COLORADO HIGHWAYS BULLETIN

December, 1919

Engineering Department Number

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Standard I-Beam Bridge Design
French Roads
Western Slope Problems
Federal Aid in Eastern Colorado
Before Construction
Military and State Maps
Work on Some Federal Aid Projects
Section Line Locations
Maintenance Work

Issued by the
State Highway Department

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TREASURE MOUNTAIN

From Summit of Wolf Creek Pass on the "Spanish Trail" Legends of Buried Treasure by the Early French and Spanish Adventurers Are Associated With This Mountain.

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COLORADO HIGHWAYS
BULLETIN

Published Monthly by the Colorado Highway Department

Denver, Colorado.

With the approval of the Colorado State Auditing Board.

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than state and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, newspapers and periodicals and civic associations. Others desiring to obtain Colorado Highways can do so by sending 10 cents for each number desired. Associations desiring to distribute the magazine can obtain it at cost in lots of from 500 copies up.

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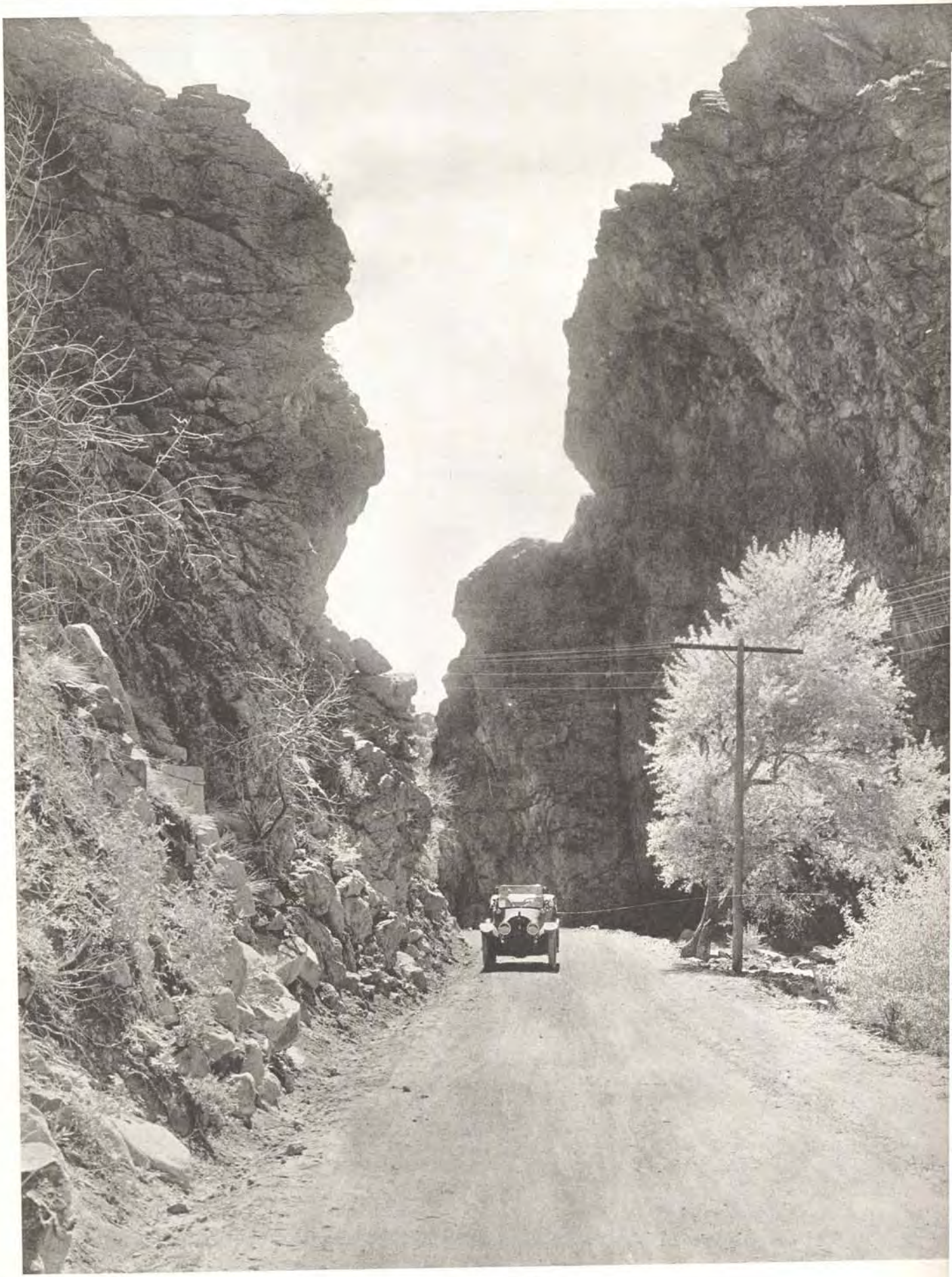


Bear Creek Canon

VOL. II DECEMBER, 1919 NO. 12

President Wilson

Links Four Very Important Subjects Together in His Message to Congress

President Wilson's Message on Agriculture, Good Roads, Forestry, Schools.

"The need of doing everything possible to promote production along economical lines, to improve marketing and to make rural life more attractive and healthful, is obvious. I would urge approval of the plans already proposed to the Congress by the Secretary of Agriculture, to secure the essential facts required for the study of this question, through the proposed enlarged programs for farm management studies and crop and estimates.

"I would urge, also, continuance of federal participation in the building of good roads, under the terms of existing law and under the direction of present agencies; the need of further action on the part of the states and the federal government to preserve and develop our forest reservoirs, and supply through the practice of better forestry methods on private holdings and the extension of the publicly owned forests; better support for country schools and the more definite direction of their courses of study along the lines related to rural problems; and fuller provision for sanitation in rural districts and the building up of needed hospital and medical facilities in these localities."

The Road

Its Paramount Importance

(Reprinted from Chambers's Journal, London, England.)

By the Right Honorable Sir J. H. A. MacDonald. K.C.B., LL.D.

"What we want, my Lords, is roads, roads, roads."
Duke of Wellington.

"It may now be laid down without risk of intelligent contradiction that if the country is to be well served by its roads, these must be capable of carrying a very different traffic, both in bulk and character, from that of the latter half of the last century, when the use of the road was comparatively trifling, because all distance locomotion by heavy vehicles had been diverted from the road to the railway. In consequence of this old roads deteriorated, and were repaired on the cheap plan, and new roads were flimsily constructed. It is now practically admitted on all hands that road construction and maintenance, neglected for half a century, are once more of paramount importance, *and that it is a matter of public necessity that the roads shall be made fit to bear the traffic which passes over them,* traffic which tends every day to increase in volume as regards all classes of vehicles, and in mileage as regards the distance per day which each vehicle accomplishes."

Editor's Note: It is evident from this article that, after centuries of road building, England still has to solve the present day traffic problem.—J. E. M.

Standard I-Beam Bridges

(Notes to accompany the plate on pages 12 and 13.)

By Robert DuBois, Field Engineer.

This plate is to be followed by others showing standard concrete girders, steel truss bridges and reinforced concrete arches. Last month was published that on concrete slab bridges. This plate is now being revised, the height of the railing being decreased by the omission of the bottom railing, while the widths of the footings of the abutments and wing walls are being increased sufficiently to make of them independent gravity retaining walls. Until this revision has been completed and the plate republished, care should be used to avoid the use of the plate on standard slab bridges without the change of these items in general accordance with those shown on the plate here published.

In order to provide for slight variations in unit prices, and, in cases, to suit special conditions, there is a slight overlapping of the allowable clear spans of one type of bridge over those of another type. Thus a bridge with a clear span of eighteen feet has been designed both as a slab bridge and as an I-beam bridge, while one of thirty-two feet clear span will be included among the concrete girder bridges as well as among the concrete encased I-beam bridges.

In every case, certain data must be secured by examination of the location in the field, before the plate can be advantageously referred to. These data should include the desirable length of clear span, the height from the bed of stream to the under clearance line of the old bridge, or, if the location is new, to some flood-water mark, so that the area of clear waterway may be made sufficient, the elevation of the roadway at each end of the bridge, and in case cut or fill be anticipated, a line of levels, and the corresponding cross sections. Soundings should be made to give an idea of the foundation conditions which may be encountered, such as the depth to bed rock, or as to the necessity for piling.

For the clear span determined upon there will be in general but one type of bridge given in the standards. In case the span selected should happen to fall within the overlapping of two types, a comparative cost estimate should be prepared. From the table of quantities given on each plate, the quantities for each span and abutment may be chosen. These, together with the estimated unit prices of the materials of construction, will give the approximate costs.

For simplicity of construction, the number of dimensions which vary with the span or height have been reduced as much as possible. These variable dimensions are indicated upon the drawing by letters, and their appropriate values given in the table of dimensions.

Two auxiliary tables have been given, containing the quantities per running foot of wing wall, and of abutment, respectively. The former of these is necessary, because of the wide range of wing wall lengths, to suit particular local conditions. It should be noted that the quantities given are for but one foot increase of length of but one wing wall, and not for a general increase in length of each of the four, in which case four times the quantities given should be used. It is expected that the second auxiliary table will permit a wide extension of the usefulness of the standards through their application to skew bridges. A skew bridge has but slightly different quantities from the normal bridge of the same clear span. When the increase in the length of an abutment has been figured from the known angle of skew, the increase in volume of each abutment can easily be derived from the second auxiliary table, and the total quantities in the bridge be estimated fairly closely.

It is further expected that these plates will be of assistance in estimating the quantities and costs of multiple span valley crossings when it is desired to establish what length of span gives the most economical construction.

Roads and Things

By N. A. Ballou, Secretary State Highway Commission.

During the past few years much has been written, more said, about road conditions in Colorado. From some of the articles written it is evident that the writer was not fully informed as to the laws under which the counties, State Highway Commission, U. S. Bureau of Public Roads and U. S. Forestry Department were operating.

This is intended to be a brief outline of the co-operative methods now employed by the aforesaid county, state and U. S. departments, also explaining in detail the jurisdiction and working plan of the State Highway Commission.

The State Highway Commission was created by an act of the legislature in 1917, and is one of the executive departments of the state. The Commission is composed of five commissioners, each representing one of five districts into which the state is divided. Also one Highway Commissioner, who is the executive officer of the Commission. All commissioners are appointed by the governor and subject to removal for cause.

The legislature classified all state roads into two classes: First—State roads which within the meaning of the act, include rights of way or location—either actually used as a highway or not—designated for the construction of a state highway upon it. State routes are in nearly every instance supervised, constructed and maintained by the counties in which they are located, the State Highway Commission contributing to the county some amount agreed upon for construction or maintenance.

Second—State highways are such parts of state routes as are designated and accepted as such by the State Highway Commission. No highway or part of same shall be declared a state highway that has not heretofore been designated as a state route. Any part of a state route designated and accepted as a state highway shall be maintained jointly by the state and county in which same is located,

but in no case shall the county be required to pay more than one-half of the maintenance expense.

Federal Aid Projects are construction projects in which the U. S. Government and State Highway Commission enter into agreement to construct. These projects must be on a declared state highway over a major portion of which mail is carried, either rural or star route.

The State Highway Commission is required to furnish the Agricultural Department, through its Bureau of Public Roads, a complete survey, including plats, plans and specifications of proposed project, for their rejection or approval. No part of the preliminary expense for this work is reimbursed to the state; the government steps in only after the project agreement has been entered into and the expense is then divided between the government and state when actual work begins, upon some agreed basis, usually 50 per cent each.

Forestry Projects are those laid out and constructed by the U. S. Forestry Department, under the supervision of the U. S. Bureau of Public Roads. In case the State Highway Department enters into an agreement with the Forestry Department for the construction of a road through or entering into a U. S. forestry, the State Highway Department is required to pay its agreed upon proportion of the preliminary expense of engineering, including plats, plans and specifications, as well as the actual construction.

The State Highway Commission prepares at its regular meeting in December of each year a budget showing the estimated receipts for the coming year, also the amount of funds set aside for the use of each county, each Federal Aid Project, Forestry Project, projects coming under the direct supervision of the State Highway Department. Also appropriations for administration of the department, which includes salaries for employes, office supplies, road building equipment, engineering supplies and other items too numerous to detail. In cases of emergency the Commission may make appropriations at other times. All appropriations are submitted to the governor for his approval.

The State Highway Commissioner, or his deputy only, can sign vouchers authorizing payment (except in the case of the absence or disability of both, then the chairman of the board can act) of accounts, and then only where an appropriation has heretofore been authorized by the Highway Commission.

The Engineering Department makes all surveys, prepares plans and specifications for all proposed work, and after contracts are let, a representative from this department is at all times on the ground to see that specifications are adhered to and prepare monthly estimates. He also makes weekly or oftener, if necessary, reports to the Chief Engineer, detailing progress of work, weather conditions, etc.

Field parties on location or survey work are in charge of a field engineer. He assumes all responsibility for his crew, makes arrangements for transportation, hotel or camp accommodations, approves all bills for expense incurred by him as well as all items of expenses incurred by members of his party. In regard to automobile expense, the State Auditing Board has prescribed that the mileage charge for a Ford car shall be 8c per mile, larger cars 10c per mile traveled; in case car is owned by the employe using same. Statements should show in detail mileage traveled, places reached, dates, etc.; in cases where cars are rented by the day, statements should give the same information. The Highway Department has at present for use of inspectors, superintendents and field engineers, only six cars, necessitating the hire of numerous cars for transportation in this department.

The expense items of the party must be covered by receipts, showing purpose, amount and where same was incurred; these receipts are listed and attached to an employe's expense form, showing to what project same is to be charged. These statements are made in duplicate and approved by field engineer before forwarding to the office. After being audited and found correct they are submitted to the chief engineer for his approval. A voucher on state auditor is then prepared; after same receives the approval signature of the State Highway Commissioner it is forwarded to the State Auditing Board for their approval.

The State Auditing Board meets Wednesday of each week, and consists of the governor, secretary of state, treasurer, auditor and attorney general. From there it goes to the auditor and after account is again audited, a warrant is issued if voucher and accounts are found correct. All vouchers issued by this department are handled in this manner, except salary vouchers for employes within the Civil Service classification. These vouchers go direct to the state auditor, and warrants issued only on certification from Civil Service Commission.

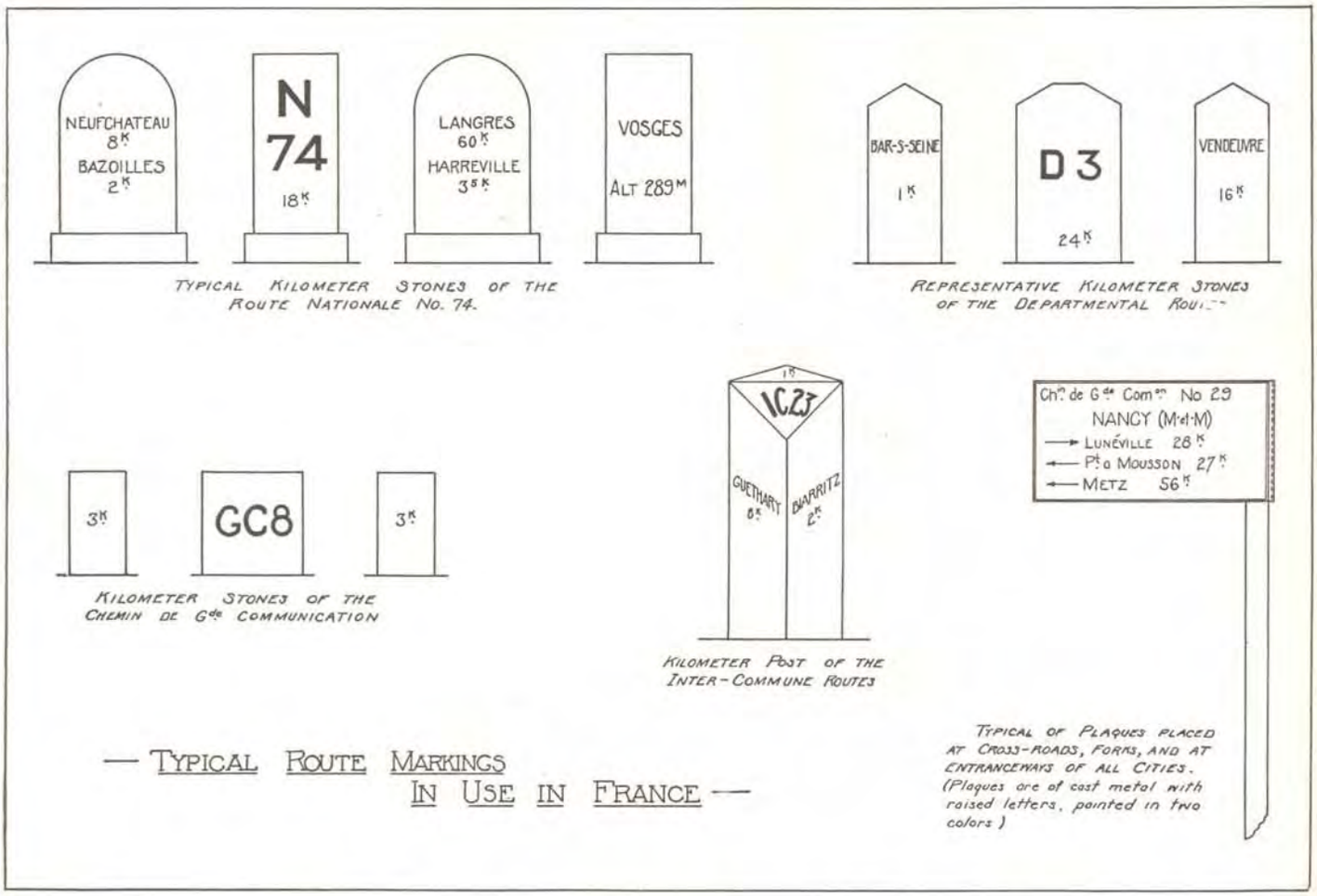
Under the present constitutional amendment the Civil Service Commission cannot place on its roster any person who is not an elector of the State of Colorado. All state employes come within the classified service, with the exception of those classed as day laborers.

Reimbursement of funds expended by counties on state highways are made on statements, certified to this office by the county clerk. Statement shows county warrant number, to whom warrants were issued, for what purpose, and on what highway the expense was incurred, and on these certified statements our voucher is issued for the state's portion of the expense, the ratio between county and state having been determined on each highway by the county commissioners and the State Highway Commission at the time the annual budget was prepared.

The State Highway Commission has received to date from the War Department through the U. S. Department of Agriculture 178 trucks for use on Federal Aid Projects and state highways. The trucks are distributed to the counties by the Highway Commission—the commissioner from each district making the assignment for the counties in their respective districts.

The Commission contracted for steel dump body and hoist equipment, and as fast as the trucks are equipped they are delivered to the counties, the counties reimbursing the state for the freight and equipment charge.

The foregoing is intended to answer in a general way inquiries regarding the subjects mentioned.



The Ease of Travel in France

By John S. Means, Field Engineer, Formerly Captain Engineers, A. E. F.

Traveling in France, aside from the delight incident to gliding over a smooth and well surfaced roadway, maintained always in excellent condition, through aisles of gigantic trees, over graceful arch bridges, and with the enjoyment augmented by the splendid natural beauties of this picturesque country, is rendered many times more pleasurable by the ease with which the tourist is able to find his way. With the facilities afforded him in this land of wonderful highways, the traveler needs spend but very little, if any, of his time in planning and following routes. This result is due to the thorough and liberal placing of kilometer stones and sign posts along all the routes.

A more detailed description of the types of roads and the way in which they are marked might be of interest. In the first place, the road system of the country has been divided into several distinct classifications, chief among which are the principal thoroughfares or Routes Nationale, the secondary or Departmental Routes, and lastly the Inter-Communal Routes. The first of these, the Routes Nationale, are the broad main highways connecting the larger cities all over the country. They are marked from end to end, at intervals of one kilometer, with stone monuments, each of which has carved upon it the route number and the distance in each direction to the next town. The route number is maintained through the entire length, making it possible to travel across a great portion of the country on the same road, necessitating no other care than an occasional glance at the passing monuments, and a due observance of the ever-present plaque or sign post at forks and cross roads. Even this latter precaution is superfluous, as the width of the road alone distinguishes it clearly from the routes of lesser importance.

The secondary, or Inter-Departmental Routes, form the lines of communication between the towns of average size, and differ only from the Nationale Routes in their narrower width. They, too, are clearly marked, with monuments distinctive of this type of road.

The Inter-Communal roads are, as the name implies, connecting links between the small country towns and villages, and are but narrow ribbons of macadam, often only of sufficient width for a single vehicle. In spite of their narrow width, which is, however, sufficient for the traffic they are called upon to carry, these small roads are as firm and substantial as the more important trunk lines, and can be relied upon by the traveler to carry him to his destination just as surely, though not so directly, and perhaps with an added increment of pleasure derived in following

these small country lanes through their many windings, touching here and there.

In keeping with this comprehensive system of road marking, which includes the kilometer and intermediate posts and cross road plaques, which are all well designed and of pleasing appearance, there is published a guide book, similar to the automobilists' Blue Book of this country, but which, due to the smaller size of France and its more highly developed road system, is more simple, compact and complete. This small volume, through careful editing and selection of subject matter, is made to contain all the important items of interest to the traveler. It includes a brief description of all the interesting tours which can be made in the various sections of the country, together with an alphabetically arranged list of every city, town and village of over a hundred population, with pertinent facts about each concerning hotels, their whereabouts and prices, telephone and telegraph offices, altitude, and distances to adjacent cities. For each city of over 2,000 population a small map is included, placed in position with the description of the city to which it pertains. These small maps, showing, as they do, the connection of the city streets with all the country roads, enable the tourist to pass through even the largest cities without delaying to inquire his way.

A system such as above so briefly described can only be obtained in many years of effort, by the expenditure of considerable money, and lastly but pre-eminently a unifying of effort by centralizing under a single head the direction of all the roads of the entire country. Through a central bureau such as this, the plans of many states and districts of our own country could be so co-ordinated, improved and regulated as to establish a comprehensive and far-sighted road system, which could be worked out gradually; one which would make it impossible for the obscure county surveyor or road supervisor to install bridges of hideous design, road markings of widely varying shapes, sizes and materials; conglomerate and often ineffective road surfacing, and endless types of culverts; a plan which would progress towards a glorious system of permanent highways, efficient and practicable methods of maintenance, and the attendant increased prosperity, national compactness and healthy growth of a unified nation.

Rapid strides in the direction of permanent roads are at present being made all over the United States, and here in Colorado many miles of concrete highways are already in place, with others soon to follow. Here, too, various standard designs for bridges and culverts are being prepared with a view toward gradually replacing the unsightly and inadequate structures with strong yet pleasing ones, which will harmonize with the surrounding landscape. So, it would appear that the coveted goal, that of making the roads of the United States superior to those of every other nation in the world, will in due course be attained.

Editor's Note: Captain Donovan's article on page 11 gives impressions of some other French roads used during the war.—J. E. M.

Section Line Roads

By Roy J. Randall, Office Engineer.

The first hardy adventurers who made the voyage in the prairie schooner across the vast empire lying west of the Mississippi River found no roads to guide them. The region being traversed has often been termed a "trackless waste"—and such it was except for the deep cut buffalo trails and Indian paths. In fact, the greater part of Western Kansas and Nebraska was a desert and the travelers were compelled to advance along the rivers so that they might have water. Thus, the first roads across this region ran parallel to the Platte, the Big Sandy, the Arkansas, the Canadian and the other rivers running eastward.

As civilization advanced, and travel increased over these roads, fortifications were built at suitable places along the routes to furnish the travelers protection from the Indians, and to enable them to obtain supplies.

These forts and supply stations grew to be towns and were inter-connected with roads, and then mining camps appeared in the mountain districts, and roads were built to haul the ore.

Up to this point the location of the roads was accomplished by a process of selection, with possibly some assistance from a few of the pioneers who possessed engineering ability. A teamster found by experience which of several tracks between two points was the best to use, and then constant travel wore this track into a road.

Later the country was sectionized, and in time we find these old roads being fenced up and the traveler forced to go around the section, over hills and through valleys, packing back and forth to get to his destination.

It was a gross mistake for the road authorities to have allowed the old roads to be fenced off. The titles to the rights-of-way occupied by these old roads could have easily been made a matter of record, and since the old roads were being traveled years before the land was settled up, these rights-of-way could not have been included in the title to the homesteads.

Individuals had no legal right to fence them off.

This evil existed largely through the laxity of the county commissioners, who, fearing the ill will of a few constituents, allowed them to fence up the roads, on which money had already been spent in improving.

Unless the character of the country is particularly favorable, it is quite improbable that a road on a section line will follow the best location. The rise and fall is excessive, and the road is liable to traverse bad ground, such as wet, swampy spots, slides, steep grades, etc.

From time to time the state and county road authorities attempted to correct these conditions by grading and building structures, and we know places where comparatively large sums of money have been spent in cutting and filling to improve a grade. If a careful job of locating had been done in the first place, following the most economical lines of grades, the right-of-way could have been purchased, grading done and the road surfaced, and the total cost would have been less than the amount spent on

the section line road, and a much better road would have been obtained.

The injury done by having a road traverse a farm is probably a matter of perspective and imagination to a certain extent. Many farms are crossed by roads, and the owners do not notice a great inconvenience because of it. They have become accustomed to it and have adapted themselves so that the thing that at first annoyed them, they later turned into an asset.

A comprehensive program for building state routes should include an outline of the location of intra-state roads between the principal centers. Many of these roads should follow the course parallel to the railroads instead of the zig-zag route. Through the farming districts where beets are raised, the dumps are necessarily along the railroads, and yet the farmers must turn off the main highways and haul over secondary roads to get their beets from the dump because the main road follows a section line instead of running as close to the railroad as the nature of the ground will allow. This is only one example of the many advantages, others of which will suggest themselves to the readers, to be obtained by selecting the most natural engineering location following the desired general route and avoiding artificial restrictions such as section line locations.

The Military and State Map Work

By A. M. Haynes, State Highway Engineering Department.

The large amount of road work now under way is supplemented and preceded, as much as possible, by these military maps, containing the condensed information from all maps, made under orders of the War Department and in which roads are the principal feature.

Mapping is little appreciated, except by the few who are responsible for results, and has been sadly neglected in Colorado.

It is discouraging work in this rough country, where surveys are generally approximate and many fraudulent. Only in smooth irrigated districts are maps accurate, and even then many show no contours.

The Geological Survey in recent years has done some excellent work, but this covers a small portion of the state.

The Geodetic Survey is of value, but least appreciated, and the work is about starved out for lack of appropriations. This survey should be continued and sufficient funds provided by Congress.

In preparing these maps we have collected all land surveys, telephone, railroad, irrigation and national forest maps, and now is the first time that many corporation right of way maps have been accessible.

These maps will save a great deal of surveying and are useful in planning the detail surveys. From them fair estimates can be made of cost of construction and of the grades and elevations to be overcome on different routes that come up for consideration.

For example, between Alamosa and Durango there is at the present time debate on the question of which is the best of three proposed routes. The military maps can furnish profiles for comparison. They assist in settling county lines which are indefinite and poorly described. They will probably aid in preventing such litigation as has been in progress between Summit and Lake counties over their boundary, which is wholly on account of erroneous maps.

There are many places where no one can tell just where the county boundary is. To illustrate the difficulties of county boundaries, the west line of Archuleta County is made six miles west of the mouth of Lost Trail Creek. This mouth is now under a reservoir. Is it any wonder that maps disagree a mile and a half on this line? At Ratoon Pass we have just built a mile and a half of road which New Mexico threatens to take away from us. That is, she has started suit for a boundary line which would take said road. But these maps are a safe defense on all sides, as we are assailed on the east, west and south.

We can show mistakes of at least some of our accusers as far as we have pursued our investigations. So far as the work has progressed and for purposes of land lines it may be considered 75 per cent complete, though, of course, much of it should be redrawn and corrected as new data is found and new surveys are made in unexplored districts.

It is the intention to complete the work except regarding contours, and copyright it in the name of the state to prevent others from doing so in their own name and restricting its use. That law should be changed. By the letter of that law, we have found ourselves warned not to copy our own work. We could furnish blue prints to the public for actual cost when proper regulations are established.

This work promotes the operation of air routes and the defense of the country. Airplane landings are located and the maps are reconstructed for use of pilots. The maps are made to match when put together and make a map of Colorado 24 feet by 30 feet, which is reduced (and for some purposes enlarged) by photography to meet the different uses of the government.

I believe these maps will contribute materially to the opening up of the state and be of great assistance in many ways.

Editor's Note: It is hoped that counties and private corporations will realize the benefit of these maps, and will give the Department all possible assistance in getting correct data upon which to base the sheets.—J. E. M.

Some French Roads

Experiences and Opinions

By John P. Donovan, Field Engineer, Formerly Captain Engineers, A. E. F.

Personal observation during the tour of duty described below is the sole base on which the comments and opinions expressed in this article are founded, and the statements of fact, causes and effects are given for what they are worth as the experiences and opinions of an individual whose part in the recent activity "somewhere in France" was but a very small one.

The present road system of the republic of France was founded by Napoleon I and consists of highways of three principal characters: the national highways, the departmental highways and the communal highways, alike in purpose and differing only in sizes of sections and means of control and maintenance. Practically all of the roads observed were macadam, a few telford, some of the communal roads were merely graveled and one stretch of asphaltic or tar concrete was observed running south from Paris. Normally the tremendous amount of maintenance work necessary is done by groups of one or two road menders, men or women, who clatter about in their wooden shoes, wielding picks, shovels, forks, tamps and wheelbarrows of medieval pattern, doing little at a time, but by dint of long hours and perseverance accomplishing much. Practically all of the roads observed had been without maintenance work for four years, except the infinitesimal amount accomplished here and there by a few superannuated men and women who thus improved their short periods of respite from labor in the farm fields.

Without the highway system of France the lines of communication of the Allies would have broken down—rather they could never have been established—and the Boche would have been an early and detestable victor. As an instance of the importance of highway traffic, and of its magnitude, the following illustration is condensed from official figures: During the defense of the Verdun sector by Petain in 1916, the railroads were quickly cut by shell fire and it became necessary to keep up the supplies of Verdun by means of trucks alone. The French service of supply organized a fleet of trucks for this purpose and for months this fleet numbered forty thousand trucks and the number of men required to operate them and to maintain the roads was over three hundred thousand. The main highway of communication ran through the center of the salient from Bar le Duc to Verdun, only about thirty miles, and a continuous procession of trucks hurried over this short road every minute of the night and during every daylight minute when the operations of the enemy permitted traffic over the road.

As Division Engineer of the Fortieth Division it was one of my duties to closely observe the roads in the divisional areas and to supervise their repair by the labor of American soldiers and Boche prisoners. Seven months of this tour of duty were spent in France in the zone of the advance, in the intermediate and in the base section of the American line of communications. In addition to this it was my fortune to make an automobile trip from Souilly, headquarters First American Army, to Le Mans, headquarters of the Brest and St. Nazaire embarkation area, and return, a distance of some two hundred and forty-five miles. This trip took me along some of the great traffic routes that supplied the Verdun sector for four years, as well as along some other highways that were used little by the French but very extensively by the A. E. F.

The conditions that were observed as to wear of road surfaces under heavy truck traffic were the same everywhere and a few typical instances will be cited.

In August, 1918, the Fortieth Division arrived in an area in the intermediate zone where the roads had escaped all the war time traffic and, in fact, all the material ravages of war up to that time. To the American eye the long stretches of wonderfully macadamized roads, carefully drained, protected from winds by double rows of sturdy plane trees, and having heaps of crushed rock for repairs scattered along side at intervals of but a few yards, were a wonderful example of highway construction. Actually, developments proved that, while they were wonderful for light traffic, a few days' heavy traffic caused marked and serious deterioration. This is evidenced by the fact that just twenty-six days after the arrival of the division the division commander issued an order containing the following words:

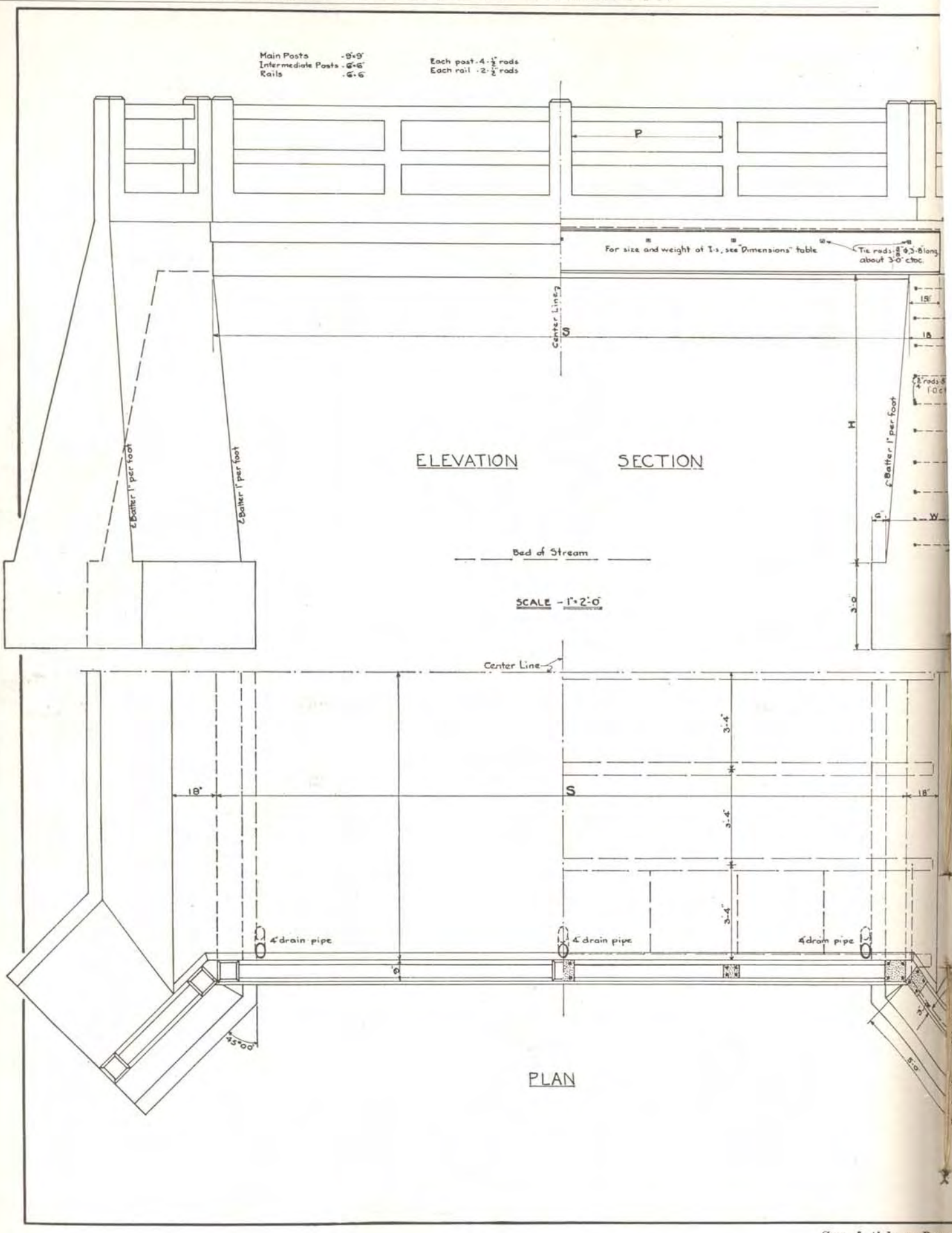
"The roads in the divisional area, over which heavy truck traffic is being carried, are becoming full of holes, which, if not soon repaired, will render them almost impassable."

And this order was issued after the roads of heavy macadam had been subjected to the truck of less than two divisions during perhaps twenty typical rainy French days.

Around every area occupied by American troops that came under my observation, all the roads rapidly deteriorated under heavy truck traffic until they became only a series of chuck holes, tremendously hard on passenger cars as well as on trucks. One macadamized road near Le Mans, having had light traffic and no maintenance for four years, developed into an excellent imitation of a corduroy road that was practically impassable at the very time when it was suddenly called upon to handle a tremendous volume of truck traffic.

Around the camps of embarkation and in the zone of the advance, where the volume of traffic was alike enormous, the evils resulting were the same except that they were magnified and speeded up by the volume of traffic. But for the presence of American road-making troops and American machinery, crushers, rollers, scarifiers and even the humble "Number Two" that were kept constantly at work even under heavy traffic, long-range shelling, continual rain and other difficulties, men and munitions could never have been moved over the impermanent, macadamized highways in sufficient quantities to meet the pressing

(Continued to page 14)



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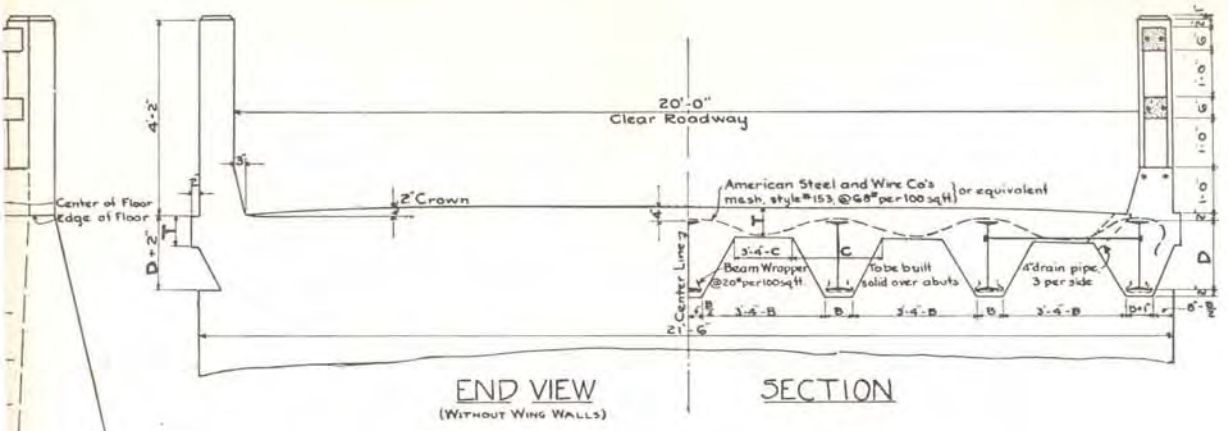

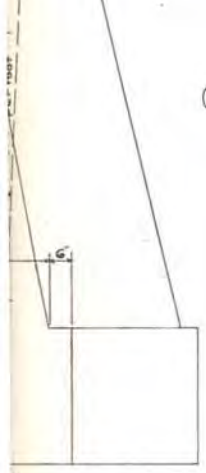

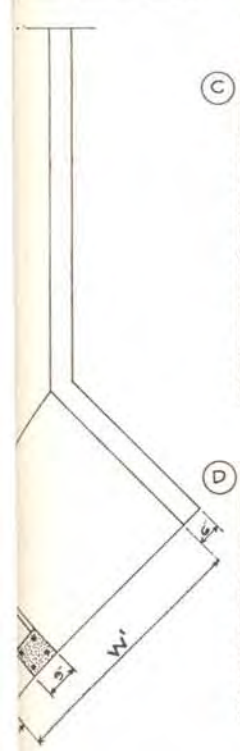

(A)

DIMENSIONS												
S Clear Span	I Beams No.	I Beams Depth D	I Beams Weight per Ft	T Floor Thickness	P No	P Clear Length	Concrete around Beams B-Width at Bottom	Concrete around Beams C-Width at Top
16'-0"	7	12"	40#	8"	3	4'-6"	6½"	1'-4"
18'-0"	7	12"	40#	8"	3	5'-2"	6½"	1'-4"
20'-0"	7	15"	42#	8"	4	4'-2½"	6½"	1'-8"
22'-0"	7	18"	55#	8"	4	4'-8½"	7"	2'-0"
24'-0"	7	18"	55#	8"	4	5'-2½"	7"	2'-0"
26'-0"	7	18"	55#	8"	4	5'-8½"	7"	2'-0"
28'-0"	7	20"	65#	8"	6	3'-11½"	7½"	2'-2"
30'-0"	7	20"	65#	8"	6	4'-3½"	7½"	2'-2"
32'-0"	7	24"	80#	8"	6	4'-7½"	8"	2'-8"
34'-0"	7	24"	80#	8"	6	4'-11½"	8"	2'-8"
36'-0"	7	24"	80#	8"	6	5'-3½"	8"	2'-8"

H	4'-0	5'-0	6'-0	7'-0	8'-0	9'-0	10'-0	12'-0	14'-0	16'-0	18'-0	20'-0
W for S 16 & 18	2'-6	3'-0	3'-6	4'-0	4'-6	5'-0	5'-6	6'-3"	7'-3"	8'-0"	9'-0"	10'-0"
W for S 20 & 24	2'-9	3'-3	3'-9"	4'-3"	4'-9"	5'-3"	5'-9"	6'-6"	7'-6"	8'-3"	9'-3"	10'-3"
W for S 26 & 28	3'-0	3'-6	4'-0	4'-6"	5'-0"	5'-6"	6'-0"	6'-9"	7'-9"	8'-6"	9'-6"	10'-6"

Tie rods are ⅝" diameter, 3'-8" long, and about 5'-0 c to c.
Abutments are to be 18" wide on top, for all spans
Floor reinforcing to be American Steel and Wire Co's mesh, style #153, weight 68 lbs per 100 sq ft ; or its equivalent.
Beam wrapper to weigh about 20 lbs per 100 sq ft
Where Rail has 4 or 6 panels, center post is to be 9"x 9"
All rods to be square and twisted, except tie rods

(B)

TOTAL QUANTITIES FOR SPANS WITH 5'-0" WING WALLS													
Span - S	Height - H	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"	12'-0"	14'-0"	16'-0"	18'-0"	20'-0"
16'-0"	Concrete-Cl. A	17.90	17.98	18.04	18.08	18.08	18.11	18.14	18.15	18.19	18.20	18.22	18.22
	" -Cl. B	38.03	48.23	59.42	71.56	82.07	95.92	110.68	138.51	173.70	207.17	248.38	288.60
	I-Beams	5180	5180	5180	5180	5180	5180	5180	5180	5180	5180	5180	5180
	Other Steel	1119	1180	1241	1302	1364	1425	1486	1609	1731	1854	1976	2098
18'-0"	Concrete-Cl. A	19.60	19.68	19.73	19.78	19.78	19.81	19.84	19.85	19.89	19.89	19.91	19.92
	" -Cl. B	38.03	48.23	59.42	71.56	82.07	95.92	110.68	138.51	173.70	207.17	248.38	288.60
	I-Beams	5740	5740	5740	5740	5740	5740	5740	5740	5740	5740	5740	5740
	Other Steel	1176	1237	1298	1359	1421	1482	1543	1666	1788	1911	2033	2155
20'-0"	Concrete-Cl. A	24.09	24.20	24.29	24.35	24.35	24.40	24.44	24.46	24.51	24.52	24.55	24.56
	" -Cl. B	39.25	49.59	60.92	73.21	83.90	97.91	112.48	140.99	176.29	209.97	251.41	291.91
	I-Beams	6615	6615	6615	6615	6615	6615	6615	6615	6615	6615	6615	6615
	Other Steel	1277	1338	1399	1460	1522	1583	1644	1767	1889	2012	2134	2256
22'-0"	Concrete-Cl. A	29.46	29.61	29.72	29.81	29.81	29.88	29.93	29.96	30.03	30.04	30.08	30.09
	" -Cl. B	39.54	49.95	61.39	73.73	84.58	98.62	113.66	141.83	177.47	211.32	252.89	293.42
	I-Beams	9432	9432	9432	9432	9432	9432	9432	9432	9432	9432	9432	9432
	Other Steel	1334	1395	1456	1517	1579	1640	1701	1824	1946	2069	2191	2313
24'-0"	Concrete-Cl. A	31.58	31.73	31.84	31.93	31.93	31.99	32.05	32.08	32.15	32.16	32.20	32.21
	" -Cl. B	39.54	49.95	61.39	73.73	84.58	98.62	113.66	141.83	177.47	211.32	252.89	293.42
	I-Beams	10202	10202	10202	10202	10202	10202	10202	10202	10202	10202	10202	10202
	Other Steel	1400	1461	1522	1583	1645	1706	1767	1890	2012	2135	2257	2379
26'-0"	Concrete-Cl. A	33.69	33.84	33.95	34.04	34.04	34.10	34.16	34.19	34.24	34.24	34.31	34.32
	" -Cl. B	39.54	49.95	61.39	73.73	84.58	98.62	113.66	141.83	177.47	211.32	252.89	293.42
	I-Beams	10972	10972	10972	10972	10972	10972	10972	10972	10972	10972	10972	10972
	Other Steel	1456	1517	1578	1639	1701	1762	1823	1946	2068	2191	2313	2435
28'-0"	Concrete -Cl. A	39.00	39.18	39.31	39.41	39.42	39.50	39.56	39.60	39.68	39.70	39.75	39.76
	" -Cl. B	40.75	51.26	62.79	75.25	86.26	100.41	115.56	143.92	179.73	213.73	255.50	296.40
	I-Beams	13878	13878	13878	13878	13878	13878	13878	13878	13878	13878	13878	13878
	Other Steel	1594	1655	1716	1777	1839	1900	1961	2084	2206	2329	2451	2573
30'-0"	Concrete-Cl. A	41.32	41.49	41.62	41.73	41.73	41.81	41.87	41.91	41.99	42.01	42.06	42.07
	" -Cl. B	40.75	51.26	62.79	75.25	86.26	100.41	115.56	143.92	179.73	213.73	255.50	296.40
	I. Beams	14788	14788	14788	14788	14788	14788	14788	14788	14788	14788	14788	14788
	Other Steel	1650	1711	1772	1833	1895	1956	2017	2140	2262	2385	2507	2629
32'-0"	Concrete -Cl. A	52.29	52.52	52.70	52.83	52.85	52.95	53.04	53.14	53.20	53.24	53.31	53.32
	" -Cl. B	41.27	51.77	63.41	75.99	86.97	101.35	116.42	145.19	181.27	215.54	257.50	298.61
	I-Beams	19320	19320	19320	19320	19320	19320	19320	19320	19320	19320	19320	19320
	Other Steel	1715	1776	1837	1898	1960	2021	2082	2205	2327	2450	2572	2694
34'-0"	Concrete -Cl. A	55.08	55.31	55.49	55.63	55.64	55.74	55.83	55.89	56.00	56.03	56.10	56.11
	" -Cl. B	41.27	51.77	63.41	75.99	86.97	101.35	116.42	145.19	181.27	215.54	257.50	298.61
	I-Beams	20440	20440	20440	20440	20440	20440	20440	20440	20440	20440	20440	20440
	Other Steel	1772	1833	1894	1955	2017	2078	2139	2262	2384	2507	2629	2751
36'-0"	Concrete - Cl. A	57.88	58.11	58.29	58.43	58.44	58.54	58.63	58.69	58.80	58.83	58.90	58.91
	" -Cl. B	41.27	51.77	63.41	75.99	86.97	101.35	116.42	145.19	181.27	215.54	257.50	298.61
	I-Beams	21560	21560	21560	21560	21560	21560	21560	21560	21560	21560	21560	21560
	Other Steel	1837	1898	1959	2020	2082	2143	2264	2327	2449	2572	2694	2816

Note:
Concrete Quantities in Cu. Yds.
Steel Quantities in Lbs
Loadings
Alternative | 100 Lbs per Sq. Ft.
Live Loads | 20 Ton Road Roller
Dead Load: Concrete - 150 Lbs per Cu. Ft.
Class A Concrete - 1:2:4
Class B Concrete - 1:2½:5

(C)

QUANTITIES PER ADDITIONAL FOOT OF WING WALL												
Concrete - Class B - Cu. Yds.												
HEIGHT - H	4'-0	5'-0	6'-0	7'-0	8'-0	9'-0	10'-0	12'-0	14'-0	16'-0	18'-0	20'-0
16'-0 span	0.700	0.873	1.044	1.214	1.502	1.749	2.015	2.512	3.164	3.784	4.572	5.436
18'-0 "	0.700	0.873	1.044	1.214	1.502	1.749	2.015	2.512	3.164	3.782	4.572	5.436
20'-0 "	0.768	0.947	1.146	1.343	1.698	1.852	2.124	2.635	3.300	3.941	4.736	5.613
22'-0 "	0.784	0.964	1.161	1.386	1.623	1.880	2.154	2.668	3.338	3.954	4.781	5.669
24'-0 "	0.784	0.964	1.161	1.386	1.623	1.880	2.154	2.668	3.338	3.954	4.781	5.669
26'-0 "	0.784	0.964	1.161	1.386	1.623	1.880	2.154	2.668	3.336	3.959	4.781	5.669
28'-0 "	0.850	1.038	1.245	1.470	1.715	1.976	2.257	2.745	3.464	4.110	4.935	5.803
30'-0 "	0.850	1.038	1.245	1.470	1.715	1.974	2.257	2.745	3.464	4.110	4.935	5.803
32'-0 "	0.872	1.064	1.274	1.502	1.749	2.015	2.299	2.792	3.517	4.167	4.995	5.896
34'-0 "	0.872	1.064	1.274	1.502	1.749	2.015	2.299	2.792	3.517	4.167	4.995	5.896
36'-0 "	0.872	1.064	1.274	1.502	1.749	2.015	2.299	2.792	3.517	4.167	4.995	5.896

Additional Class A Concrete in Curb and Rail - 0.0463 Cu. Yds
Additional Steel in Curb and Rail - 5.10 Lbs.
In abutments and wing walls, use 16'-0" rods with 6'-0" wings, and 18'-0" rods, wings 7'-0" or over

Height - H	4'-0	5'-0	6'-0	7'-0	8'-0	9'-0	10'-0	12'-0	14'-0	16'-0	18'-0	20'-0
16'-0" rods	15	19	23	27	31	34	38	46	54	61	69	77
18'-0" rods	31	38	46	54	61	69	76	92	107	122	138	153

Note: These quantities are for but one wing wall only

(D)

QUANTITIES PER ADDITIONAL FOOT OF ABUTMENT (FOR USE ON SKEW BRIDGES)												
Concrete - Class B - Cu. Yds												
HEIGHT - H	4'-0	5'-0	6'-0	7'-0	8'-0	9'-0	10'-0	12'-0	14'-0	16'-0	18'-0	20'-0
16'-0 span	0.60	0.78	0.97	1.13	1.35	1.60	1.86	2.36	3.01	3.63	4.42	5.16
18'-0 "	0.60	0.78	0.97	1.13	1.35	1.60	1.86	2.36	3.01	3.63	4.42	5.16
20'-0 "	0.60	0.78	0.98	1.15	1.36	1.61	1.87	2.38	3.03	3.66	4.45	5.19
22'-0 "	0.60	0.78	0.98	1.20	1.37	1.62	1.89	2.39	3.05	3.68	4.48	5.22
24'-0 "	0.60	0.78	0.98	1.20	1.37	1.62	1.89	2.39	3.05	3.69	4.49	5.22
26'-0 "	0.60	0.78	0.98	1.20	1.37	1.62	1.89	2.39	3.05	3.69	4.49	5.22
28'-0 "	0.60	0.78	0.98	1.20	1.37	1.62	1.89	2.40	3.06	3.69	4.49	5.24
30'-0 "	0.60	0.78	0.98	1.20	1.37	1.62	1.89	2.40	3.06	3.69	4.49	5.24
32'-0 "	0.61	0.79	0.99	1.21	1.38	1.63	1.91	2.42	3.09	3.72	4.52	5.28
34'-0 "	0.61	0.79	0.99	1.21	1.38	1.63	1.91	2.42	3.09	3.72	4.52	5.28
36'-0 "	0.61	0.79	0.99	1.21	1.38	1.63	1.91	2.42	3.09	3.72	4.52	5.28

COLORADO
STATE HIGHWAY DEPARTMENT
STANDARD
I-BEAM
BRIDGES
FOR VARIOUS SPANS AND ABUTMENT HEIGHTS
R.S.D. NOV 192

by Robert DuBois.

Some French Roads

(Continued from page 11)

demands of battle. It is no exaggeration to state that the number of road makers, American engineer troops, prisoners of war and labor battalions of all nationalities—including the "heathen Chinee"—constantly employed in road repair work reached hundreds of thousands. And ninety-nine per cent of this tremendous effort was incidental to keeping the macadamized roads in merely passable condition for heavy truck traffic.

Instances of road deterioration or destruction like those cited above could be recited to redundance. It is reiterated that the macadamized roads of France saved that country from destruction by a ferocious enemy, but that salvation would have been impossible had it not been for a most tremendous expenditure on the repair of macadamized roads of men, machinery and munitions that could have been better employed at the front. Macadamized roads did unquestionably do the work, but that work could better have been done had the roads been of concrete surface on a heavy foundation, substantial enough to carry heavy truck traffic, or of some other type—if such there be—of permanent road of low maintenance requirements.

Of by far the greater part of the roads observed the alignment and grades are ideal. Occasionally as a road goes through a village a section narrowed to fit the streets and a series of short curves and angles, blinded by ancient buildings, slows up traffic, causes accidents and makes the weak link in the highway chain.

It is quite certain that the bridge designers of France during the past century never dreamed of the possibility of carrying the tremendous weights of present-day wheeled traffic, and much trouble is caused by bridges of insufficient carrying capacity. Every bridge is a limiting factor in the value of a highway. The fortunes of war or of business may raise a highway of mediocre importance ordinarily to one of maximum importance over night, and this occurred in France, not once, but many times. Bridges of light load capacities on such highways immediately—in time of heavy traffic demand—reduce the potentially high value of the highway of which they are links to practically nothing. Perhaps bridges of short span can ordinarily easily be strengthened to carry safely heavy traffic during emergencies, but the strengthening of long-span bridges presents a very serious problem. The following cases are typical:

Two adjacent highways are carried across a large river and its tributary by suspension bridges—my recollection is that the maximum suspension span is about two hundred and fifty feet. These highways suddenly became of great importance as links in the line of communications. Each bridge was nearly a century old and one had a total capacity vehicle and load together of four tons; the other capacity was the stupendous amount of three thousand pounds. Three to five trucks, empty, to say nothing of loaded light trucks and touring cars, were obliged to make detours of from twelve to twenty miles around both of these bridges to another but substantial bridge of stone arch type. By the customary perverseness of events, this bridge was the only entrance from the south to a city of some 30,000 people, and on the city side the approach to the bridge was by way of a heavy grade on a hairpin turn. There were several accidents on this hairpin because of the serious congestion of traffic over the bridge, which was obliged to carry all of the traffic of four heavily traveled highways. Progress was further greatly impeded by the fact that in order to regain the proper route it was necessary for huge truck trains to proceed at a snail's pace for a mile and a half through the narrow, tortuous streets of a busy, crowded city.

In another locality the approaches to an important bridge were so low that in time of flood they were inundated under two feet of water, requiring traffic to detour nearly eighteen miles to reach another bridge, reached, of course, only by traveling through the very center of another large city.

Every cross roads and junction in France is furnished with an iron pipe sign post bearing cast iron signs showing distances, directions and names of towns reached by each road. The signs are usually painted dark blue with letters and arrows cast in high relief and painted white. These signs saved untold hours of aimless wandering and were of great benefit to us who were unfamiliar with the country and its language. A person of moderate intelligence can take a French road map and find his way to any part of France without asking a question if he will read his map and follow the omnipresent signs. They are an important part of any road system, but are to be found nowhere within my own knowledge except on the highways of France.

The sum of the deductions made from sorry months of experience, and watching millions expended in maintenance of macadamized roads, is as follows:

1. Macadam requires too much maintenance work to make it a satisfactory road surface under heavy traffic. Use gravel, sand or nothing until money is available to build real concrete roads.

2. Blind curves and sharp angles are elements of danger and slow up traffic, thus causing congestion at bad places.

3. Sections should not be narrowed to conform to city streets. Money spent in condemnation of property for this purpose is money well spent.

4. Every bridge must be strong enough to carry maximum loads, and the approaches are as important as the structures.

5. Highways are chains carrying traffic and as strong only as the weakest link.

The roads of France are marvelous and certainly contributed a tremendous amount to the defeat of the Boche, but they are not ideal. Unbounded admiration of French roads by automobile tourists who are metamorphosed into road experts overnight should not delude American highway planners into building roads solely on the French system. It is by criticism, not by admiration, that we learn.

Editor's Note: It is evident that in some portions of France the road surfacing for modern heavy traffic will have to be of some type other than water bound macadam.—J. E. M.

Quick Construction of Army Camps

By G. S. Lawrence, State Highway Department.

While stationed at Camp Kearney, California, I was appointed executive officer for a new camp, with orders to select a camp site adjoining Camp Kearney, suitable for a recruit depot. It was my duty to see that the work was properly done and completed in the time allotted. Work was started January 2nd, 1918. There were 1,000 recruits sent to this camp and arrived January 10, 1918, from Camp Lewis, American Lake, Washington.

The survey was made by a detail from the Colorado Engineers. The water system was installed just as soon as the survey was completed.

The mess halls, kitchens, tent floors, frames, etc., were built by civilian contractors. The mess halls and kitchens were all in one building 22x38x12 after a plan adopted by the camp quartermaster at Camp Kearney. Tables and seats were constructed of 2x4 and 1x8, two tables to a mess hal to accommodate 100 men. Kitchens with earthen floors were partitioned off from the mess halls.

There were twenty tents to a company, 10 on each side of the company street, and five men to a tent. The floors of the pyramidal tents were 16x16 and built one foot off the ground, of 2x16 and 1x12. Tent frames were built of 4x4 for the corner posts, 3 feet in length, and 4 pieces of 2x4x9. One 4x4 3 feet long was used for the center pole with a tent pin for the center ring and hood to rest on. These were braced by 1x6. The floors and tent frames were built in Camp Kearney and hauled about one-half mile to the new camp in trucks. As fast as they were hauled over there were enough soldiers to unload them and put them in place. The canvas was hauled from the quartermaster depot and distributed at the head of each company street; a detail of soldiers would carry them over and adjust them on the tent frames.

The signal corps installed the electric light system.

As this was only a temporary camp, the buildings for the latrines were not connected with a sewerage system; they were 8x20-ft. front, 8-ft. back. Roof covered with tar paper.

A trough was built on the front of these buildings for washing mess outfits. All the buildings were roughly constructed, but very practicable. Seventeen officers were detailed from Camp Kearney to receive and train the recruits. A canteen was established from Camp Kearney, also a Y. M. C. A. tent was erected, fitted up with everything to entertain the men.

One hour after the last section arrived with the 1,000 recruits they were comfortably in their tents.

The tents contained a new iron spring cot, mattress, pillow and two blankets for each man; all the recruits had were their barrack bags with their personal effects. It was quite a surprise for them to arrive at night and find a new home all complete.

It only required eight days to pick out a camp site, put in water and gas and construct all the buildings, etc., with provision made for everything in record time.

Big Thompson Canon Project

By P. J. Becker, Field Engineer.

A very interesting feature to the highway engineer in constructing highways in the mountains is surfacing. It hasn't been long ago since a teamster hauling ore down a steep grade from the mine to the mill would feel perfectly safe if he could get his wheels in the ruts of the road; if his brakes were working it made very little difference to him how deep the ruts were, he would get the ore to the mill without any trouble. This kind of a road, however, didn't satisfy the milkman, the man hauling timbers to the mines, or drivers of any light vehicles.

There always have been various opinions as to how roads should be built. What would be desirable for one class of wagons would be entirely unsatisfactory to others. However, since the advent of the automobile and motor trucks the ideas about highways have changed, and instead of the drivers of the lighter class of vehicles building a road a little wider than the ordinary, calling it a boulevard and prohibiting its use to heavy traffic, and owners of the heavier wagons building roads to suit their purpose, which the lighter vehicles could not go over, the traveling public is getting together on the road question, building roads which all can use and calling them highways.

Roads formerly consisted of series of cuts and fills. After these were built to grade the road was thrown open to traffic and often in a short time it was in a very poor condition, but a highway is constructed differently. A modern highway is not any more complete without surfacing than a railroad would be without cross ties and rails. So it is being realized more and more that surfacing is as important as road building itself. Surfacing then being essential to a good highway, the question of material for surfacing naturally arises, and it is difficult to decide just what surface to use for any particular district, as conditions, experience proves, govern to a great extent. However, in building mountain highways it is the common practice to supply the surfacing from the material available at different places along the proposed line.

It has been very noticeable during the process of widening the road in the Big Thompson Canyon (Federal Aid Project No. 9) that short stretches of the highway after having been subjected to every condition the road is expected to meet, with the possible exception of a waterspout, were in good shape, while perhaps adjoining stretches would, after a heavy rain or snow, be almost impassable. In examining these stretches it is seen that, for instance, some earth when it was first turned over would be black, resembling rich agricultural soil, but would contain enough sand and gravel to produce a natural surface, while another stretch that looked good, after being placed would not hold up under traffic and storm conditions.

Now the question arises if one piece of highway has a natural surface and adjoining stretches have not, could not the latter be brought up to similar surface conditions by combinations of the material which compose these sections?

Notes by J. E. Maloney, Chief Engineer

Temporary Editor

TO ALL, we wish a peaceful, productive, prosperous New Year.

The Highway Commission consenting, the Engineering Department assumed the task of getting out this number of the Bulletin, and the matters covered and discussed are presented for your thoughtful consideration.

So much has been printed about the French roads that the articles herewith on that subject should prove interesting.

There is room for all types of road surfacing, and there is a place for each particular type.

In considering the state road problem, remember you are dealing with 8,000 miles of state road, and that there are over 40,000 miles of county roads also to be kept up.

You properly demand that the roads be kept up.

You know it takes money to do the work.

The money now provided is sufficient for a good maintenance fund.

Don't you expect to pay for the construction work, necessary for improved conditions?

If you expect to provide the necessary funds, two ways are open—by direct levy, or by a loan. Treat the road improvement financing as you would your own business.

Is the improvement worth the cost?

If it is, then why not make the loan? Do the work and get the return from the investment.

The returns are tangible. The tourists spend their money. Transportation costs of all kinds are reduced.

On a traffic of 100,000 ton miles per mile, per year, the saving on transportation will pay the interest and sinking fund for a paved road compared with an earth road.

Considered from this view point, a loan for road improvement will pay for itself, without considering the other arguments.

THINK IT OVER.

Additional forces were added to the Engineering Department within the past few weeks.

Messrs. Randall, Walters, Strauss and Bertholf are the happy dads.

Plans and specifications provided.

Maintenance Work Accomplished by State Outfit Under Chief Inspector C. T. Brock

Highway No. 2, Adams County. Operated crusher plant near Westminster, Colo., with three trucks hauling in March, 1919. We crushed, hauled and placed 2,416.9 cubic yards of rock on 2½ miles of road bed 16 feet wide. Also for 350 feet in length, 16 feet wide, at north and south approach of Clear Creek bridge. Surfaced same with gravel, using 598.7 cubic yards of gravel. Average haul, round trip 5 miles, cost $4,165.71.

Filled in washout at end of concrete bridge on Clear Creek with crushed rock. Used 76¼ cubic yards, cost $90.70.

On Highway No. 2, Tarvia road. Operated crushing plant near Westminster, Colo. Hauled with three trucks from June 2, 1919, to September 28, 1919. Operated 76½ days. Crushed, hauled and placed 6,264.9 cubic yards rock. Average haul 4 miles, cost $7,955.06. Truck and blade operated four days, traveled 72 miles, cost $40.80.

On Highway No. 7, east of Aurora, hauling from gravel pit east of Aurora, May 9, 1919, to June 2, 1919. Also, September 29, 1919, to November 30, 1919. Operated 56 days, hauled with three trucks 25 days and with four trucks 31 days. Surfaced 2 8/10 miles road 16 feet wide with 6,483.2 cubic yards gravel. Average haul, round trip 10 miles, cost $5,078.47.

On Highway No. 31, Elbert County near Agate, Colo. Hauled gravel with three trucks from gravel pit near Agate. Hauled and placed 3,931 cubic yards gravel. Surfaced four miles road bed 18 feet wide. Average haul 10 miles, cost $3,723.30.

On Highway No. 31, Elbert County near Buick, Colo., month of November, 1919. Operated with three trucks 15 days, hauled 1,220 cubic yards rock from our pit near Buick, placed and rolled same on 1½ miles road 18 feet wide. Average haul four miles, cost $1,404.15. This material is first class for surfacing. I recommend its use for surfacing on as many miles as possible.

On Highway No. 31, Elbert County. Grading road May 21 to 31, 1919, from five miles east of Deer Trail to one mile north of Agate. Filled in road approximately 1,635 cubic yards of earth, put in three new pipe culverts, bladed roads three days with teams, October 1, 1919, to November 7, 1919. Cost $390.

Grading near Buick, on fills, approximately 9,120 cubic yards earth. Cost $1,904.60.

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Road Problems on the Western Slope

John J. Vandemoer, Field Engineer, Formerly Captain Engineers, A. E. F.

The great necessity for adequate highway facilities on this side of the range is one of the most important problems concerning the development of this section, and it is a problem which must be solved if we are going to keep pace with other communities in the state.

A certain definite plan of action has been agreed upon by the State Highway Commission in regard to what high ways are to be improved first. Just when these improvements can be made and how long it will take to complete them depends to a large extent upon what local financial arrangements can be made in each county.

In Mesa County the proposed program includes the improvement of the Midland Trail, east and west from Grand Junction, and the Rainbow Route as far as the county line. These improvements will consist of a great many different types of construction, depending upon the existing local conditions. It is proposed to begin the improvement by constructing concrete pavement, and the first contract has already been let.

Through a large section of the Grand Valley the slope of the land is quite uniform and the natural drainage is defective, making it quite difficult to obtain adequate road drainage, which is the first essential for successful road construction. This principle is borne out very strongly in France, when one studies the careful methods of road drainage and the expense entailed in the thorough way in which the water is led off the road bed. France has learned by hard years of experience that in order to overcome the natural climatic and soil conditions, it is very imperative to provide adequate drainage.

Although France has to combat her excessive rainfall and boggy valley lands, she is exceedingly fortunate in possessing in large quantities a very satisfactory grade of limestone, which is easily quarried and produces a very satisfactory road bed, which is readily repaired by the same material.

I saw no concrete roads in France, and there seemed to be no great necessity for them as long as the macadam road was satisfactory. In fact, I believe if the Western Slope, through its valley sections, could obtain a limestone as well adapted for road building as is found in portions of France, it would solve the road problem in a great many localities.

Another very important problem we are confronted with through our broad, flat, irrigated sections, is the building of substantial bridges across "washes." While I was employed in the drainage department of the U. S. Reclamation Service we used every possible means to lower the grade of these washes, in order to afford more adequate drainage to the adjacent lands. The difficulty which now presents itself on these same "washes" is to prevent these "washes" from cutting any deeper. I have in mind one "wash" in particular, across which we were building a reinforced concrete bridge, and the day following the com-

(Continued on page 21)

Before Construction

H. L. Jenness, Field Engineer, Formerly With 109th Engineers, A. E. F.

Did you ever stop to think just how much time is spent and work done when an improvement is planned for one of the roads which form the network of the state highways?

The engineering end of the location and construction of highways is probably the least known and understood by highway users and the public in general of any branch of highway work. Especially is this true in mountainous districts where the engineering work forms the most important part of the improvement.

Therefore the purpose of this article is to familiarize highway users and the public in general with the underground work which is necessary before any visible results are accomplished.

As a typical example for the purpose of this article we will take the Battle Mountain Road or Federal Aid Project No. 78, a part of State Highway No. 10 between Red Cliff and Minturn.

First comes the question of why make any change in the present road?

In this case the present road from Red Cliff through Gilman to the bridge across Eagle River four miles south of the town of Minturn has steep hills at each end with heavy grades running as high as sixteen and eighteen per cent, and is narrow with many sharp curves and a dangerous switchback. This road being one of the main transcontinental highways, known as the Pike's Peak Ocean-to-Ocean Highway, with very heavy traffic amounting to 18,000 ton miles per mile for the year 1918, and this portion being the worst stretch between Leadville and Grand Junction, it was decided by the State Highway Commission to improve the section from Red Cliff to the bridge across Eagle River, a distance of six miles north of Red Cliff.

After making the decision to improve the highway the Commission made an appropriation to cover the probable cost of construction, the County of Eagle also making an appropriation to be used with the state appropriation.

As this road is used as a post road and comes within the scope of the Federal Aid Road Act, in which the federal government pays one-half the cost of construction of improvements costing $40,000 or under per mile, this improvement was made a Federal Aid Project and as such will be constructed under the supervision of the State Highway Department, subject to the inspection of the U. S. Bureau of Public Roads.

The decision to improve the highway and the appropriation made, the next step is the reconnaissance and preliminary survey to determine the approximate location of the new road, which will conform to the state and government requirements in regard to grade and curvature, which are: A six per cent maximum grade and a one hundred foot minimum radius for curvature. The country between Red Cliff and the end of the project being a very steep hillside with many cliffs and portions of slide rock, the first

(Continued on page 23)

No. 1. Leveling Sub-Grade, Greeley Road.

Federal Aid Project --- Greeley Road

By W. A. Lewis, Field Engineer, Formerly With 109th Engineers, A. E. F.

Starting at the city limits of Greeley on Eighth Avenue and running south 2,500 feet on tangent, then a 10 degree curve to the left and a 7 degree curve to the right, thence south to within 500 feet of the city limits of Evans, a total distance of 4,700 feet, the new road is raised with a good drainage ditch on each side. From Station 33 to 47, where the old road ran along the bottom, then up a 7 per cent grade for 400 feet, the new grade cuts down the hill, fills up the low places and has a grade of 2 per cent.

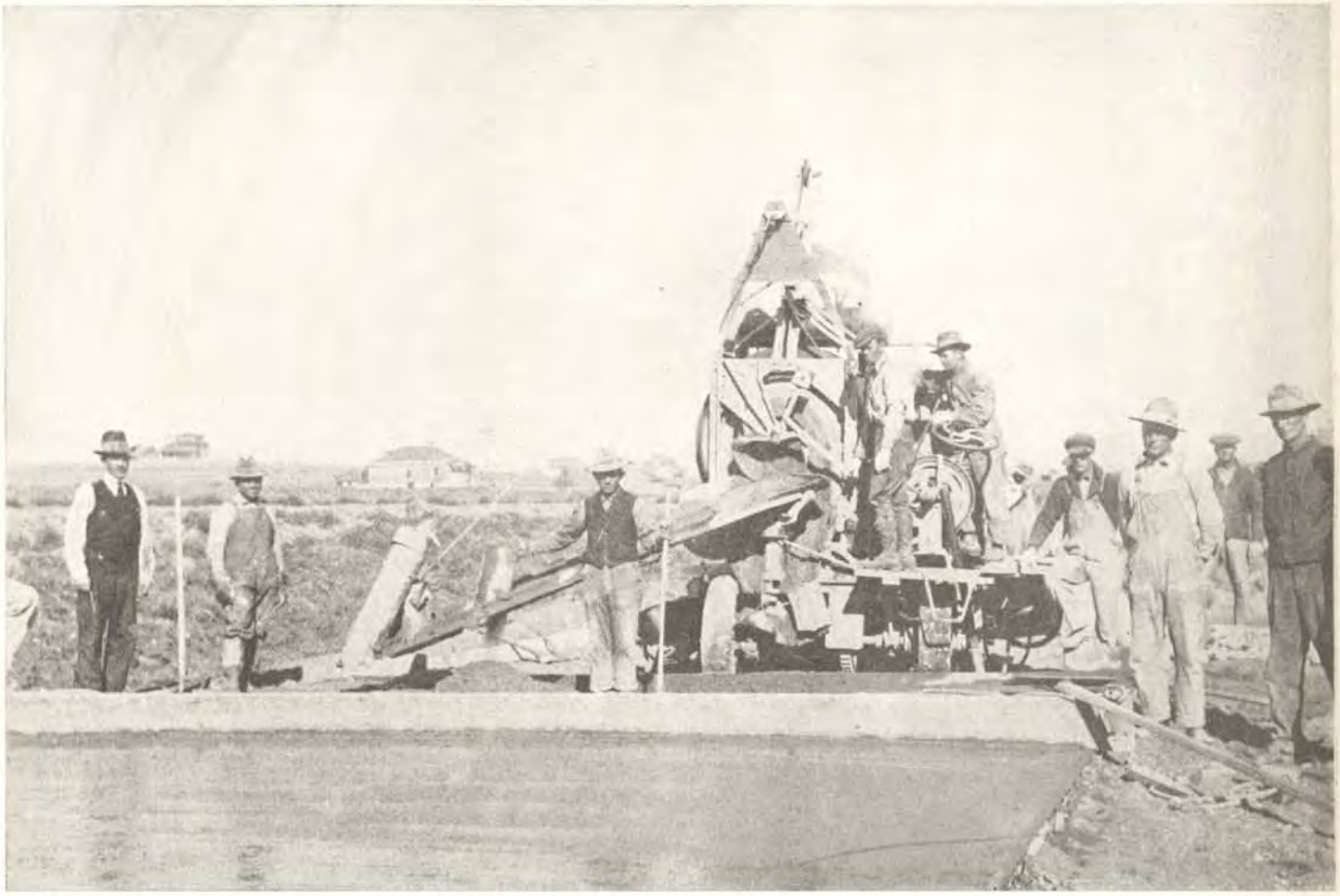
At the small draw west of Station 40-50, which has a drainage of four square miles, upon which several small reservoirs are located, heavy rains would cause a flood which would cover the road and flood the adjoining lands and fill most of the cellars in Evans. The water generally stood from one to two feet deep on the road after these storms, the road being the lowest place. All this trouble is now eliminated by a 9x5-foot culvert placed across the road with an earth dam on the west side to divert the water into a six-foot ditch on the east side. Another place which gave considerable trouble was where the road crosses the old D. L. & N. W. R. R. grade. Owing to poor drainage at this point the water would overflow the road, always leaving a pile of sand and sometimes doing considerable damage. This was eliminated by constructing a six-foot drain ditch west along the old railroad grade, leading into the spillway of the Bartelds reservoir 500 feet west of the road.

Methods of Construction—Construction was started August 18 by the Engineer Construction Company of Greeley, Mr. Clark president, starting at the lower and cutting down the hill and making the fill from Station 38 to 47. This fill was made in one-foot lifts, bladed off and rolled with a 10-ton roller, making the embankment very compact, with very little chance for shrinkage.

Very little change was made in the profile of the old road from Station 34 back to Station 0.0. However, the old surface was gone over with a scarifier, bladed, and rolled to give a good subgrade for the concrete. The work of putting on the concrete surface was started Oct. 2. This work also was started from the south end and worked north towards Greeley, as the gravel and cement was delivered from that point.

Finishing the Concrete—The strike board, a template for such graded work and belts for finishing the work were made and proved valuable and gave very satisfactory results.

In the construction of the strike board for the concrete two pieces of three-inch by eight-inch lumber 20 feet long, were used, each sawed to the exact curve of the road



No. 2. Placing the Concrete, Greeley Road.

and spaced six feet apart in the clear, being held apart by cleats on the middle and ends, which also held them rigid. Strap iron runners were nailed on the bottom to prevent wearing and working. The extra foot on each end gave plenty of room for sliding back and forth. Constructed in this manner the strike board appeared heavy and bunglesome. However, it could be carried back and forth by two men. The extra weight with the two edges gave a true form to the road besides compacting the concrete better than the single board.

Of the two belts used for surface finish the first belt was a heavy fibre belt one-half inch by ten inches and was used by see-sawing it back and forth, using about an 18-inch pull and going ahead about eight to ten inches each pull. This heavy belt was only used once. The finish belt was made of ¼-inch by 7-inch rubber covered and with a soft finish. It was used three times, twice by see-sawing and finally by a straight drag for the length of the part being finished. This operation gave a very smooth finish. After the finish belt had passed over a stone there were no connections, float marks or waves which are common to most concrete roads. The template used for checking subgrade and forms just ahead of the concrete was made of 2x6-inch lumber one-half inch shorter than the width of the concrete. Cleats were nailed on the edges to project out over the forms. A small piece of iron nailed on each cleat to prevent wearing where it would slide on the forms; a strap iron was also nailed on the bottom.

As the board was moved along sliding on the forms the sub-grade could be observed for the width of the road and any high places removed or low ones filled up, always giving an exact check on the subgrade.

Picture No. 1 shows method of leveling subgrade before the final rolling. All the gravel and cement was hauled over the road grade, cutting it up considerably. It was found desirable to level up and roll the subgrade just before the gravel was dumped, in order to prevent a lot of delay for the mixer. Rolling just ahead of the gravel left a hard surface to dump on, making the gravel easier to pick up and wheel to the mixer. At the same time it only took a few moments for one man to keep the subgrade around the mixer in shape, the main idea being to keep the mixer going without any stops.

Picture No. 2 shows the concrete coming out of the mixer going down the chute and dumping on the ground. The consistency of the concrete can be noted by the way it stands up after leaving the chute. The mix was made dry enough so that it would hardly run and had to be helped down the chute with a hoe or shovel. After being dumped it was spread with shovels and then struck to a crown

No. 4. Reverse Curve on Greeley Road.

with the strike board, after the second time over, keeping a slight ridge ahead of the board each time. The wooden floats were used and then the strike board used again. The concrete was then allowed to dry from twenty minutes to one hour, just long enough for the water on top to start drying; then the roller was used. The roller was constructed out of an old water heater and pulled back and forth with ropes, going ahead about two feet each time across. The pull across was slow so as not to drag off any water or fine mixture from the top of the concrete. After the rolling was completed the heavy belt was used. After the concrete had set about twelve hours it was covered with 2-inch soft dirt. This covering was wet down every day for ten days—after ten days the dirt was removed and the joint filler cut off about one-quarter inch above the joint.

Picture 4 shows the pavement after the dirt had been removed and the joints cut off. Also shows the reverse curve and super-elevation set about the center of the project.

Editor's Note: The above, and the article following by A. B. Collins on the Brighton Road, are typical of the paving work now under way in various sections of the state. The work at Pueblo by the Orman Construction Co. is completed, and work is under way at Lamar, Longmont and Boulder, and contracted for at Grand Junction, La Junta, Rocky Ford, Manzanola and Fowler.—J. E. M.

Federal Aid Project No. 10---Brighton Road

Station 89+68.2, End of 1918 Paving, to Station 189.

By A. B. Collins, Field Engineer.

The contract for this project was let to Mr. M. J. Kenney of Denver on August 12, 1919, and calls for the completion of 1.78 miles of concrete roadway, eighteen feet wide, 7½ inches at center, six inches thick at edge, with a one and one-half inch crown.

Immediately on award of contract, orders were placed for the necessary equipment with which to complete the work, but unforeseen factory and shipping conditions delayed the arrival of the mixer until October 27. In the meantime a mile of finished grade had been prepared, fifteen hundred feet of forms placed and sand and gravel distributed for the length of the placed forms. Three by sixes, surfaced four sides and thoroughly oiled, were used for form material and were found to be sufficiently heavy to retain excellent alignment under the conditions imposed by the distribution of sand and gravel. The forms are held in place by fifteen-inch iron pins, driven at necessary intervals, bent on the upper end to lock over the top of lateral braces.

Sand and gravel is obtained from a pit located along the main highway at the upper end of the project and is

hauled and distributed by end dump trucks, of three yards capacity. The material is exceptionally well graded by means of a rotary screen, covered with three-foot sections of one-eighth and one-half inch screen, producing three classifications, sand, pea gravel and coarse aggregate. The sand and coarse gravel thus obtained passes all specifications; the pea gravel is placed in stock piles to be used for shoulders on the completion of the paving.

The mixer used is a Foote Paver, of twenty-seven foot dry capacity, self-propelled, with a forty-horse power boiler, and geared to sixteen revolutions per minute. Discharge is through a circular spout, twelve feet long, with removable sections, permitting the distribution of material over about eight feet of roadway, without the necessity of a forward move. The discharge spout has a slope of approximately 30 degrees and the effort is made to keep the mixture, which is a one, two, three mix, at such consistency that it will not discharge of its own weight, but may be readily forced through the spout with shovels.

While the mixer has a capacity of twenty-seven feet, it has been found advisable to use eighteen-foot batches, as the width of the roadway, with the material scattered for its length, does not permit the use of a sufficient number of gravel barrows to charge without too great a delay.

The time also necessary to secure a thorough mix is appreciably lowered by using the smaller batch. The placing of both sand and gravel within the forms has been found impracticable, as it results in a congestion that causes much loss of time. It is suggested as a means of eliminating this difficulty, that the necessary gravel only be placed in the center of the roadway, which will permit of wheeling to the charger from both sides of the pile. If the shoulders are brought to grade, at the beginning of the work, at least on one side, the sand may be dumped at proper intervals on them and as it is removed a sufficient amount may be left to complete the shoulder, eliminating the extra hauling and placing of shoulder material.

The water supply for the mixer is obtained from a deep well and pumped directly into a storage tank, from where it is distributed along the work, through a two-inch pipe line.

As the concrete is placed in the forms it is thoroughly tamped and brought to grade and crowned by means of a screed board, steel-edged, and weighing approximately ninety pounds. The finishers follow immediately with a two-section galvanized iron roller, weighing thirty pounds and about five feet in width. After the free water has been rolled off the stone is finished with a twelve-inch belt. Expansion joints are placed every thirty feet, Elastite strips being used as a filler. A little difficulty has been encountered in keeping these strips in a true perpendicular position. On removal of the form board it has been found that if care is used at the joints and the mixture kept as dry as possible the tendency to throw the strips out of perpendicular is, to a great extent, eliminated.

In finishing, a split float has been used to keep the stone on either side of the joint at the same elevation. An uneven settlement of the concrete in places, however, even with the greatest of care, will result in a difference in elevation between the two sides of sometimes as much as one-eighth of an inch. As a means of eliminating this difference it has been suggested that the joint filler be cut to absolute form and that the surface be finished straight across the joint, letting the surface crack develop afterward. Two or three joints have been finished as submerged joints and the effect will be noted in the future. If this form of joint does not result in uneven surface cracks the writer is firmly of the opinion that it will offer the most satisfactory form of joint and will permit of a more uniform road surface.

Road Problems on the Western Slope

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pletion of the structure a flood came down and lowered the grade below the bridge about two feet in elevation. Fortunately we had constructed a good floor and a fairly deep cut of wall, and before the "wash" had a chance to cut any deeper we built a grade-protection structure considerably down stream, which seems to be holding up the grade of the "wash" in good shape. Our foundations are largely in quicksand, which necessitates a generous use of well selected and well placed piling, driven to refusal. Our sand and gravel for concrete are of a fair grade, although the sand is fairly fine and predominates over the gravel in the pit-run material.

There is one other feature in regard to the stability of the French roads, some of which were built in the time of Caesar and Napoleon, and that is this: the thickness of the foundation varies from two to six feet, and it is very seldom that the "bottom drops out" of any of the old roads of France. We in America can learn a lesson in this connection, and that is, not to skimp our foundation, either in bridge building or road building. One more fact which stands out very prominently in regard to the French bridges is their massiveness and absolute stability. In fact, the official A. E. F. engineer information was to the effect that "you need not fear the collapse of French bridges, regardless of your wheel-loads."

The mountain roads of Mesa County are, as a rule, well constructed and the natural road materials are much better than through its valley sections. There are a great many grade eliminations necessary and the roads as a rule are rather narrow. The cross drainage is an expensive problem and oftentimes quite difficult to solve, but as time goes on and the communities get stronger, more money can be consistently spent in mountain road improvement.

Mesa County has one mountain project which she wants the world to know about, and that is the Whitewater-Gateway road. With the first ten miles of this road improved and eventually the ten miles through the Dolores River Canon built, the road system of Mesa County would connect up with the road system of Montrose County, and the Paradox Valley would have a water grade route to a standard gauge railroad and it would have an outlet which is open all winter and does not exceed an elevation of more than 7,100 feet at any point.

Federal Aid Projects in Eastern Colorado

By L. E. Edwards, Field Engineer.

Eastern Colorado, or what is more commonly known as the dry section of Colorado, comprises the following counties: Logan, Sedgwick, Phillips, Washington, Yuma, Lincoln, Kit Carson, Cheyenne, Crowley, Kiowa, Otero, Bent, Prowers, Las Animas and Baca.

Only a few years ago a large part of Eastern Colorado was devoted entirely to stock raising and ranching, but by the employment of modern methods of farming it has been developed into one of the most productive portions of the state, producing enormous quantities of wheat, corn and other grains in addition to its stock.

This is a prairie country proper, being very level in some parts and other parts rolling, the greater part, however, being quite rolling.

There are two classes of soil in this section, namely, that which is classed as "hard land" and "sandy land." The former, constituting the level land, has two very peculiar qualities: first, that of becoming very hard when dry; and second, that of becoming very soft and very sticky and heavy when wet. The latter forms the rolling land and also the sand hills, and when it is wet it is quite firm, but when it becomes dry, which is about ninety per cent of the time, it becomes very loose and blows badly in the winds, which are very prevalent in this part of the state.

The main roads in this part of the state are divided into two groups—those running north and south, and those running east and west.

These two groups, with their feeders, form a very good system of roads, and carry a great amount of traffic, both of a transient and also local type, the transient consisting mostly of tourists, while the local is mostly heavy hauling of grain and supplies.

The task of improving these roads is a very difficult one, as the traffic on all roads except the Lincoln Highway and the Santa Fe Trail is not sufficient to demand paving, nor is the financial condition of this section such as to be able to pay for such construction, which is the only sure method to insure roads absolutely good for all conditions of weather.

These roads are, as has been mentioned before, of two kinds of material—hard soil and sandy soil, neither one of which makes a good road of itself, but by surfacing the hard soil with sand or gravel, and the sandy soil with clay or adobe, either one becomes a very good road and will carry a very heavy traffic in all kinds of weather.

This is the only substitute for paving or hard surface roads and by bringing the roads to a permanent grade and providing the proper drainage, which is in itself the secret of road construction in any soil, they become a first-class road.

The State Highway Commission, in its program for 1919 and 1920, has laid out a number of Federal Aid Projects for these roads which, when completed, will make a marked change in the condition of the roads, as they are planned to improve the worst places and those subject to heavy traffic first and then the less important ones next.

Among the projects for this section are eight projects for paving on the Santa Fe Trail, totaling an approximate mileage of six miles at an estimated cost of $33,000.00 per mile. Contracts for all of these projects have been let and approximately two miles are complete and more is under construction. This is on perhaps one of the most heavily traveled roads in the state, and is only a beginning of what is to follow in this line of work.

There are, besides these, eleven other projects for grading, drainage and surfacing—and just a few words here in regard to drainage: No matter how well a surface may be constructed, if the subgrade is not built up so as to be at all times properly drained, the work is all for nothing. Take for example the railroad grades through the country; they are all raised above the surrounding country, no matter what their condition may be, and this is the secret of their being able to keep them in repair at a minimum cost for maintenance. This principle holds equally true in road construction of any class.

Of the projects mentioned, surveys and plans for practically all paving jobs have been made and contracts let, and the balance will be completed the coming season. Of the grading and surfacing projects, surveys have been made on Projects Nos. 11, 39, 40, 43, 50 and 95. The plans for Nos. 11 and 43 have been completed and approved by the Bureau of Public Roads and bids called for. Bids were received on Nov. 21, 1920, on Project No. 43 and construction will be started soon if weather permits.

Making the survey and preparing the plans for one of these projects calls for a large amount of work, both in the field and in the office. The field work consists of obtaining the alignment, taking of profile, locating of drainage structures, such as bridges and culverts, and securing the cross sections of the location, which are used in calculating the yardage necessary to make the cuts and fills required to bring the road to a permanent grade and for determining the amount of surfacing required.

Obtaining the proper alignment and location for some of these roads is a problem in itself, as the counties in laying out the roads originally have followed the ancient custom of following section lines regardless of conditions. From this arises a number of obstacles which must be overcome, such as going over hills where the grade cannot be brought to the maximum established without causing cuts, which is the most objectionable feature in this country, as the wind blows almost constantly, especially in the winter, and these cuts fill with snow, making the roads impassable during this part of the year. This can only be overcome by a new location of the line, making detours around the hills, thus avoiding the cuts and at the same time reducing the per cent of grade.

The field work requires a party of unusually fine men, consisting of engineer in charge, an instrument man, two chainmen and a rodman, together with the equipment, which consists of transit, level, chain, rod, stakes, etc. In

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Before Construction

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difficulties encountered in making the survey were the keeping of one's footing and finding a place to set up an instrument.

After running the preliminary line from Red Cliff to the mining camp of Gilman (owned by the Empire Zinc Co.), gathering all available information in regard to possible grades and natural features favorable to the new location, the survey was then carried on through Gilman for a distance of three miles to the end of the project. This section of the present road being in need of improvement more than the three-mile section from Red Cliff to Gilman, it was also the more difficult to survey, there being places along the face of cliffs where the new road will have to be blasted out of the solid rock for a distance of several hundred feet.

The next step is the location survey in which the details of the final location of the highway are worked out on the ground. The located line is run by the transit party, composed of transitman, two chainmen, axemen, stakeman and back flagman, with the same precision and care that is used in locating a railroad line, and the methods used are similar.

The curves are traced, setting stakes at various distances, but usually twenty-five feet apart, and on this project it was with difficulty the stakes were set at all, due to the abundance of rock, and where it was impossible to drive a stake, crosses were chiseled in the rock to hold the points. Data for the profile of the line is also gathered at this time, the transit party being closely followed by the level party, composed of a levelman and rodman, who ascertain the elevation of the ground at the foot of each stake. The location of the center line of the new road being finished, there follows the important step of measuring the quantities of material to be moved. This operation is called cross-sectioning.

As can be readily seen from the above picture, the character of the country from Gilman to the end of the project is such that this was one of the most difficult and laborious parts of the field work, where a pair of wings would have been far more useful than feet.

The field work being finished after a period of six weeks, the scene of operations was shifted from Gilman to the office of the engineering department of the Highway Commission, where the information gathered in the field was used in making the map, profile and estimate of the cost of the project. This being a Federal Aid Project, it is necessary that the map, profile, estimate and specifications conform to the regulations of the Bureau of Public Roads, which are in brief: The map is composed of sheets 22 by 36 inches platted to a scale of one inch equal one hundred feet, the alignment placed at the top of the sheet with the corresponding profile directly below.

A sample of one of the Battle Mountain sheets is shown elsewhere in this issue of the Bulletin.

The cross sections were platted on sheets similar to those of the alignment and plan, and when completed the areas and cubic yards were calculated and summarized. This part of the work occupied a period of six weeks.

The project statement, which is an approximate estimate of the cost of the project, was then submitted to the Bureau of Public Roads and after being approved by the district engineer at the Denver office was then sent to Washington, D. C., and after being approved by the director of the Bureau of Public Roads in November, 1919, the State Highway Department was at liberty to advertise for bids from contractors.

There then remains the submission of the maps, specifications and detail estimates, which, after being approved by the district engineer, are sent to Washington to be approved by the director of the Bureau of Public Roads and Secretary of Agriculture.

The detail estimate covers all construction items such as cubic yards of material moved, concrete, clearing and culverts.

The next step is the letting of the contract and the actual construction work, which on this project will be done during the season of 1920 at a cost of approximately $40.000 per mile.

Federal Aid Projects in Eastern Colorado

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level country an average of four miles of line per day can be run, and about four miles of profile and cross sections, depending, of course, entirely upon the lay of the country in which the work is being done.

The office work consists of platting the alignment and profile, laying out of grades, which, according to the standards of the State Highway Commission, must not exceed a maximum of six per cent; the platting of the cross sections and calculating the yardage, designing bridges and culverts and preparing the detailed estimates upon which cost of project is to be based.

No. 43 is a typical project of the work in Eastern Colorado, except that it calls for no surfacing at present, but the grade has been designed with this in mind and surfacing will be added as soon as funds are available. The surfacing will make an additional cost of approximately $3,000.00 per mile.

Maintenance Work

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On Highways No. 8 and No. 3, near Palmer Lake, Colo. Grading and surfacing approximately five miles of highway and one new concrete bridge. Cost $10,535.75. 1,625 feet snow guards constructed to protect cuts on highway No. 8, north of Palmer Lake. Cost $1,167.40.

DRAGGING AND BLADE WORK ON ROADS.

From March 11, 1919, to November 30, 1919, on Highway No. 49, Adams County (Brighton Road). Truck and blade operated 15½ days, traveled 241 miles, cost $128.62.

On Highway No. 2, Adams County. Truck and blade operated 26½ days, traveled 539 miles, cost $318.43.

On Highway No. 7, east of Aurora. Truck and drag operated 53 days, traveled 1,343 miles, cost $710.50.

On Highway No. 31, Arapahoe County. Truck and drag operated 18½ days, traveled 431 miles, cost $244.47.

On Highway No. 31, Elbert County. Truck and drag operated 48 days, traveled 1,169 miles, cost $615.75.


BEGINNING OF PROJECT STA. 172
GILMAN
BEGINNING OF PROJECT. STA. 172.
V.C. 400'
V.C. 200'
V.C. 200'
V.C. 100'
V.C. 400'