CONNELLY

The Relative Efficiency of Land-Surveying Methods

Civil Engineering

B. S.

1911
THE RELATIVE EFFICIENCY OF LAND-SURVEYING METHODS

BY

MARTIN FRANCIS CONNELLY

THESIS

FOR THE

DEGREE OF

BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

IN THE

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

1911
UNIVERSITY OF ILLINOIS

May 25, 1911

I recommend that the thesis prepared under my supervision by MARTIN FRANCIS CONNELLY entitled The Relative Efficiency of Land-Surveying Methods be approved as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

[Signature]
Instructor in Civil Engineering

Recommendation approved:

[Signature]
Head of the Department of Civil Engineering.
INTRODUCTION

1. TRAVERSE METHOD

DISCUSSION

EXAMPLES. FIELD NOTES. COMPUTATIONS.

2. RADIATION METHOD

DISCUSSION

EXAMPLES. FIELD NOTES. COMPUTATIONS.

3. INTERSECTION METHOD

DISCUSSION

4. CONCLUSION
INTRODUCTION.

When called upon to survey a farm, the majority of surveyors will from force of habit use the traverse method. Seldom, if ever, do they even consider the advantages to be gained, both in the field and in the office, by the use of some other method. When asked for reasons for the use of the traverse method they answer that it is the only practical one; else why would it be used in preference to all others? But does the mere fact that it is very widely, perhaps almost always, used in making farm surveys prove that it is the most efficient method? If it is not the best, what is?

The only way to furnish conclusive evidence as to the efficiency of any method is to compare it with others, employing each under practically similar conditions. With this in view two fields, one containing about 36 acres, and the other about 200 acres, were chosen and surveyed by both the traverse and radiation methods. The intersection method is not practical for farm surveying hence it is not included in this comparison, although it can be used occasionally and is more accurate than the other methods. Conclusions were based upon the time taken for each successive step for each method, the number of steps required, and the accuracy of the work.
THE RELATIVE EFFICIENCY OF LAND-SURVEYING METHODS.

When a large tract of land is to be subdivided into smaller farms, or when the area of a farm is desired the services of a surveyor are required. He may employ any number of methods to make the survey but the following are the three principal ones now used and these only will be discussed. They are:

1. The Traverse Method.
2. The Radiation Method.
3. The Intersection Method.

The traverse and radiation methods are used more often in farm surveying than the intersection method, and hence will be more fully discussed. Surveys of two fields were made by each of these methods and repeated, in order to check the accuracy of the work and the time used for the different operations. Because of the infrequent use of the intersection method, no surveys were made by it. For a small farm, however, of thirty or forty acres, where the base line is entirely within the field it is a very good method to use. The method most widely used is the traverse and it will receive first discussion.

1. TRAVERSE METHOD.

The principal method now in use for obtaining the area of a field is the Traverse method. This consists of reading the angles formed by the sides of the farm, measuring the sides and from these computing the area.
The different steps taken in this survey are: (1) driving stakes at each corner of the field, (2) making offsets, (3) setting up transit, (4) placing flagpoles at corners adjacent to set-ups, (5) reading interior angles, and (6) computing the content.

The old corners should be located if possible. If not new ones must be established by driving stakes in each corner of the field. Offsets large enough to clear any obstruction to the line of sight should be taken. The driving of stakes for these offsets take up considerable time and tends to decrease the efficiency of this method. Having established the corners and offset stakes, the transit is set up at each hub and sights taken on the flagpoles on the adjacent corners. The interior angles are read twice as a check and the mean taken as the required angles. When each side has been chained the field work is completed and the notes are ready for the office. The area is then computed by the method of latitudes and departures.

The first field under consideration is a five-sided farm of about 80 acres and typifies the average farm. The time taken for each operation, i.e., driving stakes, chaining, setting up instrument, and making computations, was taken and recorded in the field or office.

Stakes were driven at each of the five corners and suitable offsets taken as shown in Fig. 1. The poles were set up at each offset stake and the interior angles read, the mean of the two readings being taken as the required angle. Five transit stations were required, one over each offset stake. Upon the completion
**SURVEY OF FIELD BY TRAVERSE METHOD.**

**Fig. 1**

<table>
<thead>
<tr>
<th>STATION OCCUPIED</th>
<th>STATION SIGHTED</th>
<th>DOUBLE ANGLE</th>
<th>ANGLE</th>
<th>DISTANCE FEET</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>178° 22' 00&quot;</td>
<td>89° 11' 00&quot;</td>
<td>2524.2</td>
<td>March 11, 1911</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>181° 32' 00&quot;</td>
<td>90° 46' 00&quot;</td>
<td>1603.3</td>
<td>M. F. Connelly. - Inst.</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>179° 06' 00&quot;</td>
<td>89° 33' 00&quot;</td>
<td>2616.4</td>
<td>P. Kircher - Rod.</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>265° 42' 00&quot;</td>
<td>132° 51' 00&quot;</td>
<td>1507.4</td>
<td>Temp. 60°</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>275° 18' 00&quot;</td>
<td>137° 39' 00&quot;</td>
<td>139.8</td>
<td>Windy, Cloudy</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CHECK**

- 89° 11' 00"
- 90° 46' 00"
- 89° 33' 00"
- 132° 51' 00"
- 137° 39' 00"

**Total** 540° 00' 00"
of the instrument work, the sides of the field were measured, recorded, and the area computed. The time spent in the field was as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Kind of Work</th>
<th>Time of Day</th>
<th>Hours</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 3, 1911</td>
<td>Offset stakes</td>
<td>10:35-11:40</td>
<td>1-05</td>
<td></td>
</tr>
<tr>
<td>Mar. 3, 1911</td>
<td>Instrument</td>
<td>1:55-4:00</td>
<td>2-05</td>
<td></td>
</tr>
<tr>
<td>Mar. 3, 1911</td>
<td>Chaining</td>
<td>1:00-5:40</td>
<td>1-40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4hrs.-50 min.</td>
</tr>
</tbody>
</table>

The same method of procedure was used in the second survey of this field. In this case the ground had been recently plowed, which fact made the chaining more difficult. The time taken was as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Kind of Work</th>
<th>Time of Day</th>
<th>Hours</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 11, 1911</td>
<td>Offset stakes</td>
<td>10:30-11:30</td>
<td>1-00</td>
<td></td>
</tr>
<tr>
<td>Mar. 11, 1911</td>
<td>Instrument</td>
<td>1:25-3:25</td>
<td>2-00</td>
<td></td>
</tr>
<tr>
<td>Mar. 11, 1911</td>
<td>Chaining</td>
<td>3:35-5:05</td>
<td>1-40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 hrs.-40 min.</td>
</tr>
</tbody>
</table>

The second field contained about 200 acres and was surveyed in the same manner as the first one with one exception. A small knoll on the south side of the field so obstructed the line of sight as to make one additional set-up necessary. This was made on top of the knoll as shown in Fig. 2. The time taken for this survey was as follows:
FIG. 2
SURVEY OF FIELD BY TRAVERSE METHOD.

![Diagram of a survey of a field by traverse method.]

<table>
<thead>
<tr>
<th>STATION OCCUPIED</th>
<th>STATION SIGHTED</th>
<th>DOUBLE ANGLE</th>
<th>ANGLE</th>
<th>DISTANCE FEET</th>
<th>NOTES.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>193° 29'.00''</td>
<td>96° 44'.30''</td>
<td>2629.1</td>
<td>May 6, 1911</td>
</tr>
<tr>
<td>D</td>
<td>A</td>
<td>166° 33'.00''</td>
<td>83° 16'.30''</td>
<td>3146.8</td>
<td>P. Kircher Inst.</td>
</tr>
<tr>
<td>E</td>
<td>D</td>
<td>359° 06'.00''</td>
<td>179° 33'.00''</td>
<td>1605.2</td>
<td>M. F. Connelly Rod.</td>
</tr>
<tr>
<td>C</td>
<td>E</td>
<td>178° 32'.00''</td>
<td>89° 16'.00''</td>
<td>1459.5</td>
<td>Weather clear, air boiling, Temp 73°</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>182° 20'.00''</td>
<td>91° 10'.00''</td>
<td>3111.6</td>
<td></td>
</tr>
</tbody>
</table>

CHECK
96° - 44'.30''
83° - 16'.30''
179° - 33'.00''
89° - 16'.00''
91° - 10'.00''
Total 540° - 00'.00''
### COMPUTATIONS FOR AREA OF FIELD 2 (a)

[Diagram of a field]

<table>
<thead>
<tr>
<th>A-B</th>
<th>B-C</th>
<th>C-D</th>
<th>D-E</th>
<th>E-A</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing</td>
<td>Side</td>
<td>5 89°-11'E</td>
<td>3 00°-03'W</td>
<td>N 89°-30'W</td>
<td>N 42°-21'W</td>
</tr>
<tr>
<td>log.</td>
<td>3 205 015</td>
<td>3 417 704</td>
<td>3 178 228</td>
<td>3 178 228</td>
<td>3 178 228</td>
</tr>
<tr>
<td>log. Cos.</td>
<td>8 153 907</td>
<td>0 000 000</td>
<td>7 940 842</td>
<td>1 119 070</td>
<td>13 15</td>
</tr>
<tr>
<td>log. lat.</td>
<td>1 358 922</td>
<td>2 616 40</td>
<td>2 616 40</td>
<td>2 616 40</td>
<td>2 616 40</td>
</tr>
<tr>
<td>log.</td>
<td>1 358 922</td>
<td>2 616 40</td>
<td>2 616 40</td>
<td>2 616 40</td>
<td>2 616 40</td>
</tr>
<tr>
<td>log. sin</td>
<td>3 205 015</td>
<td>3 417 704</td>
<td>3 178 228</td>
<td>3 178 228</td>
<td>3 178 228</td>
</tr>
<tr>
<td>log. dep.</td>
<td>3 205 015</td>
<td>3 417 704</td>
<td>3 178 228</td>
<td>3 178 228</td>
<td>3 178 228</td>
</tr>
<tr>
<td>départure</td>
<td>1 603 14</td>
<td>2 28</td>
<td>2 28</td>
<td>2 28</td>
<td>2 28</td>
</tr>
</tbody>
</table>

**Error:**

- **A-B:** 1 46
- **B-C:** 2 78
\[
\begin{align*}
\text{1.} & \quad \log 5 = 0.698970 & \quad \log 5 = 0.698970 & \quad \log 5 = 0.698970 \\
log \text{lat.} & = 1.358972 & \quad \log \text{lat.} = 3.417704 & \quad \log \text{lat.} = 1.11070 \\
\log \text{dep.} & = 3.204971 & \quad \log \text{dep.} = 0.358551 & \quad \log \text{dep.} = 3.177211 \\
\text{Area} & = 18318 & \quad \text{Area} = 2987 & \quad \text{Area} = 9891.
\end{align*}
\]

\[
\begin{align*}
\text{2.} & \quad \log 5 = 0.698970 \\
\log \text{lat.} & = 2.014332 & \quad \log \text{lat.} = 1.11070 \\
\log \text{dep.} & = 1.974101 & \quad \log \text{dep.} = 1.974101 \\
\text{Area} & = 4869 & \quad \text{Area} = 1239 & \quad \text{Area} = 4194.457
\end{align*}
\]

\[
\begin{align*}
\text{Area} & = 1 + 2 - 3 - 5 - 6 \\
& = 18318 + 4194.457 - 9891 - 4869 - 1239 - 2987 \\
& = 4193.784 \text{ sq. ft.}
\end{align*}
\]

\[
\begin{align*}
& = 96.253 \text{ acres.}
\end{align*}
\]
<table>
<thead>
<tr>
<th>Date</th>
<th>Kind of Work</th>
<th>Time of Day</th>
<th>Hours</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 29,1911</td>
<td>Offsets</td>
<td>9:00-11:00</td>
<td>2-00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inst.</td>
<td>12:30-3:45</td>
<td>3-15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chaining</td>
<td>3:45-6:15</td>
<td>2-30</td>
<td></td>
</tr>
</tbody>
</table>

7 hrs. 45 min

The above fields are fair representations of the average farm and give an idea of the work required to get the areas by the traverse method. The principal objections to this method are that the surveyor has no check on himself until the entire survey is completed, the time taken for the numerous set-ups and the distances that must be chained. This objection increases when the field to be surveyed is of a swampy or marshy nature.
2. RADIATION METHOD.

Although not in wide use at present, the applicability of the radiation method to farm surveying renders it valuable to the surveyor. In a field of small area or where the corners are all visible from one point, only one set-up is necessary. In a long narrow field two transit-points, or three at the most, are required, showing the marked advantage of this method over any other. The chaining is greatly reduced, since only the radiating lines need to be measured. In making a survey with the radiation method the steps taken are: (1) setting corner stakes, (2) driving hubs for transit, (3) setting flag-poles at each corner, (4) reading the angles, (5) chaining distances from transit point to corners of field, and (6) computing the area.

The corner stakes are driven at each corner of the field and at such points as may be chosen for transit points. Flag-poles are set behind each corner stake, and sometimes at intermediate points in the boundary line, and a sight taken on each to obtain the angle between the lines radiating from the transit-point to the corners. The sum of the angles around each transit-point should be equal to 360°. These lines are then measured and the area of each triangle computed by the formula, \( \text{Area} = \frac{1}{2} bc \sin A \).

When two transit-points are required, flag-poles may be placed in each corner of the field and at points in the boundary lines, can readily be seen from the transit-point as shown in Fig. 3.
In case point 2 can not be seen from 1, flag-poles are placed at points B and E, in the boundary lines of the field. With the transit set over 1, the angles about that transit-point and the lines, A-1, B-1, E-1, and F-1 are measured. This operation is repeated using 2, as a transit-point. The entire area is then computed. Or in case 2 can be seen from 1, flag-poles are placed at A, 1, and F, and the angles around 1, measured. With 2 as a transit point and flags at 1, G, and D this operation is repeated so as to obtain the angles around 2. The only lines required to be measured are A-1, F-1, 1-2, 2-C, and 2-D. This greatly reduces the chaining and makes the accuracy of the survey dependent upon the angular measurements. Since the transit man has a check upon the angles around any point, and since angular measurement is more accurate than linear measurement, greater accuracy may be obtained with the radiation method than with the traverse method.

For sake of comparison, the same fields were taken, as were used for the traverse method. The first, a five-sided field of about 80 acres was surveyed under conditions similar to those existing at the time the traverse was made. Two positions for
transit-points were chosen as shown in Fig. 4. Stakes were driven at each of these positions and at each corner of the field. With the transit at the north transit-point and flag poles at the north corners of the field and at the south hub, sights were taken to obtain the angles between the lines radiating from the transit-points to the flag-poles. Three readings were recorded and the mean was taken as the required angle. The distances to the flag-poles having been measured, the transit was removed to the next transit-point. Flag-poles were set at the hub just vacated and at the remaining corners and the angles and lines measured as before. The area of the entire field was then computed. The time taken was as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Kind of Work</th>
<th>Time of Day</th>
<th>Hours</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 25, 1911</td>
<td>Driving stakes and Setting flag-poles</td>
<td>10:30-11:45</td>
<td>1-15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrument</td>
<td>12:30-2:00</td>
<td>1-30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chaining</td>
<td>2:00-3:00</td>
<td>1-00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 hrs.-45 min</td>
</tr>
</tbody>
</table>

The same field was used for the second survey in order to obtain a check on the first. The time taken was as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Kind of Work</th>
<th>Time of Day</th>
<th>Hours</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 31, 1911</td>
<td>Driving Stakes etc.</td>
<td>9:30-10:35</td>
<td>1-05</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrument</td>
<td>10:35-12:00</td>
<td>1-25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chaining</td>
<td>1:15-2:25</td>
<td>1-10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 hrs.-40 min</td>
</tr>
</tbody>
</table>
### Fig. 4

**Survey of Field by Radiation Method**

<table>
<thead>
<tr>
<th>Station Occupied</th>
<th>Station Sighted</th>
<th>Triple Angle</th>
<th>Angle</th>
<th>Distance Feet</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>313°-21'-00&quot;</td>
<td>104°-27'-00&quot;</td>
<td>1155.0</td>
<td>March 25 1911</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>33°-13'-00&quot;</td>
<td>10°-06'-00&quot;</td>
<td>721.9</td>
<td>M. F. Connelly - Inst.</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>335°-09'-00&quot;</td>
<td>131°-43'-00&quot;</td>
<td>723.1</td>
<td>P. Kircher - Rod</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>338°-18'-00&quot;</td>
<td>112°-44'-00&quot;</td>
<td>2047.9</td>
<td>Weather clear and windy. Temp. 60°</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>520°-33'-00&quot;</td>
<td>173°-31'-00&quot;</td>
<td>776.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>243°-00'-00&quot;</td>
<td>97°-40'-00&quot;</td>
<td>829.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>266°-27'-00&quot;</td>
<td>88°-44'-00&quot;</td>
<td>2047.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>360°-00'-00&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
COMPUTATIONS FOR AREA OF FIELD 2(b)

\[ \text{Area} = \frac{1}{2} bc \sin A \]

\[
\begin{align*}
\text{Delta CID} & \quad \log \frac{1}{2} = 9.69897 - 10 \\
& \quad \log 721.9 = 2.85848 \\
& \quad \log \sin 104^\circ 27' = 9.98064 - 10 \\
& \quad \log \text{area} = 5.60607 \\
\end{align*}
\]

\[
\begin{align*}
\text{Area} &= 403,710 \text{ sq. ft.} \\
\end{align*}
\]

\[
\begin{align*}
\text{Delta DIE} & \quad \log \frac{1}{2} = 9.69897 - 10 \\
& \quad \log 721.9 = 2.85848 \\
& \quad \log \sin 102^\circ 06' = 9.24395 - 10 \\
& \quad \log \text{area} = 4.66060 \\
\end{align*}
\]

\[
\begin{align*}
\text{Area} &= 46,772 \text{ sq. ft.} \\
\end{align*}
\]

\[
\begin{align*}
\text{Delta IRA} & \quad \log \frac{1}{2} = 9.69897 - 10 \\
& \quad \log 776.4 = 2.89009 \\
& \quad \log \sin 88^\circ 49' = 9.99999 - 10 \\
& \quad \log \text{area} = 5.90028 \\
\end{align*}
\]

\[
\begin{align*}
\text{Area} &= 794,840 \text{ sq. ft.} \\
\end{align*}
\]

\[
\begin{align*}
\text{Delta ARB} & \quad \log \frac{1}{2} = 9.69897 - 10 \\
& \quad \log 776.4 = 2.89009 \\
& \quad \log \sin 173^\circ 31' = 9.05275 - 10 \\
& \quad \log \text{area} = 4.56068 \\
\end{align*}
\]

\[
\begin{align*}
\text{Area} &= 36,365 \text{ sq. ft.} \\
\end{align*}
\]

\[
\begin{align*}
\text{Delta IRB} & \quad \log \frac{1}{2} = 9.69897 - 10 \\
& \quad \log 829.6 = 2.91887 \\
\end{align*}
\]

\[
\begin{align*}
\text{Area} &= 841,880 \text{ sq. ft.} \\
\end{align*}
\]
\[ IB = \overline{2047.9} + \overline{829.6} = 2 \times 2047.9 \times 829.6 \times \cos 97^\circ - 40' - 00'' \]
\[ IB = 2310.6 \text{ ft} \]
\[ \sin 97^\circ - 40' : 2310.6 :: \sin BIR : 829.6 \]
\[ \angle BIR = 21^\circ - 12' \]
\[ \angle CIB = (112^\circ - 44') - (21^\circ - 12') = 91^\circ - 32' - 00'' \]
\[ \log \frac{1}{2} = 9.69897 - 10 \]
\[ \log 1155 = 3.06258 \]
\[ \triangle CIB \]
\[ \log 2310.6 = 3.36373 \]
\[ \log \sin 91^\circ - 32' = 9.99985 - 10 \]
\[ \log \text{area} = 6.12513 \]
\[ \text{Area} = 1,333,900 \text{ sq ft} \]
\[ IA = \overline{2047.9} + \overline{776.4} - 2 \times 2047.9 \times 776.4 \times \cos 88^\circ - 43' \]
\[ IA = 2182.6 \text{ ft} \]
\[ \sin 88^\circ - 43' : 2182.6 :: \sin A12 : 776.4 \]
\[ \angle A12 = 20^\circ - 50' - 00'' \]
\[ E1A = (131^\circ - 43') - (20^\circ - 50') = 110^\circ - 53' - 00'' \]
\[ \log \frac{1}{2} = 9.69897 - 10 \]
\[ \log 723.1 = 2.85920 \]
\[ \triangle E1A \]
\[ \log 2182.6 = 3.33398 \]
\[ \log \sin 110^\circ - 53' = 9.97049 - 10 \]
\[ \log \text{area} = 5.86764 \]
\[ \text{Area} = 737,300 \text{ sq ft} \]
\[ \text{Total area} = 4,193,767 \text{ sq ft} \]
\[ = 96.276 \text{ acres} \]
On making the third survey, a 200 acre field was chosen. The same method was used as in the previous surveys with the exception that the set-ups were taken on a line joining the north and south corners as shown in Fig. 5. The time for this survey was as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Kind of Work</th>
<th>Time of Day</th>
<th>Hours</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr. 22, 1911</td>
<td>Driving stakes etc.</td>
<td>8:30-9:05</td>
<td>1-35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrument</td>
<td>9:05-11:40</td>
<td>2-35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chaining</td>
<td>1:15-3:10</td>
<td>1-55</td>
<td></td>
</tr>
</tbody>
</table>

6 hrs.-5 min

A comparison of the time taken in these surveys with those of the traverse method will clearly show the advantages of the radiation method. In case of any error in reading the angles about any transit-point it can be detected immediately since the sum should equal 360°. The distance to be chained was very much less and consequently much time was saved with smaller chances for error. Only two set-ups were required, whereas with the traverse method five were necessary in all cases. In the survey of marshy ground this method is superior to any other since the area can be obtained without entering the field. In hilly country one set-up on a prominent hill would be all that would be required for the survey. The advantages of this method are therefore:— (1) minimum number of set-ups, (2) minimum amount of chaining, and (3) work readily checked as it progresses. Stadia readings should always be taken when using the radiation method, as a check on the measured distances.
### FIG. 5
SURVEY OF FIELD BY RADIATION METHOD

<table>
<thead>
<tr>
<th>STATION OCCUPIED</th>
<th>STATION SIGHTED</th>
<th>TRIPLE ANGLE</th>
<th>ANGLE</th>
<th>DISTANCE FEET</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>B</td>
<td>272°-00'-00&quot;</td>
<td>40°-40'-00&quot;</td>
<td>3126.5</td>
<td>April 22, 1911</td>
</tr>
<tr>
<td>E</td>
<td>D</td>
<td>442°-00'-00&quot;</td>
<td>180°-40'-00&quot;</td>
<td>1167.2</td>
<td>M.F. Connelly - Inst.</td>
</tr>
<tr>
<td>E</td>
<td>F</td>
<td>266°-00'-00&quot;</td>
<td>88°-40'-00&quot;</td>
<td>1461.8</td>
<td>P. Kircher - Rod.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>360°-00'-00&quot;</td>
<td>Weather - clear and cool. Temp. 65°</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>266°-09'-00&quot;</td>
<td>88°-43'-00&quot;</td>
<td>1604.1</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>E</td>
<td>273°-45'-00&quot;</td>
<td>91°-15'-00&quot;</td>
<td>3126.5</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>540°-06'-00&quot;</td>
<td>180°-02'-00&quot;</td>
<td>1458.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>360°-00'-00&quot;</td>
<td></td>
</tr>
</tbody>
</table>
3. **INTERSECTION METHOD.**

The intersection method is seldom if ever used in farm surveying. It consists of measuring-off a base line of convenient length, inside or outside of the field, and reading the angles formed by lines radiating from each end of the base line to the corners of the field. The base line must be chosen so as to have all corners of the field visible from its ends. The successive steps taken up in this survey are: (1) driving stakes at each corner of the field at both ends of the base line, (2) measuring the angles, (3) measuring the base line, and (4) computing the content. This is the most accurate of all methods of farm surveying and it should be used when possible. The principal disadvantages of the intersection method are (1) the inability to obtain a line, in the survey of the average field, from each end of which all cornorners of the field can be seen, (2) the error that is produced by a slight inaccuracy in the measurement of the base line, and (3) the angles should not be less than $50^\circ$ nor more than $120^\circ$ for accurate work.
### TABLE I
Results of Surveys by Radiation and Traverse Methods.

<table>
<thead>
<tr>
<th>No. of Survey</th>
<th>Method Used</th>
<th>Distance Chained in Ft</th>
<th>No. of Setups Required</th>
<th>Total Time for Survey</th>
<th>AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Square Ft.</td>
<td>Acres</td>
</tr>
<tr>
<td>1a.</td>
<td>Traverse</td>
<td>8392.0</td>
<td>5</td>
<td>4 hrs. - 45 min.</td>
<td>4,194,743</td>
</tr>
<tr>
<td>1 b.</td>
<td>Radiation</td>
<td>6275.0</td>
<td>2</td>
<td>3 hrs. - 45 min.</td>
<td>4,193,865</td>
</tr>
<tr>
<td>2a.</td>
<td>Traverse</td>
<td>8391.15</td>
<td>5</td>
<td>4 hrs. - 40 min.</td>
<td>4,193,784</td>
</tr>
<tr>
<td>2 b.</td>
<td>Radiation</td>
<td>6253.9</td>
<td>2</td>
<td>3 hrs. - 40 min.</td>
<td>4,193,767</td>
</tr>
<tr>
<td>3a.</td>
<td>Traverse</td>
<td>11950.2</td>
<td>5</td>
<td>7 hrs. - 45 min.</td>
<td>9,694,270</td>
</tr>
<tr>
<td>3 b.</td>
<td>Radiation</td>
<td>8818.3</td>
<td>2</td>
<td>6 hrs. - 05 min.</td>
<td>9,695,320</td>
</tr>
<tr>
<td>4a.</td>
<td>Traverse</td>
<td>11952.0</td>
<td>5</td>
<td>7 hrs. - 30 min.</td>
<td>9,693,429</td>
</tr>
<tr>
<td>4 b.</td>
<td>Radiation</td>
<td>8800.4</td>
<td>2</td>
<td>5 hrs. - 55 min.</td>
<td>9,694,509</td>
</tr>
</tbody>
</table>

**Conclusion.**

The results of the several surveys, as shown in the above table, show conclusively that the radiation method although not extensively used at present is a time saver as compared with the traverse method. It is a very difficult matter to convince surveyors that the traverse method is not the best or that there is any method as good as it. They are loath to give it up or to experiment with any other method. In the earliest stages of farm surveying, when surveys were made with the compass, the traverse method was undoubt-ly the best. But now that we have much more accurate instrument to measure angles and lengths of lines, why should the old method, used when farm surveying was in its infancy, be still employed to the exclusions of all other methods?

In making a survey, the surveyor plans to obtain the most accurate results with as little time in the field as is possible. Expenses in the field, occasioned by the services of rodmen and axemen amount to considerable and make a decided inroad upon the profits of the work. Therefore it is more in the surveyor's pocket to use the method that will give accurate results and that requires the least time in the field.
With the traverse method as shown by Table 1, more transit points must be taken. In the fields under discussions the number of stations required by the radiation method was but 40% of that required by the traverse method. The distances that were measured in the radiation method were about 75% as great as those required for the traverse method. This reduces the time spent in the field from 20% to 25% and increases the profits of the surveyor proportionally.

The radiation method requires more office work, but the saving in the field work more than compensates for this. As only one man is required to compute the area of the field, the increased expenditure of money is little.

Angular measurement is more accurate than linear measurement, therefore the radiation method is more accurate than the traverse method. The angles in the radiation method can be checked at any station before the transit is removed, but in the traverse method any error at a transit-point can not be detected until the entire survey has been finished.

In the traverse method the error of closure will show the accuracy of the work and check any blunder made in chaining. This is the principal advantage to be gained in using the traverse method, but even this becomes of minor importance if stadia readings are taken after each line has been measured in the radiation method. The errors due to chaining are: (1) omitting of entire chain length, and (2) reading the wrong fraction of a chain length at the end of the line, and these errors may be eliminated by taking stadia readings.
From the above results the writer's conclusion is, that the radiation method of farm surveying is just as efficient as the traverse method. It is the most profitable method to use because it requires less time and fewer men than the traverse method.