U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

VOL. 1, NO. 3 WASHINGTON, D. C. JULY, 1918

A SNOW-CLAD FORTRESS OF THE RANGE. MOUNT HOPE, INDEPENDENCE PASS, COLO.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

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It is the desire of the Bureau of Public Roads and the Government Printing Office to issue PUBLIC ROADS regularly on the 20th of each month, but it must be borne in mind by the readers that in these war times the tremendous volume of emergency printing takes precedence in the Printing Office and due allowance be made for delays.

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the people of Colorado have contributed not less than $35,000,000 for road improvement and maintenance during the history of the State.

To fully maintain these roads in their present condition, allowing no depreciation, will cost at least 5 per cent annually of the total amount invested or considerably more than $1,000,000.

The question is, would it be a good business proposition for the counties of this State, owning a property so valuable, to pursue the same course that any big business concern does when it annually sets aside a fixed amount for maintenance cost, and another amount to cover cost of depreciation in values? In this case with proper maintenance there is no depreciation. The answer is, without a dissenting voice from any source, "certainly we should take care of this maintenance."

PROBLEM MORE COMPLICATED DAILY.

Because of a limited State fund, much of the road improvement and maintenance in Colorado has devolved upon county authorities, and they in turn, lacking a comprehensive system, have met their road problems in divers ways.

Some of them, for example, have adopted a system of dragging which keeps their roads generally in very good condition, but others, lacking an organization, simply send out men here and there when roads become impassable or very nearly so.

Frequently lack of funds enters into the question, and with the increasing scarcity of labor and higher cost of materials the problem is daily becoming more complicated.

My own plan for betterment of roads and their maintenance follows that generally adopted by European countries where the road problem has been constantly before the public for years.

I would divide our main traveled highways into sections, varying from 8 to 10 miles, according to physical conditions. I would then place a man with a team and proper equipment in charge of each section, whose duty it would be to keep his section dragged, clean the ditches and culverts, and at odd times to repair and put on fresh surfacing material. Such men could be employed to good advantage for from six to eight months at a cost of about $100 a month. No man should be employed longer than he gives energetic, intelligent, and efficient service. No inquiry should be made as to his politics and there should be no hesitancy in his discharge for poor service.

VOLUNTEER SYSTEM UNSATISFACTORY.

It has been found from experience that volunteer or occasional dragging and repair work by roadside residents is not satisfactory. Personal affairs interfere with prompt and timely action, so I think that soon or later all States must adopt the system of constant, continued maintenance and repair by well paid employees, exacting from them the return for continued employment.

Every county should have a trained engineer as general superintendent of road building and bridge work, and these men will be rapidly developed if the compensation is sufficient to attract them.

In the meantime, pending the development of the patrol system, we are doing as much work as well as we can, but with the general policy of first opening a district to travel by a dirt road and later improving it, as traffic conditions and finance warrant.

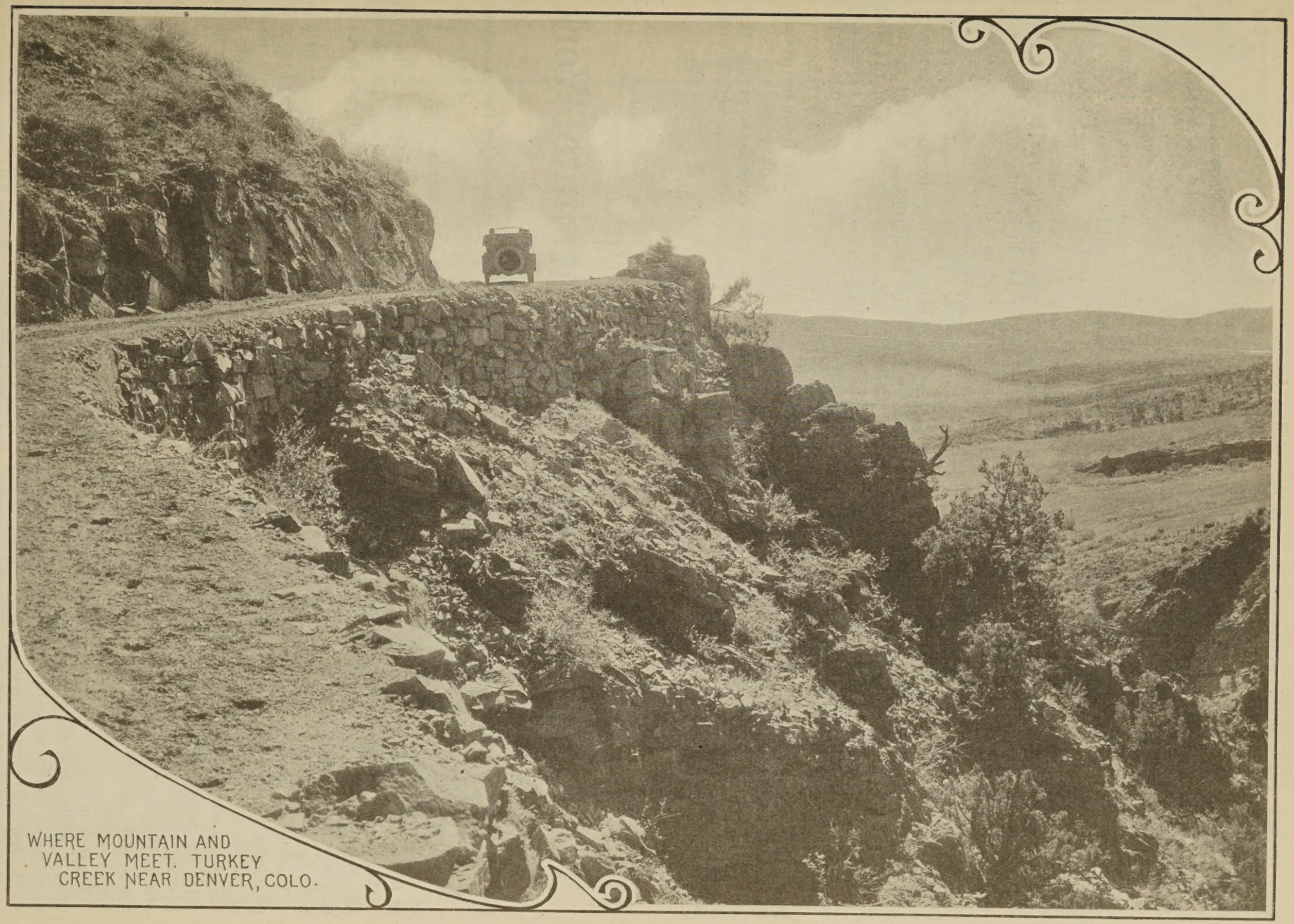
We are particularly fortunate in Colorado, as we have much natural road building material, comparatively inexpensive, by the combination of which we can build the best of dirt roads. Our climate is such that maintenance costs are moderate, and, like most of the other States, our problem is one that rests chiefly upon the education of the public to the vital, economic need of good roads with a resultant increase in road appropriations which will enable us to cope with the tremendous increase in traffic which has made of many of our mountain roads veritable business thoroughfares, carrying all manner of vehicles day and night, winter and summer.

Machinery Keeps the Kansas Roads, Built of Local Material, in Good Shape

By W. S. GEARHART, State Highway Engineer.

THE gravel and macadam roads in Kansas have all been built of local material, and now that all of the available teams are needed for farm operations, the counties are making extensive use of motor trucks and trailers for hauling metal for the maintenance of these highways. The macadam is loaded from bins and the gravel with loaders. The material is spread by the trucks as it is dumped and afterward shaped with a grader and a spike-toothed harrow. By thoroughly harrowing the loose metal all of the cores are removed and the particles key together and take their natural position in the road surface. Harrowing saves at least one-third of the rolling otherwise required.

The power used for blade grader work on the earth roads is almost exclusively gas or steam engines or motor trucks. There are in the State between 6,000 and 7,000 privately owned large traction engines, and until the threshing season



WHERE MOUNTAIN AND
VALLEY MEET. TURKEY
CREEK NEAR DENVER, COLO.

opens in July, much of this equipment is available for highway work. The engine power is at least 50 per cent more efficient than teams, and on the smooth prairie or rolling country no difficulty is experienced in operating such equipment. Ordinarily two graders are pulled by one engine, and the graders are attached with an offset hitch so as to place the grader next to the engine out in the ditch and the second one just behind it. This keeps the engine on the solid ground and where it will roll and compact the loose earth as it is pushed into the road.

For cleaning the side ditches and smoothing the shoulders the road planer is used extensively. It is necessary to hitch a heavy drag behind the planer to spread the loose earth, which is shoved up into the middle of the road, and level it down to an oval cross section; otherwise the planer leaves the road shaped like a house roof.

Some 15 counties have purchased 5-ton motor trucks to haul road and bridge building materials and to pull their blade graders and planers. The large trucks are proving very satisfactory where they are used extensively for hauling materials, and the pulling of graders and planers is merely incidental or a minor part of the use made of them. When the majority use to be made of a truck is the pulling of graders and planers, it is not very economical, for just as good if not better power in other forms can be had at less cost.

In general, it is found not economical now for the county to own the power if good power can be hired for about $32 per day or $4 per hour.

The earth road dragmen are given from 1 to 5 mile sections of road to maintain, and they are required to drag the road whenever it needs it and to do all necessary ditch cleaning, repairing of bridges and culverts, and other incidental work. Since the dragmen live along the road they maintain, they take great pride in keeping their sections in good condition, and can do this work more economically than anyone else.

The average pay for each round trip with the drag is about 75 cents. These dragmen are generally strong believers in local control of road matters, and this gives them more supervision of the road they use most than they ever have had before and really all the work they can afford to put on the highway. Under these conditions they take very kindly to suggestions and advice from the county engineer, who has direct charge of the work.

The State Highway Commission is urging that the earth roads be maintained to the highest state of perfection during the war.

Maintenance Yards are Established by California to Facilitate Work

By LESTER H. GIBSON, Assistant Highway Engineer.

THE maintenance of the California State highways has become a feature of considerable magnitude. There are now about 1,240 miles of paved highway and 1,060 miles of graded road in the system.

Maintenance yards are a necessity, and the commission has purchased sites from time to time and constructed buildings adapted to caring for the highways in their vicinity.

The largest yards are located in the more thickly populated centers and are used for supply, storage, and distributing points. They are also able to handle automobile and equipment repair on a large scale and to prepare asphaltic products for application on the pavements. Other yards vary in size and are located at junctions of the trunk lines with the laterals, and at convenient places along the highway.

Because of the extensive use of asphaltic oil and light asphalts for the thin surfacing on concrete pavements, nearly all of the principal maintenance yards are well equipped with heating plants where oil is received direct from the tank cars, stored in pits, and then, when needed, heated and pumped into the motor tanks for spraying on the pavement under pressure.

THE FRESNO MAINTENANCE YARD.

A maintenance yard of moderate size is located on the outskirts of the city of Fresno on the so-called Valley Route between San Francisco and Los Angeles.

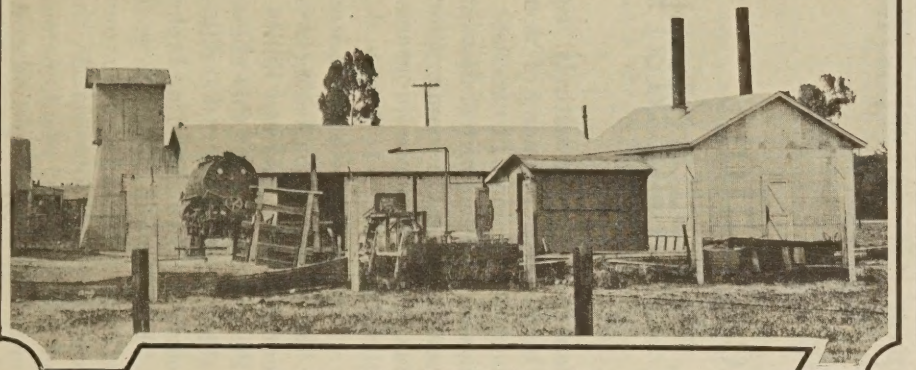
The lot, which is 125 feet square, has street and alley frontage and is surrounded by a high fence of heavy woven wire with reinforced concrete posts, and a spur track from the Southern Pacific main line enters the yard, permitting oil or other materials to be unloaded without rehandling.

The asphalt heating plant is housed in a 27 by 18 foot corrugated iron structure. A horizontal boiler, of Scotch type, with a rating of 25 horsepower is fired by fuel-oil burners. It is possible to obtain 100 pounds pressure in one hour, starting cold.

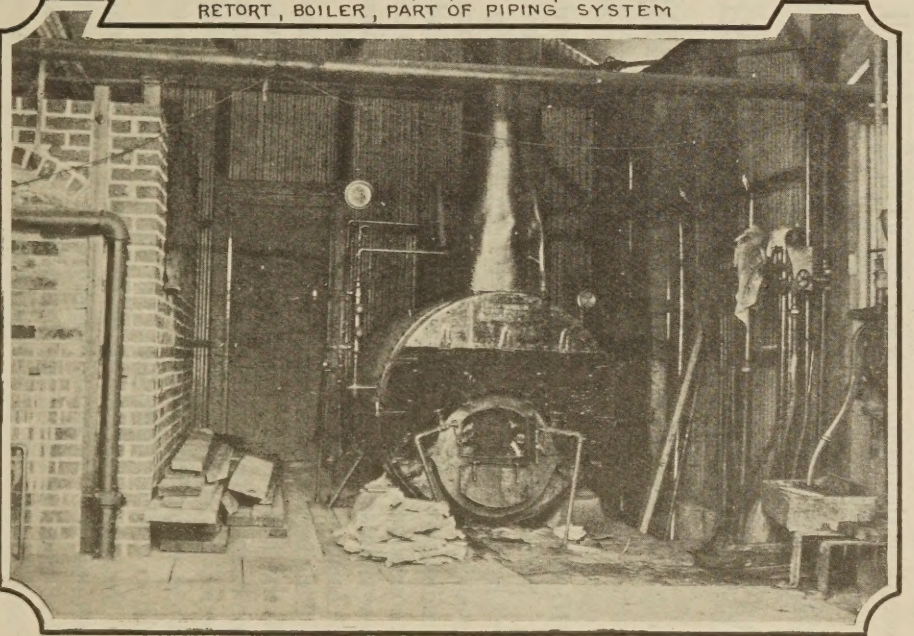
The retort is inclosed in brick, the heating chamber being roofed over with corrugated iron and banked with sand. It contains 14 runs of 3-inch wrought-iron pipe, each run being provided with a spiral 24-inch pitch. A baffle was inserted above

FRESNO MAINTENANCE SHOP

THE BUILDINGS

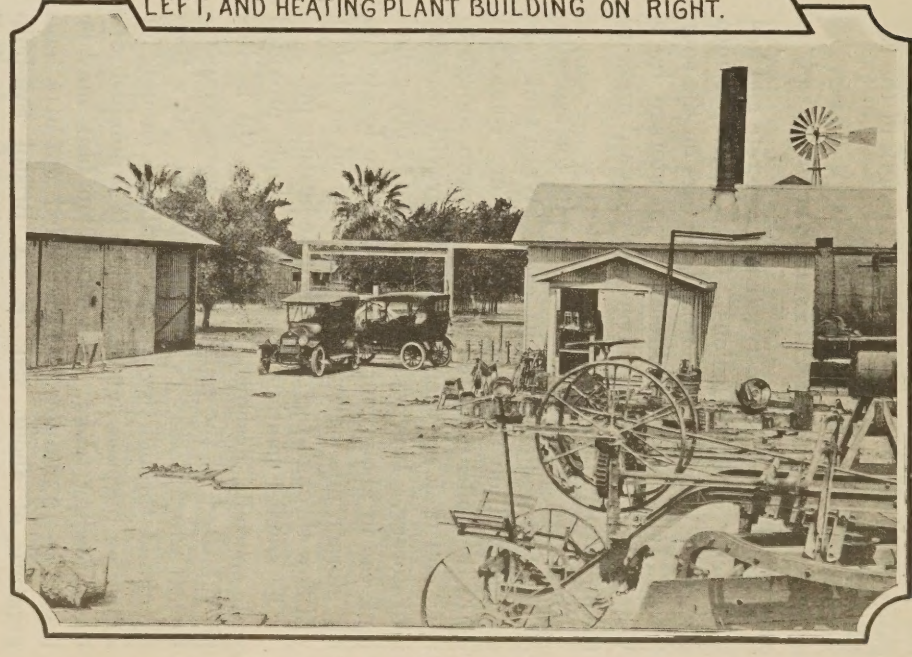


OIL HEATING PLANT
RETORT, BOILER, PART OF PIPING SYSTEM



INTERIOR

LOOKING TOWARD REAR OF YARD, SHOWING SHOP ON LEFT, AND HEATING PLANT BUILDING ON RIGHT.



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A maximum schedule of wages is fixed by law allowing the county or district to pay not more than $6 per day for man and team and $4 per day for a man. This limitation is probably the most serious difficulty to be surmounted. Abnormal conditions now prevailing practically prohibit the employment of competent and efficient help in all but very few sections of the State at the maximum wage allowed, and this results in either a well-meant effort to evade the strict interpretation of the law and get the work done, or an effort to do the most necessary work with inefficient help.

On designated State highways maintenance and improvement work can be performed by and under the State Highway Commission. Fortunately, no restrictions as to wages are placed upon the commission, and much-needed repairs are being, and will continue to be, made on several of the main routes across the State so long as labor is available. Very careful consideration is given to maintenance as well as to projects involving construction by both the highway commission and the various boards of county commissioners, before expenditures are made or labor utilized.

RECORD CROPS TO GO OVER ROADS.

Montana's response to the Nation's call for foodstuffs has been whole hearted and effective. Thousands of her acres formerly providing pasturage for her flocks and herds have been converted into fields of grain. A careful survey of the crop situation for the present year results in the prophesy that never in the history of the State have such enormous quantities of grains and other farm products been hauled over the roads as will of necessity be hauled this year. For this reason the efforts of all highway officials have been energetically turned toward the maintenance, improvement, and construction of those roads which will best serve in the marketing of food supplies. But little encouragement will be given in the promotion of sight-seeing and tourist roads. Realizing the heavy duty to which the market roads will be subjected, particular efforts will be made to so maintain them that they will be in the best possible condition to serve to advantage.

After the 1st of August all the available labor in the State will be required in the harvest fields to properly care for the millions of bushels of grain, thus necessitating that road work be practically completed by that time.

Montana will first help win the war by providing food for the armies and by maintaining those roads essential to the delivery of such food and food products. It will be time then to provide the roads for the pleasure seeker.

New Hampshire Uses Old Methods and Resorts to Local Materials

By JOHN W. CHILDS, Office Engineer.

CONDITIONS of maintenance in the State of New Hampshire are very unusual this year, causing greater problems to be faced than have ever been met since the advent of extensive automobile traffic.

The principal difficulty thus far encountered this season has been the lack of materials, rather than the scarcity of labor. To relieve the conditions resulting from the lack of road oils this department has resorted to methods used before binders came into extensive use in this State. By applying a light coat of surfacing gravel and sand, with constant care on the part of the various patrolmen in keeping the material on the road by dragging, we hope to hold the gravel roads in shape during the coming season.

Whatever oils or tar products we are able to obtain are being used on the main trunk lines where traffic is of such a nature as to prohibit such methods as are sufficient to keep the State-aid roads in shape for local traffic.

In other words, it is hoped that, by the judicious use of what oils are obtainable and by the efficient working of the patrol system, the highways of the State will accommodate the ever-increasing traffic, at least for the present season.

Some local quarries of trap rock are being exploited by the State highway department which are producing stone of a quality equal to or better than that hitherto imported from outside the State. This has relieved the department to a certain extent from the dependence on rail shipments to two Federal-aid projects and some other work.

The labor situation this year is for some unaccountable reason much improved over that of last. No difficulty has been encountered as yet in the employment of common labor, although the price is about 30 per cent higher than during normal times.

The cost of maintenance has not been backward in following the trend of the times and is from 30 to 100 per cent greater than normally. However, it is not expected that the maximum has yet been reached.

An important factor in relation to the present and future condition of the highways in the State of New Hampshire is the ever-increasing traffic. Commercially this is at least 100 and in some places even 200 per cent heavier than ever before. However, the greatest increase seems thus far to be in the tourist traffic from outside the State. This is evidenced by the extremely heavy Sunday traffic, and is noteworthy in that a large percentage of automobiles

includes small cars. It may be that the increased wages in this section are being spent in this way, but whatever be the cause the fact remains that they are here to be accommodated by our highways.

The worst feature of this new traffic is that it seems to be available only for week-end tours, with the principal object in view to cover as much ground as possible, resulting in the abuse rather than the use of the roads. It is expected that an organized traffic census will be in force soon, so that a definite knowledge of conditions will give a comparison with the traffic of normal times.

As to results of the methods in use now in the matter of maintenance, time only will tell. All that can be hoped for is that conditions will at least become no worse than at present.

Illinois Roads in Good Condition Despite Delays and Higher Prices

By H. B. PIEPMEIER, Maintenance Engineer.

ILLINOIS has approximately 95,000 miles of public highways, of which about 12 per cent have been improved with some kind of hard surfacing material. Under the exsiting State aid law, which has been effective since July 1, 1913, there have been constructed approximately 400 miles of hard surfaced roads and about 300 miles of earth roads.

The State has general supervision of the maintenance of all State aid roads. When these roads are built of concrete, brick, or bituminous concrete on a concrete foundation, the entire maintenance cost and the performance of the work are taken care of directly by the State. In the case of gravel and macadam roads the State supervises the work, and the maintenance cost is borne equally by the State and the county. In the case of earth and oiled earth roads the entire maintenance cost is paid by the county. The township highway commissioners are responsible for the maintenance of all roads which have not been improved under the State-aid law.

It is evident that systematic maintenance of all roads is a necessity. The economy of many types depends almost entirely upon the way they are maintained. In view of this condition, the State division of highways is exerting every possible effort to maintain all State roads in a condition of greatest serviceability commensurate with economy, and to influence all township road officials to do the same.

NEW CONSTRUCTION ONLY AS WAR AID.

On account of abnormal conditions, the State department is in no way encouraging construction work unless it is evident that such work will be a direct aid in winning the war. The department is further attempting to impress upon all road officials the necessity and economy of taking special care of all roads that have heretofore been constructed. This year unusual effort is being made to get all earth roads drained and a systematic plan of dragging adopted. On account of the large mileage of earth roads, any scheme which may be inaugurated to secure better drainage and a smooth earth surface will materially aid the people in marketing the farm products of this State.

In an agricultural State such as Illinois it is ordinarily difficult to secure the teams necessary for road construction and maintenance. Frequently the heaviest demand for road maintenance comes at a time when the farmers need all the extra teams and labor. The shortage of teams and labor this year is very noticeable, with the result that the rate of pay in many places is 25 per cent higher than in previous years. These labor conditions have caused delays and consequently extra work. As a result, maintenance cost has been increased from 15 to 25 per cent.

With one or two exceptions the mileage of improved roads in any one locality is so limited as to prohibit the use of a permanent maintenance gang. State maintenance work, therefore, is more or less at the mercy of labor that must be secured at the various points where the State aid roads are located. The maintenance of State roads is therefore necessarily high in cost and difficult in execution.

HARD TO DO WORK ECONOMICALLY.

In the 102 counties of Illinois there have been constructed to date about 300 distinctive sections of hard-surfaced roads, aggregating in length about 400 miles. The average length of each section is about 1½ miles, the longest section being about 8 miles. It is readily seen that where roads are isolated in this way it is difficult to do all work economically.

Practically all field maintenance work on State-aid roads is handled by regular maintenance foremen, who are supplied with a light truck of 1 ton capacity or less. The light truck enables the foreman to carry all the necessary equipment and an assistant or helper. With the light truck it is possible for one foreman and his helper to do work at two or three different times each season on 50 to 100 miles of hard roads.

A GOOD EARTH ROAD IN NOVEMBER
MAINTAINED BY SURFACE OILING.

MAINTENANCE GANG REPAIRING CONCRETE ROADS.

A MACADAM ROAD DESTROYED AS A
RESULT OF NEGLECTED MAINTENANCE.

A GRAVEL ROAD COMPLETELY DESTROYED
ON ACCOUNT OF POOR DRAINAGE.

ILLINOIS' CHIEF ROAD PROBLEM.

There are very few deposits of road-binding material in Illinois that can be utilized for maintenance work. It is necessary, therefore, to ship practically 90 per cent of all materials needed for repairs. Most shipments comprise small orders and this results in many delays and some additional expense. In a few places local material plants have been developed and a portion of the output utilized for maintenance work.

A large per cent of the State-aid roads in Illinois have been constructed of concrete. This type of road requires annual maintenance in that all cracks and joints must be kept filled with asphalt or tar. This work requires approximately 100 separate shipments of from one to five barrels of bituminous material. Such small orders are necessarily expensive and often cause many delays. This is especially true this year, as less than car-load shipments require apparently from two weeks to ten weeks for delivery.

WILL PUT ALL ROADS IN CONDITION.

During the past few years Illinois has used considerable road oil for earth road maintenance. This year the shortage of petroleum products and the excessive cost of a suitable material has reduced this practice by possibly 80 per cent. It is hoped that this may result in diverting more attention to the use of the road drag.

A comparatively small mileage of macadam and gravel roads has been maintained by surface treatments of asphalt or tar. It is hoped, therefore, that in the case of the few roads which will need surface treatments there will be little trouble in getting sufficient bituminous material.

While many delays and higher prices for all maintenance work have been experienced, most roads have been thus far properly maintained, and barring unforeseen conditions there is every indication that all roads will be kept in good condition during 1918.

Wisconsin Adopts the Patrol System and Obtains Most Gratifying Results

By J. T. DONAGHEY, Maintenance Engineer.

WISCONSIN road laws naturally divide our 77,000 miles of public highways into three classes. Class A embraces those comprising the State trunk highway system of 5,000 miles, which are intercounty roads of State-wide importance, provided for and maintained under the provisions of the State trunk highway law. Class B contains the portion of the county system of prospective State highways commonly known as the State-aid system, lying in each county which is not included in Class A, and consists of about 15,000 miles. Roads in this class are generally intertown roads of county importance only, and portions of such roads previously improved by the county are maintained by the county and the balance maintained by the town in which they lie. Class C comprises the balance of the roads in the State, 57,000 miles, which are generally roads of local importance only and maintained by the unit of government in which they lie.

The total mileage of the three classes is divided under the different types of road approximately as follows:

	Miles.
Concrete, brick, and other high types of surfacing	250
Stone and gravel macadam	2,300
Pit run gravel	9,500
Shale	600
Sand and clay	1,600
Earth	62,750

$1,500,000 FOR CLASS A MAINTENANCE.

Class A roads in each county are maintained under the provisions of the State trunk highway law, according to the directions and specifications of the State highway commission, and the cost is paid out of funds derived from the automobile license fees. The amount available for maintenance of Class A roads in Wisconsin for 1918 is approximately $1,500,000.

The State highway commission has installed a patrol system of maintenance covering the entire State trunk highway system, dividing the trunk highways lying in each county into sections from 6 to 10 miles each, employing a patrolman, who furnishes team and wagon, on a monthly basis for the entire maintenance season. The patrolman has immediate charge of the maintenance of his section under the direct supervision of the county highway commissioner. His equipment consists of a light road grader, road drag, road planer, plow, slip scraper, and the necessary small tools. He has authority to employ extra help when necessary in order to keep his section in first-class condition at all times.

Heavy grading work, resurfacing, or surface treatments of stone and gravel roads is done by a county maintenance gang.

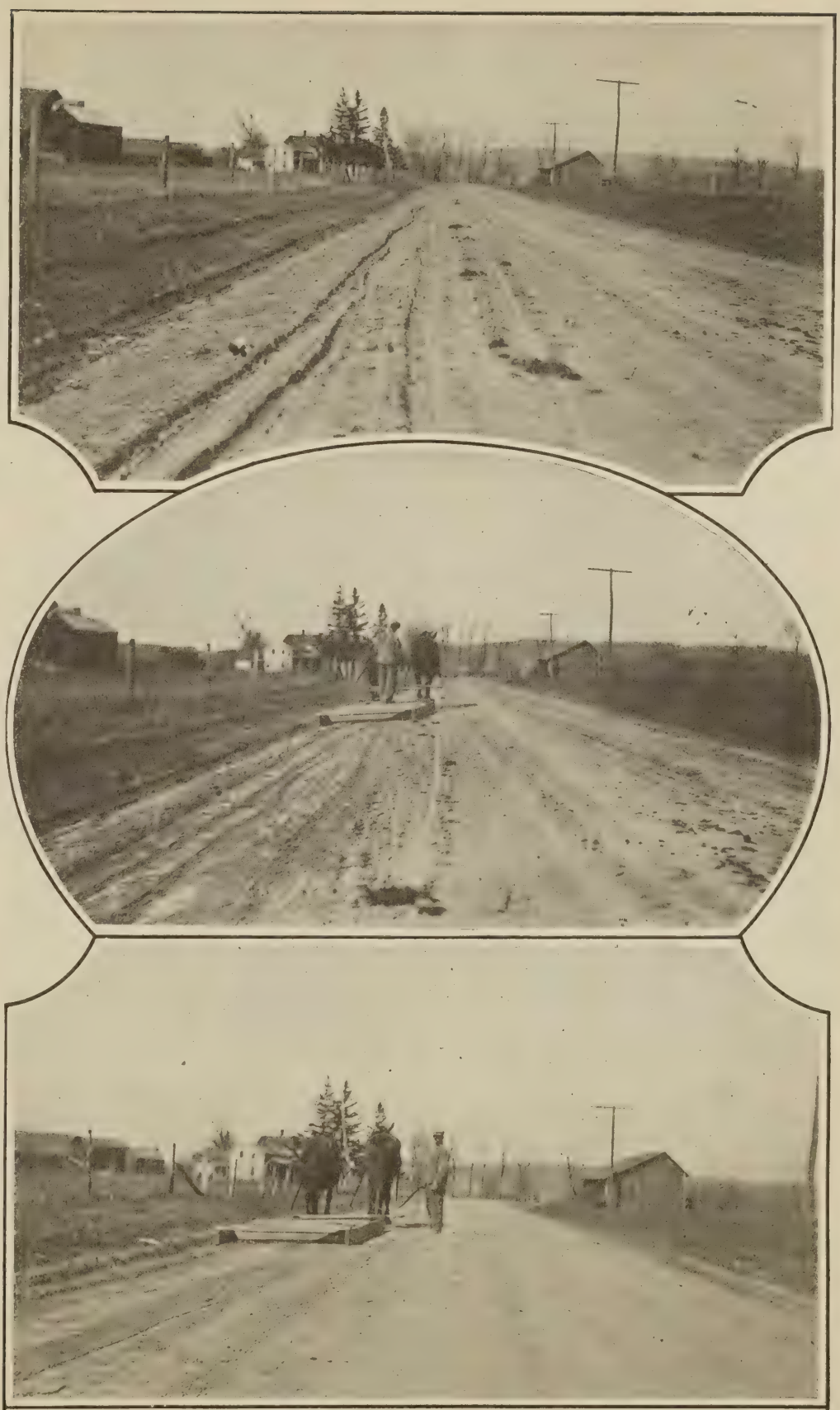
On surfaced sections the material for maintaining the surface is delivered to the roadside by motor

trucks furnished by the county, and in some instances hauled by teams during the winter months where winter hauling is practical. The majority of our counties, however, are now using motor trucks for this purpose.

GREAT IMPROVEMENT IN CONDITION.

The entire 5,000-mile system was taken over May 1 and patrolmen placed on each section, and a month later the change in the condition of the system was wonderful. From the reports received from our organization, as well as from the general public, we are led to believe that the actual condition of the roads on the State trunk highway system then was 100 per cent better than at the same period in previous years.

Class B roads (where construction has been done by the county in the past) are maintained by the county out of funds also derived from the automobile license fees, together with certain funds appropriated by the several counties. Several of the counties have adopted the same plans for maintenance of the Class B roads as is used on the State trunk system and have divided Class B roads into



SECTION OF WISCONSIN STATE TRUNK HIGHWAY WEST OF BARABOO. HEAVY CLAY SOIL, RATHER POORLY DRAINED, AND CARRIES RATHER HEAVY TRAFFIC FOR AN EARTH ROAD. TOP VIEW TAKEN AT 9 A.M. FOLLOWING HEAVY RAIN. PATROLMAN HAD MADE A TRIP ONE WAY ON THE CENTER OF THE ROAD WITH A ROAD PLANER. IN CENTER – 15 MINUTES LATER, FOLLOWING PATROLMAN'S RETURN TRIP. BOTTOM – AN HOUR LATER AFTER PATROLMAN HAD COMPLETED SECOND ROUND TRIP WITH PLANER.

patrol sections, doing practically the same class of work that is being done on the State trunk system. Portions of the Class B roads that require resurfacing or surface treatment are handled by the county gangs organized for this purpose. For the maintenance of this class of road we have available approximately $600,000. Many of the Class B roads are really as important and carry as heavy traffic as those of Class A, require practically the same form of maintenance, and are handled by the county in practically the same manner.

Class C roads are maintained entirely by the local town board under the direct supervision of local road superintendents. Some of the superintendents do excellent work, while a great many of them have but few constructive ideas. A few towns have adopted the plan of dragging the Class C roads when necessary, but, taken as a whole, the money expended for their maintenance is not well spent because of the fact that no central organization has direct control over them.

DEPEND LARGELY ON LOCAL MATERIAL.

For the maintenance of the Class A and Class B roads we are using local materials almost entirely. In the majority of counties in which there are surfaced roads there are good local gravel pits or stone quarries which are being used to good advantage. In many instances we are hauling material by motor truck or by teams during the winter months a distance of from 3 to 10 miles at a very reasonable cost. On our stone and garvel macadam roads we are aiming to maintain all such that can be maintained without a surface treatment due to the high price of oils and tars and the uncertainty of getting them when required. Fine crushed stone containing the dust and fine clay gravel used properly maintains the poorer macadam roads very cheaply.

We are not handicapped to any great extent for labor on maintenance work. The construction program in the State is considerably reduced due to war conditions and the different counties are transferring their construction organizations into the maintenance work. Although the price is somewhat higher than in previous years, by the use of modern machinery it is possible to keep the maintenance cost down to probably 20 or 25 per cent over that of past years.

Motor traffic on our mail lines of travel is increasing rapidly, making them more difficult to maintain, but by the introduction of the patrol system of maintenance we find it possible to maintain reasonably heavy traffic on earth or gravel roads at a cost not to exceed $200 per mile per year.

Pennsylvania Planned Long Ahead to Meet Labor and Material Needs

By GEORGE H. BILES, Maintenance Engineer.

WITH a road system such as Pennsylvania has of over 10,000 miles of various types, as shown in the table below, innumerable problems have to be solved continually to approach anything near a satisfactory degree of efficiency under the existing abnormal conditions brought about by the war:

	Miles.
Earth	6,693.575
Gravel	232.940
Flint	103.460
W. B. macadam	2,387.872
Bituminous macadam	144.470
Asphaltic concrete	118.756
Concrete	36.079
Brick	271.639
Toll	213.035
Stone block	3.112
Bridges	7.345
Total	10,212.283

The fundamentals in our State at the present time, of course, are labor and materials. Pennsylvania, being an industrial State and the workshop of the whole country in its present crisis, has called to this field the bulk of the man power. In addition, all transportation facilities are about taxed to their utmost in the handling of the sinews of war. This condition calls for the application of heroic measures and expedients to keep in repair the main arteries of travel, which to-day are being subjected to unprecedented traffic by all classes of vehicular transportation.

PLANNED WORK LONG IN ADVANCE.

Having compiled statistics of our resources and geological deposits during the course of several years of our maintanance opearions, it was possible to plan this work long in advance of the actual working season. The greatest asset, we believe, to a highway organization, and more especially in an era such as we are passing through at the present time, is system. Without the statistical data, Pennsylvania, under present conditions and considering the scope and character of the work, would be in a chaotic state. In localities where extensive repairs were scheduled and material was accessible, quarrying operations were carried on through the winter months and the material crushed and hauled along the road ready for use when the proper time arrived.

This arrangement had a twofold purpose; first, it provided the necessary material, and, second, it permitted the use of the same force of employes who were transferred to the road site to carry out the

work on the proposed project, thus offering more steady employment to the workmen and making the work more attractive to the local class of labor.

START WORK EARLY IN SPRING.

Depending, as the State highway department does, mostly on labor in the rural sections, the work on the large unimproved mileage is started early in the spring as soon as weather conditions permit and an effort is made to accomplish as much as possible before many of the workmen are called to imperative agricultural work. Crews of experienced roadmen are organized and are transported in motor vehicles to districts where conditions are adverse, and in this way the work, in general, can be taken up at the proper time and carried out more uniformly.

EXAMPLES OF PENNSYLVANIA MAINTENANCE. TOP-SURFACE TREATED WATER BOUND MACADAM. BOTTOM→EARTH.

A very large proportion of the work depends entirely upon the transportation of material over the railroads, and the department has been working through all State and governmental agencies for assistance in this respect. It, however, is not by any means only a question of transportation, for the sources of supply have become limited and those operating have their output contracted to such an extent in Government orders that it is difficult to get shipments except in cases of extreme emergency.

STONE ROADS GREATEST PROBLEM.

The maintenance of the many miles of stone road in the State system is the paramount problem in our work to-day. In sections where it is impossible to obtain shipments of road materials, the best materials and combinations that can be gotten locally are being used as temporary expedients. The stone road, under present conditions, requires surface treatment to withstand the ravages of the ever-increasing and changing traffic. On stone roads, which are not representative samples of first-class macadam construction, such as the old turnpikes and also light traffic or secondary roads, light dust allaying preparations are used which require little more effort than the actual application of the material with the motor pressure distributor.

The first-class hot and cold treatments which are used only on roads in good condition, call for the force of road cleaners and men to cover the surface with stone chips, small gravel or sand, fast enough to take care of the capacity of the pressure distributor. The crews employed in this work are taken from place to place, following the one distributor through the entire district, when possible.

SLAG CHIPS FOR COVERING MATERIAL.

The bituminous treatment schedule has been so classified that several products were specified, thereby distributing the whole schedule among several companies, and thus obtaining the advantage of having the application made simultaneously and insuring an early completion, which will not only make it possible to complete the work in time for the period of heaviest travel, but will release men for other work.

Covering materials have been the cause of very great concern, and to overcome this, in a measure, hard, clean slag chips which were a by-product during the winter months at the slag plants that were working on Government contracts were contracted for and delivered at the time. This arrangement has proven of great advantage, and in certain districts the work is progressing up to the schedule time.

In certain localities small portable crushing plants are being used to manufacture stone chips, and considerable quantities of acceptable gravel and coarse sands are being used. Unloading plants, motor trucks, small tractors, and mechanical devices are being used wherever practicable to conserve men and teams.

ECONOMIC PHASE IMPORTANT.

Where work of such magnitude must be prosecuted at all hazards under present conditions, the economic phase of the question is one of great importance on account of the fact that the resources or appropriations for the work do not increase proportionately with the abnormal increase in the cost. As an example, labor and material have advanced more than 100 per cent, while the available funds probably will not amount to 30 per cent more than last year. In addition, the general repair work will be more extensive, due to the increased use of the roads. It is anticipated that delays will be experienced due to the unusual conditions, but in due season it is confidently expected that the roads will be put in good travelable conditions.

Pennsylvania has been and will continue to cooperate to the limit of its resources with the National Government in the maintenance of the highways, particularly those used in this great war crisis for military purposes.

Portable Machine and Auto Truck Reduce the Difficulties in Michigan

By L. H. NEILSEN, Maintenance Engineer.

WITH about 6,000 miles of State-aid roads, a large part of which have a gravel surface, to consider, the problem of maintenance in Michigan is looming up in large proportions.

Recent legislation has put the responsibility for the condition of State aided roads squarely up to the State highway department by giving full authority to it to do the work necessary to place any deteriorated road in good condition and charge the cost up to the township through the auditor general. The municipalities must arrange also for a maintenance system that is satisfactory to the department before further State reward can be paid on new work. At the beginning of this year a division of maintenance was organized and maintenance work will be followed more closely than ever.

A considerable number of counties have organized extensive patrol systems for the maintenance of earth and gravel roads. Due to varying local conditions these systems are quite different in detail, but the essential feature of continuous maintenance is preserved in all of them.

In many cases one man provided with a wheelbarrow and the necessary small tools takes care of a section of road. He calls out local men with teams to float the roads whenever, in his judgment, that is necessary. Materials for patching are stocked at short intervals.

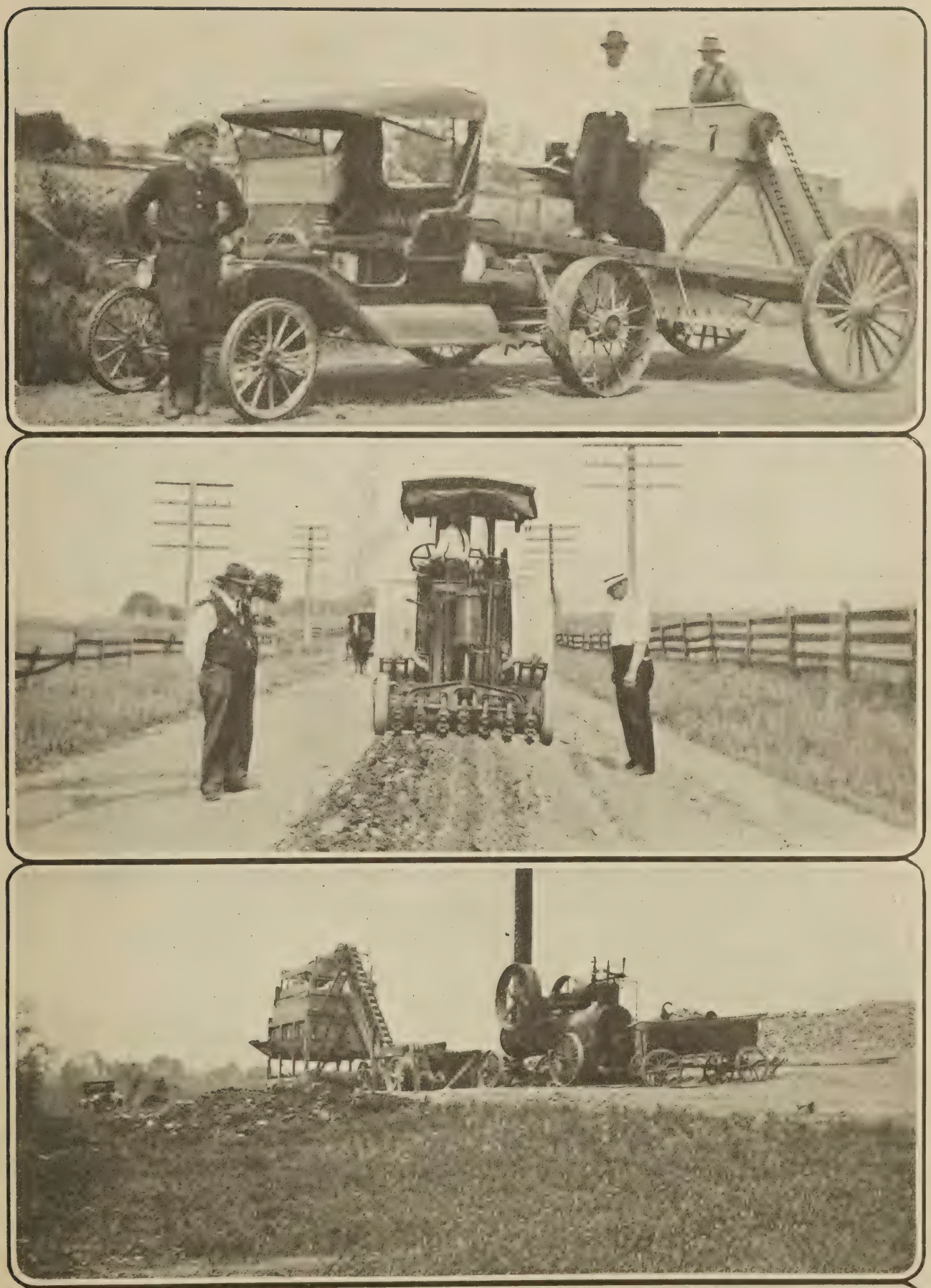
PUT BURDEN ON PATROLMEN.

Several localities have placed a man, single horse, and one-horse wagon on the roads. In such cases a light road float is furnished, the patrol man doing the necessary floating. Stock piles can be placed farther apart, but it would still be necessary to provide for the placing of repair material by independent gangs.

Several counties are using patrolmen with teams and wagons. They also do their own floating and in many cases haul their own repair material from the pits.

Gangs have been used for doing maintenance work on earth and gravel roads, but are not looked upon with favor, since their use tends to increase the interval between successive trips over the road. On hard surfaced roads and pavements, however, their use on shoulder and ditch work has been very satisfactory.

Where only isolated pieces of road occur, the employment of farmers who give as much time as may be necessary to the road seems to be the only practical method. This method is, however, open to the



MECHANICAL AIDS IN PENNSYLVANIA MAINTENANCE

TOP—MECHANICAL STONE CHIP SPREADER WITH IMPROVISED MOTIVE POWER. CENTER—ROAD ROLLER WITH SCARIFIER ATTACHMENT. BOTTOM—ENGINE, CRUSHER, AND BIN FOR CRUSHING FIELD STONE.

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objection that it is extremely difficult to get the work done at the proper time.

The success of any of the above methods depends upon the amount of supervision given.

TRIP A DAY OVER EACH ROAD.

On some of the heavier traveled gravel roads we have found that continuous floating with a road float gives very good results. In these cases a trip is made over each road every day regardless of weather conditions. It is necessary to add gravel in such amounts as will insure that there is always a thin layer of loose material present on the road surface. This gravel should not contain pebbles larger than one-half to three-fourths inch and should contain a sand or loam filler.

On limestone macadam roads patrols are also used to some extent. The usual practice is to give a bituminous surface treatment consisting of a cold application of from $\frac{1}{4}$ to $\frac{1}{3}$ gallon per square yard. This is followed in the first instance by another treatment of $\frac{1}{4}$ to $\frac{1}{5}$ gallon per square yard of the same material applied as soon as the first one is dry. The second application is covered with a pea gravel from $\frac{1}{8}$ to $\frac{5}{8}$ inch in size or washed limestone chips from $\frac{1}{4}$ to $\frac{3}{4}$ inch and then rolled with a power roller. The following year the road is patched and another light treatment placed. These applications are continued as often as required.

As soon as sufficient mileage has been put under surface treatment to warrant the expense, a light truck with two men is placed in commission. This unit patrols the surface-treated roads at intervals, patching the bituminous surface with the proper material. Either heated material is used in combination with pea gravel or clean limestone ships, or a premixed combination of sand, stone, and cold bituminous material is carried in the truck to fill the holes.

FIND ECONOMY IN LOCAL MATERIAL.

Bituminous surface treatments have also been used with success on crushed cobblestone macadam.

We have also used 2 to 3 inches of a loam filler gravel for resurfacing macadam roads, the maximum size of pebbles ranging from $\frac{1}{2}$ to $\frac{3}{4}$ inch. The road is then patched in the same manner as the gravel-surfaced roads. This is very economical and local materials can be used.

On crushed-gravel roads bituminous surface treatment has been satisfactory to some extent, although a large amount of patching is required and a wavy surface usually results.

The use of portable crushers and screens and gravel screens alone has in many cases enabled us to secure materials for maintenance in spite of car shortage. Motor trucks and in some cases tractors and trailers have replaced team hauling to a great extent.

Our reports on maintenance will not be available for some time, and it is hard to tell at this time how the condition of roads will compare with last year, as a great many of the organizations are new and are not yet operating at normal efficiency.

Washington's Work is Well in Hand; Roads are Reported in Good Condition

By GEORGE F. COTTERILL, Chief Engineer.

WASHINGTON State highways are under joint maintenance responsibility prescribed by law, combining State regulation and enforcement of standards with direct county administration.

The State highway board has defined the standards and established a uniform system for cost-keeping and reports, which control the maintenance and repair of the primary State highways constructed in 30 counties, and with a 1917 total of 1,243.77 miles. For 1918 this will increase to about 1,442 miles.

This joint maintenance system is set forth in detail in the Washington State Highway Department Bulletin No. 10, containing the "Rules, Regulations, and Requirements for the Maintenance of Primary Highways as prescribed by the State Highway Board." It is based upon four fundamental features, viz:

1. A series of county maintenance funds, apportioned by law from certain State funds (mainly motor-vehicle license revenue), assuring each county at least $100 per mile annually for its permanently improved primary highway mileage. (N. B.—1918 county totals in all cases exceed $200 per mile). These funds are available only for maintenance and repair, with necessary equipment, upon (*a*) the constructed primary State highways, and (*b*) other main county highways improved to a standard legally defined as "permanent highway" construction. The mileage in the latter class somewhat exceeds that in the first, making a total of about 3,000 miles of permanent highway construction on primary State and main county highways. If the county maintenance fund for any reason proves insufficient for primary highway maintenance, two

other county credits are obligated to provide any deficit. Maintenance has prior claims on three funds.

ADVANCE ANNUAL ESTIMATES.

2. Advance annual estimates, prepared by county engineers in direct charge of maintenance, covering all expected maintenance, requirements, compiled separately for each section of continuous, similar construction and surfaced type of highway (short bridges and other structures included in their respective sections). These estimates are required on uniform State forms, with segregation of maintenance and repair costs under defined item headings. Estimates are first submitted to county boards of commissioners for review, with right to modify, followed by approval and appropriation of totals, which become an advisory budget for the respective county engineers. Certified copies of all sectional annual estimates are transmitted to the State highway commissioner, who has final review and right to modify as necessary in his judgment for adequate maintenance provision.

3. Monthly reports of actual expenditures, prepared by the 20th of the following month, by responsible county engineers in direct maintenance charge, certified both to county commissioners and to State highway commissioner for State records. These monthly reports are on uniform series of forms provided by State highway department, with segregation of items, division of highway sections, etc., corresponding to the annual estimates. The column arrangement of these monthly reports carries forward each month a simple system of budget bookkeeping charged against the approved annual estimate and appropriation.

4. Reserve enforcement power of the State highway board by which, in event any primary State highway section is not maintained in accordance with prescribed standards, the State highway commissioner may cause direct maintenance work to be done until such standards are reached. This action can be taken only after 15 days' notice to responsible county authority, and continued delinquency. Payment for such direct State work is a prior claim upon the county maintenance fund, and if necessary upon the the two other county reserve maintenance credits.

From June to December, 1917, the 30 county engineers reported expenditures totaling $210,829 upon 1,244 miles of primary State highway, or an average of $169.50 per mile for seven months' maintenance, repairs, and general upkeep of these main-traffic highways of the State. In the various counties the average maintenance charge ranged from $14.29 up to $498.91 per mile. These great variances arise from unusual repairs, incidental improvements charged as maintenance, equipment purchases, and supervision charges, as well as from varying traffic wear and construction types.

With this seven months' experience of 1917 requirements, the 30 county maintenance administrations estimated and appropriated in January, 1918, a total of $480,000 for the full calendar year of 1918, or an average of $333 per mile for the 1,442 miles of primary State highways covered by the estimates. In these 1918 budgets the various county averages range from $137.58 up to $1,372.84 per mile as an estimate of their maintenance requirements. The reports thus far at hand cover actual expenditures for the first four months of 1918, showing a total slightly exceeding $160,000 or almost exactly one-third of the total annual budget for the first third of the year.

COMPARATIVE MAINTENANCE COSTS.

An interesting series of comparative maintenance costs for the various highway construction types is available from the 1917 record. The figures for a single (and fractional) year, qualified by many special and local considerations, are only circumstances upon which it would be unsafe to base any convincing conclusions. The 1918 figures will add greatly to comparison values, but it will require at least four years to produce statistics and averages which will fairly present comparative maintenance costs. At present these figures must be applied with special analysis of the detail reports for local sections.

PRIMARY STATE HIGHWAYS.

Expenditures for maintenance and repair, June to December, inclusive, 1917.

Type of highway.	Mileage maintained.	Expenditure.	Average per mile.	Sections reported.	Number of counties.	Remarks.
Brick pavement	8.81	$9,456.51	$1,073.38	3	1	Including extensive replacements.
Concrete pavement	90.59	5,092.45	56.21	20	10	1 to 4 years' use.
Asphalt pavement	5.97	326.03	54.61	3	2	Do.
Asphaltic concrete	19.74	319.76	16.19	5	2	Mostly first-year nominal maintenance.
Bitulithic, including Warrenite.	14.41	2,978.50	206.70	3	3	1 to 7 years' use.
Bituminous macadam	40.21	5,493.49	136.62	12	6	2 to 8 years' use.
Macadam, also crushed rock surfacing.	135.74	24,282.44	178.89	34	12	1 to 10 years' use.
Gravel surfacing	816.56	144,362.87	176.79	94	25	Do.
Natural earth grade	109.74	11,043.37	100.63	12	4	
Bridge and trestle, decking and repairs.	2.00	7,474.47	3,737.23	4	3	Mainly new decking, Skagit River bridge.
All types	1,243.77	210,829.89	169.50	190	30	

Highway maintenance is well in hand for 1918, with ample provision despite fully 50 per cent increased costs of the war period. Scarcity of labor is apparent and becoming more acute. Car service occasions little difficulty, as local materials are available for most maintenance needs. All reports indicate our State highways in good condition and well maintained. Traffic requirements are constantly increasing, and these main roads are proving their usefulness with each added mile of permanent improvement.

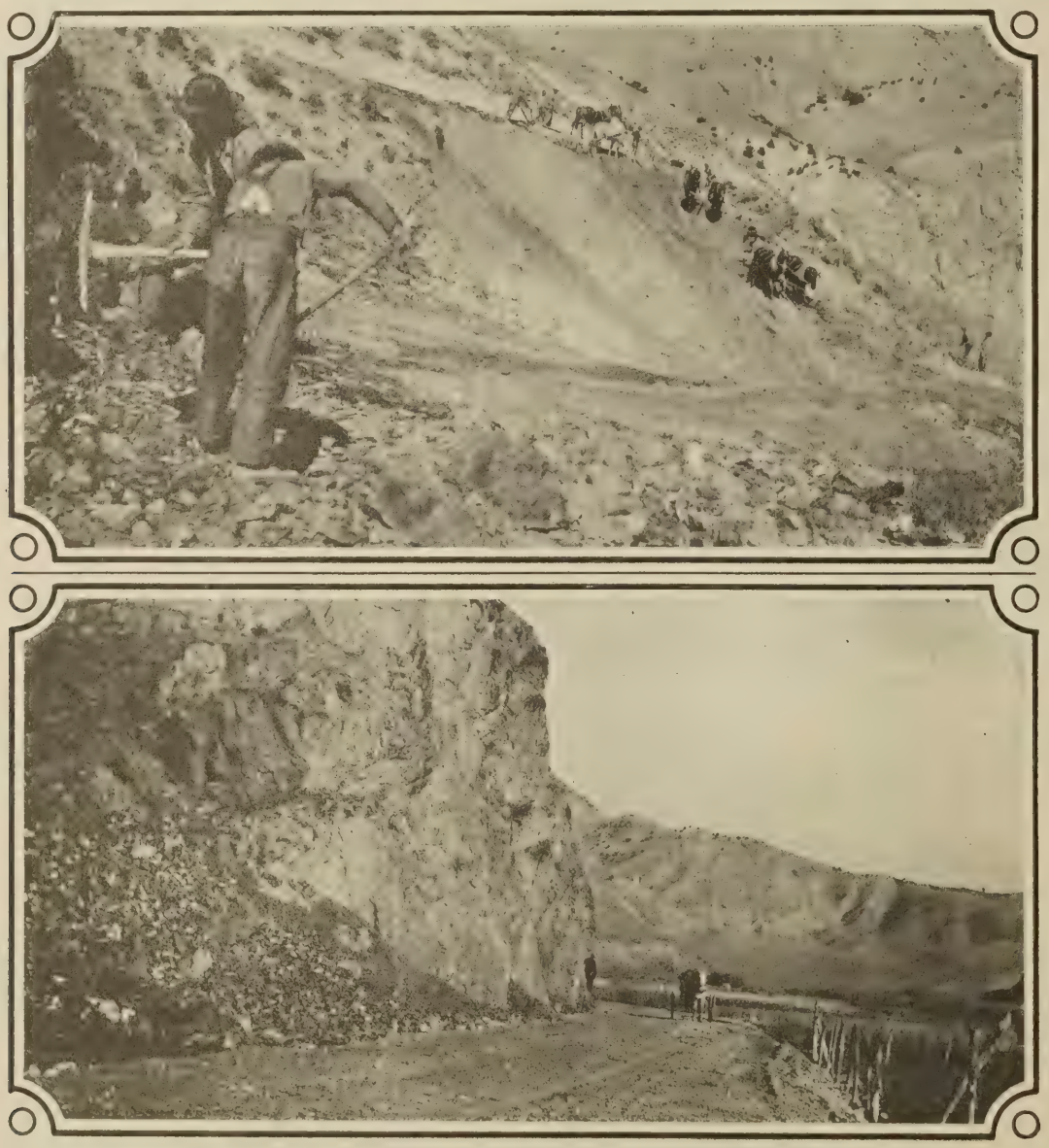
Power Operated Machinery Saves Both Time and Money on the Roads of Utah

By IRA R. BROWNING, State Road Engineer.

JUST as the national needs for feeding and equipping our armies and our allies have stimulated production of foodstuffs, forage, and all materials that are military and industrial necessities, so the imperative need for increased transportation facilities has stimulated road construction, improvement, and maintenance.

The argument that increased production is ineffective unless adequate means for transportation are furnished, can not be satisfactorily answered except by good roads connecting the producing areas with shipping points and market centers.

The scarcity of labor for road construction and maintenance has been an important factor, not only in limiting the road work to the absolutely essential highways, but also in providing mechanical equipment and power operated road machinery to a more marked extent than ever before. While the initial cost of this equipment is a considerable item of expense in connection with the State road work in Utah, the results achieved and the reduced cost of construction and maintenance, have already demonstrated the advantage of power-operated road-building equipment as compared with construction involving horse-drawn implements.



MACYSVALE—SEVIER ROAD, PIUTE COUNTY, UTAH.
TOP—SCRAPING ROCKY LOAM FROM HILL SIDE TO MAKE FILL IN SWAMP AROUND OBSIDIAN CLIFF.
BOTTOM—VIEW OF COMPLETED ROAD AROUND OBSIDIAN CLIFF.

WHAT MACHINERY ACCOMPLISHES.

A typical case was the grading of a road in Utah County, using a heavy grader drawn by a tractor. The total cost was less than $30 per mile; while with horse-drawn plows, scrapers, and graders the expense would have been at least $150 per mile for the same road.

The use of the road scarifier drawn by either a truck or a tractor, for reducing the irregularities on a gravel or macadm road, and providing a bond for new surfacing material, affords another illustration. The steady pull on the drawbar of a tractor or large truck, together with the uniform speed and the perfect control, render the operation of scarifying roads with power-drawn equipment twice as efficient or at one-half the cost of the same work with horse-drawn implements.

The use of the steam shovel on heavy cuts and side-hill construction, especially in view of the advanced wages for men and teams, has solved a very serious problem in road construction. With the operation of two or three shifts per day the steam shovel can save its original cost in actual reduction of unit cost of excavation in the course of a few months.

The use of portable compressors and jack-hammer drills has done much toward reducing the time and labor for cutting out defective areas and patching and maintaining hard surfaced roads; also for the removal of intrusive points of ledge rock and the bowlders encountered during excavation.

PATROL SYSTEM FOR MAIN ROADS.

The maintenance of earth and shale or gravel surface roads is becoming more of a problem as the traffic and intensity of loading increases. The labor of repairing and maintaining these highways is therefore sure to increase. It has been demonstrated in Utah that the greatest saving and improvement is effected by establishing a patrol system for the main roads. If a foreman residing along the road has a 10-mile section extending each side of his home, and he is authorized and encouraged to plan ahead for the requirements of his road section, he will have piles of material suitable for repairing ruts and maintaining the road surface in good condition at convenient points along the road. He will so plan his work that the grading, crowning, dragging, and draining of the roads will be attended to at the proper time, even though this may be outside of the ordinary working hours.

Allowing a road section foreman the initiative and placing upon him the responsibility of maintaining his road in commendable condition for traffic has proved, where the foreman had ambition and capacity, the most economical and effective system yet devised and tested in this State.

The present plans of the State road commission include a power unit, such as a tractor or heavy truck, for each county; also the extension of the road patrol system to cover all of the principal State roads.

New Jersey Has Millions to Keep Up Roads But Finds the Task Difficult

By W. G. THOMPSON, State Highway Engineer.

SITUATED as it is between two great manufacturing and shipping centers, and having an enormous internal vehicular traffic of its own, New Jersey's road maintenace problem is becoming increasingly difficult to handle to the satisfaction of all concerned. The unusual requirements of crushed stone, sand, cement, and bituminous products by the Federal Government for its war work, and by contractors on buildings, etc., directly or indirectly required for war purposes, has placed all such materials at a premium, while the great increase in the use of the highways has made greater than ever the need for better pavements and for the maintenance and repair of those we now have.

The combination of continuous heavy trucking and heaving due to frost expansion during the past winter ruined thousands of square yards of pavement and foundation. This required in many cases that long stretches of the subfoundation be removed and the holes filled with field or crushed stone before replacing the pavement or surfacing; also the replacing of many longitudinal and cross drains which had become clogged through freezing and thus contributed to the heaving of the foundation.

POOR DRAINAGE CAUSE OF FAILURE.

Most of the serious failures of our pavements were due to inadequate drainage of the foundation, which lack is being remedied as rapidly as possible.

Maintenance of macadam pavement presents the most serious problem, and although these are being replaced rapidly by more durable surfaces, there are hundreds of miles to be repaired each year. The method found most satisfactory is to give the surface a light coat of tar, after which there is spread upon it sufficient sand to take up the tar, thus forming a carpet coat which presents an agreeable riding surface and prevents the macadam top from raveling. On roads having a considerable motor traffic, this treatment must be given every year. The annual cost of maintenance of such

pavements certainly emphasizes the economic wisdom of laying durable asphaltic or concrete pavements as rapidly as possible.

Many of our counties have a regularly organized patrol system, where one or two men constantly patrol a definite section of road, and have a team or light motor truck to transport the material used. Piles of half-inch stone and barrels of tar or emulsified asphalt are placed at convenient intervals along the road, and as holes or ravelings develop, stone and bitumen sufficient to fill the holes flush with the pavement surface are mixed upon a mixing board. This system is economical and satisfactory, inasmuch as it provides a smooth surface for vehicles at all times, as opposed to the old method, still in vogue in many localities, of allowing the pavement to become full of potholes before making repairs.

GRAVEL ROADS A CONSTANT CARE.

Where it is impracticable to secure for repairs the material of which any bituminous pavement is composed, temporary and satisfactory repairs are made by filling the holes with hand-mixed stone and emulsified asphalt, which if well tamped will, after it has set, maintain a good surface for months under heavy traffic.

As the southern and coastal sections of New Jersey have many seashore resorts, maintenance of the hundreds of miles of gravel roads leading to them imposes a heavy burden upon the communities involved, especially during the summer months; and constant scraping is required. This work is started immediately the frost leaves the ground in the spring and is religiously carried on after every rain. From April until freezing weather in the fall no smoother, easier surface for automobiles can be found than these gravel roads. The use of a lignin binder on several of the more heavily traveled gravel roads has, to a considerable extent, prevented raveling and wearing away of the surface and kept it intact during the winter. This is usually applied in two coats by a pressure distributor early in the summer.

Embargoes on freight shipments, the recent and proposed future increases in freight rates, together with Government requirements of stone, gravel, cement, sand, and the bituminous materials, have increased prices and made deliveries so uncertain that many communities have been unable to secure bids on extensive repairs. The establishment within this State of numerous cantonments, hospitals, loading plants, and other Government activities requiring employment of thousands of men has so reduced the supply of common labor, and the abnormal increase in wages incident to this demand has in many localities resulted in almost prohibitive costs of road maintenance; in fact, many localities are unable to secure labor or teams at any price.

$4,600,000 FOR ROADS.

The inevitable result will be rapid deterioration of pavements under the constant and rapidly increasing traffic, although the counties and townships are making every effort to meet the demand. The State has allotted $1,600,000 as aid to the counties for repairs and maintenance, to which should be added approximately $3,000,000 raised by the counties for the same purpose.

The recent decision to allow preference to shipments by rail of road materials after the necessary tonnage for coal, coke, and ore is supplied will greatly assist highway maintenance. This decision evidences the general realization of the importance of the highways as aids to commercial transportation. The State authorities hope the Federal Government will find it unnecessary to seriously curtail the use of asphaltic and tar binders, as the only effective means of preventing the destruction of hundreds of miles of macadam roads is the annual or biannual application of tar or asphaltic oil, which with sand or screenings added makes a very satisfactory carpet coat.

FEEDERS ALL IMPORTANT.

The highways must be kept in condition at any cost, and but little highway work can in these days be classed as unessential. The main routes between large cities are generally considered most important, but the feeders to these, including country roads, carry farm products to city markets, and are all important. Produce from the farms of New Jersey is carried from 30 to 75 miles by motor truck to such large cities as Philadelphia, Newark, and New York. Therefore to fail to keep the farming country roads in good condition is to invite a curtailment of production and delivery of foodstuffs.

It therefore behooves all highway officials to work in and out of season for the extension of the existing system with first-class durable pavement, and for the proper maintenance of the maximum mileage that finances and material supply will permit; and to urge a closer cooperation with the Federal Government to the end that its highways transport shall be aided and expedited to the fullest possible extent.

This will mean that in addition to keeping the pavement in good condition during summer and winter, the several States and communities provide as liberally as possible for snow removal during the winter. This is not an unmixed blessing, as the removal of snow and consequent possible distribution of traffic over the entire pavement will minimize the deterioration resulting from confining traffic to one wheel track, which is inevitable where the entire pavement width is not clear of snow.

Soil Conditions Make the Situation in Nevada Unusually Difficult to Meet

By C. C. COTTRELL, State Highway Engineer

THE small amount of money available and the hundreds of miles of roads in Nevada do not permit elaborate maintenance methods and the ones now used must appear to those unfamiliar with pioneer conditions to be very crude.

A wrong impression would be conveyed if it were that the roads of Nevada are bad; on the other hand they are good, and viewed with respect to the natural soil, climatic conditions, sparseness of settlement and lack of road finances, they are excellent.

Generally speaking, the construction of roads in Nevada has in the past consisted merely of clearing the sagebrush, and until the last few years little attention was given to them, as their condition served the local interests passably well. With the coming of the motor vehicle, however, and its peculiar adaptation to the long hauls of Nevada, a feeling has swept the State that something must be done to improve the roads, and any public official who neglects to work in that direction is exceedingly unpopular.

The maintenance of all the roads in Nevada is at the present time in the hands of the various boards of county commissioners, and while the statutes provide different methods of doing the work in the several counties, in actual practice it is most often handled directly by, or under the immediate directions of, the county commissioners.

AT TOP—NATURAL SOIL ROAD IN NEVADA, WHICH BECAUSE OF THE EXCELLENT GRAVELLY SOIL IN WHICH IT IS LOCATED REQUIRES BUT LITTLE MAINTENANCE. AT BOTTOM—ROAD ACROSS LOW ALKALI FLAT WHICH BECAUSE OF THE SILTY SOIL IN WHICH IT IS LOCATED AND THE LONG DRY SUMMER RAPIDLY CUTS UP UNDER TRAFFIC. THIS ROAD HAS BEEN RELOCATED IN BETTER MATERIAL.

DRAG COMING INTO WIDER USE.

The big problem is to maintain a hard and smooth surface during the long, dry summer months and to prevent the roads from becoming muddy in the winter. The road grader, while not the best implement to use, is the device most often employed. In the early spring, while the soil is still damp, material is brought toward the center to crown the roadbed and fill up the ruts and chuck holes; very often twice over each side of the road is considered sufficient for that purpose. The drag, with its lower operating cost and its puddling effect, is just now beginning to be appreciated and used.

There are many miles of road which, because of the light traffic and the excellent gravelly nature of the material in which they are located, require little if any attention. On the other hand, there are some sections of road across low, highly alkaline flats which, because of the very silty soil in which they are located, never can be satisfactorily maintained. The only feasible improvements are either to relocate the road in better material or to surface it with gravel or crushed rock; the relocation is by far the more preferable. The small precipitation during the winter months serves to smoothen and harden the roadway in these flats. The summer traffic, however, soon cuts the surface, forming ruts and chucks, and the constant churning of the

wheels turns it into a sea of fine, white-powdered alkali dust, coating everything and everybody in sight. New roads are being constructed rapidly to avoid these flats.

Loose sand is found in but comparatively short stretches and is handled either by corduroying the road with sagebrush, straw, or manure which, while effective, is but a temporary expedient, by relocating the road entirely, or by placing a clay material on top of the sand, forming a top-soil road. Suitable material for a top soil, however, is very scarce over the entire State.

BADGERS UNDERMINE WHEEL TRACK.

In some portions of the State badgers, which are very numerous, burrow holes in the wheel track of the road. It is the general opinion that this location is selected by the badger in order to secure a firm walled burrow. Under traffic these holes rapidly develop into large chucks which in the dry summer can be repaired only by filling them with gravel or shale shoveled from a wagon. To drag or grade the road at that season of the year would ruin it.

Systematic and more intelligent methods of construction and maintenance are being rapidly adopted by the various counties, and each year witnesses a big improvement in road conditions over those of the previous year.

Local organizations, such as good-roads clubs and automobile clubs, have done much to further the good-road movement and have been the means of getting large numbers of volunteer workers out on the roads on specified "good-road" days.

It requires some time and a big effort to bring roads which barely served local interests with their slow-moving horse-drawn vehicles to the condition of effectively serving the whole country with its heavily laden trucks and swift-moving automobiles, but the people of Nevada are keen to accomplish that result as soon as possible and they are doing it.

Connecticut Turns to Labor-Saving Devices and Substitute Material

By C. J. BENNETT, Highway Commissioner.

CONNECTICUT, like other States, is faced at the present time with the necessity of maintaining its roads under extremely adverse conditions. On the one hand, we have a concentrated truck and motor vehicle traffic unparalleled in the history of highway maintenance in this or any other country. On the other hand, we see a shortage of labor and the difficulty of securing materials for maintenance purposes.

It is therefore imperative for us to find a means to meet these difficulties, or our roads will deteriorate beyond hope of repair. In other words, in order to keep our work at the same standard of excellence which has been maintained heretofore, we are obliged to use methods and machinery hitherto unemployed.

The first requisite to meet this situation is additional attention on the part of the supervising agents; second, the utilization of machinery and labor-saving devices to a greater extent than in the past; and third, the securing of substitutes for material formerly used but not at present available, meaning, in case three, that local available materials must be used even though less adapted to requirements.

In a broad way, an attempt has been made first to increase the effort of the supervising agents by an appeal to their patriotism by a suggestion of necessity of work at high pressure to maintain a standard of excellence which has always been a matter of pride, and also to increase wages so as to make it more attractive for the men than in the past.

In connection with labor saving by the use of machinery, the motor truck has been utilized to a great extent in delivering material, spreading sand, gravel, and oil, and transporting gangs of men from one point to another at high speed. Advantage has been taken of mechanical loaders for gravel and sand, doing away with hand shoveling so far as is possible. Mechanical spreaders for sand and gravel to cover oil or other bituminous material have been utilized where possible. In fact, wherever it is feasible to substitute any machine, in such a manner as to save labor, it has been done even at a money loss. The department has also purchased a great amount of equipment so that local material can be quickly utilized. Such equipment consists of stone crushers, gravel screens, and machinery of a like nature.

As a result of this effort we hope, with considerable optimism, that the highways in this State will be kept to a standard equal to that heretofore set.

Idaho Economizes Effectively Through the Use of Motor Trucks

By H. C. ALLEN, State Highway Engineer.

THE maintenance work done on the Idaho State highways during the past 12 months has been rather difficult, and some of it ineffective, largely on account of the dry season in 1917 and the beginning of 1918. The light volcanic ash soil prevailing in the southern portions of the State pulverizes readily under traffic, and no amount of labor will produce a firm road surface in its dry condition.

During the latter part of last season two auto sprinkling trucks of 1,000-gallon-tank capacity were put to work in the Twin Falls and Pocatello districts on unsurfaced roads. Many places were practically impassable from deep dust and chuck holes. The application of water soon began to bring them to a firmer condition, and doubltess was the means of saving the roads in that section from very serious impairment.

The first work of the present season consisted largely of reshaping with engine graders, the ordinary three-way drag being used to considerable extent on both dirt and gravel surfaced roads after rains. The urgent demand for teams on agricultural work has caused some roads to be unduly neglected and quite a good deal of dragging has been done with trucks. This method is proving economical and effective.

Last year's experience with auto sprinkling, with a light-drag attachment, demonstrated the economy and effectiveness of that form of maintenance. The sprinklers are again being put into service while the road surface is yet in good shape and it is confidently expected that it will be so maintained.

A considerable portion of Idaho highways are of such natural material that once being put in good shape in the spring, they will stand up well for the summer under ordinary traffic. The correct shaping of road sections in the fall to permit them to go into the winter properly is accomplished with drags and some grader work. All of which work it is our purpose to do largely by mechanical means.

With the increase of auto-truck traffic our problems are increasing and the large one now to be met is to provide funds from the sources responsible for the rapid deterioration of road surfaces. The primary object of auto tax should be to maintain already constructed roads. In Idaho, 75 per cent of such tax goes to the counties, and the remaining 25 per cent to the State highway department. Almost one-fourth of the State's share is used for auto number plates, registration and a certain interest fund, leaving only about one dollar in five of the original tax collected to be spent on trunk road maintenance. The auto tax moneys in the hands of the counties is put into road and bridge funds and spent at the discretion of the county commissioners, usually in an ill-advised and ineffective manner.

A better distribution of existing revenues and more effective application to road maintenance will be of great benefit to the State. Legislation in that direction will be promoted at the next session of the legislature, in 1919.

STATE HIGHWAY MANAGEMENT, CONTROL AND PROCEDURE.

A bulletin has just been completed in the Bureau of Public Roads dealing with the organization, powers, and duties of State highway departments; classification, control, and procedure in the construction and maintenance of roads to which the States contribute the whole or a portion of the cost; the origin of State road funds and the purposes to which those funds are applied.

It has been decided to publish the bulletin as a serial in "Public Roads," beginning with the August number. It contains a chapter for each State, in which the following subjects are treated: Development and results of State participation and control of road work; organization, powers, and duties of highway departments, including personnel of State and local forces; classification of roads to which the State contributes a portion or the whole cost, including the methods of selection of such roads, powers of State highway departments in granting aid, procedure in making surveys, letting contracts, and the control exercised by State and local authorities in superintending construction and maintenance; sources of State road funds, purposes to which those funds are applied, basis of allotment and apportionment of such funds, and amounts applied to the various purposes for the latest fiscal or calendar year.

Each State chapter will be accompanied by a chart showing the organization, personnel, and lines of responsibility of the State and local road officials, and the relations existing between them.

The State chapters have been summarized and analyzed and the results will appear in the form of tables, charts, and text so arranged as to enable the reader to obtain a comprehensive knowledge of the whole study without having to refer to the various State chapters except for details. This part of the bulletin deals with the history and present trend of State aid and State highway control; the organization of highway departments and the control exercised by those departments; the classification and control of State and State aid roads; and the sources, control, and disposition of State road funds.

The bulletin was prepared by M. O. Eldridge, assistant in road economics; G. C. Clark, and A. L. Luedke, engineer economists.

$280,000,000 PUT INTO HIGHWAYS AND BRIDGES BY STATES IN 1917

Prepared in the MANAGEMENT BRANCH, BUREAU OF PUBLIC ROADS, by ANDREW P. ANDERSON, Highway Engineer.

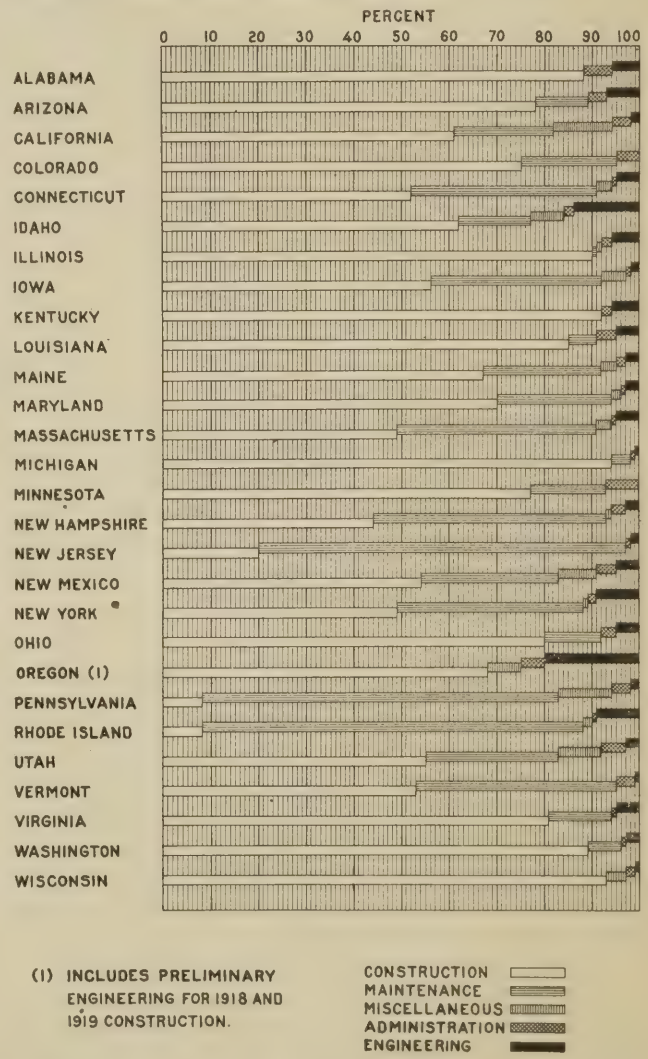
CASH expenditures on rural roads and bridges in the United States in 1917 amounted to $279,915,332. To this should be added the value of statute and convict labor, which can not be fixed to any great degree of accuracy but probably amount to not less than $15,000,000, thus making the grand total expenditure for the year $295,000,000. This total is made up of the actual expenditure of such items as labor, materials, supervision, and administration directly connected with the construction, improvement, and upkeep of our public roads and bridges, and does not include interest on bonds and other outstanding obligations.

This, however, does not represent the total outlay by the States and communities because of their rural public roads. At the present time there are outstanding more than $400,000,000 in road and bridge bonds and long-term warrants maturing at the rate of about $20,000,000 per year and requiring about an equal amount annually for the payment of interest charges.

The full extent of this bond burden, however, is impossible of any exact determination. For a number of years past road and bridge bonds have been issued at the rate of about $40,000,000 pre annum, and while there is apparently a slight decrease in the amount issued or sold during 1917, there seems to have been no decided decrease in the amount of such bonds voted or authorized. Moreover, the bonds actually designated for road and bridge purposes do not represent the full extent of the burden. General bonds are issued in many cases to cover actual or threatened deficits occasioned wholly or in part by road and bridge expenditures. Furthermore, outstanding road and bridge bonds or warrants are often taken up by general refunding bonds and their identity as pertaining to road work thus entirely lost. Such data as available, however, serve to call attention to the abuses to which the bond method of financing often is subjected. To issue bonds for the financing of road improvements frequently is both advisable and necessary. But this does not justify much of the present-day practice. Millions of dollars' worth of road bonds having a term of 30 years or more are still issued every year for the payment of improvements which can not possibly last one-half of the term of the bonds and in many cases will actually not last one-third of the time.

MOVEMENT TO LIMIT BOND-TERM GAINS.

The movement to limit the term of road bonds so as to make the term fall within the life of the improvement seems to be gaining ground gradually. However, only a few States have as yet embodied these requirements in definite workable legislation. Perhaps the best examples of such legislation are found in New Jersey and Wisconsin.



In New Jersey the attempt is made to limit the time in accordance with the class of construction while in Wisconsin the same effort is made on the basis that the State highway construction is naturally of a higher character than the requirements for town roads and will therefore have a longer life.

New Jersey (ch. 240, Laws 1917) provides that the term of bonds for constructing or reconstructing the

pavement of roads, streets, or highways, or widening such pavements shall not exceed the probable period of the usefulness of such improvement and in any case the term shall not exceed the following:

If constructed of sand and gravel, 5 years; if constructed of water-bound macadam or bituminous macadam by the penetration method, 10 years; if constructed of bituminous concrete, 15 years; if constructed of blocks of any material or sheet asphalt laid on a concrete foundation, 20 years; if constructed of concrete not less than 6 inches thick, 20 years; if for the acquisition of land for roads, streets, or highways, 30 years.

Wisconsin (chs. 174, 465, and 500, Laws 1917) provides that for town and county bonds to defray the cost of town and county road improvements the bonds shall not have a term in excess of 10 years, while the term of county bonds for the improvement of roads on the State-trunk line system shall not exceed 20 years.

TABLE I.—EXPENDITURES DURING THE YEAR 1917 BY OR UNDER THE SUPERVISION OF THE STATE HIGHWAY DEPARTMENTS.

State.	Funds.			Distribution of expenditures.[a]						State funds available 1918 (approximate).	Local road and bridge expenditures 1917, not under State highway department (approximate).
				Construction.		Maintenance, roads and bridges.	Engineering.	Administration.	Equipment and miscellaneous.		
	State.	Local.	Total.	Roads.	Bridges.						
Alabama	$89,511	$79,511	$169,021.78	$131,530	$17,643		$9,849	$10,000		$154,000	$2,500,000
Arizona	543,422		543,422.44	289,353	136,856	$57,288	40,500	19,426		1,000,000	1,026,000
Arkansas	80,262	1,545,000	1,625,262.17	1,345,000	200,000		80,262	(1)		300,000	1,710,000
California	3,058,030	128,170	3,186,200.00	1,918,740	(2)	687,100	79,000	129,870	[3] $371,490	2,500,000	[4] 15,059,000
Colorado	703,000	767,000	1,470,000.00	862,000	[5] 270,000	270,000		68,000		900,000	1,100,000
Connecticut	2,197,264	330,962	2,528,225.49	[6] 1,029,410	271,260	994,402	145,058	22,778	65,317	3,600,000	1,476,000
Delaware [7]	21,600		21,600.00			1,286	9,029	5,775	5,510	200,000	300,000
Florida	23,797		23,797.39				12,036	7,207	4,554	200,000	6,361,000
Georgia	1,910	16,440	18,350.00	9,500	[5] 500		7,450	900		10,000	4,300,000
Idaho	473,132	369,591	842,723.00	391,676	134,219	126,806	115,732	19,157	55,133	600,000	1,250,000
Illinois	1,258,338	1,810,390	3,068,728.42	2,735,935	46,683	40,503	166,075	60,000	19,534	2,000,000	7,015,000
Indiana	14,000		14,000.43	2,539			2,360	6,904	2,197	1,050,000	14,000,000
Iowa	89,787	15,535,619	15,625,406.22	2,506,241	[5] 6,223,637	5,685,781	[8] 370,144	89,787	749,817	700,000	.....
Kansas [7]	10,000		10,000.00				(9)	10,000		25,000	6,000,000
Kentucky	1,501,650	1,422,000	2,923,651.00	2,844,002	(2)		46,049	23,600	10,000	950,000	2,000,000
Louisiana	182,295	358,681	540,976.02	430,708	35,984	9,841	42,107	20,060	2,276	200,000	3,000,000
Maine	1,112,675	632,308	1,744,982.04	1,019,755	150,973	438,676	53,693	37,734	44,154	1,000,000	1,500,000
Maryland	2,804,707	278,975	3,083,681.94	1,857,549	387,065	730,652	80,110	26,313	1,993	3,000,000	3,000,000
Massachusetts	4,231,802	601,000	4,832,802.00	2,261,354	78,195	2,090,000	281,891	57,339	114,023	4,000,000	4,662,000
Michigan	1,704,359	3,968,794	5,673,153.00	5,125,224	187,751	247,178	62,000	43,000	8,000	2,000,000	5,517,000
Minnesota	1,429,865	2,722,895	4,152,759.54	2,290,541	[11] 922,346	672,039	267,834	(10)		1,600,000	3,872,000
Mississippi	6,500		6,500.00				(9)	6,500		6,500	3,250,000
Missouri [7]	367,913	7,021	374,933.38	190,645		148,068	7,735	12,038	16,447	1,250,000	7,000,000
Montana [1]	25,729	239,140	264,869.34	15,500	223,640		19,671	6,058		150,000	3,092,000
Nebraska [7]	[12] 9,500	93,900	103,400.00		94,000	4,200	5,200	(12)		450,000	4,500,000
Nevada [7]	36,796		36,795.85				16,766	20,030		300,000	300,000
New Hampshire	589,254	449,451	1,038,704.78	448,002		505,014	26,608	27,634	31,448	650,000	1,200,000
New Jersey	1,501,902	2,778,995	4,280,897.40	758,049	56,023	3,302,333	85,834	59,271	19,388	5,500,000	2,000,000
New Mexico	280,578	265,289	545,867.40	233,526	60,000	159,800	28,419	20,912	43,210	350,000	300,000
New York	9,432,679	2,282,452	[13] 11,715,130.65	5,635,027		4,537,709	1,108,622	273,874	159,899	14,000,000	[14] 9,970,000
North Carolina [10]	20,000		20,000.00				(9)	20,000		300,000	5,500,000
North Dakota [1]	28,638	1,341	29,979.26	[15] 1,676			23,260	5,043		250,000	2,838,000
Ohio	2,835,649	2,181,456	5,017,104.49	3,171,895	288,117	1,145,886	239,576	116,669	54,961	4,000,000	7,000,000
Oklahoma	286,922	2,888,433	3,175,355.25	374,653	1,486,525	705,136	147,684	12,715	448,642	1,750,000	547,000
Oregon	711,000		711,000.28	475,418	9,172		143,639	34,131	48,641	1,500,000	5,000,000
Pennsylvania	4,351,566	111,768	4,463,333.19	251,959	80,445	3,347,906	75,318	206,121	[16] 501,584	6,000,000	7,000,000
Rhode Island	486,725		486,724.84		40,262	387,116	43,054	5,000	11,293	750,000	375,000
South Carolina [7]	27,161		27,160.75				8,500	3,500	15,161	25,000	1,250,000
South Dakota [17]	5,000		5,000.00				(9)	5,000		100,000	2,750,000
Tennessee	231,500	50,000	281,500.00			250,000	9,800	21,700		1,100,000	2,200,000
Texas [17]	10,000		10,000.00				7,000	3,000		600,000	10,000,000
Utah	120,200	822,929	943,129.44	471,553	48,393	264,538	33,428	44,043	81,175	750,000	950,000
Vermont	578,883	376,606	955,489.01	466,881	45,114	402,010	2,472	39,013		600,000	725,000
Virginia	695,171	1,641,608	2,336,778.74	1,754,243	144,102	298,868	109,165	20,896	9,505	1,400,000	1,800,000
Washington	2,031,392	92,299	2,123,690.53	1,896,821	(2)	[18] 138,596	61,883	26,391		3,500,000	4,992,000
West Virginia [17]		2,700,000	2,700,000.00	2,400,000	300,000					350,000	5,500,000
Wisconsin	1,050,888	3,335,666	4,386,554.00	3,650,560	431,206		61,919	77,869	[19] 165,000	2,430,000	5,500,000
Wyoming [7]	37,845	2,846	40,690.65	673	5,992		24,052	9,444	529	70,000	549,000
Total and average	47,290,796	50,888,536	98,179,332.11	49,248,138	[20] 12,376,103	27,648,732	[20] 4,110,784	[20] 1,734,702	3,060,881	74,120,500	181,736,000

[1] Included under engineering.
[2] Included under roads.
[3] Consists largely of engineering for future construction.
[4] Does not include San Francisco County.
[5] Includes culverts.
[6] Includes $80,085.34 for elimination of dangerous conditions on trunk line highways.
[7] State Highway Department organized during year.
[8] By counties.
[9] Included under administration.
[10] Estimated; exact data not obtainable.
[11] Includes 415 culverts.
[12] Remainder not segregated from expenditures of irrigation department.
[13] State and county highways only.
[14] Town highways and bridges, includes $2,664,000 of State funds.
[15] Does not include $58,945.43 of local funds expended under supervision of State engineer's office.
[16] Includes $256,188 for the purchase of turnpikes and about $150,000 for operating the expenses of offices and traveling expenses.
[17] Complete data not available.
[18] To June 15, 1917, only.
[19] County supervision.
[20] Partial totals.

The expenditures on our city, town, and village streets are not included in these compilations, as no complete records are available as to their amounts. However, from the available data the expenditures on account of our streets are estimated to amount in

round numbers to $300,000,000 annually. With the present tremendous development of motor-truck and automobile traffic the city, town, and village streets have become an integral part of our road system and a vital factor in the efficient operation of almost any general system of motor hauling and especially those

and bridge expenditures was about 10 per cent over and above those of each previous year. During the years 1916 and 1917, however, this increase was reduced to about 2 and 3 per cent, respectively. This, however, does not signify any general decline in road work. On the other hand, the reverse is true. The

TABLE II.—ROAD MILEAGE.

State.	Work done in 1917 under State supervision.			Total all State and State-aid roads built to Jan. 1, 1918.	Mileage of rural public roads.		
	State and State-aid roads built	Roads maintained with State aid, 1917.	Number of bridges built by State or State aid, 1917.		Total all surfaced roads in State (approximate).	Total all public rural roads in State.	Percentage of surfaced roads in State.
	Miles.	*Miles.*					
Alabama	[1] 67		3	726	6,050	55,446	10.9
Arizona	[2] 50	270	8	422	425	12,075	3.5
Arkansas	225		10	759	1,725	50,743	3.4
California	313	2,213	17	2,220	12,800	61,039	20.9
Colorado	[3] 1,120	4,000	[4] 145	[5] 8,425	2,500	39,780	6.3
Connecticut	59	1,457	8	[6] 1,686	3,160	14,061	22.4
Delaware		19		160	300	3,674	8.2
Florida					3,800	17,995	21.1
Georgia	[7] 7		2	7	13,200	80,669	16.4
Idaho	[7] 75	451	76	488	825	24,396	3.4
Illinois	[8] 470	449	88	1,237	12,750	95,647	13.3
Indiana					31,000	73,347	42.5
Iowa	[9] 1,332	109,000	[10] 45,000	1,338	1,400	104,074	1.3
Kansas					1,500	111,052	1.3
Kentucky	[24] 698			2,000	13,900	57,916	24.0
Louisiana	83	500		837	2,700	24,563	11.0
Maine	170	3,750	[12] 19	1,968	3,420	23,537	14.5
Maryland	96	1,189	6	1,400	3,000	16,459	18.2
Massachusetts	[13] 158	1,559	24	2,094	9,050	18,681	47.5
Michigan	1,053	3,940	24	4,993	10,600	74,190	14.3
Minnesota	[14] 1,984	11,439	[15] 749	11,995	6,900	93,517	7.4
Mississippi					2,700	45,779	5.9
Missouri	28	11,361		[16]	7,500	96,041	7.8
Montana	29		38	59	850	39,204	2.2
Nebraska			6		1,400	80,272	1.8
Nevada					340	12,182	2.8
New Hampshire	[17] 82	1,388		1,362	1,975	14,020	14.1
New Jersey	66	2,500	4	2,120	6,050	14,817	41.0
New Mexico	75	2,200	21	921	600	11,873	5.0
New York	410	6,639	[18] 679	7,175	18,400	79,398	23.2
North Carolina					6,850	50,758	13.5
North Dakota	7			7	1,150	68,796	1.7
Ohio	289	2,053	850	1,650	31,800	86,354	36.8
Oklahoma	[19] 794	2,153	[10] 1,904	2,694	500	107,916	.5
Oregon [11]	75			488	4,950	36,819	13.4
Pennsylvania	[20] 10	8,844	83	2,000	10,600	91,576	11.6
Rhode Island		325	7	325	750	2,170	34.5
South Carolina					3,800	42,226	9.0
South Dakota					800	96,306	.8
Tennessee		3,200		150	8,875	46,050	19.2
Texas					12,100	128,960	9.4
Utah	[21] 200	3,000	40	3,640	1,550	8,810	17.5
Vermont	116	4,339	64	2,127	2,220	14,249	15.7
Virginia	[22] 523	2,153	47	4,986	5,900	53,388	11.0
Washington	324			2,301	6,225	42,428	14.7
West Virginia	[16]	[16]			1,600	32,024	5.0
Wisconsin	[23] 1,000		231	6,070	15,250	77,280	19.8
Wyoming	7		8	7	550	14,797	3.8
Total and average	11,996	181,391	50,161	80,933	296,290	2,457,334	12.0

[1] Includes 25 miles of earth roads.
[2] Includes 16 miles of earth roads.
[3] Includes 1,000 miles of earth roads.
[4] Also 1,300 culverts.
[5] Includes about 6,500 miles of earth roads.
[6] Includes about 200 miles of reconstruction.
[7] All earth roads.
[8] Includes 174 miles of earth roads.
[9] Includes 921 miles of earth roads.
[10] Includes culverts.
[11] Estimated, exact data not obtainable.
[12] 11 not completed.
[13] Includes 6 miles of earth roads.
[14] Includes 1,570 miles of earth roads.
[15] Includes 415 culverts.
[16] No data.
[17] Includes 13 miles of earth roads.
[18] Town bridges.
[19] Includes 549 miles of earth roads.
[20] Also 199 miles resurfaced.
[21] Includes 150 miles of earth roads.
[22] Also 129 miles of reconstruction. Includes 90 miles of earth roads.
[23] Includes 527 miles of earth roads.
[24] Includes 132 miles of earth roads.

involving the delivery of country produce. It is, therefore, hoped that more definite data in regard to the extent, cost, and conditions of our streets may soon be available.

EFFECT OF PRESENT CONDITIONS ON WORK.

Present abnormal conditions are having a decided effect on road and bridge work. From 1904 to 1916 the average annual increase in the total rural road expenditures by or under the control or supervision of the several State highway departments have steadily continued to increase. Thus, while the total amount of funds expended by or under the supervision of the State highway departments in 1917 exceeded those of 1916 by more than 30 per cent, the total expenditure of strictly local funds by the local communities during the same period decreased 10 per cent.

The amount of State funds devoted to road and bridge work continue to show a large annual increase. In 1904 eleven State highway departments expended a total of $2,550,000 for road and bridge work, and in 1914 thirty-one State highway departments expended $24,221,000, while in 1917 every State in the Union made some contribution to this work which amounted to a grand total of $47,291,000 of State funds as distinguished from local funds. Furthermore, the utilization of convict labor in road work or the preparation of road materials under competent State supervision is coming the several State highway departments directed the expenditure of $16,343,000 for maintenance. In 1916 this had increased to $18,453,000, while in 1917 it had grown to $27,648,732. This increase is in part due to the heavier traffic and the rising prices of labor and materials, but more largely to the growing tendency to centralize the control of all our important highway work under competent State control or supervision.

On the other hand, the ever-increasing demands on our roads by the present-day traffic are compelling more substantial improvements as well as better

TABLE III.—CASH ROAD AND BRIDGE EXPENDITURES FOR THE CALENDAR YEARS 1904, 1914, 1916, AND 1917.

State.	Year in which first State-aid law passed.	State funds expended by or under State highway department.				Total State funds expended for road work from passage of law to Jan. 1, 1918.	Total cash expenditure from all sources. (Approximate.)			
		1904	1914	1916	1917		1904	1914	1916	1917
Alabama	1911	.....	$170,232	$102,422	$89,511	$778,338	$378,040	$3,949,019	$4,186,384	$2,669,022
Arizona	1909	.....	.....	441,202	543,422	2,024,012	67,591	982,721	1,988,221	1,569,422
Arkansas	1913	.....	115,000	55,483	80,262	300,745	681,934	1,522,696	3,443,887	3,335,262
California	1895	$11,251	.....	4,285,964	3,058,030	23,915,085	2,157,396	19,171,985	20,392,434	18,245,200
Colorado	1909	.....	301,274	607,628	703,000	2,335,379	635,395	1,937,546	2,313,208	2,570,000
Connecticut	1895	219,165	1,307,381	1,865,948	2,197,264	20,592,791	1,195,125	3,640,963	3,200,948	4,004,225
elaware	1903	14,000	31,000	31,000	21,600	277,295	90,803	511,628	512,000	321,600
Florida	1915	.....	.....	10,484	23,797	35,416	437,184	2,280,255	4,010,484	6,384,797
Georgia	1908	.....	.....	.....	1,910	1,910	894,936	3,688,172	3,750,000	4,318,350
Idaho	1905	.....	49,812	100,057	473,132	1,146,001	201,648	1,371,469	1,948,118	2,092,723
Illinois	1905	.....	387,989	1,119,202	1,258,338	4,064,167	3,844,424	8,734,713	10,356,669	10,083,728
Indiana	1917	.....	.....	.....	14,000	14,000	3,438,389	14,233,986	13,500,000	14,014,000
Iowa	1904	.....	74,000	90,821	89,787	436,543	2,344,107	10,187,507	14,427,877	15,625,406
Kansas	1911	.....	9,080	10,000	10,000	50,000	692,823	5,544,048	5,610,000	6,010,000
Kentucky	1912	.....	18,000	708,346	1,501,650	2,826,711	1,161,194	2,474,621	4,448,533	4,923,651
Louisiana	1910	.....	161,186	184,533	182,295	973,155	345,452	1,777,572	3,458,643	3,540,976
Maine	1901	44,885	467,149	1,055,250	1,112,675	8,033,134	1,472,393	2,042,007	3,167,215	3,244,982
Maryland	1898	.....	356,845	2,280,000	2,804,707	22,667,849	873,471	6,000,052	5,560,000	6,083,682
Massachusetts	1892	575,606	242,560	2,701,236	4,231,802	25,933,030	2,871,222	6,091,875	6,499,141	9,494,802
Michigan	1905	.....	657,264	982,939	1,704,359	5,869,999	1,816,504	9,261,998	10,082,939	11,190,153
Minnesota	1905	.....	1,309,956	1,390,525	1,429,865	7,108,564	1,607,417	6,458,940	8,742,278	8,024,760
Mississippi	1915	.....	.....	6,500	6,500	13,000	339,669	3,960,377	3,256,500	3,256,500
Missouri	1907	.....	277,253	482,860	367,913	2,641,945	1,570,801	5,513,049	7,982,860	7,374,933
Montana	1913	.....	13,516	26,150	25,729	86,225	308,744	2,888,400	3,475,569	3,356,869
Nebraska	1911	.....	.....	110,000	9,500	497,350	494,886	1,796,278	4,500,000	4,603,400
Nevada	1911	.....	.....	.....	36,796	56,796	46,876	245,014	275,000	336,796
New Hampshire	1903	44,000	491,520	414,669	589,254	4,263,712	872,606	1,590,464	2,045,410	2,238,705
New Jersey	1891	250,000	1,306,596	1,167,843	1,501,902	11,025,321	3,274,811	7,208,287	5,784,354	6,280,897
New Mexico	1909	.....	115,732	385,684	280,578	1,329,217	35,458	556,399	828,952	845,867
New York	1898	1,056,460	8,544,126	9,409,655	9,432,679	115,464,832	3,937,739	23,231,964	19,901,391	21,685,131
North Carolina	1901	.....	5,000	10,000	20,000	68,500	624,381	5,215,491	5,510,000	5,520,000
North Dakota	1909	.....	.....	.....	28,638	28,638	456,130	2,402,384	2,711,295	2,867,979
Ohio	1904	.....	1,855,338	2,885,071	2,835,649	17,394,548	4,776,318	14,334,246	12,992,625	12,017,104
Oklahoma	1911	.....	.....	300,000	286,922	617,245	447,320	2,112,681	3,625,000	3,722,355
Oregon	1913	.....	10,697	165,662	711,000	1,295,637	649,718	5,310,467	5,955,662	5,711,000
Pennsylvania	1903	127,767	1,976,768	3,663,352	4,351,566	38,816,129	4,887,266	10,424,580	34,464,563	11,463,333
Rhode Island	1902	79,397	.....	543,152	486,725	4,937,661	376,812	446,496	943,152	861,725
South Carolina	1917	.....	.....	.....	27,161	27,161	334,082	1,024,480	1,250,000	1,277,161
South Dakota	1911	.....	.....	.....	5,000	5,000	268,723	1,217,809	2,708,000	2,755,000
Tennessee	1915	.....	.....	200,000	231,500	435,000	629,141	2,370,560	4,600,000	2,481,500
Texas	1917	.....	.....	.....	10,000	10,000	2,543,613	9,920,079	10,500,000	10,010,000
Utah	1909	.....	157,732	179,400	120,200	1,109,332	158,286	803,071	1,855,160	1,893,129
Vermont	1898	127,381	458,456	632,800	578,883	4,883,247	567,397	1,023,941	1,607,800	1,680,389
Virginia	1906	.....	523,578	542,524	695,171	3,951,245	687,751	3,224,529	3,691,249	4,136,779
Washington	1905	.....	1,343,431	859,672	2,031,392	10,443,853	1,344,842	7,944,717	7,518,343	7,115,691
West Virginia	1909	.....	.....	10,967	.....	[1] 141,945	587,870	2,483,747	5,510,967	8,200,000
Wisconsin	1911	.....	1,482,379	950,000	1,050,888	6,219,889	1,924,026	9,880,240	10,570,764	9,886,554
Wyoming	1911	.....	.....	.....	37,845	81,082	74,476	669,661	450,000	589,691
Total	.....	2,549,850	24,220,850	40,969,001	47,290,796	355,228,634	59,427,180	240,263,784	272,634,424	279,915,332

[1] Of this $118,000 was returned to the counties in 1911 by act of legislature.

to be a more and more important factor, while the employment of statute labor or working out the road and poll taxes is decreasing from year to year. In one-half of our States the use of convict labor in road work under State direction or control has definitely passed what may be called the experimental stage and proved a success.

One of the most notable features in the increase in the amount of funds expended under the supervision or control of the several State highway departments is that relating to maintenance. In 1914 maintenance methods, regardless of price and conditions. The reasons for these increasing traffic demands are readily apparent. At the present time approximately 5,000,000 motor vehicles, of which about 10 per cent are motor trucks or commercial vehicles, are used on our public roads and streets. These motor vehicles represent a maximum potential traffic capacity of certainly not less than 1,000,000,000 vehicle miles per day and a total horsepower of at least 120,000,000. Fifteen years ago all traffic on our roads may be said to have been

horse-drawn. To-day, in addition to the horse-drawn traffic, which is probably nearly as large as ever except in regard to pleasure vehicles, we have this enormous motor vehicle traffic. Even in such a representative agricultural State as Iowa the average of 7-day counts recently made by the Iowa State highway commission and Iowa State College (at 47 stations in 17 counties) showed that the horse-drawn traffic formed less than 14 per cent of the total. It can, therefore, readily be seen why the traffic demands on the roads of to-day are so much greater than those of a few years ago.

The public rural roads of the United States at the present time have a total length of 2,457,334 miles, of which about 296,290 miles or 12 per cent are improved with some form of surfacing. The mileage of hard surfaced roads has for a number of years been increasing at the rate of about 15,000 miles per annum. During 1917 it is estimated that this mileage was somewhat reduced, amounting to about 14,000 miles. Of this mileage about 7,000 miles were surfaced under state supervision and also about 5,000 miles were improved by grading or otherwise. Thus, of the actual road construction work of a more or less permanent nature in the United States last year, more than one-half was directly under competent State supervision. In addition to this work of construction the several State highway departments also supervised the maintemance of 181,000 miles, most of which were main and truck line highways.

The expenditures for 1917 by or under the various State highway departments are shown in table 1 and the work accomplished is shown in table 2. Table 3 shows the expenditures of State and local funds for the years 1904, 1914, 1916, and 1917. Figure 1 shows the distribution of the 1917 expenditures for construction, maintenance, engineering, administration, and miscellaneous items. The variations especially in the items of administration and engineering as shown in figure 1 probably are due more to differences in bookkeeping and definition of what items should be included under these heads than any other casuse. There is great need for a common standard so that these items for the several States may be fairly comparable. At present no comparison is possible without an exhaustive study to determine just exactly what items are included in each case.

These compilations include no expenditures from Federal funds under the Federal aid road act. Only a relatively small amount of Federal aid road work was completed during 1917, and this, together with all obligations entered into under this act, are fully described in volume 1, May, 1918, of Public Roads. Neither do these compilations contain any of the expenditures for road and street work by the War or Navy Departments in or at cantonments, military reservations, training stations, and similar places.

LOWER 36-FOOT CONCRETE BRIDGE TO REMEDY SUBSIDENCE.

By HARRY C. FISHER, Chief Engineer, Mobile County, Ala.

Cedar Point Road leads south from Mobile, Ala., a short distance from and parallel to the shore of Mobile Bay. It crosses several marshes, subject to tidal overflow, with soil a semiliquid mud, in which there is an accumulation of decomposing marsh grass. The roots of this grass form a mattress that in most places will sustain the weight of a man, but when this crust or mattress is penetrated, a very unstable condition of the soil is encountered, which extends to considerable depth.

When Cedar Point Road was reconstructed and hard surfaced in 1913, the county decided to construct a concrete bridge over Perch Creek, which flows through one of the above-described marshes. The bridge is of the I-beam slab type, and a 36-foot span. The foundation was secured by driving twenty-two 50-foot piling under each pier. The piling were cut off 3 feet below mean low water, upon which was placed a double grillage constructed of 12 by 12 inch timbers. Upon this grillage the concrete piers were constructed.

A pile driver with a 3,500-pound drop hammer was used to drive the piling. When the hammer hit the piles placed in the leads, they would slip through the soft mud to considerable and varying depths. In fact, no firm foundation was encountered, as the piles were going freely when driven their entire length. However, after the piles were left standing for any length of time it would take a considerable blow from the hammer to move them.

When completed, the floor of the bridge was approximately 5 feet above the general elevation of the marsh.

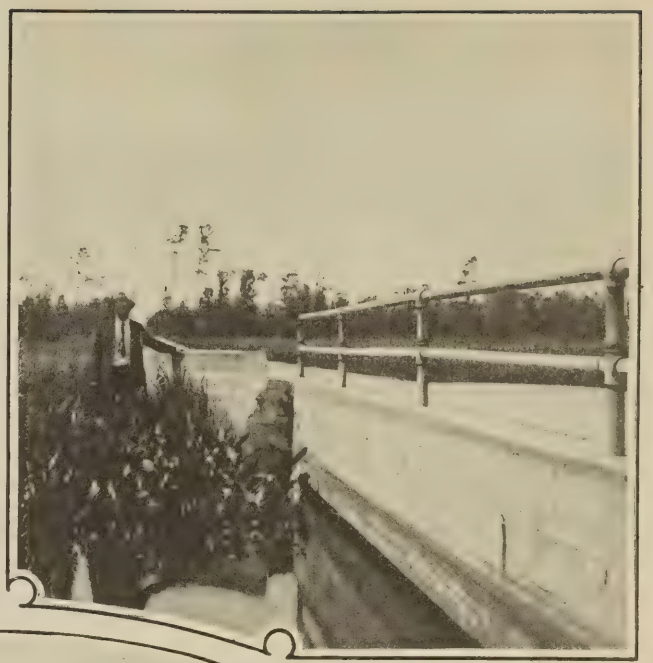
From the time the bridge and approaching fill were completed trouble was experienced with the subsidence of the fill, and the resulting pressure caused the wing walls to fracture at their junction with the pier. This fracture opened up more and more until eventually one of the wing walls was standing off a foot from the pier. The piers also fractured horizontally along the bottom of the floor system, and on each pier this fracture eventually opened up 3 inches on the outside of the pier.

After repeated attempts to keep the fill to grade, and finding that subsidence always occurred after new material was placed on the fill, it was decided in the latter part of 1917 to lower the bridge. As enough of the grillage extended beyond the concrete pier to support jackscrews, eight were placed under the floor system on one end of the bridge and the pier relieved of the weight of the bridge. The concrete pier was then chipped off about 3 feet and the floor system securely blocked up with heavy timbers and the jacks removed to the other end, and the operation repeated. The bridge was then lowered to its present elevation and all joints closed with grout.

The fill was removed to the new grade, and all subsidence and movement of the wing walls and piers seems to have ceased since the weight of the fill has been removed. The fill over the marsh is constructed on a mattress of logs.

All of the work had to be done when north winds prevailed, thus bringing the tide to a very low stage.

Showing the original elevation of the floor; being at the top of hand rail.

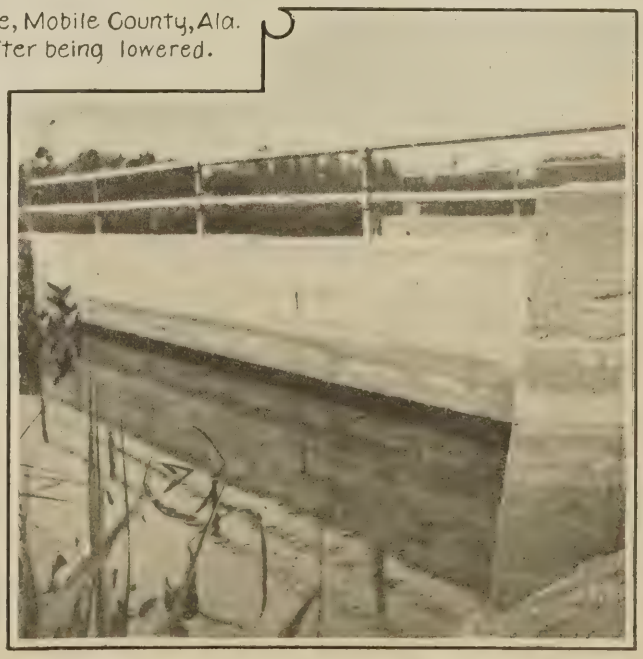


Showing general elevation of Marsh.

Showing fracture and movement of wing wall.

Side view after being lowered at ordinary low tide.

Perch Creek Bridge, Mobile County, Ala.
Showing elevation after being lowered.



DRAINAGE INCREASINGLY VITAL WITH GROWTH IN HEAVY TRAFFIC

By E. W. JAMES, General Inspector, Bureau of Public Roads

DURING the past 20 years the principal development in highway engineering has been in designing surfaces to meet the conditions imposed by a rapidly growing automobile traffic. The subject of drainage has received only such attention as engineers have been forced to give it, usually after the fact, to remedy failures in pavements resulting largely from foundation weakness more or less directly attributable to faulty drainage conditions left uncorrected at the time of original construction.

Not infrequently a far-seeing engineer intending to take proper steps to effect sound foundation construction by an adequate and suitable control of drainage has been compelled to cut out one proposed feature after another because of the apparently unwarranted initial expense, because of lack of funds, or of the opposition of local administrative officials who are willing to risk large public expenditures rather than curtail the length of construction. Too frequently the policy has been one of millions for surface and not one cent for drainage.

There has been very little added during this time to our knowledge of the natural conditions that have to be combatted for the purpose of road construction in controlling ground water, capillarity, or frost. It appears, however, that we are at the beginning of a new phase of this matter. Like the competition between the big gun and armor plate designers, that between the manufacturer and operator of motor vehicles and the highway engineer has reached a stage where the engineer must save himself either by agreement or by adopting a new method of defense. The method of agreement lies obviously through legislation which will restrict the wheel loads, control the width and type of tires, and diameters of wheels, and in some measure also control the width of bodies.

BECOMING MATTER OF FOUNDATIONS.

When the recent failure in several States of a considerable mileage of first-class road is considered, it appears that the problem of the immediate future is going to be the development of adequate foundations to handle a fast-growing motor-truck traffic. The last available figures indicate that there are some 200,000 motor trucks and commercial vehicles now registered in the United States. The great majority of these are in the northeastern block of States, with heavy concentration in other States having improved roads.

Whether the increase in number of trucks in the next decade will in any way approximate the increase in pleasure automobiles during the last one is not a matter of special moment, but it is of the greatest importance whether the gross tonnage of trucks increases rapidly. A single truck of some designs will provide a tonnage equal to five or six touring cars. A single truck operating between fixed termini has damaged a road in a single month to more than the ordinary cost of maintenance for a whole year. A string of trucks operating over a road not properly supported by the existing foundation has entirely destroyed in two weeks a well-built surface costing $8,000 per mile.

Such destruction as this must be stopped or the cost of motor-truck hauling, if properly allocated, will amount to prohibitive figures even for 1 or 2 mile hauls. and for long hauls will produce conditions perilously near bankruptcy in many of our counties. An engineer of the Bureau of Public Roads was recently asked what type of road would be adequate to accommodate traffic of 20 tons on two 10-inch steel tires, moving at 20 miles per hour. The inquiry was made because the design of such a trailer was being seriously considered. Just how far the tendency indicated by the above conditions is going to continue cannot be definitely foreseen, but so far as present motor-truck traffic is concerned our existing roads are frequently not adequate.

PROLIFIC CAUSE OF FAILURES.

Careful inspection indicates that failures have largely been the result of weak foundations at the time frost is "coming out of the ground," when the water content of the soil is high and foundations are consequently weakened. What degree of weakening is permissible under any conditions before failure is reasonably certain is not known because we never know even approximately the factor of safety in the bearing power of our sub-base or subgrade. The few studies made in this direction have little application to road conditions, because the moisture content of the soil and its grading or texture, which so strongly affect capillarity, have never been adequately considered. Further, it is doubtful if within the immediate future any increase of knowledge of soil conditions will be sufficient to indicate a method of direct control. Capillarity can not be adequately controlled. It must be met.

The same degree of approximation in our road foundation design will doubtless prevail until con-

siderably more data are available regarding soil moisture and its effects. In the meantime such information as we have can be used for what it is worth. Some recent examinations made by an engineer of the Bureau of Public Roads furnish the following interesting data:

Clay below a concrete pavement contained 18.88 per cent by weight, or about 46 per cent by volume, of water. In another case clay contained 12.7 per cent by weight; in still another case, 12.23 per cent. Clay loam under an asphalt pavement on a 7-inch concrete base contained 13.58 per cent by weight, or about 33 per cent by volume, of water.

Sand cushions under grouted brick and on a concrete base have been found to contain 6.38 per cent of water by weight; and under a tar-filled brick pavement and on a concrete base 9.05 to 13.76 per cent. Under wood block on a concrete base the sand cushion may contain as high as 12.7 per cent of water by weight.

TOP - WATER AT BOTTOM OF 8-INCH SURFACE TREATED MACADAM ON A 6-FOOT FILL.
BOTTOM - OUTLET OF SUB DRAINAGE SYSTEM FOR THIS FILL OPPOSITE HOLE SHOWN ABOVE. TILE STOPPED UP AND OUTLET DRY.

STUDIES OF CAPILLARY ACTION.

These figures may be considered as being the natural moisture content of the various materials under the conditions existing. In every case the structures were first class and believed to be adequately drained.

Some extended studies of the action of capillarity conducted by the Irrigation Division of the Bureau have furnished additional interesting data.

The following table shows the height to which capillary water rises in certain soils in twenty-four hours:

	Inches.
Light sandy soil	14
Gravelly soil	16
Decomposed granite (loam)	21
Heavy granite loam	16
Heavy clay loam	11
Heavy lava ash	16
Pure sand	9

In one day the capillary water moves upward about one-half its apparent final limit. In three days it moves about two-thirds its apparent final limit. In some soils the movement upward in the first two hours is as high as one-third of its movement for 30 days. In pure sand it rises in one-half hour approximately one-half as high as in one day, and in one day about 70 per cent as high as in twelve days.

The movement is more rapid at the start in light soils, and slows down rapidly. After three days the movement is exceedingly slow in pure sand. In heavy soils the movement is uniformly slower and more sustained.

In light soils the per cent of water in the soil decreases rapidly with the height above the source of water, while in some heavy soils the water content is strikingly uniform at different depths.

Horizontal capillarity occurs with much faster water movement and greater uniformity of moisture content. The speed and distance varies with different soils and ranges from 7 to 33 feet in the first 24 hours.

SOURCE MUST BE REMOVED.

An examination of the above figures indicates that capillarity in some cases fills the soil perilously near to the saturation point even when drainage is considered adequate. And the rapidity with which capillary action occurs when there is a source of free water makes it imperative that such source be removed with the greatest promptness and prevented from occurring within a considerable distance, either vertically or horizontally, from soils which are depended upon to support heavy loads.

The action of capillarity indicates that if water is to stand or flow along a road embankment for even a few hours, regard must be given to the height of the subgrade above the water line, and the lateral distance of the watercourse from the road surface.

Assuming that the supply of free water will not endure more than one day at a time, it is apparent that a height of 18 inches in the subgrade above the water line will insure that the moisture content near the surface is not increased. Where the free water is present at a considerable distance to one side this height may safely be reduced. Shallow ditches a short distance from the center line tend, by horizontal capillarity, to increase the water content of the subgrade at a higher level than deep ditches similarly located. If the grade is through standing water or against a continuous source of free water so that the soil remains continuously moist, capillarity will lift the water about 4.5 times higher than in dry soil, and this fact must be considered in designing cross section and grade across swamps, marshes, or against irrigation or drainage ditches in which water is present for long periods.

WHERE SPECIAL DRAINAGE IS NEEDED.

These conditions affect the design of cross section and the establishing of grade in places where the presence of free water is foreseen or where run-off is expected to be slow and considerable, if the full bearing power of the natural soil is to be developed. If the design of cross section can not, because of immediate local conditions, be made to meet the above requirements, then special drainage should be provided or additional bearing value given by some suitable treatment.

The writer recalls a specific case in Florida where a light sand and sandy loam were reinforced by a 4-inch layer of natural sand-clay preparatory to placing wearing surface. The cementing value of the sand-clay mixture was counted upon in the design to furnish a nonflowing base adequate to distribute the comparatively light loads probably to come upon the surface. Wherever the road was located on a ridge or high well-drained natural soil, this base appeared adequate; but where a grade was thrown up across marsh land, swamps, or near standing water in the "flat woods," the elevation above prevailing water level was so little that even when the clay base appeared dry and satisfactory, just so soon as surfacing was laid and evaporation at the surface of the clay thereby reduced, the clay became sufficiently moistened from the underside, by water supplied by capillarity, for the bond of the clay to yield and the base to become more or less plastic and flowing.

Experience alone has developed many of the features of our present highway cross-section designs. Certain bearing powers of the soil are more or less unconsciously assumed as we follow accustomed practice. Now that the loads likely to come upon our roads are so much greater, it is a problem of the utmost importance to determine how much heavier our foundations must be, just what loads soils with different moisture contents may be depended upon to bear, and what means if any, can be developed to insure no increase of moisture above a safe point. Of course, these problems are closely correlated. How does moisture content affect the bearing power of soils? And ultimately what method of design will be most economical? Will it be cheaper in a given condition to drain excessively or to thicken the foundation? These matters are to-day a closed book to the highway engineer.

Finally, we must face the natural law at work through capillarity and realize that it can not be removed. It must be met.

LITTLE TO ENCOURAGE CHEAP ROADS.

In matters of practice we shall find little to encourage the builder of cheap roads. Tile drains, French drains, the various types of subbase will doubtless have to be used much more extensively in some sections than they have ever been. Grades will have to be kept higher in flat locations and to retain the general crescent design of the crown and thus avoid deep cut ditches, construction lines will be much wider than customary. This will have its effect on width of right of way.

In a few, a very few, States where systematic road construction and maintenance have required the development of an adequate permanent organization

of engineers, road builders, and maintenance forces, experience has resulted in producing a practice that more and more completely meets the conditions that the past have caused failure of our roads under increasing traffic or imperfect drainage features. This practice is to consider the design of short sections of road as a local problem. Frequently the cross-section design is changed several times in a mile, gravel base, sand, crushed rock, telford, V-drain, or stone base is placed where needed to meet the local drainage and soil conditions. To be sure, much of this work has been done as betterment or maintenance, subsequent to the original construction. Each spring certain bad locations have been torn up and repaired by providing the necessary drainage or foundation. As engineers will in general realize, some of these failures are due to conditions that were not apparent at any time during the preliminary survey and investigation, and appear to have developed after construction. But the greater part of such repairs are to meet conditions that could have been ascertained by proper preliminary investigation and adequate engineering design preceding original construction.

TOP - WATER STANDING IN MUD HOLE ON SHOULDER AT EDGE OF PAVEMENT ON 5-FOOT FILL. BOTTOM - MOISTURE BEING SHOVED THROUGH FROM BASE OPPOSITE MUD HOLE SHOWN AT TOP.

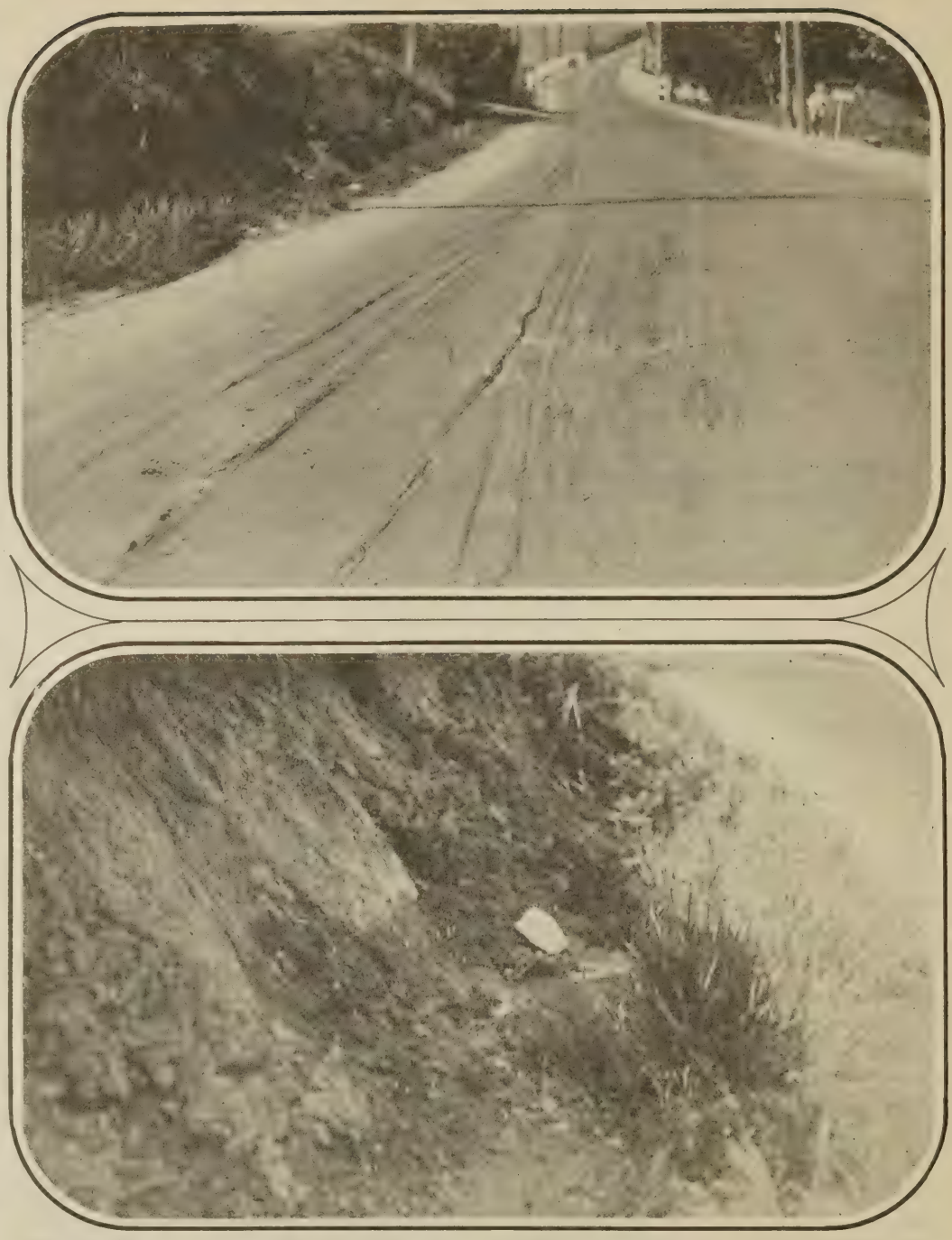
In a great majority of highway plans, however, will be found a single cross-section design, expected to be adequate to meet conditions mile after mile, through cut and fill, uphill and down.

DETAILS WILL BECOME FEATURES.

Under the increasing truck traffic, drainage will have to be considered more carefully, moisture content of many soils in many locations considered allowable under past conditions will have to be reduced to save or develop such bearing value as the soil may have, and a great deal of subgrade will have to be reinforced by the addition of suitable subbase. All of these details, considered heretofore as special features, will become the features ordinar y considered in careful design of high-class, costly pavements. A foundation and wearing

course costing $16,000 per mile are not going to be subjected to what is now known to be an utterly destructive traffic without that due examination of soil conditions and adequate provision for furnishing a proper support in the natural ground that will save the surface and foundation from destruction at a reasonable cost.

Within a few months there has appeared an article in one of the engineering journals in which the writer said that the day of open stone bases was past; that telford, field stone, V-drain, etc., were no more dependable than a firm, well-compacted earth subgrade. This statement in the light of the traffic which has developed in the last six months becomes daily more and more surprising. An earth subgrade can be kept dry only when capillarity is destroyed or its range in distance exceeded, and for most cases the latter possibility is not within the reach of road designs. The writer is more and more convinced that the older types of large stone foundation, with large interstices, included the principles which will be found of greatest effect in resisting the failure of subgrade bearing because of excessive soil moisture. This opinion is strengthened by a consideration of frost action, especially in the spring, when alternate freezing and thawing may be expected.



TOP- FAILURE IN 6-INCH CONCRETE ROAD DUE TO SOFTENING OF SUBGRADE BY WATER BEING ABSORBED FROM DITCH WHICH HAS BEEN FILLED UP AND NOT CLEANED OUT.
BOTTOM- WATER STANDING IN DITCH OPPOSITE FAILURE SHOWN ABOVE.

SALVAGING CAUSES TROUBLE.

It has been the custom in recent years in the limestone sections of Tennessee and Kentucky, when it became necessary to rebuild some of the old "pikes," to salvage the telford, crush it, and place it back as macadam. In one case, at least, this was done on first-class engineering advice, and in this case the result was not satisfactory. The reason for failure appears to have been due to insufficient drainage of the base, which had been provided for years by the old telford and was most carefully closed by the new construction. The result of this condition is greatly emphasized by severe frosts.

Some designs for V-drain, in order to save stone, require that the drain be carried out practically to 0 depth at the extreme edges, so that the stone or other road metal is practically without drainage at those points.

In northern localities difficulty has been experienced when V-drains of this design have been used

with the edges of the road crust heaving in the spring. This is probably due to the freezing of accumulated water near the edges of the drain. Such water will accumulate in the interstices as a result of shallow thaws, which do not free the deeper areas of frost. The melted snow can not run off and fills the upper layers of the V-drain, especially near the edges, until the voids are too full to allow expansion on freezing. The result is that during succeeding freezes the edges of such drains will heave. The remedy is to increase the depth of V-drain at the edge and to provide drainage close to the surface through the shoulder, so that such drains will certainly clear with the shallow thaws and permit water to flow freely from the V-drain. Experience indicates that the depth of V-drain, in addition to the surfacing material, should not be less than 4 inches at the edges and that a depth of 6 or 8 inches is better.

OUTLETS SHOULD BE PROVIDED.

Outlets for conducting water away from the V-drain should be provided at all low points in the grade. These outlets may consist of tile running from the lowest point of the V to a culvert or cross-drain, or of ditches filled with the same kind of material as that composing the V-drain and running from the lowest point in the V to any lower point outside of the road where they may empty.

The error has often been made of depending on tile or French drain to remove the excessive and damaging moisture from soils that do not readily give up their contained water. While tile drains for agricultural purposes may in the same soils be entirely satisfactory, because rapidity of action is not essential, they are not adequate for road drainage. The recent failures in Maryland, shown in the accompanying illustrations, disclose that much of the spotty failure on some of the roads is due to pockets of heavy pipe clays left in the subgrade of roads that were, in general, very well drained. The only treatment for such cases is to remove the offending material and replace it for a sufficient depth with sand, gravel, or some sort of stone base having free lateral drainage.

When road construction is approached in the spirit necessary to meet the conditions cited here, the result will be a series of cross-section designs, instead of a single design to meet all conditions, much more general use of subbase and tile drainage, more careful consideration of the material of the subgrade, and the methods used in finishing it. To do these things intelligently, there will have to be undertaken by some one extensive studies of existing conditions. These are matters about which much may be learned by a close and studied observation of failure.

CONSTRUCTING A CONCRETE ROAD AT MARINE CAMP IN THE WINTER

By C. L. BROWN, Senior Highway Engineer, Bureau of Public Roads

THE following description of the concrete-road work done on the highway between Quantico, Va., and the main highway between Richmond and Washington, together with the photographs accompanying it, is given not because the construction of concrete roads is new, or that it possesses any unusual features outside of the time of the year in which it was constructed, but because it is unusual to attempt the construction of concrete roads with the temperature below freezing.

Early in October, 1917, it was decided necessary to build a substantial roadway from the Marine Corps camp at Quantico to the main highway leading to Washington. This road, in the spring of the year and during the wet season, was almost impassable. The drainage is bad. It was very essential that this stretch of road should be improved at the earliest possible date, in order to furnish an outlet by road from the camp to Washington and also provide a means of communication between the artillery range and the camp. The Bureau of Public Roads was called upon to advise with the Navy Department, and after consideration it was decided to construct this road of concrete. It was planned to do as much of this work as possible before the winter season set in, which ordinarily in this latitude is not early.

WORK DONE IN FIVE MONTHS.

The construction company, which had the contract for the construction of the marine camp at Quantico, undertook this work under the direction of Maj. H. L. Roosevelt, post quartermaster of the camp. The writer was detailed by the Bureau of Public Roads to advise the quartermaster and look after the engineering incidental to the construction of this highway.

The work was started late in October and was completed March 13, 1918. During this time the thermometer sometimes reached zero and below, and during a large portion of the time the temperature was between zero and 32° F. It was necessary to adopt all possible measures to protect the concrete, both during its laying and curing.

The engineering features in connection with this were not unusual. The width was 18 feet, the thickness at the center 8¼ inches, and at the sides 6

THAWING OUT THE SUBGRADE

PLANT FOR HEATING THE WATER

HEATING THE GRAVEL

HEATING MATERIALS

inches. The road is reinforced with a wire mesh reinforcement weighing 28 pounds per 100 square feet. The concrete was mixed in the proportions of 1 part Portland cement, 1½ parts of fine aggregate, and 3 parts of coarse aggregate that consisted of washed and screened gravel. The grade and alignment followed the old roadway as nearly as possible and the few short, steep grades were reduced and some of the excavated material wasted to avoid heavy fills, which would undoubtedly settle later and cause bad cracks in the roadway.

PLANK ROAD FOR TRAFFIC.

Investigation proved that a good detour could be provided to the east of this road, which would allow the road to be entirely closed to public travel without serious inconvenience. The traffic incidental to the construction of the road was taken care of during the construction of the concrete road by the construction of a plank road along the side of the highway.

A camp was constructed for housing the laborers at a point midway between the two ends of the road. At this point were also constructed the stables for the live stock. Cement sheds were built at convenient places and filled with cement before the pavement reached these points. The storage of the cement was not sufficient and the necessary balance was hauled by truck and teams from Quantico during construction.

The usual method of construction of this kind of work was pursued until it became necessary to keep the concrete from freezing. The work was begun on the end of the road farthest from Quantico and continued toward Quantico. Later, work was started at Quantico and carried on simultaneously with the other work. For the first two weeks after starting the work was carried on night and day. It was then decided to abandon the night shift and work only the day shift.

About November 23, 1917, it became necessary to adopt precautions against freezing. There was a great deal of delay due to the difficulty in obtaining from a commercial plant in Fredericksburg sand and gravel which they were unable to wash during the extreme cold weather.

HOW CONCRETE WAS PROTECTED.

The road was graded and the necessary drainage structures built as far in advance as possible of the concrete work. The sand and gravel were delivered during construction when they could be obtained, and were hauled in and dumped in rows on the subgrade ahead of the mixture. Care was taken to deliver the materials in the right quantities for the concrete and avoid the hauling in of materials after the work was started.

When it was decided that the work must proceed regardless of the weather, attention was given to the question of protecting the concrete, and the following methods were adopted: These methods constituted practically the unusual features in the construction of this road and are well illustrated by the photographs accompanying this article. The water was pumped into an elevated tank and from there flowed by gravity into a tubular boiler, where it was heated. In dumping the sand and gravel in rows on the subgrade, plain sheet iron pipe about 2 feet in diameter was first laid on the subgrade and the material dumped on this. Fires were built in these pipes and in this way both the sand and gravel were heated to a proper temperature. These fires also served to keep the subgrade from freezing so that the concrete could be laid on an unfrozen subgrade. After the materials had been properly heated, mixed, and deposited, the finishers followed up the work immediately.

A mixer of two-bag capacity was used to mix the concrete. This mixer had a 20-inch revolving iron tube 18 feet long on the discharge end. This tube allowed a much drier mixture to be used and deposited the concrete in the best possible condition on the roadbed. The mixture was held in the mixer for one minute. The strike board was of a heavy plank cut to the crown of the road and the wearing edge shod with sheet iron.

ROLLER GIVES GOOD RESULTS.

At first a small wooden hand float was used to finish the concrete surface, but later a Macon roller was used with very good results. The roller was 6 feet long and 10 inches in diameter. It was passed over the surface of the road from one edge to the other and back again; then advanced one-half its length and the rolling repeated. This operation was kept up until the roller reached the unscreeded concrete. After a short wait the rolling was repeated.

After the cold weather set in and it became necessary to protect the concrete the previous method was used as far as possible, but at times it was necessary to omit the second rolling and cover the concrete at once. The method of covering the concrete is shown in one of the illustrations. Four-inch by 4-inch blocks 1 foot long were placed on the side forms on each side of the road, and 2-inch by 12-inch planks, 20 feet long, were stood on edge on these blocks and spiked to them. These planks spanned the pavement at as frequent intervals as necessary. On these planks were placed 2-inch by 6-inch planks lengthwise of the road. Over these in turn was spread a heavy canvas that covered the top and came over the edges and rested on the ground. Marsh hay was then spread over the canvas and banked against the sides, thus shutting out the cold air. The concrete then was covered until danger of damage by frost had passed, then the covering was moved ahead and used over again. Several thousand feet of this pavement were in service during the winter. It was covered with snow and ice and many auto trucks and light vehicles passed over it, but in the spring the surface showed no signs of frost action.

PLACING MATERIAL

PROTECTING THE CONCRETE

JOINTS SPACED IRREGULARLY.

No attempt was made at the regular spacing of the joints; they were placed from 50 to 150 feet apart. The joint filler was three-eighths inch thick, made up of an asphaltic strip which extended entirely across the road. As used at first, the filler extended above the surface of the concrete a half inch, but later the concealed joint was used. This latter method allowed the surface to be finished continuously, making a smooth joint. Where the filler extended above the surface it was hard to get both sides on the same plane.

Until the ground became frozen it was a simple matter to do the excavating and grading. After the frost was in the ground it was found by experiment that a heavy wood fire built on the ground would remove the frost to a depth of 10 to 14 inches. As there was plenty of wood to be had for the cutting this method was adopted. Logs were cut 10 feet to 15 feet long and a heavy fire was built over the full width of the subgrade. After the frost was out of the ground the fire was worked ahead and the excavation carried down to the finished subgrade. The good supply of wood so close at hand was one great advantage of this method of softening up the ground.

There was one cut where the excavation was too deep to be taken out this way, so holes were drilled below the frost line and the ground loosened up with dynamite.

The steam jet method was tried but did not give satisfactory results.

The results show that it is possible to build a concrete pavement during freezing weather, but, if possible, it is better to postpone the work until warmer weather.

WASHINGTON MAKES A RECORD IN FEDERAL AID ACCOMPLISHMENT

THE State of Washington has attained distinction in the record of Federal aid progress. It is the only State with more than one project that had all of its projects under final agreement before May 1, 1918, provided for the expenditure of its complete apportionment, $215,642.72, for the first two years, had six of its seven projects under contract before the first of this year, and completed its first project January 21, 1918. The five other projects averaged one-third complete on the first of May. No further agreements involving work to be done prior to July 1 could be made before that date.

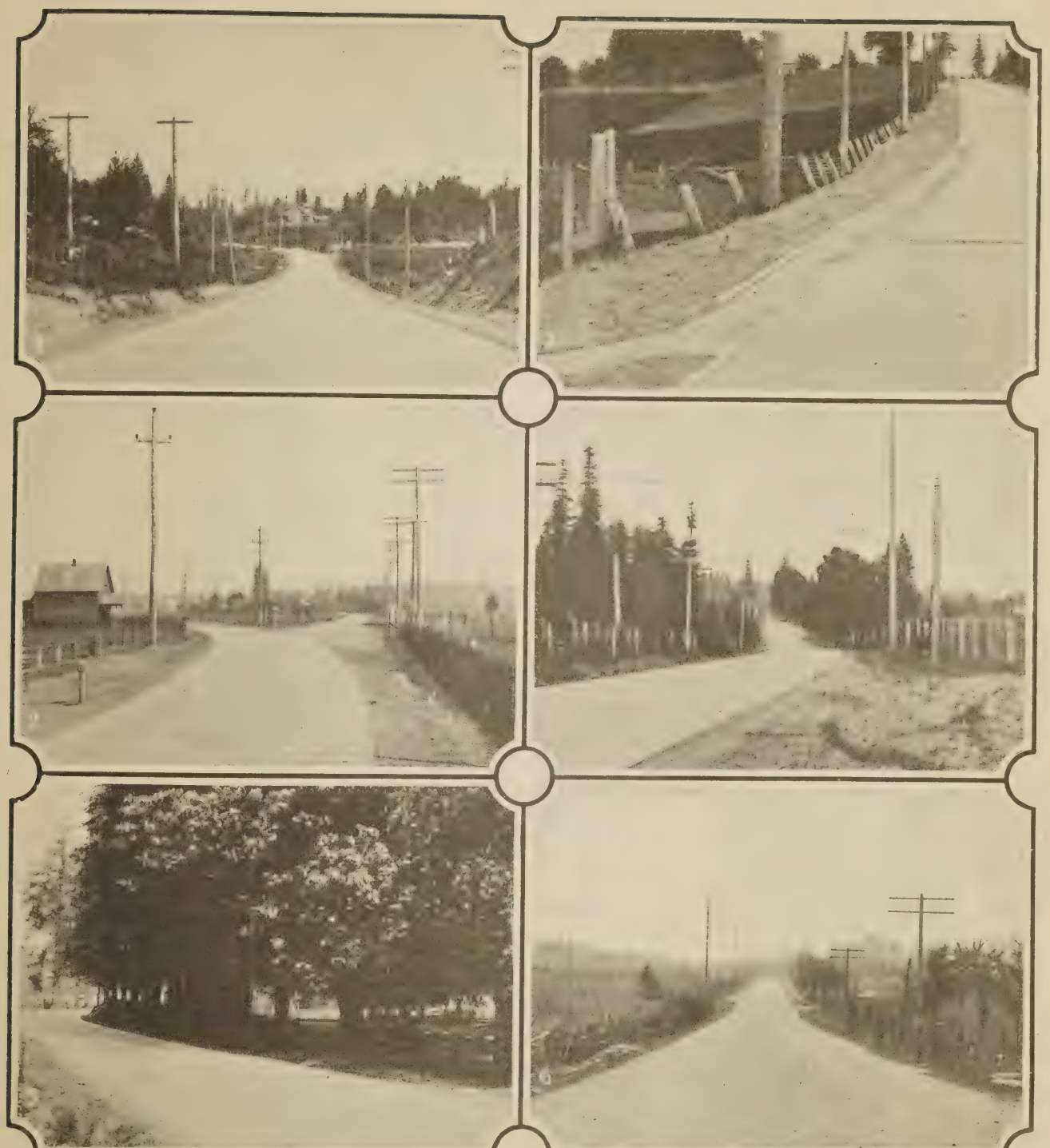
Washington's first completed project is 3.52 miles of concrete pavement on the Pacific Highway, leading northeasterly from Olympia to Camp Lewis, Tacoma, and Seattle. It is on the main highway route from California and Oregon, crossing the Columbia River at the interstate bridge between Portland and Vancouver, reaching the southernmost inlet of Puget Sound at Olympia, and generally paralleling the easterly shore of Puget Sound to the international boundary and the British Columbia cities beyond the border.

Prior to the Federal aid, about 15 out of the 25 miles between the city limits of Olympia and Tacoma had been permanently improved with hard-surface pavements, 1 mile easterly from the Olympia limits and 14 miles southwesterly from the Tacoma limits; the intervening 10-mile section being a well-improved gravel-surfaced highway. Under the heavy traffic, reaching 600 vehicles per day, and increasing constantly, this 10-mile gravel-surfaced section required an annual expenditure averaging $500 per mile for repair and upkeep. Moreover, under such traffic, adequate maintenance to proper standards of smoothness had become impossible at any expenditure.

WORKED THROUGHOUT SEASON.

Under these conditions the extension for 3½ miles northeasterly from the 1-mile section of concrete pavement constructed in 1916 easterly from the Olympia city limits was made the subject of the first Washington project with Federal aid. Application was made March 24, 1917 (within two weeks from the passage of the State act assenting to Federal aid); project approval followed April 26, and plans, specifications, etc., received final Federal approval July 19, 1917, the contract, however, having been let June 9, 1917. The work continued throughout the season of 1917, sections of the pavement being thrown open to the heavy traffic as soon as it was deemed sufficiently seasoned, the whole 3½ miles being in use by December 8, 1917. Final completion was certified January 21, 1918. The total cost was $64,580.32, of which $30,865.22 was provided by Federal aid and $33,715.10 from State and Thurston County permanent highway funds.

The type of construction is one-course concrete, 1-2-3 mix; the pavement is 20 feet in width, flat base, 6 inches thick at edges, 7½ inches at crown. The maximum curve is 8 degrees, with extra width and superelevation, making double-track traffic entirely safe at 35 miles per hour. The old gravel highway had a roadbed of ample width and furnished an ideal base with only minor revisions of location to ease a few curves. Comparatively slight subgrading was necessary and the material thus obtained supplied ample



WASHINGTON'S COMPLETED FEDERAL AID PROJECT.

① FIRST QUARTER MILE. ② 400 FEET EAST SHOWING DETAIL OF EXTRA WIDTH GUTTER CURB, AND OUTLET TO PROTECT SHOULDERS AND SLOPES FROM DRAINAGE RUTS AND WASH-OUTS. ③ HOW DANGEROUS GRADE CROSSING WAS AVOIDED ④ LEADING TO "CLOSE UP" CURVE. ⑤ "CLOSE UP" CURVE ROUNDING AN OLD PIONEER HOMESTEAD. ⑥ 500 FEET BEYOND 5 LOOKING BACK OVER OLD GRAVEL ROAD AND SHOWING CONTRAST.

shoulders, nowhere less than 5 feet wide. Altogether the project includes a broad-guage pavement on an ample roadbed. The grade maximum is 5 per cent, the general project being level, with undulations varying not to exceed 50 feet in their extremes.

NOT A DEFECT IN SIX MONTHS.

With a winter season's exposure to more than usual possibilities of washouts and settlements, and under an increasingly large volume and heavier tonnage of constant traffic, not a single defect manifested in the first six months of use. Not a dollar of maintenance cost has been required throughout that period, in marked contrast to the $500 per mile annual average for inadequate maintenance of the former graveled highway. With this object lesson, Thurston County has recently voted a bond issue sufficient (with some Federal aid from the

third fiscal year apportionment) to extend similar concrete pavement over the 6½ miles of remaining gravel section to connect with the pavement 14 miles south of Tacoma.

Washington Federal aid project No. 1 was carried to completion under the constant personal oversight of State Highway Commissioner James Allen, whose headquarters at Olympia made frequent inspection convenient throughout the construction period. District Engineer Eugene R. Hoffman was in direct supervision of the work from its design and specifications through to final completion. Included in the first draft call three months after this important public work had commenced, Commissioner Allen secured Engineer Hoffman's exemption without his knowledge or consent, on the proper ground of the responsible work he had in hand. While this exemption was granted without limit, Mr. Hoffman declined to await another draft call, and joined an engineer regiment as a volunteer in January, as soon as Federal aid project No. 1 and an important companion project (concrete overcrossing of Northern Pacific Railway on the Pacific highway at Nisqually) were completed. He was almost immediately assigned to duty in France, after only a month of training at Camp Dix.

FEDERAL AID RECORD IN MAY.

In May the Secretary of Agriculture acted upon 111 projects, 35 of which went to final agreement. All covered 939.32 miles of road, for which the States estimated that they would expend $6,947,805.56, and asked Federal aid to the extent of $2,424,217.19.

Texas led in the number of projects acted upon, 15 of them reaching approval. The mileage involved is 249.7, the estimated cost $1,234,267.19, and the Federal aid allowed $440,829.37. Arkansas came next with 11 projects, covering 53.12 miles of construction, at an estimated cost of $312,398.20, toward which $112,992.23 was allowed as Federal aid. In 10 projects approved for Wisconsin that State undertook to build 48.7 miles of road for $337,355.01, with $111,863.66 of Federal aid.

While there were only five Pennsylvania projects approved, they were all of concrete construction, involving 49.08 miles to be built at an estimated cost of $1,535,587.37, toward which the Federal Government will allow $490,870.

Georgia is spending its money and $83,108.08 for the building of six bridges, for which it intends to pay $235,003.40. Oklahoma also has one bridge project which figures to cost $175,000, including the allowance of $50,000 Federal aid.

The most expensive single project is one in Pennsylvania, 32.82 miles of concrete in Dauphin, Lebanon, and Berks Counties, to cost $938,080 with a Federal aid allowance of $328,200. The longest single project is 59.20 in Bosque County, Tex., and the shortest 0.66 mile of brick or concrete in Lewis County, W. Va.

MAY FEDERAL AID STATISTICS.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Alabama	28	Coosa	5.80	Topsoil		May 29	$30,463.87	$15,231.93
Arizona	1	Pinal		Bridge		May 29	[1] 8,023.84	[1] 4,000.00
Arkansas	8	Lonoke	1.97	Water-bound macadam		May 29	8,871.72	3,169.00
	9	Monroe	8.08	Gravel, asphalt carpet coat	May 10		74,943.66	37,471.83
	10	Cross	1.46	Gravel		May 29	4,532.15	2,266.07
	11	Woodruff	2.99	Bituminous macadam		...do...	22,459.69	10,000.00
	12	St. Francis	7.60	Gravel		...do...	22,368.50	10,000.00
	13	...do...	4.94	...do...		...do...	26,180.00	5,467.10
	14	Jefferson	5.15	...do...		...do...	21,400.50	10,000.00
	15	Prairie	4.50	Bituminous gravel		...do...	25,197.83	10,000.00
	16	Lawrence	4.57	Macadam	May 10	...do...	22,698.22	7,500.00
	17	Craighead	5.81	...do...	...do...		69,509.55	10,000.00
	18	Benton	6.05	Gravel	May 6		14,236.47	7,118.23
Delaware	2	Sussex	11.60	Concrete	May 17		425,590.00	2,000.00
Georgia	2	Chattanooga	13.40	Gravel	May 21		33,000.00	15,000.00
	7	Macon	0.89	Two bridges	May 2		119,964.83	59,982.41
	11	Lowndes	0.42	...do...	May 23		55,088.57	25,000.00
	13	Muscogee	0.34	...do...	...do...		59,950.00	29,975.00
Iowa	13	Webster	12.00	Gravel	May 21		56,466.17	28,233.08
	15	Mills	13.00	Earth	May 9		45,870.00	17,455.35
Kansas	5	Bourbon	8.70	Water-bound macadam	May 28		60,812.44	9,121.87
	12	Geary	1.12	Concrete or brick	May 24		38,311.41	11,200.00
Kentucky	4	Carter	11.53	Earth	May 18		95,810.00	47,905.00
Michigan	6	Osceola	14.105	Gravel		May 29	148,196.85	74,248.83
	18	Grand Traverse	3.112	Gravel or macadam	May 6		44,050.05	22,025.02
	20	Van Buren and Kalamazoo	5.585	Concrete		May 25	131,152.08	55,850.00
Minnesota	3	Mille Lac	39.58	Gravel		May 8	127,312.17	50,000.00
	6	Carver	26.49	Earth		May 29	54,932.37	15,000.00
	10	Renville	12.00	Gravel	May 6		40,000.00	15,840.00
	12	Washington	5.265	...do...		May 25	20,089.61	10,000.00
	17	Carlton	12.00	...do...	May 13		29,700.00	11,500.00
	19	Goodhue	4.60	...do...		May 29	35,508.99	10,000.00
	20	...do...	21.85	...do...	May 6		82,599.00	35,000.00
	21	Wabasha	15.10	Earth	...do...		39,558.75	15,000.00
Mississippi	17	Hinds	4.26	Gravel	...do...		14,756.50	7,378.25
	19	Montgomery	9.11	...do...	May 2		30,573.84	15,000.00
	21	Lowndes	7.24	...do...	May 6		17,897.00	7,500.00
	22	Benton	11.80	...do...	May 2		68,097.48	24,000.00
	25	Amite	7.14	...do...	May 6		27,590.20	13,795.10
	26	...do...	7.86	...do...	...do...		22,643.50	10,000.00
Missouri	3	Vernon	6.54	Macadam		May 2	41,514.00	10,378.54
Montana	5	Big Horn	2.00	Gravel	May 9		9,949.28	4,974.60
	6	Dawson	12.00	Gravel, shale surface	May 14		19,210.00	9,605.00

[1] Amount increased over estimate previously approved.

MAY FEDERAL AID STATISTICS—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Montana	7	Dawson	12.25	Gravel	May 14		$19,853.24	$9,926.62
	8	Meagher	10.50	Earth	May 2		24,090.00	12,045.00
Nevada	7	Washoe	9.50	Gravel or macadam	May 6		81,954.40	40,977.20
New Hampshire	8	Sullivan	0.74	Telford base, modified asphalt surface		May 23	14,268.91	7,134.45
	9	Coos	0.85	Bituminous gravel		May 20	15,369.69	7,681.84
	16	Hillsborough	2.26	Modified asphalt surface	May 31		40,000.00	20,000.00
New Mexico	7	Quay	2.82	Earth gravel surface		May 29	12,179.27	6,089.63
North Carolina	5	Burke		Topsoil		May 13		[1] 2,500.00
	14	Halifax	8.61	Clay gravel		May 29	19,017.83	5,000.00
	16	Haywood	14.29	Gravel and sand-clay		May 1	64,705.05	15,000.00
	23	Burke	7.80	Topsoil	May 28		35,693.68	7,500.00
North Dakota	8	Eddy	9.29	Gravel		May 28	22,771.38	11,385.69
	22	Townes	21.20	Earth	May 17		15,943.00	7,971.50
	23	Lamoure	10.00	do		May 29	9,641.67	4,820.83
Ohio	18	Highland	7.43	Macadam	May 2		140,993.00	27,119.50
Oklahoma	1	Cleveland and McClain	0.372	Bridge	May 24		175,000.00	50,000.00
Pennsylvania	9	Butler	3.69	Reinforced concrete		May 11	111,954.92	36,900.00
	10	Lawrence	2.29	do		May 13	101,331.47	22,900.00
	11	Lycoming	6.95	do		May 16	249,298.39	69,570.00
	16	Butler	3.33	do		May 28	134,922.59	33,300.00
	17	Dauphin, Lebanon, and Berks.	32.82	Concrete	May 31		938,080.00	328,200.00
South Dakota	2	Lincoln	10.00	Gravel	May 6		41,553.16	20,776.58
	5	Minnehaha	3.00	Concrete or macadam	May 23		50,304.01	19,716.82
	6	Moody	9.13	Earth, partly graveled	May 28		26,774.44	13,387.22
	7	Deuel	8.60	Gravel	May 29		28,943.38	14,471.69
Tennessee	1	Hamilton	1.87	Waterbound macadam		May 14	54,737.67	25,937.07
	2	do	3.60	do		May 1	36,909.69	18,454.84
Texas	8	Hays	24.68	Gravel, bituminous top		May 25	46,926.55	21,565.50
	9	Lee	6.35	Gravel, concrete culverts	May 4		21,513.13	10,756.57
	24	Dallas	.972	Concrete		May 13	27,182.84	9,720.00
	32	Harris	3.183	Bituminous concrete		May 23	129,317.36	34,533.25
	48	Bosque	59.20	Gravel	May 20		237,208.81	60,000.00
	50	Coke	18.65	Sand-clay and gravel	May 6		44,836.00	20,000.00
	51	Madison	15.00	Gravel	May 31		57,035.00	25,000.00
	53	Jefferson	5.60	Concrete or shell, bituminous surface	May 6		94,237.00	20,000.00
	56	do	5.40	Concrete	do		88,968.00	20,000.00
	58	Ellis	11.54	Macadam	May 22		133,102.20	66,551.10
	60	Randall	19.00	Sand-clay	May 21		24,766.50	11,380.00
	62	Foard	30.25	Gravel and sand-clay	May 6		59,224.00	20,000.00
	64	Fannin	8.90	Gravel and concrete	May 22		75,645.90	37,822.95
	65	Fisher	23.00	Gravel	May 6		90,750.00	35,000.00
	70	Colorado	18.00	Bituminous and gravel	May 18		103,554.00	44,000.00
Vermont	1	Chittenden	0.922	Gravel		May 23	18,436.29	9,218.14
Virginia	7	Albemarle	3.163	Macadam	May 28		35,164.10	17,582.05
	8	Lee	.043	Bridge	do		16,370.00	8,185.00
Washington	8	Douglas	18.65	Macadam	May 18		127,500.00	63,750.00
	9	do	6.43	Gravel or macadam	do		37,500.00	18,750.00
	12	Thurston	3.55	Concrete	May 23		87,954.10	35,000.00
West Virginia	13	Roane	1.00	do	May 28		16,150.00	8,075.00
	15	Jackson	1.00	do	May 10		24,414.64	10,000.00
	21	Lewis	.66	Brick or concrete	May 18		21,335.00	6,935.00
	22	Hancock	1.051	Brick on concrete base	May 17		17,638.50	8,550.00
	23	Kanawha	3.00	Asphaltic concrete	May 11		73,220.12	20,000.00
	24	Preston	3.85	Bituminous macadam	do		36,960.00	10,000.00
Wisconsin	24	Jackson	2.50	Concrete	May 6		44,998.12	14,999.37
	28	La Crosse	2.32	Bituminous macadam	May 18		42,368.59	14,122.86
	29	Washburn and Barron	9.90	Earth	May 29		30,810.82	10,270.27
	32	Winnebago	3.52	Concrete	May 18		74,838.48	24,946.16
	34	Iowa	8.17	Earth	May 27		22,869.00	7,623.00
	35	Dodge	3.18	Gravel or macadam	May 4		29,958.50	9,986.17
	36	Milwaukee	.78	Concrete	May 11		22,978.39	7,659.46
	41	Grant	2.16	Earth	May 6		20,713.00	6,904.33
	43	Trempealeau	3.30	do	May 11		17,985.11	5,995.04
	44	Juneau	11.87	Earth, partly sand-clay surface	May 28		29,865.00	9,955.00
Wyoming	3	Lincoln	6.23	Earth	May 20		13,428.14	6,714.07
	13	Carbon	13.88	do	May 11		14,500.75	7,250.37
	15	Lincoln	2.817	do	May 28		15,969.69	7,984.84
	18	Uinta	12.50	do	May 29		5,940.00	2,970.00
Total	111		939.3203				6,947,805.56	2,424,217.19

[1] Increased Federal aid allowance on project previously approved.

SEES BENEFIT IN REGULATING USE OF ASPHALTIC OIL.

What will be the probable effect upon the use of asphaltic oils in road construction of the regulations of the United States Fuel Administrator? The direct answer is that the use of asphaltic oil in road construction will be heavily curtailed. This statement of facts is or should be self-evident to all readers who have followed the effects of the war upon the industries of the country for the past few months, and the fact that fuel-oil regulations were necessary would, to the thinking man, imply automatically that the use of oil for other than fuel purposes must be curtailed.

As to the extent to which the use of asphaltic oils will be limited in road construction and maintenance, it would be as impossible to even approximately estimate as it would be to state with any reasonable accuracy the probable duration of the present war.

Personally, I would plead for the anticipation of Government curtailment, and believe that every person interested in road work is under moral obligation to his country to refuse to bid upon work which is not essential, and if necessary to change occupation to some essential war industry for the period of the war in order to assist, rather than hamper, the efforts of the Fuel Director. In other words, I would state that the question to each person interested in road construction should not be

"How can I get this across and get this material?" but rather "How can I best arrange that the use of this material will not be necessary as long as it is needed by the Government for other purposes?"

Aside from the quantity which may be available, and from the attitude of those who need, or think they need such material under present conditions, there is one very important bearing which a shortage of asphaltic oil will have upon the road question, and in this respect I believe that the above shortage will be a blessing in disguise.

It has long been the custom of county and city officials and road contractors to underestimate the real value of asphaltic road oils, the reason for this being that the material has in the past been comparatively cheap, and there has been a tendency to take a long chance at getting good results upon poorly prepared roadways, with the result that the work has been improperly done and only partially staisfactory results secured.

Under present conditions it will be necessary to secure the maximum of efficiency from each gallon of asphaltic road oil available for road treatment, which will lead to a more careful study of the essentials of successful treatment, and in the end, I believe, will result in vastly improved construction of roadways intended for asphaltic oil treatment.

The writer, after over seven years of practical experience with road oil treatments in the southwest, is willing to stand by his early declaration, that the best road it is possible to construct is none too good to oil, and this follows directly in line with my statement above, that I believe the present curtailment of asphaltic oil for road purposes will ultimately be of vast benefit.

—Philip Bell, Dallas, Tex.

STATE AID ONLY FOR WAR NEEDS.

The executive committee of the New Jersey State Highway Commission has decided to withhold approval of State aid from all highway projects not vitally essential to the war needs and activities or to the economical welfare of the various counties in the State. It was further decided that to be eligible for State aid for highways the counties and municipalities must properly maintain the routes of the New Jersey highway system that lie within their respective borders until such time as the commission will assume jurisdiction.

CELEBRATE OPENING OF HIGHWAY.

The State and citizens celebrated early in July the completion of the Asheville-Charlotte highway, a part of the scenic roads through the North Carolina mountains. Addresses were made by the governor and members of the State Road Commission.

ROADS AT $81,000 A MILE.

An adequate idea of the present cost of road construction may be gathered from three bids received recently by the New Jersey State Highway Department for the construction of one and eight-tenths miles of Route No. 1 of the State highway system from Menlo Park to Metuchen. The lowest of these bids was for $145,000, or a fraction more than $81,000 per mile. These bids were the first received for the proposed work on the State highway system and afford a possible basis for estimating the actual cost of construction as compared with the engineering estimate of the department, which was lower than the lowest bid. The roads will be 10½ inches of concrete in the center and 8 inches on the sides, with macadam shoulders 3 feet wide.

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OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING ROAD PUBLICATIONS.

NOTE.—(Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free).

REPORTS.

*Report of the Director of the Office of Public Roads for 1914. 5c.
*Report of the Director of the Office of Public Roads for 1915. 5c.
Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.

BULLETINS.

(In applying for these bulletins the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28").

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53.")

*Dept. Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
583. Report on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.

*Department supply exhausted

OFFICE OF PUBLIC ROADS CIRCULARS.

(In applying for these circulars the name of the office as well as the number of the circular should be given, as "Office of Public Roads Circular No. 89.")

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation. and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
*96. Naphthalenes in Road Tars. 1. The Effect of Naphthalene upon the Consistency of Refined Tars. (1911.) 5c.
*97. Coke-Oven Tars of the United States. (1912.) 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads. 5c.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.

FARMERS' BULLETIN.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239.")

F. B. *239. The Corrosion of Fence Wire. 5c.
311. Sand-Clay and Burnt-Clay Roads.
338. Macadam Roads.
*403. The Construction of Concrete Fence Posts. 5c.
*461. The Use of Concrete on the Farm. 5c.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

(In applying for these separates the numbers should be given, as "Yearbook Separate No. 638.")

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D–2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle.
Vol. 6, No. 6, D–8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D–12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10. No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No 10, D–15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

*Department supply exhausted.

FARMERS IN FIRST-LINE TRENCHES OF THE FOOD ARMY

The efforts and achievements of the millions of farm men and women have been noble and remarkable. The farmers have occupied the first-line trenches of the food army. They and the agencies assisting them—the Federal Department, the State colleges, and departments of agriculture—were prepared when we entered the war and had been for years, and I venture the assertion that no section of our people and no agencies have done a better job. They were charged with the responsibility for maintaining and increasing food production. How they have discharged their tasks the results of last year's production operations and of this year eloquently testify. But farmers are not spectacular performers—they never are. They do not furnish sensations and headlines. They have no fixed labor day. They work in season and out of season—from early morning till dusk; but they do not work in the limelight. They are not in the view of people living in cities, the centers of intense publicity.

Urban dwellers ordinarily devote very little thought to rural districts and to sources of food supply. Heretofore they have not had to think much about food. If it is abundant, as it usually is, they take it for granted. If it becomes scarce, they develop hysteria and an amazing capacity for making suggestions. Within the last year city people have manifested an intense interest in food, and, not knowing their Government, some of them have developed the highly interesting proposal that some Government agency should be created to give attention to production. They have seen windows placarded and papers filled with pleas for conservation, for investments in Liberty bonds, and for subscriptions to the Red Cross. They have wondered why they have not seen similar evidence of activity in the field of production. They do not know of the thousands of men and women quietly working in every rural community of the Nation and the millions of bulletins and circulars dealing with the problems from hundreds of angles. They forget that the field of work lies outside the city. They do not recognize that both the problem and the method are different.

It is one thing to ask a man to save. It is one thing to ask a man to invest in Liberty bonds. These things tremendously aid the Nation; but they are also a certain benefit to the individual. It is another thing to ask a man to put his labor and capital into the production of food, facing the hazard of the weather, of distribution, and of the market. Advice to him to do so is one thing; assistance to him to lessen his hazard is another; and such assistance is furnished so quietly that a great part of the Nation knows nothing of it and innocently assumes that nothing is done.—*Extract from speech of Secretary Houston at Dubuque, Iowa.*