

COMPREHENSIVE HIGHWAY LOCATION

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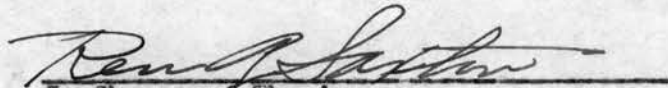
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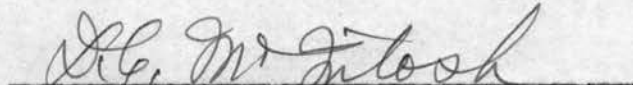
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PREFACE

In submitting a thesis on Comprehensive Highway Location the writer finds that the material composing the body of the theme is so closely related that it is necessary to submit the data in two parts rather than constant digression from one phase of the subject to another. Part one deals with the personnel, equipment, and the important field methods of obtaining the necessary information to be recorded. Part two describes the development of the project concerned in words, figures and illustrations.

The body of this thesis is not the how, as is clearly illustrated and taught in college, but the other side of the question, namely, the what. Any graduate in Civil Engineering knows how to operate the transit and level, how to record both transit and level notes and the method of chaining, marking and driving stakes. In addition to this it is then necessary that he be able to select and record the actual features that govern the type of work he may be performing.

As one phase of highly developed Engineering the writer has chosen Highway Location placed in a Comprehensive view. The following statements are considered to be of major importance and are actual tabulations and developments from the field of Highway Location, classified as to importance and broad enough in scope to cover the information required for nine hundred miles of Highway Location in Oklahoma.

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PERSONNEL

The Chief of Party is the engineer in charge of survey, and as such he has full charge and authority as to the organization of the party and the assignment of duties to the members thereof. Each party is composed of a Chief of Party, Instrumentman, Rodman, Head Chainman, Rear Chainman and Stakeman. In especially heavily wooded or underbrush areas, this is augmented by the addition of one or two Axemen, where this additional force will increase the speed of the party.

It is the duties of the Instrumentman to run the transit and level, to take notes or perform any other duties assigned to him by the Chief of Party. He is responsible to the Chief of Party for the care of instruments or any other equipment assigned to him. He also assists the Chief of Party in platting profile, making plats, taking topography, as he may be directed.

The Rodman, Head Chainman, Rear Chainman and Stakeman perform such duties as may be assigned to them.

EQUIPMENT

Parties under normal conditions are furnished the following equipment:

1 Tudor Automobile	1 8 lb. Maul
1 Truck	1 Round Pointed Shovel
1 Transit	1 Pick
1 Level	Double Bitted Axes
2 Hand Levels	1 Hand Axe
2 Chains	2 8 oz. Plumb Bobs
2 Metallic Tapes	1 Sounding Set
2 Level Rods	2 18" Pipe Wrenches
4 Range Poles	Water Kegs
1 Pole Axe	Office Equipment

LOCATION SURVEY

A location survey means a survey for the obtaining of complete information necessary for the active plans for the construction of a finished highway.

When a Chief of Party is assigned to a location between certain control points, he goes over the same to make his own reconnaissance, in order to determine the general direction or course to be followed to obtain the best alignment. This portion of work is given his strict attention as the alignment is the most important feature of the entire survey, since it is the policy of good location to keep the curvature to a minimum, thereby reducing the hazards, and tending to shorten the travel distance between control points. It is also necessary that attention be paid to the obstructions to be encountered and to the possibilities of avoiding them or passing through or near them with the least possible damage. The Chief also takes into consideration the possibilities of obtaining the least possible grade, as the utility of the road in some measures depends on this feature. In considering the above he must be guided by the cost of construction and endeavor to keep the line as economical as possible in the country through which the highway will pass.

During the course of any survey, streams will be encountered that will require bridges, and the Chief knows from experience that in the choice of a stream crossing he may effect a saving in the cost of structure without materially changing either the length or the economy of the location.

Where railroads are encountered, the Chief of Party is particularly on the look-out for the possibility of grade separations, either by overhead or underpass location of which the former is preferable. In the matter of location, while it is essential from an economical standpoint that the length of line be held to a minimum, the service of the highway to the population of the rural districts and the economical value to the industries along the route should be considered and weighed against any increase in length. In this connection the approach to the cities and the possible route through the centers of population must permit easy access to the cities and towns, and also cause the least impediment to the line of traffic passing through the centers of population.

As urban approaches sometime offer conditions vastly different from those encountered in the field, it is necessary to make special surveys to determine the most feasible and economical route near populated centers. These take into consideration the alignment and grades determined by the city authorities or the duly appointed planning commission and should be made with an idea of fitting into the plans of these bodies.

Special surveys are also made in rough mountainous country where it is necessary to plot in detail the topograph of the country on stated contour intervals, in order that a paper location may be projected thereon for field use.

In making a location the first item to be considered is the shortest distance necessary to get from one point to another. This, of course, would of necessity be a straight line drawn between the two points, but such a line may offer difficulties of construction and the added cost would be excessive, and in some cases would not fit the conditions under

which the location was being made. Therefore, the first consideration is to obtain a line as near the straight line as possible which will be economical to construct, will fit into and make satisfactory connection with the existing or proposed parts of the Highway system and will serve the communities and rural districts through which it passes with the greatest commercial value and convenience to them.

PRELIMINARY

When a party is assigned to a location, the Chief determines the limits of the survey and if possible runs the survey from west to east or south to north, unless the location is to be made on section lines or unless instructions have been to run on a certain definite location as in the case of a relocation where it is proposed to better the alignment and grade. The Chief of Party runs the preliminary line, in which are placed hubs at the angle points, but the actual curves are not run in the field. This preliminary line may start at either end or at some intermediate point between the limits of the survey. It is essential, however, that the start of this survey be referenced with suitable reference points and where possible is tied into section corners and also to any physical features which may be at or near the point of beginning. In any preliminary line the angle points are marked by a regular hub. Ordinary lath are used for stakes.

This preliminary line is run as regular stadia or chain survey as desired. In either case it is necessary in most cases only to run levels over the most broken ground where there is some question as to whether or

not the allowable gradient can be obtained. These levels are run from any data for comparison purposes and it is not necessary to tie them into Government or permanent bench levels. In any case, notes are kept on the preliminary line in such a manner as to give all the necessary information and with references that will make it possible for the line to be established with ease.

TRANSIT LINE

After the preliminary line has been run and a tentative location decided upon, a regular location transit line is run over the preliminary line so determined.

The beginning point of the line is permanently marked and referenced to permanent points so that the same can be accurately located at any time. The transit line is run by the tangent method and is marked at least each 100 feet with a line stake with the station number thereon. Stakes are also placed at every break in the profile and at all points where the contour of the ground off center line requires that cross sections be taken, and these are marked with the station number and with the plus to the point in question. Stakes are placed at all fence lines crossed by the center line and at the flow lines of all streams where possible.

Plusses are taken to all permanent features either physical or topographical which are located within 400 feet of the center line and at a greater distance when they will in any way influence the design of

the road.

As an added assistance in following the line a strip of red cloth is tied to the top wire of the fence lines where the center line crosses same.

Ties are made to all permanent physical features along the line which might be of aid in identifying the exact location of the line in future years.

Throughout the line, and not over 1000 feet apart, permanent points are set and these are referenced to some permanent object or to permanent reference points. For this purpose a 1-inch iron rod not less than 15-inches in length with a prick point on same is used so that the center line can be located with accuracy. When the center line is along a finished or graded road, the center line points are placed on an offset line and the information is properly recorded in the notes. When the centerline points are set in a traveled road, they are driven at least six inches below the surface of the road and are thoroughly referenced. In rolling country, it is desirable to set the permanent points on the crests of the hills even if they are less than 1000 feet apart. The P. C., P. I., and P. T. of all curves are set as permanent points and are so referenced.

In referencing permanent points to trees, the trees are well blazed facing the point and a nail is placed in the blaze. The angle and distance from the permanent point on the center line are shown in the notes. Reference points should be at least 45 degrees apart and outside of the right of way except where the land is cultivated, and then they are placed as far as possible in a position where they will not be disturbed.

In wooded country trees on both sides of the center line are blazed

on both sides; so they will be plainly visible when one is following the center line.

Exact ties are made to all section corners, quarter corners, corporation limits, sub-divisions and all other property lines which are fixed.

When the center line crosses a railroad, ties are made to the nearest structure if it is within reasonable distance, or to some known point of the railroad survey as well as to a mile post of the railroad. Plusses are taken to the inside of the first rail encountered. When the center line parallels a railroad, ties to the nearest rail are made at least every 500 feet and all drainage structures of the railroad carefully recorded. At the intersection of the center line with a railroad, the angle between the two are carefully measured and all topography taken along the railroad for at least 1000 feet on each side of the center line.

Particular attention is given to all drainage which crosses the center line, or is near to the right of way, and enough measurements taken to the center line of flow so that it may be properly shown on the plans. In the case of large streams their location is shown when they are within 1000 feet of the center line.

In locations through cities and villages complete topography is recorded showing all details such as buildings, lot lines, street lines, pavement, curbs, side walks, sewers, water pipes, man holes, telephone lines and any other topography which will in any way influence the design of the road.

In cities and villages where storm sewers do not exist, a special study is made of the drainage conditions and recommendations are made as to the structures which will provide proper drainage and avoid future property damage.

The magnetic bearing of all tangents are shown. These are computed from some known section line or from a line, the true bearing of which is known and checked against the bearing as read in the field.

On curves the deflection, degree, tangent length and length of the curve is shown and the deflection noted as to right or left of center line.

Where power, telegraph or telephone lines are encountered, their location and the owners' names are recorded and recommendations as to what poles will of necessity have to be moved.

Where section lines are crossed or section corners encountered, the section, township and range numbers are shown.

In all cases curves are kept to the least possible degree, and on important roads this should not be in excess of three degrees, on a maximum grade of 3 per cent unless there is some very good reason for exceeding these limits. In rough country, curvature will increase, but no curve over a five degree is used without giving the location careful study.

If the center line is along a section line, the angle made by the section lines at the section corners, if they are small, may be left in the line and properly recorded. However, if they are of such size that they will be noticeable in the completed road, they are hidden at the top of the nearest high point of the profile. When the angles between the section lines are small, it is often possible to establish a straight line which will be close to the section lines through a number of miles. Such a line is so located that the right of way can be purchased for an equal distance each side of the section line.

When locating through any city or village the street should be 100 feet in width and free from any obstructions; if there are no 100 feet streets available, an 80 feet street may be used but any width less than 80 feet is not considered without special study.

Because of the present high speed traffic, special study and development has been made of extra widening, super-elevation and runoff of curves. In as much as the super-elevation is closely related to the cubic spiral in effect, the runoff for each permissible degree of curvature will be given to clarify the problem of mountainous location.

Curves that reverse in direction must have the distance from the corresponding P. C. and P. T. as tabulated in table I; no P. C. or P. T. can be nearer a bridge or permanent structure than the runoff allowed by the degree of curve. Curves that compound need less consideration as to runoff since the super-elevation of the larger degree of curvature may be carried on to that of the lesser and be diminished accordingly.

Runoff is further defined as the distance back on the tangent from the P. C. that the super-elevation and extra widening starts, being three-fourths super-elevated and one-half widened at the P. C. and continuing the same distance beyond the P. C. to full super-elevation and widening. The corresponding situation is equally in effect at the P. T.

TABLE I RUNOFF

Degree of Curvature	Runoff
0° - 30'	0 Ft.
1° - 00'	120 Ft.
1° - 30'	128 Ft.
2° - 00'	140 Ft.
2° - 30'	152 Ft.
3° - 00'	160 Ft.
3° - 30'	180 Ft.
4° - 00'	200 Ft.
4° - 30'	220 Ft.
5° - 00'	240 Ft.
5° - 30'	260 Ft.
6° to 12°	280 Ft.

LEVELS

The datum for all levels is established by the U. S. G. S. surveys.

A line of bench levels is run over the entire line and permanent bench marks set at least every 1000 feet. These benches, where possible, are set over 50 feet from the center line and so placed that they will not be disturbed before or during construction. In wooded country a 60-penny spike in a properly blazed tree answers the purpose. In open country iron rods are driven flush with the ground line and properly guarded. It has not proved satisfactory to use spikes in fence posts or telephone poles.

The profile levels are run independent of bench levels and are checked into same at each bench mark.

When the center line crosses a railroad, the profile of the railroad for at least 1000 feet each side of the center line is shown. If a grade separation is to be made, the elevation from the base of rail is recorded. In any event the notes show if the top or base of rail is used and the height of rail.

In villages or cities where sidewalks or curbs exist, elevations of same are shown.

Where center line parallels a railroad, the elevation of the nearest rail is shown every 500 feet and oftener if there is a break in the grade on the railroad.

When the line begins or ends at a finished project, the profile as far back of the point of beginning or ahead of the end of the line as necessary is taken so that proper grade connections can be made.

Accurate elevations of high water at all streams are shown. In the larger streams it will generally be found that at some time there has been a flood that was extremely high. This elevation is shown as well as the high water that may be expected from year to year.

A profile is prepared of the line and a recommended grade established. On final plans it is probable that this grade line will be changed to balance quantities and if for any reason the ones established cannot be changed a note of the fact is made and reason supplied.

In establishing a profile all vertical curves are figured to permit at least 600 feet sight distance.

All grades are kept to a maximum of 5 per cent if possible. If the

alignment is good and the road not too important, in extreme cases a grade up to 6 per cent may be used, with the idea that in the future, in the event of paving, these grades will be reduced.

CROSS SECTIONS

Cross sections are taken either with the Y-level or hand level. If a Y-level is used, the notes are kept in the level book and taken in conjunction with the center line profile. If a hand level is used, notes are kept in a separate book. In either case the actual elevations of one set of cross sections are shown on each page of the notes.

All cross sections are carried 50 feet on each side of the center line, except where heavy cuts or fills are expected; then they are extended the necessary additional width. When it becomes necessary to borrow outside of the standard 100 feet right of way, adequate cross sections are taken of suitable borrow pit locations. This is especially true where an overpass grade separation is possible or probable.

With the present 36-foot roadway in level country the 100-foot right of way will provide material for only about $2\frac{1}{2}$ -feet fill on center line. If more fill than this is anticipated, the cross sections are taken for a greater width than 50-feet each side of center line.

At all culvert locations cross sections are taken for 200 feet on each side of the center line in the flow line of the stream; these are in addition to the cross sections taken at right angles to the culvert location from the center line.

DRAINAGE

The actual drainage areas of all streams under 1000 acres are run out by a careful stadia survey. Experience has taught that small areas are within 5 per cent of the true area while larger areas are from 1 to 2 per cent of the true area as represented by the traverse. If a drainage area of over 1000 acres is regular, the area is determined by checking the divides from the section lines which surround same. The areas of most of the larger streams can be obtained from U. S. G. S. topographical maps. It is important that the drainage areas be correct and when areas of over 1000 acres cannot be obtained in any other way, they are run out.

The size of any highway or railroad bridge which may be over or near the proposed bridge location is checked, and notes recorded as to its ability to carry all flood waters.

Special attention is given to all drainage in cities and villages and at all road intersections.

In computing the areas of openings required, care is used in selecting the constant to be applied. It is not desired to have openings far in excess of the requirements, but they must of necessity, unless relief is provided, be ample to carry all flood waters.

The smallest openings recommended for cross drains are 18-inch reinforced concrete pipes and 3 feet by 2 feet reinforced concrete boxes.

Drainage areas for all side drains which may be required at street crossings or road intersections are obtained.

Cross or side drains are recommended at all section lines where section line roads are open for public travel.

BRIDGES, CULVERTS & CHANNEL CHANGES

In the data for culverts, the drainage area, the constant, the square feet of opening required, and the size of culvert as well as the culvert design are recorded.

Channel changes are worked out in detail with the center line, profile and cross sections. The proposed section of the channel is shown.

Culverts should be at right angles to the center line; in the event a skew is to be placed, the angle of skew and all data for the channel changes at each end of same are shown.

If possible all bridges should be located at right angles to the stream, and channel changes are made where same will speed the flow of water or improve the bridge location.

At all bridge sites, a careful location of the stream is shown from 500 to 1000 feet on each side of center line and further if necessary to show the true nature of the stream. A profile is run parallel with, and 50 feet from the center line on each side of the ravine section. Profiles of the wetted perimeter are made above and below the bridge location, at right angles to the stream, to aid the bridge design. Cross sections are frequently extended several hundred feet to the right and left of center line for topographical mapping of the vicinity near the proposed bridge site.

SOUNDINGS

From the established grade line on the profile the approximate depths of cuts are determined, and soundings on the center line in all cuts are made to the depth of the proposed grade line. If rock is found the elevation is recorded; if unclassified material is found to the depth of the cut, a log of same is recorded.

At all bridge sites, soundings are taken on both sides of the stream. If rock is found, the elevation is given, also the location of the test hole. In the event rock is not found at a depth of 30 feet, which is the limit of regular party equipment, a log of the materials encountered and their elevation is furnished.

At points where soundings cannot be made on account of sand or gravel or suitable material for a foundation found at a maximum depth of sounding, arrangements are made for bridge sounding equipment.

RIGHT OF WAY

Correct ties are made to all section and quarter corners available and to any other permanent land ties which can be found. All section lines as well as county lines are stationed in like manner as corporation limits of cities and villages. Complete information of abandoned sub-divisions is secured to complete the desired information. The services of County Engineers and County Surveyors are sometimes secured for the active location of obliterated corners.

Copies of the townsite map of all incorporated villages and cities

passed through are obtained and furnished with the notes.

The minimum right of way required is 100 feet, 50 feet on each side of center line. When heavy fills are encountered, additional right of way is requested to cover borrow pit operations.

When the center line is along the right of way of a railroad company, their maps are secured and carefully examined to ascertain if at any place the railroad may have unfenced additional right of way as this property usually cannot be obtained.

Upon completion, or during the survey, the Chief of Party fills out property owners' reports. These are placed with a reliable Abstractor who is requested to furnish all information for each piece of property that comes in contact with the center line.

The owner's name and address

The owner's wife's name and address

Mortgage

Amount of mortgage

Book and page recorded

Assignee and his address

Date assigned

Book and page number recorded

Right of way cannot be obtained from cemeteries and church grounds; consequently these must be avoided. The same condition is true of a lone grave that is frequently found in isolated places and Indian family graveyards generally found on top of small hills.

RAILROAD CROSSINGS

Since the Federal appropriation of \$4,800,000,000 has been made, a part of which is designated for grade appropriations, and which has led to increased activity in this field, it would be in order to give the specific field method of securing data on such projects.

It is desirable to eliminate all grade crossings with railroads. When this cannot be done the angle between the center line and the railroad is made as near 90 degrees as possible and in no case less than 70 degrees.

Grade crossing separations are placed in two classes: the overhead crossing or overpass, where the highway is carried over the tracks of the railroad and undergrade or underpass, where the highway is carried under the tracks of the railroad.

OVERPASSES

As a rule each separation presents different problems so that it is impossible to set fixed rules that apply to all cases.

The most desirable separation is the overpass, unless the conditions are such that proper sight distance and drainage can be obtained by an underpass.

In the location of an overpass it is made, if possible, where the tracks of the railroad are in a cut or where there are supporting hills or ridges close enough to the railroad so that the required fill will be reduced as much as possible. However where these conditions do not

exist an overhead crossing can be made in relatively flat country without excessive costs, if the borrow for the approach fills can be easily obtained. From an engineering standpoint the resulting structure may not be one of beauty, however, it will serve the purpose for which it was intended.

The overpass crossing is flexible as to the angle of crossing and may be made on any angle from 90 to 45 degrees, without excessive cost of the structure itself. Unless special conditions warrant excessive angles, the angle that can be obtained as near 90 degrees is recommended.

The approach curves, if any, are designed as light as possible and in no case over 3 degrees unless absolutely unavoidable, and in any case located such that the runoff will be entirely off the bridge structure. If difficulty is encountered in meeting the above requirements, it has been found possible in some cases to use a lighter degree of curve and carry same over the entire structure. If this is deemed the true remedy, the curve is designed of such length that the P. G., or P. T., is well off the structure; so that there is no change in the super-elevation throughout the entire length of the bridge structure.

UNDERPASSES

There are locations where the underpass crossings are the proper structure to use, but as a general rule these are voided. The reason for avoiding their use can readily be seen by taking a casual glance at most of those now in use.

Poor drainage and short sight distance condemn the utility of most

underpasses now in existence. The angle of crossing must be kept as near as possible to 90 degrees and not located less than 60 degrees, as the length and volume required for the abutments increase very rapidly. This in turn increases the cost. The use of an angle as small as 60 degrees is sometimes recommended when it will improve and shorten alignment. For example when it is desired to cross from one side of a railroad to another, if a 90 degree underpass was located, the curves and length of line into and out of the underpass will more than offset the additional cost of a 60-degree angle.

In no case are approach curves designed greater than a 3-degree if the curve is in a cut, and the P. C., and P. T. of the curve are far enough from the underpass so that the runoff is at least 100 feet outside the structure.

Generally if a drain point for an underpass is not found within 2000 feet of the structure, the layout as a whole is considered undesirable; however, if no other type can be used, methods are developed to block off all surplus drainage possible and recommend pumping the portion of water which falls in the underpass. A 24-inch pipe is deemed sufficient in size to meet the drainage requirements if the above condition prevails. Because of the present day height of loads the required distance from the base of rail to the flow line of the sewer is designed not less than 22 feet and the minimum fall of the sewer $\frac{1}{2}$ -foot per each 100 feet in length.

From the intersection of the center line of the survey and the center line of the track, a straight line is established for the sewer to the outlet. Alignment, profile and cross sections are taken for 50 feet each side of this outfall line.

FIELD METHODS

In this development it is not desirable to use greater than 5 per cent grades on the approach fills; however, it is considered good practice to carry the structure on a vertical curve. Thence, if 5-percent grades are recommended on approach fills, the structure would be designed on a 1000 feet vertical curve, and the entire length of the improvement would occupy at least 2000 feet of line in level country.

All wire lines which cross the center line are shown, heights of the lowest and highest wires, and number of cross arms in the event they will have to be raised or lowered to clear the structure.

If the tracks of the railroad where they cross the center line of the survey are on tangent, the information required at the crossing is relatively simple as the angle between the center line and the railroad governs the design of the structure. If, however, the tracks are on a curve across the center line, further information is required and the method in which this information is obtained is shown on the accompanying print.

The points "A" and "C" are located which are the intersection of the center line with the gauge or the inside line of the head of the rail. The point "B" is figured and established which is midway between points "A" and "C" and is the center line of the track. First a 50-foot station then stations 1, 2, 3, 4, and 5, are made along the rail in both directions from either points "A" or "C", and angles are turned to these points as shown.

If the track is on a curve, it will necessarily have super-elevation

and the difference in elevation is shown on lines D-E, F-G and H-I. These points are opposite each other; consequently, the true difference in elevation is shown. From point "B" at least three stations are established along the center line of the track, and angles are measured from the tangent to the railroad curve at point "B" to the points. This procedure determines the degree of railroad curve and serves as a check on the angles that have been turned from either points "A" or "C".

A profile is made at all points to which angles have been turned and extended for 1000 feet each side of the center line. This profile may prove that an adjustment is needed in the railroad grade. In taking elevation data, if the proposed structure is to be an overpass, the top of rail is used; if an underpass, the base of rail is the control point.

CLASSIFICATIONS

The classification of materials as defined by the Bureau of Public Roads, is as follows:

Class "A":

This includes the removal of all material of whatever character, except loose and detached rocks or boulders of a solid volume of one-half cubic foot or more, that in their natural condition can be loosened with a plow and six powerful horses.

Class "B":

This consists of detached boulders of solid volume of one-half cubic foot to one-half cubic yard and all materials such as shale, cemented gravel, disintegrated stone and permian red beds which can not be moved

with the use of picks and bars or heavy machinery without blasting even though the contractor may resort to blasting to facilitate the work.

Class "C":

This includes all rock in ledge formation, and all other materials which cannot be removed without continuous drilling and blasting, and all detached rocks or boulders measuring more than one-half cubic yard.

The above guide is used to complete the required information as to classification and is determined by surface indication as well as the log compiled from soundings and results duly recorded.

PART II

INTRODUCTION

The project to be discussed was selected, from the field of experience, because of the many obstacles that the country offered to a location that would remain in the limitations of the Government specifications as to grade and alignment. The geographical location of the subject is in Pittsburg County, connecting two old locations between the villages of Krebs and Blocker on State Highway No. "31". On the present county highway connecting these control points is found numerous sharp curves, steep grades, and two miles of road that is below the flood water of the principal stream, Gaines Creek, thereby offering only seasonal travel. Even though sections of this highway had been revised and improved, the road as a whole was impractical and dangerous to all season travel; consequently the authority and appropriation for the engineering.

An observation of the Highway Location Map, folded in the back of this thesis, will show that, from whatever angle viewed, the country appears to be very mountainous with an unusual number of streams to be crossed in the event of a successful location. The general direction of the route lies in the North East Quadrant, and the line appears to have many curves. If a map were submitted without the center line shown, the resulting picture would be one that offered real difficulties to any location and even more so if viewed on the ground because of the heavy timber and short sight distance available.

DESCRIPTION OF PROJECT

Starting at the lower right hand corner of the Highway Location Map and continuing along the center line, the project will be described by miles in order to convey the details that were developed by almost every step described under Part I.

Mile 1. Station 291 + 32.5 is the official beginning of the project.

The line continues on the tangent established on the old survey and extends over fairly level country, connecting with the bridge tangent, on a tributary of Mud Creek, with a 0°-30' curve.

Miles 2 and 3. These miles were so designed as to utilize the present concrete bridge over Mud Creek tributary, since it was of sufficient width of roadway and was built to carry heavy coal trucks. It skirts the edge of a high rocky hill and heads for the Gaines Creek crossing. The country traversed was beginning to be rough and broken with frequent culverts and channel changes necessary to carry the sudden rush of water from the mountain on the right. The success of this tangent made necessary the removing of a house near Station 442 as any change in the tangent would materially affect the cost of construction.

Mile 4. This section has the most important stream crossing of any mile. The line approaches Gaines Creek on a 3-degree curve, cutting in to a gravel ridge that slopes down from Buffalo Mountain and crosses the creek at a 90-degree angle with the stream. The left bank of the creek is about 5 feet above the annual high water mark. The right bank is 10 feet lower than the left bank and is subject to constant overflow; consequently the proposed bridge will be extended over this bank so as

to provide additional opening. The line continues over broken ground, crosses an overflow slough and intersects a rather abrupt gravel ridge from Cyclone Mountain. In the event of a relief opening being necessary, the overflow offered an ideal location due to its distance from Gaines Creek and is so proposed. The gravel ridge just mentioned together with the ridge from Buffalo Mountain offered the shortest crossing on Gaines Creek by virtually confining the waters between the mountains. Even the mountains are considered natural barriers, their proximity made possible the raising of the grade above the high waters at a tremendous saving over that offered by any other crossing. The point, in fact, is that the utility of the entire project rested with this bridge location.

Mile 5 continues up the mountain slope, heads several deep ravines, and drops into a crooked drain, that had to be channel changed, in order to utilize its canyon slope to start a 3000 feet climb to a high ridge.

Mile 6 is called Sky Line Drive because of its position on a high gravel ridge that offers scenic beauty in all directions and especially to the southeast as it overlooks a large fertile valley. This ridge is a natural pass between two prominent mountains and because of its position is remains a beauty spot in the mind's eye of the writer.

Mile 7 is a long gradual descent to the Ash Creek crossing following two 1-degree curves and riding a canyon line from Station 640 to Station 655. Ash Creek is a meandering stream with low banks subject to overflow and back waters from Gaines Creek. The crossing was selected because of the good alignment obtainable and the low rocky ridge just across the creek to decrease the length of the necessary fill. The channel change, 785 feet long, was made with the idea in mind to straighten the course of the stream and provide material for the approach fills.

Mile 8 has three interesting features: the Elm Creek crossing, the mountain pass or saddle and the beginning of a long 1-degree--30 minute curve, rarely seen in rough mountain location. Elm Creek is very similar in its characteristics to that of Ash Creek. The bridge location was made to fit with the back tangent by a 2-degree curve and of such direction ahead as to provide for the entrance to Jones Canyon. A skew channel change was designed 530 feet long to increase the flow of the water and provide class "A" fill material. From Elm Creek the line encounters another gravel ridge, lies above the flood water line and starts a 1-degree and 30-minute curve that passes through the saddle at station 704 and continues for 3100 feet up Jones Canyon.

Miles 9 and 10 are known as Jones Canyon Line since it parallels Jones Creek on the left and is bounded on both sides by high rocky mountains. These miles are designed in a series of curves in both directions with tangents of no considerable length. Extreme difficulties were encountered in this section in securing an alignment that would keep down construction costs, stay above Jones Creek at flood times, cross the fast mountain drainage advantageously, allow for curve runoff, and be so placed as to encounter only the unavoidable detached boulder rock that covers the mountain slope. The skew bridge location on Jones Creek was selected about 30 feet below the present concrete bridge now in place and crosses the stream just below the intersection of its two main tributaries. To facilitate the detour problem during construction, it was recommended to leave the present bridge in place. The borrow necessary for the approach fills was solved by the alignment being so located as to open cuts in the only available material suitable for use; the point in fact is that the borrow pit was located on the center line. As the line con-

tinues past Jones Creek cutting into the low slope of the mountain on the left, it opens up on a north and south one-quarter section line that the present road follows into the village of Blocker.

The office design necessary for the correct line in these two miles was detailed far beyond that of any other section or combined sections. It is believed that Jones Canyon is the critical and real test of confined location on this project and, as such, will be given a more detailed description than otherwise brought out in this thesis.

First a preliminary line was run along the old road and used as a base line. From this line all the topographical and physical features were located, being chiefly that of solid rock outcrops, Jones Creek, high water traverse, available borrow pits and the extreme limits of possibly placing a line both to the right and left. These data were drafted to a suitable scale which gave a plan view of the confined route that it was possible to follow. A series of intersecting tangents were then superimposed along the straighter portions of the route and curves placed at the intersection of these tangents. The information necessary for complete alignment notes was scaled from the preliminary line and worked out on the ground. Next it was necessary to run a set of levels of the canyon along the center line to secure detailed information for a field profile. By placing a temporary grade line on the profile it was found that all grades were within the limitations, and vertical curves could be used that would allow 1000 feet of sight distance.

Now for an explanation of locating the borrow pit on the center line, which in fact resolves itself into an open cut, and the matter of predetermined borrow. As the preliminary developed at the approach of Jones Creek, it was necessary to place the center line below the flood level to secure an adequate crossing, and as the grade must be above the

overflow, the matter of borrow became a problem. The nearest approach to a borrow pit solution lay in transporting available material of classified nature across the creek, the cost of which would be prohibitive unless as a last resort. The solution was reached when the line approaching the creek was so designed to lie near the mountain, necessitating a deep cut, close to the stream, by virtue of the grade line.

Mile 11 and 12 follows closely that of the present road until it crosses the Fort Smith & Western Railroad and continues north on the centerline of Main Street in Blocker to the city limits. From this point on there was the necessity of turning 90-degrees to the right, or east, in the next one-half mile north in order to equate with a new road being built east from the northeast corner of section 24. This angle was used in two curves to insure minimum farm damages and to aid materially the drainage situation.

Station 923 + 68.0 is the end of the project.

For a summation of this project there will be given briefly the maximums attained in grade and alignment, which are within limits, but are in fact the measure of a projects utility.

Forty and one-half per cent of the alignment is curves.

Maximum degree of curvature is 3-degree --30 minute.

Maximum grade is 5 per cent.

Travel distance saved by this location is 3.0136 miles or 20 per cent.

FINAL COST REPORT

The purpose of this report is to break down the total cost of the project into its component parts so that its various costs may be analysed and compared with that of other locations. Even though the total cost of the project is important, the real comparison is made by the cost per mile. It might be added however that the average cost per mile of locations state wide for the year of 1934 was \$100.01.

A complete record of the man days is kept of the 8 phases of location the party performs. A reference to the Party Record shows the actual number of days that each man was employed on each of the 8 divisions. The total salary of the men while employed on preliminary is entered in the Field Expenditure to the right of preliminary and under salary. This same procedure is followed for the seven remaining phases to constitute the complete location totals in so far as salary is concerned. The complete totals for supplies, gas travel and miscellaneous are entered in the table to cross add the total expenditure.

The percent of the total salary that represents preliminary is calculated, and this per cent is used to determine the corresponding amounts of supplies, gas travel and miscellaneous from their respective totals. This statement is shown in the salary column by the amount of \$225.31 is 15 per cent of \$1533.08 and in the supply column as 15 per cent of \$42.26 is \$6.24 etc.

The average cost per mile of the 8 phases is found by dividing the expenditure, say of preliminary which is \$282.88, by the total length of complete location, 11.97 miles, for the result shown of \$23.63. When this procedure is followed through the remaining steps, the actual cost per mile is found to be \$160.05.

Report No. 147 A
County Pittsburg
Div. 2 Hy. 31

FINAL COST REPORT

Feb. 17th. 1934
Proj. SWO 422
Party No. 3

Survey from North East of Krebs

To Blocker

Started Dec. 16th. 1933 Completed Feb. 17th. 1934 Time 64 Days

PARTY RECORD

DAYS EMPLOYED ON

Name	Position	Prelim	Loc. & Topog	Level Prof.	C. Sec.	D. A.	Br.	Off. Misc.	Time Lost
	Chief	11	9				1	32	11
	Inst'man	3						3	3
	Inst'man	6	9	9	6	1	5	9	9
	Rodman	8	10		4	11	8	9	14
	Chainman	10	10	9	6	1	8	8	12
	Chainman	11	11		4	11	8	8	11
	Chainman	4	4		3	2	1	3	5
	Chainman	5	8	1	6	7	9	3	6

FINAL REPORT ON FIELD EXPENDITURES

	Miles	Salary	Supplies	Gas-Travel	Misc.	Total	Av. Cost Per Mi.
1. Preliminary	25	225.31	6.24	42.96	8.37	282.88	23.63
2. Trans. Loc. & Topog.	11.97	233.45	6.77	45.25	8.81	294.28	24.57
3. B. Levels & Prof.	"	69.81	2.07	14.00	2.73	88.61	7.40
4. Cross Sections	"	107.61	3.29	22.29	4.35	137.54	11.48
5. Drainage Areas 6,605 Ac		118.10	3.51	23.51	4.63	149.75	12.50
6. Bri. Sur. & Sound'g	4	153.76	4.35	29.33	5.74	193.18	16.13
7. Office & Miscel.		341.16	8.20	55.43	10.82	451.61	34.70
8. Time Lost		283.88	7.83	52.96	10.32	344.99	29.64
Complete Location Totals		1533.08	42.26	285.73	55.77	1916.84	160.05

Total Approp. \$ 2500.00 Expended \$ 1916.84 Balance \$ 583.16

REMARKS: The time lost column appears large however this item includes time lost due to Sundays, Sickness, Rain & Snow and Christmas Holidays.

C.E. Fischbeck.
Chief of Party.

CONCLUSION

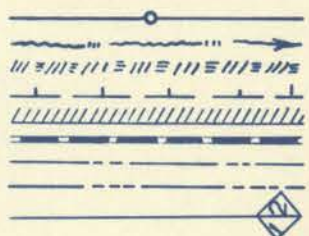
During the writing of this thesis there has been no attempt to bring out the instruction given to the personnel of the party in regard to accuracy and then speed, both of which are very essential to a successful location. Field technique is a matter of individual development to fit the ability of the party. Even though these factors enter into every day practice, there seems to be no better motto than the saying, "There is no substitute for results".

Mrs. J. E. Lawrence

COMPREHENSIVE HIGHWAY LOCATION MAP FOR THESIS REFERENCE

LEGEND

CENTER LINE OF LOCATION
STREAMS
MOUNTAINS
EDGE OF OVERFLOW LANDS
CITY LIMITS
RAILROADS
SECTION LINES
TOWNSHIP & RANGE LINES
MILE MARKERS



C. E. FISCHBECK LOCATION ENGINEER
OKLAHOMA STATE HIGHWAY DEPARTMENT

SCALE 1"=2000'

