1022 Issued August 26, 1907.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—FARMERS' INSTITUTE LECTURE 7.

A. C. TRUE, Director.

SYLLABUS

OF

ILLUSTRATED LECTURE

ON

ROADS AND ROAD BUILDING.

BY

THE OFFICE OF PUBLIC ROADS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
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PREFATORY NOTE.

This syllabus of a lecture upon Roads and Road Building, prepared in the Office of Public Roads of the United States Department of Agriculture, is accompanied by forty-one lantern slides illustrating the topic. The syllabus and views have been prepared for the purpose of aiding farmers' institute lecturers in their presentation of this subject before institute audiences. The various methods of road construction given are those suitable for country roads and are adapted to different sections of the country according to the materials available.

The numbers in the margins of the pages of the syllabus refer to similar numbers on the lantern slides and to their legends as given in the Appendix. Those in the body of the text refer to corresponding numbers in the list of authorities and references.

In order that those using the lecture may have opportunity to acquaint themselves fully with the subject, references to its recent literature are given in the Appendix.

JOHN HAMILTON,
Farmers' Institute Specialist.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON, *Secretary of Agriculture.*

WASHINGTON, D. C., *July 1, 1907.*

ROADS AND ROAD BUILDING.

By the Office of Public Roads.

INTRODUCTION.

View.

Every progressive farmer recognizes the advantages which come from living in a farming community supplied with a system of roads passable at all seasons of the year. Not to mention the discomfort and loss of social intercourse resulting from poor highways, he can estimate in dollars and cents the loss he is incurring from poor transportation facilities.

The farmer's expense of hauling is greatly increased by bad roads. He may be obliged to deliver his product at the local 1
shipping point when prices are low and the roads passable, or wait for a better market and run the risk of having to haul over rough roads with more horses to the wagon and a much lighter 2
load. The expense of hauling under these difficulties may amount to double or even four times the normal cost.[1][a] A large tonnage of perishable merchandise that can not be handled with profit when hauled over poor roads would be put in motion by improved highways, and a larger profit realized on many products which are now moved with little advantage, thus directly benefiting both the producer and the consumer.[2] The cost of hauling twelve principal crops to shipping points in the United States during the crop year 1905–6 has been estimated by the Bureau of Statistics of the Department of Agriculture as $72,984,000.[3] This excludes crops hauled to local mills.

Serviceable roads also enhance the market value of real estate. 3
From figures recently compiled in the Office of Public Roads a comparison of the percentage of improved roads with the acreage values of farm lands in the United States has been made.[4] These figures show that the average percentage of improved roads in all States where the land is worth less than $20 per acre is 1.9 per cent, whereas in the States showing an acreage value of more than $20 improved roads constitute an average of 9 per cent of the total mileage. The States, therefore, which show a high percentage of improved roads have on

[a] Numbers refer to list of references on p. 14.

View.

the average a much higher acreage value than the States which show a low percentage. Take the figures from Mississippi, for instance, the farm lands of that State are worth on the average only $15.94 per acre,[5] while the percentage of improved roads is 0.38 of 1 per cent. Contrasting these figures with those for Indiana we find that the farm lands in that State are valued at $54.97 per acre, and that the improved roads constitute 35 per cent of the total mileage. While the quality of the soil, nearness to market, relative population, and wealth affect the price
4 of land, these figures indicate that the improvement of roads constitutes a most important factor in the enhancement of farm values. A well-kept farm located on a smooth, hard road,
5 affording quick and easy access to markets, schools, and churches, will not lack ready buyers at a good price.

In comparing the percentage of roads improved with the population per mile of road, it seems evident that States having the highest percentage of improved roads have the largest population per mile of road. Thus serviceable roads are a factor in encouraging immigration.[6]

METHODS OF CONSTRUCTION.

The method of road improvement will vary altogether with the use to which the road is to be put and will depend upon the money and materials available. It is impossible to give estimates of the cost of roads which will apply to all parts of the country alike, as these details will vary according to the cost of materials, price of labor, width and depth of road surfaced, and amount of grade.

The macadam type of surfacing is well adapted to main ways connecting centers of population on which there is a moderate volume of travel. The roads less traveled may be surfaced with gravel. Roads of sand-clay and of burnt-clay furnish an economical form of construction in localities having no hard materials available.

LOCATION.

Whatever the type of road, proper grades and drainage are
6 of the utmost importance. All grades should of course be as nearly level as possible. However, in road construction little is ordinarily done beyond reducing the hills to the maximum
7 grade adopted and removing the irregularities between the hills. In American practice the maximum grade for important roads has been generally fixed at 5 per cent, where such a grade can be had without too great cost for cutting and filling and for payment for damage to abutting property. By 5 per cent is meant a vertical rise of 5 feet in 100 feet of horizontal dis-

tance.[7] In the endeavor to secure routes covering the shortest distances between fixed points a road is often made to go over a steep hill instead of around it. Steep grades become covered at times with coats of ice or slippery soil, making them very difficult to ascend with loaded vehicles as well as dangerous to descend.

DRAINAGE.

The surface water should always have opportunity to drain from the roadway as quickly as possible, and water should never be permitted to remain under a road. The road surface must be "crowned" or rounded up toward the center, so that 8
there may be a fall of from ½ inch to 1 inch to the foot from the center to the sides, thus compelling the water to flow rap- 9
idly from the surface into the gutters, which should be constructed on one or both sides of the road. The fall from the center to the sides on macadam roads need not be so great as on earth or gravel roads. To prevent the washing of the gutters into deep gullies, they may be paved with bricks or field stones, or side drains may be constructed, consisting of narrow trenches filled with broken stones or small gravel stones, with 10
a pipe 5 or 6 inches in diameter near the bottom. The pipe is carried to a proper outlet. Sometimes the pipe is omitted and the entire trench is filled with stones, in which case it is called a "blind drain." Such drains serve to cut off the subsurface water before it can get under the road. The water should never be carried in the gutters or in side ditches any farther than is necessary. When the volume of water is small it may often be conducted across the road in tile pipes buried sufficiently deep so as not to be broken by vehicles upon the road. For large volumes of water, culverts of rubble masonry or 11
Portland cement concrete may be built.

EARTH ROADS.

Owing to the absence in many sections of the country of rock, gravel, or other hard substances with which to build durable roads and because of the excessive cost of such material where it is transported from a distance, the majority of our public highways are necessarily earth roads. The split-log 12
drag has been of great service in the improvement of earth roads. This simple implement is made of the halves of a split log framed together by wooden braces about 3 feet in length, 13
so that the split surfaces of the log shall be in front. The face of the drag lies at an angle of 45° with the line of the road, thus drawing the earth toward the center. The rear log should 14
follow in the track of the first. Drags should be used just

View.

after rains or continued wet weather to smooth the earth surface and prevent ruts from forming to hold the water. The drag not only smooths the road but crowns it and puddles the mud so that it is hard when dry. These drags have been used with success on clay or water-holding soils, and many sections of rural roads are maintained by the use of this implement alone. Every farmer should own one and after a rain he should spend a few hours dragging the road adjacent to his farm. If there are many depressions to fill the drag should be used when the road is wet, but after it has made the road fairly smooth it gives the best results if used when the earth begins to dry. All stumps, roots, vegetable matter, rocks, etc., should be first removed from the surface and the holes filled in with suitable material. The width of the traveled way should depend upon the requirements of traffic and should ordinarily be from 12 to 18 feet.

SAND-CLAY ROADS.

Natural sand-clay roads may frequently be found in localities where the soil contains the right proportions of sand and clay. In sections of the country where the prevailing subsoil is composed entirely of clay, or, on the other hand, is of an extremely sandy character, these materials may be properly mixed so as to overcome the objectionable features of each, provided the material to be added is conveniently available. Sand-clay roads are well adapted for light traffic, and when the cheapness of this kind of construction is considered it will be seen that for certain localities it is preferable to macadam. The best sand-clay road is one in which the wearing surface is composed of grains of sand in contact in such a way that the voids or angular spaces between the grains are entirely filled with clay, which acts as a binder.

If natural drainage does not exist, artificial methods must be used. The best natural drainage is usually found upon a loose gravel or a sandy soil. If the land is dry and the sand deep enough to absorb quickly the heaviest rains, no special attention need be given to drainage of sand-clay roads other than to provide the proper crown to the surface of the finished road to divert the water from it. The roadbed should first be crowned as nearly as possible to the form desired in the finished road. If the clay is to be placed upon sand, it will be found more economical to crown first a section of the road nearest the source of the clay. The first load of clay is dumped on this prepared section at the point nearest the clay bed, each succeeding load thus being hauled over the preceding. The materials should not be mixed in a dry state, but, on the other hand, they should be thoroughly mixed and puddled with water. This is most

View.

easily brought about after a hard rain, the clay having been previously spread and the larger lumps broken up. The surface should then be covered with a few inches of sand and plowed and harrowed thoroughly by means of a turning plow and a cutaway or disk harrow. In cases where the plowing and harrowing are considered too expensive the mixing may be left to traffic. If the sand is to be placed upon a clay subsoil, the clay surface should be plowed and harrowed to a depth of about 4 inches and then covered with 6 or 8 inches of sand. Upon the completion of the mixing and puddling the road should be shaped while it is still soft enough to be properly finished with a scraper, and at the same time stiff enough to pack well under the roller or under the action of traffic.[8]

22 23

BURNT-CLAY ROADS.

In large areas in the South there is little or no sand to be found, and the clays are of a particularly plastic and sticky variety. These clays may be burned so as not only to destroy their plastic qualities, but also as far as possible to form hard, brick-like lumps capable of sustaining traffic.

The road is first plowed up from ditch to ditch; furrows are then dug across the road about 4 feet apart and extending through and beyond the width to be burned. The first course of wood is laid longitudinally, so as to form a series of flues in which the firing is started. Another layer of wood is thrown irregularly across this floor in crib formation, with spaces left between in which the lumps of clay are piled. Then a third course of wood is laid parallel to the first, and each opening and crack filled with brush, chips, bark, small sticks, or any other combustible material. A deep covering of clay is finally placed on top. The whole is then tamped and rounded off so that the heat will be held within the flues as long as possible. The fires are started on the windward side, 15 flues at a time. After the burned surface is sufficiently cooled to permit working it is smoothed down to form a proper crown and rolled. The subgrade is burned as well as the material above.[9]

24 25 26

DUST PREVENTIVES.

Tars, oils, and various other substances are increasing in use for road-surface application. These preparations are intended to fix the wearing coat upon the road to prevent dust and to form a waterproof coating. Owing to the increasing use of motor vehicles, treatment of this kind seems essential to preserve the wearing surface of roads where there is much of this sort of traffic. The tar and oil are sprinkled upon the road hot: generally a layer of sand or screenings is scattered on top.

27 28

View.

The tarred roads are hard, smooth, and resemble asphalt, except that they show a more gritty surface.[10]

HARD ROADS.

Gravel Roads.—Although it is impracticable and in many cases impossible for communities to build good stone roads, a surface of gravel may frequently be used to advantage, giving far better results than could be obtained by the use of earth alone. Seaside and river gravel, which is composed usually of rounded, water-worn pebbles, is unfit for surfacing roads. It has no angular projections or sharp edges, and will not bind together. Inferior qualities of gravel can sometimes be used for foundations, but where it becomes necessary to employ such material even for that purpose it is well to mix just enough sandy or clayey loam to bind it firmly together. For the wearing surface or the top layer the pebbles should, if possible, be comparatively clean, hard, angular, and tough, so that they will readily consolidate and will not be easily pulverized by the impact of traffic into dust and mud. They should be coarse, varying in size from a half inch to an inch and a half.

The best gravel for road building stands perpendicular in the bank; that is, when the pit has been opened up, the remainder stands compact and firm and can not be dislodged except by the use of a pick, and when it gives way falls in solid masses. Such material usually contains tough, angular gravel, and may be placed on a properly prepared roadbed without further treatment.

In constructing a gravel road the roadbed should be first brought to the proper grade; ordinarily an excavation is then made to the depth of 8 to 10 inches, varying in width with the requirements of traffic. The surface of the roadbed should have a fall from the center to the sides the same as that to be given the finished road, and should if possible be thoroughly rolled and consolidated until perfectly smooth and firm. A layer of good gravel not thicker than 6 inches should then be
29 spread evenly over the prepared roadbed. Next a roller should be used, or, if this can not be had, the road may be thrown open to traffic until it becomes fairly well consolidated. If the gravel is too dry to consolidate easily, it should be kept moist by sprinkling. As soon as the first layer has been properly consolidated, a second and if necessary a third layer, each about 6 inches thick, is spread on and treated in the same manner until the road is built up to the required thickness and cross section. The last or surface layer should be rolled or left to be consolidated until the wheels of heavily loaded vehicles passing over it make no visible impression.[11]

View.

Shell Roads.—In many of the Eastern and Southern States road stones are not available, nor is it possible to secure good coarse gravel. Oyster shells can be secured cheaply in most of these States, and when applied in a layer of 6 inches and rolled, with a similar top layer, directly upon sand or sandy soil, form excellent roads for light traffic. Shells wear much more rapidly than broken stone or gravel of good quality, and consequently roads made of them require more constant attention to keep them in good order.[12]

Stone Roads.—For ordinary country roads experience has shown that the broken-stone way need not be more than from 12 to 15 feet wide, if suitable shoulders 3 to 5 feet wide are built on each side of the stone. The modern practice is to make the macadam surface as thin as possible, yet with sufficient body to stay in place, the theory being that the macadam is only a wearing surface. Three inches of macadam, after rolling, is the least thickness which is practicable, and, except in unusual cases, a depth greater than 6 inches after rolling is rarely necessary, if the foundation is suitable. The material of the foundation is of much importance. It should be composed of porous material free from clay or loam and sufficiently strong to sustain any load likely to come upon it.

The principal qualities necessary in road-building stones are hardness and toughness. Trap rock has long been considered the best material for macadam purposes, but, except in certain localities, these stones are not common. Stone from a ledge, because of its uniformity in desirable qualities, is usually better than field stone and makes a smoother and more durable road, but if the ledge is of an inferior grade of rock it should not be used merely because it is ledge in preference to field stone of a better quality of rock.

Tools and Machinery.—In addition to the shovels, picks, and other ordinary implements of construction, a considerable outlay for machinery is necessary. Portable stone-crushing outfits may be bought at prices ranging from $1,600 to $2,500 and 30
are well adapted for country use. From 80 to 100 tons (60 to 80 cubic yards) of broken stone per day may reasonably be expected if the plant is kept in good condition. Steam road rollers are now used to a great extent. Macadam roads may of course be built with rollers drawn by horses; they may also be built without any rolling other than results from the wheels of moving vehicles. There are several excellent makes of steam rollers which may be had at prices ranging from $2,500 to $3,500. Since water is always needed in rolling macadam, a watering cart or sprinkler should be provided with a capacity of from 450 to 600 gallons. A road machine is a most service-

View.

able implement in shaping and repairing earth roads and in
31 preparing the foundation for macadam roads.

The importance of proper grades and drainage for all roads has already been mentioned. It is not enough that the roadway for a macadam road shall be graded with reasonable care. The surface upon which the broken stones are to be placed must be hard, smooth, and carefully crowned. If the foundation is not hard and firm, the stones will be pressed into it by the roller and wasted. Usually a trough-shaped section is made, sufficient material being left on the sides to form shoulders for
32 the macadam. After the roadbed is shaped to the approximate cross section it should be rolled thoroughly until it is hard, firm, and smooth.

Stones ranging in diameter from 1¼ to 2½ inches should be
33 spread first for the lower course, to a depth which will allow for a shrinkage of 35 per cent under the roller. When 100 feet
34 or so of the first course of stone has been spread, the rolling should begin. It will be found best to begin the rolling at the outer edge of the macadam, running upon the shoulder a few inches. The second course, consisting of stones varying in
35 diameter between ½ inch and 1¼ inches, should be spread and rolled as was the lower course. After the stones are thoroughly
36 compacted the binder should be spread. This top course is usually a little more than 1 inch in depth in 6-inch work. The
37 watering cart should then be put on in advance of the roller and as much as possible of the dust flushed into the interstices
38 between the stones. The roadway should be wet and rolled until it puddles on the surface, showing that the voids are substantially filled.

All trees which are ornamental or which are of value as shade trees should be preserved and protected. They are a considerable factor in reducing the cost of maintenance, since they lessen the evaporation of the moisture from the macadam. They add greatly to the attractiveness of the road. A good arrangement for trees with large tops is to set them about 50 feet apart on each side of the road, but alternated, so that there will be a tree every 25 feet along the road.[13]

39 MAINTENANCE.—Some one has said that the maintenance of a macadam road should begin on the day the road is completed,
40 and this is true of all types of roads. The mistake is often made of building a fine road and then allowing it to go to ruin.
41 It is usually not necessary to do much to the macadam surface for a year or two except to fill any small holes or incipient ruts which may occur. It is well to have piles of material for mending the road placed at convenient intervals along its length.

ROAD ADMINISTRATION.

The administration of the road funds of any community, to be successful, must be conducted along business lines. When we consider that there are in round numbers 2,152,000 miles of public roads in the United States and that approximately $80,000,000 are expended upon them every year, we realize that so large a sum should be carefully spent and in accordance with business principles.[14] In the first place, road administration should be free from political influence. Secondly, men specially trained for their work are essential. It seems to be a popular opinion that any one can build a road and that special training is unnecessary, and yet no man in building a house would dream of hiring painters to lay the brick and bricklayers to do the painting. This is the reason statute labor is inefficient. Each man does his share of the work ignorantly and grudgingly, and is not required to have any knowledge of road construction.

A good system would be to have a highway engineer competent to pass upon any question affecting the construction or maintenance of roads placed in charge of the road work of the county. He should report directly to the county court. This engineer should be responsible for road construction; for the repair and maintenance of roads; should prepare contracts and specifications; repair and maintain bridges; have charge of all road machinery and purchase all material, and should account regularly to the county court for all money expended under his direction. If one county could not afford to employ an engineer, two or three counties might share the expense and the benefits. Under this engineer's immediate jurisdiction should be placed a certain number of skilled road supervisors or road overseers, each having a given territory for which he is responsible. In his territory the overseer should have direct supervision over every road gang, and each gang should be in charge of a foreman. Under this system of organization there would be no waste of public revenues in ill-conducted efforts at road building, for every item of work performed would be a part of a general system devised in the office of the highway engineer and approved by the county court.

In some cases it might be found better to centralize the road work and authority of the State under direction of a State engineer, with his corps of assistant engineers acting in lieu of the county engineers described in the last paragraph. This State system would probably have the advantage of less aggregate outlay for engineers and provide a more methodical system of county roads; but on the other hand there would be lacking an intimate knowledge of local needs and conditions which would be possessed by the county engineer. The State system would also weaken in a measure local authority over roads.

APPENDIX.

LANTERN SLIDES.

No. of view.

1. One bale of cotton hauled with difficulty.
   Taken by S. C. Lancaster, Office of Public Roads.
2. Eleven bales of cotton hauled on same road as in No. 1 after it had been improved.
   Taken by S. C. Lancaster, Office of Public Roads.
3. A rise of value in real estate due to an improved road.
   The owner of this land gave up living on it because of the bad road and sold it for $1,500 to the present owner. A short time after the sale the road was improved as shown in the picture, and the first owner offered to buy it back for $3,000. This was refused. He afterwards offered $5,000 for the farm and was again refused. The first owner lived in the little cabin, but the purchaser built himself a good home.
   Taken by S. C. Lancaster, Office of Public Roads.
4. Clay road before improvement.
   From U. S. Dept. Agr., Office of Public Roads Bul. 27, Pl. I.
5. Same road as in No. 4 after improvement.
6. The road should be well located, with easy curves.
7. A well-located road on a sidehill.
8. Crown on earth road.
9. Road with center lower than sides and consequent formation of mud holes.
10. Side drain under construction.
    From U. S. Dept. Agr., Office of Public Roads Bul. 29, Pl. III.
11. Concrete culvert.
12. Perspective view of split-log drag.
13. Plan and elevation of split-log drag.
14. Road before dragging.
15. Side view of drag.
16. Drag in use.
17. Rear view of drag.
18. Road after dragging.
19. Road in Arkansas before dragging.
20. Same road as in No. 19 after having been dragged for one year.
21. Sandy road difficult to travel over.
    From U. S. Dept. Agr., Office of Public Roads Bul. 27, Pl. I.
22. Sand-clay road in process of construction.
    From U. S. Dept. Agr., Office of Public Roads Bul. 27, Pl. II.
23. Finished sand-clay road.
24. First course of wood laid across trenches. (In foreground.)
25. Pile of clay and wood completed and firing started.
26. Surface of burnt clay smoothed and crowned.

No. of view.

27. Dust raised by automobile going at high speed.

28. Tar poured on road and spread with brooms.

29. Finished gravel road.

30. Portable crushing plant, including stone crusher, engine, and boiler, portable bins, revolving screen, and elevator to lift the stone after it is broken and to discharge it into the screen.

From U. S. Dept. Agr., Office of Public Roads Bul. 29, Pl. II.

31. Preparing subgrade with road machine drawn by traction engine.

32. Subgrade of road being rolled to make it hard and smooth.

33. First course of stone.

34. Showing placing of first course of stone.

35. Second course of stone.

36. Second course after rolling.

37. Binder course.

38. Completed road surface.

39. Road in Missouri in almost impassable condition.

40. The transformation wrought by an improved highway.

41. Showing variety of traffic over a well-built road.

Taken by S. C. Lancaster, Office of Public Roads.

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8. U. S. Dept. Agr., Office of Public Roads Bul. 27.
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11. U. S. Dept. Agr., Farmers' Bul. 95.
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13. U. S. Dept. Agr., Office of Public Roads Bul. 29, p. 23.
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Public road mileage and expenditures in the United States in 1904.

State.	Mileage. All public roads. Total mileage.	Miles of road per square mile of area.	Population per mile of road.	Mileage. Improved roads. Surfaced with gravel.	Surfaced with stone.	Surfaced with other materials.	Total mileage of improved roads.	Percentage of all roads improved.	Expenditures. By counties, townships, and districts. From property and poll taxes payable in cash.[a]	From labor taxes.[b]	From bond issues.	By States on State-aid roads.	Total.	Per mile of public road.	Per inhabitant.
	Miles.	*Miles.*		*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Per ct.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*
Alabama	50,089	0.97	36	1,261.5	392.5	66	1,720	3.43	378,039.77	1,198,394.50			1,576,434.27	31.47	0.86
Arizona	5,987	.05	20	216	1	0	217	3.62	67,591.43	41,718.00			109,309.43	18.25	.89
Arkansas	36,445	.67	36	181	55	0	236	.64	681,933.80	713,409.00			1,395,342.80	38.28	1.06
California	46,653	.29	31	5,843.5	418.5	2,541.5	8,803.5	18.87	2,146,145.36			11,251.00	2,157,396.36	46.24	1.45
Colorado	30,214	.30	17	121	57	0	178	.58	601,060.63	71,828.00		34,335.00	707,223.63	23.40	1.31
Connecticut	14,088	2.90	64	1,896.5	463.6	0	2,360.1	16.75	975,960.01			219,165.00	1,195,125.01	84.83	1.32
Delaware	3,000	1.53	61	2	14	50	66	2.20	76,802.88			14,000.00	90,802.88	30.26	.49
District of Columbia	191	3.18	1,459	70	61	0	131	68.58	176,000.00				[c] 176,000.00	921.46	.63
Florida	17,374	.34	30	17.5	345	523	885.5	5.09	437,184.10	140,395.00			577,577.10	33.24	1.09
Georgia	57,203	.96	38	659	438	537	1,634	2.85	894,936.33	1,185,936.00			2,080,872.33	36.37	.93
Idaho	18,163	.20	9	195	17	0	212	1.16	201,648.00	409,940.00			311,588.00	17.15	1.92
Illinois	94,141	1.60	51	6,800	1,106.5	17.5	7,924	8.41	[d] 3,844,423.73	[e] 366,526.50			4,210,950.23	44.73	.87
Indiana	68,306	1.90	36	20,582	3,295	0	23,877	34.94	[d] 2,095,970.30	[e] 896,718.75	1,342,418.95		4,335,108.00	63.46	1.72
Iowa	102,448	1.81	21	1,403	241	20	1,664	1.62	[d] 2,344,106.50	762,501.00			3,106,607.50	30.32	1.39
Kansas	101,196	1.20	14	158.5	111.7	3	273.2	1.26	[d] 692,823.45	[e] 539,994.00			1,232,817.45	12.18	.83
Kentucky	57,137	1.40	37	1,408	8,078	0	9,486	16.60	[d] 1,161,194.03	987,495.00			2,148,689.03	37.60	1.00
Louisiana	24,897	.54	55	26	0	8	34	.13	345,451.86	606,421.00			951,872.86	38.23	.68
Maine	25,528	.85	27	2,236	87.5	0	2,323.5	9.10	1,427,508.21			44,885.49	1,472,393.70	57.67	2.12
Maryland	16,773	1.70	70	480	840	250	1,570	9.35	873,470.50				873,470.50	52.07	.73
Massachusetts	17,092	2.12	164	6,621.1	1,212.7	10	7,843.8	45.89	2,295,616.48			575,605.99	2,871,222.47	167.98	1.02
Michigan	69,296	1.20	35	6,777	248.5	0	7,025.5	10.13	[d] 1,816,504.21	[e] 1,363,283.67			3,179,787.88	45.88	1.31
Minnesota	79,324	1.00	22	6,179	67.5	1	6,247.5	7.87	[d] 1,542,641.99	[e] 354,212.25	64,775.00		1,961,629.24	24.72	1.12
Mississippi	38,698	.83	10	109	0	40	140	.38	339,669.45	1,335,816.00			1,675,485.45	43.29	1.08
Missouri	108,133	1.50	28	1,871.5	861.5	0	2,733	2.52	[d] 1,570,801.29	798,171.50			2,368,972.79	21.90	.76
Montana	22,449	.15	10	65	0	0	65	.28	308,743.81	95,354.00			404,097.81	18.02	1.66

[a] This column includes property taxes and poll taxes payable in cash. In some States, however, property taxes may be worked out. See footnote *d*. It has been impossible to ascertain the extent to which such taxes were actually paid in labor instead of in cash.

[b] This column includes labor taxes, and poll taxes payable in labor. In some States, however, the statutes permit the payment of labor taxes in cash. See footnote *e*. It has been impossible to ascertain what part of these taxes were so paid.

[c] One-half the cost of road construction and repairs in the District of Columbia is paid from Congressional appropriation, the other half by the District out of the general revenues from taxation of property.

[d] Part of this amount was paid in labor instead of in cash, as provided for in the law of this State. See footnote *a*.

[e] Part of this amount was paid in cash instead of labor, as provided for by the laws of this State. See footnote *b*.

Public road mileage and expenditures in the United States in 1904—Continued.

State.	Mileage.								Expenditures.						
	All public roads.			Improved roads.					By counties, townships, and districts.						
	Total mileage.	Miles of road per square mile of area.	Population per mile of road.	Surfaced with gravel.	Surfaced with stone.	Surfaced with other materials.	Total mileage of improved roads.	Percentage of all roads improved.	From property and poll taxes payable in cash.	From labor taxes.	From bond issues.	By States on State-aid roads.	Total.	Per mile of public road.	Per inhabitant.
	Miles.	*Miles.*		*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Per ct.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*
Nebraska	79,462	1.00	13	0	17	6	23	0.02	[a] 494,886.40	383,661.00			878,547.40	11.05	0.82
Nevada	12,585	.11	3	60	4	0	64	.50	46,875.85				46,875.85	3.72	1.10
New Hampshire	15,116	1.67	27	1,175	118	0	1,293	8.55	828,606.35			44,000.00	872,606.35	57.72	2.12
New Jersey	14,842	1.97	127	481.5	1,901	40	2,422.5	16.32	3,024,811.25			250,000.00	3,274,811.25	220.64	1.75
New Mexico	15,326	.12	12	2	0	0	2	.01	35,457.56	130,194.00			165,651.56	10.80	.84
New York	73,798	1.54	98	3,692	2,184	0	5,876	7.96	2,881,268.99	1,754,785.83		1,056,460.00	5,692,514.82	77.05	.79
North Carolina	49,763	1.00	38	422	399	438	1,259	2.52	624,380.78	734,306.45			1,358,687.23	27.30	.71
North Dakota	59,332	.84	5	205	7	0	212	.35	[a] 456,130.22	[b] 94,210.50			550,340.72	9.28	1.72
Ohio	69,439	1.79	59	16,159	7,160.5	142.7	23,462.2	33.78	[a] 3,932,563.97	[b] 929,766.00	843,753.64		5,706,083.61	82.17	1.37
Oklahoma	43,554	1.10	9	0	0	0	0	.....	[a] 447,319.59	[b] 327,456.00			774,775.59	17.79	1.94
Oregon	34,258	.36	12	2,235	209	145	2,589	7.55	649,717.97	146,658.00			796,375.97	23.24	1.92
Pennsylvania	99,777	2.21	63	0	2,161	0	2,161	2.10	[a] 4,759,499.16			127,766.52	4,887,265.68	48.98	.77
Rhode Island	2,361	2.24	181	774.5	247	0	1,021.5	43.26	297,414.71			79,397.45	376,812.16	171.44	.94
South Carolina	41,830	1.30	32	179	69	1,630	1,878	4.48	334,081.90	411,619.60			745,701.50	17.82	.55
South Dakota	59,295	.70	7	147	4	0	151	.25	[a] 268,722.57	[b] 114,560.50			383,283.07	6.46	.95
Tennessee	48,989	1.17	41	2,511	1,774	0	4,285	8.74	386,013.85	892,635.75	343,127.55		1,621,777.15	33.10	.80
Texas	121,409	.46	25	167	1,909	52	2,128	1.75	1,607,216.70	[b] 1,594,545.00	936,395.79		4,138,157.49	34.08	1.35
Utah	7,090	.08	39	597	11	0	608	8.57	135,210.78	60,390.00		23,075.00	218,675.78	30.84	.79
Vermont	14,521	1.58	23	1,672.5	281	0	1,953.5	13.45	440,016.12			127,381.21	567,397.33	39.07	1.65
Virginia	51,812	1.29	35	720	755	125	1,600	3.08	687,751.06				687,751.06	13.27	.37
Washington	31,998	.48	16	1,928	48.5	0	1,976.5	6.17	1,344,842.19	91,228.00			1,436,070.19	44.88	2.77
West Virginia	26,178	1.06	36	26.5	217	11	254.5	.97	[a] 587,870.28	[b] 305,415.00			893,285.28	34.12	.93
Wisconsin	63,593	1.17	33	9,899.8	733.2	0	10,633	16.72	[a] 1,924,025.88	[b] 257,236.50			2,181,262.38	34.30	1.05
Wyoming	10,447	.10	8	0	0	153	153	1.46	[c] 324,475.73	[b] 21,456.00			345,931.73	9.45	1.04
Total	2,151,570	[d] .73	[d] 35	108,232.9	38,621.7	6,809.7	153,664.3	7.14	53,815,387.98	19,818,236.30	3,530,470.93	2,607,322.66	79,771,417.87	[d] 37.07	[d] 1.05

[a] Part of this amount was paid in labor instead of in cash, as provided for in the law of this State. See footnote *a* on preceding page.
[b] Part of this amount was paid in cash instead of labor, as provided for by the laws of this State. See footnote *b* on preceding page.
[c] Of this amount $250,000 was expended for roads in Yellowstone National Park, appropriated by Congress and expended under the direction of a United States Army engineer.
[d] This figure was obtained from a comparison of totals.

O

ROAD ADMINISTRATION.

The administration of the road funds of any community, to be successful, must be conducted along business lines. When we consider that there are in round numbers 2,152,000 miles of public roads in the United States and that approximately $80,000,000 are expended upon them every year, we realize that so large a sum should be carefully spent and in accordance with business principles.[14] In the first place, road administration should be free from political influence. Secondly, men specially trained for their work are essential. It seems to be a popular opinion that any one can build a road and that special training is unnecessary, and yet no man in building a house would dream of hiring painters to lay the brick and bricklayers to do the painting. This is the reason statute labor is inefficient. Each man does his share of the work ignorantly and grudgingly, and is not required to have any knowledge of road construction.

A good system would be to have a highway engineer competent to pass upon any question affecting the construction or maintenance of roads placed in charge of the road work of the county. He should report directly to the county court. This engineer should be responsible for road construction; for the repair and maintenance of roads; should prepare contracts and specifications; repair and maintain bridges; have charge of all road machinery and purchase all material, and should account regularly to the county court for all money expended under his direction. If one county could not afford to employ an engineer, two or three counties might share the expense and the benefits. Under this engineer's immediate jurisdiction should be placed a certain number of skilled road supervisors or road overseers, each having a given territory for which he is responsible. In his territory the overseer should have direct supervision over every road gang, and each gang should be in charge of a foreman. Under this system of organization there would be no waste of public revenues in ill-conducted efforts at road building, for every item of work performed would be a part of a general system devised in the office of the highway engineer and approved by the county court.

In some cases it might be found better to centralize the road work and authority of the State under direction of a State engineer, with his corps of assistant engineers acting in lieu of the county engineers described in the last paragraph. This State system would probably have the advantage of less aggregate outlay for engineers and provide a more methodical system of county roads; but on the other hand there would be lacking an intimate knowledge of local needs and conditions which would be possessed by the county engineer. The State system would also weaken in a measure local authority over roads.

APPENDIX.

LANTERN SLIDES.

No. of view.

1. One bale of cotton hauled with difficulty.
   Taken by S. C. Lancaster, Office of Public Roads.
2. Eleven bales of cotton hauled on same road as in No. 1 after it had been improved.
   Taken by S. C. Lancaster, Office of Public Roads.
3. A rise of value in real estate due to an improved road.
   The owner of this land gave up living on it because of the bad road and sold it for $1,500 to the present owner. A short time after the sale the road was improved as shown in the picture, and the first owner offered to buy it back for $3,000. This was refused. He afterwards offered $5,000 for the farm and was again refused. The first owner lived in the little cabin, but the purchaser built himself a good home.
   Taken by S. C. Lancaster, Office of Public Roads.
4. Clay road before improvement.
   From U. S. Dept. Agr., Office of Public Roads Bul. 27, Pl. I.
5. Same road as in No. 4 after improvement.
6. The road should be well located, with easy curves.
7. A well-located road on a sidehill.
8. Crown on earth road.
9. Road with center lower than sides and consequent formation of mud holes.
10. Side drain under construction.
    From U. S. Dept. Agr., Office of Public Roads Bul. 29, Pl. III.
11. Concrete culvert.
12. Perspective view of split-log drag.
13. Plan and elevation of split-log drag.
14. Road before dragging.
15. Side view of drag.
16. Drag in use.
17. Rear view of drag.
18. Road after dragging.
19. Road in Arkansas before dragging.
20. Same road as in No. 19 after having been dragged for one year.
21. Sandy road difficult to travel over.
    From U. S. Dept. Agr., Office of Public Roads Bul. 27, Pl. I.
22. Sand-clay road in process of construction.
    From U. S. Dept. Agr., Office of Public Roads Bul. 27, Pl. II.
23. Finished sand-clay road.
24. First course of wood laid across trenches. (In foreground.)
25. Pile of clay and wood completed and firing started.
26. Surface of burnt clay smoothed and crowned.

No. of view.

27. Dust raised by automobile going at high speed.

28. Tar poured on road and spread with brooms.

29. Finished gravel road.

30. Portable crushing plant, including stone crusher, engine, and boiler, portable bins, revolving screen, and elevator to lift the stone after it is broken and to discharge it into the screen.

From U. S. Dept. Agr., Office of Public Roads Bul. 29, Pl. II.

31. Preparing subgrade with road machine drawn by traction engine.

32. Subgrade of road being rolled to make it hard and smooth.

33. First course of stone.

34. Showing placing of first course of stone.

35. Second course of stone.

36. Second course after rolling.

37. Binder course.

38. Completed road surface.

39. Road in Missouri in almost impassable condition.

40. The transformation wrought by an improved highway.

41. Showing variety of traffic over a well-built road.

Taken by S. C. Lancaster, Office of Public Roads.

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