened and surfaced. District X, Route 32, Section C. Earl W. Heple, San Jose, \$52,927. Contract awarded to Kiss Crane Service, Berkeley, \$38,174.

MODOC COUNTY—Between Likely and Cedar Pass, about 13.3 miles, construction of a graded roadbed, placing road-mixed surfacing and seal coat on imported borrow on a portion, placing plant-mixed surfacing and seal coat upon imported borrow on other portions. District II, Routes 73, 28, Sections C.D,Alt,C. Contract awarded to Harms Bros. & Powers & Patterson, Sacramento, \$97,368.

PLACER COUNTY—Between Lincoln and Yuba County line, about 2.5 miles to be surfaced with plant-mixed surfacing. District III, Route 3, Section B. Contract awarded to Hemstreet and Bell, Marysville, \$12,350.

PLUMAS COUNTY—Between Crescent Mills and Greenville, about 4.2 miles to be surfaced with road-mix surfacing. District II, Route 83, Section B. Poulos & McEwen, Sacramento, \$22,694; Lee J. Immel, Berkeley, \$25,663. Contract awarded to Oranges Bros., Stockton, \$17,831.

PLUMAS COUNTY—Between Quincy and Western Pacific Subway about 6.8 miles to be graded and surfaced with gravel base and plant-mixed surfacing and reinforced concrete box culverts to be constructed. District II, Route 21, Section D. Johnston Rock Co., Inc., Stockton, \$149,346; Fredrickson Bros., Emeryville, \$150,750; Hemstreet & Bell, Marysville, \$153,032; Parish Bros., Sacramento, \$171,745; Isbell Construction Co., Reno, \$183,058. Contract awarded to Harms Bros., Sacramento, \$134,110.

RIVERSIDE COUNTY—Across Pinto Gulch about 26 miles east of Indio, a bridge to be constructed. District XI, Route 64, Section I. Hensler & MacDonald, Highway Highlands, \$26,830; Roland T. Reynolds, Anaheim, \$28,225; The Contracting Engineers Co., Los Angeles, \$29,696. Contract awarded to J. S. Metzger & Son, Los Angeles, \$25,623.

SACRAMENTO COUNTY—Between the American River bridge and North Sacramento, a reinforced concrete viaduct to be constructed and about 0.4 mile of roadway to be graded and paved with portland cement concrete, asphalt concrete and plant-mix surfacing. District III, Route 3, Section B, N. Sac. Heafey-Moore Co. & Fredrickson & Watson Construction Co., Oakland, \$637,144; Campbell Construction Co. Sacramento, \$548,843; A. Soda and Son and Parish Bros., Oakland, \$641,611. Contract awarded to Earl W. Heple, San Jose, \$528,136.

SACRAMENTO COUNTY—Across Cosumnes River and Overflow channels, bridges to be repaired. District III, Route 4, Section A. F. Kaus, Stockton, \$15,280; Albert H. Siemer & John Carcano, San Anselmo, \$22,414. Contract awarded to M. A. Jenkins, Sacramento, \$14,722.

YOLO COUNTY—Across Sacramento River at Knights Landing, leaves of existing bascule bridge to be redecked. District III, Route 87, Section A. P. F. Bender, North Sacramento, \$9,945; M. A. Jenkins, Sacramento, \$10,784; F. Kaus, Stockton, \$13,621; Lee J. Immel, Berkeley, \$13,253. Contract awarded to C. C. Gildersleeve, Berkeley, \$9,844.

Supreme Court Upholds Authority of Public Works

(Continued from page 11)

The decision is important because it clearly is applicable to the whole question of regulation of encroachments in State highways, including those existing pursuant to permits issued by the department. It is important, also, because:

It upholds validity of Section 680 of the Streets and Highways Code;

It validates, in effect, the procedure adopted by the department for the relocating of the water main;

It clarifies the authority of the department over holders of so-called "State franchises" to occupy highways, including rights conferred by Section 536 of the Civil Code, by the Irrigation District Acts, Public Utility District Act, Metropolitan Water District Act, by former Section 19 of Article XI of the Constitution, and other similar enactments.

The legal office wishes to express its appreciation of the cooperation received from Colonel Jno. H. Skeggs, District Engineer, District IV, and Mr. E. G. Poss and other members of the district staff, in preparation and trial of the case in the superior court.

Coast Road Grading Project Near Completion

(Continued from page 18)

The project is operating on a two-shift basis and at the present rate of progress will be completed well ahead of schedule.

The budget for the Ninety-third-Ninety-fourth Fiscal Years provides funds for completion of the grading from the end of the present project to a connection with the old road at Rob Roy and for surfacing the project from Watsonville to Rob Roy.

When this work is completed, an overtaxed traffic artery will be relieved, saving more than two miles of travel distance between Watsonville and Santa Cruz.

The military value of this improvement is significant by reason of the fact that it makes easier access to Camp McQuaide, which is located between the highway and the ocean, and also shortens travel time and relieves traffic congestion between the many military training camps in this coast area.

State of California
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Department of Public Works

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MORGAN KEATON, Deputy Director

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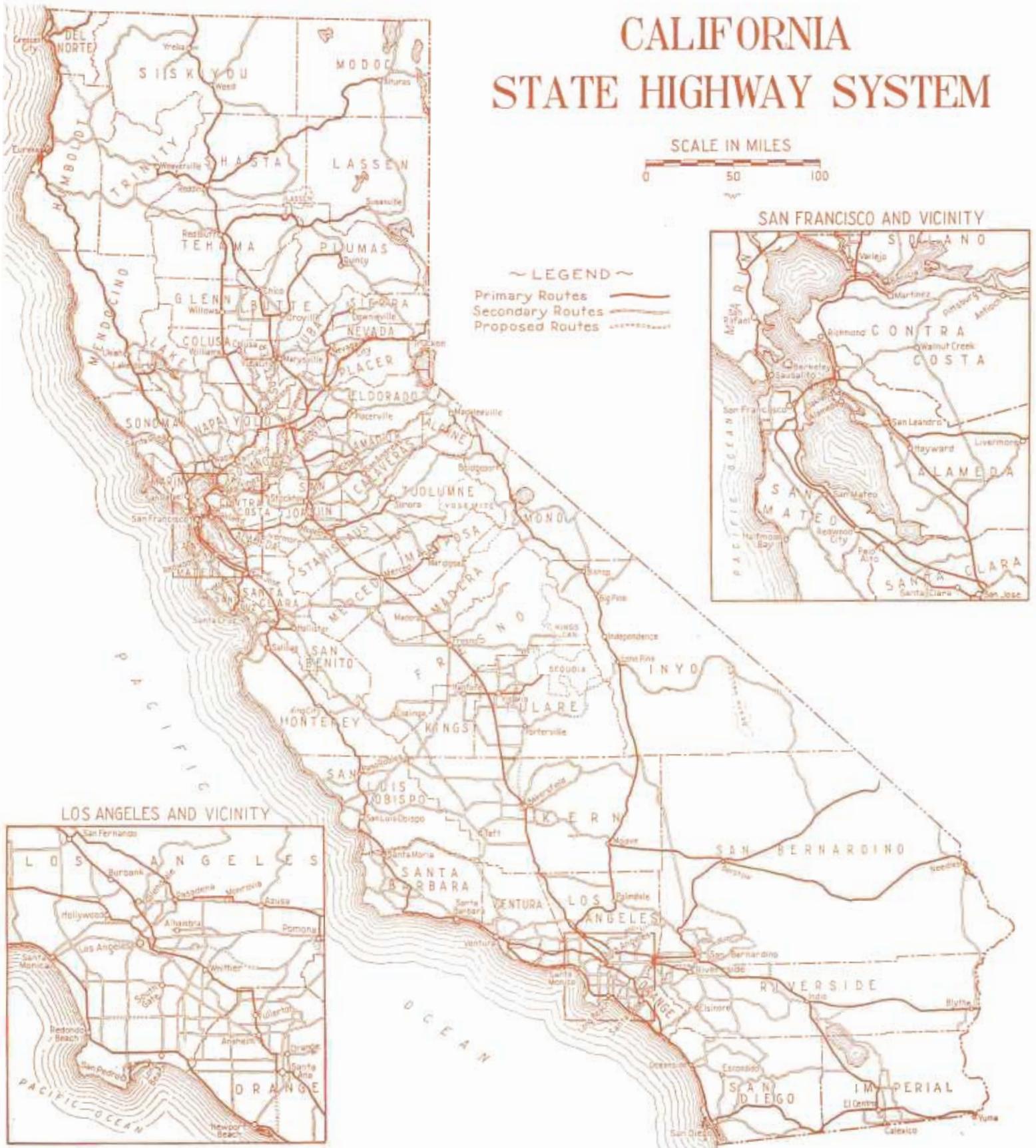
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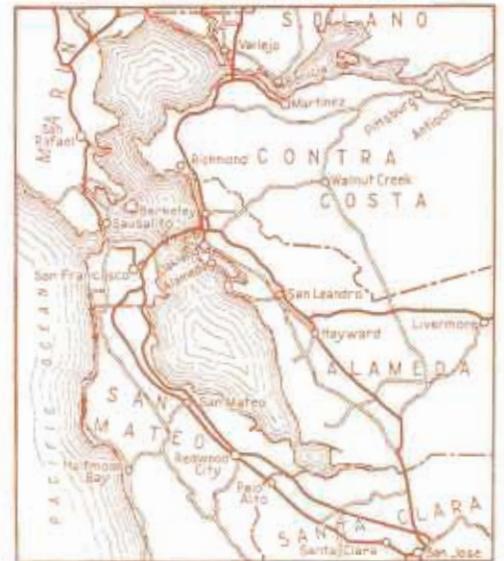


~ LEGEND ~

- Primary Routes
- Secondary Routes
- Proposed Routes



SAN FRANCISCO AND VICINITY



LOS ANGELES AND VICINITY

