

The Bureau of Public Roads

The Bureau of Public Roads is in the Department of Agriculture. Its most important work is the administration of Federal aid road work and the construction of roads in the national forests which has been delegated to it by the Secretary of Agriculture. Its other activities include research in all phases of the design and construction of roads and economic investigations to determine their value and the service they render to the community. Its agricultural engineering branch conducts investigations and disseminates information with regard to the utilization of water for irrigation, the drainage of farm lands, the use of mechanical power on the farm, and water supply and sewerage of farm homes, the design and arrangement of farm buildings and their heating, lighting and ventilation, and other matters connected with agriculture which involve the employment of engineering knowledge.

The Bureau was created in 1893 under the name of the Office of Road Inquiry. Its first activities, which with some enlargement were its only functions until 1916, involved the investigation of the best methods of road design and construction and the dissemination of the results of its investigations by means of published reports and demonstrations in the form of object-lesson roads constructed for local communities under the supervision of its engineers.

Federal Aid Legislation

The application of the Federal-aid principle to road improvement goes back to the Federal-aid road act of 1916. This act provided \$75,000,000 for the fiscal years 1917-21 inclusive, and laid down the principles for Federal aid administration which have been continued since with only slight modification with the exception of the requirement of the designation of the Federal-aid highway system made in 1921.

The outstanding features of Federal-aid as at present administered are as follows. Appropriations have been made for each fiscal year since 1916, and have been divided in three parts, one part being apportioned among the States in proportion to area, one in proportion to population and the third in the ratio that the mileage of rural post roads in each State bears to the total mileage of such roads in the United States. Federal-aid may be used by the States only for the purpose of constructing roads on the Federal aid highway system which will be described later. The order in which roads are taken up for improvement, the type of improvement, preparation of plans and specifications, letting of contracts and supervision of construction are all under the control of the various State highway departments but subject to the approval of the Secretary of Agriculture who acts through the Bureau of Public Roads. The bureau is headed by the chief of bureau and chief engineer under whom are divisions of design, construction and control in charge of the several phases of the work. ~~Co-ordinated~~ with the State

Highway departments is through eleven district engineers, each with a district including a group of States, those in the five Western districts reporting to Washington headquarters through a deputy chief engineer with office at San Francisco. Each State is required to have an adequate highway department and the Federal government deals only with such agencies.

In general Federal participation is limited to 50 per cent of the cost and for recent appropriations may not exceed \$15,000 per mile, exclusive of bridges more than 20-feet in span, for which participation is limited only to one-half the cost. In the public land States both limitations on cost per mile and percentage of cost paid out of Federal funds may be increased by a percentage which is determined from the area of unappropriated public lands.

Provision is made for adequate maintenance of all Federal-aid roads. No Federal money is available for this purpose but the States agree to maintain all roads constructed with Federal-aid. Should a State fail to do this, authority is given the Secretary of Agriculture to discontinue Federal-aid to the State and to put the road in a proper condition of maintenance out of any Federal-aid funds available to the State. Federal-aid to the State may be resumed upon reimbursement of the cost of maintenance which money is apportioned among all the States.

The Federal-aid Highway System

The Federal Highway Act approved November 9, 1921, provided that all Federal money subsequently appropriated was to be applied

only to a limited system of main interstate and intercounty roads which it directed the Secretary of Agriculture and the State highway departments to select in cooperation. The system, which has come to be known as the Federal-aid highway system, must consist of not more than 7 per cent of the total mileage of road existing in each State on the date of the passage of the act. Except with the joint consent of the Secretary of Agriculture and the State highway departments, not more than three-sevenths may be primary highways of interstate importance, the remainder being secondary roads or roads of intercounty importance. Taken together, however, both classes represent the main roads of the country.

This system will serve directly nearly every city of 5,000 population or greater and, with the secondary and local roads which will be connected with it, will carry the increasing highway traffic of the nation with a minimum of inconvenience and delay. The Federal aid system itself will penetrate within 10 miles of the homes of 90 per cent of the people. The system as at present approved includes 182,135 miles.

The total mileage of road as certified in each of the States and the mileage included in the system are shown in the following table:

TABLE 1. - MILEAGE OF FEDERAL AID HIGHWAY SYSTEM OF THE UNITED STATES June 30, 1946.

<u>States</u>	<u>Certified Total Mileage</u>	<u>Mileage of Approved System</u>
Alabama	50,551	4,074.00
Arizona	21,000	1,451.00
Arkansas	71,550	5,007.03
California	70,000	4,074.00
Colorado	48,000	3,392.00
Connecticut	12,000	85.43
Delaware	3,500	25.18
Florida	27,548	1,300.00
Georgia	80,892	5,558.00
Idaho	40,000	2,700.00
Illinois	56,771	5,000.22
Indiana	70,900	4,079.00
Iowa	109,113	7,212.00
Kansas	124,143	7,000.00
Kentucky	53,000	3,700.75
Louisiana	40,000	2,644.00
Maine	23,104	1,375.00
Maryland	14,810	1,475.49
Massachusetts	20,535	1,300.00
Michigan	75,000	5,235.00
Minnesota	101,050	6,219.50
Mississippi	53,000	3,604.00
Missouri	111,510	7,530.00
Montana	67,100	4,661.00
Nebraska	80,272	5,569.05
Nevada	22,000	1,590.00
New Hampshire	14,212	977.39
New Jersey	17,100	1,190.30
New Mexico	47,607	3,230.00
New York	81,273	5,010.00
North Carolina	60,000	3,701.10
North Dakota	106,002	6,035.00
Ohio	84,497	5,300.50
Oklahoma	112,690	5,828.00
Oregon	41,806	2,814.00
Pennsylvania	90,000	4,070.54
Rhode Island	2,368	242.43
South Carolina	50,318	3,230.00
South Dakota	115,330	5,731.00
Tennessee	65,204	3,230.00
Texas	182,816	11,129.00
Utah	24,057	1,588.00
Vermont	14,900	1,043.00
Virginia	53,330	3,075.50
Washington	42,428	2,907.70
West Virginia	31,629	1,993.75
Wisconsin	70,000	5,493.30
Wyoming	46,300	3,071.70
Total	2,352,190	182,134.70

***NOTE:**

These States have completed or provided for completion of the 7% system and additions in excess of 7% have been authorized.

The total amount that has been authorized by all acts up to and including the fiscal

year 1929 is \$240,000,000.

TABLE 2. - APPROPRIATIONS FOR FEDERAL AID ROAD CONSTRUCTION

Fiscal Year	By Post Office Appropriation Act for Fiscal Year					Total
	July 11, 1916	By Act of Feb. 28, 1919	By Act of Nov. 9, 1921	Year 1925	By Act of Feb. 12, 1926	
1917	\$ 5,000,000	-	-	-	-	\$5,000,000
1918	10,000,000	-	-	-	-	10,000,000
1919	15,000,000	\$ 50,000,000	-	-	-	65,000,000
1920	20,000,000	75,000,000	-	-	-	95,000,000
1921	25,000,000	75,000,000	-	-	-	100,000,000
1922	-	-	\$75,000,000	-	-	75,000,000
1923	-	-	-	\$50,000,000	-	50,000,000
1924	-	-	-	65,000,000	-	65,000,000
1925	-	-	-	75,000,000 a/	-	75,000,000
1926	-	-	-	-	\$75,000,000 b/	75,000,000
1927	-	-	-	-	75,000,000 b/	75,000,000
1928	-	-	-	-	75,000,000 c/	75,000,000
1929	-	-	-	-	\$ 75,000,000 d/	75,000,000
Total	\$75,000,000	\$200,000,000	\$75,000,000	\$190,000,000	\$150,000,000	\$840,000,000

a/ \$75,000,000 authorized, \$25,000,000 since appropriated.

b/ Authorized only, not yet appropriated.

Progress in Federal-aid Road Construction

The Federal-aid road projects completed during the fiscal year contributed a net addition of 9,417.3 miles to the mileage of improved roads in the Federal-aid highway system. Added to the mileage improved with Federal assistance in previous years, the above brings the total length of improved Federal-aid roads up to 55,902.8 miles.

At the close of the year construction was in progress on 10,961.8 miles and projects involving the improvement of 2,469.5 miles additional had been approved. Including the mileage of projects in these latter stages, all of which is included in the Federal-aid system, the total mileage improved or in process of improvement with Federal aid was 69,334.1 miles. With the exception of a few hundred miles improved prior to the designation of the Federal-aid Highway system in 1921, all of this mileage is included in the system.

It is entirely consistent with the interests of the Federal Government to participate in the improvement of every mile of the designated system, but that will not be necessary. With negligible exceptions the roads included in the Federal-aid system are also parts of the several State highway systems. This is inevitable from the fact that important interstate roads are almost invariably essential State arteries also; and because of its importance to the

States a very considerable mileage included in the system had already been improved prior to its designation.

The net mileage requiring construction in order to complete the improvement of the system, has, therefore, always been considerably less than the mileage of the system, and the work of improvement has always been carried on by the States independently as well as in cooperation with the Federal Government. In fact, as shown in the following table, the State reports indicate that the mileage independently improved is in excess of that improved with Federal assistance; so that it is probable that the mileage within the system at present initially improved or in process of improvement is not far from three-quarters of the total.

It is, however, not the intention to imply that the work of improvement is three-quarters done. Much of the betterment that has been effected is merely the first step toward the improvement that will ultimately be required. Of the nearly 56,000 miles improved with Federal aid nearly 10,000 miles are unsurfaced, the improvement consisting merely of the proper grading and draining of the roadbed. An additional large mileage is surfaced with sand-clay and gravel.

TABLE 3. - FEDERAL-AID MILEAGE COMPLETED DURING THE FISCAL YEAR 1926, INCLUDING ORIGINAL AND STAGE CONSTRUCTION, COMPARED WITH TOTAL MILEAGE COMPLETED IN 1925 BY THE STATE HIGHWAY DEPARTMENTS

Group of States	Federal-aid mileage (original and stage construction) completed fiscal year 1926	Mileage completed by State highway departments 1925	Ratio of Federal-aid to State program
	Miles	Miles	Per cent
New England	161.4	631.0	25.6
Middle Atlantic	785.7	1,687.4	46.6
South Atlantic	1,239.6	3,201.9	38.7
East North Central	836.8	4,321.1	19.4
West North Central	3,365.3	6,538.5	51.5
East South Central	1,046.6	1,113.5	94.9
West South Central	1,384.0	3,165.9	43.6
Mountain	1,300.6	1,483.1	87.6
Pacific	490.4	1,009.8	48.6
Total	10,610.4	23,152.2	45.9

As traffic is constantly increasing these roads can not long be permitted to remain as they are, and there is a definite agreement between the State and Federal agencies that they will be further improved as traffic requires and funds for the purpose become available.

All such improvements have been made in conformity with the policy of stage construction under which the condition of the highways, where traffic permits, is gradually advanced to the ultimate state of improvement with high-class surfacing or pavement by successive stages. An exactly similar policy was followed by the builders of the railroads, whose first

object was to "get the traffic through," leaving until a later date the perfecting processes of ballasting, banking of curves, etc. It is the only satisfactory method of dealing with the conditions existing in many of the Southern, Middle Western, and Western States in which there are thousands of miles of main road still entirely devoid of any improvement whatever.

That the purpose to continue the improvement as required is being conscientiously fulfilled is indicated by the fact that during the fiscal year secondary stages of improvement were completed on 1,193 miles previously improved with Federal aid. This work, involving the construction of 886.7 miles of gravel surfacing, 15.7 miles of concrete pavements, and smaller mileages of several other types of surfacing is not represented in the 9,417.3 miles reported as improved, all of which was original improvement, and does not add to the total of 55,902.8 miles improved up to the close of the year. From the standpoint of the year's work, however, it does represent an accomplishment; and it may, therefore, be said that the mileage improved during the year was actually 10,610.3 miles, which exceeds the performance of any previous year except the last when 11,328.6 miles of original construction were completed.

Improvement of Transcontinental Roads Approaching Completion

Ten years ago, when the Federal-aid plan was adopted, there were only five States in which there was a single improved trans-State highway. They were Massachusetts, Connecticut, New York, New Jersey,

and Maryland, all Eastern States, and all of that small group in which the movement for better highways was begun in the nineties.

In 16 States there was then no State highway department nor the semblance of a plan for the development of through routes across the State; and even of those States in which a recently created State agency was feeling its way toward a more scientific and businesslike administration of State highways there were few in which the conception of a connected State highway system had yet been clearly apprehended.

Today 25 States have continuously improved highways entirely across them in at least one direction and 16 of these have completed such trans-State arteries in two directions.

It is the primary purpose of the Federal-aid road legislation to expedite the continuous improvement of such cross-State highways in all States and finally to provide a completely articulated system of main interstate highways for the Nation. The goal, as represented by the Federal-aid highway system, is clearly defined and progress toward it has proceeded for the last five years at least without deviation. That progress will be continued with a more pronounced single-mindedness of purpose in the future until it shall be possible to travel by highway without obstacle in any direction across all States and throughout the Nation.

There is now one transcontinental road which is 97 per cent improved. It extends from Washington through St. Louis, Topeka,

and El Paso to San Diego. Of its entire length 93 per cent is surfaced and 4 per cent is merely graded and drained; and of the surfaced portion more than half is improved with bituminous macadam or better and the remainder is gravel. From Washington to St. Louis there is no unimproved section and nearly 96 per cent is surfaced with bituminous macadam or some higher type of pavement. From St. Louis to Texarkana 2 per cent of the distance is unimproved and 63 per cent is improved with a gravel surface, the rest with superior types. From Texarkana to El Paso there are unimproved sections to the amount of 4 per cent of the distance, gravel surfaces 50 per cent, and bituminous macadam or better the rest of the way; and from El Paso to San Diego, with the exception of 6 per cent of the distance, the route is surfaced 60 per cent with gravel or equivalent and the remainder with pavements and surfaces of higher types.

This road from Washington to San Diego is more nearly completed than any other transcontinental route. Of its total length of 3,133 miles, 2,907 miles are surfaced and 131 miles are graded and drained, leaving only 95 miles without improvement.

Next in point of improvement is the route from Atlantic City, N. J., to Astoria, Oreg. Of its total length of 3,240 miles, one-eighth is still unimproved, nearly another eighth is graded and drained, and the rest is improved with some form of wearing surface. Of other east-and-west routes, that from Norfolk, Va., to Los Angeles is 68 per cent improved; and from Chicago to Los Angeles, partly by this same line, is 63 per cent improved. From Boston to Seattle through the

northern tier of States the most direct through road is 73 per cent improved and 69 per cent surfaced either with permanent or temporary surfacing.

Types of Federal-Aid Roads

The 9,417.3 miles involved in the projects completed during the year consist of 2,161.3 miles of graded and drained earth roads, 627.3 miles surfaced with sand-clay, 3,274.1 miles with gravel, 58.2 miles with water-bound macadam, 553.2 miles with bituminous macadam, 179.6 miles paved with bituminous concrete, 2,464.3 miles of Portland cement concrete, 78.1 miles of brick, and 21.3 miles of bridges more than 20 feet in span.

The earth, sand-clay, and gravel roads are mainly in the South and in the States west of the Mississippi. Of the 6,062.7 miles of these three types completed during the year only 187.4 miles are in the Northern and Eastern States. The small mileage of waterbound macadam is scattered among the States of all geographic groups except the Middle Atlantic, West North Central, and Pacific and the several higher types of construction including bituminous macadam and better are found in all sections, forming the highest percentage of the total however in the Northern and Eastern States.

A similar sectional distribution of the several types of construction exists with respect to all highways constructed with Federal aid; and, as shown by Table 4, there is an appropriate relation between the types constructed in the various geographic sections and

what may be termed the potential motor vehicle traffic as represented by the ratio of motor vehicle registration to mileage of the Federal-aid system in each section.

TABLE 4. - RELATION OF POTENTIAL MOTOR VEHICLE TRAFFIC AND TYPES OF FEDERAL-AID ROADS COMPLETED TO JUNE 30, 1926

Geographic Division	Number of motor vehicles per mile of Federal-aid system ^{1/}	Percentage of mileage of roads completed	
		Bituminous macadam and higher types	Waterbound macadam and lower types
Middle Atlantic	343	28.5	1.5
New England	223	70.8	29.2
Pacific	193	35.2	64.8
East North Central	187	70.3	29.7
South Atlantic	85	35.9	64.1
West South Central	74	21.8	78.2
West North Central	62	14.2	85.8
East South Central	61	25.8	74.5
Mountain	32	9.5	90.5
All States	109	31.4	68.6

^{1/} As registered in the several States during the calendar year 1925.

In Table 4 the several geographic divisions are arranged in the descending order of the ratio of their motor vehicle registration to the mileage of the Federal-aid highway system in each; and it will be observed that with the exception of the Pacific and East South Central groups the several divisions would be rated in the same order on the basis of their percentage of mileage suitable for medium and heavy motor vehicle traffic.

In addition to the 9,417.3 miles of original construction completed during the year, stage construction was completed on 1,193 miles, all of which had been previously constructed to lower type with Federal aid. This secondary construction was divided by types as follows: Semi-clay, 7.8 miles; gravel, 886.7 miles; waterbound macadam, 6.8 miles; bituminous macadam, 46.3 miles; bituminous concrete, 49.5 miles; Portland cement concrete, 195.7 miles.

That this process of gradual improvement is being continued at a desirable rate is indicated by the fact that stage construction was in progress on 1,328.9 miles, including 943.6 miles of gravel, 75.3 miles of waterbound macadam, 36.5 miles of bituminous macadam, 44.9 miles of bituminous concrete, 227.8 miles of Portland cement concrete, and 0.8 miles of brick.

Both in mileage of stage construction completed and in mileage under construction the West North Central States led all other groups by a wide margin, the Mountain and South Atlantic States being next in order. No work of this character has been undertaken in the New England or Middle Atlantic States and only a relatively small mileage is in the East North Central States. From Table 4 it will be observed that these are the groups in which the original construction is predominantly of the highest character, and in which there is consequently the least need for further improvement.

In view of the general increase in motor-vehicle traffic throughout the country it is interesting to observe from Table 5 that the greatest increase in mileage was of those types, including the gravel,

bituminous, and pavement types, which are most suitable for motor-vehicle traffic.

TABLE 5.-- MILEAGE OF FEDERAL-AID HIGHWAYS AT THE CLOSE OF THE FISCAL YEARS 1925 and 1926 AND PERCENTAGE OF INCREASE.

Type	Mileage at close of fiscal year 1925	Mileage at close of fiscal year 1926	Percentage increase dur- ing fiscal year 1926.
Graded and drained	9,079.2	9,653.7	6.3
Sand-clay	4,446.3	4,926.2	10.8
Gravel	18,013.8	22,547.3	25.1
Waterbound macadam	1,032.2	1,123.3	8.8
Bituminous macadam	2,564.2	3,176.3	23.8
Bituminous concrete	1,370.5	1,626.1	18.6
Portland cement con- crete	9,234.6	11,976.6	29.8
Brick	644.2	752.0	16.8
Total	46,385.0	55,781.5	20.2

The types least suitable for motor-vehicle traffic are the graded and drained earth roads, and those surfaced with sand-clay and waterbound macadam; those preeminently adapted to such traffic are the bituminous types, concrete and brick. Although the new construction of the first group amounted to 30.3 per cent of the total new mileage, the net addition of mileage of this character was only 12.2 per cent of the total net increase; the net increase of the types most suitable for motor traffic was 39.5 per cent.

cent, although the new mileage of these types constructed was only 34.9 per cent of the total new mileage. The gravel type, which is the cheapest type capable of resisting moderate motor-vehicle traffic and the usual choice for the secondary improvement of earth roads, increased 48.2 per cent in net mileage, although in the new construction it constituted only 34.9 per cent. These differences between the new construction and net increases of the several types reflect the beneficial results of the stage construction.

The following table shows the status of Federal-aid construction as of June 30, 1926 (See table attached.)

National Forest Road Construction

Since 1916 a total of \$77,000,000 has been provided for the construction of roads in and adjacent to the National forests. For each of the fiscal years 1927, 1928 and 1929, \$7,500,000 has been authorized.

These appropriations for forest road construction are being expended in the several States in which the forests are located on specifically designated systems of forest highways comprising a total of 13,459 miles, of which 11,271 miles are in the 11 States of the Mountain and Pacific groups and the Territory of Alaska.

In all States affected, with the exception of New Mexico and Oregon, the designation of these systems is the result of agreement between the State highway departments, the Forest Service, and the Bureau of Public Roads, and has been formally approved by the Secretary of Agriculture. In the two States mentioned as exceptions final agreement between the cooperating agencies has not yet been reached and the systems have not been approved by the Secretary, but pending final action work is proceeding upon systems designated by the Bureau of Public Roads.

The highways comprising the systems in the several States are classified according to their character as class 1 highways, which are necessary sections or extensions of the Federal-aid system lying wholly within the forests; class 2 highways which are extensions of the Federal-aid systems extending to towns outside of the forests, and class 3 highways which are largely of local service to communities within the forests.

The mileage of the systems in the several States, classified as above described, is given in Table 7.

TABLE 7. - CLASSIFIED MILEAGE OF FOREST HIGHWAY SYSTEMS
IN THE SEVERAL STATES

State	Mileage of forest highway systems			
	Class 1	Class 2	Class 3	Total
	Miles	Miles	Miles	Miles
Western:				
Alaska			306.5	306.5
Arizona	174	473	246	893
California	312.9	995.6	737	2,045.5
Colorado		1,243	527	1,770
Idaho		754	347	1,101
Montana	145	652	377	1,174
Nevada		36	94	130
New Mexico 1/	115	211	199	525
Oregon 1/	58	872.4	445	1,375.4
Utah		415	237	652
Washington	18.4	263.7	147.8	429.9
Wyoming		390	149	539
Total	823.3	6,625.7	3,822.3	11,271.3
Eastern:				
Alabama			34	34
Arkansas	131	51	20	202
Florida	3	13	106	122
Georgia			81	81
Maine			11	11
Michigan			20	20
Minnesota		38.5	142	180.5
Nebraska			25	25
New Hampshire	18.3	15.5	61	94.8
North Carolina	49		195	244
Oklahoma			33	33
Pennsylvania	24.5		166	190.5
South Carolina		6	22	28
South Dakota	2	253	59	214
Tennessee		35	188	223
Virginia		28	273	301
West Virginia		4	159	163
Total	227.8	364	1,596	2,187.8
Grand total	1,051.1	6,989.7	5,418.3	13,459.1

1/ System designated by the Bureau of Public Roads not yet approved by the Secretary of Agriculture.

It is planned to expend approximately 70 per cent of each annual appropriation for the construction of the highways of classes 1 and 2, which undoubtedly serve the greatest traffic at present, using the balance for the improvement of the class 3, or local forest highways. The administration, survey, and construction of these highways and their maintenance for the first two years, constituting the principal road construction activity conducted independently by the United States Government, has been delegated to the Bureau of Public Roads.

There were 622.5 miles of forest highway projects completed, which, added to the mileage completed previously, bring the total of improved mileage up to 3,045.6 miles, equivalent to 22.6 per cent of the designated systems. The mileage completed in the several States during the year and to date is shown in Table 81.

Outstanding among the forest highways recently completed are such noteworthy projects as the Mount Hood Loop road in Oregon, the Prescott-White Spar road in Arizona, the Warm River-Yellowstone road in Idaho, the Smith River Canyon road in northern California, the Neakwin-Siletz River road in Oregon, the Berthoud Pass road in Colorado, the Canoncito-Pecos road in New Mexico, and the Cody-Yellowstone road in Wyoming. For the engineering features involved in their construction and the difficulties overcome these roads are not surpassed in the world.

Table 8. - MILEAGE OF COMPLETED FOREST HIGHWAY PROJECTS BY STATES

State	Mileage of forest highway projects completed	
	During 1926	Total to June 30, 1926
	Miles	Miles
Western:		
Alaska	30.7	146.4
Arizona	89.2	216.6
California	56.4	202.6
Colorado	32.1	211.4
Idaho	44.4	383.6
Montana	66.9	303.3
Nevada	9.4	94.2
New Mexico	44.3	164.1
Oregon	133.5	464.9
Utah	16.3	259.0
Washington	29.6	184.1
Wyoming	39.6	173.8
Total	592.4	2,804.0
Eastern:		
Arkansas	2.3	56.8
Florida	6.2	64.2
Georgia		8.6
Minnesota	19.4	34.6
New Hampshire	2.2	2.2
North Carolina		16.4
South Carolina		5.3
South Dakota		34.8
Tennessee		12.2
Virginia		6.5
Total	30.1	241.6
Grand total	622.5	3,045.6

Highway Research Activities

The highway research activities have been developed along two principal lines, the physical and the economic. The physical researches include investigations to determine the effect of the abrasive and impact forces of traffic on various types of road surface, the design of surfaces to withstand such forces, the study of the characteristics of subgrade soils and the effect of moisture on their bearing power, the strength and wearing qualities of various highway materials, studies of bridge stresses and bridge design and numerous other less important physical phases of the road construction problem. Physical investigations are conducted on a large scale at the experimental farm of the Department of Agriculture at Arlington, Va., and experiments are also conducted in cooperation with universities, State highway departments and other agencies.

The economic researches include the study of the laws of traffic distribution, the best methods of administering and financing road construction and the benefits resulting, in the form of reduced operating costs of vehicles and increased production and land value, as a result of the improvement of the roads.

Agricultural Engineering Activities

The investigational and extension work in agricultural engineering includes a wide variety of work described by the following headings:

- a. Methods of utilizing water for irrigation.
- b. Pumping for irrigation.
- c. Irrigation appliances and equipment.
- d. The flow of water in ditches and pipes of various materials.
- e. The measurement of water for irrigation.
- f. Customs, laws and regulations relating to irrigation.
- g. The drainage of irrigated lands.
- h. The construction, operation and maintenance of land drainage improvements.
- i. The drainage of various soils.
- j. The organization, financing and regulation of drainage districts.
- k. Gullying and erosion and their prevention.
- l. The drainage of tidal marshes and swamp lands.
- m. Farm domestic water supply and sewage disposal.
- n. The utilization of mechanical farm equipment.
- o. The construction and arrangement of farm buildings.
- p. The lighting, heating and ventilation of farm homes and structures.