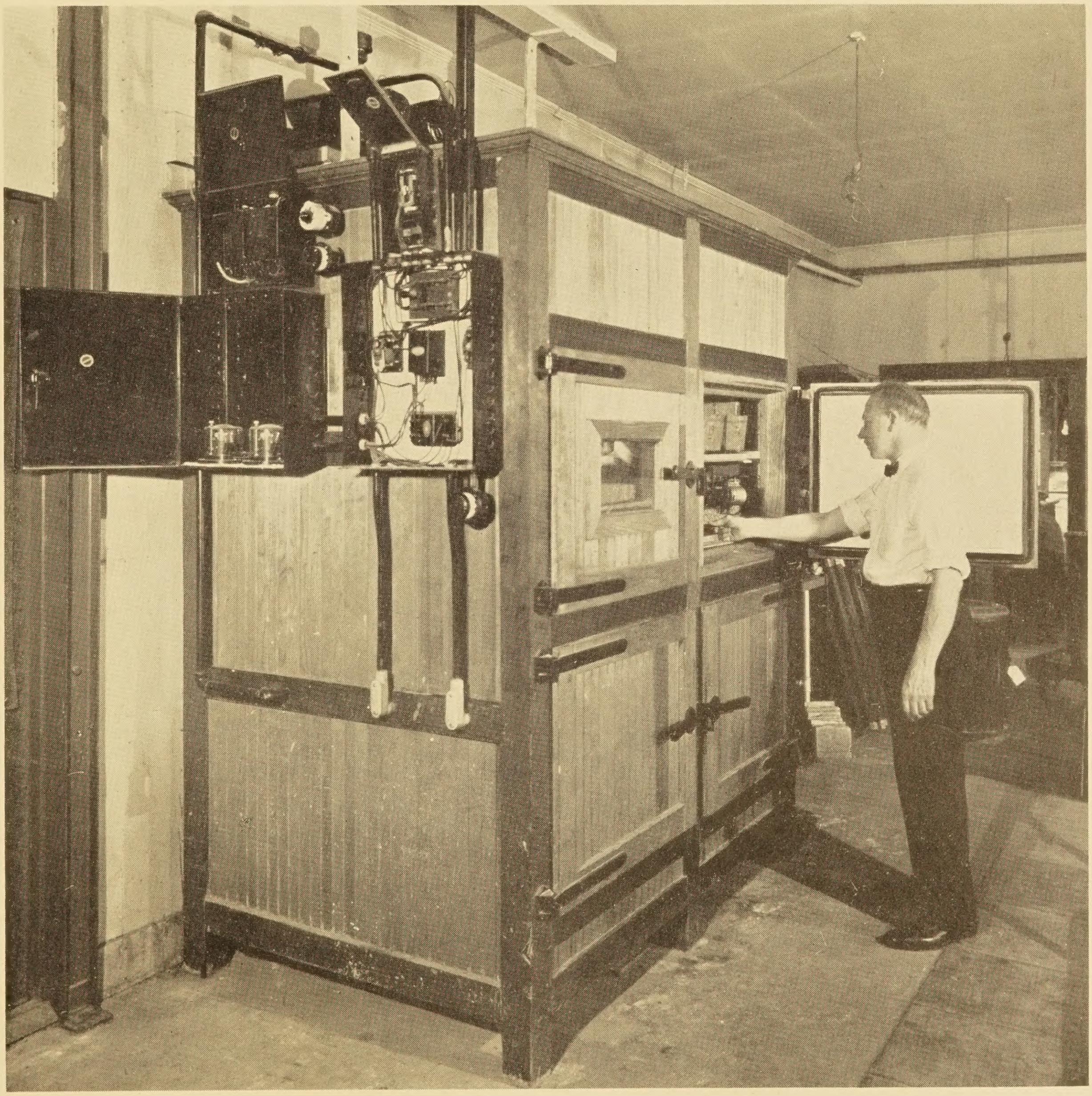
PUBLIC ROADS

A JOURNAL OF HIGHWAY RESEARCH

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

VOL. 20, NO. 4 ▽ JUNE 1939



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PUBLIC ROADS ▸▸▸ *A Journal of Highway Research*

Issued by the

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

D. M. BEACH, *Editor*

Volume 20, No. 4 June 1939

The reports of research published in this magazine are necessarily qualified by the conditions of the tests from which the data are obtained. Whenever it is deemed possible to do so, generalizations are drawn from the results of the tests; and, unless this is done, the conclusions formulated must be considered as specifically pertinent only to described conditions.

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TOLL ROADS AND FREE ROADS

A SPECIAL REPORT by the Bureau of Public Roads on the feasibility of constructing and operating as a toll facility a system of six transcontinental high ways and on needed highway improvments was transmitted to Congress by the President on April 27, 1939, with a message recommending the report for the consideration of Congress.

The report shows that a system of transcontinental superhighways cannot be supported by tolls and will not solve any considerable part of the problem of providing adequate highway facilities.

The report was made in accordance with the Federal Aid Highway Act of 1938, approved June 8, 1938, which directed the Chief of the Bureau of Public Roads to investigate and report his findings "with respect to the feasibility of building, and cost of, superhighways not exceeding three in number, running in a general direction from the eastern to the western portion of the United States, and not exceeding three in number, running in a general direction from the northern to the southern portion of the United States, including the feasibility of a toll system on such roads."

The report states that the building of such a system is entirely feasable from a physical standpoint but the system would not come within 50 percent of being self-supporting if operated as a toll facility. The report adds, however, that a system of toll roads such as the Bureau was required to report on does not meet the most urgent highway needs, and presents a master plan designed to meet these needs.

In this plan five classes of improvement are listed. A bold attack on the congestion and delays on main arteries by constructing express highways through cities, belt-line distribution routes around them, and bypasses around small towns, is proposed. It is also proposed to create a national system of interregional highways, approximately 27,000 miles in extent, by modernizing and improving existing routes of travel and building new roads where necessary to provide more direct travel.

In studying the feasibility of a toll system, the Bureau selected six routes, located in accordance with the terms of the act, aggregating 14,336 miles. Its detailed studies show that the cost of constructing this system for fast-moving traffic, without crossing other highways or railroads at grade, would be about $2,899,800,000, which is at the average rate of $202,270 per mile.

The average estimated annual expenditure for the period 1945–60, required for financing the construction, maintaining the property, and operating the facility would be $184,054,000, which is at the average rate of $12,840 per mile per year.

Estimates of the potential traffic on the proposed toll system were based on actual traffic counts on the main highways of the country and studies of the character of highway travel. A number of facts led to the conclusion that only a small portion of present traffic could be attracted to the toll system. Long-distance travel constitutes only a small fraction of the total travel. Counts made on east-west highways at stations established on a line extending from Canada to Mexico showed only 300 passenger vehicles crossing the line daily in transcontinental travel. The system could be expected to serve adequately only that portion of the traffic having origin and destination close to one of the six routes. Access to the highways would have to be controlled both for collection of tolls and to prevent interference with flow of traffic by entering vehicles. Vehicles traveling distances less than the spacing of access points would not use the toll roads.

It is estimated that the utilization of the system would average, during the period 1945–60, 12,450,000 vehicle-miles per day. Assuming toll charges of 1 cent per vehicle-mile for passenger vehicles and an average of 3.5 cents per vehicle-mile for trucks and busses, this

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TO THE CONGRESS OF THE UNITED STATES:

I transmit herewith a letter from the Secretary of Agriculture, concurred in by the Secretary of War, enclosing a report of the Bureau of Public Roads, United States Department of Agriculture, on the Feasibility of a System of Transcontinental Toll Roads and a Master Plan for Free Highway Development.

The report, prepared at the request of the Congress, is the first complete assembly of data on the use being made of our national highway network. It points definitely to the corrective measures of greatest urgency and shows that existing improvements may be fully utilized in meeting ultimate highway needs.

It emphasizes the need of a special system of direct interregional highways, with all necessary connections through and around cities, designed to meet the requirements of the national defense and the needs of a growing peace-time traffic of longer range.

It shows that there is need for superhighways, but makes it clear that this need exists only where there is congestion on the existing roads, and mainly in metropolitan areas. Improved facilities, needed for the solution of city street congestion, are shown to occupy a fundamental place in the general replanning of the cities indicated as necessary in the report "Our Cities", issued in September 1937 by the National Resources Committee.

The report also points definitely to difficulties of right-of-way acquisition as obstacles to a proper development of both rural highways and city streets, and makes important and useful recommendations for dealing with these difficulties.

I call the special attention of the Congress to the discussion of the principle of "excess-taking" of land for highways. I lay great emphasis on this because by adopting the principle of "excess-taking" of land, the ultimate cost to the Government of a great national system of highways will be greatly reduced.

For instance, we all know that it is largely a matter of chance if a new highway is located through one man's land and misses another man's land a few miles away. Yet the man who, by good fortune, sells a narrow right-of-way for a new highway makes, in most cases, a handsome profit through the increase in value of all of the rest of his land. That represents an unearned increment of profit—a profit which comes to a mere handful of lucky citizens and which is denied to the vast majority.

Under the exercise of the principle of "excess-taking" of land, the Government, which puts up the cost of the highway, buys a wide strip on each side of the highway itself, uses it for the rental of concessions and sells it off over a period of years to home builders and others who wish to live near a main artery of travel. Thus the Government gets the unearned increment and reimburses itself in large part for the building of the road.

In its full discussion of the whole highway problem and the wealth of exact data it supplies, the report indicates the broad outlines of what might be regarded as a master plan for the development of all of the highway and street facilities of the Nation.

I recommend the report for the consideration of the Congress as a basis for needed action to solve our highway problems.

FRANKLIN D. ROOSEVELT

THE WHITE HOUSE,
April 27, 1939.

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travel would produce an average annual revenue of $72,140,000. This is considerably less than the $184,-054,000 estimated average annual cost and leads the Bureau to conclude that the system studied could not be supported by toll collections.

The portion of the proposed system estimated to be most nearly self-supporting is the 172 miles from a point near Philadelphia, Pa., to a point near New Haven, Conn. With the increase in traffic expected by 1960, this portion of the system would earn slightly more than the estimated cost for that year.

The report states, "If, as an actual test of the feasibility of a limited mileage of toll roads, it is the desire of the Congress to make provision for the construction of a section of highway of substantial length upon which there is a reasonable prospect of the recovery of the costs through tolls, it is recommended that such provision be made applicable to a section of highway, properly located, and extending from an appropriate point near Washington, D. C., to an appropriate point near Boston, Mass."

The report recommends the construction of a special system of direct interregional highways, with all necessary connections through and around cities, designed to meet the requirements of the national defense in time of war and the needs of a growing peace-time traffic of longer range. A system of such roads, including 26,700 miles, has been tentatively selected on the basis of the detailed traffic data available. Existing main highways can be modernized to form a large part of the system but some new highways will be needed to provide directness of travel. Although these roads represent less than 1 percent of the total mileage of rural roads, the Bureau estimates they would serve, when improved as indicated, at least 12.5 percent of the total vehicle travel on rural highways.

More complete information on the character of traffic in and near cities than has heretofore been available is presented. Traffic maps in the report show that about 90 percent of the traffic on main highways near the entrances to large cities is bound to or from points in cities themselves and cannot be bypassed around them. It is found also that a large part of the traffic is destined to or bound from points in the very heart of the city or points most conveniently reached by going through the center of the city.

There is great need, the report indicates, for express highways cut directly into and through the center of the big cities. These are needed not only for service of the through traffic delivered by the main rural highways but also for the daily in-and-out movement of local traffic between the downtown section and suburbs centering about the main highways at the periphery of the city.

The West Side Highway and Henry Hudson Parkway in New York, and the recently constructed express highway in St. Louis are cited as early examples of such facilities. The provision of similar facilities in Pittsburgh is now receiving serious consideration.

By preference such express highways should be constructed as attractively landscaped depressed thoroughfares passing under all cross streets.

Bypasses—the remedy usually proposed for the relief of congestion on through streets in cities—are said to be only a partial and, by themselves, a not very effective remedy. They are recommended around the smaller towns and a new type of belt-line distribution road around cities is proposed. For maximum effectiveness, both the bypass and distribution highways must be free of cross traffic, parked vehicles and developments immediately adjacent, to preserve their initial advantage against the encroaching growth of the urban community, which otherwise soon converts them into ordinary local streets.

Outside of city limits on the main highways the report shows there is need of modernization of the existing roads to ease curvature, reduce gradients, and extend sight distance in order more safely to serve fast-moving traffic. Near the cities, also, a steadily increasing mileage of four-lane divided highways is believed to be required.

According to the report, such improvements are required on most of the mileage of the Federal-aid and State highway systems, especially those parts built before the recent considerable increase in the travel speed of motor vehicles. For the most part they involve only local changes in the existing roads. By such changes the bulk of the highway traffic that moves between adjacent cities will be amply served.

The report sketches the general outlines of a Master Plan for the improvement of roads and streets to meet the real needs of highway transportation. In addition to the several classes of improvements previously mentioned, the plan includes improvement of a carefully selected mileage of secondary and feeder roads to give direct service to a larger number of rural dwellers. The selection would be made from among the 2,618,-000 miles of roads outside of the Federal-aid and primary State highway systems. Constituting about 83 percent of the country's total road and street mileage, these lesser roads serve at present only about 13 percent of the total vehicle mileage of traffic. Located on them, however, are the homes and working places of about 75 percent of the rural population. The purpose of the improvement of an additional mileage of these roads, therefore, is shown to be that of affording better access to rural property rather than the service of a large increment of traffic. The choice of the roads to be improved should be made in close conformity with a program looking to the promotion of economically and socially beneficial land use.

The report discusses at length the limitations hitherto placed upon road improvement by difficulties of right-of-way acquisition, and shows that similar difficulties are now the principal obstacle standing in the way of needed improvements of the several types described, especially within and in the vicinity of cities.

Taking the city of Baltimore as an example of a universal condition, it shows, by spotting the location of properties on which the city holds tax liens and properties being acquired for Federal slum clearance projects, that a wide belt of decadent property surrounds the central business section. Decay of values within this zone (the result of the outward movement of the homes of the more well-to-do citizens) is rapidly approaching a critical point. Creation of new values is beginning to occur, generally without regard to any well-conceived future street plan. In Baltimore, proposed slum clearance projects are shown to lie in the path of desirable express highway locations. All of which indicates the great importance of early consideration of the new street plans which must form the framework upon which the cities of the future will be erected. It also indicates the need and present timeliness of effective measures for the acquisition of land in the

(Continued on page 75)

TESTS OF CONCRETE CURING MATERIALS

BY THE DIVISION OF TESTS, BUREAU OF PUBLIC ROADS

Reported by F. H. JACKSON, Senior Engineer of Tests, and W. F. KELLERMANN, Associate Materials Engineer

NUMEROUS methods and procedures used for curing concrete pavements are included in the scope of the investigation herein reported. However, the investigation did not include the use of cotton mats which have proven highly effective as a curing medium, not only on account of their ability to retain moisture over a considerable period of time but also because they protect the concrete from large fluctuations in temperature at early ages when its ability to resist temperature stresses is low.

The reason for the omission of cotton mats was twofold. First, the investigation did not involve any study of thermal insulation but was for the purpose of determining the ability of various curing agents to retain moisture and thereby promote the development of strength. In the burlap curing that was used as a basis for the comparison of the other methods, the burlap was kept in a saturated condition at all times and therefore, insofar as moisture loss is concerned, the results were the same as would have been obtained with saturated cotton mats. Second, the technical and practical advantages of cotton mats have been demonstrated conclusively by previous investigations, both in the laboratory and in the field.

Thorough and complete curing has always been recognized as one of the most important single factors involved in the construction of a concrete pavement. The importance of delaying moisture loss until the concrete has attained sufficient strength to furnish high resistance to the shrinkage stresses resulting from drying is self-evident. For this reason, provisions for curing form a very important part of every concrete pavement specification.

For many years concrete pavements were cured almost entirely by means of a thorough and continuous application of water for periods up to 10 days after placing. Curing began by covering the concrete with wet burlap applied just as soon after finishing as possible. This was kept continuously wet until the following day when it was replaced by a covering of earth or straw kept continuously wet for periods of from 7 to 10 days. It has always been pretty generally agreed that, theoretically at least, the above method is ideal. However, it requires continuous wetting over a considerable period of time, a procedure which is not only expensive but requires constant and efficient supervision to insure full compliance.

TESTS MADE TO COMPARE CURING MATERIALS AND TO DEVELOP STANDARD TEST PROCEDURE

So long as only small amounts of pavement were involved and daily yardages were limited, it was possible to enforce such curing provisions without great difficulty. However, as methods of construction became more efficient, and daily yardages increased, the cost of curing by water as well as the difficulty of enforcing the requirements mounted rapidly. As was bound to happen, this condition has resulted within the last several years in the introduction of numerous substitute methods of curing, designed to accomplish the same purpose without the use of water. Most of these methods, involving the use of such materials as various grades of waterproof paper coverings, sodium silicate, liquid bituminous products, rubber emulsion, etc., depend entirely for their efficiency on the ability of the materials to retain water within the concrete. The materials seal the surface and their use is justified on the theory that adequate curing can be accomplished by retaining the contained water.

Many attempts have been made from time to time to study the effectiveness of different methods of curing concrete through the construction of experimental roads, curing different sections by different methods. Such procedure would seem to be a very logical method of ascertaining the comparative value of different curing materials. Actually, however, the impossibility of controlling other variables that may affect the result, particularly weather conditions, make it of distinctly questionable value.

There are many problems regarding concrete pavement construction that may be studied with profit through the construction of experimental roads. However, in the authors' opinion curing is not one of them. It is believed that such comparisons should be made only in the laboratory under closely controlled temperature and humidity conditions, using a test procedure that will permit direct comparisons of the efficiency of different curing materials. Having determined, by means of a series of tests of this type, the degree of compliance that may reasonably be expected, suitable requirements could be written into standard specifications and the test procedure used as a standard routine laboratory method of evaluating the various materials and processes offered for use.

The tests reported herein were made with the twofold purpose of obtaining comparative data on the effectiveness of various curing materials and methods now in common use and of developing a standard laboratory test procedure for use in specifications. The procedure followed has been made available to Committee C–9 of the A. S. T. M. in developing a tentative method for testing curing agents. The curing materials that were investigated included, in addition to burlap, calcium chloride, used both as a surface application and as an admixture; sodium silicate; six waterproof papers; a special curing blanket consisting of two layers of burlap with a jute bat between; an asphalt emulsion; an asphalt cutback; a straw-colored lacquerlike liquid; and a rubber (latex) emulsion. The last four materials were proprietary liquid curing compounds applied in the form of a spray. A brief description of each of the materials investigated is given in table 1.

STUDIES MADE OF 38 DIFFERENT CURING PROCEDURES INVOLVING 14 MATERIALS

Several of the surface-sealing materials were used both with and without a preliminary 24-hour application of wet burlap. In addition, the time elapsing between the molding of the specimen and the application of the curing material was varied. The comparative effects of burlap curing for 1, 2, and 3 days without subsequent curing were also investigated. In all, 38 different curing procedures involving 14 materials were studied, the results being compared with the results obtained with specimens cured continuously with wet burlap in sealed containers (ideal curing) as well as with specimens exposed to the air without protection of any kind. To provide ideal curing the specimens were first covered with two layers of wet burlap. Over this was placed a metal cover that was sealed around the edges to prevent any loss of moisture.

TABLE 1.—*Description of curing materials*

Type	Description
Burlap	Weight, 9 ounces per square yard.
Paper A	2 layers of paper cemented together with bitumen and reinforced with sisal fibers.
Paper B	2 layers of paper, reinforced in both directions at about ½-inch intervals and cemented together with bitumen, bitumen applied to 1 layer only.
Paper C	Same as paper B, except bitumen applied to both layers of paper.
Paper D	Single layer of unreinforced paper, treated with a white emulsion.
Paper E	Same as paper D, except treated with a brown emulsion.
Paper F	Same as paper D, except treated with a brown-white emulsion.
Sodium silicate	Commercial grade as used for curing concrete. Applied with a brush.
Calcium chloride	Standard commercial product (flake) as used for curing concrete.
Curing blanket	Consists of 2 layers of burlap with jute bat between. Weight 22 ounces per square yard.
Liquid curing material A.[1]	Special asphalt emulsion used for curing concrete. Applied with a spray gun.
Liquid curing material B.[1]	Special asphalt cut-back used for curing concrete. Applied with a spray gun.
Liquid curing material C.[1]	A straw-colored lacquerlike liquid. Applied with a spray gun
Liquid curing material D.[1]	A rubber emulsion (latex). Applied with a spray gun.

[1] The liquid curing materials are all proprietary compounds, the exact composition of which was not determined.

The results of five series of tests, four after 7 days of exposure under the temperature and humidity conditions described below, and one after 28 days of exposure, are reported. A brief description of each procedure, including the type of curing material involved, whether used with or without an initial application of burlap, the time of application, and the duration of application, is shown in table 2. This table also indicates the series in which each procedure was used.

In series A to D, inclusive, the specimens were exposed for 7 days in an atmosphere maintained at 100° F.±2° F. with a relative humidity of 32 percent ±2 percent, using for this purpose a specially designed curing cabinet in which the temperature and humidity were controlled automatically within the limits indicated. In series E, the specimens were exposed for 28 days. Each result reported in series A to D, inclusive, with certain exceptions noted in series B, is the average of either five or six individual determinations made on different days. The results of the tests after 28 days, series E, are the averages for from two to five specimens, as noted in subsequent tables.

In series A, 19 methods in addition to the standard or ideal method and the method involving no curing treatment, were investigated. These included burlap for 1, 2, and 3 days; paper A and liquid curing material A with and without burlap; the other papers and liquid curing materials without burlap, that is, as recommended by the manufacturers; calcium chloride, both as a surface application and as an admixture; sodium silicate; and the curing blanket. It will be noted that in this series, surface sealing materials when used without burlap were applied 3 hours after molding. This would represent about the maximum time that might be required in the field. Burlap in this series, however, was applied immediately after molding.

TABLE 2.—*Description of curing procedures*

Method No.	Curing procedure	Used in series				
		A	B	C	D	E
1a	Wet burlap, sealed with metal cover continuously	x	x	x	x	x
2	No treatment	x	x	---	x	x
3a	Wet burlap for 1 day, applied immediately after molding	x	---	---	x	x
4a	Wet burlap for 2 days, applied immediately after molding	x	x	---	x	x
4b	Wet burlap for 2 days, applied 1 hour after molding	---	x	---	---	---
4c	Wet burlap for 2 days, applied 3 hours after molding	---	x	---	---	x
4c-1	Wet burlap for 2 days, applied 3 hours after molding [1]	---	x	---	---	---
4c-2	Wet burlap for 2 days, applied 3 hours after molding [2]	---	x	---	---	---
5a	Wet burlap for 3 days, applied immediately after molding	x	x	---	x	x
5b	Wet burlap for 3 days, applied 1 hour after molding	---	x	---	---	---
5c	Wet burlap for 3 days, applied 3 hours after molding	---	x	---	---	x
5c-1	Wet burlap for 3 days, applied 3 hours after molding [1]	---	x	---	---	---
5c-2	Wet burlap for 3 days, applied 3 hours after molding [2]	---	x	---	---	---
6a	Wet burlap for 1 day, applied immediately after molding followed by paper A for 6 days	x	x	---	x	x
6b	Wet burlap for 1 day, applied 1 hour after molding, followed by paper A for 6 days	---	x	---	---	---
6c	Wet burlap for 1 day, applied 3 hours after molding, followed by paper A for 6 days	---	x	x	---	x
7a	Wet burlap for 1 day, applied immediately after molding, followed by sodium silicate	x	---	---	x	x
7c	Wet burlap for 1 day, applied 3 hours after molding, followed by sodium silicate	---	---	---	---	x
8a	Wet burlap for 1 day, applied immediately after molding, followed by calcium chloride (surface application)	x	---	---	x	x
8c	Wet burlap for 1 day, applied 3 hours after molding, followed by calcium chloride (surface application)	---	---	---	---	x
9a	Wet burlap for 1 day, applied immediately after molding, followed by liquid curing material A	x	---	---	x	x
9c	Wet burlap for 1 day, applied 3 hours after molding, followed by liquid curing material A	---	---	x	---	x
10c	Wet burlap for 1 day, applied 3 hours after molding, followed by liquid curing material B	---	---	x	---	---
11a	Wet burlap for 1 day, applied immediately after molding, calcium chloride admixture	x	---	---	x	x
11c	Wet burlap for 1 day, applied 3 hours after molding, calcium chloride admixture	---	---	---	---	x
12c	Curing blanket, for 3 days, applied 3 hours after molding	x	---	---	x	x
13b	Waterproof paper A, for 7 days, applied 1 hour after molding	---	x	---	---	---
13c	Waterproof paper A, for 7 days, applied 3 hours after molding	x	x	x	x	x
14c	Waterproof paper B for 7 days, applied 3 hours after molding	x	---	---	x	x
15c	Waterproof paper C for 7 days, applied 3 hours after molding	x	---	---	x	x
16c	Waterproof paper D, for 7 days, applied 3 hours after molding	x	---	---	x	x
17c	Waterproof paper E, for 7 days, applied 3 hours after molding	x	---	---	x	x
18c	Waterproof paper F, for 7 days, applied 3 hours after molding	x	---	---	x	x
19b	Liquid curing material A, applied 1 hour after molding	---	x	---	---	---
19c	Liquid curing material A, applied 3 hours after molding	x	x	x	x	x
20b	Liquid curing material B, applied 1 hour after molding	---	x	---	---	---
20c	Liquid curing material B, applied 3 hours after molding	x	x	x	x	x
21b	Liquid curing material C, applied 1 hour after molding	---	x	---	---	---
21c	Liquid curing material C, applied 3 hours after molding	x	x	---	x	x
22c	Liquid curing material D, applied 3 hours after molding	x	---	---	x	x

[1] The burlap was sprinkled intermittently in such manner as to keep it continuously wet.
[2] The burlap was sprinkled intermittently and allowed to become dry between wettings.

SPECIMENS SEALED TO PERMIT MOISTURE LOSS ONLY THROUGH CURING MEDIUM

Series D was a duplication of series A, run several months later. In series B the effect of varying the time of application of the curing agent was investigated. For burlap, the effects of delaying the application 1 hour and 3 hours are shown as well as the effects of continuous sprinkling and of intermittent sprinkling. The relative effects of applying paper A and liquid curing materials A, B, and C, 1 hour after molding, as well as 3 hours, are also shown. Series C was run in order to obtain additional data on the effect of using waterproof paper and liquid curing material with a preliminary 24-hour application of wet burlap for comparison with the usual method which does not require burlap. Series E gives the results of a series of tests after 28 days of exposure, using, in general, the same methods as used in series A and D in which the specimens were exposed 7 days.

The effectiveness of each curing method was measured both in terms of relative moisture loss and relative strength, using test specimens of 1 : 2 mortar, 6½ inches wide by 12 inches long by 2 inches deep. The curing material was applied to the top or molded surface of the specimen, and sealed around the edges in such a manner that moisture could escape only through the curing medium itself. The rate of moisture loss was measured for each method by determining the loss in weight at various intervals during the exposure period.

The specimens were molded in watertight sheet metal pans, the bottoms of which were reinforced with angle sections for a stiffening effect. This was done because it was frequently necessary to handle them at about the time initial set was taking place and it was felt that molds that were not rigid might allow stresses to be set up within the specimen.

The procedure followed in fabricating the specimens was to mix just sufficient mortar for one test specimen at a time. A well-graded concrete sand was used in the mortar together with sufficient water to produce a plastic consistency. In each series, the water-cement ratio was maintained constant. However, because of slight differences in grading of sand used in the different series, it was necessary to vary slightly the water-cement ratio from series to series. The maximum difference did not exceed 0.02 by weight. The mortar was puddled into the molds with the gloved fingers, after which the surface was struck off with a single stroke of a steel blade. No troweling was done. Immediately after molding, the specimens were weighed, these weights being taken as the initial weights from which the moisture losses were computed.

In all instances where burlap was applied immediately after molding (except where it was sealed in as in method 1), the specimens were not placed immediately in the humidity-controlled curing cabinet, but were placed in an oven maintained at 100° F. ±2° F. but without humidity control. Where burlap was applied 1 or 3 hours after molding, the specimens were placed in the humidity-controlled cabinet until the burlap was applied after which they were placed in the oven. This was necessary because the procedure for burlap curing required that the material be kept saturated for the entire time of application. This would have made it impossible to maintain a constant humidity in the cabinet.

The burlap cover was kept saturated by immersing an overhanging end in a pan of water. It was found that in order to insure even and continuous saturation over the entire surface of the specimen it was necessary to use three layers of burlap. This method of keeping the specimens wet was used in order to avoid the necessity of opening the oven doors frequently for the purpose of sprinkling.

RELATIVE EFFICIENCY OF EACH CURING METHOD DETERMINED

At the conclusion of the period of burlap curing the specimens were removed from the oven, the burlap removed and the specimens immediately placed in the curing cabinet (where burlap curing only was involved) or covered with the final curing material and then placed in the cabinet.

In instances where burlap curing was not involved, the procedure was to place the specimen in the humidity-controlled cabinet immediately after molding. After the concrete had set, or after passage of a prescribed interval of time, the specimen was removed for the purpose of applying the curing material, after which it was replaced in the cabinet for the duration of the test.

At the conclusion of the exposure period the specimens were removed from the cabinet, the molds removed and the specimens immersed in water for 2 days prior to testing for flexural strength. For series A to D, inclusive, the age at test was therefore 9 days whereas for series E it was 30 days. To facilitate absorption of water, the upper and lower surfaces of each specimen

TABLE 3.—*Series A; results of tests after 7 days* [1]

Method No.	Type of curing	Procedure				Water remaining in specimens at age indicated [2]						Flexural strength	Relative efficiency, based on—	
		Burlap		Final curing material										
		Applied after molding	Duration of application	Applied after molding	Duration of application	3 hours	1 day	2 days	3 days	4 days	7 days		Water loss	Strength
		Hours	*Days*	*Hours*	*Days*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Lb. per sq. in.*		
1a	Burlap	0	7	-----	-----	-----	-----	-----	-----	-----	102	1,018	100	100
2	None	-----	-----	-----	-----	97	79	77	76	74	73	561	0	0
3a	Burlap	0	1	-----	-----	-----	101	95	93	92	90	861	59	66
4a	do	0	2	-----	-----	-----	-----	102	98	96	94	988	72	93
5a	do	0	3	-----	-----	-----	-----	-----	102	99	97	996	83	95
6a	Paper A with burlap	0	1	24	6	-----	101	101	100	100	100	1,025	93	102
7a	Sodium silicate with burlap	0	1	24	6	-----	101	98	96	95	94	908	72	76
8a	Calcium chloride with burlap	0	1	24	6	-----	101	96	95	94	90	1,022	59	101
9a	Liquid material A with burlap	0	1	24	6	-----	101	101	100	100	100	1,055	93	108
11a	Calcium chloride admixture with burlap	0	1	(3)	(3)	-----	101	97	96	95	92	947	66	84
12c	Curing blanket	-----	-----	3	3	96	-----	-----	90	89	86	740	45	39
13c	Paper A	-----	-----	3	7	96	96	96	95	95	95	769	76	46
14c	Paper B	-----	-----	3	7	97	96	95	94	94	94	768	72	45
15c	Paper C	-----	-----	3	7	97	97	97	96	95	95	808	76	54
16c	Paper D	-----	-----	3	7	96	84	82	80	80	77	571	14	2
17c	Paper E	-----	-----	3	7	96	84	82	81	80	78	634	17	16
18c	Paper F	-----	-----	3	7	95	84	82	80	79	77	610	14	11
19c	Liquid material A	-----	-----	3	7	95	96	96	96	95	94	791	72	50
20c	Liquid material B	-----	-----	3	7	96	95	95	93	93	92	762	66	44
21c	Liquid material C	-----	-----	3	7	96	90	89	88	87	85	673	41	25
22c	Liquid material D	-----	-----	3	7	96	94	93	93	92	92	724	66	36

[1] All results average of 5 tests. [2] Based on total water in specimens after molding. [3] Mixing water contained 2 percent calcium chloride.

were rubbed with a carborundum stone prior to immersion. This procedure was followed in an effort to place all specimens in a uniform condition, insofar as contained moisture was concerned, prior to test. As will be discussed in detail later, this apparently was not accomplished under all conditions, possibly accounting for certain discrepancies in the strength results that were observed.

Flexure tests were made at the conclusion of the 2-day resaturation period, the load being applied at the center of a 9-inch span, with the top surface as molded in tension.

The rate at which specimens cured by the different methods gave up water at various periods from time of molding up to and including 7 days of exposure, the flexural strengths at 9 days, and the "relative efficiency," from the standpoint of both water retention and strength, are shown in tables 3 to 6, inclusive; except that table 5 (series C) contains no data on relative efficiency because in this series no values were obtained on the specimens receiving no curing treatment (method no. 2). Corresponding values for 28-day exposure are shown in table 7.

Relative efficiency as used in this report is a value that represents the comparative effectiveness of the particular method involved on the basis of 100 for specimens cured by the ideal method (method 1a) and 0 for specimens receiving no curing treatment (method 2). Thus, in series A, table 3, the strength of the ideally cured specimens averaged 1,018 pounds per square inch, whereas, the specimens receiving no curing treatment averaged 561 pounds per square inch. The difference, 457 pounds per square inch, may be considered as representing the gain in strength that was attained through ideal curing. On this basis, method 3a, 24-hour burlap curing, with a strength of 861 pounds per square inch, had a relative efficiency of 66. Values for relative efficiency based on water loss were computed in the same manner.

Thus, from table 3 it will be noted that the specimens given no curing treatment (method 2) averaged 27 percent moisture loss at 7 days, whereas, the specimens

TABLE 4.—*Series B; results of tests after 7 days* [1]

Method No.	Type of curing	Procedure				Water remaining in specimens at age indicated [2]							Flexural strength	Relative efficiency based on—	
		Burlap		Final curing material											
		Applied after molding	Duration of application	Applied after molding	Duration of application	1 hour	3 hours	1 day	2 days	3 days	4 days	7 days		Water loss	Strength
		Hours	*Days*	*Hours*	*Days*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Lb. per sq. in.*		
1a	Burlap	0	7									103	924	100	100
2	None							73	71	69	68	65	574	0	0
4a	Burlap	0	2						102	96	94	91	879	68	87
4b	do	1	2			99			99	92	90	87	841	58	76
4c	do	3	2				96		103	95	93	90	827	66	72
[3] 4c-1	Burlap sprinkled intermittently	3	2				96		99	95	93	90	798	66	66
[4] 4c-2	do	3	2				96		90	86	85	82	714	45	37
5a	Burlap	0	3							104	99	95	910	79	96
5b	do	1	3			99				99	94	90	907	66	95
5c	do	3	3				96			102	96	92	859	71	81
[3] 5c-1	Burlap sprinkled intermittently	3	3				97			99	94	91	885	68	92
[4] 5c-2	do	3	3				96			90	89	85	698	53	32
6a	Paper A with burlap	0	1	24	6			102	102	101	101	100	894	92	91
6b	do	1	1	24	6	99		99	99	99	98	97	956	84	109
6c	do	3	1	24	6		96	103	102	101	101	100	925	92	100
13b	Paper A			1	7	99		97	96	96	95	94	855	76	80
13c	do			3	7		96	95	95	94	94	93	838	74	75
19b	Liquid material A			1	7	99		92	89	88	87	85	773	53	57
19c	do			3	7		96	95	95	94	94	93	849	74	79
20b	Liquid material B			1	7	99		92	90	88	87	84	807	50	67
20c	do			3	7		95	94	94	93	92	92	919	71	99
21b	Liquid material C			1	7	99		85	82	80	79	76	657	29	24
21c	do			3	7		95	88	86	84	83	81	733	42	45

[1] All results average of 5 tests except as noted.
[2] Based on total water in specimens after molding.
[3] Average of 3 tests. Burlap kept constantly in a moist condition.
[4] Average of 2 tests. Burlap allowed to become practically dry before each sprinkling.

TABLE 5.—*Series C; results of tests after 7 days* [1]

Method No.	Type of curing	Procedure				Water remaining in specimens at age indicated [2]						Flexural strength
		Burlap		Final curing material								
		Applied after molding	Duration of application	Applied after molding	Duration of application	3 hours	1 day	2 days	3 days	4 days	7 days	
		Hours	*Days*	*Hours*	*Days*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Lb. per sq. in.*
1a	Burlap	0	7								104	843
6c	Paper A with burlap	3	1	24	6	96	102	102	102	102	100	810
9c	Liquid material A with burlap	3	1	24	6	96	104	103	102	102	100	823
10c	Liquid material B with burlap	3	1	24	6	95	102	101	101	100	98	826
13c	Paper A			3	7	95	94	94	94	93	92	786
19c	Liquid material A			3	7	95	95	95	94	94	94	818
20c	Liquid material B			3	7	95	94	93	92	92	90	786

[1] All results average of 6 tests.
[2] Based on total water in specimens after molding.

TABLE 6.—*Series D; results of tests after 7 days* [1]

Method No.	Type of curing	Procedure				Water remaining in specimens at age indicated [2]						Flexural strength	Relative efficiency based on—	
		Burlap		Final curing material										
		Applied after molding	Duration of application	Applied after molding	Duration of application	3 hours	1 day	2 days	3 days	4 days	7 days		Water loss	Strength
		Hours	*Days*	*Hours*	*Days*	*Percent*	*Per cent*	*Percent*	*Percent*	*Percent*	*Percent*	*Lb. per sq. in.*		
1a	Burlap	0	7								104	897	100	100
2	None					96	76	73	71	71	67	597	0	0
3a	Burlap	0	1				103	94	91	90	86	808	51	70
4a	do	0	2					104	98	96	92	875	68	93
5a	do	0	3						104	99	95	909	76	104
6a	Paper A with burlap	0	1	24	6		103	102	102	102	100	943	89	115
7a	Sodium silicate with burlap	0	1	24	6		103	96	94	92	89	865	59	89
8a	Calcium chloride with burlap	0	1	24	6		100	95	93	91	88	867	57	90
9a	Liquid material A with burlap	0	1	24	6		102	101	101	101	99	943	86	115
11a	Calcium chloride admixture with burlap	0	1	(3)	(3)		103	95	93	91	88	845	57	83
12c	Curing blanket			3	3	96			89	87	84	741	46	48
13c	Paper A			3	7	96	95	95	94	94	93	785	70	63
14c	Paper B			3	7	95	95	94	94	94	93	780	70	61
15c	Paper C			3	7	96	95	95	95	95	94	805	73	69
16c	Paper D			3	7	96	81	78	76	75	71	623	11	9
17c	Paper E			3	7	95	83	80	78	77	74	621	19	8
18c	Paper F			3	7	95	83	79	78	76	73	600	16	1
19c	Liquid material A			3	7	96	96	95	95	95	94	822	73	75
20c	Liquid material B			3	7	96	94	93	92	92	90	759	62	54
21c	Liquid material C			3	7	96	92	89	88	87	84	678	46	27
22c	Liquid material D			3	7	95	93	91	91	90	89	719	59	41

[1] All results average of 5 tests.
[2] Based on total water in specimens after molding.
[3] Mixing water contained 2 percent calcium chloride.

TABLE 7.—*Series E; results of tests after 28 days* [1]

Method No.	Type of curing	Procedure				Water remaining in specimens at age indicated [2]									Flexural strength	Relative efficiency based on—	
		Burlap		Final curing material													
		Applied after molding	Duration of application	Applied after molding	Duration of application	3 hours	1 day	2 days	3 days	4 days	7 days	14 days	21 days	28 days		Water loss	Strength [3]
		Hours	*Days*	*Hours*	*Days*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Lb. per sq. in.*		
1a	Burlap	0	28											102	1, 156	100	100
2	None					95	75	72	72	71	68	64	62	59	558	0	0
[4] 3a	Burlap	0	1				101	94	92	91	90	84	83	81	756	51	42
[5] 3c	do	3	1			96	103	93	92	92	87	84	82	79	773	47	31
[4] 4a	do	0	2					103	98	97	95	91	89	86	834	63	56
[5] 4c	do	3	2			97		102	97	96	92	89	87	83	822	56	38
[4] 5a	do	0	3						102	99	97	91	90	88	810	67	52
[5] 5c	do	3	3			96			103	98	95	91	88	86	841	63	42
[4] 6a	Paper A with burlap	0	1	24	27		102	101	101	100	100	99	97	96	1, 216	86	125
[5] 6c	do	3	1	24	27	96	103	102	102	102	100	99	98	96	1, 185	86	96
[4] 7a	Sodium silicate with burlap	0	1	24	27		101	97	96	94	93	88	87	85	773	60	46
[5] 7c	do	3	1	24	27	96	104	98	97	96	93	90	88	85	819	60	38
[4] 8a	Calcium chloride with burlap.	0	1	24	27		99	97	95	95	93	89	87	85	909	60	69
[5] 8c	do	3	1	24	27	96	103	98	97	95	92	89	85	81	908	51	52
[4] 9a	Liquid material A with burlap.	0	1	24	27		101	100	100	99	99	96	96	94	1, 106	81	106
[5] 9c	do	3	1	24	27	96	101	100	98	98	96	94	93	91	953	74	60
[4] 11a	Calcium chloride admixture with burlap.	0	1	(6)	(6)		104	98	96	95	93	89	87	84	770	58	46
[5] 11c	do	3	1	(6)	(6)	96	104	96	95	94	90	87	85	83	848	56	44
12c	Curing blanket			3	3	96			89	88	85	81	79	76	682	40	21
13c	Paper A			3	28	97	96	95	94	94	93	92	91	90	799	72	40
14c	Paper B			3	28	96	95	93	93	93	92	90	88	86	780	63	37
15c	Paper C			3	28	96	95	95	95	95	94	93	93	92	866	77	52
16c	Paper D			3	28	95	82	78	78	76	74	70	67	65	589	14	6
17c	Paper E			3	28	95	83	80	79	78	75	72	69	66	563	16	2
18c	Paper F			3	28	95	81	78	77	76	74	70	67	65	564	14	2
19c	Liquid material A			3	28	96	94	94	94	93	92	91	90	89	891	70	56
20c	Liquid material B			3	28	95	93	90	91	90	88	85	83	80	692	49	23
21c	Liquid material C			3	28	95	88	84	83	82	79	75	73	71	610	28	10
22c	Liquid material D			3	28	95	89	88	88	88	86	85	85	82	726	53	29

[1] Results average of 5 tests except as noted.
[2] Based on total water in specimens after molding.
[3] The relative efficiency based on strength was computed for each test separately from the strength of the ideally cured specimens and the specimens given no curing treatment in that test, and the average of these values is the relative efficiency shown.
[4] Average of 2 tests.
[5] Average of 3 tests.
[6] Mixing water contained 2 percent calcium chloride.

cured continuously under burlap (method 1a) gained 2 percent in weight. By giving this value a rating of 100 and that for specimens given no curing treatment a rating of 0, the relative efficiency of, say, method 3a, with a moisture loss of 10 percent, was found to be 59. This method of rating the efficiency of the various curing procedures is considered more satisfactory than expressing the result as a ratio of the value for ideal curing because it is a measure based on the difference in result between ideal curing and no curing treatment, whereas the latter expresses the result in terms of ideal curing only.

SURFACE SEALING MATERIALS DID NOT COMPLETELY PREVENT MOISTURE LOSS

The relative efficiencies of the several curing procedures are also shown in tables 8 to 12, inclusive, to facilitate comparisons between similar methods as well as to provide ready comparison of the results obtained for the same procedure in different series.

TABLE 8.—*Effect of time of application and duration of curing using wet burlap*

Method No.	Procedure	Relative efficiency based on—							
		Water loss				Strength			
		Series A	Series B	Series D	Average	Series A	Series B	Series D	Average
3a	Burlap for 1 day; applied immediately after molding	59	----	51	55	66	----	70	68
4a	Burlap for 2 days; applied immediately after molding	72	68	68	69	93	87	93	91
5a	Burlap for 3 days; applied immediately after molding	83	79	76	79	95	96	104	98
4b	Burlap for 2 days; applied 1 hour after molding	----	58	----	58	----	76	----	76
5b	Burlap for 3 days; applied 1 hour after molding	----	66	----	66	----	95	----	95
4c	Burlap for 2 days; applied 3 hours after molding	----	66	----	66	----	72	----	72
5c	Burlap for 3 days; applied 3 hours after molding	----	71	----	71	----	81	----	81
4c-1	Burlap for 2 days; applied 3 hours after molding; sprinkled intermittently; kept continuously wet	----	66	----	66	----	66	----	66
5c-1	Burlap for 3 days; applied 3 hours after molding; sprinkled intermittently; kept continuously wet	----	68	----	68	----	92	----	92
4c-2	Burlap for 2 days; applied 3 hours after molding; sprinkled intermittently; allowed to become dry between wettings	----	45	----	45	----	37	----	37
5c-2	Burlap for 3 days; applied 3 hours after molding; sprinkled intermittently; allowed to become dry between wettings	----	53	----	53	----	32	----	32

TABLE 9.—*Comparison of various curing papers and effect of time of application*

Method No.	Type of paper	Procedure	Relative efficiency based on—							
			Water loss				Strength			
			Series A	Series B	Series D	Average	Series A	Series B	Series D	Average
13b	A	Paper for 7 days; applied 1 hour after molding	----	76	----	76	----	80	----	80
13c	A	Paper for 7 days; applied 3 hours after molding	76	74	70	73	46	75	63	61
14c	B	Paper for 7 days; applied 3 hours after molding	72	----	70	71	45	----	61	53
15c	C	Paper for 7 days; applied 3 hours after molding	76	----	73	74	54	----	69	62
16c	D	Paper for 7 days; applied 3 hours after molding	14	----	11	12	2	----	9	6
17c	E	Paper for 7 days; applied 3 hours after molding	17	----	19	18	1[illegible]	----	8	12
18c	F	Paper for 7 days; applied 3 hours after molding	14	----	16	15	11	----	1	6

TABLE 10.—*Comparison of various liquid curing materials and effect of time of application*

Method No.	Type liquid curing material	Procedure	Relative efficiency based on—							
			Water loss				Strength			
			Series A	Series B	Series D	Average	Series A	Series B	Series D	Average
19b	A	Liquid for 7 days; applied 1 hour after molding.	----	53	----	53	----	57	----	57
20b	B	Liquid for 7 days; applied 1 hour after molding.	----	50	----	50	----	67	----	67
21b	C	Liquid for 7 days; applied 1 hour after molding.	----	29	----	29	----	24	----	24
19c	A	Liquid for 7 days; applied 3 hours after molding.	72	74	73	73	50	79	75	68
20c	B	Liquid for 7 days; applied 3 hours after molding.	66	71	62	66	44	99	54	66
21c	C	Liquid for 7 days; applied 3 hours after molding.	41	42	46	43	25	45	27	32
22c	D	Liquid for 7 days; applied 3 hours after molding.	66	----	59	62	36	----	41	38

TABLE 11.—*Comparison of paper and liquid curing materials with and without preliminary curing with burlap, and effect of time of application*

Method No.	Procedure	Relative efficiency based on—							
		Water loss				Strength			
		Series A	Series B	Series D	Average	Series A	Series B	Series D	Average
6a	Burlap applied immediately, followed in 24 hours by paper A for 6 days.	93	92	89	91	102	91	115	103
6b	Burlap applied 1 hour after molding, followed in 24 hours by paper A for 6 days.	----	84	----	84	----	109	----	109
6c	Burlap applied 3 hours after molding, followed in 24 hours by paper A for 6 days.	----	92	----	92	----	100	----	100
13b	Paper A for 7 days; applied 1 hour after molding.	----	76	----	76	----	80	----	80
13c	Paper A for 7 days; applied 3 hours after molding.	76	74	70	73	46	75	63	61
9a	Burlap applied immediately followed in 24 hours by liquid material A.	93	----	86	90	108	----	115	112
19b	Liquid material A applied 1 hour after molding.	----	53	----	53	----	57	----	57
19c	Liquid material A applied 3 hours after molding.	72	74	73	73	50	79	75	68

TABLE 12.—*Relative efficiencies of miscellaneous curing materials*

Method No.	Type of curing	Procedure	Relative efficiency based on—					
			Water loss			Strength		
			Series A	Series D	Average	Series A	Series D	Average
7a	Sodium silicate with burlap.	Burlap applied immediately followed in 24 hours by sodium silicate.	72	59	66	76	89	82
8a	Calcium chloride with burlap.	Burlap applied immediately followed in 24 hours by a surface application of calcium chloride.	59	57	58	101	90	96
11a	Calcium chloride admixture with burlap.	Burlap applied immediately for 1 day; 2 percent calcium chloride admixture added to mixing water.	66	57	62	84	83	84
12c	Curing blanket	Curing blanket for 3 days; applied 3 hours after molding.	45	46	46	39	48	44

In the following discussion of the results shown in tables 3 to 7, inclusive, consideration will be given first to the rate at which specimens cured in various ways lost water during the exposure period. In general, the values obtained for the various methods checked very closely from series to series. The data also show that the different methods varied considerably in their ability to retain moisture. As would be expected, burlap covering applied immediately and kept saturated (methods 3a, 4a, and 5a) not only retained all of the mixing water during the entire period of application, but also added water in amounts of from 1 to 4 percent. However, as soon as the burlap was removed, the specimens started losing water, the amount retained at the end of 7 days depending upon the duration of the burlap curing.

It will also be observed that, where the initial curing material was not applied until 3 hours after molding (methods in which the letter c follows the numeral), the specimens lost from 3 to 5 percent of the mixing water before they were covered. Where burlap was used and removed at the end of 24 hours (as, in methods 6c and 9c), all of this water was regained during the first day after application. However, where no burlap was used (methods 13c to 22c, inclusive), the loss was permanent, the surface sealing materials being unable to supply moisture lost during this period. In series B, table 4, tests were run with burlap applied 1 hour after molding as well as after 3 hours (methods 4b, 5b, and 6b). For some unknown reason this procedure did not result in adding water to the specimens, the amount of contained moisture being exactly the same at the end of the burlap curing period as when it was applied.

It will be noted that none of the surface sealing materials was completely effective in retaining all of the mixing water throughout the 7-day exposure period. For these materials moisture losses varied from 1 to 3 percent for the most effective materials to as much as 25 percent for the poorer materials. Furthermore, for a given material, this loss was about the same whether the material was used with or without burlap. When exposure in the curing cabinet was carried to 28 days (table 7), further loss in moisture was observed in every instance, the amounts ranging from 2 to 11 percent, depending upon the material. In general, papers A, B, and C and liquid curing materials A and B were the most efficient of the surface seals in retaining water; sodium silicate, the curing blanket, and liquid curing materials C and D were intermediate; and papers D, E, and F were the least efficient. However, as stated above, none of the surface sealing materials studied was completely effective in retaining moisture during the 7-day exposure period.

STRENGTH DETERMINATIONS AFFECTED BY NONUNIFORM MOISTURE DISTRIBUTION WITHIN SPECIMENS

The relative efficiencies of the several curing procedures based on both water loss and flexural strength after 7 days of exposure, as given in tables 3 to 6, inclusive, have been regrouped in tables 8 to 12, inclusive, in order more readily to compare the effect of varying the details of similar methods of application as well as to facilitate comparisons of the results of each method from series to series.

In studying these data the reader is cautioned against drawing conclusions regarding the comparative values of the different methods based on comparisons of individual relative efficiencies. This applies particularly to efficiencies based on flexural strength results. As will be noted from the tables, these values for a given method varied considerably from series to series. The variations were more pronounced for the surface sealing materials such as paper and the liquid curing materials, than where methods involving burlap only were used. Furthermore, they seem to follow a general trend in that the efficiencies calculated from the results of tests made in series A are, in general, low; those obtained from series B, are, in general, high; while the results obtained from series D are, as a rule, intermediate. As previously mentioned, these discrepancies may possibly be the result of variations in the moisture condition of the specimens at the time of test.

As is well known, the distribution of moisture within a flexure specimen at the time of test will appreciably affect its strength. In general, if the shell of the specimen contains more moisture than the core (a condition usually resulting from incomplete saturation after drying), the extreme fibers will be in compression and the observed breaking load will be higher than the true value. On the other hand, if the shell contains less moisture than the core (a condition usually associated with incomplete drying) the observed value will be lower than the true value. Because of the fact that these specimens were tested after an immersion period during which they may not have absorbed sufficient water to become completely saturated, it is possible that the comparatively high relative strengths obtained in certain series may have resulted from incomplete saturation of the specimens.

In preparing the specimens for test, every effort was made to insure uniform distribution of moisture. This, of course, is the only condition under which flexure tests of concrete should be made. However, inspection of the fractured specimens indicated that in many instances complete saturation was not accomplished even after 48 hours of immersion. The ideally cured specimens (method 1a) were, of course, thoroughly saturated when tested. The specimens that were given no curing treatment, as well as those cured with the least efficient surface sealing materials, because of their lack of density, absorbed water more readily upon immersion than the specimens cured by the more efficient surface sealing materials. Therefore, if the low ratings for the various curing materials were obtained because of more complete saturation, these ratings may possibly be considered to represent more nearly the true curing effect than where high ratings for the same method are shown.

In spite of wide variations in strength results in the different series, it is felt that the strength data are significant in that they indicate definite trends insofar as the general effectiveness of the several classes of curing materials are concerned. These trends will be pointed out in the following discussion of tables 8 to 12, inclusive.

EFFICIENCY OF LIQUID CURING MATERIALS INCREASED BY DELAYING APPLICATION FOR 3 HOURS

In table 8 the results of varying the time of application after molding and the duration of curing with wet burlap are given. It will be noted that, regardless of the time elapsing before the application of the burlap, the efficiency of this method of curing is increased as the length of the period of application is increased. This is true for both water loss and strength. For instance, method 3a, where the burlap was applied immediately and remained in place for 1 day, had a

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relative efficiency based on water loss of 55 and on strength of 68. When the same material was allowed to remain in place 3 days (method 5a) the efficiency based on water loss was raised to 79 and that based on strength to 98. The effect of delaying application of the burlap was to lower the efficiency as measured by strength (methods 4a, 4b, and 4c, for 2-day curing compared with methods 5a, 5b, and 5c, for 3-day curing). The same trends appear when the efficiency is measured by water loss, except that for both 2-day and 3-day curing the amount of water remaining at the end of the 7-day period was somewhat less when the burlap was applied 1 hour after molding than when applied 3 hours after molding. This reversal of trend has already been commented upon.

The results for methods 4c–1, 5c–1, 4c–2, and 5c–2 show the effects of continuous and intermittent sprinkling. Comparing 4c with 4c–1 and 5c with 5c–1, it will be noted that about the same results were obtained when the burlap was kept wet by sprinkling as when continuously saturated by keeping an end of the covering immersed in water. The effectiveness based on both water loss and strength was, however, seriously affected when the burlap was allowed to dry between the sprinklings (results for method 4c compared with 4c–2 and 5c with 5c–2). These data illustrate the importance of maintaining a continuously wet covering when burlap is used.

The results obtained with the six curing papers are shown in table 9. Papers A, B, and C, seem to be about equally effective as is also true for papers D, E, and F, except that the latter three papers show much poorer results. Papers D, E, and F, in fact, gave strengths little better than those for specimens receiving no curing treatment. The effect of period of application for paper A may be noted by comparing methods 13b and 13c. It will be observed that the efficiency of the paper, especially from the standpoint of strength, is somewhat less when the time of application is delayed.

Comparisons of the effectiveness of the various liquid curing compounds when used without burlap, that is, as recommended by the manufacturers, may be made from table 10. It will be observed that liquid materials A and B were considerably more effective than materials C and D. However, in no instance except one does the average efficiency approach that obtained by, say, the 3-day burlap curing shown in table 8, method 5a. The exception is method 20c, series B. This is an instance where an unusually high value may have resulted from incomplete saturation of the specimens.

It will be observed also that in every instance except one, the relative efficiency of the liquid curing materials is increased by delaying the application until 3 hours after molding. This is just the reverse of the trend shown for curing with paper A (table 9). This increased efficiency may possibly be accounted for by the fact that when the liquid material was sprayed on at the end of 3 hours, surface moisture had disappeared to an extent which permitted a more perfect seal than when the material was applied at the end of 1 hour. The results emphasize the necessity of watching this detail carefully when applying such materials in the field.

PRELIMINARY CURING WITH BURLAP BENEFITED SPECIMENS LATER CURED WITH OTHER MATERIALS

Table 11 permits a comparison of the results obtained with paper A and liquid curing material A when used with and without an initial curing of wet burlap. It will be observed from the data that for both methods the efficiency of the surface sealing material is materially increased by the prior use of burlap. Additional data along this line are shown in table 5 (series C). The results of these tests were not included in table 11 because, due to the omission of the method involving no curing treatment, no calculations of relative efficiency could be made.

The results indicate that when application of the burlap is delayed for 3 hours, the strengths of the specimens cured without burlap (13c, 19c, and 20c) are very nearly as high as when burlap was used. However, because the saturated burlap returned to the specimen water lost during the first 3 hours, the total water retained at the end of 7 days was somewhat higher when burlap was used than when the paper and liquid curing materials were used as recommended by the manufacturers. In general, the conclusion is that for best results such surface sealing materials as paper, liquid asphalt, etc., should be used following application of wet burlap for 24 hours.

In table 12 are shown the results of tests with sodium silicate, calcium chloride, and the special curing blanket.

In testing these materials the general practice as used in the field was followed. For sodium silicate the results indicate an effectiveness somewhat less, in general, than for a 3-day application of burlap and considerably less than the best waterproof paper or liquid curing materials used with burlap.

The results with calcium chloride are rather conflicting. For instance, the strengths obtained in the surface application method are somewhat higher than would be expected from the water losses indicated. It is apparent that, at the low relative humidity to which these specimens were subjected (32 percent) the calcium chloride withdrew water from the specimen rather than from the air. The strengths, however, are quite high. The admixture did not seem to provide any better water-retaining properties than many of the surface seals. Moreover, under these conditions, the strengths of the specimens containing the admixture were quite low. This also may have been due to the low humidity and high temperature (100° F.) to which the specimens were exposed.

PROTECTION AGAINST MOISTURE LOSS OF GREATEST IMPORTANCE

The special curing blanket, which was wet once when applied and remained in place 3 days, was quite low in efficiency as measured by both strength and water loss. Attention is directed to the fact that this blanket was of burlap and jute and it should not be confused with the cotton mats which, as previously stated, have proven highly effective for curing purposes. Neither should the results obtained with the jute blanket be regarded as representative of what would have been obtained had the blanket been wet at sufficiently frequent intervals to have kept it in a continuously moist condition.

Relative efficiencies of the various curing materials based on water retention and strength at the end of 28 days, are shown in table 7. Attention is called to the fact that, for methods 3 to 11, inclusive (methods involving the use of burlap), the results are the average of only two tests for the "a" methods and three tests for the "c" methods, instead of five tests as in all other instances.

With the above limitation in mind, it may be noted that all of the methods involving burlap only, that is methods 3a to 5c, inclusive, had low ratings after 28 days as compared to the corresponding results at 7 days. Furthermore, the beneficial effects of burlap curing for 3 days as compared to curing for 1 day appear to be somewhat less pronounced. Specimens cured with waterproof paper A following burlap curing (methods 6a and 6c) developed high strength at 28 days. Attention is called to the fact that the paper remained in place for the full 28-day period. The same material without initial burlap curing (method 13c) showed a relative efficiency of only 40 as regards strength.

Liquid curing material A gave high strengths when the burlap was applied immediately (method 9a) but showed a comparatively low relative efficiency when application of the burlap was delayed 3 hours (method 9c). Without burlap, liquid material A (method 19c) showed a rating of 56, only slightly lower than the combination in which the burlap was applied after 3 hours. These trends seem to parallel in general the indications at 7 days (table 5, series C and table 11). With respect to burlap curing as compared with the sealing materials, it might be pointed out that in this high-temperature, low-humidity atmosphere, the curing with burlap was discontinued at 3 days, whereas, curing continued to some extent under the seals that were effective.

The relative efficiencies of the methods employing sodium silicate, calcium chloride, and the curing blanket (methods 7, 8, 11, and 12) are about the same at 28 days as at 7 days, when judged from the standpoint of water retention, but are much lower when considered from the standpoint of strength. However, the small number of specimens represented make any comparisons involving these methods of doubtful value.

The most significant point in connection with the 28-day test data lies in the fact that in only two instances did the strength ratings anywhere near approach that of method 1a. These methods, burlap applied immediately followed by waterproof paper A (method 6a), and burlap applied immediately followed by liquid bituminous material A (method 9a), provide the most nearly perfect continuous seals of any of the methods tested, thus emphasizing the conclusion that the greatest curing efficiency is provided by those methods that protect the concrete against moisture loss to the greatest extent.

The results obtained in this investigation seem to warrant the following general conclusions:

A. As regards burlap used alone:

1. The effectiveness of burlap is increased by lengthening the duration of application.

2. The effectiveness of burlap is decreased by increasing the time elapsing between the placing of the concrete and the application of the burlap.

3. Burlap is not as effective when sprinkled intermittently as when kept continuously saturated.

B. As regards surface sealing materials:

1. The effectiveness of such materials as waterproof paper and liquid curing materials applied with a spray gun is materially increased when preceded by application of wet burlap for 24 hours.

2. The effectiveness of such membrane coverings as liquid curing materials A and B is materially improved by applying the covering 3 hours after molding as compared to an application made 1 hour after molding.

TOLL ROADS AND FREE ROADS

(Continued from page 66)

cities, for future street developments and also for other kinds of public works and developments.

As one of its most important recommendations, the report suggests the creation of a Federal Land Authority with adequate capitalization and authority to issue obligations, which would be empowered to acquire, hold, sell, and lease lands, in connection with all sorts of public improvements, in ways designed to accomplish (1) the total or partial self-liquidation of such improvements, (2) the coordination of the various classes of improvements by the establishment of a proper relation in their use of land, and (3) the elimination of embarrassing delays in the accomplishment of desirable improvements, and of restriction likely to warp the form, and partially to defeat the purpose, of the improvements.

The report, entitled "Toll Roads and Free Roads," has been printed as House Document No. 272, Seventy-sixth Congress, first Session. Single copies can be obtained without charge from the Bureau of Public Roads, United States Department of Agriculture, Washington, D. C.

MOTOR-FUEL CONSUMPTION, 1938

[Compiled for calendar year from reports of State authorities [1]]

State	Tax rate per gallon [2]	Gross amount reported [3]	Amount exempted from payment of tax [4]	Gross amount assessed for taxation	Amount subject to refund of entire tax	Net amount taxed: Total	Net amount taxed: At prevailing rate	At other rates: Rate per gallon	At other rates: Amount
	Cents	*1,000 gallons*	*1,000 gallons*	*1,000 gallons*	*1,000 gallons*	*1,000 gallons*	*1,000 gallons*	*Cents*	*1,000 gallons*
Alabama	6	226, 838		226, 838		226, 838	226, 838		
Arizona	5	102, 711	5, 487	97, 224	12, 690	84, 534	84, 534		
Arkansas	6½	166, 200	6, 256	159, 944		159, 944	143, 479	(5)	16, 465
California	3	1, 763, 625	33, 284	1, 730, 341	158, 413	1, 571, 928	1, 571, 928		
Colorado	4	227, 258	10, 445	216, 813	28, 869	187, 944	187, 944		
Connecticut	3	326, 263	7, 377	318, 886	6, 176	312, 710	312, 710		
Delaware	4	56, 638	1, 256	55, 382	2, 892	52, 490	52, 490		
Florida	7	338, 650	11, 812	326, 838		326, 838	326, 838		
Georgia	6	339, 392	10, 471	328, 921		328, 921	328, 921		
Idaho	5	95, 077	3, 870	91, 207	9, 130	82, 077	81, 888	2½	[6] 189
Illinois	3	1, 358, 680		1, 358, 680	102, 664	1, 256, 016	1, 256, 016		
Indiana	4	612, 714	2, 057	610, 657	47, 778	562, 879	562, 879		
Iowa	3	524, 535		524, 535	78, 629	445, 906	445, 906		
Kansas	3	459, 433	121, 906	337, 527		337, 527	337, 527		
Kentucky	5	256, 516		256, 516		256, 516	256, 516		
Louisiana	7	247, 176	4, 965	242, 211	4	242, 207	234, 941	2	[7] 7, 266
Maine	4	144, 866	882	143, 984		143, 984	137, 406	1	[8] 6, 578
Maryland	4	271, 434	4, 226	267, 208	18, 600	248, 608	246, 433	3	[9] 2, 175
Massachusetts	3	690, 203	2, 702	687, 501	25, 247	662, 254	662, 254		
Michigan	3	1, 053, 961	81, 484	972, 477	43, 184	929, 293	928, 920	1½	[10] 373
Minnesota	4	536, 861	24, 749	512, 112	64, 668	447, 444	447, 444		
Mississippi	6	190, 248	9, 147	181, 101		181, 101	171, 044	1	[11] 10, 057
Missouri	2	608, 472		608, 472	27, 386	581, 086	581, 086		
Montana	5	117, 164	6, 455	110, 709	21, 259	89, 450	89, 450		
Nebraska	5	232, 817	9, 469	223, 348	39	223, 309	223, 309		
Nevada	4	34, 771	2, 886	31, 885	1, 927	29, 958	29, 958		
New Hampshire	4	85, 157		85, 157	2, 443	82, 714	82, 714		
New Jersey	3	812, 804	3, 257	809, 547	67, 112	742, 435	742, 435		
New Mexico	5	96, 450	6, 410	90, 040	8, 390	81, 650	81, 521	7½	[12] 129
New York	4	1, 802, 216	64, 987	1, 737, 229	52, 557	1, 684, 672	1, 684, 672		
North Carolina	6	403, 333	6, 294	397, 039		397, 039	385, 834	1	[11] 11, 205
North Dakota	3	122, 866	1, 353	121, 513	35, 738	85, 775	85, 775		
Ohio [13]	4	1, 278, 825	63, 190	1, 215, 635	8, 797	1, 206, 838	1, 157, 015	1	[8] 49, 823
Oklahoma	4	403, 795	12, 311	391, 484	41, 294	350, 190	350, 190		
Oregon	5	230, 187	4, 927	225, 260	26, 616	198, 644	197, 797	1	[14] 847
Pennsylvania	4	1, 403, 587	6, 519	1, 397, 068		1, 397, 068	1, 397, 068		
Rhode Island	3	120, 886	1, 023	119, 863	2, 989	116, 874	116, 874		
South Carolina	6	192, 170		192, 170	3, 387	188, 783	188, 783		
South Dakota	4	132, 002	7, 353	124, 649	24, 981	99, 668	99, 668		
Tennessee	7	280, 862	14, 976	265, 886	1, 723	264, 163	264, 163		
Texas	4	1, 267, 298	23, 886	1, 243, 412	167, 561	1, 075, 851	1, 075, 851		
Utah	4	92, 950	5, 100	87, 850		87, 850	87, 850		
Vermont	4	64, 324	1, 024	63, 300		63, 300	63, 300		
Virginia	5	355, 150		355, 150	20, 823	334, 327	334, 327		
Washington	5	341, 023	6, 044	334, 979	25, 282	309, 697	309, 697		
West Virginia	5	190, 397		190, 397	1, 482	188, 915	188, 915		
Wisconsin	4	542, 883	16, 884	525, 999	41, 187	484, 812	484, 812		
Wyoming	4	65, 356	1, 980	63, 376		63, 376	63, 376		
District of Columbia	2	139, 612	5, 586	134, 026	701	133, 325	133, 325		
Total	[15] 3. 96	21, 406, 636	614, 290	20, 792, 346	1, 182, 618	19, 609, 728	19, 504, 621		105, 107

[1] An analysis of motor-fuel usage, similar to that given in the right-hand portion of table Motor-Fuel Consumption, 1937, previously issued will be published in a subsequent table.
[2] No changes in tax rates reported during 1938.
[3] Export sales and other amounts not representing consumption in State have been eliminated as far as possible. In cases where States failed to report amounts exempted from taxation, the gross amount taxed is shown in this column.
[4] Includes allowances for evaporation and other losses, Federal use, other public use, and nonhighway use, where initial exemptions rather than refunds are made.
[5] Within 300 feet of border, tax is reduced to that of adjacent State. Gallons taxed at 2 cents, 3,787,000; at 4 cents, 12,678,000.
[6] Motor fuel used in aviation.
[7] Represents evaporation or loss allowance under 5-cent tax not allowed under additional 2-cent tax, which is administered under a separate law.
[8] 3 cents per gallon refunded on nonhighway uses.
[9] 1 cent per gallon refunded on motor fuel used in vehicles licensed to operate exclusively in cities.
[10] 1½ cents per gallon refunded on motor fuel used in interstate aviation.
[11] 5 cents per gallon refunded on nonhighway uses.
[12] Diesel oil taxed at 7½ cents per gallon.
[13] Amounts given do not include 66,240,000 gallons of liquid fuel (kerosene, fuel oil, etc.) taxed at 1 cent per gallon but not subject to the 3-cent tax on motor-vehicle fuel.
[14] 4 cents per gallon refunded on motor fuel used in aviation.
[15] Weighted average rate.

STATE MOTOR-FUEL TAX RECEIPTS, 1938

[Compiled for calendar year from reports of State authorities]

State	Tax rate per gallon [1]	Receipts from taxation of motor fuel					Other receipts in connection with motor-fuel tax					Net total receipts	Less tax on aviation gasoline	Adjusted net total receipts
		Gross tax collections	Deductions by distributors for expenses [2]	Gross receipts by State	Refunds paid	Net receipts by State	Distributors' and dealers' licenses	Inspection fees [3]	Fines and penalties	Miscellaneous receipts [4]	Total			
	Cents	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*
Alabama	6	13, 523		13, 523		13, 523		56			56	13, 579		13, 579
Arizona	5	5, 016		5, 016	773	4, 243						4, 243		4, 243
Arkansas	6½	10, 004		10, 004		10, 004		88			88	10, 092		10, 092
California	3	51, 853		51, 853	4, 752	47, 101	14			2	16	47, 117		47, 117
Colorado	4	8, 623		8, 623	1, 158	7, 465						7, 465		7, 465
Connecticut	3	9, 471	94	9, 377	185	9, 192	50				50	9, 242		9, 242
Delaware	4	2, 211		2, 211	142	2, 069	3		1		4	2, 073		2, 073
Florida	7	22, 801		22, 801		22, 801	28	403			431	23, 232		23, 232
Georgia	6	19, 831	198	19, 633		19, 633						19, 633		19, 633
Idaho	5	4, 543		4, 543	455	4, 088				2	2	4, 090	5	4, 085
Illinois	3	40, 325	806	39, 519	3, 038	36, 481		405	2		407	36, 888		36, 888
Indiana	4	24, 170		24, 170	1, 911	22, 259		511			511	22, 770		22, 770
Iowa	3	15, 504		15, 504	2, 271	13, 233	1				1	13, 234		13, 234
Kansas	3	10, 017		10, 017		10, 017	13	105		33	151	10, 168		10, 168
Kentucky	5	12, 655	127	12, 528		12, 528			3		3	12, 531		12, 531
Louisiana	7	16, 543		16, 543		16, 543		77	7		[5] 84	16, 627		16, 627
Maine	4	5, 755		5, 755	197	5, 558						5, 558		5, 558
Maryland	4	10, 695		10, 695	766	9, 929						9, 929		9, 929
Massachusetts	3	20, 951		20, 951	757	20, 194						20, 194		20, 194
Michigan	3	29, 025		29, 025	1, 301	27, 724	4				4	27, 728	45	27, 683
Minnesota	4	22, 048		22, 048	2, 668	19, 380	1	187		2	190	19, 570		19, 570
Mississippi [6]	6	10, 696		10, 696	515	10, 181						10, 181		10, 181
Missouri	2	12, 059		12, 059	557	11, 502		125	9		134	11, 636		11, 636
Montana	5	5, 491		5, 491	1, 039	4, 452						4, 452		4, 452
Nebraska	5	11, 365	86	11, 279	253	11, 026	7	107		30	144	11, 170	31	11, 139
Nevada	4	1, 304	26	1, 278	77	1, 201			1		1	1, 202		1, 202
New Hampshire	4	3, 395		3, 395	98	3, 297			1		1	3, 298		3, 298
New Jersey	3	24, 348		24, 348	2, 054	22, 294	68				68	22, 362		22, 362
New Mexico	5	4, 486		4, 486	420	4, 066	24				24	4, 090		4, 090
New York	4	68, 917	689	68, 228	2, 096	66, 132	63				63	66, 195		66, 195
North Carolina	6	23, 860		23, 860	560	23, 300		1, 002		6	1, 008	24, 308		24, 308
North Dakota	3	3, 632	55	3, 577	1, 323	2, 254		64			64	2, 318		2, 318
Ohio	4	[7] 48, 031		48, 031	2, 049	45, 982						45, 982		45, 982
Oklahoma	4	15, 855	317	15, 538	1, 633	13, 905			5		5	13, 910		13, 910
Oregon	5	11, 246		11, 246	1, 400	9, 846						9, 846	8	9, 838
Pennsylvania	4	52, 574	653	51, 921	7	51, 914	80		7		87	52, 001		52, 001
Rhode Island	3	3, 754		3, 754	262	3, 492	3				3	3, 495		3, 495
South Carolina	6	11, 451		11, 451	197	11, 254		240			240	11, 494	32	11, 462
South Dakota	4	4, 986	100	4, 886	838	4, 048		64			64	4, 112	10	4, 102
Tennessee	7	18, 375		18, 375	99	18, 276		1, 044			1, 044	19, 320	89	19, 231
Texas	4	50, 041	500	49, 541	6, 821	42, 720				27	27	42, 747		42, 747
Utah	4	3, 576	54	3, 522		3, 522	1		1		2	3, 524	46	3, 478
Vermont	4	2, 530		2, 530		2, 530						2, 530		2, 530
Virginia	5	17, 661		17, 661	1, 041	16, 620			1		1	16, 621		16, 621
Washington	5	16, 684		16, 684	1, 263	15, 421	1			9	10	15, 431		15, 431
West Virginia	5	9, 470		9, 470	84	9, 386	11				11	9, 397		9, 397
Wisconsin	4	20, 902		20, 902	1, 649	19, 253		194			194	19, 447		19, 447
Wyoming	4	2, 505		2, 505		2, 505	3				3	2, 508	30	2, 478
District of Columbia	2	2, 523		2, 523	14	2, 509	11				11	2, 520		2, 520
Total	[8] 3. 96	817, 281	3, 705	813, 576	46, 723	766, 853	386	4, 672	38	111	5, 207	772, 060	296	771, 764

[1] No changes in tax rates reported during 1938.

[2] The indicated States make allowances to distributors for expense of collecting the tax. In Kentucky, South Dakota, and Utah allowances of 2¼, 4, and 3 percent, respectively, of the tax otherwise due are made in consideration of both expense of collection and gallonage losses in handling. In these States the allowances for expenses only have been estimated as 1, 2, and 1½ percent, respectively.

[3] Fees for inspection of motor-vehicle fuel. Wherever possible, fees for inspection of kerosene and other nonmotor-vehicle fuels have been eliminated.

[4] Includes fees for motor-fuel carrier permits, refund or exemption permits, and miscellaneous unclassified receipts.

[5] Receipts from tax on lubricating oil, $784,000, not included in this table.

[6] Special county taxes of 3 cents per gallon in Hancock County and 2 cents per gallon in Harrison County, amounting to $163,000 in 1938, are imposed for sea-wall protection and are not included in this table.

[7] Ohio imposes a 3-cent tax on motor-vehicle fuel and a 1-cent tax on all liquid fuels. The receipts from the 1-cent tax applicable to nonmotor-vehicle fuels (kerosene, fuel oil, etc.) were $633,000. These receipts have been eliminated from the total given, which represents a 4-cent tax on motor-vehicle fuel.

[8] Weighted average rate.

STATE MOTOR-VEHICLE REGISTRATIONS, 1938

[Compiled for calendar year from reports of State authorities [1]]

State	Registered motor vehicles, private and commercial [2]					Other registered vehicles		Publicly owned vehicles						Dealers' registrations and plates [7]		1937 total registered motor vehicles	Year's change in motor-vehicle registrations	
	Total motor vehicles	Passenger motor vehicles			Motor trucks, tractor trucks, etc.			Federal [5]			State, county, and municipal [6]							
		Total	Automobiles (including taxicabs)	Motor busses[3]		Trailers and semitrailers [4]	Motorcycles	Motor vehicles	Trailers and semitrailers	Motorcycles	Motor vehicles	Trailers and semitrailers	Motorcycles	Regular registrations	Extra sets of plates		Increase or decrease	Percentage change
Alabama	301,990	250,074	243,745	6,329	51,916	3,890	816	1,992	55	4	3,755	------	143	2,781	------	313,359	−11,369	−3.6
Arizona	128,791	105,793	105,354	439	22,998	4,567	452	2,374	97	4	2,054	181	23	1,704	------	129,210	−419	−.3
Arkansas	220,391	167,045	166,687	358	53,346	10,162	517	2,067	25	1	3,193	13	31	489	------	229,867	−9,476	−4.1
California	2,510,867	2,213,152	2,213,152	(8)	297,715	142,268	11,802	7,539	276	75	24,502	1,646	1,157	4,532	------	2,484,653	26,214	1.1
Colorado	332,774	277,860	276,767	1,093	54,914	1,422	1,271	2,347	23	7	------	------	------	3,559	------	337,217	−4,443	−1.3
Connecticut	440,335	369,693	368,664	1,029	70,642	5,356	1,883	655	6	1	3,891	87	294	2,848	7,731	436,564	3,771	.9
Delaware	64,078	53,559	53,559	(8)	10,519	2,772	231	312	4	------	896	25	62	729	------	63,599	479	.8
Florida	423,021	352,978	351,209	1,769	70,043	17,324	1,496	1,787	25	15	5,072	317	168	2,638	------	418,145	4,876	1.2
Georgia	432,360	359,204	356,609	2,595	73,156	12,684	1,233	2,665	45	33	4,019	63	138	2,164	------	441,847	−9,487	−2.1
Idaho	137,851	109,716	109,595	121	28,135	18,172	548	1,541	80	------	1,548	89	11	419	------	142,110	−4,259	−3.0
Illinois	1,780,865	1,565,202	1,565,202	(8)	215,663	23,073	6,194	3,317	98	19	9,492	323	654	4,199	------	1,768,946	11,919	.7
Indiana	922,788	795,118	793,969	1,149	127,670	62,914	4,543	1,631	86	15	6,169	------	195	2,467	------	956,016	−33,228	−3.5
Iowa	740,021	650,534	650,534	------	89,487	[9] 87,447	2,558	1,412	22	6	6,054	357	66	1,887	------	745,602	−5,581	−.7
Kansas	573,985	476,587	476,241	346	97,398	6,728	1,084	1,504	61	9	------	------	------	2,045	------	586,685	−12,700	−2.2
Kentucky	414,207	350,531	349,940	591	63,676	(10)	1,116	1,571	11	109	4,325	------	------	859	------	404,455	9,752	2.4
Louisiana	326,199	248,754	248,287	467	77,445	14,586	1,020	1,827	27	13	4,725	380	63	321	------	323,498	2,701	.8
Maine	196,690	154,027	153,861	166	42,663	[11] 10,144	834	552	10	5	2,087	164	31	735	------	200,907	−4,217	−2.1
Maryland	395,347	339,896	338,885	1,011	55,451	4,208	1,460	2,366	61	21	------	------	------	8,462	------	387,410	7,937	2.0
Massachusetts	843,789	739,323	734,585	4,738	104,466	13,122	765	2,717	31	11	[12] 5,700	------	------	2,981	20,315	846,556	−2,767	−.3
Michigan	1,408,835	1,269,894	[13] 1,269,894	(8)	138,941	141,647	4,294	2,542	81	17	------	------	------	1,957	------	1,505,111	−96,276	−6.4
Minnesota	821,241	705,271	705,019	252	115,970	31,033	2,226	2,509	56	10	4,790	------	------	------	------	822,598	−1,357	−.2
Mississippi [14]	215,195	163,709	161,015	2,694	51,486	1,771	318	1,475	57	1	------	------	------	2,380	------	226,286	−11,091	−4.9
Missouri	837,118	703,457	702,941	516	133,661	33,368	1,792	2,085	27	6	2,177	------	9	2,114	------	835,895	1,223	.1
Montana	171,326	130,188	130,188	(8)	41,138	2,953	456	2,090	27	------	2,201	------	------	986	------	173,892	−2,566	−1.5
Nebraska	407,330	342,275	342,047	228	65,055	41,294	1,125	1,199	14	8	2,462	------	46	1,492	------	412,726	−5,396	−1.3
Nevada	38,424	30,899	30,695	204	7,525	1,218	109	696	21	2	639	48	8	81	336	40,655	−2,231	−5.5
New Hampshire	124,379	97,635	97,635	(8)	26,744	4,767	896	655	19	1	------	------	------	556	------	125,939	−1,560	−1.2
New Jersey	1,000,684	868,734	863,665	5,069	131,950	7,276	4,767	2,763	26	14	10,477	------	545	2,493	------	994,497	6,187	.6
New Mexico	116,537	89,592	89,123	469	26,945	2,575	357	2,178	67	------	911	------	41	405	------	118,106	−1,569	−1.3
New York	2,584,123	2,259,468	2,259,468	------	324,655	40,771	10,391	5,629	49	81	26,083	881	1,036	5,381	------	2,561,703	22,420	.9
North Carolina	537,242	461,141	460,298	843	76,101	42,317	1,705	2,181	42	3	11,671	------	------	8,529	------	525,350	11,892	2.3
North Dakota	174,256	141,195	141,111	84	33,061	849	296	788	12	------	699	------	------	585	522	173,188	1,068	.6
Ohio	1,870,249	1,686,555	1,686,555	(8)	183,694	105,249	9,073	2,476	85	6	18,768	1,125	576	4,054	18,445	1,876,132	−5,883	−.3
Oklahoma	535,399	441,184	438,979	2,205	94,215	36,498	1,090	2,435	42	14	6,719	------	------	3,733	------	547,263	−11,864	−2.2
Oregon	357,321	297,492	296,837	655	59,829	(8)	1,531	2,821	33	4	4,071	------	------	653	838	360,348	−3,027	−.8
Pennsylvania	1,976,466	1,730,893	1,725,674	5,219	245,573	26,225	10,561	3,983	123	24	17,800	463	1,226	29,614	------	1,984,821	−8,355	−.4
Rhode Island	168,888	149,634	149,223	411	19,254	631	704	460	16	1	1,409	23	105	388	------	167,586	1,302	.8
South Carolina	287,913	246,585	245,117	1,468	41,328	5,396	1,011	1,570	14	5	4,468	------	146	792	1,586	296,224	−8,311	−2.8
South Dakota	180,632	152,138	152,040	98	28,494	19,080	436	1,241	17	2	1,132	152	12	709	------	184,743	−4,111	−2.2
Tennessee	398,624	337,584	336,900	684	61,040	(8)	1,502	2,168	45	2	7,105	------	------	582	------	400,384	−1,760	−.4
Texas	1,548,343	1,231,424	1,230,548	876	316,919	50,944	3,980	5,368	148	75	15,905	1,193	378	3,307	------	1,552,114	−3,771	−.2
Utah	127,004	107,038	106,373	665	19,966	569	428	1,758	56	10	1,378	64	46	385	------	126,692	312	.2
Vermont	87,402	78,360	78,265	95	[15] 9,042	1,853	450	648	14	------	------	------	------	602	------	88,958	−1,556	−1.7
Virginia	441,462	373,896	373,896	------	67,566	9,350	1,743	3,231	217	52	5,470	165	183	5,268	------	440,713	749	.2
Washington	523,328	440,128	439,328	800	83,200	17,826	2,025	3,215	77	27	6,950	336	164	1,503	3,291	535,483	−12,155	−2.3
West Virginia	275,691	230,637	230,024	613	45,054	3,058	1,212	1,188	6	------	5,109	148	70	10,209	------	290,837	−15,146	−5.2
Wisconsin	840,291	703,807	703,227	580	136,484	5,047	3,346	2,300	39	5	8,546	204	360	2,428	------	854,374	−14,083	−1.6
Wyoming	80,765	63,176	63,176	------	17,589	10,209	272	1,300	26	9	681	57	------	368	------	81,837	−1,072	−1.3
District of Columbia	162,863	148,614	147,495	1,119	14,249	809	622	1,262	20	62	[16] 2,366	106	94	2,308	------	184,119	−21,256	−11.5
At large	------	------	------	------	------	------	------	5,371	45	10	------	------	------	------	------	------	------	------
Total	29,485,680	25,261,649	25,213,601	48,048	4,224,031	1,085,422	108,541	109,716	2,564	799	257,469	8,610	8,081	139,681	53,064	29,705,220	−219,540	−.7

[1] Registration periods ending not earlier than Nov. 30 and not later than Jan. 31 are considered calendar-year periods. In those States where the registration period is definitely removed from the calendar year, registration figures were obtained for the calendar-year period.

[2] Wherever possible publicly owned vehicles and vehicles not for highway use have been eliminated from these columns.

[3] A complete segregation of motor busses from other vehicles is not available. The figures given represent common-carrier busses in most cases, although in some States contract busses and contract school busses are included. In some cases city busses are not included. Where no busess are tabulated, they are included with automobiles, unless otherwise noted.

[4] Figures for trailers and semitrailers are as reported. Apparent inconsistencies are due to the fact that some States require the registration of tourist trailers, light work trailers, and similar vehicles, whereas other States register only freight-carrying trailers and semitrailers.

[5] Data on Federal vehicles obtained through agency of Procurement Division, Department of the Treasury.

[6] State, county, and municipal vehicles are included with private and commercial registrations in Colorado, Kansas, Maryland, Michigan, Mississippi, New Hampshire, and Vermont. An unknown number of Federal vehicles are included in the figures for Indiana, Iowa, Kentucky, Louisiana, Montana, New York, and Virginia. Some States give State-owned vehicles only; others exclude certain classes from registration, such as fire apparatus and police vehicles.

[7] Figures include new-car, used-car, and motorcycle dealer registrations and some wrecker and repairer registrations. Data on dealers' extra plates are incomplete, although they are apparently included with dealer registrations in some States.

[8] Included with motor trucks.

[9] Includes 63,000 light trailers registered without charge.

[10] Trailers of 1,000 pounds capacity or more prohibited on highways, although permitted in cities under city licenses. Tractor-semitrailers registered as motor trucks. Light trailers permitted but not registered.

[11] Includes light trailers and commercial semitrailers. Commercial full trailers included with motor trucks.

[12] Of these vehicles approximately 1,700 are also included with private and commercial registrations.

[13] Taxicabs included with motor trucks.

[14] License year changed to Nov. 1 during 1938. Registrations recorded on this table are for 10-month period through Oct. 1938. Registrations for 1939 in Nov. and Dec. 1938 were: Automobiles, 150,822; motor busses, 1,367; motor trucks, 41,012; total motor vehicles, 193,201.

[15] Trucks under 1,500 pounds capacity included with passenger cars.

[16] Includes 405 automobiles of the diplomatic corps.

STATE MOTOR-VEHICLE RECEIPTS, 1938

[Compiled for calendar year from reports of State authorities

State	Total receipts, registration and other fees	Motor-vehicle registration fees: Total[2]	Motor-vehicle registration fees: Passenger motor vehicles: Total	Motor-vehicle registration fees: Passenger motor vehicles: Automobiles (including taxicabs)	Motor-vehicle registration fees: Passenger motor vehicles: Motor busses[3]	Motor-vehicle registration fees: Motor trucks, tractor trucks, etc.	Registration fees, other vehicles: Trailers and semitrailers	Registration fees, other vehicles: Motorcycles	Total registration fees, all vehicles	Miscellaneous receipts: Total	Miscellaneous receipts: Dealers' licenses and plates	Miscellaneous receipts: Operators' and chauffeurs' permits	Miscellaneous receipts: Certificates of title	Miscellaneous receipts: Special titling taxes[4]	Miscellaneous receipts: Fines and penalties	Miscellaneous receipts: Transfer or reregistration fees	Miscellaneous receipts: Other receipts	Miscellaneous receipts: Unclassified refunds	Miscellaneous receipts: Estimated service charges, local collectors[5]
	1,000 dollars	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*
Alabama	4,314	3,858	------	------	------	------	------	------	3,858	456	3	251	------	------	193	------	9	------	------
Arizona	1,076	809	398	371	27	411	62	2	873	203	4	25	93	------	------	------	81	------	------
Arkansas	2,908	2,495	1,575	1,499	76	920	220	3	2,718	190	57	124	------	------	2		2	------	------
California[6]	23,930	21,049	16,996	16,996	(7)	4,053	989	60	22,098	1,832	74	150	------	------	130	1,263	215	------	------
Colorado	2,544	2,049	1,571	1,571	------	[8] 478	30	2	2,081	463	27	113	159	------	27	66	80	−9	------
Connecticut	6,611	4,249	2,822	2,698	124	1,427	20	6	4,275	2,336	106	1,663	------	------	169	104	300	−6	------
Delaware	1,216	894	607	607	(7)	287	32	1	927	289	7	135	33	------	80	13	21	------	------
Florida	6,432	5,815	4,044	3,853	191	1,771	259	8	6,082	350	22	10	206	------	------	1	22	−20	109
Georgia	1,974	1,465	985	875	110	480	148	2	1,615	359	12	319	------	------	------	7	21	------	------
Idaho	2,380	2,269	1,638	1,614	24	631	33	3	2,305	75	25	38	------	------	------	------	12	------	------
Illinois	21,591	19,925	14,022	14,022	(7)	5,903	175	16	20,116	1,475	91	400	429	------	16	425	132	−18	------
Indiana	9,635	7,599	5,905	5,822	83	1,694	316	8	7,923	1,712	50	694	274	------	36	277	264	−112	229
Iowa	11,797	11,188	8,415	8,415	------	2,773	93	9	11,290	507	49	162	------	------	2	190	104	------	------
Kansas	3,823	3,463	2,543	2,543	(7)	920	109	4	3,576	247	21	46	134	------	------	35	11	------	------
Kentucky	4,599	2,971	1,745	1,666	79	1,226	(9)	2	2,973	1,626	25	522	------	865	3	196	15	------	------
Louisiana	4,892	4,215	2,936	2,868	68	1,279	587	4	4,806	86	12	103	------	------	77	------	1	−37	------
Maine	3,582	2,725	1,898	1,882	16	827	[10] 66	4	2,795	787	44	559	------	------	30	119	35	------	------
Maryland	5,069	3,584	2,963	2,810	153	621	119	7	3,710	1,359	45	348	171	390	329	97	31	−52	------
Massachusetts	6,759	4,121	2,740	2,609	131	1,381	28	1	4,150	2,609	70	2,532	------	------	3	------	66	−62	------
Michigan	20,856	17,801	12,609	[11] 12,609	(7)	5,192	1,002	16	18,819	2,037	91	943	664	------	------	259	80	------	------
Minnesota	9,377	8,832	6,889	6,734	155	1,943	259	7	9,098	279	58	122	------	------	7	------	22	------	------
Mississippi[12]	4,001	3,947	------	------	------	------	------	------	3,947	54	5	------	------	------	43	------	6	------	------
Missouri	9,439	8,273	6,936	6,936	(7)	1,337	140	9	8,422	1,017	78	290	392	------	2	238	17	------	------
Montana[13]	1,546	1,169	852	852	(7)	317	13	1	1,183	363	22	172	62	------	56	41	10	------	------
Nebraska	2,442	2,135	1,242	1,220	22	893	58	2	2,195	247	30	68	------	------	------	66	83	------	------
Nevada	265	245	155	154	1	90	5	------	250	15	2	------	------	------	1	11	1	------	------
New Hampshire	2,711	2,262	------	------	------	------	------	5	2,267	444	23	343	------	------	30	------	48	------	------
New Jersey	20,204	13,806	9,804	9,509	295	4,002	284	10	14,100	6,104	62	3,875	464	------	219	532	961	−9	------
New Mexico	1,643	1,505	955	929	26	550	34	1	1,540	103	11	------	------	------	1	29	62	------	------
New York	47,124	43,418	31,675	31,675	------	11,743	573	46	44,037	3,087	208	1,067	------	------	544	947	360	−39	------
North Carolina	7,211	6,871	4,113	4,056	57	2,758	(7)	7	6,878	333	32	121	147	------	56	------	12	−35	------
North Dakota	1,523	1,404	1,073	1,062	11	331	3	2	1,409	114	17	14	57	24	1	------	2	−1	------
Ohio	27,204	22,370	14,610	14,610	(7)	7,760	1,148	(14)	23,518	3,686	235	753	418	------	------	586	44	------	1,650
Oklahoma	5,779	4,401	2,643	2,544	99	1,758	218	5	4,624	1,155	48	207	292	------	186	------	125	------	297
Oregon	2,922	2,598	1,523	1,484	39	1,075	(7)	4	2,602	320	25	74	175	------	24	------	22	------	------
Pennsylvania	34,513	27,710	19,145	18,612	533	8,565	390	29	28,129	6,384	377	2,998	1,668	------	------	872	578	−109	------
Rhode Island	2,778	2,217	1,732	1,692	40	485	2	3	2,222	556	17	426	------	------	------	68	45	------	------
South Carolina	1,633	1,316	732	732	------	584	71	1	1,388	245	19	191	------	------	27	21	31	−44	------
South Dakota	1,983	1,583	1,359	1,355	4	224	30	1	1,614	369	17	------	23	319	------	------	10	------	------
Tennessee	4,173	3,907	------	------	------	------	(7)	------	3,907	266	(15)	259	------	------	5	------	7	−5	------
Texas	20,263	18,716	12,015	11,865	150	6,701	520	17	19,253	1,010	41	417	------	------	------	398	154	------	------
Utah	1,097	921	510	510	(7)	411	34	1	956	141	14	19	66	------	1	16	25	------	------
Vermont	2,365	1,994	1,420	[16] 1,407	13	[16] 574	25	3	2,022	343	26	280	------	------	------	42	7	−12	------
Virginia	6,134	5,449	4,092	4,092	------	1,357	134	6	5,589	545	59	80	245	------	------	141	38	−18	------
Washington	3,262	2,487	1,389	1,389	------	1,098	207	6	2,700	562	14	165	219	------	18	------	10	------	136
West Virginia	5,498	4,524	3,478	3,458	20	1,046	57	5	4,586	912	43	144	136	525	------	47	17	------	------
Wisconsin	13,001	12,377	9,375	9,168	207	3,002	322	16	12,715	286	23	35	------	------	------	215	13	------	------
Wyoming	601	552	360	360	------	192	34	1	587	14	8	------	------	------	------	4	2	------	------
District of Columbia	2,145	1,333	------	------	------	------	------	------	1,333	812	1	298	70	------	406	29	8	------	------
Partial totals[17]	------	------	224,489	221,735	2,754	91,070	8,849	346	------	------	------	------	------	------	------	------	------	------	------
Full totals	388,825	330,866	------	------	------	------	------	------	340,061	48,764	2,350	21,555	6,597	2,123	2,724	7,360	4,222	−588	2,421

[1] Receipts for registration periods ending not earlier than Nov. 30 and not later than Jan. 31 are considered calendar-year receipts. In those States where the registration period is definitely removed from the calendar year, registration receipts were obtained for the calendar-year period.

[2] Segregation of registration fees by type of vehicle was not available for Alabama, Mississippi, New Hampshire, Tennessee, and the District of Columbia. Total motor-vehicle registration fees in those States include trailer and motorcycle fees, except in New Hampshire, for which motorcycle fees were reported separately. Dealers' license fees in Tennessee are also included in this column.

[3] The motor-bus registration fees are incomplete (see footnote 3 of preceding table). Where no fees are tabulated, the fees of busses are included with those of automobiles, unless otherwise noted.

[4] Proceeds of special excise and privilege taxes on new-car sales have been segregated and entered in this column. Receipts from a 2-percent motor-vehicle excise tax in Oklahoma, imposed as part of a general sales tax, are not included in this table. Proceeds of this tax were $1,104,000 in 1938.

[5] In many States county or local officers are allowed service charges for issuing registrations, operators' licenses, etc. In the majority of cases these charges are included in registration and other fees. The amounts shown in this column are estimates of service charges collected and retained by local officials and not reported elsewhere in the table.

[6] Registration fees include proceeds of State "vehicle license fees", $10,854,000, imposed in addition to the regular registration fees of $11,244,000.

[7] Included with motor-truck fees.

[8] Fees of 23,978 light trucks included with those of passenger vehicles.

[9] Trailers of 1,000 pounds capacity or more prohibited on highways, although permitted in cities under city licenses. Tractor-semitrailers registered as motor trucks. Light trailers permitted but not registered.

[10] Fees of light trailers and commercial semitrailers only. Fees of commercial full trailers included with those of motor trucks.

[11] Fees of taxicabs included with those of motor trucks.

[12] License year changed to Nov. 1 during 1938. Receipts recorded in this table are for calendar year and include fees for 1939 registrations received from Oct. 1 through Dec. 31.

[13] Registration fees are collected by counties and State does not maintain complete record. Figures given are estimates supplied by State.

[14] Included with fees of automobiles.

[15] Included with motor-vehicle registration fees.

[16] Fees of trucks under 1,500 pounds capacity included with those of passenger cars.

[17] Totals of columns for which full classified data were not available for all States

STATE MOTOR-CARRIER TAX RECEIPTS, 1938

[Compiled for calendar year from reports of State authorities]

State	Proceeds of State imposts on motor vehicles operated for hire and other motor carriers [1]							Total
	Gross-receipts taxes [2]	Mileage, ton-mile, and passenger-mile taxes	Special license fees and franchise taxes [3]		Certificate or permit fees [3]	Caravan taxes	Miscellaneous receipts	
			On weight or capacity basis	On flat rate basis				
	1,000 dollars	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*
Alabama		195			6			201
Arizona	166							166
Arkansas					1			1
California	2, 595			83		57		2, 735
Colorado		583			11			594
Connecticut	253							253
Delaware [4]								
Florida		272		1	2			275
Georgia		4		67	3			74
Idaho	24		46		1	9		80
Illinois [4]								
Indiana			619	138	10			767
Iowa		473		64				537
Kansas		1, 152			15			1, 167
Kentucky		273			39		[5] 18	330
Louisiana					8		3	11
Maine				5	12		2	19
Maryland [6]								
Massachusetts				84	11		[5] 4	99
Michigan		427						427
Minnesota					40			40
Mississippi		44	73		6		6	129
Missouri			492					492
Montana	26			13	3			42
Nebraska				24	23			47
Nevada			152	38		3		193
New Hampshire				3				3
New Jersey		74						74
New Mexico		174			3			177
New York [4]								
North Carolina	253							253
North Dakota		3			13		1	17
Ohio			469					469
Oklahoma		1, 456			8			1, 464
Oregon	292	504		248			25	1, 069
Pennsylvania	13							13
Rhode Island				9	1			10
South Carolina		80	147				[5] 3	230
South Dakota		12	443		22			477
Tennessee		338	58		2			398
Texas				100	8			108
Utah		9						9
Vermont [4]								
Virginia	248				5			253
Washington	16		117	19	37			189
West Virginia		79						79
Wisconsin		334	1, 246		431		3	2, 014
Wyoming		181			25	14		220
District of Columbia		114		102				216
Total	3, 886	6, 781	3, 862	998	746	83	65	16, 421

[1] Complete classification of motor-carrier tax receipts is not available in all States. The classified receipts, in some cases, include miscellaneous small receipts not classified.

[2] Numerous States impose taxes on the gross receipts of motor carriers in connection with general State sales taxes or taxes on all transportation companies or public utilities. This column includes only the proceeds of gross-receipts taxes reported by the States as special taxes on motor carriers.

[3] It is often difficult to make a distinction between the 3 classes of receipts listed in the third, fourth, and fifth columns of figures. In general, the proceeds of special weight or capacity taxes and taxes imposed at a flat rate per vehicle are included under special license fees and franchise taxes, application or filing fees required for the issuance of certificates of convenience and necessity to common carriers and corresponding permits to contract and other motor carriers are included under certificate or permit fees.

[4] No special taxes on motor carriers reported.

[5] Motor-carrier drivers' licenses.

[6] Ton-mile and passenger-mile taxes paid by motor carriers in lieu of registration fees included in table, State Motor-Vehicle Receipts, 1938.

STATUS OF FEDERAL-AID GRADE CROSSING PROJECTS

AS OF MAY 31, 1939

STATE	COMPLETED DURING CURRENT FISCAL YEAR					UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION					BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS
			NUMBER					NUMBER					NUMBER			
	Estimated Total Cost	Federal Aid	Grade Crossings Eliminated by Separation or Relocation	Grade Crossing Structures Reconstructed	Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Federal Aid	Grade Crossings Eliminated by Separation or Relocation	Grade Crossing Structures Reconstructed	Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Federal Aid	Grade Crossings Eliminated by Separation or Relocation	Grade Crossing Structures Reconstructed	Grade Crossings Protected by Signals or Otherwise	
Alabama	$ 253,090	$ 252,891	6		6	$ 1,229,062	$ 1,227,124	15	1		$ 62,800	$ 55,800	2		1	$ 842,726
Arizona						229,905	227,701	3			268,471	245,000	2			282,973
Arkansas	575,492	573,236	13			127,127	127,045	2			166,256	166,256	3			1,235,963
California	1,362,358	1,361,783	5	3		1,691,373	1,690,278	10			80,272	80,272	1			1,296,732
Colorado	84,715	81,327	2		2	487,708	487,708	4			46,030	42,268			19	928,224
Connecticut						18,930	12,665				171,920	166,540		1		832,360
Delaware	33,995	33,516			14	45,420	45,420	2		9	2,320	2,320			1	509,994
Florida	17,416	17,416	1			428,094	428,094	2			79,700	79,700	1		1	1,158,058
Georgia						436,950	436,950	7			138,600	138,600	2	2	5	2,319,120
Idaho	180,246	172,543	4			388,794	357,136	5								454,970
Illinois	534,280	534,280	4		11	2,577,545	2,520,545	17	3	53	713,450	713,450	3		24	2,467,151
Indiana	688,790	578,620	4	4		894,116	867,216	3	1	89	169,040	169,040		1	10	1,313,772
Iowa	1,038,701	1,001,200	12	2	20	311,091	272,806	6			176,113	165,100	7		11	1,673,923
Kansas	552,846	552,740	5		5	978,678	978,678	12			121,659	121,659	2		8	1,426,390
Kentucky	165,688	165,688	1		8	667,203	667,203	9	4	23	277,438	229,489	2	1		1,108,511
Louisiana	11,980	11,980				435,221	428,478	4			394,361	393,570	10			1,053,899
Maine	53,997	53,877	2			409,266	409,266	3	3	1	67,020	67,020	1			296,231
Maryland						72,189	72,189	1			228,200	131,407	1		4	1,023,901
Massachusetts	54,710	54,710		1		540,425	539,162	4	3							1,727,702
Michigan	957,084	915,797	8	1	45	628,626	628,626	5	2		252,690	252,690	1		19	2,137,219
Minnesota	38,606	38,332		1	1	780,054	779,733	3	5	2	552,469	551,149	4	1	11	1,601,920
Mississippi	356,600	356,600	4			603,614	603,614	8								934,587
Missouri	296,960	295,421	4	1		1,082,570	1,082,570	5	1		567,910	564,120	4	2		1,679,326
Montana	365,654	360,772	4			860,225	860,225	9			29,070	29,070	1			335,656
Nebraska	156,731	156,459	6			938,073	938,073	26			436,342	436,342	4		33	581,225
Nevada	161,386	161,033		3	6	237,364	237,364	1	1		30,558	30,558			11	127,618
New Hampshire	70,205	69,765		1	2	67,609	67,562	5		1	102,775	102,302	3			351,621
New Jersey	125,381	120,155	1	1	1	557,101	557,101	2	2	1						1,682,615
New Mexico	264,915	264,649	7	1		99,655	99,655	2			2,861	2,861			1	651,283
New York	1,032,101	1,027,600	5	3	2	1,980,555	1,975,205	4	10		141,300	140,850		1	1	4,962,223
North Carolina	154,540	154,540	2	1	1	1,316,400	1,281,300	7	7	12	344,210	344,210	2	1	29	1,165,321
North Dakota	209,450	208,387		1		865,312	816,910	8	1		225,990	225,990	4			637,098
Ohio						844,902	808,140	10	1		890,980	890,980	6		2	3,363,901
Oklahoma	40,774	30,792			4	330,960	296,960	2		43	38,600	38,600			8	2,370,197
Oregon	675,679	540,671	2	2		39,002	39,002				129,997	129,997	2			499,890
Pennsylvania	213,129	197,923	2			1,967,294	1,755,395	3	3		6,200	6,200			1	4,901,633
Rhode Island						438,791	438,791	1	3							152,459
South Carolina	71,586	71,136	1	1	2	648,088	593,572	17	2	2	148,179	148,179			36	969,965
South Dakota	128,909	128,276	2		9	281,970	281,970	5	2		45,750	45,750	1		11	1,132,919
Tennessee	12,460	12,460			4	690,870	690,870	2	3	2	181,800	181,800	1	1	3	1,380,090
Texas	907,616	905,342	15	3		2,461,147	2,430,362	22	2		775,513	747,615	6	1		2,348,659
Utah	111,307	111,307	2		4	37,700	37,700	2			314,590	314,590			118	238,940
Vermont	245,681	230,614	6	2	8	9,806	9,806			1	20,630	20,440			6	317,470
Virginia	506,768	505,695	17	3	4	489,013	400,013	6		2	368,462	368,462	4	2	18	900,508
Washington	403,227	391,758	5	3	2	667,163	665,753	7	1		86,637	86,637		1	13	541,588
West Virginia	221,081	217,381	1		3	399,541	383,781	7		2	18,800	18,800	1		1	964,852
Wisconsin	202,131	200,987	3			1,194,012	1,153,188	11			486,783	466,619	4	2	4	1,138,789
Wyoming	154,992	154,992		2	4	207,460	128,040	1	1		17,010	17,010			7	508,822
District of Columbia	30,215	30,215		1							283,544	243,750	1			134,436
Hawaii	3,820	3,650				226,770	226,770	5	1							360,830
Puerto Rico	61,900	61,550	2			222,399	220,980	6			180,009	179,127	3			418,719
TOTALS	13,789,192	13,370,066	158	41	168	33,143,143	32,284,695	301	63	243	9,843,309	9,552,189	89	17	417	61,444,979

STATUS OF FEDERAL-AID HIGHWAY PROJECTS

AS OF MAY 31,1939

STATE	COMPLETED DURING CURRENT FISCAL YEAR			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS
	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$ 6,865,382	$ 3,146,870	239.4	$ 8,201,012	$ 4,087,296	307.8	$ 790,650	$ 394,870	25.1	$ 3,195,425
Arizona	2,478,830	1,791,914	125.5	1,087,983	770,477	44.4	387,516	275,336	24.2	1,891,240
Arkansas	1,807,728	1,792,834	107.1	3,180,413	3,176,988	207.9	287,230	284,675	16.5	1,739,673
California	10,660,759	5,749,563	242.7	5,446,871	2,990,017	73.8	708,497	373,994	7.4	4,526,559
Colorado	2,668,693	1,418,126	104.0	4,482,913	2,491,726	115.1	526,310	294,780	13.4	2,334,908
Connecticut	1,108,390	540,911	11.0	991,398	491,639	11.5	1,175,632	584,078	10.5	1,331,528
Delaware	737,221	363,900	17.8	469,157	233,315	6.3	959,430	439,005	28.1	1,309,553
Florida	3,187,007	1,554,568	65.6	2,686,920	1,343,460	58.8	360,000	180,000	6.4	3,604,620
Georgia	5,264,142	2,520,321	266.6	5,184,610	2,592,305	265.0	2,798,090	1,399,045	151.4	6,430,397
Idaho	2,217,937	1,258,987	207.3	1,615,454	968,318	51.0	585,952	357,952	11.3	1,677,410
Illinois	11,694,439	5,779,935	313.9	9,045,107	4,519,658	194.3	2,785,837	1,402,873	69.2	4,058,327
Indiana	6,100,734	2,944,390	154.4	4,637,526	2,267,413	93.3	3,382,522	1,638,509	83.8	2,717,697
Iowa	7,697,389	3,649,025	263.5	4,749,799	2,060,133	169.8	992,251	466,100	33.4	2,098,676
Kansas	5,450,953	2,695,427	729.9	4,159,141	2,071,865	182.2	3,949,338	1,974,669	214.7	4,129,725
Kentucky	5,577,596	2,755,411	209.2	3,387,868	1,693,934	76.9	1,712,357	854,622	45.6	3,290,557
Louisiana	1,520,282	750,988	38.3	11,249,627	2,716,380	52.5	2,034,965	996,706	28.5	2,703,740
Maine	2,852,507	1,392,847	65.0	1,746,024	873,011	35.6	229,340	114,670	8.3	885,654
Maryland	1,085,456	540,462	17.1	2,809,978	1,393,851	46.1	1,478,470	601,000	23.4	1,966,544
Massachusetts	2,224,695	1,112,271	12.7	3,597,796	1,796,208	27.4	1,690,757	842,320	11.5	2,569,343
Michigan	8,367,645	3,935,500	174.1	4,606,814	2,302,912	135.7	1,044,005	518,800	27.1	3,472,482
Minnesota	5,016,326	2,403,668	311.8	5,958,771	2,957,196	290.0	1,932,467	964,549	138.1	4,196,914
Mississippi	6,571,088	2,879,023	284.0	7,506,132	2,704,636	322.7	964,960	389,026	24.6	3,017,235
Missouri	5,874,711	2,821,779	163.2	4,066,976	2,004,496	120.5	3,515,532	1,732,020	141.6	4,821,352
Montana	1,976,018	1,109,693	91.0	2,961,682	1,672,769	151.3	1,048,187	545,933	55.3	4,547,527
Nebraska	4,596,076	2,191,021	389.2	5,314,067	2,676,027	455.0	2,972,212	1,487,606	297.4	2,894,348
Nevada	1,605,062	1,359,894	181.3	1,547,105	1,333,852	51.1	5,525	4,752	.3	1,685,095
New Hampshire	1,178,535	579,858	23.7	155,856	77,222	1.9	1,499,682	641,278	41.2	1,064,453
New Jersey	2,637,665	1,305,520	18.3	3,238,336	1,616,613	28.8	651,440	324,905	2.9	2,554,918
New Mexico	2,663,604	1,718,927	284.9	1,738,989	1,059,524	56.8	254,901	159,078	52.3	1,700,652
New York	14,674,939	6,929,962	260.4	11,788,050	5,761,000	192.7	1,651,100	784,550	29.7	4,878,073
North Carolina	7,425,054	3,518,610	312.1	6,178,259	3,085,072	381.5	1,219,850	593,015	61.6	2,571,387
North Dakota	3,437,179	3,230,743	260.9	434,490	243,744	57.5	2,695,724	1,444,843	280.4	3,741,698
Ohio	8,688,354	4,269,480	103.3	8,965,962	4,413,652	90.1	2,478,020	1,238,680	35.8	7,719,985
Oklahoma	6,512,822	3,402,954	259.8	2,277,875	1,206,176	42.7	1,695,511	902,011	48.2	4,367,419
Oregon	3,193,688	1,851,995	111.0	2,302,916	1,404,057	123.7	848,583	508,595	50.5	2,325,013
Pennsylvania	8,606,088	4,219,429	142.1	9,873,562	4,763,267	92.5	2,449,516	1,212,229	28.3	5,159,514
Rhode Island	1,303,817	643,270	17.3	283,232	141,616	2.6	808,450	404,105	9.2	1,135,058
South Carolina	5,344,560	2,368,578	266.4	2,936,804	1,310,986	86.4	12,800	5,800		2,455,379
South Dakota	2,098,918	1,173,486	259.0	4,561,349	2,522,510	440.8	1,355,820	774,810	103.5	3,565,685
Tennessee	6,342,829	3,144,817	199.3	3,586,924	1,793,462	75.2	1,076,200	538,100	42.6	4,753,103
Texas	15,787,639	7,781,722	997.8	13,691,525	6,734,943	616.7	2,189,313	1,082,315	159.7	7,433,747
Utah	1,381,405	924,538	110.9	2,334,010	1,642,830	80.0	338,825	213,007	22.4	1,220,382
Vermont	1,295,915	610,413	33.9	726,484	345,593	17.7	196,970	98,295	4.3	625,523
Virginia	6,996,034	3,490,418	240.3	2,410,592	1,202,986	65.2	1,360,156	678,228	34.4	1,682,467
Washington	4,755,291	2,454,520	113.7	2,417,868	1,263,050	24.6	1,344,410	687,800	15.2	1,395,555
West Virginia	1,851,636	1,309,930	66.7	1,638,812	822,136	39.1	2,032,752	997,715	46.9	2,249,743
Wisconsin	5,061,870	2,498,459	176.2	6,772,589	3,311,880	183.3	2,333,622	1,129,715	81.2	2,379,411
Wyoming	2,515,959	1,526,600	281.3	1,318,352	813,064	119.5	405,066	226,576	41.4	1,178,481
District of Columbia							200,400	100,200	1.2	387,300
Hawaii	1,107,990	544,953	21.9	937,620	460,715	13.3	436,537	200,128	5.7	1,312,925
Puerto Rico	598,026	294,485	11.9	1,680,341	835,295	34.5	180,179	89,230	3.1	502,865
TOTALS	230,666,883	118,252,995	9,358.7	202,941,941	101,021,275	6,413.1	68,033,859	34,153,098	2,698.8	145,457,265

U. S. GOVERNMENT PRINTING OFFICE: 1939

PUBLICATIONS *of the* BUREAU OF PUBLIC ROADS

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. As his office is not connected with the Department and as the Department does not sell publications, please send no remittance to the United States Department of Agriculture.

ANNUAL REPORTS

Report of the Chief of the Bureau of Public Roads, 1931. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1933. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1934. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1935. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1936. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1937. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1938. 10 cents.

HOUSE DOCUMENT NO. 462

Part 1 . . . Nonuniformity of State Motor-Vehicle Traffic Laws. 15 cents.

Part 2 . . . Skilled Investigation at the Scene of the Accident Needed to Develop Causes. 10 cents.

Part 3 . . . Inadequacy of State Motor-Vehicle Accident Reporting. 10 cents.

Part 4 . . . Official Inspection of Vehicles. 10 cents.

Part 5 . . . Case Histories of Fatal Highway Accidents. 10 cents.

Part 6 . . . The Accident-Prone Driver. 10 cents.

MISCELLANEOUS PUBLICATIONS

No. 76MP . . The Results of Physical Tests of Road-Building Rock. 25 cents.

No. 191MP . . Roadside Improvement. 10 cents.

No. 272MP . . Construction of Private Driveways. 10 cents.

No. 279MP . . Bibliography on Highway Lighting. 5 cents.

Highway Accidents. 10 cents.

The Taxation of Motor Vehicles in 1932. 35 cents.

Guides to Traffic Safety. 10 cents.

Federal Legislation and Rules and Regulations Relating to Highway Construction. 15 cents.

An Economic and Statistical Analysis of Highway-Construction Expenditures. 15 cents.

Highway Bond Calculations. 10 cents.

Transition Curves for Highways. 60 cents.

DEPARTMENT BULLETINS

No. 1279D . . Rural Highway Mileage, Income, and Expenditures, 1921 and 1922. 15 cents.

No. 1486D . . Highway Bridge Location. 15 cents.

TECHNICAL BULLETINS

No. 55T . . . Highway Bridge Surveys. 20 cents.

No. 265T. . . Electrical Equipment on Movable Bridges. 35 cents.

Single copies of the following publications may be obtained from the Bureau of Public Roads upon request. They cannot be purchased from the Superintendent of Documents.

MISCELLANEOUS PUBLICATIONS

No. 296MP. . Bibliography on Highway Safety.

House Document No. 272 . . . Toll Roads and Free Roads.

SEPARATE REPRINT FROM THE YEARBOOK

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

TRANSPORTATION SURVEY REPORTS

Report of a Survey of Transportation on the State Highway System of Ohio (1927).

Report of a Survey of Transportation on the State Highways of Vermont (1927).

Report of a Survey of Transportation on the State Highways of New Hampshire (1927).

Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio (1928).

Report of a Survey of Transportation on the State Highways of Pennsylvania (1928).

Report of a Survey of Traffic on the Federal-Aid Highway Systems of Eleven Western States (1930).

UNIFORM VEHICLE CODE

Act I.—Uniform Motor Vehicle Administration, Registration, Certificate of Title, and Antitheft Act.

Act II.—Uniform Motor Vehicle Operators' and Chauffeurs' License Act.

Act III.—Uniform Motor Vehicle Civil Liability Act.

Act IV.—Uniform Motor Vehicle Safety Responsibility Act.

Act V.—Uniform Act Regulating Traffic on Highways.

Model Traffic Ordinances.

A complete list of the publications of the Bureau of Public Roads, classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to the U. S. Bureau of Public Roads, Willard Building, Washington, D. C.

STATUS OF FEDERAL-AID SECONDARY OR FEEDER ROAD PROJECTS

AS OF MAY 31, 1939

STATE	COMPLETED DURING CURRENT FISCAL YEAR			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS
	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$ 234,900	$ 117,450	18.4	$ 834,850	$ 412,050	38.6	$ 281,200	$ 57,000	.3	$ 776,746
Arizona	453,523	295,507	36.1	178,710	125,948	17.3	156,461	95,882	18.2	352,655
Arkansas	84,303	77,740	7.8	365,195	362,504	40.2	216,817	215,819	35.5	463,432
California	1,829,287	1,020,549	106.5	1,011,858	516,201	48.4	144,022	83,604	7.6	796,555
Colorado	1,013,189	531,073	58.9	430,110	227,544	17.2	411,300	198,662	12.6	235,477
Connecticut	89,160	44,560	1.4	190,504	81,072	3.1				286,249
Delaware	22,730	11,365	5.3	80,840	40,420	17.5	56,990	28,495	7.6	239,720
Florida	20,122	10,061		762,533	380,450	26.3	112,300	51,950	5.6	432,644
Georgia	452,681	216,050	54.1	500,726	250,363	68.0	170,780	85,390	23.4	1,083,775
Idaho	497,893	222,141	57.2	141,851	84,508	2.6	104,744	55,679	8.6	295,511
Illinois	1,869,237	919,055	161.1	1,426,632	659,316	74.1	482,300	232,650	33.1	824,301
Indiana	686,994	288,067	75.9	1,013,370	500,585	85.2	306,177	143,452	22.1	674,221
Iowa							47,751	22,015	35.4	1,657,792
Kansas	223,100	111,544	23.1	76,778	38,389	18.5	337,700	168,850	8.9	1,388,064
Kentucky	798,767	243,871	106.1	827,302	237,026	34.3	817,962	236,063	90.4	375,487
Louisiana	173,954	82,335	15.8	628,292	268,940	48.1	420,276	189,660	37.0	398,713
Maine	367,659	178,826	23.3	259,316	124,811	12.5	26,634	13,317	2.1	147,458
Maryland				188,974	94,487	15.1	142,000	52,355	10.2	388,839
Massachusetts	57,625	28,490	.9	248,093	123,561	4.7	425,290	209,605	8.6	491,067
Michigan	390,291	191,920	34.2	1,008,104	504,052	62.7	682,200	317,700	37.1	973,816
Minnesota	273,069	126,708	42.2	702,410	349,161	61.1	114,184	57,092	1.4	1,252,244
Mississippi				325,662	162,831	23.8	379,100	189,450	37.5	798,585
Missouri	460,053	219,093	57.8	698,120	325,640	62.1	510,000	228,015	99.4	740,888
Montana	14,071	7,865		125,531	71,135	10.8	595,970	335,609	42.0	925,284
Nebraska	583,291	282,472	95.6	756,444	369,266	143.3	221,378	101,375	44.3	551,345
Nevada	427,436	345,390	68.8	120,169	104,184	15.5	26,563	23,035	1.6	214,637
New Hampshire	218,767	108,445	6.0	60,759	29,708	2.4				181,847
New Jersey	171,820	79,020	2.5	332,120	164,010	8.3	134,520	66,375	9.4	561,573
New Mexico	625,191	380,030	42.1	550,676	335,062	36.0	137,262	79,009	7.5	251,965
New York	2,306,430	1,115,917	167.4	1,899,000	949,500	99.6	127,000	55,000	7.3	968,966
North Carolina	695,412	346,576	77.2	1,077,044	538,500	102.4	308,800	147,960	32.7	397,347
North Dakota	108,510	56,615	26.8	115,030	61,606	8.3	42,770	22,907	8.2	875,949
Ohio	147,535	73,767	3.8	357,610	185,580	14.5	435,680	217,840	25.2	1,891,932
Oklahoma	304,728	160,942	35.8	167,850	89,311	7.1	602,040	297,148	32.4	985,103
Oregon	471,113	274,000	63.2	337,945	203,492	38.9	248,846	149,320	22.7	376,545
Pennsylvania	1,818,211	858,708	128.4	2,128,643	1,046,540	118.1	155,992	77,996	6.4	767,700
Rhode Island	70,486	33,379	3.5	194,923	97,438	5.8				130,199
South Carolina	587,550	254,282	68.1	672,277	278,769	67.8	169,800	66,200	12.4	278,661
South Dakota	11,519	6,250								1,058,050
Tennessee	273,975	129,470	14.8	762,064	308,132	34.2	125,640	62,820	.6	871,038
Texas	3,244,257	1,536,859	466.9	2,332,640	1,107,801	233.8	344,079	168,536	41.1	1,238,037
Utah	603,604	308,008	53.2	242,850	112,763	22.0	112,625	60,401	10.0	237,908
Vermont	232,410	106,201	13.8	90,306	45,153	4.0	43,300	20,500	.5	110,867
Virginia	864,925	378,562	74.6	650,974	323,724	63.9	111,660	47,622	10.1	415,340
Washington	560,544	291,226	64.5	705,929	370,896	40.4	42,369	22,300	1.2	280,706
West Virginia	242,491	119,483	21.4	153,296	76,648	8.3				515,848
Wisconsin	548,482	263,669	23.4	725,191	357,540	33.2	428,654	202,717	5.0	751,110
Wyoming	416,758	254,565	59.0	356,182	220,069	20.2	112,098	70,081	5.8	227,835
District of Columbia										73,125
Hawaii				170,080	85,040	4.6	22,900	11,450	1.3	223,510
Puerto Rico	224,621	110,876	11.3	131,604	64,530	8.8	140,883	68,620	6.1	75,974
TOTALS	25,772,674	12,818,982	2,478.2	27,117,367	13,466,256	1,933.6	11,037,017	5,307,526	876.4	30,512,640