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THE COLLECTION AND DISPOSITION OF MOTOR VEHICLE REVENUES[1]

By HENRY R. TRUMBOWER, Economist, Bureau of Public Roads

DURING the calendar year 1925 the gross receipts derived from motor-vehicle license fees and gasoline taxes in the United States amounted to $406,648,561. These figures refer only to the revenues collected and received by the several States and by the District of Columbia; they do not include any of the collections made by cities and municipalities on account of local license fees or gasoline taxes. The gross receipts resulting from motor-vehicle registration fees, licenses, permits, fines, etc., amounted to $260,619,621; the total tax earnings on gasoline and motor-vehicle fuel, after deducting all refunds, amounted to $146,028,940. The registration fees, according to these figures, constituted 64 per cent of the total motor-vehicle revenues collected by the States, and the gasoline taxes 36 per cent. The relation of the license fees and the gasoline taxes to the total motor-vehicle revenues for each of the years since 1920 is set forth in Table 1.

TABLE 1.—*Total gross receipts from license fees and gasoline taxes, 1920 to 1925*

Year	License fees		Gasoline taxes		Total motor-vehicle revenues
	Amount	Per cent	Amount	Per cent	
1920	$102,546,212	99	$1,475,136	1	$104,021,348
1921	122,478,654	96	5,302,259	4	127,780,913
1922	152,047,823	93	11,923,442	7	163,971,265
1923	188,970,992	84	36,813,939	16	225,784,931
1924	225,492,252	74	79,734,490	26	305,226,742
1925	260,619,621	64	146,028,940	36	406,648,561

In 1925 the total motor-vehicle revenues were practically four times as great as in 1920; and in the same period the number of registered motor vehicles in the country slightly more than doubled. In 1920 the total motor-vehicle revenues, including license fees and gasoline taxes, averaged $11.27 per vehicle; in 1925 the average had risen to $20.27 per vehicle. The increase in total motor-vehicle revenues was, therefore, due to two causes—an increase in the number of motor vehicles from which license fees were collected, and an increase in the average receipts per motor vehicle on account of the rapidly extended application of the gasoline tax and increases in the fees charged for licenses. The license fees in 1920 averaged $11.18 per vehicle; in 1925 the average was $13.06. The gasoline taxes in 1925 amounted to more than the total license fees collected in 1921 and almost as much as the 1922 license fees. Constituting, in 1925, 36 per cent of the total motor-vehicle receipts whereas in 1920 they were but 1 per cent, it is evident that the gasoline tax revenues have become a substantial part of the country's total motor-vehicle revenues.

These motor-vehicle revenues collected by the States, when compared with the country's total annual expenditures on rural highways, make a very impressive showing. Our rural highway expenditures, according to the best estimate that can be made, amounted in 1925 to $1,288,939,707. It follows, therefore, that the amount collected in the form of license fees and gasoline taxes was equivalent to 31.5 per cent of the total rural highway expenditure. This ratio has been increasing from year to year.

In this study no attempt is made to investigate and analyze the license fee schedules and the gasoline tax rates of the several States which, through their application, have produced these motor-vehicle revenues. Such analyses have been presented in other reports in considerable detail. At the present time it is believed that those concerned with the subject of highway finance will be interested in a study of the disposition and distribution of the annual motor-vehicle revenues by the several States and certain administrative policies and procedures relating to their collection. This study is limited, more or less, to these phases of the subject and is divided into two parts; the first relating to the motor-vehicle license fees, and the second to the gasoline tax revenues.

PART 1. RECEIPTS FROM MOTOR-VEHICLE REGISTRATION FEES, LICENSES, PERMITS, FINES, ETC.

The figures presented herewith cover the total funds received by State and county officials in connection with the operation of the motor-vehicle license laws. The total receipts are recorded by all the States but there are still a considerable number which do not report the detailed sources of receipts. It is hoped that in the future reports more complete details can be presented.

Officers in charge of registration and license fee collection.—In each of the States a State officer or department is made responsible for the collection of the license fees and supervises the enforcement of the motor-vehicle registration laws. In a majority of the States this officer is the secretary of state. There are, however, a number in which the legislatures have created separate motor-vehicle departments and there are others in which the collecting and registering function is delegated to the respective State highway departments. At the present time there are 22 States in which the secretary of state is the responsible officer. These are Arizona, Colorado, Delaware, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Michigan, Minnesota, Missouri, Nevada, Ohio, Oregon, South Dakota, Utah, Vermont, Washington, Wisconsin, and Wyoming.

In 9 States there are separate motor-vehicle departments, the administrative heads of which are known as commissioners of motor vehicles or registrars. The States of this group are California, Connecticut, Maryland, Massachusetts, Montana, New Hampshire, New Jersey, North Dakota, and Virginia.

There are 7 States in which the respective highway departments supervise motor-vehicle registrations and the collection of license fees in addition to their regular duties of constructing and maintaining the State highway systems. These are Arkansas, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Texas, and West Virginia.

In the States of Alabama, Kentucky, New York, and Tennessee the State tax commissions have charge. In Florida and New Mexico the duty is performed by the

[1] Report of the highway finance committee, Highway Research Board, National Research Council, presented at the annual meeting of the board at Washington, D. C., December 3, 1926.

State comptroller. In Idaho the bureau of law enforcement is responsible; in Mississippi it is the auditor of public accounts; in Nebraska the department of public works; and in North Carolina the commissioner of revenue.

Although there is a State officer or State department responsible for the collection of the motor-vehicle license fees in each of the States, there are 16 States where the laws provide that certain county officers shall make the collections and distribute the registration plates. In 5 States—Iowa, Kansas, Nebraska, South Dakota, and Washington—the county treasurers make the direct collections. In Arizona, Idaho, and Nevada it is the county assessor who collects the license fees in the first place. The clerk of the county court is the collecting officer in Kentucky, South Carolina, and Tennessee. In Mississippi and Texas the county tax collector collects the motor license fees, together with the other local taxes. The probate judges are the local collecting officers in Alabama and the county sheriffs in Arkansas, and the State comptroller in Florida is authorized and directed by law to establish county agencies to collect the fees in each locality.

COLLECTION EXPENSES VARY WIDELY

Collection and administrative expenses.—The gross receipts from motor-vehicle registration fees, licenses, permits, fines, etc., and the amounts reported by the several States as spent for collection and administration are set forth in Table 2.

TABLE 2.—*Relation of collection and administrative expenses to gross receipts from license fees, etc.*

State	Gross receipts	Collection and administrative expenses	
		Amount	Per cent of gross receipts
Alabama	$2,511,129		
Arizona	405,592	$18,000	4.5
Arkansas	3,150,000	12,000	.4
California	7,816,298	951,076	12.2
Colorado	1,430,299	71,515	5.0
Connecticut	5,644,247		
Delaware	680,700		
Florida	3,645,628	261,220	7.2
Georgia	3,010,415	98,297	3.3
Idaho	1,192,587		
Illinois	12,969,754		
Indiana	4,649,663	205,681	4.4
Iowa	9,741,103	713,036	7.3
Kansas	4,610,090	230,505	5.0
Kentucky	3,780,062	132,105	3.5
Louisiana	3,400,045	40,000	1.2
Maine	2,182,135		
Maryland	2,576,301	250,000	9.7
Massachusetts	9,843,901	921,514	9.4
Michigan	14,526,002	300,000	2.1
Minnesota	9,744,834		
Mississippi	1,530,000	45,900	3.0
Missouri	7,267,098	432,023	5.9
Montana	915,253	32,000	3.5
Nebraska	3,936,458	98,411	2.5
Nevada	209,197	10,584	5.1
New Hampshire	1,736,094	114,610	6.6
New Jersey	10,515,323	1,177,057	11.2
New Mexico	457,874	31,991	7.0
New York	25,506,245		
North Carolina	8,359,844	149,761	1.8
North Dakota	1,083,573	150,000	13.8
Ohio	13,147,231		
Oklahoma	4,576,572		
Oregon	5,370,202	200,000	3.7
Pennsylvania	21,926,972		
Rhode Island	1,863,955	306,492	16.5
South Carolina	2,366,076	187,729	7.9
South Dakota	2,445,112	21,511	.9
Tennessee	3,060,948	54,243	1.8
Texas	13,477,931	476,146	3.5
Utah	554,235		
Vermont	1,497,146	82,037	5.5
Virginia	4,300,950		
Washington	4,980,026	240,059	4.8
West Virginia	3,354,247	264,386	7.9
Wisconsin	7,896,210	380,000	4.8
Wyoming	482,857		
District of Columbia	291,207	36,820	12.6
Total	260,619,621	8,696,709	

Thirty-four States and the District of Columbia reported that their collection and administrative expenses incurred on account of the registration and licensing laws amounted to $8,696,709 for that year. The total gross receipts for these same States which reported their collection and administrative expenses were $155,199,173. In these States, therefore, the collection and administrative expenses averaged 5.6 per cent of the total receipts. Among the individual States, however, there is a wide variation in this ratio, as shown in the table. In Arkansas the reported collection and administrative expenses were only $12,000, or 0.4 per cent, of the receipts; in Rhode Island they averaged 16.5 per cent. These are the two extremes.

In making such a comparison it must be borne in mind that certain items of expense are probably charged to this account in some States, whereas in other States similar expenditures are provided for by other funds or sources of revenue. In a number of States, as already pointed out, the actual collection of the fees and the registration of the motor vehicles is carried out by local county officers, such as sheriffs, county clerks, treasurers, or assessors. In such cases it is likely that a large part of the expenses connected with the administration of motor-vehicle licensing laws are borne by the local units of government, and that the reported expenses refer only to the administrative costs incurred by the State officials, who furnish the license plates and have but general supervision over the registration and licensing. In Tennessee, for instance, where the reported collection and administrative expenses amounted to only 1.8 per cent of the gross receipts, the county clerks collect the license fees from the car owners in their respective counties and charge each applicant in addition a fee of 50 cents, which the law authorizes as their compensation in full.[2]

In other States, where the ratio of collection and administrative expenses to gross receipts appear large and considerably above the average, services are rendered by State motor-vehicle departments and costs are incurred which are not found to the same extent in other States. In States like Maryland and Massachusetts, for example, the function of enforcing all provisions of the motor-vehicle laws relating to the use of the highways rests with the State motor-vehicle departments to a much greater degree than it does in many of the other States. Maryland's expense ratio is 9.7 per cent, and in Massachusetts it is 9.4 per cent. Somewhat similar conditions prevail in New Jersey, where the ratio is 11.2 per cent.

There are still other States in which the State departments are required to examine all applicants for licenses as to their ability and fitness to drive. Where such provisions are in effect and where the costs of this additional service are borne by the motor-vehicle departments and charged against the department's gross receipts, the ratio of expenses to receipts is naturally higher than in States where such services and costs are not involved.

A number of States, although permitting the deduction of collection and administrative expenses from the gross receipts, place limits upon expenses of this character. Arizona fixes the maximum at $25,000, North Dakota at $150,000. The California law provides that the motor-vehicle department's administrative expenses shall be kept within 20 per cent of the gross amount collected in license fees; Georgia limits

[2] Motor Vehicle Laws of Tennessee, art. 5, sec. c., passed Apr. 16, 1919.

it to 15 per cent; in New Mexico the limit is 5 per cent; and in North Carolina the administrative expenses may not exceed 10 per cent of the collections. The Rhode Island legislature has limited the State board of public roads which registers the motor vehicles and collects the license fees to an annual expenditure of $30,000 for plates, $89,000 for clerical salaries, and $30,000 for other expenses.

If the expense ratio which has been found to exist in these States, which have reported their respective collection and administrative expenses, is applied to the total gross license fee receipts of all of the States the resulting estimate of total collection and administrative expenses amounts to approximately $14,500,000. The remaining $246,100,000 is available for highway purposes and other uses. In most cases where no collection and administrative expenses are reported the legislatures make definite appropriations to meet such costs and all of the total receipts are turned over to the State treasurer's department, usually to the credit of certain highway funds.

In discussing these variations in administrative expense ratio it must be observed that one of the reasons for them is the variation in the fees charged. For example, no more labor or expense is necessary in registering cars where the license fees average $10 per car than where the average is but $5. The expense ratio will differ, however, in direct proportion to the amount of fees charged.

COLLECTION COSTS FROM 7 CENTS TO $3 PER CAR

The collection and administrative expenses of the States which reported this item amount to an average of 70.4 cents per motor vehicle registered. These States, in 1925, reported a total registration of 12,266,460 vehicles. When the collection costs are averaged over the number of cars registered in each of the reporting States wide variations are also noticed. In Arkansas these administrative expenses amounted to 7 cents per registered vehicle; that is the lowest. The highest average is found in Rhode Island, $3.02 per vehicle. It would appear that both of these averages are not only extreme but abnormal. The registration of automobiles in Rhode Island is in the hands of the State highway commission, and it is quite possible that the figures which were reported as the expense resulting from the administration of the motor-vehicle registration law may contain other items of expense incurred by the commission which pertain to other functions and duties of the commission.

TABLE 3.—*Relation of collection and administrative expenses to number of cars registered*

State	Number of cars registered	Collection and administrative expenses	
		Amount	Per car registered
Alabama	194,580		
Arizona	68,029	$18,000	$0.26
Arkansas	183,589	12,000	.07
California	1,440,541	951,076	.66
Colorado	240,097	71,515	.30
Connecticut	250,669		
Delaware	40,140		
Florida	286,388	261,220	.91
Georgia	248,093	98,297	.40
Idaho	81,506		
Illinois	1,263,177		
Indiana	725,410	205,681	.28
Iowa	659,202	713,036	1.08
Kansas	457,033	230,505	.50
Kentucky	261,647	132,105	.51
Louisiana	207,000	40,000	.19
Maine	140,499		
Maryland	234,247	250,000	1.07
Massachusetts	646,153	921,514	1.43
Michigan	989,010	$300,000	$0.30
Minnesota	569,694		
Mississippi	177,262	45,900	.26
Missouri	604,166	432,023	.72
Montana	94,656	32,000	.34
Nebraska	338,719	98,411	.29
Nevada	21,169	10,584	.50
New Hampshire	81,498	114,610	1.40
New Jersey	580,554	1,177,057	2.00
New Mexico	49,111	31,991	.65
New York	1,625,583		
North Carolina	340,287	149,761	.44
North Dakota	144,972	150,000	1.04
Ohio	1,346,400		
Oklahoma	424,345		
Oregon	216,553	200,000	.93
Pennsylvania	1,330,433		
Rhode Island	101,756	306,492	3.02
South Carolina	168,496	187,729	1.11
South Dakota	168,028	21,511	.13
Tennessee	244,626	54,243	.22
Texas	975,083	476,146	.49
Utah	90,500		
Vermont	69,576	82,037	1.18
Virginia	282,650		
Washington	328,442	240,059	.73
West Virginia	217,589	264,386	1.22
Wisconsin	594,386	380,000	.64
Wyoming	47,711		
District of Columbia	103,092	36,820	.36
Total	19,954,347	8,696,709	

TABLE 3.—*Relation of collection and administrative expenses to number of cars registered*—Continued

DISPOSITION OF LICENSE-FEE RECEIPTS

In the preceding tabulations a figure of $8,696,709 is used as representing the collection and administrative expenses incidental to the licensing of motor vehicles in 34 States and the District of Columbia. The reports, made by several other States indicated that certain expenditures were made for license-fee collection and other miscellaneous administrative purposes. As the two kinds of expense were not separated in the reports, these were not used in making the foregoing analysis. In determining what portion of the total gross receipts was used for highway and other related purposes in the following study all these reported expense items have been deducted, thus leaving balances available for other purposes. Excluding the District of Columbia it is found that the total gross receipts amounted to $260,328,414 and that the sum reported by the various States as the collection and administrative expense item was $11,955,927. Ten of the States did not report any administrative expense items for the reason that their motor-vehicle departments are maintained by definite appropriations from the general funds, thus making it unnecessary to make deductions from the license receipts in order to carry on the affairs of the departments.

After deducting the collection and administrative expenses as reported there is left a balance of $248,372,487. The disposition of this total amount is the subject of our further study. For the country as a whole it was as follows:

Purpose	Amount	Per cent of total
Construction and maintenance of State highway system	$177,452,200	71.5
Construction and maintenance of local roads	48,396,471	19.5
Principal and interest payments on State and local highway bonds	19,124,014	7.7
Transfers to general funds	478,183	.2
Expenses of highway departments	618,655	.2
Traffic control and patrol	770,391	.3
Other purposes	1,532,573	.6
Total	248,372,487	100.0

In studying this disposition of the motor-vehicle license receipts, it is significant to note that after a deduction of the reported administrative expenses 91 per cent of the balance is devoted directly to the construction and maintenance of highways; 71.5 per cent for State highway system, and 19.5 per cent for local roads. This 91 per cent of the available revenues for highway construction and maintenance amounts to $225,848,671, 79 per cent of which is spent on State highway systems and 21 per cent on local roads. Of these special revenues $19,124,014, or 7.7 per cent of the total amount available, was devoted to principal and interest payments on State and local highway bonds. The license fees devoted to other purposes constituted but 1.3 per cent of the total amount available.

HOW THE STATES DISTRIBUTE THE LICENSE RECEIPTS

The major legislative provisions relating to the distribution and disposition of the license fees derived from the registration and regulation of motor vehicles in the several States are as follows:

Alabama.—The expenses incident to the collection of the fees are first deducted. Of the balance, 80 per cent is credited to the State and 20 per cent is turned back to the incorporated city or town in which the owner of the registered vehicle resides. If the owner resides outside of an incorporated city or town the 20 per cent share is remitted to the county in which he resides. The statutes provide that the 80 per cent share credited to the State shall be used exclusively to create a sinking fund for the prompt payment of the principal and interest on the State road bonds outstanding, and for the construction, maintenance, and improvement of public highways, roads, and bridges. The statutes are silent as to the manner in which the incorporated municipalities and counties may use their shares of license fee revenues.

Arizona.—All the license fees are credited by the State treasurer to the State road-tax funds and out of this fund the legislature has appropriated a sum not to exceed $25,000 for the purpose of meeting the administration and collection expenses.

Arkansas.—A special fund is created in the State treasurer's office known as the State highway fund. All the money which the State receives from the collection of license fees and gasoline and oil taxes is credited to this fund. The State highway commission allots the sum of $3,000,000, or as much thereof as is available in the treasury by July 1 of each year, to the counties, apportioned on the basis of population. For the purpose of determining the use of these county-allotted funds the statutes classify the counties.

Class A includes 13 counties, named in the law, which are required to use the whole of the funds derived from the State in part payment of highway bonds and interest coupons. Class B includes only 3 counties which are required to devote 90 per cent of their State allotment to bond and interest payments and to place the remaining 10 per cent in the county highway improvement fund. Class C includes 11 counties which are required to devote 75 per cent of their State allotment to bond and interest payments and to credit the remaining 25 per cent to the county highway improvement fund. In class D there are 10 counties which are required to devote 50 per cent of their State allotment to bond and interest payments and the remaining 50 per cent to the county highway improvement fund. Class E includes 13 counties, the allotment being divided 25 per cent for bond and interest payments and 75 per cent credited to the county highway improvement fund. No counties are put in class F, of which the stated percentages are 10 per cent for bond and interest payment and 90 per cent for the county highway improvement fund. Class G contains 26 counties which are authorized to place all of their State allotments into their respective county highway improvement funds. The county courts are authorized to expend the funds put into the county highway improvement fund upon the public highways for construction and maintenance purposes.

California.—The motor-vehicle license fees are kept by the State treasurer in a motor-vehicle fund. From this fund are deducted the expenses of the motor-vehicle department, which may not exceed 20 per cent of the revenues. One-half of the balance in the motor-vehicle fund is paid over to the counties in proportion to the number of motor vehicles registered. The amount paid by the State for State inspectors and traffic officers is deducted from this county allotment. All amounts paid to the counties are credited to the road funds of the counties and are to be expended exclusively in the construction and maintenance of public roads, bridges, and culverts within the respective counties. The board of supervisors has the power to devote a portion of such allotted funds to the construction, maintenance, and repair of streets and bridges within incorporated cities. Annual reports have to be made by the county supervisors to the State department of public works showing the amount of money received and the disposition thereof. The balance in the State motor-vehicle fund is expended under the direction of the State department of public works for the maintenance, repair, widening, resurfacing, and reconstruction of State roads and highways. The funds allocated to the State department are not to be used for construction purposes though that use is permitted to the county highway officials.

Colorado.—The State treasurer deducts from the receipts derived from motor-vehicle license fees the necessary administrative expenses. Fifty per cent of the balance is expended by the State highway commission for the construction, maintenance, and improvement of the State highways and for no other purpose. The remaining 50 per cent is paid over to the counties, in proportion to the money collected, for the exclusive purpose of constructing, maintaining, and improving county roads and bridges.

Connecticut.—All license revenues are expended by the State highway commissioner for the construction, maintenance, or reconstruction of State highways. The law makes no mention of administrative expenses.

Delaware.—The State treasurer is directed to pay out of motor-vehicle revenues the interest on highway bonds and to put into a separate fund annually the necessary amount to meet the sinking-fund requirements. The balance is to be expended by the State highway department for the construction and maintenance of State highways.

Florida.—After deducting the collection and administrative expenses 5 per cent of the receipts from motor-vehicle license fees is set aside for the maintenance of the State road department; 25 per cent is allocated to the counties as a State-aid fund for the purpose of construction and maintenance of county roads. This amount is apportioned among the counties on the basis of the amount of fees collected. The balance, or 70 per cent, is placed in a fund to be used by the State road department for the construction and maintenance of State and Federal-aid roads.

Georgia.—The highway commission allocates the net amount of license fees collected to the counties according to post-road mileage. Such funds are expended by the highway commission in the building, repairing, and maintaining of public roads in each of the counties.

Idaho.—The county assessors who collect the license fees are directed to remit 10 per cent of their collections to the State treasurer who places these payments in the State highway fund. Ninety per cent of the fees collected accrue to the counties. The county commissioners of each county apportion to the interest and sinking fund of the county such amounts as are necessary for the current year. The balance of the fees is divided by the county commissioners among the regularly organized highway districts in proportion to the collections made from such districts. If any balances remain they are apportioned to the county road and bridge funds.

Illinois.—All license fees are deposited with the State treasurer and become a part of the State road fund. This fund is used for the purpose of meeting the principal and interest requirements on highway bonded indebtedness. If there is any balance left it is to be used for the improvement of the highways of the State or for the construction and maintenance of durable, hard-surfaced roads along designated routes.

Indiana.—After collection expenses are deducted all the receipts derived from motor-vehicle license fees are placed in a State highway fund which is available to the State highway commission for construction and maintenance purposes.

Iowa.—The law provides that 2½ per cent of the license fee collections shall be credited to a maintenance fund for the State highway commission and that 3½ per cent shall be credited to a maintenance fund for the motor-vehicle department. The balance, less 50 cents per license issued which is retained by the county treasurer to cover his registration expenses, 0.5 per cent of which is credited to a reimbursement fund, is turned into the primary road fund. This primary road fund is apportioned among the counties in the same ratio that the area of each county bears to the total area of the State. The law defines primary roads as those main marked roads which connect all the county seat towns with the main market centers. A small fund known as the Federal engineering fund is also created out of the license fees.

Kansas.—The county treasurers collect the license fees and remit to the Secretary of State 50 cents for each motor-vehicle license issued. Of the balance 25 per cent remains in the county where collected and is divided among the townships in proportion to the amount collected in each. The remaining 75 per cent of the fees is transmitted to the State treasurer and placed in the State highway fund, to which is also added the money derived from the gasoline tax. There is withdrawn annually from this State highway fund the sum of $300,000, which is placed in another fund known as the State-aid road fund and expended in the various counties upon the State highway system under the direction of the State highway commission acting in conjunction with the boards of county commissioners. Forty per cent of this sum is distributed equally among all of the counties of the State and 60 per cent is distributed in proportion to assessed valuation. The remainder of the State highway fund, after deducting the sum of $300,000 and a sum not to exceed $75,000 for the maintenance of the State highway commission, is distributed among the counties in the same proportion as noted above. The fund thus created in the various counties is known as the county and State road fund and is used for the construction, reconstruction, and maintenance of State roads in the counties. Not more than 20 per cent of this fund can be expended on county or township roads.

Kentucky.—All motor vehicle license fee receipts are deposited in the State road fund, out of which are paid the expenses of the State tax commission incident to the enforcement of the registration law. The balance of the fund is used only for the purpose of construction, reconstruction, maintenance, and repair of roads and highways.

Louisiana.—All license fees are deposited with the State treasurer and credited to the account of the general highway fund which is used by the State highway commission for the construction and maintenance of State highways.

Maine.—All the fees collected are turned over to the State treasurer and are used for the administration of the office and duties of the highway commission, including the expenses of administering the motor-vehicle department. The balance is used for the repair and maintenance of the State-aid highways under the direction of the commission and to meet the interest and principal payments of the bond issues for highway construction purposes.

Maryland.—The commissioner of motor vehicles is directed to remit to the State treasurer all license-fee revenues received by him to be placed in a special fund. Out of this fund the legislature's appropriations for the department's administrative expenses are met. The balance is distributed in quarterly installments 20 per cent to the city of Baltimore for use on its roads, 80 per cent to the State roads commission to be used for the oiling, maintenance, and repair of the State and State-aid roads.

Massachusetts.—All the motor-vehicle revenues received and collected by the registrar of motor vehicles are credited to a fund known as the highway fund. Out of it the department's administrative expenses are paid. The balance is used under the direction of the highway division of the department of public works for maintaining, repairing, improving and constructing town and county roads; for maintaining, repairing and improving State highways and bridges; for construction of State highways partially financed through Federal-aid funds; for engineering services, purchase and maintenance of road-building machinery, snow removal, erection and maintenance of warning and direction signs, care of shrubs and trees on State highways; to meet the interest and sinking-fund payments on State highway bonds; to meet the State's share of the interest and sinking-fund payments on metropolitan park loans; and to meet the State's share of the cost of maintenance of boulevards in the metropolitan park district and the cost of construction of such boulevards. The distribution of funds for all of these purposes is left to the State commission except for those fixed or contractual payments which have to be met.

Michigan.—All license fees are deposited in the State treasury to the credit of the State highway fund. Six million dollars are returned to the counties in proportion to the amounts received as license fees from the owners of motor vehicles within the several counties. These funds are to be used for highway purposes under the jurisdiction of county authorities. Further appropriations from this State highway fund for 1925 were: (*a*) A sum not less than $1,200,000 to meet the interest and sinking-fund payments of State highway bonds; (*b*) $2,000,000 for the maintenance of State trunkline,

Federal-aid and nontrunk-line highways; (*c*) $1,000,000 for building trunk-line bridges, including grade separations; (*d*) $500,000 for nontrunk-line highway maintenance and for nontrunk-line bridges; (*e*) the balance not otherwise appropriated for opening, widening, and improving State trunk-line and Federal-aid highways. There is also appropriated out of the State highway fund the sum of $300,000 to cover the operating expenses of the State highway department.

Minnesota.—The proceeds of the license fees and motor-vehicle taxes are deposited in the State treasury and constitute a fund known as the trunk-highway sinking fund. The law provides that out of this fund there shall be taken and deducted annually the amount required during the year as interest and principal payments on State highway bonds. After these payments are made or determined upon the balance is transferred from the trunk-highway sinking fund to the trunk-highway fund which is used by the State department of highways for administration, maintenance, and construction purposes. Up to the present time the State has not issued any highway bonds so it is not necessary to set aside any funds for interest and principal payments upon such bonds. The law also provides that the State shall reimburse the counties for certain work done by the counties on roads that are now a part of the State highway system. In fulfilling this requirement the State has made itself responsible for the interest and principal payments of such county bonds and there is set aside out of the trunk-highway sinking fund a sum amounting to $2,000,000 a year for these specific purposes.

Mississippi.—The county tax collector who collects the motor-vehicle license fees deducts 3 per cent as his commission, and turns the balance of his collections into the county road fund. These funds are used to maintain, repair, construct, or extend the highways in the county, preference being given to designated State highways.

Missouri.—All moneys arising from motor-vehicle license fees after deducting the administration and collection costs are deposited in the State treasury and credited to a State road fund. The revenues derived from the sale of option stamps are also turned into this fund. Out of this fund are paid: (*a*) The administrative cost and expenses of the State highway department; (*b*) $400,000 biennially for the purpose of providing the sum of not more than $25 per mile per annum for dragging and otherwise improving intercounty-seat highways; (*c*) the amount needed to match Federal-aid allotments; (*d*) the remainder to be used in the construction of State roads.

Montana.—After deducting from the receipts all administrative and collection expenses, 50 per cent of the balance is transmitted back to the counties from which the fees came and is deposited to the credit of the general road fund of the county; the remaining 50 per cent is deposited to the credit of the State highway fund, which is used for construction and maintenance purposes.

Nebraska.—The county treasurer of each county collects the motor-vehicle license fees. Thirty per cent of the fees are transmitted by the county treasurers to the State treasurer to be credited to the State highway fund and used for the maintenance of the State highway system. The remainder of the revenues is kept by the counties; 75 per cent to be used for the maintenance of that part of the State highway system within the respective counties and 25 per cent credited to the county's road dragging fund.

Nevada.—All motor-vehicle revenues are placed by the State treasurer in a motor-vehicle license fund. Disbursements from this fund are made as follows: (*a*) To meet the interest and principal payment requirements of the State highway bonds; (*b*) to meet the expenses of administering the registration law 50 cents per vehicle registered is placed in a motor-vehicle expense fund; and (*c*) after these requirements are met the State controller is directed to transfer the balance at the end of each three-month period to the State highway fund which is used by the State commission for the purpose of constructing, equipping and maintaining the highways designated as the State highway system.

New Hampshire.—After all expenses of the commissioner of motor-vehicles department have been met out of motor-vehicle revenues the balance is placed in a fund to be used by the State highway commissioner for the construction of State and State-aid roads and for their maintenance.

New Jersey.—The license-fee receipts, after making a deduction for the expenses of the motor-vehicle department, are deposited with the State treasurer to be used for construction and maintenance purposes by the State highway commission. The legislature at its last session appropriated $840,000 from the motor-vehicle funds and distributed this amount equally among the 21 counties. A further appropriation of $60,000 was made as aid in the maintenance of interstate bridges which had been freed by the Delaware River Free Bridge Commission.

New Mexico.—The law authorizes a collection fee of not more than 5 per cent, and the balance of the motor-vehicle revenues is deposited with the State treasurer. Two-thirds of this amount is credited to the State road fund to be used by the State highway commission for the maintenance of State highways in the several counties as near by as practicable in proportion to the fees paid by motor-vehicle owners residing in each county. The remaining third is transmitted to the county treasurers in proportion to the amount of fees paid and credited to the county road fund of each county for use in the maintenance of county roads.

New York.—Every month the collecting agency deposits 75 per cent of the funds on hand with the State treasurer and 25 per cent of the registration fees collected in each county with the treasurer of the county. The funds received by the State treasurer are used in the maintenance and repair of the improved roads of the State under the direction of the State commissioner of highways. All funds received by the county treasurers are used for the permanent construction and maintenance of town highways and county roads. The funds accruing to the city of New York are credited to the city's general fund.

North Carolina.—After the collection and registration expenses are deducted, which may not exceed 10 per cent of the total amount collected, the motor-vehicle license fees are credited to a fund for meeting interest, sinking fund and principal payment requirements of the bonds issued by the State for highway improvements. What balance is not needed for these specific purposes is used by the State highway commission for the maintenance of highways in the State system and for construction and reconstruction purposes. A provision of the law allows cities and towns to charge a license not to exceed $50 for any motor vehicle used in transporting persons or property for hire in lieu of all other charges, fees, and licenses.

North Dakota.—The moneys received into State treasury as motor-vehicle license fees are expended as follows: A sum not to exceed $150,000 per annum for expenses of the State highway commission for carrying out provisions, of the motor-vehicle registration act and the State highway commission act; a further sum of $130,000 annually to meet State obligations for bridge loans; 50 per cent of balance paid to county road funds for the construction and maintenance of county roads; the remaining 50 per cent shall remain in State highway fund for construction, reconstruction, and maintenance of Federal-aid and State-aid roads.

Ohio.—Fifty per cent of the license fees collected is turned back for the use of the municipal corporation or county in which the fees are originally collected. Such moneys constitute a fund which is used for the maintenance and repair of public roads, highways and streets and for no other purpose. The remaining 50 per cent of the receipts is deposited in the State treasury and credited to a State maintenance and repair fund. The expenses incident to the administration of the registration law are paid out of this fund and the remainder is for the use of the director of highways and public works.

Oklahoma.—An amount equal to 40 per cent of the revenues derived from license fees is credited to the State highway construction and maintenance fund; 60 per cent is transmitted to the counties in proportion to the amount collected in each respectively. This fund is used for construction and maintenance. The county treasurers are directed to turn over to the treasurers of incorporated cities and towns 15 per cent of the fees collected from motor vehicle owners residing within such incorporated places which amount is credited to the local street and alley fund. The balance of the county's share is credited to the county highway construction and maintenance fund.

Oregon.—After deducting the collection and administrative expenses the revenues derived from registration fees are divided between the State and the counties, 75 per cent of this balance is transferred to the State highway fund, 25 per cent is transmitted to the county treasurers of the various counties in proportion to the receipts from each county. In each county there is created a motor-license fund arising from the money received from the State. This county fund is used and disbursed in the following order: (*a*) Payment of interest and principal of county highway bonds; (*b*) where no bonds have been issued or where other provision has been made for the interest payment and retirement of such bonds, the funds are used to prepare the roadbeds and bridges for the the construction of State highways; (*c*) if provision has been made for meeting bond requirements and for the payment of expenses of preparing the roadbed then the money may be used in the discretion of the county court for general road improvements.

Pennsylvania.—The receipts derived from the licensing and registering of motor vehicles are placed in a fund known as the motor-license fund. Out of this fund are paid all the administrative expenses of the State highway department which is responsible, along with its other duties, for the collection of the license fees. A prior lien on this fund is the amount of money necessary for the payment of interest and sinking-fund charges on highway bonds issued by the State. The rest is at the disposal of the highway department for the purpose of assisting in the maintenance, construction, reconstruction, and improvement of State and State-aid highways, and also for the maintenance of interstate bridges.

Rhode Island.—All the motor-vehicle revenues are deposited in the State treasury and out of them are paid the costs of license plates not to exceed $30,000, the annual salaries of clerks employed by the State board of public roads not to exceed $89,000, and other expenses not to exceed $30,000. The balance is used for the construction, repair, and maintenance of, and removal of snow from State roads and highways under the direction of the State authorities.

South Carolina.—The receipts from motor-vehicle license fees are expended by and under the direction of the State highway department for the construction and maintenance of the State highway system.

South Dakota.—The collections are made by the county treasurers who forward one-half of the receipts to the State treasurer to be placed in the State highway fund for construction and maintenance purposes; 2 per cent is transmitted to the secreatry of state to be placed in the State motor-vehicle fund for the purpose of meeting his expenses incurred in connection with the registration law; and 48 per cent is credited to the motor-vehicle fund of the county in which the money is collected. The law further provides that 75 per cent of the funds in the State highway fund shall be apportioned for expenditure among the counties on the basis of assessed valuation; the remaining 25 per cent, after the commission's expenses are deducted, is used by the State highway commission for highway purposes.

Tennessee.—Fifty per cent of the net receipts is distributed equally among the counties of the State and the remaining 50 per cent is expended upon such State highways for construction and maintenance as may be designated by the highway commission. The State highway commission also has the right to designate the roads in the several counties upon which the counties are to spend their respective shares of the funds and the character of construction and maintenance.

Texas.—The motor vehicle license fees are based upon two separate computations; 17½ cents per horsepower is one part of the license fee, the other is the result of applying a certain rate to the weight of the vehicle. The county collector of taxes who collects the license fees is directed to deposit to the credit of the county road and bridge fund an amount equal to 17½ cents per horsepower for every vehicle registered. The balance of the fees derived from the weight factor is transmitted and credited to the State highway department. Approximately three-fourths of the total collections is turned over to the State department and one-fourth is retained by the counties.

Utah.—All the fees are deposited with the State treasurer and credited to a fund known as the motor-vehicle registration fund. Out of this fund are paid the registration expenses. The balance is applied to interest and principal payments on State road bonds.

Vermont.—The net fees are turned over to the State treasurer and are made available for road maintenance by the State highway department.

Virginia.—After deduction of registration and collection expenses the motor-vehicle revenues are deposited in the State treasury and are expended by the highway commission for the construction and maintenance of State highways and bridges.

Washington.—The State treasurer places all fees to the credit of the motor-vehicle fund in the State

treasury from which are paid annually: Expenses of the motor-vehicle department for issuing licenses; repayments to counties entirely surrounded by water; the sum of $1,400,000 to the credit of a State-treasury fund called "primary highway maintenance fund"; the balance to paving and general road construction as provided by appropriation.

The primary highway maintenance fund is distributed as follows:

(1) To each first and second class city in which are streets forming a part of the primary State highway, a sum equal to $500 per mile for each primary highway in such city for maintenance and improvement of streets.

(2) To each third and fourth class city, similarly to above, $300 per mile.

(3) To each county in which are located primary highways, similarly, $300 per mile.

(4) The balance to the counties in proportion to money paid into the highway fund for maintenance of primary highways.

West Virginia.—The collection of license fees and the registration of motor vehicles are under the jurisdiction of the State road commission. The receipts are placed in the State road fund. Out of it are paid the commission's expenses and the balance is devoted to: (*a*) Principal and interest payments on State highway bonds; (*b*) the maintenance and construction of State roads.

Wisconsin.—After deducting collection and administrative expenses the net motor-vehicle license fees and the net gasoline-tax receipts and Federal-aid allotments are appropriated for the use of the State highway commission under the following restrictions and directions of the legislature:

(1) One hundred thousand dollars allocated annually to meet the expenses of the highway commission; (2) after the commission's expenses are set aside, 10 per cent of the remainder of the appropriation is devoted to the improvement of the State trunk highway system to be expended on such projects as the commission shall from time to time determine; (3) $100,000 is set aside annually for the marking and signing of the State trunk highway system; (4) the counties receive from $300 to $500 per mile for the maintenance of the State trunk highway system, the cities receive similar payments per mile of streets forming State trunk highway connections, and special sums are provided for, to be paid counties, cities, and villages which provide and maintain free swing or lift bridges on the State trunk-highway system; (5) $250,000 is appropriated annually to pay the State's portion of the cost of bridges; (6) $25,000 for improving highways forming connections between State charitable institutions and the State trunk-highway system; (7) $50,000 for the construction and maintenance of roads in State parks; (8) $15,000 for the purpose of making surveys of local road materials; (9) for the improvement of roads and streets not part of the State trunk highway system in towns, villages, and cities (each town and village receives $25 per year for each mile of such streets, cities with a population of not more than 10,000 receive $50 per mile, cities with a population from 10,000 to 39,000 receive $100 per mile, cities with a population from 40,000 to 150,000 receive $150 per mile, and cities with a population in excess of 150,000 receive $200 per mile); (9) the balance remaining after the amounts for the above-named pruposes are appropriated is used for the improvement of the State trunk highway system and the county trunk highway systems.

Wyoming.—The revenues derived from motor-vehicle license fees are devoted to the interest and sinking-fund payments on State highway bonds.

PART II. RECEIPTS FROM GASOLINE TAXES

As has already been indicated the gasoline tax continues to furnish a more and more important source of funds derived from motor-vehicle owners and operators used for highway purposes. In 1925 there were only four States—Illinois, Massachusetts, New Jersey, and New York—which did not resort to the gasoline tax as a revenue-producing measure for the construction and maintenance of highways. The tax rate ranges from 1 to 5 cents per gallon. In 1925 a total tax of $146,028,940 was collected from the sale of 6,457,783,284 gallons of gasoline used in motor vehicles, from which it appears that the average tax rate is 2.2 cents per gallon. In the four States mentioned above which did not collect this type of tax, and in other States in which a gasoline tax was not in effect during the whole 12-month period, there was consumed by motor vehicles, according to the best estimates that can be made, 2,131,056,365 gallons of gasoline which was not taxed.

The gasoline tax is a comparatively new method of raising funds for highways. Although a form of sales tax it is generally conceded that the gasoline tax is in essence a type of road toll and that its yield and earnings reflect more or less directly the use made of the highways by motor vehicles and measure to a certain degree the benefits resulting therefrom.

Point of collection.—There are only three States—Colorado, North Carolina, and Pennsylvania—which do not collect the tax at the source. These States gather the tax from the dealer who sells to the consumer. In all other States the tax is collected at the source. This usually means the collection from the person or corporation which makes the original sales in the States. In most of the laws they are termed manufacturers, importers, distributers, or wholesalers.

Collection period.—In all except four of the States which have in effect a gasoline tax the collections are made monthly. In California, Georgia, Pennsylvania, and Tennessee the gasoline taxes are paid to the respective States quarterly. In most cases where the tax is collected at the source, the tax is remitted by the wholesale distributers accompanied by sworn statements showing in detail the receipts and sales.

Refunds.—The laws of 28 States provide for a refunding of the tax paid on gasoline sold for other purposes than for automobile use. The Indiana law, for example, has this provision: "* * * the tax does not apply to gasoline purchased for use in operating stationary gas engines, tractors used for agricultural purposes, motor boats, aeroplanes or aircraft, or for use in cleaning or dyeing, or for any other commercial use." Whether the tax is paid by the wholesaler or by the dealer, gasoline used for these purposes has, in most cases, been taxed when sold to the consumer and the consumer in the first instance pays the tax which is included in the price he pays for the gasoline. Where gasoline is sold under such circumstances, there is usually a provision made in the law whereby the consumer can secure a refund of the amount of taxes paid upon gasoline not used in motor vehicles by presenting a sworn statement of his purchase accompanied by

invoices or purchase memoranda. There are still 16 out of the 44 States which collect the tax which have not made any provision for refunds and which tax all the gasoline sold irrespective of its use. The 28 States which grant refunds collected, during 1925, $100,604,852 and refunded $4,109,513, or 4.1 per cent. It is no doubt true that a great many persons buying and using but small quantities of gasoline for purposes other than highway use never take the trouble to secure any refunds. How great that number is can not be determined definitely. There may also be a few who through false statements or otherwise secure for themselves refunds to which they are not entitled. The gross amounts collected and refunded in the 28 States which provide for refunds are set forth in Table 4.

TABLE 4.—*Gasoline tax receipts and refunds in 1925 by the 28 States providing for refunds*

State	Total gasoline tax receipts	Amount of refunds	Ratio of refunds to total receipts	Net gasoline tax receipts
			Per cent	
Arizona	$1,035,551	$179,600	17.3	$855,951
Arkansas	3,230,559	280,199	8.7	2,950,360
California	16,150,387	1,193,598	7.4	14,956,789
Colorado	1,991,531	30,585	1.5	1,960,946
Delaware	350,580	8,499	2.4	342,081
Idaho	932,064	36,621	3.9	895,443
Indiana	7,832,462	179,413	2.3	7,653,049
Iowa	3,568,184	63,069	1.8	3,505,115
Kansas	3,000,253	95,059	3.2	2,905,194
Maine	1,283,874	15,526	1.2	1,268,348
Maryland	2,022,986	45,950	2.3	1,977,036
Michigan	8,742,392	506,314	5.8	8,236,078
Minnesota	3,989,282	125,342	3.1	3,863,940
Missouri	4,234,070	74,955	1.8	4,159,115
Nebraska	2,202,236	8,434	0.4	2,193,802
Nevada	335,446	16,741	5.0	318,705
New Hampshire	716,140	9,068	1.3	707,072
North Carolina	6,238,508	156,130	2.5	6,082,378
North Dakota	649,416	15,000	2.3	634,416
Ohio	9,133,785	123,835	1.3	9,009,950
Oregon	3,065,151	156,056	5.1	2,909,095
South Carolina	3,870,588	5,185	0.1	3,865,403
South Dakota	2,122,406	274,808	12.9	1,847,598
Virginia	3,863,117	161,166	4.2	3,701,951
Washington	3,205,114	184,302	5.8	3,020,812
West Virginia	2,222,329	35,590	1.6	2,186,739
Wisconsin	4,155,469	123,793	3.0	4,031,676
Wyoming	460,972	4,675	1.0	456,297
Total	100,604,852	4,109,513	4.1	96,495,339

GASOLINE TAX REFUNDS VARIABLE

The ratio of the refunds to the total collections varied a good deal in the several States. The lowest amount refunded relative to the total gasoline-tax receipts is found in South Carolina, where the ratio is 0.1 per cent; the highest in Arizona, where it is 17.3 per cent. In South Dakota the refunds were 12.9 per cent of the collections. In both of the latter States unusual conditions are found with respect to these refunds. It has been intimated by some one that the refunds in Arizona were relatively high because taxes were paid on certain amounts of gasoline which were afterwards shipped outside of the State, which resulted in claims having been put in for refunds. The reasonableness and justice of exempting from taxation gasoline not used by motor vehicles can be readily admitted, in as much as the prime purpose of the tax is to secure funds from users of the highways in proportion to the use.

Collection costs.—Only 21 States reported separately the cost of collecting gasoline taxes. In these States the gross amount collected in 1925 was $82,456,346, and collection costs as reported were $217,393. The collection costs, therefore, amounted to an average cost for these States of $2.64 per thousand dollars, or 0.264 per cent. The details are set forth in Table 5.

TABLE 5.—*Costs of gasoline tax collection*

State	Gross amount collected	Total number of gallons taxed	Reported collection costs	Collection costs per $1,000 collected	Collection cost per million gallons taxed
Alabama	$2,140,802	107,040,092	$9,461	$4.42	$88.39
California	16,150,387	747,839,462	7,393	.46	9.89
Florida	7,657,507	210,323,517	6,000	.78	28.53
Georgia	4,418,824	138,802,152	4,200	.95	30.26
Idaho	932,064	30,809,320	9,466	10.16	307.24
Indiana	7,832,462	272,980,870	12,436	1.58	45.56
Iowa	3,568,184	175,255,740	5,520	1.55	31.50
Maine	1,283,874	56,513,741	5,596	4.36	99.02
Maryland	2,022,986	98,851,813	2,500	1.24	25.29
Michigan	8,742,392	411,803,894	41,358	4.73	100.43
Mississippi	2,494,274	83,142,469	1,800	.72	21.66
Missouri	4,234,070	207,955,474	23,429	5.53	112.66
Nebraska	2,202,236	109,690,122	4,963	2.25	45.25
New Mexico	537,356	20,490,892	26,868	50.00	1,311.22
Oregon	3,065,151	96,969,835	6,553	2.14	67.58
Tennessee	3,407,886	122,000,680	22,768	6.68	186.62
Utah	1,064,004	32,217,216	3,750	3.52	116.40
Virginia	3,863,117	123,398,365	5,604	1.45	45.41
West Virginia	2,222,329	76,331,660	7,560	3.37	98.26
Wisconsin	4,155,469	201,583,789	10,000	2.41	49.61
Wyoming	460,972	20,746,056	228	.49	10.99
Total	82,456,346	3,344,747,159	217,363	[1] 2.64	[1] 65.00

[1] Average.

It is noted that the collection costs vary materially in this group of States which represent approximately half of the number of States levying a gasoline tax. In California the reports show that it costs the State only 46 cents to collect $1,000 of gasoline taxes; in New Mexico, which is at the other extreme, the collection costs amount to $50 per $1,000 collected. These differences in collection costs can be explained in several ways. It is quite probable that some of the States in arriving at these cost figures include only such extra expenditures incurred by those State officers whose duty it is to collect the gasoline tax which are over and above the office expenses prior to the assumption of the new duty. In New Mexico, on the other hand, the law provides that the collection expenses shall not exceed 5 per cent of the collections and, according to the reports, the collection costs come right up to this maximum limit fixed by statute. There is another consideration which should have an effect on this ratio: It should not involve any greater costs to collect a tax of 2 or 3 cents per gallon than a tax of 1 cent per gallon. It would, therefore, appear that if the States followed a uniform system of cost accounting, the collection costs per $1,000 would be correspondingly lower in the States charging the higher gasoline tax rates.

In Table 5 the collection costs are also computed on a per-million-gallon basis. In making that comparison of costs the element of the tax rate is completely eliminated. The costs range from $9.86 per million gallons in California to $1,310 in New Mexico, the average for this group of States being $65 per million gallons.

Aside from New Mexico the costs of collecting this amount of revenue are low when compared with the collection costs of other forms of revenue. In 1924 the collection of the custom revenues cost the Federal Government $22.50 per $1,000; the internal-revenue collection costs were $12.10 per $1,000. These figures are compared with the collection cost of $2.64 per $1,000 of gasoline taxes received. The collection cost of these Federal taxes per $1,000 amounts to over five times the collection cost of the gasoline tax.

DISPOSITION OF THE GASOLINE-TAX REVENUES

The gasoline-tax revenues in 1925 amounted to $144,921,949 after deducting $217,393 which 21 States

reported as their total collection costs. In addition to this amount $889,598 was collected in the District of Columbia. In the analysis which follows these District of Columbia revenues are not included. The disposition of the gasoline-tax revenues was made for the following purposes in the amounts indicated.

Purpose	Amount	Per cent
Construction and maintenance of State highway system	$97,084,753	67.0
Construction and maintenance of local roads	31,848,464	22.0
Principal and interest payments on State and local bonds	5,853,703	4.0
Transfers to general fund	3,722,796	2.6
Use on city streets	3,097,892	2.1
Other purposes	3,314,341	2.3
Total	144,921,949	100.0

According to this classification 89 per cent of the net gasoline-tax receipts is used directly for the construction and maintenance of rural highways, 67 per cent being devoted to State highway systems and 22 per cent to the construction and maintenance of local roads. The remaining 11 per cent is also used for the most part for road and street purposes.

Disposition of gasoline-tax revenues by States.—The statutes of the several States make definite provision for the disposition of the gasoline-tax revenues just as in the case of the receipts from license and registration fees analyzed in Part I. The laws of some of the States provide that the money derived from the gasoline tax shall be distributed and applied in the same manner as the license fees; in other States a totally different policy is followed. In the analysis of the statutory provisions made by the different States with respect to the disposition of gasoline-tax revenues which follows, these similarities and dissimilarities of policy are set forth.

Alabama.—The tax is collected by the State tax commission, placed in the State treasury, and all receipts are distributed equally every month among the 67 counties, to be used only for maintenance and repair of roads and bridges.

Arizona.—The Secretary of state collects the tax and after deducting collection expenses deposits the money with the State treasurer to the credit of the gasoline-tax fund. One-half of this fund is turned over to the State road-tax fund and the other half is turned back to the counties in proportion to the amount collected in each to be used for the maintenance of county roads.

Arkansas.—All gasoline and oil tax revenues are deposited in the State highway fund. The distribution is set forth in detail in the section of this article devoted to the disposition of motor-vehicle revenues.

California.—The gasoline-tax revenues are deposited in the motor-vehicle fund, together with the license fees. The disposition of this fund is set forth in the section of this article devoted to the disposition of motor-vehicle revenues.

Colorado.—Fifty per cent of the receipts from the gasoline tax is deposited to the credit of the State highway fund to be used for the construction, maintenance, and improvement of the State highways. The remaining 50 per cent is apportioned among the several counties according to the mileage of State routes and State highways.

Connecticut.—The gasoline-tax revenues are expended in the same manner as the license fees by the State highway commissioner for the construction, maintenance, or reconstruction of State highways.

Delaware.—The State uses the gasoline-tax revenues in the same manner as the motor-vehicle license fees.

Florida.—Three-fourths of the gasoline-tax receipts are placed in the State road fund for the construction and maintenance of State and Federal-aid roads; the remaining fourth is divided equally among the counties to be used for construction and maintenance purposes.

Georgia.—Of the 3½-cent tax collected for each gallon of gasoline sold, the law provides that 1½ cents shall be allocated to the State highway department to be used for matching Federal aid; 1 cent is turned back to the county treasurers on the basis of the county mileage of the State-aid road system to be used for construction and maintenance; and 1 cent is set aside to meet the deficiency in the State treasury arising out of the deficiency of the rental of the Western Atlantic Railroad.

Idaho.—The balance after administrative expenses have been paid is placed in the State highway fund. The distribution of this fund is set forth in the section of this article devoted to the distribution and division of the motor-vehicle license fees.

Illinois.—No gasoline tax is in effect.

Indiana.—The law provides that the gasoline-tax revenues after the collection expenses have been deducted shall be deposited in the State highway fund; two-thirds of the net receipts are used by the State highway commission for construction and maintenance, and one-third is transferred to the general fund and credited to a special fund known as county, cities, and town gasoline fund. Three-fourths of this special fund are distributed as follows: 50 per cent is divided equally among the counties and 50 per cent is divided among the counties in proportion to the mileage of free gravel, macadam, and county-unit roads. The counties are required to use the funds they receive for the construction and maintenance of roads. The remaining fourth of this special fund is distributed among the cities and incorporated towns of the State in proportion to population and is to be used for the maintenance and repair of streets, preference being given to those streets connecting State highways.

Iowa.—The collection expenses are paid out of the gross receipts. The balance is divided as follows: One-third is credited to the primary road fund, the distribution of which is described in the license fee section; two-thirds is apportioned among the counties on the basis of area. One-half of this fund apportioned among the counties is placed in a county road fund and one-half is placed by each county in a township road fund on the basis of township road mileage.

Kansas.—The gasoline-tax receipts are placed in the State highway fund. The manner in which this fund is apportioned and used is set forth in the motor-vehicle license fee section of this article.

Kentucky.—Gasoline-tax revenues are used only for the purpose of construction, reconstruction, maintenance, and repair of roads and highways and for interest and sinking-fund payments of State bonds issued for highway purposes.

Louisiana.—The gasoline-tax revenues are credited to the general highway fund and are allotted for the exclusive purpose of the upkeep, repair, and maintenance of the State highways and bridges.

Maine.—The gasoline-tax receipts are placed in the State highway fund and are used in the following manner: 16⅔ per cent for the maintenance of State highways and bridges and State-aid highways; 16⅔ per cent for the construction of third-class highways; 33⅓ per cent for the construction of State highways; and 33⅓ per cent for the construction of State-aid highways.

Maryland.—The gasoline-tax receipts are used for the maintenance and reconstruction of the roads of the State highway system.

Massachusetts.—No gasoline tax is in effect.

Michigan.—The revenues derived from the gasoline tax are used for the following purposes: (*a*) To meet deficiencies in appropriations owed to several counties on State-award highways; (*b*) for the payment of interest on State highway bonds; (*c*) the balance is used for the general construction, improvement, and betterment of the public highways within the State.

Minnesota.—The gasoline-tax revenues are credited to the trunk-highway fund. The manner in which this fund is expended is described in the preceding section relating to the disposition of motor-vehicle license fees.

Mississippi.—The gasoline-tax revenues are placed in the State highway fund. Fifty per cent of the revenues is used for the maintenance of the highway department and for the construction and maintenance of State highways and bridges. The remaining 50 per cent is returned to the counties in proportion to the number of motor vehicles registered and is used for the construction and maintenance of county roads, bridges, and culverts.

Missouri.—All the money derived from the gasoline tax is expended by the State highway commission for the construction and maintenance of State highways.

Montana.—The gasoline-tax receipts are apportioned in the following manner: (*a*) 15 per cent is credited to the State highway fund; (*b*) 55 per cent is divided equally among the counties; and (*c*) 30 per cent is turned into the general fund of the State.

Nebraska.—The revenues derived from the gasoline tax are placed in the gasoline highway fund, which is used for the construction and maintenance of State and Federal aid highways.

Nevada.—All the gasoline-tax receipts are deposited in a gasoline-license tax fund. Fifty per cent of this fund is transferred to the State highway fund to be used for construction and maintenance purposes; 50 per cent is transferred to the State highway fund of the various counties in proportion to the number of registered motor vehicles.

New Hampshire.—The gasoline-tax revenues are used in the same manner and for the same purposes as the motor-vehicle license fees.

New Jersey.—No gasoline tax is in effect.

New Mexico.—The gasoline-tax revenues are placed in the State road fund and are used for the maintenance of State highways.

New York.—No gasoline tax is in effect.

North Carolina.—The gasoline-tax revenues are credited to the State highway fund and are disposed of by the State highway commission in the following manner: (*a*) $250,000 is set aside to meet the expenses of the State highway commission; (*b*) a sum is appropriated sufficient to meet the annual interest charges on the $65,000,000 bond issue for highway purposes; (*c*) a sum is appropriated sufficient to create $500,000 sinking fund annual payments upon the $65,000,000 bond issues; and (*d*) the balance is used by the State highway commission for the construction and maintenance of roads.

North Dakota.—All the revenues derived from the gasoline tax with the exception of $200,000 are deposited in the State highway fund for the construction, reconstruction, and maintenance of the Federal-aid and State-aid highways.

Ohio.—The law provides that the gasoline-tax receipts shall be distributed and disposed of by the State treasurer in the following manner: (*a*) The first $50,000 collected is placed by the State treasurer in a gasoline rotary tax fund to which sums are regularly added to keep this fund floating at $50,000; (*b*) 30 per cent of the balance is paid out to State municipal corporations, in proportion to the number of motor vehicles within such municipalities during preceding calendar year, for street maintenance purposes; (*c*) 25 per cent is divided equally among the counties for maintaining and repairing county road systems; and (*d*) 45 per cent is apportioned to and expended by the State highway department for the purpose of maintaining, repairing, and keeping in passable condition the roads and highways of the State.

Oklahoma.—One-third of the gasoline-tax revenues is credited to the highway fund of each county and is apportioned to each county in that percentage which the population and area of the county bear to the population and area of the State, to be used for the construction and maintenance of county or township roads; two-thirds of the receipts are deposited to the credit of the State highway construction and maintenance fund.

Oregon.—The gasoline-tax revenues are all placed in the State highway fund to be used for construction and maintenance purposes on the State highway system.

Pennsylvania.—The money derived from the gasoline tax is distributed in the following manner: One-fourth is credited to the counties in proportion to the amount of taxes collected and is used for the construction and maintenance of highways and for the payment of interest on county road bonds; three-fourths are deposited in the State motor-license fund and used to meet interest and sinking-fund payments on State highway bonds; and the balance is used for construction and maintenance purposes.

Rhode Island.—The gasoline tax revenues are placed in the State highway fund and are used for the construction and maintenance of secondary roads.

South Carolina.—Three-fifths of the gasoline-tax revenues are credited to the State highway department, and two-fifths are distributed among the counties on the basis of the amount of license fees collected, for the construction and maintenance of roads not in the State highway system.

South Dakota.—The receipts derived from the gasoline tax are placed in the State highway fund and are expended by the State highway commission for the construction, reconstruction, and maintenance of highways and roads under the commission's jurisdiction.

Tennessee.—The gasoline-tax revenues are all used for the construction and maintenance of highways of the State.

Texas.—The receipts derived from the gasoline tax are apportioned as follows: (*a*) One-fourth to the free school fund; (*b*) three-fourths to the State highway fund for construction and maintenance purposes.

Utah.—The gasoline-tax receipts are placed to the credit of a fund for the payment of interest and sinking-fund charges on State road bonds.

Vermont.—The gasoline-tax revenues are available the same as the motor-vehicle license fees for road maintenance by the State highway department.

Virginia.—The receipts derived from the gasoline tax are disposed of in the following manner: (*a*) 2 cents of the rate is appropriated for the construction of

roads and projects on the State highway system; (*b*) 1 cent is devoted to the construction of roads and bridges on county highway systems distributed among the counties on the basis of the total State taxes paid by counties into the State treasury; (*c*) the extra 1½ cents, added to the former rate in 1926, is turned over to the counties if they match the amount by an appropriation of their own.

Washington.—All the gasoline-tax receipts are placed in the motor-vehicle fund, the disposal of which is set forth in the preceding section devoted to the disposition of motor-vehicle license fees.

West Virginia.—The revenues derived from the gasoline tax are disposed of in the same manner as the revenues derived from motor-vehicle license fees.

Wisconsin.—The gasoline-tax revenues, together with the motor-vehicle license fees, are all placed in a fund from which the annual appropriations for State highway purposes are made. These have been set forth in detail in the preceding section.

Wyoming.—The receipts derived from the gasoline tax are apportioned among the counties in proportion to the number of miles of State highway in each and used for maintenance purposes.

GAS TAX DISTRIBUTION LIKE LICENSE FEE USE IN 14 STATES

In 14 of the 44 States which have in effect a gasoline tax there is no distinction made between the revenues derived from this kind of tax and the revenues produced by the license fees, so far as the distribution and use of these funds are concerned. They are: Arkansas, California, Connecticut, Delaware, Idaho, Kansas, Kentucky, Louisiana, Minnesota, Rhode Island, Vermont, Washington, West Virginia, and Wisconsin. The remaining 30 States provide for a disposition of the gasoline tax receipts different from that of the motor-vehicle license fees.

According to the reported figures a somewhat larger proportion of the gasoline-tax revenues is used for the construction and maintenance of local roads than is found in the case of motor-vehicle license fee receipts. In 1925, 22 per cent of net gasoline-tax revenues was devoted to local highway purposes; the proportion of the motor-vehicle license fees for that purpose amounted to only 19.5 per cent. The sum of money taken out of license fees for local highway purposes, however, was greater; $48,396,471 derived from motor vehicle license fees was used for local highway purposes and $31,848,464 derived from gasoline taxes.

In only eight States is there any direct provision in the law which calls for an apportionment of any of these motor-vehicle revenues or gasoline taxes among cities or municipalities. These States are Alabama, Indiana, Maryland, Ohio, North Carolina, Oklahoma, Washington, and Wisconsin. The laws in these States provide that certain portions of the funds which the State receives shall be allocated to municipalities and shall be used by them for street improvements. These provisions have already been covered in the digest of the laws of the various States pertaining to the distribution of the license fees and gasoline taxes. It is believed, however, that special attention should be called to this particular phase of the disposition of motor-vehicle revenues at this point because of the rather wide interest given to this phase of the subject at this time.

In Alabama 20 per cent of the balance from motor-vehicle license fees (after deducting collection expenses) is turned back to the incorporated city or town in which the owner of the registered vehicle resides.

The gasoline-tax law of Indiana provides that a certain portion of the net revenues derived from the gasoline tax shall be distributed among the cities and incorporated towns of the State. The details relating to the apportionment of the gasoline-tax receipts are set forth in that part of the gasoline-tax section devoted to Indiana. The net result is that 8⅓ per cent of the net gasoline-tax collection is distributed among the cities and incorporated towns of the State for the maintenance and repair of their streets. In using this money preference is to be given to those streets connecting State highways. In 1925 the cities and incorporated towns of the State were entitled to receive according to these provisions $636,684.

The Maryland law makes direct provision that 20 per cent of all the license fees collected in the State shall be paid over to the city of Baltimore for use on its streets. The number of motor vehicles registered in the city of Baltimore in 1925 was 44 per cent of the total number of vehicles registered in the whole State of Maryland. It would appear therefore that the city of Baltimore had returned to it approximately half of the registration fees collected within its limits. This conclusion is obviously based on the assumption that the average license fee per vehicle collected in Baltimore does not differ materially from the average license fee collected throughout the State. No part of the gasoline-tax revenues is apportioned to Baltimore nor do any of the other cities and municipalities in the State share in either the license-fee or gasoline-tax receipts.

The Wisconsin law provides that a portion of both the license-fee receipts and the gasoline-tax revenues shall be paid over to towns, villages, and cities for the improvement of roads and streets not part of the State and county trunk highway systems. The payments are based upon the amount of mileage in the municipalities and the amount paid per mile varies according to the size and population of the municipality. The details are fully set forth in the motor-vehicle license fee section. For the fiscal year ended June 30, 1926, according to the report of the Wisconsin Highway Commission, the net amount of license fees and gasoline taxes collected by the State was $13,279,529. Of this amount $1,865,218, or 14 per cent, was turned over to towns, villages, and cities. The mileage upon which these payments were based amounted to 62,743 miles. The towns received $1,422,854, or 76 per cent, of the total amount of money distributed in this manner, and they contained 90 per cent of the total mileage. Villages received $37,540, or 2 per cent, of the amount distributed. There were 161 cities in the State, of various sizes, which received $404,824, or 21.6 per cent, of this amount, based upon 4,330 miles of streets, which was but 6.9 per cent of the total mileage upon which these payments to localities were based. For the 161 cities which participated in these revenues, the average received per city was $2,514. For Milwaukee, the largest city in the State, it amounted to $109,700, based on 548.5 miles of streets not included in the State highway system. Eight of the cities received over $10,000 each. Forty-seven cities received between $1,000 and $10,000, and 86 received less than $1,000 each. The sum of this amount of $404,824, which was distributed among the cities and the $37,540 given to villages for municipal street improvements, or a total of $442,365, constituted but 3.4 per cent of net revenues derived from motor-vehicle fees and the gasoline tax.

North Carolina allows any city or town to charge a license fee not exceeding $50 for any motor vehicle used in transporting persons or property for hire in lieu of all other charges, fees, and licenses.

Oklahoma laws provide that from the 60 per cent of funds raised by the motor-vehicle tax and returned to counties from which collected, the board of county commissioners are required to pay to the incorporated towns and cities of their counties 15 per cent of all money collected in such towns and cities to be credited to the street and alley fund.

The laws of Washington transfer out of the motor-vehicle fund the sum of $1,400,000 annually to the credit of the primary highway maintenance fund from which latter fund is transferred annually to each first and second class city a sum equal to $500 per mile for each mile of primary highway in such city, and similarly to each third and fourth class city $300 per mile.

Ohio cities receive a part of the license fees and also of the gasoline tax receipts. Fifty per cent of the license fees is turned back to the municipalities in which the tax was collected. Thirty per cent of the gasoline tax receipts is also returned to the municipalities. The gasoline tax apportionment is made on the basis of the number of vehicles registered. In 1925, although the gasoline tax was in effect only after April 18, the apportionments of revenues from this source amounted to $2,702,985. That year the total license fee revenues were $13,147,231, and one-half of this amount was transferred to counties and municipalities. Just what portion of this transfer of funds went to municipalities is not disclosed by the reported figures. The funds derived from the license fees and the gasoline tax are to be used by cities for street maintenance purposes only.

In New York the law provides that 25 per cent of the license fees collected in each county shall be retained by the county for road maintenance purposes to be expended under the direction of the State commissioner of highways. Inasmuch as the city of New York comprises several counties its share of the license-fee revenues is credited to the city's general fund, the law being silent as to how the city is to use these funds.

The analysis of the statutory provisions relating to the disposition of the motor-vehicle fees and gasoline taxes by the States shows that where the States are directed to transfer a portion of these funds to counties or municipalities a number of different bases are used in making the apportionments. In 22 States there is such a transfer of funds. In 16 States the amount of fees collected from local government units, such as county or city, is named as the basis of apportionment; in two States it is the number of registered motor vehicles. One State uses population as a basis; one State uses area, one State uses road or street mileage; and one State makes an equal distribution among the counties.

There are 21 States which distribute a portion of the gasoline tax receipts. Five States distribute these receipts in proportion to the amounts collected; 4 distribute them according to mileage; 3 use the number of motor vehicles registered as a basis; and 3 divide the portion to be distributed equally among the counties. One State uses population as a basis of distribution; one uses the amount of State taxes paid as a basis. Area and mileage, population and area, mileage and equal distribution among counties, registration and equal distribution among counties furnish the bases in four other States, respectively.

The total disbursements in 1925 for rural highway purposes are reported to have been $1,288,939,707. This amount includes the outlays for highway improvements made by the State highway commissions and by the local authorities. In arriving at this total there are included as expenditures the transfers of funds from State commissions to local authorities and also the transfer from local to State authorities. After making a deduction of these transfers of funds the net total disbursements are found to be $1,241,049,094. The total collections from motor vehicles, including license fees and gasoline taxes, amounted to $406,648,561, an amount equivalent to 32.8 per cent of the net disbursements. Not all of these motor-vehicle revenues which the States collected were used or were available for highway purposes.

The net disbursements made by the State highway commissions were $623,549,605 in 1925. To meet these expenditures the States received $199,845,163, or 32 per cent of the disbursements, from motor-vehicle license fees; and $89,328,340, or 14 per cent, from gasoline taxes. It may, therefore, be said that $289,173,503, or 46 per cent, of the net highway disbursements made on behalf of State highway commissions was derived from motor-vehicle revenues.

The net disbursements for local highways were $617,499,489. To meet these expenditures the local highway authorities received $71,379,424, or 11.5 per cent, of the total disbursements as their share of the motor-vehicle revenues. The sum of $46,545,445, or 7.5 per cent, of the disbursements was derived from motor-vehicle license fees, and $24,833,979, or 4 per cent, came from gasoline taxes.

These funds for highway purposes derived from motor-vehicle license fees and gasoline taxes and their relation to the total net disbursements, State and local, for highway improvements may be summarized as follows:

Total net highway disbursements, State		$623, 549, 605
Total net highway disbursements, local		617, 499, 489
Total		1, 241, 049, 094
Sources of highway funds, State:		
License fees	$199, 845, 163	
Gasoline tax	89, 328, 340	
Total		289, 173, 503
Ratio of these sources to State highway disbursements, 46 per cent.		
Sources of highway funds, local:		
License fees	$46, 545, 445	
Gasoline tax	24, 833, 979	
Total		71, 379, 424
Ratio of these sources to local highway disbursements, 11.5 per cent.		
Total funds derived from motor-vehicle license fees and gasoline tax, State and local		360, 552, 927
Ratio to total highway disbursements, State and local, 29 per cent.		

The disbursements covered the items of construction on roads and bridges, maintenance, administration and engineering, retirement and payments on bonds, interest payments, equipment, machinery and repairs, etc. The funds to meet these expenditures in addition to those derived from motor-vehicle revenues were obtained from bond issues, taxation, and Federal aid. The Federal-aid funds may also be regarded as having been derived from the excise taxes on automobiles collected by the Federal Government inasmuch as the

(Continued on p. 229)

EARTH PRESSURES ON CULVERT PIPES[1]

By G. M. BRAUNE Dean, School of Engineering, University of North Carolina

STRUCTURES that are constructed of elastic materials having practically uniform physical properties, and which are subjected to applied loads of known magnitude, direction, and position may be safely designed in accordance with an exact mathematical theory. This is not true, however, of structures which are subjected to applied loads caused by the weight of granular materials, because the loads become variable depending upon the movement of the granular materials and, in consequence thereof, the attendant variable frictional and cohesive forces. In other words, the deflection or deformation of the supporting structure is, in this case, an important function governing the magnitude and direction of the applied loads. Therefore, in order to determine the effect of loads on structures due to the action of granular materials, such, for instance, as earth embankments on culvert pipe, it becomes necessary to perform large-size experiments that will conform as far as possible to actual practical conditions.

Certain experiments on a large scale extending over a period of several years with the object in view of solving this problem have been conducted by Dean Anson Marston, of the Iowa State College at Ames, Iowa.

The apparatus at Ames was apparently designed on the assumption of obtaining earth pressures on a rigid body practically free from deflection or deformation. The earth pressure of embankments, varying from 16 to 20 feet in height, acting on wooden cylindrical bodies 40 inches in diameter and supported from the top of the inside, were transferred by a system of levers to a number of platform scales where the readings were observed and recorded.

In the second progress report presented April 7, 1922, at Chicago to the joint concrete culvert pipe committee, Dean Marston stated that his experiments showed that the maximum pressures obtained on the cylindrical body as determined from actual scale readings for a projection condition was about 1.9 times the weight of the material directly over the cylinder.

Other experiments to determine pressures on culvert pipe have been made near Farina, Ill., under the auspices of a subcommittee of the American Railway Engineering Association, and directed by J. R. Wilks, former chief engineer of the Armco Culvert and Flume Manufacturers' Association.

The embankment from which these pressures were obtained was 35 feet high and located on a new line of the Illinois Central Railway. Different kinds of pipes were used, consisting of corrugated metal, heavy cast iron, and reinforced concrete, with sizes ranging from 24 inches to 42 inches in diameter. The apparatus used to obtain the pressures consisted of a series of soil pressure cells, commonly known as Goldbeck cells, which were attached to the inside surface of the pipe. The results of these experiments as found in the report of the subcommittee of the American Railway Engineering Association are as follows:

The intensity of vertical pressure measured by the top cells of the corrugated or so-called flexible culvert is about 54 per cent of the weight of the unit column of material above the cell, whereas for the so-called rigid type of culvert the cell reading showed 1.58 times the weight of the material above the cell. Or, in other words, the intensity of vertical pressure measured by the top cells on the flexible type is about one-third of the measured vertical pressure on the rigid type of culvert.

In 1922, Frank Page, chairman of the North Carolina Highway Commission, and Charles M. Upham, chief engineer, made the suggestion to the staff of the engineering school of the University of North Carolina that a series of experiments be undertaken at Chapel Hill to determine earth pressures on culvert pipe, using conditions that would conform to the practice as closely as possible. Accordingly, a site was chosen for the experiments on a private roadway near the Pittsboro Road, about 1 mile south of Chapel Hill, N. C. The conditions surrounding the site are admirable for the performance of the experiments as it is accessible to the main highway with sufficient working material close at hand. The profile of the original ground permitted a good location for the culvert pipe apparatus and the formation of embankment up to 20 feet in height, or greater if desired.

TEST PIPE IN PLACE

DESIGN OF APPARATUS

The main objects to be observed in the design (fig. 1) were to eliminate, as far as possible, the movement of the supporting element under the culvert pipe and provide an ample place for the weighing apparatus and convenient space for the observer.

The housing for the weighing apparatus consists of a reinforced concrete box culvert 58.5 feet long, 7 feet wide, and having a clear height of 7 feet. The ground for the foundation of the culvert box was excavated sufficiently at the lowest point of the roadway so as to obtain the desired elevation of the test pipes.

The weighing apparatus which was placed inside of the culvert box consists of four platform scales, each having a capacity of 30,000 pounds, designed and constructed especially for these experiments by Riehle Bros., of Philadelphia. They have been calibrated a number of times and are considered to give quite accurate results. Steel columns extending up to the roof of the culvert box are supported on the scale platform and on top of these columns the test pipes are placed.

[1] This paper by Dean Braune and the accompanying discussion by Dean Marston were presented at the annual meeting of the American Association of State Highway Officials, at Pinehurst, N. C., Nov. 12, 1926. The investigations reported in Dean Braune's paper were made in cooperation with the North Carolina State Highway Commission and the U. S. Bureau of Public Roads. The work was directly supervised by Prof. H. F. Janda, of the engineering school of the University of North Carolina. The author desires to acknowledge his indebtedness to Dr. William Cain for valuable advice and assistance, and to the manufacturers by whom the pipe used in the experiments were furnished.

The columns are only 5 feet long but in order to eliminate any appreciable deformation they were provided with an excessive cross-sectional area so as to keep the unit stress below 1,000 pounds per square inch. The concrete roof of the culvert box is supplied with a slot large enough to permit the insertion of the test pipes. In the first series of experiments the four test pipes, consisting of cast iron, were 30 inches in diameter and 2½ feet long, with a barrel thickness of 1 inch. These pipes were submerged in the roof of the culvert so that one-half of the pipe extended above the top surface of the roof. This condition would be termed a "50 per cent projection."

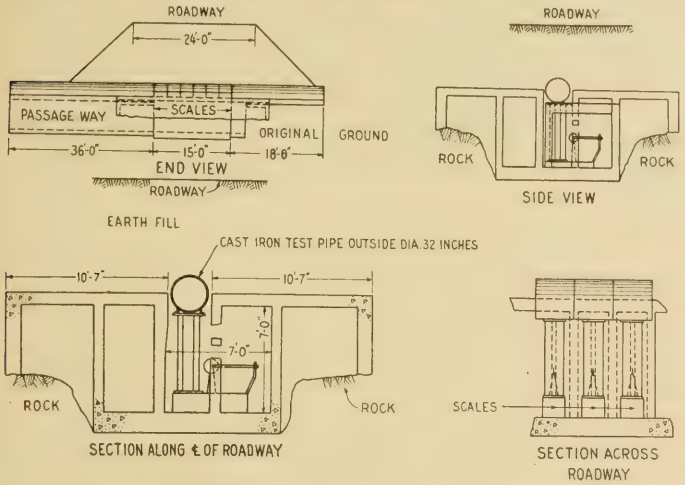


FIG. 1.—SKETCH OF APPARATUS FOR EARTH PRESSURE EXPERIMENTS AT CHAPEL HILL, N. C.

In the second series of experiments which are now under way, the bottom of the pipe is placed flush with the top surface of the culvert roof, constituting what is termed a "100 per cent projection."

The filling material consisted of sand of a fairly uniform character, obtained from a small creek about a half mile from the site. Besides the sand, a fill material of clay was used in one set of experiments.

The embankment was given a minimum width of 24 feet at the top when the fill had reached its maximum height of 20 feet with side slopes of 1½ to 1.

Concerning the action of earth pressures on elastic culvert pipes the following is quoted from a paper entitled: "Design of Culvert Pipes," by Dr. William Cain:

> The simple laws of mechanics and certain experiments indicate that the vertical earth pressure, E, on pipe culverts varies according to the relative deflections of the top of the pipe and the adjacent soil. In diagram No. 1 (fig. 2) the top of the pipe deflects much more than the adjacent soil and there will be a tendency for the prism directly over the pipe to move downward, relative to the earth alongside it, and through friction and cohesion it transfers part of its weight to the soil adjacent to the pipe. Therefore, the earth pressure, E, is less than W, the weight of the material directly over the pipe. In the case illustrated by diagram No. 2, the deflections of the top of the pipe and the soil adjacent are assumed to be the same and there will be equal settlement of both the prism of earth and the adjacent soil, no relative motion ensuing. Consequently, there will be no friction exerted along the sides of the prism and the earth pressure, E, will then be equal to W. The other case, illustrated by diagram No. 3, is just the converse to that of the first diagram. The earth outside the prism over the pipe is moving downward, relatively to the prism itself, this being due to the rigidity of the pipe. Thus, through the medium of friction and cohesion, part of the weight of the outside material is transferred to the prism over the pipe and E becomes much greater than the weight of the prism W.

We will call the ratio of the actual earth pressure to the weight of the prism of earth directly over the pipe, K—that is, $K = \frac{E}{W}$. Now, in accordance with the theory as expressed above, K should vary, depending on the relative deflections of the pipe and the earth alongside of the pipe, or in other words its value would be dependent on the rigidity of the pipe. For flexible pipe, therefore, K should be less than unity, but greater than unity for the rigid type of pipe.

THE WEIGHING CHAMBER

FIRST TESTS MADE WITH PIPE IN 50 PER CENT PROJECTION

Four sections of cast-iron pipe, each having a diameter of 30 inches, a length of 2½ feet, and a barrel thickness of 1 inch, were placed on the weighing machines so as to permit a 50 per cent projection—that is, 50 per cent of the circumferential surface of the test pipe extended above the concrete roof surface of the box culvert. (The concrete roof surface here corresponds to the original ground surface alongside of pipe.) The embankment was made of sand carefully deposited on top of and on each side of the pipe for a distance of 12 feet.

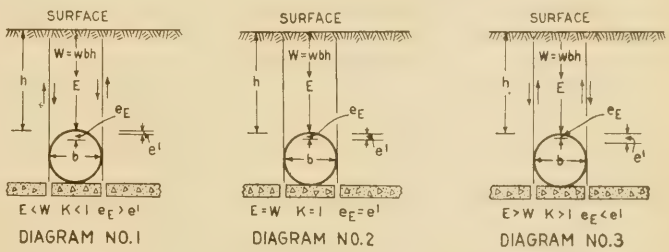


FIG. 2.—DIAGRAMS ILLUSTRATING THE ACTION OF EARTH PRESSURES ON ELASTIC CULVERT PIPES, ACCORDING TO DR. WILLIAM. CAIN

The embankment was formed in 1-foot layers permitting the side slopes to assume the natural repose.

During the construction of the embankment, scale readings were taken at 1-foot intervals and at the same intervals samples were taken for the determination of the physical properties of the sand. In order to record active earth pressures the deflection of the surface upon which the earth bears should be in the same direction as the pressure. Therefore the tendency of the movement of the scale platform should be in a downward direction. This condition was obtained

by running the rider out so that the scale beam was always down and the platform up. When the readings were taken the rider was run in until the beam just began to float. Thus the mass of earth tended to move down and was supported in part by friction and cohesion. The vertical earth pressure exerted upon the pipe was read on the scales.

Except during actual work on the fill, or during pressure observations, a tarpaulin was kept over the surface in order to maintain the moisture content as constant as possible.

A preliminary test was first made in which the embankment was carried up to an elevation of 7 feet. The passive pressures were obtained for this test so as to get a comparison with the active ones. After

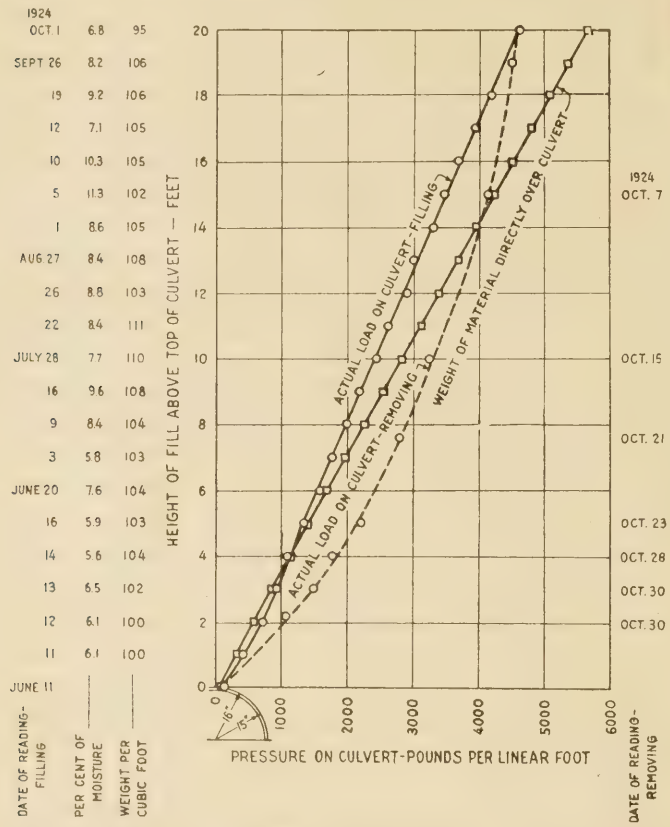


Fig. 3.—Results of First Experiment at Chapel Hill, N. C., Showing Pressures on Culvert Corresponding to Various Heights of Sand Fill During the Placing and Removal of the Fill. The Test Was Made on a Culvert with 50 Per Cent Projection

removing this fill a new one was started on June 11, 1924, in which the active pressures were obtained and recorded for each 1-foot interval until a height of 20 feet was reached on October 1, 1924. The results of this experiment are shown in Figure 3, in which is recorded the scale pressure curve and also a curve showing the actual weights of the prism of material resting on top of the pipe.

If we call W the weight of the prism of material immediately over the test pipe, and E, the pressure transmitted as observed from the scale readings we obtain for this experiment a ratio $K=\frac{E}{W}=0.84$. In other words, this experiment showed that the earth pressure, E, on the test pipe is 84 per cent of the weight of the earth prism immediately over the test pipe. This ratio remains practically constant for the entire height of the fill except for the first 4 feet, where the earth pressures are greater than the weight of the earth prism.

Fill at Chapel Hill, N. C., at End of Time and Weather Test

It should be noted that this ratio, K, as given above, was obtained for a 50 per cent projection of the pipe. In the second series of experiments that are now being performed the pipe has been placed so as to obtain a 100 per cent projection—that is, the sides of the pipe will be fully surrounded by filling material. Under this method of laying the pipe, a greater deflection of the material alongside the pipe should be obtained, and

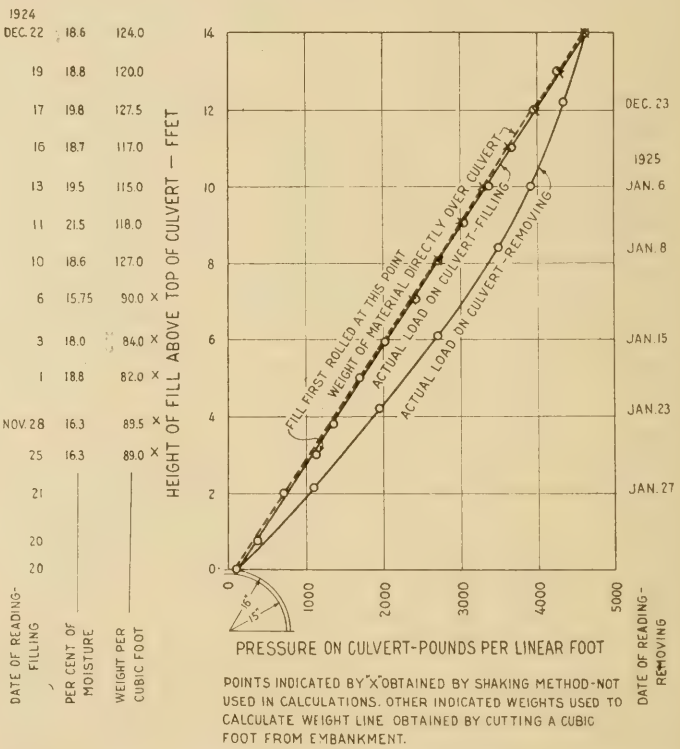


Fig. 4.—Results of the Test at Chapel Hill, N. C., Showing Pressures on a Culvert, in 50 Per Cent Projection, Corresponding to Various Heights of Clay Fill, During the Placing and Removal of the Fill

consequently in accordance with the theory as outlined above, K should be greater than for the 50 per cent projection.

Referring again to the first sand fill, the fill having been built up to a height of 20 feet, was then removed

by stages and readings were taken at intervals during its removal. It was observed that for equal heights the pressures during removal were greater than during the filling, and these pressures are shown in comparison with those recorded at the same heights during filling in Figure 3.

CLAY FILL AND 50 PER CENT PROJECTION

The next test to be undertaken was that of a 50 per cent projection condition and clay fill. The procedure in obtaining the scale pressures was the same as in the case of the sand filling, except that the clay was rolled at each 1-foot layer after the third with a 4-ton road roller. The 14-foot clay fill was started on November 20 and completed December 22, 1924, and the results of the test are recorded in Figure 4 where it is seen that the pressures are about equal to the weight of the prism over the pipe—i. e., the ratio $K=1$.

The clay fill was then removed and the next test undertaken was that of the trench-condition clay fill. The trench condition as suggested by Dean Marston designates that method of laying in which the pipe is laid in a trench so that the top of the pipe is below the ground surface alongside. It was believed that under this condition the pressures would be lessened, and this theory was borne out by the test.

With the test pipes in place a clay fill was made up to a height of 4.15 feet above the roof of the culvert. A trench was then dug across the entire width of the fill down to the concrete slab so that the test pipe sections were uncovered. The original width of the trench was 43 inches and the depth 48 inches to the top of the pipe. After the trench had been dug, it was filled in as loosely as possible with the clay which had been removed from it and the forming of the embankment was then resumed. From this point the fill was constructed in the same manner as the projection clay fill and was completed to a height of 11 feet when a layer of sand 6 inches thick was spread on the surface and the fill was allowed to remain in place from February 25, 1925, to May, 1926.

The pressures for this trench condition were found upon completion of the embankment to be less than for the projection condition, the ratio (K) of the pressure to weight of the prism over the pipe decreasing, as the fill was raised, from a value of unity at the 4-foot level, to approximately 0.6 for the 10-foot height (fig. 5).

The pressures, read at frequent intervals during the year that the embankment was in place, decreased from March 3, 1925, to the middle of August of the same year, when a total of 33 per cent decrease had taken place. After that time a slow increase occurred and at the last reading, May 3, 1926, a third of the lost pressure had been recovered.

Sudden variations in the weather had but little effect upon the pressure, but it can be seen from the curve, Figure 6, that a heavy rainfall produces a slight temporary increase.

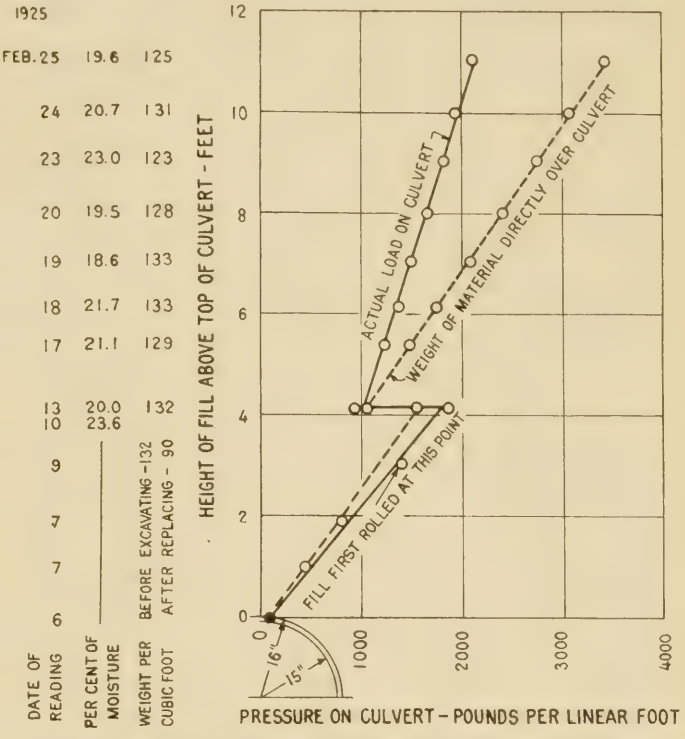


Fig. 5.—Results of Tests of Pipe Laid Under a Trench Condition in Clay Fill Showing Pressures on Culvert Corresponding to Various Heights of Fill

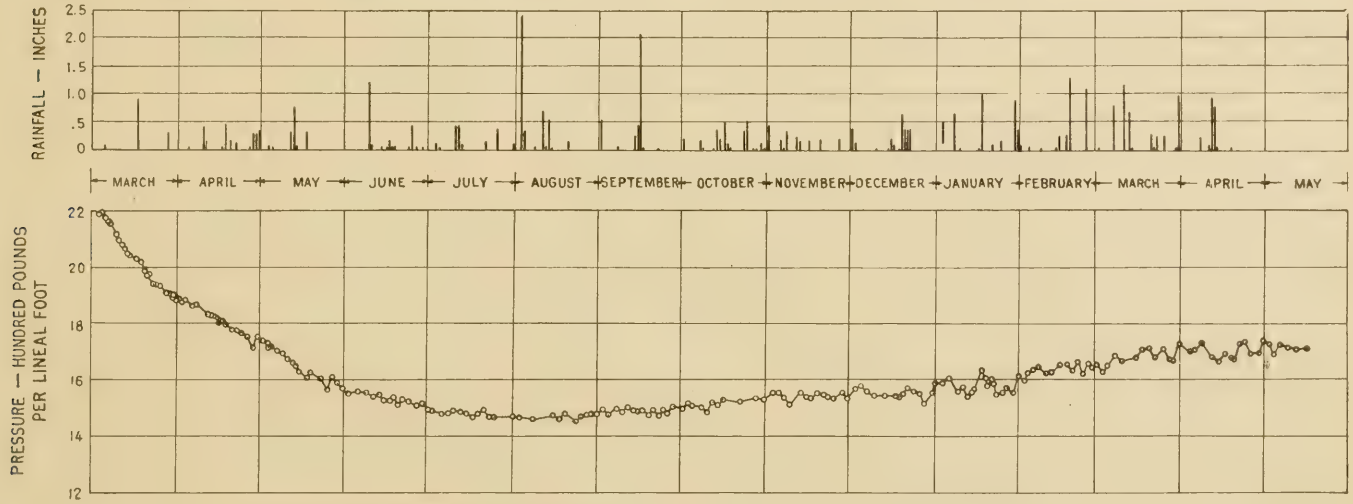


Fig. 6.—Effect of Time and Weather on the 11.05-Foot Trench Condition Clay Fill

100 PER CENT PROJECTION IN SECOND TEST SERIES

The second series of experiments was undertaken with the idea of ascertaining the influence of deflection of the pipe on the pressures. It was believed that the pressure was an important function of the deformation or deflection of the culvert pipe. It was therefore decided that a series of experiments should be performed, using test pipes of different flexibility, varying from a practically rigid body to one of large deflection, but using the same apparatus that had previously been employed.

It was also proposed to use pipes 30 and 20 inches in diameter in order to obtain a relation of pressures for different sizes. In this series of experiments, however, the bottoms of the pipe are placed flush with the floor of the culvert, thus establishing a condition of 100 per cent projection.

Five different kinds of pipes of varying flexibility having a diameter of 30 inches and a length of 2 feet 6 inches have so far been tested. These consist of a solid concrete plug of practically no deformation, cast-iron pipe with a barrel thickness of 1 inch, smooth steel pipe five-sixteenths inch thick, corrugated pipe No. 12 gauge, and a smooth wrought-iron pipe of No. 12 gauge.

The fill material so far has consisted of the same kind of sand that was used in the first series of experiments, deposited in the same manner as heretofore described.

Four pieces of each kind of pipe were placed on the weighing machines with the bottom of the test pipe flush with the top surface of the culvert roof.

Embankments 12 feet in height have been built for each set of experiments, and scale readings have been observed and recorded for each 1-foot interval. In addition to the scale readings it was deemed desirable to obtain pressures from soil-pressure cells and accordingly each of the four test pipes for the different sets of experiments were supplied with seven pressure cells.

When the experiment is completed and the large amount of data obtained have been thoroughly studied and digested, an attempt will be made to find a correlation between the experimental data and the practical design for the strength of culvert pipe. However, the tests so far performed confirm the theory on culvert pipes, namely, that the pressures vary inversely as some power of the deflection of the pipe, and values of the ratio, K, have been obtained ranging between limits above and below unity.

DISCUSSION

By ANSON MARSTON, Director, Iowa Engineering Experiment Station

The Iowa Engineering Experiment Station has been engaged in research to determine the loads supported by underground conduits (of which pipe culverts are one class) for 17 years. For several years this work has been carried on in cooperation with the United States Bureau of Public Roads; and the station expects to continue the work actively for several years.

Five bulletins and one progress report have already been published at various dates from 1913 to 1926;[1] and other reports will be published in cooperation with the Federal bureau in the near future.

The Iowa culvert researches have resulted in a complete mathematical theory of vertical loads and active horizontal pressures on culverts of all sizes, shapes, and degrees of flexibility, which apparently is well borne out by extensive experimental and field data obtained by the station, and which is easily fitted to Dean Braune's experiments and to the tests conducted by the corrugated pipe interests for the American Railway Engineering Association, at Farina, Ill., as published by the association early this year and as referred to by Dean Braune.

Culvert pipe in common use are of two types: (1) Rigid culvert pipe, made of burnt clay, plain concrete, reinforced concrete, or cast iron; and (2) flexible culvert pipe, made of corrugated sheets of iron or steel.

Flexible culvert pipe.—The flexible pipe are not of themselves able to carry much vertical load, but under usual conditions of use they distort sufficiently to greatly lessen the vertical load by shortening their vertical diameters and, by materially lengthening their horizontal diameters during distortion under the vertical load, they develop important passive horizontal resistances in the surrounding materials, sufficient to bring about a condition of equilibrium somewhat changeable, it is true, but usually pretty stable.

Rigid culvert pipe.—The rigid pipe, on the other hand, do not distort enough, up to the point of objectionable cracking and distortion, to greatly reduce the vertical load or to develop passive horizontal resistances which can safely be counted upon to help materially. Only active horizontal pressures, such as are usually calculated by Rankine's formula (say, one-fourth to one-third the vertical pressures in the materials alongside), can safely be counted upon to help sustain the vertical load.

Our mathematical theory of loads on culverts enables the computation of the vertical loads on both rigid and flexible culvert pipe (and on rectangular culverts as well) for all conditions of construction, and for different yielding of foundations as well, provided that the relative shortening of the vertical height of culvert, settlement of the culvert foundation under load, settlement of the granular filling materials alongside, and settlement of the original surface alongside under the embankment weight can be forecast approximately.

Already data are available from which safe loads (sometimes perhaps larger than are sure to develop) can be calculated.

FINE CONDITIONS OF INSTALLATION RECOGNIZED

For load calculation purposes, culvert construction conditions, for both pipe and rectangular culverts, can be divided into five classes, illustrated by Figures 1 to 5, inclusive.

1. *Ditch condition.*—This is the loading condition in which all the filling material in the prism above the culvert moves down relative to the materials alongside as it settles. The typical case is that in which the culvert is constructed in a ditch reaching to the top of the embankment, but there are several other cases which bring about the ditch condition. The load on the cul-

[1] Buls. 31, 36, 47, 57, and 76, and Second Progress Report on Culvert Pipe Investigations, Iowa Eng. Exper. Sta.

vert under this condition is given by the formula—

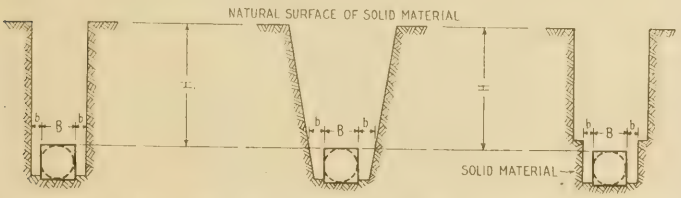
$$W = C_d w (B+2b)^2 \quad \text{---------- (1)}$$

where W = load on the culvert in pounds per linear foot
w = weight of material in pounds per cubic foot
B = breadth of culvert in feet
b = clearance between the side of the culvert and the side of the ditch in feet

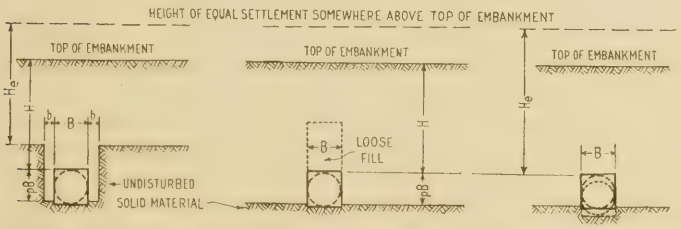
$$\text{and} \quad C_d = \frac{1 - \epsilon^{-2K\mu\frac{H}{B}}}{2K\mu} = \text{ditch coefficient}$$

in which ϵ = the base of Naperian logarithms
μ = the coefficient of friction of ditch filling against the sides of the ditch.
H = height of ditch filling above top of pipe in feet.
K = the ratio of lateral to vertical earth pressure.

Formula (1) is now widely established in engineering literature.[2]

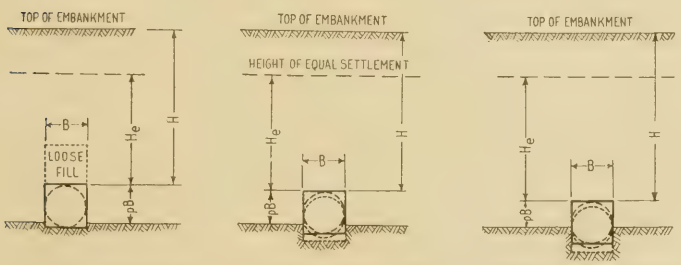


(*a*) Conduit in trench with vertical sides (*b*) Conduit in trench with steep, sloping sides (*c*) Conduit in narrow trench in solid material at bottom of wider trench



(*d*) Conduit in trench in solid materials with embankment overhead (*e*) Sufficient loose fill over conduit (in 1 or more layers) to insure greater settlement of all material over conduit than of materials alongside (*f*) Yielding of foundation plus shortening of vertical diameter sufficient to insure greater settlement of all material over conduit than of materials alongside

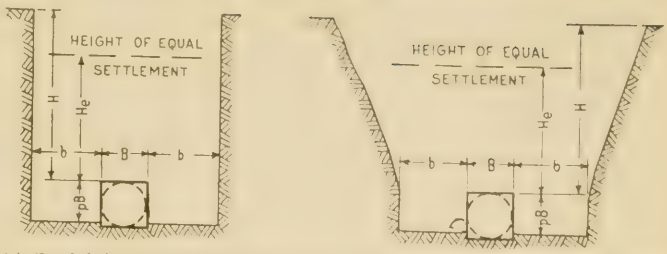
FIG. 1.—TYPICAL EXAMPLES OF DITCH CONDITION OF LOADS ON CONDUITS FROM TRENCH FILLS OR EMBANKMENT MATERIALS



(*a*) Loose fill sufficient to insure greater settlement of material over conduit than of materials alongside only to a level below top of embankment (*b*) Yielding of foundation and shortening of vertical diameter sufficient to insure greater settlement of material over conduit than of materials alongside only to a level below top of embankment (*c*) Yielding of foundation and shortening of vertical diameter sufficient to insure greater settlement of material over conduit than of materials alongside only to a level below top of embankment

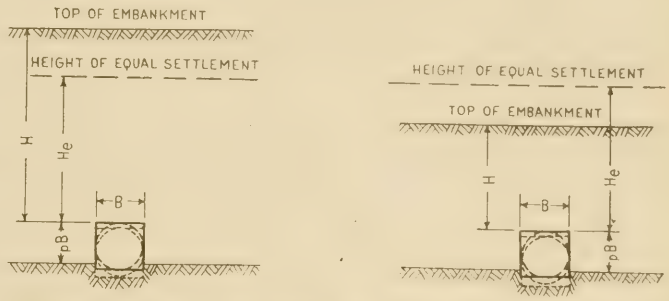
FIG. 2.—TYPICAL EXAMPLES OF IMPERFECT DITCH CONDITION OF LOADS ON CONDUITS FROM TRENCH FILLS AND EMBANKMENT MATERIALS

[2] See Bul. 31, Iowa Engineering Experiment Station, 1913.



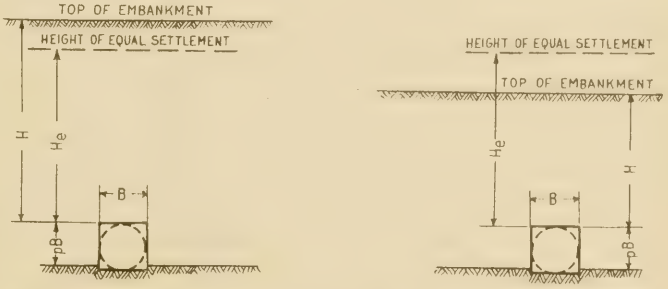
(*a*) Conduit in trench with vertical sides (*b* large in proportion to pB). (*b*) Same as (*a*) except sides of trench sloping

FIG. 3.—TYPICAL EXAMPLES OF THE COMBINED DITCH-PROJECTION CONDITION



(*a*) Yielding of foundation plus shortening of vertical diameter considerable, but less than settlement of material alongside originally at level of top of conduit (*b*) Yielding of foundation plus shortening of vertical diameter considerable, but less than settlement of material alongside originally at level of top of conduit. Same as (*a*) except that height of equal settlement is above top of embankment

FIG. 4.—TYPICAL EXAMPLES OF THE IMPERFECT PROJECTION CONDITION



(*a*) Foundation rock or other quite unyielding material. Conduit rigid pipe or rectangular in shape (*b*) Same as (*a*) except that height of equal settlement is above top of embankment

FIG. 5.—TYPICAL EXAMPLES OF THE PROJECTION CONDITION

2. *Imperfect ditch condition.*—In this the ditch condition is established imperfectly by loosely filled material over the pipe, or by shortening of the vertical diameter or by yielding of the foundation or by a combination of these circumstances. Formula (1) usually applies part way up, after which the load increases at a rate equal to R_1wB, in which R_1 is a constant greater than unity. In another case, however, the load equals wB up to a height of equal settlement, H_e, above which the load increases at a rate R_2wB, in which R_2 is a constant less than unity.

3. *Combined ditch and projection condition.*—This condition is encountered when a culvert is built projecting above the bottom of a ditch which is relatively very much wider than the outside breadth of the culvert. The projection condition formula (see 5) applies up to a height of equal settlement, H_e, above which the load increases according to the ditch-condition formula (see 1).

4. *Imperfect projection condition.*—In this the culvert projects above the original surface alongside, on which the embankment rests, but there is a material shortening of the vertical diameter under load, or settlement of foundation, or both, sufficient to lighten the vertical load on the culvert, yet less than the settlement of the embankment materials alongside at the level of the top of the culvert. The load is given by the projection-condition formula (2) slightly modified (see 5).

5. *Projection condition.*—In this the culvert projects above the original surface alongside and is built on foundations which do not settle materially relative to the original surface alongside, on which the embankment is built, and the vertical height of the culvert is not shortened materially by the load.

The load for the projection condition is given by the formula [3]

$$W = C_p w B^2 \quad \text{----------(2)}$$

$$C_p = \frac{\epsilon^{2K\mu\frac{H_e}{B}} - 1}{2K\mu} + \left(\frac{H}{B} - \frac{H_e}{B}\right)\epsilon^{2K\mu\frac{H_e}{B}} = \text{projection coefficient}$$

Figure 6, from the second progress report, 1922, provides the means by which formulas (1) and (2) may be simply applied to calculations of loads on culverts.

Figures 7 (Bul. 31), 8 (second progress report), and 9 (1926 A. R. E. A. Proc.) show conclusively that formulas (1) and (2) are confirmed closely by actual culvert load measurements.

The original tests reported by Dean Braune fall between formulas (1) and (2), except his trench-condition clay fill, which checks closely with formula (2) to a height of 4 feet and with formula (1) above 4 feet.

HEIGHT OF EQUAL SETTLEMENT MEASURED

The mathematical derivation of formula (2) demonstrates the theoretical existence in the fill of a height of equal settlement, H_e, at which the materials over the pipe and those alongside settle equally. Unpublished data obtained by the Iowa Engineering Experiment Station in 1925–26, demonstrate by actual measurements the existence of such a height of equal settlement, approximately at the computed level.

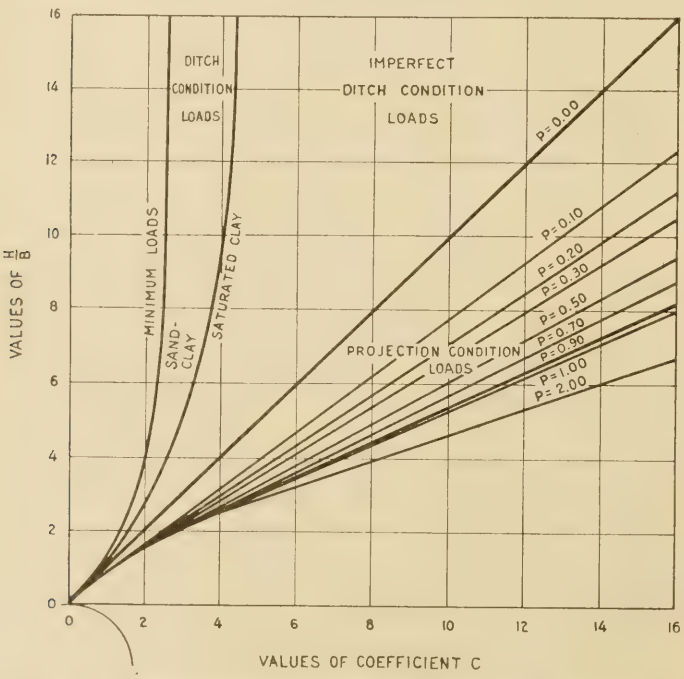


Fig. 6.—Computation Diagram for Loads on Culverts

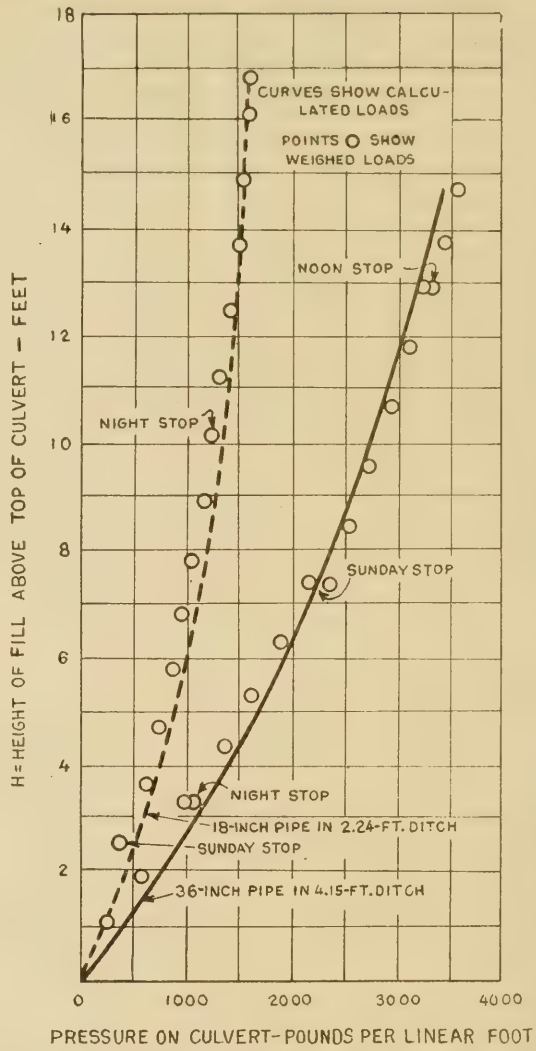


Fig. 7.—Comparison of Calculated Loads on Pipes with Actual Weight of Loads

Many measurements reported in Bulletin 76, Iowa Engineering Experiment Station, 1926, show that for 36-inch concrete culvert pipe, the shortening of the vertical diameter under load up to the point of cracking is insignificant relative to the settlement of the foundation and materials alongside. The Farina experiments show that the same was true for 42-inch cast-iron pipe, the vertical diameter of which shortened only 0.3 inch under 35 feet of fill, whereas the culvert settled 3½ inches into the foundation.

This discussion has referred so far to loads on pipes due to filling materials only. R. W. Crum's report on field examinations of culverts shows that the great majority of culverts are built under fills of 5 feet or less. In all such cases the load on the pipe due to the embankment is nearly equal to the actual weight of the materials directly over the pipe. But, in such shallow fills, important additional superloads are transmitted to culverts as a result of the weight and impact of vehicles.

[3] See Second Progress Report on Culvert Investigations, Iowa Engineering Experiment Station, April, 1922.

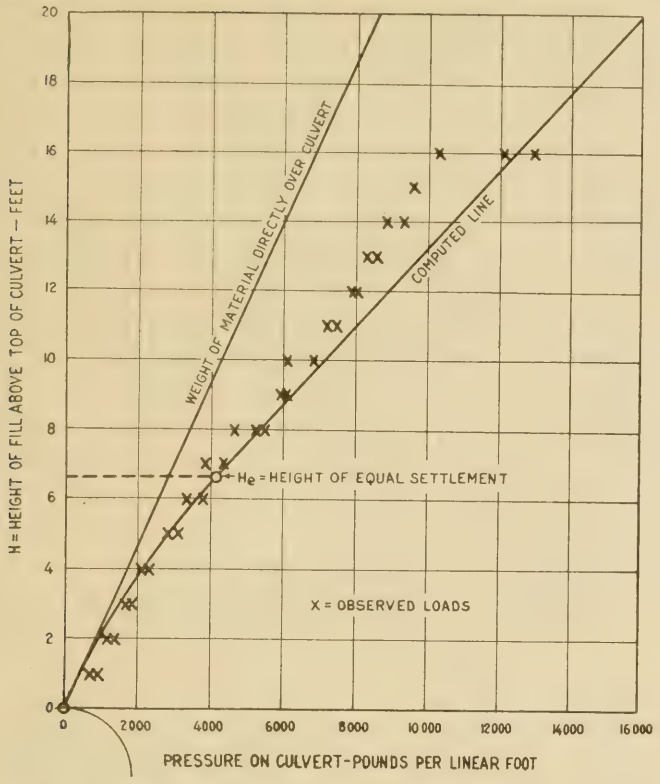


FIG. 8.—COMPARISON OF ACTUAL AND THEORETICAL LOADS ON PIPE. THE MATERIAL OF THE FILL WAS SAND AND GRAVEL WITH A WEIGHT OF 126.5 POUNDS PER CUBIC FOOT

The Iowa Engineering Experiment Station will shortly publish a bulletin in cooperation with the Bureau of Public Roads giving the results of three years active experimentation with loads transmitted to culvert tops from static and moving superloads. These show that culverts should be designed to carry superloads equal to

$$W_s = IC_tT \qquad (3)$$

Where W_s = total allowance for superload and impact
I = impact coefficient = 1.50 to 2.00
T = heaviest weight on one wheel

$$C_t = a\sum \frac{3}{2\pi}\frac{H^3}{H_s^5}$$

In the formula for C_t a is one of the small uniform unit areas into which the top of the culvert must be divided for summation calculations. H is the vertical distance from top of culvert to the roadway as used before and H_s is the slant height from center of unit area to point of application of superload to roadway. The expression $\frac{3}{2\pi}\frac{H^3}{H_s^5}$ would if multipled by the superload give the intensity of vertical pressure at the center of the small unit area corresponding to the value of H_s.

In conclusion, it is desired to call the attention of highway engineers to the great differences in the actual supporting strength of culvert pipe which may be caused by variations in the bedding of the pipe during construction. The several conditions of bedding classified and the effect of each upon the safe load are as follows:

Impermissible bedding, in which the pipe is laid without bedding below the horizontal diameter, may weaken the culvert pipe 20 per cent or more.

Ordinary bedding, refers to the case in which the bottom of the pipe is carefully bedded for 90 per cent of the circumference.

First-class bedding, in which, in addition to ordinary bedding, the earth is very carefully deposited and tamped under and around the pipe, may increase the strength 25 per cent.

And, finally, properly designed concrete cradle bedding, may double the supporting strength. A forthcoming bulletin of the Iowa Engineering Experiment Station, 1926 (the Bureau of Public Roads cooperating), gives the results of tests of such beddings with reinforced concrete pipe up to 84 inches in diameter.

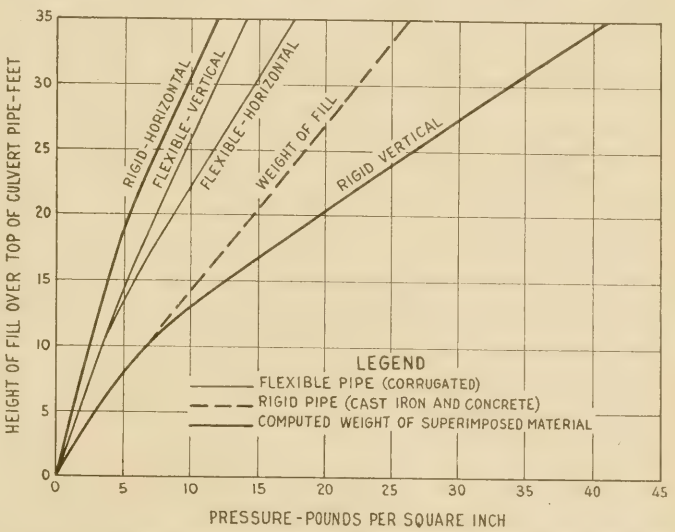


FIG. 9.—APPROXIMATE AVERAGE VERTICAL PRESSURES ON THE TOP OF RIGID AND FLEXIBLE CULVERT PIPES CORRESPONDING TO VARIOUS HEIGHTS OF FILL AS SHOWN BY THE FARINA TESTS (BUL. 284, VOL. 27. 1926, A. R. E. A.).

(Continued from p. 221)

Federal-aid payments for highway work have been up to this time very much less than the total amount collected through this tax since the tax has been in effect. The Federal-aid payments in 1925 amounted to $95,749,998, which is equivalent to about 7.7 per cent of the country's total rural highway disbursements. If these figures are added to the funds derived from motor-vehicle revenues used for highway purposes, we arrive at an amount equivalent to 36.7 per cent of the total disbursements. Although a larger sum was collected in the form of license fees and gasoline taxes, the funds derived from these sources actually used for highway purposes were considerably less. Before any further attempts are made to withdraw a still larger part of the motor-vehicle receipts and use them for purposes other than for rural highways, a careful study should be made as to the extent to which highway expenditures in the various States are met through motor-vehicle contributions. A part of these motor-vehicle revenues is also used for administrative expenses. It behooves each State in that connection to see to it that such costs are kept at a minimum so that as large a share of the license fees and gasoline taxes as possible shall be devoted to the purpose for which they are intended.

THE DOWNWARD KICK OF THE REAR WHEELS OF VEHICLES IN STARTING FROM REST TO MOTION

By THOMAS K. A. HENDRICK, Highway Research Board, National Research Council

When a vehicle, at rest on the highway, starts, what is the measure of the effect on the pavement of the changed condition of rest to motion? The configuration, mass, and acceleration of the vehicle, obviously, determine the answer. Doubtless the answer would be given qualitatively, for it is believed that no quantitative measurements have ever been made. Qualitatively one would say that the pavement does not suffer in the slightest. It is not known that any highway specifications account for this specific force. But it is conceivable that the increase in the size and weight of motor trucks and the increasing number of quick-starting taxicabs, may make a quantitative answer desirable.

Experiments have, therefore, been made by the writer, along lines suggested by Prof. C. J. Tilden, chairman of the department of engineering mechanics, Yale University, on a bicycle, 3 Buick cars, 3 motor trucks (5 to 13 tons gross weight), and 5 taxicabs. The measurements were made by means of Toledo scales whereon the increase of force can be read directly from the dial scale as the indicator advances.

For the bicycle, the 550-pound scale, in the Sheffield laboratory of engineering mechanics, Yale University, was used. Through the courtesy of the Connecticut State Highway Department, the 40,000-pound scales located at West Haven, Conn., were used for automobiles, trucks, and taxicabs. All measurements were made with the rear wheels only on the platform of the scales.

When a vehicle is started from rest, according to D'Alembert's principle of reversed effective forces, there is applied at the center of gravity of the mass accelerated, as a result of the inertia of the vehicle, a reversed effective force equal to the mass times the acceleration and opposite in direction to the direction of motion. This reversed effective force, when added to the system of external forces, produces an imaginary condition of static equilibrium in all the forces acting on the vehicle. For this condition the laws of static equilibrium, $\Sigma H = 0$, $\Sigma V = 0$, and $\Sigma M = 0$, rigorously hold.

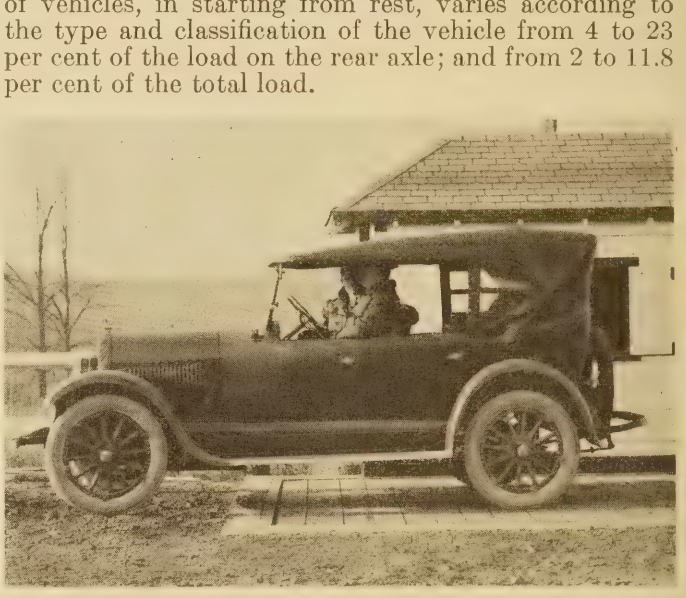
Applying the principle of the summation of moments about the point of contact of the front wheel, as a point of moments, it is readily seen that the reversed effective force causes a downward thrust or downward "kick" on the rear wheels, and an uplift on the front wheels. This downward "kick" was registered in the experiments made on the dial of the scale by the rapid advance of the indicator. The difference in the reading before and during starting measures the downward "kick" in pounds.

It is important to emphasize that this registration of the downward "kick" in pounds on the dial of the scale is independent of the acceleration and the location of the center of gravity in so far as it is not computed from these quantities. It is, in itself, a direct measurement of the downward "kick."

RESULTS OF EXPERIMENTS

For each of the vehicles experimented with, 20 readings were made except in the case of the bicycle for which 21 readings were made. Each reading represents a separate, independent start, and the average of the readings was taken as the "kick" caused by each vehicle. The start was a normal start except in the case of the Buick 6-cylinder car. By "normal start" is meant that the vehicle was started as one would normally start on getting into a car on the highway and driving off. The drivers were experienced, their experience ranging from one to five years. The gasoline was controlled by foot accelerator except in the case of the Buick car, above mentioned, in which it was controlled by the throttle which was opened to the position necessary for a speed of 35 miles per hour on a level road.

As a result of the tests, it is believed that it can be stated that the downward "kick" of the rear wheels of vehicles, in starting from rest, varies according to the type and classification of the vehicle from 4 to 23 per cent of the load on the rear axle; and from 2 to 11.8 per cent of the total load.



SHOWING THE SCALES USED FOR MEASURING THE DOWNWARD KICK OF AUTOMOBILES AND TRUCKS. FOR NORMAL STARTS THE AVERAGE DOWNWARD KICK OF THE 4-CYLINDER, 5-PASSENGER TOURING CAR SHOWN WAS 7.6 PER CENT OF THE LOAD ON THE REAR AXLE

For light passenger vehicles, with about 1,700 pounds on the rear axle and 3,200 pounds total weight, the average downward "kick" is about 6.4 per cent of the load on the rear axle or about 3.4 per cent of the total load.

For trucks with a total weight of 22,000 pounds 13,000 pounds on the rear axle, the downward "kick" is about 5.3 per cent of the load on the rear axle or 3.2 per cent of the total load.

For taxicabs, with a total weight of 3,500 pounds, and a weight on the rear axle amounting to 1,900 pounds, the downward "kick" is about 18.2 per cent of the latter or about 9.1 per cent of the total load.

In some cases, depending upon the load and body characteristics of the vehicle, and the idiosyncrasies of the driver, the downward "kick" of the rear wheels of some passenger cars may easily be one-fourth of a ton and for heavy trucks it may easily be one-half a ton.

MOTOR TRUCK IMPACT TESTS NOW IN PROGRESS

A special series of field motor-truck impact tests, now being carried on by the Bureau of Public Roads, is expected to be completed within a few months. The objectives of these tests were determined from a study of the data secured during the original program which has been completed and reported on.[1] The work is in cooperation with the Society of Automotive Engineers and the Rubber Association of America.

Based upon the findings of the original program, it is believed that motor-truck impact reactions are dependent on four major variables, namely, road roughness, tire equipment, wheel load, and vehicle speed. It is not believed that the effect of one variable should be considered without due regard for the other three. From the original program it was possible to plot lines of equal impact reaction for one road condition, four tire types, and various combinations of load and speed. The result was a series of isodynamic curves from which could be read the maximum total vertical reactions in thousands of pounds that might be reasonably expected to occur on that particular road for any combination of wheel load and truck speed. The data were segregated by tire types such as pneumatic, new cushion, new solid, and worn-out solid equipment; and the curves represented a range of wheel loads up to 20,000 pounds and speeds from 0 to 30 miles an hour. The tests were made on the Arlington test road which had been roughened by artificial obstructions.

With this preliminary isogram as a basis, a program of tests was formulated, the field work of which is expected to be completed within a few months. A number of highway sections have been selected as representative in type and roughness. These sections were marked off in one-twentieth mile lengths and points were spotted on the pavement with traffic white to guide the trucks over the test sections. The road sections were calibrated carefully at varying speeds by means of the "roughometer" described in the September, 1926, number of PUBLIC ROADS. The roughness limits ranged from 100 to 800 units at a speed of 30 miles per hour.

Tire equipment was selected to represent the four types used in the preliminary investigation, namely, pneumatic, new cushion, new solid, and worn-out solid. The average deflections of the four types under a static load of 10,000 pounds were approximately 2.5 inches, 1 inch, 0.7 inch, and 0.2 inch, respectively. The tires were mounted permanently on extra wheels in order that tire changes might be made rapidly and conveniently by substituting wheels.

At the beginning of the tests the rear-wheel loads were standardized at 2,500, 5,000, 7,500, and 10,000 pounds. Two trucks were used, a 2-ton truck for the 2,500 and 5,000 pound loads and a 5-ton truck for the other loads. The light load of each truck was accurately measured on platform scales and securely fastened in position. Then the heavier load was built up on each truck by adding 100-pound lead or iron weights. The positions of these extra weights were marked on the trucks so that the wheel loads might be duplicated readily.

The trucks were operated at speeds varying by small increments from the minmum up to the maximum speed obtainable. The average speed of each run was computed from stop-watch observations and the known length of the test section. Variations in speed were observed from speedometers mounted on the trucks. Runs varying from the average speed by more than one-half mile per hour as registered by the speedometer were not recorded.

A field-test program of this character made necessary a mobile organization and equipment. To provide for this a field office and two loading and storage platforms were built on a 16-foot, 3-ton trailer chassis. On a 2-ton truck chassis a special platform body was constructed with a swinging chain hoist placed at the forward end. In addition to hauling the trailer this service truck was used to carry the spare wheels, gasoline, and general equipment necessary for the tests.

The 2-ton and 5-ton test trucks were equipped with the coil-spring accelerometers developed by the bureau, which were mounted so as to follow the vertical motion of the right rear wheels.

Municipal authorities in the District of Columbia and in Alexandria, Va., were interested cooperators in the tests made within their jurisdiction. Traffic officers were assigned to assist in the work, and they were extremely valuable in making it possible to conduct the tests on the streets with safety. No parking signs were placed temporarily at several points to facilitate the tests.

The value sought in these tests for each combination of the four variables was the average of the five highest impacts occurring within the one-twentieth mile section. This represents the magnitude of the average impact which occurs at the rate of 100 per mile. Since the unsprung component of motor-truck impact is generally the important quantity, it was considered sufficient to compute this unsprung component and add to it the sprung component determined by static weighing in order to arrive at the total impact force. An attempt will also be made to express the absolute maximum in terms of the average of the five highest impacts. The indications at present are that useful and reasonably accurate results may be obtained.

[1] See PUBLIC ROADS, vol. 7, No. 4.

Apportionment of Federal-aid funds for the fiscal year ending June 30, 1928

State	Amount	State	Amount
Alabama	$1,547,220	New Hampshire	$365,625
Arizona	1,056,994	New Jersey	934,611
Arkansas	1,277,896	New Mexico	1,186,763
California	2,483,437	New York	3,635,217
Colorado	1,376,520	North Carolina	1,713,356
Connecticut	472,685	North Dakota	1,194,951
Delaware	365,625	Ohio	2,762,209
Florida	899,451	Oklahoma	1,751,891
Georgia	1,979,209	Oregon	1,182,202
Idaho	935,193	Pennsylvania	3,335,735
Illinois	3,154,429	Rhode Island	365,625
Indiana	1,926,772	South Carolina	1,054,988
Iowa	2,044,999	South Dakota	1,220,064
Kansas	2,068,532	Tennessee	1,614,766
Kentucky	1,417,947	Texas	4,497,272
Louisiana	1,013,308	Utah	846,906
Maine	680,794	Vermont	365,625
Maryland	635,119	Virginia	1,442,714
Massachusetts	1,089,100	Washington	1,131,532
Michigan	2,214,691	West Virginia	793,636
Minnesota	2,120,741	Wisconsin	1,870,455
Mississippi	1,307,879	Wyoming	934,369
Missouri	2,405,175	Hawaii	365,625
Montana	1,551,499		
Nebraska	1,585,138	Total	73,125,000
Nevada	948,510		

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.

ANNUAL REPORT

Report of the Chief of the Bureau of Public Roads, 1924.
Report of the Chief of the Bureau of Public Roads, 1925.

DEPARTMENT BULLETINS

No. 105D. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
*136D. Highway Bonds. 20c.
220D. Road Models.
257D. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*314D. Methods for the Examination of Bituminous Road Materials. 10c.
*347D. Methods for the Determination of the Physical Properties of Road-Building Rock. 10c.
*370D. The Results of Physical Tests of Road-Building Rock. 15c.
386D. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
387D. Public Road Mileage and Revenues in the Southern States, 1914.
388D. Public Road Mileage and Revenues in the New England States, 1914.
390D. Public Road Mileage and Revenues in the United States, 1914. A Summary.
407D. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
*463D. Earth, Sand-Clay, and Gravel Roads. 15c.
*532D. The Expansion and Contraction of Concrete and Concrete Roads. 10c.
*537D. The Results of Physical Tests of Road-Building Rock in 1916, Including all Compression Tests. 5c.
*583D. Reports on Experimental Convict Road Camp, Fulton County, Ga. 25c.
*660D. Highway Cost Keeping. 10c.
*670D. The Results of Physical Tests of Road-Building Rock in 1916 and 1917. 5c.
*691D. Typical Specifications for Bituminous Road Materials. 10c.
*724D. Drainage Methods and Foundations for County Roads. 20c.
*1077D. Portland Cement Concrete Roads. 15c.
*1132D. The Results of Physical Tests of Road-Building Rock from 1916 to 1921, Inclusive. 10c.
1259D. Standard Specifications for Steel Highway Bridges, adopted by the American Association of State Highway Officials and approved by the Secretary of Agriculture for use in connection with Federal-aid road work.
1279D. Rural Highway Mileage, Income and Expenditures, 1921 and 1922.

DEPARTMENT CIRCULARS

No. 94C. TNT as a Blasting Explosive.
331C. Standard Specifications for Corrugated Metal Pipe Culverts.

MISCELLANEOUS CIRCULARS

No. 60M. Federal Legislation Providing for Federal Aid in Highway Construction.
62M. Standards Governing Plans, Specifications, Contract Forms, and Estimates for Federal Aid Highway Projects.

FARMERS' BULLETINS

No. *338F. Macadam Roads. 5c.
*505F. Benefits of Improved Roads. 5c.

SEPARATE REPRINTS FROM THE YEARBOOK

No. *739Y. Federal Aid to Highways, 1917. 5c.
*849Y. Roads. 5c.
914Y. Highways and Highway Transportation.

OFFICE OF PUBLIC ROADS BULLETIN

No. *45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.

OFFICE OF THE SECRETARY CIRCULARS

No. 49. Motor Vehicle Registrations and Revenues, 1914.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
63. State Highway Mileage and Expenditures to January 1, 1916.
*72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads. 5c.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
161. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Highway Act and Amendments Thereto.

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. 24, D- 6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 10, No. 5, D-12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction.
Vol. 11, No. 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

*Department supply exhausted.

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

STATUS OF FEDERAL AID HIGHWAY CONSTRUCTION

AS OF

DECEMBER 31, 1926

GOVERNMENT PRINTING OFFICE

STATES	FISCAL YEARS 1917-1926			FISCAL YEAR 1927									BALANCE OF FEDERAL AID FUND AVAILABLE FOR NEW PROJECTS	STATES
	PROJECTS COMPLETED PRIOR TO JULY 1, 1926			PROJECTS COMPLETED SINCE JUNE 30, 1926			*PROJECTS UNDER CONSTRUCTION			PROJECTS APPROVED FOR CONSTRUCTION				
	TOTAL COST	FEDERAL AID	MILES	TOTAL COST	FEDERAL AID	MILES	ESTIMATED COST	FEDERAL AID ALLOTTED	MILES	ESTIMATED COST	FEDERAL AID ALLOTTED	MILES		
Alabama	$ 18,226,411.34	$ 8,725,985.09	1,298.3	$ 1,708,147.90	$ 825,708.63	101.0	$ 5,498,744.76	$ 2,593,686.42	287.9	$ 295,817.78	$ 147,908.89	22.7	$ 3,603,385.97	Alabama
Arizona	10,949,878.25	5,863,772.35	729.8	521,097.34	352,011.23	35.7	1,343,390.41	919,184.58	75.9	22,957.56	16,607.49		3,522,667.35	Arizona
Arkansas	18,364,544.50	7,666,698.35	1,323.0	1,360,033.39	667,684.72	96.6	3,963,716.51	1,859,736.54	254.1	1,443,663.80	720,968.79	98.4	1,968,612.60	Arkansas
California	27,142,596.90	13,003,592.30	1,058.0	4,037,071.01	2,045,065.55	149.7	9,688,765.12	4,682,948.28	208.2	64,943.48	29,364.45	1.7	4,795,281.42	California
Colorado	13,905,904.64	7,127,288.18	745.0	958,040.35	522,177.14	37.9	5,857,348.44	2,856,362.73	266.8	211,960.04	118,880.34	17.1	3,077,623.61	Colorado
Connecticut	5,414,567.19	2,100,585.80	117.1	415,786.78	153,899.62	8.0	5,998,783.30	1,672,924.81	76.1				878,355.77	Connecticut
Delaware	4,918,052.29	1,781,665.60	124.3	741,382.64	306,931.14	17.6	915,210.80	373,034.06	25.4	194,011.77	10,000.00	7.1	368,052.21	Delaware
Florida	3,832,680.26	1,824,362.32	132.9	2,120,466.67	1,049,833.65	62.7	9,007,138.20	4,040,758.40	229.1	318,826.56	125,724.10	6.5	1,943,726.53	Florida
Georgia	24,791,206.97	11,664,237.86	1,794.0	2,962,273.28	1,453,529.53	193.0	10,706,286.40	5,253,001.01	468.8	15,264.89	7,632.44	4.4	2,032,761.16	Georgia
Idaho	11,061,198.14	5,882,112.70	724.7	1,708,277.16	929,954.24	79.0	2,128,711.33	1,335,307.38	169.9	375,382.97	229,622.70	30.3	1,117,822.98	Idaho
Illinois	44,116,611.86	20,619,995.74	1,377.7	2,012,307.84	980,960.66	68.1	10,137,571.69	4,866,489.69	361.6	665,850.50	325,680.26	24.1	6,193,490.65	Illinois
Indiana	16,949,425.87	8,172,125.19	534.3	2,537,876.26	1,199,358.66	76.0	17,337,352.74	8,157,219.31	497.3				2,602,423.84	Indiana
Iowa	29,062,375.40	11,926,302.10	2,114.8	3,272,974.60	1,491,965.64	212.0	12,412,418.41	5,434,917.20	639.3	1,557,432.01	381,288.35	56.6	2,296,088.71	Iowa
Kansas	32,826,601.64	12,590,489.25	1,160.6	678,298.12	303,264.40	55.5	14,324,663.10	5,659,543.16	800.2	2,401,379.15	837,355.37	93.2	2,142,290.82	Kansas
Kentucky	20,737,706.10	8,492,082.25	758.3	1,277,442.23	486,957.94	48.9	7,074,068.96	3,352,830.21	342.8	1,326,319.76	656,264.63	62.6	1,642,620.97	Kentucky
Louisiana	13,830,592.68	6,144,739.99	1,055.9	886,239.31	393,861.22	31.9	3,779,484.19	1,821,118.75	169.7	1,318,275.09	608,819.21	40.6	1,317,176.83	Louisiana
Maine	8,747,552.76	4,192,507.39	303.6	644,409.76	271,914.49	21.9	3,417,586.53	1,198,470.65	95.3	138,832.05	69,416.02	5.7	1,413,313.45	Maine
Maryland	10,924,943.10	5,112,991.22	423.3	193,172.47	96,586.23	15.7	1,560,297.86	703,957.44	72.7				646,641.11	Maryland
Massachusetts	18,353,757.71	6,657,260.62	374.5	412,120.06	121,949.75	5.1	5,468,749.89	1,483,354.92	78.2	1,085,305.70	308,090.10	20.7	2,627,170.61	Massachusetts
Michigan	25,997,240.78	11,827,052.30	963.0	854,634.64	404,909.66	28.4	14,222,085.99	6,454,713.62	406.5	856,335.00	363,026.50	21.5	3,507,353.92	Michigan
Minnesota	37,170,985.95	15,586,116.56	3,181.9	7,860,229.10	3,430,029.11	461.6	2,756,734.28	494,800.00	202.2	3,445,644.84	48,000.00	163.4	2,153,575.33	Minnesota
Mississippi	15,146,088.52	7,414,534.10	1,129.0	1,131,550.92	563,148.80	71.7	7,939,100.95	3,872,016.84	408.8	128,702.10	64,351.05	13.0	1,521,846.21	Mississippi
Missouri	28,989,166.92	13,736,014.85	1,543.2	6,857,642.11	3,018,747.35	214.3	14,385,915.26	5,702,559.25	382.9	2,124,659.26	937,679.73	101.5	1,796,609.82	Missouri
Montana	11,400,983.81	6,333,465.89	1,054.9	1,156,333.27	762,162.86	65.5	1,721,275.20	1,471,555.90	143.3	875,848.89	462,880.20	94.5	5,956,319.15	Montana
Nebraska	11,533,401.62	5,474,202.62	1,768.3	1,922,511.90	948,935.00	224.8	13,064,579.56	6,378,254.32	1,359.6	494,339.17	235,345.62	46.0	3,183,635.54	Nebraska
Nevada	7,558,195.51	5,130,934.59	538.8	2,190,619.83	1,879,898.84	215.1	1,784,241.70	1,547,311.92	226.5				1,185,579.65	Nevada
New Hampshire	4,992,558.60	2,377,450.07	237.6	104,262.46	50,101.07	3.6	1,443,736.05	655,765.31	41.4				451,800.55	New Hampshire
New Jersey	16,346,301.01	5,098,342.21	290.3	5,575,268.35	2,302,312.27	19.7	4,617,894.57	907,168.56	58.4	232,146.38	42,765.00	2.9	1,051,442.96	New Jersey
New Mexico	12,404,337.77	7,339,657.38	1,427.0	36,773.39	21,877.50	0.6	2,968,018.56	2,035,691.50	249.5	300,577.16	184,067.12	9.9	2,577,855.50	New Mexico
New York	43,224,279.79	17,911,957.19	1,197.0	2,501,509.66	934,544.67	58.1	40,669,973.00	10,572,982.70	665.2	5,189,000.00	1,229,797.50	67.0	7,031,130.04	New York
North Carolina	27,009,419.47	11,177,337.94	1,267.9	5,677,359.00	2,274,655.41	124.7	4,380,616.71	2,025,475.48	135.6	497,429.00	238,440.59	20.1	1,714,652.58	North Carolina
North Dakota	12,313,311.40	6,031,859.78	2,193.1	2,588,498.16	1,258,555.51	355.1	5,535,261.05	2,965,233.20	807.9	532,299.12	266,150.00	79.2	1,421,811.51	North Dakota
Ohio	47,699,532.90	17,371,787.03	1,364.1	2,771,726.59	1,160,121.47	100.9	12,857,841.20	4,876,402.19	374.6	1,408,279.96	557,593.66	17.9	4,528,100.65	Ohio
Oklahoma	28,247,950.33	13,159,999.15	1,178.9	973,143.32	475,218.56	41.7	3,474,535.94	1,408,119.84	197.3	1,993,265.31	682,396.34	78.6	2,085,944.11	Oklahoma
Oregon	17,027,878.42	8,593,214.79	939.2	702,784.65	403,640.92	23.7	3,250,886.94	1,816,407.15	128.0	345,457.42	7,000.00	11.8	1,241,286.14	Oregon
Pennsylvania	61,366,150.80	21,560,732.04	1,168.8	250,508.96	47,888.62	3.2	29,858,176.82	8,526,177.50	597.2	3,083,860.09	1,093,440.41	64.9	3,446,277.43	Pennsylvania
Rhode Island	3,988,616.09	1,558,829.06	86.7	274,781.19	113,520.00	7.6	2,026,527.69	531,795.00	35.4	239,058.07	74,175.00	5.0	754,874.94	Rhode Island
South Carolina	15,020,639.90	6,766,322.93	1,481.9	1,471,111.01	571,994.39	71.8	5,540,232.74	2,374,083.28	190.2	99,046.24	42,921.58	10.3	1,101,189.82	South Carolina
South Dakota	17,468,373.19	8,603,826.97	2,181.2	1,045,179.92	517,228.44	177.9	3,748,415.33	1,901,410.05	655.0	113,029.83	30,539.05	12.9	1,333,849.49	South Dakota
Tennessee	21,624,631.57	10,276,584.02	780.0	1,199,774.63	567,186.82	44.3	9,011,110.36	3,867,387.29	246.7	822,734.62	279,030.92	24.7	1,905,167.95	Tennessee
Texas	69,163,673.48	27,440,254.72	4,920.2	4,385,425.62	1,997,934.76	278.3	17,586,290.20	7,861,596.05	744.6	2,726,243.68	1,302,431.02	82.2	6,501,486.45	Texas
Utah	8,253,178.03	5,098,440.68	546.4	825,999.14	615,614.05	79.1	1,510,499.60	1,143,262.36	124.4	708,494.96	539,986.25	40.6	1,268,381.66	Utah
Vermont	4,242,042.64	2,017,699.51	134.5	144,445.28	66,281.32	3.2	2,152,080.83	826,574.77	39.9				723,576.40	Vermont
Virginia	21,990,249.44	10,385,728.11	1,005.2	1,238,406.67	553,255.39	40.8	5,886,599.53	2,524,847.71	164.9	1,006,321.00	30,640.23	24.1	1,449,756.56	Virginia
Washington	17,078,511.63	7,782,909.46	668.6	300,577.74	116,642.49	8.7	4,382,234.09	2,045,600.00	95.0	140,581.59	52,000.00	7.0	1,280,156.05	Washington
West Virginia	9,473,716.44	4,141,062.65	382.9	951,130.88	432,685.36	26.5	5,634,425.23	2,201,847.66	164.3	1,434,758.96	529,950.92	84.5	840,600.41	West Virginia
Wisconsin	24,856,508.19	10,332,705.73	1,592.1	101,729.42	50,664.71	9.3	8,937,409.85	4,264,448.88	399.0	64,661.52	32,330.00	0.2	4,569,120.68	Wisconsin
Wyoming	10,928,302.56	6,040,887.05	1,133.5	878,558.47	559,909.00	107.6	2,485,341.14	1,577,526.63	178.6				1,322,320.32	Wyoming
Hawaii				343,664.15	97,440.00	6.5	1,277,417.35	393,912.64	18.4				974,425.36	Hawaii
TOTALS	966,692,834.36	426,178,703.58	52,526.6	84,763,456.60	39,840,718.69	4,190.6	365,729,746.36	151,489,782.13	14,580.6	40,298,997.28	13,920,561.83	1,575.4	113,070,233.77	TOTALS

* Includes projects reported completed (final vouchers not yet paid) totaling: Estimated cost $ 125,978,145.08 Federal aid $ 51,768,588.79 Miles 4,534.4