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ASPHALT IN ROAD CONSTRUCTION

By JULES L. GOLDBERG, Chief Editorial Division.

ASPHALT CONCRETE STREET AT NORFOLK, VA., 1914.

Of the materials used for road construction probably less knowledge of the properties and characteristics of the bitumens exists in the public mind than of any of the others. These bituminous materials may be divided into two classes—(1) those consisting of or containing petroleum or asphalt, and (2) those consisting of or containing tar products.

To the layman, asphalt and tar are only black, sticky substances. This is evidenced by the frequent tendency to confuse them or to use the terms synonymously. Although both are composed mainly of hydrocarbons and their derivatives, tar is a product obtained chiefly by the destructive distillation of coal in the manufacture of gas or coke or, in the case of water gas tar, by the cracking of oil vapors at very high temperatures, while asphalt is a semisolid or solid substance formed by the partial evaporation or distillation of certain petroleums. This definition applies whether such distillation or evaporation has occurred in nature, as in the case of the lake asphalts, or has been conducted as a refining process. The distinctly different nature in derivation of tar and asphalt and their different behavior when incorporated in a road makes it highly desirable that the two should not be confused.

ASPHALT AND ASPHALTIC PREPARATIONS.

It may be well to explain further in popular verbiage some of the terms used in connection with paving asphalt and asphaltic preparations. Thus a refined asphalt (R. A.) is one which has been brought into such a condition that it is suitable for direct use or may be made suitable by the addition of a flux. Asphaltic cement (A. C.) is an asphalt which is of suitable consistency for direct use in highway work. If a refined asphalt is too hard for direct use it is brought to a suitable consistency by combining it with a flux. When an asphalt is manufactured from petroleum it is usually made directly into an asphaltic cement, although it may, if desired, be turned out in a much harder condition. Crude native asphalt is almost invariably subjected to a refining process, which consists simply of removing the water and more volatile hydrocarbons and skimming off any vegetable matter which may rise to the surface of the melted material.

The flux used is generally a residuum produced from petroleum by distilling off the lighter and more volatile constituents. It may be mixed with melted refined asphalt in proper proportions to form an absolutely homogeneous fluxed asphalt or asphaltic cement (A. C.) of any desired consistency.

An asphalt cement of suitable consistency for a given purpose may be thinned to a fluid consistency with a volatile petroleum distillate, and the resulting product is called "cut-back" asphalt. Upon exposure this will rapidly become asphalt cement through evaporation of the light solvent. An asphalt cement may also be thinned to fluid consistency by the addition of water, provided an emulsifying agent, such as soap, is present in the mixture, and the resulting product is called emulsified asphalt. The term "liquid asphalt" is sometimes applied to a fluid petroleum product or road oil which is highly asphaltic in character and possesses the property of adhesiveness or stickiness to a marked degree. An asphalt petroleum is one which contains a considerable amount of asphalt dissolved in the lighter oils present and from which asphalt may be readily manufactured by evaporation or distillation to remove these light oils.

CHARACTERISTICS OF ASPHALTS.

The suitability of asphalt for road building purposes is determined by certain properties which long experimentation and observation have demonstrated to be essential. These properties or characteristics are indicated by the penetration, the ductility, the flash point, the loss by volatilization, change in consistency after subjection to heat test, the specific gravity and the solubility in stated solvents, usually carbon disulphide or carbon tetrachloride.

The hardness of an asphalt is expressed as penetration, which is a measure of the depth to which a standard needle will penetrate it at a standard temperature during a definite period of time when the needle is loaded with a known weight. Unless otherwise indicated, the temperature, weight, and time factors are understood to be 25° C. (77° F.), 100 grams, 5 seconds, and the units of penetration to indicate hundredths of a centimeter—thus, a 50 penetration asphalt is one in which the standard needle under standard test conditions penetrates to a depth of 50 hundredths of a centimeter. Thus, the softer the asphalt the higher is its penetration.

The ductility is expressed as a measure of the distance which a standard briquet of the asphalt will stretch without breaking, at a standard temperature, when the ends of the briquets are pulled apart at a definite rate of speed. The temperature is usually specified as 25° C. (77° F.) and the rate of speed as 5 centimeters per minute. Ductility is then expressed as the number of centimeters which the test specimen will stretch without breaking.

The flash point of an asphalt is that temperature at which it evolves vapors which ignite upon contact with a flame. This temperature should be higher than any to which the asphalt should be heated during its application in highway work.

The loss by volatilization of an asphalt is the per cent by weight which it loses when a sample is heated and maintained at a temperature of 163° C. (325° F.) for a period of 5 hours under standard conditions of test.

The determination of specific gravity and solubility needs no amplification.

ASPHALT CEMENT SPECIFICATIONS.

The consistency of asphalt cement as determined by the penetration test should be varied in accordance with conditions of temperature, traffic, and the type of pavement in which the asphalt cement is to be incorporated. The following table gives the Bureau of Public Roads' penetration limits for different types of pavement under different conditions:

Penetration limits for different types of pavements.

Type of road.	Location.	Penetration at 25° C.
Asphaltic macadam	Northern United States	120–150
Do	Middle belt, United States	90–120
Do	Southern United States	80–90
Asphaltic concrete, coarse graded	Northern United States	70–80
Do	Southern United States	60–70
Asphaltic concrete (Topeka type)	Northern United States	60–70
Do	Southern United States	50–60
Sheet asphalt	Northern United States	50–60
Do	Southern United States	40–50
	Heavy traffic, Northern United States.	....

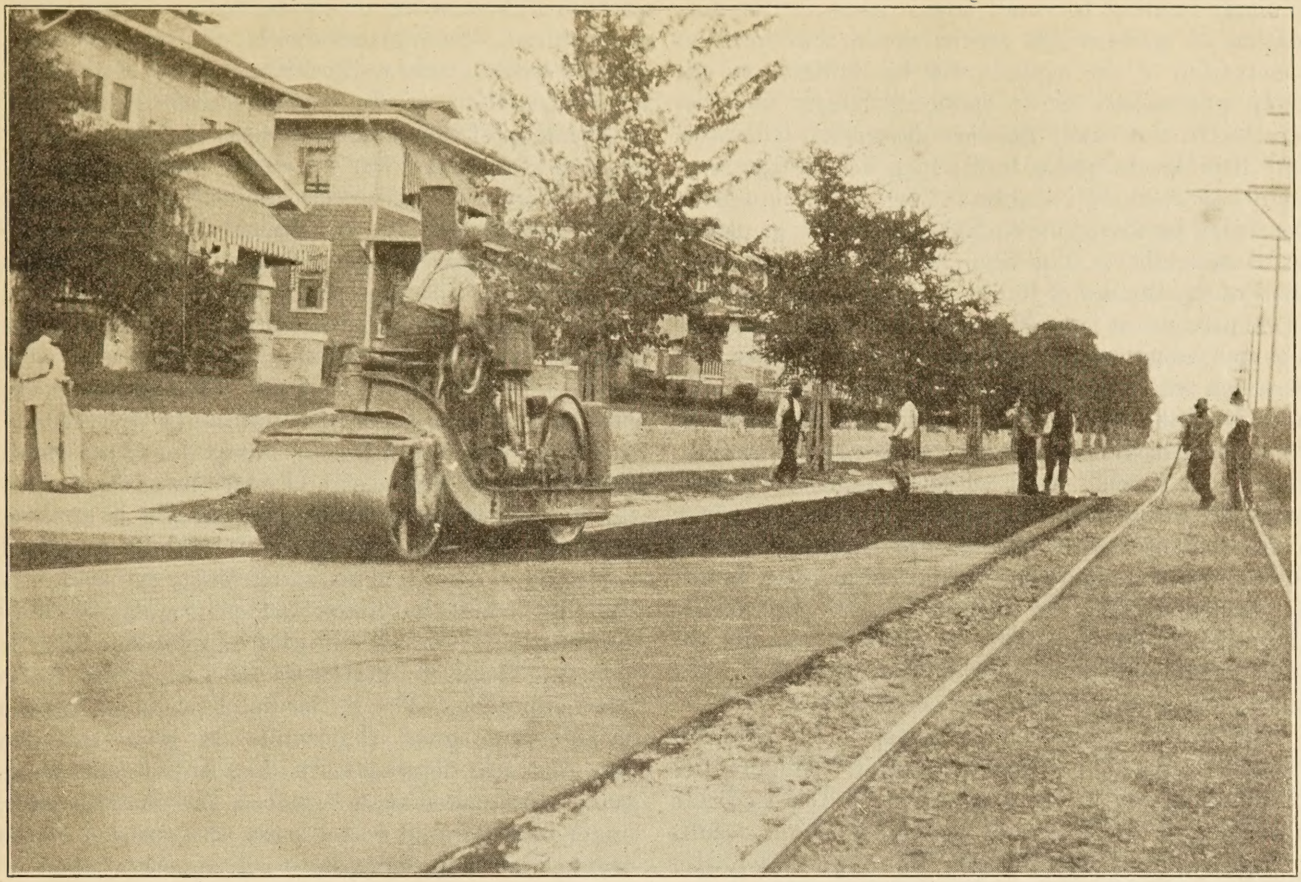
These penetration limits are only general, and in cases where special conditions of climate, traffic, and nature of stone are to be met it may be necessary to vary these limits.

TYPES OF CONSTRUCTION.

The most common types of roads and pavements in which asphalt serves as a binder are asphalt macadam, asphaltic concrete, sheet asphalt, and asphalt block.

Asphalt macadam.—The maximum value of asphalt macadam for relatively heavy traffic has seldom been developed because of the fact that its foundation has not been properly designed for such traffic. This, coupled with careless or unscientific methods of construction, have in general placed the pavement upon a lower plane of efficiency than it deserves. Provided careful attention is paid to the details of construction, the asphalt macadam will in many cases prove not only satisfactory but economical.

Foundations.—An existing macadam or Telford makes an excellent foundation for asphalt macadam pavements, provided it is sufficiently thick and well drained to afford adequate support. Too often the thickness of the old road is overestimated. In many cases pavements have been laid on old broken-stone roads, presumably 6 inches or more in thickness, which in reality averaged but little over 2 inches



ROLLING TOPPING COURSE OF ASPHALT, RHODE ISLAND AVENUE NE., WASHINGTON, D. C., OCTOBER, 1919.

of true broken stone. Under such conditions failure of the new pavement is almost sure to follow if subjected to heavy loads when the subgrade is wet. Broken-stone foundations for ordinary traffic should seldom be less than 6 inches thick, and for heavy traffic should run from 8 to 12 inches in thickness. Deficiency in thickness should be remedied by the addition of fresh broken stone, which should be thoroughly rolled and filled with screenings to make a finished macadam. The old road should preferably be disturbed as little as possible, but when badly worn into ruts or potholes, or when it is to be materially widened, scarifying, reshaping, and bonding with water may be necessary in order to prevent irregularities from showing up in the finished pavement.

Old gravel roads may sometimes be utilized as foundations, but gravel carrying a high percentage of clay can not be depended upon to support heavy loads. Old brick, block, and concrete pavements make satisfactory foundations, provided all bad depressions are first patched with either hot or cold mix asphaltic concrete.

General features of construction.—The asphalt macadam is laid upon the prepared foundation in a single course of large size broken stone of about the same dimensions and grade as in ordinary macadam construction. A wider range in types of rock may however be allowed owing to the fact that the natural cementing value of the rock may be ignored. After rolling the layer of coarse stone, hot asphalt cement is applied in such quantity as not merely to cover the surface, but to flow into the voids between the stone fragements and thus penetrate the entire wearing course. Application of the asphalt cement may be made either with hand pouring pots or mechanical distributors as later described. After such application the surface voids are filled by spreading and rolling in a thin layer of stone chips. All surplus of stone chips and dust is then broomed off of the surface and a second application or seal coat of asphalt cement is made, covered with stone chips, and the pavement completed by rolling.

Spreading and compacting coarse broken stone.—Before laying the pavement all excess dirt and fine material should be swept from the surface of the foundation. This will not only promote a closer bond between pavement and foundation, but will tend to prevent the broken stone from becoming coated with dust and thus interfere with the adhesion of the asphalt cement to the surface of individual fragments. As the completed thickness of the pavement is usually made from 2 to 3 inches, the broken stone should all pass a 2-inch ring. It should consist of sound, durable, and angular fragments of uniform quality and should contain no dirt or other objectionable matter, occurring either free or as a coating on the stone. Wide variations in sizes, particularly running to small sizes, result in the formation of spots which are so dense that uniform penetration of the asphalt will be hindered or entirely prevented. Such spots, although not discernible in the newly finished pavement, will ravel and disintegrate under traffic long before the pavement has attained its normal life. For this reason the size of broken stone should be carefully inspected as to suitability. For this class of work specifications of the Bureau of Public Roads require a broken stone product at least 95 per cent of which will pass a 2-inch laboratory screen, and at least 85 per cent of which will be retained upon a 1-inch screen. In addition the specifications require that from 25 to 75 per cent of the product shall pass a 1½-inch screen. Except in special cases which require a different method of treatment than here considered the rock should be sufficiently hard to prevent the excessive formation of dust during initial compaction before the first application of asphalt is made. To insure this quality specifications frequently require the rock to show a French coefficient of wear of not less than 7 when subjected to the abrasion test.

The broken stone should be shoveled and not dumped in place upon the foundation. The practice of dumping loads where the stone is required and spreading or flattening out the piles not only results in segregation of fine material, thus hindering proper penetration of the asphalt at spots, but also makes it impossible to uniformly compact the wearing course. An uneven, bumpy road will therefore be the result.

After being spread uniformly over the foundation to the desired thickness, usually about 3 inches loose, the broken stone should be dry rolled until the fragments have firmly interlocked. A 10 or 12 ton three-wheel roller is usually satisfactory for this purpose and should be operated exactly as in macadam construction. The extent of rolling is a most important consideration and should be carefully watched. If the stone is not thoroughly keyed together before the asphalt cement is applied it is practically impossible to properly consolidate the pavement for heavy traffic after the asphalt has chilled or set. The result will be a wearing course, which will develop waves and ruts in the course of time. On the other hand, if the broken stone is overrolled, dust begins to accumulate on the surface of the fragments and tends to prevent proper adhesion of the asphalt. There is also danger of filling the voids with fine material produced by crushing the larger fragments under the roller and thus preventing uniform penetration of the asphalt. Extreme overrolling will moreover round the fragments and prevent interlocking. On the whole, however, there exists a general tendency to underroll and much unsatisfactory work in the past is directly responsible to this tendency. If during rolling any surface irregularities appear they should be remedied by loosening the surface and removing or adding coarse stone as may be required. Such places should, of course, be again compacted to insure uniformity.

Manipulation of the asphalt cement.—The first application of hot asphalt cement should be made as soon as possible after the coarse broken stone has been compacted. Whether application is made by hand pouring or by a mechanical distributor, there are certain important details which should be closely observed. In the first place, no asphalt should be applied unless the entire depth of coarse stone is thoroughly dry, and after a rain sufficient time should be allowed for drying out. The broken stone surface should be clean and uniform in texture and should be free from all ruts, bumps, or depressions. For this reason traffic should never be allowed upon the compacted course before the asphalt is applied, and any existing irregularities should be remedied before application. This is extremely important in spite of the fact that many surface irregularities may apparently be rolled out after application of the asphalt. Such elimination is more than apt to be but temporary. The initial bond produced by the asphalt is so great that while the stone may be squeezed into depressions it does not become thoroughly compacted at such places, and months later, under concentrated wheel loads, the position of the original ruts and depressions will appear at the surface of the pavement.

Before application the asphalt cement should be heated to a temperature between 275 and 350° F., which will render it sufficiently fluid to penetrate the wearing course before congealing, provided the weather is not cold. If heated above 350° F. for an appreciable length of time the asphalt will harden and may be otherwise injured by coking or burning. If heated lower than 275° F. proper penetration will be hindered or prevented, and an excess will remain near the surface and cause bleeding in hot weather. Application of the asphalt should not be made in cold weather, and the air temperature at time of application should preferably be not less than 65° F.

The proper normal consistency of asphalt cement will vary somewhat with climatic and traffic conditions, also with the kind of rock which is used. Because of relative ease of application in cool weather a strong tendency exists to use a softer asphalt than is altogether desirable. Such practice is apt to produce a wavy road under concentrated motor traffic. Penetration limits for asphalt cement were indicated in the table given previously.

Uniformity in rate of application of the asphalt cement and its depth of penetration into the pavement are equally important and should receive just as close attention as the proper proportioning and thorough combination of concrete. A surplus of asphalt at any point will produce a soft fat spot which will develop into a bump, while a deficiency will tend to promote disintegration and raveling once the seal coat is broken. The proper quantity of asphalt to use for first application on a compacted course 2½ inches thick is from 1.5 to 1.75 gallons per square yard. Less than 1.5 gallons will not penetrate uniformly for the entire depth and the pavement will not be thoroughly bonded. On the other hand, much in excess of 1.75 gallons will create a surplus which is apt to work to the surface in warm weather and cause bleeding or produce general waviness of the pavement under the shove of heavy traffic. Proper and uniform distribution can only be secured by the use of suitable methods.

Hand pouring.—In spite of the general impression to the contrary excellent results may be obtained by applying the asphalt with hand-pouring pots. It is necessary, however, that the pots be properly designed and that at all times the spouts be kept open for their full width. Two types of pots should be used—one with a slotted spout not less than 8 inches wide and the other with a one-half inch nozzle. In the former the slot should be horizontal so that the operator walking directly across the road may carry it in one hand and apply the asphalt for a full width of 8 inches. When pouring, the spout should be kept close to the broken stone surface and never more than 2 or 3 inches above it. The pot with small nozzle should be used only to touch up spots or narrow strips that may be occasionally missed with the wider spout. Great care should be taken that there is no overlapping, but that each strip poured makes a neat joint with the preceding strip.

It is not ordinarily advisable to pour the strips at right angles to the center line of the road, as such practice repeated with the seal coat is more apt to develop a washboardy appearance in the finished road after it has been subjected to traffic. A better method is to pour the asphalt diagonally across the road and, when seal coating, to cross the pouring lines of the first application at approximately right angles.

As an aid to uniform distribution, alternating the direction of pouring on each succeeding trip is desirable. Before pouring, the pot should be gauged, so that during application it will be emptied on one or two trips across the road. Thus a 3-gallon charge will cover a strip 8 inches wide and 25 feet long if applied at the rate of a little over 1.6 gallons per square yard. If the road is, say, 20 feet wide, the angle of application for a 3-gallon charge is ascertained by measuring off 25 feet diagonally across the road, from side to side. A constant check should be kept on distances, and until the pourer becomes experienced, a string should be stretched to guide each trip. With a little practice the pourer will soon learn to keep the rate of distribution uniform by walking somewhat faster when the pot is full than when it is nearly emptied. It is advisable to have at least two heating kettles and two pourers on the job.

Mechanical distribution.—Excellent results may be obtained with mechanical distributors provided they are properly designed and operated. Most of the modern distributors are of heavy construction and large capacity and apply the heated asphalt under pressure through a set of nozzles set in a frame close to the road surface. As the distributor passes over the course of compacted broken stone before the asphalt reaches the road it is very important that the load be so distributed that rutting will not occur. Many otherwise well-constructed roads have been seriously injured by rutting due to the use of a distributor with too narrow tires.

In operating a mechanical distributor it is very important that applications should not overlap at either the sides or ends, and that at the completion of an application the pipes and nozzles should not be allowed to drain onto the road and thus produce fat spots. All nozzles should be kept clean and free so as to avoid unnecessary touching up. For covering narrow strips that may have been missed by the distributor a narrow-spout pouring pot may be used. Rate of application is controlled by measuring off the distance that the contents of the distributor should cover in a single trip. The width of application being known. The speed of the distributor should then be adjusted so as to just cover the distance during the emptying of the tank when the feed of asphalt to the nozzles is set. Slight adjustments in feed should be made by an experienced operator when variations in speed occur during distribution.

It should be remembered that the covering capacity of a large mechanical distributor is greater than the rolling capacity of a single roller and the natural desire to use a distributor to its maximum capacity should not be alllowed to handicap the construction of the road through under-rolling.

Filling surface voids.—Immediately after the first application of asphalt has been made, and progressing with it, a thin uniform layer of small-size broken stone should be spread over the surface in such quantity as to fill the surface voids. The road should then be rolled with the addition of more broken stone if necessary until the surface is tight and thoroughly bonded.

The size of broken stone used for this purpose is commonly known as three-quarter inch. Specifications of the Bureau of Public Roads require at least 95 per cent to pass a 1-inch laboratory screen, and at least 85 per cent to be retained upon a one-quarter inch screen. It should be as clean and free from dust as possible, and thoroughly dry when applied, or otherwise its bond with the road will be interfered with and this will prevent proper adherence of the seal coat which is next applied. The same effect will be produced if dust or dirt are allowed to collect upon the surface of the asphalt treatment before the small stone is spread. For this reason the stone should be spread as soon after application of the asphalt as possible.

It should be broadcasted with a wide swing of the shovel in order to distribute it uniformly in a very thin layer. The use of an excessive amount is not only wasteful, but will result in caking on the surface and in the formation of an excessive amount of stone dust under the roller. After the road has been thoroughly rolled it should be carefully broomed to clean the surface and remove all fine material which is not firmly held in place by the asphalt. The road is then ready for the application of the seal coat.

Application of seal coat and cover.—The second application or seal coat of asphalt is made in exactly the same manner as described for the first application except that the quantity is less. From 0.5 to 0.75 gallon per square yard will ordinarily be required, the exact rate being dependent upon the texture of the surface treated. The surface should be uniformly coated, but an excess is to be avoided in order to prevent the formation of an unnecessarily thick mat or carpet. The same grade of asphalt should be used as in the first application.

Immediately after the asphalt is applied it should be covered with a uniform layer of small size broken stone such as used after the first application. The road should then be rolled until the surface is smooth and uniform. An excess of cover should be avoided, as it will grind up under traffic and overload the seal coat with mineral matter. Such overloading will reduce the life of the seal coat and promote disintegration. In general the amount of cover should be kept to the minimum required to blot up the excess asphalt and prevent it from sticking to the wheels of vehicles. The mat so produced should not exceed a thickness of one-half inch and should preferably be about three-eighths inch.

Asphaltic concrete.—Asphaltic concrete is composed of a mixture of mineral aggregates and asphalt cement usually prepared at a central plant and laid while still hot upon a suitable foundation. Various patented combinations and an unpatented mixture commonly known as Topeka are the types of asphaltic concrete which are most widely used. The thickness, after compaction, is customarily 2 inches, and the surface of those types constructed with a relatively coarse aggregate and showing an open texture is given a seal coat of hot asphalt cement followed by a light covering of stone chips or sand, which is forced into the surface by rolling.

Foundations.—Old gravel, macadam, Telford, cobble, stone block, brick, and cement concrete have been satisfactorily used as a foundation. Cement concrete, bituminous concrete, macadam, or crushed stone base should be used on new construction—the type to be governed by local conditions.

Should an old gravel, macadam, or Telford road be used care must be exercised to see that adequate drainage has been provided and that the thickness is such as will withstand the loads which the finished road must support. A thickness of not less than 6 inches of gravel or crushed stone, free from an admixture of earth, is advisable, and additional thickness up to 10 or 12 inches under heavy traffic and poor subsoil conditions may be necessary. Ordinarily the old gravel or macadam surface should be lightly scarified, brought to uniform grade and contour, and thoroughly rolled. To this old material should be added a course of clean crushed stone, 1 to 1½ inches in size, the thickness of which will be governed by the depth of the old material. Two inches evenly spread and bound into the old scarified surface by thorough rolling will be sufficient if the total thickness of the base so obtained is not less than the minimum mentioned above.

When old cobble, stone block, brick, or cement concrete are to be used as base, the irregularities in contour should be taken up by the addition of open mix binder, which is an asphaltic concrete from which the finer aggregate is omitted.

When a new cement concrete base is required it should, under any but exceptional conditions, be 6 inches in thickness of a 1: 3: 6 mixture. A thinner base over a very favorable subsoil has been successfully used, but there is danger of heavy trucks shattering a lighter foundation should the subsoil become so misplaced by action of water or otherwise as to require the concrete foundation to act as a beam with considerable span. A thicker base or richer mix is generally unnecessary unless the traffic is composed of exceptionally heavy units and uniform support of the subgrade can not be depended upon. The 1: 3: 6 mixture and 6-inch thickness have been very generally used throughout the Borough of Manhattan, New York City, over a long period of years and have demonstrated their suitability under any normal conditions. This is the type of base in use on Fifth Avenue and other important streets. Where water has been kept out of the subgrade the 6-inch base has carried heavy loads successfully. The top surface of the concrete base should not be smoothed but left rough, which improves the bond between base and surface mixture.

It is claimed by some engineers that a bituminous concrete or bituminous macadam foundation offers some advantages not possessed by other types such as its superior protection against underlying water, its freedom from cracking, its superior bond with the wearing surface and its shock absorbing properties. These claims, on the other hand, are dis-

CONCRETE BASE, BINDER COURSE, AND ROLLING ASPHALT TOPPING, RHODE ISLAND AVENUE NE., WASHINGTON, D. C., OCTOBER, 1919.

puted by exponents of other types of bases as possessing little or no merit.

The use of a bituminous base should be attended by greater care in the preparation of the subgrade, since with this type of base greater reliance must be placed in the supporting value of the subgrade than when a thicker macadam having greater load-distributing properties on a concrete base having slab strength, is used.

Mixtures.—Several different mixtures varying widely in proportions and nature of aggregate, all known as asphaltic or bituminous concrete, are in use, but for the purpose of this article only mixtures having a carefully and mechanically graded aggregate of broken stone sand and filler combined with asphalt cement will be considered. A mixture of this type, knownas a modified Topeka, has the following proportions specified by the Bureau of Public Roads:

The broken stone shall consist of angular fragments of rock, excluding schist, shale, and slate, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter, occurring either free or as a coating on the stone. It shall be that product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent.
Passing ½-inch screen, not less than	95
Retained on ¼-inch screen, not less than	20

The sand shall be composed of sound, durable stone particles, free from a coating of clay or loam. When tested by means of laboratory screens the sand shall meet the following requirements:

	Per cent.
Passing ¼-inch screen	100
Retained on 200-mesh sieve, not less than	90

The mineral filler shall consist of limestone, dust, dolomite dust, Portland cement, or natural cement. It shall be free from foreign or other objectionable material. When tested by means of laboratory sieves, the mineral filler shall meet the following requirements:

	Per cent.
Passing 30-mesh sieve	100
Total passing 200-mesh sieve, not less than	65

The total mineral aggregate shall consist of a uniform mixture of the broken stone, sand, and mineral filler, the required grading of each being such as to produce, when properly proportioned, a mixture conforming to the following limitations for grading. The exact proportion of each constituent producing a total mineral aggregate within these limitations shall be as directed by the engineer. When tested by means of laboratory screens and sieves the total mineral aggregate shall meet the following requirements:

	Per cent.
Passing ½-inch and retained on ¼-inch screen	5 to 10
Passing ¼-inch screen and retained on 10-mesh sieve	11 to 25
Passing 10-mesh and retained on 40-mesh sieve	7 to 25
Passing 40-mesh and retained on 80-mesh sieve	11 to 36
Passing 80-mesh and retained on 200-mesh sieve	10 to 25
Passing 200-mesh sieve	5 to 11

Proper proportioning of this aggregate is secured by accurate weighing and the quantity of asphalt cement is determined in like manner.

In order to show the comparison between this and a coarse aggregate type such as bituminous concrete, proportions of the latter material as specified by the Bureau of Public Roads, are as follows:

The broken stone shall consist of angular fragments of rock, excluding schist, shale, and slate, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter, occurring either free or as a coating on the stone. The stone shall meet the following requirements:

	Per cent.
French coefficient of wear, not less than	8
Toughness, not less than	8

That portion of the product of the crusher, which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent.
Passing $\frac{1}{2}$-inch screen, not less than	95
Retained on $\frac{1}{4}$-inch screen, not less than	85

That portion of the product of the crusher, which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent.
Passing 1-inch screen, not less than	95
Total passing $\frac{3}{4}$-inch screen	25 to 75
Retained on $\frac{1}{4}$-inch screen, not less than	85

The sand for fine aggregate shall be composed of sound, durable stone particles, free from a coating of clay or loam. When tested by means of laboratory screens the sand shall meet the following requirements:

	Per cent.
Passing $\frac{1}{4}$-inch screen	100
Total passing 40-mesh sieve	30 to 70
Retained on 200-mesh sieve, not less than	90

The mineral filler shall consist of limestone dust, dolomite dust, Portland cement, or natural cement. It shall be free from foreign or other objectionable material. When tested by means of laboratory sieves, the mineral filler shall meet the following requirements:

	Per cent.
Passing 30-mesh sieve	100
Total passing 200-mesh sieve, not less than	65

Mixing and laying.—The mixing plant includes bucket elevator, rotary drier, an additional elevator, screen, storage bins, weighing devices, and mixer through which the aggregate passes in the order named. Heating tank and weighing device are required for the asphalt cement. Both mineral aggregate and asphalt cement are heated to temperatures varying from 200° to 300° F., depending upon the character of the asphalt cement used.

The mixing continues until all particles are thoroughly coated with bitumen and the hot mixture delivered on the road at a temperature of from 200° to 300° F. It is here dumped upon the foundation or dumping platform, at a point other than where it is to be finally spread and compacted, and is entirely rehandled by shoveling into place with hot shovels. It is then raked to uniform grade, contour, and thickness (usually about $2\frac{3}{4}$ inches before compression) and rolled with a 10 or 12 ton tandem roller. Depressions developing during rolling are brought up by additional material, and the rolling should continue until thorough compaction is secured.

Over this surface is sometimes spread a thin even flush coat of asphaltic cement at a temperature of about 200° F., to be followed by a uniform coating of hot crushed stone screenings or coarse sand. The rolling continues with a 5 to 8 ton roller until the entire mixture has cooled. The finished thickness is usually specified as not less than 2 inches, although other thicknesses have been laid with success.

No attempt has been made here to do more than outline the salient features in connection with the construction of asphaltic concrete pavements. Complete specification may be secured from a variety of sources, but those contained in the American Highway Engineers' Handbook include examples of the best standard practice.

Conditions favoring selection of asphaltic concrete.—Asphaltic concrete possesses many of the desirable qualities universally attributed to sheet asphalt pavements. The stability of the coarse aggregate types, in particular, obviates the necessity for a curb to protect the edges, and even with the finer aggregate, raveling at this point is unusual except in cases where a narrow paved surface forces a heavy traffic to constantly cross and recross such edges. Under these conditions a good asphaltic macadam shoulder will satisfactorily protect the pavement.

A new construction, asphaltic concrete, offers the advantages of a surface able to withstand heavy traffic immediately following construction. When the subgrade is suitable it ordinarily requires a relatively cheap foundation, is but slightly affected by temperature variations, is easy of repair, low in maintenance cost, and possesses a tendency to iron out rather than to roughen up under traffic. It is low in tractive resistance, low in abrasive wear on automobile and motor truck tires, and because of its smooth surface causes but little vibration in motor vehicles. This is not only a source of comfort, but reduces the maintenance expense upon such vehicles.

It is peculiarly adapted as a resurfacing material, as uniform contact can be secured with all types of old pavement surfaces. It is economical in that it utilizes to the utmost the previous investment made in the old pavement.

Sheet asphalt.—Sheet asphalt is composed of a mixture of fine mineral aggregates and asphalt cement, prepared at a central plant and laid hot upon the foundation in much the same manner as that previously described for asphaltic concrete. There is a distinct difference in the method of construction, however, inasmuch as sheet asphalt is laid in two courses, called binder and wearing

ASPHALT GRAVEL MIX ON GRAVEL BASE NEAR STERLING, MASS., ON MAIN TRUNK LINE TO CAMP DEVENS, MADE IN 1912.

course. A paint coat is sometimes substituted for the binder course, but is not suitable for heavy-traffic streets. Standard practice favors the use of 1½-inch binder and 1½-inch wearing course. No seal coat or covering of stone chips or sand is required.

Foundation.—Because it is a more expensive type and is usually subjected to more severe traffic conditions, the foundation should be more carefully selected than in the case of asphaltic concrete. A rigid cement concrete base is generally used, although water bound and bituminous macadam, old cobble stone, stone block, brick, asphalt block, and asphaltic concrete have been used with success. Although a study of each individual case, taking into consideration the character of traffic, climatic conditions, character of subsoil, drainage, and condition of old pavement will be necessary when sheet asphalt is to be used as a resurfacing material, it may be said in general that the conditions should be such as will assure the carrying of the full weight of individual units of traffic by the old pavement without displacement to even a slight degree.

A Portland cement concrete foundation of 1:3:6 proportions and 6 inches in thickness, as mentioned for asphaltic concrete, is suitable under normal conditions for sheet asphalt, and is the type almost universally used. Its surface should be left rough.

A bituminous concrete or macadam base offers the same advantages as have been noted under asphaltic concrete, but have not been used to the same extent for sheet asphalt.

Mixtures.—The mineral aggregate requires the closest study, as it is chiefly upon its proper selection, proportioning, and grading that the success of the finished pavement will depend.

The sand must be hard, clean, moderately sharp, and the grains must be of such a nature that the asphaltic cement will readily adhere to them; quartz should predominate.

In addition it must be graded within limits which have been demonstrated to give the most satisfactory results. Mr. Francis P. Smith gives the following as standard mesh compositions:

	Light traffic.	Heavy traffic.
	Per cent.	*Per cent.*
Passing 200-mesh sieve	0 to 5	0 to 5
Passing 100-mesh sieve	10 to 15	10 to 25
Passing 80-mesh sieve	6 to 15	10 to 20
Passing 50-mesh sieve	10 to 40	5 to 40
Passing 40-mesh sieve	10 to 30	5 to 30
Passing 30-mesh sieve	10 to 20	10 to 15
Passing 20-mesh sieve	10 to 15	5 to 10
Passing 10-mesh sieve	5 to 12	2 to 8
Passing 8-mesh sieve	0 to 5	None.

The total for that passing the 100 and 80 mesh sieves may be from 18 to 25 per cent for light traffic, and 25 to 40 per cent for heavy traffic.

To secure the above compositions a mixture of two or more sands will usually be required.

A filler of very fine material, usually rock dust or Portland cement, is used to fill the voids, between the sand grains and to afford a greater density of the mixture. At least two-thirds of such filler should pass a 200-mesh sieve and a material portion should be impalpable dust.

The binder course consists of asphaltic concrete with a somewhat lower percentage of bitumen than would be required in a wearing course. As usually specified it contains 5 or 6 per cent of asphalt cement, about 25 per cent of material passing a 10-mesh sieve, and 40 per cent material passing a half-inch screen. If the binder course is to have a thickness of 1½ inch, stone up to 1 inch diameter may be used.

Although sheet asphalt wearing courses whose compositions show rather wide variations have given excellent service, a mixture used upon Fifth Avenue, New York, may be taken as illustrative of good practice.

ASPHALT CEMENT.

	Per cent.
Asphalt cement	10. 8
Passing 200-mesh sieve	13. 2
Passing 100-mesh sieve	12. 0
Passing 80-mesh sieve	11. 0
Passing 50-mesh sieve	24. 0
Passing 40-mesh sieve	11. 0
Passing 30-mesh sieve	8. 0
Passing 20-mesh sieve	6. 0
Passing 10-mesh sieve	4. 0

Mixing and laying.—Binder and wearing surface mixtures are prepared at a plant closely resembling that used for asphaltic concrete. The same plant may be used for both types with few changes. The two mixtures are run alternately or as required, but more binder should not be prepared than can be covered with the wearing course during the same day.

The binder may be delivered upon the street at a somewhat lower temperature than the top course material; the former varying from 200 to 300° F. and the latter from 225 to 350° F.

The binder after being dumped is completely rehandled and shoveled into place, raked to uniform thickness and thoroughly rolled to a uniform contour and grade parallel to that of the finished pavement. The wearing course should be added as soon as compaction of the binder is completed, and the whole thoroughly rolled with a 12-ton tandem roller. After the first rolling of the wearing surface and while it is still hot a light sprinkling of Portland cement should be added.

Conditions favoring selection of sheet asphalt.—Sheet asphalt is particularly adapted to city streets and it has been the standard pavement for American cities during the last 30 years. In all of our largest cities it has carried very heavy traffic with relatively low maintenance costs, and its ease of repair and construction under difficult traffic conditions have made it especially popular. Replacement of pavement sections after street openings have been made can be carried out without leaving a weak and unsightly joint and resurfacing does not require a disturbance of the foundation nor does it involve difficulties at manhole openings and street-car tracks which have a fixed elevation flush with the pavement surface. It has low tractive resistance, causes a relatively slight abrasion to motor-vehicle tires, and is noiseless and dustless.

Asphalt block.—Asphalt blocks are made from an asphaltic concrete, compressed under hydraulic pressure and laid in a similar manner and upon a similar foundation to that required for other types of block pavements. Their dimensions are usually 5 by 12 by 2 to 3 inches.

Foundation.—The cement concrete foundation of the type mentioned for sheet asphalt and asphaltic concrete is preferable for asphalt block. Over such foundation is spread a one-half inch 1:4 mortar bed, upon which the blocks are laid while the mortar is still fresh. Still another method of construction calls for laying the blocks in a dry 1:4 mortar bed.

Mixture.—The same rules applicable to the securing of a good asphaltic concrete are equally applicable to asphalt block mixtures, with the exceptions that the coarse mineral aggregate is of smaller sizes and the asphalt cement should be low in ductility and penetration.

General.—Asphalt blocks have been widely used for city pavements and offer the advantage of requiring fewer skilled laborers on the street. They can be laid rapidly, repaired or resurfaced readily, and offer many of the qualities attributed to both sheet asphalt and block pavements.

SURFACE TREATMENTS.

Surface treatments with road oils consist in general of two methods—(1) that in which it is desired to have the material act only as a dust preventive and (2) that in which it is desired to have the material form a thin bituminous mat or carpet.

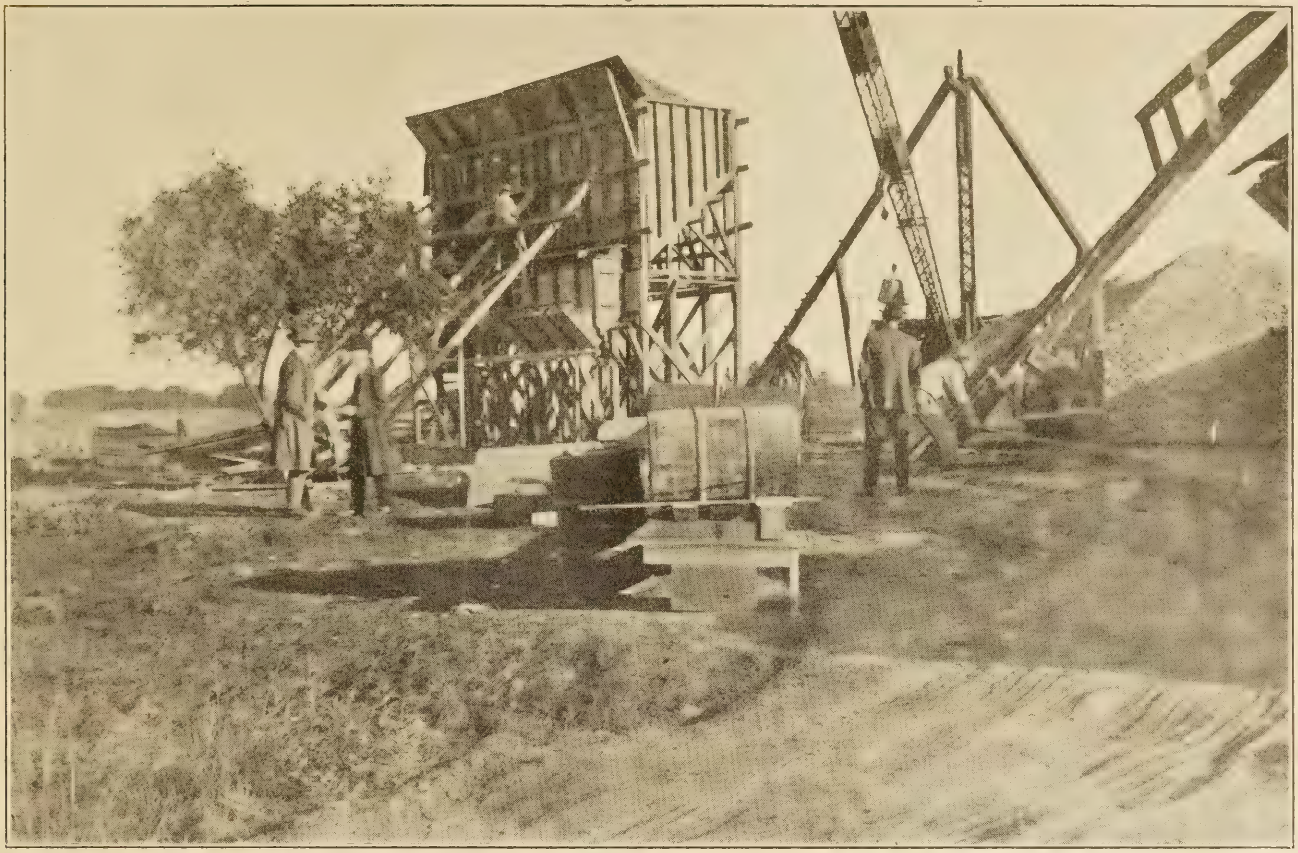
Oils for use as dust preventives are, as a rule, comparatively thin fluids which may be applied cold. To obtain the best results the road surface should be free of any great excess of dust when the application is made. The oil may be applied without heating, and the application should preferably be made by means of a pressure distributor at the rate of from one-eighth to one-fourth of a gallon per square yard. No cover of earth, sand, gravel, or stone chips should be necessary. The number of applications required to lay the dust successfully throughout an entire season will depend upon traffic and climatic conditions; one may prove sufficient, but three or four may be required.

Oils for use in surface treatment when it is desired to form a wearing mat are applied with or without heating, and are usually more viscous than are the dust preventives. For this treatment the road surface should be in a good state of repair, well consolidated, free from holes or depressions, and thoroughly swept for the removal of dust before application is made. Newly constructed roads should be permitted to consolidate under traffic before oil is applied. The oil, if heated, should be brought to a temperature of from 200° to 250° F. The initial application should be made by means of a pressure distributor at the rate of from one-third to one-half of a gallon per square yard. It should be covered with a uniform layer of stone chips or pea gravel.

ASPHALT JOINT FILLERS.

Asphalt is extensively used as a joint filler for brick pavements and asphalt or asphalt mastic. The latter, consisting of a mixture of asphalt with fine sand, is similarly used for stone block pavements. Such joint filler obviates the necessity for special expansion joints, and by permitting a certain amount of flexibility reduces any tendency of the finished pavement to crack by reason of contraction or expansion in the base. Cuts through the pavement for repairs to sewer, water mains, etc., can readily be made and the opening closed without damage to individual bricks and blocks. The asphalt carpet produced by a small excess of the filler protects the edges of brick and block from wear, reduces the noise customarily caused by these types of pavement, and reduces the slipperiness—an important consideration on grades.

SOME POINTS IN HANDLING MATERIALS.



MINNESOTA PROJECT 58. STORAGE BINS FOR SAND AND STONE AT RAILROAD STATION, WORTHINGTON. STOCK PILE AND DERRICK AND FOUR CHUTES OPERATED SIMULTANEOUSLY BY ONE MAN. BATCH MEASURING BOXES ABOVE CHUTES.

AN economical method of handling concrete aggregate was installed by Minneapolis contractors in constructing Federal-aid project No. 58, in Nobles County, Minn.

This project consists of 5.5 miles of one-course concrete pavement with proportions of 1:2:4, to be laid 18 feet wide, 7½ inches thick at the middle, and 6½ inches thick on the sides.

The project begins about 1 mile from the city limits of Worthington and is in two sections, running due west; one of 2 miles and one of 3.5 miles with a section of 6.5 miles between, which was gravel surfaced in 1918 and is not included in this project.

The road was graded 24 feet wide in 1918 by county forces, and the grading to be done in this project consisted in widening the road to 30 feet and placing 6-inch drain tile in all cuts. The soil is a heavy, yellow clay on the first section and a black soil on the second section.

The contract was let on July 14, 1919, to contractors whose bid was as follows:

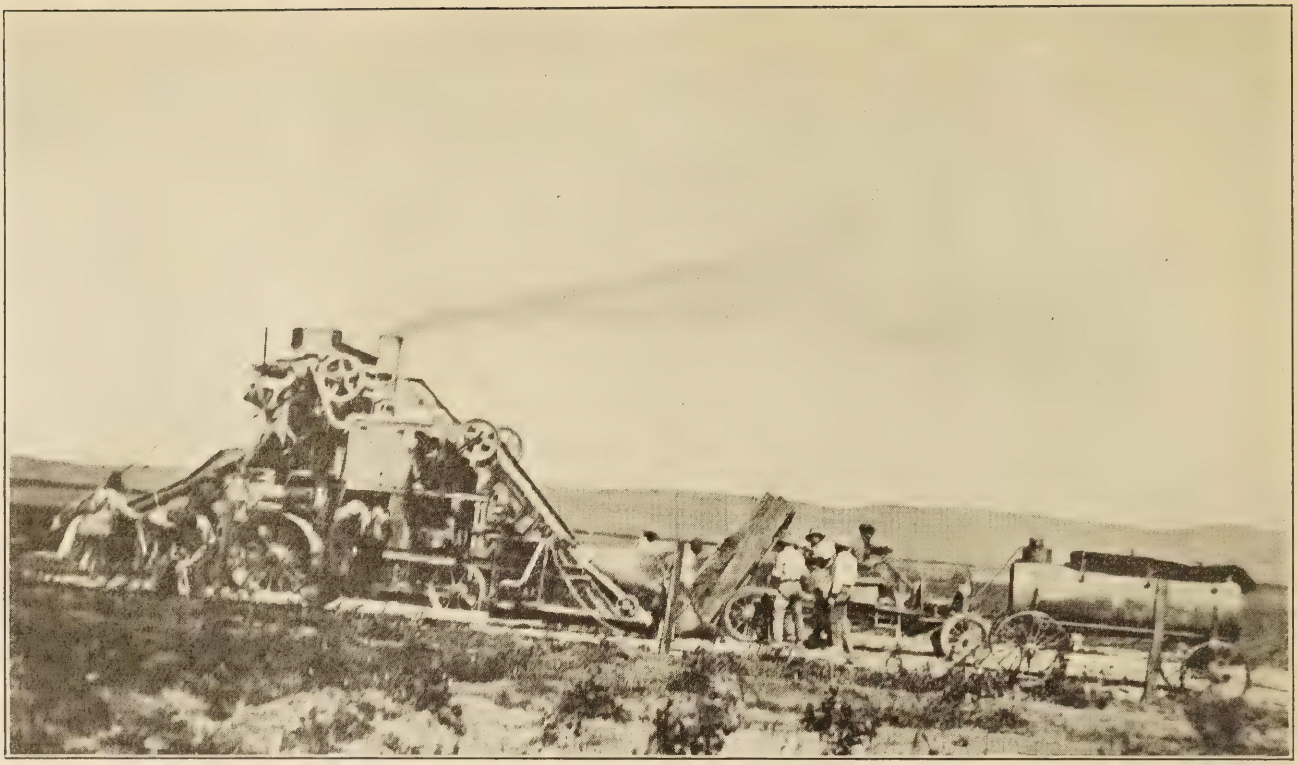
Excavation, 15,304 cubic yards, at $0.65	$9, 947. 60
Tile in place, 30,000 linear feet, at $0.22	6, 600. 00
Concrete pavement, 58,340 square yards, at $2.74	159, 851. 60
Total bid	176, 399. 20

Concreting began September 8, 1919, at Station 160 and was continued until October 24, when work was shut down for the season at Station 96+75, during which time 12,650 square yards were laid. Atlas cement, Mankato sand, and Jasper quartzite were brought in by train to Worthington, and water was pumped from Whiskey Creek at Station 54.

A 3-sack mixer was used with a tamper, and four 5-ton trucks hauled aggregate from the railroad at Worthington. These trucks were divided into four compartments across the truck, each with a capacity for a complete batch, and each compartment had a separate end gate which was operated by hand from the outside. The truck was backed up to the mixer skip, the body elevated, and the lower gate opened, allowing a batch to run into the skip. While the skip was being hoisted, the truck and the mixer moved forward a few feet to be ready for the next batch, and the operation was repeated until the truck was empty.

Water was pumped by a gasoline pump through a 2-inch pipe for a maximum distance of 2 miles.

At the railroad station there was erected a cement storage bin holding over a carload, with a bucket elevator operating from a boot placed at the end of the ties. The bin was divided into four compart-



MIXER IN OPERATION ON A WYOMING FEDERAL-AID PROJECT.

ments; each had a measuring box holding three sacks, located just above a steel chute which discharged into the truck. One man operated all four chutes simultaneously.

Bulk cement was delivered to the cement bin and was unloaded into the elevator boot by one man using a wide scoop running on two small wheels. This method of handling cement caused a good deal of trouble, as the cement arched over the opening into the chute, and was later discarded for a platform built on a level with the car floor and reaching to the truck roadway. Four men, each with a steel wheelbarrow holding three sacks of cement, loaded from the car and wheeled and dumped them simultaneously into the compartments of the truck alongside.

About 100 feet beyond the cement bin there was a combined sand and stone bin; the stone storage being double the capacity of the sand storage. Between this bin and the siding (see photograph) there was a crane with a clamshell bucket which unloaded sand and stone from cars on the siding into the bins or on to the stock pile.

Each bin had four measuring boxes above four steel chutes, which were discharged simultaneously by one man. After the truck had received cement in each compartment, it drew alongside the sand bin and received sand into each compartment; and then a few feet beyond stone was dumped into the compartments.

There were 30 men employed in the different operations from the arrival of the material on the cars to the finished pavement.

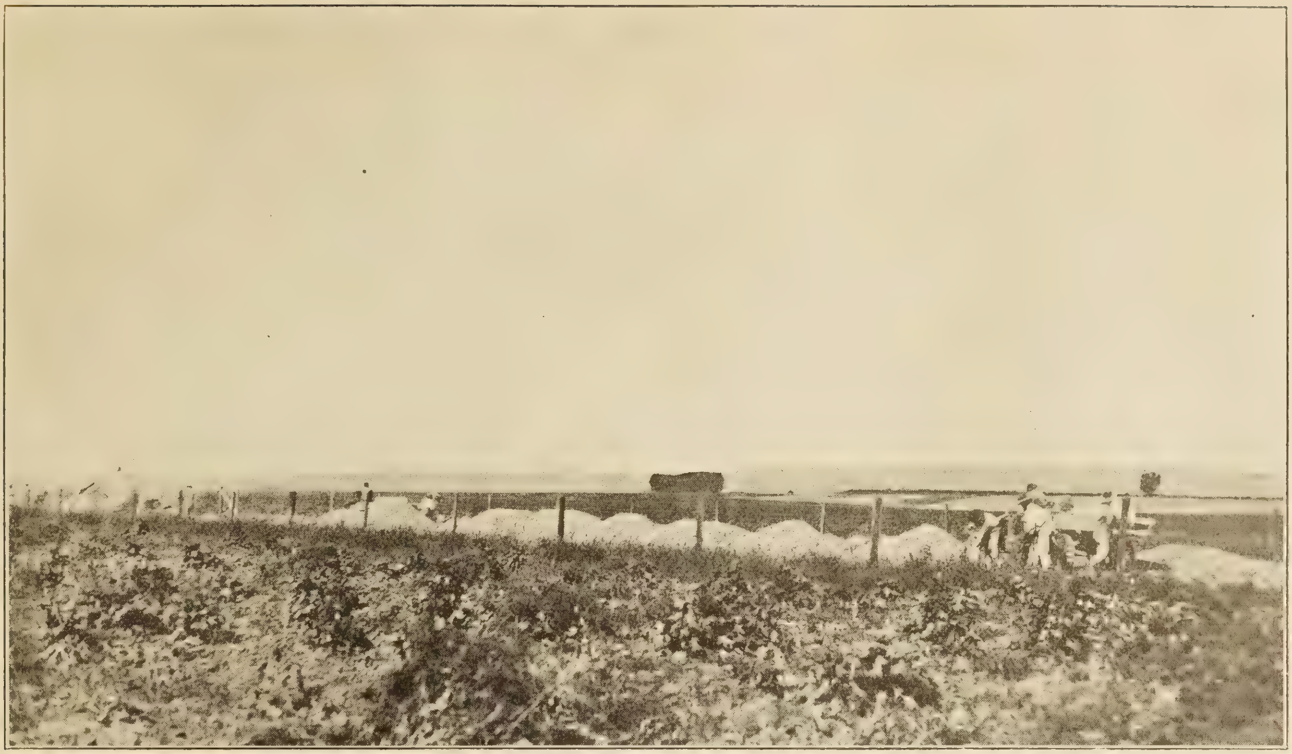
At loading plant.—One foreman, 1 mechanic, 2 men at sand and stone bin, 4 men at cement bin, 2 men with crane clamshell, 4 drivers for 5-ton trucks.

At road.—One foreman, 2 mixer operators, 3 men at chute and spreading concrete, 2 men placing side forms, 2 men on steel reinforcement, etc., 2 men on mechanical tamper, 4 men covering finished pavement, watering and removing forms.

The entire time occupied in loading from the time the truck stopped at the cement bin until it started from the stone bin was four and one-half minutes.

The following notes relative to a new method of handling materials which has been developed on Wyoming Federal-aid project No. 20 also may be of interest to those who are engaged in concrete highway construction.

The material from the gravel pit is hauled out to the road in large trucks and deposited in stock piles. Experience has, however, developed the fact that the movement of material over the prepared subgrade is a matter of considerable importance, as the use of heavy units for this purpose is certain to destroy the subgrade and to cause a considerable expenditure for the reshaping of the subgrade. Moreover, if materials are dumped in small piles on the subgrade there is the ever present possibility



STOCK PILES, SHOWING LABORERS LOADING A TRUCK, ON A FEDERAL-AID PROJECT IN WYOMING.

that a percentage of the earthy materials of which the subgrade is usually composed may find their way into the batch.

These two considerations have led the contractor on this project to adopt the system of dumping his materials at the end of the road in a large stock pile, and, for the purpose of moving them to the mixer, he has provided six Ford trucks with light bodies, which, when loaded with the materials for a single batch, can be dumped by hand. The bodies on these trucks are divided into compartments which will accommodate a four-sack batch of material. After being loaded at the stock piles a truck is driven to the mixer and the charge dumped directly into the hopper.

As can be seen at a glance, the cost of loading the truck, even from material piles placed on the ground, is no greater than the cost of loading wheelbarrows would be. The cost of operation and the wear on the trucks is said to be no greater than the constant reshaping of the subgrade where the aggregate is delivered on the subgrade by heavy trucks or by wagons. In short, the scheme is working satisfactorily on this project and with every appearance of reasonable economy.

For somewhat greater economy in operation it would be entirely feasible to build loading bins and to drive the trucks onto an elevated platform, permitting them to discharge into hoppers which could in turn be discharged into the light delivery trucks. By proceeding in this fashion a considerable amount of labor could be eliminated but the cost of the plant would be somewhat increased. The system most advisable for any individual project will, of course, depend on the length of the project and the amount of material to be handled.

AUTOMOBILE LICENSE FEES.

Up to October 18 the number of pneumatic-tired machines registered in Pennsylvania was over 435,000 for the year 1919, and the license fees received had passed the $5,000,000 mark. It is expected that the fees for the year will be about $5,100,000. In 1918 the State received in fees $4,048,185.50 from 678,786 registrations, of which 363,001 were pneumatic-tired machines.

COUNTY MATERIAL PLANT.

Maricopa County, Ariz., has a road program of 278 miles. The county supervisors and highway commissioners have decided to install a material plant with a capacity of 2,000 tons a day. It is estimated that this will save the county $3,000 a mile in rock, sand, and gravel alone in the construction of the highways, or a total saving of $834,000.

CALL FOR BIDS.

Fresno County, Calif., supervisors have called for bids on the first six units of the highway system for which the county has been bonded for $4,800,000, and which will cost $5,500,000. The bids will be on 1–2–4 and 1–3–6 concrete mix.

MATERIAL MUST BE MOVED EARLY.

WHEN seeds of information sown in a campaign of education fall upon the minds so fertile and receptive as those of the people of our Nation, the result is astounding. The hearty, liberal, country-wide response to the call for money to construct a network of highways adequate to meet the demands and requirements of the marvelous growth of traffic has been more than astounding. Inspired by the passage of the first Federal aid road act by which the Government appropriated $75,000,000 to enter into copartnership with the State and stimulated by the further appropriation of $200,000,000, the States, one after the other, and the counties of the States have provided for vast sums to further the doctrine of good roads until now there is $633,000,000 immediately available for construction in 1920.

GREATEST IN HISTORY.

And in contemplating these figures it must be remembered that in no year in the history of road building has as much as one-fourth of this sum been expended upon new highways. But that the States will go far toward exceeding the expenditures of any previous year and constructing a greater mileage than ever before is forecast by the fact that several have already laid out programs that call for the building of more than a thousand miles within their respective boundaries. The people ask for these roads and are willing to pay for them. Illinois, with a population of approximately 6,000,000, has authorized a bond issue of $60,000,000 (about $10 per capita), and a little county in Arkansas (Phillips), with a population of less than 50,000, has pledged itself for $3,734,000 for good roads. That is about $75 per head, and with the money they propose to put 117 miles of road in places where there were hardly any before.

It is estimated that last year $138,000,000 was expended in new construction. To put into construction the great sum available presents a tremendous task to the highway builders of the country. One factor will determine the degree of success with which this task may be accomplished. That is the movement of material. Without material there can be no roads. Without open-top cars there can be no material. There must be a complete utilization of the open-top cars for the movement of material at the time and all the time that such cars are available. Reports of the Railroad Administration show that in the earlier months of the year there are many thousands of open-top cars standing idle. But in 1919, when the road-building season was well advanced, there was general complaint that no cars were available for the movement of material. The supply, always inadequate, was being used for the transportation of other products.

MESSAGE TO STATE AUTHORITIES.

Recently Thomas H. MacDonald, the chief of the Bureau of Public Roads, in a letter to the State highway departments, in which he points out that the only possible relief is to use the present transportation and materials production agencies in the most efficient manner possible, said:

"It is a matter in which the State highway departments may take a large measure of satisfaction that road building is the one big public activity which got under way early in 1919, which opened a large field for unemployed labor, which offered a market for construction materials, and which has continued to increase in volume as the months have passed. It is too early to have definite figures available for this year's production of roads and total expenditures, but it is estimated that the expenditures during 1919 for hard surfaced highways, exclusive of sand-clay and similar types, will total approximately $138,000,000. The largest previous year's total expenditures for like purposes, that of 1916, was $136,000,000.

But the test of the road building organizations is ahead. The estimated summary of the funds which will be available for highway work during 1920 for the construction of surfaced highways is as follows:

Brought forward from unfinished work 1919 contracts	$165,000,000
Funds available from State and county taxes and Federal aid	273,000,000
One-fifth State and county bond issues not before available	50,000,000
One-third of the unexpended balance of State and county bond issues previously available	45,000,000
Available from new bond issues to be voted on the fall of 1919 and spring of 1920	100,000,000
Total	633,000,000

PROGRAM IS TREMENDOUS.

"This large total is more than four times the amount of money that has been expended during any previous year for like purposes. To accomplish the physical undertaking of putting into actual road construction this sum or anywhere near this sum is tremendous. It is so much greater than any program that has heretofore been attempted that a great increase in the principal factors controlling the actual production of highways is absolutely essential. These principal factors are material supplies, shipping facilities, labor supply and contractors' organization.

"The acute deficiency of open-top cars demands that our first attention be directed toward increasing shipping facilities for road materials. These facilities may be increased by two methods—first, by the more efficient use of open-top car equipment, and second, by a large increase in the supply of new cars. During frequent conferences with the Railroad Administration it has become apparent that a more efficient use may be made of the present open-top car equipment by starting the shipping season earlier than has been the general practice in the past. It has been customary to wait until contractors' organizations were ready to begin work before starting the shipment of materials. Under these conditions many thousands of open-top cars lie idle during the latter part of February, all of March, and the earlier part of April. In the spring of 1919 the number of open top cars that were idle totaled more than 250,000. As the season advanced and road contracts were actually under way, the car shortage manifacted itself here and there almost continuously, but at three different times complaints received at this office were general.

FACTORS THAT AFFECT MOVEMENT.

"We must recognize that if a strike threatens the railroads, road material will not be moved because it is not perishable. If the movement of coal demands the cars, there will be a shortage of cars for the movement of road materials. The importance of the movement of road materials must be impressed upon the public and the railroads, and for the present the road builders must correlate their calls for service so far as possible with the situation which exists—that at any critical moment when shipping facilities are involved road materials will be the first to suffer.

"Therefore, everything possible must be done to facilitate transportation of road materials under these handicaps. Railroad transportation has become too important a factor in the amount of work that can be accomplished to allow it longer to be regarded as incidental. It has become the biggest item in road production. Contracts should be awarded as early as possible that the contractors may know the amount of materials they will require at different points and they should be encouraged to place their orders for the materials requiring rail transportation as long in advance of the time they will be actually required as possible. The placing of materials in storage piles involves some expense, but this expense is small in comparison to the loss occasioned by lack of materials when the contractors' organization is waiting.

CONTRACTS SHOULD BE AWARDED EARLY.

"From the experience this year and in view of the greatly increased program for next year, it seems apparent that contracts which are not awarded during the winter months will have little opportunity of being supplied with materials which require rail hauling. Again, contracts should be awarded early and contractors should be encouraged to place their orders so that the material producers will operate their plants during all seasonable weather. In the past too many contracts have been held until later in the year, and material supplies have not been started moving during the period when the car supply is at its maximum. Also, contract prices have usually bean lower for work awarded early in the season, and the State Departments and the Federal Bureau must recognize and respond to the public confidence which has been shown by the appropriations of large sums for highway improvement, by adopting every method that will help to secure the lowest prices and the most efficient expenditure of these funds.

"In view of the greatly enlarged program of road construction and the large amount of unfinished contracts which will have to go over because of lack of road materials, it would seem unnecessary to further accent the need for taking advantage of the supply of open-top car equipment in February, March, and April.

THE ONLY POSSIBLE RELIEF.

"It is apparent that many contractors who have not before been so engaged are looking to the highway field, and that the contractors' organizations will be expanded. The labor shortage may in part be met by improved machinery and equipment, but the transportation and the supply of materials can not be so readily or quickly expanded to take care of the greatly increased needs. Unless a forward looking policy recognizing these conditions is adopted at once, it is not apparent that a greatly increased production of roads will be possible next year over the miles constructed this year, yet the public is demanding of road building organizations a greatly increased production.

"Every official in an administrative capacity in the road building organizations knows that it is common for the public to demand great activity and immediate production of roads as soon as bonds have been voted. The fact that more than four times as much money is available for roads next year than has been true heretofore means that these demands will become intensified, and it will be a difficult task to impress upon the public the fact that the production of roads is controlled by factors largely outside of the control of the highway officials.

"The only possible relief is to use the present transportation and materials production agencies in the most efficient manner possible, and at the same time bend our efforts to obtain an increased car supply and an increased production of road materials. But these policies, to be effective, must be adopted by the State Departments and the Federal Bureau individually and collectively, at once, and the first step is to place under contract during December and January as great a mileage of roads as possible. In doing this the bureau wishes to cooperate with and aid the States in every way possible."

ILLINOIS DEVISES A PLAN.

The highway department of the State of Illinois has devised a plan which it hopes will result in the shipment and storage in the early part of the season of a large portion of the material the State will require in the construction of the 1,000 miles of highway called for by the 1920 plans. To supply the necessary material for this program will mean a severe tax upon the material producers unless the construction season be extended. In order to bring this about and thus assist in relieving the open-top-car situation, as well as a possible shortage of materials, the State has decided to pay for such materials as sand, gravel, and stone as delivered, without waiting for the same to be incorporated into the work. Vouchers will be issued direct to the railroad company for the freight and to the sand, gravel, and stone producers for these materials. The same will be charged against the contractor and the amount thus paid will go to reduce estimates due the contractor as such materials are used.

This arrangement will apply not only to contracts now uncompleted, but also to the contracts to be awarded in 1920. In order to make this effective on existing contracts, a supplemental agreement will be made with the contractor and the surety company. This supplemental agreement will be forwarded to the contractor for his signature with the request that he procure the signature of the surety company at an early date.

Only the hearty cooperation of all the forces engaged in the building of our roads and the utilization to the fullest extent of equipment and producing power will bring in 1920 a result in road building accomplishment such as the public has a right to expect.

NEBRASKA ROAD BUILDING.

The road building situation in Nebraska under Federal aid is reviewed in the October issue of the Monthly Bulletin of the State department of public works. Under the original Federal-aid act Nebraska was entitled to $1,600,000 from the National Government. By the amendment to the last post-office appropriation bill this amount was increased to $5,866,303.82. The Nebraska Legislature of 1917 accepted the provisions of the Federal-aid law, appropriated $640,000 for road construction under it, and authorized the State board of irrigation, highways, and drainage to lay out a system of roads for the approval of the Secretary of Agriculture.

The legislature of 1919 abolished the State board of irrigation, highways, and drainage, and created a State department of public works, and appropriated $3,093,262 for Federal-aid roads, bringing the total appropriation to date up to $3,733,262, leaving a balance of $2,133,041.82 to be taken care of by the legislature in 1921.

As laid out the State highway system includes approximately 4,500 miles of road located so that every county seat and every important town is connected. Up to October 1 project statements for the construction of 2,240 miles of this system had been submitted to the Secretary of Agriculture. Seven hundred miles of work had been placed under contract, for an aggregate cost of about $2,500,000, and it is estimated that 500 miles will be completed before the close of the present season. Surveys have been made this year on about 1,500 miles additional, and it is expected that the balance will be in shape, so that the work can be placed under contract before April 1, 1920. Before the close of the season 212 miles more of work will be placed under contract, of which 17 miles are brick paving in Douglas County, 6 concrete in Dodge, and 1 concrete in Butler. All the rest is either plain earth or graveled surface.

HERE'S A NEW ONE.

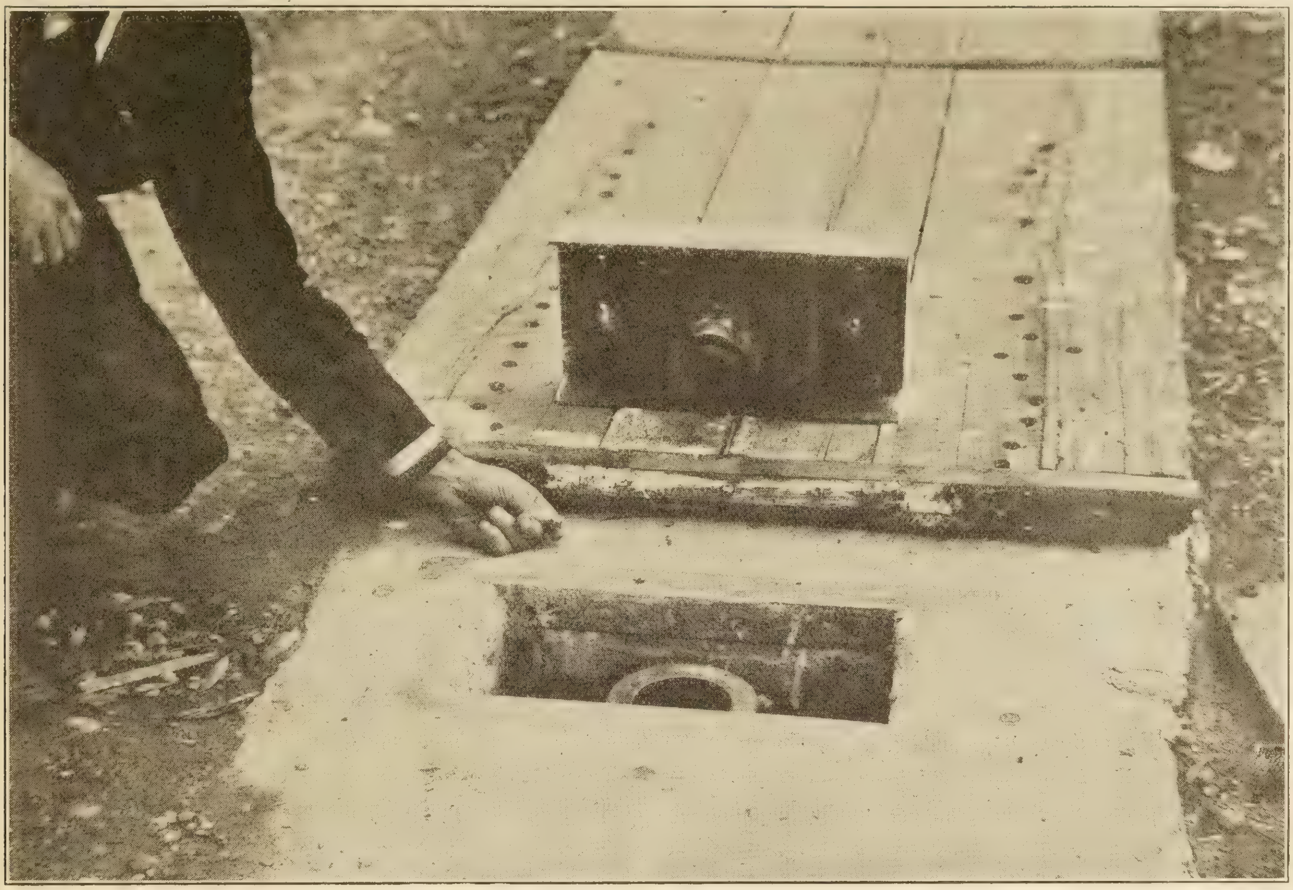
An interesting side light is thrown on the problems which highway engineers sometimes have to solve by the following comment recently found in the report of one of the engineers inspecting a Federal-aid project in New Mexico: "Relative progress is only fair due to the fact that operations have been greatly handicapped for want of water. As this is a very hot and dry season of the year, the cattle take nearly all the supply. The road construction is, therefore, greatly handicapped." We have heard of a good many difficulties which engineers have encountered in constructing concrete roads, but this is the first time that we ever heard of construction being delayed because the cattle had made away with the water supply.

WISCONSIN CONSTRUCTION.

It has been estimated that Wisconsin in 1919 will expend about $12,600,000 on highways. Of this amount $7,600,000 will be for State trunk and State-aid construction and maintenance, with the rest for township roads. The construction on the State trunk highway system will cost about $3,600,000 and that on State-aid roads about $2,000,000. Maintenance will cost about $2,000,000. A total of 146.99 miles of concrete roads is included in this program.

THE PRESENT STATUS OF IMPACT TESTS ON ROADWAY SURFACES.

By A. T. GOLDBECK, Enginee · of Tests, Bureau of Public Roads.



CLOSE-UP VIEW OF IMPACT MEASURING DEVICE.

IT has been estimated that the funds available for highway construction in this country during 1920 total $633,000,000, and this is more than four times the amount expended in any other previous year. It is likely that the future will show even higher figures than these and that road construction will be pushed as rapidly as road-material resources, equipment, hauling facilities, and labor will permit. In the face of such an enormous program it behooves us to build wisely lest we be extravagant either by too much or by too little initial expenditure for our various road systems.

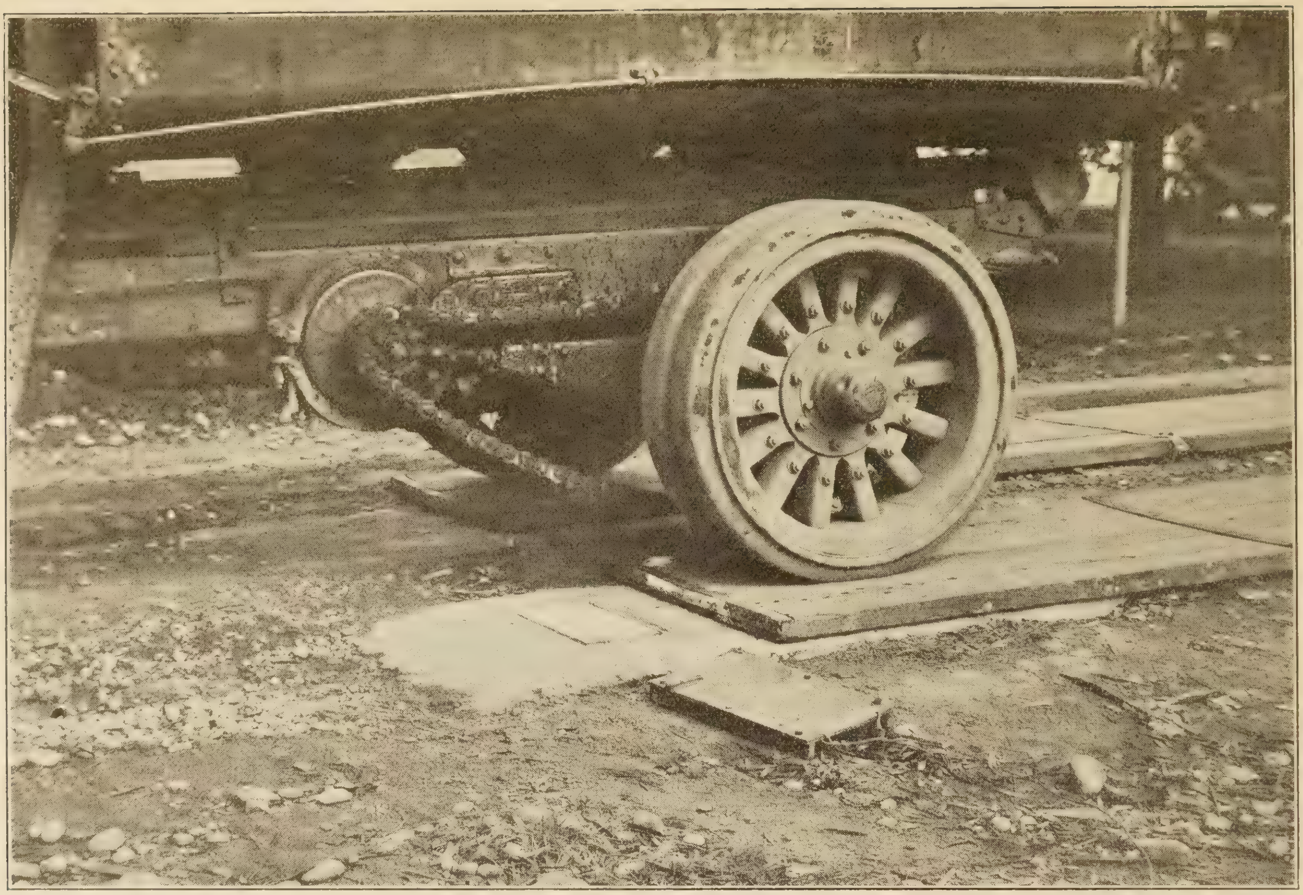
Unfortunately, the necessity for such vast expenditures comes almost simultanelusly with a new class of traffic which exerts a different kind of destructive effect on roads than has been exerted by traffic in the past. The heavy motor truck has transformed the road problem from one whose solution in days gone by depended upon precedent into an exceedingly important problem of design. We must be able to design our future roads to carry known maximum loads under known conditions of subgrade and weather, just as we are now able to design our bridge structures. We must not be satisfied with a constant cross section irrespective of subgrade conditions, but we must change the design of the road as nearly as practicable with changing conditions of subgrade. At the same time we must better subgrade conditions by more careful drainage. Recognizing these facts, and with the rational design of road surfaces as a goal, the Bureau of Public Roads has begun experiments to find out something of the fundamentals affecting road design.

Just as in the design of a bridge structure, the design of a road requires not only a knowledge of the materials in the structure and their behavior under stress, but it also requires a knowledge of the forces acting on the structure tending to deform it out of shape. Obviously, then, one of the fundamental problems is to determine just what forces are being exerted on roads tending to destroy them.

IMPACT ACTION ON SMOOTH SURFACE.

Anyone who has stood on a hard-road surface during the passage of a heavy truck has noticed the vibration set up in the pavement, indicating that the truck is exerting more or less of an impact action even though the surface be comparatively smooth. Such action, of course, is much accentuated after the surface becomes worn in spots or wavy, and the impact then becomes very noticeable. Heavy loads at rest on road surfaces exert but little effect except on surfaces which, for some reason, are too soft to bear the load. Actual tests have been made on a concrete road to gain some idea of the fiber stress in the concrete directly under a heavy wheel load of a loaded truck.[1] The indications are that when a wheel load of 8,500 pounds is at rest

[1] Thickness of concrete slabs, by A. T. Goldbeck, Public Roads, April 1919.



VIEW OF TOP OF JACK FOR MEASURING IMPACT OF TRUCKS.

on an 8-inch concrete slab laid on a rather wet clay subgrade the fiber stress in tension is only about 34 pounds per square inch directly under the load, and since the modulus of rupture of the ordinary concrete road mixture is well over 400 pounds per square inch, and possibly as high as 600 pounds per square inch, the danger of serious cracking of the concrete under static loads is practically nil except at the corners of the slabs.

We must turn to impact then for an explanation of some of the past failures of road surfaces under motor truck traffic. How great can these impacts be as compared with the static weight of trucks? What impacts are likely to be exerted on road surfaces depending upon their degree of smoothness, and what effect have these impacts on different kinds and thicknesses of surface when laid on different subgrades? These are some of the questions we must answer before we can hope to design a road rationally.

The impact tests now being conducted by the Bureau of Public Roads aim to determine—

(1) The amount of impact delivered to road surfaces.

(2) The effect of this impact on different types of surface.

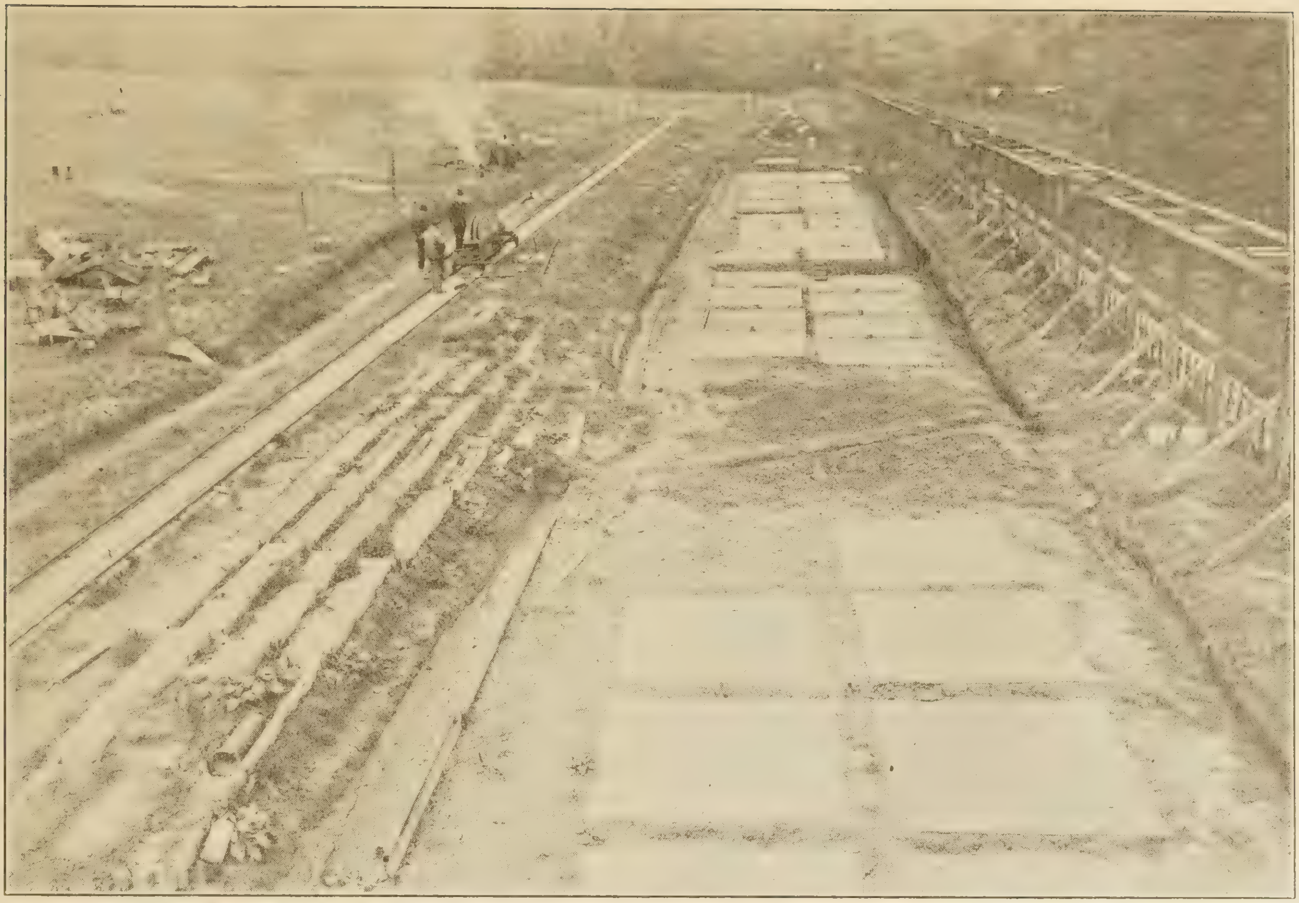
MEASUREMENT OF IMPACT DELIVERED TO ROAD SURFACES.

The method now being used for measuring the amount of impact delivered by trucks has been described elsewhere.[1] In brief, it consists of delivering the impact of a moving truck to a small copper cylinder, the blow deforming the cylinder a definite amount, depending on the intensity. In these experiments a concrete pit has been constructed in the road surface and a hydraulic jack has been placed in this pit. The plunger of the jack is enlarged at the top with a platform of suitable size for receiving the blow of one wheel of the truck. The copper cylinder which measures the blow is placed under the plunger of the jack and the blow is transmitted through the plunger to the copper cylinder. The cylinders used are turned from one-half inch copper rod and are one-half inch in length. A large number of these cylinders are prepared and are given a special heat treatment to make them uniform in their physical characteristics. A number of them are selected from each lot prepared and are subjected to pressure in a testing machine, and the deformation of the cylinder is noted for each load applied. In this way it is possible to check up the uniformity of the lot of cylinders and also to determine how much load is required to deform them to a definite length. The impact deforming the copper cylinder is stated in terms of the static load required to deform it to the same length.

A little thought will show that there are a number of different ways in which impact can be delivered to a road by a motor truck, and the test has been arranged to approximate these different conditions. For instance, the truck while in motion is caused to fall through definite heights striking the plunger of the jack. Again, the truck is made to strike obstructions of different heights placed directly on the plunger of the jack and, as described later, several other variations of impact have been investigated.

The speed of the truck has been made one of the variables in these investigations in order to permit of determining something of the law of the effect of

[1] Preliminary Report of Impact Tests of Autotrucks on Roads, by E. B. Smith and J. T. Pauls, Public Roads, July, 1918.



GENERAL VIEW OF SLABS TO BE TESTED UNDER IMPACT.

speed of impact. Different sizes and makes of trucks loaded with different loads are being used. Thus far the tests have been confined to solid-tired vehicles, but it is the aim to extend them to an investigation of pneumatic tires and to special types of cushioned wheels and special tires. The impact of the rear of the truck only has been investigated, as this impact is greater than that of the front wheels.

RESULTS OBTAINED.

In this discussion no attempt will be made to treat of all the results obtained, but, rather, the essential features of the data will be pointed out. A number of curves are given, and these have been selected from a large number of test results because they, in general, show the maximum impacts that have been measured. In the tests here recorded a class B 3 to 5 ton standard Army truck, a 5½-ton truck, and a 1½-ton truck have been used. All of these trucks were supplied by the Motor Transport Corps of the War Department.

CLASS B THREE TO FIVE TONS STANDARD ARMY TRUCK

Referring to curve 1, which shows the results obtained with the class B truck loaded with 5 tons of sand and having a total weight of 7,750 pounds on one rear wheel and an unsprung weight of 1,837 pounds on one rear wheel, it should be noted that in general the higher the fall the greater is the amount of impact produced. The maximum impact pressure, when the truck was running 15 miles per hour and fell through a height of 3 inches, was 42,000 pounds, and this was 5.4 times the static load pressure exerted by the rear wheel. When the rear wheel dropped through a height of only one-fourth inch at 15 miles per hour, the impact pressure produced was 28,000 pounds, or 3.6 times the static load pressure. It will be well to note here that the unsprung weight of this truck is very heavy, and it will be seen, as pointed out later on, that this has the effect of producing high impact pressures.

In curve 2 the same truck loaded in the same manner as above was used, but the rear wheel of the truck was caused to strike an obstruction which was placed on the plunger of the measuring jack. It will be noted that this condition of impact is very much less severe than shown in curve 1 described above. In general, the impact pressure seems to increase with the velocity and also with the height of the obstruction.

In obtaining the results shown on curve 3, wedge-shaped blocks were mounted on the plunger of the jack, the angle of inclination of the blocks being varied for the several tests. The rear wheel of the truck simply rolled over these wedge-shaped blocks and produced pressure on the copper cylinder as shown in the curve. As would be expected, the pressure produced increases with the angle of inclination of the block and also increases with the speed. This condition of pressure is realized in the road surface when a truck rolls into a depression and the wheels strike the far side of the depression, and these tests show that the steeper the far side of the depression the greater will be the pressure produced on the road.

Should the depression be deep enough and the speed of the truck sufficient, the wheels will leave the surface of the road, jumping over the depression and landing on the far wide with considerable impact. This condition was tested by placing wedge shaped blocks on top of the jack as in the previous test, elevat-

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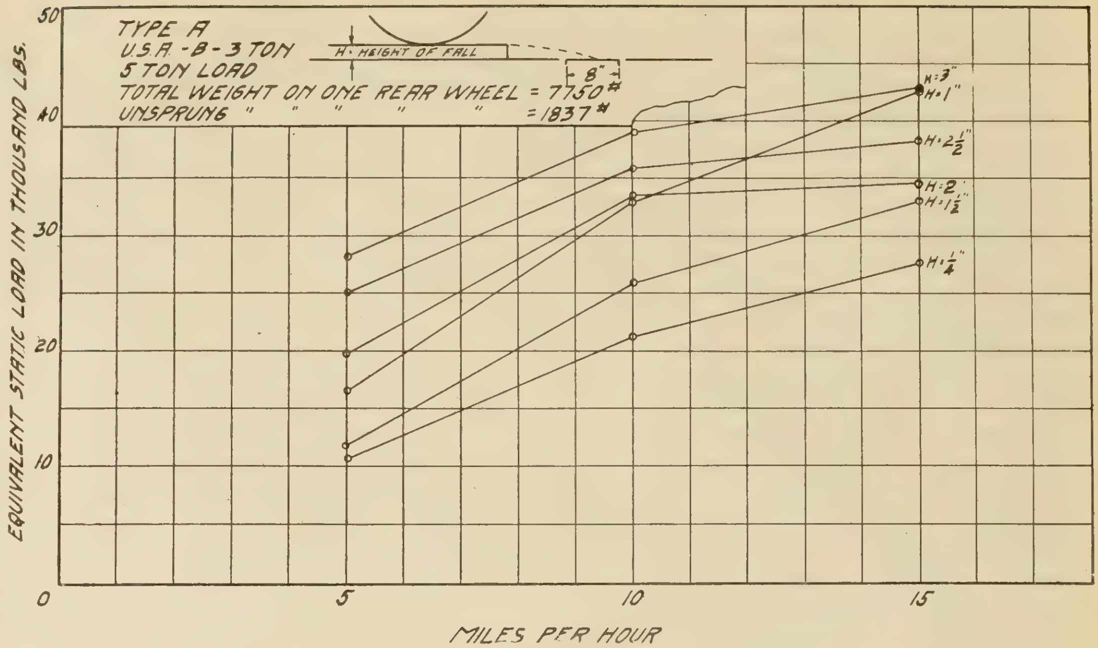
ing the point of jump off and running the truck at a speed such that it fell on the center of the wedge-shaped block, giving pressures as shown in curve 4. The height of fall in each of these cases was 2 inches. It will be seen that this gives a very severe condition of impact. These tests were very difficult to make, as it necessitated very careful driving to make the rear wheel land directly on the center of the jack. A large number of runs had to be made before results of any value at all could be obtained.



CURVE 1.

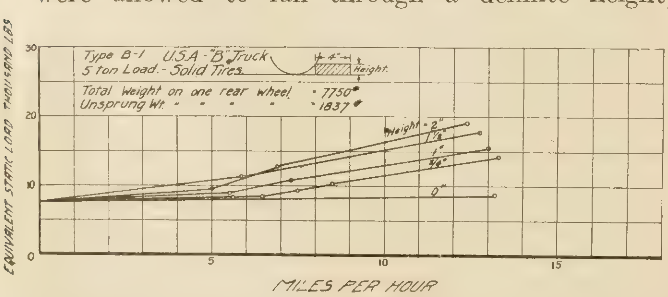
FIVE AND ONE-HALF TON TRUCK.

In curve 5 results are shown obtained with a 5½ ton truck carrying a load of 5.65 tons, having a total weight of 8,060 pounds on one rear wheel and an unsprung weight of 1,000 pounds on one rear wheel.

NO. 1	ORIGINAL, 0.5" DIA.	0.501" LONG	
NO. 2	DEFORMATION = 28.3%	= 12,250 LBS.	STATIC LOAD
NO. 3	" = 48.9%	= 21,500 "	" "
NO. 4	" = 66.9%	= 40,000 "	" "

DEFORMATION OF COPPER CYLINDERS.

The tests shown in this curve were obtained by running the truck at different speeds and allowing it to fall through different heights. It will be noted in general that the pressure increases with the speed and to some extent with the height of fall. In the particular set of results recorded here, both wheels were allowed to fall through a definite height,



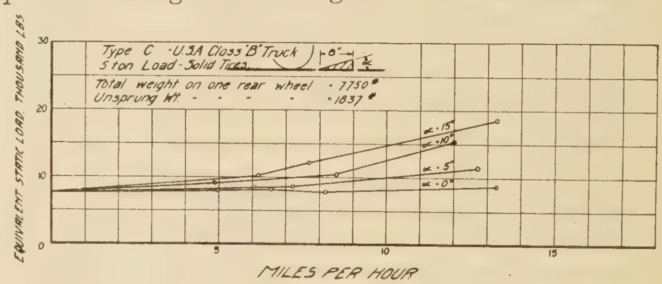
CURVE 2.

whereas in the other tests only one rear wheel was allowed to fall. When two wheels fall through a certain height a slightly increased pressure under one wheel is produced than when one wheel only falls through the same height.

In curve 6 the pressure measured was produced by the truck striking an obstruction placed on the jack, and this pressure is much less than in the previous case, as shown in curve 5. The same general tendency for pressures to increase with the speed and with the height of the obstruction is shown just as in the case of the class B Army truck.

In curve 7 are shown the results obtained when the truck rolled over wedge-shaped blocks placed directly on the jack. The same general shape of curves was obtained as in the case of class B truck, the intensity being somewhat less in this case.

Curves 8, 9, and 10 show the impact pressures produced with a 1½-ton truck carrying a load of 3,660 pounds having a total weight on one rear wheel of

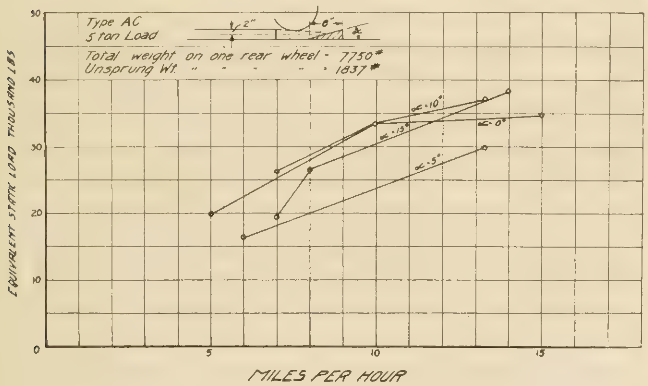


CURVE 3.

3,475 pounds and an unsprung weight of 1,065 pounds. In curve 8 resuts were obtained with the truck falling through various heights to the weighing device. In curve 9 the obstruction was placed on the weighing device and in curve 10 wedge-shaped blocks over which the truck rolled were placed on the plunger of the device for measuring the impact pressure. These curves are of the same general shape as the preceding ones, and in view of the fact that this truck was lighter, the pressures obtained were less than previously described.

GENERAL DISCUSSION OF IMPACT PRESSURE TESTS.

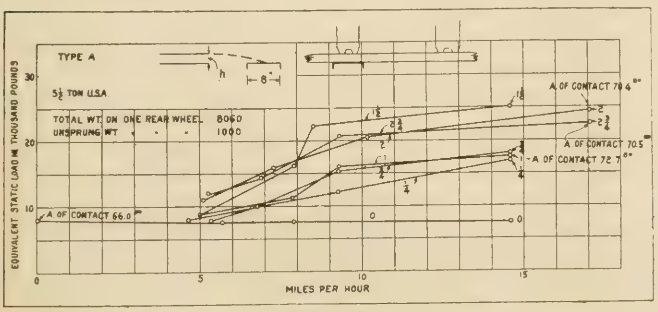
It is seen from the preceding test results that under certain conditions the impact pressure produced by heavy motor trucks is very large, the highest pressure thus far measured being in the neighborhood of 42,000 pounds when the weight on the rear wheel causing this pressure was only 7,750 pounds. It was pointed out that the unsprung weight on one rear wheel of this truck was 1,837 pounds. In the case of the 5½-ton truck which has an unsprung weight of 1,000 pounds, it has been shown that the impact pressures produced were very much smaller than in the case of the class B Army truck. Considering a specific case, when the class B Army truck, whose total weight of 7,750 pounds on one rear wheel, unsprung weight 1,837 pounds on one rear wheel, fell through a height of 2 inches at a speed of 15 miles per hour, the impact pressure produced was about 34,500 pounds. In the case of the 5½-ton truck loaded with a load of 8,060 pounds on one wheel, with an unsprung weight of 1,000 pounds on one rear wheel, and under corresponding conditions of speed and height of fall, the impact pressure produced was only 23,500 pounds, or only 68 per cent of the impact pressure of the Army truck. The unsprung weight of the 5½-ton truck was only



CURVE 4.

56 per cent of that of the Army truck, whereas the gross load carried on the rear wheel was slightly larger in the case of the class B truck. The indications are, therefore, that a light unsprung weight tends to lessen the impact of a truck on the road surface.

Referring to curve 9, giving results for a 1½-ton truck having a total weight of 3,470 pounds on one rear wheel and 1,065 pounds unsprung weight on one rear wheel, the impact pressure at a speed of 15 miles per hour and with a height of fall of 2 inches, was in the vicinity of 14,000 pounds per square inch. It will be noted that the unsprung weight of this truck is practically the same as that of the 5½-ton truck and the impact pressure produced is very much lower than in the case of the 5½-ton truck, so that it can not be said that unsprung weight alone influences the impact pressure produced on the road, but the sprung weight also exerts some influence on this pressure.



CURVE 5.

VIEW OF IMPACT MACHINE FOR TESTING ROAD SLABS.

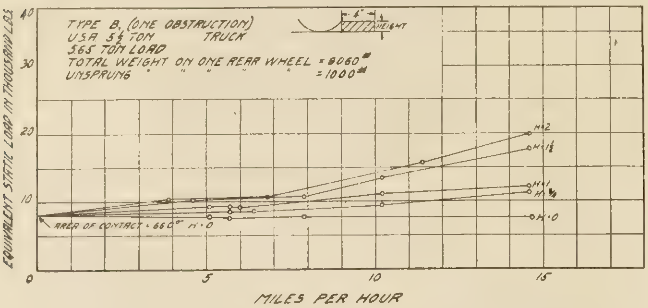
GROSS LOAD NOT ONLY FACTOR.

These facts are very significant, for they show that the gross load of a truck is not the only factor which influences the pressure of the wheels of the truck on the road surface. It is possible to have vastly different impact pressures exerted on the road by two different trucks both having the same gross weight but having different distribution of their sprung and their unsprung weights, and when questions of road design are to be considered the actual wheel pressure on the road is the all-important thing rather than the gross load of the truck. Would it not seem logical to take these facts into consideration in framing legislation dealing with the restriction of maximum sizes of motor trucks on roads, and moreover, do these facts not open the way toward a more equitable system of license fees than the more or less arbitrary systems based on gross load, carrying capacity, or horsepower now in use?

The effect of the speed of trucks on the amount of impact produced on road surfaces is indicated by these tests. It has been stated that the impact of vehicles on roads varies as the square of the speed, but the present tests indicates that within practical speed limits this is not the case. In the results obtained thus far the impact on the road varies with some power of the speed, this power, however, being less than two and extending down as low as one. The present data do not warrant a close analysis to determine this relation.

SPRING DEFLECTION A FACTOR.

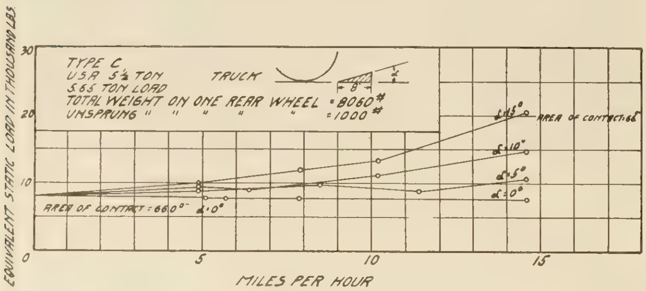
At first thought it would seem that the impact should vary directly as the height of the fall when a truck rolls off an obstruction and falls on a road surface, but these tests indicate that this is not true, the reason being that the action of the springs of the vehicle give the unsprung weight an acceleration above that due to gravity and, depending upon the spring action and upon the amount of sprung and unsprung weight, the impact effects with various heights of fall are likely to vary with different trucks.



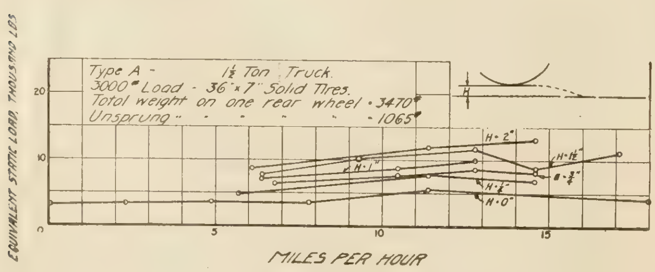
CURVE 6.

The amount of spring deflection at the instant the impact occurs is another factor influencing the amount of impact on the road.

Having determined the amount of impact exerted on surfaces by trucks under these artificial conditions, the next question arises as to what impacts are actually produced on road surfaces of different degrees of roughness. Undoubtedly the road having a rough surface will be subjected to greater impact than the smooth road, and information of this character has as yet not been obtained, but it is hoped that it will be possible to obtain these results within the coming year by means of special equipment now being constructed.

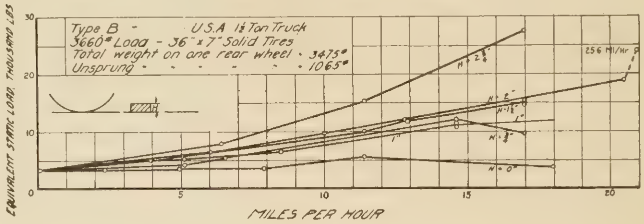


CURVE 7.



CURVE 8.

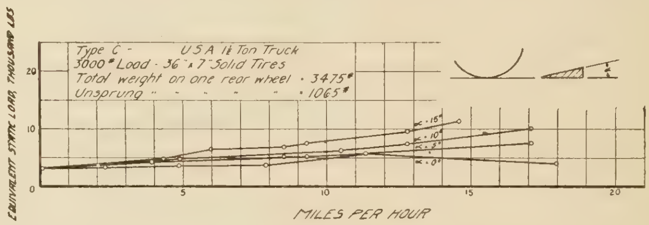
What use shall be made of the results of the impact tests in the design of road surfaces? The theory for the design of beams under static loads states that the strength of the beam varies as the square of the depth, and in one instance use has been made of this theory to place road surfaces of different kinds on an equal basis so far as their load-carrying capacity is concerned. On the other hand, it may be shown theoretically that when loads are applied with impact on beams their strength varies directly as their depth and not as the square of the depth. With rubber-tired vehicles it is a question as to whether the impact produced is of a suddenness requiring design by the latter theory, and it would seem to be reasonable that in view of the cushion effect of rubber tires the load-carrying capacity of the slab will vary as some function intermediate between D and D^2. When the proper theory to use is determined, knowledge of the amount of load applied by impacts will permit of actually designing roads to properly sustain these loads.



CURVE 9.

DETERMINATION OF THE EFFECT OF IMPACTS ON ROAD SURFACES.

Having obtained the amount of impact exerted by trucks, the next question is that of the damaging effect of impacts on road surfaces. We are attempting to gain some information on this point through a series of tests now under way. We have constructed a number of slabs 7 feet square laid directly on the subgrade. Half of these sections are laid on a subgrade which is purposely kept wet and half of them are on a well-drained subgrade. The sections thus far constructed include concrete in depths varying from 2 inches to 10 inches and brick constructed on varying thicknesses of concrete base. Various kinds of brick have been used, including repressed, wire-cut lug and vertical fiber brick. We have used monolithic, semimonolithic and sand cushion construction; both Portland cement grout and bituminous mastic fillers have been used. One section is laid on a bituminous mastic cushion with



CURVE 10.

a bituminous mastic filler. In other sections the brick have been laid directly on a subgrade and in still others on a prepared macadam base. We are testing these slabs by means of an impact machine which is designed to represent the conditions existing on the rear wheel of a truck. This machine has an unsprung weight of 3,000 pounds and will carry a sprung weight of 9,000 pounds. These weights correspond approximately to those that would exist on the rear wheel of a 7½-ton truck. The lower end of the sprung weight is shoed with a solid rubber tire and the whole weight will be raised to a height such that when allowed to fall, the impact delivered will be one that might be delivered by a 7½-ton truck. The observations will consist of noting the behavior of the surface under repeated impacts of this machine and will also include measurements of

(Continued on page 25.)

GROWTH OF FEDERAL AID WORK.

By A. C. BRUCE, Office Engineer, Bureau of Public Roads.

THE growth of the Federal aid post road work carried on under the supervision of the Bureau of Public Roads is graphically shown by the progress curves herewith presented. These curves show the status of work from month to month since the passage of the act in July 1916, to the latest monthly statement dated October 31, 1919. There are many stages of the work not shown, but the four principal stages outlined in the act are covered, namely, project statements approved by the Secretary; plans, specifications and estimates recommended for approval by the Chief Engineer; project agreements executed by the Secretary; and vouchers passed for payment by the auditor.

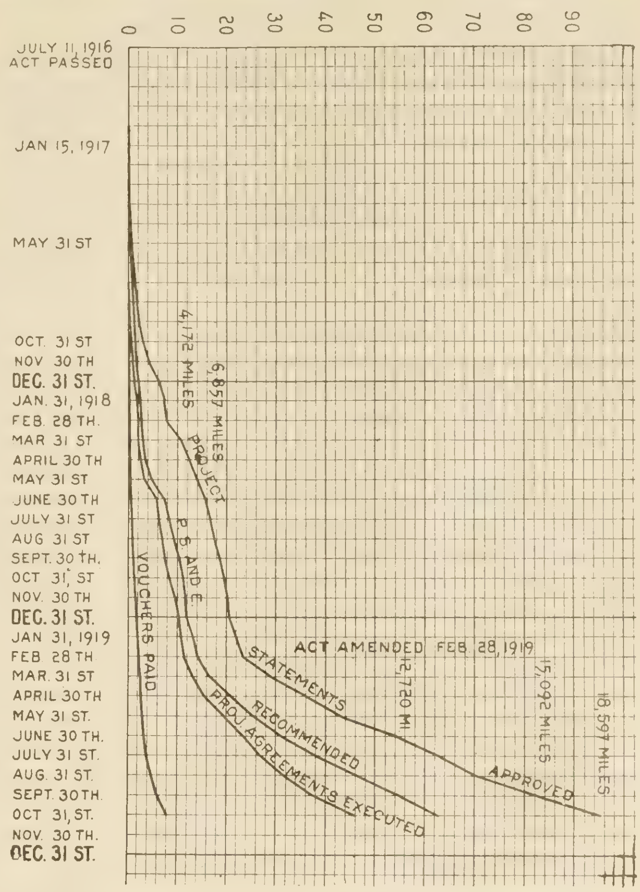
It will be seen that a very noticeable impetus was given to all stages of the work by the passage of the amendment to the act, February 28, 1919, whereby an appropriation of $200,000,000 was added to the original $75,000,000.

The actual value of work completed to date on Federal aid projects is considerably in excess of that shown by the curve "Vouchers paid." This is due to the fact that there is a lag of from one to four months between the completion of work and the presentation of the vouchers. There are also some projects which require that Federal aid payments shall be made only upon completion of the entire project. There is every indication that this season's completed work will call for Federal-aid payments of at least $25,000,000.

On October 31, 1919, there were 1,929 project statements approved by the Secretary. These represented a total of 18,597 miles and were estimated to cost $225,159,801, of which amount Federal aid was requested to the amount of $95,498,-139.65. If the curve can be assumed to indicate the probable future progress of the work, it would be expected that the total $275,000,000 Federal aid would be covered by approved project statements about December 31, 1921.

Plans, specifications and estimates have been recommended for approval by the chief engineer for 1,373 projects. These projects represent 10,373 miles of road with a total cost of $145,777,433, of which Federal aid has been recommended for $62,745,137. The approved plans for the above roads show practically all the usual types of construction, and the estimates show a range in cost per mile from $2,500 to $100,000.

At the same rate of progress as that shown on the curve for the past six months, sufficient plans would be recommended by the chief engineer by October 31, 1921, to take up the entire $275,000,000.



(Continued from page 24.)

deflection of the surface. Nothing can be said of the results at the present as the tests have not progressed to that extent. We aim to continue these investigations with bituminous surfaces laid on concrete bases using a 1 : 3 : 6 as well as a 1 : 1½: 3 base. In addition, broken stone bases will be used under the bituminous surfaces.

With the completion of these tests it is hoped that sufficient data will have been accumulated to place the design of roads on a much sounder basis than at present and it is hoped that the results combined with the results of still other investigations will finally lead to a suitable method for determining with certainty on road types and cross-sections for definite subgrade and load conditions. In conclusion, the writer wishes to give due acknowledgement for the work of E. B. Smith and J. T. Pauls who are conducting these impact tests in detail.

VOTE ROADS BONDS.

Three districts of Kanawha County, W. Va., have voted a total of $1,459,000 in bonds for the improvement of highways. The districts are Cabin Creek, $904,000 of bonds, Elk, $395,000, and Union, $160,000.

NEARLY $25,000,000 ALLOWED IN FEDERAL AID IN TWO MONTHS.

IN September and October Federal-aid allowance to roads in the projects approved by the Secretary of Agriculture called for $24,780,906.43, or about one-fourth of the total amount of Federal-aid money apportioned to the States under the Federal-aid act and the amendment to the last post-office appropriation law for the present fiscal year. In the two months agreements signed by the Secretary and modifications to previous agreements the Federal-aid allowance amounted to $14,046,541.73. The cost of the roads in the statements approved is estimated at $52,722,392.10 and that in the project agreements signed at $32,284,579.31.

Up to the close of office hours October 31 last, 1,927, project statements, representing 18,596.788 miles of highway, had been approved, while the Secretary of Agriculture had signed 1,065 project statements, representing 8,407.293 miles of road. The total amount of Federal aid allowed in the statements approved amounted to $95,498,140.85 and in the agreements executed to $46,107,333.38. The highways included in these projects are estimated to cost $225,267,847.25 in the statements approved and $107,549,468.74 in the agreements signed by the Secretary.

SEPTEMBER A BANNER MONTH.

The Bureau of Public Roads considered more Federal-aid projects in September than in any previous month. The record shows 165 project statements approved, 8 revised statements approved, and 2 withdrawals, while 98 project agreements and 23 modifications of previous agreements were signed by the Secretary of Agriculture. The statements approved were for 1,606.62 miles of road, estimated to cost $27,645,241.91, with Federal aid amounting to $12,703,746.24. The agreements signed were for 625 miles of road, estimated to cost $13,056,082.22 and a Federal-aid allowance of $5,680,742.89.

In the number of statements approved Minnesota led with 16, while there were 2 revisions from that State. New Hampshire and West Virginia each had 15 projects approved, Nebraska coming next with 11. The Nebraska mileage was 217.367, mostly for earth, gravel, and sand-clay roads, that of Minnesota 161.25, West Virginia 81.11, and New Hampshire's only 13.436, an average of less than a mile to a project.

The Nebraska mileage was the greatest included in the projects approved during the month from any one State. Indiana had the second largest, 185.8, that of Minnesota came third, followed by Montana with 106.5 miles and New Mexico with 95.5. The Indiana roads are all to be of asphalt, brick, or concrete, while the Minnesota and West Virginia projects include a considerable mileage of hard-surface construction. The Montana and New Mexico roads are to be mostly earth or gravel.

In five States the statements approved show estimated cost of roads in excess of $1,000,000, and in three States the Federal aid allowed is more than $1,000,000. The five States together had 34 statements and 4 revisions approved, with an estimated cost of the roads $15,184,871.51, or 54.7 per cent of the total for all the States. The Federal aid allowed for these statements amounts to $6,986,322.94, more than one-half the total for the month. In each of five other States the roads will have an estimated cost of over $900,000.

Indiana not only led all the other States in the estimated cost of the roads embraced in the statements and in the amount of the Federal-aid allowance, but the aggregate for that State was by far the greatest for both cost and Federal aid for one month since the passage of the law. The totals of the only four projects approved for that State are estimated cost $7,128,013.20 and Federal-aid allowance $3,537,330.80.

LARGEST PROJECT TO DATE.

One of the four Indiana projects breaks the record for estimated cost and for Federal-aid allowance. It is for 114.4 miles of road running from Evansville north through Vanderburgh, Warrick, Spencer, Dubois, Orange and Lawrence counties estimated to cost $4,223,076 and will be given Federal aid to the amount of $2,111,538. Another Indiana project, for 56.7 miles in Lake, Porter, and Laporte Counties, of the same construction, will cost $2,292,351, with an allowance of $1,134,000. This is the third largest project, in estimated cost, in the records.

Kansas follows Indiana in September's record. Her five projects approved have an aggregate cost of $3,498,754.59 for 87.28 miles of road and will receive $1,309,200 Federal aid. The largest Kansas project is for 44.5 miles of concrete road in Sumner County, estimated to cost $1,622,808, with an allowance of $667,500. Unlike the Indiana projects, this is all in one county and is to date the largest project on record for a single county. A second Kansas project, for 25.07 miles of asphalt, brick, or concrete road in Dickinson County, will cost $1,119,648.47, according to the estimate, and will receive Federal aid to the amount of $376,050.

BIG PROJECTS IN ILLINOIS.

Illinois had two new projects and a revised project approved, for an aggregate mileage of 50.83, an estimated cost of $1,995,711.40 and Federal aid of $1,043,090.70. The revised project was for additional mileage of 10.7, added estimated cost of $837,001.80 and Federal aid of $463,735.90, for a bituminous macadam or concrete road in Kankakee and Iroquois Counties. This revision gives this project, Illinois No. 2, a total length of 65.2 miles, an estimated cost of $1,741,701.80, and an allowance of $870,850.90, making it the fourth largest project approved in the history of Federal aid up to September 30, 1919.

Sixteen new and two revised projects in Minnesota, aggregating 161.25 miles in length, are estimated to cost $1,436,385.64 and will receive an allowance of $673,997.68. Texas is the fifth State whose project approvals for the month exceed $1,000,000. Seven new and one revised project in that State, 87.491 miles long, will cost $1,126,006.68 and receive Federal aid amounting to $422,703.

California will receive $475,688.95 Federal aid on four projects estimated to cost $951,377.90; Maryland $456,464 of Federal aid for five new and one revised project to cost $948,879.25, and West Virginia $438,689.10 Federal aid for 15 projects estimated to cost $912,124.90.

HIGH COST OF ROADS PER MILE.

The 2.01 miles of concrete or brick road in Cuyahoga County, Ohio, project No. 84, estimated to cost $190,011, is the highest costing project approved in September. It is at the rate of $94,532.83 a mile. This is probably the highest cost per mile of any project approved to date. In a recent issue the cost of a short project in Massachusetts, 0.578 mile long, was stated to be at the rate of $127,864 a mile. This was a mistake, as included in the project was a concrete bridge at the estimated cost of $49,758, bringing down the cost per mile of the road to a much smaller amount.

New Jersey's only project approved during the month is a concrete road which is estimated to cost at the rate of $85,404.34 a mile. A short road in Grand Forks County, N. Dak., less than a mile in length, will cost at the rate of $65,904.17 a mile. In Kanawha County, W. Va., 2.6 miles of concrete road are estimated to cost $53,302.19 a mile. In her 5 projects approved Kansas has the high average of $40,086. 55 a mile for 87.28 miles of road.

In the project agreements for September, Pennsylvania led all the States, with 22 agreements signed by the Secretary of Agriculture for a total of 114.586 miles of road, estimated to cost $5,534,619.60, and a Federal-aid allowance of $2,324,927.72. Washington was second in the record, with 12 original and 3 modified agreements, for 77.47 miles of road, estimated to cost $1,602,431.80, for which the Federal aid will be $745,039.69.

APPROVALS AND AGREEMENTS IN OCTOBER.

October was another big month in the consideration of Federal-aid projects, and the figures for both statements approved and agreements executed made records. Statements approved numbered 185, and there was 1 revised statement in which the allowance of Federal aid and the estimated cost of the road was increased. This is the largest number of statements so far approved in a single month. The mileage of the roads involved showed an increase of 232 miles over the large September mileage. There was a decrease, however, from the previous month in the estimated cost of the roads and in the total amount of Federal aid called for in the approved projects.

In project agreements signed by the Secretary of Agriculture there was a big increase over the September figures, making the October record far ahead of that of any previous month. The Federal-aid allowance on these agreements was at the rate of $100,000,000 a year. The Federal-aid allowance in the projects approved during the month was at the rate of $145,000,000 a year. Of the agreements executed all represented approvals made in previous months.

The figures for October were: Project statements approved, 185; revised, 1; withdrawn, 3; mileage of projects, 1,848.098; estimated cost of roads, $25,502,372.28; Federal aid allowed $12,077,150.19. Project agreements signed, 138; modifications of previous agreements, 20; mileage, 888.948; estimated cost, $19,227,497.09; Federal aid allowed, $8,365,-798.92.

IOWA FIRST IN MONTH'S RECORD.

In the statements approved the estimated cost of roads in eight States is greater than $1,000,000, while two States will receive Federal aid amounting to more than that amount. Several States which have not heretofore taken high rank in the monthly record of approved statements came to the front in October.

Iowa is the banner State for the month, being first in total mileage involved in the approvals, in the estimated cost of the roads and in the Federal aid allowed. She was third in the number of projects approved, 14. The total mileage of the roads in these 14 projects is 216.81, no other State's approvals representing as much as 200 miles. The estimated cost of the roads is $3,978,847.95 and the Federal-aid allowance $1,951,750.

North Carolina with an estimated cost of $2,182,-381.36, an allowance of $1,091,190.66, for 18 roads having a mileage of 135.61, stood next to Iowa in the amount of Federal aid and the cost of the roads, and second in number of projects and fourth in mileage.

Tennessee was third in estimated cost and Federal aid allowed, the figures being, respectively, $1,849,-

780.39 and $924,890.17, for 6 projects having a mileage of 97.69. Georgia had 23 statements approved, 8 more than North Carolina, the second State in the number of projects. They were for 147.05 miles, next to the largest mileage of the month. The estimated cost of the roads is $1,779,729.56, the fourth on the list. Michigan, Oregon, Missouri, and Texas are other States represented by approved statements aggregating more than $1,000,000.

In the cost of the roads in the agreements executed Ohio led all the other States, with an estimated cost of $2,543,483.80, for which there will be a Federal-aid allowance of $1,119,000. Illinois was second in the estimated cost of her project agreements, $2,877,565.18, and first in the amount of Federal aid, $1,431,900.74. Indiana came third in the cost of the projects and second in Federal-aid allowance, the figures being $2,294,383.23 and $1,125,000. Washington and Georgia are other States in which the estimated cost of the roads in the agreements exceeded $1,000,000.

MICHIGAN'S LARGE PROJECT.

Michigan, with only two project statements approved in October, holds the distinction of presenting the largest one for month, while her second project is also one of the big ones approved. The largest project was her No. 35, for 25.559 miles of brick, concrete, or bituminous road in Jackson and Washtenaw Counties between Jackson and Ann Arbor, estimated to cost $1,018,050, for which the Federal-aid allowance is $509,025. The other Michigan project is estimated to cost $627,110 and will receive an allowance of $287,850. It is for 14.211 miles of road in Wayne County, between Dearborn and Flat Rock, known as the Telegraph Road, and will be built of brick, concrete, or bituminous.

Iowa had three large projects approved, their aggregate cost being estimated at $2,543,483.80, for which there is Federal aid amounting to $1,234,600. Two of these projects are parts of the North Iowa Pike. The largest is that part of the pike in Hancock County between the Cerro Gordo County line and Kossuth—24.9 miles of brick or concrete road, estimated to cost $953,350.20, with an allowance of $476,600. That part of the pike in O'Brien County, between Sheldon and the Clay County line, also to be of brick or concrete, 22.59 miles long, will cost $832,436 and receive $416,000 Federal aid. The third of the big Iowa projects, 17.1 miles of brick or concrete, is in Black Hawk County, part of the Hawkeye Highway, between Waterloo and Cedar Falls, with a cost of $757,697.60 and Federal aid of $342,000.

A large Tennessee project has an estimated cost of $721,134.47 and is given an allowance of $360,567.23. It is 48.876 miles long, is to be macadam, and is a part of the Bristol-Memphis Highway, between Tate Springs and Kingsport, in Grainger, Hawkins, and Sullivan Counties. The cost of this macadam road will average over $14,750 a mile. It runs through east Tennessee mountainous and hilly country. Among the other Tennessee projects is No. 16, for a bridge 0.237 mile long, over the Cumberland River near Clarksville, in Montgomery County, which will cost $176,543.

Maryland project No. 37, 19 miles of concrete road between Ingleside and Lamber, in Queen Anne and Kent Counties, will cost $660,000. Arizona and Oregon are represented in the projects, which will cost between $500,000 and $600,000; an Oklahoma project will cost $399,300; and projects in Mississippi and North Carolina are estimated to cost about $342,000 each.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	12	Lowndes	2.50			Oct. 24	$16,861.80	$8,430.90
	48	Barbour	8.66	Sand-clay		Oct. 25	40,838.41	20,419.20
	63	Dale	6.34	do		Oct. 24	35,337.61	17,668.80
	67	do	22.29	do	Oct. 13		138,440.50	69,220.25
	68	Bullock	10.23	do	Oct. 20		78,135.47	39,067.73
	69	Lamar	6.84	Earth and gravel	do		26,581.50	13,290.75
	70	Barbour	3.00	Sand-clay	Oct. 10		28,711.01	14,355.50
Arizona	8	Maricopa	6.641	Concrete or bituminous		Oct. 24	210,978.02	105,489.01
	12	Yavapai	1.961	Macadam		Oct. 2	133,054.11	39,220.00
	16	Pinal and Gila	20.00	Macadam or gravel	Oct. 2		539,803.00	269,901.50
	19	Yapavai	15.144	Earth and gravel	Oct. 10		56,622.15	28,311.07
Arkansas	31	Cleveland	7.62	Gravel	do		86,216.90	23,000.00
	33	Cross	4.74	do	Oct. 30		41,492.70	12,500.00
	35	Pulaski	8.81	Bituminous	Oct. 16		188,419.60	87,500.00
	36	Washington	41.40	Gravel	Oct. 8		215,229.41	100,000.00
	39	Grant	14.30	do	Oct. 24		52,090.50	15,000.00
California	21	Ventura	5.19	Concrete		Oct. 11	166,885.40	83,442.70
	22	Los Angeles	1.29	do		do	42,310.40	21,155.20
	23	do	5.23	Bituminous		do	100,070.85	50,035.42
	31	Del Norte	4.08	Gravel	Oct. 11		37,510.00	18,755.00
Colorado	11	Yuma	7.49	Earth	Oct. 23		24,036.37	12,018.18
	22	Otero	.407	Concrete		Oct. 24	10,572.92	5,286.46
	27	Mesa	.265	do	Oct. 27		10,286.10	5,143.05
	36	Boulder	1.523	do	Oct. 13		44,855.52	22,427.76
	37	do	1.102	do	do		44,622.88	22,311.44
	43	Kit Carson	18.049	Earth	Oct. 23		43,218.78	21,609.39
	69	Otero	.413	Concrete		Oct. 3	10,605.92	5,286.46
Delaware	5	Kent	5.981	do		Oct. 6	210,143.11	54,000.00
	7	Newcastle	2.01	do	Oct. 20		93,500.00	22,310.61

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Georgia	3	Brooks and Lowndes		Sand-clay		Oct. 23	[1] $21,204.02	[1] $11,584.70
	7	Madison		do		Oct. 3	[1] 48,491.50	24,733.45
	11	Lowndes		2 bridges		do	[1] 16,643.09	12,532.90
	12	Thomas		do		Oct. 24	[1] 17,893.55	[1] 10,463.30
	16	Merriwether	[1] 0.28	Topsoil or sand-clay		Oct. 3	[1] 9,050.10	[1] 5,974.56
	19	Bleckley	[1] 1.48	Earth		do	[1] 12,304.38	[1] 6,308.39
	28	Paulding	9.505	Sand-clay or gravel		do	40,215.91	20,000.00
	29	Emanuel		10 bridges		Oct. 28	140,438.01	70,219.00
	38	Brooks		do		Oct. 25	58,353.29	29,176.64
	42	Chatham	13.534	Brick, concrete, or bituminous		Oct. 3	524,091.08	200,000.00
	44	Hall	4.00	Concrete		do	26,361.24	13,180.62
	49	Mitchell	13.367	Sand-clay		do	67,997.43	33,998.71
	50A	Colquit	.35	Concrete		do	14,128.99	7,000.00
	60	Stephens	11.014	Sand-clay		do	61,298.95	25,000.00
	80		6.00	Concrete or other durable surface	Oct. 4		100,012.00	50,000.00
	82	Lumpkins	8.50	Gravel	Oct. 3		68,558.38	34,279.19
	83	Walton	5.83	Sand-clay	do		29,242.88	14,621.44
	84	do	9.25	do	do		50,757.14	25,378.57
	85	Haralson	5.00	do	do		30,442.50	15,221.25
	86	do	4.00	do	do		29,531.26	14,765.63
	87	do	4.00	do	do		58,338.50	10,013.12
	88	Brooks	7.00	Asphalt, brick, or concrete	do		125,009.50	50,000.00
	89	Baker and Mitchell		Bridge	Oct. 8		60,786.00	30,000.00
	90	Cook	14.70	Concrete	Oct. 3		225,305.41	50,000.00
	91	Lowndes	4.90	Permanent	Oct. 2		99,110.00	49,555.00
	92	Wilkes	5.20	Concrete	do		127,250.20	50,000.00
	93	Taylor and Upson	3.00	Sand-clay	do		44,996.49	22,000.00
	94	Dooley	12.50	do	do		54,851.50	25,000.00
	95	Mitchell	12.20	do	Oct. 3		84,092.80	40,000.00
	96	Floyd	7.25	Bituminous	Oct. 15		89,166.00	44,583.00
	97	Troup	5.15	Sand-clay	Oct. 8		49,410.57	24,705.28
	98	do	5.47	do	Oct. 2		48,375.25	24,187.62
	99	Thomas	4.30	Bituminous	Oct. 8		92,011.59	39,536.69
	100	Terrell	12.50	Sand-clay	Oct. 25		65,869.65	25,000.00
	101	Sumter	3.00	Bituminous	Oct. 8		56,791.10	28,395.55
	102	Cobb	4.00	do	Oct. 24		79,817.65	39,908.82
	103	Chatham	3.306	Concrete or bituminous	Oct. 11		110,003.19	50,000.00
Idaho	18	Latah	22.40	Macadam	Oct. 3		295,630.83	147,815.41
	20	Boundary	18.00	Gravel	do		181,217.00	90,608.50
	21	Bonneville	10.00	Concrete or bituminous	Oct. 13		280,197.39	140,098.69
	22	do	3.00	do	Oct. 10		93,150.20	46,575.10
	25	Bingham	2.00	do	Oct. 18		60,881.70	30,440.85
Illinois	[2] 2	Will, Kankakee, Iroquois	17.113	Bituminous, macadam, and concrete		Oct. 23	578,877.06	289,438.52
	3C	Will	6.788	Brick part way		Oct. 11	213,499.17	106,749.58
	[3] 5	Marshall	12.278	Concrete and earth		Oct. 3	269,557.61	134,778.80
	[3] 5	do	8.465	do		Oct. 20	178,773.43	89,386.71
	[4] 7	Grundy, Bureau, LaSalle, Putnam, and Marshall.	18.112	Concrete			371,362.33	185,681.15
	[5] 8	Madison, Macoupin, Sangamon.	19.57	Brick and concrete		Oct. 10	644,481.13	322,240.56
	[5] 8	do	16.459	do	Oct. 23		621,014.45	303,625.42
Indiana	1	Elkhart	6.355	Brick, concrete, or bituminous		Oct. 24	273,761.62	127,100.00
	2	St. Joseph	4.684	do		Oct. 6	192,359.20	93,680.00
	3AB	Marion and Johnson	7.307	do		do	311,774.05	146,140.00
	5	Wayne	1.489	do		do	41,415.60	20,707.80
	6A	Vigo, Putnam, and Clay	7.37	do		Oct. 24	292,354.81	146,177.40
	7	Marion	6.14	do		Oct. 6	197,040.69	98,520.34
	8A	Hamilton and Marion	5.765	do		Oct. 24	226,571.35	113,285.67
	10A	Marshall and St. Joseph	8.398	do		do	301,861.97	150,930.98
	11	St. Joseph and Elkhart	3.501	do		do	128,796.91	64,398.45
	12	Jackson	2.462	do		Oct. 6	75,377.44	37,688.72
	13A	Hancock and Henry	8.854	do		Oct. 24	253,069.59	126,534.79
Iowa	10	Calhoun	18.36	Gravel		Oct. 11	130,754.30	65,000.00
	37	Buena Vista	12.86	do	Oct. 24		45,267.20	22,600.00
	39	Greene	7.41	Brick or concrete	Oct. 2		293,920.00	146,900.00
	43	O'Brien	22.59	do	Oct. 23		832,426.00	416,000.00
	50	Davis	10.20	Earth	do		62,310.60	31,150.00
	51	Guthrie	20.00	do	do		140,586.60	70,200.00
	52	Audubon	26.25	do	Oct. 29		149,842.00	74,900.00
	56	Henry	20.90	do	Oct. 23		91,377.00	45,500.00
	60	Van Buren	11.10	do	do		54,120.00	27,000.00
	62	Black Hawk	17.10	Brick or concrete	Oct. 20		757,697.60	342,000.00
	77	Fremont	18.50	Earth	Oct. 23		147,400.00	73,700.00
	84	Sioux	3.00	Brick or concrete	Oct. 3		108,872.50	54,400.00
	93	Howard	11.00	Gravel	Oct. 23		84,851.25	42,400.00
	94	Hancock	24.90	Brick or concrete	Oct. 20		953,350.20	476,600.00
	109	Palo Alto	11.00	do	Oct. 23		256,817.00	128,400.00
Kansas	31	Geary and Dickinson	.308	do		Oct. 24	10,971.13	4,620.00
	34	Bourbon	5.91	Bituminous	Oct. 2		172,260.00	86,130.00
	37	Montgomery	12.14	Gravel	Oct. 3		295,020.00	147,510.00
Kentucky	6	Rockcastle	6.818	Earth		Oct. 3	89,754.21	44,877.10
Louisiana	10	Richland	[1] 1.91	Gravel		Oct. 6	[1] 19,923.43	[1] 9,961.21
	38	Natchitoches	17.89	do		Oct. 25	214,546.47	107,273.23
	43	Calcasieu	11.79	Shell and gravel		Oct. 24	245,092.59	122,546.29
	45	Caddo	8.35	Gravel		do	65,945.27	32,972.63
	47	East Carroll	35.06	do	Oct. 31		306,972.37	183,486.18
Maryland	15A	Baltimore	2.03	Concrete		Oct. 11	71,402.98	35,701.49
	24A	Allegany	3.86	do		do	253,152.88	77,200.00
	26A	Baltimore	1.99	do		do	51,819.46	25,909.73
	33AB	Carroll	2.08	do		do	72,155.54	36,077.77
	35	Washington	9.50	do	Oct. 2		331,650.00	165,825.00
	37	Queen Anne and Kent	19.00	do	Oct. 30		660,000.00	330,000.00
Massachusetts	27	Essex	3.559	Bituminous	Oct. 3		73,488.57	36,744.28
	28	Berkshire	3.66	Concrete	do		141,110.75	70,555.37
Michigan	35	Jackson and Washtenaw	25.559	Brick, concerete, or bituminous	Oct. 8		1,018,050.00	509,025.00
	42	Wayne	14.211	Concrete	Oct. 28		627,110.00	287,850.00
Minnesota	38	Mower	24.60	Earth		Oct. 8	149,788.29	70,000.00
	39	Fillmore	8.30	Gravel		Oct. 6	94,156.38	47,000.00

[1] Modified agreements. Amounts given are increases over those in the original agreements.
[2] Includes sections 3, 8, 9, 10, and H-15d of project.
[3] First agreement on project 5 includes sections B, C, D, and G-15d and second sections E and M.
[4] Agreement is for sections A, C, D, and F-29a of project No. 7.
[5] The first of project 8 agreements is for sections D and E and the second for sections G, I, F, and J-15d.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Minnesota	41	Isanti	5.52	Gravel		Oct. 16	$48,574.13	$24,287.06
	49	Chippewa	15.09	do		Oct. 3	85,586.53	40,000.00
	50	Mahnomen	3.99	do		Oct. 16	15,238.02	7,500.00
	53	Lyons	9.05	do		Oct. 14	93,157.91	46,000.00
	78	Yellow Medicine	14.09	do	Oct. 10		49,852.66	24,926.33
	83	Pennington	4.70	do			31,154.14	15,577.07
	86	Aitken	10.30	do	Oct. 15		61,369.00	30,684.50
	88	Chippewa	5.00	do	Oct. 14		49,410.84	24,705.42
	90	Rock	6.00	Concrete	Oct. 3		213,071.65	106,535.82
	94	Polk	9.9	Gravel	Oct. 6		64,271.07	32,135.53
	101	Cottonwood	8.07	do	Oct. 28		68,901.37	34,450.68
Mississippi	14	George		Sand-clay		Oct. 13	[1] 5,927.69	[1] 6,358.68
	48	Yazoo	4.00	Concrete	Oct. 11		103,400.00	51,700.00
	61	Sharkey	13.10	do	Oct. 8		342,531.64	100,000.00
	81	Bolivar	4.47	do	Oct. 1		108,432.50	54,216.25
Missouri	7A	Mississippi	15.30	Gravel		Oct. 14	444,442.86	222,221.43
	20	Cass	19.00	Macadam	Oct. 8		170,869.88	85,434.94
	23	Pettis	5.30	Bituminous	Oct. 2		60,761.80	30,380.90
	27	Cooper	7.80	do	do		129,438.10	64,719.05
	30	Morgan	11.10	Gravel	Oct. 3		46,123.00	23,061.50
	31	Washington	3.53	do	Oct. 11		12,053.02	6,026.51
	33	Polk	13.80	do	Oct. 31		58,294.50	29,147.25
	34	Pemiscot	5.50	do	Oct. 30		51,324.24	25,662.12
	35	do	6.00	do	Oct. 23		69,863.20	34,931.60
	36	Christian	9.50	do	Oct. 30		35,382.60	17,691.30
	37	Gentry	8.17	do	Oct. 28		186,313.60	93,156.80
	39	Lewis	7.70	do	Oct. 30		67,759.67	33,879.83
	40	New Madrid	19.00	do	do		189,999.23	94,999.61
	41	Pemiscot	4.50	do	do		42,619.22	21,309.61
Montana	13	Park	4.13	do		Oct. 25	21,994.66	10,997.33
	18	Custer	3.99	do		Oct. 6	21,954.62	10,977.31
	35	Wibaux	5.68	do		Oct. 20	24,221.83	12,110.91
	39	Ravalli		Bridge		Oct. 25	20,751.50	10,375.75
	47	Carter	13.00	Earth	Oct. 3		22,000.00	11,000.00
	52	Yellowstone	2.00	Gravel	Oct. 8		63,910.00	31,955.00
	57	do	1.10	Concrete	Oct. 16		40,920.00	20,460.00
Nebraska	3	Hall		Earth		Oct. 4	[1] 84,262.97	[1] 42,131.48
	5	Madison and Platte	[2] .22	Earth and sand-clay		Oct. 11	[2] 12,425.20	[2] 6,212.60
	20	Douglas	15.04	Earth		Oct. 25	49,865.76	24,932.88
	32	Adams and Webster	27.31	do		Oct. 4	138,829.44	69,414.72
	46	Red Willow	17.14	do		do	107,310.12	53,655.06
	61	Blaine	9.40	Sand-clay	Oct. 24		46,750.00	23,375.00
	77	Adams	11.28	Earth		Oct. 16	60,793.30	30,396.65
	81	Dodge	5.94	Concrete		Oct. 27	199,440.34	60,221.17
	96	Custer	30.20	Sand-clay	Oct. 30		107,250.00	53,625.00
	101	Scottsbluff	6.25	Gravel	Oct. 6		46,156.00	23,078.00
	103	do		Bridge	do		107,030.00	53,515.00
Nevada	24	Churchill	17.30	Gravel or macadam	Oct. 18		220,440.00	110,220.00
	25	White Pine	.28	Sand-clay or gravel	do		8,525.00	4,262.50
New Hampshire	33	Rockingham	3.052	Gravel		Oct. 3	17,967.62	8,983.81
	35	do	1.022	Macadam		Oct. 2	13,261.49	6,630.74
	38	Hillsborough	1.04	Bituminous		Oct. 3	13,446.68	6,723.34
	43	Rockingham	1.023	Gravel		do	10,323.96	5,161.98
	46	do	.98	Macadam		do	13,165.02	6,582.51
	63	do	.758	Gravel		do	7,407.07	3,703.53
	64	do	.79	do		do	10,220.65	5,110.32
	65	do	1.22	do			13,266.00	6,633.00
	67	Strafford	.80	do		do	7,328.09	3,664.04
	69	Cheshire and Sullivan	.511	do		Oct. 11	8,998.99	4,449.49
	77	Hillsborough	.455	do		Oct. 16	7,564.70	3,782.35
	80	Rockingham		Bridge		Oct. 11	5,839.90	2,919.95
	82	Merrimack	.47	Gravel	Oct. 4		9,444.49	4,722.24
	83	Strafford	1.028	do	Oct. 3		14,572.03	7,286.01
	86	Merrimack	.673	do	Oct. 8		7,775.98	3,887.99
	87	do	.54	do	Oct. 6		9,997.79	4,998.89
	89	do	.71	do	Oct. 15		14,303.30	7,151.65
New Jersey	14	Somerset and Middlesex	3.665	Concrete		Oct. 13	94,642.14	44,348.91
	17	Burlington	3.313	do	Oct. 18		362,808.00	101,760.00
	18	Mercer	1.648	do	Oct. 6		92,601.38	32,960.00
	19	Mercer and Middlesex	1.448	do	Oct. 31		132,509.00	43,960.00
New Mexico	1A	Colbax		Gravel		Oct. 6	[1] 41,746.79	[1] 20,873.40
	3	Santa Fe		do		do	[1] 35,637.41	[1] 17,878.71
	4	Valencia		Graded earth surfaced where needed		Oct. 24	[1] 3,264.95	[1] 1,632.47
	11	Lincoln	5.396	Gravel		Oct. 28	42,661.08	21,330.54
	12	Chaves		Gravel and macadam		Oct. 23	[1] 18,248.68	[1] 9,124.34
	15	Dona Ana		Concrete		Oct. 6	[1] 76,031.39	[1] 38,015.69
	16	Lea	5.439	Macadam		Oct. 30	39,517.23	19,758.61
	28	Grant	16.00	Gravel	Oct. 30		239,475.50	119,737.75
	36	Sandoval	6.00	do	Oct. 14		48,378.00	24,189.00
	38	Union	11.10	do	Oct. 4		70,133.25	35,066.62
North Carolina	8	Cumberland	13.46	Sand-clay and gravel		Oct. 14	62,800.71	31,400.35
	25	Person	8.175	Sand-clay		Oct. 2	85,431.75	42,715.87
	47	Guilford	4.607	Asphalt or concrete		Oct. 3	141,105.71	70,552.85
	49	Lenoir	6.017	do		Oct. 16	192,712.42	96,356.21
	50	Guilford	2.003	Bituminous		Oct. 13	58,564.93	29,282.46
	53	Lenoir	7.46	Concrete	Oct. 6		232,105.50	116,052.75
	56	Forsyth	5.90	Sand-clay	Oct. 23		38,501.80	19,250.90
	58	Johnson	7.80	Gravel	Oct. 8		46,268.02	23,134.01
	59	Columbus	12.31	Sand-clay	Oct. 31		53,892.52	26,946.26
	60	Lenoir	7.87	Concrete	Oct. 6		244,048.09	122,024.04
	62	Buncombe	3.43	Macadam	Oct. 23		89,098.22	44,549.11
	63	Buncombe	3.68	do	Oct. 6		116,818.08	58,409.04
	64	Carteret	14.30	Concrete	Oct. 10		267,339.60	133,669.80
	66	Haywood	6.20	Sand-clay	Oct. 6		56,954.92	28,477.46
	67	Nash	10.00	Concrete	Oct. 8		341,550.00	170,775.00
	69	Transylvania	9.50	Sand-clay or gravel	Oct. 24		72,445.95	36,222.97
	70	Jackson	12.00	do	Oct. 20		169,587.00	84,793.50
	72	Anson	5.93	do	Oct. 6		54,724.56	27,362.28
	73	Nash	9.10	Sand-clay	Oct. 13		143,085.07	71,542.53
	74	Stanley	6.59	do	Oct. 6		69,113.22	34,556.61
	76	Cabarrus	1.35	Bituminous	Oct. 20		47,910.50	23,955.61

[1] Modified agreements. Amounts given are increases over those in the original agreements.
[2] Modified agreement. There is a decrease in the mileage, but increases in the estimated cost and Federal-aid allowance in the original agreement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
North Carolina	77	Rutherford	2.19	Concrete	Oct. 20		$67,548.03	$33,774.01
	89	Franklin and Nash	10.00	Sand-clay	Oct. 23		71,390.28	35,695.14
North Dakota	21	Bowman	17.90	Graded earth		Oct. 25	[1] 6,638.03	[1] 3,319.01
	54	Kidder	3.70	Earth and gravel	Oct. 2		12,000.00	6,000.00
	56	Stutsman	40.50	Earth	Oct. 4		143,000.00	71,500.00
	58	Sargent	19.50	do	Oct. 20		86,000.00	43,000.00
	59	Richland	14.50	do	do		52,200.00	26,100.00
	60	do	34.00	do	do		115,600.00	57,800.00
	64	Logan		Bridge	Oct. 8		6,600.00	3,300.00
	65	Stark		do	Oct. 28		8,800.00	4,400.00
	67	Traill	5.00	Earth	Oct. 20		16,500.00	8,250.00
	70	Nelson	5.50	do	do		20,570.00	10,285.00
	72	Richland	18.00	do	do		54,540.00	27,270.00
Ohio	19	Summit	16.707	Brick		Oct. 3	905,300.00	213,000.00
	21	Guernsey	1.26	Concrete		do	40,600.00	20,300.00
	22	do	3.13	Grading, bridges and culverts		do	119,000.00	59,500.00
	27	Hamilton	6.623	Asphalt, concrete or brick		Oct. 2	415,400.00	132,400.00
	32	Crawford	2.726	Brick or bituminous		Oct. 10	115.500.00	48,500.00
	37	Knox	5.08	Concrete or brick		Oct. 3	203,000.00	50,000.00
	41	Trumbull	9.88	Macadam or concrete		do	353,000.00	80,000.00
	45	Lorain	1.206	Concrete		Oct. 25	49,800.00	6,500.00
	55	Miami	3.59	do		Oct. 3	106,000.00	20,000.00
	56C	Montgomery	3.096	do		do	98,000.00	25,000.00
	56AB	do	3.04	do		do	104,100.00	45,000.00
	59C	Fayette	4.11	Macadam or bituminous		Oct. 8	99,400.00	41,100.00
	64	Hamilton	5.994	Brick, concrete or bituminous		Oct. 2	371,300.00	119,800.00
	67CEG	Logan	8.18	Concrete		Oct. 3	273,100.00	122,900.00
	71	Darke	4.611	do		do	158,000.00	45,000.00
	72	do	4.506	do		do	129,000.00	45,000.00
	73	do	4.317	do		do	178,000.00	45,000.00
Oklahoma	18	Muskogee	38.00	Gravel	Oct. 2		399,300.00	199,650.00
Oregon	11	Baker	4.43	Graded and drained earth		Oct. 2	56,068.10	25,034.05
	15	Harney	16.73	Gravel macadam		Oct. 3	217,763.70	108,881.85
	24	Gillian	14.95	Earth	Oct. 23		251,915.95	125,957.97
	25	Sherman	14.70	do	do		248,050.00	124,025.00
	28	Malheur	9.10	Gravel	Oct. 8		61,074.58	30,537.29
	29	Coos and Douglas	14.20	Gravel or macadam	Oct. 23		584,056.00	284,000.00
Pennsylvania	20B	Adams, Cumberland and York	7.70	Concrete or bituminous		Oct. 25	327,698.80	154,000.00
	58	Fayette	4.982	Brick or concrete		Oct. 8	334,930.75	99,640.00
Rhode Island	6	Providence	2.90	Bituminous	Oct. 10		123,310.88	58,000.00
South Carolina	2	Spartanburg		Concrete or brick		Oct. 6	[1] 11,310.10	[1] 9,127.51
	15	McCormick		Bridge		Oct. 25	32,991.24	16,495.62
	22	Charleston	3.987	Concrete		Oct. 24	151,041.42	71,744.66
	25	Lexington	23.97	Sand-clay		Oct. 8	86,299.37	43,149.68
	27	Spartanburg	4.001	do	Oct. 20		33,040.38	16,520.19
	29	Laurens	14.316	do	Oct. 23		94,961.83	47,480.91
	30	Pickens	5.69	do	Oct. 20		51,234.88	25,617.44
	34	Chesterfield	3.117	Gravel	Oct. 11		16,254.37	8,000.00
	35	do	3.281	Sand-clay	Oct. 23		12,679.48	6,000.00
	42	Sumter	9.787	do	Oct. 10		141,578.23	20,000.00
South Dakota	13	Davison	13.95	Gravel		Oct. 2	98,316.07	49,158.03
	20	Walworth	17.30	Earth and gravel	Oct. 2		82,775.00	41,387.50
	21	Aurora	7.76	Gravel	do		66,830.50	33,415.25
	22	Day	28.31	do	do		204,749.05	102,374.52
	23	Jackson and Washabaugh		Bridge	Oct. 8		26,646.00	13,323.00
	24	Hanson	27.34	Gravel	Oct. 20		128,457.34	64,228.67
	26	Kingsbury	13.41	do	Oct. 24		116,579.10	58,289.55
	27	Tripp	6.00	Earth	Oct. 20		56,991.00	28,495.50
	28	Charles Mix	17.54	Gravel	Oct. 24		113,989.70	56,994.85
Tennessee	3	Franklin		Waterbound macadam		Oct. 2	[1] 39,150.02	[1] 19,575.01
	4	Moore and Rutherford		Macadam and gravel		do	[1] 42,359.77	[1] 23,252.64
	8	Shelby	16.039	Bituminous	Oct. 3		370,545.33	185,272.66
	10	Henry	19.539	Gravel	Oct. 11		314,221.05	157,110.52
	14	Grainger, Hawkins and Sullivan	48.876	Macadam	Oct. 2		721,134.47	360,567.23
	15	Madison		Bridge	Oct. 13		16,091.57	8,045.78
	16	Montgomery		do	Oct. 11		176,543.40	88,271.70
	17	Overton	13.245	Macadam	do		251,244.57	125,622.28
Texas	43	Tarrant	5.80	Concrete	Oct. 2		245,982.18	116,000.00
	46	Gillespie	[2] 10.00	Gravel	Oct. 31		[2] 192,951.00	[6] 81,000.00
	84	Van Zandt	9.889	do		Oct. 2	110,135.19	40,000.00
	85	Freestone	10.04	Gravel or macadam		do	111,048.80	37,500.00
	86A	Montague	9.839	Gravel		do	101,358.08	50,679.04
	90	Taylor	20.66	Earth and gravel	Oct. 20		66,128.58	30,030.00
	91	do	2.998	Gravel		Oct. 2	13,618.48	4,950.00
	95	Red River	2.18	Concrete and gravel		do	30,087.88	15,000.00
	101	McLennan	1.01	Concrete	Oct. 31		41,899.00	20,000.00
	102	Henderson	11.66	Gravel	Oct. 3		108,984.06	30,000.00
	103	Milam	9.07	do	Oct. 31		40,002.60	20,000.00
	105	Wood	11.50	do	Oct. 2		83,028.00	41,500.00
	108	Kendall	5.778	do	Oct. 31		42,635.17	21,000.00
	109	Wood	21.70	do	do		168,364.22	63,500.00
	114	De Witt	12.10	do	do		72,170.01	36,085.00
Vermont	6	Orange	2.35	Gravel or macadam		Oct. 3	38,015.01	19,007.50
	11	Chittenden	1.40	Concrete or bituminous		do	47,973.80	23,986.80
Virginia	24	Alleghany	8.03	Slag macadam		Oct. 16	87,294.68	43,647.34
	43	Albemarle	7.50	Macadam	Oct. 3		130,625.00	65,312.50
	57	Pulaski	4.07	do	Oct. 4		57,970.00	28,985.00
	60	Lee	5.00	do	Oct. 6		87,120.00	43,560.00
Washington	17	Whatcom	2.70	Concrete		Oct. 25	116,682.13	54,000.00
	30	Skagit	7.70	do		Oct. 3	269,130.70	134,565.35
	31	Lewis		Bridge		Oct. 25	35,076.14	17,538.07
	33	Clarke	4.25	Concrete		Oct. 3	141,805.00	70,902.50
	34	do	6.62	do		Oct. 20	226,033.84	113,016.92
	36	do	3.32	do		Oct. 16	95,229.53	47,614.76
	38	Yakima	2.94	do		Oct. 3	105,478.05	52,739.02
	39	do	5.03	do		do	158,361.96	79,180.98
	42	Grays Harbor	4.20	do		do	130,559.93	65,279.96
	43	do	2.82	do		do	84,650.02	42,325.01
	44	Clarke	4.03	do	Oct. 6		164,677.26	60,000.00
	45	do	2.16	Earth	Oct. 28		91,033.25	43,200.00

[1] Modified agreements. Amounts given are increases over those in the original agreements.
[2] Revised project statement. Amounts given are increases over those in those in the original statement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
West Virginia	29	Ritchie	5.00	Concrete		Oct. 14	$160,654.65	$41,650.00
	45	Putnam	4.00	Brick, concrete or bituminous		do	125,152.30	48,000.00
	68	Nicholas	2.00	Earth		do	29,229.20	14,614.60
	73	Mineral	12.00	Gravel	Oct. 11		71,534.00	35,744.00
	79	Pocahontas	5.57	Bituminous	Oct. 20		84,370.00	42,185.00
	80	Marshall	.485	Brick	Oct. 11		23,700.00	9,700.00
	81	Tyler	1.50	Concrete	Oct. 23		40,360.00	15,360.00
	82	Gilmer	10.00	Earth	do		57,250.00	28,625.00
	83	Lewis	2.00	Brick or concrete	do		88,390.00	18,390.00
Wisconsin	66	Richland	[1] .41	Concrete		Oct. 11	[1] 5,412.60	[1] 1,804.19
	81	Trempealeau	4.74	Gravel		Oct. 13	68,391.49	22,797.16
	88	Sawyer	4.315	Earth		Oct. 3	29,457.29	9,819.09
	92	Brown	5.14	Concrete		Oct. 25	122,617.78	40,872.59
	96	Rock	5.99	do		Oct. 23	159,842.07	53,280.69
	100	Grant	1.135	Earth	Oct. 31		27,000.00	9,000.00
	103	Milwaukee	1.50	Concrete		Oct. 14	44,446.68	14,815.56
Wyoming	6	Converse	[2] 7.50	Earth	Oct. 10		[2] 7,689.00	[2] 3,844.50
	7	Minta	[2] 1.50	Graded and drained earth	do		[2] 2,242.02	[2] 1,121.01
	8	Park		Bridges	do		[2] 8,564.52	[2] 4,282.26
	24	Lincoln	4.18	Earth		Oct. 3	37,554.88	18,777.44
	28	Sheridan	4.164	Macadam		Oct. 10	51,574.93	25,787.46
	31	Natrona	1.218	Bituminous or concrete	Oct. 28		170,098.50	77,710.00
	34	Lincoln	17.49	Macadam		Oct. 13	131,682.35	65,841.17
	35	Platte	12.74	Gravel		Oct. 14	102,403.88	51,201.94
	43	do	7.00	Earth	Oct. 6		19,690.00	9,845.00
Total	347		2,737.046				44,729,869.37	20,444,949.11

[1] Modified agreements. Amounts given are increases over those in the original agreements. [2] Statements previously approved withdrawn.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN SEPTEMBER, 1919.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	11	Lowndes	0.75	Gravel		Sept. 9	$28,490.31	$14,245.15
	49	Limestone	9.97	do		Sept. 2	53,185.89	26,592.94
	52	Calhoun	4.00	Macadam	Sept. 4		53,154.26	26,577.13
	54	Coosa	1.50	Sand-clay	Sept. 10		7,990.40	3,995.20
	66	Lauderdale	1.96	Gravel	Sept. 30		20,558.23	10,279.11
Arkansas	23	Jackson	8.85	do		Sept. 11	86,416.88	40,000.00
	27	Columbia	14.03	Macadam	Sept. 16		53,807.60	23,046.05
	30	Franklin	23.79	Gravel	Sept. 26		147,571.60	70,000.00
	32	Hempstead	8.07	do	Sept. 30		76,823.01	25,000.00
California	15	Monterey	.50	Bridge, concrete		Spet. 11	285,403.58	142,701.79
	20	Lake	9.36	Earth		Sept. 2	116,807.02	58,354.01
	27	Tuolumne	12.79	Concrete	Sept. 10		279,152.50	139,576.25
	28	Placer	6.60	do	do		147,895.00	73,947.50
	29	Amador	10.74	Earth	do		71,940.00	35,970.00
	30	Tuolumne	21.90	Concrete	Sept. 29		452,390.40	226,195.20
Colorado	2	Huerfano-Los Animas		Brick or concrete and gravel, limestone or basalt base.		Sept. 26	[1] 239,290.71	[1] 119,645.36
	7A	Montrose	2.102	Graded and drained earth		Sept. 11	26,075.35	13,037.67
	13	Boulder	.417	Concrete		Sept. 30	10,485.41	5,237.70
	14	do	.504	do		Sept. 27	20,628.77	10,314.38
	33	Larimer	2.765	do	Sept. 27		74,983.59	37,491.79
	92	Pueblo		Bridge	Sept. 29		69,850.00	34,925.00
Florida	17	Manatee	10.28	Brick or concrete	Sept. 8		207,650.54	103,825.27
	18	Putnam	12.72	Asphalt or concrete	Sept. 20		302,265.70	151,132.85
	19	Hamilton	7.12	Asphalt, brick or concrete	do		172,776.73	86,388.36
Georgia	79	Bibb	6.57	Concrete	Sept. 2		193,831.00	80,855.20
	81	Dougherty		Bridge	Sept. 5		245,498.00	110,000.00
Idaho	16	Jefferson	7.51	Earth	Sept. 10		90,000.00	45,000.00
Illinois	25	Kankakee and Iroquois		Bituminous, macadam, or concrete		Sept. 30	[2] 23,873.66	[2] 11,936.83
	2	do	10.70	do	Sept. 20		[3] 837,001.80	[3] 463,735.90
	10	Will and Grundy	20.80	Concrete	Sept. 29		739,384.60	369,692.30
	11	Vermillion	19.53	Brick	Sept. 27		419,325.00	209,662.50
Indiana	14	Vigo	4.70	Asphalt, brick, or concrete	Sept. 10		183,585.60	91,792.80
	16	Vanderburgh, Warrick, Spencer, Dubois, Orange, and Lawrence.	114.40	do	do		4,223,076.00	2,111,538.00
	17	Lake, Porter, and Laporte	56.70	do	Sept. 20		2,292,351.00	1,134,000.00
	18	Tipton and Howard	10.00	Brick, concrete, or bituminous	Sept. 27		429,000.00	200,000.00
Iowa	13	Webster	12.15	Gravel		Sept. 20	132,639.23	28,233.08
	24	Polk	7.75	do			[1] 67,721.50	[1] 23,041.07
	54	Scott	8.46	Brick or concrete	Sept. 29		400,563.62	169,000.00
	61	Cerro Gordo	6.00	do	Sept. 20		242,611.60	120,000.00
	104	Polk	6.50	do	Sept. 29		337,147.25	130,000.00
Kansas	7	Douglas	18.289	Concrete		Sept. 10	767,828.56	274,342.50
	19	Allen	4.527	Gravel or macadam		Sept. 29	87,726.28	43,863.13
	29	Dickinson	25.07	Asphalt, brick, or concrete	Sept. 4		1,119,648.47	376,050.00
	31	Geary and Dickinson	.31	Concrete	do		10,971.12	4,650.00
	32	Dickinson	10.40	Brick or concrete	do		486,670.80	156,000.00
	35	Sumner	44.50	Concrete	Sept. 29		1,622,808.00	667,500.00
	36	Cherokee	7.00	do	do		258,656.20	105,000.00
Kentucky	14	Nelson	3.00	Rock, asphalt, or bituminous	Sept. 10		49,981.80	24,990.90
	17	Clark	6.60	Bituminous	Sept. 27		119,925.63	59,962.81
	18	Jefferson	4.50	Concrete	do		180,000.72	90,000.00
Louisiana	39	Concordia	18.10	Gravel		Sept. 29	200,226.40	100,113.20
	42	Jefferson	13.58	do		Sept. 30	135,493.09	67,746.54
Maryland	2B	Prince Georges	.91	Cement concrete		Sept. 20	26,414.85	13,207.42
	3	Allegany		do		Sept. 16	[1] 43,205.75	[1] 23,300.00

[1] Modified agreements. Amounts given are increases over those in the original agreement.
[2] Modified agreement. Amounts given are reductions over those in the original agreement.
[3] Revised statement. Figures given are increases over those in the original statement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN SEPTEMBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Maryland	4	Garrett	2.12	Concrete		Sept. 20	$80,671.27	$40,335.63
	7B	Baltimore and Hartford	1.36	do		Sept. 30	40,268.80	20,134.40
	25	Charles	7.00	Gravel	Sept. 10		132,000.00	66,000.00
	31	do	7.20	do	do		143,000.00	71,500.00
	32	St. Marys	6.25	do	Sept. 20		117,700.00	58,850.00
	33	Carroll	1.100	Concrete	Sept. 4		[1] 39,179.25	[1] 39,614.00
	34	Anne Arundel	6.50	Gravel	Sept. 29		121,000.00	60,500.00
	36	do	9.00	Concrete	Sept. 30		396,000.00	180,000.00
Massachusetts	17	Essex	1.794	Bituminous	Sept. 20		61,136.51	30,568.25
	22	Franklin	6.36	Bituminous and gravel	Sept. 10		129,357.69	64,678.84
	24	Bristol	2.756	Bituminous		Sept. 30	39,055.50	19,527.75
	26	Franklin	9.558	Concrete	Sept. 20		414,782.11	191,160.00
Michigan	13	Livingston		Gravel		Sept. 16	[2] 98,679.02	[2] 49,339.51
	27	Charlevoix	5.447	Concrete		do	161,073.85	80,536.92
	34	Washtenaw	[1] .260	Concrete or bituminous		Sept. 30	[3] 8,537.10	[3] 4,268.55
Minnesota	15	Becker		Gravel		Sept. 16	[2] 21,234.19	[2] 25,069.22
	28	Grant	[1] .96	do	Sept. 20		[1] 29,746.28	[1] 15,873.14
	43	Cottonwood	4.07	do		Sept. 5	25,001.75	12,000.00
	54	Lac qui Parle	38.51	do		Sept. 30	68,213.39	30,000.00
	55	do	6.47	do		Sept. 20	9,620.35	4,000.00
	56	do	16.93	do		Sept. 30	33,398.17	16,000.00
	57	Beltrami	29.76	do	Sept. 9		153,580.05	76,000.00
	60	Sherburne	6.51	Asphalt, brick, or concrete		Sept. 11	229,169.24	114,584.62
	62	Dodge	6.87	Gravel	Sept. 27		[1] 48,042.89	[1] 23,631.92
	66	Big Stone	10.50	do	Sept. 19		53,955.00	26,977.50
	68	Rice	4.63	do	Sept. 5		29,865.00	14,932.57
	69	do	4.31	do	Sept. 20		20,024.40	10,012.20
	70	Cook	4.50	do	Sept. 19		36,862.54	18,431.20
	71	Martin	5.50	do	do		44,792.44	22,396.22
	72	do	4.60	do	do		47,758.92	23,879.46
	73	Crow Wing	3.64	Concrete	do		107,944.76	53,972.38
	75	Murray	17.70	Gravel	Sept. 23		150,306.20	50,000.00
	76	Morrison	12.03	do	Sept. 27		46,349.09	23,174.54
	77	Rice	5.50	do	Sept. 10		43,796.91	21,898.45
	81	Marshall	26.65	do	Sept. 27		139,304.88	55,000.00
	82	Pipestone	11.55	Concrete	Sept. 10		378,840.00	189,420.00
	84	St. Louis	1.13	do	Sept. 9		50,000.12	20,000.00
	85	Cottonwood	5.42	Gravel	Sept. 27		33,742.83	15,871.41
	87	Yellow Medicine	6.00	do	Sept. 10		21,473.32	10,736.66
Mississippi	53	Adams	11.80	do	Sept. 29		119,174.00	59,587.00
	77	Jackson	2.64	Concrete	Sept. 18		92,529.89	46,264.94
Missouri	18	do	3.07	Bituminous macadam		Sept. 30	61,394.83	30,697.41
	21	Ripley	13.50	Earth and gravel	Sept. 18		28,292.00	14,146.00
	22	Randolph	1.75	Brick or concrete	Sept. 20		56,124.20	28,062.10
	24	Cooper	5.55	Bituminous	Sept. 29		88,578.60	44,289.30
	25	Clay	13.07	do	Sept. 26		324,572.21	162,286.10
	28	St. Charles	1.66	do	do		22,736.56	11,368.28
	29	Saline	9.20	do	Sept. 25		168,013.76	84,006.88
Montana	48	Fallon	26.00	Earth	Sept. 29		33,000.00	16,500.00
	53	Yellowstone	37.00	Gravel	Sept. 18		164,984.60	82,492.30
	55	Ravalli		Bridge	Sept. 26		22,000.00	11,000.00
	59	Park	14.50	Gravel	Sept. 27		47,685.00	23,842.50
	60	do	29.00	do	Sept. 29		135,520.00	67,760.00
Nebraska	21	Box, Butte, and Sheridan		do		Sept. 11	[3] 519.19	[3] 259.60
	36	Chase and Hayes		Earth		do	[2] 2,828.45	[2] 1,414.23
	28	Casa and Otoe	.48	do		do	[2] 813.90	[2] 496.95
	29	Butler		do		do	[2] 2,716.78	[2] 1,358.39
	30	Furnas	19.42	do		Sept. 27	87,993.21	43,996.60
	66	Cherry	24.70	Earth and sand-clay	Sept. 20		87,857.00	43,928.50
	68	Hitchcock and Red Willow	24.20	Sand-clay	Sept. 19		87,348.80	43,674.40
	69	Banner and Ocott's Bluff	25.85	Earth	Sept. 10		73,370.00	36,685.00
	80	Grant	13.20	Earth and sand-clay	do		44,105.60	22,052.80
	83	Antelope and Boone	33.90	do	Sept. 4		79,200.00	39,600.00
	85	Garfield, Greeley, and Valley	42.00	do	Sept. 23		113,740.00	56,870.00
	88	Burt, Cumming, and Dodge	21.20	Earth	Sept. 27		60,500.00	30,250.00
	99	Thomas	14.80	Sand-clay	Sept. 19		59,778.40	29,889.20
	104	Hall	3.00	Gravel	do		23,799.58	11,889.79
	105	Dawson	13.40	do	do		45,016.40	22,508.20
	106	Gage	1.117	Brick or concrete	Sept. 29		58,287.29	22,340.00
Nevada	21	Washoe	.97	Concrete		Sept. 12	42,407.07	19,400.00
New Hampshire	21	Cheshire and Coos	3.59	Gravel		Sept. 20	16,214.31	8,107.00
	24	Grafton and Hillsborough	.95	Bituminous		Sept. 2	12,628.39	6,314.19
	26	Merrimack	.87	Gravel		Sept. 20	9,892.52	4,946.26
	28	Grafton and Merrimack	1.06	do		do	14,749.02	7,374.51
	50	Cheshire	1.25	Bituminous macadam		do	19,299.77	9,649.88
	51	do	.853	Bituminous		do	11,665.08	5,832.54
	55	Strafford	1.25	Gravel	Sept. 10		10,043.00	5,021.50
	57	Cheshire	1.09	do	Sept. 4		11,905.19	5,952.59
	60	do	2.17	do	do		20,006.36	10,003.18
	62	Strafford	.80	do	Sept. 20		7,938.15	3,969.07
	71	do	1.22	do	Sept. 4		16,810.97	8,405.48
	72	Merrimack	1.10	do	Sept. 20		15,984.10	7,992.05
	74	Carroll	1.27	Macadam	Sept. 10		14,903.55	7,451.77
	76	Hillsborough	1.34	Gravel	do		16,888.03	8,444.01
	77	do	.59	do	do		7,286.51	3,643.25
	78	Rockingham	1.50	do	Sept. 20		12,001.55	6,000.77
	79	do	1.136	do	do		7,590.44	3,795.22
	80	do		Bridge	Sept. 10		7,777.00	3,888.50
	81	Grafton		do	Sept. 20		15,000.00	7,500.00
	84	do		do	do		13,000.00	5,000.00
	85	Merrimack	.47	Gravel	Sept. 19		3,812.32	1,906.16
New Jersey	4	Monmouth	[1] 1.328	Concrete		Sept. 5	[2] 76,918.63	[2] 26,258.76
	15	Middlesex and Union	3.55	do	Sept. 4		303,185.41	71,000.00
New Mexico	24	Roosevelt	15.00	Gravel	Sept. 27		123,475.00	61,737.50
	25	Curry	15.00	do	do		122,353.00	61,176.50
	32	San Miguel	15.00	Gravel or macadam	Sept. 10		182,593.13	91,296.51
	33	Mora	13.50	Gravel	do		135,303.30	67,651.65
	34	Rio Arriba	20.00	do	Sept. 4		108,020.00	54,010.00
	35	San Juan	17.00	do	Sept. 20		51,620.80	25,810.40
North Carolina	43	Beaufort	2.20	Concrete		Sept. 11	95,089.62	44,000.00

[1] Revised statement. Figures given are increases over those given in the original statement
[2] Modified agreements. Amounts given are increases over those in the original agreement.
[3] Modified agreement. Amounts given are reductions over those in the original agreement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN SEPTEMBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Noath Carolina	65	Pitt	9.60	Concrete	Sept. 20		$325,608 80	$162,804.40
	71	Durham	6.30	Bituminous	Sept. 26		236,445.00	118,222.50
North Dakota	6	Eddy		Gravel and earth		Sept. 26	[1] 7,495.16	[1] 3,747.58
	19	Ramsey	17.10	Graded earth		Sept. 2	20,122.58	10,061.29
	25	Ward	5.02	Gravel		do	36,935.71	18,467.85
	27	Benson	24.04	Graded earth		Sept. 11	87,123.76	43,561.88
	35	Logan	22.06	Earth		Sept. 30	75,351.40	37,675.70
	48	Pierce	21.60	do	Sept. 29		51,700.00	25,850.00
	49	Golden Valley	19.30	do	Sept. 18		26,937.58	13,468.79
	50	Griggs	4.00	do	Sept. 20		8,030.00	4,015.00
	52	Grand Forks	.928	Concrete	Sept. 29		61,160.00	18,556.00
	53	Stark	5.50	Earth	do		11,990.00	5,995.00
	55	Stutsman	6.00	do	do		19,800.00	9,900.00
Ohio	42	Seneca	4.28	Bituminous, concrete, or brick		Sept. 12	169,000.00	42,800.00
	49	Morgan	3.257	Macadam		do	82,000.00	41,000.00
	53	Mercer	5.739	Concrete		Sept. 30	173,060.00	61,500.00
	59AB	Fayette	8.69	Macadam or bituminous		Sept. 12	206,000.00	86,900.00
	84	Cuyahoga	2.01	Concrete or bituminous	Sept. 4		190,011.00	40,200.00
	90	Jackson	2.48	Macadam	Sept. 23		43,835.00	20,000.00
	97	Noble	9.47	Concrete or macadam	Sept. 18		220,000.00	67,100.00
	98	Jefferson	2.328	Brick and concrete	Sept. 25		109,000.00	46,560.00
	101	Adams	6.16	Macadam	Sept. 20		119,000.00	48,000.00
	102	Seneca	2.03	Brick or bituminous	Sept. 29		90,000.00	20,300.00
	103	do	2.25	Asphalt or brick	Sept. 23		59,000.00	22,500.00
	105	Lucas	3.508	Concrete	Sept. 30		88,000.00	44,000.00
Oklahoma	8	Ottowa	15.63	Bituminous		Sept. 20	328,313.51	164,156.75
	14	Oklahoma	.753	Concrete		Sept. 30	26,626.10	13,313.05
Oregon	16	Wasco	2.00	Bituminous		Sept. 25	50,807.57	25,403.78
Pennsylvania	18	Clarion	5.04	Brick		Sept. 2	260,853.04	109,053.23
	20C	Adams, Cumberland, York	4.60	Concrete or bituminous		do	199,765.44	92,000.00
	30B	Bradford	2.588	Concrete		Sept. 12	133,621.84	51,760.00
	38	Crawford	3.13	Concrete or bituminous		Sept. 11	130,181.26	62,600.00
	39	Dauphin	6.397	Concrete, brick, or bituminous		do	323,155.20	127,940.00
	42	Union	2.55	Concrete or bituminous		Sept. 12	90,536.47	45,268.24
	46	Lancaster	7.137	do		Sept. 2	272,000.25	136,000.12
	47	Lycoming	7.44	Concrete		Sept. 11	355,113.78	154,279.55
	49	Dauphin	4.69	do		Sept. 20	205,549.08	93,800.00
	50	Lancaster	4.07	Concrete or bituminous		Sept. 11	178,302.23	84,360.01
	51	McKean	5.975	Concrete or brick		do	254,820.24	119,500.00
	52	Northumberland	4.81	Brick, concrete, or bituminous		do	219,589.16	96,200.00
	53	Bradford	5.944	do		Sept. 20	344,861.88	118,880.00
	54	Bucks	2.819	Bituminous or concrete		Sept. 29	123,063.10	56,380.00
	55	Butler	7.892	Brick or concrete		Sept. 30	386,357.73	157,840.00
	59	Lehigh	5.705	do		Sept. 12	263,572.21	114,100.00
	60	Somerset	7.175	do		Sept. 29	451,264.88	148,981.30
	61	do	6.065	do		Sept. 12	321,670.69	124,251.87
	62	Sullivan	3.298	Asphalt, brick, or concrete		do	168,481.15	65,960.00
	63	Susquehanna	5.745	Concrete		do	246,040.41	114,900.00
	64	Tioga	5.315	Asphalt, brick, or concrete		do	294,214.28	106,300.00
	67	York	6.201	Brick or concrete		Sept. 29	311,605.28	144,573.40
Rhode Island	5	Providence and Kent	.946	Bituminous		do	34,529.00	17,264.50
South Carolina	9	Newberry		Top soil		do	[1] 7,442.82	[1] 3,721.42
	18	Greenwood		do		do	[1] 11,044.38	[1] 5,522.19
	31	Spartanburg	1.99	Asphalt	Sept. 10		57,749.92	28,874.96
South Dakota	16	Hughes	17.83	Earth and gravel	Sept. 29		70,367.88	35,183.94
	17	Lake	12.14	Gravel	Sept. 27		73,926.60	36,963.60
	18	Hand	15.03	do	do		121,369.05	60,684.52
	19	Hyde	6.95	do	Sept. 29		60,414.75	30,207.37
Tennessee	13	Carroll	2.79	do	Sept. 10		31,951.08	15,975.54
Texas	56	Jefferson		Concrete	Sept. 18		[2] 70,928.82	[2] 59,948.42
	80	Harris	9.269	Concrete and macadam		Sept. 2	91,280.79	25,000.00
	82	Jasper	16.21	Gravel	Sept. 26		146,506.80	30,000.00
	89	Wood	10.20	do	Sept. 29		43,999.08	10,000.00
	97	Brazos	10.33	Gravel and concrete	do		99,995.62	37,752.75
	99	Calhoun	4.621	Shell	Sept. 10		13,663.32	6,500.00
	100	Rockwell	13.36	Concrete	Sept. 18		544,816.03	200,000.00
	101	Bowie	14.78	Gravel	Sept. 26		87,009.47	43,502.59
	104	Sabine	13.69	do	Sept. 19		119,087.54	35,000.00
Vermont	4	Addison		Bridge		Sept. 11	[1] 25,728.44	[1] 1,363.95
Virginia	19	Hanover and Carolina				Sept. 16	[1] 10,772.28	[1] 5,386.14
	25	Pittsylvania		Bituminous macadam		do	[1] 8,548.85	[1] 4,274.43
	31	Northampton	1.59	Concrete		Sept. 12	49,654.44	24,827.22
	49	Caroline and Spotsylvania	.30	Bridge and approaches		Sept. 19	11,569.25	5,784.62
Washington	5	Cowlitz		Graded and drained earth		Sept. 5	[1] 37,441.80	[1] 18,720.90
	14	Okanogan	[1] 5.44	Gravel		Sept. 2	[1] 45,625.79	[1] 22,881.65
	15	do	.87	do		do	31,130.82	16,780.63
	16	Stevens	13.00	do		do	168,821.25	84,410.62
	19	Jefferson	[4] 3.49	do			[3] 46,999.15	[3] 23,499.57
	20	Spokane	7.83	Gravel or macadam		Sept. 26	90,755.98	45,377.99
	21	Grant	4.88	do		Sept. 2	48,695.19	24,347.59
	22	Spokane	4.50	Concrete		Sept. 12	144,494.04	72,247.02
	23	do	3.88	do		do	128,584.28	64,292.14
	24	King	6.41	do		Sept. 29	199,292.26	99,646.13
	25	Thurston	6.83	do		Sept. 2	208,120.32	46,600.00
	26	Grays Harbor	2.90	do		do	88,366.41	44,183.20
	27	Lewis	6.70	do		do	243,863.07	121,931.53
	28	Snohomish	1.12	do		Sept. 5	35,534.09	17,767.04
	37	Douglas	2.79	Macadam		do	21,710.44	10,855.22
	41	Thurston	6.16	Gravel		Sept. 30	109,996.06	54,998.03
West Virginia	8	Wayne	1.93	Concrete		Sept. 29	91,115.62	30,000.00
	9	Jackson		do		do	[1] 13,272.53	[1] 6,193.48
	15	do		do		Sept. 20	[1] 12,959.28	[1] 6,978.00
	18	Tyler		do		Sept. 11	[1] 3,863.10	[1] 4,964.80
	33	Preston	2.52	Asphalt macadam		Sept. 16	30,000.00	15,000.00
	35	Monongalia	4.50	Concrete		Sept. 11	88,654.00	44,000.00
	43	Raleigh	1.43	Bituminous		do	17,267.97	8,600.00
	51	Wayne	3.20	Earth		Sept. 30	46,313.71	23,156.85
	53	Harrison	2.489	Brick		Sept. 20	88,265.50	38,000.00
	54	Greenbrier	1.98	Bituminous		Sept. 16	30,768.94	15,384.47

[1] Modified agreements. Amounts given are increases over those in the original agreement.
[2] Revised statement. Figures given are increases over those in the original statement.
[3] Statements previously approved withdrawn.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN SEPTEMBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approval.	Project agreement signed.	Estimated cost.	Federal aid.
West Virginia	60	Monroe	4.00	Macadam	Sept. 4		$53,800.00	$26,900.00
	61	Summers	6.00	Earth	Sept. 10		38,000.00	19,000.00
	64	Jefferson	7.37	Bituminous	Sept. 4		77,390.00	38,695.00
	65	Logan	1.30	Concrete	Sept. 23		39,380.00	19,690.00
	66	Wirt	4.48	Earth	Sept. 20		39,625.00	19,812.00
	67	Berkeley	8.00	Bituminous	do		82,840.00	41,420.00
	68	Nicholas	2.01	Earth	Sept. 10		29,229.20	14,614.60
	69	Braxton	9.60	do	Sept. 20		79,875.00	39,937.00
	70	Grant	9.00	do	do		47,200.00	23,600.00
	71	Tucker	7.00	do	Sept. 27		57,150.00	28,575.00
	72	Hampshire	8.50	do	Sept. 29		57,500.00	28,750.00
	74	Kanawha	2.60	Concrete	Sept. 27		138,585.70	51,920.00
	75	Calhoun	4.50	Earth	Sept. 30		39,050.00	19,525.00
	76	Brooks	1.00	Concrete or bituminous	do		28,800.00	14,400.00
	78	Randolph	5.75	Macadam	do		103,700.00	51,850.00
Wisconsin	10	Walworth		Concrete		Sept. 2	[1] 10,499.22	[1] 3,499.74
	45	Ashland	7.931	Earth	Sept. 18		38,999.36	12,999.78
	52	Lacrosse	1.39	Bituminous			18,007.50	6,002.50
	57	Shawano	7.70	Gravel		Sept. 12	58,493.22	19,497.74
	59	Jefferson	1.64	do		do	14,148.64	4,716.21
	71	Marathon	4.94	Earth and gravel		Sept. 11	40,851.37	13,617.12
	82	Vernon	3.28	Bituminous		do	46,370.20	15,456.73
	83	Jackson	2.57	Earth		Sept. 30	24,014.99	8,005.00
	84	Crawford	2.26	do		Sept. 20	25,116.49	8,372.16
	86	Lafayette	3.47	do		Sept. 30	40,762.44	13,587.48
	89	Polk and Burnett	8.198	do		Sept. 12	45,339.00	15,113.00
	93	Marquette	4.07	Sand-clay		Sept. 30	24,936.86	8,312.29
	95	Milwaukee		Bridge	Sept. 20		[2] 2,388.76	[2] 796.22
	98	Washburn	.568	Earth		Sept. 12	5,385.84	1,795.28
	99	Douglas and Washburn	7.04	Gravel	Sept. 10		63,000.00	21,000.00
	101	Barron	4.253	Earth	Sept. 29		44,793.77	14,931.25
	102	Waukesha	2.31	Concrete	Sept. 10		59,966.94	19,988.98
	103	Milwaukee	1.50	do	do		44,455.73	14,818.57
Wyoming	23	Niobrara		Earth		Sept. 26	23,526.91	11,763.45
	27	Weston	12.614	Earth and gravel	Sept. 30		88,000.00	44,000.00
	29	Albany	26.57	Gravel		Sept. 30	134,549.05	67,274.52
	37	Goshen	19.29	do	Sept. 27		171,734.20	85,867.10
	41	Crook		Bridge	Sept. 4		9,790.00	4,895.00
	42	Sheridan	9.323	Gravel	Sept. 30		79,970.00	39,985.00
	47	Fremont		Bridge	Sept. 29		14,300.00	7,150.00
Total	292		2,231.62				40,701,324.13	18,384,499.13

[1] Modified agreements. Amounts given are increases over those in the original agreement.
[2] Revised statement. Figures given are increases over those in the original statement.

ROAD BUILDING IN ILLINOIS.

Since last April Illinois has let contracts for over 500 miles of concrete roads of the highest type, the total cost of which will be $16,380,000. None of this work comes under the Illinois State highway program to be carried out with the funds derived from the bond issue of $60,000,000 voted last fall.

Included in the contracts are 89.44 miles of the Lincoln Highway crossing the northern part of the State from Chicago Heights to Clinton, Iowa; 59.15 miles on Dixie Highway from Chicago to Danville; 228.71 miles on the Chicago, Peoria, Springfield to St. Louis, highway; and 121.8 miles on the national highway from St. Louis to Terre Haute, Ind.

A BIG COUNTY RECORD.

In the year ending September 30, 1919, Kent County, Mich., built 189 miles of road, including 21 miles of concrete, 7.75 miles of stone macadam, 12.75 miles of stone base and gravel top and 147 miles gravel. Under the Covert law of Michigan providing for State aid to roads, contracts have been let for 30.95 miles of concrete and 6.25 miles of gravel roads. The county spent during the year $56,392 for maintenance of highways.

OHIO ROAD CONSTRUCTION.

According to State Highway Commissioner Taylor, Ohio has contracts under way covering 500 miles of road, of which the cost will be about $14,500,000. The largest mileage under contract at any time previous was 371 miles in 1916. For the two years ending June 30, 1921, the State appropriation for main market roads is $2,255,500 and for the intercounty roads $6,466,500. The automobile license fees available for maintenance and repairs will amount to about $5,000,000. The Federal aid granted for 1919 and 1920 amounts to $10,205,625. The figures make a total of $23,927,625 for the Ohio State highway system. In addition to this the expenditures for construction and maintenance of county and local roads will be large. At the recent election 66 counties voted on special local levies for road purposes.

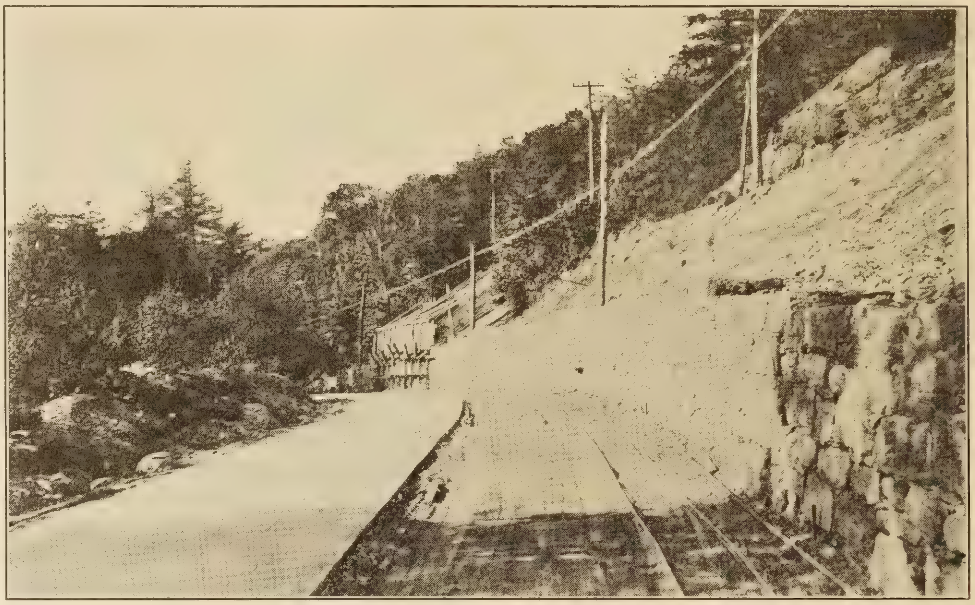
CONNECTICUT FUNDS.

The Connecticut State highway commission had made an allotment of $1,342,000 to the 147 towns of the State for the improvement of roads, exclusive of trunk lines and Federal-aid roads. To this amount the towns will appropriate $375,700.

ROADS FOR MOTOR TRUCK TRAFFIC.

By C. J. Bennett, State Highway Commissioner, Connecticut.

IT IS hard for the highway engineer to keep step with the advance in the design of motor vehicles. No sooner does he apparently solve the problem than his friends who are in the business of producing motor vehicles develop a machine which entirely revolutionizes conditions.



CONSTRUCTION OF ROAD AT NAUGATUCK, CONN., IN TWO PARTS TO ACCOMMODATE TRAFFIC. INDUSTRIAL TRACK FOR THE DELIVERY OF MATERIAL AND STONE BINS IN THE BACKGROUND.

Generally, in the design of this vehicle, no attention is paid to the character of the road over which these units must operate. Considerable discussion could be aroused over the wisdom of designing motor trucks and motor vehicles with such a disregard for the conditions, but it is not the province of this article to originate such a discussion, chiefly because the motor truck is here, and we must redesign our roads to take care of this agency.

A discussion of the economic side of this question, as to whether it is right to design something that will take the place of railroad facilities instead of trying to improve such railroad facilities, is also beside the mark. Thus, there are many instances where, contrary to his judgment, the highway engineer is forced to change his ideas and design for traffic which up to two years ago was almost beyond imagination.

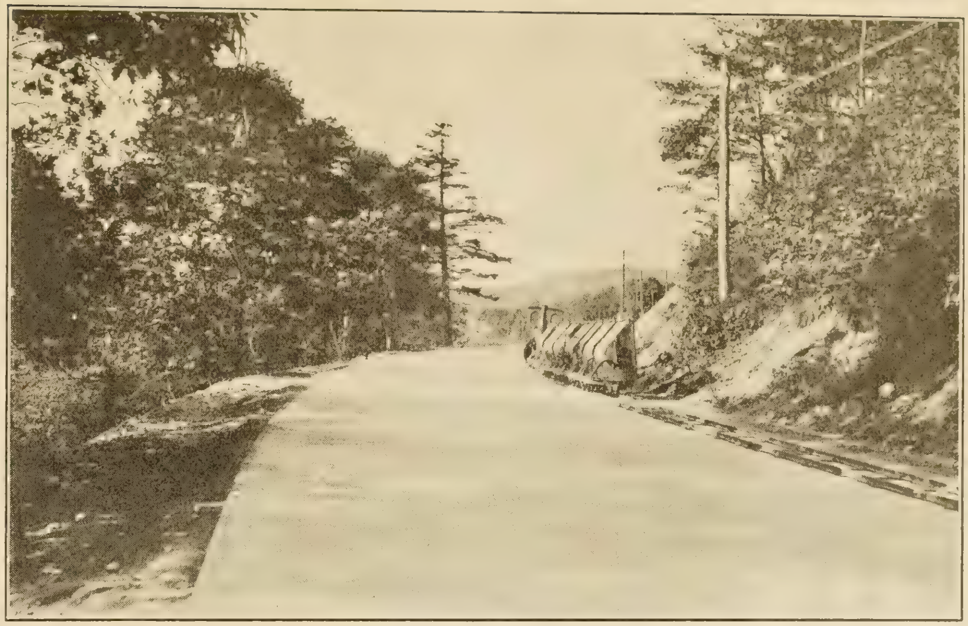
COMPLETED ROAD, NAUGATUCK, CONN., WHICH WAS CONSTRUCTED IN TWO PARTS.

HALFWAY MEASURES OF NO AVAIL.

It is the intent of this article to convince the highway engineer that he is faced with a serious problem and to show him that halfway measures will not avail for its solution. Notwithstanding restrictions as to the weight, loading, size, speed, and width of motor trucks, these will gradually increase, and there must be cooperation between the producer of these trucks and the highway engineer in order that the engineer may know the extreme limit beyond which he must not be required to go in the design of highways. This discussion will not include a discussion of road surfaces necessary for passenger-car traffic, since the road that will serve the motor truck will probably well serve the passenger automobile.

For purposes of argument, let us assume, therefore, that the extreme weight of the motor vehicle, including the load, shall be 15 tons, that its width shall not exceed 9 feet, and that its load per inch width of rubber tire shall not exceed 700 pounds. The speed of this vehicle should be restricted so that it would at all times be under reasonable control, particularly in sections where houses or buildings are close together along the borders of the highway over which the truck is to be operated.

It will be noted that the limit of weight and size has been set quite high in order to do away with any objection on that particular point from the manufacturer.

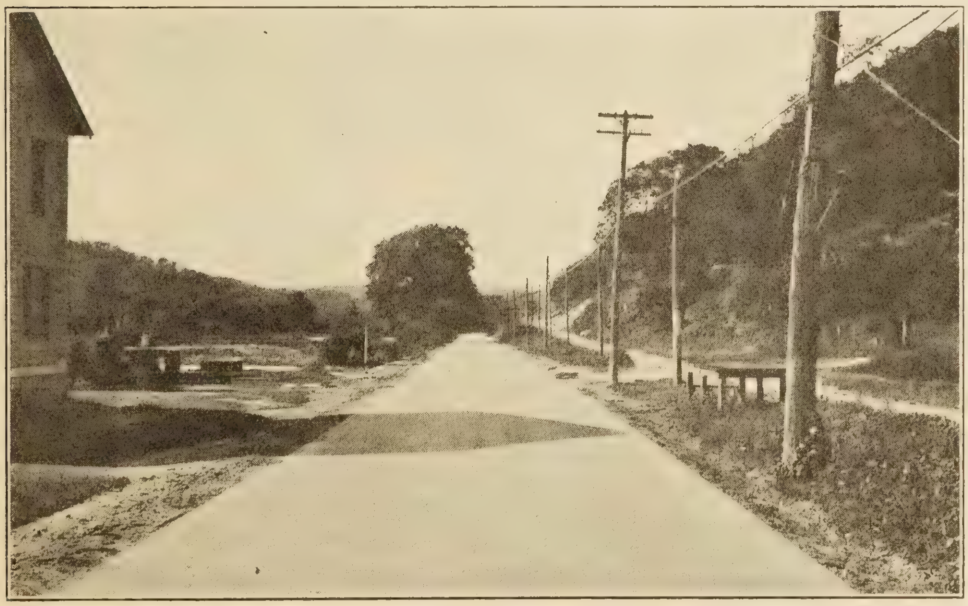


COMPLETED ROAD, NAUGATUCK VALLEY, CONN., SHOWING INDUSTRIAL TRAIN USED DURING THE CONSTRUCTION.

QUESTIONS TO BE SETTLED.

We now have a statement of our problem which gives rise to three questions:

First. What shall be the width of the road?



SECTION OF NAUGATUCK VALLEY ROAD, CONN., SHOWING THE FINISHED PAVEMENT.

Second. What shall be its character both as to surface and foundation?

Third. What shall be done with the bridges at present existing?

Answering the first question, let us assume that the motor truck is to operate over a highway traversed by a maximum of 4,000 vehicles per day. With reasonable traffic restrictions, a width of 22 feet should be sufficient for this class of traffic. This will provide for two lines of vehicles to pass in opposite directions at high speed. For any highway in which the traffic exceeds the amount stated above sufficient width should be provided for three or four lines, adding 10-foot-width units at a time for each line of vehicles.

As was stated above, no attention has been paid to the economic side of this problem or to the wisdom of building roads of this character for a selected type of traffic. What we are attempting to do is to state fairly what is necessary to accommodate the classification of traffic that already exists.

TYPE OF ROAD TO BE USED.

Answering the second question as to the type of road to be used, this question subdivides itself (*a*) as to foundation and (*b*) as to surface. With traffic of the character and magnitude specified above, great care must be taken in the foundation, both for the road itself and for the road surface. In cases of difficult soil conditions, additional foundations must be added and drainage provided to carry away the water so that the general subsurface of the road itself shall be uniform and sufficient to transmit the surface concentrated loads evenly to the earth beneath. It is evident, at least to the writer, that if the character of the traffic is as stated above, any foundation other than a monolithic foundation would be unsatisfactory; that is, no loose stone foundation will be sufficiently strong at all times to carry the loads. Consequently, the foundation for the surface must be bound together with Portland cement or with a bituminous binder. Again, it is not the purpose of this article to specify any particular method of getting results. It is merely intended to generalize and point the way to success.

(*b*) What shall be the type of road surface for this class of traffic? Here, again, we are faced with the necessity of securing a road surface which will stand impact from the passing loads and wear evenly under the stress of traffic. Consequently, no road surface should be installed for this character of traffic which does not closely approximate the surface of the highest type of city pavements which are now constructed. Such surfaces may be of brick, of concrete properly prepared, or of bituminous material, or even of granite block. In other words, in order that the roads which we build may stand the traffic to which they will probably be subjected, no pavement should be designed unless it is a hard surface pavement or can easily be tranformed into such when the necessity arises.

SELECTION OF ROUTE VITALLY IMPORTANT.

It is, of course, idle to assume that roads of this character can be built everywhere. Consequently, the selection of routes for such traffic is of vital importance, and the road construction of this type should be concentrated on these routes, and conversely the traffic itself should be required to follow the route. In other words, there should be a restriction as to the roads upon which the heavy motor trucks should operate.

Answering the third question, in consideration of the bridges, this is a serious question because we have a large investment in highway bridges which are in fairly good condition and which were never designed for such heavily loaded vehicles as we find above. Many of these bridges, especially those of shorter span can be strengthened so as to carry these excess loads. The larger, and of course most expensive bridges, cannot be expected to stand up under these strains, and must be replaced with structures designed to meet the changing conditions. The construction of such bridges will mean an enormous expenditure of money, and great care should be taken in their design, both as to selection of type and execution of the work itself. The use of reinforced concrete is strongly recommended for bridges where it is possible to design such structures, and such bridges should not be designed without careful study and the knowledge of all the factors that enter into the problem. The width of these bridges should be sufficient to accommodate at least three lines of vehicles and, on the important routes, four.

MUST MEET PROBLEM FAIRLY.

The above may appear to be a very extravagant statement of the needs of traffic at the present time, but the writer has come to believe that the motor truck is a vital part of our transportation facilities and that it has come to stay, and we must meet the problem fairly by designing for an extreme load approximating that stated above. He also believes that the motor truck manufacturer must restrict himself within the limits stated, and not attempt to exceed in any dimension the specifications made.

The motor truck operator must also use judgment in the loading and operation of these vehicles and consent to restrictions both as to dimensions and routing, so that the general public welfare may be served.

WISCONSIN COUNTY BONDS.

Five Wisconsin Counties—Jefferson, Washington, Wood, Racine, and Green—voted in September in favor of bond issues for road building, the total amounting to $11,850,000. Rock County voted a $1,500,000 issue in April, making the total for the year $13,350,000. Propositions for bond elections are being urged to come before county boards in November, aggregating $32,000,000 in these counties: Dane, $10,000,000; Grant and Dodge, $5,000,000 each; Walworth, $3,000,000; Brown and Waukesha, $2,500,000 each; and Douglas and Waupaca, $2,000,000 each.

Racine County voted in favor of the bonds by a majority of 2,038, out of a total vote of 3,962, only one township casting an adverse vote. Washington County's vote was 2,351 to 1,543, all the cities and villages but one favoring and 8 out of 14 townships voting yes. In Jefferson County the vote was 2,623 for and 1,540 against, the cities and villages favoring and the townships voting against by a majority of 178. Wood County gave a majority of 891 in a vote of 3,811, the country districts voting adversely by a small majority. In Green County the proposition for an issue of $3,000,000 was the constitutional limit. There was an active campaign, ending in a majority of 119 in a vote of 2,836.

MAINE VOTES BONDS.

On September 8 by a vote of about five to one Maine indorsed the proposal to raise the bonded indebtedness of the State for State highways from $2,000,000 to $10,000,000, giving an additional $8,000,000 to be spent on the State road system.

MOTOR VEHICLES AND THE HIGHWAYS.

By WILLIAM D. SOHIER, former Chairman Massachusetts Highway Commission.

ROAD building is a constant evolution, because no sooner is the improved road built to carry a vehicle of a certain weight and size than the builder of the vehicles tries to increase both the weight and size.

I personally believe that there should be a very stringent regulation and limitation on both the weight and speed, as well as the width, height, and length of the vehicles that are allowed to use our highways and bridges.

I believe, also, that if heavy trucks are to be allowed to use the highways there should be some provision for routing them, so that they can not wander at will over our little country roads, destroying bridges and culverts, and tearing up roads that are now adequate for all local traffic. If heavy trucks are to use the highways they should be confined to using the main lines only, and only such weights should be permitted as can safely use the highways and bridges that have been already constructed at great expense.

Otherwise we shall have a great many miles of road that it has taken many years to improve and build up destroyed, a great many bridges broken down, and even our main roads will be put out of commission, so that no one can use them for long periods of time.

PAST A GUIDE TO FUTURE.

In considering what traffic the highways will have to carry in the near future, we can only judge by our past experience. That the motor traffic will increase is sure. This is well shown by the following table, showing the increase in Massachusetts in motor vehicles in six years, in the number of operators, and in the fees collected.

Motor vehicles, and especially trucks, are constantly increasing.

The increase in the number of motor vehicles registered in Massachusetts indicates the increase in traffic.

	1912	1915	1918	Per cent of increase, 6 years.
Automobiles and trucks	50,132	102,633	191,019	280
Motor cycles	5,034	9,520	12,708	150
Operators and chaffeurs	65,600	133,700	225,272	240
Motor vehicle fees	$616,236	$1,235,723	$2,159,257	250

There are over three times as many automobiles and trucks registered as there were six years ago, over three times as many operators, and the fees collected are three times as large, this based on the statistics collected for 1918; and during the first nine months in 1919 over 209,000 automobiles and trucks have been registered.

FEES PAY FOR MAINTENANCE.

All the fees are spent in maintaining and improving the main highways. In fact, last year we practically maintained all our main highways with the money collected from this source.

How the truck traffic has increased is shown by the following tables:

Automobiles, trucks, and commercial vehicles, etc., in Massachusetts.

	1915	1916	1917	1918	Per cent of increase, 3 years
Trucks	12,053	18,194	25,505	32,676	.171
Automobiles	90,580	118,615	145,801	158,343	75
Motor cycles	9,520	10,713	10,956	12,708	33

A large number of trucks belonging to the Government, and also trucks owned in other States, are using our roads, so that the increase in volume of truck traffic is much larger than the foregoing figures indicate.

The number of trucks and commercial vehicles registered has increased from 12,000 in 1915 to over 39,000 in 1919, more than three times as many trucks as there were three years ago.

CHANGES IN TRAFFIC.

The change that has taken place in traffic is clearly shown by the following table. This is made up from traffic counts taken every three years from 1909 to 1918. An actual count is made for 14 hours a day for 7 days in August and 7 days in October. The table which follows shows the average number of vehicles that are using our main highways, and is based upon the average count in each of these years at 44 stations on main lines.

Average daily traffic on main roads in Massachusetts.

	1909	1912	1915	1918	Per cent of increase, 9 years.
Light horse	91	68	40	24	−73½
Heavy horse	88	88	72	43	−51
Total horse	179	156	112	67	−62½
Automobiles and light trucks	131	280	555	923	+604
Heavy trucks	....	17	45	75	[1] +341
Total motors	131	297	600	998	+661
Total vehicles	310	453	712	1,065	+243

[1] In 6 years.

This clearly shows what is happening on our roads.

While the traffic has increased very rapidly, actually having increased over threefold in the last nine years, it is changing even more rapidly than it is increasing, and the change is even more significant from the road builder's point of view.

There were only one-third as many light horse-drawn vehicles in 1918 as there were in 1909. There were only one-half as many heavy horse-drawn vehicles.

On the other hand, the number of automobiles and light trucks using our main highways has increased sevenfold in nine years.

MOST IMPORTANT FEATURE.

But what is even more important and makes more difference in the character of road which we must build and maintain, is the increase in heavy trucks In 1909 there were practically no trucks using our roads. In 1912 there was an average of 17 a day. In 1915 there were 45 a day, and in 1918, 75 a day, the counts being made at the same stations. In other words, the number of trucks using the main highways has increased four and one-half times in six years.

The change in the traffic is perhaps even more graphically shown by the following table of percentages:

Per cent of total traffic.

	1909	1912	1915	1918
Light horse	29	15	5½	2
Heavy horse	28	19	10	4
Total horse	57	34	15½	6
Trucks	....	4	6½	7
Motors	43	62	78	87

It is astonishing, but true, that while horse-drawn vehicles constituted 57 per cent of all the traffic on our main highways in 1909, in 1918 the horse-drawn vehicles were only 6 per cent of the traffic, and motor vehicles, which were only 43 per cent of our traffic in 1909, were 87 per cent in 1918.

We must not forget that the total traffic using our roads has increased over threefold.

While the horse-drawn vehicles are to-day only 6 per cent of the total traffic using our highways, the heavy motor trucks—to wit, over 1 ton not on pneumatic tires—have already become 7 per cent of the total traffic.

WHAT SHOULD OUR HIGHWAYS STAND?

Perhaps even more significant is the change in the last three years. During that short period of time both the automobile traffic and the motor truck traffic has increased 66 per cent, or an increase of about 22 per cent a year.

With traffic increasing as it is, and especially the heavy truck traffic, we have now to solve the problem of whether our roads can stand such traffic, and whether they can or should be so constructed that they will not be destroyed within a very short time.

I should say that it was practically an impossibility for any rural community to furnish roads every mile of which could withstand the strain to which they are subjected—unless possibly on a few main through highways, and even on those the weights should be sufficiently limited not to destroy a highway that is of as expensive construction as the community can afford to pay for and the ordinary traffic warrants.

The weight and speed of trucks should be limited before the roads are destroyed, before highways that have cost the communities millions of dollars to build and which are entirely adequate for all the other traffic that uses the roads, are ruined, which would mean that they are of no use for any kind of traffic.

WEIGHTS MUST BE LIMITED.

Even in cities like London, experience conclusively shows that the weights to be transported over the highways must be limited, because in a great many instances 6-inch or even thicker concrete foundations have been shattered under a wood block or asphalt pavement.

It needs no argument to show that we can not afford to construct such pavements even on main lines on all of our country roads, costing, as they would to-day, from $5 to $7 a square yard (including foundation) or from $50,000 to $70,000 for an 18-foot hardened surface a mile. The cost is prohibitive on the country roads, even on main lines.

To illustrate, in New England on many main through lines the best and most expensive surface that the community can afford to build is gravel. In New Hampshire and Vermont particularly a great many miles of their main highways are of gravel except near the larger cities. Often they have to be oiled, but they are very satisfactory for the motorists who use them. More than a thousand motors on a pleasant summer day is very common.

However, if these same roads were used by a few 5-ton trucks with 5-ton loads when they were soft, the work of many years would be destroyed, and these very satisfactory motoring highways would be almost worthless.

The cost, use, and value received and paid for should be considered.

As an example—in Massachusetts we have maintained and improved every year, for several years, a main through line 26 miles long by widening, surfacing, draining, etc., using a gravel surface and oiling it and keeping it constantly patched and maintained. Every year its condition is improved.

AS TO THE COST.

This has cost less than $1,000 a mile a year, and this highway has an average traffic in summer of over 800 motors a day, with an average of about 20 trucks a day. Calling it 1,000 vehicles a day for 200 days a year, the average cost has been a half cent a vehicle a mile.

Assuming that this highway were constructed of concrete, 6 inches thick and 18 feet in width, that it would be adequate for heavy trucks and would last 20 years:

Such a highway at present prices would cost from $30,000 to $40,000 a mile to construct, including grading, drainage, etc. Assume you can borrow the money for 5 per cent on 20-year serial bonds:

The average interest, say 2½ per cent on $40,000 would be, per year	$1,000
One-twentieth of principal redeemed would be	2,000
Call the annual maintenance per mile for guardrail, shoulders, drainage, etc	100
Yearly cost of highway	3,100
Gravel road, oiled, maintained, etc., per year	1,000
Excess cost for truck road, per year	2,100

This extra yearly cost is for 1 mile of road to carry heavy trucks in addition to the lighter motors.

Assume they use the road 300 days a year. That would be $7 a day additional cost for the truck traffic.

If 20 trucks use this road daily, it would cost the community 35 cents a mile per day per truck. If 100 trucks use the road it would cost 7 cents a mile per day per truck.

WHERE THE BURDEN FALLS.

Why should the community pay this additional cost of $2,100 a mile a year to enable a few users of the highway to transport excessive loads?

The cost must be paid by someone, and heavy freight should not be transported over highways unless on the whole it is economical for the community. It is much cheaper to transport heavy weights on rails than to construct highways each and every foot of which can withstand a weight of from 10 to 15 tons on four wheels.

This gravel road to which I refer is the Newburyport Turnpike, a main line between Boston and Newburyport.

Another example in the western part of the State, the Mohawk Trail, is on the main line east and west from Boston via Fitchburg, Greenfield, North Adams, and Williamstown.

It was built over Florida Mountain with special appropriations by the legislature. Twenty-two miles of that road is situated in three towns, Charlemont, Savoy, and Florida. A part of it is constructed with a bituminous top, but probably even that is not strong enough to carry a very large number of heavy trucks heavily loaded—and by this I mean trucks in excess of 2½ or 3 tons. The rest of the road is practically a graded dirt road, kept constantly oiled and maintained. However, it adequately cares for all the present traffic, often over 1,000 motors a day.

TOO MUCH FOR LOCAL COMMUNITIES.

But before the construction of this road is completed, with a reasonably good surface sufficient for all vehicles that will use it except for vehicles in excess of 6 tons including vehicle and load, the State will spend at least $1,000,000 in the three towns mentioned, Charlemont, Savoy, and Florida.

When you consider that the total valuation of these three towns in which these 22 miles of road which will cost $1,000,000 is located is less than $1,500,000 it becomes self-evident that the local communities could not possibly construct any such road as that, much less could they construct one to carry heavy trucks at probably twice the cost.

It is costing about $750 a mile a year to maintain these 22 miles of road in these three towns. Therefore it is also self-evident that these towns can not afford to maintain a road of even the character that is there now, because it would require a tax rate of over $11 on all the property located in those towns to maintain even that one road, to say nothing of all the other roads in the towns.

TRUE OF MACADAM ROADS ALSO.

The facts I have given relating to a gravel road are also true of a vast number of the older macadam roads in this country. Massachusetts has a very large mileage of these roads built over 10 years ago. We are maintaining them, and can maintain them, with bituminous surface treatments and constant care and maintenance, for many years, to carry 1,000 vehicles or more a day at a cost of $600 to $1,000 a mile a year, even at present prices for labor and materials.

They are not strong enough, however, to withstand large numbers of 5-ton trucks with 5-ton loads. To rebuild them all in a few years is a financial impossibility. Meantime they should not be made useless because a few truck owners abuse them.

Of course, it may be entirely possible, and probably is, for some of our richer communities to build and maintain their main streets so they can withstand heavy truck traffic; I might add that they not only can afford to do this, but they can not afford not to do it.

In Massachusetts the highway commission has constructed, or helped to construct, over 2,200 miles of improved highways on main routes. To construct these of concrete, even at $30,000 a mile, would cost $66,000,000, whereas our net debt for State highways and State-aid roads is to-day under $6,000,000, many roads having been improved by cooperative work and by use of the motor vehicle fees.

URGES LIMIT OF WEIGHT.

We can not now afford to increase our expenditures tenfold, and even if we did, and after we had reconstructed these 2,200 miles of road, there would still remain 15,000 miles of country road which must be maintained as dirt or gravel roads for a good many years to come.

I do believe, however, that the main through lines, especially between large centers of population, should, when they are constructed or reconstructed, be built of a permanent form of construction and designed to carry reasonably heavy loads, but never excessive loads. There should be an absolute limit of weight beyond which the makers of motor vehicles and the users of the highways should not be allowed to go. Meantime, until they are constructed or reconstructed, the users of the highways should be restrained by law from destroying our improved roads.

TRAFFIC CENSUS SHOWS VALUE OF PAVED ROADS TO LOS ANGELES.

By JOHN C. VEENHUYSEN, Superintendent of Roads, Los Angeles County, Calif.

TRAFFIC census of our main highways has been taken ever since our road department was organized in 1914, with the main object to watch and measure the increase in traffic due to the improvement of highways as well as to the increased use of motor-driven vehicles, and to the gradual development of the country through which these roads are located. Also, the idea prevailed that it might be possible to show some fixed ratio in maintenance expenditures of paved roads with the amount of traffic they carry, but ultimate results have shown that such was not borne out by the facts—at least, not when such roads are kept in continuous repair, preventing any serious damage on account of neglecting smaller defects due to wear and tear of the traffic.

In taking up the matter of paved roads in general, we must necessarily look into their reason. Some of our roads are of general importance, as direct commercial highways, connecting densely populated centers of habitation or export and import termini, such as Los Angeles and Long Beach Harbors. Some are rural highways, where there is a well-fixed traffic of field and dairy products in a certain direction, with a variable amount of local traffic over intermediate sections of the road. Some are highways mainly used for pleasure, incidentally used for local traffic or commercial character. Some highways have a steady traffic during the whole year, especially the first-named commercial highways, whereas some have a very variable traffic, depending on seasons and crop movements.

METHOD OF TAKING THE CENSUS.

It is not possible to establish a correct average traffic over a highway of any considerable length where it is receiving traffic from feeders or where traffic is not carried over the full length of the road on account of it being crossed by secondary roads which absorb part of the traffic going or coming in a certain direction. For that reason we have established fixed points of vantage from where our census is taken for each road, and we take the exact count of vehicles passing that point for seven consecutive days in shifts of eight hours for each day. The count is taken by hours and is so segregated, in order to show the fluctuation of traffic. Standard weights have been adopted for the classes of vehicles, and these standards are very conservative and only accepted after study of the types of the various vehicles which are most commonly used. The data so collected is averaged for the seven days, as to number of vehicles and the corresponding weights. By platting the traffic curves for each road, we find that each road represents a different curve depending upon the special character of the traffic and local conditions, showing wide variation in the time of the peak of traffic on various roads and the shifting of this peak to different hours in succeeding census on the same road. Another feature is the regular, steady decrease of horse vehicles and a material increase of motor trucks as freight carriers.

FIGURES FOR FOUR HIGHWAYS.

Under following are some of our traffic data:

Harbor Boulevard, connecting Los Angeles City with San Pedro Harbor.—Macadam road, traveled width 24 feet, length 11.33 miles between city limits.—In operation since March, 1912.

Date of census.	Average traffic in tons per 24 hours.	Average daily number of vehicles traveling.			
		Horse.	Motor-cycles.	Automo-biles.	Motor trucks.
Oct., 1914	2,857.41	237	124	910	216
Apr., 1916	2,977.66	77	110	1,265	274
Aug., 1917	4,376.12	83	118	2,598	283
Apr., 1918	5,439.83	39	169	3,542	331
Apr., 1919	6,043.41	24	102	3,600	421

Long Beach Boulevard, connecting Los Angeles City with city of Long Beach.—Macadam road, traveled width 16 feet, length 12.47 miles between city limits.—In operation since March, 1911.

Date of census.	Average traffic in tons per 24 hours.	Average daily number of vehicles traveling.			
		Horse.	Motor-cycles.	Automo-biles.	Motor trucks.
Nov., 1914	1,933.68	69	76	1,109	121
Apr., 1916	3,213.83	24	93	1,630	206
June, 1917	2,913.31	25	85	1,966	163
July, 1918	5,176.25	28	93	3,483	267
June, 1919	8,327.30	25	92	5,682	387

Both these are principally commercial highways.

Under following is a road which is principally a pleasure road, with some mixed agricultural traffic.

Washington Boulevard, connecting Los Angeles City with city of Venice.—Macadam road, traveled width 16 feet, length 9.16 miles between city limits.—In operation since July, 1911.

Date of census.	Average traffic in tons per 24 hours.	Average daily number of vehicles traveling.			
		Horse.	Motor-cycles.	Automo-biles.	Motor trucks.
Aug., 1915	4,105.58	54	159	2,972	108
Nov., 1916	3,753.72	97	89	2,471	96
July, 1917	6,905.71	53	188	5,341	180
May, 1919	8,832.80	41	86	6,946	196

Following is a rural road, carrying principally agricultural and dairy products, in addition to local travel from Los Angeles City to the village of Downey.

Telegraph-Laguna Road.—Macadam road, traveled width 18 feet, length 4.53 miles.—In operation since August, 1913.

Date of census.	Average traffic in tons per 24 hours.	Average daily number of vehicles traveling.			
		Horse.	Motor-cycles.	Automobiles.	Motor trucks.
Dec., 1915	574.42	98	31	284	19
Dec., 1917	2,404.62	46	38	1,587	131
June, 1919	3,064.42	39	41	1,809	141

The above are samples showing traffic on roads of different character but of the same type of improvement.

THE SAVING OVER OTHER ROAD TYPES.

To determine their economic value, we figure the operative income of the road on the basis of tonnage of freight moved and miles passenger traffic. Our figures show that there is a direct saving in cost of hauling of 15 cents per ton-mile on paved roads against ordinary dirt roads, and after most careful consideration of all factors—economy in wear and tear of tires, engine and body of auto, fuel, lubricants, and especially saving in time—there is a direct saving of 2 cents per mile traveled by auto on a paved road against the ordinary dirt road, and that this saving is a very conservative average. The motor truck traffic reduced to ton-miles and the automobile traffic to miles traveled and computed on the basis of above figures of 15 cents and 2 cents, respectively, will establish the operative income of the road.

As our traffic, with rare exceptions, shows steady increase, we accept the traffic census taken as a basis for the coming year, in order to be conservative, and therefore ignore the increase during that year. Even so, our figures show remarkable results. Of above mentioned roads, the Harbor Boulevard showed for year 1918 an operative income as follows:

Horse traffic	ton miles	326,675		
Motor truck traffic	do	3,421,086		
Total	do	3,747,761	at $0.15	$562,164.10
Auto traffic	miles	14,647,763	at 0.02	292,955.26
Total				855,119.36

ECONOMIC VALUE TO THE PUBLIC.

As the cost of improving this road and maintenance since it came into operation up to January 1, 1919, has been $364,434.10, the result obtained is such that there can be no doubt whatsoever as to the economy of road improvement to the community.

The fact that this is not readily recognized by the public at large is due to the condition that this operative income does not show up in revenue, but in saving of expenses to the public without their directly realizing it. Lower cost of transportation is reflected in lower prices, economy in time of transportation brings dairy and agricultural products to the markets in fresher condition, and the public become gradually so accustomed to these conditions that they forget about it.

Road improvement as a means of development of communities and suburban districts is a factor so well known that mention is hardly necessary. Especially in the suburban rural districts in this county there has developed along these improved roads a method of disposing of agricultural products—vegetables, fruit, etc.—to the passing traffic, which has become a matter of importance and can not longer be ignored. This method of disposing of and acquiring these products is greatly appreciated by buyer and seller—the buyer acquiring them fresher and at no higher cost, and the seller disposing of them with less trouble and greater profit. It may decrease, to some extent, freight traffic but again it increases passenger traffic, and therefore becomes another factor influencing the traffic conditions on some of our principal roads.

A BIG COUNTY PROGRAM.

The supervisors of Wayne County, Mich., have in mind the construction of 350 miles of concrete highways, which would be 25 per cent of the roads outside the cities, and estimated to take care of 80 per cent of all traffic in all weathers. At the present rate of construction it would take from 12 to 15 years to build this mileage, and it has therefore been recommended that the half-mill county tax for improved highways be restored. This tax has not been levied for two years, maintenance and repairs having been cared for out of the county's share of automobile license fees. It is estimated that it will cost $1,500,000 to bring the bridges of the county up to modern requirements.

IDAHO HIGHWAY FUNDS.

So far the counties and special districts of Idaho have voted for highway bonds to the amount of about $10,000,000, and it is estimated that when the bond-voting campaign is completed the total will run up to about $15,000,000. Federal aid will add several millions to this. Most of this money will be spent in 1920.

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ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Applications for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.

REPORTS.

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.
Report of the Chief of the Bureau of Public Roads for 1919.

BULLETINS.

(In applying for these publications the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28.")

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
*48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53.")

Dept. Bul. 105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock
370. Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A Summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.
660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads.

* Department supply exhausted.

OFFICE OF PUBLIC ROADS CIRCULARS.

(In applying for these circulars the name of the office as well as the number of the circular should be given as "Office of Public Roads Circular No. 89.")

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Prservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magniture on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.

FARMERS' BULLETIN.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239.")

F. B. 338. Macadam Roads.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

(In applying for these separates the numbers should be given as " Yearbook Separate No. 638.")

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D-2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D-3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D-4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D-6. A New Penetration Needle.
Vol. 6, No. 6, D-8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D-12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10, No. 7, D-13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.
Vol. 17, No. 4, D-16. Ultramicroscopic Examination of Disperse Colloids Present in Bituminous Road Materials.

* Department supply exhausted.