

on which King Cheops employed 100,000 men for a period of ten years. The historian informs us that this road, when completed, was of massive stone blocks ten feet in thickness, and lined on either side with temples, mausoleums, porticos and statues. The main purpose of this road was to afford a passage over the sandy desert for the tremendous quantities of stone and other material needed in the construction of the Great Pyramids.

Babylon, the city of hanging gardens and great walls, did not neglect the construction of roads and bridges, which were so essential to her military and commercial supremacy. Strabo informs us that the streets of Babylon were paved about 2000 B.C., and that splendid thoroughfares radiated to Memphis, Susa, Ecbatana and Sardis. Herodotus speaks of a great royal road extending from Susa to Sardis, a distance of about 312 miles, along which stations were established at intervals of 18 to 25 miles, where the couriers were supplied with fresh mounts. The distance travelled by these couriers is estimated at from 60 to 120 miles a day. It is asserted that asphalt was used as a mortar in building the great walls around Babylon nearly 2000 years before Christ.

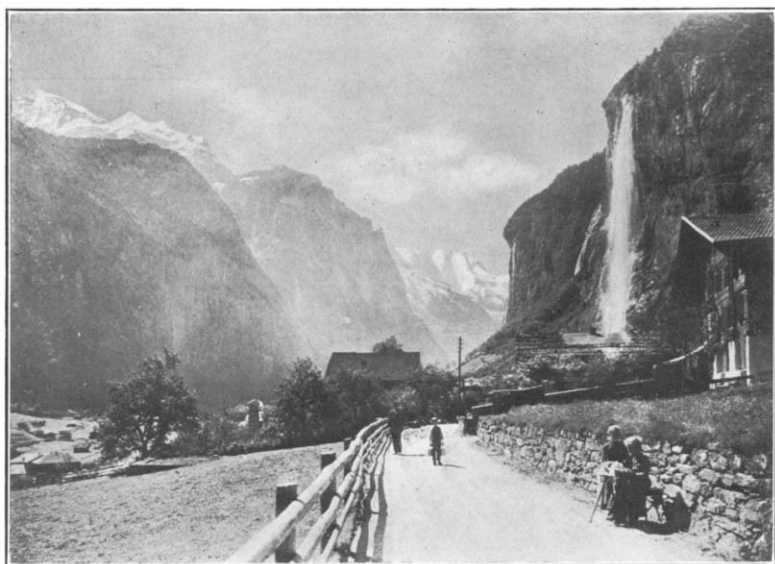
The Romans are generally supposed to have learned the art of road building from the Carthaginians, though authentic records of this seem lacking. The destruction of Carthage was so complete that scarcely a trace is left of her ancient road system to tell either of its extent or its character. In Gaul, no less than 13,000 miles of road are said to have been improved, and in Britain at least 2500 miles. The great military roads which crossed the Alps traversed westward through Gaul to Spain, and eastward to Austria and the regions of the Danube, and even Africa and Asia were included in this great highway system. It is estimated that under present conditions such roads as the Appian Way would cost upward of \$200,000 per mile, for the Roman system of construction was crude, expensive, and far more massive than conditions required.

After the fall of Rome a long period of inactivity followed, and the roads were allowed to fall into ruin and decay. It was not until the time of Louis XIV that any decided effort was made to again improve the roads of Europe. Under the administration of Colbert as Comptroller of Finance, which began in 1661, 15,000 miles of broken-stone roads were constructed. This

was done under the old feudal *Corvée*, or forced labor system, which imposed an almost unbearable hardship upon the peasantry. The *Corvée* was finally abolished in 1787.

The present superb road system of France was founded by Napoleon. He built many great roads throughout the Empire, among others the road over the Simplon Pass, which was begun in 1800 and required six years for completion. In 1775 the great French engineer, Tresauget, published the first treatise

FIG. 1.



Road in Lauterbrunnen, Switzerland.

on broken-stone roads, and also devised the system of continuous repair which is still practised by the French government. Too much credit cannot be given to the work of Tresauget. He was the real father of modern road building, and his work preceded that of MacAdam and Telford by about forty years.

In seeking a comparison between the systems of road administration in Europe and the United States by which we may profit in working out our road problems, we should go deeper than methods and practice and endeavor to understand the principles underlying each system. Administrative control of roads in

England and France, for example, has always followed diametrically opposite courses, the English always clinging to localized control, authority and responsibility, and the French throughout their entire history adhering to the plan of extreme centralization, whereby power began and ended with the central government. We are, therefore, justified in describing the road system of England as resting upon the basic principle of localized control and the French system as resting upon the basic principle of centralized control. Germany, being a confederation of states, affords an example midway between the extremes represented by

FIG. 2.



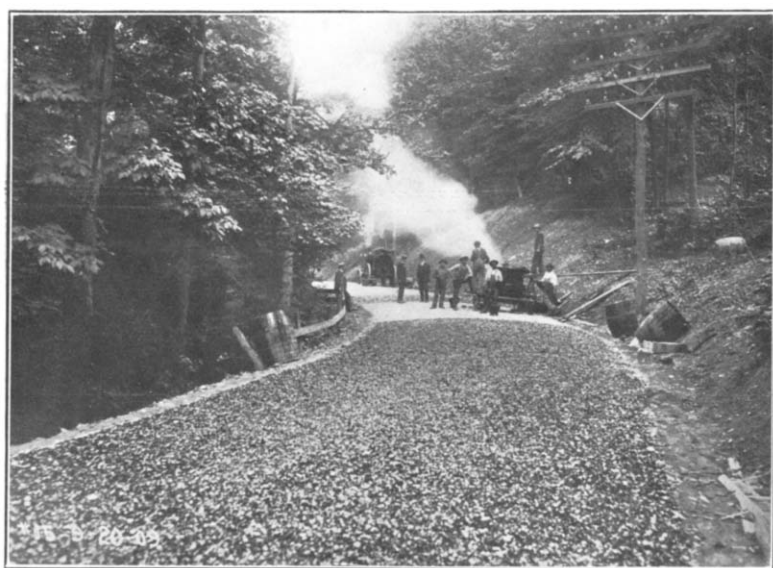
Bad road. Porto Rico, 1901.

England and France, while Switzerland having peculiar conditions by reason of geographical location, area and source of revenue, affords an exceptional example for study. I shall, therefore, confine my observations to the systems of administrative control in England, France, Germany and Switzerland, and endeavor to point out the salient features of each, and to institute such comparison with American systems as will best aid in arriving at a determination of our points of weakness and of strength. I shall include in my analysis of road administration the very important subject of road maintenance, which, although the product of effective administration, is so vital as to be worthy of special treatment and discussion.

The basis of the French system is the School of Roads and Bridges, one of the finest technical schools in the world, and maintained at the expense of the national government. From the graduates of this school are chosen the highway engineers who are entrusted with the building and maintenance of the roads in France.

At the head of the administrative organization is an inspector-general of bridges and highways, under whom are chief engineers

FIG. 3.



Tarred road under construction. — Utsen, N. Y.

in charge of the road work of single departments and communes. Single subdivisions of departments are under the direction of district engineers and assistant engineers, the latter being equal in rank to non-commissioned officers in the army. The subdivisions are under the direction of principal conductors and ordinary conductors. Next in line come the foremen of construction gangs, the clerks employed at headquarters, and finally the cantoniers or patrolmen, each having from 4 to 7 kilometers of highway under his immediate supervision. This great administrative machine, working in complete harmony with definite lines

of responsibility clearly established, accomplishes results with military precision and regularity. And, in this great army of workmen, not the least important unit is the cantonier or patrolman, who has charge of a single section of the road. He keeps the ditches open, carefully fills holes and ruts with broken stone, removes dust and deposits of sand and earth after heavy rains, trims the trees and bushes, and when ordinary work is impossible he breaks stone and transports it to the points where it is likely

FIG. 4.



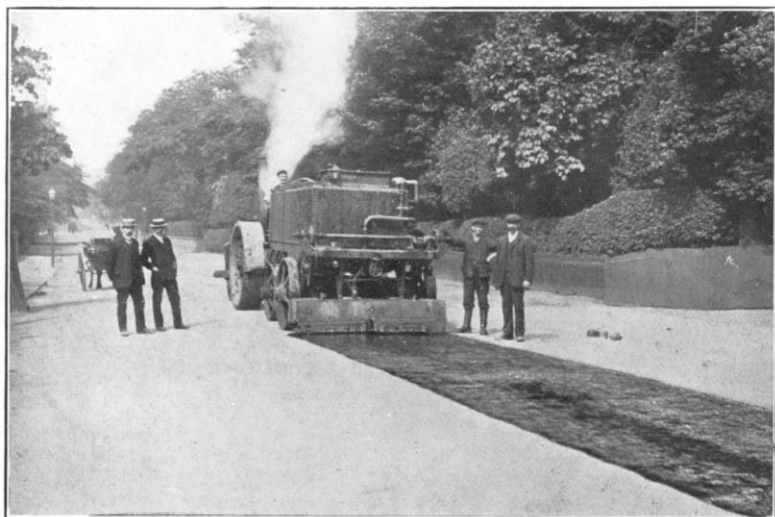
Tarred road completed. Ithaca, N. Y.

to be needed. He brings all matters requiring attention to the notice of his chief. The conductors go over the road at regular intervals and direct chief cantoniers, and all reports are transmitted to the central authorities, so that at any time the exact condition of the roads throughout France may be ascertained. Each year the conductors prepare estimates of necessary expenses for the next year under three heads, namely, Maintenance, Heavy Repair and New Work, and the government appropriations are based upon these careful estimates.

The first law in England relating to highways, of which we

have any record, was passed in 1285 and directed "those ways to be enlarged where bushes, woods or dykes be, where men may lurk." In 1346 a law was passed granting permission to levy toll on some of the roads leading out of London. This was the beginning of the toll system, which was as unsatisfactory as the parish system. The foundation of the statute labor system was laid in Great Britain in 1555 when an act was passed providing for the working of the roads in each parish by forced labor. Turnpikes or toll roads were first legally inaugurated throughout

FIG. 5



English tar spreader. Proed Aitken Machine.

England in 1663, and for a time gained considerable popularity. During the period from 1700 to 1770, 530 turnpike acts were passed by Parliament, and in 1840 there were in England and Wales 104,772 miles of turnpike road. The wastefulness and expense of this system became increasingly apparent and aroused such hostility on the part of the people that armed bodies of men assembled for the purpose of destroying the toll-gates. In 1871 the census showed that 5000 persons in England and Scotland were engaged in merely collecting tolls. In 1857 Ireland freed itself from toll-gates, and turnpike trusts were done away with

in England and Scotland by an act of Parliament in 1878. Since that time the policy of extreme localization has been somewhat modified by the more rational and practical plan of combining parishes into highway districts and requiring the county to bear a portion of the burden of maintaining the main roads.

There are at present 149,759 miles of road in England, for which the annual expenditure for the year 1905 to 1906 amounted

FIG. 6.

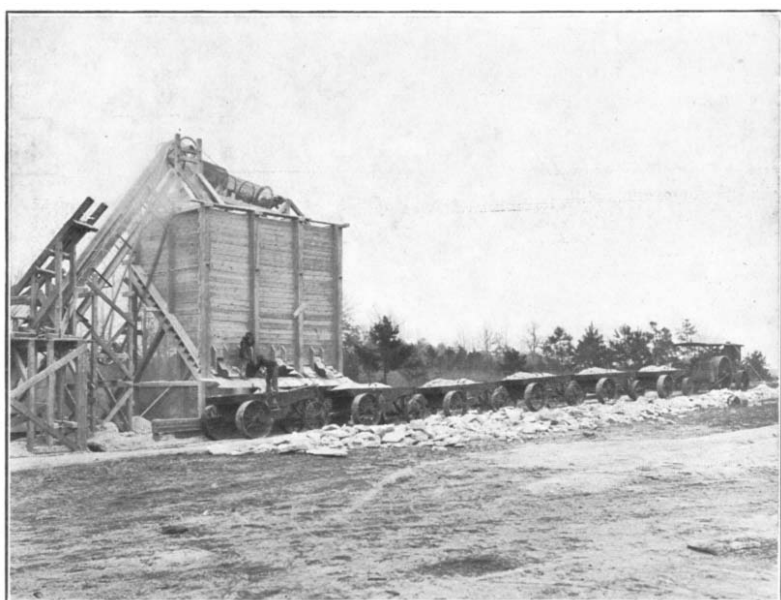


Constructing shell road on planks from bottom. New Orleans, La.

to \$78,050,000. The annual road expenditure per mile in England will thus be seen to be about \$520 per mile as against about \$38 per mile in the United States. In view of the fact that most of the principal roads of England have already been constructed, this large annual expenditure would appear to be devoted in a large measure to maintenance. It would also seem that a road system which requires an outlay of \$520 per mile for its entire mileage must be inefficient and costly. The explanation of this is found, perhaps, in the fact that in England the maintenance of the public highways devolves entirely on local authorities.

Jurisdiction over the road is vested in, first, the county boroughs; second, the county councils; third, the urban district councils; fourth, the rural district councils. The county boroughs are certain large towns which hold charters from the crown entitling them to the privilege of self-government. In this the maintenance of the highways devolves entirely upon the borough or town council. In most counties the maintenance of the highways devolves upon urban councils in the urban districts and rural coun-

FIG. 7.



Crushing plant, traction engine and train. Atlanta, Ga.

cils in the rural districts. The only exception to the control of the urban and rural district councils is in the case of main roads which are highways between large towns, and the maintenance of these roads devolves upon the county councils.

As to skilled supervision, it may be said that no qualifications are required by law to be possessed by the men in charge of road building and maintenance, but it is the general practice, at least in important districts, to appoint experienced highway engineers for this work. It will thus be seen that the English

system lacks strong central control in the counties, there being four different classes of government units, each acting largely independent of the others.

Germany is a confederation of States, and it follows that road administration is conducted separately by each State of the Empire. The Imperial Government exercises very little control over the highways, and does not in any way contribute toward their construction or maintenance. The Kingdom of Saxony

FIG. 8.



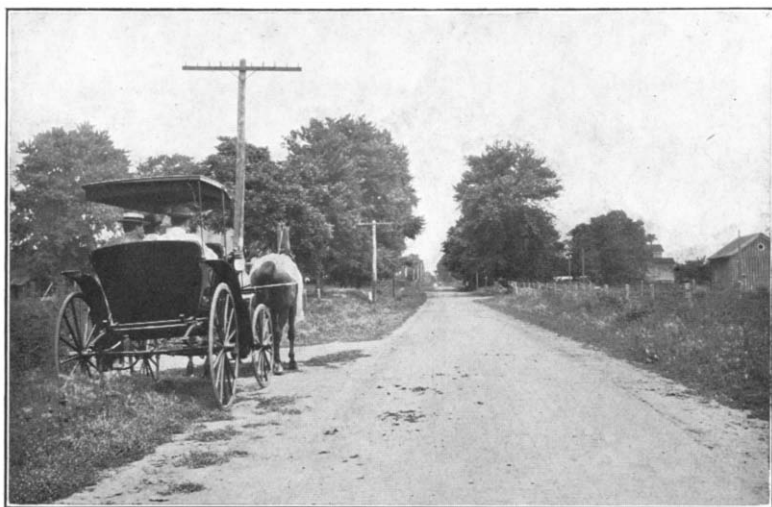
Macadam road. Chelmsford, Mass.

may be taken as a representative State of the German Empire. In Saxony the highways are divided into State roads, county roads and private ways. The State roads comprise those which are built and maintained by the State. The county roads are generally termed communicating roads, and are built and maintained at the expense of the parishes through which they lead. A striking feature of the Saxony road system is the practice of planting fruit trees along the road. The fruit yields a revenue of about \$10,000 a year from the State roads, while the amount

obtained from the fruit grown on the county roads represents a much larger sum.

The State roads are cared for by a commission of engineers. The kingdom is divided into 17 road districts, in each of which there is a road inspector. Under these inspectors are road masters who are employed constantly throughout the year. Each road master has about 37 miles of road under his direction and a road force of about 15 men. In the case of the minor roads, the direct responsibility is borne by the county authorities. They

FIG. 1



Brick road. Monmouth, Ill.

levy and collect the revenues necessary for maintenance and new construction. The communities engage the road employees for the continued care of the highways. The technical supervision, however, is exercised by the road masters of the State force.

The road system of Switzerland is local in character, the various cantons having jurisdiction over the roads within their respective borders. Each canton has at the head of its road system an engineer with capable assistants. In the canton of St. Gaul, which is fairly representative, there are under the control of the engineers 5 inspectors or road masters who are assigned to certain districts in the canton. The engineers and their assist-

ants must have an academic education and possess a diploma from the Polytechnic Institute, while the road masters are required to have a good technical education.

It is apparent from the foregoing that while the units of administration in European countries range all the way from the localism of England to the highly centralized system of France, through varying degrees, skilled supervision is provided for by all of the systems, as well as an ample cash revenue sufficient to en-

FIG. 12



Section, drag on dirt road. Arlington, Va.

able the engineers to carry out the plans for improvement and maintenance. England is the most striking example of extreme localization, and, it is a significant fact, also the most striking example of lack of uniformity in road work and of excessive expenditure in proportion to mileage. It is also significant that the most perfect road system is that of France, which is admittedly the most highly centralized of all the road systems. France, with a total mileage of about two and one-third times that of England, expends about the same amount annually for mainten-

ance. Certainly the inference must be plain, that centralization makes for economy and efficiency in the administration of the public roads.

It is instructive to contrast the developments in the United States with those in Europe. In mileage we have the most extensive system of roads which any country has ever possessed since the world began. During all the years since the white man first blazed a path through the wilderness in North America, our roads have been expanding in an ever increasing network, until we have to-day about 2,155,000 miles. Year by year we have been frittering away our millions maintaining the roads in their primitive condition, until the yearly tribute of road taxes in the United States amounts to over \$80,000,000, and our army of road overseers and supervisors has grown more than 100,000 strong. England, with only 150,000 miles of road, expends about \$80,000,000 a year, or nearly fourteen times as much per mile. According to the latest road census we have less than 40,000 miles of road surfaced with stone, or less than 2 per cent. of our total mileage, and practically no provision for maintaining even these. Small as our annual expenditure for roads has been, it has aggregated during the forty years from 1870 to 1910 a total of upward of \$2,600,000,000. We may, therefore, say that road building in the United States, considering area, population and wealth, is practically at the same point at which it stood 40 years ago, and the \$2,600,000,000 expended have produced few appreciable results.

The reason for this is not hard to find. When we turn to the subject of road administration in the United States we find that about half of the States are operating under practically the same road laws as prevailed in England when America was a colony. This system of road administration provides for the payment of road taxes partly in labor, and localizes the work to an extreme degree. Organization is almost entirely lacking and no requirements are made to secure skill or knowledge on the part of the road officials. With few exceptions, no system of accounting is in force, and no definite lines of authority are established, such as would guarantee the wise and equitable conduct of the work.

In the last 20 years a number of the States have gradually broken away from this antiquated system, and it is to these

States that we must turn for examples of the best results in road building in the United States. About half of our States at present have adopted in principle or practice, or both, the system of centralizing conduct of all parts of the road work in the State under a State highway department, thereby securing uniformity in methods, economy and skill in supervision. In some of the State highway departments the work is educational and investigative, with a view to ultimately giving these departments administrative powers. Some of the States, notably Kansas, Missouri and West Virginia, have provided for skilled supervision in the counties through the appointment of county highway engineers. In most of these States appropriations have been made from the State treasuries, or the aid of the State convict force has been given toward carrying on road work throughout the counties.

I desire to comment particularly upon what I consider to be the most important point in highway work, and one which should engage the attention of American road builders and legislators at the present time—that is, road maintenance. In the past, by far the largest portion of our annual expenditure has been for maintenance of our unimproved roads in almost their primitive condition. Now that we are actually building roads which compare with the best of Europe, it is of the utmost importance that we make provision for the safeguarding and maintaining of these roads built at so great an expense.

In a careful study of the highway laws which have been enacted in the past 15 years, I find almost no provision for maintenance, although large sums are authorized for construction. The erroneous impression generally prevails that when a so-called permanent road is constructed it is there for all time, and the expense has practically all been met in the first cost. I have investigated the cost of maintaining roads in the leading countries of Europe, and the figures may almost be said to be a revelation. In 1901 England and Wales maintained 26,598 miles of main road at a cost of \$370.34 per mile. In 1907 England and Wales maintained 27,556 miles of main road at a cost of \$446.74 per mile, or, in six years the cost of maintenance had increased \$76.40 per mile, an increase of over 20 per cent. In France the increase in cost of maintaining the national roads has been about 5 per cent. in the same period. The cost of maintaining main and urban roads in England and Wales in

1905 and 1906 was \$440.47 per mile. In France the cost of maintaining all roads during 1904 was \$243.33 per mile. While these last figures are not strictly comparable, one being for 1904 and one being for 1905, yet the mere fact of one year's difference in time fails to explain the difference of \$197.14 per mile in cost of maintenance—the natural inference being in favor of the superiority of the French system. In 1906 the average cost of road maintenance was \$214.13 per mile. In Belgium the annual cost of maintaining the provincial roads is \$277 per mile.

These figures express most forcibly two facts: first, that even the best of improved highways are not self-maintaining, and second, that the cost of maintenance varies tremendously with the degree of centralization of the administrative organization which has the roads in charge. France, with its most highly centralized organization, is maintaining her roads at about 54 per cent. of what it costs England and Wales with her very local and loosely centralized organization. Furthermore, the alarming increase in the cost of maintenance has been far more rapid in the countries with local and poorly organized systems of highway administration. We have just seen that while the rate of increase in maintenance from 1901 to 1907 in England and Wales was over 20 per cent., it was only 5 per cent. during the corresponding period in France. In England the maintenance is intermittent and varies with the ideas of the local administrative units. In France the maintenance is continuous and highly specialized.

Many of our States have spent and are spending large sums of money on their highways, with but little thought or provision for maintenance. If experience of European countries is of any value, this must prove disastrous in two ways; first, the cost of maintenance will be high the more local and loosely centralized the organization for maintenance; second, systems of intermittent maintenance are sure to increase in cost from year to year as they have in Europe. It is high time that our legislators take note of these facts and provide ways and means so that our roads constructed at so great cost can be efficiently and economically maintained and not allowed to go to ruin, and that exorbitant sums need not be expended in fruitless efforts to maintain them unsystematically and in an unscientific manner.

It must also be evident from a study of expenditures in

Europe that our road revenues are entirely inadequate. While our annual expenditure of \$80,000,000 may seem a large sum, it is only about \$38 per mile to meet all new construction, bridge building and other class of maintenance. We not only must have more money for building roads, but also definite provision for maintenance, a system of continuous repair and a centralized, skilled supervision.

MEMORANDUM OF WORK OF THE OFFICE OF PUBLIC ROADS.

The Office of Public Roads was established under an Act of Congress approved March 3, 1893, making an appropriation of \$10,000 to the Department of Agriculture for carrying out the following provisions:

Making inquiries in regard to systems of road management throughout the United States.

Making investigations in regard to the best methods of road making.

To prepare didactic publications on this subject suitable for publication, and to assist the Agricultural Colleges and Experiment Stations in disseminating information on this subject.

The work of the Office was, at first, of necessity very limited. In 1897 the construction of short sections of sample roads under the supervision of skilled road builders from the Office was begun in a small way, in co-operation with the various Agricultural Experiment Stations.

In December, 1900, a testing laboratory was established for determining the value of different road building materials, and two years later the appropriation for the Office was increased to \$20,000, the bill also providing for the investigation of the chemical and physical character of road materials. From this modest beginning, the work of the Office has grown in a conservative way until at the present time the annual appropriation amounts to about \$117,000.

The work of the Office is entirely educational and investigative. In the educational work, an effort is made to arouse a vigorous yet conservative sentiment in favor of the betterment of public roads. Advice and suggestions are freely given upon application, intending to aid in bringing about needed reforms in legislation and administration and to introduce by practical and instructive methods the form of construction and maintenance best adapted to each locality. Every improvement in methods and materials with which the Office becomes acquainted is in turn given out to the people to be utilized as fully as practicable.

Briefly summarized, the educational work of the Office may be said to have for its objects:

1. Reforms in road laws.
2. Reforms in road administration.
3. The introduction of the best methods of construction and maintenance.
4. Improvement in the efficiency of local road builders.
5. The utilization of the most suitable road building materials available.

In carrying out its educational policy, the Office has availed itself of three very effective mediums:

1. The publication and wide distribution of government bulletins.
2. Practical lectures and expert oral advice.
3. The building of object-lesson or demonstration roads.

The results thus far accomplished in the educational field have been most gratifying. The Office has issued upwards of 200 publications, including its annual reports. These publications deal with nearly every phase of road work and most of them are for free distribution to the public. The bulletin on macadam roads tells in a plain, practical way what a macadam road is, how it should be built, how it should be maintained and what the various materials are and how they should be used.

The bulletin on sand-clay roads gives similar information for this class of construction.

A bulletin has also been issued telling in detail how to construct and use a split-log drag on an earth road. The experimental work of the Office is fully set forth in various publications in order that they may be utilized to the fullest extent by other investigators.

The lecture work covers a wide field ranging from informal talks before farmers and county-road officials to papers and addresses presented before great organizations, national in their scope, such for example, as The American Society for Testing Materials; the American Society of Civil Engineers and the American Road Makers' Association.

The Office does not maintain a corps of trained lecturers, but its engineers and practical road builders are utilized for this purpose with very great success, because they know whereof they speak. In most cases, the Office pays the entire expenses of their assignments, although it is not an invariable rule, as a co-operative sharing of the expenses is arranged when practicable.

The Office employs a corps of engineers which has come to be recognized as a body of consulting specialists in highway engineering. This work covers so wide a field geographically that in the course of a few years these men become familiar with practically every condition, every material and every method of construction. It is quite natural, therefore, that they should be called upon to advise upon intricate and difficult points of road building throughout the entire country. This expert examination and advice is conducted independently of the regular object-lesson road work.

In the building of object-lesson roads, the Office has found perhaps its greatest field of usefulness. For many years the Office furnished the engineers and experts to lay out, plan and erect the building of these object-lesson roads, as well as the machinery with which to do the work, but the furnishing of road machinery has been discontinued, and the Office is now demonstrating what can be done with facilities locally available. The old plan of furnishing machinery involved considerable delay and expense, and established a standard which could only be continued through the purchase of a similar equipment by the local authorities. Since the practice of furnishing machinery has been discontinued, the Office has about trebled the amount of work done and has reduced the cost.

Another improvement has been made in this project, in having the instruction given by the engineers apply practically to the entire road system of a given locality, the actual construction, however, being confined to a small section of road.

Since its establishment, the Office has constructed about 364 object-lesson and experimental roads in 35 States, illustrating the construction of macadam, brick, gravel, sand-clay, burnt-clay, shell and cartli-roads, as well as many experimental roads of special materials and binders. This assistance is granted free of cost to local communities, the Office requiring only a simple form of application, in which local authorities agree to furnish the rights-of-way, the necessary machinery, materials, labor, fuel, etc., and in which the Office agrees to pay the salary and entire expenses of the engineer so assigned. In the building of these object-lesson and experimental roads, the Office has been instrumental in saving many hundred thousand dollars in the aggregate, through the selection of materials; the substitution of correct methods for incorrect methods, and less expensive types

of roads for the more expensive types, where, by reason of peculiar conditions, the efficiency of the road was not sacrificed by the change.

For example, Pike County, Alabama, had determined upon a large bond issue to be expended in the building of gravel and macadam roads. Upon application from the local authorities, an engineer from this Office was sent to Pike County, and after due examination found ideal conditions for sand-clay roads, and induced the local authorities to change their plans so as to utilize to the fullest extent this cheaper form of construction. To-day, Pike County has over 200 miles of superb sand-clay roads, built at an average cost of \$600 per mile, which is about one-fifth of what the macadam roads would have cost.

GOVERNMENT STUDYING CONDITIONS IN YELLOW PINE FORESTS OF THE SOUTHWEST.

A study of conditions in the yellow pine forests of the Southwest, made during the past season by the United States Forest Service at the recently established Coconino Forest Experiment Station, has brought out very strikingly the difficulty of securing natural reproduction in this type of forest.

In northern Arizona, perhaps at least half of the forest is without young growth of any kind, and old cuttings are frequently barren wastes. The most important factors in bringing this about are the climate, fire, methods of cutting, disposal of brush, and grazing; in most cases two or more of these factors work together in preventing reproduction.

Climatic conditions, even when they do not injuriously affect the older trees, are apt to be especially unfavorable for the establishment of a good crop of seedlings, and curiously enough, in a region noted for its heat and aridity, frost is one of the most serious enemies of the young growth. The rainfall is very unevenly distributed throughout the year, and while in most of the yellow pine region it probably averages about twenty inches, this comes mainly in midsummer and winter.

Spring is the most arid season of the year, and it is almost impossible for seedlings to get started then. The result is that a majority of the seeds germinate during August, and not having time to fully complete the season's growth, are killed by early fall frosts. Foresters who had previously investigated this problem had realized in a general way the importance of frost, but it was not until actual experiments by means of sample plots were made that this point was definitely settled.

Owing to the extremely trying climatic conditions, some protection to the young seedlings for the first year or two is necessary. Consequently light cuttings are favorable, and the disposal of brush by scattering rather than by burning helps to protect the seedlings from the weather. The greater part of the region is quite heavily grazed, and experiments have shown that sheep, in particular, do a great deal of damage to young seedlings. Sample counts showed that within a pasture from which sheep were excluded, only 5.4 per cent. of the young trees were injured by the grazing of burros and cattle, while immediately outside of this same pasture, where the sheep were allowed to run at will, 28.2 per cent. of the young growth was damaged. Trees up to three or four feet in height are apt to be injured in this way, but the full extent of the damage is often not realized, since the inconspicuous young seedlings are damaged most severely. Fires, of course, completely destroy young growth on burned over areas, and their prevention is absolutely necessary if a satisfactory second crop is to be secured.

While the study has not yet been completed, the preliminary results are of great practical interest and value, and point to the methods of management which must be used in this type of forest. Light cuttings, disposal of the brush by lopping and scattering, and the exclusion of sheep until the cut-over areas have a satisfactory young growth, seem to offer the best means of furnishing a sufficient supply of seed and of protecting the young growth from unfavorable weather conditions and from destruction by grazing.