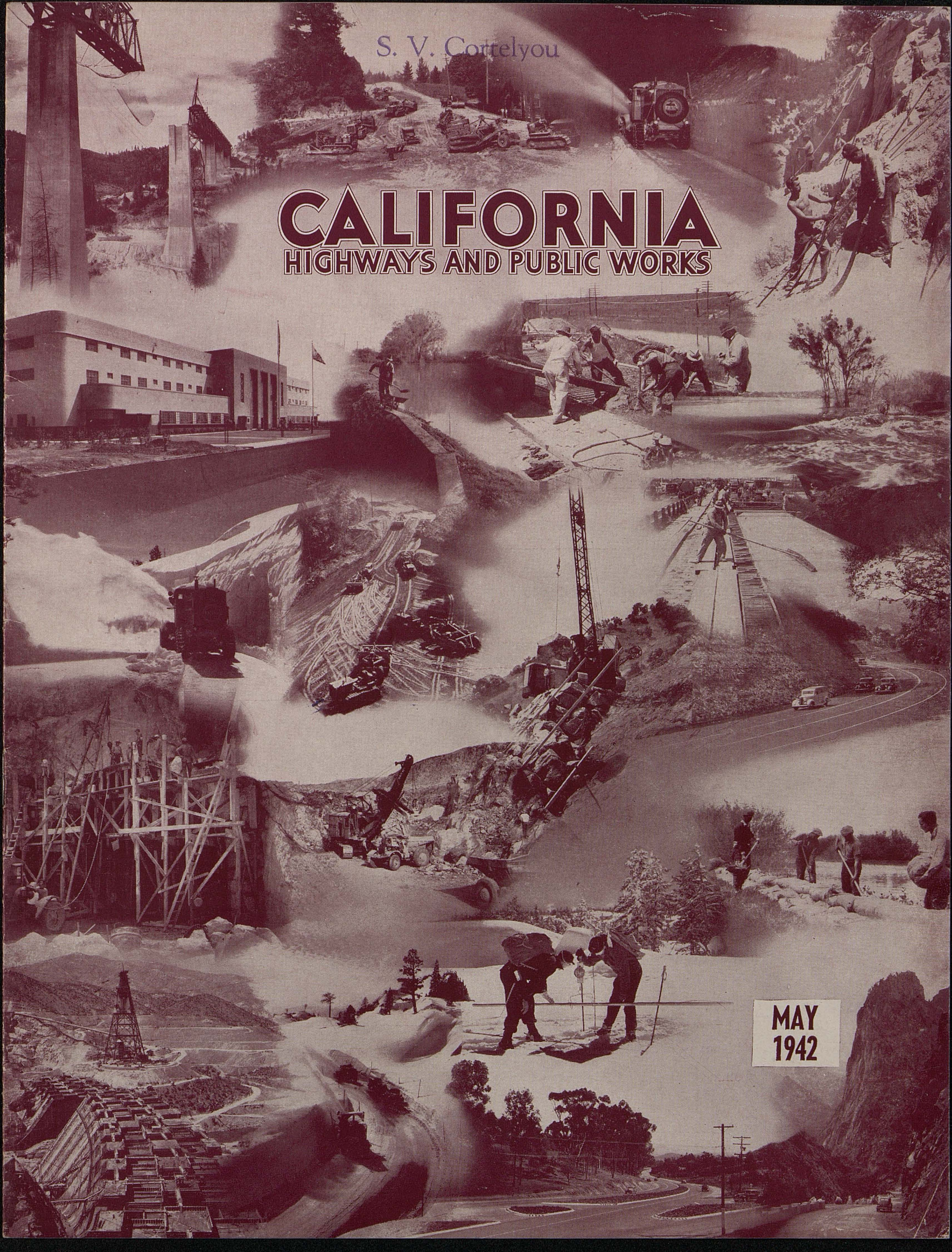
S. V. Cortelyou

CALIFORNIA
HIGHWAYS AND PUBLIC WORKS



MAY
1942

CALIFORNIA HIGHWAYS AND PUBLIC WORKS

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

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

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Divisions of Department of Public Works Swing Into Full Stride on War Defense Efforts

Following is a summary of a report made to Governor Culbert L. Olson by Director of Public Works Frank W. Clark pursuant to a request from the Governor made to heads of all State departments. Director Clark's report covered defense activities of the Divisions of Highways, Water Resources and Architecture of the Department of Public Works.

IN January I announced that war defense work would subordinate normal activities of all divisions of the State Department of Public Works during 1942.

I am pleased to report that the defense contributions since that time by the Division of Highways, the Division of Architecture and the Division of Water Resources have far exceeded my anticipations.

During the past three months, at the request of Governor Culbert L. Olson, the department has prepared a number of confidential reports for the military authorities for which it has been highly commended.

The Division of Highways has made surveys on the amount and location of publicly owned dirt-moving and construction equipment in the metropolitan centers of the State; on the suitability of various highway routes in southern California for evacuation purposes with particular reference to water supplies and housing facilities; and on strategic bridges.

Pursuant to a request to Governor Olson from the War Production Board, the Division of Highways has also completed a survey of scrap metal and equipment now stored in various highway district maintenance storage places and in shops. A total of 191 tons of such material already has been reported to the War Production Board.

In the shops of the Division of Highways there was produced a blackout adapter for lamps and lanterns used at night on highways by construction and maintenance crews. This invention has been made available to the State Council of Defense and through that agency may be obtained by cities and counties for use on county roads and municipal streets.

The Maintenance Department of the Division of Highways is entrusted with maintaining armed guards on powder magazines, maintenance yards and other important storage locations. A 24-hour guard is maintained.

In addition the Maintenance Department through arrangements with the Pacific Telephone and Telegraph Company maintains a direct connection with 21 swing drawbridges operating on 21 navigable streams in Sacramento, San Joaquin, Napa and Sonoma counties and from a special telephone communications office can notify all bridge tenders almost instantly of orders for a blackout.

Surplus equipment which has accumulated during the past decade in California's 2,000 State-owned buildings, including State schools, colleges, hospitals and other institutions is being catalogued and pooled to meet war shortages of critical material.

A survey of State property undertaken by State Architect Anson Boyd at the request of Governor Olson as Chairman of the Council of Defense, already shows that well over $100,000 worth of useable discarded equipment will be available for exchange among State agencies and institutions to aid in maintaining these indispensable services and thereby eliminating to a great extent the use of critically needed war supplies.

The State's properties are being conditioned by the various departments involved in cooperation with the Division of Architecture to withstand the months or years when metal and other critical materials will go into guns, planes, munitions and other war necessities instead of normal peacetime repair parts.

For purposes of keeping purchases of surplus stock necessary for the duration to a minimum, the Division of Architecture is obtaining detailed information relative to the type, kind, make, age, and condition of surplus parts now in storage in various places to the end that these parts and stocks

(Continued on page 4)

GOVERNOR ASKS CARE IN PREVENTING TIRE DAMAGE ON ROADS

Several thousand employees of the Division of Highways in the eleven highway districts throughout California will cooperate in a campaign to protect motorists from tire damage on State roads.

In accordance with a request from Governor Olson, Director of Public Works Frank W. Clark has requested all personnel of the Division of Highways, particularly the maintenance crews, to be especially vigilant in removing from highways and highway shoulders any objects such as nails, glass, bottles, metal wire, etc., which might cause injury to tires.

Mr. William A. Lippman of Palm Springs started a one-man campaign to gather metal scraps and broken glass he found on highways in Riverside County. In one trip over U. S. Route 60 between Beaumont and Riverside, Mr. Lippman gathered quite a collection of such tire hazards and reported his findings to the Commandant at March Field and to Governor Olson. Clark thereupon issued instructions to the Division of Highways and wrote the following letter to Mr. Lippman:

"Governor Olson has referred to me your very interesting letter of April 3, 1942.

"The Governor has expressed a great interest in your suggestion and today wrote me asking me to reply to you direct and requesting me to instruct our highway maintenance crews throughout the State to be as vigilant as possible in seeking for and removing any obstacles on the highways or highway shoulders that might be injurious to tires. * * *

"I am today issuing appropriate instructions to our highway maintenance organizations throughout the State and am also instructing the editor of our California Highways and Public Works magazine to run a suitable story on the subject in his next issue. In this manner, I think your proposal will be called directly to the attention of thousands of individuals and organizations in California who will be in a position to cooperate in this worthwhile aim.

"May I thank you for calling the matter to our attention."

Army Engineers Study California Soil and Foundation Test Methods in Runway Design

By O. J. PORTER, Senior Physical Testing Engineer

REPRESENTATIVES of the United States Army Engineer Offices throughout the United States attended a lecture course and conference on the California method of determining the relative bearing value of soils and its application to design of highways and runways. The conference was held April 6th to 10th at the Sacramento District Office of the U. S. Engineering Department and the Materials and Research Department of the State Division of Highways.

Army engineers inspect runway test pavement at Stockton field. Electric recording equipment for measuring subgrade pressure and pavement deflection under heavy wheel loads is mounted in station wagon at left

The various meetings were planned by the office of the Chief of Army Engineers at a conference attended by the writer in Washington, D. C., during the month of February.

Among the U. S. Engineers attending the lectures were the following: T. A. Middlebrooks, Principal Engineer and head of the Soils Section, Office of the Chief of Army Engineers in Washington, D. C.; E. J. Merrick, Principal Engineer and Chief of Design of the Caribbean Division in New York City; Lt. H. A. Fidler, Officer in Charge of Foundation Investigations, North Atlantic Division, Ithaca, N. Y.; W. I. Kennerson, Senior Engineer, and Assistant Chief, War Construction Section, South Atlantic Division, Atlanta, Ga.; R. Philippe, Senior Engineer in Charge of Divisional Soils Section, Ohio River Division, Cincinnati, O.; S. M. Gleaser, Engineer and Head of Specifications Section, Upper Mississippi Valley Division, St. Louis, Mo.; F. F. Smalla, Associate Engineer and Head of Airport Section, Great Lakes Division in Cleveland, O.; F. B. Slichter, Principal Engineer and Chief of Design Section, Missouri River Division, Kansas City, Mo.; R. M. German, Assistant Engineer, Lower Mississippi Valley, Vicksburg, Miss.; Ralph Hansen, Division Soils Engineer, Dallas, Tex.; H. E. Brown, Engineer in Charge of Research Section of North Pacific Division, Portland, Ore.; W. L. Davis, Associate Engineer and head of U. S. District Laboratory, Sacramento; M. C. Collins, Senior Engineer and Assistant Head Engineer and S. M. Cotten, Associate Engineer, South Pacific Division, San Francisco; W. H. Jervis, Engineer and head of the Soils Section, Vicksburg, Miss.

PROGRAM OF MEETINGS

Following is the program, together with a digest of the proceedings of the conference:

On April 6, 1942, a morning meeting was held at the U. S. district office at which introductory remarks covering the purpose and scope of the lecture course were scheduled by Col. R. C. Hunter, U. S. District Engineer; C. H. Purcell, State Highway Engineer; T. A. Middlebrooks, U. S. Principal Engineer; T. E. Stanton, Materials and Research Engineer, State Division of Highways."

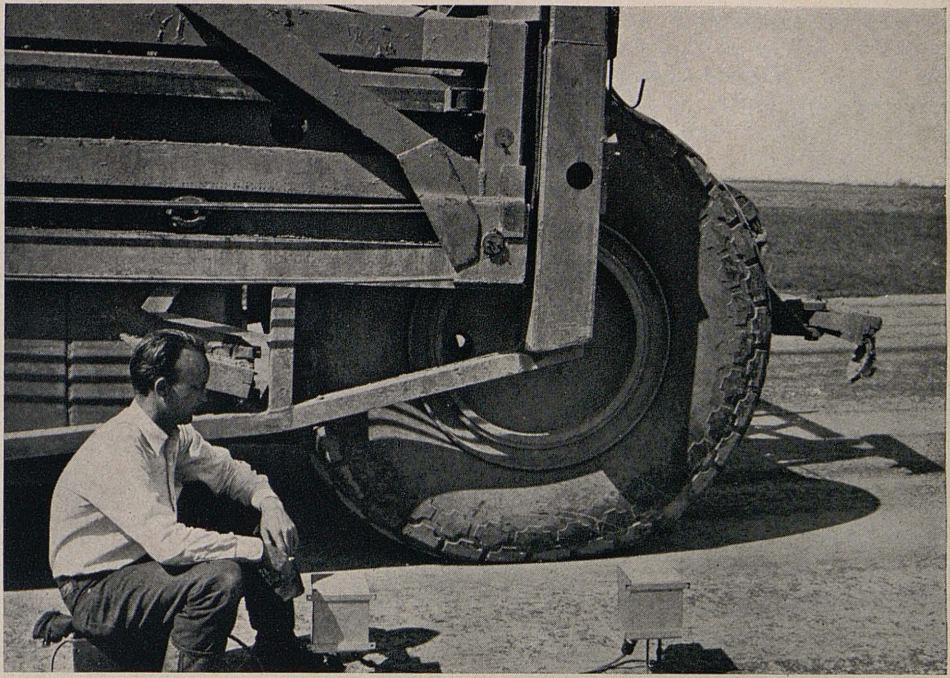
Speaking for Col. Hunter, who was called away from Sacramento, G. E. Goodall, U. S. Principal Engineer, welcomed the visiting engineers to Sacramento and related the facts of the Sacramento district's successful application of California's test methods to runway design during the past year.

Because of urgent defense work on access highways in the southern section of the State, Highway Engineer Purcell was unable to attend and Mr. Stanton, on behalf of Mr. Purcell, offered the full cooperation of the Division of Highways.

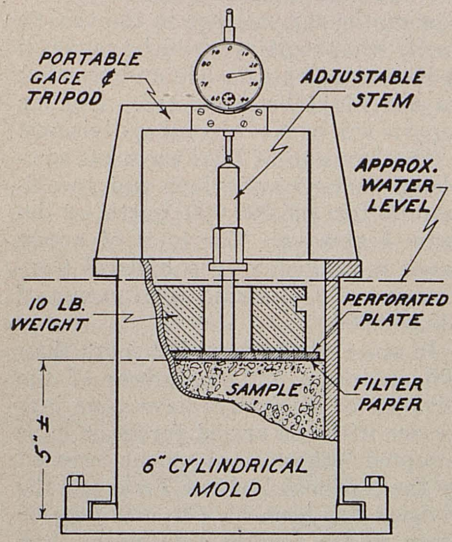
Mr. Stanton invited the engineers to visit the State Materials and Research Department. He also reviewed the development in 1929 of California's test procedure for determining the compacted density and optimum moisture content of soils and cited the need for thorough consolidation to obtain maximum stability of subgrade on highways and airport work.

Followed an introduction and detailed outline of the lecture course by the writer.

This talk was illustrated with slides showing various types of subgrade failures on highways and airports. A comparison was made between highway and runway service requirements, including intensity and repetition of loads, influence of dynamic reactions of trucks and planes, and the effect of these factors on pavement and subgrade design.



Determining deflection of pavement under loads corresponding in footprint and contact pressure to those of heavy bombers. Electric eye equipment in boxes in foreground



Expansion test for determining swell of bearing value specimens

An announcement of subsequent meetings and field trips was made by Wilson L. Davis, Associate Engineer, Chief, U. S. E. D. Laboratory, Sacramento.

The afternoon meeting was held at the Materials and Research Laboratory of the California Division of Highways at which a demonstration of test procedure was given by the writer that included: (a) Preparation of samples; (b) compaction test; (c) optimum moisture test; (d) bearing and expansion tests.

The next day morning and afternoon meetings were held at the State Materials and Research Laboratory at which performances of test procedures were made by engineers attending the course and in the evening a lecture was given by the writer at the U. S. district office on (a) compaction tests; (b) bearing tests; (c) expansion tests, which was followed by a discussion with Mr. Middlebrooks as chairman.

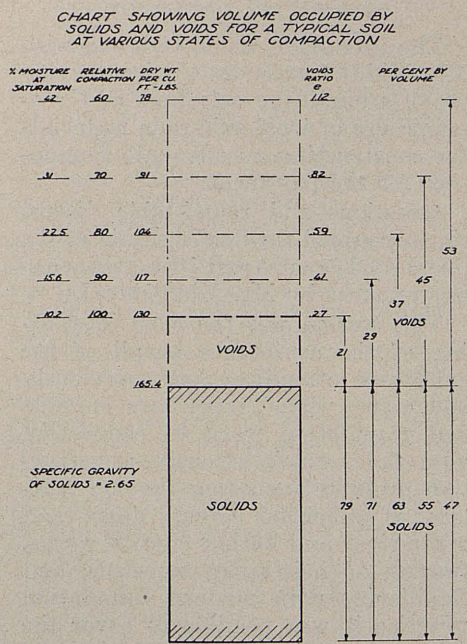
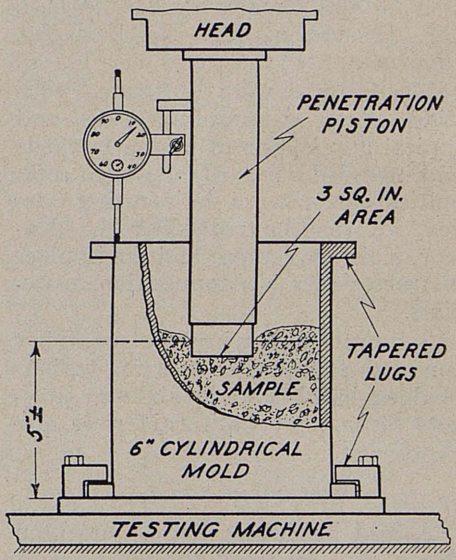


Chart showing volumes of solids and voids for various states of compaction



Bearing test equipment for determining resistance of base and subgrade material

The reasons for the development of the tests were discussed and it was pointed out that the detailed procedure was only adopted after establishing an empirical relationship between the test values and the performance of subgrade and base materials in actual service.

In this study of field conditions good compaction and high density were found necessary to avoid settlement and failure of the roadway under traffic. Blanket courses of pit run gravel or layers of selected subgrade material of high bearing value were also found to be both desirable and economical for constructing a satisfactory foundation for highways.

A morning meeting was held on April 8th at the U. S. E. D. Sacramento District Laboratory at which a demonstration of sampling methods and test procedure was given by U. S. Associate Engineer, W. L. Davis, showing quick methods for obtaining undisturbed samples for determining the bearing value of subgrade material in its natural condition of density. The exploration of soil deposits by hand-boring methods, including soil augers and the California type soil sampler were also demonstrated.

ILLUSTRATED WITH SLIDES

At the afternoon meeting the following subjects were covered: (a) Exploration, Soil Sampling Conditions, and Procedure by Mr. Davis; (b) Deep Borings in Unstable Airport Areas by Mr. Ferron, Assistant Physical Testing Engineer, State Division of Highways; (c) Preparation of Soil Profiles by Mr. Porter; (d) Discussion, Mr. Middlebrooks, Chairman.

The lectures were illustrated with slides showing sampling tools and typical application of boring methods and included a free discussion of difficulties encountered in securing correct information regarding the density, moisture content and the in-place characteristics of foundation materials.

Soil profiles showing condensed, but complete foundation data for various bridges, buildings and highway projects throughout California were also illustrated.

VISIT FLYING FIELD

A field inspection trip to Stockton flying field occupied the morning of April 9th that included: (a) Inspection of runway test section on unstable soil; (b) demonstration of electrical equipment for measurement of pavement deflection and subgrade pressure by J. E. Barton, Associate Physical Testing Engineer, State Division of Highways.

During this trip the engineers were able to observe the action of heavy wheel loads on the runway test section and to formulate an independent opinion regarding the thickness of foundation required over the unstable adobe soil present at this field.

Much interest was shown in the electrical equipment previously developed by the California Division of Highways in cooperation with the General Electric Co. for measuring the pavement deflection and subgrade pressure under moving loads and particularly the results obtained on the test section with a heavy bomber which showed the influence of the dynamic reactions for warm-up and take-off motor speeds.

UNSTABLE CONDITIONS SHOWN

A trip to Sacramento Air Depot in the afternoon permitted an inspection of unstable foundation conditions on a county road to the field and a runway at the field.

At the evening meeting in the district office, the writer lectured on "Soil Conditions and Design of Flexible Pavements."

The tests recently made for the Army Engineers on the Stockton Runway Test Section with wheel loads duplicating the footprint and contact pressure of heavy bombers were presented, together with a tentative criteria for the design of foundations for flexible pavements. The necessity of drainage and the proper use of thick layers of imported fill material and substantial base courses to carry heavy bombers over weak soils was clearly developed during this session.

FOUNDATION DISCUSSION

The discussion which followed with Mr. Middlebrooks as Chairman centered around the selection and economic use of local subgrade materials for constructing an adequate foundation for the pavement.

Questions and round-table discussions occupied the final meeting at the district office on April 10th, with closing remarks by Mr. Middlebrooks.

This session was the most interesting of the conference as all of the engineers attending had previously had many years' experience on soils and foundation work in connection with the Army's extensive construction program including the construction of airports, levees, dams and other river and harbor control works. Because of their broad experience and familiarity with modern foundation practice it was possible to cover the subject in sufficient detail during the week allotted for the conference.

Public Works Activity in Defense Efforts

(Continued from page 1)

may be exchanged through the offices of the division.

In order that this procedure be operable, it is proposed that these exchanges be made on a "loan" or "in kind" basis. It is probable a very substantial sum will be represented by equipment which may be so interchanged to the mutual benefit of all agencies involved.

The Division of Architecture is completing a survey of all public schools in California to determine to what extent they offer protection against bombing raids and incendiary explosives.

The Division of Water Resources made an exhaustive report on dams and water supplies throughout the State.

In accordance with instructions issued by Governor Olson to all State departments this division has also completed a check of every motor vehicle in its control, including the mileage to be expected from the rubber now on the car, mileage in the vehicle itself, what repairs could be made in order to prolong its life and to what its use could be restricted. Similar reports will be made by other divisions.

The Division of Highways has completed surveys and plans and specifications for $25,000,000 worth of defense highways. The total of access roads requested by the Federal Government of California is in excess of $45,000,000.

In spite of the fact that more than 200 engineers and employees of the Division of Highways have gone into service with the armed forces or have accepted other employment created by the National Defense Program, the division has been able to complete or place under construction more than $7,344,535 worth of military roads.

Normal highway construction has had to give way to work urgently required by the Army and the Navy. Indicative of the extent to which the Division of Highways is devoting its time and engineering talent to defense is the fact that projects advertised for bid opening during April totaled $2,473,700, of which $1,634,500 were for military access road projects and $420,000 for improvement to the strategic highway network.

64 Highway Construction Contracts Under Way April 1; 34 for Bridge Structures

IN a report to Governor Olson covering the work of the Division of Highways for the month of March, 1942, Director Frank W. Clark states that the extent of State highway construction under way at the present time may be gauged by the 98 contracts in force with the Department on the first of April. Of these contracts, 64 are for road construction and 34 for the construction of bridges and grade separations.

The value of State highway contracts awarded during the month of March totaled $4,156,700. Of this amount $3,284,200 were for construction and improvement to roads serving as access to military establishments and financed from Federal funds authorized for such construction by the Defense Highway Act of 1941.

Projects advertised in March for bid opening during April totaled $2,473,700, of which $1,634,500 were for Access Road projects and $420,000 for improvement to the Strategic Highway Network.

Activities of the Division of Highways during March are indicated by the total amount of $9,306,500 in work orders written for construction and maintenance and for the projects advertised for bid opening in April. Segregation of this total to the various phases of the work is shown in the following tabulation.

CONSTRUCTION		
Construction and Maintenance Contracts	$4,156,700	
Day Labor Construction	654,200	
Day Labor Minor Improvements	300	
Day Labor Access Road Construction	248,900	
Day Labor Flight Strip Construction	20,000	
Engineering	209,600	
Right of Way	26,000	
Right of Way for Route 2 in Los Angeles	306,300	
Subtotal		$5,622,000
ADVERTISED FOR BID OPENING IN APRIL		2,473,700
MAINTENANCE		
General Maintenance	$426,600	
Replacements	577,500	
Slide Removal	151,000	
Buildings and Plants	800	
San Francisco - Oakland Bay Bridge (Operation, Maintenance and Insurance)	54,900	
Subtotal		$1,210,800
Total		$9,306,500

The following summary gives the type, mileage and estimated costs for contract work put under way during March.

Type	Miles	Amount
Grade and pave	3.8	$509,000
Grade and plant-mixed surface	12.2	547,200
Grade and plant-mixed surface on cement treated base	22.9	1,422,200
Grade and bituminous surface treatment	11.7	742,200
Grading only	3.2	337,200
Bridges and grade separations	(5)	559,700
Oiling roadside vegetation	553.0	17,200
Miscellaneous contracts	----	22,000
Total		$4,156,700

A similar tabulation for projects advertised for bid opening during the month of April is given below.

Type	Miles	Amount
Grade and pave	20.0	$1,176,400
Grade and plant-mixed surfacing	10.6	235,000
Grade and plant-mixed surfacing on cement treated base	14.0	798,000
Armor coat	12.0	91,300
Bridges	(4)	173,000
Total		$2,473,700

Mass Highway Traffic Must Be Safeguarded

H. S. Fairbank of the Public Roads Administration of the Federal Works Agency in an address delivered before the American Society of Civil Engineers, in Roanoke, Va., recently said:

"Automatic counters throughout the country show that February, 1942, traffic on rural highways was 7.6 per cent less than that of the same month a year earlier, and January travel was only 1.1 per cent greater than that of January, 1941. In contrast, rural traffic increased each month of 1941 over the corresponding month of the previous year, with December, 1941, traffic 12.5 per cent greater than a year earlier."

While predicting further declines in "unessential" travel, the Public Roads official emphasized that "large elements of the total highway transport are essential in the highest degree," and that "these essential movements must be safeguarded."

He quoted from a survey of 749 Michigan corporations manufacturing war materials, showing that 70 per cent of these firms received 50 per cent, 38 per cent received 90 per cent, and 13 per cent received 100 per cent of their incoming materials by truck. Seventy-six per cent ship 50 per cent, 43 per cent ship 90 per cent, and 15 per cent ship 100 per cent of their products by truck.

Of the 434,700 workers employed at these plants, 75 per cent were reported to travel to work by automobile.

Every noble activity makes room for itself.

Bids and Awards for April

LOS ANGELES COUNTY—Santa Monica Blvd. between Croft Avenue and Fairfax Avenue, about 0.7 mile to be surfaced with asphalt concrete. District VII, Route 162, Section A. Southwest Paving Co., Roscoe, $29,282; Vido Kovacevich, South Gate, $31,-242; Griffith Co., Los Angeles, $33,650. Contract awarded to Frank West, Los Angeles, $27,076.

MONTEREY COUNTY — Between 0.7 mile north of Monterey Avenue in Marina and Castroville, about 5.2 miles to be graded and paved with Class "B" Portland cement concrete. District V, Route 56, Section I. United Concrete Pipe Corp., Los Angeles, $497,709. Contract awarded to Granite Construction Co., Watsonville, $474,514.

MONTEREY COUNTY — An overhead crossing over the tracks of the Southern Pacific Co. one-half mile northeast of Castroville to be constructed. District V, Route 22, Section A. Dan Caputo, San Jose, $39,-789; Trewhitt-Shields & Fisher, Fresno, $39,905; Granite Construction Co., Watsonville, $42,900; Bert P. Ward & Son, San Jose, $44,283; Harry J. Oser & Peter Sorensen, Redwood City, $46,790; Earl W. Heple, San Jose, $48,360; John Carcano, San Rafael, $49,775; F. Kaus, Stockton, $54,900; A. Soda & Son, Oakland, $71,527. Contract awarded to Kiss Crane Service, Berkeley, $37,721.

SACRAMENTO COUNTY — Between Ben Ali and McClellan Field, about 3.3 miles, to be graded and paved with Portland cement concrete. District III. N. M. Ball Sons, Berkeley, $141,981; A. Teichert & Son, Inc., Sacramento, $147,316; Frederickson & Westbrook, Sacramento, $148,-315. Contract awarded to J. R. Reeves, Sacramento, $134,138.

SAN BERNARDINO COUNTY—Between Cherry Avenue and San Bernardino, about 8.6 miles to be surfaced with plant-mixed surfacing. District VIII, Route 9, Sections A, B, Ria., C, S. Bd. Vido Kovacevich, South Gate, $109,717; Griffith Co., Los Angeles, $110,419; Oswald Bros., Los Angeles, $111,725; W. P. Powell Paving Co., Los Angeles, $113,229; W. E. Hall Co., Alhambra, $114,938; P. J. Akmadzich, Sunland, $119,495; Basich Bros., Torrance, $119,520; J. E. Haddock, Ltd., Pasadena, $141,645. Contract awarded to George Herz & Co., San Bernardino, $106,719.

SAN DIEGO COUNTY—A reinforced concrete slab bridge across Las Chollas Creek in the city of San Diego to be constructed. District XI, The Contracting Engineers Co., Los Angeles, $88,312; Bent Co., Los Angeles, $88,408; V. R. Dennis Construction Co., San Diego, $94,802; R. E. Hazard & Sons, San Diego, $104,813; Carlo Bongiovanni, Los Angeles, $123,508. Contract awarded to Oberg Bros., Los Angeles, $80,102.

SOLANO COUNTY—Between 3.1 miles north of Fairfield and Ulatis Creek, about 5.3 miles, borders of crusher run base to be constructed on each side of the existing pavement and armor coat applied thereto. District X, Route 7, Section C, Vacaville. A. J. Clausen, Berkeley, 32,596; Beerman and Jones, Sonora, $36,730; Lee J. Immel, Berkeley, $36,733. Contract awarded to Sheldon Oil Co., Suisun, $28,475.

Electronic Roadside Speed Timer Developed by Division of Highways

By W. M. RIETH, District Traffic Engineer

THE Division of Highways has recently put into use an electronic timer to determine the speed of traffic on California highways. After two years of experimentation the Traffic and Safety Department of the Division has perfected an instrument which satisfies the requirements of portability, accuracy and convenience of operation.

The speed at which traffic will move over a completed project, particularly the maximum speed, is perhaps the most important factor to be considered in the design of sight distance, superelevation curvature and gradient.

Speed is an important factor also in traffic accidents. It directly influences road capacity and is to be considered in connection with all studies seeking to solve congestion problems.

There has been an absence of definite, reliable data on traffic speeds, partially due to the lack of an adequate and accurate measuring mechanism. Traffic engineers have recognized the need for this information and attempted to have a suitable instrument constructed for procuring speed data.

An ideal instrument is one which satisfies the requirements of portability, accuracy, is easily concealed, simple to operate, and records total vehicles and speeds.

Such an instrument is the two-cell, photoelectric, bidirectional, electronic timer. A built-in electric counter tallies vehicles automatically. The traffic speeds are read and recorded manually. Experiments are now under way to obtain the automatic recordation of speeds. The length of base line is seventeen and six-tenths inches. The heaviest unit weighs 55 pounds. It can be set up by one person anywhere, day or night, in less than five minutes. Most of this time is required to accurately align the eight beams upon the photo-cells. However, this has been reduced to a minimum by installing low-power, telescope rifle sights, with cross-hairs, on each unit.

The complete assembly consists of: (1) a two-beam light unit and a 6-volt storage battery; (2) a two-beam photo-cell receiver unit; and (3) an amplifier unit and meter. The photo-cells and amplifier secure their energy from the regular 6-volt car battery in the car, operated by the recorder. The two small lights in the light source draw approximately 5½ amperes. The average storage battery will operate these continuously for 16 hours or longer. The total current drain of the photo-cells, amplifier, and meter is only 3½ amperes, and the regular car battery is used.

A good car battery will stand about a 35-ampere drop without affecting the starting or the car's operation. Experience shows that if the car motor is run for approximately 15 minutes every two hours, the battery voltage will drop a very small amount in 10 hours of speed-checking. The charging of the battery by running the car motor does not interfere with the continuous operation of the photoelectric meter.

The accuracy of the meter is well within any normal requirements. Numerous checks have been made against vehicle speedometers of different brands. Speedometers previously checked by other methods and found to be reasonably accurate, were used for checking.

The accuracy of the meter is dependent upon the initial graduation of the meter scale. This was done with a synchronous motor-driven propeller with wide blades. Speed of the motor was regulated to accurately break the light beams at a known time.

During this test, it was discovered that a base line of 17.6 inches would give even 10 and hundred increments as a reciprocal of even miles per hour. For example, one-thousandth of a second time-interval between breaking of the two beams equaled 100 miles per hour.

It may seem to the average person that it would be impossible to secure accurate results with such short time-intervals, but one need only consider the fact that light and electricity travel at a speed of approximately 186,000 miles per second, to realize that the element of speed does not nearly approach its maximum capacity in the meter. With few alterations made in the meter during the experimental stage, it was used to measure the muzzle velocity of rifle bullets.

The meter can be set up and operated by any one who can hook up a radio to the antenna, ground, and plug the cord into an outlet. Operation is as simple as tuning a radio in the home. It is impossible to connect the meter incorrectly.

After the instrument has been set up, and the switch turned on, it takes about one minute for the tubes to warm up. The meter needle moves to the speed at which a vehicle is traveling as it passes through the beam and remains at that point until the reading is cleared by pressing a button. Other passing vehicles do not affect the reading until the meter is cleared. If the meter fails to operate, it is because the light beams are not properly focused upon the photo-cells.

Continuous transporting of the unit in a car may cause the telescopes to get out of alinement. The instrument, however, is fairly rugged and will stand about the same amount of vibration and jarring as a radio.

One of the greatest obstacles in perfecting the meter was the variation in the voltage, which prevented the successful use of dry-cell batteries. To maintain a constant voltage over a long period of operation a vibrator type of supply is used. The output is filtered through a 20-henry choke and 16 and 8 mmf condensers. Two voltage regulator tubes, VR90-30 and VR150-30, are used to stabilize the voltage.

Tubes can be replaced with any standard brand. However, the vacuum-tube voltmeter tube is quite critical as to tube characteristics. It has

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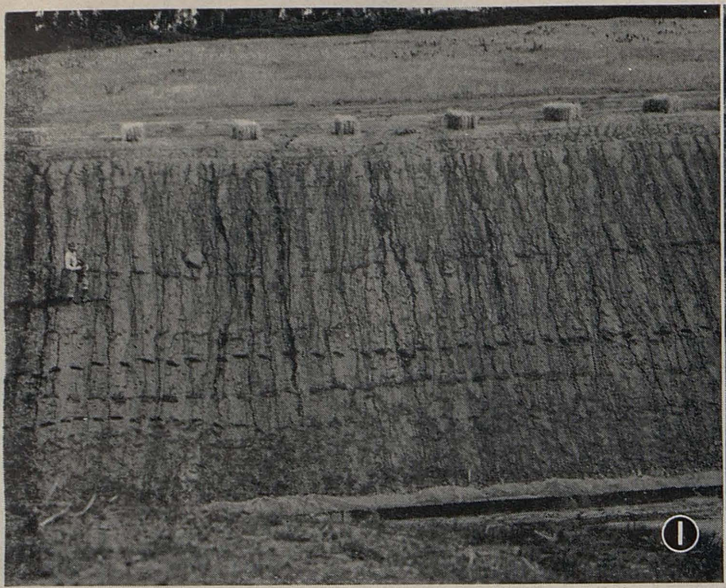
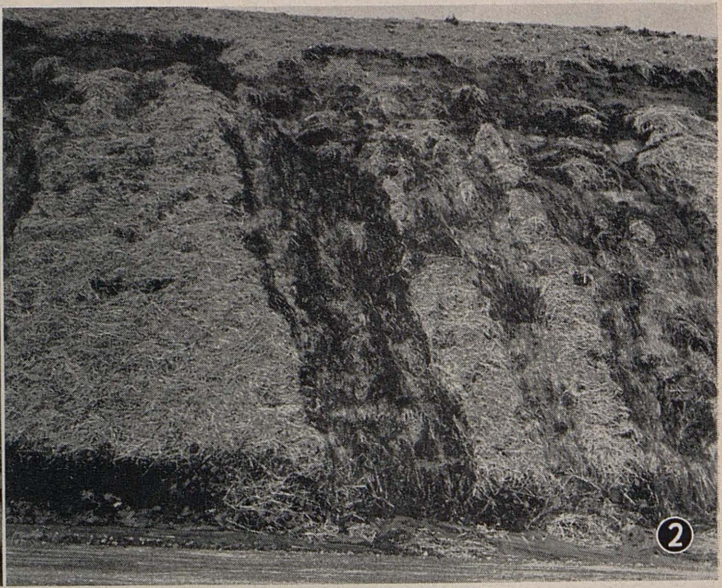
Views of new photo-electric roadside speed timer in action at top. Units of the apparatus are shown below with District Traffic Engineer W. M. Rieth who supervised its development





(1) Erosion gullies formed on a top soiled cut slope by 2.13 inches of rain. Note no intercepting drain ditches. (2) Result of 3 days rain, 3.95 inches in 24 hours, on newly treated slopes. Failure due to lack of bond of top soil to subsoil

Low Cost Vegetative Stabilization of Highway Slope Cuts and Fills

By H. DANA BOWERS, Landscape Engineer

MODERN highway construction with its improved alignment and grades, has necessarily resulted in increased excavation. There naturally follows an increase in the depth of cuts, the height of fills, the quantity of slides and erosion damage and subsequent maintenance costs.

To reduce the hazard and expense of maintaining high, steep slopes, they are being flattened, where possible, to a more natural angle of repose. This flattening, however, has brought about an increase in potential surface erosion by exposing more surface area to weathering action.

Progressively and by experimentation, methods of low cost vegetative erosion control have been worked out under varying conditions.

One of the best examples of the value of vegetative slope erosion control is to be seen on the new construction project between Watsonville and Rob Roy in Santa Cruz County.

This road traverses sharply rolling alternately grassed and heavily wooded terrain. The soil is blow sand containing a small amount of clay and is highly erodable.

Ample evidence was at hand during reconnaissance as to the erosion problems involved. Every break in the natural protective sod or humus covering revealed the ravage of erosion. It was obvious that deviation from standard 1:1 slope construction methods was necessary if a road was to be economically maintained in the existing material.

Cut slopes were designed at $1\frac{1}{2}$:1 and specifications were written to include the salvaging and spreading of top soil. Contract specifications for this item of work follows:

CONTRACT SPECIFICATIONS

"Where designed cut slopes are $1\frac{1}{2}$ to 1 or flatter, the top soil on the natural ground shall be reserved and later placed on the slopes. After the slopes have been staked or outlined by the engineer, the top soil containing the natural grasses, roots, seeds and decomposed vegetable matter shall be removed from the area to be excavated and placed in windrows or stockpiled on both sides of the roadway immediately outside the slope lines. The top soil shall be removed to such depth as to provide sufficient material to cover the cut slopes to a depth of at least six inches (6").

"The cut slopes shall be left in a roughened condition with all debris or loose material removed. Hand sloping will not be required and variations from the planned slope at any point of not more than one-half foot will be satisfactory.

"After the roadway excavation has been completed, the top soil from the windrows or stockpiles shall be drifted down over the surface of the cut slopes in a reasonably uniform manner.

"Quantities of top soil removed and placed in windrows or stockpiles will be included in the quantity of roadway excavation to be paid for. The work of handling top soil will be paid for once only as roadway excavation, which price shall include full compensation for removing top soil, placing in windrows or stockpiles, and also for removing it from stockpiles or windrows and drifting the material over the cut slopes as specified above and no additional allowance will be made therefor.

SIX INCHES OF TOP SOIL

"Where, in the opinion of the engineer, the quantity of top soil available is insufficient to provide a layer six inches thick over the cut slopes, or the top soil is of such character as to render it useless for planting or seeding purposes, a suitable top soil shall be furnished from other locations as designated by the engineer. Excavating and transporting such top soil will be paid for at the contract prices for roadway excavation and overhaul, which prices shall include full compensation for drifting the material over the cut slopes as specified above.

"In all cases of slope treatment, the areas shall be seeded as directed by the engineer and such work of seeding will be paid for as extra work as provided in Section 4, article (e), of the Standard Specifications."

Since the amount of humus bearing top soil was known to be insufficient to provide complete erosion protection, a Federal Aid erosion control day labor project was approved by the PRA to supplement the work done under the contract.

WORK PROCEDURE OBSERVED

This was gotten under way immediately following construction and the following procedure was observed:

1. Commercial 6-10-6 fertilizer was spread on the cut slopes at the rate of 10 pounds to 1,000 square feet.

2. Western Rye grass seed was sown at the rate of one pound to 400 square feet.

3. Straw was spread at the rate of three tons± per acre and incorporated with the slopes by shoving or tucking into the loose soil.

These operations, including materials, cost .0032 cents per square foot or approximately three cents per square yard.

Fill slope treatment varied slightly in that cheaper seed and no fertilizer was used. Barley was sown on the fills followed by the straw cover held in place by the same method as used on the cut slopes. Although high winds were experienced, no loss of straw resulted even before the sprouting of the seed which completely covered the straw and held it permanently in place.

To obtain full knowledge of the value of any type of work the failures as well as the successes and their causes should be discussed. In order to illustrate the accomplishment and results of this project they are presented in chronological order.

Work was started December 1, 1941. Up to that time 2.13 inches of rain had fallen on the top soiled slopes with a slight gullying effect. See Photo No. 1. No intercepting drain ditches had been constructed which accounted for the more pronounced gullies. Slopes with a high humus content cover, showed no evidence of erosion from this amount of rainfall.

CHRONOLOGY OF WORK

On December 14, 1941, approximately 12 acres of cut slope had been treated. During the 24-hour period on this date, 3.95 inches of rain fell. The heaviest intensity was 1½ inches per hour for a 30-minute period, which according to records was the maximum for a 10-year period. The total for the month was 10.8 inches.

Less than 20 per cent loss resulted from this storm. The appearance of the slopes, however, belied this estimate due to the slipouts occurring mostly at the upper portion of these cuts and sliding down over the straw to the gutter leaving a trail of mud flow behind. See Photo No. 2.

The greatest loss was caused by overflowing water. Broad and shallow intercepting ditches were then constructed and run on flat contours to drain into the natural undisturbed ground. The slipouts were repaired and the gullies packed with straw and seeded.

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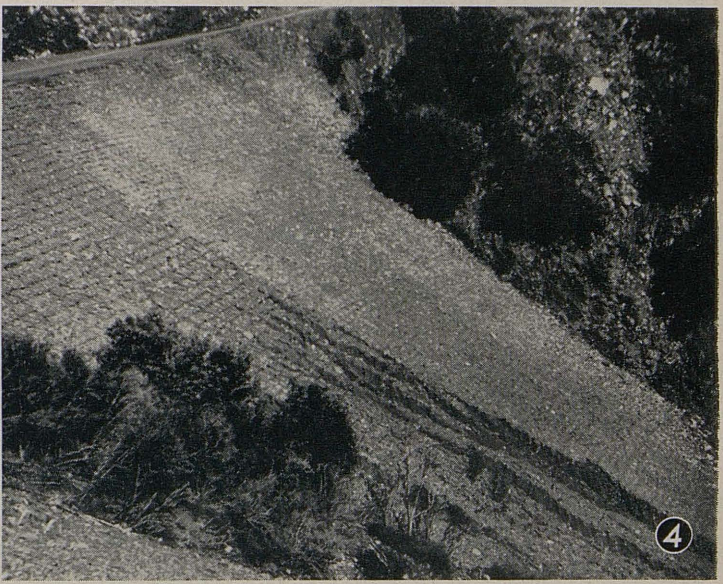

(3) Loss of top soil caused by first rain. No additional loss from subsequent rains has occurred. Soil is clay loam. (4) Fill slope protected by wattle method. On far half wattles were placed approximately 2 feet apart; on near half 4 feet apart. Note effects of erosion

(5) Barriers that retard the flow of water are not successful. Note deep slip out. Highly erodible soils must not be allowed to move. (6) A down drain poorly installed. Water flows under pipe. Flattened and blanketed with humus material would promote grass growth over which water would flow without scouring

In January, 1942, the rainfall totaled 4.75 inches, of which 2.12 inches occurred in a 24-hour period.

With the exception of occasional gullies caused by overflow from above, originating in swales where down drains were needed to keep the drainage off the slope surface, the failure was negligible. These gullies were again repaired.

In February, 4.57 inches of rain fell with 1.37 inches during a 24-hour period. In March and to date approximately 5 inches has fallen. No additional surface erosion damage to the treated slopes occurred except those areas kept constantly saturated from underground seepage. These areas have continued to slough and cave in and unless the willow stakes planted in these wet spots are effective, will in all probability, continue to do so during the winter months. Where possible, these slopes will be flattened and drains installed.

Intercepting drain ditches at top of slope like above also need vegetative protection

The northerly section of the project is still under construction and on which no erosion control work has been done. Severe erosion has taken place on both cut and fill causing slough material to encroach on private property. The extreme erodible condition of the soil can be fully appreciated by the fact that the damage to the new work has occurred since the heavy rainfall of December, 1941. Photo No. 6 illustrates the erosion experienced on this section.

The southerly end of the project was not included in the erosion control work. These slopes received no treatment other than top soiling and seeding under the construction contract. All loss of top soil occurred during the first heavy rain of December 14th and no additional loss has resulted since (See Photo No. 3). This would seem to verify the need of a bond between the top soil and subsoil. The soil on this section is clay loam and not subject to the erosion as is the sand of the northern portion of the project.

CONCLUSIONS REACHED

Giving due consideration to pertinent factors involved and upon observation of the results of various methods of control under varying conditions in the State, the following conclusions have been reached:

1. Under normal or favorable soil and weather conditions a permanent cover can be economically established on $1\frac{1}{2}$:1 slopes.

2. Where the character of the subsoil precludes root penetration and where saturation occurs, $1\frac{1}{2}$:1 is too steep and failure can be expected. In this case slopes must be 2:1 and occasionally flatter to reduce the pull of gravity on unstable subsoil stratum.

3. Slopes must be in a loose cultivated condition before the application of top soil or other stabilization treatments.

4. The value of top soil as an erosion contral agent is in direct proportion to its humus content. When the humus content of the soil is low, additional humus must be provided.

5. To reduce loss of top soil or other applied protection during the first heavy rains a complete bond of the top soil to the subsoil is necessary. Usually the first gentle rains of the season will accomplish this. In the event of heavy down pour, however, the surface application becomes saturated and slips down over the subsoil unless the subsoil is of such character as to absorb the moisture. To prevent this loss, where conditions warrant the cost, a bond may be effected by artificial watering during application.

IMPORTANCE OF BOND

6. The thickness of top soil or treatment applied has little direct bearing on the per cent of loss if a bond is effected. This is evidenced by the fact that practically no loss of top soil or other treatment occurs after the first heavy rain. After bonding, only natural erosion gullies form and these are minimized by reason of the existing humus in the top soil cover. A rapid and successful growth of any nature can not be expected when plant food is lacking; therefore, the thickness of top soil applied depends upon growing conditions. Where good growing conditions exist the amount of top soil may be reduced and vice versa.

7. Exposure is most important and dictates in many cases the extent of treatment necessary. Conditions being equal, a northerly exposed slope can be vegetated much more economically than that of a southern exposure. Less humus content is needed to retain the moisture for plant growth on slopes with a northern exposure. Exposures should be con-

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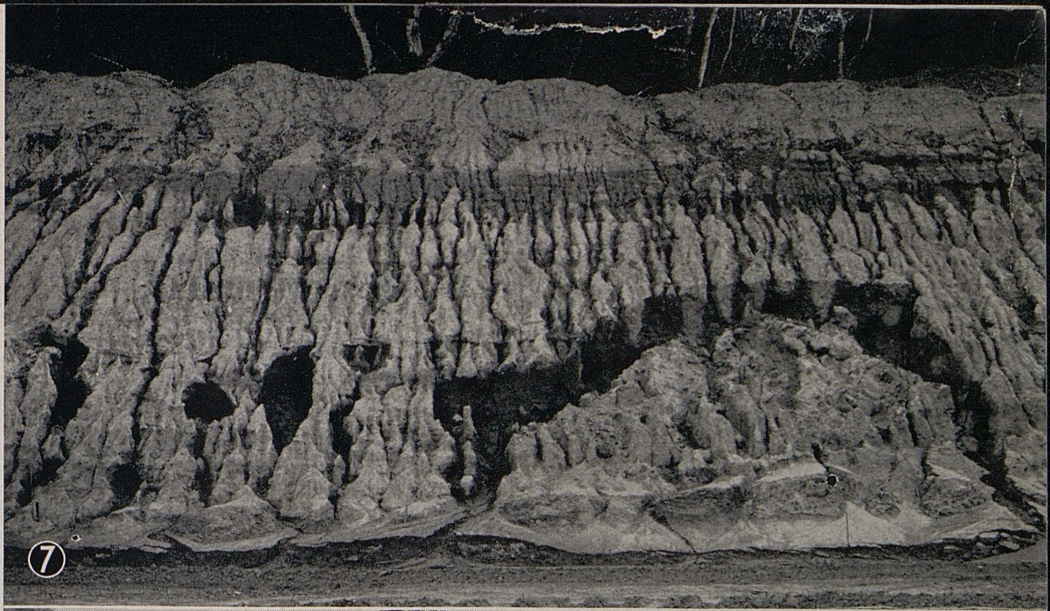
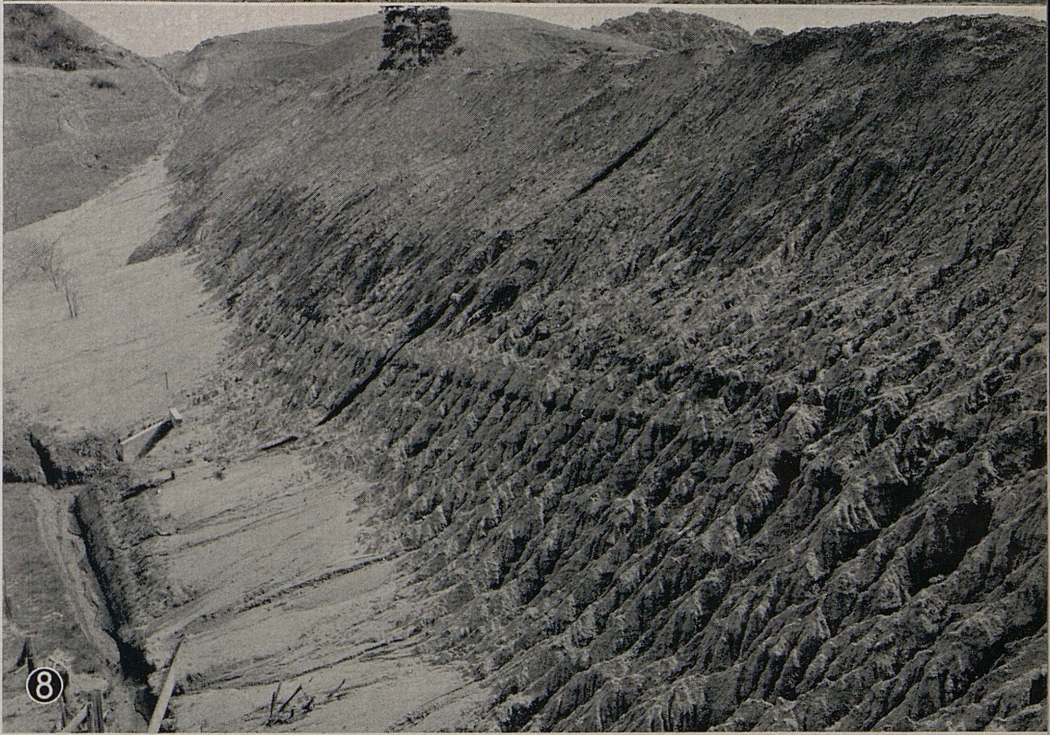
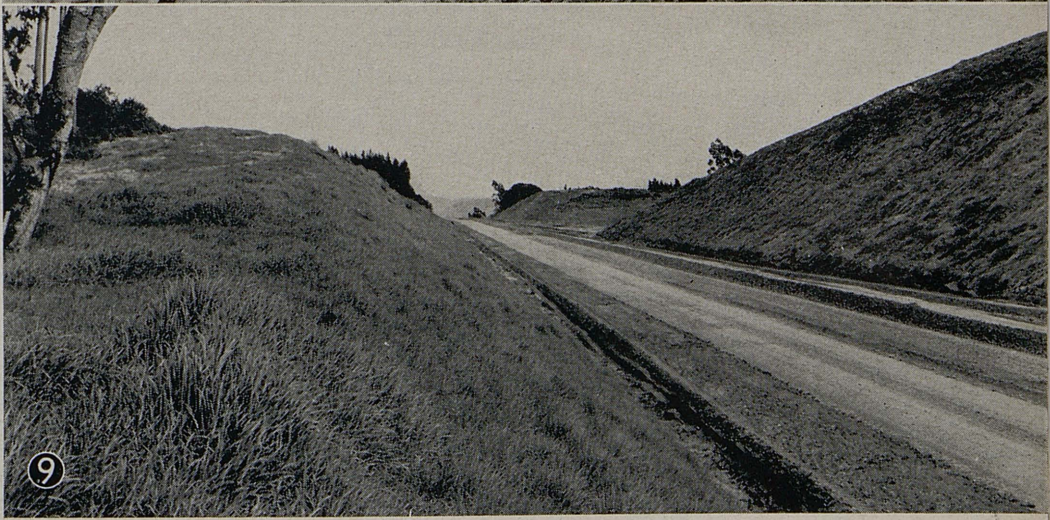






Typical erosion occurring on cut slopes during construction are shown in Nos. 7 and 8. On the same job and same soil $1\frac{1}{2}$:1 cut slopes are shown in No. 9 that were stabilized with top soil, rye grass and straw

Seven Types of Bank Protection Used for Highway Along Santa Clara River

By G. A. TILTON, Jr., Assistant Construction Engineer

IN less than one mile along the Santa Clara River in Ventura County, seven types of recently constructed bank protection serve to protect the State Highway. These installations are as follows:

(1) 30 foot steel rail tetrahedron spur jetties.

(2) Sacked concrete riprap revetment.

(3) Portland cement concrete revetment.

(4) Rock and wire mattress.

(5) Steel rail and cable and rock-fill double fence.

(6) Combination of sacked concrete riprap revetment and rock and wire toe mattress.

(7) Combination of portland cement concrete revetment and rock and wire toe mattress.

Selection and adaptation of each type of bank protection has been based on experience and principles of design outlined in the State Division of Highways *"Joint Departmental Report on Performance of Revetment and Bank Protection" compiled subsequent to the 1937-8 floods in Northern and Southern California.

Steel Rail and Cable and Rock-fill Double Fence

The first type to be installed was the steel rail and cable and rock-fill double fence, constructed in 1938-1939 shortly after the disastrous March, 1938, floods. One thousand fifty-one feet of double fence was built at a vulnerable point where the Santa Clara River overtopped and washed out the State highway roadbed a short distance east of the town of Piru. With no solid foundation available, and the river paralleling the highway, a training type of bank protection was selected. The steel rail and cable and rock-filled double fence type, with an adjustable rock and brush-fill basket between the steel rail fences met the requirements.

* July, 1939, California Highways and Public Works.

Each fence consists of 60 pound steel rails, 30 feet long, spaced 12 feet center to center and driven 23 feet into the streambed, the rails being connected longitudinally with $\frac{3}{4}$-inch steel wire cables. Both the inner and outer rail fence is lined on the outside with 9 feet 8 inches of 58-inch galvanized woven wire fencing. Inside the steel rail fences spaced 5 feet apart, an adjustable basket of galvanized woven wire fencing is fixed to the outer fence, and filled with alternate layers of brush and rock cobbles. When scour under the fence occurs, the rock and brush filler is free to drop into the scoured area.

Sacked concrete riprap, 12 inches thick with rock and wire toe mattress, 8 inches thick and 14 feet 6 inches wide

Portland cement concrete revetment on 1½:1 slope 10 inches thick with rock and wire mattress 14 feet 6 inches wide

The installation cost $10 per foot including deadmen and has proved to be highly efficient. As in all fence types of bank protection, struts of similar construction to the training fence are connected with the bank to interrupt damaging flow back of the fence at times when the training fence is overtopped.

Combination Portland Cement Concrete Revetment and Rock and Wire Mattress

In 1940, two years after the fence type was constructed, a heavy flow in the Santa Clara River began to threaten sections of the State highway above and below the recently installed double heavy fence type, requiring further protection to the newly paved and realigned roadbed.

Downstream from the steel rail and cable and brush and rock-fill fence, the river impinges upon a curving bank. With no foundation available, and an easily eroded vertical bank, the site required a type

Thirty-foot steel rail tetrahedrons, shown in middle ground, and sacked concrete riprap installation in foreground

Steel rail and cable and rock-fill double fence bank protection

of protection that would prevent erosion of the bank and at the same time provide against scour.

Portland cement concrete revetment on a $1\frac{1}{2}$:1 slope, 10 inches thick, protected with an 8-inch rock and wire toe mattress 14 feet 6 inches wide, was selected for this location.

Section of the combination type of slope revetment and horizontal toe mattress was predicated on the theory that the stream flow on the outside of a curve, next to the bank, is directed diagonally downward along the bank and reaches a maximum at the bottom of the revetment where it meets the streambed. If the downward diagonal flow, which is primarily the resultant of the superinduced head next to the bank and the stream flow parallel to the bank, is interrupted at the bottom of the revetment and deflected horizontally by a resistant body, scour at the bottom of the revetment is prevented.

The rock and wire toe mattress not only interrupts and deflects the damaging downward diagonal flow horizontally, but being flexible, has the property of being able to settle into scoured sections at the outer end of the mattress and stop further destructive action.

Experience with toe mattresses in the past three years has been highly gratifying and appears to justify the theory upon which the design is based.

Portland cement concrete in the revetment consists of creek-run aggregate and 4 sacks of cement per cubic yard.

Rock and wire toe mattress is made up of 58-inch Elwood Type I galvanized woven wire fencing bound together with No. 12 galvanized wire ties 8 inches center to center. Three-quarter-inch wire cables connected to deadmen spaced 10 feet center to center back of the revetment are attached to a longitudinal $\frac{3}{4}$-inch cable to which the mattress is fixed. At the point where the rear edge of the mattress meets the concrete revetment, any fixed connection between them is avoided by providing a weep hole for the deadman cable.

Portland cement concrete revetment cost $12 per cubic yard and the rock and wire toe mattress 40¢ per square foot, exclusive of deadmen.

Economic selection of this combination of types of bank protection is dependent upon availability of local materials for creek-run concrete and rock-fill for the mattress.

Combination Sacked Concrete Riprap Revetment and Rock and Wire Mattress

At the upper end of the original construction of steel rail and cable and rock-fill double fence, where stream flow was threatening the newly aligned highway, a firm foundation for revetment was available for only a part of the distance to be protected.

Sacked concrete riprap revetment, 12 inches thick, protected at the toe with a rock and wire mattress 8 inches thick and 14 feet 6 inches wide, was selected for places subject to scour where no foundation was available and sacked concrete riprap revetment without toe protection was selected where firm foundation was available.

Sacked concrete riprap revetment consists of ordinary secondhand burlap sacks filled with approximately 1 cubic foot of creek run, 4-sack, portland cement concrete, laid in tiers upon a prepared slope. Joints are broken and concrete is of such consistency as to produce sufficient mulch on the outside of the sacks to provide a light bond between them.

One of the most interesting observations of the "Joint Departmental Survey of Bank Protection" made in 1938, was the outstanding success of sacked concrete riprap revetment in Northern California.

Although no definite technical conclusions have been reached as to reasons for the outstanding success of properly placed sacked concrete riprap revetment, several theories have been advanced.

In general, a revetment with a smooth surface tends to increase the velocity of stream flow towards its lower end, which, when released against material presenting a higher frictional factor, erodes and causes serious damages at the downstream end.

The roughness of surface presented to stream flow in any direction, by the broken and recessed sack joints appears to retard the velocity by creating turbulence. The reduced velocity tends to minimize scour, both at the bottom of the revetment where it meets the streambed and at the downstream end of the installation.

Where scour has occurred and where settlement or adjustment of

(Continued on page 15)

Low Cost Vegetative Stabilization of Highway Slope Cuts and Fills

(Continued from page 11)

sidered when salvaging top soil for blanketing the slopes.

8. For best results, the variety of vegetative cover introduced should encourage the rapid run-off of water rather than its retention. See Photos Nos. 4 and 5. Herein lies the value of straw as an initial protection if properly placed. When combed down the slope, the downward slant of the stems hastens the drainage. An excess of straw can be detrimental unless this is done, since it may retain water and cause saturation and slipouts. The grass or grain seed sown, serve only to bind the straw or other humus mulch until the natural grasses, etc., take over. In California the natural dissemination of seeds will rapidly replace artificially sown varieties with few exceptions. Therefore, since it is not possible to purchase in quantity or economically, the seed of the native grasses of the region involved, any economical grass or grain that will serve the purpose for the first year may be utilized.

INTERCEPTING DITCHES

9. Complete protection from drainage water flowing over the slopes must be provided. Intercepting ditches must be broad and shallow for the promotion of grass growth. They should be run on contours where possible and on a flat grade to prevent the cutting action of flowing water. They must also be maintained and kept open, otherwise their use is impaired. Down drains pay big dividends if properly installed. Oil mix alone around the intake, however, does not provide a permanent installation. Wider, flatter, well sodded intakes designed to slow down the cutting force of the water, although slightly more expensive to install, by reason of increased labor, would tend to improve with age rather than to deteriorate and develop cracks that defeat the entire purpose of the installation. (See Photo No. 6.)

10. Surface erosion control is of no value where water comes from within the slopes. Often small seepages can be controlled with water-loving plants such as willow, etc.

11. In sandy soil where no solid stratas exist, root penetration is no guarantee against failure when saturated. Sections the depth to which roots penetrate will slip out. Soils of this nature should be sloped to at least 2:1 to reduce gravity pull and vegetation in the form of vines encouraged that take root at intervals. This, of course, can only be done economically where climatic conditions are favorable. Vine growth tends to hold the slope as a unit. This also applies to fill slopes where sections of luxuriantly sodded fill have been known to slip out 12 to 18 inches in depth.

FILL SLOPE STABILIZATION

There are several types or methods of controlling erosion that have been used on highway slopes. Practically all work done in the past, however, has been applied to fills. This is by reason of the fact that only within the last few years have cut slopes been constructed flat enough to apply practical stabilization.

The factors involved in fill slope stabilization are more favorable than for cut slopes. The fact that the soil has been aerated, improves its adaptability to revegetation, as compared to the hard sterile condition of cut slopes. Fills allow considerable percolation of water beneath the applied protection, which up to a certain point is favorable. Cut slopes have little of this advantage and when conditions become abnormal, some loss can be expected during the establishment period.

The comparatively loose condition of fills, favor the deep penetration and formation of fibrous root systems that tend to tie the slope together. These comparisons must be kept in mind when arriving at a method to apply.

Generally speaking, a good rule to follow in the application of slope stabilization is "a little close together" rather than "a lot far apart."

Photos Nos. 4 and 5 illustrate this axiom. Photo No. 4 consisted of 2″ pipe and Elwood fencing, backfilled with brush, etc., at 10′ intervals.

Photo No. 4 shows a comparison of two types of Wattle control. The near side consisted of Wattles placed 4′± apart held in place with 2″x2″x4′ stakes. The far side of the photo consisted of small Wattles 2′ ± apart held in place with 1′ stakes. This proves the value of a more complete cover and refutes the theory of supporting stakes in compacted fill.

Seven Types of Bank Protection Used for Highway Along Santa Clara River

(Continued from page 14)

material supporting the revetment has taken place, sacked concrete riprap has a sufficiently light bond between the sacks to permit adjustment without serious damage.

Sacked concrete riprap cost ranged from $7.50 to $12.00 per cubic yard prior to the present high price and shortage of burlap sacks.

Steel Rail Tetrahedron Spur Jetties

Previously described types and combination of types provided protection to the highway up to a point where the State highway and river bank begin to diverge.

Above the point of divergence, easily eroded vertical banks of silt, that receded with each storm, presented a growing threat to the highway and head works of the sacked concrete riprap. With no firm foundation available, and being faced with the impracticability of extended and expensive revetment upstream, steel rail tetrahedrons, placed as spur jetties, were selected.

Experience with the permeable type of bank protection along California State Highway System, either as jack straw or tetrahedron spur jetties, or as training jetties, indicates increasing success in locations such as the above where they are particularly adapted. Permeable jetties designed as spurs tend to collect drift and confine scour to the outer units, as well as to retard velocities and cause deposit of detritus back of the jetties.

Steel rail tetrahedrons consist of 30 foot No. 60 used steel rails connected together with ¾-inch cables. Cost per 30-foot unit including cables was $208.

Construction was under supervision of District Engineer S. V. Cortelyou and A. N. George, District Construction Engineer, Los Angeles.

Traveling Highway Bridge Crew Sandblasts and Paints 135 Spans

By T. H. DENNIS, Maintenance Engineer

CALIFORNIA'S traveling bridge-paint crew, organized under Superintendent Carl Markhoff in 1930, has to date sandblasted and painted 135 of the 450 steel structures on the California State Highway System. Up to the latter part of August, 1941, this work had involved sandblasting and painting 11,125,000 square feet of surface, and had required 7,450 tons of sand and 17,100 gallons of paint.

The crew is composed of a bridge superintendent, a foreman, a timekeeper, two structural-steel painters and seven skilled laborers, six of whom sandblast and paint, with the seventh performing general work about camp, such as mixing paints, repairing hose and sprayguns, and servicing compressors. This crew works as either one or two separate units, and is supplemented by six unskilled laborers, hired locally, who serve as watchmen, flagmen, and sand and staging handlers.

The equipment used by Unit No. 1 is a portable outfit mounted on a truck and trailer, which is moved daily to and from the work out of the nearest town or highway maintenance station. The equipment of Unit No. 2 is moved with heavy truck and trailer units under a special arrangement with the headquarters equipment department. It remains at the bridge site during the course of work.

Painting programs are made up annually, based on the recommendation of the bridge department, supplemented by the bridge superintendent's personal estimate of the work and materials required. Allotments are issued for each structure, and upon completion of the work the superintendent makes a final report giving the unit-costs of each item of work in terms of labor, equipment and material.

Special attention is paid to the season of the year, since weather conditions affect costs materially. Bridges along the north coast are painted between June and September, Central Valley structures between October and January, and south-coast bridges between February and June.

Sandblasting is the most expensive item in bridge painting, and the efficiency of the nozzle is of utmost importance. Our experience with the special $\frac{1}{4}$-inch metal-core sandblast nozzle illustrated has been especially satisfactory. The orifice of this nozzle has been found to increase only $\frac{1}{32}$ inch after 100 hours of service. A new nozzle will use $1\frac{1}{2}$ tons of sand in 8 hours' operation, and when this amount is exceeded by 50 per cent the nozzle is replaced. We find it desirable, therefore, to check the amount of sand used in each sand chamber and the diameter of the nozzle orifice daily.

A recent improvement in this equipment is a shut-off valve, which is fastened to the end of the nozzle for the purpose of shutting off the flow of sand. This saves sand and permits the operator to inspect the work or move staging without shutting off the sand chamber. It is also a safety measure, since the shutoff valve eliminates the hazard of undirected flying sand.

TIME-SAVING DEVICE

A simple time-saving device is a Y-connection used on the sand chamber illustrated, which permits two guns to be operated from the chamber under the regulation of one tender. Flexible hose connections greatly reduce the time of connecting and disconnecting the air lines from sand chambers that must be removed from the bridge deck for the safety of travelers at the close of each day's work.

These connections are particularly helpful when painting bascule structures over navigable waterways. On this type of bridge the 2-inch metal air line is stopped on either side of the hinge and a flexible connection made with a rubber hose. Since most passages are made by small craft, which do not require a full opening, the flexible connection often makes it unnecessary to break hose connections and suspend painting operations. When full opening is required, the connectors simplify and reduce the work of disconnecting and reconnecting the air hose.

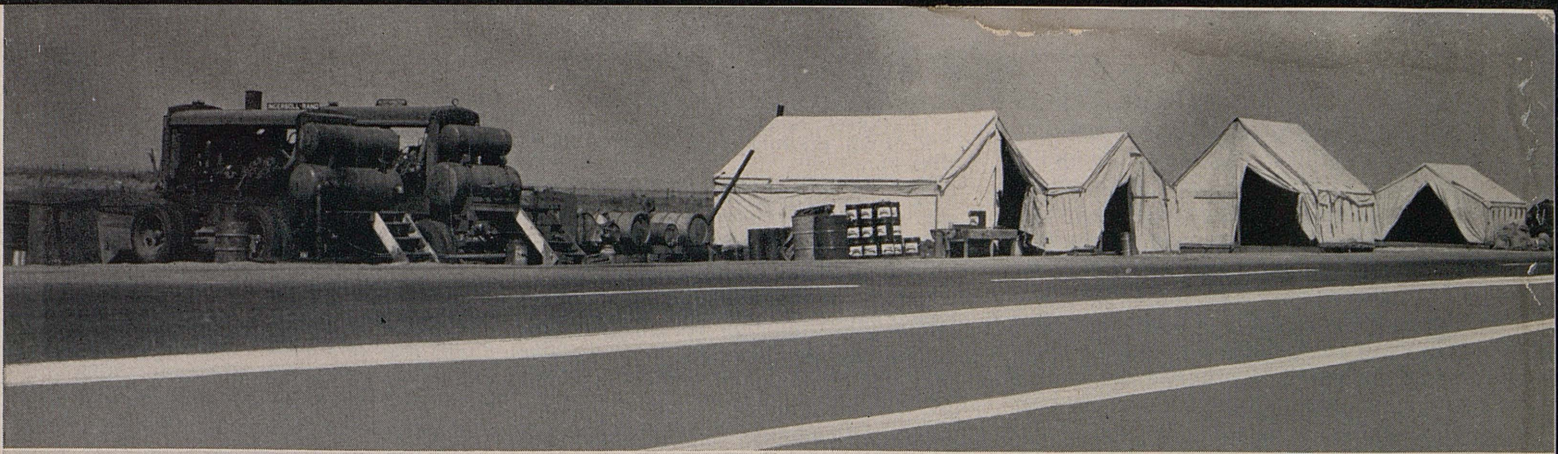
Sand for sandblasting is purchased dried and sacked. Although this represents a cost several times that of bulk material, the differential quickly disappears in the laborious task of drying, screening, and handling the bulk sand. Specifications for Grade B sand require that 95 to 100 per cent pass a No. 20 sieve, 0 to 20 per cent pass a No. 30 sieve and 100 per cent be retained on a No. 40 sieve.

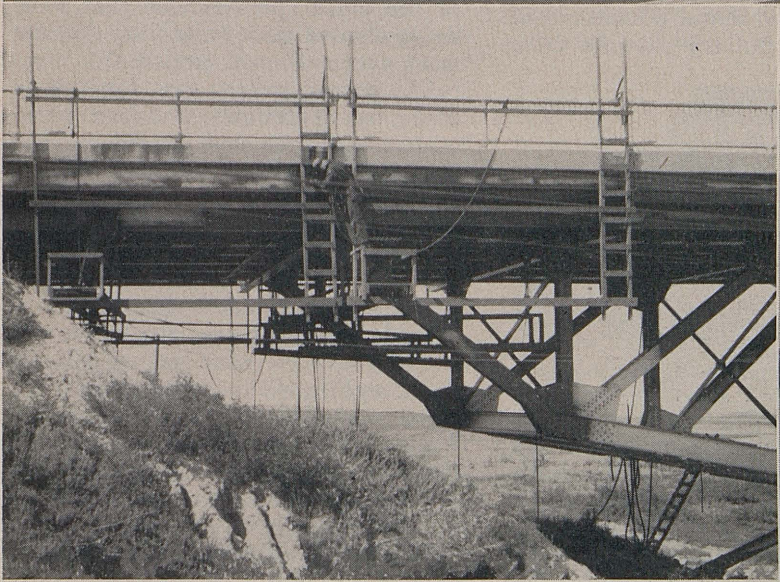
CATWALKS IMPORTANT

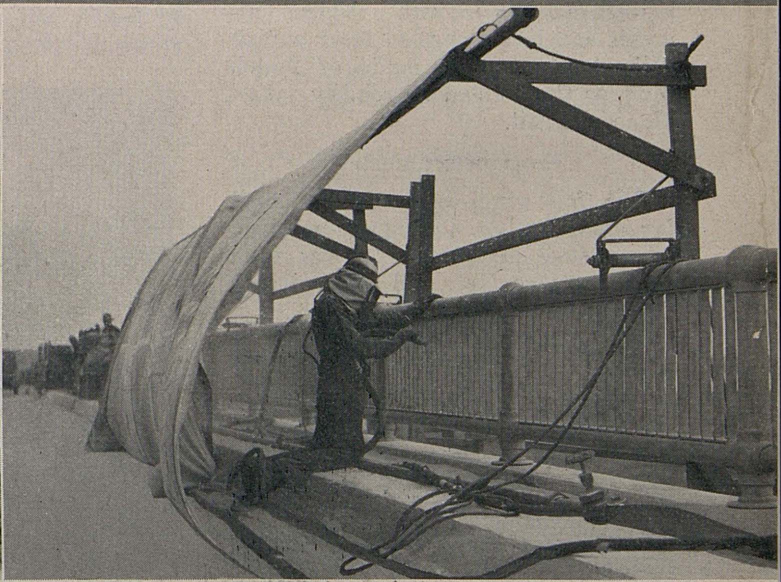
Although staging or catwalks may not be classed as equipment, they are important to the progress of the work and the safety of the men. They are usually built of two 2 x 6-inch timbers laid on edge and floored with 1 x 4-inch boards on 6-inch centers. Railings are made of 2 x 4-inch materials, nailed and bolted.

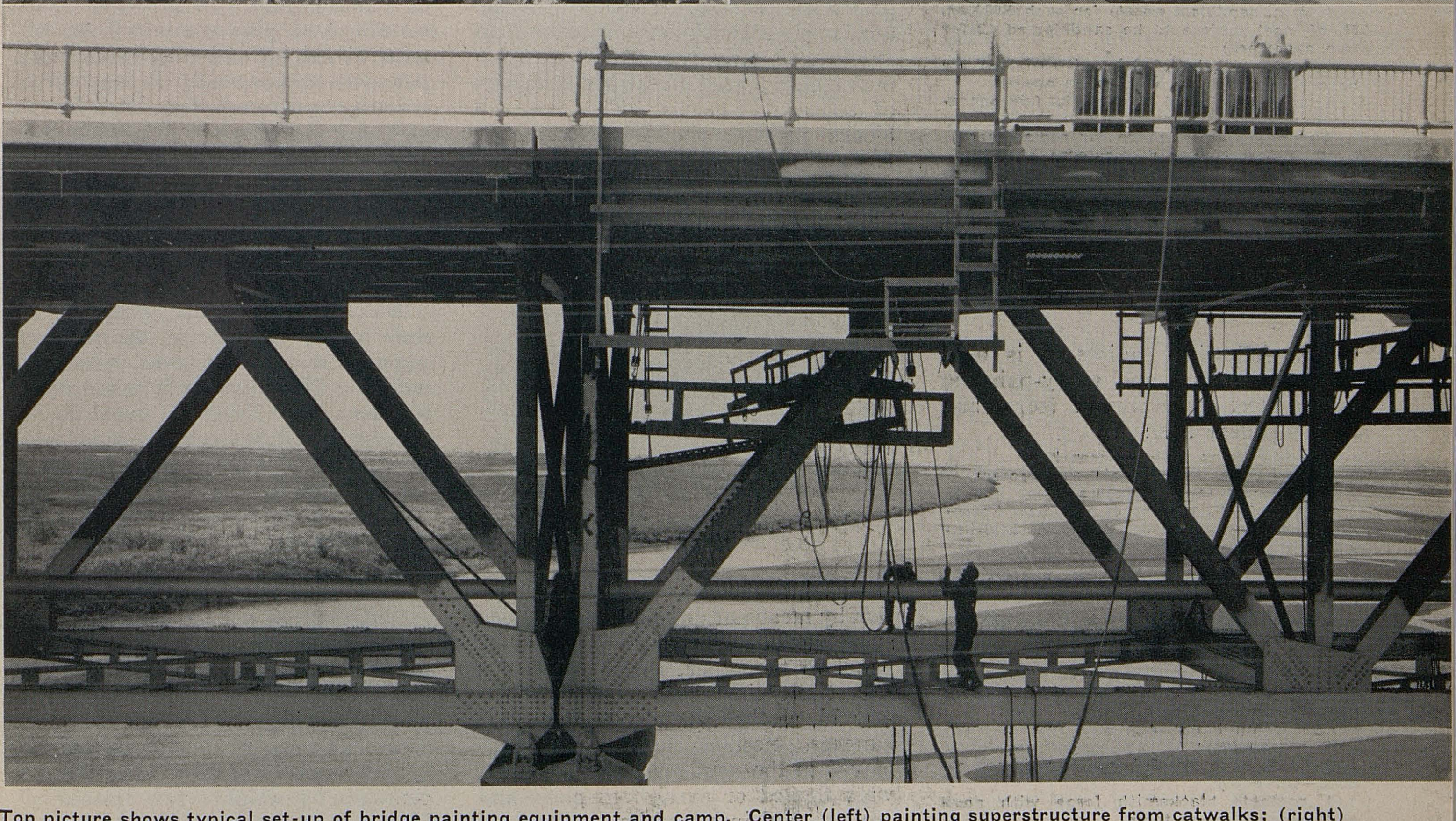
Catwalks used above deck on truss-type bridges are built somewhat less than panel length in order to clear the plumb posts and sway-bracing. They are raised or lowered by double-sheaved block and tackle suspended from chains attached to the top laterals at the panel-points and hooked up below with a triangular hanger at the end of the catwalk. Triangular hangers with an eye at the apex are recommended, since there is less likelihood that the hook on the blocks will disengage from the hanger.

Catwalks below deck are preferably built longer than the deck









Top picture shows typical set-up of bridge painting equipment and camp. Center (left) painting superstructure from catwalks; (right) sandblaster at work on bridge railing. Canvas screen protects passing vehicles. Bottom—Raising catwalks on steel span over river width; 3 x 6-inch stringers are suitable for a 35-foot length. They are supported by means of needle beams hung from the bottom chord by adjustable steel hangers or straps with holes that match, providing a 24-inch extension. The angle where the hanger rests on the top of the bottom chord of the bridge structure is heavily reinforced to prevent the hanger from straightening. Above this reinforcing is a handle by which the hanger can be moved. Where catwalks can be suspended from a pipe rail, the hanger is made of 2-inch pipe, so that it can be readily rolled along the rail.

EQUIPMENT USED

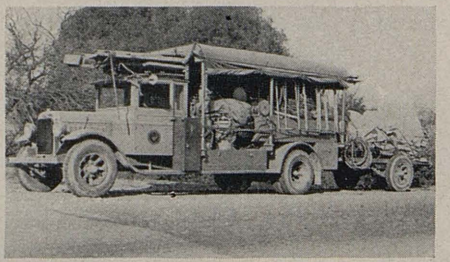
The following equipment is used for sandblasting and spray-painting minor steel structures of less than 20,000 square feet, and for painting major structures.

1 ½-ton truck with express body
1 3-ton truck with built-in lockers and canopy
1 210-cu.-ft. (actual) air compressor, mounted on 3-ton truck
1 1-ton two-wheel trailer
1 7½-cu.-ft. sand chamber
2 50 to 75-ft. lengths of sandblast hose—¾-in. inside diameter, three ply, 3/16-in.-walled pure gum tube
3 sandblast operators' helmets
1 compressed-air purifier—10 to 35-cu.-ft. capacity
1 ¼-in. sandblast nozzle for each 5,000 sq. ft. of steel surface to be sandblasted (2 for two operators)
4 50-ft. lengths of ¾-in. oil-resistant air hose—three, four or five ply, as needed
3 10-gal. pressure paint tanks (six operators)
7 spray-guns (1 extra for replacement)
12 approved-type respirators
8 75-ft. lengths of ⅜-in. fluid paint hose with ⅜-in. standard pipe-thread connections
8 75-ft. lengths of 5/16 in. air paint hose with ¼-in. standard pipe-thread connections
Also 1-inch pipe for air as needed, staging suitable for the structure to be painted, miscellaneous small tools, rope falls, ladders, wrenches, scraping knives, paint brushes, etc.

The following equipment is used for sandblasting and spray-painting major steel structures of more than 20,000 square feet:

1 ½-ton truck with express body
2 315-cu.-ft. (actual) air compressors
2 7½-cu.-ft. sand chambers
4 50 to 75-ft. lengths of sandblast hose—¾-in. inside diameter, three ply, 3/16-in.-walled pure gum tube
5 sandblast operators' helmets
2 compressed-air purifiers—10 to 35-cu.-ft. capacity
1 ¼-in. sandblast nozzle for each 5,000 sq. ft. of steel surface to be sandblasted
4 50-ft. lengths of ¾-in. oil-resistant air hose—three, four or five ply, as needed
1 air-driven power drill with drills as needed
1 riveting hammer
1 rivet buster
2 50-ft. lengths of ½-in. oil-resistant air hose—three ply
1 portable blacksmith forge with anvil and complement of tools
1 dehydrating outfit
3 10-gal. pressure paint tanks (six operators)
7 spray-guns (1 extra for replacement)
12 approved-type respirators
8 75-ft. lengths of ⅜-in. fluid paint hose with ⅜-in. standard pipe-thread connections
8 75-ft. lengths of 5/16-in. air paint hose with ¼-in. standard pipe-thread connections
Also 2-inch pipe in 20-foot lengths, with tees at each joint, extending from set-up on shore to extreme end of bridge; staging suitable for the structure to be painted; miscellaneous small tools, rope falls, ladders, wrenches, etc.

When the bridge deck is wider than 32 feet it will be found advantageous to swing an auxiliary catwalk from



Equipment Used by Bridge-Paint Unit No. 1

the I-beam stringers as a support for the inside end of the main catwalk. The inner end of the main catwalk remains free, and can be moved along the auxiliary catwalk to any position its length permits. The falls for the auxiliary catwalk are attached to 4x4-inch beams resting on 2x4x12-inch blocks placed on the lower flanges of adjacent I-beams. The 2x4-inch blocks prevent the 4x4-inch beams from slipping off the flanges.

Where there is sufficient water under the bridge, the catwalks can be

Equipment Used by Bridge-Paint Unit No. 2

floated into place and raised to position by means of double-sheaved block and tackle. In moving from one panel to the other, the catwalks are lowered to the water surface or the ground, as the case may be, the steel hangers, needle beams and falls moved to the next panel, and the catwalk floated or carried to place and again raised into position.

This discussion of equipment can hardly be concluded without mentioning the paint agitator. This device uses an air drill to drive a shaft mounting a 6-inch propeller. The shaft extends through the cover of a standard paint container, and its speed and direction of rotation can be regulated as desired.

The foregoing discussion has concerned itself largely with crew organization and equipment. We come now to the paint specifications that have demonstrated their suitability for our work over a 10-year period.

The special primer coat for steel is made up as follows: red-lead paste containing 7 per cent linseed oil, 100 lb.; leafed metallic lead paste, 15 lb.; raw linseed oil, 2 gal.; drier, 1 pt.; mineral spirits, 1½ pt. The weight per gallon ready for application is not to be less than 27 lb.

Our modified second-coat steel paint is made up as follows: red-lead paste containing 7 per cent linseed oil, 100 lb.; graphite, 43 lb.; raw linseed oil, 8 gal.; mineral thinner, 3 pt.; drier, 7 pt.; leafed metallic lead paste, 42 lb. The weight per gallon of this paint ready for application is not to be less than 17½ lb.

Leafed metallic lead paste consists of a minimum of 90 per cent flaked metallic lead, plus or minus 9 per cent mineral spirits and plus or minus 1 per cent stearic acid. It must be of smooth consistency, free from lumps, and it must pass the following fineness specification: maximum retained on a 100-mesh screen, 2 per cent; maximum retained on a 200-mesh screen, 11 per cent; maximum retained on a 325-mesh screen, 20 per cent.

No. 3-B finish-coat graphite (a dull black) consists of 45 per cent pigment and 55 per cent vehicle by weight. The pigment is made up of 95 per cent Type B graphite by weight and 5 per cent carbon black. The vehicle consists of the following percentages by weight: raw linseed oil, 75 per cent; spar varnish, 10 per cent; drier, 5 per cent; turpentine, 10 per cent. The weight per gallon of this paint, mixed and ready for application, must be not less than 10½ lb.

No. 3-C finish-coat graphite (also a dull black) consists of 47 per cent pigment by weight and 53 per cent vehicle. The pigment is 100 per cent Type A amorphous graphite, and the vehicle consists of the following percentages by weight: raw linseed oil, 75 per cent; spar varnish, 10 per cent;

drier, 5 per cent; turpentine, 10 per cent. The weight per gallon of this paint must not be less than 10.7 lb.

TYPICAL PAINT JOB

Let us now describe the routine followed on a typical paint job. Since day-to-day routine varies little, the description will be limited to the set-up of equipment and the start of sandblasting and painting operations.

The structure spans a navigable waterway and is 586 feet long. It consists of two Strauss trunnion bascule lift spans, two counterweight spans and two truss spans. The work order called for sandblasting and applying primer and second-coat paint to 68,000 square feet of surface area, and a finish coat to the entire structure—some 78,000 square feet of surface area.

Materials, such as lumber for staging, tent and screen frames, sand and paint, had been requisitioned in advance by the superintendent, to be delivered to the bridge site when ordered.

While equipment Unit No. 2 was being moved from the last job, the members of the crew drove their personal automobiles to the new work and sought suitable living quarters. When the equipment arrived it was unloaded at the side of the roadway a short distance from the bridge. The following two days were spent setting up the two compressors, laying the 2-inch pipe line for air, and building tents, catwalks and screens.

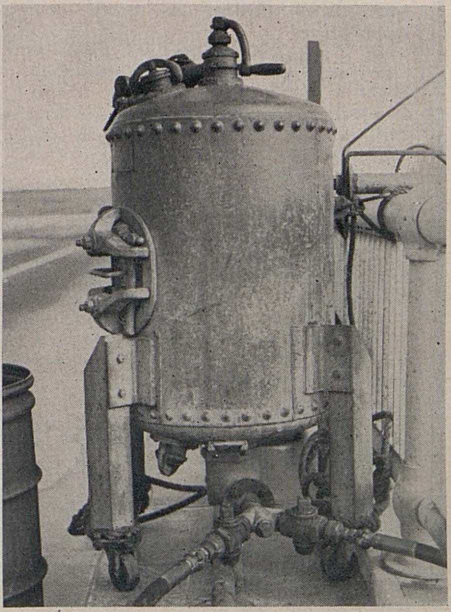
TEES INSTALLED

During this period the sandblast sand and paint were delivered and stored. The compressors were jacked up, leveled and set on blocks to take their weight off the pneumatic tires. Tees were installed every 20 feet and unions every 200 feet in the pipe line, which extended from the compressor over the bridge deck. This insured air delivery at all points and quick replacement of leaky or damaged pipe.

Catwalks and screens were built, since it has not been economical to haul this bulky material any great distance. On the third day stagings were hung in the top of the counterweight truss, two sandblast chambers were moved on to the bridge deck, sandblast hoses and air hoses for the operators' helmets were hauled up on to the staging, and the work was under way.

Two operators worked from each sand chamber, with a skilled laborer at each chamber to regulate the flow of sand and air. Two laborers supplied the chambers with dry sand, which was hauled out to the deck on a ½-ton truck equipped with an express body. No flagmen were required during the painting above deck, since the breeze was strong enough to carry away the spent paint.

After 6 hours of sandblasting, this operation was stopped, since all steel is prime-coated the day it is cleaned. While the painters were greasing their hands and faces preparatory to painting, the steel was cleaned of dust and sand, and the catwalks were moved into position.



Y-connection used on sandblast chamber permits two guns to be operated under the regulation of one tender. Flexible hose connections (A) save time

PAINTING OPERATIONS

Painting operations proceed at a much faster rate than those of sandblasting. A good painter is able to spray-paint 200 to 300 square feet of surface area in an hour, whereas an experienced sandblaster cleans but 80 to 120 square feet in the same period. One factor contributing to this differential is our insistence that the steel be sandblasted to bright metal, rather than stopping at the bloom.

On completion of the day's painting, the paint pots were removed from the bridge deck, and the catwalks lowered and moved some three panels distant for the following day's sandblasting. This is necessary, since the sand and dust otherwise would mark the previous day's painting.

Two night watchmen were assigned to guard the equipment and stores, screen the recovered sand, clean out the mixing boxes in the sand chambers, wash the spray-guns, and set out and take in warning lanterns.

When sandblasting and painting had progressed to within 8 feet of the deck, screens were placed between the operators and traffic. These were moved along with the work, to prevent interruptions by traffic.

Second and finish coats were applied following a 72-hour interval between the prime and second-coat applications—the number of painters and time of painting being expanded as conditions permitted.

Before sandblasting below deck the steel members were washed with a detergent, followed by an application of clear water, to determine the sound paint. Lacking steam, it was necessary to mix the detergent with water and apply through the sand chambers. The detergent was composed of 47 per cent sodium metasilicate, 40 per cent sodium sesquisilicate, 10 per cent sodium tetraphosphate and 3 per cent nacconal.

COST OF WORK

This operation proved profitable, since it disclosed considerable sound paint, which was covered with grime and dirt. The sandblasting below deck was carried on similarly to the operations above deck, except in the matter of staging, which was hung from the lower chords by hangers or supported on auxiliary catwalks suspended from I-beams.

No unusual provisions were necessary other than the special arrangement of quick-coupling hose connections required for the passage of boats. Only during the passage of large boats was it necessary to remove these connectors completely. No delays were experienced on this particular bridge from either fog or rain.

The job required 60 working days. Costs per square foot of surface area for the various operations, including labor, materials, equipment, rental, idle time and transportation, were as follows: sandblasting, 9.09c.; prime coat, 2.83c.; second coat, 2.32c.; finish coat, 2.83c.; total for these operations, 17.07c.; washing steel, 1.57c.

Average unit-costs of materials were $4.60 per ton for sandblast sand, $2.65 per gal. for red-lead prime coat, $1.75 per gal. for second-coat graphite paint and $1.10 per gal. for finish-coat graphite paint.

The materials provided the following coverages per gallon: prime coat, 370 square feet of surface area; second coat, 450 square feet; finish coat, 450 square feet. A ton of sand cleaned an average of 340 square feet.

Through this operation another important structure was protected for a 10-year period. The crew had the equipment loaded and ready for transport some 4 hours after the last spray-gun was laid down. The men were off in their own automobiles to a new job, where good advance planning again did its best to make the work merely routine.

Roadside Speed Timer

(Continued from page 6)

been found that the 7B7 tube in the voltmeter circuit varies with different brands and even different tubes of the same brand. It is necessary to sort over a few tubes to secure one for replacement in case of failure or damage to the one in the set.

Wilbur Smith, traffic engineer for South Carolina State Highway Department, provided data, diagrams, and results of his early experiments with photo-electric, roadside speed meters, which were used as a basis for further development. The actual laboratory construction and experimental work for this meter was performed by Dr. John Blackburn, Ph.D., Consulting Physicist, Hollywood, California. Much credit is given these two men for their work.

15,000 Chinese Coolies Equal Work of Forty Steam Shovels

Recently some 90 miles of new road needed for the transport of material, for the new Yunnan-Burma railway, was constructed within 50 days. The work was done by 15,000 Chinese coolies supplied only with hoes and baskets; they moved about 3,000,000 cubic yards of dirt in that time. The equivalent work by mechanical means would have needed 40 steam shovels for completion in the same time.—Modern Transport, January 17, 1942.

There are three sides to any question: Your side; the other fellow's side; the truth.

In Memoriam

Charles M. MacDonald

February 18, 1887—April 3, 1942

The friends of Charles M. MacDonald, Highway Maintenance Foreman, were shocked to learn of his passing due to a sudden heart attack at Quincy, California, on April 3, 1942.

Mr. MacDonald was born February 18, 1887 in Montezuma, Iowa. He attended elementary and high schools in Montezuma, and in 1906 entered Iowa State College to study civil engineering.

In 1909 Mr. MacDonald went to work as assistant to the construction engineer with the Southern Pacific Company in New Mexico and Arizona, and in 1912 was assigned to the office of the construction engineer in San Francisco.

From 1918 to 1927 he was employed as cashier and manager by the A. F. Wells Company, Engineers, San Francisco. During 1927 to 1930 he returned to the Southern Pacific Company.

In 1930 Mr. MacDonald went to work for the Western Pacific Railroad Company in charge of accounting on construction.

In 1933 Mr. MacDonald entered the employ of the Division of Highways as a Construction Crew Foreman. While with the State he was located in various districts, and was employed as a maintenance foreman stationed at Quincy when death occurred.

Mr. MacDonald is survived by his wife, Mrs. Mabelle MacDonald in Susanville, a son, Charles MacDonald, Jr., in Stanford University, two sisters, Mrs. Jean Wade of Montezuma and Mrs. Florence Feluts of Western Springs, Illinois, and two brothers, Ross MacDonald of Montezuma and Thomas H. MacDonald, Commissioner of Public Roads Administration, Washington, D. C.

Funeral services and burial took place in Susanville, California.

War Department
U. S. Waterways Experiment Station
Engineer Department Research Centers
Vicksburg, Mississippi

California Highways & Public Works
P. O. Box 1499
Sacramento, California

Gentlemen:

It would be very much appreciated if you could send to the Experiment Station five copies of your magazine, vol. 20, No. 3 for March 1942. The copy already in the Research Centers Library has proved of real value to the Engineering Staff here.

For the Acting Director:

Very truly yours,

Katharine McDiarmid, Librarian

Commercial Use of Highways Contributes $1,190,000,000 Taxes

THE density of traffic on our highways and roads is increased by the wide variety of vehicles using them, and the greater the number of vehicles per day, the less it costs per vehicle, for each contributes to highway construction and maintenance costs by means of tax payments.

Truck taxes for the year 1940 were reported at $476,342,000. Buses paid $38,028,340 of special motor taxes in 1940. Automobile taxes amounted to $1,280,000,000. Since 53 per cent of total passenger car mileage is commercial in nature, approximately $678,000,000 of this amount is paid on commercial use of passenger cars.

This total annual commercial contribution of $1,190,000,000 may be viewed as a direct saving for noncommercial users of passenger automobiles, since much of this large sum would have to be paid by them if it were not collected from commercial users.

About 85 per cent of the traffic on highways consists of passenger car traffic. We would build most highways for that traffic alone. Since they can be used also by trucks, truck-trailers and buses it decreases the cost paid by the passenger car owners.

The inherent advantages of motor vehicles that have been considered, tend to increase the traffic density on the highways and hence decrease the cost per vehicle for all those that use it.

Dump trucks, farmers' trucks, railroad trucks, the workman going to his job, the salesman, etc., use the highways for long and short hauls.

In addition to the contributions to the cost of providing highways received from the numerous classes of traffic using them, there is some contribution of other taxpayers, for whom roads and highways have been provided, in whole or in part, to serve purposes other than transportation.

—*Motor Transportation*

Motor Freight Gains in 1941

Reports from 202 motor carriers in 42 states show that the volume of revenue freight transported in April of 1941 was 1,509,143 tons against 1,111,604 tons in April of 1940—a gain of 38 per cent, according to the Automobile Club of Southern California.

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