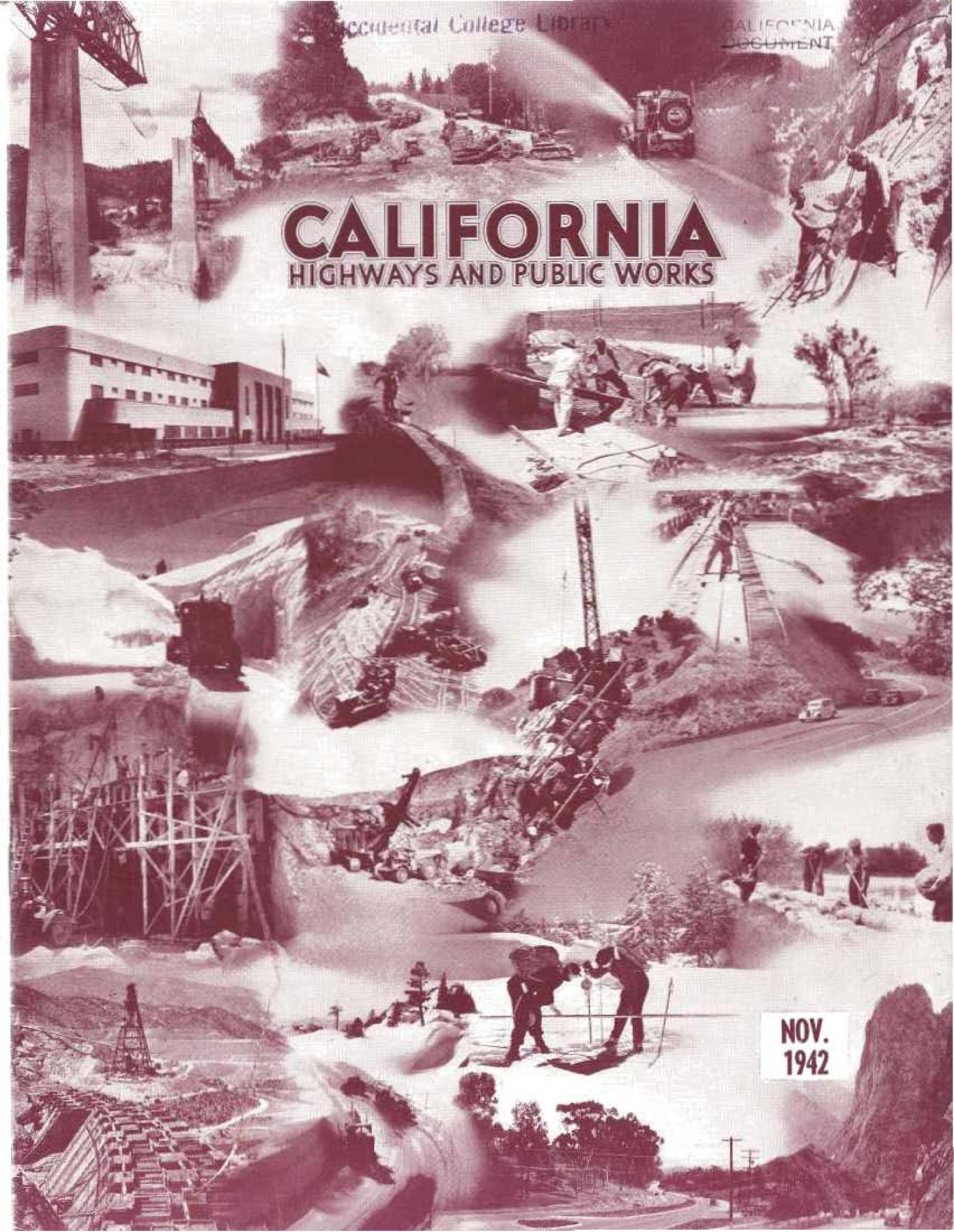
CALIFORNIA
HIGHWAYS AND PUBLIC WORKS



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CALIFORNIA HIGHWAYS AND PUBLIC WORKS

Official Journal of the Division of Highways, Department of Public Works, State of California [PRINTED IN U.S.A.]

FRANK W. CLARK, Director C. H. PURCELL, State Highway Engineer J. W. HOWE, Editor K. C. ADAMS, Associate Editor

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War Depletes Personnel of Division of Highways and Creates Serious Problem of Road Maintenance

By C. H. PURCELL, State Highway Engineer

THE war has created a serious problem for the State Division of Highways. We are confronted with the task of holding or obtaining sufficient trained personnel to maintain our highways, to complete the construction of the many going projects that are of vital importance to our war program and to make the necessary surveys and plans and handle the construction of other vitally needed projects.

Over 2,900 employees have left the service of the Division of Highways since January 1, 1941, and at the present time others are leaving at the rate of about two per day. Many have entered the armed forces; others have resigned to accept employment elsewhere. Replacements are increasingly difficult to obtain and at several locations in California, due to the scarcity of men and the difficulty of obtaining living quarters, it has been impossible to fill the vacancies.

In spite of our best efforts in recruiting new personnel, we have approximately 1,300 fewer employees now than a year ago.

During the past several months survey, plan and construction work has been steadily increasing due to many access road and emergency flight strip projects being added to our program. On October 1st of this year, 124 contracts were under way, 46 of which were access road or flight strip projects. The estimated cost of completing these contracts was $13,553,000. In comparison, the estimated cost of completing contracts under way on October 1, 1940, was $8,645,000.

It is interesting to note that on October 1, 1940, there were 1,285 engineers employed by the Division of Highways, while only 1,122 engineers were on the pay roll on October 1, 1942. In addition to the 124 going contracts, 52 other projects, estimated to cost $9,378,000, have been certified for construction by Federal authorization.

In several sections of the State, maintenance work has increased greatly, due to military traffic and hauling to defense establishments causing heavy damage to highways. With winter coming on there is a strong possibility of having some of our roads closed unless replacements can be obtained. It is estimated that a minimum of an additional 100 equipment operators and 200 laborers will be required to maintain our roads during this coming winter.

The many Federal war measure regulations relating to highway construction and maintenance have also added on a tremendous amount of additional work, and only through our employees working long hours has it been possible to keep up with the heavy survey, construction, and maintenance program. Many projects are undermanned and in some cases untrained employees are being used for work that they would ordinarily not be assigned to.

The following figures indicate the seriousness of our personnel situation:

MANY IN U. S. SERVICE

	Number of employees who have left the employment of the Division of Highways subsequent to January 1, 1941		
	Military Leaves of Absence	Resignations	Total
Engineering personnel	175	616	791
Maintenance personnel	159	1,568	1,727
Clerical personnel	40	313	353
Miscellaneous	12	46	58
Totals	386	2,543	2,929

EMPLOYEE LOSSES

	Total Number of Highway Employees			
	July 1941	January 1942	July 1942	October 1942
Engineering personnel	1,457	1,257	1,175	1,122
Maintenance personnel	3,297	3,380	2,529	2,439
Clerical personnel	710	742	716	724
Other personnel	342	333	334	297
Total pay roll	5,806	5,712	4,754	4,582

(Continued on page 9)

Strategic Network and Access Roads Defined

"A great many people have the idea that the strategic network of highways is a system of military roads separate from the ordinary highway system of the nation. It is nothing of the sort," Brig. Gen. Philip B. Fleming said in a recent statement. "The strategic net-work is simply that part of the nation's highway system which the War Department has designated as most important for military improvements.

"Since Pearl Harbor, highway building and maintenance have had to be sharply curtailed. With a few notable exceptions the Public Roads Administration, through which the Federal Works Agency carries on its federal aid highway program, is concentrating on providing access roads in areas of military, naval or wartime industrial concentration, and on remedying critical deficiencies in the strategic network.

"Average length of the access roads is only about three miles. Those that do not form part of the primary or secondary systems of the States in which they are located are now being wholly financed from funds made available by the Defense Highway Act of 1941. Those that are a part of the State systems are financed from regular federal aid funds, except that the Government bears 75 per cent of the cost instead of the customary 50 per cent."

California Is Striding Ahead in the Conservation of Rubber

By JAMES M. CARTER, Director of Motor Vehicles and Chairman, State Highway Traffic Advisory Committee

CALIFORNIA has played a leading part in the Nation-wide effort to conserve vital war transportation almost from the time the country's rubber supply was cut off by hostilities in the Orient.

Because it was already in existence when the war started, the California Highway Traffic Advisory Committee to the War Department was recognized by the Secretary of War and the Office of Defense Transportation as the logical coordinating agency through which this work was to be done.

With the adoption of the Nation-wide conservation program by the ODT, the Highway Traffic Advisory Committee to the War Department was delegated as the national agency. The several State committees, of which the California group is one, were given charge of the program in their respective States. To localize the program and bring it closer to the people, war transportation committees were set up in every important community and administrators named to handle purely local problems.

The writer was named chairman of the California committee by Governor Olson. Serving on the committee are Charles H. Purcell, State Highway Engineer; Larry Barrett, chairman of the California Highway Commission, and E. Raymond Cato, Chief of the California Highway Patrol.

To facilitate the committee in carrying out the program, technical assistants were drawn from the Departments of Public Works and Motor Vehicles. J. W. Vickrey, Traffic and Safety Engineer of the Division of Highways, was appointed Executive Secretary and Arthur B. Waugh, Public Relations Counsel of the Department of Motor Vehicles, was appointed Director of Information. District Engineers of the Highway

JAMES M. CARTER

54,000 Communities Require Motor Transport

More than 54,000 communities in the country, as compared with 48,000 10 years ago, depend entirely upon motor transport, according to the 1942 edition of "Motor Truck Facts" now being released by the Motor Truck Committee of the Automobile Manufacturers Association.

Included in the information is the fact that of 741 war factories in Michigan, the average plant utilizes truck transportation to the extent of 65 per cent of incoming freight, and 69 per cent of outgoing freight.

In California with 5,533 communities, 1,868 of them, or 33.8 per cent are served only by roads.

WHY OUR COUNTRY MUST SAVE CARS AND TIRES

TODAY—7 out of 10 typical industrial workers depend on cars to get to work, 2 use public transportation and one walks.

NEXT JANUARY—out of every 10 tires on workers' cars today, 4 will be worn out.

AUGUST, 1943—8 out of every 10 tires will be worn out; public transportation will be available to only 4 out of 10 workers when their cars give out.

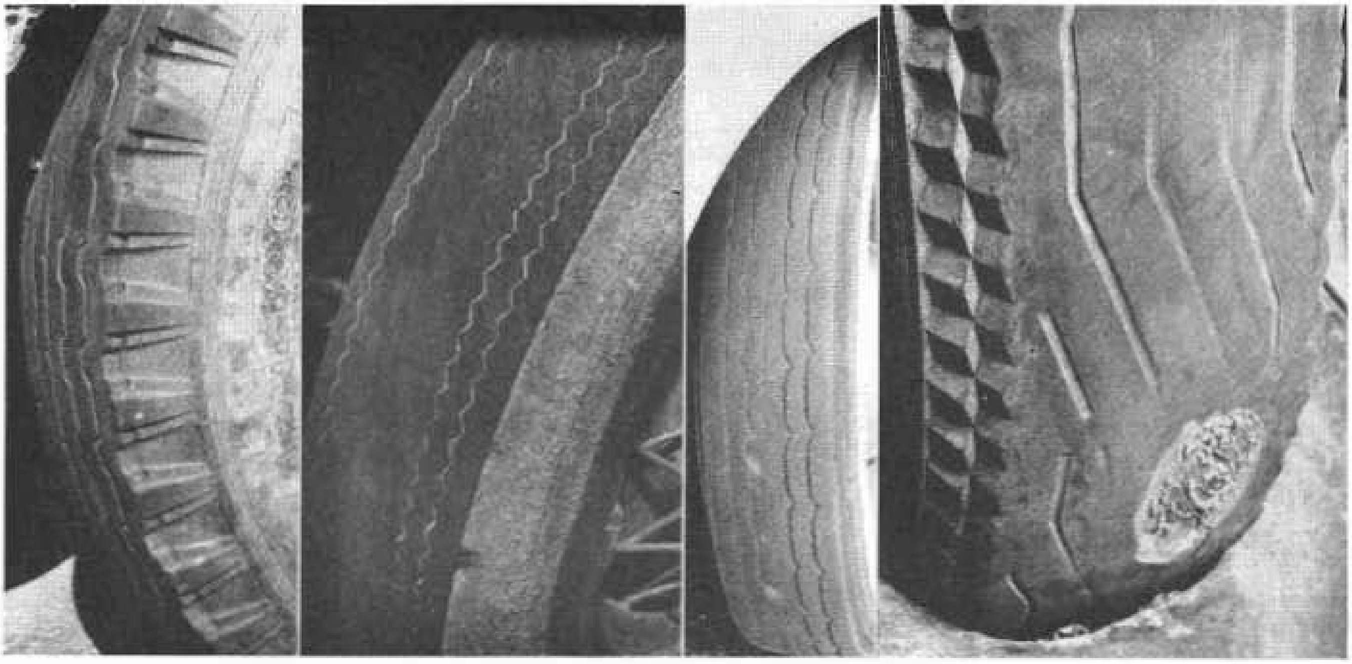
West Virginia Road Commission Survey

57 Per Cent of All Car Mileage Is For Business

Some interesting facts concerning the use of automobiles are revealed in the latest issue of Automobile Facts and Figures magazine.

Car mileage for strictly business purposes averages 57 per cent for all States. Automobile trips for necessity uses amount to 77 per cent and trips for recreational and social uses are given as 23 per cent.

Some other interesting facts in connection with automobile use are that the oldest cars have a high percentage of necessity driving and commercial travelers have the highest mileages while physicians make the most trips.



Tire on left shows result with wheel out of balance or worn bearings, causing uneven wear and cup-like indentations. Next tire shows wear on side because wheel is out of alignment. Third view, a combination of bad wheel alignment and bad brakes cause wear on one side and spots on tread. Right picture shows what happens when you have rough, catching spots on brake bands or egg-shaped brake drum, causing wheel to stop in one position and wearing hole in tire.

Division were named assistant secretaries to act in their respective areas and highway patrol inspectors and captains were designated as coordinators in their areas. Highway engineers and attaches were borrowed to make surveys and give other technical assistance.

COMMITTEE OBJECTIVE

The committee adopted as its objective the conservation of vital war transportation by the prolongation of all rubber-borne transportation facilities now in use and the maximum use of mass transportation facilities. The methods proposed to carry out this program were:

1. **Systematic staggering of store, office, industrial and school hours.**
2. **Planned neighborhood-by-neighborhood group riding to and from stores, offices, industries, and schools based on common destinations.**
3. **Regulation of street and highway traffic to make possible more safe and efficient use of vehicles.**
4. **Securing compliance with speed regulations as proposed by the President and Governor and later by the Rubber Administrator.**
5. **Encourage individuals, groups and agencies to use any additional methods to conserve vital war transportation.**

Means to Save Rubber Suggested by Jeffers

Rubber Director William M. Jeffers has asked all newspapers to carry a special message on tire conservation "as frequently as possible" from October 5th until the start of Nationwide gasoline rationing about November 22d.

Jeffers offered a suggested text for a one or two column box and said he hoped each editor would consider the request as "a personal appeal from me."

The suggested text:

A message to every driver:

You can save rubber and help win the war if you will do these things:

1—Drive only when absolutely necessary.

2—Keep under thirty-five miles per hour.

3—Keep your tires properly inflated.

4—Have them inspected regularly.

5—Share your car with others.

—WILLIAM M. JEFFERS

Throughout, it has been the policy of the committee to work with the city administrators and war transportation committees within their geographical jurisdictions in an advisory and stimulative capacity.

The work has gone forward smoothly and effectively. War transportation committees and administrators have been appointed in every California city with a population over 10,000 and in a number with a population somewhat less. These agencies are all carrying out a conservation program in keeping with their own local problems but based on the general principles of the ODT plan.

COORDINATORS NAMED

In the Los Angeles Metropolitan and the San Francisco areas, special committees and coordinators have been named to handle the difficult and intricate problems of conservation and mass transportation peculiar to those communities.

Active support is being given all of these agencies by the State Highway Traffic Advisory Committee.

Realizing that the greatest problem confronting it was to reach the indi-

(Continued on page 19)

Highway Culvert Location and Slope From a Review of California Practice

R. ROBINSON ROWE, Assistant Engineer, Bridge Department
G. A. TILTON, Jr., Assistant Construction Engineer

FOREWORD

This is the third of a series of technical abstracts from a joint departmental review of culvert practice of the California Division of Highways, by a committee composed of Clarence F. Woodin, Assistant Maintenance Engineer; Robert L. Thomas, Assistant Engineer, Surveys and Plans; and the writers. Following the preliminary outline of subjects in the August number of the California Highways and Public Works, the series opened with:

September issue—Comparative Hydrology Pertinent to California Culvert Practice; October issue—Debris Control at Culvert Entrances on California Highways.

The series continues with a discussion of culvert location with respect to the natural channel. Typical locations are named, defined and compared, with recommendations. Obviously horizontal and vertical locations are not independent, but the two subjects are developed separately for easier reference. The vertical location involves the consideration of slope, for which new guides are presented.

MODERN traffic demands and development of earth-moving equipment justifies our increasingly higher standards for alignment and grade. In consequence, cuts through ridges are deeper and embankments over depressions are higher. Further, higher embankments increase the burden on culverts so that stronger and more expensive conduit sections are required.

To offset the combination of greater length and higher unit cost, every expedient seems to have been tried. The committee observed and studied many cases in which expedients of first-cost economy had sacrificed hydraulic essentials. Judgment, rather than rule, must be the determinant, but some general rules should be helpful in avoiding wide use of expedients which should be applied only in limited fields.

LOCATIONS CLASSIFIED

To clarify the study, location practice has been classified as illustrated in **Figure 12a-g.** The *Bottom Location* is the natural position for the culvert, with flow line generally coinciding with channel bed. With few exceptions, this is the best location hydraulically, even if alignment must be curved **(Figure 13a)**, or grade line broken **(Figure 13b)**. Conduit cost will be a maximum, but alternatives should not be compared without estimating total culvert cost, including headwalls, spillways, channel changes, revetment, maintenance and probable damage if natural conditions are altered.

In the *Modified Bottom Location*, the outlet grade is raised above natural grade, shortening the distance between embankment slopes. This has been successful for small pipe culverts in steep channels, as the conduit can project and cantilever from the bank so that outfall will clear the toe of the embankment slope. Even for medium-size culverts of pipe or box section, the modification has been applied by aligning the conduit with the gradetour (grade contour), so that the culvert is built throughout on solid earth and outfalls to one side of the natural channel **(Figure 14)**.

If both entrance and outlet are set well above natural grade, the alignment usually ignores the natural channel, following a gradetour on that side of the ravine where highway grade is low. This has been designated a *Sidehill Location* (or a *Top Location* if conduit is laid just below the roadway grade). For the latter, hazard of flood overtopping the roadway should be investigated. In either case, the embankment must serve as a dam and may require special attention, such as use of impervious borrow or greater compaction on the upstream slope and provision for drainage of the rest of the prism.

Such a location increases stage for some distance upstream, aggrades the bed with mineral debris and leaves a stagnant pond after each flow. Selection of this type presumes that these changes are tolerable. In some cases, however, aggradation filled the channel rapidly, so that approach channels had to be maintained; but bottom locations would have passed debris through the culverts indefinitely with little maintenance.

Also, for *Sidehill Locations*, conduits may be subjected to unusual stress by the shearing force induced by weight of a settling embankment. Unbalanced pressures at such points have caused total collapse of pipes. This can be avoided by adjusting alignment and grade of the culvert until the conduit is entrenched throughout in firm material.

DIVERSION ALIGNMENT

The *Diversion Location* is the substitution of a normal (or nearly so) alignment for the natural skew of the channel. Four alternatives are sketched as typical of installations observed in the study. All require that the channel be positively changed or that embankment toes resist erosion by flood flows. For high velocity flow, this means revetment of earth slopes and careful design of headwalls and endwalls.

As a general rule, flood waters should be conducted under the highway at first opportunity, as for alternative (a), minimizing scour of embankment and entrapment of debris. If the culvert gradient will be steep or if free drop is planned at outfall, then alternative (c) may be justified, but estimates should include annual cost of maintaining channel and embankment toe above the culvert entrance. Alternative (b) is a compromise that can be justified only when local conditions limit channel changes at both ends. Alternative

Culvert Locations Defined

Bottom Location

Culvert located in approximate line and profile of natural channel.

Modified Bottom Location

Culvert entrance in bottom of natural channel and outlet projecting from embankment slope.

Sidehill Location

Culvert entrance and outlet well above bottom. Wrong: On an unstable berm. Right: In trench or on solid berm.

Top Location

Culvert entrance and outlet near roadway grade, well above bottom.

Diversion Location, Normal

Culvert normal to roadway, diverting a skewed stream at entrance or outlet or both.

Diversion Location, Preferred

Small skews eliminated, moderate skews retained, large skews reduced.

Transverse Relief Location

Culvert located transverse to roadway to intercept gutter flow at regular intervals.

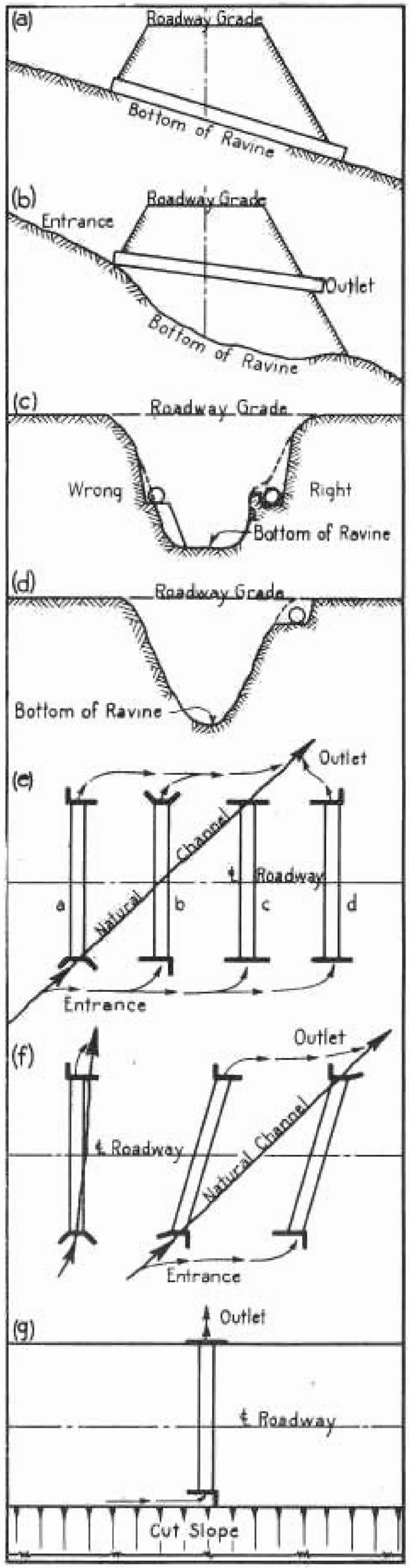


Figure 12

(d) will usually be a *Sidehall Location* and should be studied as such. Rarely, in a U-shaped valley, this alignment will resemble a *Bottom Location*, with the advantage of dry trench or structure excavation, but with all the disadvantages of alternatives (a) and (c) combined.

REDUCTION OF SKEW

One point should be emphasized as a general criticism of alignment in *Diversion Location*. Reduction of skew should be considerate of extra cost of skew construction and of channel change and maintenance. At one extreme, consider a box culvert 100 feet long on a 3 degree skew. Extra cost of framing the skew structure would probably exceed the alternative channel adjustment (about 5 feet) for a normal alignment. At the other extreme, suppose the channel skew was 45 degrees, a normal culvert would appear to save 41 feet of conduit by adding 100 feet of channel work. But an 8 degree skew culvert would have saved 40 feet of conduit by adding only 86 feet of channel.

Hence, as a general rule, small skews should be eliminated, moderate skews retained and large skews reduced—the limits being determinable for each site by cost comparison. Accordingly, the second illustration of *Diversion Location* **(Figure 12 f)** indicates the preferred locations.

SLOPES GENERALLY

In the September installment, it was recommended that culverts be designed to carry a 10-year flood without static head (on crown at entrance) and that balanced design of culvert and appurtenances be based on the 100-year flood. Either of these rules may (for some particular site) determine size of culvert or its gradient. Generally, however, the first rule will determine only a minimum waterway area and the second will yield balanced combinations of area, gradient and conduit texture for cost comparison.

Since gradient assumes its greatest importance when considering the rule for a 100-year flood, we have defined *critical slope* as the gradient which will just carry the 100-year flood with a full waterway.

CHARTS PRESENTED FOR COMPUTATIONS

Chart C **(Figure 15)** has been prepared to show the relationship between full capacity and critical slope for culverts of concrete or corrugated

Figure 13a. Bottom Location—reinforced concrete arch on curved alignment and uniform gradient in bottom of ravine. Figure 13b. Bottom Location—reinforced concrete arch on straight alignment and broken gradient. Figure 14. Modified Bottom Location—corrugated metal pipe, with entrance in bottom of ravine and alignment following grade tour in sidehill trench, to an outlet well above and to one side of natural channel.

metal. The relationships were derived from published (1) (2)* discharge formulae and depend upon size, shape and texture of the conduit, but not its length. For circular sections, the slope is obtained in one step with the isopleth (computation line drawn on nomograph, or represented by a straight edge) intercepting the 100-year flood on the discharge scale and the diameter scale corresponding to the pipe material. For non-circular sections (box or arch) of cast-in-place concrete, there are two steps, the first isopleth intercepting perimeter and area scales to obtain a turning point on the diameter scale, whence a second isopleth through the discharge obtains the critical slope.

Before applying this chart, a minimum conduit section should be determined from the 10-year flood criterion, remembering that the 10-year flood is only 55 to 65 per cent of the 100-year flood. Chart D **(Figure 16)** gives this directly for circular conduits and a series of isopleths rotated through the 10-year flood on the discharge scale will give a series of equivalent rectangular box dimensions.

* Numbers in parenthesis refer to bibliography listed at end of this article.

EXAMPLE

The following example illustrates the use of the charts. Suppose for a certain culvert site that we have estimated the 100-year flood at 250 and the 10-year flood at 145 second-feet. From Chart D (Q=145) the least diameter for a circular section is 60 inches. For this first criterion, it is presumed that there will be no backwater in the barrel; hence, **capacity is governed by size and shape of entrance, regardless of slope and texture of the conduit.** From Chart C, (Q—250) the critical slope is 0.71 per cent for a spun (centrifugally-cast reinforced-concrete) pipe, or 0.95 per cent for a cast (reinforced-concrete) pipe, or 3.85 per cent for a (corrugated) metal pipe. For the second criterion, **slope and texture of conduit assume importance.**

If any of these pipes is selected tentatively and laid on its critical slope, the depth of headwater pool above crown of culvert will just equal the entrance head. If laid on a flatter gradient the headwater stage will be increased; if on a steeper gradient, the headwater stage will not be affected, but the pipe will flow only part full, with velocity increasing towards the outlet.

Particularly, for a culvert 200 feet long, if the metal culvert were laid on a 0.95 per cent gradient instead of the critical 3.85 per cent, backwater stage would be increased by 5.8 [=200(.0385–.0095)] feet. On the other hand, if a cast pipe was laid on a 3.85 per cent grade instead of its critical 0.95 per cent, pipe would flow only half-full at outlet with a velocity of 25.5 feet per second.

Usually the culvert slope will be determined approximately by the gradient of the existing channel, in which case Chart C will indicate the type of conduit which will pass the 100-year flood with least backwater and/or minimum outfall velocity. For this example, a box culvert would serve on slopes of 0.5 to 0.8 per cent, a cast pipe on slopes of 0.8 to 1.2 per cent and a metal pipe for slopes of 3.4 to 4.3 per cent. These ranges (illustrative only) do not cover extremely flat, very steep, or intermediate (1.2 to 3.4 per cent) slopes.

ADAPTATION TO ANY SLOPE

However, there are expedients available. For very flat slopes, there are two alternatives—either compute the backwater stage at culvert entrance and design protection therefor, or select a larger opening. If the natural slope was 0.3 per cent, Chart C will show that a 6 x 4 box culvert would cause 0.6 foot of backwater, which could be avoided by using an 8 x 4 box.

For very steep channels there will be no backwater, but the problem is to avoid erosion from high velocity of outfall. There are 4 alternatives: (1) The multiple culvert; (2) an extended culvert discharging at high velocity well beyond toe of embankment; (3) a projecting culvert with free fall at outlet; and (4) a broken-grade flow line. For any of these, the roughness of the metal culvert is a distinct advantage.

The first three alternatives are common practice and fields of application seem well understood, but the fourth is rarely used. The theory is best explained by the preceding example, assuming a 15 per cent slope for the natural channel If the 60-inch by 200-foot metal pipe is laid on this uniform slope, outfall will be half-section at 25.5 feet per second. If the grade is broken by laying the upstream half on a 26 per cent and downstream half on a 4 per cent gradient, then outfall will be full-section at 12.8 feet per second. True, velocity will be high (30+ feet per second) in the upstream half, but this disposes of much of the excess energy in increased friction. The excess kinetic energy at grade break is lost in turbulence common to sudden expansions of wetted section; at some stages, this loss will occur in a hydraulic jump.

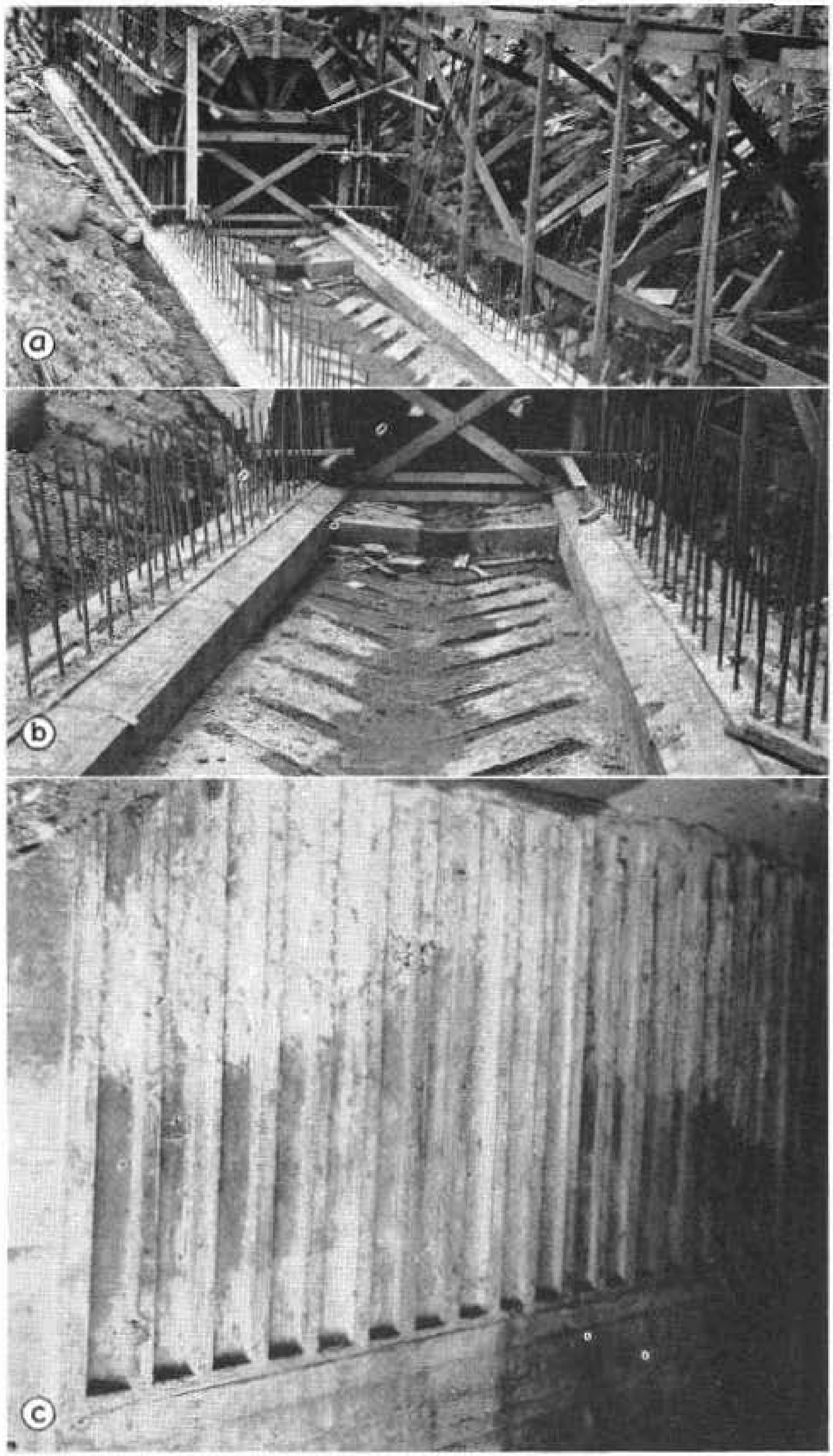


Figure 17—a, b. Invert steps and herring-bone roughening to create turbulence and reduce outlet velocity. c. Fluted sidewalls to further reduce velocity. (McNamee Creek, I-Men-56-A.)

For the intermediate range, modifications of either metal pipe or box

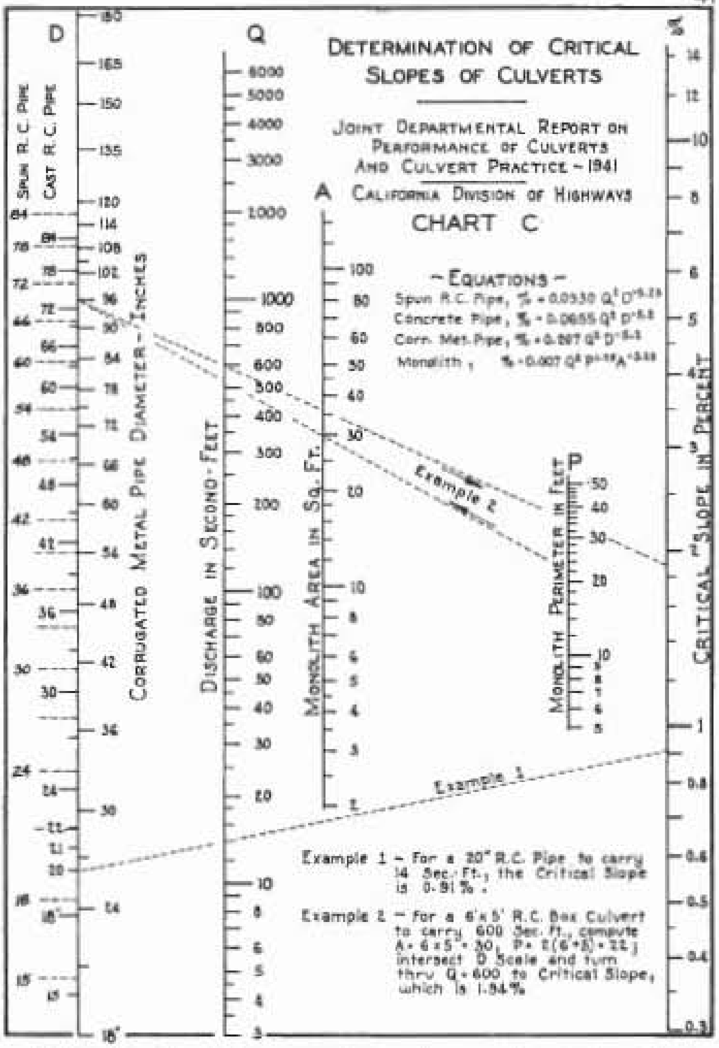


Figure 15. Chart for computing optimum culvert slope from estimated 100-year flood.

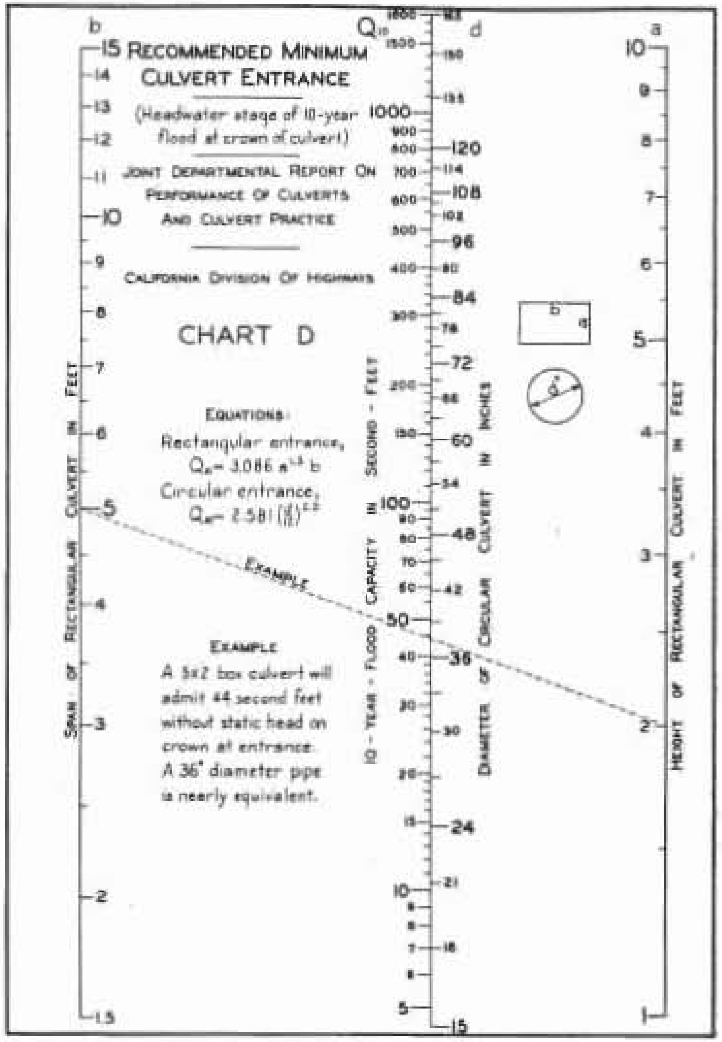


Figure 16. Chart for determining minimum culvert entrance section from estimated 10-year flood.

culvert are practical. For the metal pipe, the backwater stage can be computed and headwalls designed accordingly, or a larger pipe may be specified. The box (or arch) culvert can be roughened, or its grade broken, or its invert stepped, or high velocity anticipated at outlet. For the example, if natural slope is 1.5 per cent: (1) a 60-inch metal culvert would create 4.7 feet of backwater; or (2) a 72-inch metal culvert would just eliminate backwater; or (3) a 6 x 4-foot box culvert could be provided with outlet protection designed for effluent velocity of 17.7 feet per second; or (4) the box culvert could be laid on successive gradients of 2.4 per cent and 0.6 per cent, broken at midpoint; or (5) the box culvert could be laid on its critical slope (0.6 per cent) with invert stepped down 0.9 foot at each third point; or (6) the inner surfaces (or a proper portion thereof) of the box culvert could be built rough or (7) 160 feet of cast RC pipe at 0.95 per cent gradient could be followed by 40 feet of metal pipe at 3.85 per cent, saving some excavation.

EXPERIMENTAL CULVERT

Alternatives (5) and (6) have been combined in an experimental arch culvert **(Figure 17a-c)** at McNamee Creek (I-Men-56-A). Here the natural channel slope was 3.8 per cent; 50-foot steps with 0.9 foot risers reduced the effective gradient on the steps to 2.0 per cent. The barrel was the standard 73-sq.-ft. arch by 252 feet long under a 60-foot embankment. Its invert was roughened in a herring-bone pattern by pressing 2 x 6's down in fresh concrete. The walls below springing were fluted by nailing scabs to the forms.

Several other types were suggested to the committee, but disapproved because of hazard of blocking by drift. One, which would be very economical for clear water on a steep slope, provided a normal entrance waterway, contracting at once to increase velocity and friction, then expanding near outlet to regain low-velocity outfall. Others provide baffles or weirs, as for canal chutes and drops.

The hazard of silt deposit in culverts laid on flat gradients is well known. To avoid such deposit, culvert slope must assure a velocity throughout its barrel greater than the ruling velocity of the stream—not only at flood stage, but at all stages of roily flow. For some sites, this principle will warrant laying culverts on gradients somewhat steeper than critical. This is particularly applicable to box culverts, but sufficiently high velocity at low stage may be gained by shaping the invert like a broad, flat V.

Summarizing its findings, the committee recommends generally that:

(1) Culverts be located to fit natural channels in line and grade, following moderate curvature and breaks in grade in so far as practical.

(2) For modified bottom or sidehill locations, culverts should be entrenched in firm material beyond probable plane of rupture. At such locations, the outlet site should be so selected that protection against scour will be practical.

(3) For any but the bottom location, economy in first cost must be justified by a showing of adequacy for all contingencies and of tolerable maintenance charges.

(4) Transverse relief locations on long grades should be specified at intervals not exceeding 300 feet.

(5) For a diversion location in a skew channel, culvert entrance should intercept the flow as directly as practical. Economy will lie in total elimination of small skews, retention of moderate skews and reduction of large skews—all subject to permissibility of channel change at outlet.

(6) As one step in balancing design for the 100-year flood, the locator or designer should select a combination of conduit and gradient that will carry that flood with full section to (or nearly to) the outlet, so as to control the velocity of effluent.

(7) The gradient selected should assure culvert velocity equal to or greater than ruling velocity of the stream at all stages of roily flow.

(8) Grade-breaks, stepped inverts and artificial roughening may participate in the selection, but baffles, weirs and contracted sections should be avoided for all surface run-off.

Bibliography

(1) Flow of Water through Culverts (Bulletin 1, University of Iowa, Studies in Engineering, 1926).

(2) Flow of Water in Concrete Pipe (F. C. Scobey, Bulletin No. 852, Dept. of Agriculture, 1920).

The dinner guest's nose was exceptionally large, and father had noticed Willie staring at it. Expecting the boy to make some frank and outspoken comment, he gave him a disapproving glance. "That's all right, dad" came the reassuring response, "I'm not going to say anything. I'm just looking at it!"

In Memoriam

Clifford David Good

June 9, 1897—September 25, 1942

The sudden and untimely passing on September 25th of Clifford D. Good, of the legal staff representing the Division of Highways at San Francisco, caused deep sorrow to all his friends and associates. He had been in State service since December, 1934, when he was appointed to a position as condemnation investigator and trial attorney where his genial and generous personality won him many friends.

Clifford David Good was born June 9, 1897, in Meckling, S. D. He attended Graham Grammar School in Los Angeles, Los Angeles High School, and the University of Southern California. He was admitted to the practice of law before the District Court of Appeal on the ninth day of August, 1920, in San Francisco.

He was married March 1, 1921, to Pearl Stover, of San Francisco. The widow, a son, George, and the decedent's mother, Mrs. Jennie W. Good, survive him.

Bids and Awards for October, 1942

ALAMEDA COUNTY—Between Distribution Structure and University Avenue, about 2.5 miles to be widened with Portland cement concrete and the existing pavement to be surfaced with asphalt concrete. District IV, Route 69. Piazza and Huntley, San Jose, $290,133. Contract awarded to Lee J. Immel, Berkeley, $277,035.

LOS ANGELES COUNTY—On Stewart St., Exposition Blvd. & Dorchester Ave. in the city of Santa Monica, about 0.9 mile to be surfaced with plantmixed surfacing. District VII. Contract awarded to Griffith Co., Los Angeles, $46,345.

MONTEREY COUNTY—Between Salinas and ½ mile north of Santa Rita, about 2.9 miles to be graded and paved with Class "B" Portland cement concrete and a timber bridge to be widened. District V, Route 2, Sections A,J. Contract awarded to Granite Construction Co., Watsonville, $261,212.

ORANGE COUNTY—On Katella Avenue and Denni Street, between Los Alamitos Blvd. and Farquhar Avenue, about 1.3 miles to be graded and surfaced with plantmixed surfacing. District VII. Contract awarded to Griffith Co., Los Angeles, $69,401.

SAN DIEGO COUNTY—Furnishing and installing traffic signals system at Barnett Avenue and Midway Drive and at Lytton Street and Rosecrans Street on Route 12 in the city of San Diego. District XI. Contract awarded to Econolite Corp., Los Angeles, $4,900.

SOLANO COUNTY—Tennessee and Georgia Streets, between Vallejo and Route 7, about 1.1 miles to be graded and surfaced with plantmixed surfacing. District X. E. A. Forde, San Anselmo, $73,117; Chas. L. Harney, San Francisco, $78,863. Contract awarded to A. G. Raisch, San Francisco, $68,415.

War Depletes Personnel of Division of Highways

(Continued from page 1)

It will be noted from the foregoing that the largest percentage of departures are in the engineering and maintenance personnel classifications. It will also be noted that the number of employees resigning to accept employment elsewhere is greater than those leaving to enter the military service.

In practically all lines of work, our personnel may find other employment at increased pay and in some cases the necessity of increasing earnings to cover increased cost of living has practically made it necessary for the employee to leave the Division of Highways. In several other cases employees have resigned to enter defense work with the hope that they would be deferred from the draft.

In the past it has been the practice of the Division of Highways to employ college engineering students, during the heavy Summer construction period, to assist in engineering work. These students have been assigned to such duties as chainmen and rodmen on survey work, load checkers and weighmen on surfacing projects, and as office assistants. It is expected that, prior to the Summer of 1943, most of these young men will be in the military service and that it will be necessary for the State to look elsewhere for engineering assistants. The Department is now looking for qualified women to place in some of these positions.

Employees who have remained in the State's service during this emergency are to be commended for their conscientious endeavor to keep the work rolling, and we all know that these men and women will willingly continue their long hours of work and do everything in their power to insure that highways, which are so important to the war program, will be constructed and will be maintained.

The Division of Water Resources and Division of Architecture have contributed also to the armed forces.

The following Division of Highways employees are now in the military service:

THE ROLL

Employees of the Department of Public Works i

DIVISION OF

George C. Abarr
Victor D. Adams
Jack E. Allen, Jr.
Rex J. Allen
Omar G. Alexander
Cecil L. Aisthorpe
Raleigh L. Arneal
Haig Ayanian
George Angerina
Ernest Apperson
Hartwell R. Ball
Robert A. Ball
Jack Barlas
Edward P. Bannon
Fred M. Barnes
Loren M. Barnett
Meldon L. Bauders
Horace S. Berry
D. Maurice Berry
Donald W. Bergevin
Abramo Bertolozzi
Jack Bishop
William C. Blackburn
Mervyn R. Blacow
Glenn Blair
Joseph B. Bland
Raymond H. F. Boothe
William R. Borden
Carroll Bovey
Evan G. Bower
John L. Braddock
George C. Bradley
James K. Brenner
Elmer Brewster
Carroll B. Brown
Willard Brown
Laurence L. Brown
Clarence J. Brownell
Gerry Brummund
Will F. Bruning
Eugene F. Burge
Ernest Calanchi

Alfred E. Calhoun
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Heslin F. Cardinal
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Julien R. Charle
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Francis Christensen
John Christensen
William W. Clark
Byron F. Clarke
Charles W. Clawson
Eldred O. Cochran
John A. Coffey
William C. Coffin
Robert J. Collins
Mortimer Colodny
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Fernando P. Cordero
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Frank B. Cressy
Raymond Cullivan
Raymond C. Cummings
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Larry R. Dale
Arthur E. Dana
Charles W. Dana
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Cedric B. Davis
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Edwin T. Drish
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L. Parlin Estes
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Don G. Evans
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Thomas E. Ferneau
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Paul Flessatti
Duane Fountain
Frank D. Fraga
George W. Frank
Francis Frates
Paul Friedorff
Basil N. Frykland
Charles R. Gallagher
Jerrold M. Gayner
George Garlinghouse
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Thomas G. List
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Herbert A. Long
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Dick Zilioli, Jr.
Harry Zook

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Medill P. Thiebaud
Carl A. Werner
David B. Willets

RCHITECTURE

A. A. Sauer
A. P. Weadock

This stretch of new Watsonville-Rob Roy highway shows easy grade alignment and sight distance advantages.

New Watsonville-Rob Roy Route

THE last of three contracts on the Watsonville-Rob Roy Junction project in Santa Cruz County was completed during the middle of last month and the new highway was opened to traffic on Saturday morning, October 17th.

Saving more than two miles in travel distance between Watsonville and Rob Roy Junction, this project is of importance to the Pajaro Valley. It eventually will run to Santa Cruz.

On December 2, 1940, the first contract, calling for the grading of 6.2 miles from the northerly end of Main Street in Watsonville to a point 1.6 miles south of Rob Roy Junction and involving the expenditure of $285,481.77 of State and Federal Aid funds, was awarded.

The second contract was awarded on October 20, 1941, and provided for a crusher run base on the entire 7.8-mile section and the grading of 1.6 miles south of Rob Roy Junction. This contract was for $372,654.98.

On June 12, 1942, the third contract, providing for an armor coat surfacing from Watsonville to Rob Roy Junction was awarded and the completion of this job at a cost of $64,842.23 made possible the opening of the new highway on October 17th.

The present three-lane highway will relieve heavy traffic congestion which the old road was unable to handle. The new location lies between the old road and the coast line, and crosses several ancient tidal channels which had filled up with alluvial waste and vegetable matter in the form of peat land. The peat formation in these areas varies in depth of from 10 to 43 feet.

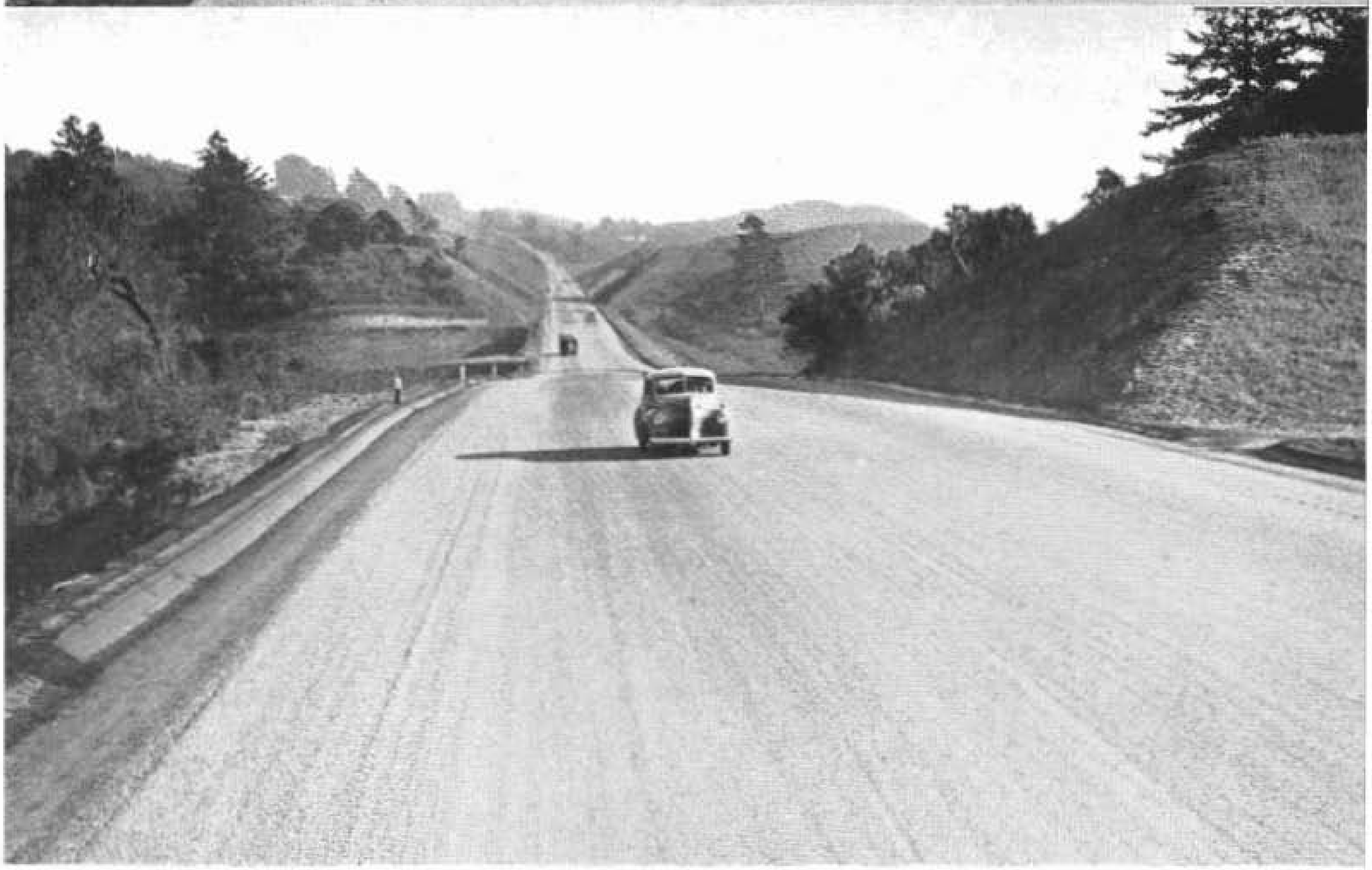
Special foundation treatment to support the superimposed load placed thereon by the highway fills was required. Test borings determined the character and depth of the peat formation and foundations at Harkins and Watsonville Sloughs were stabilized by constructing vertical sand drains to permit the escape 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, spaced on 13-foot centers parallel to center line and on 11-foot centers at right angle to center line.

Clear water was injected into the wells 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 3-foot sand blanket was placed over the entire area to provide a drainage outlet from the sand drains.

The 35-foot fill at Harkins Slough required approximately 70,000 cubic yards of material and at Struve Slough, 84,000 cubic yards of fill material was placed, 35,000 cubic yards of which provided for subsidence and displacement of the peat land foundation.

Some of the major contract items:

1,225,000 cubic yards road 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.



Two views of three-lane highway between Watsonville and Rob Roy Junction which replaces old two-lane road and relieves traffic congestion in Pajaro Valley. Highway ultimately will extend to Santa Cruz.

Palm trees on right were moved and reset outside of curb line. Palms on left were left in place.

Riverside Has New Divided Highway

By A. E. SMITH, Assistant District Construction Engineer

THREE adjoining State Highway contracts have been under way concurrently since early Spring to produce a four-lane divided highway from Riverside southerly to about five miles north of Perris. This is a portion of the Inland Route to San Diego and is identified as U. S. Highway 395.

The old road consisted of two traffic lanes and was sorely taxed to meet the demands of a rapid increase in traffic volume. This traffic increase was chiefly due to large scale daily transportation of workmen to and from military establishments, and the hauling of construction materials. In addition there was a large increase in the usage of the highway by Army personnel and equipment.

The northerly of the three contracts extended from the city limits of Riverside, along the Box Springs Grade to the overhead crossing over the tracks of the Atchison, Topeka and Santa Fe Railway Company near Box Springs Station.

DIVIDING STRIP

On this portion for the greater part a 30-foot central dividing strip was constructed between the near edges of the new pavement placed on dual roadway sections. Each roadway section was paved with two standard lanes of Portland cement concrete pavement seven inches in thickness placed over a 12-inch blanket of selected material. Shoulders were constructed of plant-mixed surfacing using paving asphalt as binder.

Cut slopes were constructed in general by keeping the top of the slopes at a constant distance from center line. As the height of each cut decreased the slope thus became flatter, terminating at the daylight point. In addition, the tops of the slopes were rounded. The result was a uniform blending of the roadway excavation slopes with the adjoining terrain that produced a naturalistic appearance, free of construction scars. Top soil was placed uniformly over these slopes and is to be seeded to grass to check erosion until native plant growth has been established.

Near the City of Riverside the four traffic lanes were brought together, by omission of the dividing strip, to conform to city street sections ahead. In this area it was necessary to move many large palm trees to provide for the wider roadway section. These palms were moved and reset outside

(Continued on page 20)

Top—View west. Pepper trees previously bordered old two-lane road. One row now in dividing strip. Center—Dual roadway sections each paved 23 feet in width. Dividing strip is 30 feet wide between near edges of pavement. Bottom—View west. Island between traffic channels constructed of bars made of plant-mixed surfacing and painted white. Grade separation structure in center.

Quick Method Devised For Placing Asphalt Concrete Pavement Bars

By BLAIR GEDDES, Assistant District Traffic and Safety Engineer

FACED with a specific problem involving installation of raised pavement bars in an area of high traffic concentration, the City and County of San Francisco and Daly City in San Mateo County, working in cooperation with engineers of the Division of Highways, have done some extensive experimenting with precast asphalt concrete bars.

These bars have been installed in advance of streetcar safety zones at each intersection. They have been placed at varied angles and varied spacings to provide opportunity to study their effectiveness and to determine the most advantageous arrangement.

City Engineer R. A. Klassen of Daly City evolved a new variation which is proving a success. Realizing that it would be impracticeable to maintain barricades to protect plant-mixed bars during the curing period and desiring a more substantial job than can be obtained with that material, he decided to experiment with asphalt concrete. The result exceeded his expectations.

The bars were placed in advance of safety zones adjacent to street car tracks with nine bars on eight foot centers at each zone.

PLYWOOD FORMS USED

Eighteen forms were constructed of one-quarter inch plywood with one by four strips fastened on top, rabbeted at the edge, to provide a track for the finishing tool. The inside edges of this form were champfered on a 45 degree angle to allow removal of the form without disturbing the completed bar.

Finishing tools consisted of two metal floats and a small tamper for finishing the ends. The floats were constructed of pieces of salvaged steel plate which were cut almost in two along the center, then formed to the proper shape and the opening filled with an electric arc. An iron wheelbarrow with a wood fire was used to transport and heat the tools.

The mix used was Type C surface course and was obtained in quantities of one ton per delivery. With the eighteen forms it was possible to construct thirty-six bars before the material cooled to a point where it was not workable. This brought the requirements to approximately fifty-five pounds per bar, including loss from cooling in the truck.

The crew consisted of one truck driver and two laborers who performed all of the work including picking up the material at the plant and transporting it to the site of the work.

The placing procedure consisted of spotting the forms in place, chalk marking the pavement, then moving the forms aside, and painting the areas with emulsified asphalt for a tack coat. After the emulsion had set the forms were replaced in position and weighted down ready for the asphalt concrete to be placed and ironed off.

Immediately upon completing the zone the forms were removed and carried ahead to be spotted in position in a third zone while material was being placed in the second zone which provided for practically continuous placing of material, thus minimizing the excessive loss of material through cooling in the truck. By the time the last bar was placed in the fourth zone the first bars had cooled sufficiently so that the crew could return and clean up in the same rotation that the bars had been placed and remove the barricades, eliminating the necessity of maintaining barricades or lights over night.

Two coats of paint were applied to the bars, the first coat being applied the day after placing, the second coat, which included beads, being applied after all bars were completed on the project. The bars have been in place for approximately three months, and to date show no signs of ravelling, cracking, or staining of the paint.

BARS COST 85 CENTS

City Engineer Klassen estimates that the cost is approximately 85 cents per bar in place, exclusive of painting, including the cost of preparing tools and forms, but is confident that this cost can be appreciably reduced in future work where the project can be organized for continuous operations.

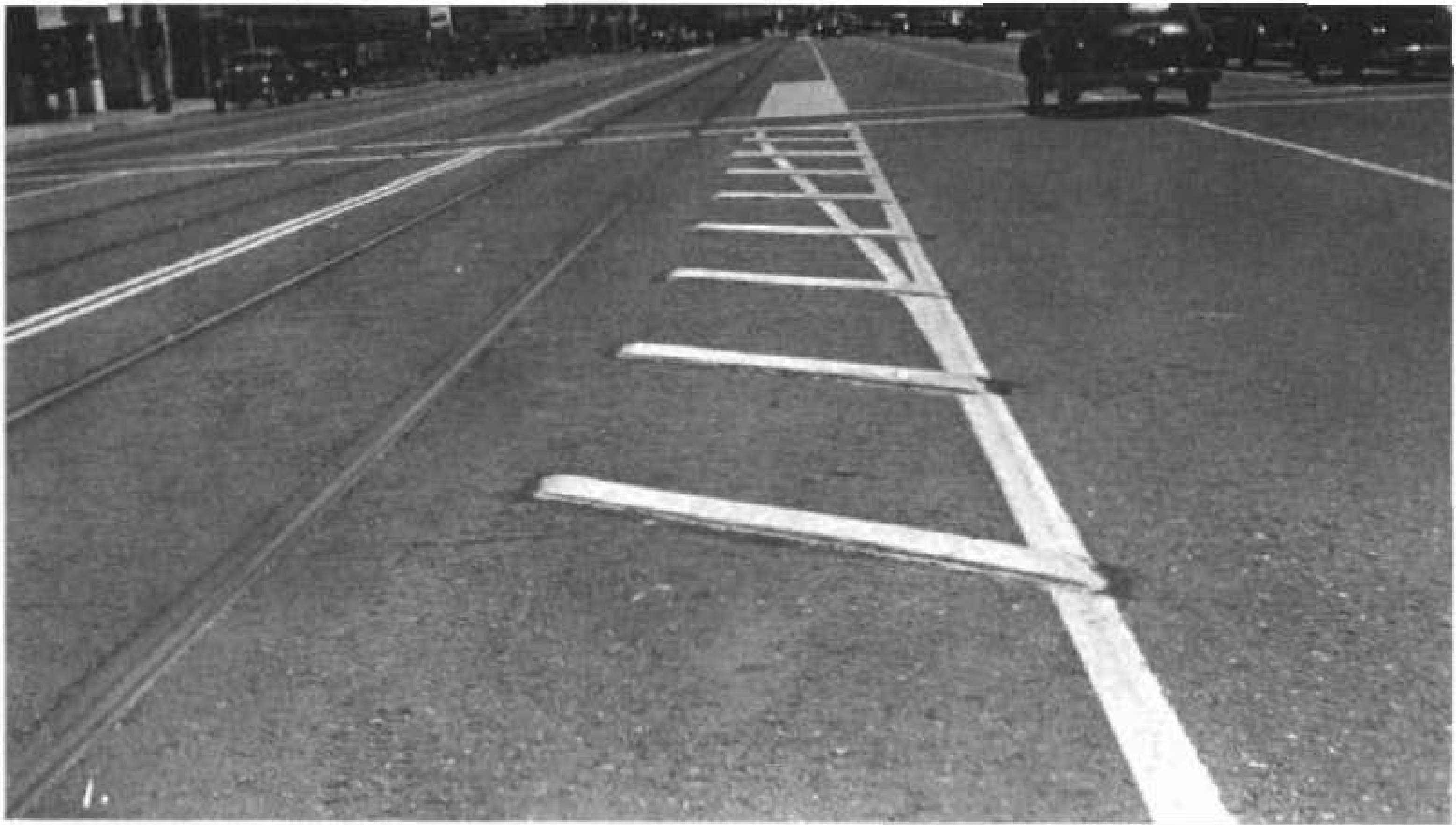
For additional bars which will be placed in the near future, Mr. Klassen intends to revise the shaping irons by increasing the crown to one and one-half inches in place of the present one inch to make an effective height of two inches per bar which will not only increase visibility but will also provide a more distinct reaction when cars strike.

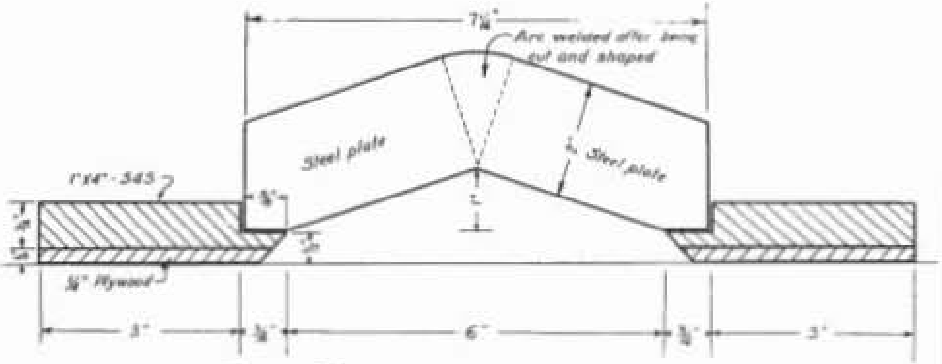
In San Francisco, bars placed to date on Van Ness Avenue have been installed in transitional pattern as shown in pictures 1 and 2. This type

Law Prohibiting Glass on Roads Rigidly Enforced

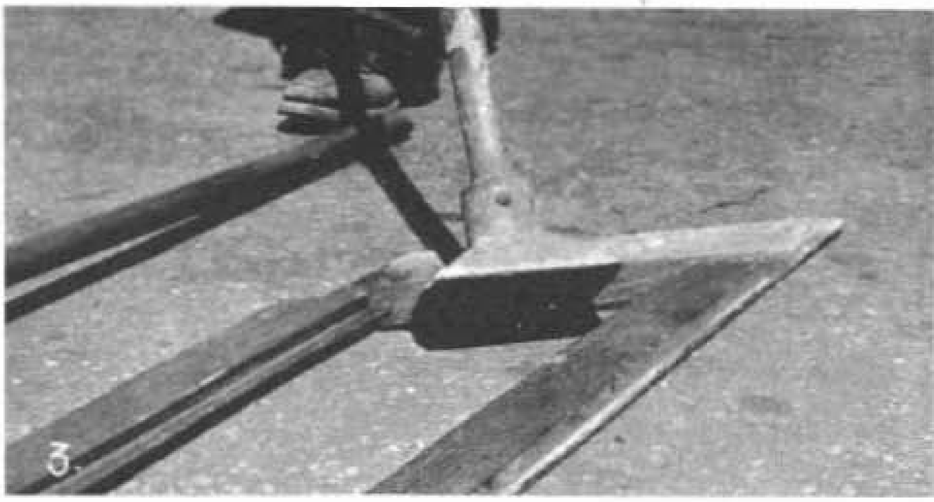
Section 601 of the Vehicle Code, making unlawful the throwing on any street or highway of any glass, nails or other substance which might injure auto tires, is being rigidly enforced. The person who, unintentionally or otherwise, leaves such material in the street is responsible for its removal. This includes headlight and other glass left on the pavement as a result of vehicular collisions.

The necessity of placing and accepting responsibility in this matter is of paramount importance at this time. Widely scattered defense industries make thousands of workers dependent on personally-owned cars for transportation.





CROSS SECTION OF FORM AND SHAPING IRON



1—Durable, raised bars of asphalt concrete instead of plant-mixed bars placed in advance of safety zones adjacent to street-car tracks by use of plywood forms that rendered unnecessary the building of barricades needed to protect plant mix bars while curing. 2—Shaping iron on tracks in form. 3—Tamping iron for shape in ends of bars. 4—City Engineer Klassen of Daly City, who devised method, and equipment operator Cafferreta of installation required an adjustable form to make the varied lengths of bars. Forms consist of troughs made of timber and lined with sheet metal as shown in picture 3. Movable end fillets vary the length of bar and form the chamferred end. Mesh reinforcing is placed at the bottom of the bar on each side to provide additional strength. After casting and partial cooling, anchoring holes are punched near each end of the bar with a large spike, the forms are then inverted over a 2 x 6 board and the bar is complete. After a run of bars has been completed they are placed side by side, given a light cement wash and then painted with a spray gun.

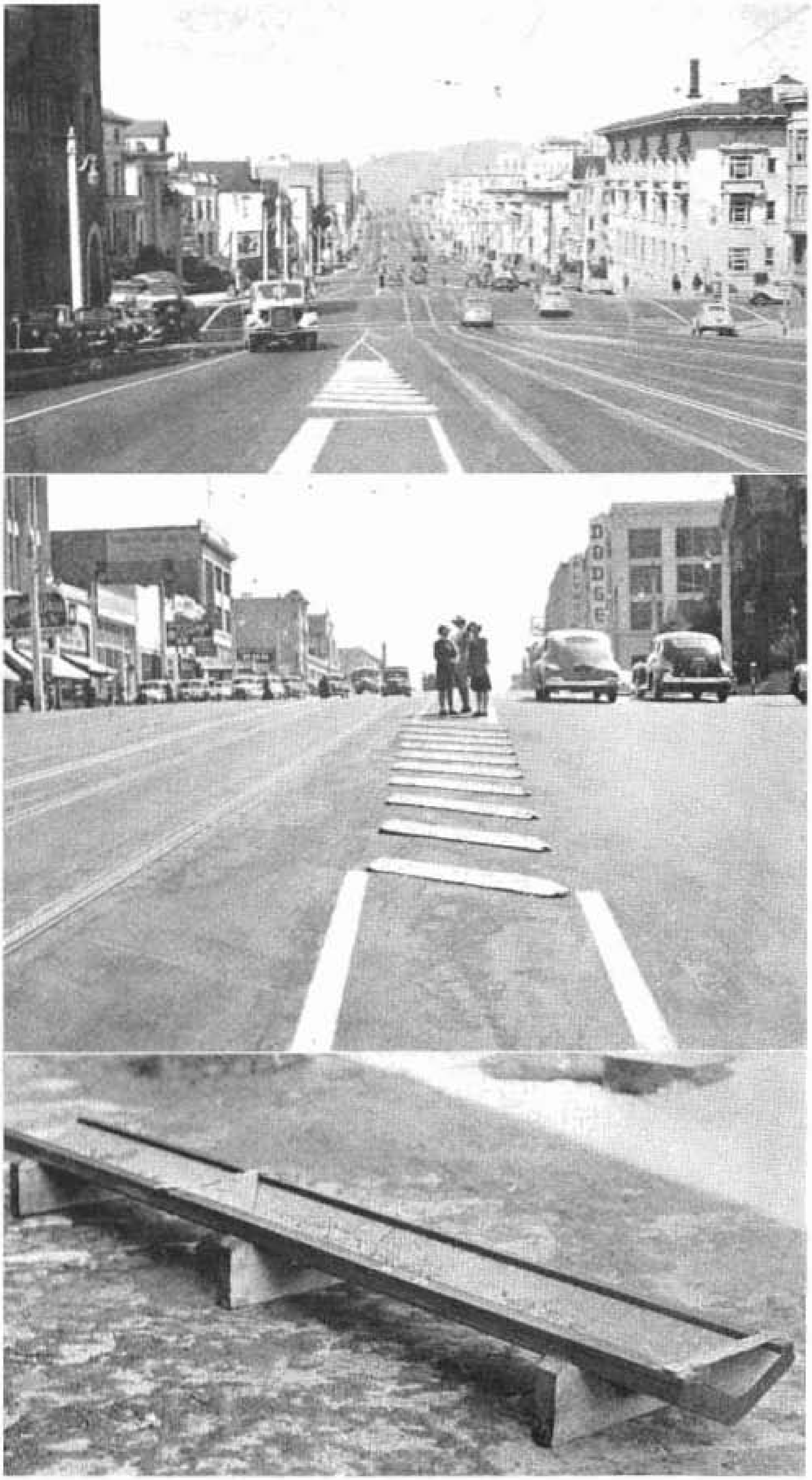
The San Francisco installation procedure is as follows: The zone is marked and bar locations determined, proper length bars are laid adjacent to their final position, paint binder is applied to the area where each bar is to be placed and a thin course of A. C. is spread and leveled off to remove any irregularities in the pavement. The bar is then given a coat of paint binder on the bottom and slid from the board to its final position, spiked in place and weighted down with sand bags until the leveling course has cooled and set.

Complete breakdowns of cost items have not been made to date but preliminary checks indicate that the cost per completed bar in place will be somewhat less than $1.

One of the factors influencing the selection of this method of operation is the extremely heavy traffic on the streets where these bars have been and are to be installed. The truck which transports the material to the site can be unloaded in a limited time and then moved to a location which does not interfere with normal traffic flows. Another reason is that more tamping can be accomplished in the form than can be done while casting in place.

Summer Guest (disappointed): See here, your ad said that this hotel had a splendid view for miles. I see no such outlook.

Proprietor: Certainly, sir. Just stick your head out of the window and look straight up.



Top—Looking north on Van Ness Avenue from corner Pacific Avenue. Center—Looking south toward Jackson Street. Bars in foreground. Bottom—Casting form set for 4-foot bars.

California is Striding Ahead in the Conservation of Rubber

(Continued from page 3)

LAWRENCE BARRETT

E. RAYMOND CATO

vidual driver, the committee, at the outset, engaged in a State-wide program of publicity designed to acquaint the public with the seriousness of the rubber shortage. The press, radio and public forums were utilized for this purpose.

This, combined with active enforcement of the lowered speed maximum by the California Highway Patrol, brought an immediate public response. For several weeks there has been a continuous decrease in pleasure driving as well as a gradual lessening of speed.

Upon the issuance of the Nation-wide order by the Rubber Administrator setting the maximum speed limit at 35 miles per hour, the California Highway Patrol was given instructions to enforce this speed limit.

SPEEDERS WARNED

Enforcement of the order has been educational rather than arbitrary. Citations of arrest are issued only when conditions, such as worn tires, impaired vision or slippery pavements, are present which make driving above 35 per hour unsafe. In all other cases white warning cards are given the offenders and they are told they are violating their patriotic duty by exceeding the 35 mile limit.

Happily, there have been surprisingly few actual arrests considering the number of vehicles involved. The driving public is accepting the new speed limit voluntarily and, for the most part, graciously. Reports to the Rationing Boards and the power of the Department to revoke or suspend licenses, together with the patriotic attitude of the vast majority of our citizens, have brought about excellent observance of the new speed limit.

The prospect of gasoline rationing gives promise of solving the problem of conservation to a considerable degree insofar as the individual driver is concerned.

For that reason, the committee has decided to place greater emphasis on the group riding and staggered hours features of the conservation.

To encourage the formation of group riding clubs approximately 500,000 cards have been printed and are being distributed to the various local war transportation committees.

GROUP RIDING

The purpose of these cards is to locate persons desirous of obtaining rides and to get them in touch with others having a common destination who have cars they are willing to share.

(Continued on page 20)

PEACE-TIME PRACTICE — 3 cars take 5 persons to work (1.6 persons per car) for 18 months (average life expectancy of each car)

GROUP RIDING — same 3 cars (used in weekly rotation) transport the same 5 persons (5 to a car) for 54 months

Plan $500,000,000 Post-War Highway Building Program

Brigadier General Philip B. Fleming, Federal Works Administrator, has announced that the first actual engineering work on post-war public construction — a projected highway building program to cost nearly $500,000,000—is well under way.

The engineering work, extending from conception of the improvements through surveys and the preparation of detailed plans and specifications ready for the contractors' bids, is going forward as a joint Federal-State undertaking. It is being financed from a special $10,000,000 fund which the Congress authorized in the Defense Highway Act of 1941 with the requirement that the States match funds for projects according to the usual Federal-aid plan.

(Continued from page 19)

Group riding groups already are functioning at the numerous defense plants with good results. It is hoped by the new plan to extend the plan to business and professional men with common destinations. Housewives are being encouraged to form such clubs to carry children to and from school and for routine shopping.

Staggered hour plans are being operated in various parts of the State, notably Los Angeles and San Diego, with marked success. The effect of these programs, wherever tried, has been to reduce the burden on street cars and buses during peak hours when congestion is very heavy.

The committee feels this is a prolific field for further effort and is lending encouragement to local committees to sponsor such movements. Committees named by the Railroad Commission and by the Los Angeles coordinator have done much to encourage staggered hours in the crowded Los Angeles and San Francisco areas.

In carrying on its program of conservation, the committee has had the active cooperation of the State Council of Defense, the Office of Price Administration and the various local representatives of the Office of Defense Transportation.

Inasmuch as the rubber shortage promises to be acute for many months the committee feels there is still much work to be done. The task of conserving vital war transportation should be a continuous one. Although the public is fairly well informed on the subject there must be no letup in public education.

Driving must be confined strictly to the essentials to prolong to the utmost the useful life of tires now on the road. These tires constitute the Nation's principal stockpile and represent our greatest safeguard against collapse of our transportation system.

The analysis made by the Baruch Committee of the rubber supply on hand indicates there is sufficient for the civilian to maintain an average of 5,000 miles per year. This fact, however, does not mean that the civilian should drive 5,000 miles a year if he can transact his essential business by driving less.

Individual sacrifices should and must be made. They are merely one of the contributions every citizen must make to the war effort and are comparatively small when compared with those the men of our armed forces are making.

Riverside Has New Divided Highway

(Continued from page 14)

of the curb lines, thus preserving the striking appearance of the palm-bordered approach to Riverside.

TREES LEFT IN PLACE

Along frontages of the University of California Citrus Experimental grounds two rows of large pepper trees that bordered the old road were left in place, one row falling in the space utilized for the separation strip between north bound and south bound traffic lanes. At the intersection with Iowa Avenue, and with Pennsylvania Avenue free turning lanes were provided to facilitate traffic flow.

The centrally located contract was about 1.5 miles in length with its northerly terminus at the railroad overhead crossing. It included widening the railroad overhead structure from a two-lane to a four-lane section with a four-foot division curb between the two inside lanes; constructing a roadway separation structure; constructing a graded two-lane roadway adjacent to the existing road with an intervening separation space, and placing imported borrow, cement treated base and plant-mixed surfacing.

On the southerly contract, continuing from the central one and extending to about five miles north of Perris, the four-lane divided highway section was constructed with a 30 to 79-foot separating space between inside traffic lanes. On this portion also a cement treated base was placed over a blanketing layer of imported material, and was topped with plant-mixed surfacing.

BASE MATERIAL

Cement treated base material was mixed in the contractor's mixing plant, set up at the aggregate pit site. Graded aggregate was mixed with 7 per cent of cement and from 8.5 per cent to 10.0 per cent of water and hauled to the job in dump trucks. It was spread on the street by two self-propelled, mechanical spreading and finishing machines which pushed the trucks immediately ahead of them while the trucks were discharging the mixture, to keep an even supply passing through the machines.

The partially compacted base material was then rolled with a three-axle roller weighing about 14 tons. The rolled surface was kept moist by a mist-spray until covered with a curing seal of asphaltic emulsion, applied at the approximate rate of one-sixth gallon per square yard.

Plant-mixed surfacing, in which the mineral aggregate was mixed with paving asphalt, 150-200 penetration, was placed over the cement treated base to a thickness of three inches. The surfacing was laid in two courses of 1½ inch each and was shaped and compacted using motor powered graders and pneumatic tired rollers. A heavy three-axle roller was used for final rolling.

ENGINEERS' PROBLEMS

While the plans were being drafted for these three units and during the time that construction operations were under way, "priority control of critical materials" introduced many new problems for the engineers.

Some 10,000 lineal feet of concrete pipe was used in the drainage system. Although the concrete pipe required some steel for reinforcement, the amount was small compared to the approximate 300,000 pounds of steel that would have been required if metal culvert pipes had been used.

Gravity type headwalls were constructed and unreinforced concrete drop inlets were used with timber covers. A lighting system was omitted also to save critical materials.

Considering the three construction units as one major project, the result is a four-lane divided highway 10.3 miles in length of which 3.84 miles is paved with Portland cement concrete and the balance with plant-mixed surfacing placed over cement treated base.

CONGESTION RELIEVED

At the intersection of U. S. 395 and U. S. 60 near Box Springs Station a grade separation structure was constructed to pass the east bound traffic on U. S. 60 under the north bound traffic on U. S. 395. All other traffic movements around this intersection were isolated to definite channels designed to obtain a minimum of interruption to traffic. Islands between traffic channels were constructed of plant-mixed bars, painted white, to form a physical barrier in these areas.

Acute traffic congestion was in evidence on the old two-lane road. After opening the new four-lane divided section to traffic, congestion was completely alleviated.

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