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THESIS
TRIANGULATION OF
THE MICHIGAN
AGRICULTURAL COLLEGE
CAMPUS

E. S. Anderson W. E. Frazier
1920

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THESIS

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SUPPLEMENTARY
MATERIAL
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TRIANGULATION OF
THE MICHIGAN AGRICULTURAL COLLEGE CAMPUS

A Thesis Submitted to
The Faculty of
MICHIGAN AGRICULTURAL COLLEGE

By

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Candidates for the Degree of

Bachelor of Science

June, 1920

THESIS

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INTRODUCTION.

Geodesy is that branch of science which treats of making extended measurements on the surface of the earth. Primarily the object of this work is to locate controlling points for extensive surveys.

This thesis deals with the extension of the triangulation of the M. A. C. Campus and the connection of this triangulation system on the campus to the system which covers the M. A. C. Farm (as shown in map*).

All measurements are subject to more or less unknown and unavoidable sources of error. Repeated measurements of the same quantity can not be made to agree precisely. Some method of adjustment was therefore necessary which assigned the most probable values to the unknown quantities in view of all the measurements that had been taken and the conditions which were to be satisfied.

Such adjustments were made by the Rigorous Method, which is explained under the head of "Triangulation Adjustments and Computation" on a later page.

*See blue prints in Appendix.

1. Enlarged triangulation system. Scale 1" = 200'.
 2. Sketch showing location of triangulation system.
-

APPARATUS USED.

A. Instruments:

- a. Transit (repeating instrument reading to 30").
- b. Theodolite (repeating transit).
- c. Direction instrument.
- d. Dumpy level; (used in preliminary survey of base line).

B. Flags.

C. Stakes, etc.

D. Stations.

E. Tapes: 200' and standard.

(See next page for pictures of Instruments.)



1. Flag.



2. Theodolite Repeating
Instrument.



3. Theodolite Direction
Instrument.



4. Repeating Transit.

PRINCIPLES OF THE TRIANGULATION.

The word "Triangulation" as used in Geodeic surveying includes all those operations required to determine either the relative or the absolute positions of different points on the surface of the earth, and such operations are based on the properties of plane and spherical triangles. (Correction for spherical excess was not necessary in this case.)

For the triangulation suitable points, called stations, were selected and marked throughout the area to be covered, the selection of these stations depended upon the character of the landscape and also the object of the survey. The stations thus selected were regarded as forming the vertices of a set of mutually connected triangles, the complete figure being called a triangulation system. At least one side and all the angles in the system were measured, using utmost care. All the remaining sides were obtained by computations of the successive triangles.

The stations forming the triangulation system are called triangulation stations, and are namely: 4, 8, 24, 25, Ag. Bldg., Engin. Bldg., N. Base, and For.

A map of the system is shown on Plate II. The system is made up of the quadrilateral 4, 8, 24, and 25, quadrilateral 24, 25, Ag. Bldg., and Engin. Bldg., and quadrilateral Engin. Bldg., Ag. Bldg., N. Base and For., making three quadrilaterals in all.

The preliminary work of examining the campus for the proposed survey was the reconnaissance. As much information as

possible was obtained from existing map, and then an examination of the campus helped to locate the relative positions of the probable station points.

This part of the work called for the greatest care and judgement, as it practically controlled the accuracy of the survey. Every effort was therefore made to secure the best arrangement of the stations. The base line is usually much smaller than the principal lines of the triangulation system, and therefore required a specially favorable location in order that its length might be accurately determined. A gently sloping ground, not over four per cent, is suitable for a base line. The line from stations 4 to 8 was used as a base line.

In this system of triangulation four of the old stations were used, namely, For., North Base, 4 and 8. To connect up the two systems, stations 24, 25, Engin., and Ag. Bldg., were used as intermediate stations.

For a matter of formality we will call the system on the campus System No. 1, and the system of triangulation on the farm System No. 2.

Two of the stations, namely, Engin. Bldg., and Ag. Bldg. could be seen from System No. 2, but not from System No. 1, so stations 24 and 25 were placed as intermediates, so that stations Ag. Bldg., and Engin. Bldg., and also 4 and 8 could be seen from stations 24 and 25. Stations 4, 8, 24, and 25 form Quadrilateral No. 1; 24, 25, Engin. Bldg., and Ag. Bldg. form Quadrilateral No. 2; and Ag. Bldg., Engin. Bldg., For., and N. Base form Quadrilateral No. 3. The intervisibility of any two stations was finally determined by observations from

each station. Also each station angle was measured with a small compass mounted on a tripod to see if angles were of a reasonable magnitude.

The triangulation system required permanent stations so at stations 24 and 25 concrete posts 6" x 6" x 36" with an iron center were placed six inches under the sod. A brass plate was screwed in the roof of the Agricultural Building and was used as station Ag. Bldg. A brass plug was cemented in the roof of the Engineering Building and was used as station Engin. Building.

BASE LINE MEASUREMENT.

The line between stations 4 and 8 was used as the base line. A preliminary survey was made of the line and it was found that the ground was quite level. Starting at station 8 we computed the elevation so that no part of the tape when used would touch the ground. Four foot 2" x 2" stations were driven firmly in the ground at every fifty feet and a nail placed at right elevations. Every 200' a 2" x 4" was driven down flush with the right elevation and a brass strip was nailed on top, one of its edges on line between 4 and 8. These stations were made in this way to record the length while measuring the base line. Over station 8, it was necessary to build a station which would be directly over the original station but also at the same elevation as that of the rest of the line. This was accomplished by driving a couple of 2" x 4" pieces

in on each side of the station, and placing another across the tops of the two vertical ones. A hole was bored in the cross-piece over the station, a strip of brass nailed over one-half of the hole, and then by means of a plumb the station was plumbed up and a notch made on the edge of the brass directly over the original station. The tape used was a 200' wire tape. Corrections were made for absolute length, sag and temperature.

The amount of sag was taken care of by standardizing the tape at the time of measuring and on the same ground. In order to do this a comparator was built, which consisted of a stretch of boards on a level piece of ground and two points, at a permanent and well determined distance of 100' apart, were fixed. Each of these points were raised as was station 8, and a stake similar to the stakes in the course was set at the midway point. Thus the tape could be compared with the 100' length on the ground (which was laid off with a standard tape) in the same supported way in which the base line was measured. The difference was noted so that the correction could afterwards be applied.

For measuring the base line the same tape was used. The tape was stretched along the course, the rear end was fastened to a straining stake a few feet back of the rear station. The front end was connected with a spring balance for giving the desired pull of 15 lbs. The strain at this end was also resisted by a suitable stake beyond the forward stake. In this way no strain was allowed to come on any of the stakes. The two-by-fours at the 200' marks being set with sufficient care,

the end of the tape came on the strip of brass. The strip of brass had been placed on top of the two-by-four. A scratch had been made on the strip of brass and the distance between this scratch and the end of the tape was measured with a pair of dividers, note being made of the distance and whether plus or minus. Four measurements were made of the base line and the average taken. For each reading of the tape the temperature was also read.

In measuring the base line the temperature varied more or less during the progress of the work but as a rule it has been found satisfactory to apply a correction due to the average temperature. The length was corrected to a temperature of 62° F.

The accuracy possible in the determination of the length of the base line depends upon the precision with which the various constants of the measuring apparatus have been obtained and the precision with which the field work is done. The precision of the measurement was judged by making four measurements and then the arithmetic mean was used.

MEASUREMENT OF ANGLES.

The measurement of angles was done mostly on afternoons and in cloudy weather. Due to some disadvantages, and to the location of two of our stations it was impossible to use the larger instruments; however, a high grade transit was used and great care was used in placing flags and setting up of the

instrument and in reading of angles. The angles where possible were checked with the larger instrument.

Two theodolites were used in checking the angles; the readings of the direction instrument were not used. These types are used for fine angle work and are considered the best. The readings which were used in the computations were made with a surveyor's transit reading to 30". Each angle was measured six times direct and six times inverted. The angles were also measured with B. and L. Theodolite S. T. T. 3.

(See next page for Sample of Notes.)

After the angles had been measured a horizontal correction was necessary which was the dividing up of the error, and adding or subtracting to each angle the allotted amount, the addition being made when the angles failed to make 360° and the subtraction when over 360° (see sample of notes).

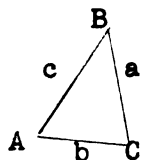
The three angles of a triangle, in like manner, should add up to 180° , and the interior angles of a quad should add up to 360° . It was necessary, therefore, to satisfy these geometrical conditions. This was done by means of the "Rigorous Method", which is a system worked out and which satisfies all of these conditions. (See any text on Geodesic Surveying.)

After the system was satisfactorily adjusted, the distance between the various stations were computed. This consisted in solving each triangle in order, as a plane triangle, by the ordinary sine ratio. In case of the quadrilaterals the two diagonals and the sides adjacent to the known side were computed from the triangles involving the base; the side opposite the base was then computed from both the triangles in which it

Left Hand Page.				Right Hand Page.			
Sta. For.	Time & No.	Tel. D.or R.	Ver. A.	Ver. B.	Mean Angle.	Reptd Angle	Correction for H. Closure.
SAMPLE OF NOTES.							
Eng. to Ag.	0 1 6 6	D D D R	00" 17°4'30" 102 29 30 0 00 00	00" 29'00" 29 00 00 00	0°00'00" 102 29 15.0 0 00 00.0	102°29'15" 102 29 15.0	17°4'52" 17 4 52.5 <u>17 4 52.5</u> 17 4 54.3
Ag. to N. Base	0 1 6 6	D D D R	00" 66°19'30" 38 0 0 0 0 0	00" 19'30" 37°59'30" 359 59 30	0°00'00" 37 59 45.0 359 59 45.0	37°59'45" 38 0 0.0	66°19'57" 66 20 0.0 <u>66 19 58.8</u> 66 20 0.3
N. Base to Eng.	0 1 6	D D D	00" 276 34 30 219 30 0	00" 29 30	0°00'00" 219 29 45.0 359 58 45.0	219°29'45" 219 31 0.0	276°34'57.5" 276 35 10.0 <u>276 35 3.8</u> 276 35 5.4

at For.
 Eng. to Ag. 17°04'54".3
 Ag. to N. Base 66 20 00.3
 N. Base to Eng.
276 35 05.4
 359 59 60.0
 360 00 0.0

occurred. These two values were exactly the same showing what no mistake was evident.



Given A, B, a.

$$c = \frac{a \sin (A + B)}{\sin A}$$

$$b = \frac{a \sin B}{\sin A}$$

SINE RATIO used in
solving of triangles.

RESULTS.

In checking up our results with that of a previous survey we found that we were three-tenths of a foot off on line For. and N. Base. Our result was 1511. and the previous survey result was 1511.871. In order to come as close as possible to the average result of the two surveys we added one-fourth of the difference for Quad. No. 1; the average of the two results was taken for Quad. No. 2, and three-fourths of the difference was added for Quad. No. 3, using lines 4 to 8 the same as measured and N. Base to For. the same as previous result.

APPENDIX.

Computations.

QUAD. NO. 1,

2.7443681	log sin 555.096 (4 to 8)
9.7161248	
<u>12.4604929</u>	
9.9996921	
<u>2.4608008</u>	+ 208 (1/4 diff.) = 2.4608216
9.7949653	(line 4 to 24 = 288'.949)
<u>12.2557661</u>	
9.6437957	
<u>2.6119704</u>	log of 24 to 25.

2.7443681	
9.5778567	
<u>12.3222248</u>	
9.9709621	
<u>2.3512627</u>	+ 208 = log of 8 to 25 = 2.3512835
9.9243176	8 to 25 = 224!534
<u>12.2755803</u>	
9.6636105	
<u>2.6119698</u>	log of 24 to 25.

2.6119704	one way
2.6119698	other way
<u>2.6119701</u>	average log
417	average difference
<u>2.6120118</u>	log 24 to 25

24 to 25 = 409.279 ft.

QUAD. NO. 2.

$$\begin{array}{r}
 2.6119701 \\
 9.6823680 \\
 \hline
 12.2943381 \\
 9.3950854 \\
 \hline
 2.8992527 + 417 = \log 25 \text{ to Ag.} = 2.8992944 \\
 9.8475813 \quad \text{dist.25 to Ag.} = 793.039 \\
 \hline
 12.7468340 \\
 9.9744135 \\
 \hline
 2.7724205 = \log \text{ Ag. to Eng.} \\
 + 417 = 2.7724623
 \end{array}$$

$$\begin{array}{r}
 2.6119701 \\
 9.9997075 \\
 \hline
 12.6116776 \\
 9.6687791 \\
 \hline
 2.9428985 + 417 = \log 24 \text{ to Eng.} = 2.9429402 \\
 9.7159534 \quad \text{dist.24 to Eng.} = 876.880 \\
 \hline
 12.6588519 \\
 9.8864315 \\
 \hline
 2.7724204 \text{ checks } \log \text{ Ag. to Eng.} \\
 + 417 = 2.7724622
 \end{array}$$

Dist. = 592.192 Ag. to Eng.

QUAD. No. 3.

2.7724205	
<u>9.9729875</u>	
12.7454080	
<u>9.5028001</u>	
3.2426079	+ 625 (3/4 of Diff.) = 3.2426704
<u>9.8986549</u>	(Ag. to N. Base Dist.) = 1748.559
13.1412628	
<u>9.9618499</u>	
<u>3.1794129</u>	

2.7724203	
<u>9.7996196</u>	
15.5720401	
<u>9.4679719</u>	
3.1050682	+ 625 = log Eng. to For. = 2.1050707
<u>9.9070570</u>	Distance = 1273.715
13.0111252	
<u>9.8317125</u>	
<u>3.1794127</u>	Use average = 3.1794128
	834 Whole diff.
	<u>3.1794962</u>

Dist. = 1511.871 The same as in previous survey.

TABULATION OF RESULTS

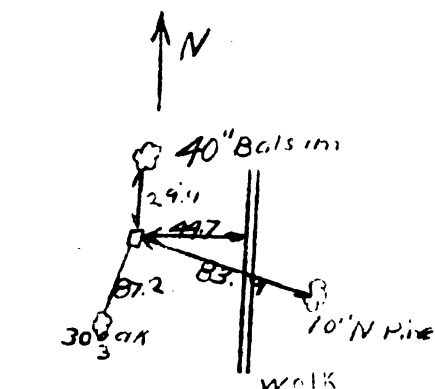
Point	x	"	y	Azm to	Azimuth	Distance	Log
Sta. 1.	0		0	4	284°49'22.7"	445.235	2.6485864
4.	+430.415	-114.168		8	281 56 40.0	555.096	2.7443681
				24	342 45 35.80	288.949	2.4608216
8.	+973.500	-229.052		25	13 27 16.20	224.534	2.3512835
24.	+515.053	-447.424		25	278 02 53.40	409.279	2.6120118
				Engin.	338. 08 35.77	876.880	2.9429402
25.	+920.202	-390.135		Ag.	321 11 44.33	793 .039	2.8992944
Engin.	+841.511	-1203.984		Ag.	256 28 13.92	592.192	2.7724622
				For.	20 18 29.09	1273.715	3.1050707
Ag.	+1417.169	-1065.431		N.Base.	345 01 47.12	1748.559	3.2426704
For.	+399.547	-2398.512		N.Base.	283 43 29.55	1511.871	3.1794962
N.Base.	+1868.123	-2754.619					

0.0 point is taken at Station 1 as shown on Plate II

DESCRIPTION OF STATIONS.

Sta. 25

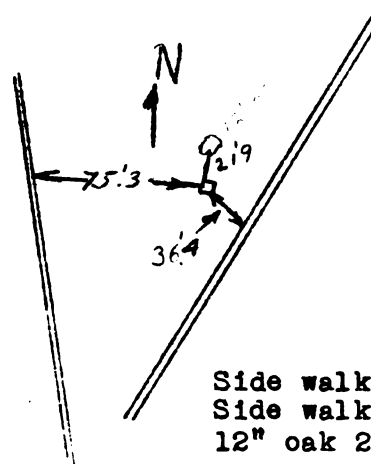
Center of iron rod.



Walk 44.7E
30" oak 87!2 S 15° W
10" N. Pine 83!2 E.
40" Balsam 29!9 N.

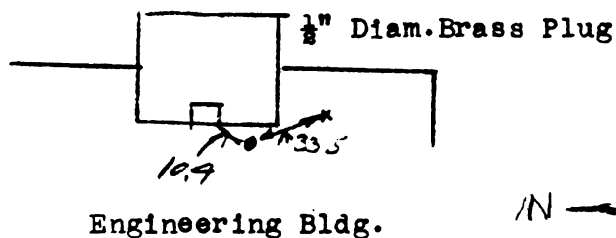
Sta. 27

Center of iron rod



Side walk 36!4 N
Side walk 75!3 W
12" oak 21!9 N.

Sta. Eng.

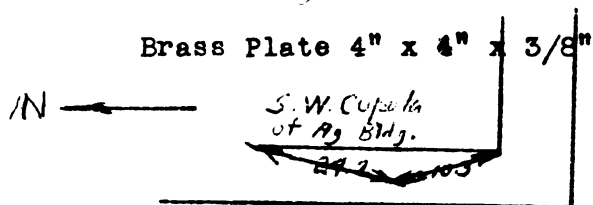


Engineering Bldg.

N

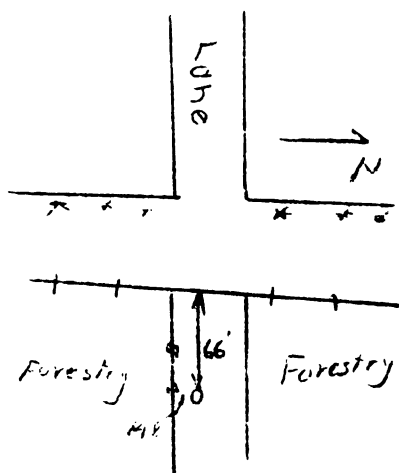
10!4 N.W. of Elevator Cupola
to brass plug
33!5 guy pole for wireless.

Sta. Ag.



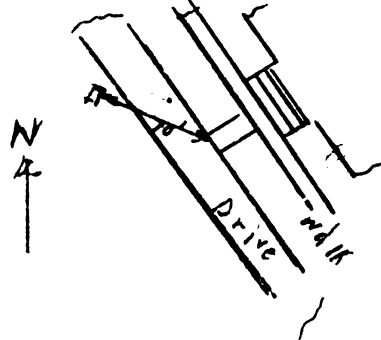
10!3 from S.W. cor. of cupola
24!2 from N.W. cor. of cupola
4!3 from dist. from cupola

Sta. For.
2" iron pipe.



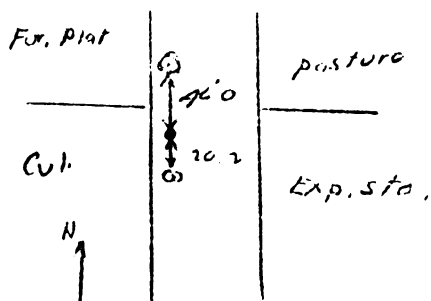
66' E. of C.L.P.M. Spur.
5.7 from south fence
14!8 from nearest concrete gate post

Sta. No. 8 Concrete Post.



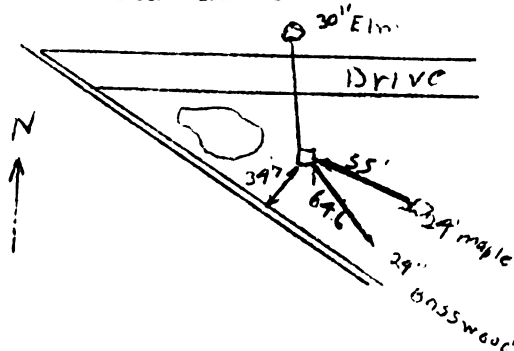
In front of Woman's Bldg.
70' N.W. end of walk in
front of building, and is
3!5 from S.W. line of main
drive.

Sta. N. Base.



N. Base is about 400 ft. south of
bridge over Red Cedar.
15' from west fence.
Maple 46!0 N. 0° W.
Maple 20!2 S. 18°5 W.
Cor. Post 53.5 W. 72° E.

Sta. No. 4.



In front of Taft's House.
13!5 south of main drive
26.4 east of shrubbery
24" Maple 55' S. 70° E.

RIGOROUS ADJUSTMENT OF QUAD NO. 1.

Measured Angles.	Angle-equation Adjustment		Log sin A, B, etc.,	d	Side-equation Adjust-ment.	Adjusted Angles.	Check. by Sines
	For 360° Angles.	Adjusted Values.					
a	89° 50' 42.5	+9.0625	A	89° 50' 34.8625	08 +21x ₁ -0.92	89° 50' 33.9425	9.9996921
b	38 35 14.2	"	B	38 35 06.5625	264 +2x ₁ +1.98	38 35 08.5425	9.7949653
c	22 13 30.5	"	C	22 13 51.3875	516-21x ₂ -5.13	22 13 46.2575	9.5778567
d	31 20 06.3	"	D	31 20 27.1875	345-x-2x ₂ +4.07	31 20 31.2575	9.7161248
e	57 08 27.4	"	E	57 08 53.1625	1364+2x ₂ -0.62	57 08 52.5425	9.9243176
f	69 16 22.5	"	F	69 16 48.2625	86+x-2x ₃ +1.68	69 16 49.9425	9.9709620
g	26 07 41.6	"	G	26 07 38.8375	430-x+2x ₄ -4.98	26 07 33.8575	9.6437957
h	27 26 42.5	"	H	27 26 39.7375	405-x-x ₄ +3.92	27 26 43.6575	9.6636105
359 58 47.5			360° 00' 00.0000		360 00 00.0000		-5

$$d_a = 0.8$$

$$d_b = 26.4$$

$$d_c = 51.6$$

$$d_d = 8.0$$

$$d_e = 27.2$$

$$d_f = 0.8$$

$$d_g = 13.6$$

$$d_h = 21.6$$

$$d_i = 43.0$$

$$d_j = 40.5$$

$$d_k = 82.5$$

$$d_l = 82.5$$

$$d_m = 82.5$$

$$d_n = 89.4$$

$$d_o = 129.0$$

$$d_p = 129.0$$

$$d_q = 129.0$$

$$d_r = 129.0$$

$$d_s = 129.0$$

$$d_t = 129.0$$

$$d_u = 129.0$$

$$d_v = 129.0$$

$$d_w = 129.0$$

$$d_x = 129.0$$

$$d_y = 129.0$$

$$d_z = 129.0$$

$$d_{aa} = 129.0$$

$$d_{bb} = 129.0$$

$$d_{cc} = 129.0$$

$$d_{dd} = 129.0$$

$$d_{ee} = 129.0$$

$$d_{ff} = 129.0$$

$$d_{gg} = 129.0$$

$$d_{hh} = 129.0$$

$$d_{ii} = 129.0$$

$$d_{jj} = 129.0$$

$$d_{kk} = 129.0$$

$$d_{ll} = 129.0$$

$$d_{mm} = 129.0$$

$$d_{nn} = 129.0$$

$$d_{oo} = 129.0$$

$$d_{pp} = 129.0$$

$$d_{qq} = 129.0$$

$$d_{rr} = 129.0$$

$$d_{ss} = 129.0$$

$$d_{tt} = 129.0$$

$$d_{uu} = 129.0$$

$$d_{vv} = 129.0$$

$$d_{ww} = 129.0$$

$$d_{xx} = 129.0$$

$$d_{yy} = 129.0$$

$$d_{zz} = 129.0$$

$$d_{aaa} = 129.0$$

$$d_{bbb} = 129.0$$

$$d_{ccc} = 129.0$$

$$d_{ddd} = 129.0$$

$$d_{eee} = 129.0$$

$$d_{fff} = 129.0$$

$$d_{ggg} = 129.0$$

$$d_{hhh} = 129.0$$

$$d_{iii} = 129.0$$

$$d_{jjj} = 129.0$$

$$d_{kkk} = 129.0$$

$$d_{lll} = 129.0$$

$$d_{mmm} = 129.0$$

$$d_{nnn} = 129.0$$

$$d_{ooo} = 129.0$$

$$d_{ppp} = 129.0$$

$$d_{qqq} = 129.0$$

$$d_{rrr} = 129.0$$

$$d_{sss} = 129.0$$

$$d_{ttt} = 129.0$$

$$d_{uuu} = 129.0$$

$$d_{vvv} = 129.0$$

$$d_{www} = 129.0$$

$$d_{xxx} = 129.0$$

$$d_{yyy} = 129.0$$

$$d_{zzz} = 129.0$$

$$d_{aaaa} = 129.0$$

$$d_{bbbb} = 129.0$$

$$d_{cccc} = 129.0$$

$$d_{dddd} = 129.0$$

$$d_{eeee} = 129.0$$

$$d_{ffff} = 129.0$$

$$d_{gggg} = 129.0$$

$$d_{hhhh} = 129.0$$

$$d_{iiii} = 129.0$$

$$d_{jjjj} = 129.0$$

$$d_{kkkk} = 129.0$$

$$d_{llll} = 129.0$$

$$d_{mmmm} = 129.0$$

$$d_{nnnn} = 129.0$$

$$d_{oooo} = 129.0$$

$$d_{pppp} = 129.0$$

$$d_{qqqq} = 129.0$$

$$d_{rrrr} = 129.0$$

$$d_{ssss} = 129.0$$

$$d_{tttt} = 129.0$$

$$d_{uuuu} = 129.0$$

$$d_{vvvv} = 129.0$$

$$d_{wwww} = 129.0$$

$$d_{xxxx} = 129.0$$

$$d_{yyyy} = 129.0$$

$$d_{zzzz} = 129.0$$

$$d_{aaaaa} = 129.0$$

$$d_{bbbbb} = 129.0$$

$$d_{ccccc} = 129.0$$

$$d_{ddddd} = 129.0$$

$$d_{eeeee} = 129.0$$

$$d_{ffffff} = 129.0$$

$$d_{ggggg} = 129.0$$

$$d_{hhhhh} = 129.0$$

$$d_{iiiiii} = 129.0$$

$$d_{jjjjj} = 129.0$$

$$d_{kkkkk} = 129.0$$

$$d_{lllll} = 129.0$$

$$d_{mmmmm} = 129.0$$

$$d_{nnnnn} = 129.0$$

$$d_{ooooo} = 129.0$$

$$d_{ppppp} = 129.0$$

$$d_{qqqqq} = 129.0$$

$$d_{rrrrr} = 129.0$$

$$d_{sssss} = 129.0$$

$$d_{ttttt} = 129.0$$

$$d_{uuuuu} = 129.0$$

$$d_{vvvvv} = 129.0$$

$$d_{wwwww} = 129.0$$

$$d_{xxxxx} = 129.0$$

$$d_{yyyyy} = 129.0$$

$$d_{zzzzz} = 129.0$$

$$d_{aaaaaa} = 129.0$$

$$d_{bbbbbb} = 129.0$$

$$d_{cccccc} = 129.0$$

$$d_{dddddd} = 129.0$$

$$d_{eeeeee} = 129.0$$

$$d_{fffffft} = 129.0$$

$$d_{gggggg} = 129.0$$

$$d_{hhhhhh} = 129.0$$

$$d_{iiiiiii} = 129.0$$

$$d_{jjjjjj} = 129.0$$

$$d_{kkkkkk} = 129.0$$

$$d_{llllll} = 129.0$$

$$d_{mmmmm} = 129.0$$

$$d_{nnnnnn} = 129.0$$

$$d_{oooooo} = 129.0$$

$$d_{pppppp} = 129.0$$

$$d_{qqqqqq} = 129.0$$

$$d_{rrrrrr} = 129.0$$

$$d_{ssssss} = 129.0$$

$$d_{tttttt} = 129.0$$

$$d_{uuuuuu} = 129.0$$

$$d_{vvvvvv} = 129.0$$

$$d_{wwwwww} = 129.0$$

$$d_{xxxxxx} = 129.0$$

$$d_{yyyyyy} = 129.0$$

$$d_{zzzzzz} = 129.0$$

$$d_{aaaaaaa} = 129.0$$

$$d_{bbbbbbb} = 129.0$$

$$d_{ccccccc} = 129.0$$

$$d_{dddddtt} = 129.0$$

$$d_{eeeeeee} = 129.0$$

$$d_{fffffft} = 129.0$$

$$d_{ggggggg} = 129.0$$

$$d_{hhhhhhh} = 129.0$$

$$d_{iiiiiiii} = 129.0$$

$$d_{jjjjjjj} = 129.0$$

$$d_{kkkkkkk} = 129.0$$

$$d_{lllllll} = 129.0$$

$$d_{mmmmmm} = 129.0$$

$$d_{nnnnnnn} = 129.0$$

$$d_{oooooooo} = 129.0$$

$$d_{ppppppp} = 129.0$$

$$d_{qqqqqqq} = 129.0$$

$$d_{rrrrrrr} = 129.0$$

$$d_{sssssss} = 129.0$$

$$d_{ttttttt} = 129.0$$

$$d_{uuuuuuu} = 129.0$$

$$d_{vvvvvvv} = 129.0$$

$$d_{wwwwwww} = 129.0$$

$$d_{xxxxxxx} = 129.0$$

$$d_{yyyyyyy} = 129.0$$

$$d_{zzzzzzz} = 129.0$$

$$d_{aaaaaaaa} = 129.0$$

$$d_{bbbbbbbb} = 129.0$$

$$d_{cccccccc} = 129.0$$

$$d_{dddddttt} = 129.0$$

$$d_{eeeeeee} = 129.0$$

$$d_{fffffft} = 129.0$$

$$d_{ggggggg} = 129.0$$

$$d_{hhhhhhh} = 129.0$$

$$d_{iiiiiiii} = 129.0$$

$$d_{jjjjjjj} = 129.0$$

$$d_{kkkkkkk} = 129.0$$

$$d_{lllllll} = 129.0$$

$$d_{mmmmmm} = 129.0$$

$$d_{nnnnnnn} = 129.0$$

$$d_{oooooooo} = 129.0$$

$$d_{ppppppp} = 129.0$$

$$d_{qqqqqqq} = 129.0$$

$$d_{rrrrrrr} = 129.0$$

~~SECRET ONLY~~

Plates attached to cover.

Plate I. Enlarged Triangulation System.

" II. Location of. " "

Pocket

PLATE I

FOR.

h

Log. 3.1794963
1511.876

12

Pocket

PLATE I

FOR.

h

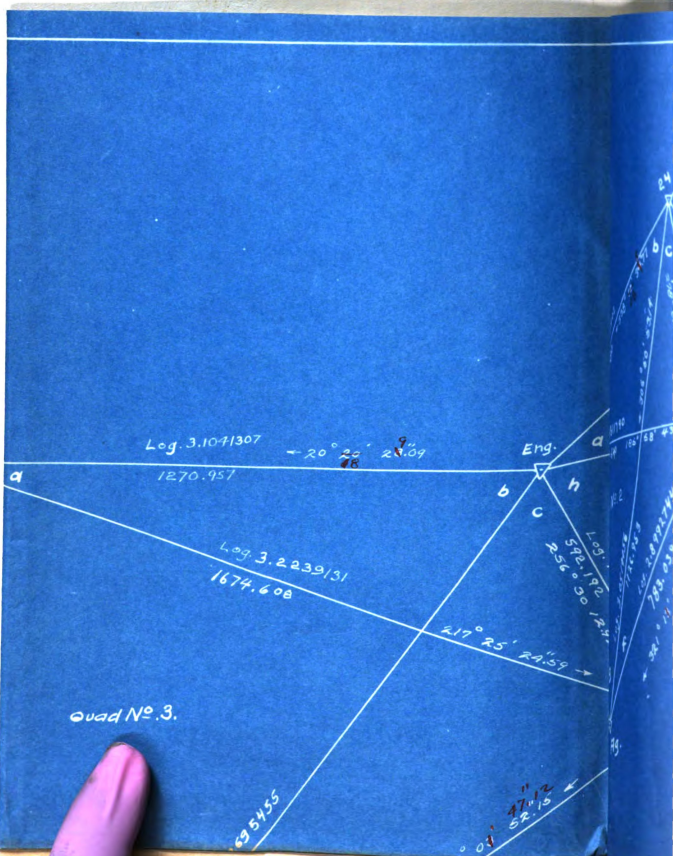
Log. 3.1794963
1511.876

2

Notes attached to cover.

Plate I. Enlarged Triangulation System.

" II. Location of. "

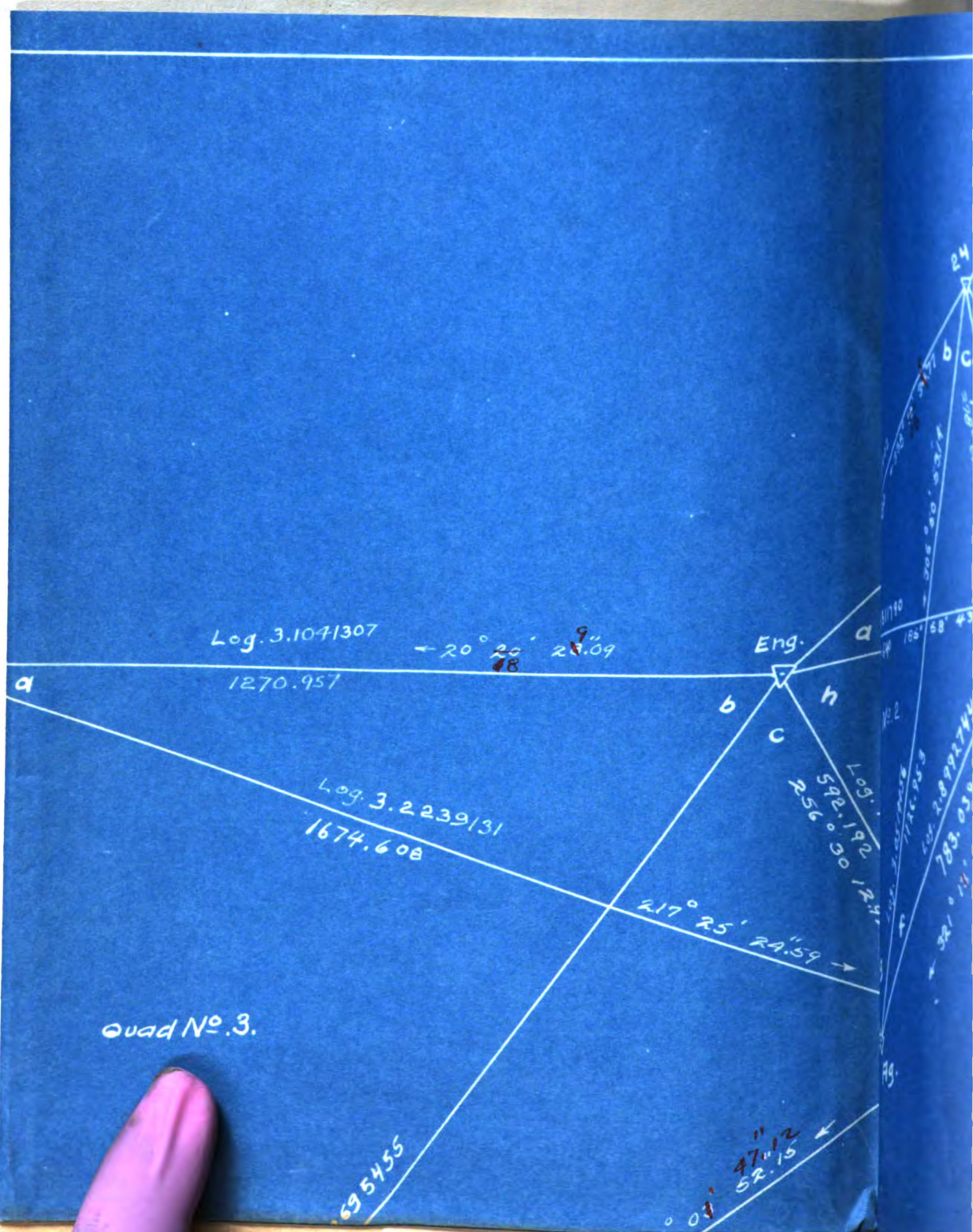


FOR USE ONLY

Plates attached to cover.

Plate I. Enlarged Triangulation System.

" II. Location of. "





QUAD. NO. 1.

a.	87°	50'	33.9425
b.	38	35	08.5425
c.	22	13	46.2575

Pocket



QUAD. NO. 1.

a.	$87^{\circ} 56'$	33.9425
b.	$38^{\circ} 35'$	08.5425
c.	$22^{\circ} 13'$	46.2575

" II. Location of "

QUAD.	NO.	QUAD.	NO.
a	27° 48'	a	08
b	31	b	16
c	28	c	07
d	92	d	27
e	44	e	26
f	14	f	33
g	50	g	43
h	70	h	27
a	17° 04'	a	08
b	53	b	16
c	70	c	07
d	39	d	27
e	52	e	26
f	18	f	33
g	42	g	43
h	66	h	27

Pocket

PLATE II

en-5

2

Pocket

PLATE II

en - 5

2

Plate I. Enlarged Trinaulation System



Plates attached to cover.

Plate I. Enlarged Triangulation System



12
88
69 16 49
57 08 52
91 16

Negatives of instruments

**SUPPLEMENTARY
MATERIAL**

CONTENTS OF POCKET

- | | | | | | |
|---|--|-----|------|---|-----|
| A | Tracing of Plate II | | | | |
| B | Tracing Rigorous Adjustment of Quad. No. I | | | | |
| C | " | " | " | " | |
| D | " | " | " | " | II |
| E | Blue Print; Tringulation Data for Mich. A.C. Survey. | | | | III |
| F | Negatives of Instruments. | - 4 | 1886 | | |

Pocket

SUPPLEMENTARY
MATERIAL

Negatives of instruments

100
686
THS
Suppl. F



Point. 15-1
x +6128.
y -2736.
Point. RJ-1
x
y
Point.
x
y

CONTENTS OF POCKET

- A Tracing of Plate II
- B Tracing Rigorous Adjustment of Quad. No. I
- C " " " " " " " " " " " "
- D " " " " " " " " " " " "
- E Blue Print; Tringulation Data for Mich. A.C. Survey.
- F Negatives of Instruments. - 4, inside

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