Recommended procedure for the computation of rights of way

Leon Hershkowitz
RECOMMENDED PROCEDURE
FOR THE
COMPUTATION OF RIGHTS OF WAY

BY
LEON HERSHKOWITZ

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A
THESIS
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1949

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Approved by
Professor of Civil Engineering
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INTRODUCTION

This thesis sets forth a recommended procedure for the computation of areas included in "rights of way," using the principle of double meridian distances.

For a considerable number of years, it has been the opinion of the author that steps should be taken to arrive at some form of standardization in the procedures necessary in the computation of areas involving right of way and to more or less standardize legal descriptions pertaining thereto.

One need only examine the records of the various County Recorders in one particular state or in different states and he would be entirely convinced that such a need is paramount.

The methods or procedures used for the computation of rights of way are almost as numerous as the number of agencies employing the same. One railway company will differ from another railway company; one public service or utility organization will differ from another public service or utility organization; the State of Missouri will differ from the State of Illinois, and the Federal Government has its own recommendations as to the correct procedure to be applied.

Needless to say, this wide variation of practice leads only to confusion and may subsequently result in lost boundaries.
The method and procedure set forth in this thesis was used by the author while under the employment by the State of Illinois for approximately ten years as Right of Way Engineer and is used in that state today. Although it may be a little more involved and take considerably more time than the average system used by other agencies, the ultimate result is one that will weather any type of legal action, and what is of more importance, will definitely fix points and boundaries for many generations to come.
PART I
SURVEY DATA

In order to properly compute areas, using the principle of double meridian distances, it is necessary to obtain certain field data while the formal survey is being made; needless to say such data should be obtained with the utmost accuracy. The following is an outline, together with explanations of important data that should be obtained:

(1) ASTRONOMICAL OBSERVATIONS

Since the principle of double meridian distances is going to be used and all courses reduced to true bearings, it is necessary to make certain astronomical observations in order to determine a true meridian. This can be acc-

(1) Owing to the fact that the United States Coast and Geodetic Survey and the United States Geological Survey has established a system of rectangular coordinates of survey stations throughout the entire country, it would be more appropriate to utilize their information in arriving at a true bearing for your centerline of survey, as the accuracy of these two agencies cannot be surpassed.
by making observations on the sun for altitude and reducing this information to a true meridian on the earth’s surface. The former method is somewhat more accurate, and is generally accepted by the United States Coast and Geodetic Survey as well as the United States Geological Survey as the best method to be employed.

After a true meridian has been established it is quite simple to compute the true bearing of the centerline of your survey and subsequently to compute the true bearings and distances of your enclosure from data referred to the survey centerline.

(2) PROPERTY LINE STATIONS AND FENCE DISTANCES

All features of your area of enclosure must be accurately tied in with the centerline of survey. This includes (a) property line boundaries, and (b) existing fence line distances.

(a) Property Line Stations

Any convenient method used in determining the property line stations is permissible as long as there is an understanding between the surveyor and the computer as to the procedure employed. In order to eliminate any misunderstanding, it is always a good policy for the surveyor to actually indicate in the survey notes, distances measured and how they were measured. Figure 1 illustrates the information that should be furnished in the survey notes concerning data on a property line.
It will be noted in Figure 1 that the surveyor has

determined the stations of the north and south property
lines by aligning himself on the centerline of the survey
on a point at which the north or south property lines, if
produced, would intersect the centerline of the survey.
Distances from the centerline of the survey to property cor-
ners were measured by a perpendicular distance. The exact
reverse of the above procedure would accomplish the same
results, however, as previously stated, the method used
by the surveyor must be indicated in the field notes.

(b) Existing Fence Line Distances

Should the survey follow an existing roadway, property
lines (fence lines) will be encountered on the right and
left. If there are no predominate breaks, that is offsets amounting to more than one foot, for all general purposes it can be assumed that the existing fence lines run in straight lines from one five hundred foot station to another five hundred foot station, regardless as to how wavey the existing fence lines may appear to the naked eye.

For this reason, the survey notes should accurately indicate the existing fence line distances from the centerline of the survey at every five hundred foot station; however if there should be a predominate break in the existing fence line, note of the same should be made. From the above information, bearings and distances of five hundred feet of existing fence line can be computed. (See Figure 2.)

FIGURE 2
Bearings & Distances of Existing Fence Lines
It will be noted from Figure 2 that the bearing and distance of the existing fence line between stations 15\%00 and 20\%00 is to be computed. Knowing the perpendicular distance to the fence line at each station and the horizontal distance between each station, the functions of a right triangle with base AB can be determined and the bearing and distance of the course A to C can be computed as follows:

\[
\text{Tan of angle } \angle BAC = \frac{CB}{AB} = \frac{5.1}{500.0} = 0.0102
\]

\[
\text{Angle } \angle BAC = 0^\circ 35'.
\]

Therefore, the bearing of the course A to C would be North 24\%10' East minus 0\%35' or North 23\%35' East or South 23\%35' West. Then, too, the true length of the course A to C would be computed as follows:

\[
\text{Cos of the angle } \angle BAC = \frac{AB}{AC}
\]

\[
\text{Cos } 0^\circ 35' = \frac{500}{AC}
\]

\[
AC = \frac{500}{0.99995} = 500.02 \text{ ft.}
\]

The bearing and distance of the existing fence line between station 25\%00 and the north property line can be computed as follows:

Considering the north property line running due east and west, the angle MDH in the triangle DMH has the same value as the bearing of the centerline of the survey, that is, 24\%10', therefore the two sides, DH and MH can be computed as follows:
Tan of the angle MDH = \frac{MH}{MD}

or Tan 24° 10' = \frac{MH}{31.4}

MH = 0.44872 \times 31.4 = 14.09 \text{ ft.}

Cos of the angle MDH = \frac{DM}{DH}

or Cos 24° 10' = \frac{31.4}{DH}

DH = \frac{31.4}{0.91233} = 34.42 \text{ ft.}

Therefore, the station perpendicular from the centerline of the survey at the point where the existing fence line joins the north property line is 26 ° 80.6 - 14.09 or station 26 ° 66.51. The horizontal distance DF can now be figured by subtracting from station 26 ° 66.51, station 25 ° 00 or the distance DF = 166.51 ft.

In the triangle DEF, the angle FDE can now be computed as follows:

Tan of the angle FDE = \frac{FE}{FD} = \frac{7.1}{166.51} = 0.04264

angle FDE = 2° 27'

From this angle, the bearing of the course E to D can be figured by adding 2° 27' to the bearing of the centerline of survey, making the bearing of the course E to D equal to South 26° 37' West. The distance of the course E to D can be computed as follows:

Cos of the angle FDE = \frac{DF}{DE}

Cos of 2° 27' = \frac{166.51}{DE}

DE = \frac{166.51}{0.99909} = 166.66 \text{ ft.}
The bearing and distance of the course P to C can be computed in a similar manner as outlined above.

The bearing and distance of the course DK can be computed as follows:

In the triangle GHK, the angle GKH is 24° 10'; since there is 50 feet of right of way to be acquired, the distance GH = 50 feet.

\[ \cos \text{ of the angle GKH} = \frac{KG}{KH} \]

\[ \cos 24° 10' = \frac{50.0}{KH} \]

\[ KH = \frac{50.0}{0.91236} = 54.80 \text{ ft.} \]

The distance DH was previously figured as being 34.42 ft., the distance KD = KH - DH or 54.80 - 34.42 = 20.38 ft.

The bearing of the course KD is due east or west as previously assumed.

(3) DATA FROM TANGENTS OF CURVE

When a curve is encountered it is more advantageous to obtain all survey data in reference to tangents rather than the centerline of the curve.

At this point it should be explained that areas computed by double meridian distances are figured from straight line courses. When a curve is encountered, the bearing and distance of a chord is computed as shown by figure 4.

This involves the area of a segment shown cross hatched in figure 4, which subsequently must be added, in this case, to the computed area. A more detailed explanation of this
FIGURE 3
Survey Data Necessary on Curves

FIGURE 4
Bearing & Distance of Chord
computation will be found in Part II of thesis.

(4) INFORMATION CONCERNING ABSTRACT OF TITLE

As the survey progresses, information concerning property ownership should be obtained as thoroughly as possible.

Personal contact should be made with the people living on the property whether they be owners or tenants, in an effort to determine proper ownership. A few courteous questions asked while the survey is being made will save a considerable amount of time and expense when the titles are finally abstracted at the County Court House. Ascertain the correct section of the land involved. If there is the least doubt as to the exact property line, have it pointed out on the ground. Determine whether the property is or is not an estate, or trusteeship, the names of the heirs or other people involved. Also make an effort to determine any encumbrances, if any. As previously stated any amount of the above information obtained will always lessen the burden of the legal department making a final abstract.

(5) LOCATION OF CORNER STONES

The last data to be obtained during the survey, for the proper computation and description of rights of way, but by no means the least in importance, is the location of corner stones and properly tying them in with the center-line of the survey. One should never go more than a mile and a half in any one direction for a corner stone to reference in your area to be acquired as right of way. Figure 5 shows the data necessary concerning corner stones.
Needless to say, when corner stones are encountered along the centerline of the survey, action should be taken to have them properly reset in the event a permanent structure covers them.

Part II of this thesis, which immediately follows, outlines a method or procedure to be used in computing areas by the principal of double meridian distances. It will be noted that typical examples have been used that include the various types of surveys encountered.

(2) The names of property owners, land sections, townships, ranges and counties in the State of Illinois used herein are fictitious and are used only for demonstrative purposes.
PART II

TYPICAL EXAMPLES

EXAMPLE NO. 1
(See plat: No. 1)

FOLLOWING EXISTING ROADWAY ON TANGENT

The object is to obtain 50 feet of right of way from the James F. Smith property or to determine that area between the present fence line, which is the northerly boundary of the present roadway and a line 50 feet northerly of and parallel to the proposed centerline of improvement.

Since the reference stone is nearer the easterly property line of the land in question, the point of beginning of the area to be computed should be at the intersection of the easterly property line and the proposed northerly right of way line, as shown on Plat No. 1.

Proceeding in a clockwise direction around the area the first course to compute would be BD as shown in Figure 6.

Assuming that the easterly and westerly property lines of the land in question run due north and south and that the true bearing of the centerline of the proposed improvement is North 89° 15' East, Figure No. 6 is drawn on an exaggerated plane in order to show the corrections involved and that would not exist if the centerline ran due east and west.

The angle ABC = ADE = 0° 45' for reason of the assumptions stated above.
BC = 30.8 ft., DE = 50.0 ft.

For the Triangle ABC:

\[
\tan 0^\circ 45' = \frac{AC}{BC}
\]

\[
\frac{AC}{30.8} = 0.01309
\]

AC = 0.40 ft.

\[
\cos 0^\circ 45' = \frac{CB}{AB}
\]

\[
\frac{30.8}{AB} = 0.99991
\]

AB = 30.8 ft.

For the Triangle ADE:

\[
\tan 0^\circ 45' = \frac{AE}{DE}
\]
\[ \frac{AE}{50.0} = 0.01309 \]

\[ AE = 0.65 \text{ ft.} \]

\[ \cos 0^\circ 45' = \frac{DE}{DA} \]

\[ \frac{50.0}{DA} = 0.99991 \]

\[ DA = 50.0 \text{ ft.} \]

\[ DA - AB = BD \]

\[ 50.0 - 30.8 = 19.2 \text{ ft.} \]

Therefore, the bearing and distance of the first course, BD is South 19.2 feet.

If the distance AC = 0.40 ft. is added to station 329/81.2, the station of the intersection of the existing fence line and the easterly property line, perpendicular from the centerline is computed. That station is 329/81.60. Likewise, if the distance AE = 0.65 ft., is added to station 329/81.2, the station of the intersection of the easterly property line and the northerly right of way line, perpendicular from the centerline is computed. That station is 329/81.85.

Compute the second course, BY, as shown in Figure 6, as follows:

The horizontal distance of the course BY can now be found by subtracting station 325/00 from station 329/81.6, or the distance BX = 481.60 ft. The distance XY can be found by subtracting the distance the fence is out from the centerline at station 325/00 from the distance the fence is out from the centerline at station 329/81.6. \( XY = 1.2 \text{ ft.} \)
In the triangle BXY:

\[ \tan \angle XBY = \frac{XY}{XB} = \frac{1.2}{481.5} = 0.00249 \]

\[ \text{Angle } XBY = 0^\circ 08' \]

\[ \cos 0^\circ 08' = \frac{BX}{BY} \]

\[ \frac{481.60}{BY} = 1 \]

\[ BY = 481.60 \]

By subtracting 0°08' from the bearing of the centerline, we have the bearing of the course BY. Therefore, the bearing and distance of the second course BY is South 89°07' West, 481.60 ft.

Compute the third course GK as follows: (See Fig. 7)

For the triangle GHK:

\[ \tan \angle KGH = \frac{HK}{GH} = \frac{0.5}{500.0} = 0.00100 \]
Angle KGH = 0° 03'

\[ \cos 0° 03' = \frac{KG}{HG} \]

\[ KG = \frac{500.0}{1} = 500.0 \text{ ft.} \]

The bearing of the course GK can be found by adding 0° 03' to the bearing of the centerline 89° 15', or 89° 18'. Therefore, the bearing and distance of the third course GK is South 89° 18' West, 500.00 ft.

Compute the fourth course EG as follows: (See Figure 7)

For the triangle EFG:

\[ \tan \text{angle } GEF = \frac{FG}{FE} = \frac{3.30}{500.0} = 0.00660 \]

\[ \text{Angle } GEF = 0° 23' \]

\[ \cos 0° 23' = \frac{FE}{GE} \]

\[ GE = \frac{500.0}{0.99998} = 500.01 \text{ ft.} \]

The bearing of the course EG can be found by adding 0° 23' to the bearing of the centerline 89° 15' or 89° 38'. Therefore, the bearing and distance of the fourth course EG is South 89° 38' West, 500.01 ft.

Compute the fifth course, BE as follows: (See Figure 7)

For the triangle EDE:

\[ \tan \text{angle } BED = \frac{DB}{DE} = \frac{1.80}{500.0} = 0.00360 \]

\[ \text{Angle } BED = 0° 12' \]

\[ \cos 0° 12' = \frac{ED}{BE} \]

\[ BE = \frac{500.0}{0.99999} = 500.0 \text{ ft.} \]
The bearing of the course BE can be found by subtracting 0° 12' from the bearing of the centerline 89° 15' which is 89° 03'. Therefore the bearing and distance of the fifth course BE is South 89° 03' West, 500.0 ft.

Compute the sixth course AB as follows: (See Figure 7)

For the triangle ABC:

\[ \tan \text{angle } ABC = \frac{AC}{BC} = 0.70 \]

\[ \angle ABC = 0° 05' \]

\[ \cos 0° 05' = \frac{CB}{AB} \]

\[ AB = \frac{500.0}{1} = 500.0 \text{ ft.} \]

The bearing of the course AB can be found by subtracting 0° 05' from the bearing of the centerline 89° 15', which is 89° 10'. Therefore, the bearing and distance of the sixth course AB is South 89° 10' West, 500.0 ft.
Making similar assumptions as previously referred to, that is, assuming that the westerly property line runs due north and south and that the true bearing of the centerline of the proposed improvement is North 89° 15' East, Figure 8 is also drawn on an exaggerated plane in order to show the corrections involved and that would not exist if the centerline ran due east and west.

The angle $ABC = ADE = 0° 45'$ for reason of the assumptions stated above.

\[ BC = 30.6 \text{ ft.}; \quad DE = 50.0 \text{ ft.} \]

For the triangle $ABC$:

\[ \tan 0° 45' = \frac{AC}{BC} \]

\[ \frac{30.6}{AC} = 0.01309 \]

\[ AC = 0.40 \text{ ft.} \]

\[ \cos 0° 45' = \frac{CB}{AB} \]

\[ \frac{30.6}{AB} = 0.99991 \]

\[ AB = 30.6 \text{ ft.} \]

For the triangle $ADE$:

\[ \tan 0° 45' = \frac{AE}{DE} \]

\[ \frac{AE}{50.0} = 0.01309 \]

\[ AE = 0.65 \text{ ft.} \]

\[ \cos 0° 45' = \frac{DE}{DA} \]

\[ \frac{50.0}{DA} = 0.99991 \quad DA = 50.0 \text{ ft.} \]
DA - AB = ED

50.0 - 30.6 = 19.4 ft.

If the distance AC = 0.40 ft. is added to station 303/40.3, the station of the intersection of the existing fence line and the westerly property line, perpendicular from the centerline is computed. That station is 303/40.7. Likewise, if the distance AE = 0.65 ft. is added to station 303/40.3, the station of the intersection of the westerly property line and the northerly right of way line, perpendicular from the centerline is computed. That station is 303/40.95.

Compute the seventh course BX, Fig. 8, as follows:

The horizontal distance of the course BY can now be found by subtracting station 303/40.7 from station 305/00, or the distance BY = 159.3 ft.

The distance XY can be found by subtracting the distance the fence is out from the centerline at station 303/40.7 from the distance the fence is out from the centerline at station 305/00. XY = 0.30 ft.

In the triangle BXY:

\[
\tan \text{angle XBY} = \frac{XY}{BY} = \frac{0.30}{159.3} = 0.00188
\]

Angle XBY = 0° 06' 

\[
\cos 0° 06' = \frac{BY}{BX}
\]

\[
\frac{159.30}{BX} = 1
\]

BX = 159.30 ft.

By subtracting 0° 06' from the bearing of the centerline.
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<th>FUNCTION</th>
<th>LAT.</th>
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<th>DOUBLE</th>
<th>AREA</th>
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<td></td>
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<td>S-</td>
<td>E+</td>
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**PLATE No. 1**
we have the bearing of the course EX. Therefore, the bearing and distance of the seventh course EX is South 89° 09' West, 159.30 ft.

The bearing and distance of the eighth course BD had previously been computed and is North 19.40 ft.

Compute the ninth and last course as follows:

This last course is the proposed right of way line, 50.0 ft., northerly of and parallel to the proposed center line and extends from the westerly to easterly property lines of the tract in question.

Since it is parallel to the centerline, its bearing will be North 89° 15' East. The distance can be computed by subtracting from station 329/81.2, station 303/40.3, or subtracting from station 329/81.35, station 303/40.95. Either subtraction will give 2640.90 ft. Therefore, the bearing and distance of the ninth and last course is North 89° 15' East, 2640.90 feet.

Having computed the bearings and distances around the area under consideration, the next step is to transpose this information on a workable double meridian distance sheet as shown by Plate No. 1. It will be noted on Plate No. 1, that the courses around the area involved have been listed, starting with the most easterly bearing first; this has a significance of making all the computations under the column headed D.M.D., positive; otherwise, algebraic differences would be involved. Under the column headed function, enter the natural sine and cosine of the corresponding
bearing of each course. The departure of the course is obtained by multiplying the sine of the bearing of the course by the distance of the course; the latitude of the course is obtained by multiplying the cosine of the bearing of the course by the distance of the course. Since the bearing of the course is in a northeasterly direction, the latitude will be north or plus, and the departure will be east or plus; the latitude and departure of each succeeding course is computed as above, and providing no error has been made in your previous computations, the sum of the north latitudes should equal the sum of the south latitudes, and likewise, the sum of the east departures should equal the sum of the west departures. Otherwise your area is not properly closed. If this condition is not satisfied, it is likely that an error has been made and a check of your work should be undertaken and corrections accordingly made until the area does close.

The next step is to compute the double meridian distance of each course under the column headed D.M.D. For these values, the departures only are used. The D.M.D. of the first course is equal to the departure of the first course; the D.M.D. of the second or any subsequent course is equal to the D.M.D. of the previous course, plus the departure of the previous course, plus the departure of the course itself. The D.M.D. of the last course is equal to the departure of the last course with an opposite sign.

To obtain the double area of each course, the D.M.D.
of each course is multiplied by the latitude of that particular course, considering the signs and placing the value either under the column headed north or plus, or south or minus. The double area is then found by subtracting the sum of the lesser column from the sum of the larger column and dividing by two.

For the area concerning the James P. Smith property, 49,765 square feet is involved; this has been converted to 1.142 acres by dividing by 43,560 square feet, the number of square feet in one acre.

The following is the legal description of the area to be obtained from the James P. Smith property:

In general, the land in question may be described as being a part of the SE 1/4 of Section 3, Township 26 North Range 9 West of the 4th Principal Meridian, Warren County, State of Illinois, a more detailed description is as follows:

From a stone at the N.E. Corner of the S.W. 1/4, Section 3, Township and Range aforesaid, running thence south 2638.46 feet to centerline station 330'02.64 of proposed improvement; thence South 89° 15' West along said centerline, 21.44 feet; thence northerly along the easterly property line of the James P. Smith property 50.0 feet to the point of beginning #1.

From the point of beginning #1, running thence south 19.20 feet along the easterly property line of the James P. Smith property, to the intersection of said
easterly property line and present fence line; running thence South 89° 07' West, 481.60 feet; thence South 89° 18' West, 500.00 feet; thence South 89° 38' West, 500.01 feet; thence South 89° 03' West, 500.00 feet; thence South 89° 10' West, 500.00 feet; thence South 89° 09' West, 159.30 feet to a point which is the intersection of the present fence line and the westerly property line of the James P. Smith property, (the last six courses being along the present fence line or the southerly property line of the James P. Smith property); running thence north along the westerly property line of the James P. Smith property, 19.40 feet to a point 50.0 feet northerly and perpendicular distant from the centerline of improvement; running thence North 89° 15' East, 2640.90 feet along a line parallel to the centerline of improvement, the point of beginning #1. Containing 1.142 acres more or less.

The area to be obtained from the property of Harold S. King as shown also on Plat #1 is computed by the procedure and method as used in computing the James P. Smith area. The double meridian distance sheet (Plate #2) for the Harold S. King area is also included. It would be well for the engineer or student to completely compute each bearing and distance of every course involved for the benefit of practice. All information concerning this area is shown on Plat #1.
<table>
<thead>
<tr>
<th>Course</th>
<th>Dist.</th>
<th>Function</th>
<th>lat</th>
<th>dep</th>
<th>d.m.d.</th>
<th>Double</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>N88°30' E</td>
<td>160.20</td>
<td>5:99996</td>
<td>1.40</td>
<td>160.20</td>
<td>+ 160.20</td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>N88°31' E</td>
<td>500.00</td>
<td>5:9991</td>
<td>6.84</td>
<td>499.95</td>
<td>+ 820.35</td>
<td>5,611</td>
<td></td>
</tr>
<tr>
<td>N88°24' E</td>
<td>500.00</td>
<td>5:99995</td>
<td>5.24</td>
<td>499.97</td>
<td>+ 1820.27</td>
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<tr>
<td>N88°06' E</td>
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<td>7.90</td>
<td>499.94</td>
<td>+ 2820.18</td>
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<tr>
<td>N88°20' E</td>
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<td>5:9993</td>
<td>5.82</td>
<td>499.97</td>
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<tr>
<td>N88°19' E</td>
<td>480.20</td>
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<td></td>
</tr>
<tr>
<td>South</td>
<td>19.00</td>
<td>5:9998</td>
<td>19.00</td>
<td>499.94</td>
<td>+ 5820.40</td>
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<td></td>
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<tr>
<td>389°15' W</td>
<td>2640.40</td>
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<td>34.56</td>
<td>2640.20</td>
<td>+ 2640.20</td>
<td>91,245</td>
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</tr>
<tr>
<td>North</td>
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<td>5:9998</td>
<td>20.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>52,097 = 1.186 Acres</td>
<td></td>
<td></td>
<td>43,560</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Name: Harold S. King

Double-Meridian Distance

Plate No. 2
EXAMPLE NO. TWO
RELOCATION ON TANGENT

The object is to compute the area of a tract of land from the Glen W. Porter property, 100 feet in width, being 50.0 feet on either side of the centerline of the proposed improvement, and shown by Plate #2.

As one can readily see, this is a very simple area to compute. Assuming that the southerly and northerly property lines of the land in question run due east and west and in so far as the easterly and westerly right of way lines are parallel to the centerline of improvement, the computations would be as follows:

The length of the first course, EF, as shown in figure 9 is found by constructing the right triangle DEF, DF being
RIGHT OF WAY PROJECT
ILLINOIS STATE BOND ISSUE ROUTE 75
S.E. 1/4 SEC. 3
T. 25 N. R.3 W. 4 P.M.
STARK COUNTY
PLAT NO. 2

SCALE 1"=100'
perpendicular to the centerline of the improvement and 100.0 feet, the angle DFE being 10° 32'.

\[
\cos 10° 32' = \frac{DF}{EF} = \frac{100.0}{EF}
\]

\[
\frac{100.0}{EF} = 0.98325
\]

\[
EF = 101.71 \text{ feet}
\]

Therefore, the bearing and length of the first course EF is South, 101.71 feet.

The bearing of the second course CF, is South 10° 32' East as this line is parallel to the centerline of the improvement. The length of the course CF is found by subtracting from station 48 + 56.11, station 22 + 16.23, which is 2639.88 feet.

The bearing of the third course, AC, is the reverse of the first course EF, or due north, the distance of the course AC, is the same as the course EF, or 101.71 feet.

The bearing of the fourth course AE is the reverse of the second course, CF, or North 10° 32' West; the distance of the course AE is the same as the course CF, or 2639.88 feet.

Since the area involved concerning the property of Glen W. Porter is an exact parallelogram, it is quite unnecessary to go through the formalities of a double meridian distance computation sheet. The area can be computed by multiplying the length which is 2639.88 feet by the perpendicular width, which is 100.0 feet. This gives an area of 263,988 square feet, or 6.060 acres.

The following is the legal description of the area
to be obtained from the Glen W. Porter property:

In general, the land in question may be described as being a part of the SE 1/4 section 3, Township 25 North, Range 3 West of the 4th Principal Meridian, Stark County, State of Illinois. A more detailed description is as follows:

From a stone at the N.E. corner of the SE 1/4 section 3, township and range aforesaid, running thence west 864.32 feet to centerline station 48/87.12 of proposed improvement; thence South 10° 32' East along the centerline of proposed improvement 31.01 feet to the northerly property line of the tract in question; thence westerly along said northerly property line 50.86 feet to the point of beginning. Said point of beginning being on the northerly property line of the tract in question, 50.0 feet westerly of and perpendicular distant from the centerline of the proposed improvement.

From the point of beginning, running thence East along the northerly property line of the tract in question, 101.71 feet to a point 50.0 feet easterly of and perpendicular distant from the centerline of the proposed improvement; thence South 10° 32' East, 2639.88 feet to a point on the southerly property line of the tract in question, said point being 50.0 feet easterly of and perpendicular distant from the centerline of the proposed improvement; thence West, 101.71 feet along the southerly property line of the tract in question to a point 50.0 feet westerly of and perpendicular
distant from the centerline of the proposed improvement; thence North 10° 32' West, 2639.88 feet to the point of beginning. Containing 6.060 acres, more or less.
**EXAMPLE NO. THREE**

**RELOCATION OF TANGENT AND CURVE**

The object is to compute the area of a tract of land from the George M. Jones property, 100.0 ft. in width, being 50.0 ft. on either side of the centerline of the proposed improvement and shown by Plat No. 3.

The first course to compute is AC as shown in Figure 10, as follows:

From point "A", drop a line AB perpendicular to the centerline of proposed improvement. Assuming that the westerly property line of the tract in question runs due north and south, the angle CAB in the triangle ABC is 20° 05',

\[
\cos 20° 05' = \frac{AB}{AC} = \frac{100.0}{AC}
\]
\[
\frac{100.0}{AC} = 0.93919
\]

\[AC = 106.47 \text{ feet}\]

Therefore, the bearing and distance of the first course, AC, is North, 106.47 feet.

The bearing and distance of the second course AE is computed as follows:

First compute the station on the centerline that point "A" is perpendicular distant from. In the triangle AHF:

\[\tan 20^\circ 05' = \frac{FH}{FH} = \frac{FH}{AH} = \frac{50.0}{50.0}\]

\[FH = 0.36562\]

\[FH = 18.28 \text{ feet} = CG\]

By adding 18.28 feet to station 140/66.32 we arrive at the desired station of 140/54.6. By subtracting station 140/54.6 from station 147/74.48 (point of curvature), the distance AE has been computed. Since AE is parallel to the centerline of the improvement, the bearing and distance of the second course AE is North 69° 55' East, 719.88 feet.

It is next convenient to compute the last course, CD, before going into the curve detail.

Since \(FH = CG = 18.28 \text{ feet}\), the station on the centerline of improvement perpendicular from point C can be found by subtracting 18.28 feet from station 140/66.32, which is station 140/48.04. By subtracting station 140/48.04 from station 147/74.48 (point of curvature), the distance CD is found, which is 756.44 feet. Therefore, the bearing and distance of the last course, CD, is South
69° 55' West, 756.44 feet.

The bearing and distance of the third course XE (chord) as shown on figure 11 can be computed as follows:

In the triangle AOB, \( AB = 99.23 \) feet \((395.54 - 296.31)\)
and \( AO = 954.93 \) feet \((Radius \ of \ Curve)\)

\[
\tan \angle AOB = \frac{AB}{AO} = \frac{99.23}{954.93} = 0.10391
\]

Angle \( \angle AOB = 5^\circ 56' \)

Therefore, the angle \( \angle OEA = 180^\circ 00' - (90^\circ 00' + 5^\circ 56') \)

\[
\cos 5^\circ 56' = \frac{OA}{OB} = \frac{954.93}{OB}
\]

\[
\frac{954.93}{OB} = 0.99464
\]

\( OB = 960.08 \) feet
In the triangle OBE, the angle OBE is equal to $161^\circ 01'$
\((180^\circ 00' - 54^\circ 04')\) \text{, the side OE is 1004.93 feet}
(Radius \(\neq 50.0 \text{ feet}\) and the side OB is 960.08 feet. The
angle OEB can now be computed.

\[
\frac{OE}{\sin OBE} = \frac{OB}{\sin OEB}
\]

\[
\frac{1004.93}{\sin 161^\circ 01'} = \frac{960.08}{\sin OEB}
\]

\[
1004.93 \times \frac{960.08}{0.32529} = \sin OEB
\]

\[
\sin OEB = 0.31078
\]

\[
OEB = 18^\circ 06'
\]

Therefore, the angle BOE is equal to $180^\circ 00'$ -
\((18^\circ 06' \neq 161^\circ 01') = 0^\circ 53'$ and the angle BOX is $38^\circ 11'$(45^\circ 00' - 5^56' \neq 0^\circ 53'$).
The angle OXE = OEX = $70^\circ 56.5'$
\((180^\circ 00' - 38^\circ 11')\).
Knowing the bearing of a line perpendicular to the centerline and the angle OXE, the bearing of
the line XE (chord) can now be computed as North $89^\circ 00.5'$
East. The length of the line XE (chord) = \(2R \frac{\sin 38^\circ 11'}{2}\)

\[
XE (\text{chord}) = 2 \times 1004.93 \times \sin 19^\circ 05.5' = 657.39 \text{ feet.}
\]
Therefore, the bearing and distance of the chord XE is
North $89^\circ 00.5'$ East, 657.39 feet. XE (arc) can be computed
as follows:

First find the length of arc along the centerline which
subtends the angle $38^\circ 11'$

\[
L_1 = \frac{38^\circ 11'}{3600} \times 100 = 636.38 \text{ feet}
\]

then:
The bearing and distance of the fourth course EF can be computed as follows:

In the triangle OBE:

\[
\frac{EB}{\sin \angle EOB} = \frac{OB}{\sin \angle EOB} = \frac{960.08}{\sin 18^\circ 06'}
\]

\[
EB = \frac{960.08 \times 0.31078}{0.01542} = 47.64 \text{ feet}
\]

In the triangle OBF:

\[
\frac{OF}{\sin \angle OBF} = \frac{OB}{\sin \angle OBF} = \frac{960.08}{\sin 18^\circ 59'}
\]

\[
OF = \frac{960.08 \times 0.32529}{0.34512} = 904.93 \text{ (R - 50.0 feet)}
\]

Angle OBF = 180°00' - 161°01' = 18°59'

Therefore, the angle BOF = 180°00' - (159°48' / 18°59')

\[
BF = 2781.91 \times 0.02123 = 59.06 \text{ feet}
\]

\[
EF = EB / BF = 47.64 / 59.06 = 106.70 \text{ feet}
\]
Assuming that the easterly property line of the tract in question runs due north and south, the bearing and distance of the fourth course will be South 106.70 feet.

The bearing and distance of the fifth course FY (chord) can be computed as follows:

The angle FOY is equal to 40°17' (45°00' - [50°56' - 1°13'] = 40°17')

The angle OFY = OYF = 89°56.5' (180°00 - 40°17'). Knowing the bearing of a line perpendicular to the centerline and the angle OFY, the bearing of the line YF (chord), can now be computed as North 89°56.5' West. The length of the line YF (chord) = 2R \(\sin \frac{40°17'}{2}\).

\[ YF \text{ (chord)} = 2 \times 904.93 \times \sin 20°08.5' = 623.03 \text{ feet.} \]

Therefore, the bearing and distance of the fifth course, the chord YF is North 89°56.5' West, 623.03 feet.

YF (arc) can be computed as follows:
First find the length of arc along the centerline which subtends the angle 40°17'.

\[ L_2 = \frac{40°17'}{60°00'} \times 100 = 671.38' \]

\[ \frac{L_2}{YF \text{ (arc)}} = \frac{954.93 \text{ (R)}}{904.93 \text{ (R - 50.0)}} \]

\[ YF \text{ (arc)} = 636.22 \text{ feet} \]

The sixth and last course has previously been computed.

Having determined the bearings and distances of all the courses involved, set up your double meridian distance sheet as shown by Plate #3 and compute as previously explained.

Owing to the fact that bearings and distances along chords
<table>
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<tr>
<th>COURSE</th>
<th>DIST.</th>
<th>FUNCTION</th>
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</thead>
<tbody>
<tr>
<td>N69°55'E 719.88'</td>
<td>247.20</td>
<td>N+ 676.10</td>
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<tr>
<td>N85°00.5'E 657.39'</td>
<td>11.38</td>
<td>E+ 657.30</td>
</tr>
<tr>
<td>South 106.70</td>
<td>106.70</td>
<td>W+ 2009.50</td>
</tr>
<tr>
<td>N85°56.5'W 623.03'</td>
<td>0.65</td>
<td>N+ 623.00</td>
</tr>
<tr>
<td>S69°55'W 756.44'</td>
<td>259.80</td>
<td>E+ 710.40</td>
</tr>
<tr>
<td>North 106.47</td>
<td>106.47</td>
<td>W+ 0.00</td>
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**LAT.**

<table>
<thead>
<tr>
<th>NAME: George M. Jones</th>
<th>DOUBLE-MERIDIAN DISTANCE</th>
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<tbody>
<tr>
<td>Plate No. 3</td>
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**DEP.**

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<td>623.00</td>
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**D.M.D.**

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<td>1,329</td>
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<td>184.561</td>
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<td>191</td>
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<tr>
<td>469.109</td>
<td>191,329</td>
</tr>
<tr>
<td>277,780</td>
<td>138,890</td>
</tr>
<tr>
<td>27,492</td>
<td>166,382</td>
</tr>
</tbody>
</table>

**DOUBLE AREA**
were used, the areas of segments must be considered and added or subtracted, as the case may be, to the area as computed by the D.M.D. sheet.

The chord \( XE \) cuts through the area involved so this segment must be added. The chord \( YF \) falls beyond the area involved so this segment must be subtracted.

The computations are as follows:

The area of a segment equals

\[
\frac{\pi R^2 \Delta}{360} - \frac{R^2 \sin \Delta}{2}
\]

Area of north segment

\[
\frac{3.1416 \times 1004.93^2 \times 38.1333}{360} - \frac{1004.93^2}{2} \times 0.61818
\]

\[385,000 - 312,145\]

Area of north segment = 72,855 square feet.

Area of South segment

\[
\frac{3.1416 \times 904.93^2 \times 40.28333}{360} - \frac{904.93^2}{2} \times 0.64657
\]

\[310,100 - 264,737\]

Area of south segment = 45,363 square feet.

Therefore, the net amount of square feet 27,492 is to be added to the area computed by the D.M.D. sheet.

The following is the legal description of the area to be obtained from the George M. Jones property:

In general, the land in question may be described as being a part of the SW 1/4 of the NE 1/4 section 14 Township, 23 North, Range 8 West, 4th Principal Meridian, Marshall County, State of Illinois. A more detailed description is
as follows:

From a stone at the S.E. corner of the N.E. 1/4 of the N.E. 1/4 of section 14, township and range aforesaid, running thence south 964.38 feet to station 169/33.41 on the centerline of the proposed improvement; thence North 65°05' West, 1508.16 feet to a point on the easterly property line of the tract in question; thence north along said easterly property line, 47.64 feet to the point of beginning, said point of beginning being on the easterly property line of the tract in question 50.0 feet northeasterly of and radially distant from the centerline of the proposed improvement.

From the point of beginning, running thence south, 106.70 feet along the easterly property line of the tract in question to a point 50.0 feet southwesterly of and radially distant from the centerline of the proposed improvement; thence to the right on a curve left, parallel to the centerline curve of proposed improvement, having a radius of 904.93 feet, through an arc of 636.22 feet to a point 50.0 feet southeasterly of and perpendicular distant from centerline station 147/74.48 of proposed improvement; thence South 69°55' West, 756.44 feet to a point on the westerly property line of the tract in question, said point being 50.0 feet southeasterly of and perpendicular distant from the centerline of the proposed improvement; thence north, 106.47 feet along said westerly property line to a point 50.0 feet northwesterly of and perpendicular
distant from centerline of the proposed improvement; thence North 69°55' East, 719.88 feet to a point 50.0 feet north-westerly of and perpendicular distant from centerline station 147/74.48 of the proposed improvement; thence to the right on a curve right, parallel to the centerline curve of the proposed improvement, having a radius of 1004.93 feet, through an arc of 669.70 feet to the point of beginning, containing 3.820 acres more or less.
EXAMPLE NO. FOUR
ON: TANGENT AND CURVE, ALSO FOLLOWING OLD ROADWAY

The object is to compute the area of a tract of land from the Thomas H. Reese property which lies between the easterly boundary of the present roadway and a line 50.0 feet easterly of and parallel to the centerline of the proposed improvement, as shown by Plat No. 4.

Assuming that the northerly property line of the tract in question runs due east and west; in the triangle ACD, figure No. 12, the angle ACD is equal to 0°44'.

\[
\tan 0^\circ 44' = \frac{AD}{CD} = \frac{AD}{50.0}
\]

\[
\frac{AD}{50.0} = 0.01280
\]
AD = 0.64 feet

Subtracting 0.64 feet from station 68/44.32, the station where the easterly right of way line intersects the northerly property line is computed; this is station 68/43.68. The bearing and distance of the first course, CF, can now be determined by subtracting from station 86/50.68, station 68/43.68, which gives a distance of 1807.0 feet. Since the course CF is parallel to the centerline of the proposed improvement, its bearing would be South 0°44' West.

Using figure No. 12, it is convenient to compute the bearing and distance of the last course BC.

In the triangle ACD:

\[
\cos 0°44' = \frac{CD}{CA} = \frac{50.0}{CA}
\]

\[
50.0 = 0.99992 \cdot CA
\]

\[
CA = 50.0 \text{ feet}
\]

In the triangle ABE, the angle ABE is equal to 0°44'.

\[
\tan 0°44' = \frac{EA}{EB} = \frac{EA}{26.3}
\]

\[
\frac{26.3}{EA} = 0.01280
\]

\[
EA = 0.34 \text{ feet}
\]

\[
\cos 0°44' = \frac{BE}{EA} = \frac{26.8}{EA}
\]

\[
\frac{26.8}{EA} = 0.99992
\]

\[
EB = 26.80 \text{ feet}
\]

\[
CA - EB = CB
\]

\[
50.0 - 26.8 = 23.2 \text{ feet}
\]
Therefore, the bearing and distance of the last course CB is East, 23.20 feet.

The bearing and distance of the second course, XM (chord) may be computed as follows: (See figure No. 13)

First compute the bearing of the old fence line ZE.

In the triangle ABC:

\[ \tan 20^\circ 40' = \frac{BC}{BA} = \frac{BC}{141.0} \]

\[ \frac{BC}{141.0} = 0.37720 \]

\[ BC = 53.19 \text{ feet} \]

\[ \cos 20^\circ 40' = \frac{AB}{AC} = \frac{141.0}{AC} \]

\[ \frac{141.0}{AC} = 0.93565 \]

\[ AC = 150.70 \text{ feet} \]
BE = 65.0 feet
CE = BE - BC
CE = 65.0 - 53.19 = 11.81 feet

In the triangle CDE:
\[
\cos 20°40' = \frac{ED}{EC} = \frac{ED}{11.81}
\]
\[
\frac{ED}{11.81} = 0.93565
\]
ED = 11.05 feet

Tan 20°40' = \frac{CD}{ED} = \frac{CD}{11.05}

\frac{CD}{11.05} = 0.37720
CD = 4.17 feet
AD = AC \neq CD
AD = 150.70 \neq 4.17 = 154.87

Construct triangle ZYE with ZY parallel to back tangent of curve, then:

DY = 27.3 feet
EY = DY - DE
EY = 27.3 - 11.05
EY = 16.25 feet

In the triangle ZYE:

Tangent of the angle EZY = \frac{EY}{ZY} = \frac{16.25}{514.49} = 0.03158

Angle EZY = 1°49'

By adding the angle of 1°49' to the bearing South 0°44' West, the bearing of the old fence line ZE is computed, which is South 2°33' West or North 2°33' East.
The length of the old fence line, ZE, can also be computed as follows:

\[ \cos 1^\circ 49' = \frac{ZV}{ZE} = \frac{514.49}{ZE} \]

\[ \frac{514.49}{ZE} = 0.99950 \]

\[ ZE = 514.75 \text{ feet} \]

The distance of the old fence line at station 86/50.68 must be computed in order to proceed with the computation of the bearing and distance of the second course XM (chord). This distance can now be computed by a direct proportion.

\[ \frac{ZE}{YE} = \frac{NY}{NP} \]

\[ \frac{514.75}{16.25} = \frac{364.07}{NP} \]

\[ NP = 11.49 \text{ feet} \]

Therefore, the distance of the old fence line at station 86/50.68 is:

\[ DE \neq NP \]

\[ 11.05 \neq 11.49 = 22.54 \text{ feet} \]

From the above information, the bearing and distance of the course XM (chord) can now be computed.

Knowing the bearing of a line perpendicular to the centerline and the bearing of the old fence line ZE, the angle ABM, figure No. 14, can be determined and is 88°11'.

In the triangle ABM:

\[ AB = R \neq 22.54 \]

\[ AB = 1145.92 \neq 22.54 = 1168.46 \text{ feet} \]
The angle $\angle AMB = 77^\circ34'$

Therefore, the angle $\angle BAM = 180^\circ00' - (77^\circ34' + 88^\circ11') = 14^\circ15'$

\[
\begin{align*}
\frac{AB}{\sin \angle AMB} &= \frac{AI}{\sin \angle AEM} \\
1168.46 &= \frac{1195.92}{\sin 88^\circ11'} \\
\sin \angle AMB &= 0.97655 \\
\text{angle } \angle AMB &= 77^\circ34'
\end{align*}
\]

\[
\begin{align*}
\frac{BM}{\sin \angle BAM} &= \frac{AM}{\sin \angle ABM} \\
BM &= \frac{1195.92}{\sin 88^\circ11'} \\
BM &= 294.38 = 294.52 \text{ feet} \\
0.99950
\end{align*}
\]

The angle $\angle AXM = 180^\circ00' - \frac{14^\circ15'}{2} = 82^\circ52.5'$

$XM \text{ (chord)} = 2R \frac{\sin \frac{14^\circ15'}{2}}{2} = 296.68 \text{ feet}$
Knowing the bearing of a line perpendicular to the centerline and the angle AXM, the bearing of the course XM (chord) can be determined and is South 7°51.5' West. Therefore, the bearing and distance of the second course XM (chord) is South 7°51.5' West, 296.68 feet.

The length of XM (arc) can be computed from $L = \frac{D}{D} \times 100$

$XM_{\text{arc}} = \frac{14.25}{4.791} \times 100 = 297.43$ feet

The bearing of the third course ZM, figure 13, has previously been computed as North 2°33' East; the length of this course is BM, figure 14, plus the distance from a point opposite the point of curvature to a point opposite station 85.00.

$ZM = BM / 150.76$

$ZM = 294.52 / 150.76 = 445.28$ feet
The fourth, fifth, sixth and seventh courses are computed as previously explained and are as follows:

For the fourth course CG, figure 15:

\[
\frac{DCG}{DG} = \frac{1.1}{500.0} = 0.00220
\]

Angle DCG = 0°08'

\[
\cos 0°08' = \frac{DC}{GC} = \frac{500.0}{GC}
\]

\[
\frac{500.0}{GC} = 1
\]

CG = 500.00 feet

The bearing of the course CG is 0°44' minus 0°08' or North 0°36' East and its distance 500.0 feet.

For the fifth course BC, figure 15:

\[
\frac{FBC}{FC} = \frac{1.4}{500.0} = 0.00280
\]

Angle FBC = 0°10'

\[
\cos 0°10' = \frac{FB}{CB} = \frac{500.0}{CB}
\]

\[
\frac{500.0}{CB} = 1
\]

CB = 500.00 feet

The bearing of the course BC is 0°44' plus 0°10' or North 0°54' East and its distance 500.00 feet.

For the sixth course AB, figure 15:

\[
\frac{ABE}{AE} = \frac{2.3}{500.0} = 0.00460
\]

Angle ABE = 0°16'

\[
\cos 0°16' = \frac{BE}{BA} = \frac{500.0}{BA}
\]

\[
\frac{500.0}{BA} = 0.99999 \quad BA = 500.0 \text{ feet.}
\]
The bearing of the course AB is 0°44' minus 0°16' or North 0°28' East and its distance 500.00 feet.

For the seventh course AK, figure 15:

\[
\tan \angle HAK = \frac{HK}{HA} = \frac{1.5}{156.02} = 0.00961
\]

\[
\angle HAK = 0°33'
\]

\[
\cos 0°33' = \frac{HA}{KA} = \frac{156.02}{KA}
\]

\[
\frac{156.02}{KA} = 0.99995
\]

\[
KA = 156.02 \text{ feet}
\]

The bearing of the course AK is 0°44' plus 0°33' or North 1°17' East and its distance 156.02 feet.

The eighth and last course has previously been computed.

The double meridian distance sheet was next computed and is shown by Plate No. 4. It includes computation of segment to be added, as the chord having the bearing of South 7°51.5' West, cuts inside the curve.

The following is a legal description of the area to be obtained from the Thomas H. Reese property:

In general, the land in question may be described as being a part of the S.W. 1/4 section 4, Township 27 North, Range 3 West 4th principal meridian, Hancock County, Illinois. A more detailed description is as follows:

From a stone at the S.W. corner of the N.E. 1/4 section 9, township and range aforesaid, running thence west 1420.63 feet to centerline station 120/1231 of proposed improvement; thence North 21°24' East, 3157.24 feet; thence North 0°44'
East, 2015.30 feet; thence east 50.0 feet to the point of beginning No. 1. Said point of beginning being on the northerly property line of the tract in question add 50.0 feet easterly of and perpendicular distant from the center-line of the proposed improvement.

From the point of beginning running thence South 0°44' West, 1807.00 feet to a point 50.0 feet easterly of and perpendicular distant from centerline station 86/50.68; thence to the right on a curve right, parallel to the centerline curve of proposed improvement, having a radius of 1195.92 feet, through an arc of 297.43 feet, to a point on the easterly boundary of the present roadway; thence North 2°33' East, 445.28 feet; thence North 0°36' East, 500.00 feet; thence North 0°54' East, 500.00 feet; thence North 0°28' East, 500.00 feet; thence North 1°17' East, 156.03 feet, (the last five courses being along the easterly boundary of the present roadway) to a point on the northerly property line of the tract in question; thence east, 23.20 feet along said northerly property line to the point of beginning. Containing 2.126 acres more or less.

The area to be obtained from the Lamar H. Hunt property as shown also on Plat #4 is computed by the procedure and method as used in computing the Thomas H. Reese area. The double meridian distance sheet (Plate #5) for the Lamar H. Hunt area is also included. It would again be well for the engineer or student to completely compute each bearing and distance of every course involved for the benefit of practice.
<table>
<thead>
<tr>
<th>COURSE</th>
<th>DIST.</th>
<th>FUNCTION</th>
<th>LAT.</th>
<th>DEP.</th>
<th>D.M.D.</th>
<th>DOUBLE</th>
<th>AREA</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>N+</td>
<td>S-</td>
<td>E+</td>
<td>W-</td>
<td>N+</td>
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<tr>
<td>N2°33'E</td>
<td>445.28</td>
<td>S:04449</td>
<td>444.84</td>
<td>19.81</td>
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<td>500.00</td>
<td>S:01047</td>
<td>499.98</td>
<td>5.24</td>
<td>+44.86</td>
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<tr>
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<td>500.00</td>
<td>S:01571</td>
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<td>7.86</td>
<td>+57.96</td>
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<tr>
<td>N0°28'E</td>
<td>500.00</td>
<td>S:00814</td>
<td>500.00</td>
<td>4.07</td>
<td>+69.89</td>
<td>34,944</td>
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</tr>
<tr>
<td>N10°17'E</td>
<td>156.03</td>
<td>S:02240</td>
<td>155.99</td>
<td>3.50</td>
<td>+77.46</td>
<td>12,083</td>
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<tr>
<td></td>
<td>East</td>
<td>23.20</td>
<td></td>
<td></td>
<td></td>
<td>104.16</td>
<td>0</td>
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<tr>
<td>50°44'W</td>
<td>1807.00</td>
<td>S:01280</td>
<td>1806.86</td>
<td>23.12</td>
<td>+104.24</td>
<td>188,347</td>
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<tr>
<td>57°51'/W</td>
<td>296.68</td>
<td>S:13672</td>
<td>293.89</td>
<td>40.56</td>
<td>+40.56</td>
<td>11,920</td>
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</tr>
<tr>
<td></td>
<td>Curve</td>
<td>S:</td>
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<td>107,245</td>
<td>200,267</td>
</tr>
<tr>
<td></td>
<td>Corr.</td>
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<td>C:</td>
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<td></td>
<td>107,245</td>
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<tr>
<td></td>
<td>TTR²Δ</td>
<td>S:</td>
<td>C:</td>
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<td></td>
<td>93,022</td>
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<tr>
<td></td>
<td>ΔR²SinΔ</td>
<td>S:</td>
<td>C:</td>
<td></td>
<td></td>
<td>93,594</td>
<td></td>
</tr>
<tr>
<td></td>
<td>360°</td>
<td>S:</td>
<td>C:</td>
<td></td>
<td></td>
<td>2.149 Acres</td>
<td></td>
</tr>
<tr>
<td></td>
<td>177.920 - 177.348 = 572 a'</td>
<td>93,594</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Name: Thomas H. Reese

DOUBLE-MERIDIAN DISTANCE

PLATE NO. 4

Job:
All information concerning the area is shown on Plat #4.
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<thead>
<tr>
<th>COURSE</th>
<th>DIST.</th>
<th>FUNCTION</th>
<th>LAT.</th>
<th>DEP.</th>
<th>D.M.D.</th>
<th>DOUBLE</th>
<th>AREA</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>N+</td>
<td>S-</td>
<td>E+</td>
<td>W-</td>
<td>N+</td>
</tr>
<tr>
<td>N21°24'E</td>
<td>326.81'</td>
<td>S:36.488</td>
<td>304.27</td>
<td>119.20</td>
<td>+119.20</td>
<td>36.269</td>
<td></td>
</tr>
<tr>
<td>N11°04'E</td>
<td>393.15'</td>
<td>S:19.195</td>
<td>385.83</td>
<td>75.50</td>
<td>+313.90</td>
<td>121,112</td>
<td></td>
</tr>
<tr>
<td>N0°44'E</td>
<td>1807.86</td>
<td>S:01.280</td>
<td>1807.72</td>
<td>133.70</td>
<td>+412.50</td>
<td>745.685</td>
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<td>East</td>
<td>16.80</td>
<td>S:</td>
<td>16.80</td>
<td></td>
<td>+452.40</td>
<td>0</td>
<td>0</td>
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<tr>
<td>51°19'W</td>
<td>157.35'</td>
<td>S:02.26</td>
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<td>3.60</td>
<td>+465.60</td>
<td>73.242</td>
</tr>
<tr>
<td>50°28'W</td>
<td>500.00'</td>
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<td>499.99</td>
<td>4.10</td>
<td>+457.90</td>
<td>228,945</td>
<td></td>
</tr>
<tr>
<td>50°53'W</td>
<td>500.00'</td>
<td>S:01.54</td>
<td>499.94</td>
<td>7.70</td>
<td>+446.10</td>
<td>223,023</td>
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</tr>
<tr>
<td>50°32'W</td>
<td>500.00'</td>
<td>S:00.93</td>
<td>499.98</td>
<td>4.70</td>
<td>+433.70</td>
<td>216,841</td>
<td></td>
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<tr>
<td>50°38'W</td>
<td>493.15'</td>
<td>S:06.33</td>
<td>492.16</td>
<td>31.20</td>
<td>+397.80</td>
<td>195,781</td>
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<tr>
<td>50°46'E</td>
<td>348.41'</td>
<td>S:01.38</td>
<td>348.38</td>
<td>4.60</td>
<td>+371.20</td>
<td>129,319</td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>187.90</td>
<td>S:</td>
<td>187.90</td>
<td></td>
<td>187.90</td>
<td>129,319</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>CURVE</td>
<td></td>
<td></td>
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<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:** Lamar H. Hunt

**Double-Meridian Distance**

**PLATE NO. 5**

\[
\text{81,831} = 1.879 \text{ Acres} \quad \text{82,053} = 1.879 \text{ Acres} \\
\text{81,831} = 1.879 \text{ Acres} \quad \text{82,053} = 1.879 \text{ Acres}
\]
CONCLUSIONS

The exact location and description of property transfers cannot be overemphasized. The average engineer is prone to take the line of least resistance in computing and describing a certain area to be acquired and for this reason, the abstracting of title, in too numerous cases, is quite difficult.

The examples set forth in this thesis deal entirely with right of way acquisition in connection with railways, highways, pipe lines, power lines, etc.; however the same principles set forth herein can be used in computing the area and in describing the location of a piece of property, regardless as to what the situation may be.

The ultimate object, of course, is to arrive at some system of standardization that will not materially differ personally as well as geographically, whether it be the system used herein or some other suitable method as long as the desired results are obtained.

It is the belief of the author that the method herein employed in computing and describing certain areas to be obtained is one that will weather the critical eye of any eventuality, from a legal as well as engineering point of view.

There is no escaping the fact that the method used herein is more complicated and involved than other ordinary methods employed, and that the work must be checked and rechecked to eliminate any possible errors; however the extra work involved and time consumed is of little importance when balanced against the true and definite description and location of the
property involved.

As stated in the introduction, the method as outlined in this thesis will definitely fix points and boundaries for many generations to come.
Leon Hershkowitz was born on November 13, 1903, at Iola, Kansas, the son of Isaac M. and Hattie Hershkowitz.

His early education was received in the grade schools at Iola, Kansas, Kansas City, Missouri, and Collinsville, Oklahoma; and high schools at Tulsa and Collinsville, Oklahoma. He entered the Missouri School of Mines in September, 1922, specializing in Petroleum Chemistry. He left the School of Mines in 1926 to accept a position with the Texas Corporation in their oil refinery at Port Arthur, Texas, as a research chemist. At this time he married Helene, the daughter of Fred and Nellie Strobach of Rolla, Missouri.

He was with the Texas Corporation for a period of one year during which time he was instrumental in developing the first lubricating oil through vacuum distillation.

It was necessary for him to give up his position with the Texas Corporation and move to a different climate on account of the malarial condition that existed in Port Arthur, Texas, his wife having contracted the fever soon after their arrival.

After leaving the Texas Corporation, the depression at that period had begun and good positions were at a premium, so employment was accepted with the St. Louis and San Francisco Railway Company as a rodman. He was with the railway company for about one year when he became associated with the Department of Public Works and Buildings, Division
of Highways, State of Illinois. He was with this organization from April, 1928, to June, 1938, during which time he acted in the following capacities: Chief of Survey Party; design engineer; estimating engineer; pavement and bridge inspector; resident engineer; and for the period of 1934 to 1938, right of way engineer.

At this time, the Civilian Conservation Corps was created by the Federal Government and a request was made and received for a leave of absence from the State of Illinois to enter active service with the U.S. Army in connection with conservation work and he ultimately commanded camps at Aledo and Anawan, Illinois.

In January, 1940, he returned to the campus of the Missouri School of Mines to complete his studies, graduating in January, 1941, with a B.S. degree in Civil Engineering.

In June, 1941, he was called to active duty with the U.S. Army, Corps of Engineers in the rank of Captain and assigned to the 43rd Engineer Regiment. This organization took an active part in the Tennessee, Arkansas, and Louisiana maneuvers and after Pearl Harbor was on its way to an overseas assignment. He saw duty in Australia and New Guinea and returned to the United States in October, 1944. He was assigned to duty at Fort Leonard Wood, Missouri, for a period of approximately one year before returning to civilian life.

In January, 1946, he again entered the Missouri School of Mines for graduate work in Civil Engineering and at the same time acted as assistant in the C.E. Department.
In September, 1946, he accepted a full time position as Instructor in Civil Engineering.

In August, 1948, he received a Master of Science in Civil Engineering degree.