U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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HIGHWAY ADMINISTRATION AND ROAD CONDITIONS IN FRANCE

IN OCTOBER, 1919, the Department of State, at the instance of the transportation section of the Council of National Defense, transmitted a questionnaire to American consuls regarding highways and highway transport conditions throughout the world.

To date replies have been received from about 90 consular districts. The data is voluminous and much of it is of considerable value. The questions which were asked, and to which replies are being received in one form or another were as follows:

1. Total number of miles of road in the country, outside of incorporated cities and towns.
2. Classification as to character of improvement and type of roads.
3. Classification according to administration.
4. Cost of construction per mile, also per square yard, under the various stated classifications.
5. Cost of ordinary maintenance per mile and per square yard per annum under the various classifications given, excluding resurfacing and extraordinary repairs.
6. Annual amount of Government expenditure for construction, for ordinary maintenance, and for extraordinary repairs.
7. Amount and character of local contribution of each administrative class and nature of apportionment and securement.
8. Nature of governmental direction of construction and maintenance, including jurisdiction and supervision, describing administration and organization.
9. Comparison and relation of units of government in other countries for purpose of comparison with the United States, namely, the correlation between our States, counties, and road districts and our Federal Government.
10. Whether or not any tax is levied on abutting land; if a tax, the nature, amount, and method of collection.
11. Where obtainable, secure concrete tables showing cost per ton-mile of highway transportation, both before and after road improvement, the desideratum being to ascertain the saving in hauling freight on highways on the basis of the ton-mile because of the road improvement.
12. Cost of hauling produce or freight per ton-mile, giving data on which such estimates are formed, including tonnage, general nature of freight, kind of vehicles used, whether cost of vehicles and power taken into calculation; if so, what percentage of cost charged for annual depreciation. Maximum load in each case, number of individuals figured in making up estimates, and wages or cost of labor in the activity, and average length of haul on which the calculation is made.
13. Whether good road or highway construction has to any degree been substituted for railway branch lines or feeders to railroads; whether railroads, where under private ownership, contribute in any way to tax or contribution, directly or indirectly, toward road construction.
14. Average length of highway haul for produce or other commodities from point of origin to destination, excluding rail and water haul.
15. National and local sources and methods of raising revenue for highway construction and maintenance.
16. Explain system of estimates, accounting, and cost keeping, tracing road funds from origin to final audit and approval, submitting such forms and reports as are customarily used, also table of salaries and administrative personnel.
17. Any concrete information obtainable where highway improvements have increased the value of abutting and contiguous property and the percentage of such increase in value.
18. Number of highway transportation units in operation and type, specifying separately motor passenger and freight vehicles, and other means of travel such as horse, mule, or bullock drawn wagons.
19. Plans for future highway construction and type of road to be constructed.
20. General forecast as to possibilities of future development of country through means of improved highways transportation.

On account of the value of much of the material which is being received, the Bureau of Public Roads will publish the most important data in Public Roads in serial form.

INFORMATION FROM FRANCE.

France has been selected as the subject of the first installment because of its preeminence in matters of road construction. Subsequent issues will publish the data on the British Isles, Canada, Switzerland, Sweden, and other countries. The greater nations will be treated as fully as the data at hand will permit; the information received from the lesser countries will be abstracted and published in condensed form. Those who are interested to obtain more information than is contained in the published data may do so by applying either to the Bureau of Public Roads or to the Council of National Defense where the original reports are on file.

The French information published in this installment has been obtained from the consular offices at Lyon and St. Etienne, which, together, are responsible for 20 of the 87 departments, as follows: Ain, Belfort (Territory), Drôme, Haute-Saône, Haute-Savoie, Isere, Jura, Rhône, Savoie, Saône-et-Loire, Allier, Côte-d'Or, Doubs, Ardeche, Aveyron, Cantal, Haute-Loire, Lozere, Loire, and Puy-de-Dome.

It is, therefore, in no sense complete, but it is sufficiently inclusive to convey a knowledge of road conditions, and methods of administration in our sister Republic far more exact than the average American highway engineer has heretofore possessed.

The French units of government corresponding to the American units are as follows:

The State corresponding to our Federal Government.

The Departments corresponding to our States.

The arrondissments corresponding to our counties.

The communes corresponding to our townships.

All roads are classified as follows:

Routes nationales, or National highways, which are under the administration of the National Government.

Routes departementales, or State highways, which are under the direction of the Departments.

Chemins de grande communication, or main lines of communication, and chemins d'intérêt commun, or roads of general interest, correspond to our State-aid roads and are built by the communes, supplemented by grants from the Departments.

Chemins vicinaux ordinaires, or ordinary country roads, are almost entirely at the expense of the communes, with occasional aid from the Federal Government.

THE NATIONAL HIGHWAYS.

The routes nationales, or national highways, are constructed and maintained in condition by the ministry of public works, under which in direct charge is the Service des Ponts et Chaussées, or the department of roads and bridges. Funds for construction and maintenance of roads of this class are derived solely from national sources, except that in certain cases of special repairs, as when it is necessary to tar the roads, a special tax is levied on the beneficiaries by the improvement (either 50 per cent of the cost or in proportion to the advantages deemed to accrue).

Plans and specifications are prepared by the department of roads and bridges, and the construction and maintenance of the roads are executed under the supervision of the Parisian Department.

Basing the estimate on the returns from nine Departments, which report the mileage of the roads of the several classes, the routes nationales constitute approximately 6 per cent of the total mileage of roads in the country.

Gravel and macadam are the prevailing types of surfaces, the roads of heaviest traffic being paved with stone blocks. Owing to the general increase in the weight and volume of traffic in all Departments, there is a tendency to replace madacam with more durable pavements. Asphalt will be used on certain routes, and where it is not sufficient paving stones will be used to resist the traffic.

The width of the national highways varies from about 19 feet to 29 feet including sideways or shoulders. Their thickness is difficult to determine, owing to the fact that they have been built up through successive applications of stone decade after decade. Many of them undoubtedly are upward of 20 inches in thickness. One road of this class, route national 23, which was resurfaced by the American Army, is reported by the officer in charge of the work to have the following composition, totaling 42 inches in thickness: A surface course of 3 inches of limestone, underlain successively by 4 inches of trap rock, 7 inches of coarse gravel, 18 inches of crushed granite in 3 or 4 inch fragments and 10 inches of Telford base. In resurfacing it is common to add from 3 to 4 inches of new stone.

The average cost of construction of all national highways before the war was 45,000 francs per kilometer, or about $13,685.75 per mile.[1] As the prewar costs of nearly all commodities and services have since been increased from 250 to 300 per cent, the cost of such construction is now probably from $32,000 to $40,000 per mile.

The 1920 budget estimates the cost of maintaining the roads of this class at 1,800 francs per kilometer, or about $550 per mile.

STATE HIGHWAYS.

The routes départementales, or State highways, constitute about 4½ per cent of the entire mileage of roads. They are paid for entirely from the funds of the Departments. The departmental commission appoints the personnel of the road service, a corps of State engineers known as agents-voyers, which consists of a chief road surveyor, two district road surveyors, and from 20 to 40 local road surveyors for each of the 87 departments. This corps assumes control over the preparation of the plans, and the execution of surveys, construction, and maintenance for the departmental roads. The Federal Government intervenes in the construction only when it is necessary to take possession of private property for the public use or to approve laws dealing with the alignment of buildings along the thoroughfares.

In type of construction the departmental roads are similar to the routes nationales. In width they average from 5 to 6 meters, i. e., from about 16 to 20 feet. Their thickness is usually considerably less than that of the national highways, conforming in this respect more closely to the dimensions of American roads. In the Department of Haute-Savoie, for example, the specified minimum thickness is 0.20 meter or 7.84 inches.

Before the war the Departments were paying in the neighborhood of $8,000 per mile for roads of this class. It is estimated that this cost under present conditions will be tripled. The cost of maintenance, which in the prewar days was about $300 per mile, is expected to amount to $500 or $600 per mile this year.

In many of the Departments all roads have lately been reclassified, and the departmental classification

[1] The rate of exchange in this conversion as in all others in this article is assumed to be 1 franc=19.3 cents.

TOP, THE CONDITION OF ROUTE NATIONALE 23, FRANCE, AFTER THE ARMISTICE. BOTTOM, THE SAME ROAD AFTER IT WAS RESURFACED BY THE ENGINEERS OF THE AMERICAN ARMY.

has been abandoned. Roads formerly in this class have been denominated main lines of communication and will be maintained hereafter by joint funds of the Departments and the communes.

MAIN HIGHWAYS AND COMMUNAL ROADS.

Roads of these classes, comprising the chemins de grande communication, the chemins d'intérêt commun, and the chemins vicinaux ordinaires constitute the large majority, approximately 90 per cent of the total of 417,500 miles of road in France.

As the national roads are designed to connect the principal cities of the Republic, so the main lines of communication connect the lesser cities of only local importance.

The road surveyors, or agents-voyers, have charge of the construction and maintenance of these roads. In general, the costs are defrayed from the funds of the communes supplemented by grants from the Department, the latter paying as much as 55 per cent. The communes interested meet their quotas from their ordinary sources of revenue, or if this is insufficient, by a special small tax of a few centimes levied upon all whose names are enrolled on the direct tax list. In addition to the monetary taxes, the communes also exact three days' labor per year of every able-bodied male inhabitant between the ages of 18 and 60, or in lieu of the labor a cash contribution at a regular rate per day. If a man is the head of a family he is responsible for the labor or prestation of every able-bodied male member or employee of his family as well as for every beast of burden and every vehicle which he owns, for these also are subject to the three days' prestation. Public-spirited citizens often contribute to the construction of the roads by the free transfer of their lands for that purpose. In such cases, the value of such lands is deducted from the amount of the contribution due from the town.

SPECIAL TAX ON HEAVY VEHICLES.

One of the taxes levied by the French which will be of special interest to highway engineers in America is the special tax which is levied upon large industries whose business is such as to impose unusual wear and tear on the roads by their heavy traffic. This tax is known as the industrial subsidy.

No special taxes are levied upon abutting property. In general, roads are constructed, not for the purpose of increasing property values, but to unite the towns and villages and facilitate their mutual intercourse and commercial relations. The Frenchman concedes that the creation of new roads adds to the value of the property traversed, but such increase is too variable, he thinks, to ascertain with accuracy. Moreover, it is much less important than one would suppose on account of the great number of roads already existing. It is the exception where the construction of a new oad increases the value of abutting or contiguous property to any notable extent. If the owners of property wish to increase the value of their lands unprovided with roads, they construct them at their own expense.

While the main routes are not departmental roads, but rather are supposed to belong to the communes through which they pass, the fact that they extend over several towns gives them an intercommunal value which justifies placing them under departmental administration. The closest American counterpart of the roads of this class are the State-aid roads of our States. For the reason above stated the roads of this class are placed under the administration of the Department prefect or governor, subject to the payment by the towns interested of the annual quota for their maintenance and repair. Estimates relative to the funds required for construction, maintenance, and repair are prepared annually by the Department road surveyors, and such estimates for the coming year are incorporated in the primitive budget established by the general council of the Department in its second session. At the first session in the year for which the estimates have been made the council votes a supplementary budget to which are added the funds left over from the preceding quarter and the new receipts. Expenditures for construction are approved by the prefect and paid by the treasurer of the Department.

The departmental accounts are settled annually, but the road accounts extend over a period of 14 months, at the end of which the treasurer renders his accounts and vouchers showing the receipts and expenditures for the construction and maintenance of the roads to the cour des comptes at Paris which audits the accounts of the treasurers of all the Departments.

The roads of general interest and the ordinary country roads which are comprised in the last two classifications are solely of communal value and concern, except that where the commune requires aid in keeping its roads in shape, it may receive aid from the Federal Government, or under rare conditions from the Department. Any balance which remains in the funds derived from the regular and special taxes after the share of the commune in the cost of the main highways has been met is devoted to the construction and repair of the roads of lesser importance. There is, moreover, a provision allowing an extra day of prestation to be devoted to these classes of roads.

The agents-voyers do not concern themselves with the roads of this class; they are administered entirely by the mayors of the towns. On a smaller scale the machinery established to account for and expend the town road funds is similar to that which has already been described for the Department, the accounts of the town treasurer being verified annually by the council of the prefecture if the ordinary resources of the town do not reach the sum of 30,000 francs, and by the cour des comptes, if they exceed that sum.

Like nearly all roads in France the main and lesser communal roads are generally surfaced with macadam, and are from 4 to 5 meters in width, with a minimum thickness of about 6 inches. On the main roads the grades compare favorably with those of the national and departmental highways, and on the lesser roads the grades do not generally exceed 8 per cent, though occasionally an aclivity of 10 or 12 per cent is found, in which case the road becomes little better than a mule path, its outside width not exceeding 3 meters or about 10 feet.

WAR HALTS SYSTEMATIC MAINTENANCE.

The famous maintenance system to which America and the world have turned for a pattern of all that is best in road up-keep was totally disrupted by the war. Almost no attention could be given to the roads from 1915 to the end of 1918, except in the war areas. In such areas the effort was to keep the roads passable for army traffic, not, as in other days, to maintain them in perfect condition. Such neglect has been attended by its natural result. The roads, especially the national and departmental roads and the main lines of communication which have borne the brunt of the war traffic, are in a serious condition of disrepair. This is especially true in the neighborhood of army camps and in the environs of large industrial centers.

Many of the Departments are now setting about to repair the damage which has been done and it is hoped that by 1923 the condition will be greatly ameliorated. The task is made more difficult than it was before the war by reason of the fact that while the traffic of heavy units has fallen off since the war, it has not, by any means, dropped to the prewar density. Heavy motor camions are now to be seen in far greater numbers than in former years, and the deterioration of the roads is expected to be more rapid than formerly.

LABOR AND MATERIAL LACKING.

Necessary as it is that the work of rehabilitation be prosecuted with the utmost expedition, the Departments are faced with the fact that the desired speed will not be possible to attain. Many of the cantonniers are not yet released from the military service. Labor to take their places and to augment the usual forces is scarce and expensive. Supplies of material have not been obtainable except at great difficulty, particularly because of the lack of enough railway cars. Before the war, machinery was not used in the construction of the French roads in any manner approaching the use which is made of it in America and England. Now it is recognized as an essential to replace laborers and animals by mechanical devices. Already a number of the departmental councils are in touch with leading French, British, and American manufacturers looking to the purchase of equipment and machinery with which to carry on the war against the forces of road destruction. Indeed the recital of the difficulties which, for the French highway engineer, have followed in the train of the war, and the plans which are being made for the solution of the problems sounds to an American like a description of the situation which confronts his own country. The problems of the two countries seem to be identical; the general lines of the solutions which are being worked out are similar; and it would seem that great benefit would result to the engineers of the two Republics from a more intimate interchange of experiences.

PAY OF ENGINEERS AND LABORERS.

Engineers in public service in the United States will no doubt be interested in the scale of salaries paid to their brothers in France, listed in the following table, which applies to the Department of the Loire.

	Salary per year.
Agent-voyer en chef (State highway engineer)	$2,120–$2,700
Agent-voyer d'arrondissement (district engineer)...	1,740– 2,030
Agent-voyer cantonaux (resident engineer)	1,060– 1,740
Employés expéditionnaires (assistant engineers)....	870– 1,350
Dames dactylographes (stenographers)...............	695– 1,000

The salaries seem somewhat low in American eyes, but the numerous perquisities and allowances add to them materially, particularly if the engineer is so fortunate as to have a family. Thus there is an annual allowance for traveling expenses which varies from $150 to $450. The annual quarters allowance is only from $20 to $60. But for his family the engineer receives a substantial gratuity for each child under 16 years of age. For each of the first two he receives $63 per month. For the third child the allowance is $87 per month, and if he is blessed with a more numerous family he receives $93 per month for the fourth and each younger child.

Wages of laborers have not yet reached the high levels attained in the United States, but they have greatly increased since 1905. In that year road foremen in the Department of Saone-et-Loire were paid only $16 per month, and laborers received $12 for a month's work. The rates reported from the Department of the Loire for 1920 are $55 to $61 per month for road foremen and $46 to $55 per month for laborers. In addition the laboring forces also receive allowances similar to those received by the engineers. If he is stationed in a large industrial city the chief cantonier receives a monthly addition to his pay which varies from $3 to $7.30; laborers similarly situated receive from $2 to $6 monthly. The chief cantonier receives the equivalent of about $24 per year for his bicycle which he uses in making inspections, and if he makes a trip exceeding 20 kilometers on foot or 30 kilometers by bicycle, he is allowed 35 cents additional. His lodging is paid for at the rate of $1 a night, and in addition to all these, foremen and laborers alike are granted the same gratuities for family maintenance which are extended to the engineers; in their case, however, only for children under 13 years of age.

THE USE OF ROADS.

The reports indicate that the maximum haul for produce or other commodities from the point of origin to destination, excluding rail and water haul, is about 40 kilometers (18.5 miles). This is the maximum round-trip distance which may be covered by an ordinary team of horses in one day; the average haul by road is somewhat less. For distances exceeding 18 miles the railroad is used where there is one. However, since the railway strike a large number of industries in the larger centers transport their commodities by motor trucks, in which case the haul is reported as much greater, but no definite limits are assigned.

In some small towns and villages short roads have been constructed leading to the railway stations situated near the towns, and in such cases it is the railway company which pays the cost of constructing such roads.

The use of motor trucks has greatly increased since the transport crisis, and it is reported that the companies engaged in moving freight charge from 21 to 26 cents per kilometric ton per kilometer, which is from 31 to 38 cents per ton-mile, approximately. No estimate as to the actual cost to the companies was obtainable, nor as to the percentage of profit contained in their public prices. More indicative, perhaps, of real costs is the estimate given by the municipal road service of the Department of Rhone. No profit being figured in the costs of operating and care of the municipal trucks, the actual cost to the municipality is stated as averaging 3 francs per 4½ kilometric tons per kilometer, which is about 20 cents per ton-mile.

MARKING THE HIGHWAYS.

The increased use of the roads by motor traffic during and since the war and the prospective influx of tourist traffic has directed attention to the importance of a revision of the system of highway marking.

The small iron signs which have heretofore been used have been suitable for low-speed traffic but will not do for a rapidly moving traffic, as the inscriptions are so small that they can not be read while cars are in motion, and at night they are often without the radius of automobile headlights.

During the war the French and allied armies had recourse to striking signs with large letter inscriptions, painted on wood or canvas, or, whenever possible, on the walls of houses. These were placed at a proper height to be seen by drivers without difficulty by day or night. The direct result has been that the French Ministry of Public Works has decided to carry out the ideas developed through the war traffic: (1) By indicating noteworthy places, such as the names of towns, or dangerous places, and (2) by denoting the distance and direction to other places of importance.

A circular issued in August, 1919, by the ministry and addressed to all prefects of the departments, requires that the names of villages must be conspicuously posted, on a post or the wall of a building, as far as possible, perpendicular to the axis of the road and on its right.

A standardization of danger signals will result from the decision to use only the four signals adopted by the International Conference relating to automobile traffic held on October 11, 1909. The four signs indicate inclines, turns, road crossings, and railroad crossings, respectively, and they are to be placed at about 275 yards from the danger point unless special conditions prevent. They are to be perpendicular to the road and on the right of the direction followed.

Direction signs will be placed at the entrance to and exit from all hamlets, as well as at branch and cross roads. At road intersections there is to be a different signboard for each direction, containing only the following information: (*a*) The name of the first place or village in the direction indicated, and (*b*) the name of the first important town in that direction. The latter name will be identical on successive posts until the town in question is reached. Beside each name will be the distance in kilometers. The inscriptions are to be headed with an arrow and an abbreviation indicating the class of the road. All signs are to be placed so that they are within the radius of the lights of vehicles, and 6 feet 6 inches above the road if they are in a place where there is much pedestrian traffic, and 6 feet 3 inches high at the most if on a wall. The latter placing is recommended.

The inscriptions are to be white on a dark-blue background, with the lettering at least 5.9 inches in height, except for danger signals. Numerals will be a little smaller than letters. Iron, varnished sheet iron, or wooden signs are authorized. Enamel signs are not recommended, as they deteriorate too easily and are difficult to repair. Legislation is in preparation enabling the painting of signs on walls adjoining the roads, notwithstanding the opposition of the owner.

In carrying out the arrangements for the placing of these signs care is to be exercised to safeguard good appearance; the signs are to be looked after, so that the inscription will always be legible, and old-style signs are to be suppressed if they conflict with the new ones. It is hoped that the entire program of marking the roads of the Nation will be completed by December 31, 1921.

SUGGESTIONS FOR IMPROVEMENT OF THE DEVAL ABRASION TEST FOR ROCK.[1]

By F. H. JACKSON, Senior Assistant Testing Engineer, Bureau of Public Roads.

THIS Deval abrasion test is probably the best known and most widely used of the methods which have been developed for testing the quality of road-building rock. It has been in continuous use in this country for over 20 years and, in general, has been considered satisfactory for the purpose for which it was designed; that is, to measure the relative resistance of rock to wear or abrasion. In spite of this fact, however, it must be confessed that the method is weak in at least two particulars. In the first place, experiments made recently have indicated the possibility of a considerable error in results obtained due to variations in laboratory manipulation. For instance, Mattimore, in 1917, reported[2] a series of results in which 10 tests on a sample of dolomite made in the same laboratory and by the same operator but on different days showed a maximum variation in percentage of wear of 0.9 per cent. A corresponding series of tests on syenite showed a maximum variation of 1.3 per cent. In the same year Reinecke and Clark[3] in a paper before the society reported a maximum variation of 0.6 per cent on 17 duplicate sets of limestone, and a corresponding maximum variation of 0.3 per cent on 7 duplicate sets of igneous rock. In both of the cases cited, care was exercised to insure, as nearly as possible, the use of identical material in all of the check tests. The variations noted are therefore assumed to be due to laboratory manipulation alone.

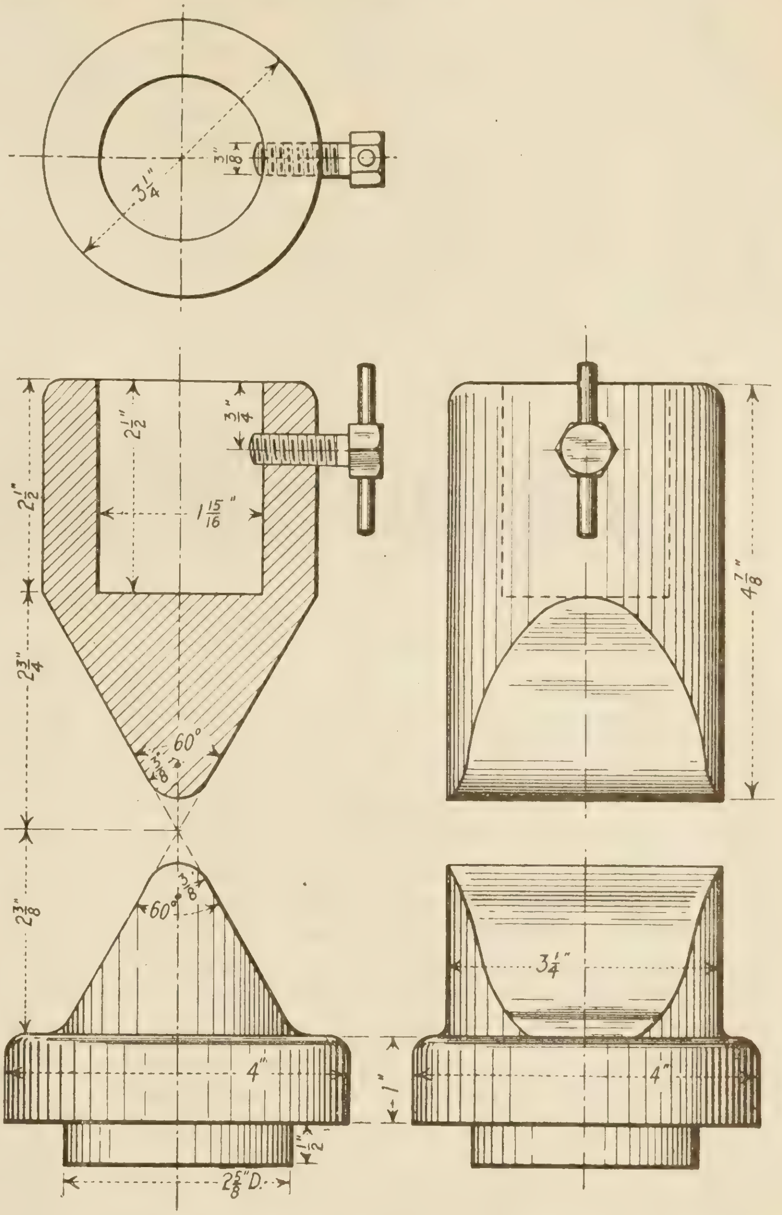

FIG. 1.—KNIFE EDGES USED ON MACHINE FOR PREPARATION OF SAMPLES FOR ABRASION TEST.

Results of tests made by the author along the same line are given in Table I. The results shown in the table were obtained from time to time in the course of the routine work of the laboratory of the Bureau of Public Roads and extended over a period of a year or more. No effort was made to specially prepare any of the samples. They were, however, all prepared by the same operator—an experienced man who has been engaged in this work for the past 18 years. These results indicate clearly the degree of accuracy which may be expected in a given laboratory and under average normal conditions. It will be noted that the average maximum deviation for the four types examined amounts to approximately 0.8 per cent. This would correspond, in the case of granite, trap, or other hard rock having, for instance, an average percentage of wear of 3, to a possible variation of from 12 to 16 in French coefficient of wear, or 4 points. This is rather a serious error and calls for a greater tolerance in interpreting the results of tests than we have been in the habit of considering necessary. The principal reason for the discrepancies noted is the practical impos-

[1] Paper read at the annual meeting of the American Society for Testing Materials, Asbury Park, N. J., June 22-25, 1920.
[2] Proceedings, Am. Soc. Test. Mats., Vol. XVIII, Part II, p. 415 (1918).
[3] Ibid., p. 398.

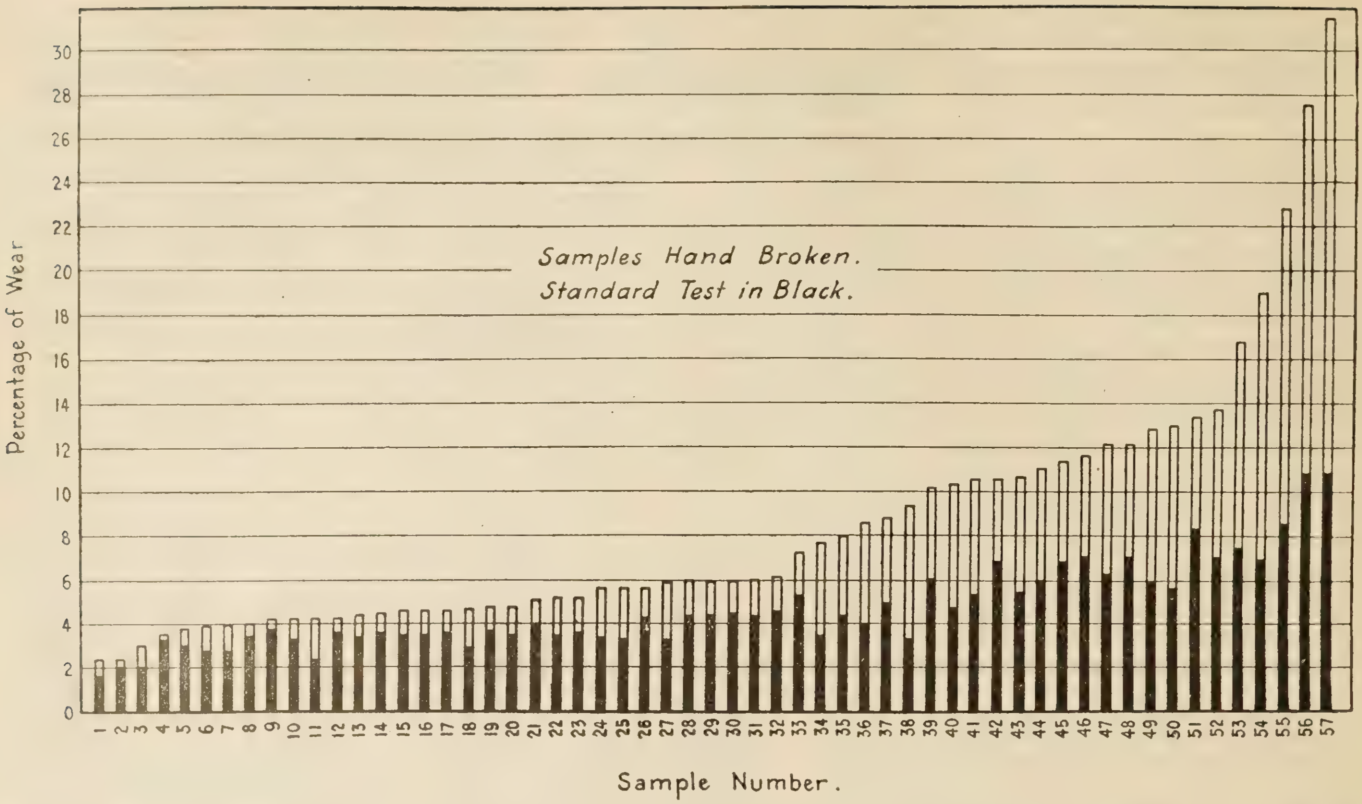

FIG. 2.—DIAGRAM SHOWING COMPARATIVE RANGE IN PERCENTAGE OF WEAR OF ROCK TESTED IN THE STANDARD AND SLOTTED ABRASION CYLINDERS.

sibility of securing by the ordinary method of hand-breaking a test sample consisting of 50 pieces all of the same size and shape. It is, of course, obvious that variations in either respect will affect the results obtained, particularly if the stone be unusually soft or brittle. The present standard method requires that a sample of rock for the abrasion test shall weigh within 10 g. of 5,000 g. and shall be composed of 50 pieces of freshly broken stone of as nearly the same size as possible. While no reference is made to the shape of the pieces, the assumption has always been that cubical fragments should be prepared. It has been the author's experience that such a sample is extremely difficult to prepare in the ordinary manner in a reasonable length of time. As a matter of fact, it may be doubted whether it is even approximated in the majority of laboratories.

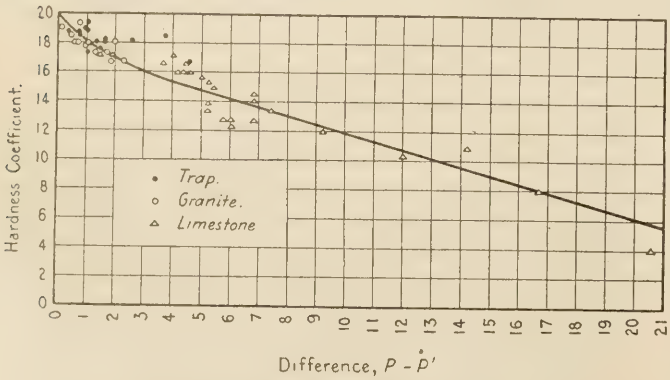

FIG. 3.—RELATION BETWEEN COEFFICIENT OF HARDNESS AND DIFFERENCE BETWEEN THE PERCENTAGE OF WEAR AS DETERMINED BY THE STANDARD METHOD AND WITH THE SLOTTED CYLINDER.

TABLE I.—*Comparative results of abrasion tests using standard and proposed methods.*

Test No.	Type of rock.	Percentage of wear by standard method. Individual results.			Average.	Maximum deviation.	Percentage of wear by proposed method. Individual results.			Average.	Maximum deviation.
1	Granite....	4.0	4.3	4.6	4.3	0.6	6.0	5.8	5.7	5.9	0.3
2	.....do.....	5.0	4.4	4.6	4.7	0.6	6.0	5.9	6.1	6.0	0.2
3	.....do.....	3.0	3.3	2.9	3.1	0.4	3.9	4.1	4.0	4.0	0.3
4	Trap.......	2.0	2.7	2.5	2.4	0.7	3.0	3.2	3.0	3.1	0.2
5	.....do.....	2.9	2.5	2.6	2.7	0.4	4.0	4.1	4.3	4.2	0.3
6	Limestone.	5.9	6.3	6.8	6.3	0.9	12.0	12.3	12.4	12.2	0.4
7	.....do.....	9.3	10.8	10.6	10.2	1.5	29.4	29.0	29.6	29.4	0.6
8	Sandstone.	5.8	6.7	7.0	6.5	1.2	13.1	13.0	13.3	13.2	0.3
	Average.	......	......	......	......	0.8	......	......	......	......	0.3

USE OF FORCING PRESS.

Appreciating the need of a more rapid as well as accurate method of preparing samples, the laboratory of the Bureau of Public Roads has been for some time experimenting with a forcing press equipped with suitable knife edges for breaking stone. It was first used by the laboratory in the preparation of granite paving block samples for test because it was found that the variations obtained when specimens were hand-broken were so great that the results were of little value. It has a capacity of 20,000 pounds,

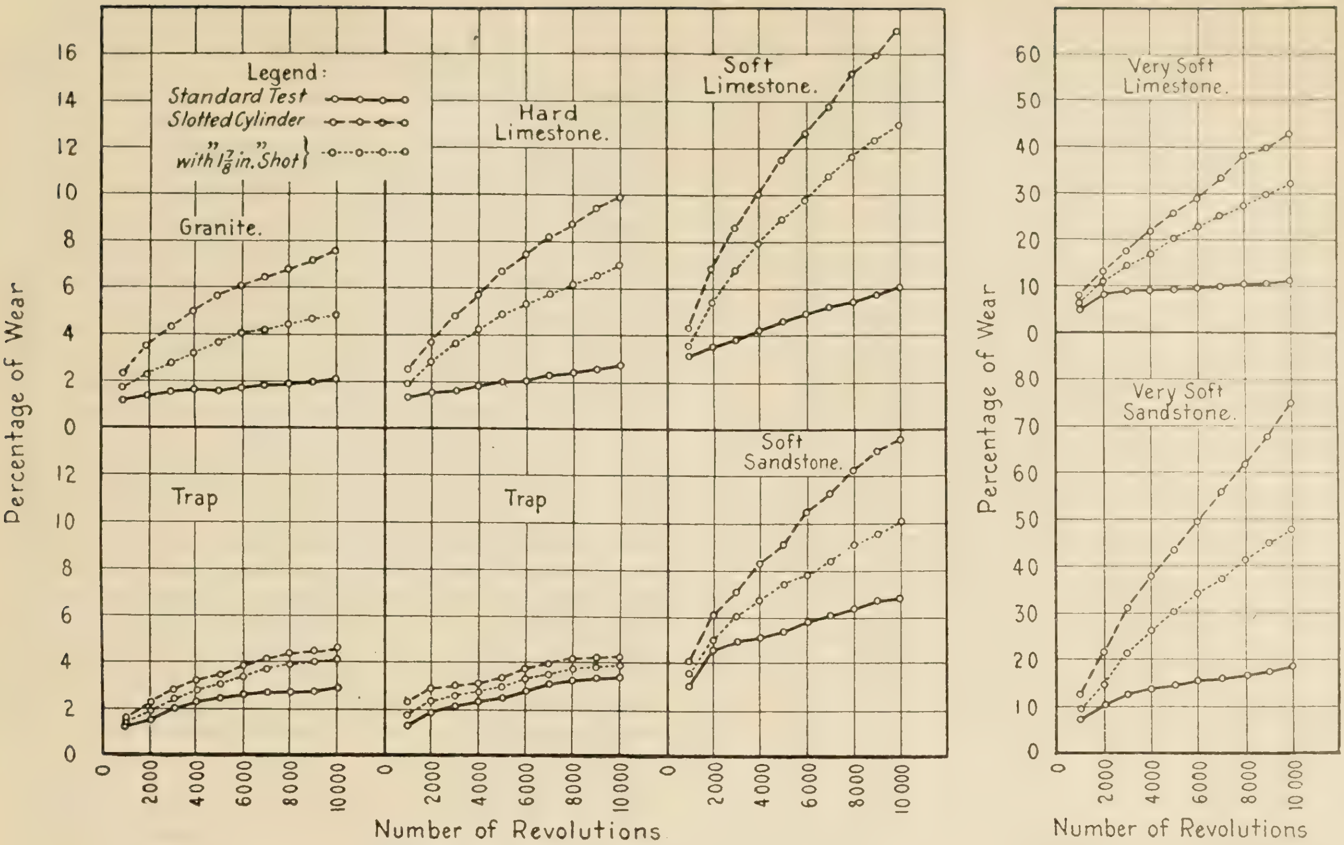

FIG. 4.—CURVE SHOWING THE RELATION BETWEEN PERCENTAGE OF WEAR AND DURATION OF TEST.

which is sufficient to break an ordinary standard-size granite block. By the use of this machine, small cubical fragments of the size desired may be prepared conveniently from practically all types of rock with the exception of some traps and the very highly foliated or laminated varieties, such as gneiss and schist. With these types it is always a question of doing the best possible with the material in hand. A standard sample prepared in the above manner will consist of 50 pieces, approximately cubical in shape, each of which should weigh from 85 to 115 grams. Results of tests on samples of different types of rock prepared in this manner and compared to tests on the same materials prepared in the usual way are shown in Table I.

The Deval test has been criticized also from another point of view. In a paper presented at the 1918 annual meeting of the American Society for Testing Materials, Scofield[4] called attention to the action of the so-called "dust cushion" on the inside of the abrasion cylinder. He showed that in eliminating this cushion by removing the dust of abrasion during the test, a much greater range in values could be obtained, especially among the softer rock types. Other investigators working along the same line had independently reached the same conclusion. Indeed, the present method is so obviously wrong in principle it is remarkable that it has not been changed before.

In regard to the elimination of this "dust cushion" the author sees no better way than to simply mill a series of longitudinal slots in the standard abrasion cylinder through which the dust may escape as fast as it is formed. The slots adopted by the Bureau of Public Roads laboratory are $1\frac{1}{2}$ inches apart, center to center, and one-sixteenth inch wide. A cylinder slotted in this manner has been in use in the laboratory for a number of years. The exact spacing or length of the slots, however, apparently makes very little difference in the actual results obtained, provided there are a sufficient number of openings to permit all of the dust to escape.

Several other suggestions in the way of improving this test, such as the use of small shot as an abrasive agent, a graded instead of a one-size sample, etc., have been offered from time to time. Some of these will be briefly discussed in the conclusions to this paper.

[4] Proceedings, Am. Soc. Test. Mats., Vol. XVIII, Part II, p. 417 (1918).

TABLE II.—*Results of comparative abrasion test for rock.*

No.	Type of rock.	Hardness.	Toughness.	Percentage of wear, standard test.	Percentage of wear, slotted test.	Difference.
1	Trap	18.7	35	1.6	2.4	0.8
2	.....do	18.7	....	2.0	2.4	0.4
3	.....do	18.0	32	2.0	3.0	1.0
4	Granite	19.0	10	3.2	3.5	0.3
5	Trap	18.5	43	3.0	3.8	0.8
6	.....do	17.3	21	2.7	3.9	1.2
7	.....do	....	....	2.7	4.0	1.3
8	Granite	18.0	14	3.4	4.0	0.6
9	.....do	18.7	10	3.7	4.2	0.5
10	.....do	18.0	14	3.2	4.2	1.0
11	Trap	18.0	26	2.3	4.2	1.9
12	Granite	18.0	9	3.6	4.2	0.6
13	.....do	18.7	13	3.3	4.3	1.0
14	.....do	18.7	10	3.5	4.4	0.9
15	Quartzite	18.7	16	3.4	4.5	1.1
16	Granite	18.7	9	3.4	4.5	1.1
17	.....do	18.7	10	3.5	4.5	1.0
18	Trap	18.0	20	2.8	4.6	1.8
19	Granite	19.3	11	3.6	4.7	1.1
20	.....do	18.7	10	3.4	4.7	1.3
21	.....do	18.0	10	3.8	5.0	1.2
22	Quartzite	18.7	17	3.3	5.1	1.8
23	Limestone	17.2	15	3.5	5.1	1.6
24	.....do	17.3	....	3.3	5.6	2.3
25	Granite	16.7	8	3.2	5.6	2.4
26	.....do	17.3	7	4.2	5.6	1.4
27	Trap	18.3	18	3.2	5.8	2.6
28	Granite	17.3	7	4.2	5.9	1.7
29	.....do	16.7	8	4.3	5.9	1.6
30	.....do	....	7	4.4	5.9	1.5
31	.....do	18.0	9	4.3	6.0	1.7
32	.....do	16.7	8	4.5	6.1	1.6
33	.....do	18.0	8	5.2	7.2	2.0
34	Limestone	15.0	10	3.4	7.7	4.3
35	Sandstone	16.7	8	4.3	8.0	3.7
36	Trap	16.7	9	4.0	8.6	4.6
37	Limestone	17.3	15	4.8	8.8	4.0
38	.....do	12.3	6	3.3	9.3	6.0
39	.....do	16.0	8	6.0	10.2	4.2
40	.....do	12.3	6	4.7	10.4	5.7
41	.....do	13.9	8	5.3	10.6	5.3
42	Granite	18.5	6	6.8	10.6	3.8
43	Limestone	15.7	5	5.4	10.7	5.3
44	.....do	15.0	7	5.9	11.1	5.2
45	.....do	16.0	6	6.8	11.4	4.6
46	.....do	16.5	6	7.0	11.7	4.7
47	.....do	12.1	9	6.2	12.2	6.0
48	.....do	13.3	3	7.0	12.2	5.2
49	.....do	12.7	4	5.9	12.9	7.0
50	.....do	13.5	6	5.6	13.0	7.4
51	.....do	15.9	6	8.3	13.4	5.1
52	.....do	14.3	7	7.0	13.8	6.8
53	.....do	12.0	7	7.4	16.8	9.4
54	.....do	10.2	7	6.9	19.1	12.2
55	.....do	11.0	5	8.5	22.9	14.4
56	.....do	8.0	5	10.8	27.6	16.8
57	.....do	4.0	4	10.8	31.4	20.6

DISCUSSION OF RESULTS OBTAINED.

The work covered in the following discussion was carried out, therefore, with two primary objects in view:

1. To determine how variations in the results of tests due to laboratory manipulation may be reduced:
2. To determine the comparative range in values obtained with and without the "dust cushion."

The results of a number of tests made on samples prepared by machine and tested in the slotted abrasion cylinder are given in Table I, and may be compared to the values obtained in the ordinary manner and to which reference has already been made. It will be noted that the average maximum deviation of 0.8 per cent observed with the standard method has been reduced to 0.3 per cent by the use of machine-broken fragments. The individual losses, on the other hand, have been increased in varying amounts due to the elimination of the dust cushion. Tests in the closed cylinder using machine-broken fragments showed slightly lower average results than with the standard method, no doubt due to the absence of wedge-shaped or flat pieces which frequently find their way into a sample prepared in the usual way. The results of a number of tests on a large variety of rock types are given in Table II. These results are plotted in figure 2 in the order of their loss by abrasion in the slotted cylinder. They are of interest in showing the relative effect of the dust cushion as measured by the hardness of the rock. This relationship is plotted in figure 3 in which the hardness of the stone determined by the Dorry hardness test [5] is plotted against the difference, $P\text{-}P'$, between the abrasion loss in the slotted and in the standard cylinder. Taking into account the fact that all of the test results given in Table II were obtained on samples hand-broken in the usual way and are liable therefore to a possible error of nearly one per cent, the relationship is fairly well defined, and shows clearly the value of using the slotted cylinder in differentiating between the wearing qualities of the softer types of rock.

In figure 4 are plotted the results of a number of tests made in both the standard and slotted abrasion cylinders in which the loss by abrasion was determined at the end of each 1,000 revolutions. A comparative run was made also in each case using six 1⅞-inch cast-iron shot as an abrasive agent. These tests were made in order to determine the practicability of accelerating the wear by means of an abrasive and at the same time speeding up the test by cutting down the total number of revolutions. According to the results shown in the figure it would appear theoretically possible to obtain about the same loss at the end of 2,000 revolutions when shot are used as would be obtained at the end of 10,000 revolutions without the abrasive. As a matter of fact, however, experiments have shown that the gain in time thus effected would be more than counterbalanced by the resulting loss in accuracy. It has been found impossible to obtain check tests closer than 1 per cent when an abrasive is used, due probably to the breaking up of the fragments composing the sample under the action of the shot. This action makes the test a measure of toughness rather than of resistance to wear. Inasmuch as the amount of this action would depend to a large degree on the prevalence of insipient fractures or minute seams in the rock which would not affect the value of the material in road construction, the use of an abrasive is not recommended. The effect of these minute fractures which frequently can not be detected by the eye has been noted in connection with the standard test for toughness of rock.[6]

The following conclusions may be drawn:

1. Results of the standard Deval abrasion test as conducted in the usual way are accurate to within 1 per cent.
2. The difficulty of properly preparing samples by hand in a reasonable length of time is the principal reason for the discrepancies in results observed.
3. Samples may be prepared conveniently and accurately by means of the machine described in this paper.
4. The range in values of percentage of wear is greatly increased by the use of a slotted cylinder which permits the dust of abrasion to escape as fast as it is formed.
5. In general, the difference between percentage of wear as determined in the standard and in the slotted cylinder increases as the coefficient of hardness of the rock decreases.

[5] Bulletin No. 347, U. S. Department of Agriculture, p. 6.
[6] Proceedings, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 414 (1918).

THE CHARACTERISTICS OF STEAM DISTILLED PETROLEUM RESIDUALS[1]

By B. A. ANDERTON, Chemist, Bureau of Public Roads.

IN THE interpretation of the results of tests on bituminous road materials, it is well understood that a given set of values must be considered as a whole; in other words, the significance of almost any result is dependent upon other results or combinations of them. So in the preparation of specifications, the selection of suitable requirements to secure the desired materials must therefore be done with the influence of other requirements always in mind. We have all seen specifications for asphalts and road oils with which no commercial product could possibly comply on account of some unattainable requirement.

The writer is not aware that there is in the literature on bituminous materials any great amount of data on the relationships between the various tests with regard to the types of crude petroleum involved, and particularly as affected by the variations in process of manufacture. With the experience of many years' testing of bituminous materials, some general conclusions have been well brought out; as, for example, the relatively high specific gravity, insolubility in petroleum naphtha, and percentage of fixed carbon of products from Mexican petroleum; also, the relatively low ductility, high melting point, and high insolubility in naphtha of blown oils. But, in general, it is quite difficult to correlate available data in order to demonstrate specific relations along these lines, and in this paper the writer will endeavor to make some contribution to the subject which, while not entirely new material, may be of interest as setting forth in a definite manner the significance of some of our present tests.

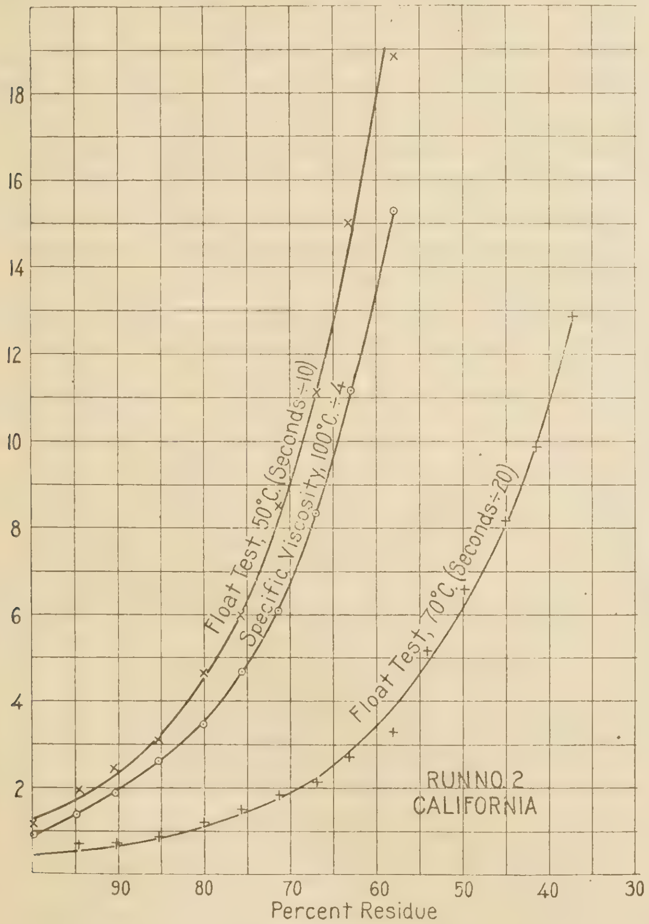

FIG. 1.—TYPICAL TESTS OF CONSISTENCY WITH PROGRESS OF DISTILLATION.

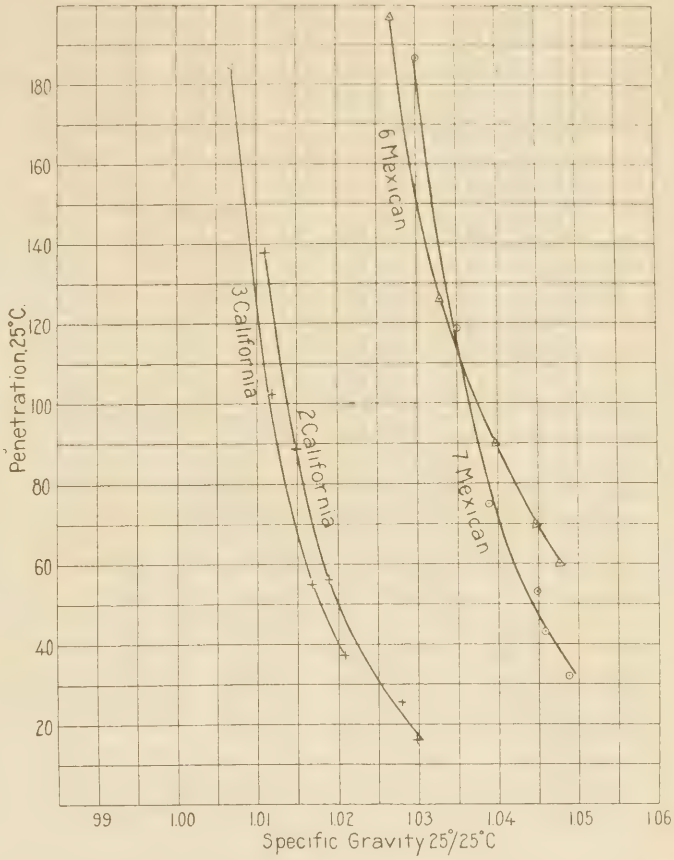

FIG. 2.—PENETRATION OF CALIFORNIA AND MEXICAN ASPHALTS SHOWING GREATER SPECIFIC GRAVITY OF MEXICAN PRODUCTS.

The opportunity to study the characteristics of petroleum residuals in this manner comes as a result of the operation of a small experimental refinery by the United States Bureau of Public Roads. A number of runs have been made, all of which up to the present time have involved steam distillation. Three typical crude petroleums have been used from California, southern Texas, and Mexican fields, respec-

[1] Paper presented at the annual meeting of the American Society for Testing Materials, Asbury Park, N. J., June 22-25, 1920.

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tively, whose important characteristics are shown in Table I. During each distillation steam was passed through the still at such a rate as to maintain a fairly constant ratio of water to oil distillate in the flow from the condenser. These ratios were as follows:

Petroleum.	California.			Texas.		Mexican.	
Run No.	1	2	3	4	5	6	7
Average steam ratio	0.69	1.21	0.92	0.75	0.55	0.65	0.83

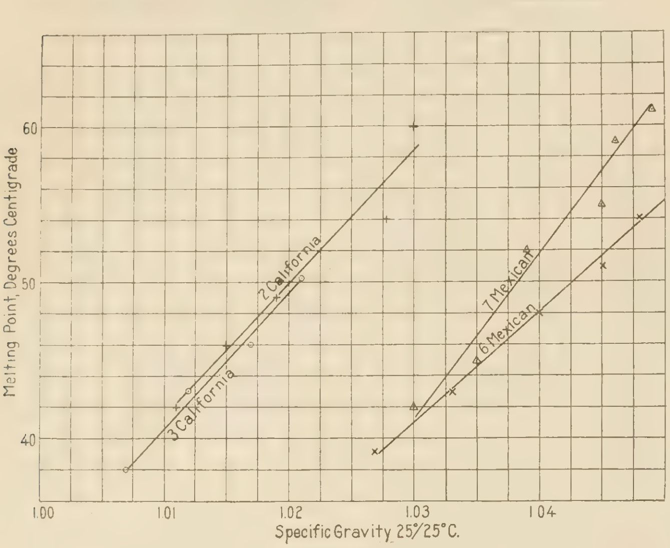


FIG. 3.—MELTING POINTS OF CALIFORNIA AND MEXICAN ASPHALTS SHOWING GREATER SPECIFIC GRAVITY OF MEXICAN PRODUCTS.

TABLE I.—*Characteristics of crude petroleum as shown by tests on three typical petroleums.*

Property.	Petroleum, source.		
	California, Kern River.	Texas, Sour Lake.	Mexico, Panuco.
Water, per cent by volume	6.0	0.0	2.9
Specific gravity 25°/25° C.	0.965	0.935	0.985
Flash point, degrees centigrade	115	54	52
Burning point, degrees centigrade	...	122	110
Specific viscosity, Engler, 25° C.	...	22.8	...
Specific viscosity, Engler, 50° C.	...	5.25	...
Specific viscosity, Engler, 100° C.	2.82	1.60	...
Float test, 32° C., seconds	...	...	40.6
Float test, 50° C., seconds	8.6	...	26.5
Float test, 70° C., seconds	6.6	...	16.5
Loss at 163° C., 5 hours, 50 g., per cent	8.76	15.70	11.73
Float test residue, 50° C., seconds	20.8	4.9	78.7
Float test residue, 70° C., seconds	...	...	38.3
Bitumen insoluble in 86° B. naphtha, per cent	3.4	0.31	20.09
Fixed carbon, per cent	3.58	1.38	10.77
Organic matter insoluble, per cent	0.01	0.07	0.09
Inorganic matter insoluble, per cent	0.0	0.06	0.00
Total bitumen (soluble in CS_2), per cent	99.99	99.87	99.91

As distillation proceeded, samples were taken systematically from the experimental still and tested, following the standard methods of the American Society for Testing Materials whenever they were applicable. Otherwise tests were carried out according to the methods in use by the Bureau of Public Roads.[1] It can readily be seen that these series of samples, all produced from the same still-charge of petroleum, and representing the changes in characteristics of the residuals taking place as the distilla-

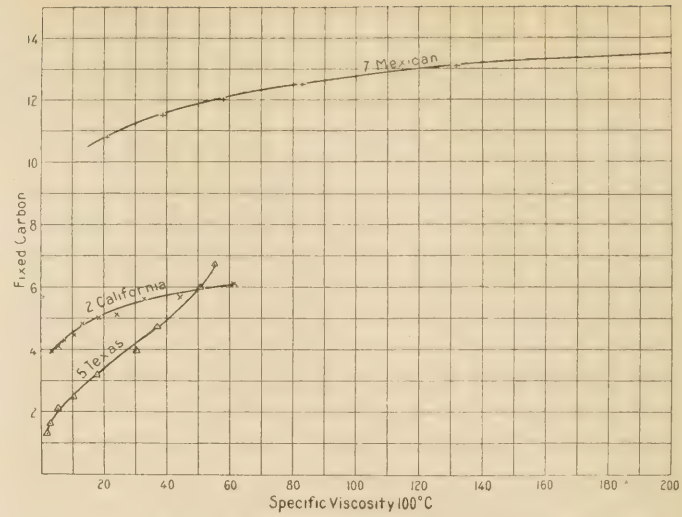


FIG. 4.—THE FIXED CARBON OF TYPICAL FLUID RESIDUALS.

tion continued, permit a study of interrelations between tests which could not ordinarily be accomplished with a collection of miscellaneous samples, affected possibly in different degree by variations in the original crude and in method of treatment. As an example of the development in consistency as the distillation progressed, figure 1, representing the specific viscosity and float tests of residues secured in one distillation of California petroleum, may be shown. Abscissae indicate the percentage of the crude removed as distillate or, on the scale given, the percentage of residue in the still. These curves are typical, not only of the graphical representation of other test results, but of other crudes. With very few exceptions, a smooth curve can be drawn with such plotted points, representing the actual relation of the two variables fairly well.

Within the space of the present paper it will be possible to discuss only the most prominent relations

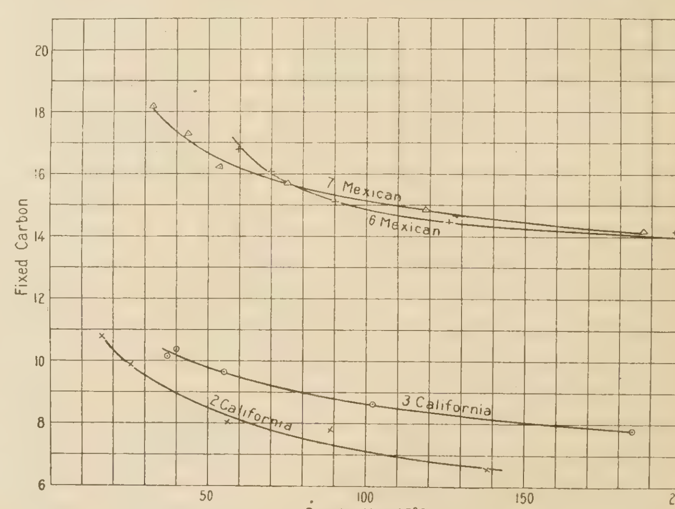


FIG. 5.—THE FIXED CARBON OF TYPICAL CALIFORNIA AND MEXICAN ASPHALTS.

[1] Methods for the Examination of Bituminous Road Materials, Bul. No. 314, U. S. Department of Agriculture.

which have presented themselves as a result of the work so far, which, as may be mentioned again, has dealt entirely with steam distillation. The samples examined should be considered as typical of their type; and little attempt will be made to discuss the test results theoretically, or to derive mathematical relationships, as it is felt that the scope of the available data is at present too limited for discussion of that nature. The data are presented graphically, requiring in most cases little explanation or comment.

Tests have shown clearly the greater density of Mexican asphalts. In figure 2, asphalts up to 200 penetration produced from the Mexican petroleum have a specific gravity of about 0.02 to 0.03 higher than for corresponding California products. It will be noted that there is a distinct difference in the two curves 6 and 7, although in both runs the crude was the same Mexican petroleum. This may be explained by the use of a greater volume of steam during distillation 7.

In figure 3 the greater specific gravity of Mexican asphalts than of California asphalts for a given melting point is shown. The difference is more significant when it is borne in mind that a California asphalt of the same melting point is considerably harder at normal temperature, as will be shown later. In figure 3 it has seemed best to represent the relations as straight lines, owing to the small number of points and having in mind the accuracy of the tests. The divergence between the two Mexican series is again noted.

Considering the percentage of fixed carbon in Mexican, California, and Texas residuals, figure 4 will show the high percentage for Mexican products, increasing slowly with specific viscosity at 100° C.

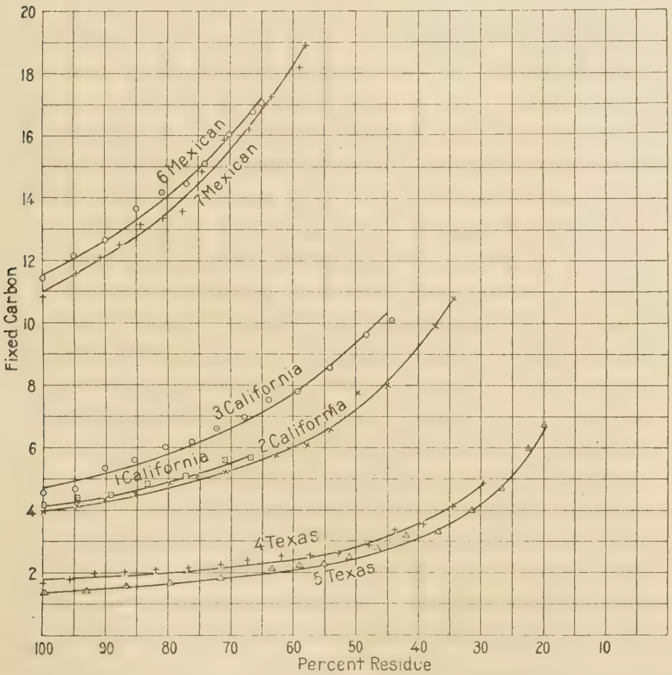


FIG. 6.—THE DEVELOPMENT OF FIXED CARBON IN STEAM DISTILLATION.

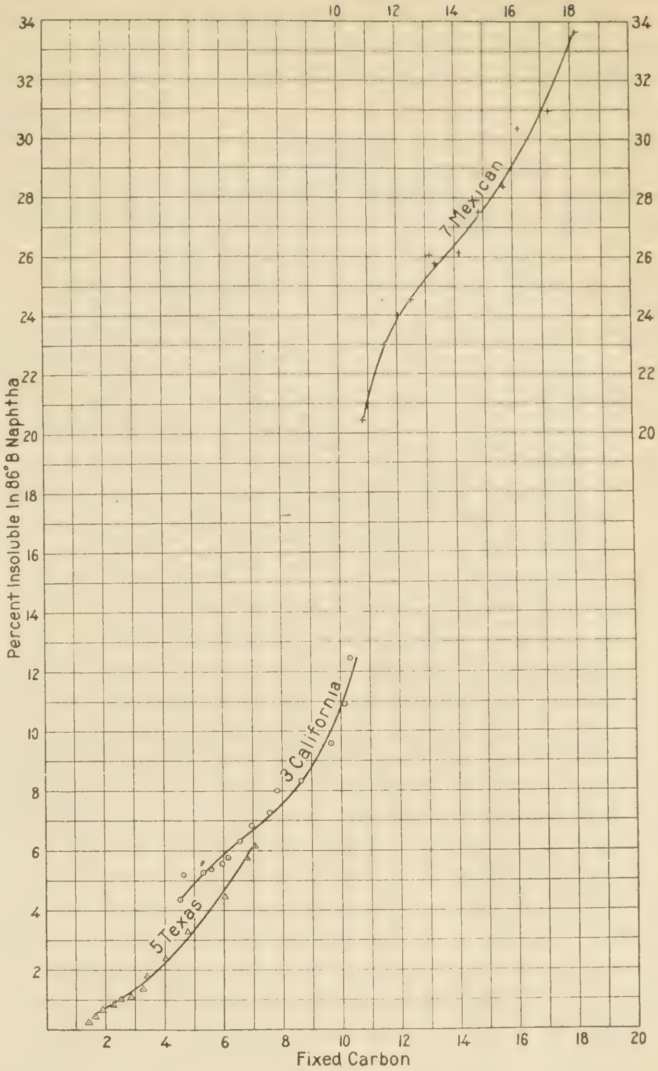


FIG. 7.—GENERAL RELATION BETWEEN FIXED CARBON AND PERCENTAGE OF BITUMEN INSOLUBLE IN 86° B NAPHTHA.

The Texas residuals increase rapidly in fixed carbon, but it is of interest to note that the final point on this curve represents a residue of only 20 per cent of the crude oil, attained at a high still temperature. The Texas petroleum would produce by steam distillation alone only a small quantity of residuals suitable for road work, and most likely of an inferior quality.

The higher fixed carbon for Mexican asphalts of less than 200 penetration is demonstrated in figure 5. Comparison with figure 2 will show that the form and relation of the two Mexican curves is similar, indicating a closer relation between specific gravity and fixed carbon.

An interesting relation which apparently is independent of the type of oil used, and which may point out the specific value of the fixed carbon test, should be discussed at this point. If the percentage of fixed carbon for successive residues is plotted against the percentage of residue, as in figure 6, it is noticed that in general the plotted points show a tendency

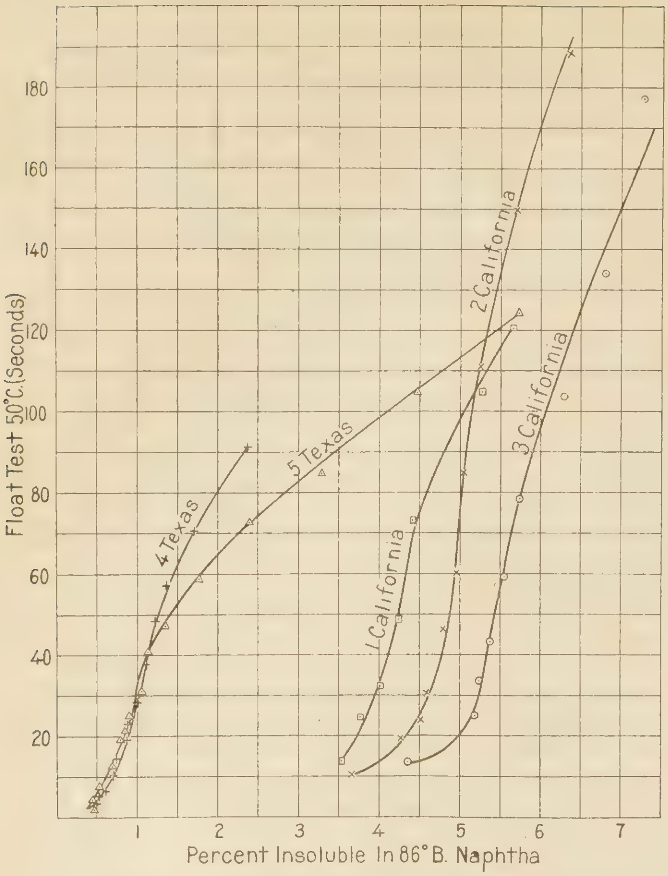


FIG. 8.—THE NAPHTHA INSOLUBLE OF FLUID TEXAS AND CALIFORNIA RESIDUALS.

to lie along the curve of a hyperbola. Also, by multiplying the percentage of fixed carbon by the percentage of the still charge represented by the corresponding residue, the series of values shown in Table II is obtained.

TABLE II.—*Product of fixed carbon by percentage residue of still charge.*

Designation of residue.	California.			Texas.		Mexican.	
	1	2	3	4	5	6	7
R0	4.15	3.95	4.52	1.68	1.38	11.48	10.80
R2	4.17	3.87	4.40	1.72	1.34	11.58	10.75
R2	3.99	3.87	4.81	1.74	1.39	11.42	10.95
R3	3.99	3.83	4.79	1.71	1.32	11.66	10.93
R4	3.89	3.88	4.48	1.64	1.32	11.46	11.08
R5	3.75	3.80	4.70	1.54	1.36	11.17	10.79
R6	3.79	3.64	4.75	1.56	1.31	11.18	10.55
R7	......	3.76	4.74	1.57	1.25	11.27	11.06
R8	......	3.59	4.82	1.52	1.28	11.11	11.26
R9	......	3.52	4.64	1.45	1.31	11.08	10.86
R10	......	3.58	4.67	1.38	1.35	......	10.91
R11	......	3.89	4.68	1.39	1.24	......	10.71
R12	......	3.60	4.49	1.45	1.26	......	10.92
R13	......	3.70	......	1.41	1.27	......	......
R14	......	3.71	......	1.41	1.35	......	......
R15	......	3.44	......	1.46	1.35	......	......
R15A	......	......	......	1.32	1.29	......	......
Average	3.96	3.66	4.65	1.53	1.32	11.34	10.91
Mean deviation	.13	.14	.12	.11	.04	.18	.12
Maximum deviation	.21	.29	.25	.21	.08	.32	.36

It will be seen that for all distillations the values for a given run are practically constant. Judging from the deviations from an average value, they are as constant as should be expected with the fixed carbon test. Accepting the constancy of the product, the relation may then be expressed by the equation

$$RC_R = 100\ C_{100}$$

where C_R is the percentage of fixed carbon of a steam distilled petroleum resudual, which is R per cent of the original having a fixed carbon of C_{100} per cent. In this connection it may be noted that subsequent work in which residuals have been air-blown has shown that blowing materially increases the percentage of fixed carbon.

In figure 7 the general tendency of the fixed carbon and percentage of bitumen insoluble in 86° Baumé naptha to increase together is shown.

The proportional rate of increase for a given material, however, evidently varies quite widely, and in this curve, as in some others involving naphtha insoluble it is indicated that at some point in the distillation, reactions begin within the petroleum, gradually increasing in importance as the temperature rises, which result in the actual formation of bodies of an asphaltic character. Particularly is this evidenced in figure 8, when the naphtha insoluble is plotted against consistency by the float test at 50° C.

The reversal of curvature is quite striking in this diagram. If the point at which the curvature reverses is estimated from the graphs, and taken at a float test of 30 seconds for the Texas, and 60 seconds in the case of the California, it may be of interest to add that the temperature of the Texas oil at this point in the distillation was 295 to 300° C., while the California oil had a temperature of 250 to 260° C.

That some asphaltic products soften more readily upon heating than others and that this susceptibility to heat may be greatly modified by variation in the process of manufacture, are well understood facts. In specifications for paving asphalts, therefore, various combinations of requirements for melting point, ductility, penetration at 0° or 46° C., etc., together with the consistency at normal temperature, are

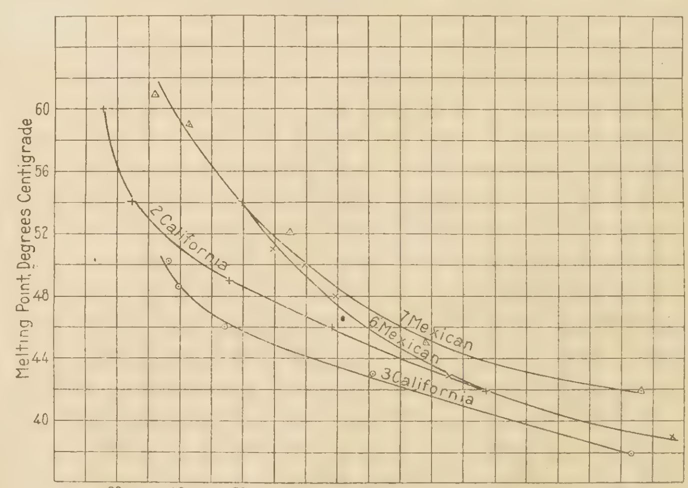


FIG. 9.—THE MELTING POINT OF MEXICAN AND CALIFORNIA ASPHALTS.

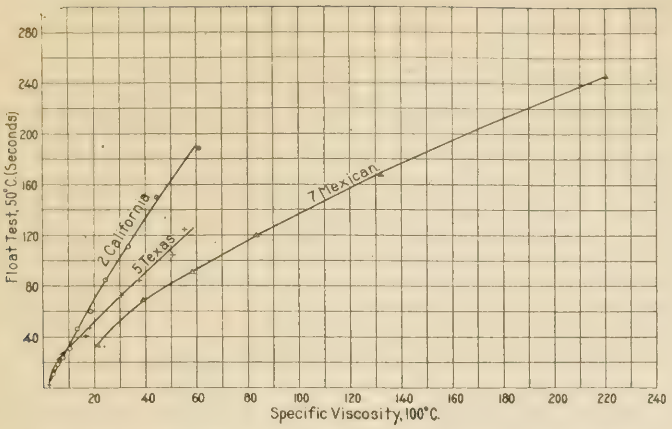


FIG. 10.—THE FLOAT TEST OF TYPICAL FLUID RESIDUALS.

utilized to secure a material having suitable qualities for the particular work in hand. The variation in ball and ring softening point for typical Mexican and California asphalts is shown in figure 9.

Another test which, though looked upon usually as a consistency test, is not often utilized to investigate susceptibility to temperature, may be used to advantage on a wide range of products. This is the float test. That this test is essentially a test of viscosity is made apparent by the great similarity of the curves shown in figure 1. The results of the float test are, however, greatly influenced by the way in which the material tested softens on heating, and consequently, as the bath temperature is set at a higher point, the test becomes more and more a measure of the susceptibility of the material. It may be considered as giving a measure of viscosity combined with susceptibility. Figures 10 and 11 will illustrate this. In figure 10, the California, Texas, and Mexican products show a decreasing susceptibility, in this order, by having a lower float test at a lower temperature for the same specific viscosity at 100° C.

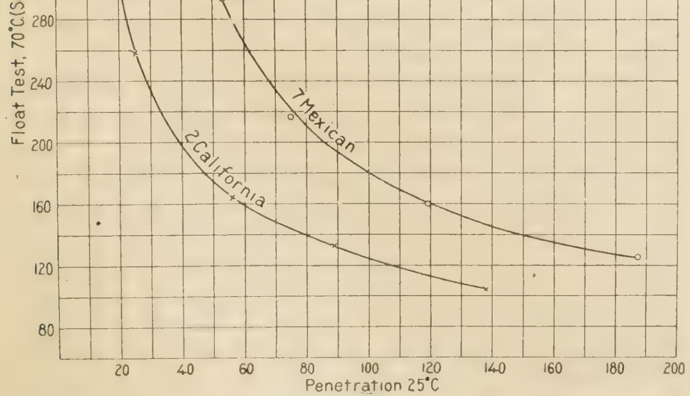


FIG. 11.—THE FLOAT TEST OF MEXICAN AND CALIFORNIA ASPHALTS.

A large number of float tests have been made at 70° C., in order to secure data on the change in consistency over a wide range of products, especially to cover the range of consistency where the viscosity test at 100° C. or the penetration at 25° C. is not readily applicable. The results of these tests on the harder asphalts also indicate the greater susceptibility of the California products, as may be seen in figure 11.

As the penetration increases, the difference in float test becomes more marked; at 35 penetration the Mexican asphalt gives a float test twice that of the California asphalt.

It will be realized that the relations which the writer has tried to bring out graphically represent data compiled from typical petroleums only, and that the characteristics of residual oils and asphalts may be greatly modified by changes in method of refining. In the writer's judgment, two features—the significance of the fixed carbon test in relation to the progress of steam distillation and the development of the float test as a measure of viscosity and susceptibility to temperature changes—should prove the two points of greatest interest and value resulting from these tests.

INDIANA ROAD CONSTRUCTION IS STANDARDIZED.

Uniform road construction is expected throughout Indiana as a result of an order issued by the State highway commission requiring the standardization of road plans and specifications for county highways which are subject to the approval of the commission. The regulation became effective July 1 and covers all county road projects submitted to the commission for approval.

The regulation is similar to the Federal order requiring the use of standardized plans and specifications by the State for all roads for which Government aid is expected. The action of the commission extends the use of the approved standards to the roads which will be built in Indiana under the provisions of the county unit road law, by which the State shares the cost.

Officials of the commission have compiled the standards for the Indiana roads, which are identical with the requirements made of the State by the Federal Government. The standards will apply to all county-aid projects proposed under the State highway law, the county unit road law, and the free gravel road law.

Many counties of the State already have adopted the commission standards voluntarily to keep their road construction up to the specifications prescribed by the Federal and State engineers.

Members of the commission, in discussing the regulation, declared that it will have the effect of standardizing road construction throughout Indiana.

GOOD PROGRESS IN IMPACT TESTS.

THE investigations now being made by the Bureau of Public Roads to determine the forces exerted by motor trucks on roads are showing some very instructive results. Various sizes of trucks have been used in these tests varying from a 1-ton truck up to a 7½-ton truck carrying an excess load. The truck is run over a special device for producing artificial impact conditions and the impact pressure is measured through the deformation of specially prepared copper cylinders. The blow of the truck deforms the copper cylinder and the magnitude of the blow is expressed in pounds required to deform the cylinder, the latter being determined in a testing machine.

Recent tests were made with a 3-ton Packard truck loaded with a 4½-ton load so that the total weight on each rear wheel was 7,000 pounds, the unsprung portion being 1,700 pounds and the sprung portion 5,300 pounds. The truck was equipped first with an old solid tire that had been worn down to a thickness of 1 inch. Then, with exactly the same load on the truck, a wheel was used fitted with a new solid tire 2½ inches in thickness. And finally, the truck was equipped with pneumatic tires 42 by 9 inches inflated to a pressure of 142 pounds per square inch. The following table shows very clearly the bad effect an old tire is likely to have on a road surface and the comparative lack of impact when trucks are equipped with pneumatic tires:

Approximate speed.	Height.	Old tire.	New tire.	Pneumatic tire.
	Inches.			
5.7	2	11,600	9,400	7,100
10.2	2	18,500	14,100	7,800
14.6	2	26,500	18,700	8,300

The question of impact is one of very great interest to those who are called upon to decide upon road design, and it is probable that the results of these tests may lead to a rational basis for determining license fees.

IMPACT ON SURFACES OF DIFFERENT TYPES.

A number of slabs have been tested by means of a machine designed to give impact conditions resembling those on the rear wheel of a heavy truck. The unsprung portion of the weight of this machine is 1,500 pounds and the sprung portion weighs 6,000 pounds. The test is made by raising the unsprung weight through a height of one-eighth of an inch, allowing it to fall 500 times, then to a height of one-half inch with 500 repetitions, then three-eighths inch more in height, and so on until the slab fails. Up to date about 12 slabs have been tested when laid on a rather wet subgrade and there is a surprising difference in the strength of the different types of pavements tested. Thus, the total number of blows required to cause failure have varied with the different slabs from 67 up to almost 2,000. It is expected that a detailed account of the results of these tests will be published toward the end of the summer.

RELATIVE WEAR OF DIFFERENT PAVEMENTS.

The bureau is making a study of the relative wearing qualities of different types of pavements and tests have about been completed on a short section of pavement containing 49 different types subjected to the wear of a special truck equipped with five large cast-iron wheels. The results of this investigation are very instructive and bring out very many interesting points in connection with pavement design. The relative wearing qualities of hard as compared with soft brick are brought out very distinctly in this test. The relative resistance to wear of various kinds of stone block sections is also shown up to good advantage. A chance to compare grout and asphalt fillers for both brick and stone block is furnished by this investigation. Likewise, the relative wearing qualities of concrete when mixed with various kinds of coarse aggregates is indicated. Results of this test are also being worked up in a paper to be published within a very short time.

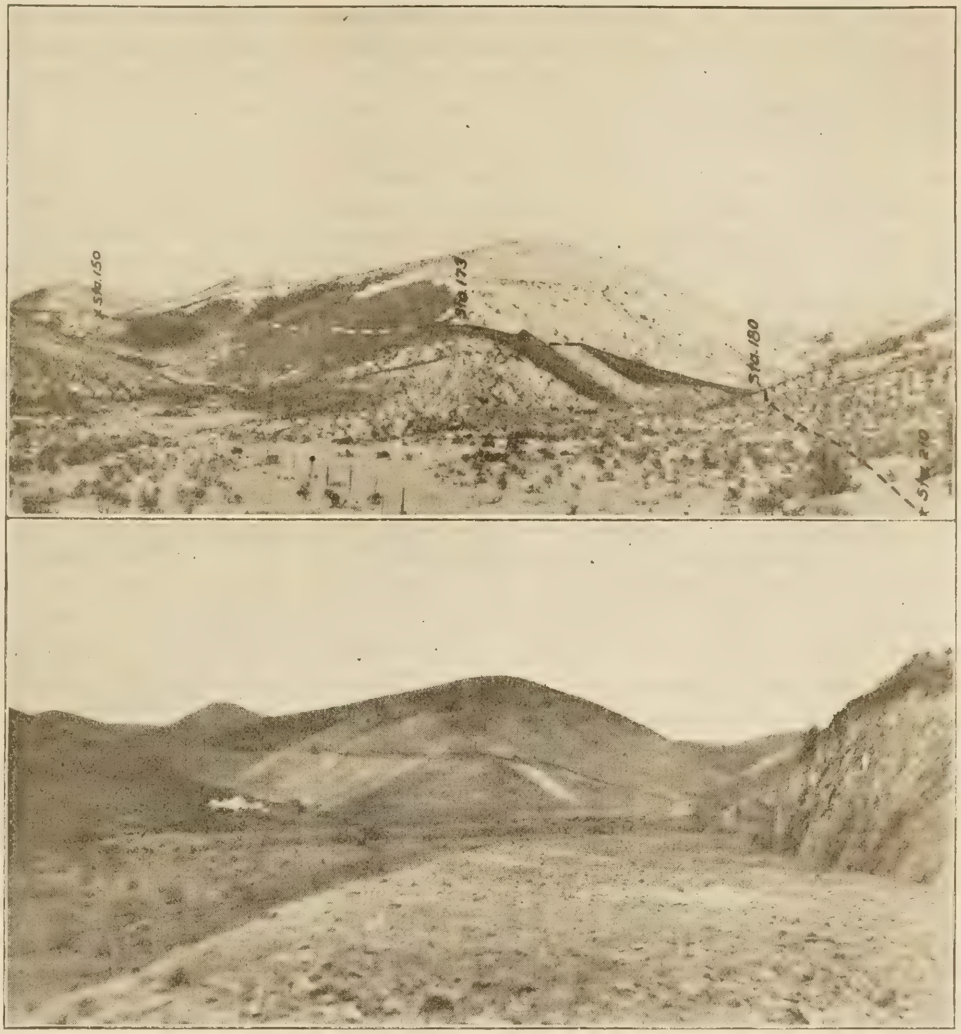
INVESTIGATION OF SUBGRADE MATERIALS.

The investigation of subgrade materials started a few months ago with the cooperation of the district engineers and State engineers is proceeding at a very satisfactory rate. A number of samples have been received from various parts of the country and laboratory analyses of many of these samples are partially completed. The methods being used by the Division of Tests have been described and will shortly appear as a paper so that any other laboratories wishing to conduct similar investigations may have some guide as to the method of procedure being followed by the Bureau of Public Roads.

The samples analyzed have been taken from parts of the roads that have failed very badly as well as from adjacent parts of the same roads that have withstood heavy traffic successfully. It is hoped that by a comparison of the laboratory results on these samples with the reported behavior of the road in service differences in the subgrade materials will become apparent so that we will be able to say what physical characteristics soils must possess to give them high bearing value.

PHOTOGRAPHIC HINTS FOR ENGINEERS.

By JOHN K. HILLERS, Jr., Photographer, Bureau of Public Roads.



TOP, A GENERAL VIEW OF OREGON FEDERAL-AID PROJECT NO. 17, FROM STATIONS 150 TO 210, PHOTOGRAPHED ON JANUARY 10, 1920, BEFORE WORK WAS STARTED, LOCATION SHOWN BY DOTTED LINE. BOTTOM, VIEW OF THE SAME LOCATION SHOWING THE COMPLETED GRADE.

SO MANY and important are the uses of photography in connection with engineering works that the camera has become almost as essential as the transit as an engineering instrument. Indeed, it can often be made to do much of the work of the latter instrument, as witness the part it played in France in the mapping of the battle-front areas. No great use has been made of it in this way in connection with highway work, but the writer is not at all convinced that it has not valuable possibilities which have so far been overlooked. Just a suggestion of its usefulness in making reconnaissance surveys is contained in the pictures reproduced on this page. As for its value in recording details of construction for the illustration of engineering reports, as a means of studying the causes of deterioration of engineering structures by preserving a record of the appearance of the structure at various stages of failure, and as a means of picturing the tangible results of engineering vision—these uses are too well understood by the engineering profession to require any dwelling upon.

But though practically all engineers appreciate the value of the camera as an aid to them in their daily work, there are many, unfortunately, who fail to make the most of it, largely for the lack of a working understanding of a few simple principles. In this article the writer will not attempt to do more than call attention to these principles, the application of which by engineers generally will go far to improve the character of engineering photography.

STUDY THE LENS.

The most important part of any camera, of course, is the lens. It is the eye of the camera, and, like its human counterpart, it has its limitations. Not only are differences in performance to be expected of lenses of different kinds and by different makers, but even among stock lenses of the same kind and by the same maker there are differences of sufficient importance to make it decidedly worth while for engineers to follow this first bit of advice—"get acquainted with your lens." Test it—"calibrate" is the engineering term, I believe—calibrate it, then, by trying it with various exposures and different openings in all sorts of light and upon all sorts of objects close at hand and far away. Preserve a record of the conditions and the manner of taking each picture and compare the results to determine the limitations and capabilities of your particular lens.

The lenses used by engineers generally are of two classes, known respectively as the rapid rectilinear lens and the more modern anastigmatic lens. The latter was developed to correct the defects of the rapid rectilinear lens which are manifested by a certain cloudiness around the edges of photographs taken with a large opening and short time. The anastigmats will give good definition under these conditions, and in this feature alone lies their superiority to the ordinary rapid rectilinear lens. Many engineers seem to think they must have an anastigmatic lens to enable them to take good photographs. It is not at all necessary, and really, is altogether unnecessary, if exposures be made, as they should be in nearly all engineering work, with a small opening and relatively long time. Under these conditions the ordinary rapid rectilinear lens will give entirely satisfactory results.

THE STOP AND LIGHT.

Next to the lens in importance are the shutter and diaphragm, which together constitute the lids which open and close over the eye and regulate the amount of light admitted to the sensitive film at the back of the camera. The shutter, a set of flanges, which when properly operated, open and close across the lens, regulates the duration of exposure. The operation is controlled either by a cable release, a bulb, or by a small lever at the side of the shutter. By the adjustment of the small pointer at the top of the lens the shutter can be set to open when pressure is applied to the control and remain open until a second pressure is applied, or to remain open only as long as the pressure is maintained. These two positions, known as "time" and "bulb," and designated on the scale as T. and B., are used for long-time exposures. In addition to them there are other positions for the pointer, at which the shutter will open and automatically close after one-hundredth, one-fiftieth, one-twenty-fifth, and one-fifth of a second, respectively.

The iris diaphragm or aperture consists of a series of flanges which can be regulated to alter the size of the opening through which light is admitted to the lens. The settings or stops of these flanges, which form the openings which have become standard and which are now afforded by all cameras, are designated in accordance with two systems of numerals. The systems of designation are the U. S., or uniform system, and the F. system of the Royal Photographic Society, wherein the opening is expressed by fractions of the focal length. The openings designated by these two systems, however, are identical in size, the identity being as indicated in the following table:

Comparison between the F. and U. S. systems.

F. system....	F. 4.5	F. 8	F. 11.3	F. 16	F. 22	F. 32	F. 45
U. S. system...	1.2	4	8	16	32	64	128

By the proper combination of time of exposure and size of opening the light is admitted to the sensitized film through the lens in just the amount which is necessary to imprint the desired image upon the film surface. The same amount of light may be admitted either by the combination of a large opening and a short exposure, or by long exposure with a small opening, but the results of the two combinations will differ. The picture taken with the large opening and short exposure will present a more or less flat aspect, lacking in depth or the quality of distance and in sharpness of definition or detail. The picture taken with the small opening will be sharp in definition; minute details, such as the leaves of trees, will stand out prominently, and the perspective will be well developed. It follows, therefore, that if one wishes to obtain a picture in which detail will be subordinated, as when it is desired to minimize the defects of a road surface, the large opening and short exposure make the proper combination. If, on the contrary, as should be the case in engineering pictures, the desired result involves the sharp definition of detail, the proper procedure is to use a small opening and a long exposure. It is for this reason that the rapid rectilinear lens should be as useful to the engineer as the anastigmatic lens.

In comparing the work of these two lenses, however, one must remember to compare pictures taken with a stop opening of the same relative size (F. value). Do not expect as great depth of focus with an anastigmat set at an opening of F. 6.3, as the rapid rectilinear lens gives at its largest opening, No. 4, corresponding to F. 8. The anastigmat at F. 8 will give as great depth of focus as will a rapid rectilinear lens of the same focal length, with the same opening while, on the other hand, the rapid rectilinear will not work at all at F. 6.3.

FOCUSING.

No matter what camera you are operating you must look to the focusing as well as to the stop and light. All engineers are familiar with the small focusing scale which is carried on practically all cameras. Set at any of the figures from 6 to 100 with which such scales are usually marked, the lens will be brought to the proper distance from the focal plane (*i. e.*, the surface of the film) to focus sharply upon an object at the distance indicated. If the camera be set in this manner for a focus of 100 feet, every object from a point at that distance on to the horizon will be in focus, regardless of the size of the opening. Objects closer than 100 feet to the camera, however, will not be sharply defined unless the diaphragm be stopped down to a small opening. If, instead of setting the focus at 100 feet, it be set at 25 feet, it will be found that the only objects which will be in sharp focus, if the aperture be large, will be those which lie in a plane at a distance of 25 feet from the camera. Objects nearer at hand and farther away will be out of focus unless the size of the aperture is reduced.

To obtain a first-hand knowledge of the effect of the size of the aperture upon the sharpness of the focus, it would be an excellent thing if every engineer would try this simple experiment at the first opportunity: Place a camera on a tripod and point it at some object, a tree, for instance. Remove the back of the camera and place a piece of ground glass in its place. Set the diaphragm for the largest opening and open the shutter. With the head about 1 foot away, and the eyes on a level with the camera, throw a piece of black cloth over the head and the back of the camera to cut off the light except that entering through the lens. When the eyes become accustomed to the darkness, an inverted image will be seen upon the ground glass. Now move the lens back and forth until the tree is sharply defined on the ground glass. If the tree selected is about 25 feet away, the rest of the picture or the distance from the tree to the lens and from the tree to the horizon will be out of focus. Now stop down the diaphragm first to 16, then to 32, and finally to 64. At each stage it will be observed that the image becomes fainter and fainter and at stop 64 it will be difficult to see it. But coincidently the image becomes sharper and sharper and, by looking closely when the stop is at 64, it will be noticed that everything in the picture is sharply defined. This simple experiment will impress upon anyone, better than anything the writer can think of, the fact that the size of the aperture or the stop that is used has its effect upon the focus of the picture as well as upon the amount of light admitted.

For the ordinary purposes of the highway engineer a much better picture will be obtained by focusing on a point 25 feet distant from the camera and stopping down for definition than by focusing at 100 feet and using a large opening. The former practice will reproduce in clean-cut definition all the immediate foreground where the objects will be large enough to show small detail and will picture with at least as great a degree of sharpness as can be obtained by the second method all objects at whatever distance from the camera.

In using the first method, however, it is of course necessary to increase the time of exposure as the size of the aperture is reduced; and right here is where the tripod comes into its own.

The average field engineer, to whom it becomes second nature "to consider the size of his pack to save his back" objects to the tripod as so much useless weight to be dragged around. For the same reason he selects a 3A rather than a 4A Kodak. But while it is not particularly important which size of camera he uses, since photographs can be enlarged or reduced to any size at pleasure, when it comes to the tripod "there's a reason." And in the opinion of the writer the reason is so pertinent that he is convinced that the failure to give heed to it is responsible for much that is mediocre and more that is positively poor in engineering photographs.

BE SURE OF THESE THINGS.

In making engineering photographs it is best to use the tripod for both time and instantaneous exposures. Having set the instrument, be sure of four things:

First. That the shutter is set properly (for time or instantaneous exposures as desired).

Second. That the diaphragm stop is set at the proper opening.

Third. That an unexposed section of the film is turned into position.

Fourth. That the camera is focused on the principal object to be photographed.

After placing the camera on the tripod, select the view. Look over the subject carefully and estimate what stop and time of exposure will be suitable for the conditions as to light and color of object. For cloudy days the writer uses an exposure of $\frac{1}{2}$ second and the 32 stop; on bright days $\frac{1}{5}$ second and 32 stop; very bright days $\frac{1}{5}$ second and the 64 stop or $\frac{1}{2}$ second and the 128 stop. Remember that you must give the picture sufficient light to develop the darkest places. An old by-word among photographers is "photograph the shadows and let the high lights take care of themselves." And don't forget that the general color of the surroundings has a lot to do with the adjustment of the aperture. On roads or structures other than concrete, $\frac{1}{5}$ second and the 32 stop will give good results on a bright day. Concrete requires less opening than dirt, macadam, or bituminous macadam.

If the camera must be pointed into the sun, shield the lens from the direct rays with a hat or notebook.

If there is action in the picture use an exposure of $\frac{1}{25}$ or $\frac{1}{50}$ of a second and a stop of 8 or 16, according to the brightness of the day. If there is anything as fast as a moving automobile or railroad train, don't use any exposure longer than $\frac{1}{100}$ second.

Best of all, if there is doubt as to the working of the camera, follow the advice given early in this article. Take six exposures of the same picture, varying the opening, and be sure to record the exposure and opening, and then check the results against the record. If the films are developed in the field ask the photographer not to cut them apart.

AS TO THE SUBJECT.

The hints which have been given so far deal with the manipulation of the camera. Perhaps that is the only subject upon which the writer is competent to speak; but so many pictures have passed through his hands, in which there is evident a lack of regard for the preparation of the subject that a few words on that matter may not be amiss.

If the aim is to show the details of a structure or a road, or a road failure, or what not, mount the camera as close to the subject as possible in order to include in the picture all that is desired. Get the subject in the foreground where the details will be large, and then stop down for definition.

If dimension is of the essence of the subject, lay a white rule in the picture where the figures will show prominently, or get a man into the photograph with whom to compare sizes.

If the subject is a depression or an elevation below or above a general surface, take the photograph at a time of day when the length of the shadow will bring out the depth or height of the subject. Such a picture taken at midday will not be satisfactory. For this purpose it is best also to photograph into the sun.

If the picture is a construction picture, in which the workmen are supposed to be at work, try to catch them before they know they are being photographed; but if they must know it, ask them as one gentlemen

[Concluded bottom column 2, next page.]

LAST APPORTIONMENT OF FEDERAL AID.

THE last apportionment of Federal funds to aid the States in road construction under the existing Federal aid act became available July 1. This will be the largest apportionment yet certified under the Federal aid act, amounting to $100,000,000, three-quarters of which is derived from the appropriation of 1919 and $25,000,000 from the original appropriation of 1916. A deduction of $3,000,000, or 3 per cent of the funds, will be made to provide for the expense of administering the Federal aid act by the Department of Agriculture. The balance of $97,000,000 will be divided among the States in proportion to their population, area and mileage of post roads. The allotments to the several States from the two portions of the fund are given in the table of apportionment printed below.

Under the law the States are required to enter into formal agreements with the Secretary of Agriculture for the construction upon which this money is to be used before July 1, 1922. Any money which is not taken up before that time will be reapportioned among all the States in the same manner in which the original apportionments are made. All previous apportionments have been taken up in the time allotted, and it is not likely that the States will fail to absorb this last apportionment. To do so, however, will mean that the States must survey, plan, and let contracts for at least $200,000,000 worth of Federal aid road construction in the next two years.

If the States continue to pay more than 50 per cent of the cost, as they have in the past, the cost of the roads constructed with this last apportionment may reach $250,000,000. In other words, it will be necessary to plan for construction at the rate of at least $100,000,000 and probably more per year. Some appreciation of what that means may be gleaned from the fact that in 1915 the expenditure for all roads in the United States, constructed under State supervision, was only $80,000,000.

Since 1915, however, State highway departments have been greatly expanded, and efficient machinery has been developed which will undoubtedly be able to handle the greater volume of work.

Remainder of 1916 Federal aid appropriation.

	Sum apportioned.		Sum apportiond.
Alabama	$526,220.88	Minnesota	710,522.33
Arizona	343,411.04	Mississippi	451,889.29
Arkansas	421,294.52	Missouri	846,974.90
California	763,668.88	Montana	501,747.53
Colorado	438,939.79	Nebraska	533,435.50
Connecticut	153,337.36	Nevada	319,086.11
Delaware	40,668.70	New Hampshire	103,709.73
Florida	286,861.98	New Jersey	296,889.11
Georgia	674,287.74	New Mexico	399,616.96
Idaho	306,512.48	New York	1,242,973.28
Illinois	1,091,266.98	North Carolina	569,763.45
Indiana	671,763.32	North Dakota	384,056.95
Iowa	720,332.18	Ohio	926,561.70
Kansas	717,811.16	Oklahoma	575,619.53
Kentucky	487,938.86	Oregon	394,038.01
Louisiana	340,557.78	Pennsylvania	1,147,986.51
Maine	240,057.54	Rhode Island	58,314.22
Maryland	216,749.65	South Carolina	359,004.76
Massachusetts	368,197.21	South Dakota	403,944.86
Michigan	722,916.99	Tennessee	565,478.48

Remainder of 1916 Federal aid appropriation—Continued.

	Sum apportioned.		Sum apportioned.
Texas	1,465,399.62	West Virginia	265,038.19
Utah	282,393.91	Wisconsin	636,236.34
Vermont	112,519.27	Wyoming	308,428.96
Virginia	494,418.46		
Washington	361,156.95	Total	24,250,000.00

Apportionment of 1919 Federal aid appropriation.

	Sum apportioned.		Sum apportioned.
Alabama	$1,578,662.63	Nevada	$957,259.32
Arizona	1,030,233.12	New Hampshire	311,129.20
Arkansas	1,263,883.57	New Jersey	890,667.34
California	2,291,006.63	New Mexico	1,198,850.89
Colorado	1,316,819.38	New York	3,728,919.83
Connecticut	460,012.07	North Carolina	1,709,290.35
Delaware	122,006.11	North Dakota	1,152,170.85
Florida	860,585.94	Ohio	2,779,685.11
Georgia	2,022,863.22	Oklahoma	1,726,858.75
Idaho	919,537.45	Oregon	1,182,114.02
Illinois	3,273,800.93	Pennsylvania	3,443,959.54
Indiana	2,015,289.95	Rhode Island	174,942.65
Iowa	2,160,996.56	South Carolina	1,077,014.28
Kansas	2,153,433.46	South Dakota	1,211,834.58
Kentucky	1,465,816.57	Tennessee	1,696,435.42
Louisiana	1,021,673.35	Texas	4,396,198.84
Maine	720,172.62	Utah	847,181.75
Maryland	650,248.96	Vermont	337,557.82
Massachusetts	1,104,591.62	Virginia	1,483,255.37
Michigan	2,168,750.98	Washington	1,083,470.84
Minnesota	2,131,567.00	West Virginia	795,114.58
Mississippi	1,355,667.88	Wisconsin	1,908,709.01
Missouri	2,540,924.70	Wyoming	925,286.88
Montana	1,505,242.60		
Nebraska	1,600,306.43	Total	72,750,000.00

PHOTOGRAPHIC HINTS FOR ENGINEERS.

[Concluded from page 21.]

of another please to look busy. Our own files are full of pictures which, taken collectively, would prove beyond the peradventure of a doubt that workmen never work.

If the picture is to represent a finished road or structure, see that it is really finished before it is photographed. See that the ditches and shoulders are trimmed; that the road surface is clear of litter and free of defect, and, unless construction details limit, take the picture so as to include a beautiful tree or some bit of scenery that will add to the beauty of the picture.

At times, roads are constructed in which the alignment or the grades, the location in other words, is not all that it should be in places. Sometimes such faults are deliberately passed over in the plans for economic reasons, or for numerous other reasons; sometimes thay are the result of poor design or oversight. If the faults themselves are to be the subject of the pictures, emphasize them by a suitable set-up. An ugly break in the grade will show up best from a set-up at a distance and slightly to one side of the road, which will make it stand out much like an angle in alignment. Angles in alignment can be caught best by shooting along the edge of the road rather than along the center. The same is true of wavy edges of concrete roads.

But unless the defect is to be the subject, try to take the picture in such a way as to exclude it. There are few things more beautiful than a perfect road threading its way over hill and dale, and promising fresh delights at every turn to all who will follow it. Pictures of such roads speak more eloquently of the benefits of improved highways than the most carefully developed argument of engineer or economist. They are valuable, therefore, not only as a record of completed work, but as an inspiration to all who see them for more roads and better roads.

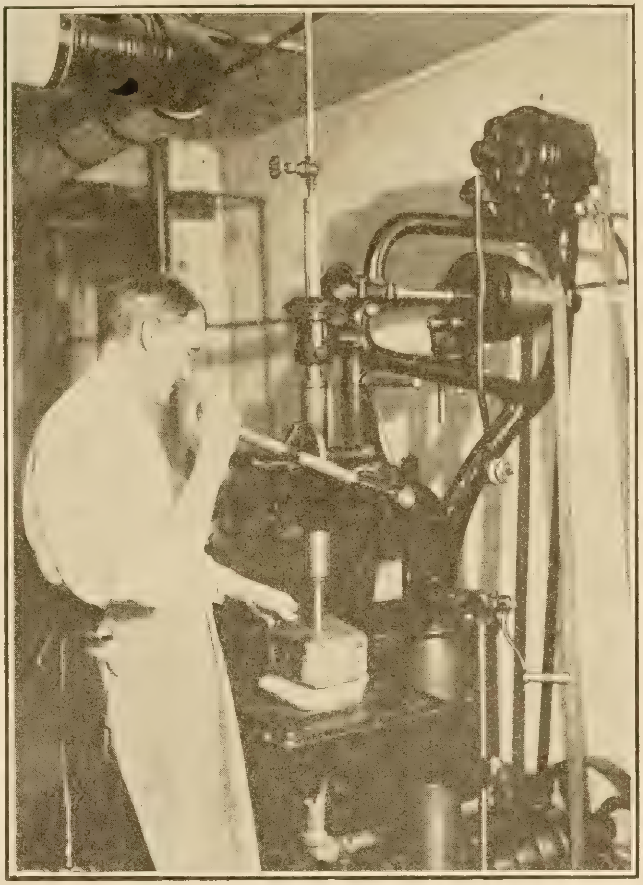
THE MANUFACTURE AND USE OF LABORATORY DIAMOND CORE DRILLS.

By F. H. SCHLOER, Instrument Maker, U. S. Bureau of Public Roads.

THE many requests which have been received from time to time by the Bureau of Public Roads regarding the proper construction and use of laboratory diamond drills indicates that much difficulty has been experienced by numerous road materials laboratories along these lines. For this reason it has been deemed advisable to publish somewhat in detail the methods used by the Bureau in the manufacture of these drills, and, inasmuch as the life of a drill depends to a very large extent on the way it is used, some precautions regarding their proper use are also given.

Black carbons or diamonds used for laboratory drills should range from $\frac{1}{16}$ inch to $\frac{3}{32}$ inch in size and should be dense and regular in shape. Diamonds suitable for the work will weigh in the neighborhood of 0.1 carat each and from six to eight diamonds are required for a 1-inch drill. They may be obtained from any of the diamond importers.

The diamond drill used by the bureau consists of a steel or bronze crown soldered to the end of a seamless steel tube about $4\frac{1}{2}$ inches long and $1\frac{1}{8}$ inches outside diameter and carrying six diamonds, each about $\frac{3}{32}$ inch in diameter. The other end of the steel tube carries a No. 2 Morse taper hollow drill shank through which water is admitted to the inside of the drill. The drill crown proper is made either of Tobin bronze or soft cold-rolled steel, 1 inch internal diameter, $1\frac{7}{32}$ inches external diameter, $\frac{1}{4}$ inch high, with a recess $\frac{5}{32}$ inch in depth by $1\frac{1}{8}$ inches in diameter in which the steel tube is soldered. A detail view of the drill crown showing the various dimensions is shown on page 24.



THE DRILL IN USE SHOWING PROPER METHOD OF BEDDING THE SAMPLE.

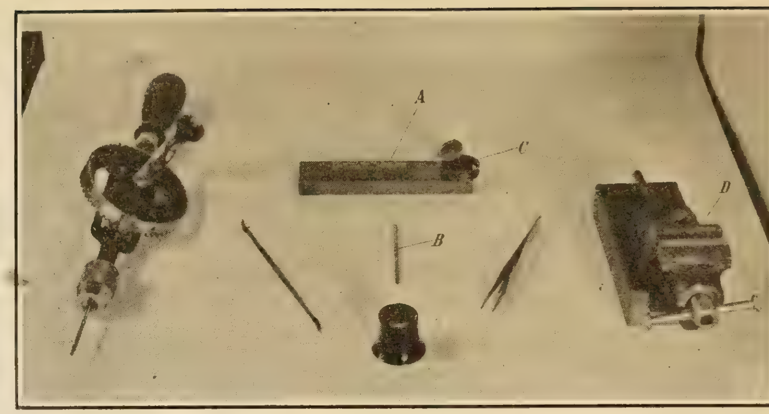
SETTING DIAMONDS IN DRILL CROWN.

On the next page are shown the various pieces of apparatus used in the operation of setting the diamonds in the drill crown. *A* is a piece of cold drawn steel $1\frac{1}{4}$ by $\frac{1}{2}$ by 6 inches, with a yoke *C* and thumbscrew and is used to hold the drill crowns. After mounting a crown in the clamp as shown, six holes are drilled in the face of the crown at equal distances apart, three of the holes almost breaking through the outside of the face of the ring and three almost breaking through the inside of the face. The holes should be slightly smaller than the diamonds which are to be used, and each should be slightly nicked on the thin edge with a fine file. A diamond is then placed in one of the holes, gently tapped with a piece of brass so as to hold it in place after which the crown is placed in a small jeweler's vice *D*, having jaws of soft steel or brass, with which the diamond is forced into the hole. Should the diamond not stand the pressure and crumble it is not fit for drilling. It should be possible to force any diamond good enough for drilling purposes into a hole in the above manner. Flat drills *B*, made of $\frac{1}{8}$-inch drill rod, turned about $\frac{1}{2}$ inch long and of a size slightly smaller than the diamonds, are used for drilling the holes. It has been found that the flat drills are better than twist drills for they are stiffer and do away with a center punch. After the diamonds are all set, the drill is soft soldered to the end of the steel tube and is then ready for use.

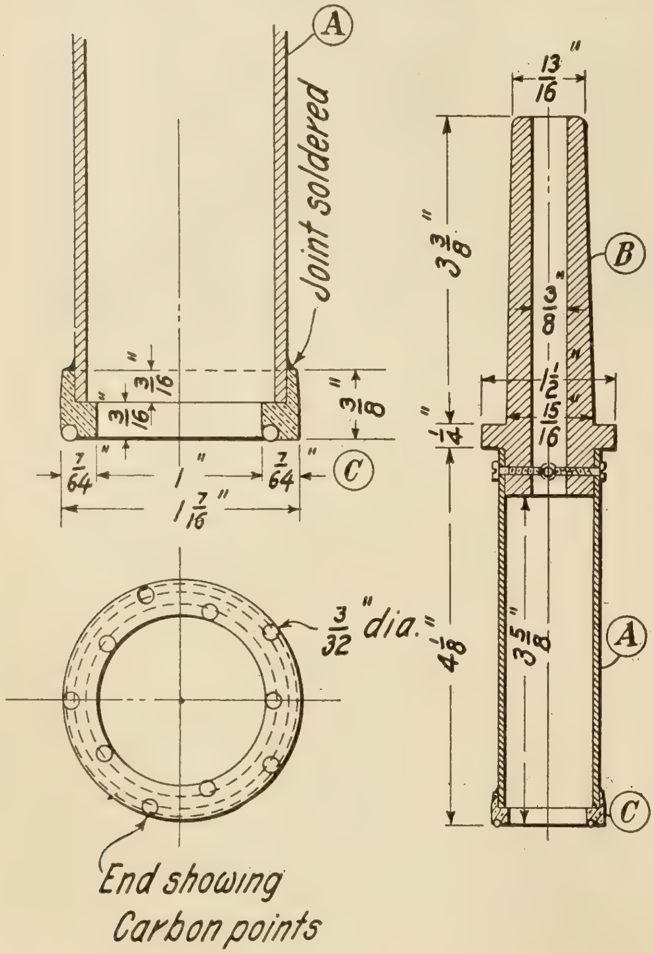
Any drill press equipped with a hollow spindle and with the table so arranged that the water carrying the rock cuttings may be properly collected and carried away is satisfactory for use in rock drilling. A drill press equipped with a No. 2 Morse taper is large enough. The speed of the drill should be about 300 revolutions per minute.

USING THE DIAMOND DRILL.

Great care should be exercised when first using a diamond drill. A block of very soft limestone or sandstone should be selected and a number of cores cut from this stone until it is found that the drill is working properly, after which it may be used on harder rock. The sample should be bedded on a bag filled with sand, as shown on page 23, or in the case of very small pieces it may be necessary to mount the samples in plaster of Paris before drilling. Plenty of water should be used on the inside of the drill so as to keep the space under the crown entirely free from rock cuttings, which, especially in the case of soft rock, have a tendency to "gum up" the drill. After one or two cores have been drilled, their diameter should be measured, and if it is found that the drill is cutting cores more than 25 millimeters or less than 24 millimeters in diameter, one or two of the diamonds must be reset. If the drill crown is turned to the dimensions shown, however, and the diamonds set as indicated, the cores should come out very close to 25 millimeters in diameter. The pressure should be applied always by hand and never automatically on account of the tendency of carbons to shatter if subjected to any appreciable impact. When drilling stone by hand, the pressure on the drill may be regulated in accordance with the character of the material being drilled. This is, of course, not the case if an automatic feed is used. A much greater pressure may be used when drilling fine-grained, homogeneous materials, such as trap, even if the rock is very hard, than in the case of coarse-grained, nonhomogeneous materials or stone in which minerals of greater hardness than the mass of the rock are embedded. With a properly constructed drill, it should be possible to cut a core 4 inches in length from rock of medium hardness in about 10 minutes. The drills made by the Bureau of Public Roads will cut from 20 to 50 feet of rock before it becomes necessary to discard them, depending, of course, on the average hardness of the stone being used.



APPARATUS USED IN SETTING THE DIAMONDS.



DIAMOND CORE DRILL

FIGURE SHOWING DIMENSIONS OF THE DRILL CROWN.

CORRECTIONS.

The jinx was working overtime when the captions were added to the illustrations in our June issue. We do our best to make amends as follows:

Page 5. The caption of the top picture should read: "Bulkhead bridge over the West Walker River, Nev., on Federal-aid project No. 83."

Page 9. The photograph at the left is a view of Pennsylvania Federal-aid project No. 29, from Milford to Matamoras, a bituminous concrete road. At the right is a concrete Federal-aid project, No. 22, from Tobyhanna to Mount Pocono, Pa.

Page 11. The second word of the caption should be "road."

Page 19. The caption should read as follows: "Matchless Crater Lake in Crater Lake National Park. A forest road now under construction will reach this lake."

FEDERAL AID ALLOWANCES.

AT THE close of the fiscal year June 30, 1920, all States with the exception of Oklahoma and South Dakota had entered into agreements with the Secretary of Agriculture for the construction of road projects which will call for the expenditure of their allotments of Federal funds for the fiscal years 1917, 1918, and 1919. The excepted States had not taken up the entire amount of their allotments for the fiscal year 1918, but owing to the fact that during that year they had no recognized State highway departments they are allowed under the law until June 30, 1921, to take up their apportionments for 1918.

Three States, Illinois, Maryland, and Washington, had executed agreements calling for the entire amount of Federal money available to them for each year up to and including the fiscal year 1920; and several other States have submitted plans, specifications, and estimates for projects which will entirely consume their allotments up to the beginning of the current fiscal year.

At the beginning of the new fiscal year, July 1, 1920, 2,984 project statements had been approved representing 29,319.35 miles of Federal-aid road which it is estimated will cost $384,916,819.53 and on which Federal aid to the amount of $163,841,503.93 had been approved.

On the same date project agreements had been entered into for 1,963 projects involving 15,178.08 miles which it is estimated will cost $253,990,389 and for which $109,838,173.71 of Federal aid will be allowed.

PROJECT STATEMENTS APPROVED IN JUNE, 1920.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Alabama	74	Montgomery	11.180	Gravel	June 12	$187,399.08	$93,699.54
Arizona	28	Pinal	7.500	Selected material	...do	185,630.50	90,000.00
Arkansas	92	Grant	4.760	Macadam	...do	30,534.46	14,400.00
	93	Crittenden	8.650	Concrete	June 25	267,953.40	43,000.00
	94	.....do	9.380	Gravel	...do	105,927.25	40,000.00
	95	.....do	8.450	Concrete	...do	307,711.80	73,500.00
	96	Poinsett	4.250	.....do	...do	148,104.00	42,000.00
	100	Mississippi	10.670	.....do	...do	413,163.30	100,000.00
	40	Hempstead	9.510	Gravel	June 8	[1] 63,789.00	[1] 19,000.00
Georgia	157	Pierce	8.900	Sand-clay	June 3	133,608.75	40,000.00
	159	Miller		Bridge	June 4	65,120.00	25,000.00
	136	Brooks and Lowndes		.....do	June 3	48,839.12	24,419.56
	152	Grady		.....do	...do	30,668.00	15,000.00
	153	Newton	9.900	Sand-clay	...do	80,000.80	40,000.00
	154	Wayne	12.000	.....do	...do	79,915.00	39,000.00
	156	Decatur	1.230	.....do	June 12	37,778.40	15,000.00
Iowa	55	Scott	19.330	Earth	June 4	85,052.00	42,500.00
Minnesota	180	St. Louis	1.030	Concrete, brick, or asphalt	June 8	50,481.20	20,600.00
	182	.....do	.990	.....do	June 7	36,119.60	18,059.80
	183	.....do	1.620	.....do	...do	56,944.80	28,472.40
Missouri	118	Stoddard	15.000	Gravel	June 4	126,999.99	63,499.99
	122	Pettis	4.750	Bituminous macadam	June 8	63,000.00	31,500.00
Montana	116	Musselshell		Bridge	June 12	19,453,50	9,726.75
	119	Wheatland	7.250	Earth	...do	64,392.88	32,196.44
	120	Ravalli	6.000	Gravel	...do	33,145.20	16,572.60
	20	Missoula	[1]7.000	.....do	June 28	[1] 21,985.26	[1] 10,992.63
New Hampshire	107	Merrimack	1.000	.....do	June 3	15,000.00	7,500.00
	92	.....do	.500	.....do	...do	8,000.00	4,000.00
	118	Grafton	.340	.....do	June 7	10,229.98	5,114.99
New York	70	Rockland	3.850	Concrete	June 12	154,000.00	77,000.00
	67	Albany and Schenectady	11.100	.....do	June 11	632,700.00	221,445.00
	69	Delaware	10.570	.....do	June 12	517,300.00	181,055.00
Ohio	144	Allen	6.258	.....do	June 3	290,000.00	75,600.00
	115	Brown	2.794	Macadam	...do	85,000.00	40,000.00
	116	.....do	5.774	.....do	...do	168,000.00	82,500.00
	132	Mahoning	1.750	Brick	...do	79,742.66	26,250.00
	141	Summit	2.270	Concrete and brick	...do	145,810.23	21,000.00
	153	Clermont	6.974	Macadam	...do	240,600.00	120,300.00
South Carolina	43	Sumter	18.181	Sand-clay	...do	137,760.59	25,000.00
	50	Dillon	19.767	.....do	June 8	131,647.94	40,714.39
	78	York	8.066	Top soil	...do	55,353.73	12,000.00
Tennessee	28	McMinn	14.507	Concrete, asphalt, or bituminous macadam	June 3	342,660.50	171,330.25
Texas	145	Tom Green	10.000	Bituminous	June 4	250,548.21	100,000.00
	164	Erath	31.267	Gravel and crushed rock	...do	350,217.99	162,000.00
	163	Childress	10.150	Sand-clay	June 8	70,004.69	35,000.00
	38	Lamar	4.850	Gravel	June 11	172,417.46	86,208.73
	161	Limestone	23.371	.....do	...do	289,611.31	59.400.00
	167	Delta	11.700	.....do	June 25	280,156.06	110,000.00
	19	Eastland	[1] 28.300	.....do	June 3	[1] 117,983.80	[1] 35,000.00
Vermont	16	Washington	1.265	.....do	...do	37,161.24	18,580.62
West Virginia	94	Fayette	5.200	Macadam	June 30	74,565.00	33,480.00
	96	Nicholas	2.210	Earth	...do	49,000.00	24,500.00
	95	Ohio	1.000	Concrete	June 8	45,531.20	13,290.00
Wisconsin	144	Chippewa	3.580	Earth	June 4	41,560.08	20,000.00

[1] Withdrawn.

PROJECT AGREEMENTS EXECUTED IN JUNE, 1920.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	39	Madison	7.729	Gravel	June 7	$114,634.58	$57,317.29
	59	Jefferson	5.030	Bituminous concrete on concrete base	June 8	225,694.64	104,087.45
	42	Talladega	5.690	Top soil	June 25	72,499.77	36,249.88
	69	Lamar	10.950	Gravel	June 26	103,885.90	51,942.95
	73	Choctaw	6.311	Sand-clay	...do....	66,343.42	33,171.71
	74	Montgomery	11.180	Gravel	June 29	187,399.08	93,699.54
	44	Dale		Bridge	June 28	[1] 30,760.95	[1] 11,997.98
	23	Coffee		Sand-clay	June 25	[1] 40,988.91	[1] 20,494.45
	18	Jefferson	1.920	Bituminous macadam	June 10	[1] 181,333.94	[1] 69,732.32
	12	Lowndes		Sand-clay	June 14	[1] 2,721.40	[1] 1,360.70
	26	Cleburne		Gravel	June 7	[1] 13,176.15	[1] 6,588.08
Arizona	15AB	Gila	18.047	....do	June 8	88,734.29	44,367.14
	19A	Yavapai	10.792	....do	June 21	104,420 58	52,210.29
	13	Greenlee	5.368	....do	June 28	183,241.46	91,620.73
	18ABE&F	Pima and Cochise	16.740	Bridge, and gravel	...do....	256,766.76	128,383.37
	21	Coconino	1.098	Concrete or bituminous top on concrete	June 26	68,826.23	25,139.46
	23B	Pinal	5.199	Gravel	June 21	67,403.49	33,701.74
	23ACE&F	....do	17.084	Gravel or caliche	June 26	233,744.08	116,872.04
	16	Pinal, Gila	19.978	Broken stone	June 30	1,242,587.92	432,367.92
	8	Maricopa		Concrete and bituminous concrete	June 15	[1] 11,989.23	[1] 5,994.61
Arkansas	60	Yell	31.830	Bituminous macadam	June 5	307,419.42	130,000.00
	26	Johnson	12.920	....do	June 30	143,685.45	60,000.00
	38	Sevier and Howard	9.840	Gravel	...do...	59,969.73	24,000.00
	43	Lincoln and Desha	2.050	....do	...do...	22,579.92	7,700.00
	61	Vendor	23.140	....do	...do...	70,785.73	34,500.00
	69	Conway	5.940	....do	...do...	58,974.30	12,500.00
	75	Dallas	21.550	....do	...do...	90,825.54	30,000.00
	76	....do	14.070	....do	...do...	53,996.25	20,000.00
	83	Sevier	8.600	....do	...do...	35,038.30	17,000.00
	31	Cleveland		....do	...do...		[1] 15,000.00
California	41	Imperial	14 860	Reinforced concrete	May 24	355,389.46	177,694.73
Colorado	15	Logan	0.651	Concrete	May 29	24,981.28	12,490.64
	32	Adams	5.737	....do	June 4	188,717.47	94,358.73
	92	Pueblo		Gravel and bridge	...do....	125,224.34	62,612.17
	82	Jefferson	2.017	Concrete	...do....	77,990.25	38,995.12
	23	Mesa	5.860	Gravel	...do....	64,806.83	32,403.41
	34	Weld	1.568	Concrete	May 29	68,582.47	31,360.00
	43	Yuma	18.061	Earth	...do....	61,785.62	30,892.81
	64	Costilla	7.831	....do	...do....	28,094.84	14,047.42
	35	Weld	1.193	Concrete	...do....	48,768.41	23,860.00
	11	Yuma	7.497	Earth	June 14	25,981.86	12,990.93
	41	Logan	0.309	Gravel and bridges	June 11	87,769.25	43,884.62
	78	Eagle	2.758	Earth	...do....	113,649.53	55,174.00
	83	Arapahoe	2.699	Concrete	June 14	108,790.71	53,980.00
	91A	Las Animas	5.651	Gravel	...do...	73,352.01	36,676.00
Connecticut	4	Hartford, Tolland, New London.	32.186	Concrete	June 16	1,835,264.71	643,720.00
Florida	11	Duval Nassau and Baker	15.400	Brick Grouted on sand foundation	June 23	706,379.48	320,876.97
	21A	Baker	5.680	Cement grouted brick on sand foundation	June 25	247,174.54	113,600.00
	22	....do	8.900	....do	...do...	362,259.16	178,000.00
	23	Duval	12.800	....do	...do...	583,142.12	258,576.06
	24	Columbia	9.890	....do	...do...	400,946.12	197,800.00
Georgia	70	Morgan	7.386	Concrete	June 24	253,167.51	121,000.00
	122	Grady		Bridge	...do...	23,051.65	11,525.82
	81	Dougherty		....do	June 7	295,574.40	110,000.00
daho	9	Adams and Idaho	20.680	Earth	June 29	670,095.65	335,047.82
	11	Elmore	26.580	Gravel	June 21	269,969.00	134,984.50
	5	Lemhi		Earth and gravel	June 26	[1] 70,121.96	[1] 43,288.08
Iowa	33	Clarke	8.450	Earth	June 3	65,269.60	32,600.00
	65A	Boone	11.510	Gravel	...do...	103,899.84	36,200.00
Kansas	35 ABC	Summer	8.535	Concrete	June 22	369,689.59	128,025.00
	51	Franklin	0.835	Concrete or bituminous filled brick mono	June 19	61,559.27	6,000.00
	44	Saline	5.250	Brick or concrete	June 22	358,540.41	78,750.00
	45	....do	7.015	Mono brick or concrete	...do...	460,633.61	105,225.00
Kentucky	13	Carter	15.039	Earth	June 30	176,032.95	88,016.47
	17	Clark	6.017	Rock asphalt	...do...	233,032.95	116,516.47
	23A&B	Whitley	6.545	Brick on concrete base and rock asphalt on macadam.	...do...	176,671.12	67,913.07
	24	Jessamine	6.969	Surface-treated macadam	...do...	124,041.41	62,020.70
	26	Jefferson	11.143	Rock asphalt on macadam	...do...	593,280.64	239,655.00
	29A	Laurel	1.287	....do	...do...	67,649.39	25,740.00
	15	Boone and Kenton	2.108	Concrete	June 25	97,422.12	42,160.00
	21A	Bell	5.245	Rock asphalt	...do...	126,736.57	63,368.28
	20	Breathitt	6.535	Earth	June 26	236,057.17	118,028 58
	10	Larue	3.348	Waterbound macadam		[1] 69,993.11	[1] 34,996.55
	3	Rowan		Earth	June 30	[1] 261,768.80	[1] 123,933.16
Maine	8	Waldo	2.540	Bituminous macadam	June 16	122,788.17	61,394 08
	9	Cumberland	4.720	Concrete	...do...	244,369.52	101,748.13
	19	Franklin	2.690	Gravel	...do...	63,327.44	31,663.72
	26	Cumberland	3.920	Bituminous macadam	...do...	109,891.57	54,945.78
	10	....do	2.520	Concrete	...do...	113,282.88	50,400.00
	11	....do	7.080	....do	...do...	322,357.83	146,572.99
	14	Penobscott	4.710	Bituminous macadam	...do...	184,842.57	92,421.28
	18	Franklin	3.880	Gravel	...do...	102,429.47	51,214.73
Massachusetts	21	Berkshire	3.637	Concrete	June 21	167,178.00	72,740.00
	13	Middlesex	6.450	....do	June 29	289,550.14	130,504.25
	22	Franklin	6.430	Bituminous concrete and gravel	...do...	115,039.43	57,519.71
	29	Hampshire	2.626	Bituminous macadam	...do...	93,115.11	46,557.55
	32	....do	3.078	....do	...do...	173,896.52	86,948.26
	33A	Middlesex	2.182	....do	...do...	94,446.00	43,640.00
	37	Berkshire	1.164	....do	...do...	41,158.15	20,579.07
	38	Essex	2.827	Bituminous macadam and concrete	...do...	151,589.35	56,540.00
Michigan	35	Washtenaw and Jackson	25.157	Bituminous concrete on concrete	June 12	1,071,097.33	503,140.00
	38	St. Clair	16.594	Concrete	...do...	740,789.30	370,394.65
	42	Wayne	14.211	....do	...do...	573,196.89	284,220.00
Minnesota	116	Sibley	1.080	Gravel	June 7	57,667.83	21,600.00
	78	Yellow Medicine	14.030	....do	June 8	57,195.69	20,000.00
	82	Pipestone	9.703	Concrete	June 3	353,389.64	100,000.00
Mississippi	49	Coahoma	10.660	....do	June 14	319,877.77	100,000.00
	75	Chickasaw	5.680	Gravel	...do...	72,900.99	36,450.49
	93	Pearl River	12.980	....do	...do...	114,341.00	57,170.50
	32	Lee	15.420	Concrete	June 26	565,587.61	282,793.80
	48	Yazoo	3.928	....do	...do...	131,819.18	65,909.59
	61	Sharkey	13.060	....do	June 28	249,172.07	100,000.00
	20	Walthall		Gravel	June 14	[1] 22,934.88	[1] 11,606.75
Missouri	24	Cooper	5.570	Bituminous macadam	June 9	88,554.82	44,277.41
	27	....do	7.835	....do	...do...	129,409.96	64,704.98
	53	Lawrence	21.060	Gravel	...do...	101,714.39	50,857.19

PROJECT AGREEMENTS EXECUTED IN JUNE, 1920—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Missouri	61	Jackson	2.100	Earth	June 9	$136,493.17	$52,883.15
	78	St. Louis	6.070	Concrete and hillside brick	...do....	304,539.32	126,270.20
	79	St. Louis	12.680	Asphalt, concrete, and hillside brick	...do....	649,249.23	257,970.64
	94	Buchanan	.376	Asphalt, concrete	...do....	29,892.11	7,520.00
	36	Christian	9.306	Gravel and concrete	June 24	65,418.17	32,709.08
	52	Cape Girardeau	3.180	Concrete	June 9	102,523.67	51,261.83
	39	Lewis	7.935	Gravel	June 23	96,067.97	48,033.98
	54	Gentry	8.857	Bituminous macadam	...do....	181,536.64	90,768.32
	60	Lewis	5.800	Gravel on macadam	...do....	88,637.80	44,318.90
	62	Marion	10.260	Gravel	...do....	81,502.80	40,751.40
	68	Lewis	4.281	.....do	...do....	50,127.45	25,063.72
	77	St. Louis	15.762	Concrete and hillside brick	...do....	688,325.88	329,068.82
	80	.....do	7.026	Concrete	...do....	303,000.69	144,928.43
	81	Jasper	2.760	.....do	...do....	95,373.75	47,686.87
	26	Dunklin	8.620	Gravel	...do....	118,016.27	59,008.13
	18	Jackson		Bituminous macadam	...do....	[1] 21,101.78	[1] 10,550.89
	23	Pettis		.....do	...do....	[1] 7,290.70	[1] 3,645.35
Montana	70A	Silver Bow	9.110	Paving	May 21	335,877.10	167,938.55
	14	Park		Bridge	June 8	55,049.50	27,524.75
	15	Rosebud	3.560	Gravel	June 15	21,767.07	10,883.53
	61	Wibaux	6.860	.....do	June 24	35,732.16	17,866.08
	9B	Madison	4.580	Selected material	June 25	25,286.77	12,643.38
	44	Gallatin	4.924	Concrete	June 28	206,966.06	98,480.00
	49	Meagher	20.280	Earth	...do....	150,216.79	75,108.39
	51	Gallatin	.840	Concrete	...do....	68,759.08	16,800.00
	63	Missoula	19.611	Gravel	...do....	133,976.55	66,988.27
	64	Cascade	18.260	.....do	...do....	259,409.49	129,704.74
	83	Valley	1,890	.....do	June 18	16,717.71	8,358.85
	100	Flathead	3.210	.....do	June 28	31,581.33	15,790.66
	101	Blaine	10.800	.....do	...do....	51,805.00	25,902.50
	106	Carbon	11.630	.....do	...do....	97,624.89	48,812.44
	57	Yellowstone	1.039	Concrete	June 30	52,764.85	20,790.00
	68	Deer Lodge	9,376	.....do	...do....	333,465.28	166,732.64
	53A	Yellowstone		Gravel	May 21	[1] 56,291.70	[1] 28,145.85
	20	Missoula	[2] 6.870	.....do	June 28	[2] 21,993.54	[2] 10,996.77
	40	Gallatin		.....do	...do....	[1] 3,153.69	[1] 1,576.84
	8	Meagher		.....do	...do....	[1] 11,960.26	[1] 5,980.13
	69	Jefferson	.703	Bituminous concrete, or concrete	June 30	27,716.14	13,858.07
	93	Flathead	3.380	Gravel	June 29	21,474.72	10,737.36
	29	Missoula	1.313	Earth and gravel	June 30	56,630.83	26,260.00
	33	Musselshell	4.350	Gravel	...do....	21,993.34	10,996.67
	52	Yellowstone	1.995	Concrete	...do....	94,876.70	39,900.00
	54	Cascade		Gravel	...do....	[1] 2,744.94	[1] 1,372.47
	92	Granite	6.664	Earth	...do....	98,514.48	50,860.49
Nebraska	135A	Merrick	9.330	Gravel	May 13	47,627.27	23,813.63
Nevada	23	Mineral	9.330	Earth	June 7	183,357.90	91,678.95
	27	Clarke		Bridge	...do....	87,407.10	43,703.55
	30	Ormsby	3.490	Concrete	...do....	126,177.19	63,088.59
	29A & B	Washoe	10.480	.....do	...do....	414,915.29	207,457.64
	19	Pershing	27,810	Gravel	June 30	103,718.21	51,859.10
	7	Washoe		Concrete	June 20	[3] 112,091.73	[3] 55,488.23
New Mexico	14B	Santa Fe	8.258	Earth	June 3	48,184.68	24,092.34
	13A	Valencia	10.859	Crushed stone	June 24	82,789.92	41,394.96
	24	Roosevelt	11.365	Caliche, two course	June 22	88,321.51	44,160.75
	39	Quay		Bridge	June 14	130,459.03	65,229.51
	25	Curry	15.437	Caliche	June 23	153,992.71	76,996.35
	32	San Miguel	15.084	Crushed stone	...do....	157,970.20	78,985.10
	47	Grant	15.228	Gravel	...do....	116,120.63	58,060.31
	33	Moro	12.705	.....do	...do....	190,989.67	95,494.83
	11	Lincoln		.....do	June 3	[3] 4,814.19	[3] 2,407.09
New York	33	Schoharie	10.330	Reinforced concrete	June 11	412,983.67	144,544.28
	39	Tioga	7.250	.....do	...do....	289,905.86	144,952.93
	43	Clinton	7.900	.....do	...do....	316,000.00	158,000.00
	44	Genesee	2.710	.....do	...do....	108,400.00	54,200.00
	53	Jefferson	3.250	.....do	June 12	121,500.00	42,525.00
	63	Tompkins	4.470	.....do	June 15	177,400.00	62,090.00
	59	Onondaga	3.940	.....do	...do....	157,600.00	78,800.00
	65	Otsego and Schoharie	10.580	.....do	...do....	423,200.00	151,013.50
	14A & B	Chautauqua	7.630	.....do	June 22	305,200.00	152,600.00
	31	Schuyler and Seneca	11.430	.....do	June 15	433,997.95	221,998.97
	32	Fulton and Saratoga	11.310	.....do	June 21	449,500.00	195,470.00
	41	Orleans	2.050	.....do	June 15	82,000.00	28,700.00
	58	Chemung and Tioga	3.620	.....do	...do....	144,800.00	72,400.00
	60	Herkimer	1.090	.....do	...do....	43,600.00	21,800.00
	11	Orange	2.580	.....do	June 24	103,200.00	51,600.00
	13	Chautauqua	6.500	.....do	...do....	260,000.00	130,000.00
	22	Broome	4.090	.....do	...do....	215,000.00	75,250.00
	35	Jefferson	8.370	.....do	...do....	334,800.00	167,400.00
	40	Oswego	9.370	.....do	...do....	356,600.00	124,810.00
	46	Dutchess	2.480	Bituminous macadam	...do....	114,900.00	40,215.00
	69	Delaware	10.570	Reinforced concrete	...do....	517,300.00	181,055.00
	37	Jefferson	2.610	.....do	June 25	90,700.00	31,745.00
	19	Franklin	2.840	.....do	June 28	113,600.00	56,800.00
	48	Wayne	1.790	.....do	June 29	71,600.00	35,800.00
	54	Madison	5.990	Concrete	...do....	239,600.00	119,800.00
	57	Genesee	2.100	Reinforced concrete	June 28	78,500.00	27,475.00
	61	Livingston	5.180	.....do	...do....	211,100.00	73,885.00
	26	Steuben	2.780	.....do	June 29	111,200.00	55,600.00
	47	Delaware	12.540	.....do	...do....	633,400.00	221,690.00
	49	Wayne	.990	.....do	...do....	39,600.00	19,800.00
	16	Ontario and Wayne	6.990	.....do	...do....	279,600.00	139,800.00
North Dakota	39A	Grant	6.000	Earth	June 4	32,562.63	16,281.31
	100	Burleigh and Morton		Concrete	June 15	876,000.00	438,000.00
	64	Logan		Bridge	...do....	3,858.50	1,929.25
	22	Towner	17.489	Earth	June 29	75,820.47	37,910.23
	36A	Baines	14.250	.....do	...do....	61,708.55	30,854.27
	19	Ramsey		.....do	June 30	[3] 30,153.05	[3] 15,076.53
	44	Bottineau		.....do	June 20	[1] 5,590.41	[1] 2,795.21
	18	Ramsey		Gravel	June 28	[3] 15,218.72	[3] 7,609.36
	16	Grand Forks		.....do	June 21	[1] 37,519.71	[1] 18,759.85
Ohio	44	Lorain	2.688	Brick, bitumen, or reinforced concrete	May 21	129,000.00	50,000.00
	63	Hamilton	2.723	Concrete, semimono brick, warrenite, bitulithic, or bitolslag.	...do....	163,[illegible]00.00	54,400.00
	75	Belmont	3.839	Bituminous macadam	June 24	139,200.00	40,000.00
	79	Fulton	6.191	Concrete	June 8	206,000.00	80,000.00
	118	Wood	3.378	Reinforced concrete or bituminous concrete	June 24	177,100.00	20,000.00
	138	Clermont	4.821	Water-bound or bituminous macadam	June 8	154,700.00	70,000.00

PROJECT AGREEMENTS EXECUTED IN JUNE, 1920—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Oklahoma	17	Canadian and Grady		Bridge	June 2	$294,135.38	$147,067.69
	18	Muskogee	29.533	Gravel	June 17	408,741.32	204,370.66
Oregon	36	Wasco	7.750	Earth	June 1	76,958.64	38,479.32
South Carolina	81	Charleston	7.384	Concrete	June 3	325,931.99	78,488.26
	28	Orangeburg	20.241	Cement and sand-clay	June 17	376,631.88	125,614.93
	84	Laurens	14.131	Top soil	do	84,731.87	32,301.06
	94	Union	3.873	do	do	23,521.89	4,200.00
South Dakota	34	Spink	10.880	Gravel	June 2	136,922.10	68,461.05
	26	Kingsbury	14.110	do	June 23	140,712.29	70,356.14
	33	Miner	11.518	do	do	125,422.73	62,711.36
Tennessee	32	Lauderdale	7.717	Bituminous macadam	June 3	268,735.02	134,367.51
	33	Crockett	5.666	do	do	172,012.30	86,006.15
	42	Hamblen	8.314	do	do	169,013.31	84,506.65
	43	Shelby	7.429	do	do	172,501.28	86,250.64
	27	Lewis and Lawrence	20.466	Earth	June 15	88,282.92	44,141.46
	14	Grainger, Hawkins, and Sullivan.	50.129	Bituminous macadam	June 24	1,216,367.13	608,183.56
	26	Maury	11.872	Rock asphalt	do	443,277.85	221,638.92
	35	Hamilton	10.143	Concrete	do	374,348.32	187,174.16
Texas	117	Denton	10.034	Gravel surface treated	June 7	198,754.52	75,000.00
	90	Taylor	19.925	Gravel	June 19	114,781.52	40,030.00
	100	Rockwall	13.360	Concrete	do	570,620.60	200,000.00
	104	Sabine	13.690	Gravel	do	187,384.35	85,000.00
	112	Bexar	7.236	Gravel surface treated	do	77,830.50	35,802.33
	113	Hill	22.810	do	do	458,168.47	124,000.00
	132A	Parker	15.066	do	do	257,819.14	100,000.00
	137	Limestone	28.329	Earth and crushed limestone	do	339,302.75	92,600.00
	82	Jasper	16.210	Gravel and earth	June 21	146,711.71	30,000.00
	128A	Montague	7.472	Sand clay	June 19	56,456.14	20,000.00
	135AB	Schliecher	7.430	Stone macadam	June 22	137,385.58	68,692.79
	154	Bastrop	2.260	Gravel	June 21	20,761.38	10,270.00
	156	Titus	5.150	do	June 22	42,684.04	21,000.00
	92	Hood	27.540	Earth	June 21	180,132.07	70,000.00
	111	Scurry, Mitchell, and Nolan.	21.523	Gravel	June 30	137,131.61	67,150.00
	125	Liberty	8.518	do	June 21	149,257.18	65,000.00
	57	Wilbarder	[4] 2.066	Concrete	June 4	[4] 10,605.17	
	31	Bexar		Gravel and gravel surface treated	June 21	[1] 50,515.94	[1] 25,257.97
	59	Calhoun		Gravel	June 26	[1] 7,173.53	[1] 2,790.00
	117	Benton		Gravel surfaces treated	June 29	[1] 27,274.30	[1] 25,000.00
	131	Bexar	15.767	Concrete-asphalt top; gravel-bitumen top	June 22	204,031.83	81,078.81
	138	Limestone	11.917	Limestone macadam	June 21	192,680.87	48,000.00
	140A	Williamson		Bridge	do	24,851.81	10,000.00
	149	Orange	10.260	Concrete	do	422,683.52	200,000.00
	143	Denton	8.000	Gravel and bitumen top	June 28	204,294.58	100,000.00
	43	Tarrant	5.857	Concrete	June 30	309,391.62	116,000.00
	120	Cass	12.638	Gravel	June 29	122,513.08	37,487.04
	99	Calhoun	4.616	Mudshell on gravel base	June 26	14,180.21	6,500.00
	115	Smith	8.720	Concrete and gravel	June 29	175,955.11	87,257.24
	118	Webb	17.500	Gravel	do	166,570.78	41,507.12
	132B	Parker	16.590	Gravel, bitumen top	June 28	427,441.48	140,000.00
	148	Kleberg	18.600	Gravel	June 29	388,962.58	125,000.00
	151	Bee	21.617	Gravel, bitumen top	do	424,192.72	200,000.00
	86B	Montague	8.090	Gravel	do	104,202.41	51,200.00
	21	Gregg		Surface-treated macadam	June 30	[1] 28,666.67	14,333.33
Utah	9GHJK	Millard	23.670	Concrete	June 4	553,596.88	276,798.44
	4CDE	Carbon and Emery	30.530	Earth	June 16	317,044.11	158,522.05
Vermont	3	Caledonia	.730	Waterbound macadam	June 21	28,776.66	14,388.33
	5	Franklin	.710	do	do	17,003.91	8,501.95
	12	Bennington and Rutland	13.570	Gravel	do	287,118.48	143,559.24
	13	Addison	4.070	Waterbound macadam	do	117,688.23	58,844.11
	14	Windham	5.600	Gravel	June 23	149,536.42	74,768.21
	15	Chittenden	4.030	Bituminous macadam	do	153,787.37	76,893.68
	16	Washington	1.260	Gravel	do	41,980.73	20,990.36
	6	Orange		Bituminous macadam	June 22	[1] 6,619.03	[1] 3,309.52
Washington	35	Whitman	21.370	Crushed rock	May 13	297,899.21	148,949.60
West Virginia	66A	Wirt	2.582	Earth	June 28	39,625.00	19,812.50
Wisconsin	107	Monroe	.880	Concrete	June 22	36,000.99	14,000.50
	135	Buffalo	1.950	do	do	88,999.49	33,500.00
	61	Sauk	.760	Gravel	June 24	25,992.67	9,000.00
	111	Eau Claire	1.900	Concrete	do	83,183.25	28,253.00
	133	Waushara	2.319	Sand-clay	do	18,436.57	7,000.00
	150	Dodge	6.450	Concrete	do	260,422.44	91,212.00
	159	Washington	1.710	do	do	60,236.22	20,750.00
	164	La Crosse	2.100	do	do	89,045.96	33,000.00
	104	Ozaukee	2.460	do	do	100,563.48	30,759.29
	108	Juneau	1.630	Earth	do	27,951.63	11,547.00
	110	Waukesha	3.040	Concrete	do	96,054.81	31,000.00
	113	Douglas	5.795	do	do	283,417.17	95,275.97
	115	Walworth	4.720	do	do	197,812.41	77,465.00
	118	Ashland	1.400	Gravel	do	19,859.51	7,000.00
	123	Manitowoc	3.880	Concrete	do	132,437.50	44,650.00
	139	Brown	2.910	do	do	97,954.05	30,000.00
	153	Eau Claire	.444	do	do	17,219.40	5,800.00
	31	Taylor		Earth	June 22		[1] 3,890.68
	54	Adams		Sand-clay	do		[1] 4,222.70
	72	Jefferson and Dodge		Concrete	June 24	[1] 107,582.99	[1] 37,194.33
	157	Green Lake	.610	do	do	22,903.29	8,434.34
	161	Juneau	.935	do	do	30,208.09	10,086.83
	170	Oneida	4.660	Gravel	do	45,329.87	15,300.00
	171	Richland		Concrete bridge	do	28,139.27	10,427.07
	173	Rusk	1.020	Earth	do	9,315.03	3,300.96
	143	Calumet	4.820	Concrete	do	162,000.00	54,000.00
	162	Kenosha	3.010	do	do	122,137.68	43,388.00
Wyoming	68	Hot Springs	4.281	Selected material	June 15	54,133.75	27,066.87
	45	Albany	2.705	Gravel	do	27,501.85	13,750.92
	55	Uinta	4.012	do	do	27,307.41	13,653.70
	60	Carbon	2.384	do	do	16,567.21	8,283.60
	69	Johnson	10.750	do	do	92,169.57	46,084.78
	40	Niobrara	11.894	Selected material	do	27,118.74	13,559.37
	53	Hot Springs	.959	Gravel	do	36,395.26	18,197.63
	56	Converse	7.169	do	do	66,350.47	33,175.23
	78	Fremont	9.238	Selected material	do	81,561.54	40,780.77
	17	Uinta		Sand-clay	do	[1] 23,894.75	[1] 11,947.37

[1] Modified agreements. Amounts given are increases over those in the original agreements.
[2] Canceled.
[3] Modified agreements. Second revision. Increase.
[4] Modified agreements. Amounts given are decreases from those in the original agreements.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

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 1916. 5c.
*Report of the Director of the Office of Public Roads for 1917. 5c.
Report of the Director of the Bureau of Public Roads for 1918.
Report of the Chief of the Bureau of Public Roads for 1919.

DEPARTMENT BULLETINS.

Dept. Bul. 105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
220. Road Models.
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.
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*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
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386. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
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388. Public Road Mileage and Revenues in the New England States, 1914.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States, 1914. 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.
583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.
660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads.
Public Roads, Vol. I, No. 11. Tests of Road-Building Rock in 1918.

OFFICE OF PUBLIC ROADS BULLETINS.

Bul. *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.
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OFFICE OF PUBLIC ROADS CIRCULARS.

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*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.
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*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.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
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.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.
Public Roads Vol. I, No. 1. Automobile Registrations, Licenses, and Revenues in the United States, 1917.
Vol. I, No. 3. State Highway Mileage and Expenditures in the United States, 1917.
Vol. I, No. 11. Automobile Registrations, Licenses, and Revenues in the United States, 1918.

DEPARTMENT CIRCULAR.

No. 94. TNT as a Blasting Explosive.

FARMERS' BULLETINS.

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*505. Benefits of Improved Roads. 5c.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways, 1917.

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 for Use in Testing Bituminous Materials.
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.
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.
Vol. 17, No. 4, D-16. Ultra-Microscopic Examination of Disperse Colloids Present in Bituminous Road Materials.

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