Serial No. 9

DEPARTMENT OF COMMERCE U. S. COAST AND GEODETIC SURVEY E. LESTER JONES, SUPERINTENDENT

GEODESY

APPLICATION OF THE THEORY OF LEAST SQUARES TO THE ADJUSTMENT OF TRIANGULATION

BY

OSCAR S. ADAMS

COMPUTER UNITED STATES COAST AND GEODETIC SURVEY

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Special Publication No. 28



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APPLICATION OF THE THEORY OF LEAST SQUARES TO THE ADJUSTMENT OF TRIANGULATION

By OSCAR S. ADAMS Computer United States Coast and Geodetic Survey

GENERAL STATEMENT

In this publication the aim has not been to develop the theory of least squares, but to illustrate the application of the method to the problems arising in the adjustment of triangulation. The general idea has been to collect material in one volume that will serve as a working manual for the computer in the office and for such other members of the Survey as may desire to make these special applications. It has not been deemed necessary to insert the derivation of formulæ except in the case of a few special ones that are not usually found in the textbooks on least squares.

For the general theory reference should be made to such books as the following:

Crandall: Geodesy and Least Squares. Helmert: Die Ausgleichungsrechnung nach der Metode der kleinsten Quadrate. Jordan: Handbuch der Vermessungskunde, volume 1. Merriman: Textbook of Least Squares. Wright and Hayford: Adjustment of Observations.

Some of the simpler cases are treated first, such as the local adjustment at a station, the adjustment of a simple quadrilateral, etc. After these is given the development of the condition equations for latitude and longitude closures, followed by a sample adjustment including the condition equations for these closures, together with the equations for length and azimuth conditions.

A method of adjustment by the variation of geographic coordinates is then developed and applied first to a quadrilateral, then to a figure with a few new points connected with a number of fixed points. The same method is applied to the adjustment of a figure with latitude, longitude, length, and azimuth conditions. A sample adjustment of a vertical net is carried through and lastly there is given the development of the formulæ for the computation of vertical observations, together with examples of the method of computation.

STATION ADJUSTMENT

The general rule followed by the observers of the Coast and Geodetic Survey is to measure the angles at each station in the order of azimuth, thus giving rise to no conditions except the horizon closure. Occasionally, however, sum angles are observed and, when this is done, other conditions are introduced in addition to the horizon closure making it necessary to adjust the angles at the station by the method of least squares. If all angles were observed in the same way, the weight of each would be unity and the adjustment would be made without regard to weights. In the adjustment given below the angles were measured by the usual Coast and Geodetic Survey repetition method; that is, six measures of the angles with the telescope direct and six with it reversed for each set. A station has been chosen at which there are angles measured with one, two, and three sets in order to illustrate the method of weighting.

An and a second s						
Observed stations		А	ngle	$\overset{ ext{Weight}}{p}$	v	Adjusted final seconds*
Boulder-Tower.	° 65	, 06	$ \begin{array}{c} 26.6 \\ 30.9 \\ 30.4 \end{array} $ 29.3	3	vı	" 29. 9
Tower-Tyonek	19	46	27.7 25.0 28.0 26.9	3	v_2	27.5
Tyonek-Round Point	8	39	14.618.414.815.9	3	v3	15.9
Round Point-Boulder	266	27	47.9	1	<i>v</i> 4	46.7
Round Point-Birch Hill	66	23	$20.6 \\ 23.0 $ 21.8	2	v_5	22.4
Birch Hill-Boulder	200	04	22.2 22.3 22.2	2	<i>v</i> 6	24.3
Boulder-Tyonek	84	52	56.2	1	<i>v</i> 7	57.4
Tyonek-Birch Hill	75	02	35.0	1	v8	38.3
Round Point-Moose Point	64	32	$12.9 \\ 09.8 $ 11.4	2	vy	11.3
Moose Point-Birch Hill	1	51	11.2	1	v10	11.1

Observed angles, Gray Cliff

List of directions, Gray Cliff

Observed station	Direction	Adjusted final seconds*
Boulder Tower Tyonek. Round Point Moose Point Birch Hill	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	" 00.0 29.9 57.4 13.3 24.6 35,7

* These values result from the computation on p. 13.

There have been formed a complete list of directions without using five of the angles, each of which, then, gives rise to a condition, there being five conditions in all. The equations expressing these conditions are formed in the following manner:

Angle	Round Point–Boulder, observed,	266	27	$47.9+v_4$
Angle	Round Point-Boulder, from the list,	266	27	$47.9 - v_1 - v_2 - v_3$
	Condition No. 1,		0=	$=+0.0+v_1+v_2+v_3+v_4$
Angle	Round Point-Birch Hill, from the list,	66	23	22. $6+v_9+v_{10}$
Angle	Round Point-Birch Hill, observed,	66	23	21. $8+v_5$
	Condition No. 2,		0=	$=+0.8-v_5+v_9+v_{10}$

In the same way the other condition equations are formed. As a result there are finally:

Condition equations

1. $0=+0.0+v_1+v_2+v_3+v_4$ 2. $0=+0.8-v_5+v_9+v_{10}$ 3. $0=-3.1+v_1+v_2+v_3+v_6+v_9+v_{10}$ 4. $0=+0.0+v_1+v_2-v_7$ 5. $0=+3.5+v_3-v_8+v_9+v_{10}$

FORMATION OF NORMAL EQUATIONS BY DIFFERENTIATION

According to the theory of least squares, the most probable values will be determined by making the $\Sigma p_n v_n^2$ a minimum, subject to the given conditions. By the method of Lagrangian multipliers the formation of the normal equations can be much simplified.

With the use of these the function u that is to be made a minimum is

$$\begin{split} & u = 3 \, v_1^2 + 3 \, v_2^2 + 3 \, v_3^2 + 1 \, v_4^2 + 2 \, v_5^2 + 2 \, v_6^2 + 1 \, v_7^2 + 1 \, v_8^2 + 2 \, v_9^2 + 1 \, v_{10}^2 - 2 \, C_1(+v_1 + v_2 + v_3 + v_4 + 0.0) - 2 \, C_2(-v_5 + v_9 + v_{10} + 0.8) - 2 \, C_3(+v_1 + v_2 + v_3 + v_6 + v_9 + v_{10} - 3.1) - 2 \, C_4(+v_1 + v_2 - v_7 + 0.0) - 2 \, C_5(+v_3 - v_8 + v_9 + v_{10} + 3.5). \end{split}$$

The C's are merely undetermined multipliers, the values of which will be determined by the solution. The factor 2 is included to obviate later on the use of the fraction $\frac{1}{2}$; the minus sign is used for convenience. The function will be rendered a minimum if the partial differential coefficients with respect to v_1, v_2 , etc., are equated to zero. By this means ten equations will be formed, giving the ten v's expressed in terms of the C's.

Differentiating with respect to v_1 , v_2 , etc., in succession and equating the results to zero, the following equations are obtained:

$$\begin{array}{l} 3 \ v_1 - C_1 - C_3 - C_4 \!=\! 0 \\ 3 \ v_2 - C_1 - C_3 - C_4 \!=\! 0 \\ 3 \ v_3 - C_1 \! -\! C_3 \! -\! C_5 \! =\! 0 \\ v_4 - C_1 \! =\! 0 \\ 2 \ v_5 + C_2 \! =\! 0 \\ 2 \ v_6 - C_3 \! =\! 0 \\ v_7 + C_4 \! =\! 0 \\ v_8 + C_5 \! =\! 0 \\ 2 \ v_9 - C_2 \! -\! C_3 \! -\! C_5 \! =\! 0 \\ v_{10} \! -\! C_2 \! -\! C_3 \! -\! C_5 \! =\! 0 \end{array}$$

Therefore

$$\begin{array}{l} v_1 = +\frac{1}{3} \ C_1 + \frac{1}{3} \ C_3 + \frac{1}{3} \ C_4 \\ v_2 = +\frac{1}{3} \ C_1 + \frac{1}{3} \ C_3 + \frac{1}{3} \ C_4 \\ v_3 = +\frac{1}{3} \ C_1 + \frac{1}{3} \ C_3 + \frac{1}{3} \ C_5 \\ v_4 = +C_1 \\ v_5 = -\frac{1}{2} \ C_2 \\ v_6 = +\frac{1}{2} \ C_3 \\ v_7 = -C_4 \\ v_8 = -C_5 \\ v_9 = +\frac{1}{2} \ C_2 + \frac{1}{2} \ C_3 + \frac{1}{2} \ C_5 \\ v_{10} = +C_2 + C_3 + C_5 \end{array}$$

Thus all of the v's are now expressed in terms of the C's. These can now be substituted in the condition equations forming five normal equations containing five C's and these equations may then be solved for the C's. If the normals are formed from these values, fractions will occur in practically all of the coefficients. This can be avoided by replacing C_1 by 6 C_1' , C_2 by 6 C_2' , etc. This is equivalent to using 12 C_1' , 12 C_2' , etc., in the original function instead of 2 C_1 , 2 C_2 , etc., which, of course, is perfectly valid.

The equations will then stand as follows:

 $\begin{array}{l} v_1 = +2 \ C_1' + 2 \ C_3' + 2 \ C_4' \\ v_2 = +2 \ C_1' + 2 \ C_3' + 2 \ C_4' \\ v_3 = +2 \ C_1' + 2 \ C_3' + 2 \ C_5' \\ v_4 = +6 \ C_1' \\ v_5 = -3 \ C_2' \\ v_6 = +3 \ C_3' \\ v_7 = -6 \ C_4' \\ v_8 = -6 \ C_5' \\ v_9 = +3 \ C_2' + 3 \ C_3' + 3 \ C_5' \\ v_{10} = +6 \ C_2' + 6 \ C_3' + 6 \ C_5' \end{array}$

Dropping the prime and substituting these values in the first condition equation the following normal equation is obtained:

In a similar manner the other normal equations are formed, giving in all the following five equations:

This manner of forming the normal equations is called the method of correlates and is most conveniently carried out by means of a table of correlates formed as on page 11.

After the determination of the C's by the solution of the normal equations, the v's may be computed from the equations of the v's

in terms of the C's. In the tabulated form below the first column is multiplied by C_1 , the second by C_2 , etc. The sum of the first line multiplied by the $\frac{6}{p}$ for that line gives v_1 ; so also for the other v's.

	$\frac{6}{p}$	1	2	3	4	5	£	v's*	Adopted v's
1 2 3 4 5	2 2 2 6 3	$^{+1}_{+1}_{+1}_{+1}$	-1	$^{+1}_{+1}_{+1}$	+1 +1	+1	+3 +3 +3 +1 -1	$\begin{array}{r} +0.\ 618 \\ +0.\ 618 \\ -0.\ 050 \\ -1.\ 182 \\ +0.\ 585 \end{array}$	+0.6 +0.6 -0.0 -1.2 +0.6
6 7 8 9 10	3 6 3 6		+1 +1	+1 +1 +1	-1	-1 + 1 + 1 + 1	$+1 \\ -1 \\ -1 \\ +3 \\ +3$	$\begin{array}{r} +2.133\\ +1.230\\ +3.234\\ -0.069\\ -0.138\end{array}$	+2.1+1.2+3.3-0.1-0.1

Correlate equations

* These values result from the computation on p. 13.

FORMATION OF THE NORMAL EQUATIONS

After the condition equations are tabulated in correlates as above, the next step is the formation of the normal equations. In forming these the various products must be multiplied by $\frac{1}{p}$ or by $\frac{a}{p}$ in which p is the weight of the given v and a is some constant. (See the direct formation on p. 9.) It is most convenient to choose a so as to make most of the values integers, if this can be done without making the quantities too large. In this case 6 is the L. C. M. of the p's, hence it is chosen for a. The normal equations are formed by taking the algebraic sums of $\frac{6}{p}$ times the products of the various columns. Normal No. 1 is, in symbols—

$$\Sigma\frac{6}{p} \cdot 1 \cdot 1 + \Sigma\frac{6}{p} \cdot 1 \cdot 2 + \Sigma\frac{6}{p} \cdot 1 \cdot 3 + \Sigma\frac{6}{p} \cdot 1 \cdot 4 + \Sigma\frac{6}{p} \cdot 1 \cdot 5 + \eta + \left(\Sigma\frac{6}{p} \cdot 1 \cdot \Sigma + \eta^{\dagger}\right)$$

The algebraic sum of the sigma products in the formation checks or controls the formation of the normals. Each Σ line in the correlates is the algebraic sum of that line in the table. As is easily seen, the sum of the products of this column in the formation of the normals should check the algebraic sum of the coefficients of the normal. On the first normal +12+6+4+2=+24, which is the same as the algebraic sum of the products in the correlates. The Σ column in the normals also includes the constant term. In the third normal +6+9+18+4+11=+48. In the Σ columns of the normal +48-3.1=+44.9.

 $\dagger \eta$ is the constant term of the condition equation.

	1	2	3	4	5	η	Σ	C's*
$ \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} $	+12	+12	$^{+6}_{+9}_{+18}$	+ 4 + 4 + 10	+2 + 9 + 11 + 17	+0.0 +0.8 -3.1 +0.0 +3.5	+24 +30.8 +44.9 +18 +42.5	$\begin{array}{c} -0.19700 \\ -0.19531 \\ +0.71069 \\ -0.20547 \\ -0.53917 \end{array}$

Normal equations

* These values result from the computation on p. 13.

DISCUSSION OF METHOD OF SOLUTION OF NORMAL EQUATIONS

In the normal equations the coefficients in each equation occurring before the diagonal term are omitted, as the equations are symmetrical with regard to the diagonal line. The set just given when written in full is as follows:

	1	2	3	4	5	ŋ	Σ
1	+12		+ 6	+ 4	+ 2	+0.0	+24
2		+12	+ 9		+ 9	+0.8	+30.8
3	+ 6	+ 9	+18	+ 4	+11	-3.1	+44.9
4	+ 4		+ 4	+10		+0.0	+18
5	+ 2	+ 9	+11		+17	+3.5	+42.5

It can be seen that the coefficients may be omitted to the left of the diagonal line and each equation may be read from the top down to the diagonal term and then across the page.

The Doolittle method of solution is used. Equation No. 1 is copied and then divided by the diagonal term (+12 in this case), the signs being changed. Since No. 2 does not occur on No. 1, this also is divided at once by the diagonal term with a change of sign. No. 3 has +6 on No. 1 and +9 on No. 2; accordingly, the divided coefficients of No. 1 are multiplied by +6 and those of No. 2 by +9 and these give the two products on No. 3. These are then added algebraically and divided by the diagonal term with change of sign to give C_3 in terms of No. 4 and No. 5 plus a constant term. In a similar manner No. 4 and No. 5 are eliminated, the division on No. 5 giving the value of C_{z} . The back solution is then carried through $C_4 = +0.17778C_5 - 0.10962$. When the value of C_5 is substituted, $C_4 = -0.09585 - 0.10962 = -0.20547$. So also for the remaining C's. For an explanation of the omission of the terms before the diagonal term, see page 22. For a full discussion of the Doolittle method of solution, see Wright & Hayford, Adjustment of Observations, page 114 et seq.

APPLICATION OF LEAST SQUARES TO TRIANGULATION.

1	2	3	4	5	η	Σ
$^{+12}_{C_1}$		$+ 6 \\ - 0.5$	+ 4 - 0.33333	$^{+2}_{-0.16667}$	+0.0 +0.0	$^{+ 24}_{- 2}$
	$^{+12}_{C_2}$	+9 - 0.75		+ 9 - 0.75	$+0.8 \\ -0.06667$	+30.8 - 2.56667
	$\frac{1}{2}$	+18 - 3 - 6.75	$^{+4}_{-2}$	+11 - 1 - 6.75	-3.1 -0.6	+44.9 -12 -23.1
		$+ 8.25 C_3$	+ 2 - 0.24242	+ 3.25 - 0.39394	-3.7 +0.44848	+ 9.8 - 1.18788
		1 3	+10 - 1.3333 - 0.4848	- 0.6667 - 0.7879	+0.0 +0.8969	+18 - 8 - 2,3758
			$+ \begin{array}{c} 8.1819 \\ C_4 \end{array}$	- 1.4546 + 0.17778	+0.8969 -0.10962	+ 7.6242 - 0.93184
			1 2 3 4	$\begin{array}{r} +17 \\ -0.3333 \\ -6.75 \\ -1.2803 \\ -0.2586 \end{array}$	+3.5 -0.6 +1.4576 +0.1595	$ \begin{array}{r} +42.5 \\ -4 \\ -23.1 \\ -3.8606 \\ +1.3554 \end{array} $
				+ $8.3778 C_5$	+4.5171 -0.53917	+12.8949 - 1.53917

Solution of normal equations

Back solution

5	4	3	2	1
-0. 53917 -0. 53917	$ \begin{array}{r} -0.10962 \\ -0.09585 \\ \hline -0.20547 \\ \end{array} $	+0. 44848 +0. 21240 +0. 04981 +0. 71069	-0.06667 +0.40438 -0.53302 -0.19531	+0. 08986 +0. 06849 -0. 35535 -0. 19700

Computation of corrections

1	2	3	4	5
-0.197 +0.711	-0.197 + 0.711	-0.197 +0.711	-0.197	+0.195
-0.205 +0.309	-0.205 +0.309	-0.539 -0.025	-0.197 6 -1.182	+0.195 3 +0.585
+0.618	+0.618	-0.050^{2}		
	1	and the second s		
6	7	8	9	10
6	7 +0. 205	8 +0.539	9 0.195 +0.711	$ \begin{array}{r} 10 \\ -0.195 \\ +0.711 \end{array} $
6 +0.711 +0.711 3		8 +0.539 +0.539 6	9 0.195 +0.711 0.539	$ \begin{array}{r} 10 \\ -0.195 \\ +0.711 \\ -0.539 \end{array} $
$ \begin{array}{r} $			$9 \\ -0.195 \\ +0.711 \\ -0.539 \\ -0.023 \\ 2$	$ \begin{array}{r} 10 \\ -0.195 \\ +0.711 \\ -0.539 \\ -0.023 \\ e \end{array} $

ADJUSTMENT OF A QUADRILATERAL

GENERAL STATEMENT

After the local conditions—that is, those arising from the relations of the angles to one another at each station—are satisfied there are general conditions arising from the geometrical relations necessary to form a closed figure which must be satisfied. To illustrate this, let the case of a quadrilateral be taken. The angles of each triangle should sum up to 180° plus the spherical excess of the triangle. Except in rare cases this does not happen with the observed angles; therefore condition equations are needed to bring it about. There are four triangles in a quadrilateral, but if three of them close the other will also close. There will then be three angle equations in the quadrilateral. A fourth equation must be included to insure that the lines at the pole will pass through the same point. When this condition is satisfied, and the triangles are closed, the same values will be obtained for the various sides when the computation is carried through different triangles.

In the adjustment of triangulation in the United States Coast and Geodetic Survey the method of directions is used; that is, an angle is considered as the difference of two directions.* If v_1 is the correction to the first direction in order of azimuth at a given station and v_2 the correction to the second direction, the correction to the angle will be $-v_1+v_2$, or the algebraic difference of the v's applying to the directions. To avoid the use of so many v's, the custom is to write (1) instead of v_1 ; thus the angle given above will have the correction symbol -(1)+(2), in which 1 and 2 are not quantities but the subscripts of the corresponding v's.

An angle equation simply states that the sum of the corrections to the angles of a given triangle is to equal the failure in the closure of the triangle. In the triangle $A_3A_2A_1$ (see fig. 1 on p. 16) the angle at A_2 is to be corrected by -(1) + (2), the angle at A_1 by -(4) + (6), and the angle at A_3 by -(8) + (9). The sum of the angles needs to be increased by 2''.3 to make up the sum of 180° plus the spherical excess. (See triangle on p. 23.) Therefore -(1) + (2) - (4) + (6)-(8) + (9) = +2.3, or, as it is usually written, 0 = -2.3 - (1) + (2)-(4) + (6) - (8) + (9).

Three angle equations in a quadrilateral will bring about the closure of the four triangles, but it is possible to have all of the triangles close and still the sides fail to check when computed through different triangles. To make the computation of lengths consistent a side equation must be added to the three angle equations. In figure 1 on page 16 the sides can be made consistent in the following manner:

* See lists of directions on p. 16.

In the triangle $A_1A_4A_2$

$$\frac{\text{side } A_2A_4}{\text{side } A_1A_4} = \frac{\text{sine angle } A_1}{\text{sine angle } A_2} = \frac{\text{sine } [-(5)+(6)]}{\text{sine } [-(1)+(3)]}$$

in the triangle $A_1A_3A_4$

 $\frac{\text{side } A_1A_4}{\text{side } A_3A_4} = \frac{\text{sine angle } A_3}{\text{sine angle } A_1} = \frac{\text{sine } [-(7)+(9)]}{\text{sine } [-(4)+(5)]}$

and in the triangle $A_2A_3A_4$

 $\frac{\text{side } A_3A_4}{\text{side } A_2A_4} = \frac{\text{sine angle } A_2}{\text{sine angle } A_3} = \frac{\text{sine } [-(2)+(3)]}{\text{sine } [-(7)+(8)]}$

If the sides are consistent, the product of these three equations gives

 $\frac{\sin \left[-(5)+(6)\right] \sin \left[-(7)+(9)\right] \sin \left[-(2)+(3)\right]}{\sin \left[-(1)+(3)\right] \sin \left[-(4)+(5)\right] \sin \left[-(7)+(8)\right]} = 1$

In a spherical triangle the same equation is obtained by using the sine of the side in place of the side. In the end the equation given above results, since the sines of the sides cancel out as did the sides above.

Passing to logarithms, we have

 $\log \sin \left[-(5)+(6) \right] + \log \sin \left[-(7)+(9) \right] + \log \sin \left[-(2)+(3) \right] - \log \sin \left[-(1)+(3) \right] \\ -\log \sin \left[-(4)+(5) \right] - \log \sin \left[-(7)+(8) \right] = 0$

As this will not be exactly true when the observed angles or angles adjusted only for closing errors of the triangles are used except in rare cases, a condition equation must be formed to accomplish this result. From the table of logarithms we find the amount of change of the log sine of the given angle for 1" change in the angle, and this multiplied by the v's applying to the angle will give the change in the log sine of that angle. It is customary to consider the log sines in six places of decimals, hence the change in the log sine for 1" will be taken as units in the sixth place of decimals.

 $\log \sin e [-(5)+(6)]$ 20 50 56. 7=9.5513374-5.53(5)+5.53(6)35.0 = 9.9450972 - 1.13(7) + 1.13(9) $\log \sin e [-(7)+(9)]$ 61 47 log sine [-(2)+(3)] 32 09 01. 2=9. 7260280-3. 35(2)+3. 35(3) Total.....=9.2224626-3.35(2)+3.35(3)-5.53(5)+5.53(6)-1.13(7)+1.13(9)1 11 0 log sine [-(1)+(3)] 133 53 46. 3=9. 8576926+2. 03(1)-2. 03(3) $26 \quad 40 \quad 23.5 = 9.6521506 - 4.19(4) + 4.19(5)$ $\log \sin e [-(4)+(5)]$ $31 \quad 03 \quad 42.5 = 9.7126180 - 3.50(7) + 3.50(8)$ $\log sine [-(7)+(8)]$ -3.50(7)+3.50(8)-5.53(5)+5.53(6)-1.13(7)9. 2224626 -3.35(2)+3.35(3)+1.13(9)-2.03(3) - 4.19(4) + 4.19(5)-3.50(7) + 3.50(8)9.2224612 + 2.03(1)0 = +1.4 - 2.03(1) - 3.35(2) + 5.38(3) + 4.19(4) - 9.72(5) + 5.53(6) + 2.37(7) - 3.50(8)+1.13(9)91865°-15-2

(See tabulated form of this equation on p. 17.)

This condition requires the lines from A_2 , A_1 , and A_3 to pass through the same point at A_4 . If v's are found that satisfy this equation, at the same time satisfying the three angle equations given on page 17. they will render the quadrilateral consistent in all respects.

In a full quadrilateral (see figure 1) there are four conditions. These can be put in as three angle equations and one side equation, or two angle and two side, or one angle and three side equations. (See article by C. A. Schott, Appendix No. 17, United States Coast and Geodetic Survey Report of 1875, p. 280.) To illustrate the fact, a quadrilateral is adjusted using two angle equations and two side equations. (See p. 20.) In order to hold the closure of the triangles, the logarithms in the side equations must be found at least to seven places to hold the closure to tenths of seconds. Of course this method would never be used in practice, as the side equations require much more work, but the fact is interesting as an illustration of what can be done in the method of adjustment. Four side equations or

four angle equations could not be used, for the fourth is functionally related to the other three, and hence they would not be independent conditions.

In a set of equations, if an identical one is included, the diagonal

normal is divided by this term.

FIG. 1. term of the reduced normal will become zero with the possible exception, of course, of a few units in the last place of solution due to accumulations. In any case, if the reduced diagonal term falls below unity, there may be danger of instability, since in this case any accumulations in the last place of the solution are increased when the

Lists of directions

Stations observed	Dir afte adju	ections er local istment	Final sec- onds*	Stations observed	Directions after local adjustment		Final sec- onds*	
STATION A1 A3 A4 A2	0 26 47	, ,, 00 00.0 40 23.5 31 20.2	59.8 23.5 20.5	STATION A ₃ A ₄ A ₂	。 0 31 61	, 00 03 47	,, 00. 0 42. 5 35. 0	00. 7 42. 0 34. 8
STATION A ₂ A ₁ A ₃ A ₄	0 (101 4 133 4	00 00.0 44 45.1 53 46.3	59.5 46.1 45.8	STATION A ₄ A ₂ A ₁ A ₃	0 25 116	00 15 47	00. 0 16. 2 20. 0	00. 1 16. 9 19. 2

* These values result from the following computation.

Angle equations *

 $\begin{array}{l} 0 = -2.3 - (1) + (2) - (4) + (6) - (8) + (9). \\ 0 = +3.6 - (2) + (3) - (7) + (8) - (10) + (12). \\ 0 = +2.2 - (4) + (5) - (7) + (9) - (11) + (12). \end{array}$

Side equation

Symbol	Angle	Logarithm	Tabular differ- ence	Symbol	Angle	Logarithm	Tabular differ- ence
-7+9 -5+6 -2+3	61 47 35.0 20 50 56.7 32 09 01.2	9. 9450972 9. 5513374 9. 7260280 9. 2224626	+1.13 +5.53 +3.35	-4+5 -1+3 -7+8	° ' '' 26 40 23.5 133 53 46.3 31 03 42.5	9. 6521506 9. 8576926 9. 7126180 9. 2224612	+4. 19 -2. 03 +3. 50

 $\begin{array}{c} 0 = +1.4 - 2.03(1) - 3.35(2) + 5.38(3) + 4.19(4) - 9.72(5) + 5.53(6) + 2.37(7) - 3.50(8) + \\ 1.13(9). \end{array}$

FORMATION OF NORMAL EQUATIONS BY DIFFERENTIATION

The function u to be rendered a minimum is the sum of the squares of the v's, subject to the four given conditions.

 $\begin{array}{l} u = v_1^2 + v_2^2 + v_3^2 + v_4^2 + v_5^2 + v_6^2 + v_7^2 + v_8^2 + v_9^2 + v_{10}^2 + v_{11}^2 + v_{12}^2 - 2C_1(-2.3 - v_1 + v_2 - v_4 + v_6 - v_8 + v_9) - 2C_2(+3.6 - v_2 + v_3 - v_7 + v_8 - v_{10} + v_{12}) - 2C_3(+2.2 - v_4 + v_5 - v_7 + v_9 - v_{11} + v_{12}) - 2C_4(+1.4 - 2.03 v_1 - 3.35 v_2 + 5.38 v_3 + 4.19 v_4 - 9.72 v_5 + 5.53 v_6 + 2.37 v_7 - 3.50 v_8 + 1.13 v_9) \end{array}$

Differentiating with respect to the v's in succession and equating to zero, there result after transposition the following equations:

```
\begin{array}{l} v_1\!=\!-C_1\!-\!2.03\ C_4\\ v_2\!=\!+C_1\!-\!C_2\!-\!3.35\ C_4\\ v_3\!=\!+C_2\!+\!5.38\ C_4\\ v_4\!=\!-C_1\!-\!C_3\!+\!4.19\ C_4\\ v_5\!=\!+C_3\!-\!9.72\ C_4\\ v_6\!=\!+C_1\!+\!5.53\ C_4\\ v_7\!=\!-C_2\!-\!C_3\!+\!2.37\ C_4\\ v_8\!=\!-C_1\!+\!C_2\!-\!3.50\ C_4\\ v_9\!=\!+C_1\!+\!C_3\!+\!1.13\ C_4\\ v_9\!=\!+C_1\!+\!C_3\!+\!1.13\ C_4\\ v_{10}\!=\!-C_2\\ v_{11}\!=\!-C_3\\ v_{12}\!=\!+C_2\!+\!C_8 \end{array}
```

By the substitution of these values in the four condition equations the following normal equations result:

 $\begin{array}{l} +6 \ C_1 -2 \ C_2 +2 \ C_3 +4.65 \ C_4 -2.3 =0 \\ -2 \ C_1 +6 \ C_2 +2 \ C_3 +2.86 \ C_4 +3.6 =0 \\ +2 \ C_1 +2 \ C_2 +6 \ C_3 -15.15 \ C_4 +2.2 =0 \\ +4.65 \ C_1 +2.86 \ C_2 -15.15 \ C_3 +206.0470 \ C_4 +1.4 =0 \end{array}$

These normal equations are formed most easily by means of the tabular form of the correlate equations given on page 18.

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The sum of the squares of each column gives the diagonal term in that equation in the normals. All coefficients before the diagonal term are omitted; each equation is read by starting at the top of the tabular form below, reading down the column to the diagonal term, and then along the horizontal line. Compare the full normals given above with the tabular form below. After the diagonal terms are determined column No. 1 in the correlates is multiplied by column No. 2 and the algebraic sum of the products taken for the coefficient of normal No. 1 on No. 2; this is also the coefficient of No. 2 on No. 1. Column No. 1 times No. 3, with the algebraic sum of the products, gives the coefficient of No. 1 on No. 3 in the normals; also No. 3 on No. 1. Finally, the algebraic sum of the products of column No. 1 by column No. 4 gives the coefficient of normal No. 1 on No. 4. The algebraic sum of the products of column No. 1 by the Σ column should check the algebraic sum of the coefficients of normal No. 1. To this should be added algebraically the constant term of normal No. 1 and the sum placed in the Σ column of normal No. 1. (See the table of normals below.)

In the same way the sum of the products of column No. 2 times column No. 3 is determined for the second normal, and by continuing the process all of the normals are formed.

After the C's are determined by the solution of the normals the v's are most conveniently computed by multiplying column No. 1 in the correlates by C_1 , column No. 2 by C_2 , column No. 3 by C_3 , and column No. 4 by C_4 . Then the algebraic sum of line No. 1 gives v_1 ; of No. 2, v_2 , etc. (See the computation of the v's on p. 19.)

	1	2	3	4	2	v's *	Adopted v's	v^2
1 2 3 4	-1 + 1 - 1	$^{-1}_{+1}$	-1	-2.03 -3.35 +5.38 +4.19	$ \begin{array}{r} -3.03 \\ -3.35 \\ +6.38 \\ +2.19 \end{array} $	-0.503 +1.004 -0.501 -0.227	-0.5 +1.0 -0.5 -0.2	0. 25 1. 00 0. 25 0. 04
5 6 7 8	+1	$^{-1}_{+1}$	+1 -1	-9.72 +5.53 +2.37 -3.50	-8.72 + 6.53 + 0.37 - 3.50	-0.015 +0.242 +0.663 -0.493	$-0.0 \\ +0.3 \\ +0.7 \\ -0.5$	0.00 0.09 0.49 0.25
9 10 11 12	+1	-1 +1	$^{+1}_{-1}_{+1}$	+1.13	$+3.13 \\ -1 \\ -1 \\ +2$	-0.170 +0.099 +0.740 -0.840	-0.2 +0.1 +0.7 -0.8	0.04 0.01 0.49 0.64
							Σv^2	3. 55

Correlate equations

Normal equations

1	2	3	4	η	Σ	<i>C</i> 's*
+6	$^{-2}_{+6}$	$^{+2}_{+2}_{+6}$	+ 4. 65 + 2. 86 - 15. 15 +206. 0470	$-2.3 \\ +3.6 \\ +2.2 \\ +1.4$	${}^{+ 8.35}_{+ 12.46}_{- 2.95}_{+ 199.8070}$	$\begin{array}{r} +0.\ 6547 \\ -0.\ 0994 \\ -0.\ 7401 \\ -0.\ 07461 \end{array}$

* These values result from the computation on p. 19.

Probable error of an observed direction = $\pm 0.6745 \sqrt{\frac{3.55}{4}} = \pm 0.6$.

1	2	3	4	η	5
$^{+6}_{C_1}$	-2 +0.33333	$^{+2}_{-0.33333}$	+ 4.65 - 0.775	-2.3 +0.38333	+ 8.35 - 1.39167
1	$+6 \\ -0.6667$	+2 + 0.6667	+ 2.86 + 1.55	$+3.6 \\ -0.7667$	+ 12.46 + 2.7833
	+5.3333 C_2	+2.6667 -0.50001	+ 4.41 - 0.82688	$+2.8333 \\ -0.53125$	+ 15.2433 - 2.85814
	1 2	+6 -0.6667 -1.3333	$\begin{array}{rrrr} - & 15.15 \\ - & 1.55 \\ - & 2.205 \end{array}$	+2.2 +0.7667 -1.4167	$\begin{array}{rrrr} - & 2.95 \\ - & 2.7833 \\ - & 7.6217 \end{array}$
		+4 C8	- 18.905 + 4.72625	+1.55 -0.3875	- 13.355 + 3.33875
		1 2 3	$\begin{array}{r} +206.0470 \\ - 3.6038 \\ - 3.6465 \\ - 89.3498 \end{array}$	+1.4 +1.7825 -2.3428 +7.3257	$\begin{array}{r} +199.8070 \\ - 6.4712 \\ - 12.6044 \\ - 63.1191 \end{array}$
			+109.4469 C4	$+8.1654 \\ -0.07461$	+117.6123 - 1.07461

Solution of normal equations

Back solution

4	3	2	1
0. 07461 0. 07461	-0.3875 -0.3526 -0.7401	-0.5312+0.0617+0.3701-0.0994	+0.3833 +0.0578 +0.2467 -0.0331 +0.6547

Computation of corrections

$ \begin{array}{r} 1 \\ \hline -0.6547 \\ +0.1515 \\ \hline -0.5032 \\ -0.5 \\ \end{array} $	$\begin{array}{r} 2 \\ \hline +0.6547 \\ +0.0994 \\ +0.2499 \\ \hline +1.0040 \\ +1.0 \end{array}$	$ \begin{array}{r} 3 \\ \hline -0.0994 \\ -0.4014 \\ \hline -0.5008 \\ -0.5 \\ \end{array} $	$\begin{array}{r} 4 \\ \hline -0.6547 \\ +0.7401 \\ -0.3126 \\ \hline -0.2272 \\ -0.2 \end{array}$	$5 \\ -0.7401 \\ +0.7252 \\ -0.0149 \\ -0.0$	$ \begin{array}{r} $
7 +0.0994 +0.7401 -0.1768 +0.6627 +0.7	8 -0.6547 -0.0994 +0.2611 -0.4930 -0.5	9 +0,6547 -0,7401 -0,0843 -0,1697 -0,2	10 +0.0994 +0.0994 +0.1	11 +0.7401 +0.7401 +0.7	12 -0,0994 -0,7401 -0,8395 -0,8

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ADJUSTMENT OF A QUADRILATERAL BY THE USE OF TWO ANGLE AND TWO SIDE EQUATIONS *

(See fig. 1 on p. 16.)

Angle equations

$$0 = -2.3 - (1) + (2) - (4) + (6) - (8) + (9)$$

$$0 = +3.6 - (2) + (3) - (7) + (8) - (10) + (12)$$

Side equations

Symbol	Angle	Logarithm	Tabular differ- ence	Symbol	Angle	igle Logarithm	
-7+9 -5+6 -2+3	61 47 35.0 20 50 56.7 32 09 01.2	9. 9450972 9. 5513374 9. 7260280 9. 2224626	+1.13 +5.53 +3.35	-4+5 -1+3 -7+8	26 40 23.5 133 53 46.3 31 03 42.5	9. 6521506 9. 8576926 9. 7126180 9. 2224612	+4.19 -2.03 +3.50

0 = +1.4 - 2.03(1) - 3.35(2) + 5.38(3) + 4.19(4) - 9.72(5) + 5.53(6) + 2.37(7) - 3.50(8)+1.13(9)

$ \begin{array}{r} -2+3\\ -11+12\\ -8+9\\ -5+6 \end{array} $	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	9. 7260280 9. 9998442 9. 7084309 9. 5513374	$+3.35 \\ -0.06 \\ +3.54 \\ +5.53$	$ \begin{array}{r} -7+8\\ -4+5\\ -1+2\\ -10+11 \end{array} $	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	9.7126180 9.6521506 9.9908094 9.6300613	+3.50 +4.19 -0.44 +4.46
		8.9856405				8. 9856393	

0 = +1.2 - 0.44(1) - 2.91(2) + 3.35(3) + 4.19(4) - 9.72(5) + 5.53(6) + 3.50(7) - 7.04(8)+3.54(9)+4.46(10)-4.40(11)-0.06(12)

Correlate equations

1.5.	1	2	3	4	Σ.	v's†	Adopted v's
1 2 3 4	-1 + 1 - 1	$^{-1}_{+1}$	$-2.03 \\ -3.35 \\ +5.38 \\ +4.19$	-0.44-2.91+3.35+4.19	$ \begin{array}{r} - 3.47 \\ - 6.26 \\ + 9.73 \\ + 7.38 \\ \end{array} $	$-0.495 \\ +0.996 \\ -0.502 \\ -0.227$	-0.5 +1.0 -0.5 -0.2
5 6 7 8	+1 -1	$^{-1}_{+1}$	$\begin{array}{r} -9.72 \\ +5.53 \\ +2.37 \\ -3.50 \end{array}$	$\begin{array}{r} -9.72 \\ +5.53 \\ +3.50 \\ -7.04 \end{array}$	-19.44+12.06+ 4.87-10.54	$\begin{array}{r} -0.013 \\ +0.240 \\ +0.659 \\ -0.500 \end{array}$	-0.0+0.3+0.7-0.5
9 10 11 12	+1	-1 +1	+1.13	+3.54 +4.46 -4.40 -0.06	$\begin{array}{r} + 5.67 \\ + 3.46 \\ - 4.40 \\ + 0.94 \end{array}$	$\begin{array}{r} -0.159 \\ +0.113 \\ +0.717 \\ -0.830 \end{array}$	-0.2+0.1+0.7-0.8

Normal equations

	1	2	3	4	η	Σ	C's*
1 2 3 4	+6	-2 + 6	+ 4.65 + 2.86 +206.0470	$\begin{array}{r} + & 9.45 \\ - & 8.80 \\ + 208.2153 \\ + 276.0980 \end{array}$	$-2.3 \\ +3.6 \\ +1.4 \\ +1.2$	+ 15. 80 + 1. 66 +423. 1723 +486. 1633	$\begin{array}{r} +0.2328 \\ -0.8398 \\ +0.16435 \\ -0.16302 \end{array}$

* For triangles, see p. 23 † These values result from the computation on p. 21.

APPLICATION OF LEAST SQUARES TO TRIANGULATION.

1	2	3	4	η	Σ
$^{+6}_{C_1}$	-2 +0. 33333	+ 4.65 - 0.775	+ 9.45 - 1.575	-2.3 +0.38333	+ 15. 80 - 2. 63333
1	$+6 \\ -0.6667$	+ 2.86 + 1.55	- 8.80 + 3.15	+3.6 -0.7667	+ 1.66 + 5.2667
7	+5.3333 C_2	+ 4.41 - 0.82688	- 5.65 + 1.05938	+2.8333 -0.53125	+ 6.9266 - 1.29875
	1 2	$\begin{array}{r} +206.\ 0470 \\ -3.\ 6038 \\ -3.\ 6465 \end{array}$	$\begin{array}{r} +208.\ 2153 \\ -\ 7.\ 3238 \\ +\ 4.\ 6719 \end{array}$	+1.4 +1.7825 -2.3428	$\begin{array}{r} +423.1723 \\ -12.2450 \\ -5.7275 \end{array}$
		$+ 198.7967 \\ C_3$	+205.5634 - 1.034038	+0.8397 -0.004224	+405.1998 - 2.038262
		1 2 3	+276.0980 - 14.8838 - 5.9855 -212.5604	+1. 2 +3. 6225 +3. 0015 -0. 8683	$\begin{array}{r} +486.1633 \\ -24.8850 \\ +7.3379 \\ -418.9920 \end{array}$
			+ 42.6683 C4	+6.9557 -0.16302	$+ 49.6240 \\ - 1.16302$

Solution of normal equations

Back solution

4 0. 16302 0. 16302	3 -0.00422 +0.16857 +0.16435	2 -0.5312 -0.1727 -0.1359 -0.8398	1 +0.3833 +0.2568 -0.1274 -0.2799 +0.2328

Computation of corrections

$ \begin{array}{r} 1 \\ -0,2328 \\ -0,3336 \\ +0.0717 \\ -0.4947 \\ -0.5 \\ \end{array} $	$\begin{array}{r} 2 \\ +0.2328 \\ +0.8398 \\ -0.5506 \\ +0.4744 \\ \hline +0.9964 \\ +1.0 \end{array}$	3 -0.8398 +0.8842 -0.5461 -0.5017 -0.5	4 -0.2328 +0.6886 -0.6831 -0.2273 -0.2	$5 \\ -1.5975 \\ +1.5846 \\ -0.0129 \\ -0.0$	6 +0. 2328 +0. 9089 -0. 9015 +0. 2403 +0. 3	
7 +0. 8398 +0. 3895 -0. 5706 +0. 6587 +0. 7	8 -0, 2328 -0, 8398 -0, 5752 +1, 1477 -0, 5001 -0, 5	9 +0.2328 +0.1857 -0.5771 -0.1586 -0.2	10 +0. 8398 -0. 7271 +0. 1127 +0. 1	11 +0.7173 +0.7173 +0.7	12 -0. \$398 +0. 0098 -0. \$300 -0. \$	

SOLUTION OF A SET OF NORMALS INCLUDING TERMS USUALLY OMITTED

A set of four normal equations is solved below with inclusion of the terms omitted in the Doolittle method of solution.

1	2	3	4	η	Σ
$^{+6}_{-1 C_1}$	6 -2 +0.33333	$^{+2}_{-0.33333}$	+ 4.65 - 0.775	-2.3 + 0.38333	+ 8.35 - 1.39167
-2 + 2 (1)	$+6 \\ -0.6667$	+ 2 + 0.6667	+ 2.86 + 1.55	$+3.6 \\ -0.7667$	+ 12.46 + 2.7833
	+5.3333 -1 C ₂	+ 2.6667 - 0.50001	$+ 4.41 \\ - 0.82688$	$^{+2.8333}_{-0.53125}$	+ 15.2433 - 2.85814
$+2 \\ -2$	+2 +0.6667 (1) -2.6667 (2)	+ 6 - 0.6667 - 1.3333	$\begin{array}{rrrr} -&15.15\\ -&1.55\\ -&2.205\end{array}$	+2.2 +0.7667 -1.4167	$\begin{array}{rrrr} - & 2.95 \\ - & 2.7833 \\ - & 7.6217 \end{array}$
		$^{+ 4}_{- 1 C_3}$	- 18.905 + 4.72625	$^{+1.55}_{-0.3875}$	-13.355 + 3.33875
+4.65 -4.65	+2.86 +1.55 -4.41	$\begin{array}{r} -15.15 \\ -1.55 (1) \\ -2.205 (2) \\ +18.905 (3) \end{array}$	$\begin{array}{r} +206.0470 \\ - 3.6038 \\ - 3.6465 \\ - 89.3498 \end{array}$	+1.4+1.7825-2.3428+7.3257	$\begin{array}{r} +199.8070 \\ - 6.4712 \\ - 12.6044 \\ - 63.1191 \end{array}$
			+109.4469 - 1 C4	$+8.1654 \\ -0.07461$	+117.6123 - 1.07461 '

Solution of normals

DISCUSSION OF THE SOLUTION

The quantities in heavy type are the ones omitted in the Doolittle method of solution of normal equations. They sum up to zero with the possible variation of a few units in the last place of the solution. This shows that the method is one of curtailed substitution. It can also be seen that the quantity in the Σ column is the direct sum of all the quantities in each horizontal line including those in heavy type. All of the quantities in heavy type occur in the regular solution. This is of value in the control of the solution. If an equation fails to check the Σ column after it is added up, the error can generally be located by adding back through noting that the coefficient is changed in sign because it is multiplied by -1. Note the product of equation No. 1 on No. 4; -1.55 and +1.55 are the products of No. 1 on No. 3 and No. 2, respectively; -4.65 is the coefficient of No. 4 on No. 1 with sign changed. The method is the same in all cases. Care should be taken with such coefficients as No. 2 and No. 3 on No. 1. They have the same value with opposite sign. If a mistake should be made on them the Σ column control would not catch it. Care should be taken not to make a mistake in the η column and a compensating one in the Σ column. There is most danger of this in the addition. The control would not catch this and it would take much labor to correct it later.

After each equation is added, it should be added horizontally to check the Σ column. If the check fails an error has been made and it must be found before proceeding. A slight variation in the last place of the solution is of course unavoidable. After the division of each equation by the reduced diagonal term, a horizontal addition should be made (including, of course, -1) to check the correctness of the division. No time is ever lost in using care in the solution of the equations. It takes so much time and labor to rectify a mistake later that every means should be employed to detect and correct it in the solution. The larger the set, the more important it is to be on guard against errors. It is possible to carry a set through with almost absolute assurance that the solution is correct.

If, in a given equation, the solution fails to check and the check of adding back through is satisfied, a mistake has been made somewhere in the solution columns and a compensating mistake in the Σ column. This can be caught by building up the omitted columns to the left of the given equation. They should each sum up to zero. If any one does not, the mistake in addition has been made in that equation in the column of the one being eliminated.

Symbol	Station	Observed angle	Correction	Spheri- cal angle	Spherical excess	Plane angle	Logarithm
$ \begin{array}{r} -8+9 \\ -1+2 \\ -4+6 \end{array} $	$\begin{array}{c} A_2 - A_1 \\ A_3 \\ A_2 \\ A_1 \end{array}$	• / // 30 43 52.5 101 44 45.1 47 31 20.2	" +0.3 +1.5 +0.5	52. 8 46. 6 20. 7	0.0 0.1 0.0	" 52. 8 46. 5 20. 7	3. 772745 0. 291568 9. 990809 9. 867787
	$A_3 - A_1 \\ A_3 - A_2$		+2.3		0.1		4.055122 3.932100
-10+11 - 1+ 3 - 5+ 6	$\begin{array}{c}A_2-A_1\\A_4\\A_2\\A_1\\A_1\end{array}$	25 15 16.2 133 53 46.3 20 50 56.7	+0.6 +0.0 +0.3	16.8 46.3 57.0	0.0 0.1 0.0	$16.8 \\ 46 2 \\ 57.0$	3. 772745 0. 369936 9. 857693 9. 551339
	$\begin{array}{c}A_4-A_1\\A_4-A_2\end{array}$		+0.9		0.1		4.000374 3.694020
-10+12 -2+3 -7+8	$\begin{array}{c}A_2-A_3\\A_4\\A_2\\A_3\end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$-0.9 \\ -1.5 \\ -1.2$	19. 1 59. 7 41. 3	0.1 0.0 0.0	19.0 59.7 41.3	3. 932100 0. 049306 9. 726023 9. 712614
	$\begin{array}{c} A_4 - A_3 \\ A_4 - A_2 \end{array}$		-3.6		0.1		3. 707429 3. 694020
-11+12 - 4+ 5 - 7+ 9	$\begin{array}{c}A_1-A_3\\A_4\\A_1\\A_3\end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-1.5 + 0.2 - 0.9	02.3 23.7 34.1	0.1 0.0 0.0	02. 2 23. 7 34. 1	4.055122 0.000156 9.652151 9.945096
	$\begin{array}{c} A_4 - A_3 \\ A_4 - A_1 \end{array}$		-2.2		0.1		3. 707429 4. 000374

Solution of triangles *

* For the method of solution of triangles see United States Coast and Geodetic Survey Special Publication No. 8, p. 6.

Position computation,

I	1					1	1		
a Second	A_2 to A_1 A_1 and A_3	8				1.	• 56 01	20 44	" 26.6 46.6
α	A_2 to A_3					+2	58	05 8	13.2 05.9
α′	A3 to A2		First and	gle of triar	ıgle	1	80 78 30	00 13 43	00. 0 19. 1 52. 8
ф Дф	60 5 +	$ \begin{array}{c c} \bullet & & & \\ 60 & 56 & 01.089 & & \\ - & & 56.720 & & \\ \end{array} $			λ 4λ	149		34 9	19. 237 15. 880
ϕ'	60 50	6 57.809	A_3	- λ'		1.	49	25	03.357
$\frac{1}{2}(\phi+\phi')$	• / // 60 56 29	$\begin{array}{c} s\\ \cos \alpha\\ B\end{array}$	3.932100 9.314765 8.509299	${\sin^2 lpha \over C} lpha$	7.8 9.9 1.6	86420 98109 65750 D		$3.5122 \\ 2.3224$	
	//	h	1.756164		9.5	0279		5.8346	
2d and 3d terms	-57.0380 + 0.3184				0.3	183 001			-
$-\Delta\phi$	-56.7196						1		
	$ \begin{array}{c} s\\ \sin \alpha\\ A'\\ \sec \phi' \end{array} $	$\begin{array}{c} 3.\ 932100\\ 9.\ 990544\\ 8.\ 508600\\ 0.\ 313737\end{array}$	$\sin \frac{d\lambda}{2}(\phi+\phi')$	() 2.7 9.9	44981 41572				
		2.744981		2.6	2.686553				
-		"		1	/				
	Δλ		Δα	-48	5.89				1

STATION A3

STATION A4

, 0 11 13.2 59.7 A2 to A3 05 α 258 Second) + 32 08 As and As angle j A2 to A4 ă 290 -14 12.9 29.0 1α +4 180 110 116 00 18 47 00.0 41.9 19.1 α At to A2 First angle of triangle 0 , " $01.089 \\ 55.340$ 56 $\phi_{\Delta\phi}$ 60 A_2 149 34 19.237 07.795 $\lambda_{\Delta\lambda}$ 5 ϕ' 60 55 05.749 λ' 149 29 11.442 A_4 0 1 " $\begin{array}{c} \textbf{3. 694020} \\ \textbf{9. 538954} \\ \textbf{8. 509299} \end{array}$ 8 s^2 7.38804 60 55 33 $\cos \alpha$ $9.94466 \\ 1.65750$ $\frac{1}{2}(\phi + \phi')$ $\sin^2 \alpha$ h^2 $3.484 \\ 2.322$ B C D ... 1st term +55.2425h 1.742273 8.99020 5.806 2d and 3d) + 0.0979terms 0.0978 +55.3404-46 1 $\begin{array}{c} 3.\ 694020\\ 9.\ 972328\\ 8.\ 508601 \end{array}$ 8 $\sin \alpha$ A' 2.488262 11 $\sec \phi'$ 0.313313 $\sin \frac{1}{2}(\phi + \phi')$ 9.941507 2.488262 2.429769 11 11 -307.7953 -269.0112 -10

* For an explanation of the forms for computing differences of latitude, longitude, and azimuth see United States Coast and Geodetic Survey Special Publication No. 8, pp. 6-11.

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secondary triangulation *

STATION A3



STATION A4

α Third angle α Δα	$A_3 \text{ to } A_2$ $A_4 \text{ and } A$ $A_3 \text{ to } A_4$ $A_4 \text{ to } A_3$	2				$ \begin{array}{r} & \circ \\ & 78 \\ - & 31 \\ \hline \\ & 47 \\ - \\ \hline \\ & 180 \\ 227 \\ \end{array} $, 13 03 09 3 00 06	" 19. 1 41. 3 37. 8 36. 8 00. 0 01. 0
ф 4ф	<u>60</u>	56 57.809 1 52.060		A.8	λ Δλ	149 +	25 4	03.357 08.086
¢'	60 5	55 05.749		4.	\lambda'	149	29	11.443 - 1
¹ ₂ (φ+φ')	° / // 60 56 0: //	$2 \begin{array}{c} 8 \\ \cos \alpha \\ B \end{array}$	3. 707429 9. 832475 8. 509298	sin² a	7.4 9.7 1.6	1486 3052 h ² 5808 D	4.098 2.322	
1st term 2d and 3d)	+111.995	9 h	2.049202		8.8	0346	6. 420	
terms j — Jø	+112.059	8			0.0	636 3	1	
-	$sin \alpha A' sec \phi'$	$\begin{array}{r} 3.\ 707429\\ 9.\ 865259\\ 8.\ 508601\\ 0.\ 313313\\ \hline 2.\ 394602 \end{array}$	$\sin \frac{d\lambda}{2}(\phi+\phi')$	2.394602 9.941540 2.336142				
	Δλ	" +248.0858	-⊿α	/' +216.84				

Station	Lat	titu ongi	de and tude	Seconds in meters	А	zim	uth	Back azimuth		Back azimuth		Back azimuth		Distance	Logarithm
A 3	° 60 149	, 56 25	77.809 03.357	$1789.4 \\ 50.5$	° 78 108	, 13 57	" 19.1 11.9	·• 258 288	, 05 46	'' 13.2 47.7	A_2 A_1	<i>Meters</i> 8552. 6 11353. 3	$3.932100 \\ 4.055122$		
A4	60 149	55 29	05.749 11.442	177.9 172.4	$110 \\ 135 \\ 227$	18 33 06	41.9 58.7 01.0	$290 \\ 315 \\ 47$	14 27 09	12.9 11.4 •37.8	$\begin{array}{c}A_2\\A_1\\A_3\end{array}$	$\begin{array}{r} 4943.3\\ 10008.6\\ 5098.3 \end{array}$	3. 694020 4. 000374 3. 707429		

List of geographic positions, Turnagain Arm, Alaska. Valdez datum

DEVELOPMENT OF CONDITION EQUATIONS FOR LATITUDE AND LONGITUDE CLOSURES

After the conditions arising from the closure of triangles and from the equality of sides or lengths computed by different routes have been satisfied, cases frequently arise where azimuth, latitude, and longitude conditions must be satisfied. There is given now a development of a form of condition equations that will bring about a closure in geographic position.

Discrepancies in latitude and longitude arise whenever a chain of triangulation or a traverse closes on itself. The discrepancies may be distributed throughout the whole loop or in a selected portion of it, depending upon the circumstances. Of course the most rigid adjustment would require the discrepancies to be distributed throughout the whole chain. At times, however, this would require more labor than the importance of the work would justify. Also some parts of the loop may be much better determined than other parts, in which case the more poorly determined part should be required to make up the discrepancies.

The discussion of the form of equations to be employed to effect the closure without discrepancies will be based upon the position computation formulæ employed by the United States Coast and Geodetic Survey. (See United States Coast and Geodetic Survey Special Publication No. 8, p. 8.)

The amount to be distributed being, of course, small compared with the total change in latitude and longitude, the only term of the latitude computation formula that need be considered is the first one. No appreciable changes due to the adjustment will take place in the other terms.

The formation of the equations must always start from a line fixed in length and azimuth. If a scheme of triangulation should start from a fixed line and run to two points which are fixed in position but are not the ends of a single line, then the formation of the equations for each of the two points must start from the fixed line.

There are, of course, two elements that enter into the determination of the position of any point as computed from a known point; these are the distance from the known point and the azimuth of the line from the known to the unknown point.

In the triangle 1 2 3, let 1 and 2 be fixed in position, and let us consider what change in the position of 3 will be produced by small changes in angles A, B, and C. The length to be carried forward is 1 to 3. Starting with the length 1 to 2, we have log 1 to $3 = \log 1$ to $2 - \log \sin B + \log \sin A$. The change in length, then, depends upon the changes in angles A and B and the change in azimuth of the line 1 to 3 depends upon the change in angle C. The angles A and B, therefore, are called the length angles and angle C the azimuth angle.

If we can derive a linear expression for the effect of each of these separately, the total effect will be the sum of the two.

Let ∂_A and ∂_B represent the change of the log sin for a change of one second in the angles A and B; v_A and v_B the number of seconds change in angles A and B, respectively. Then the change in log sin

A will equal $\delta_{\rm A}(v_{\rm A})$, and the change in log sin B will equal $\delta_{\rm B}(v_{\rm B})$; therefore, the change in log 1 to 3 is $+\delta_{\rm A}(v_{\rm A}) - \delta_{\rm B}(v_{\rm B})$. The change in the logarithm of the first term of the latitude due to the change in length is equal to $+\delta_{\rm A}(v_{\rm A}) - \delta_{\rm B}(v_{\rm B})$. This is the change in the logarithm, but for convenience of computation it is better to determine what change in the antilogarithm will be produced by this change; or, in other words, to determine what this logarithmic



change will amount to in seconds of arc. From the nature of logarithms, if we know the number to which a given logarithm corresponds, the change in the number due to any *small* change in the logarithm can be found by multiplying the logarithm change by the number and dividing by M (the modulus of the common system of logarithms). This can also be shown by differentiation:

Let
$$y = \log_{10} x$$

 $dy = M \frac{dx}{x}$

Therefore $dx = \frac{x}{M} dy$, dy being the small change in the log and dx the corresponding small change in the number.

 $+\delta_{A}(v_{A}) - \delta_{B}(v_{B})$ must then be multiplied by $(\phi_{B} - \phi_{c})$, (in which ϕ_{B} is the computed latitude of 3 and ϕ_{c} is the latitude of 1), and the product divided by M; this will give the change in seconds in the latitude of 3 due to the change in length of 1 to 3.

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Next must be considered the change in latitude due to the change in the azimuth angle C. If s is the length in meters of 1 to 3, the length of the small arc through which 3 turns is equal to $s(v_c)$ arc 1" (as $ds = rd\theta$ for a circle about the origin in polar coordinates), v_c



equals the number of seconds change in angle *C*, and arc 1" is included to reduce this angle to circular measure.

Let 3 be the original position of 3 and 3' the position due to a small rotation of 1 to 3 about 1.

3 to $3' = sv_c$ arc 1''

Fig. 3. The azimuth of 3 to 3' is 90° $+ \alpha$. The change in latitude due to $s(v_c)$ arc 1'' is equal to $-s(v_c)$ arc 1'' cos (90° $+ \alpha$) times the *B* factor in the position computation,

 $= +s(v_{\rm c}) \operatorname{arc} 1^{\prime\prime} \sin \alpha B$

 $= + (v_c) \operatorname{arc} 1^{\prime\prime} Bs \sin \alpha$

But $\lambda_{\rm B} - \lambda_{\rm C} = s \sin \alpha A' \sec \phi'$ Therefore $s \sin \alpha = \frac{\lambda_{\rm B} - \lambda_{\rm C}}{A' \sec \phi'}$

Therefore the change in latitude = $\frac{B \operatorname{arc} 1^{\prime\prime}}{A^{\prime} \sec \phi^{\prime}} (\lambda_{\scriptscriptstyle B} - \lambda_{\scriptscriptstyle C}) (v_{\scriptscriptstyle C}).$

In a similar way the change in longitude due to a change in length is,

$$\frac{\lambda_{\rm B}-\lambda_{\rm C}}{M} \bigg[+ \delta_{\rm A}(v_{\rm A}) - \delta_{\rm B}(v_{\rm B}) \bigg]$$

and the change in longitude due to the change in azimuth is, $s(v_c) \operatorname{arc} 1^{\prime\prime} \sin (90^\circ + \alpha) A^{\prime} \sec \phi^{\prime} = + (v_c) \operatorname{arc} 1^{\prime\prime} s \cos \alpha A^{\prime} \sec \phi^{\prime}$ $-s \cos \alpha B = \phi_B - \phi_c \text{ (neglecting the small terms)}$

$$s \cos \alpha = -\frac{\phi_{\rm B} - \phi_{\rm C}}{B}$$

Therefore change in longitude = $-\frac{A' \sec \phi' \operatorname{arc} 1''}{B} (\phi_{\rm B} - \phi_{\rm c})(v_{\rm c}).$

The usage is to point off the log change for one second of arc as an integer in the sixth place of logarithms; therefore as a number the tabular difference $=\frac{\partial_A}{10^6}$ and $\frac{\partial_B}{10^6}$.

The total change in seconds of latitude in the triangle is

$$\frac{(\phi_{\rm B} - \phi_{\rm C})}{10^6 M} \left[+ \delta_{\rm A}(v_{\rm A}) - \delta_{\rm B}(v_{\rm B}) \right] \pm \frac{B \operatorname{arc} 1^{\prime\prime}}{A^{\prime} \operatorname{sec} \phi^{\prime}} \ (\lambda_{\rm B} - \lambda_{\rm C})(v_{\rm C}).*$$

The total change in longitude is,

$$\frac{(\lambda_{\rm B}-\lambda_{\rm C})}{10^6} \left[+ \delta_{\rm A}(v_{\rm A}) - \delta_{\rm B}(v_{\rm B}) \right] \mp \frac{A' \sec \phi' \ {\rm arc} \ 1''}{B} \ (\phi_{\rm B} - \phi_{\rm C})(v_{\rm C}).*$$

^{*} The upper sign being used for a right azimuth angle, the lower sign for a left.

In this way the change could be determined for each triangle in the chain and the sum placed equal to the discrepancy, but this would require a very great amount of work.

If any change takes place in the first triangle while the remaining triangles are for the moment supposed to remain fixed, this length change and azimuth change will affect not only this triangle, but will persist in each succeeding triangle. As a consequence the change of length and azimuth in the first triangle will be felt in the computation of every point after it in the chain. Let ϕ_n and λ_n be the computed ϕ and λ of the end point. The change in the first triangle will apply not merely to $\phi_{\rm B} - \phi_{\rm c}$, etc., but to $\phi_n - \phi_{\rm c}$, etc.

Therefore the change in the final position due to the changes in the first triangle is, for latitude,

$$\frac{(\phi_n - \phi_c}{10^6 M} \left[+ \delta_A(v_A) - \delta_B(v_B) \right] \pm \frac{B_c \operatorname{arc} 1^{\prime\prime}}{A_n \operatorname{sec} \phi_n} (\lambda_n - \lambda_c) (v_c),^*$$

and for longitude,

$$\frac{(\lambda_n - \lambda_c)}{10^6 M} \left[+ \delta_{\rm A}(v_{\rm A}) - \delta_{\rm B}(v_{\rm B}) \right] \mp \frac{A_n \sec \phi_n \operatorname{arc} 1^{\prime\prime}}{B_c} (\phi_n - \phi_c) (v_c).$$

In the same way the change in the final position due to changes in the second triangle can be determined, and so on through the whole chain. Each triangle will have an A, B, and C angle, Abeing the length angle next to the known side; B, the one opposite the known side; and C, the azimuth angle.

The equations will finally stand

$$0 = + (\phi_n - \phi_{n'}) + \Sigma \left[\frac{(\phi_n - \phi_c)}{10^8 M} \delta_A(v_A) - \frac{(\phi_n - \phi_c)}{10^8 M} \delta_B(v_B) \right] \\ + \Sigma \pm \frac{B_c \operatorname{arc} 1''}{A_n \operatorname{sec} \phi_n} (\lambda_n - \lambda_c) (v_c).* \\ 0 = + (\lambda_n - \lambda_{n'}) + \Sigma \left[\frac{\lambda_n - \lambda_c}{10^6 M} \delta_A(v_A) - \frac{\lambda_n - \lambda_c}{10^6 M} \delta_B(v_B) \right] \\ + \Sigma \mp \frac{A_n \operatorname{sec} \phi_n \operatorname{arc} 1''}{B_c} (\phi_n - \phi_c)(v_c).*$$

 ϕ_n is the computed latitude of the final point and $\phi_{n'}$, the fixed latitude; so also for λ_n and $\lambda_{n'}$.

It is exact enough to take $\phi_n - \phi_c$ and $\lambda_n - \lambda_c$ to minutes and tenths of a minute, so that it is advisable to divide the equations by 60 since, as they stand, $\phi_n - \phi_c$, etc., are in seconds. Also it is best to multiply through by 10⁶ M to remove this factor from the denominator of the first summation.

* Upper sign for right azimuth angle, lower for left.

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Then we have

$$\begin{split} 0 &= +\frac{M}{60} \ 10^{6}(\phi_{n}-\phi_{n'})^{\prime\prime} + \mathcal{E}[(\phi_{n}-\phi_{c})^{\prime} \ \delta_{A}(v_{A}) - (\phi_{n}-\phi_{c})^{\prime} \ \delta_{B}(v_{B})] \\ &+ \mathcal{E} \pm \ 10^{6} \ M \frac{B_{c} \ \operatorname{arc} \ 1^{\prime\prime}}{A_{n} \ \operatorname{sec} \ \phi_{n}} \ (\lambda_{n}-\lambda_{c})^{\prime} \ (v_{c}). \ * \\ 0 &= +\frac{M}{60} \ 10^{6} \ (\lambda_{n}-\lambda_{n'})^{\prime\prime} + \mathcal{E}[(\lambda_{n}-\lambda_{c})^{\prime} \ \delta_{A}(v_{A}) - (\lambda_{n}-\lambda_{c})^{\prime} \ \delta_{B}(v_{B})] \\ &+ \mathcal{E} \mp \ 10^{6} \ M \frac{A_{n} \ \operatorname{sec} \ \phi_{n} \ \operatorname{arc} \ 1^{\prime\prime}}{B_{c}} \ (\phi_{n}-\phi_{c})^{\prime}(v_{c}). \ * \end{split}$$

The A and B factors change so slowly that for any chain they can be taken for the mean ϕ and also sec ϕ_n can be used in the same way. A table can then be prepared for functions designated as a_1 and a_2 and defined as follows:

$$a_1 = +10^6 M \frac{B \operatorname{arc} 1^{\prime\prime}}{A \sec \phi}$$
$$a_2 = -10^6 M \frac{A \sec \phi \operatorname{arc} 1^{\prime\prime}}{B},$$

the A and B factors and the ϕ being used at a convenient interval. A table has been computed for latitudes starting at 24° for intervals of 4° up to 56°. The minus sign is used with a_2 in order that the same sign can be used on the directions of the azimuth angle for both latitude and longitude equations. If the discrepancy to be made up by the adjustment is large, or if the chain extends over a great distance of latitude, it would be best to compute the values of a_1 and a_2 using A_n and ϕ_n and the B for the mean ϕ .

If the chain to be adjusted extends principally east and west, in place of $\phi_n - \phi_c$ a summation of the first terms (h) in the position computations should be used. $\Sigma_n^c h$ would then replace $\phi_n - \phi_c$, the sign being used that would conform to $\phi_n - \phi_c$. These quantities should then be used throughout in forming the equations.

If the latitude and longitude equations are to be included in the main adjustment and the equations all solved simultaneously, the computation of the positions through the chain must be made with one length carried through the figures by means of the observed plane angles; that is, the angles as observed each diminished by $\frac{1}{3}$ of the spherical excess of the triangle. This could be done by carrying the length through a selected chain of triangles and then computing each of the various positions over a single line. Both lines of the triangle could not be used because the observed plane angles must be used in carrying the length and, under ordinary circumstances, the triangle would not be closed. To obviate this difficulty, it is best to use only the observed A and B angles and to conclude the C angle, using, of course, the concluded correction symbols on this

angle. This method gives a much more reliable determination of the discrepancy, as it furnishes a check on each position, and thus prevents a mistake being left in the computation. If the figure adjustment is carried out first, there is no need to follow this method as the triangles would then be closed. In this case it is the general custom of the United States Coast and Geodetic Survey to choose the best chain of triangles and to form the equations through them, using the angle method in place of the direction method. Equations with absolute terms equal to zero must be included for the various triangles in order to hold them closed; also, if a length equation is included in the figure adjustment, it must be retained with zero discrepancy to hold the length. If the figure ends on a fixed line and a length equation is not put in the figure adjustment, the discrepancy must be put on the length equation used with the latitude and longitude equations. After adjustment is made for these final discrepancies the cross lines are computed by two sides and the included angle.

The best results are probably obtained by the solution of all the equations at once, but this entails so much work that the angle method is often used in chains of minor importance.

We have finally:

$$\frac{M}{60}$$
 10⁶ = 7238.24

$$0 = +7238.24(\phi_n - \phi_{n'})'' + \Sigma[(\phi_n - \phi_c)'\delta_{\mathbb{A}}(v_{\mathbb{A}}) - (\phi_n - \phi_c)'\delta_{\mathbb{B}}(v_{\mathbb{B}})] + \Sigma \pm a_1(\lambda_n - \lambda_c)'(v_c).$$

$$0 = +7238.24(\lambda_n - \lambda_{n'})'' + \Sigma[(\lambda_n - \lambda_c)'\delta_{\mathbb{A}}(v_{\mathbb{A}})]$$

 $-(\lambda_n-\lambda_{\rm c})'\delta_{\rm B}(v_{\rm B})]+\Sigma\pm a_2(\phi_n-\phi_{\rm c})'(v_{\rm c}).$

In the equations $v_{\rm A}$, $v_{\rm B}$, and $v_{\rm c}$ would be replaced by their correction symbols, care being taken to use $v_{\rm c} = -v_{\rm A} - v_{\rm B}$, if the azimuth angle has been concluded in carrying the position computation through the chain.

If an azimuth equation occurs, the constant term must be corrected by $+(\lambda_n - \lambda_{n'}) \times \text{sine}$ of the mean ϕ , this being the amount that the azimuth will change from the changes in the back azimuths due to the changes in longitude.

It should be noted that whenever a discrepancy of position is adjusted into a section of a loop, an external condition is placed upon the chain, as at best only part of this discrepancy is due to errors in the chain, the rest being due to the remainder of the loop. It is necessary to hold some parts of the triangulation fixed; otherwise when a loop closure is put in it would frequently be necessary to readjust nearly all of the triangulation of the country. The result is, however, that some chains of triangulation, excellent in themselves, get some rather large corrections due to the position closure.

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EQUATIONS IN A NET

In the adjustment of a quadrilateral, use is made of the two kinds of condition equations that are necessary for the adjustment of any figure that does not contain external conditions such as length, azimuth, or loop closure. In fact most figures can be broken up into successive quadrilaterals. In forming the length equation, use is made of the two length angles in the various triangles passed through. In fig. 5, on page 37, the length angles are lettered A and B. The angle omitted is the azimuth angle of the given triangle. The log sin of the A angle is added to the first length and the log sin of the B angle to the final length. So with all of the triangles through which the length is carried. The discrepancy is found and the equation formed in the same way as in the case of an ordinary side equation. See the formation of the length equation on page 37. If the spherical angles are used a correction for arc to sine must be applied to each length. (See the table of these corrections in Special Publication No. 8, p. 17.)

An azimuth equation is formed by adding algebraically to the first azimuth the various azimuth angles up to the second line fixed in azimuth. When passing from one end of a line to another, the azimuth difference due to convergence of the meridians, must be applied as determined in the computation of positions. The algebraic sum of the v's upon these angles must make up the discrepancy between the computed and fixed azimuths. See the computation on page 38.

The determination of the exact number of side and angle equations in a net and the manner in which they come in, is one of the difficulties encountered by a beginner in the adjustment of triangulation. This is especially true if the net is somewhat complicated. The best method for this determination is to plot the figure point by point. By plotting the triangle Tower, Turn, and Dundas, in the figure on page 34 one angle equation is determined. Add Lazaro by the lines Lazaro to Turn and Lazaro to Tower. This gives another angle equation, making two. Another angle equation and a side equation are obtained by putting in the line Lazaro to Dundas. This makes a total of three angle equations and one side equation for the quadrilateral, just as it should be. Next plot Nichols by the lines Nichols to Lazaro and Nichols to Tower; this is a closed triangle and gives a fourth angle equation. Put in Tow Hill by the lines Tow Hill to Nichols and Tow Hill to Lazaro; this does not give an angle equation as it is not a closed triangle. Draw the line Tow Hill to Tower; this gives a second side equation. In this way one can continue through the whole figure. If a full line Nichols to Turn were in the figure, it would give another angle and another side

equation. The angle equation added would have to include the directions on this line as would also the side equation. This method shows at once where the equations come in and what new v's must appear in the equations.

Lines sighted over in only one direction have no effect on the number of angle equations. If the closed part of the figure is plotted, omitting all of the extra lines—that is, putting in each station with only two lines from those already plotted, a closed framework of the figure will be formed. The first triangle requires three lines, those after the first require two lines. The number of angle equations in the framework of the figure is thus equal to the number of lines in the figure minus the number of stations plus one. Every full line added to this framework gives another angle equation. Therefore, the whole number of angle equations in a net is equal to the whole number of full lines minus the number of occupied stations plus one.

The lines sighted over in one direction have the same effect on the number of side equations that the full lines have. If the full framework of the figure is plotted with two lines to each station from those already determined, no side equation will as yet appear in the figure. Every extra line put in gives a side equation. The first triangle fixes three stations; the stations after these require two lines to be used in plotting them. Thus the number of lines needed to plot the framework is equal to twice the number of stations minus three. The full number of side equations will then be equal to the number of all the lines minus twice the number of all the stations plus three.

Let n = total number of lines.

n' = number of lines sighted over in both directions.

S =total number of stations.

S' = number of occupied stations.

Then

The number of angle equations in a net = n' - S' + 1.

The number of side equations in a net = n - 2S + 3.

These formulas should be used to check the number determined by directly plotting the figure.

In figure 4 on page 34,

$$n = 41$$

 $n' = 38$
 $S = 18$
 $S' = 17$

Therefore number of angle equations = 38 - 17 + 1 = 22.

number of side equations = 41 - 36 + 3 = 8.

For convenience in solution it is best to use triangles with the larger angles for the angle equations, reserving the small angles to be used in the side equations. This will keep the large coefficients in the side equations from appearing on the same directions as are used in the angle equations and will aid in the solution of the normals. The small angles need to appear in the side equations, as their tabular differences are proportionally much less affected by the dropping of decimal places than are those of the larger angles.

ADJUSTMENT OF A FIGURE WITH LATITUDE, LONGITUDE, AZIMUTH, AND LENGTH CLOSURE CONDITIONS



FIG. 4.

In this figure, in addition to the angle, side, and length conditions, there are included conditions for azimuth, latitude, and longitude.

×
Angle equations

0 = -	5.5 - (1) + (2) - (4) + (6) - (10) + (11)
0 = +	4.0 - (1) + (3) - (5) + (6) - (12) + (13)
0 = +3	12.0 - (2) + (3) - (9) + (10) - (12) + (14)
0 = -	8.0 - (8) + (9) - (14) + (16) - (25) + (26)
0=-	2.9 - (16) + (17) - (23) + (25) - (31) + (32)
0	0.0 - (16) + (18) - (24) + (25) - (33) + (34)
0	0.0 - (10) + (21) + (20) + (20) + (20) + (21) + (
0 = -	3.2 - (23) + (24) - (30) + (32) - (34) + (35)
-=0	2.3 - (17) + (19) - (29) + (31) - (36) + (37)
-=0	3.2 - (17) + (21) - (28) + (31) - (42) + (45)
-=0	3.2 - (19) + (21) + (36) - (38) - (42) + (44)
0 = +	5.0 - (21) + (22) - (40) + (42) - (49) + (52)
0	$1 \circ (20) \downarrow (20) (47) \downarrow (40) (40) \downarrow (71)$
0 = -	1.0 - (20) + (22) - (47) + (48) - (49) + (51)
+=0	3.7 - (40) + (43) - (46) + (47) - (51) + (52)
0 = +	5.2 - (40) + (41) - (50) + (52) - (56) + (58)
0 = -	2.5 - (39) + (40) - (52) + (55) - (59) + (61)
0 = +	2.8 - (50) + (55) - (57) + (58) - (59) + (60)
0	
0 = -	3.1 - (33) + (33) - (39) + (02) - (07) + (08)
-=0	1.7 - (54) + (55) - (59) + (63) - (71) + (72)
+=0	2.1 - (62) + (63) - (66) + (67) - (71) + (73)
0 = +	2.3 - (63) + (65) - (70) + (71) - (74) + (75)
0-1	$61 - (64) \pm (65) - (74) \pm (76) - (77) \pm (78)$
0-+	0.1 - (01) + (00) - (11) + (10) - (11) + (10)
0 = +	0.1 - (69) + (70) - (75) + (76) - (77) + (79)

Azimuth equation

 $0 = (-7.1^{*} - 0.2) - (1) + (2) + (9) - (10) - (14) + (21) + (40) - (42) - (52) + (55) - (59) + (63) + (70) - (71) - (75) + (76)$

Computation of correction to azimuth constant:

 $\begin{array}{c} \log 0.277 = 9.\ 442\\ \log \sin.\ \mathrm{mean}\ \phi = 9.\ 912\\ \log \ \mathrm{correction} = 9.\ 354\\ \mathrm{correction} = -0.\ 2\end{array}$

Side equations

Symbol	Angle	Logarithm	Tabular differ- ence	Symbol	Angle	Logarithm	Tabular differ- ence
-9+11 -12+13 -1+2	° ' '' 93 11 39.1 25 52 38.1 24 17 25.4	9.9993248 9.6399291 9.6142236 9.2534775	-0.12 + 4.34 + 4.67	-13+14 - 1+ 3 -10+11	° , '' 16 37 43.4 110 36 08.7 42 00 30.0	9.4566222 9.9712965 9.8255810 9.2534997	$+7.05 \\ -0.79 \\ +2.34$

 $\begin{array}{l} 0 = -22.2 - 5.46(1) + 4.67(2) + 0.79(3) + 0.12(9) + 2.34(10) - 2.46(11) - 4.34(12) + 11.39(13) \\ -7.05(14) \end{array}$

 -7+9 +15-16 +25-27 -25+26	$111 \\ 36 \\ 20$	09 08	20.5 04.3	9.9696969 9.7706188 9.7000325	-0.81 +2.88 +3.64	$\begin{cases} + 7 - 9 \\ +14 - 15 \\ -25 + 27 \\ -8 + 9 \end{cases}$	} 21 89	40 23	38.8 18.6	9.5674745 9.9999753 9.8729041	+5.30 +0.02
-23+20	30	04	51.5	9.4403482		- 0+ 9	3.7	10	10.2	9. 4403539	71.05

 $\begin{array}{l} 0 = -5.7 - 4.49(7) + 1.88(8) + 2.61(9) - 5.30(14) + 8.18(15) - 2.88(16) - 0.74(25) + 3.64(26) \\ - 2.90(27) \end{array}$

Side equations—Continued

Symbol	Angle	• Logarithm	Tabular differ- ence	Symbol	Angle	Logarithm	Tabular differ- ence
-16+18 -23+24 -30+31	38 29 18.8 27 51 39.2 9 31 16.8	9. 7940405 9. 6696203 9. 2185744 8. 6822352	+2.65 +3.98 +12.55	-24+25 -30+32 -17+18	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	9.3384902 9.9050754 9.4387305 8.6822961	+9.43 -1.56 +7.37

 $\begin{array}{l}0=-60.9-2.65(16)+7.37(17)-4.72(18)-3.98(23)+13.41(24)-9.43(25)-14.11(30)\\+12.55(31)+1.56(32)\end{array}$

-17+19 -28+29 -42+44	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	9.7617712 9.2387486 9.8910323 8.8915521	+ 2.98 + 11.97 + 1.70	-29+31 -44+45 -19+21	16 21 23.9 23 37 23.0 43 39 34.4	9. 4496564 9. 6028386 9. 8390831 8. 8915781	$^{+7.17}_{+4.81}_{+2.21}$
----------------------------	--	--	-----------------------	----------------------------	--	--	----------------------------

 $\begin{array}{c} 0 = -26.0 - 2.98(17) + 5.19(19) - 2.21(21) - 11.97(28) + 19.14(29) - 7.17(31) - 1.70(42) \\ + 6.51(44) - 4.81(45) \end{array}$

$\begin{array}{c} -49+52\\ -20+21\\ -46+47\end{array}$	89 47 52.8 26 37 18.2 33 20 40.5	9.9999973 9.6513730 9.7401044 9.3914747	$^{+0.01}_{+4.20}_{+3.20}$	-21+22 -46+48 -51+52	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	9. 6477280 9. 9834943 9. 7602524 9. 3914747	$+4.25 \\ -0.59 \\ +2.99$
--	--	--	----------------------------	----------------------------	--	--	---------------------------

 $\begin{array}{l} 0 = +0.0 - 4.20(20) + 8.45(21) - 4.25(22) - 3.79(46) + 3.20(47) + 0.59(48) - 0.01(49) \\ + 2.99(51) - 2.98(52) \end{array}$

$-39+41 \\ -59+60 \\ -50+52$	$ \begin{array}{c} 105 \\ 27 \\ 37 \end{array} $	37 49 39	$20.7 \\ 50.7 \\ 24.5$	9.9836521 9.6691879 9.7859918	-0.59 + 3.99 + 2.73	-60+61 -50+55 -40+41	$22 \\ 125 \\ 63$	$08 \\ 14 \\ 10$	$21.3 \\ 18.4 \\ 28.9$	9.5761788 9.9120934 9.9505530	$^{+5.17}_{-1.49}_{+1.07}$
				9.4388318						9.4388252	

 $\begin{array}{l} 0 = + 6.6 + 0.59(39) + 1.07(40) - 1.66(41) - 4.22(50) + 2.73(52) + 1.49(55) - 3.99(59) \\ + 9.16(60) - 5.17(61) \end{array}$

-71+73 -59+62 -53+54	59 58 18	$25 24 \\ 43 17 \\ 17 51$	4.7 7.2 1.0	9.9349784 9.9317900 9.4968619	$^{+1.24}_{+1.28}_{+6.37}$	-62+63 -53+55 -72+73	$\begin{array}{rrrr} 43 & 56 \\ 59 & 03 \\ 22 & 50 \end{array}$	28.3 08.4 29.2	9.8413093 9.9333037 9.5890357	$^{+2.19}_{+1.26}_{+5.00}$
				9.3636303					9.3636487	

 $\begin{array}{l} 0 \!=\! -18.4 \!-\! 5.11(53) \!+\! 6.37(54) \!-\! 1.26(55) \!-\! 1.28(59) \!+\! 3.47(62) \!-\! 2.19(63) \!-\! 1.24(71) \\ \!+\! 5.00(72) \!-\! 3.76(73) \end{array}$

$\begin{array}{r} -74+76 \\ -63+64 \\ -69+70 \end{array}$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	9.9988462 9.6748099 9.9435708	-0.15 + 3.92 + 1.15	-64+65 -69+71 -75+76	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	9.8854273 9.9898451 9.7419627	$^{+1.76}_{-0.46}_{+3.18}$
1		9.6172269				9.6172351	

 $\begin{array}{l} 0 \!=\! -8.2 \!-\! 3.92(63) \!+\! 5.68(64) \!-\! 1.76(65) \!-\! 1.61(69) \!+\! 1.15(70) \!+\! 0.46(71) \!+\! 0.15(74) \\ \!+\! 3.18(75) \!-\! 3.33(76) \end{array}$

Symbol	Angle	Logarithm	Tabular differ- ence	Symbol	Angle	Logarithm	Tabular differ- ence
$\begin{array}{c} \text{Turr} \\ -4+6 \\ -2+3 \\ -7+9 \\ +15-16 \\ +25-27 \\ -23+25 \\ -28+31 \\ -21+22 \\ -39+40 \\ -54+55 \\ -63+65 \\ -69+70 \\ \end{array}$	$\begin{array}{c} \textbf{-Dundas} \\ \textbf{113} \textbf{41} \textbf{59, 6} \\ \textbf{86} \textbf{18} \textbf{43, 3} \\ \textbf{111} \textbf{09} \textbf{20, 5} \\ \end{array} \\ \begin{array}{c} \textbf{36} \textbf{08} \textbf{04, 3} \\ \textbf{40} \textbf{27} \textbf{12, 5} \\ \textbf{26} \textbf{20} \textbf{06, 8} \\ \textbf{26} \textbf{22} \textbf{55, 0} \\ \textbf{42} \textbf{26} \textbf{51, 8} \\ \textbf{40} \textbf{45} \textbf{17, 4} \\ \textbf{78} \textbf{24} \textbf{38, 4} \\ \textbf{61} \textbf{25} \textbf{13, 8} \end{array}$	$\begin{array}{r} -6\\ 4.266771\\ 9.9617359\\ 9.9999997\\ 9.96969699\\ 9.7706188\\ 9.8121311\\ 9.6470132\\ 9.6477280\\ 9.8121312\\ 9.6477280\\ 9.8147959\\ 9.910544\\ 9.9435708\\ 2.6534656\end{array}$	$\begin{array}{c} -0.92 \\ +0.14 \\ -0.81 \\ +2.88 \\ +2.47 \\ +4.25 \\ +4.25 \\ +2.30 \\ +2.44 \\ +0.43 \\ +1.15 \end{array}$	$\begin{array}{c} \text{Ham-s}\\ -10+11\\ -12+14\\ +7-9\\ +14-15\\ \hline \\ -25+27\\ -31+32\\ -42+45\\ -49+52\\ -49+52\\ -59+61\\ -71+72\\ -74+75\\ -77+79\\ \end{array}$		$\begin{array}{r} -1\\ 3.898371\\ 9.8255810\\ 9.8297327\\ 9.5674745\\ 9.9999753\\ 9.9498922\\ 9.9843478\\ 9.999973\\ 9.8840631\\ 9.7752272\\ 9.9404164\\ 9.9983924\\ 2.6534708\\ \end{array}$	$\begin{array}{r} +2.34\\ +2.30\\ +5.30\\ +0.02\\ -1.07\\ +0.58\\ +0.01\\ +1.77\\ +2.84\\ +1.18\\ +0.18\end{array}$

Length equation

 $\begin{array}{l} 0 = -5.2 - 0.14(2) + 0.14(3) + 0.92(4) - 0.92(6) - 4.49(7) + 4.49(9) + 2.34(10) - 2.34(11) \\ + 2.30(12) - 7.60(14) + 8.18(15) - 2.88(16) - 4.25(21) + 4.25(22) - 2.47(23) + 5.37(25) \\ - 2.90(27) - 4.25(28) + 3.18(31) + 1.07(32) - 2.30(39) + 2.30(40) + 0.58(42) - 0.58(45) \\ + 0.01(49) - 0.01(52) - 2.44(54) + 2.44(55) + 1.77(59) - 1.77(61) - 0.43(63) + 0.43(65) \\ - 1.15(69) + 1.15(70) + 2.84(71) - 2.84(72) + 1.18(74) - 1.18(75) + 0.18(77) - 0.18(79) \\ \end{array}$



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	0	/	11		0	1	11
Turn–Dundas	357	33	07.7	Cat–Round	109	42	29.5
-1+2	24	17	25.4	-52+55	87	34	53.9
Turn-Tower	21	50	33.1	Cat-Beaver	197	17	23.4
Azimuth difference*	-180	07	07.6	Azimuth difference	+180	01	40.2
Tower–Turn	201	43	25.5	Beaver-Cat	17	19	03.6
+9-10	51	11	09.1	-59+63	102	39	45.5
Tower-Lazaro	150	32	16.4	Beaver-Lim	119	58	49.1
Azimuth difference	-180	14	01.2	Azimuth difference	-180	05	20.3
Lazaro–Tower	330	18	15.2	Lim-Beaver	299	53	28.8
	(101	38	55.1	+70-71	40	55	17.8
-14+21	22	32	57.3	Lim-South Twin	258	58	11.0
	l 78	57	17.7	Azimuth difference	+180	06	48.1
Lazaro-Round	173	27	25.3	South Twin-Lim	79	04	59.1
Azimuth difference	-180	01	37.8	-75+76	33	30	23.0
Round-Lazaro	353	25	47.5	South Twin-Ham	112	35	22.1
+40-42	63	49	17.6	Fixed azimuth	112	35	29.2
Round–Cat	289	36	29.9				
Azimuth difference	+180	05	59.6	Discrepancy			-7.1
Cat–Round	109	42	29.5				

Formation of azimuth equation

Preliminary computation of triangles

Desig- nation of angle	Symbol	Station	01	bser ang	ved le	Cor- rection	Spher- ical angle	Spher- ical excess	Plane	angle	Logarithm
B C A	-10+11 - 4+ 6	Turn-Dundas Tower Turn Dundas	。 42 113	, 00 41	'' 30. 0 30. 9 59. 6			" 0.2 0.2 0.1	。 , 24 1	29.8 30.7 59.5	4. 266771 0. 1744195 9. 6142483 9. 9617359
		Tower-Dundas Tower-Turn					-	0.5			4. 0554388 4. 4029264
B A C	-12+14 - 2+ 3	Turn-Tower Lazaro Turn Tower	42 86	30 18	21.5 43.3 57.1			0.6 0.7 0.6	51 10	20. 9 42. 6 56. 5	4. 4029264 0. 1702686 9. 9990996 9. 8916183
		Lazaro-Tower Lazaro-Turn						1.9		•	4. 5722946 4. 4648133
B C A	$-14+15 \\ -7+9$	Lazaro-Tower Tow Hill Lazaro Tower	47 111	10 09	38. 8 07. 2 20. 5			2.2 2.2 2.1	21 40	36.6 05.0 18.4	4. 5722946 0. 4325371 9. 8653119 9. 9696986
		Tow Hill-Towe Tow Hill-Lazar	er CO					6.5			4.8701436 4.9745303
B C A	$-25+27 \\ -15+16$	Lazaro-Tow Hi Nichols Lazaro Tow Hill	11 89 54	23 28	18.6 47.9 04.3			3.6 3.6 3.6	36 08	15. 0 44. 3 00. 7	4. 9745303 0. 0000248 9. 9105723 9. 7706083
		Nichols-Tow H Nichols-Lazaro	i11					10.8			4. 8851274 4. 7451634

* See position computation, p. 40.

APPLICATION OF LEAST SQUARES TO TRIANGULATION. 39

Preliminary con	putation of	f triangles-	Continued
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Desig- nation of angle	Symbol	Station	Observed angle	Cor- rection	Spher- ical angle	Sphe ical excess	Plane angle	Logarithm
B C A	-31+32 -23+25	Lazaro-Nichols Ken Lazaro Nichols	° ' '' 116 59 49.5 60.2 40 27 12.5			" 0.8 0.7 0.7	° ' '' 48.7 22 32 59.5 11.8	4, 7451634 0, 0501070 9, 5837509 9, 8121294
		Ken-Nichols Ken-Lazaro				2.2		4. 3790213 4. 6073998
B C A	-42+45 -28+31	Lazaro-Ken Round Lazaro Ken	74 42 34.2 20.9 26 20 06.8			0.6 0.7 0.6	33, 6 78 57 20, 2 06, 2	4. 6073998 0. 0156525 9. 9918811 9. 6470108
		Round-Ken Round-Lazaro				1.9		4. 6149334 4. 2700631
B A C	-49+52 -21+22	Lazaro-Round Cat Lazaro Round	89 47 52.8 26 22 55.0 12.6			0.2 0.1 0.1	$52. \ 6 \\ 54. \ 9 \\ 63 \ 49 \ 12. \ 5$	4. 2700631 0. 0000027 9. 6477276 9. 9529926
		Cat-Round Cat-Lazaro				0.4		3. 9177934 4. 2230584
B C A	-59+61 -39+40	Cat-Round Beaver Cat Round	49 58 12.0 56.4 42 26 51.8			0.1 0.0 0.1	11. 9 87 34 56. 4 51. 7	3. 9177934 0. 1159371 9. 9996132 9. 8292503
		Beaver-Round Beaver-Cat				0.2		4. 0333437 3. 8629808
B C A	-71+72 -54+55	Beaver-Cat Lim Beaver Cat	36 34 55.5 47.2 40 45 17.4			0.0 0.1 0.0	55, 5 102 39 47, 1 17, 4	3, 8629808 0, 2247728 9, 9893057 9, 8147959
		Lim-Cat Lim-Beaver				0.1		4.0770593 3.9025495
B A C	-74+75 -63+65	Beaver-Lim South Twin Beaver Lim	60 40 06.2 78 24 38.4 15.5			0.0 0.1 0.0	06. 2 38. 3 40 55 15. 5	3, 9025495 0, 0595836 9, 9910543 9, 8162528
		South Twin-Li South Twin-Be	m eaver			0.1		3. 9531874 3. 7783859

Preliminary position computation,

α Turn to Dundas 357 3 Second angle Dundas and Tower + 24 1	, , , , , , , , , , , , , , , , , , ,
· · · · · · · · · · · · · · · · · · ·	0 38 6
α Turn to Tower 21 5 $\Delta \alpha$	7 07.6
$\alpha' \qquad \text{Tower to Turn} \qquad \qquad \text{First angle of triangle} \begin{array}{c} 180\\201\\42\\42\\6\\6\\6\\42\\6\\6\\6\\42\\6\\6\\6\\6\\6\\6\\6\\6$	13 31.0 00 30.0
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	56 04.052 8 43.993
ϕ' 54 35 27.323 Tower λ' 131 0	04 48.045
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	2. 8803 7. 9471 6. 4574
h 2. 8802931 9. 50172 8. 1281	7. 2848
1st term + 759. 0896 3d term +0.0134 2d term + 0.3175 4th term -0.0019	
+759.4071	
$\left \begin{array}{c} 3d \text{ and } 4th \\ terms \end{array} \right + 0.0115 \begin{array}{c} s & -6 \\ 4.4029264 \\ 5in \alpha & 9.5706383 \end{array} \right \text{ Arg} $	2 7163259
-4ϕ +759.4186 At 8.5087480 8 -11 $\sin \frac{1}{2}(\phi+\phi')$	9. 9117440
$2(\phi+\phi')$ 54 41 47 2.7193259 Corr 6	2.6310706
$\Delta \lambda$ +523.9935 $-\Delta \alpha$	+427.63

STATION TOWER

STATION LAZARO

α Second angle	Turn to Tower	o Tower and Laza	aro					$ ^{\circ}_{+ 86}$	1	, 50 18	'' 38. 6 43. 3
α <u>1</u> α	Turn to) Lazaro						108	2)9 21	21. 9 10. 7
α'	Lazaro	Lazaro to Turn ° ' '' First angle of triangle								18	11. 2 21. 5
$\phi_{\Delta\phi}$	54 +	48 4	05	6. 742 1. 101		Turn	λ Δλ	+130	40 C4	56 25	04. 052 54. 244
φ'	54	52	52 57.843			43 Lazaro λ'			21		58.296 1
s cos α B	4. 4648 9. 4936 8. 5097	${ m s}^2 \alpha { m C}$	8. 9. 1.	92963 95564 55459	$(\partial \phi)^2$ D	4. 9281 2. 3672	s ² sin ² E	α	2. 8. 6.	4681 8853 4574	
h	2.4681	452		0.	43986 '		7. 2953			7.8	8108
1st term 2d term	-293.8 + 2.7	632 3d 534 4th	term term	+0. +0. +0.	. 0020 . 0065						
3d and 4th terms	-291.10 + 0.00	098 085 013	8 Πα	4.46 9.97 8.50	+27 48133 78202 87400	Arg.		$\frac{\Delta\lambda}{\sin \frac{1}{2}(d_{1})}$	140	3. 1	1915191
-20	0 /	,, se	$sec \phi' = \frac{8.300}{0.240}$		01420	Δλ	+42	sec ½(4	1\$)	2	1040449
² (φ+φ΄)	94 00 3	$54 50 32.3$ $3\lambda +1$		3. 19 / +1554	, , , 2441	Corr.	+21	-10	z	3 +:	1040442 ,, 1270. 70

primary triangulation

	-					0	,	,,
Third angle	Dundas to Tower and	Turn Turn				-177 -113	33 41	43.6 59.6
α Δα	Dundas to	Tower				_ <u>63</u>	51 7	44.0 43.1
α'	Tower to D	undas				180 243	44	00.9 + .1
ф 1¢	54	38 0 2 4	9. 559 2. 236	559 Dundas λ 236 λ			55 9	20. 042 28. 003
φ'	54	35 2	7. 323	Tower	λ'	131	04	48.045
8 cos α B	$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		$\begin{array}{c} 8.\ 11087\\ 9.\ 90630\\ 1.\ 55194 \end{array}$	$(\partial \phi)^2$ D	4.4203 2.3681	$s^2 \frac{-h}{s^2 \sin^2 \alpha}$	2. 8. 6.	2091 0172 4528
h	2. 2091527 ,,		9.56911 6.7884				6.	6791
1st term 2d term	+161.8649 + 0.3708	3d term 4th term	+0.0006 -0.0005					
	+162.2357							
$\left. \begin{array}{c} \operatorname{3d} \operatorname{and} \operatorname{4th} \\ \operatorname{terms} \end{array} \right\}$	+0.0001		4.0554388	1.00		11		7549509
-1¢	$+162.2358$ $\sin \alpha$ A'		8. 5087480 0. 2370138	8 	-2 + 5	$ \frac{4\lambda}{\sin\frac{1}{2}(\phi+\phi')} $ sec $\frac{1}{2}(4\phi)$		9112981
$\frac{1}{2}(\phi+\phi')$	54 36 48.4 sec φ'		2.7543502	Corr.	+3			6656483
		Δλ	+ 568, 0025			-Δα		+463.07

STATION TOWER

STATION LAZARO

α Third angle	Tower to T Lazaro and	urn Turn				° 201 - 51	, 4: 10	31.0 57.1
α Δα	Tower to L	azaro				150	3:	2 33.9 01.2
α'	Lazaro to 7	Cower				180 330	18	3 32.7
φ.	54	35 17	27. 323 30. 520	Tower	λ	131 +	04 12	48.045
Δφ φ'	54	52	57.843	Lazaro	λ'	131	21	58. 295
eos α B	4.5722946 9.9398800 8.5097404	$\begin{array}{c}s^2\\\sin^2\alpha\\C\end{array}$	9. 14459 9. 38353 1. 55122	$(\partial \phi)^2$ D	6. 0428 2. 3683	$s^2 \frac{-h}{E}$	α	3. 0219 8. 5281 6. 4516
h	3. 0219150		0.07934		8. 4111		-	8. 0016
1st term 2d term	-1051.7559 + 1.2004	3d term 4th term	+0.0258 +0.0100					
3d and 4th terms	-1050.5555 + 0.0358	8	-7 4.5722946 0.6017656	4.00				2 0100404
-10	-1050. 5197	$\begin{array}{c} \sin \alpha \\ A' \\ \sec \phi' \end{array}$	9. 6917636 8. 5087409 0. 2401420	Αrg. 8 Δλ.	-25 + 18		+φ') Ιφ)	3. 0129424 9. 9119609
$\frac{1}{2}(\phi+\phi')$	54 44 12.6		3.0129424	Corr.	- 7			2. 9249033
		Δλ	+1030.2498			-10	:	+841.20

Preliminary position computation,

α Second angle	Lazaro to ' Tower and	Fower Tow Hill				$^{\circ}$ 330 + 47	1	8 32.7 0 07.2
α Δα	Lazaro to 7	Fow Hill				17	22	8 39.9 1 07.7
α	Tow Hill t	o Lazaro	180 197 21	04	$\begin{array}{c c}7 & 32.2 \\ 0 & 38.8 \end{array}$			
$\phi \\ \Delta \phi$	-54	52 48.	$\begin{bmatrix} 7, 843 \\ 1, 870 \end{bmatrix} $ Lazaro λ 4λ			131 +	22	1 58. 295 5 57. 539
φ'	54	04	25.973	Tow Hill	λ'	131	4	7 55.834
s cos α B	4. 9745303 9. 9794727 8. 5097191	${{{{{\rm sin}}^2}\over {\rm C}}}lpha$	9. 94906 8. 95521 1. 55589	$(\partial \phi)^2$ D	$\begin{array}{c} 6.9283 \\ 2.3667 \end{array}$	$s^2 \frac{-h}{E}$	$\frac{1}{2}\alpha$	3. 4637 8. 9043 6. 4597
h	3. 4637221		0.46016	· ·	9. 2950			8.8277
1st term 2d term	+2908.8550 + 2.8851	3d term 4th term	+0.1972 -0.0673					
$\left\{\begin{array}{c} 3d \text{ and } 4th \\ terms \end{array}\right\}$ $-\Delta\phi$	$\begin{array}{c c} +2911.7401 \\ + & 0.1299 \\ +2911.8700 \\ & & & & \\ & & & \\ & $		$\begin{array}{r}117\\ 4.9745303\\ 9.4776065\\ 8.5087606\\ 0.2315532\end{array}$	Arg. ⁸ 4λ	-159 + 42	$\frac{4\lambda}{\sin\frac{1}{2}(\phi+\phi')}$ sec $\frac{1}{2}(4\phi)$		3. 1924389 9. 9105687 108
$\frac{1}{2}(\phi+\phi')$	54 28 41.9	<i>Δ</i> λ	3. 1924389 '' +1557. 5388	Corr.	-117	-Δα		3. 1030184 '' +1267. 70

STATION TOW HILL

STATION NICHOLS

α Second angle	Lazaro to 7 Tow Hill a	fow Hill nd Nichols	3			$^{\circ}_{+ 54}$	22	8 39.9 8 47.9
α Δα	Lazaro to I	Vichols				- 71	5 4	7 27.8 0 14.3
α'	Nichols to	Lazaro	F	irst angle o	of triangle	180 251 89	$\frac{1}{2}$	7 13.5 3 18.6
$\phi \\ \Delta \phi$		$\begin{array}{c c}52 & 5\\9 & 2\end{array}$	57. 843 27. 012	Lazaro À		+131	2 4	1 58. 295 9 14. 397
ϕ'	54	43 3	30. 831	Nichols.	λ'	132	1	1 12.692 + 1
8 cos α B	4.7451634 9.4909674 8.5097191	$\left \begin{array}{c} s^2\\ \sin^2 \alpha\\ C \end{array} \right $	9.49033 9.95620 1.55589	(ðø)² D	5, 5072 2, 3667	−h s² sin² E	α	2. 7458 9. 4465 6. 4597
h 1st term 2d term	2.7458499 '' +556.9933 + 10.0559	3d term 4th term	$1.00242 \\ \\ +0.0075 \\ -0.0449$	-	7.8739			8.6520
$\left\{\begin{array}{c} \operatorname{3d} \operatorname{and} \operatorname{4th} \\ \operatorname{terms} \end{array}\right\}$ $-\mathcal{I}\phi$	+567.0492 - 0.0374 +567.0118	$sin \alpha \\ \Lambda' \\ sec \phi'$	+92 4, 7451634 9, 9781021 8, 5087447 0, 2384494	Arg. ⁸ Δλ	-56 + 148		+φ') Ιφ)	3. 4704688 9. 9123203
}(φ+φ')	54 48 14.3	Δλ	3. 4704688 '' + 2954. 3966	$\frac{1}{1}$		-10	e l	3.3827891 '' +2414.3

primary triangulation-Continued

						0	,	,,
α Third angle	Tower to L Tow Hill a	azaro nd Lazaro				$ \begin{array}{c} 150 \\ -111 \end{array} $	32 09	33. 9 20. 5
α 1α	Tower to T	ow Hill				39	23 35	13. 4 02. 4
α'	Tow Hill to	o Tower				180 218	48	11.0
ф 1ф	_54	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$						48. 045 07. 789
φ'	54	04 2	25. 972 Tow Hill λ'			131	47	55. 834
8 Cos α B	4. 8701436 9. 8881103 8. 5097404	$\frac{\delta^2}{\sin^2 \alpha}$	9. 74029 9. 60494 1. 55122	$(\partial \phi)^2$ D	6. 5397 2. 3683	$s^2 \frac{-h}{E} \alpha$	3. 9. 6.	2680 3452 4516
h	3. 2679943		0. 89645 8. 9080				9.	0648
1st term 2d term	+ 1853. 5073 + 7. 8786	3d term 4th term	+0.0809 -0.1160			(Δλ) ³ F	0. 7.	239 733
	+ 1861. 3859		+16				7.	972
$\frac{3d \text{ and } 4th}{terms}$	$ \begin{array}{c} - & 0.0351 \\ + 1861.3508 & \sin \alpha \\ A' \end{array} $		4. 8701436 9. 8024699 8. 5087606 0. 2315532	Arg. ⁸ Δλ	Arg. s - 98 $J\lambda$ +114		') 3. 9.	4129289 9097770 . 44
$\frac{1}{2}(\phi + \phi')$	54 19 56.6	sec ¢'	3. 4129289	Corr.	+ 16		3.	3227103
		Δλ	+2587.7893			-Δα	+	2102. 38

STATION TOW HILL

STATION NICHOLS

α Third angle	Tow Hill to Nichols and	o Lazaro d Lazaro				。 197 — 36	, 07 08	'' 32. 2 04. 3
α 1α	Tow Hill t	o Nichols				-160	59 18	27.9 55.8
α'	Nichols to	Tow Hill				180 340	40	32. 1
ф 1ф	54 +	04 39	131 +	47 23	55, 834 16, 859			
φ'	54	43 3	132	11	12.693			
s cos α B	4. 8851274 9. 9756468 8. 5097780	$sin^2 \alpha C$	9.77025 9.02568 1.54301	(∂φ)² D	6. 7403 2. 3709	$egin{array}{c} -h \\ s^2 \sin^2 \\ E \end{array}$	α 3.	3706 7959 4373
h	3. 3705522	2/1 torm	0. 33894		9. 1112		8.	6038
2d term	+ 2.1824	4th term	+0.0402					
$ \frac{3d \text{ and } 4th}{\text{terms}} $ $- 4\phi $ $\frac{1}{2}(\phi + \phi') $	-2345.0290 + 0.1694 -2344.8596 o ' '' 54 23 58.9	$\frac{ \overset{8}{\sin \alpha} }{ \overset{A'}{\operatorname{sec}} \phi' }$	70 4. 8851274 9. 5128381 8. 5087447 0. 2384494 3. 1451526 ''	Arg. ⁸ Δλ Corr.	-104 + 34 - 70	4λ sin ½(φ+ sec ½(4	$(\phi') = \frac{3}{9}, \frac{3}{3}, 3$	1451536 9101427 70 0553033 ''
		Δλ	+1396.8592			<i>−∆α</i>	+	135.80

Preliminary position computation,

α Second angle	Lazaro to 1 Nichols an	Nichols d Ken				•	71 + 22		, 57 33	'' 27. 8 00. 2
°α	Lazaro to 1	Ken.					94		30 30	28.0 53.7
Δα							180			
α'	Ken to La	First angle of triangle							59 59	34.3 49.5
ф 1ф	o ' '' 54 52 57.843 + 1 37.056					$\begin{array}{c} \lambda \\ \Delta \lambda \end{array}$	131 +	21 37		58. 295 45. 861
φ'	54	54 3	34.899		Ken –	λ'	131	ł	59	44.156
cos α B	4.6073998 8.8953917 8.5097191	$\left \begin{array}{c} s^2\\ \sin^2\alpha\\ C\end{array}\right $	9. 21480 9. 99731 1. 55589	0 1 9	$\overset{(\delta\phi)^2}{\mathrm{D}}$	4. 0250 2. 3667	$s^2 \frac{-h}{E}$	α	2. 9. 6.	0125 2121 4597
h	2.0125106		0.76800	0		6.3917			7.	6843
1st term 2d term	-102.9226 + 5.8614	3d term 4th term	+0.0002 +0.0048							
3d and 4th terms }	97.0612+ 0.0050	sin a	4.60739	-58 998	Arg		43		3	355234
$-\Delta\phi$	- 97.0562	$\frac{A'}{\sec \phi'}$	8. 50874 0. 24043	403 328	8 Δλ	$-29 \\ +87$	$\sin \frac{1}{2}(\phi - \frac{1}{2}(\phi - \frac{1}{2}))$	+φ') Ιφ)	9.	912798
$\frac{1}{2}(\phi + \phi')$	54 53 46.4		3.35523	332	Corr.	+58	Ť		3.	268032
• •		Δλ	+2265.86	607			-10	e	+1	853.67

STATION KEN

STATION ROUND

α Second angle	Lazaro to I Ken and R	Ken ound	-			94 + 78	, 30 57	'' 28.0 20.9
α 1α	Lazaro to I	Round	173	27 1	48. 9 37. 8			
α'	Round to I	Lazaro	$ \begin{array}{r} 180 \\ 353 \\ 74 \end{array} $	$\begin{array}{c} 26\\ 42 \end{array}$	11. 1 34. 2			
ϕ . 1 ϕ	54 +	52 5 9 5	131 +	21 1	58. 295 59. 402			
φ'	55	02	131	23	57.697			
s cos α B	4. 2700631 9. 9971678 8. 5097191	$\operatorname{sin^2 \alpha}_{\mathrm{C}}^{8^2}$	$\begin{array}{c} 8.54013 \\ 8.11255 \\ 1.55589 \end{array}$	$(\partial \phi)^2$ D	$5.5538 \\ 2.3667$	$s^2 \frac{-h}{E}$	$\alpha \mid \begin{pmatrix} a \\ b \\ b \\ b \\ c \\ c \\ c \\ c \\ c \\ c \\ c$	2, 7769 5, 6527 5, 4597
h	2. 7769500		8. 20857		7.9205		ŧ	5. 8893
1st term 2d term	-598.3427 + 0.0161	3d term 4th term	+0.0083 +0.0001					
3d and 4th terms }	-598.3266 + 0.0084	° sin a	-6 4.2700631 9.0562746	Arg		43		077013
- <i>4</i> φ	-598.3182	$\frac{A'}{\operatorname{sec} \phi'}$	8. 5087369 0. 2419389	8 	$-6 \\ 0$	$\sin \frac{1}{2}(\phi + \sec \frac{1}{2}(\Delta \phi))$	·φ') 9 φ)	. 913183
$\frac{1}{2}(\phi+\phi')$	54 57 57		2.0770129	Corr.	-6		1	. 990196
		Δλ	+119.4024		<i>—</i> Δα		+97.77	

primary triangulation—Continued

α Third angle	Nichols to Ken and L	Lazaro azaro				° 251 - 40	, 17 27	" 13.5 12.5
α Δα	Nichols to	Ken	+ 210	50 9	01. 0 22. 8			
α'	Ken to Nic	ehols	180 30	. 59	23.8			
ф 1ф	54 +	43 3 11 0	30. 831)4. 068	Nichols	λ $d\lambda$	-132	11 11	12. 693 28. 537
¢'	54	54 3	34. 899	Ken	λ'	131	59	44.156
cos α B	4.3790213 9.9338209 8.5097307	$\int_{C}^{s^2} \alpha$	8.75804 9.41947 1.55337	(ðø)² D	5.6450 2.3676	$s^2 \frac{-h}{s^2 \sin^2 \alpha}$		2. 8226 3. 1775 3. 4553
h	2.8225729		9. 73088		8.0126		7	7. 4554
1st term 2d term	-664.6192 + 0.5381	3d temn 4th term	+0.0103 +0.0029					
3d and 4th)	-664.0811		-2					
terms }	+ 0.0132	sin a	4. 3790213 9. 7097334	Arg.		Δλ	2	. 837928
-14	-664.0679	$\operatorname{sec} \phi'$	8.5087403 0.2404328	8 12	-10 + 8	$\frac{\sin \frac{1}{2}(\phi + \phi')}{\sec \frac{1}{2}(\Delta \phi)}$) 8	. 912392
½(φ+φ')	54 49 02.9		2. 8379276	Corr.	- 2		2	2.750320
		Δλ	-688. 5375			-Δα	-	-562.76

STATION KEN

STATION ROUND

α Third angle	Ken to La Round and	aro l Lazaro			° 273 - 26	, 59 20	" 34.3 06.8	
α Δα	Ken to Ro	und				247 +	39 29	27.5 17.8
α'	Round to 1	Ken	180 68	08	45.3			
ф 1ф	54 +	54 8	-131	59 35	44. 156 46. 458			
φ'	55	02	56.160 + 1	Round	λ'	131	23	57.698 -1
eosα B	4. 6149334 9. 5799436 8. 5097172	$\int_{C}^{S^2} \alpha$	$\begin{array}{c} 9.22987 \\ 9.93222 \\ 1.55631 \end{array}$	(ðø)² D	5. 4091 2. 3666	-h 8 ² sin ² E	α	2. 7046 9. 1621 6. 4604
h	2. 7045942		0.71840		7.7757			8.3271
lst term 2d term	-506.5172 + 5.2288	3d term 4th term	+0.0058 +0.0212					
3d and 4th terms -4ϕ	-501.2884 + 0.0270 -501.2614 \circ , , ,	$\sin \alpha \\ A' \\ \sec \phi'$	+49 4. 6149334 9. 9661083 8. 5087369 0. 2419389	$\Lambda rg.$	-30 +79		⊧¢′) ¢)	3. 331722 9. 913254
≵(φ+φ ′)	54 58 46.0	Δλ	3. 3317224 ,'' -2146. 458	Corr.	+49	-da	-	3. 244976 // -1757. 83

Preliminary position computation,

Second angle	Lazaro to I Round and	Round I Cat				$^{\circ}_{+26}$, 27 22	" 48.9 55.0
α Δα	Lazaro to	Cat			,	199 +	50 4	43. 9 21. 5
α'	Cat to Laz	aro				180 19	55	05.4
			of triangle	89	47	52. 8		
$\phi \\ \Delta \phi$	54 +	52 8	131	21 5	58. 295 19. 363			
φ'	55	01 2	26.100	Cat	λ'	131	16	38.932
cos α B	4. 2230584 9. 9734102 8. 5097191	$sin^2 \alpha C$	$\begin{array}{c} 8.44612\\ 9.06164\\ 1.55589\end{array}$	$\overset{(\delta\phi)^2}{\mathrm{D}}$	$5.4124 \\ 2.3667$	$s^2 \frac{-h}{E}$	α	2. 7062 7. 5078 6. 4597
h	2.7061877		9.06365		7.7791			6.6737
1st term 2d term	-508.3791 + 0.1158	3d term 4th term	+0.0060 +0.0005					
3d and 4th }	-508.2633 + 0.0065	8	-3 4. 2230584					
$-\Delta\phi$	508. 2568	$ \begin{array}{c} \sin \alpha \\ A' \\ \operatorname{sec} \phi' \end{array} $	9. 5308211 8. 5087375 0. 2416677	$\begin{array}{c} \operatorname{Arg.} \\ {}^{g} \\ {}^{\mathcal{J}\lambda} \end{array}$	-5 + 2		- \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	2. 504284 9. 913117
$\frac{1}{2}(\phi + \phi')$	54 57 42.0		2. 5042844	Corr.	-3			2. 417401
		Δλ	-319.3629			- <u>1</u> a		-261.46

STATION CAT

STATION BEAVER

α Second angle	Cat to Rou Round and	nd Beaver			$ \begin{array}{c} \circ \\ 109 \\ + 87 \end{array} $	4	' '' 12 58.1 34 56.4	
α 1α	.Cat to Bea	ver				+197	1	7 54.5 1 40.2
α".	Beaver to	Jat	180 17 49	1 5	19 34.7 58 12.0			
$\phi_{\Delta\phi}$	55 +	01 3 3 4	26. 100 15. 192	Cat	131	1	.6 38.932 .2 02.273	
φ'	55	05 1	1. 292	2 Beaver λ'			1	4 36,659
s cos α B	3.8629808 9.9798982 8.5097090	$\overset{s^2}{\underset{C}{\sin^2 \alpha}}$	$\begin{array}{c c} 7.7260 \\ 8.9465 \\ 1.5584 \end{array}$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			α	2. 353 6. 672 6. 464
h	2,3525880		8.2309		7.071			5. 489
1st term 2d term	-225.2102 + 0.0170	3d term 4th term	+0.0012					
	-225.1932							
3d and 4th }	+0.0012	.8	-1 3.8629808					
$-\Delta\phi$	-225.1920	$\frac{\sin \alpha}{A'}$ $\sec \phi'$	9.4732671 8.5087360 0.2423463	Arg. 8 Δλ	$-1 \\ 0$		+φ') Ιφ)	2.087330 9.913657
$\frac{1}{2}(\phi+\phi')$	55 03 18.7		2.0873301	Corr.	-1			2.000987
		Δλ	-122. 2728			- ⊿o	:	-100.23

primary triangulation—Continued

α Third angle	Round to L Cat and L	Lazaro azaro				。 353 - 63	20 49	$ \begin{array}{c c} & '' \\ & 11.1 \\ & 12.6 \end{array} $
α 1α	Round to (Cat .				+ 289	3	$\begin{array}{ccc} 6 & 58.5 \\ 5 & 59.6 \end{array}$
α'	Cat to Rou	nd	180 109	4	2 58.1			
ф	55	02 5		Round		131	2	3 57, 697
Δφ	-	1 3	0.061		42	-		7 18.765
φ'	55	01 2	26.100	Cat	λ'	131	1	6 38, 932
s cos α B	3. 9177934 9. 5259756 8. 5097071	${\mathop{\sin^2\alpha}\limits_{\mathrm{C}}^{8^2}}$	7.8356 9.9481 1.5586	(ðø)² D	3. 9069 2. 3658	-h s² sin² E	α	1.9535 7.7837 6.4643
h	1.9534761		9. 3423		6. 2727		-	6. 2015
1st term 2d term	+89.8413 + 0.2199	3d term 4th term	+0.0002 -0.0002					
	+90.0612		+2					
3d and 4th terms		8	3.9177934	A				0.040000
-40	+90.0612	$\frac{\Lambda'}{\Lambda'}$ sec ϕ'	8. 5087375 0. 2416677	s Δλ	-1 + 3		⊢φ') φ)	9. 913558
$\frac{1}{2}(\phi + \phi')$	55 02 11.1		2.6422323	Corr.	+2			2. 555790
		0	100 7071					11
		۵X	-435. 7034			-1α		-339.58

STATION CAT

STATION BEAVER

α Third angle	Round to Beaver and	Cat 1 Cat				° 289 - 42	, 36 26	3 58.5 5 51.8
α 1α	Round to 3	Beaver				+ 247	1(0 06. 7 7 40. 0
α	Beaver to	Round	180 67	17	46.7			
\$¢	\$55 +	$ \begin{array}{c c} $		Round	λ λλ	131	23	57. 697 21. 038
<i>ø</i> ′	55	05 1	1. 292	Beaver	λ'	131	14	36.659
cos α B	4.0333437 9.5888562 8.5097071	$\begin{array}{c} s^2\\ \sin^2\alpha\\ C\end{array}$	8.0667 9.9291 1.5586	$(\delta\phi)^2$ D	4.264 2.366	s² sin² E	α	2.132 7.996 6.464
h	2. 1319070	-	9.5544		6.630			6.592
lst term 2d term	-135.4899 + 0.3584	3d term 4th term	+0.0004 +0.0004					
	-135.1315							
3d and 4th }	+ 0.0008	.8	+3 4.0333437					
-4ϕ	-135.1307	$ \begin{array}{c} \sin \alpha \\ A' \\ \operatorname{Sec} \phi' \end{array} $	9.9645661 8.5087360 0.2423463	Arg. β Δλ	$^{-2}_{+5}$	Δλ sin ½(φ+ sec ½(Δ	- \$ ') \$	2.748992 9.913723
$\frac{1}{2}(\phi+\phi')$	55 04 03.7		2.7489924	Corr.	+3			2.662715
		Δλ	-561.0382			-Δα		-459, 95

91865°—15——4

Preliminary position computation,

	α Second angle	Beaver (Cat and	lo Cat Lim						$^{\circ}_{+102}$, 19 39	'' 34. 7 47. 2
	α 1α	Beaver	to Linn						119	ł	59 5	21.9 20.3
	α'	Lim to]	Beaver		$ \begin{array}{r} 180 \\ 299 \\ 36 \end{array} $	54 34		01.6 55.5				
100 March 100 Ma	$\phi \\ 4\phi$	55 +	05 2	1 (11. 292 08. 973	Beaver		λ $\Delta\lambda$	131 +	1	14 6	36. 659 30. 479
	φ'	55	07	2	20. 265	Lim		λ'	131	:	21	07.138
	s cos α B	3. 90254 9. 69883 8. 50970	95 10 sii 44	$^{8^2}_{C}$	7.8051 9.8751 1.5591	4	4. 222 2. 366	s ² sin ² E	α	2 7 6	. 111 . 680 . 465	
	h	2.11108	49		9. 2393		6	5. 588			6	. 256
	1st term 2d term	-129.14 + 0.173 -128.973	7 1 3d 35 4th	term term	+0.0004 +0.0002							
	$\left. \begin{array}{c} \operatorname{3d} \operatorname{and} \operatorname{4th} \\ \operatorname{terms} \\ -4\phi \end{array} \right\}$	+ 0.000	06 30 si	8 n α Δ' c φ'	3. 9025493 9. 9375769 8. 5087351 0. 2427356	Arg. ⁸ Δλ		-1 + 3		+φ') Ιφ)	29	. 591597 . 913918
	$\frac{1}{2}(\phi + \phi')$	55 06 15.	.8		2. 5915973	Corr.		+2			2	. 505515
			4	ſλ	+390. 4787			1	-10	e	-	-320. 27

STATION LIM

STATION SOUTH TWIN

α Second angle	Beaver to Lim and S	Lim outh Twin			° 119 + 78	10 CM	, ,, 59 21.9 24 38.4		
α 1α	Beaver to	South Twi	a				198 +	2	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
α!	South Twi	n to Beave	r	Fi	irst angle c	of triangle	$\begin{array}{r}180\\18\\60\end{array}$	24	25 28.0 10 06.2
$\phi \\ \varDelta \phi$	55 +	05 1 3 (11.292 04.190		Beaver	λ $\Delta \lambda$	131	1	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
¢'.	55 Fixed	08 1 latitude, 1	15. 482 15. 517	So	uth Twin	λ'	131 Fixed lo	1 ngitu	2 49.697 de, 49.974
s cos α B	3.7783859 9.9772093 8.5097044	$\begin{vmatrix} s^2 \\ sin^2 \alpha \\ C \end{vmatrix}$	7.5568 8.9984 1.5591		$(\partial \phi)^2$ D	4. 530 2. 366	$s^2 \frac{-h}{E}$	α	2. 265 6. 555 6. 465
h	2.2652996		8.1143			6.896			5. 285
1st term 2d term	-184.2042 + 0.0130	3d term 4th term	+0.0008						
$\left. \begin{array}{c} \operatorname{3d} \operatorname{and} \operatorname{4th} \\ \operatorname{terms} \\ -4\phi \end{array} \right\}$	-184.1912 + 0.0008 -184.1904	$sin \alpha \\ A' \\ sec \phi'$	3. 7783 9. 4992 8. 5087 0. 2429	-1 859 064 347 024	$ \begin{array}{c} \Lambda \text{rg.} \\ \overset{\$}{_{\Delta\lambda}} \end{array} $	-1	$\frac{d\lambda}{\sin\frac{1}{2}(\phi-\frac{1}{2}$	+φ') 1φ)	2. 029229 9. 913958
$\frac{1}{2}(\phi+\phi')$	55 06 43.4		2.0292	293	Corr.	-1			1.943187
		Δλ	-106.9	619			-40	r .	-87.74
Dian	nononon in l	atitudat				Dicoron	anor in L	ongitu	do

 $\begin{array}{c} {\rm Discrepancy \ in \ latitude:} \\ -0.035 \\ \times 7238.24 \pm 100 = \\ -2.5334 \end{array}$

repancy in longitude: -0.277 ×7238.24÷100= -20.0499

primary triangulation—Continued

α Third angle	Cat to Bear Lim and B	ver eaver				。 197 - 40	, 17 45	54.5 17.4
α 1α	Cat to Lim					156	32 3	37.1 39.9
α'	Lim to Cat			180 336	28	57.2 1		
ф 14	55 +	$\begin{array}{c c} 01 & 2\\ 5 & 5 \end{array}$	26. 100 54. 165	Cat	λ $\Delta \lambda$	131 +	16 4	38.932 28.206
4'	55	07 2	20.265	Lim	λ'	131	21	07.138
s cos α B	4.0770593 9.9625415 8.5097090	$s^2 \sin^2 \alpha$ C	8. 1541 9. 1999 1. 5584	(δφ) ² D	5.099 2.366	$s^2 \frac{-h}{E}$	α ,	2.549 7.354 6.464
h	2.5493098		8.9124		7.465			6.367
1st term 2d term	-354.2499 + 0.0817	3d term 4th term	+0.0029 +0.0002					
$\left. \begin{array}{c} \operatorname{3d} \operatorname{and} \operatorname{4th} \\ \operatorname{terms} \\ - 4\phi \end{array} \right\}$	-354.1682 + 0.0031 -354.1651	8 sin α A' sec φ'	4.0770593 9.5999381 8.5087351 0.2427356	Arg: $^{8}_{\lambda}$	-2 + 2		+ \$\phi') (\$)	2. 428468 9. 913752
$\frac{1}{2}(\phi+\phi')$	55 04 23.2	λĿ	2. 4284681 '' +268. 2057	Corr.	0	-40		2. 342220 ,, +219. 90

STATION LIM

STATION SOUTH TWIN

α Third angle	Lim to Bea South Twi	ver 1 and Beav	ver			° 299 - 40	5 5	4 01.6 5 15.5
α 1α	Lim to Sou	th Twin				258 +	5	8 46.1 6 48.1
α'	South Twi	n to Lim	180 79	0	5 34.2			
ф 14	55 +	07 2	0. 265 5. 217	Lim	λ 4λ	131	2	1 07.138 8 17.440
φ'	55	08 1	.5.482 So	uth Twin	λ'	131	1	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$
8 COS α B	3.9531874 9.2813974 8.5097018	$s^2 \sin^2 \alpha$ C	7.9064 9.9838 1.5597	(ðø)² D	3. 488 2. 365	s ² sin ² E	α	1.744 7.890 6.467
h	1.7442866		9.4499		5.853		Ī	6. 101
1st term 2d term	-55.4992 + 0.2818	3d term 4th term	+0.0001 +0.0001					
3d and 4th }	-55.2174 + 0.0002	s sin a	+2 3.9531874 9.9919164	Arg.		A		2. 696741
- <i>1</i> φ	-55.2172	$\frac{A'}{\sec \phi'}$	8.5087347 0.2429024	8 	$^{-2}_{+4}$	sin 1(ø- sec 1(4	+φ') 1φ)	9.914053
$\frac{1}{2}(\phi+\phi')$	55 07 47.9		2. 6967411 Corr. +					2.610794
		Δλ	-497.4404			-10	x	-408.12

50

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	<i>a</i> ₂	2.29	2.37	2.47	2.92	3, 14 3, 41	3.76	8. 24 Sta					
	aı	$^{+}_{1.93}$	1.87	1. 79 1. 71	1. 52	1.41	1.18	$a_1 = +1$ $a_2 = -5$ $a_2 = -5$					
	÷Ð	° 24	28	32 36	44	48 52	56	W	60 - 1				
	$(\phi_{a_{2}}^{\lambda}\phi_{c})$	+	- 74.2	}-120.7	- 56.3	- 56.3	- 56.3	- 56.3	- 19.6	}- 25.1	}- 11.3	- 3.4	
	+R or -I	•	$\left\{ \begin{array}{c} + 4 - 0 \\ + 10 - 11 \end{array} \right\}$	$\begin{cases} -2+3 \\ -12+14 \end{cases}$	-14+15	-15+16	$\left\{+23-25\\+31-32\right\}$	$\left\{ +25-31 \\ +42-45 \\ +42-45 \\ +21 $	$\left\{ -21+22\\ -49+52 \right\}$	$\left\{ +39-40 \\ +59-61 \\ +59-61 \\ +$	$\left\{ \begin{array}{c} +54-55\\ +71-72 \end{array} \right\}$	$\left\{ \begin{array}{c} -63 + 65 \\ -74 + 75 \end{array} \right\}$	
1	$(\lambda_n \frac{\phi}{a_1} \lambda_C)$	÷ 100	+20.2	+ 9.7	-11.0	-11.0	-11.0	-11.0	-13.4	- 4.6	- 2.1	-10.0	
	$(\lambda_n - \lambda_c) = \frac{\lambda}{\partial_{\mathbf{B}}}$	+	-39.2	-18.5	} +48.4	+ 0.2	- 9.8	+ 5.3	+ 0.1	+ 6.8	+ 5.1	+ 9.8	
	B		-10+11	-12+14	+7-9 +14-15	-25+27	-31+32	-42+45	-49+52	-59+61	-71+72	-74+75	
	$(\phi_n \frac{\phi}{\partial_B} \phi_C)$	\div 100	-47.2	-75.5	-81.1	- 0.3	+16.4	- 8.9	- 0.1	-12, 1	- 8.7	. – 1.1	
	$\left(\lambda_n^{\lambda} + \lambda_C\right) \\ \delta_{\mathbf{A}}$	÷ 100	-15.4	+ 1.1	+ 7.4	-26.3	-22.6	-38.8	-47.3	8° 8°	- 4.3	- 3.6	
	V	-	- 4+ 6	- 2+ 3	6 +2 -	+15-16 +25-27	-23 + 25	-28+31	-21+22	-39 + 40	-54+55	-63+65	
	$(\phi_n - \phi_c) = \delta_A$	$\dot{100}$	-18.6	+ 4.6	-12.4	+ 44. 1	+37.8	+65.1	+22.7	+15.7	+ 7.5	+ 0.4	
	$-\delta_{\rm B}$		-2.34	-2.30	-5.30	-0.02	+1.07	-0.58	-0.01	-1.77	-2.84	-1.18	
	$+\delta_{\mathbf{A}}$		-0.92	+0.14	-0.81	. +2.88	+2.47	+4.25	+4.25	+2.30	+2.44	+0.43	
	$\lambda_n - \lambda_c$		+16.76	+ 8.03	- 9.14	- 9.14	- 9.14	- 9.14	-11.13	- 3.82	- 1.78	- 8, 29	
	$\phi n - \phi_C$		+20.18	+32.84	+15.31	+15.31	+15.31	+15.31	+ 5.33	+ 6.83	+ 3.08	+ 0.92	
	~		56.07	04.80	21.97	21.97	21.97	21.97	23.96	16.65	14.61	21.12	12.83
			。 130	131	131	131	131	131	131	131	131	131	131
	-0-		48.11	35.46	52.96	52.96	52.96	52.96	02.94	01.43	05, 19	07.34	08.26
			54 o	54	54	54	54	54	55	55	55	55	55
	Station		Turn	Tower	Lazaro	Lazaro	I ,azaro	Lazaro	Round	Cat	Beaver	Lim	South Twin

Formation of latitude and longitude condition equations

Latitude equation

 $\begin{array}{l} 0\!=\!-2.5334-\!0.14(2)\!+\!0.14(3)\!+\!0.39(4)\!-\!0.39(6)\!-\!0.69(7)\!+\!0.69(9)\!+\!0.67(10)\!-\!0.67(11)\\ -0.66(12)\!-\!1.36(14)\!+\!1.25(15)\!-\!0.55(16)\!-\!0.09(21)\!+\!0.09(22)\!-\!0.49(23)\!+\!0.93(25)\\ -0.44(27)\!-\!0.76(28)\!+\!0.49(31)\!+\!0.27(32)\!-\!0.20(39)\!+\!0.20(40)\!-\!0.02(42)\!+\!0.02(45)\\ +\!0.14(49)\!-\!0.14(52)\!-\!0.10(54)\!+\!0.10(55)\!+\!0.08(59)\!-\!0.08(61)\!+\!0.10(63)\!-\!0.10(65)\\ +\!0.07(71)\!-\!0.07(72)\!+\!0.11(74)\!-\!0.11(75) \end{array}$

Longitude equation

 $\begin{array}{l} 0\!=\!-20.0499\!+\!1.20(2)\!-\!1.20(3)\!-\!0.59(4)\!+\!0.59(6)\!+\!0.41(7)\!-\!0.41(9)\!-\!0.35(10)\!+\!0.35(11)\\ +\!1.39(12)\!-\!0.34(14)\!-\!0.75(15)\!-\!0.30(16)\!+\!0.67(21)\!-\!0.67(22)\!-\!0.34(23)\!+\!0.07(25)\\ +\!0.27(27)\!-\!0.17(28)\!-\!0.29(31)\!+\!0.46(32)\!-\!0.16(39)\!+\!0.16(40)\!-\!0.62(42)\!+\!0.62(45)\\ +\!0.20(49)\!-\!0.20(52)\!-\!0.07(54)\!+\!0.07(55)\!-\!0.32(59)\!+\!0.32(61)\!+\!0.07(63)\!-\!0.07(65)\\ -\!0.16(71)\!+\!0.16(72)\!-\!0.06(74)\!+\!0.06(75) \end{array}$

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Correlate

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	/ 16	17	18	19	20	21	22
:																						
$\frac{1}{2}$		-1	-1																			
3	·	+1	+1									• • • • •						Ì				• • • •
$\overline{5}$		-1																				
6	+1	+1																				
7	1																					
8			-i	-1 + 1																	••••	
10	-1		$+\overline{1}$				••••													••••	••••	
11	+1													l								
12		1-1	-1																		• • • •	
14			$+1^{$	-1																		
15			• • • •			2		••••	••••							••••		• • • • •			••••	••••
16				+1	-1	-1																
17				• • • •	+1	$\frac{1}{1+1}$		-1	-1	:												
19								+1		-1		•••••										
20		••••	••••	••••	••••	••••		•••••	••••			-1			····							••••
21		•••••	• • • •	· · · ·				••••	+1	+1	-1	·····								• • • •	••••	• • • •
$\frac{22}{23}$					-1		-1					····										
24 25	• • • • •	••••	• • • •		 +1	$-1 \\ +1$	+1	• • • •		••••		••••							••••		• • • •	•••••
					1.1			••••														
$\frac{26}{27}$			••••	+1		••••	••••															
28								· · · ·	-1		••••	• • • •									• • • •	
30			••••				-1^{-1}	-1										2222				
91					1		1	1.1	1.1													
32					+1		$+1^{}$	+1	+1													
33 34	· · · ·	• • • •		••••		$-1 \\ \pm 1$			••••	• • • •	• • • •	• • • •							• • • • •	• • • •		• • • •
35							+1															
36								-1		+1												
37	• • • •							+1	• • • •			••••				• • • •	[••••		••••	••••
39										-1					-1							
40		••••	••••		• • • •	• • • •	••••	••••	••••	••••	-1	•••••	-1	-1	+1	• • • • •		• • • •	••••	• • • •	••••	• • • •
41														+1								
42 43	• • • •	• • • •		• • • •	• • • •	••••	••••	••••	-1	$^{-1}$	+1		+1		••••			••••	••••			••••
44										$^{+1}$												
45	•••••	••••	••••	••••	••••	••••	•••••	•••••	+1	••••	••••	•••••	••••	••••	••••	••••			•••••	••••	•••••	
46	••••	••••	••••	••••		••••	••••		••••	••••	•••••		-1		••••	•••••	••••	•••••	••••	••••	••••	•••••
48												$+1^{-1}$	τı 									
49 50	••••	••••		• • • •	• • • •	• • • •	••••	••••	••••	• • • •	-1	1	• • • •	-1	• • • •			••••		••••		
	••••	•••••		••••		••••	••••		••••													
$\frac{51}{52}$	•••••	••••	•••••	••••		••••	••••		• • • •	••••	$\frac{1}{1}$	+1	+1	+1	-1	••••						
53												••••	····				-1			••••		
55 55			••••												$+1^{+1}$	$+1^{+1}$	$+1^{-1}$	+1				
56														_1								
57																-1						
58 59	••••	••••		•••••	••••	••••	••••	••••	••••	•••••	••••	•••••	••••	+1	-1	$^{+1}_{-1}$	-1	-i				
60	••••															+1						
61															1.1							
															TI							
62	•••••	····		••••		••••									<i>τ</i> ι 		+1	 +1	-1 + 1		••••	

equations

						1								
	23	24	25	26	27	28	29	30	31 31	l 32	ф 33	λ 34	Σ	
	-0.55 +0.47 +0.08								-1 + 1	-0.14 +0.14 +0.92	-0.14 +0.14 +0.39	+1.20 -1.20 -0.59	$\begin{array}{r} - & 3.55 \\ + & 2.39 \\ + & 1.16 \\ - & 0.28 \\ - & 1.00 \end{array}$	1 2 3 4 5
	+0.01 +0.24	-4.49 +1.88 +2.61							$\begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	-0.92 -4.49 +4.49 +2.34	-0.39 -0.69 +0.69 +0.67	+0.59 +0.41 -0.41 -0.35	$\begin{array}{r} + 1.28 \\ - 9.26 \\ + 0.88 \\ + 8.39 \\ + 1.90 \end{array}$	6 7 8 9 10
and the subscription of th	-0.25 -0.43 +1.14 -0.71	5.30 +8.18							-1	-2.34 +2.30 -7.60 +8.18	-0.67 +0.66 -1.36 +1.25	+0.35 +1.39 -0.34 -0.75	$\begin{array}{r} -1.91 \\ +1.92 \\ +2.14 \\ -16.31 \\ +16.86 \end{array}$	11 12 13 14 15
	· · · · · · · · · · · · · · · · · · ·	-2.88	-0.27 +0.74 -0.47	-0.30 +0.52	-4.20					-2.88	—0. 55	-0.30	$\begin{array}{r} - & 7.88 \\ - & 0.56 \\ + & 0.53 \\ + & 0.52 \\ - & 5.20 \end{array}$	16 17 18 19 20
		-0.74	-0.40 + 1.34 - 0.94	-0.22	+8.45 -4.25				+1	-4. 25 +4. 25 -2. 47 +5. 37	-0.09 +0.09 -0.49 +0.93	+0.67 -0.67 -0.34 +0.07	$\begin{array}{r} + \ 6.56 \\ + \ 1.42 \\ - \ 5.70 \\ + \ 1.34 \\ + \ 5.69 \end{array}$	21 22 23 24 25
		+3.64 -2.90	-1.41	-1.20 + 1.92	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	2.90 4.25	-0.44 -0.76	+0.27 -0.17	+ 4.64 - 5.97 - 7.38 + 0.92 - 2.41	26 27 28 29 30
			+1. 25 +0. 16	-0.72	· · · · · · · · · · · · · · · · · · ·	• • • • • • • • • • • • • • • • • • •		· · · · · · · · · · · · · · · · · · ·	· · · · · · · ·	+3.18 +1.07	+0.49 +0.27	-0.29 +0.46	$\begin{array}{r} + 4.91 \\ + 3.96 \\ - 1.00 \\ 0.00 \\ + 1.00 \end{array}$	31 32 33 34 35
					· · · · · · · · · · ·	+0.59 +1.07	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	 +1	2.30 +2.30	0.20 +0.20	0.16 +0.16	$\begin{array}{r} 0.00 \\ + 1.00 \\ - 1.00 \\ - 3.07 \\ + 2.73 \end{array}$	36 37 38 39 40
		· · · · · · · · · · · · · · · · · · ·		0.17 +0.65 -0.48	· · · · · · · · · · · · · · · · · · ·	-1.66	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	1 	+0.58	-0.02 +0.02	-0.62 +0.62	$\begin{array}{r} - & 0.60 \\ - & 2.23 \\ + & 1.00 \\ + & 1.65 \\ + & 0.58 \end{array}$	41 42 43 44 45
					-3.79 +3.20 +0.59 -0.01	-4.22	· · · · · · · · · · · · · · · · · · ·		· · · · · · ·	+0.01	+0.14	+0.20	$\begin{array}{r} - 4.79 \\ + 3.20 \\ + 1.59 \\ - 1.66 \\ - 6.22 \end{array}$	46 47 48 49 50
					+2.99 -2.98	+2.73	-5.11+6.37-1.26		$\frac{-1}{+1}$	-0.01 -2.44 +2.44	-0.14 -0.10 +0.10	-0.20 -0.07 +0.07	$\begin{array}{r} + 2.99 \\ + 0.40 \\ - 6.11 \\ + 2.76 \\ + 7.84 \end{array}$	$51 \\ 52 \\ 53 \\ 54 \\ 55$
				· · · · · · · · · · · · · · · · · · ·		-3.99 + 9.16	-1.28			+1.77	+0.08	-0.32	$\begin{array}{r} -1.00\\ -1.00\\ +2.00\\ -8.74\\ +10.16\end{array}$	56 57 58 59 60
		• • • • • • • • • •				-5.17	+3.47 -2.19	-3.92 +5.68	+1	-1.77 -0.43 ± 0.43	-0.08 +0.10	+0.32	-5.70 + 3.47 - 4.37 + 4.68 + 0.50	

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
66 67 68 69 70 71										· · · · · · · · · · · · · · · · · · ·							-1 + 1		-1 + 1	····· ····· -1		 1 +1
72 73 74 75		·····	·····	· · · · · · · · · · · · · · · · · · ·			· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·					·····	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		+1	+1	1 +1		1
76 77 78 79	 	····	· · · · · ·	·····	· · · · · ·	 	 	 	 	 	 	 	 	 	·····	 		 	· · · · · ·		$^{+1}_{-1}_{+1}$	+1 -1 +1

equations—Continued

23	24	25	26	27	28	29	30	$\frac{\alpha}{31}$, ^ℓ 32	ф 33	$\frac{\lambda}{34}$	2	
							-1.61		-1.15			-1.00 0.00 +1.00 -3.76 +2.20	66 67 68 69
						-1.24 + 5.00 - 3.76	+0.46	-1 	+1.13 +2.84 -2.84 +1.18 -1.18	+0.07 -0.07 +0.11 -0.11	-0.16 + 0.16 -0.06 + 0.06	- 0. 03 + 3. 25 - 2. 76 - 0. 62 + 0. 95	71 72 73 74 75
							-3.33	+1	+0.18 -0.18			- 0. 33 - 1. 82 + 1. 00 + 0. 82	76 77 78 79

List of corrections

	v's.*	Adopted v's.	V ² .		v's.*	Adopted v's.	v².
1 2 3 4 5	+0.699 +2.448 -3.146 -1.369 -0.207	$ \begin{array}{r} +0.7 \\ +2.4 \\ -3.2 \\ -1.4 \\ -0.2 \end{array} $	0.49 5.76 10.24 1.96 0.04	41 42 43 44 45	$-0.789 \\ -1.997 \\ +0.028 \\ +1.554 \\ +0.581$	$ \begin{array}{r} -0.8 \\ -2.0 \\ +0.0 \\ +1.6 \\ +0.6 \end{array} $	0.64 4.00 0.00 2.56 0.36
6 7 8 9 10	+1.576 +0.806 -1.876 +0.498 -0.117	$^{+1.6}_{+0.7}_{-1.9}_{+0.5}_{-0.1}$	2.56 0.49 3.61 0.25 0.01	46 47 48 49 50	$\begin{array}{r} +0.\ 697 \\ -1.\ 478 \\ +0.\ 781 \\ +0.\ 735 \\ +1.\ 145 \end{array}$	+0.7 -1.5 +0.8 +0.8 +1.2	0. 49 2. 25 0. 64 0. 64 1. 44
11 12 13 14 15	$\begin{array}{r} +0.688 \\ +3.097 \\ +1.159 \\ -2.691 \\ -1.472 \end{array}$	+0.7 +3.1 +1.2 -2.7 -1.4	$\begin{array}{c} 0.\ 49\\ 9.\ 61\\ 1.\ 44\\ 7.\ 29\\ 1.\ 96 \end{array}$	51 52 53 54 55	+0.294 -0.317 -1.522 -0.138 -0.197	$+0.3 \\ -0.3 \\ -1.5 \\ -0.1 \\ -0.2$	$\begin{array}{c} 0.\ 09\\ 0.\ 09\\ 2.\ 25\\ 0.\ 01\\ 0.\ 04 \end{array}$
16 17 18 19 20	$\begin{array}{r} -0.728 \\ +0.755 \\ -0.168 \\ +0.945 \\ -0.090 \end{array}$	-0.7+0.8-0.1+1.0-0.1	0.49 0.64 0.01 1.00 0.01	56 57 58 59 60	$\begin{array}{r} +0.741 \\ +0.525 \\ -1.266 \\ -0.592 \\ -0.262 \end{array}$	+0.7+0.5-1.3-0.6-0.2	0.49 0.25 1.69 0.36 0.04
$21 \\ 22 \\ 23 \\ 24 \\ 25$	$\begin{array}{r} +0.102 \\ -0.910 \\ -1.665 \\ +0.614 \\ -1.570 \end{array}$	$+0.1 \\ -0.9 \\ -1.6 \\ +0.7 \\ -1.5$	$\begin{array}{c} 0.01\\ 0.81\\ 2.56\\ 0.49\\ 2.25\end{array}$		$\begin{array}{r} +0.524\\ +1.193\\ +0.065\\ +0.364\\ -1.294\end{array}$	+0.6 +1.2 +0.1 +0.4 -1.3	0.36 1.44 0.01 0.16 1.69
26 27 28 29 30	+2.090 +0.530 -0.966 +0.183 -1.164	$^{+2.1}_{+0.5}_{-1.0}_{+0.2}_{-1.2}$	4.41 0.25 1.00 0.04 1.44		$\begin{array}{r} -0.190 \\ -0.898 \\ +1.088 \\ -0.748 \\ -0.490 \end{array}$	$-0.2 \\ -0.9 \\ +1.1 \\ -0.8 \\ -0.5$	0.04 0.81 1.21 0.64 0.25
31 32 33 34 35	$\begin{array}{r} +0.311 \\ +1.636 \\ -0.457 \\ +1.167 \\ -0.710 \end{array}$	+0.3 +1.6 -0.4 +1.2 -0.7	$\begin{array}{c} 0.\ 09\\ 2.\ 56\\ 0.\ 16\\ 1.\ 44\\ 0.\ 49 \end{array}$	71 72 73 74 75	$\begin{array}{r} +0.134 \\ +1.234 \\ -0.130 \\ +1.360 \\ -0.203 \end{array}$	$^{+0.1}_{+1.2}_{-0.2}_{+1.3}_{-0.2}$	0.01 1.44 0.04 1.69 0.04
36 37 38 39 40	$\begin{array}{r} -0.494 \\ +1.484 \\ -0.990 \\ -0.319 \\ +0.941 \end{array}$	-0.5 + 1.5 - 1.0 - 0.3 + 0.9	$\begin{array}{c} 0.25 \\ 2.25 \\ 1.00 \\ 0.09 \\ 0.81 \end{array}$	76 77 78 79	-1.158 +0.445 -1.482 +1.037 Total	-1.2 + 0.4 - 1.5 + 1.0	$ \begin{array}{r} 1.44 \\ 0.16 \\ 2.25 \\ 1.00 \\ \hline 103.76 \\ \end{array} $

* These values result from the computation on p. 69.

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Normal equations

C's*	+0.0070 +0.2070 +0.2070 +1.9192 +1.9192 +1.9120 +1.4571 -0.7099 +0.4571 +0.4571 +0.3254 +0.9374 +0.9374	C's	$\begin{array}{c} -1.\ 2334\\ +0.\ 2325\\ +0.\ 2325\\ -0.\ 7413\\ -0.\$
· ~	$\begin{array}{c} -1.81\\ -1.33\\ -1.3395\\ +13.95\\ +14.86\\ +14.86\\ +13.76\\ +11.21\\ +3.77\\ +13.77\\ +7.72\\ +$	εų.	$\begin{array}{c} - 3.04 \\ - 3.04 \\ + 7.37 \\ + 11.43 \\ + 13.78 \\ + 13.78 \\ + 13.78 \\ + 11.03 \\ + 11.03 \\ + 5.41 \\ + 5.41 \end{array}$
μ	++++ 3,2,2,3,2,3,2,3,2,3,3,3,3,3,3,3,3,3,3,3	h	++++++++++++++++++++++++++++++++++++++
34	$\begin{array}{c} +3.08\\ -2.00\\ +1.46\\ +1.46\\ +1.29\\ +1.29\\ +1.29\\ \end{array}$	34	$\begin{array}{c} -2.52\\ -2.52\\ -0.36\\ -1.23\\ -1$
ŝ	$\begin{array}{c} -2.26\\ -2.26\\ -1.76\\ +1.76\\ +1.75\\ +1.76\\ +1.76\\ +1.25\\ -1.76\\ -1$	33	$\begin{array}{c} -0.32\\ -0.32\\ +0.03\\ +0.02\\ -0.03\\ -0.03\\ -0.03\\ -0.03\\ -0.03\\ -0.02\\ -0.03\\ -0.02\\ -0$
32	-1.33	32	$\begin{array}{c} ++6.76 \\ ++6.76 \\ +2331 \\ +3.51 \\ +2.331 \\ +2.331 \\ +2.331 \\ +2.331 \\ +2.331 \\ +0.67 \\ +3.300 \\ +0.67 \\ +0.19 \\ +0.10 \\$
31	++ $++$ $+141$	31	1 11+ ++++1
27	+8.45 +8.45	30	-4.38 -4.38 +4.50
26	+0.42 -1.82 +0.25 +0.08	29	$\begin{array}{c} + 0.02 \\ + 0.02 \\ + 0.02 \\ + 0.95 \\ + 0.95 \\ \end{array}$
25	+0.67 -0.62 -2.48 +3.31 +0.51 +0.51	28	$\begin{array}{c}+&1.66\\+&1.66\\-&1.94\\+&1.22\\+&1.94\\+&5.48\\+&5.48\end{array}$
24	-7.91 +7.53 +2.14 +2.14	27	+ + + - 15 +
33	++0.53 +0.72 +0.72	26	+0.05
11	57 	22	- 5
10	++ 1 ++ 1	21	+3
6	-2 + +6 + 6	20	
00	-2 +6	19	++ - ++ -
~	+ - 2 + - 2	18	00777 +++ +
9	+ +	17	007 7 ++ +
20	+1	16	0 57 + ++
4	+0	15	+ 1 1 - 7
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	0077 ++1	14	++++
5	4+	13	+ 1 +
	9+	12	++
		II	11. 12. 13. 16. 16. 16. 10. 10. 10. 10. 10. 10. 10. 10. 10. 10

C'S	$\begin{array}{c} -1.4817 \\ -1.4817 \\ +1.0414 \\ +0.83524 \\ +0.03872 \\ +1.32912 \end{array}$	+0.86820 -0.19135 +0.02875 +0.08500 -0.19677	-1.37166 +0.02103 -0.27282 +2.16065	
Ŵ	$\begin{array}{c} + 5.03 \\ + 8.52 \\ + 15.1601 \\ + 336.4739 \\ + 4.2703 \end{array}$	$\begin{array}{r} + 4.6556 \\ +108.3339 \\ +205.2346 \\ + 79.9881 \\ + 48.4945 \end{array}$	+ 46.82 +478,9301 + 79.9111 - 18.6051	
u	++6.1 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 2.22 		$\begin{array}{c} - & 7.3 \\ - & 5.2 \\ - & 5.334 \\ - & 20.0499 \\ - & \ddots \end{array}$	
34	$\begin{array}{c} - & 0.01 \\ - & 0.06 \\ - & 0.0639 \\ - & 7.2148 \\ - & 0.1377 \end{array}$	$\begin{array}{c} + & 0.0732 \\ + & 9.1030 \\ - & 0.7425 \\ + & 0.7206 \\ - & 0.0430 \end{array}$	$\begin{array}{c} + & 3.69 \\ - & 13.0822 \\ - & 1.0341 \\ + & 9.4562 \end{array}$	
33	$\begin{array}{c} - & 0.21 \\ + & 0.11 \\ + & 0.9624 \\ + & 24.5038 \\ + & 0.1260 \end{array}$	$\begin{array}{c} + & 0.5728 \\ - & 0.7272 \\ - & 0.0428 \\ - & 1.5212 \\ - & 0.5171 \end{array}$	+ 1.67 +49.3161 + 8.7558	
32	$\begin{array}{rrr} - & 0.93 \\ + & 3.12 \\ + & 5.5439 \\ +151.8020 \\ + & 0.8640 \end{array}$	$\begin{array}{rrr} + & 3.9252 \\ - & 53.9453 \\ + & 6.8009 \\ - & 37.6627 \\ + & 1.8338 \end{array}$	+ 6.82 + 351.4744	
31	++ 1 ++ 3 ++ 7.91	$\begin{array}{c} - & 0.05 \\ + & 11.43 \\ + & 3.82 \\ - & 0.93 \\ - & 9.74 \end{array}$	+16	
30	-10.92 -3.75	+ 8,0144		
29		+ 3. 2298 +127. 4272		
28		- 8, 1354 +158, 2846	L.	
27		- 1.8590 +149.8778		
26	-1, 1220	+6.7354		
25	+1.4732 +7.2568			
24	+ 3.7891 +156.0106			
23	+2.6386			
22	++			
21	9+			
	22	28 28 30 30	31.	

* These values result from the computation on p. 68.

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# 58 COAST AND GEODETIC SURVEY SPECIAL PUBLICATION NO. 28.

Solution of

1	2	3	23	4	6	24	7	5
$+6 \\ C_1$	$^{+2}_{-0.33333}$	$^{-2}_{+0.33333}$	$+0.53 \\ -0.08833$					
1	$^{+6}_{-0.6667}$	$^{+2}_{+0.6667}$	$+2.20 \\ -0.1767$					
	$+5.3333 \\ C_2$	$+2.6667 \\ -0.50001$	$+2.0233 \\ -0.37937$					
	$\frac{1}{2}$	$+6 \\ -0.6667 \\ -1.3333$	-0.44 + 0.1767 - 1.0117	-2		- 7.91		
		$^{+4}_{C_3}$	-1.275 + 0.31875	-2 + 0.5		$ \begin{array}{r} - & 7.91 \\ + & 1.9775 \end{array} $		
		1 2 3	+2.6386 -0.0468 -0.7676 -0.4064	+0.72		+ 3.7891 - 2.5213		
			+1.4178 C ₂₃	$+0.0825 \\ -0.05819$		+ 1.2678 - 0.89420		
		<u>.</u>	3 23	+6 -1 -0.0048	-2	$\begin{array}{rrrr} + & 7.53 \\ - & 3.955 \\ - & 0.0738 \end{array}$		-2
				$+4.9952 \\ C_4$	-2 +0.40038	+ 3.5012 - 0.70091		-2 + 0.40038
				4	$+6 \\ -0.8008$	+ 2.14 + 1.4018	-2	+2 · -0.8008
					+5.1992 $C_6$	+ 3.5418 - 0.68122	-2 + 0.384675	$+1.1992 \\ -0.23065$
					3	+156.0106 - 15.6420		+2.14
					4	$\begin{array}{r} - & 2.4540 \\ - & 2.4127 \end{array}$	+1.3624	$+1.4018 \\ -0.8169$
						$+134.3682 \\ C_{24}$	$+1.3624 \\ -0.0101393$	+2.7249 -0.0202794
	1					6 24	$+6 \\ -0.7693 \\ -0.0138$	+2 +0.4613 -0.0276
							+5.2169 C7	+2.4337 -0.46650

normals

25	31	32	33	34	ŋ	Σ
8	$+3 \\ -0.5$	-6.66 + 1.11	-2.26 + 0.37667	+3.08 -0.51333	-5.5 + 0.91667	- 1.81 + 0.30167
	+1 -1	-3.08 + 2.22	-0.91 + 0.7533	-2.00 -1.0267	+ 4.0 + 1.8333	+ 11.21 + 0.6033
		$ \begin{array}{rrrr} - & 0.86 \\ + & 0.16125 \end{array} $	- 0.1567 + 0.02938	-3.0267 + 0.56751	+ 5.8333 - 1.09375	$+ 11.8132 \\ - 2.21499$
	-4 +1	$\begin{array}{r} - 11.77 \\ - 2.22 \\ + 0.43 \end{array}$	$\begin{array}{r} - 1.76 \\ - 0.7533 \\ + 0.0783 \end{array}$	-4.07 +1.0267 +1.5133	+12.0 - 1.8333 - 2.9167	$\begin{array}{rrrr} - & 13.95 \\ - & 0.6033 \\ - & 5.9067 \end{array}$
	-3 + 0.75	-13.56 + 3.39	-2.435 + 0.60875	-1.53 + 0.3825	+ 7.25 - 1.8125	-20.4600 + 5.115
	+1.50 -0.2650 -0.9562	$\begin{array}{rrrr} + & 5.5439 \\ + & 0.5883 \\ + & 0.3263 \\ - & 4.3222 \end{array}$	$\begin{array}{r} + & 0.9624 \\ + & 0.1996 \\ + & 0.0594 \\ - & 0.7762 \end{array}$	$\begin{array}{c} -0.0639 \\ -0.2721 \\ +1.1482 \\ -0.4877 \end{array}$	$\begin{array}{r} - & 2.22 \\ + & 0.4858 \\ - & 2.2130 \\ + & 2.3109 \end{array}$	$\begin{array}{r} + 15.1601 \\ + 0.1599 \\ - 4.4816 \\ - 6.5216 \end{array}$
	$+0.2788 \\ -0.19664$	+ 2.1363 - 1.50677	+ 0.4452 - 0.31401	$+0.3245 \\ -0.22888$	- 1.6363 + 1.15411	+ 4.3166 - 3.04458
+0.67	+2 -1.5 -0.0162	$ \begin{array}{r} + & 3.84 \\ - & 6.78 \\ - & 0.1243 \end{array} $	$\begin{array}{r} + \ 0.57 \\ - \ 1.2175 \\ - \ 0.0259 \end{array}$	-0.44 -0.7650 -0.0189	$\begin{array}{r} - 8.0 \\ + 3.6250 \\ + 0.0952 \end{array}$	$ \begin{array}{r} + & 6.89 \\ - & 10.23 \\ - & 0.2512 \end{array} $
+0.67 -0.13413	+0.4838 -0.09685	$\begin{array}{rrr} - & 3.0643 \\ + & 0.61345 \end{array}$	- 0.6734 + 0.13481	-1.2239 + 0.24502	-4.2798 + 0.85678	- 3.5912 + 0.71893
-2.48 +0.2683	+0.1937	+ 8.25 - 1.2269	+ 1.48 - 0.2697	+0.37 -0.4900	$\begin{array}{r} - 0.0 \\ - 1.7135 \end{array}$	+ 13.76 - 1.4378
-2.2117 +0.42539	$+0.1937 \\ -0.03726$	+ 7.0231 - 1.35080	$+ 1.2103 \\ - 0.23279$	-0.12 + 0.02308	- 1.7135 + 0.32957	+ 12.3221 - 2.37000
+1.4732 -0.4696 +1.5067	$\begin{array}{r} +7.91\\ -5.9325\\ -0.2493\\ -0.3391\\ -0.1320\end{array}$	$\begin{array}{r} +151.\ 8020\\ -\ 26.\ 8149\\ -\ 1.\ 9103\\ +\ 2.\ 1478\\ -\ 4.\ 7843\end{array}$	$\begin{array}{r} +24.5038 \\ -4.8152 \\ -0.3981 \\ +0.4720 \\ -0.8245 \end{array}$	$\begin{array}{r} -7.2148 \\ -3.0256 \\ -0.2902 \\ +0.8578 \\ +0.0817 \end{array}$	$\begin{array}{r} -5.7 \\ +14.3369 \\ +1.4632 \\ +2.9998 \\ +1.1673 \end{array}$	$\begin{array}{r} +336.\ 4739\\ -\ 40.\ 4597\\ -\ 3.\ 8599\\ +\ 2.\ 5171\\ -\ 8.\ 3941\end{array}$
$+2.5103 \\ -0.0186822$	$+1.2571 \\ -0.0093556$	+120.4403 - 0.8963453	+18.9380 - 0.1409411	-9.5911 +0.0713792	+14.2672 - 0.1061799	+286.2773 -2.1305435
+3.31 -0.8508 -0.0255	+0.0745 -0.0127	$\begin{array}{r} + & 3.54 \\ + & 2.7016 \\ - & 1.2212 \end{array}$	+ 0.76 + 0.4656 - 0.1920	+0.80 -0.0462 +0.0972	$ \begin{array}{r} - 3.2 \\ - 0.6591 \\ - 0.1447 \end{array} $	$\begin{array}{r} + 11.21 \\ + 4.7400 \\ - 2.9027 \end{array}$
+2.4337 -0.46650	+0.0618 -0.01185	+ 5.0204 - 0.96233	+ 1.0336 - 0.19813	+0.8510 -0.16312	-4.0038 + 0.76747	+ 13.0473 - 2.50097

# 60 COAST AND GEODETIC SURVEY SPECIAL PUBLICATION NO. 28.

Solution of

	5	25	8	9	26	10	12	27
 4 6 24 7	+6 -0. 8008 -0. 2766 -0. 0553 -1. 1353	$\begin{array}{r} -0.62 \\ +0.2683 \\ +0.5101 \\ -0.0509 \\ -1.1353 \end{array}$	-2	-2	+0.42			
	$+3.7320 \\ C_{\mathfrak{s}}$	-1.0278 + 0.27540	-2 + 0.53591	-2 + 0.53591	$+0.42 \\ -0.11254$			
	4 6 24 7	+7.2568 -0.0899 -0.9408 -0.0469 -1.1353	+0.51	+0.51	-1.1220			
	5	-0.2831	-0.5508	-0.5508	+0.1157			
		+4.7003 $C_{25}$	+0.0408 +0.00857	+0.0408 +0.00857	+0.21137			
		5 25	$^{+6}_{-1.0718}_{-0.0003}$	$^{+2}_{-1.0718}_{-0.0003}$	-1.82 +0.2251 -0.0086	-2		
			$+4.9279 \\ C_8$	$+0.9279 \\ -0.18830$	-1.6035 + 0.32539	-2 +0.40585		
			5 25 8	+6 -1.0718 -0.0003 -0.1747	+0.25 +0.2251 -0.0086 +0.3019	+2 +0.3766		+8.45
				+4.7532 C ₉	+0.7684 -0.16166	$+2.3766 \\ -0.5$	-	+8.45 -1.77775
				5	+6.7354 -0.0473 -0.2127	+0.08		-1.8590
				89	-0.5218 -0.1242	$-0.6508 \\ -0.3842$		-1.3660
				= '	+5.8294 C ₂₆	-0.9550 + 0.16382		$-3.2250 \\ +0.55323$
-					8 9 26	+6 -0.8117 -1.1883 -0.1564		+8.45 -4.2250 -0.5283
	-			-		+3.8436 C10		$+3.6967 \\ -0.96178$
		•					$+6 C_{12}$	$+0.34 \\ -0.05667$

# normals-Continued

	11	13	31	32	33	34	η	Σ
			+0.1937 -0.0447 -0.0255 -0.0288	+8.61 -1.2269 -1.6199 -2.4425 -2.3420	$\begin{array}{r} +1.75 \\ -0.2697 \\ -0.2792 \\ -0.3841 \\ -0.4822 \end{array}$	$\begin{array}{r} +1.46 \\ -0.4900 \\ +0.0277 \\ +0.1945 \\ -0.3970 \end{array}$	$\begin{array}{r} -2.9 \\ -1.7135 \\ +0.3952 \\ -0.2893 \\ +1.8678 \end{array}$	$\begin{array}{r} +14.86 \\ -1.4378 \\ -2.8421 \\ -5.8055 \\ -6.0866 \end{array}$
1			+0.0947 -0.02538	+0.9787 -0.26225	+0.3348 -0.08971	+0.7952 -0.21308	-2.6398 + 0.70734	-1.3122 + 0.35161
			$\begin{array}{c} -0.0649 \\ +0.0824 \\ -0.0235 \\ -0.0288 \\ +0.0261 \end{array}$	$\begin{array}{r} +0.8640 \\ +0.4110 \\ +2.9876 \\ -2.2501 \\ -2.3420 \\ +0.2695 \end{array}$	$\begin{array}{c} +0.1260 \\ +0.0903 \\ +0.5148 \\ -0.3538 \\ -0.4822 \\ +0.0922 \end{array}$	$\begin{array}{r} -0.1377 \\ +0.1642 \\ -0.0510 \\ +0.1792 \\ -0.3970 \\ +0.2190 \end{array}$	$\begin{array}{r} -6.09 \\ +0.5740 \\ -0.7289 \\ -0.2665 \\ +1.8678 \\ -0.7270 \end{array}$	$\begin{array}{r} + \ 4.\ 2703 \\ + \ 0.\ 4817 \\ + \ 5.\ 2417 \\ - \ 5.\ 3483 \\ - \ 6.\ 0866 \\ - \ 0.\ 3614 \end{array}$
			-0.0087 + 0.00183	-0.0600 + 0.01260	-0.0127 + 0.00267	-0.0233 + 0.00489	-5.3706 + 1.12809	-1.8024 + 0.37859
			$+0.0508 \\ -0.0001$	+3.18 +0.5245 -0.0005	+0.49 +0.1794 -0.0001	$\begin{array}{r} -0.29 \\ +0.4262 \\ -0.0002 \end{array}$	$\begin{array}{r} -2.3 \\ -1.4147 \\ -0.0460 \end{array}$	+ 3.77 - 0.7032 - 0.0154
			$+0.0507 \\ -0.01029$	$+3.7040 \\ -0.75164$	+0.6693 -0.13582	$+0.1360 \\ -0.02760$	-3.7607 + 0.76314	+ 3.0516 - 0.61925
	-2		+2 +0.0508 -0.0001 -0.0095	$\begin{array}{r} +2.02 \\ +0.5245 \\ -0.0005 \\ -0.6975 \end{array}$	$\begin{array}{r} +1.20 \\ +0.1794 \\ -0.0001 \\ -0.1260 \end{array}$	$\begin{array}{r} +1.79 \\ +0.4262 \\ -0.0002 \\ -0.0256 \end{array}$	$\begin{array}{r} -3.2 \\ -1.4147 \\ -0.0460 \\ +0.7081 \end{array}$	$\begin{array}{r} +19.02 \\ -0.7032 \\ -0.0154 \\ -0.5746 \end{array}$
	-2 + 0.42077		$+2.0412 \\ -0.42944$	$+1.8465 \\ -0.38848$	$+1.2533 \\ -0.263675$	$+2.1904 \\ -0.46083$	-3.9526 + 0.83157	$+17.7270 \cdot - 3.72949$
	+0.05+0.3233		$\begin{array}{r} -0.05 \\ -0.0107 \\ -0.0018 \\ +0.0165 \\ -0.3300 \end{array}$	$\begin{array}{r} +3.9252 \\ -0.1101 \\ -0.0127 \\ +1.2052 \\ -0.2985 \end{array}$	$\begin{array}{r} +0.5728 \\ -0.0377 \\ -0.0027 \\ +0.2178 \\ -0.2026 \end{array}$	$\begin{array}{r} +0.\ 0732 \\ -0.\ 0895 \\ -0.\ 0049 \\ +0.\ 0443 \\ -0.\ 3541 \end{array}$	$\begin{array}{r} -2.60 \\ +0.2971 \\ -1.1352 \\ -1.2237 \\ +0.6390 \end{array}$	$\begin{array}{r} + \ 4.\ 6556 \\ + \ 0.\ 1477 \\ - \ 0.\ 3810 \\ + \ 0.\ 9930 \\ - \ 2.\ 8657 \end{array}$
	$+0.3733 \\ -0.06404$		-0.3760 + 0.06450	$+4.7091 \\ -0.80782$	+0.5476 -0.09394	-0.3310 + 0.05678	-4.0228 + 0.69009	+ 2.5496 - 0.43737
	-2 +1 +0.0612		+2 +0.0206 -1.0206 -0.0616	-4.83 +1.5033 -0.9233 +0.7714	$\begin{array}{r} -0.07 \\ +0.2716 \\ -0.6266 \\ +0.0897 \end{array}$	$\begin{array}{r} +1.29 \\ +0.0552 \\ -1.0952 \\ -0.0542 \end{array}$	$\begin{array}{r} -3.2 \\ -1.5263 \\ +1.9763 \\ -0.6590 \end{array}$	$\begin{array}{r} + & 7.72 \\ + & 1.2385 \\ - & 8.8635 \\ + & 0.4177 \end{array}$
	-0.9388 + 0.24425		$+0.9384 \\ -0.24415$	-3.4786 + 0.90504	-0.3353 + 0.08724	$+0.1956 \\ -0.05089$	-3.4090 + 0.88693	+ 0.5126 - 0.13336
	$^{+2}_{-0.33333}$	-2 + 0.33333		+4.24 -0.70667	-0.05 + 0.00833	-0.87 + 0.145	-1.0 +0.16667	+ 8.66 - 1.44333

Solution of

	27	11	13	14	15	28	16	17
9 26	+149.8778 - 15.0220 - 1.7842	-15.67 + 3.5555 + 0.2065	+1.02	-2.98	+2.98	- 8.1354		
10 12	- 0.0193	-0.1133	+0.1133					
	$+129.4969 \\ C_{27}$	-11.1184 + 0.0858584	$+1.1333 \\ -0.0087516$	-2.98 + 0.0230121	$+2.98 \\ -0.0230121$	$\begin{array}{rrr} - & 8.1354 \\ + & 0.0628231 \end{array}$		
	9 26 10	+ 6 - 0.8415 - 0.0239 - 0.2293	+2	+2	-2	+ 1.66		
	12 27	- 0. 6667 - 0. 9546	+0.6667 +0.0973	-0.2559	+0.2559	- 0.6985		
		$+ \begin{array}{c} 3.2840 \\ C_{11} \end{array}$	$+2.7640 \\ -0.84166$	$+1.7441 \\ -0.53109$	-1.7441 + 0.53109	+ 0.9615 - 0.29278		
		10	+6	+2	-2	+ 1.66		
		27 11	-0.0099 -2.3263	$+0.0261 \\ -1.4679$	-0.0261 + 1.4679	+ 0.0712 - 0.8093		
			$+2.9971 \\ C_{13}$	$+0.5582 \\ -0.18625$	$-0.5582 \\ +0.18625$	+ 0.9219 - 0.30760		
			27 11 13	+6 -0.0686 -0.9263 -0.1040	-2 +0.0686 +0.9263 +0.1040	$\begin{array}{rrrr} + & 4.22 \\ - & 0.1872 \\ - & 0.5106 \\ - & 0.1717 \end{array}$	+ 2	
				+4.9011 $C_{14}$	-0.9011 + 0.18386	+ 3.3505 - 0.68362	+ 2 - 0.40807	
				27 11 13	+6 -0.0686 -0.9263 -0.1040 -0.1657	$\begin{array}{rrrr} - & 1.94 \\ + & 0.1872 \\ + & 0.5106 \\ + & 0.1717 \\ + & 0.6160 \end{array}$	+ 2	+2
			-	14	+4.7354	- 0.4545 + 0.09598	+ 2.3677 - 0.5	+2 -0, 42235
-					27	+158.2846 - 0.5111 - 0.2815	+18.86	+5.48
		~			13 14 15	$\begin{array}{rrrr} - & 0.2836 \\ - & 2.2905 \\ - & 0.0436 \end{array}$	- 1.3672 + 0.2273	+0.1920
						$+154.8743 \\ C_{28}$	+17.7201 - 0.114416	+5.6720 -0.036623
			4			14 15 28	$\begin{array}{r} + \ 6 \\ - \ 0.\ 8161 \\ - \ 1.\ 1839 \\ - \ 2.\ 0275 \end{array}$	+2 -1 -0.6490
							$+ \begin{array}{c} 1.9725 \\ C_{16} \end{array}$	+0.3510 -0.17795

# normals-Continued

18	29	31	32	33	34	η	Σ
		$\begin{array}{r} + 11.43 \\ - 3.6287 \\ - 0.2080 \\ - 0.9025 \end{array}$	$\begin{array}{r} -53.9453 \\ -3.2826 \\ +2.6052 \\ +3.3456 \\ -0.2403 \end{array}$	$\begin{array}{r} -0.7272 \\ -2.2281 \\ +0.3029 \\ +0.3225 \\ +0.0028 \end{array}$	$\begin{array}{r} +9.1030 \\ -3.8940 \\ -0.1831 \\ -0.1881 \\ +0.0493 \end{array}$	+0.0 +7.0267 -2.2255 +3.2787 +0.0567	$\begin{array}{r} +108.3339 \\ -31.5142 \\ +1.4105 \\ -0.4930 \\ -0.4908 \end{array}$
		+ 6.6908 - 0.0516676	-51.5174 + 0.3978273	$-2.3271 \\ +0.0178703$	$+4.8871 \\ -0.0377391$	$+8.1366 \\ -0.0628324$	+ 77.2464 - 0.5965116
		$ \begin{array}{r} - 4 \\ + 0.8589 \\ + 0.0241 \\ + 0.2292 \\ + 0.5745 \end{array} $	$\begin{array}{r} + \ 6.76 \\ + \ 0.7770 \\ - \ 0.3016 \\ - \ 0.8496 \\ - \ 1.4133 \\ - \ 4.4232 \end{array}$	$\begin{array}{r} -0.32 \\ +0.5274 \\ -0.0351 \\ -0.0819 \\ +0.0167 \\ -0.1998 \end{array}$	$\begin{array}{r} -2.52 \\ +0.9217 \\ +0.0212 \\ +0.0478 \\ +0.2900 \\ +0.4196 \end{array}$	$\begin{array}{c} +5.\ 0\\ -1.\ 6631\\ +0.\ 2576\\ -0.\ 8326\\ +0.\ 3333\\ +0.\ 6986\end{array}$	$\begin{array}{rrrr} - & 3.04 \\ + & 7.4590 \\ - & 0.1633 \\ + & 0.1252 \\ - & 2.8866 \\ + & 6.6323 \end{array}$
		-2.3133 + 0.70442	$+ 0.5493 \\ - 0.16727$	-0.0927 + 0.02823	-0.8197 + 0.24960	+3.7938 -1.15524	+ 8.1269 - 2.47470
		-2 - 0.0586 + 1.9470	$\begin{array}{r} - & 2.31 \\ + & 1.4133 \\ + & 0.4509 \\ - & 0.4623 \end{array}$	$\begin{array}{r} -0.34 \\ -0.0167 \\ +0.0204 \\ +0.0780 \end{array}$	$\begin{array}{r} -0.36 \\ -0.2900 \\ -0.0428 \\ +0.6899 \end{array}$	+3.7 -0.3333 -0.0712 -3.1931	$\begin{array}{rrrr} + & 7.37 \\ + & 2.8866 \\ - & 0.6760 \\ - & 6.8401 \end{array}$
		- 0.1116 + 0.03724	- 0.9081 + 0.30299	-0.2583 + 0.08618	-0.0029 + 0.00097	$+0.1024 \\ -0.03417$	+ 2.7405 - 0.91438
		$\begin{array}{r} - 2 \\ + 0.1540 \\ + 1.2286 \\ + 0.0208 \end{array}$	$\begin{array}{r} - & 2.31 \\ - & 1.1855 \\ - & 0.2917 \\ + & 0.1691 \end{array}$	$\begin{array}{r} -0.34 \\ -0.0536 \\ +0.0492 \\ +0.0481 \end{array}$	$\begin{array}{r} -0.36 \\ +0.1125 \\ +0.4353 \\ +0.0005 \end{array}$	$\begin{array}{r} +5.2 \\ +0.1872 \\ -2.0148 \\ -0.0191 \end{array}$	$\begin{array}{r} + 11.43 \\ + 1.7776 \\ - 4.3161 \\ - 0.5104 \end{array}$
		- 0. 5966 + 0. 12173	-3.6181 + 0.73822	-0.2963 + 0.06046	$+0.1883 \\ -0.03842$	$+3.3533 \\ -0.68419$	+ 8.3811 - 1.71004
+2	+0.02	$\begin{array}{r} + 4 \\ - 0.1540 \\ - 1.2286 \\ - 0.0208 \\ - 0.1097 \end{array}$	$\begin{array}{r} + 3.51 \\ + 1.1855 \\ + 0.2917 \\ - 0.1691 \\ - 0.6652 \end{array}$	$\begin{array}{r} +0.\ 48 \\ +0.\ 0536 \\ -0.\ 0492 \\ -0.\ 0481 \\ -0.\ 0545 \end{array}$	$\begin{array}{c} +1.23 \\ -0.1125 \\ -0.4353 \\ -0.0005 \\ +0.0346 \end{array}$	$\begin{array}{r} -2.5 \\ -0.1872 \\ +2.0148 \\ +0.0191 \\ +0.6165 \end{array}$	$\begin{array}{r} + 13.78 \\ - 1.7776 \\ + 4.3161 \\ + 0.5104 \\ + 1.5409 \end{array}$
$^{+2}_{-0.42235}$	$+0.02 \\ -0.00422$	+ 2. 4869 - 0. 52517	+ 4.1529 - 0.87699	$+0.3818 \\ -0.08063$	$+0.7163 \\ -0.151265$	-0.0368 + 0.00777	+ 18.3697 - 3.87923
+5.48	+3. 2298	$\begin{array}{r} + 3.82 \\ + 0.4203 \\ + 0.6773 \\ + 0.0343 \\ + 0.4078 \\ + 0.2387 \end{array}$	$\begin{array}{r} + \ 6.\ 8009 \\ - \ 3.\ 2365 \\ - \ 0.\ 1608 \\ + \ 0.\ 2793 \\ + \ 2.\ 4734 \\ + \ 0.\ 3986 \end{array}$	$\begin{array}{c} -0.0428 \\ -0.1462 \\ +0.0271 \\ +0.0795 \\ +0.2026 \\ +0.0366 \end{array}$	$\begin{array}{r} -0.7425 \\ +0.3070 \\ +0.2400 \\ +0.0009 \\ -0.1287 \\ +0.0688 \end{array}$	$\begin{array}{r} +6.\ 6\\ +0.\ 5112\\ -1.\ 1107\\ -0.\ 0315\\ -2.\ 2924\\ -0.\ 0035\end{array}$	$\begin{array}{r} +205.\ 2346 \\ +\ 4.\ 8529 \\ -\ 2.\ 3794 \\ -\ 0.\ 8430 \\ -\ 5.\ 7295 \\ +\ 1.\ 7631 \end{array}$
+5.6720 -0.036623	+3.2317 -0.020867	+ 5. 5984 - 0. 036148	$+ 6.5549 \\ - 0.042324$	$+0.1568 \\ -0.001012$	-0.2545 +0.001643	$+3.6731 \\ -0.023717$	+202.8983 - 1.310087
+2 -1 -0.6490	+0.02 -0.01 -0.3698	$\begin{array}{r} + 2 \\ + 0.2435 \\ - 1.2435 \\ - 0.6405 \end{array}$	$\begin{array}{r} + \ 0.\ 67 \\ + \ 1.\ 4764 \\ - \ 2.\ 0764 \\ - \ 0.\ 7500 \end{array}$	$\begin{array}{r} +0.02 \\ +0.1209 \\ -0.1909 \\ -0.0179 \end{array}$	+0.39 -0.0768 -0.3582 +0.0291	$\begin{array}{r} +2.8^{\circ} \\ -1.3684 \\ +0.0184 \\ -0.4203 \end{array}$	$\begin{array}{r} + 38.76 \\ - 3.4201 \\ - 9.1849 \\ - 23.2149 \end{array}$
+0.3510 -0.17795	-0.3598 +0.18241	+ 0.3595 - 0.18226	- 0.6800 + 0.34474	-0.0679 + 0.03442	-0.0159 +0.00806	+1.0297 -0.52203	+ 2.9401 - 1.49054

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Solution of

1		17	19	20	10	20	91	99
	$     \begin{array}{c}       15 \\       23 \\       16     \end{array}   $	+6 -0.8447 -0.2077 -0.0625	+2 -0.8447 -0.2077 -0.0625	$\begin{array}{rrrr} + & 8.60 \\ - & 0.0084 \\ - & 0.1184 \\ + & 0.0640 \end{array}$	-2			
		+4.8851 C17	+0.8851 -0.18118	+ 8. 5372 - 1. 74760	-2 + 0.40941			
		15     28     16     17	+6 -0.8447 -0.2077 -0.0625 -0.1604	$\begin{array}{rrrr} - & 2.30 \\ - & 0.0084 \\ - & 0.1184 \\ + & 0.0640 \\ - & 1.5468 \end{array}$	+2 +0.3624	-2		
			+4.7247 $C_{18}$	$\begin{array}{rrr} - & 3.9096 \\ + & 0.82748 \end{array}$	$+2.3624 \\ -0.50001$	-2 + 0.42331		
			15 28 16 17 18	$\begin{array}{r} +127.4272 \\ -\ 0.0001 \\ -\ 0.0674 \\ -\ 0.0656 \\ -\ 14.9196 \\ -\ 3.2351 \end{array}$	-8.18 +3.4952 +1.9548	+0.95 -1.6550		1
				$+109.1394 \\ C_{29}$	-2.73 +0.025014	-0.7050 + 0.006460		
				17 18 29		-2 +1 -0.0176		
					$+3.9317 \\ C_{19}$	-1.0176 + 0.25882		
					18 29 19	$\begin{array}{c} +6 \\ -0.8466 \\ -0.0046 \\ -0.2634 \end{array}$	+2	-2
						$+4.8854 \\ C_{20}$	+2 -0.40938	-2 + 0.40938
_						20	$+6 \\ -0.8188$	+2 +0.8188
							+5.1812 C ₂₁	+2.8188 -0.54404
							20 21	+6 -0.8188 -1.5335
	i							$+3.6477 \\ C_{22}$

# normals-Continued

30	31	32	33	34	η	2
	+2 -1. 0503 -0. 2050 -0. 0640	$\begin{array}{r} + \ 0.\ 67 \\ - \ 1.\ 7540 \\ - \ 0.\ 2401 \\ + \ 0.\ 1210 \end{array}$	+0.02 -0.1613 -0.0057 +0.0121	+0.39 -0.3025 +0.0093 +0.0028	$\begin{array}{r} - 5.1 \\ + 0.0155 \\ - 0.1345 \\ - 0.1832 \end{array}$	$\begin{array}{r} +22.06 \\ -7.7584 \\ -7.4308 \\ -0.5232 \end{array}$
	+0.6807 -0.13934	- 1.2031 + 0.24628	-0.1349 + 0.02761	+0.0996 -0.02039	- 5. 4022 + 1. 10585	$+ 6.3475 \\ - 1.29936$
- 4.38	$\begin{array}{r} +4 \\ -1.0503 \\ -0.2050 \\ -0.0640 \\ -0.1233 \end{array}$	$\begin{array}{r} - 3.00 \\ - 1.7540 \\ - 0.2401 \\ + 0.1210 \\ + 0.2180 \end{array}$	$\begin{array}{c} +0.08 \\ -0.1613 \\ -0.0057 \\ +0.0121 \\ +0.0244 \end{array}$	$\begin{array}{c} +0.85 \\ -0.3025 \\ +0.0093 \\ +0.0028 \\ -0.0180 \end{array}$	$\begin{array}{r} - & 1.7 \\ + & 0.0155 \\ - & 0.1345 \\ - & 0.1832 \\ + & 0.9788 \end{array}$	$\begin{array}{r} +11.\ 03\\ -\ 7.\ 7584\\ -\ 7.\ 4308\\ -\ 0.\ 5232\\ -\ 1.\ 1500\end{array}$
-4.38 + 0.92704	+2.5574 -0.54128	- 4. 6551 + 0. 98527	-0.0505 +0.01069	$+0.5416 \\ -0.11463$	- 1. 0234 + 0. 21661	- 5.8325 + 1.23447
+ 8.0144 - 3.6244	$\begin{array}{r} -0.\ 93 \\ -0.\ 0105 \\ -0.\ 1163 \\ +0.\ 0656 \\ -1.\ 1896 \\ +2.\ 1162 \end{array}$	$\begin{array}{r} -37.\ 6627\\ -\ 0.\ 0175\\ -\ 0.\ 1368\\ -\ 0.\ 1240\\ +\ 2.\ 1025\\ -\ 3.\ 8520\end{array}$	$\begin{array}{c} -1.\ 5212\\ -0.\ 0016\\ -0.\ 0033\\ -0.\ 0124\\ +0.\ 2358\\ -0.\ 0418\end{array}$	$\begin{array}{c} +0.\ 7206\\ -0.\ 0030\\ +0.\ 0053\\ -0.\ 0029\\ -0.\ 1741\\ +0.\ 4482\end{array}$	$\begin{array}{r} -18.4 \\ + 0.0002 \\ - 0.0766 \\ + 0.1878 \\ + 9.4409 \\ - 0.8468 \end{array}$	$\begin{array}{r} +79.\ 9881 \\ -0.\ 0776 \\ -4.\ 2339 \\ +0.\ 5363 \\ -11.\ 0929 \\ -4.\ 8263 \end{array}$
+ 4.3900 - 0.040224	-0.0651 +0.000596	-39.6905 + 0.363668	-1.3445 + 0.012319	+0.9941 -0.009109	- 9.6945 + 0.088827	+60.2939 - 0.552449
-* 4.38 + 2.19 + 0.1098	+2 +0. 2787 -1. 2787 -0. 0016	$\begin{array}{r} - 3.27 \\ - 0.4926 \\ + 2.3276 \\ - 0.9928 \end{array}$	$\begin{array}{r} + 0.\ 03 \\ - 0.\ 0552 \\ + 0.\ 0252 \\ - 0.\ 0336 \end{array}$	$\begin{array}{r} +0.\ 23 \\ +0.\ 0408 \\ -0.\ 2708 \\ +0.\ 0249 \end{array}$	$\begin{array}{r} + 2.1 \\ - 2.2117 \\ + 0.5117 \\ - 0.2425 \end{array}$	$\begin{array}{r} - & 7.47 \\ + & 2.5987 \\ + & 2.9163 \\ + & 1.5082 \end{array}$
-2.0802 + 0.52908	$+0.9984 \\ -0.25394$	-2.4278 + 0.61749	-0.0336 + 0.00855	$+0.0249 \\ -0.00633$	+ 0. 1575 - 0. 04006	- 0. 4467 + 0. 11361
$\begin{array}{r} + \ 4.\ 50 \\ - \ 1.\ 8541 \\ + \ 0.\ 0284 \\ - \ 0.\ 5384 \end{array}$	$     \begin{array}{r}       -4 \\       +1, 0826 \\       -0, 0004 \\       +0, 2584     \end{array} $	$\begin{array}{r} + \ 0.19 \\ - \ 1.9706 \\ - \ 0.2564 \\ - \ 0.6284 \end{array}$	$\begin{array}{r} -0.35 \\ -0.0214 \\ -0.0087 \\ -0.0087 \end{array}$	-0.18+0.2293+0.0064+0.0064	$\begin{array}{r} + 2.3 \\ - 0.4332 \\ - 0.0626 \\ + 0.0408 \end{array}$	$\begin{array}{r} + 5.41 \\ - 2.4690 \\ + 0.3895 \\ - 0.1157 \end{array}$
+ 2.1359 - 0.43720	-2.6594 + 0.54436	-2.6654 + 0.54558	-0.3888 +0.07958	$^{+0.0621}_{-0.01271}$	+ 1.8450 - 0.37766	+ 3.2148 - 0.65804
-10.92 - 0.8744	+1 +1.0887	- 0.93 + 1.0912	-0.21 +0.1592	-0.01 -0.0254	$+ 6.1 \\ - 0.7553$	+ 5.03 - 1.3161
-11.7944 + 2.27638	+2.0887 -0.40313	+ 0.1612 - 0.03111	-0.0508 + 0.00980	-0.0354 + 0.00683	+ 5. 3447 - 1. 03156	+ 3.7140 - 0.71682
$\begin{array}{r} - 3.75 \\ + 0.8744 \\ + 6.4166 \end{array}$	$+3 \\ -1.0887 \\ -1.1363$	$\begin{array}{r} + \ 3.12 \\ - \ 1.0912 \\ - \ 0.0877 \end{array}$	$^{+0.11}_{-0.1592}_{+0.0276}$	-0.06 +0.0254 +0.0193	+ 0.1 + 0.7553 - 2.9077	+ 8.52 + 1.3161 - 2.0206
+ 3. 5410 - 0. 97075	+0.7750 -0.21246	+ 1.9411 - 0.53214	-0.0216 + 0.00592	-0.0153 +0.00419	- 2.0524 + 0.56266	+ 7.8155 - 2.14258

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Solution of normals-Continued

	30	31	32	33	34	ŋ ·	Σ
- 18 29 19 20 21 22	$\begin{array}{r} +76.0764 \\ - 4.0604 \\ - 0.1766 \\ - 1.1006 \\ - 0.9338 \\ -26.8485 \\ - 3.4374 \end{array}$	$\begin{array}{r} - 9.74 \\ + 2.3708 \\ + 0.0026 \\ + 0.5282 \\ + 1.1627 \\ + 4.7547 \\ - 0.7523 \end{array}$	$\begin{array}{rrrrr} + & 1.8338 \\ - & 4.3155 \\ + & 1.5965 \\ - & 1.2845 \\ + & 1.1653 \\ + & 0.3670 \\ - & 1.8843 \end{array}$	$\begin{array}{r} - & 0.5171 \\ - & 0.0468 \\ + & 0.0541 \\ - & 0.0178 \\ + & 0.1700 \\ - & 0.1156 \\ + & 0.0210 \end{array}$	$\begin{array}{r} - & 0.0430 \\ + & 0.5021 \\ - & 0.0400 \\ + & 0.0132 \\ - & 0.0272 \\ - & 0.0806 \\ + & 0.0149 \end{array}$	$\begin{array}{r} - 8.2 \\ - 0.9487 \\ + 0.3900 \\ + 0.0833 \\ - 0.8066 \\ + 12.1666 \\ + 1.9924 \end{array}$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$
	$+39.5191 \\ C_{30}$	- 1.6733 + 0.042342	$\begin{array}{rrr} - & 2.5217 \\ + & 0.063810 \end{array}$	- 0.4522 + 0.011443	$+ 0.3394 \\- 0.008588$	+ 4.6770 - 0.118348	+ 39.8883 - 1.009342
	$\begin{array}{c}1\\3\\\bullet\\23\\6\\-24\\7\\5\\25\\25\\25\\8\\9\\9\\26\\10\\11\\11\\13\\14\\15\\28\\16\\17\\18\\29\\9\\19\\.\\22\\30\end{array}$	$\begin{array}{c} +16\\ -1.5\\ -2.25\\ -0.0548\\ -0.0469\\ -0.0072\\ -0.0118\\ -0.0007\\ -0.0024\\ -0.0007\\ -0.0024\\ -0.0243\\ -0.2291\\ -0.3457\\ -1.6295\\ -0.0243\\ -0.2291\\ -0.3457\\ -1.6295\\ -0.0042\\ -0.0726\\ -1.3060\\ -1.3060\\ -1.3060\\ -1.3843\\ -0.2535\\ -1.4477\\ -0.8420\\ -0.1647\\ -0.1647\\ -0.0769\\ \end{array}$	$\begin{array}{c} + & 6.82 \\ + & 3.33 \\ - & 10.17 \\ - & 0.4201 \\ + & 0.2968 \\ - & 0.2017 \\ - & 1.1268 \\ - & 0.0595 \\ - & 0.0248 \\ - & 0.0595 \\ - & 0.0248 \\ - & 0.0381 \\ - & 0.0381 \\ + & 0.3037 \\ + & 0.3037 \\ + & 0.3037 \\ + & 0.3037 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\ - & 0.338 \\$	$\begin{array}{c} + 1.67 \\ + 1.13 \\ - 0.0875 \\ + 0.0652 \\ - 0.0451 \\ - 0.1772 \\ - 0.0085 \\ - 0.0122 \\ - 0.0085 \\ - 0.0085 \\ - 0.0085 \\ - 0.0085 \\ - 0.0332 \\ + 0.0333 \\ + 0.0819 \\ - 0.0653 \\ - 0.0035 \\ - 0.0096 \\ - 0.0361 \\ - 0.2005 \\ - 0.0096 \\ - 0.0036 \\ + 0.0124 \\ + 0.0124 \\ + 0.0188 \\ + 0.0235 \\ - 0.0096 \\ - 0.0085 \\ - 0.2116 \\ + 0.0235 \\ - 0.2116 \\ + 0.0245 \\ - 0.0046 \\ - 0.0191 \end{array}$	$\begin{array}{c} + 3.69 \\ - 1.54 \\ - 1.1475 \\ - 0.0638 \\ + 0.1185 \\ + 0.0185 \\ + 0.0045 \\ + 0.0045 \\ - 0.0101 \\ - 0.0202 \\ - 0.0202 \\ - 0.0213 \\ - 0.0478 \\ - 0.9406 \\ - 0.9406 \\ - 0.9406 \\ - 0.0213 \\ - 0.0478 \\ - 0.2525 \\ - 0.5774 \\ - 0.0001 \\ + 0.0229 \\ - 0.3702 \\ - 0.3702 \\ - 0.0001 \\ + 0.0029 \\ - 0.038 \\ + 0.0038 \\ + 0.0033 \\ + 0.0033 \\ + 0.0033 \\ + 0.0033 \\ + 0.0033 \\ + 0.0144 \end{array}$	$\begin{array}{c} -7.3 \\ +2.75 \\ +5.4375 \\ +0.3218 \\ +0.0415 \\ +0.0415 \\ +0.0474 \\ +0.0670 \\ -0.1335 \\ +0.0474 \\ +0.0670 \\ +0.0387 \\ +0.0387 \\ +0.0387 \\ +0.0387 \\ +0.0255 \\ +0.4024 \\ +2.6724 \\ +0.0038 \\ +0.4084 \\ +0.0038 \\ +0.4084 \\ +0.0038 \\ +0.1328 \\ -0.1328 \\ -0.1328 \\ -0.1328 \\ -0.0400 \\ +1.0043 \\ -2.1546 \\ +0.4361 \\ +0.4361 \\ +0.4361 \\ +0.4361 \\ +0.1980 \\ \end{array}$	$\begin{array}{c} + 46.82 \\ + 0.9050 \\ - 15.3450 \\ - 0.8488 \\ + 0.3478 \\ + 0.3478 \\ - 0.4591 \\ - 2.6783 \\ - 0.1546 \\ + 0.0333 \\ - 0.0333 \\ - 0.0331 \\ - 0.0333 \\ - 0.0333 \\ - 0.0333 \\ - 0.0333 \\ - 0.0334 \\ + 0.1021 \\ + 5.7248 \\ - 3.9911 \\ + 5.7248 \\ - 3.9911 \\ + 0.1624 \\ - 0.1522 \\ - 9.6472 \\ - 7.3344 \\ - 0.5.59 \\ - 0.8845 \\ + 3.1570 \\ + 0.6359 \\ + 0.1134 \\ + 1.7500 \\ - 1.4972 \\ - 1.6690 \end{array}$
		$+ \begin{array}{c} 3.1119 \\ C_{31} \end{array}$	$\begin{array}{rrr} + & 0.2312 \\ - & 0.07430 \end{array}$	- 0.0558 + 0.01793	-1.3082 + 0.42039	+ 7.0750 - 2.27353	+ 9.0541 - 2.90951
		$\begin{array}{c}1\\1\\2\\3\\3\\23\\4\\6\\24\\7\\7\\5\\8\\9\\9\\26\\10\\12\\27\\711\\13\\14\\14\\15\\28\\16\\17\\18\\12\\29\\19\\9\\19\\20\\21\\22\\30\\31\end{array}$	$\begin{array}{r} +351,4744\\ -7,3926\\ -0,1387\\ -45,9684\\ -3,2189\\ -9,4568\\ -9,4568\\ -9,4568\\ -9,4568\\ -9,4568\\ -9,4568\\ -9,4568\\ -9,4568\\ -9,4568\\ -2,7841\\ -0,2767\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ -3,8041\\ 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+8.5909\\ -0.2685\\ -0.2685\\ -0.2685\\ -0.2685\\ -0.2685\\ -0.2685\\ -0.2674\\ +0.1770\\ +0.6148\\ +1.9442\\ +0.1371\\ -0.2674\\ +0.1371\\ -0.2674\\ +0.1371\\ -0.2674\\ +0.1371\\ -0.2674\\ +0.3509\\ +0.2674\\ +0.3309\\ +0.0108\\ +0.0108\\ +0.039\\ +0.0108\\ +0.0245\\ +0.0336\\ +0.0336\\ +0.0336\\ +0.0336\\ +0.0336\\ +0.0336\\ +0.0336\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.0015\\ +0.00$	$\begin{array}{c} -5.2\\ -6.1050\\ +0.9406\\ +24.5775\\ +2.4655\\ +2.4655\\ +2.4655\\ +2.6254\\ +2.3146\\ -12.7883\\ +3.8530\\ +0.6923\\ -0.0677\\ +2.8267\\ +3.2497\\ -3.0853\\ +0.7067\\ +3.2370\\ -0.6346\\ +0.0310\\ +0.0310\\ +2.4755\\ +0.0323\\ -0.1555\\ +0.3555\\ -0.1555\\ +0.3555\\ -0.1555\\ +0.0355\\ -1.30083\\ -3.5256\\ -0.1555\\ +0.0973\\ +1.00063\\ +0.0973\\ +1.0063\\ +0.0973\\ +1.0022\\ +0.2984\\ -0.5257\\ -1.108257\\ -0.137808\end{array}$	$\begin{array}{r} +478.9301\\ -2.0091\\ +1.9049\\ -69.3594\\ -6.5041\\ -2.2030\\ -16.6447\\ -2.2030\\ -12.5558\\ +0.3441\\ -0.0227\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ -2.2937\\ $

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# APPLICATION OF LEAST SQUARES TO TRIANGULATION.

# Solution of normals-Continued

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$\begin{array}{c} 1\\ 2\\ 3\\ 3\\ 23\\ 4\\ 6\\ 24\\ 7\\ 5\\ 25\\ 25\\ 25\\ 26\\ 10\\ 12\\ 27\\ 11\\ 13\\ 14\\ 15\\ 28\\ 16\\ 17\\ 18\\ 9\\ 19\\ 20\\ 21\\ 22\\ 30\\ 31\\ 32\\ \end{array}$	$\begin{array}{c} +8.7558\\ -0.8513\\ -0.0046\\ -1.4823\\ -0.1398\\ -0.2817\\ -2.6691\\ -0.2817\\ -2.6691\\ -0.2048\\ -0.0300\\ -\\ -0.0909\\ -0.3305\\ -0.0514\\ -0.0293\\ -0.0004\\ -0.0023\\ -0.0004\\ -0.0023\\ -0.0023\\ -0.0037\\ -0.0038\\ -0.0023\\ -0.0037\\ -0.0038\\ -0.0005\\ -0.0166\\ -0.0005\\ -0.0005\\ -0.0005\\ -0.0005\\ -0.0005\\ -0.0005\\ -0.0005\\ -0.0001\\ -1.7655\\ -0.0011\\ -1.7655\\ -0.0011\\ -0.529\\ -0.0011\\ -0.052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.0011\\ -0.0052\\ -0.001\\ -0.005\\ -0.001\\ -0.005\\ -0.001\\ -0.005\\ -0.001\\ -0.005\\ -0.000\\ -0.005\\ -0.000\\ -0.005\\ -0.000\\ -0.005\\ -0.000\\ -0.000\\ -0.005\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.000\\ -0.0$	$\begin{array}{c} -1.0341\\ +1.1601\\ -0.0889\\ -0.9314\\ -0.1019\\ -0.1650\\ +0.0279\\ +1.3518\\ -0.1686\\ -0.0713\\ -0.0001\\ -0.0185\\ -0.0713\\ -0.0001\\ +0.0311\\ +0.0171\\ +0.0072\\ +0.0873\\ -0.0231\\ -0.0023\\ +0.0031\\ +0.0072\\ +0.0033\\ -0.0023\\ +0.0012\\ +0.0005\\ +0.0005\\ +0.0005\\ +0.0005\\ +0.0005\\ +0.0005\\ +0.0005\\ +0.0005\\ +0.0005\\ +0.0005\\ +0.0002\\ +0.0003\\ -0.0003\\ -0.0003\\ -0.0003\\ -0.0003\\ +0.0039\\ -0.0251\\ +0.7814\\ +0.058\\ +0.058\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0251\\ +0.0039\\ -0.0039\\ -0.0251\\ +0.0039\\ -0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0039\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ -0.0031\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.0032\\ +0.003\\$	$\begin{array}{c} - \ 2.\ 5334 \\ - \ 2.\ 0717 \\ + \ 0.\ 1714 \\ + \ 4.\ 4.\ 134 \\ + \ 0.\ 5138 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - \ 0.\ 5770 \\ - 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	+0.5508	+0.2254 -0.40481	-0.3351 + 0.60183	+ 0.4471 - 0.80298
	$\begin{array}{c}1\\2\\3\\3\\4\\6\\24\\7\\5\\25\\8\\9\\26\\10\\12\\27\\11\\13\\14\\14\\15\\28\\16\\17\\18\\29\\19\\20\\21\\22\\30\\31\\32\\33\end{array}$	$\begin{array}{c} +9.4562\\ -1.5811\\ -1.7177\\ -0.5825\\ -0.0743\\ -0.2999\\ -0.0028\\ -0.6846\\ -0.1388\\ -0.1694\\ -0.0001\\ -0.0038\\ -1.0094\\ -0.0003\\ -1.0094\\ -0.0003\\ -1.0094\\ -0.0188\\ -0.1000\\ -0.1844\\ -0.2046\\ -0\\ -0.0018\\ -0.0001\\ -0.0020\\ -0.0021\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0002\\ -0.0$	$\begin{array}{r} -20.0490 \\ + 2.8233 \\ + 3.3105 \\ + 2.7731 \\ + 0.3745 \\ - 1.0486 \\ - 0.0395 \\ + 1.0184 \\ + 0.6531 \\ + 0.5025 \\ - 0.0263 \\ + 0.1038 \\ + 1.8215 \\ - 0.2284 \\ + 0.1735 \\ - 0.1450 \\ - 0.3071 \\ + 0.9469 \\ + 0.0036 \\ + 0.0001 \\ - 0.1288 \\ + 0.0056 \\ + 0.0003 \\ + 0.0003 \\ + 0.0036 \\ - 0.0234 \\ + 0.0036 \\ - 0.0036 \\ - 0.0036 \\ - 0.0036 \\ - 0.0036 \\ - 0.0036 \\ - 0.0036 \\ - 0.0036 \\ - 0.0002 \\ + 2.9743 \\ + 0.8333 \\ + 0.1357 \\ - 3.1701 \\ \end{array}$	$\begin{array}{r} -18,6051\\ +0,0291\\ +0,0291\\ +6,7041\\ -7,8260\\ -0,8790\\ -0,8790\\ -0,8790\\ -0,8790\\ -0,8790\\ -0,8790\\ -0,6842\\ -2,1283\\ -0,6842\\ -2,1283\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,6842\\ -0,$
		C34	+ 2.16065	+ 1.16065

I	1	1	1	1	1	1	
34	33	32	31	30	22	21	20
+2.16065	+0.60183 -0.87405 -0.27282	-0.13781 +0.12358 +0.03526 +0.02103	$\begin{array}{r} -2.27353\\ +0.90832\\ -0.00489\\ -0.00156\\ \hline \\ -1.37166\end{array}$	$-0.11835 \\ -0.01856 \\ -0.00312 \\ +0.00134 \\ -0.05808 \\ -0.19077$	$\begin{array}{c} +0.5627\\ +0.0091\\ -0.0016\\ -0.0112\\ +0.2914\\ +0.1910\\ \hline \\ +1.0414\\ \end{array}$	$-1.0316 \\ +0.0148 \\ -0.0027 \\ -0.0007 \\ +0.5530 \\ -0.4479 \\ -0.5666 \\ -1.4817$	$\begin{array}{c} -0.3777\\ -0.0275\\ -0.0217\\ +0.0115\\ -0.7407\\ +0.0800\\ +0.4263\\ +0.6065\\ \hline \end{array}$
19	29	18	17	16	28	15	14
$\begin{array}{c} -0.0401\\ -0.0137\\ -0.0023\\ +0.0130\\ +0.3483\\ -0.1641\\ -0.0112\\ \hline +0.1599\end{array}$	$\begin{array}{c} +0.08833\\ -0.01908\\ -0.00336\\ +0.00765\\ -0.00082\\ +0.00791\\ -0.00028\\ +0.00475\\ \hline +0.00475\\ \hline +0.08500\end{array}$	$\begin{array}{c} +0.2166\\ -0.2477\\ -0.0029\\ +0.0207\\ +0.7425\\ -0.1824\\ -0.0183\\ -0.0950\\ +0.0703\\ \end{array}$	$\begin{array}{c} +1.1058\\ -0.0441\\ -0.0075\\ +0.0052\\ +0.0911\\ +0.0777\\ -0.1485\\ -0.0913\\ \hline +1.0884\end{array}$	$\begin{array}{c} -0.5220\\ +0.0174\\ -0.0094\\ +0.0072\\ +0.2500\\ +0.0155\\ -0.0897\\ -0.1937\\ \hline \end{array}$	$\begin{array}{c} -0.02372\\ +0.00355\\ +0.00028\\ -0.0028\\ -0.00028\\ -0.00177\\ -0.01845\\ -0.03986\\ +0.06003\\ +0.02875\end{array}$	$\begin{array}{c} +0.0078\\ -0.3268\\ +0.0220\\ -0.0184\\ +0.7204\\ -0.0004\\ -0.2128\\ -0.4597\\ +0.2624\\ +0.0028\\ \hline -0.0027\\ \end{array}$	$\begin{array}{c} -0.6842\\ -0.0830\\ -0.0165\\ +0.0155\\ -0.1670\\ +0.2141\\ -0.0197\\ -0.0005\\ \end{array}$
13	11	27	12	10	26	9	8
$\begin{array}{r} -0.0342\\ +0.0021\\ -0.0235\\ +0.0064\\ -0.0511\\ -0.0055\\ +0.1381\\ \hline +0.0285\end{array}$	$\begin{array}{c} -1.1552\\ +0.5393\\ -0.0077\\ -0.0035\\ -0.9662\\ -0.0084\\ -0.0014\\ +0.3937\\ -0.0240\\ \hline \end{array}$	$\begin{array}{c} -0.06283\\ -0.08154\\ -0.00428\\ +0.00837\\ +0.07087\\ +0.07087\\ +0.00066\\ -0.01706\\ -0.00025\\ -0.10390\\ \hline -0.19135\\ \end{array}$	$\begin{array}{r} +0.1667\\ +0.3133\\ -0.0023\\ -0.0149\\ +0.0095\\ +0.4111\\ +0.0108\\ \hline +0.8942\end{array}$	$\begin{array}{c} +0.8869\\ -0.1100\\ -0.0238\\ +0.0190\\ +0.3349\\ -0.3013\\ +0.1840\\ \hline +0.9897\end{array}$	$\begin{array}{c} +0.69009\\ +0.12208\\ +0.02563\\ -0.01099\\ -0.00847\\ +0.07899\\ -0.10586\\ +0.16213\\ \end{array}$	$\begin{array}{r} +0.8316\\ -0.9957\\ +0.0719\\ -0.0082\\ +0.5890\\ -0.590\\ +0.3402\\ -0.4948\\ -0.1404\\ \hline \end{array}$	$\begin{array}{c} +0.7631\\ -0.0596\\ +0.0371\\ -0.0158\\ +0.0141\\ +0.4017\\ +0.2825\\ +0.0613\\ \hline +1.4844 \end{array}$
25	5	7	24	6	4	23	3
$\begin{array}{c} +1.12809\\ +0.01057\\ -0.00073\\ +0.00026\\ +0.00251\\ +0.18351\\ -0.00279\\ +0.01272\\ \end{array}$	$\begin{array}{c} +0.7073\\ -0.4004\\ +0.0245\\ -0.0055\\ +0.0348\\ -0.0977\\ -0.1744\\ +0.7955\\ +0.3660\\ \hline +1.1901\end{array}$	$\begin{array}{c} +0.7675 \\ -0.3524 \\ +0.0541 \\ -0.0202 \\ +0.0163 \\ -0.6200 \\ -0.5552 \end{array}$	$\begin{array}{c} -0.10618 \\ +0.15423 \\ +0.03845 \\ -0.01885 \\ +0.01283 \\ -0.02483 \\ -0.02413 \\ +0.00720 \\ \end{array}$	$\begin{array}{c} +0.3296\\ +0.0499\\ +0.0635\\ -0.0284\\ +0.0511\\ +0.5054\\ -0.2745\\ -0.2745\\ -0.2731\\ -0.0264\\ +0.4571\end{array}$	$\begin{array}{c} +0.8503\\ +0.5294\\ -0.0308\\ +0.0129\\ +0.1328\\ -0.1783\\ +0.4705\\ -0.0271\\ +0.1830\\ +1.9492\end{array}$	$\begin{array}{c} +1.15411 \\ -0.49453 \\ +0.08567 \\ -0.03169 \\ +0.20972 \\ -0.03462 \\ -0.11342 \\ \end{array}$	$\begin{array}{c} -1.8125 \\ +0.8264 \\ -0.1661 \\ +0.0713 \\ -1.0287 \\ +0.0766 \\ +0.9746 \\ +0.2662 \end{array}$
2	1						
$\begin{array}{r} -1.0938 \\ +1.2262 \\ -0.0080 \\ +0.0034 \\ -0.3169 \\ +0.3961 \\ \hline \\ +0.2070 \end{array}$	$\begin{array}{c} +0.9167\\ -1.1091\\ -0.1028\\ +0.0233\\ +0.6858\\ -0.0738\\ -0.2641\\ -0.0690\\ +0.0070\end{array}$	Probable (	error of an ob	erved direc	$tion = \pm 0.67$	$45\sqrt{\frac{103.76}{34}}$	±1".2

# Back solution

Cam	martati	on o	fac	man	liono
Com	putut	on	y ce	rrect	nons

1	2	3	4	5	6	7	8
$\begin{array}{r} -0.007\\-0.207\\-0.459\\+1.372\end{array}$	$\begin{array}{r} +0.007\\ +0.792\\ +0.303\\ -1.372\\ -0.003\\ +0.038\\ +2.593\\ \hline \\ +2.448\\ +2.4\\ \end{array}$	$\begin{array}{r} +0.207\\ -0.792\\ +0.067\\ +0.003\\ -2.593\\ \hline -3.146\\ -3.2\\ \end{array}$	$\begin{array}{r} -0.007\\ +0.019\\ -0.106\\ -1.275\\ \hline \\ -1.369\\ -1.4\\ \end{array}$	-0.207 -0.207 -0.2	$\begin{array}{r} +0.007\\ +0.207\\ -0.019\\ +0.106\\ +1.275\\ \hline \\ +1.576\\ +1.6\\ \end{array}$	$-0.174 \\ -0.094 \\ +0.188 \\ +0.886 \\ +0.806 \\ +0.7$	-1.949+0.073-1.876-1.9
9	10	11	12	13	14	15	16
$\begin{array}{r} +0.792\\ +1.949\\ +0.008\\ +0.101\\ -1.372\\ +0.094\\ -0.188\\ -0.886\\ +0.498\\ +0.5\end{array}$	$\begin{array}{c} -0.007\\ -0.792\\ +0.200\\ +1.372\\ +0.049\\ -0.183\\ -0.756\\ \hline \\ -0.117\\ -0.1\\ \end{array}$	$\begin{array}{r} +0.007\\ -0.209\\ -0.049\\ +0.183\\ +0.756\\ \hline +0.688\\ +0.7\\ \end{array}$	$\begin{array}{r} -0.207 \\ +0.792 \\ -0.359 \\ +0.048 \\ -0.180 \\ +3.003 \\ \hline +3.097 \\ +3.1 \end{array}$	+0.207  +0.952  +1.159  +1.2	$\begin{array}{r} -0.792\\-1.949\\-0.503\\-0.205\\+1.372\\-0.160\\+0.371\\-0.735\\\hline -2.691\\-2.7\end{array}$	$ \begin{array}{r} +0.317\\+0.172\\-0.341\\-1.620\\\hline \\ -1.472\\-1.4\\\end{array} $	$\begin{array}{r} +1.949\\ -1.190\\ -0.457\\ -0.112\\ -0.359\\ -0.061\\ +0.150\\ -0.648\\ \hline -0.728\\ -0.7\\ \end{array}$
- 17	18	19	20	21	22	23	24
$\begin{array}{r} +1.190\\ -1.484\\ +0.325\\ +0.984\\ -0.260\\ +0.755\\ +0.8\end{array}$		$ \begin{array}{r} +1.484\\ -0.990\\ +0.451\\ +0.945\\ +1.0\\ \end{array} $		$\begin{array}{r} -0.325\\ +0.990\\ +1.233\\ -0.191\\ -1.617\\ -1.372\\ -0.089\\ +0.025\\ +1.448\\ \hline +0.102\\ +0.1\end{array}$	$\begin{array}{r} -1.233\\ +0.894\\ +0.813\\ +0.089\\ -0.025\\ -1.448\\ \hline -0.910\\ -0.9\end{array}$	$\begin{array}{r} -1.190 \\ +0.710 \\ -0.532 \\ -0.052 \\ +0.134 \\ -0.735 \\ \hline \\ -1.665 \\ -1.6 \end{array}$	$\begin{array}{r} -0.457\\ -0.710\\ +1.781\\ +0.614\\ +0.7\end{array}$
25	26	27	28	29	30	31	32
$\begin{array}{r} -1.949\\ +1.190\\ +0.457\\ -0.029\\ -1.249\\ +0.113\\ -0.254\\ +0.151\\ \hline -1.570\\ -1.5\end{array}$	$     +1.949 +0.141 \\     +2.090 +2.1 $	$ \begin{array}{r} -0.112 \\ -0.061 \\ +0.120 \\ +0.583 \\ \hline +0.530 \\ +0.5 \end{array} $	$ \begin{array}{r} +0.325 \\ -1.042 \\ -0.089 \\ +0.207 \\ -0.367 \\ \hline -0.966 \\ -1.0 \\ \end{array} $	$     \begin{array}{r}       -1.484 \\       +1.667 \\       +0.183 \\       +0.2     \end{array} $		$\begin{array}{r} -1.190\\ +1.484\\ -0.325\\ +1.661\\ -0.625\\ +0.067\\ -0.134\\ -0.627\\ \hline +0.311\\ +0.3\end{array}$	$\begin{array}{r} +1.190\\ -0.710\\ +0.213\\ +0.023\\ -0.074\\ +0.994\\ \hline \\ +1.636\\ +1.6\\ \end{array}$
33	34	35	36	37	38	39	40
$-0.457 \\ -0.457 \\ -0.4$	+0.457      +0.710      +1.167      +1.2	-0.710 -0.710 -0.7	$ \begin{array}{r} -1.484 \\ +0.990 \\ \hline -0.494 \\ -0.5 \\ \end{array} $	+1.484 +1.484 +1.5	$     \begin{array}{r}       -0.990 \\       -0.990 \\       -1.0     \end{array} $	$ \begin{array}{r} +0.003 \\ +0.017 \\ -0.048 \\ +0.055 \\ -0.346 \\ \hline -0.319 \\ -0.3 \\ \end{array} $	$\begin{array}{c} +1.233 \\ -0.028 \\ +0.741 \\ -0.003 \\ +0.031 \\ -1.372 \\ +0.048 \\ -0.055 \end{array}$
						-0.5	

41	42	43	44	45	46	47	48
$ \begin{array}{r} -0.741 \\ -0.048 \\ \hline -0.789 \\ -0.8 \\ \end{array} $	$\begin{array}{r} +0.325\\ -0.990\\ -1.233\\ -0.148\\ +1.372\\ +0.012\\ +0.005\\ -1.340\\ \hline -1.997\\ -2.0\\ \end{array}$	+0.028 +0.028 +0.0		$\begin{array}{r} -0.325 \\ -0.417 \\ -0.012 \\ -1.340 \\ \hline +0.581 \\ +0.6 \end{array}$	$ \begin{array}{r} -0.028 \\ +0.725 \\ \hline +0.697 \\ +0.7 \end{array} $	$\begin{array}{r} -0.894 \\ +0.028 \\ -0.612 \\ \hline \\ -1.478 \\ -1.5 \end{array}$	
49	50	51	52	53	54	55	56
$\begin{array}{c} +1.233\\ -0.894\\ +0.002\\ -0.038\\ +0.432\\ +0.735\\ +0.8\end{array}$	+0.741 +0.525 -0.121 +1.145 +1.2	$ \begin{array}{r} +0.894\\ -0.028\\ -0.572\\ +0.294\\ +0.3\end{array} $	$\begin{array}{c} -1.233\\ +0.028\\ -0.741\\ +0.003\\ +0.570\\ +0.078\\ +1.372\\ +0.038\\ -0.432\\ \hline -0.317\\ -0.3\end{array}$	-1.088 -0.434 -1.522 -1.5	$\begin{array}{c} -0.504\\ +0.541\\ -0.051\\ +0.027\\ -0.151\\ \hline \\ -0.138\\ -0.1\\ \end{array}$	$\begin{array}{c} -0.003\\ -0.525\\ +1.088\\ +0.504\\ +0.043\\ -0.107\\ -1.372\\ +0.051\\ -0.027\\ +0.151\\ \hline -0.197\\ -0.2\\ \end{array}$	+0.741 +0.741 +0.7
57	58	59	60	61	62	63	64
+0.525 +0.525 +0.5	$\begin{array}{r} -0.741 \\ -0.525 \\ \hline -1.266 \\ -1.3 \end{array}$	$\begin{array}{c} +0.003\\ +0.525\\ -1.088\\ -0.504\\ -0.115\\ -0.109\\ +1.372\\ +0.037\\ -0.022\\ -0.691\\ \hline -0.592\\ -0.6\end{array}$	$-0.525 \\ +0.263 \\ -0.262 \\ -0.2$	$\begin{array}{r} -0.003\\ -0.149\\ -0.037\\ +0.022\\ +0.691\\ \hline +0.524\\ +0.6\end{array}$	$ \begin{array}{r} +1.088 \\ -0.190 \\ +0.295 \\ \hline +1.193 \\ +1.2 \\ \end{array} $	$\begin{array}{r} +0.504\\ +0.190\\ +0.043\\ -0.186\\ +0.771\\ -1.372\\ -0.009\\ -0.027\\ +0.151\\ \hline \\ +0.065\\ +0.1\\ \end{array}$	$\begin{array}{r} +1.482 \\ -1.118 \\ \hline +0.364 \\ +0.4 \end{array}$
65	66	67	68	69	70	71	72
$-0.043 \\ -1.482 \\ +0.346 \\ +0.009 \\ +0.027 \\ -0.151 \\ -1.294 \\ -1.3$	-0.190 -0.190 -0.2	-1.088 +0.190 -0.898 -0.9	+1.088 +1.088 +1.1	$ \begin{array}{c} -1.041 \\ +0.317 \\ -0.024 \\ \hline -0.748 \\ -0.8 \\ \end{array} $	$\begin{array}{c} +0.043\\ +1.041\\ -0.226\\ -1.372\\ +0.024\\ \hline -0.490\\ -0.5\\ \end{array}$	$\begin{array}{c} -0.504\\ -0.190\\ -0.043\\ -0.105\\ -0.091\\ +1.372\\ +0.060\\ -0.019\\ -0.346\\ +0.134\\ +0.1\end{array}$	$\begin{array}{c} +0.504 \\ +0.425 \\ -0.060 \\ +0.019 \\ +0.346 \\ \hline \\ +1.234 \\ +1.2 \end{array}$
73	74	75	76	77	78	79	
$ \begin{array}{r} +0.190 \\ -0.320 \\ \hline -0.130 \\ -0.2 \\ \end{array} $	$\begin{array}{r} +0.043\\ +1.482\\ -0.030\\ +0.025\\ -0.030\\ -0.130\\ \hline \\ +1.360\\ +1.3\end{array}$	$\begin{array}{r} -0.043\\ -1.041\\ -0.626\\ +1.372\\ -0.025\\ +0.030\\ +0.130\\ \hline \\ -0.203\\ -0.2\\ \end{array}$	-1.482 + 1.041 + 0.655 - 1.372 - 1.158 - 1.2	$+1.482 \\ -1.041 \\ +0.004 \\ +0.445 \\ +0.4$	-1.482 -1.482 -1.5	$     +1.041 \\     -0.004 \\     +1.037 \\     +1.0 $	•

# Computation of corrections-Continued
Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Logarithm
-10+11 - 1+ 2 - 4+ 6	Turn–Dundas Tower Turn Dundas	° / // 42 00 30.0 24 17 25.4 113 41 59.6	" + 0.8 + 1.7 + 3.0	" 30. 8 27. 1 62. 6	" 0.1 0.2 0.2	• / // 30.7 26.9 42 02.4	<b>4. 266771</b> 0. 174417 9. 614231 9. 961733
×	Tower-Dundas Tower-Turn		+ 5.5		0.5		4. 055419 4. 402921
-12+13 - 1+ 3 - 5+ 6	Turn-Dundas Lazaro Turn Dundas	25 52 38.1 110 36 08.7 43 31 18.5	-1.9 -3.9 +1.8	36. 2 04. 8 20. 3	0.4 0.5 0.4	35. 8 04. 3 19. 9	<b>4. 266771</b> 0. 360081 9. 971300 9. 837989
	Lazaro-Dundas Lazaro-Turn		- 4.0		1.3		4. 598152 4. 464841
-12+14 - 2+ 3 - 9+10	Turn-Tower . Lazaro Turn Tower	42 30 21.5 86 18 43.3 51 11 09.1	- 5.8 - 5.6 - 0.6	15.7 37.7 08.5	0.6 0.7 0.6	15. 1 37. 0 07. 9	4. 402921 0. 170282 9. 999099 9. 891638
_	Lazaro-Tower Lazaro-Turn		-12.0		1.9		4. 572302 4. 464841
-13+14 - 4+ 5 - 9+11	Dundas-Tower Lazaro Dundas Tower	16 37 43.4 70 10 41.1 93 11 39.1	-3.9 + 1.2 + 0.2	39.5 42.3 39.3	0.4 0.4 0.3	39. 1 41. 9 39. 0	4. 055419 0. 543408 9. 973475 9. 999325
	Lazaro-Tower Lazaro-Dundas		- 2.5		1.1		4. 572302 4. 598152
$-14+15 \\ -7+9$	Lazaro-Tower Tow Hill Lazaro Tower	38. 8 47 10 07. 2 111 09 20. 5	+1.3 - 0.2	37.7 08.5 20.3	2.2 2.2 2.1	21 40 35.5 06.3 18.2	4. 572302 0. 432543 9. 865314 9. 969699
3	Tow Hill-Tower Tow Hill-Lazaro				6. 5		4. 870159 4. 974544
-25+26 -14+16 -8+9	Lazaro-Tower Nichols Lazaro Tower	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	+ 3.6 + 2.0 + 2.4	55.4 57.1 12.6	1.7 1.7 1.7	53. 7 55. 4 10. 9	4. 572302 0. 299961 9. 990962 9. 872905
	Nichols-Tower Nichols-Lazaro		+ 8.0		5.1		4. 863225 4. 745168+1
$-25+27 \\ -15+16$	Lazaro-Tow Hill Nichols Lazaro Tow Hill	89 23 18.6 54 28 47.9 64.3	+ 2.0 + 0.7	20. 6 48. 6 61. 6	3.6 3.6 3.6	17. 0 45. 0 36 07 58. 0	4. 974544 0. 000025 9. 910573 9. 770601
	Nichols-Tow Hill Nichols-Lazaro				10.8	-	4. 885142 4. 745170 ⁻¹

# Final solution of triangles

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Final solution of triangles—Continued

Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Logarithm
-26+27 - 7+ 8	Tower-Tow Hill Nichols Tower Tow Hill	° / // 59 18 26.8 62 53 10.3 35.1	" - 1.6 - 2.6	'' 25.2 07.7 39.3	" 4.1 4.0 4.1	° ' '' 21. 1 03. 7 57 48 35. 2	4.870159 0.065550 9.949433 9.927516
	Nichols–Tow Hill Nichols–Tower				12.2		4.885142 4.863225
-31+32 -16+17 -23+25	Lazaro-Nichols Ken Lazaro Nichols	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	+1.3 +1.5 +0.1	50. 8 58. 8 12. 6	0. 8 0. 7 0. 7	50. 0 58. 1 11. 9	4. 745169 0. 050108 9. 583744 9. 812130
	Ken-Nichols Ken-Lazaro		+ 2.9		2, 2		4. 379021 4. 607407
-33+34 -16+18 -24+25	Lazaro-Nichols Seel Lazaro Nichols	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	+ 1.6 + 0.6 - 2.2	10. 9 19. 4 31. 1	0, 4 0, 5 0, 5	10. 5 18. 9 30. 6	4. 745169 0. 109005 9. 794041 9. 338465
	Seal–Nichols Seal–Lazaro		+ 0.0		1.4		4. 648215 4. 192639
-33+35 -17+18 -30+31	Lazaro-Ken Seal Lazaro Ken	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	-0.3 -0.9 +1.5	21.5 20.6 18.3	0. 2 0. 1 0. 1	21. 3 20. 5 18. 2	4, 607407 0, 366640 9, 438723 9, 218592
	Seal–Ken Seal–Lazaro		+ 0.3		0.4		4. 412770 ⁺¹ 4. 192639
-34+35 -23+24 -30+32	Nichols-Ken Seal Nichols Ken	25 37 12.5 27 51 39.2 126 31 06.3	-1.9 + 2.3 + 2.8	10.6 41.5 09.1	0.4 0.4 0.4	10. 2 41. 1 08. 7	4. 379021 0. 364122 9. 669628 9. 905072
	Seal-Ken Seal-Nichols		+ 3.2		1.2		$\begin{array}{c} 4.\ 412771\\ 4.\ 648215 \end{array}$
-36+37 -17+19 -29+31	Lazaro-Ken Mid Lazaro Ken	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	+ 2.0 + 0.2 + 0.1	53.4 43.5 24.0	0.3 0.3 0.3	53. 1 43. 2 23. 7	4. 607407 0. 105542 9. 761771 9. 449655
	Mid-Ken Mid-Lazaro		+ 2.3		0.9		4. 474720 4. 162604
-42+44 -19+21 +36-38	Lazaro-Mid Round Lazaro Mid	51 05 11.2 43 39 34.4 85 15 11.7	+ 3.6 - 0.9 + 0.5	14. 8 33. 5 12. 2	0.2 0.2 0.1	14. 6 33. 3 12. 1	4. 162604 0. 108962 9. 839081 9. 998508
	Round-Mid Round-Lazaro		+ 3.2		0. 5		4. 110647 4. 270074

# Final solution of triangles—Continued

Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Logarithm
-42+45 -17+21 -28+31	Lazaro-Ken Round Lazaro Ken	• / // 74 42 34.2 78 57 17.7 26 20 06.8	'' + 2.6 - 0.7 + 1.3	" 36. 8 17. 0 08. 1	0.6 0.7 0.6	• / // • 36.2 16.3 07.5	4. 607407 0. 015651 9. 991879 9. 647016
	Round-Ken Round-Lazaro		+ 3.2		1.9	4	4. 614937 4. 270074
-44+45 -37+38 -28+29	Mid-Ken Round Mid Ken	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-1.0 -2.5 +1.2	$\begin{array}{c} 22.\ 0\\ 54.\ 4\\ 44.\ 1\end{array}$	$0.2 \\ 0.1 \\ 0.2$	21. 8 54. 3 43. 9	4. 474720 0. 397167 9. 743050 9. 238760
	Round-Ken Round-Mid		- 2.3		0. 5		4. 614937 4. 110647
-49+52 -21+22 -40+42	Lazaro-Round Cat Lazaro Round	89         47         52.8           26         22         55.0           63         49         17.6	-1.1 -1.0 -2.9	51.7 54.0 14.7	0. 2 0. 1 0. 1	51, 5 53, 9 14, 6	4. 270074 0. 000003 9. 647723 9. 952995
	Cat-Round Cat-Lazaro		- 5.0		0.4		3. 917800 4. 223072
-46+47 -40+43 -51+52	Round-Cat Spur Round Cat	33 20 40.5 111 30 09.4 35 09 14.0	-2.2 -0.9 -0.6	$38.3 \\ 08.5 \\ 13.4$	0.1 0.0 0.1	38. 2 08. 5 13. 3	3. 917800 0. 259903 9. 968671 9. 760250
	Spur-Cat Spur-Round		- 3.7		0, 2	-	4. 146374 3. 937953
-46+48 -42+43 -20+21	Round–Lazaro Spur Round Lazaro	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	+ 0.1 + 2.0 + 0.2	48, 1 53, 8 18, 4	0. 1 0. 1 0. 1	48. 0 53. 7 18. 3	4. 270074 0. 016506 9. 868888 9. 651373
•	Spur-Lazaro Spur-Round		+ 2.3		0.3		4. 155468 3. 937953
-47+48 -49+51 -20+22	Cat-Lazaro Spur Cat Lazaro	72 21 07.5 54 38 38.8 53 00 13.2	+ 2.3 - 0.5 - 0.8	09. 8 38. 3 12. 4	0. 1 0. 2 0. 2	$09.7 \\ 38.1 \\ 12.2$	4. 223072 0. 020934 9. 911462 9. 902368
	Spur-Lazaro Spur-Cat		+ 1.0		0. 5		4. 155468 4. 146374
-59+61 -52+55 -39+40	Cat-Round Beaver Cat Round	49         58         12.0           87         34         53.9           42         26         51.8	+ 1.2 + 0.1 + 1.2	13. 2 54. 0 53. 0	0.1 • 0.0 0.1	13. 1 54. 0 £2. 9	3. 917800 0. 115935 9. 999613 9. 829253
	Beaver-Round Beaver-Cat		+ 2.5		0.2		4. 033348 3. 862988

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Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Logarithm
-56+57-39+41-60+61	Round-Beaver Snipe Round Beaver	° / // 52 14 18.1 105 37 20.7 22 08 21.3	'' - 0.2 - 0.5 + 0.8	<i>i</i> , 17. 9 20. 2 22. 1	" 0.1 0.0 0.1	° / // 17.8 20.2 22.0	4. 033348 0. 102063 9. 983652 9. 576182
	Snipe-Beaver Snipe-Round		+ 0.1		0.2		4. 119063 3. 711593
-56+58 -40+41 -50+52	Round-Cat Snipe Round Cat	79 10 11.9 63 10 28.9 37 39 24.5	-2.0 -1.7 -1.5	09. 9 27. 2 23. 0	0.0 0.0 0.1	09. 9 27. 2 22. 9	3. 917800 0. 007806 9. 950551 9. 785987
	Snipe-Cat Snipe-Round		- 5.2		0.1		3. 876157 3. 711593
-57+58 -59+60 -50+55	Beaver-Cat Snipe Beaver Cat	26 55 53.8 27 49 50.7 125 14 18.4	-1.8 + 0.4 - 1.4	52.0 51.1 17.0	0.0 0.0 0.1	52. 0 51. 1 16. 9	3. 862988 0. 343980 9. 669189 9. 912095
	Snipe-Cat Snipe-Beaver	-	- 2.8		0.1		3.876157 4.119063
-67+68 -59+62 -53+55	Beaver–Cat Khwain Beaver Cat	62 13 29.4 58 43 17.2 59 03 08.4	+2.0 + 1.8 + 1.3	31. 4 19. 0 09. 7	0.1 0.0 0.0	31. 3 19. 0 09. 7	3. 862988 0. 053161 9. 931792 9. 933305
	Khwain-Cat Khwain-Beaver		+ 5.1		0.1		3. 847941 3. 849454
-71+72 -59+63 -54+55	Beaver-Cat Lim Beaver Cat	36 34 55.5 102 39 45.5 40 45 17.4	+ 1.1 + 0.7 - 0.1	56.6 46.2 17.3	0.0 0.0 0.1	56.6 46.2 17.2	3, 862988 0, 224770 9, 989306 9, 814795
	Lim-Cat Lim-Beaver		+ 1.7		0.1		4.077064 3.902553
-71+73 -62+63 -66+67	Beaver-Khwain Lim Beaver Khwain	59 25 24.7 43 56 28.3 76 38 09.2	-0.3 -1.1 -0.7	24. 4 27. 2 08. 5	0.0 0.0 0.1	24. 4 27. 2 08. 4	3. 849454 0. 065022 9. 841307 9. 988077
	Lim-Khwain Lim-Beaver		- 2.1		0.1		3. 755783 3. 902553
-72+73 -53+54 -66+68	Cat-Khwain Lim Cat Khwain	22 50 29.2 18 17 51.0 138 51 38.6	-1.4 + 1.4 + 1.3	27. 8 52. 4 39. 9	0.1 0.0 0.0	27. 7 52. 4 39. 9	3. 847941 0. 410972 9. 496870 9. 818151
	Lim-Khwain Lim-Cat		+ 1.3		0.1		3.755783 4.077064

# Final solution of triangles—Continued

Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Logarithm
-74+75 -63+65 -70+71	Beaver-Lim South Twin Beaver Lim	• / // 60 40 06.2 78 24 38.4 40 55 17.8	'' - 1.5 - 1.4 + 0.6	" 04.7 37.0 18.4	" 0.0 0.1 0.0	° / " 04. 7 36. 9 18. 4	3, 902553 0, 059585 9, 991054 9, 816260
	South Twin-Lim South Twin-Beaver		- 2.3		0.1		3. 953192 3. 778398
-77+78 -74+76 -64+65	South Twin-Beaver Ham South Twin Beaver	35 38 30.7 94 10 29.2 50 11 06.3	-1.9 -2.5 -1.7	28. 8 26. 7 04. 6	0.0 0.1 0.0	28. 8 26. 6 04. 6	3. 778398 0. 234548 9. 998847 9. 885424
	Ham-Beaver Ham-South Twin		- 6.1		0.1	{	4. 011793 3. 898370+1 <b>3. 89837</b> 1
-77+79 -75+76 -69+70	South Twin-Lim Ham South Twin Lim	85 04 23.4 33 30 23.0 61 25 13.8	+ 0.6 - 1.0 + 0.3	24. 0 22. 0 14. 1	0.1 0.0 0.0	23. 9 22. 0 14. 1	3. 953192 0. 001608 9. 741959 9. 943571
	Ham-Lim Ham-South Twin						3. 696759 3. 898371
-78+79 -63+64 -69+71	Ham Beaver Lim	49 25 52.7 28 13 32.1 102 20 31.6	+2.5 + 0.3 + 0.9	55. 2 32. 4 32. 5	0.0 0.0 0.1	55. 2 32. 4 32. 4	3. 902553 0. 119395 9. 674811 9. 989845
6	Ham-Lim Ham-Beaver		+ 3.7		0.1		3. 696759 4. 011793

# Final solution of triangles-Continued

Final position computation,

Second angle	Turn to D Dundas an	undas 1d Tower			Add die ander gestelle speed gestellen.	$ ^{\circ}_{357}_{+24}$	31	3 07.7 7 27.1				
• α 1α	Turn to To	ower				- 21	5	0 34.8 7 07.6				
α'	Tower to T	ower to Turn First angle of triangle					Turn First angle of triangle			180 201 42	4	3 27. 2 0 30. 8
$\phi \\ \varDelta \phi$		48 ( 12 3	06. 742 39. 415	Turn	$\begin{vmatrix} \lambda \\ \Delta \lambda \end{vmatrix}$	130 +	5	6 04.052 8 43.963				
$\phi'$	54	35 5	27. 327 -1	Tower	λ'	131	0	4 48015				
s cos α B	4. 402921 9. 9676448 8. 5097251	$s^{s^2}$ $sin^2 \alpha$ C	$\begin{array}{c} 8.\ 80585\\ 9.\ 14128\\ 1.\ 55459\end{array}$	$(\partial \phi)^2$ D	5. 7609 2. 3672	$s^2 \frac{-h}{E}$	α	2. 8803 7. 9471 - 6. 4574				
h	2.8802909		9. 50172		8.1281			7.2848				
1st term 2d term	+759.0859 + 0.3175	3d term 4th term	$+0.0134 \\ -0.0019$									
	+759,4034		-6									
$\left\{\begin{array}{c} 3d \text{ and } 4th \\ terms \end{array}\right\}$ $-\varDelta\phi$	$+ 0.0115 \\+759.4149$	$ \begin{array}{c} s\\ \sin \alpha\\ \Lambda'\\ \sec \phi' \end{array} $	4. 402921 9. 5706188 8. 5087480 0. 2370138	Arg.	-11 + 5	$ \begin{array}{c} \Delta\lambda\\ \sin\frac{1}{2}(\phi)\\ \sec\frac{1}{2}(\Delta) \end{array} $	$(+\phi')$	<b>2.</b> 7193010 9. 9117440 7				
$\frac{1}{2}(\phi+\phi')$	• / // 54 41 47		2. 7193010	Corr.	- 6	2.		2.6310457				
		Δλ	+523.9635			-10	z	+427.61				

STATION TOWER

#### STATION LAZARO

α Second angle	Turn to To Tower and	ower Lazaro				$\begin{vmatrix} \circ \\ 21 \\ + 86 \end{vmatrix}$	5 1	0 31.8 8 37.7
α Δα	Turn to L	azaro				-108	0 2	9 12.5 1 10.8
α'	Lazaro to	Turn	F	irst angle o	of triangle	$ \begin{array}{r} 180\\ 287\\ 42 \end{array} $	43	8 01. 7 0 15. 7
$\phi \\ \varDelta \phi$	- 54 +	48 0	06. 742 51. 079	Turn	$\lambda$ $\Delta \lambda$	130 +	$5 \\ 2$	6 04.052 5 54.366
$\phi'$	54	52	57.821 1	Lazaro	λ'	131	2	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
8 cos α B	$\begin{array}{c} \textbf{4.464841}\\ \textbf{9.4935464}\\ \textbf{8.5097251} \end{array}$	$\left  \begin{array}{c} s^2\\ \sin^2 \alpha\\ C \end{array} \right $	8. 92963 9. 95564 1. 55459	$(\partial \phi)^2$ D	4. 9281 2. 3672	$s^2 \frac{-h}{E}$	α	2. 4681 8. 8853 6. 4574
h	2. 4681125		0. 43986		7. 2953			7.8108
1st term 2d term	-293.8411 + 2.7534	3d term 4th term	+0.0020 +0.0065		-00			
	-291.0877	-	+27					
$= \frac{3d \text{ and } 4th}{terms}$	+ 0.0085 -291.0792	$\frac{\sin \alpha}{\Lambda'}$ sec $\phi'$	4. 464841 9. 9778267 8. 5087409 0. 2401420	Arg ⁸ Δλ	-15 + 42	$ \begin{array}{c} \Delta\lambda \\ \sin \frac{1}{2}(\phi - \phi -$	⊦φ′) φ)	3. 1915533 9. 9125251
$\frac{1}{2}(\phi+\phi')$	54 50 32.3		3. 1915533 "	Corr.	+27			<b>3.</b> 1040784
		Δλ	+1554.3661			<i>—</i> ⊿α		+1270.8

# primary triangulation

STATION TOWER

α Third angle	Dundas to Tower and	Turn Turn				° 177 —113	/ 33 42	43. 6 02. 6
α Δα	Dundas to	undas to Tower						41. 0 43. 0
α'	Tower to I	oundas				180 243	43	58.0
ф 1ф	_54	38 2	09, 559 12, 233	Dundas	λ Jλ	130 +	- 55	20, 042 27, 973
φ'	54	35 2	27. 326	Tower	2'	131	04	48.015
cos α B	4.055419 9.6439895 8.5097372	$\sin^2 \alpha$ C	8. 11087 9. 90630 1. 55194	$(\partial \phi)^2$	4. 4203 2. 3681	$s^2 \frac{-h}{E}$	α	2. 2091 8. 0172 6. 4528
h	2. 2091457		9. 56911		6.7884		-	6.6791
1st term 2d term	+161.8623 + 0.3708	3d term 4th term	+0.0006 -0.0005					
3d and 4th )	+162.2331		+3					
terms } —1\$	+0.0001 +162.2332		4.055419 9.9531462 8.5087480 0.2370138	Arg. ⁸ Δλ	$^{-2}_{+5}$	$ \begin{array}{c}                                     $	+φ') Ιφ)	2. 7543283 9. 9112981
$\frac{1}{2}(\phi+\phi')$	54 36 48.4	-	2.7543273 "	Corr.	+3			2.6656264
		λL	+567.9725			- 10	e	+463.05

STATION LAZARO

α Third angle	Tower to T Lazaro and	lurn Turn				$^{\circ}_{-51}$	4	3 27. 2 1 08. 5
α 1α	Tower to I	Fower to Lazaro						$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
α'	Lazaro to '	l'ower	180 330	1	8 17.4			
	•	1	"		1			
φ 4	+ 54	35 2 17 3	27. 326 30. 494	Tower	$\lambda$ $\Delta\lambda$	$+^{131}$	0 1	4 48.015 7 10.401
φ'	54	52 5	57.820	Lazaro	λ'	131	2	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
cos α B	4. 572302 9. 9398618 8. 5097404	$s^2 \alpha C$	$\begin{array}{c} 9.\ 14459\\ 9.\ 38353\\ 1.\ 55122 \end{array}$	$(\delta\phi)^2$ D	6.0428 2.3683	-1 s ² sin ² E	$\alpha$	3. 0219 8. 5281 6. 4516
h	3. 0219042		0.07934		8. 4111			8.0016
1st term 2d term	-1051.7298 + 1.2004	3d term 4th term	+0.0258 +0.0100					
	-1050. 5294		-7					
terms }	+ 0.0358	$\sin \alpha$	4.572302 9.6918222	Arg.		42		3,0130064
$-1\phi$	-1050. 4936	$\begin{array}{c} \mathbf{A'} \\ \mathbf{sec} \ \boldsymbol{\phi'} \end{array}$	8.5087409 0.2401420	8 Δλ	-25 + 18	$\sin \frac{1}{2}(\phi)$	$\left  \frac{\phi'}{\phi} \right $	9. 9119609
$\frac{1}{2}(\phi+\phi')$	54 44 12.6		3.0130064	Corr.	- 7		-	2.9249673
		Δλ	+1030.4012			-10	e	+841.3

Final position computation,

a Second angle	Lazaro to 7 Tower and	lower Tow Hill				$^{\circ}_{+ 47}$		$\begin{array}{c} '' \\ 17.4 \\ 08.5 \end{array}$
α 1α	Lazaro to 7	azaro to Tow Hill						8 25.9 1 07.5
α'	Tow Hill t	'ow Hill to Lazaro First angle of triangle						7 18.4 0 37.7
$\phi$ $\Delta \phi$	_54	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$					2 2	1 58. 417 5 57. 250
$\phi'$	54	04 2	25.798	Tow Hill	λ'	131	4	7 55.667 -2
cos α B	4. 974544 9. 9794818 8. 5097191	${{{\sin^2 \alpha} \over {C}}} \alpha$	9.94909 8.95504 1.55589	$(\partial \phi)^2$ D	6. 9283 2. 3667	-h s² sin² E	2α	3. 4637 8. 9043 6. 4597
h	3. 4637449		0. 46002		9. 2950			8.8277
1st term 2d term	+2909.0080 + 2.8842	3d term 4th term	+0.1972 -0.0673					
$\left\{\begin{array}{c} 3d \text{ and } 4th \\ terms \end{array}\right\}$	+2911.8922 + 0.1299 +2912.0221 • ' ''	$sin \alpha \\ A' \\ sec \phi'$	$\begin{array}{r}117\\ 4.974544\\ 9.4775129\\ 8.5087606\\ 0.2315526\end{array}$	$\begin{array}{c} \text{Arg.}\\ s\\ d\lambda \end{array}$	-159 + 42	$ \begin{array}{c}                                     $	+φ') 4φ)	3. 1923584 9. 9105687 108
$\frac{1}{2}(\phi+\phi')$	54 28 41.9		3. 1923584	Corr.	-117			3. 1029379
		Δλ	+1557.2502			-20	α	+1207.0

STATION TOW HILL

TION NICHOL

α Second angle	Lazaro to 7 Tow Hill a	low Hill nd Nichols	3			$^{\circ}_{+ 54}$	22	88	" 25. 9 48. 6
α 1α	Lazaro to N	Vichols		- 71	5 4	7	14.5 14.3		
α' .	Nichols to	ichols to Lazaro First angle of triangle							00. 2 20. 6
$\phi_{\Delta\phi}$	54	$ \begin{array}{c cccc} \circ & & & & & \\ & 54 & 52 & 57.820 \\ - & 9 & 27.129 \end{array} \  \  \begin{array}{c ccccc} \text{Lazaro} & \lambda \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ \end{array} $					24	21	58. 417 14. 369
φ'	54	43 3	30. 691	Nichols	λ'	132	1	.1	12.786 + 1
s cos α B	4. 745169 9. 4910534 8. 5097191	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$					$\alpha$	<b>2.</b> 9. 6.	7458 4465 4597
h	2.7459415		1.00242		7.8739			8.	6520
1st term 2d term	+557.1107 + 10.0559	3d term 4th term	+0.0075 -0.0449						
$\left\{ \begin{array}{c} \operatorname{3d} \operatorname{and} \operatorname{4th} \\ \operatorname{terms} \\ - \Delta \phi \end{array} \right\}$	+567.1666 - 0.0374 +567.1292	8 sin α Λ' sec φ'	+92 4.745169 9.9780929 8.5087447 0.2384490	Arg. ⁸ Δλ	-56+148	Δλ sin ½(φ- sec ½(Δ	+φ') 4φ)	3.	4704648 9123203
$\frac{1}{2}(\phi+\phi')$	54 48 14.3		3. 4704648	Corr.	+ 92			3.	3827851
		Δλ	+2954.3694			-40	x	+	2414. 27

# primary triangulation—Continued

STATION TOW HILL

α Third angle	Tower to I Tow Hill a	azaro nd Lazaro				° 150 —111	32 09	2 18.7 2 20.3
α Δα	Tower to T	ow Hill				- 39	2:	2 58.4 5 02.3
α	Tow Hill t	o Tower	180 218	4	7 56.1			
ф 1ф	\$	35 31		Tower	λ λ	131 +	0- 43	4 48.015 3 07.648
φ'	54	04 2	25. 799 T	'ow Hill	λ'	131	4	7 55.663 +2
8 COSα B	4. 870159 9. 8881363 8. 5097404	${{\sin^2 \alpha} \over {\rm C}}$	9.74032 9.60486 1.55122	$\overset{(\partial\phi)^2}{\mathrm{D}}$	6. 5397 2. 3683	— h s² sin ² E	α	3. 2680 9. 3452 6. 4516
h	3. 2680357		0. 89640		8.9080			9.0648
1st term 2d term	+1853.6842 + 7.8777	3d term 4th term	+0.0809 -0.1160					
$3d and 4th \\ terms $	+1861.5619 - 0.0351 +1861.5268	$\sin \alpha$	+16 4.870159 9.8024314 8.5087606	Arg.	- 98	$d\lambda$ sin $\frac{1}{2}(\phi)$	+ø')	3. 4129052 9. 9097770
*(の+の')	• / // 54 19 56.6	sec $\phi'$	3. 4129052	Corr.	+114 + 16	S3C 2(4	1φ)	44
		Δλ	,, +2587.6482			-40	Ł	// +2102.3

STATION NICHOLS

α Third angle	Tow Hill to Nichols and	) Lazaro 1 Lazaro			° - 197 - 36	, 07 08	" 18.4 01.6		
α 1α	Tow Hill to	o Nichols					160	59 18	16.8 56.0
α'	Nichols to	Tow Hill	180 340	40	20.8				
ф 4ф	54 +	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$						47 23	55. 665 17. 123
φ'	54	$\begin{array}{c c c c c c c c c c c c c c c c c c c $					132	11	12.788 -1
s cos α B	4. 885142 9. 9756388 8. 5097780	$s^2 \propto C$	9.77028 9.02582 1.54301		(ðø)2 D	6. 7403 2. 3709	$s^2 \frac{-h}{E}$	α 8 6	. 3706 . 7959 . 4373
h	3. 3705588		0. 33911			9.1112		8	. 6038
1st term 2d term	-2347.2470 + 2.1833	3d term 4th term	$+0.1292 \\ +0.0402$						
3d and 4th }	-2345.0637 + 0.1694	8	4.88514	70					
$-4\phi$	-2344. 8943		9. 51290 8. 50874 0. 23844	60 47 90	Arg. 8 Δλ	-104 + 34		+φ') ³ 1φ)	. 1452347 . 9101427 70
$\frac{1}{2}(\phi + \phi')$	54 23 58.9		3. 14523 "	47	Corr.	- 70		3	. 0553844 //
	JA +1397.1232						-Jo	ĸ  -	+1136.02

91865°—15——6

Final position computation,

α Second angle	Lazaro to 1 Nichols and	Nichols d Ken				$^{\circ}_{+ 22}$	, 57 32	" 14. 5 58. 8
α Δα	Lazaro to 1	Ken		- 94	30 30	$13. 3 \\ 53. 7$		
α'	Ken to Laz	aro	F	180 273 116	59 59	19.6 50.8		
α 1φ	54 +	52 1	57. 820 36. 965	Lazaro	$\lambda$ $\Delta\lambda$ .	131 +	21 37	58.417 45.909
$\phi'$	54	54 3	34. 785	Ken	λ'	131	59	44.326
s cos α B	$\begin{array}{c} 4.\ 607407\\ 8.\ 8949989\\ 8.\ 5097191 \end{array}$	$s^{s^2} \alpha C$	9. 21480 9. 99731 1. 55589	$\overset{(\delta\phi)^2}{\mathrm{D}}$	4. 0250 2. 3667	$s^2 \frac{-h}{E}$	α	2. 0125 9. 2121 6. 4597
h	2.0121250		0.76800		6.3917			7.6843
1st term 2d term	$ \begin{array}{r} -102.8312 \\ + 5.8614 \\ - 96.9698 \\ \end{array} $	3d term 4th term	+0.0002 +0.0048					
$3d \text{ and } 4th \\ terms \}$ $-\Delta\phi$	+ 0.0050 - 96.9648	$sin \alpha \\ A' \\ sec \phi'$	$\begin{array}{r} +58\\ 4.\ 607407\\ 9.\ 9986569\\ 8.\ 5087403\\ 0.\ 2404325\end{array}$	Λrg. ⁸ 4λ	$-29 \\ +87$		⊦φ′) φ)	3. 355242 9. 912798
$\frac{1}{2}(\phi+\phi')$	54 53 46.4		3. 3552425	Corr.	+58			3. 268040
		Δλ	+2265.9094			-1a	1	+1853.70

STATION KEN

STATION ROUND

α Second angle	Lazaro and Ken and I	d Ken Round			$\begin{vmatrix} \cdot \circ \\ 94 \\ + 78 \end{vmatrix}$	35	0 13.3 7 17.0	
α 1α	Lazaro to	Round		173	2	7 30.3 1 37.8		
α'	Round to	Lazaro	$     \begin{array}{r}       180 \\       353 \\       74     \end{array} $	24	5 52.5 36.8			
$\phi \\ \Delta \phi$	54 +	52 9	57. 820 58. 327	Lazaro	$\lambda$ $\Delta \lambda$	+131	2	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
φ'	55	02	56.147	147 Round		131	2	$\begin{array}{c c}3 & 57.916 \\ +1 \end{array}$
s cos a B	4. 270074 9. 9971633 8. 5097191	$\begin{vmatrix} s^2\\ \sin^2 \alpha\\ C \end{vmatrix}$	$\begin{array}{c} 8.54013 \\ 8.11255 \\ 1.55589 \end{array}$	$(\hat{\sigma}\phi)^2$ D	5, 5538 2, 3667	${{}^{-\mathrm{h}}_{\mathrm{s}^2\sin^2lpha}}_{\mathrm{E}}$		2. 7769 6. 6527 6. 4597
h	2.7769564		8. 20857		7.9205			5.8893
1st term 2d term	-598.3514 + 0.0161 -598.3353	3d term 4th term	+0.0083 +0.0001					
$\left\{\begin{array}{c} 3d \text{ and } 4th \\ terms \end{array}\right\}$ - $\Delta\phi$	+ 0.0084 -598.3269	$ \begin{array}{c}                                     $	$\begin{array}{c c} -6 \\ 4.270074 \\ 9.0566163 \\ 8.5087369 \\ 0.2419389 \end{array}$	Arg. ⁸ _Δ λ	-6 + 0	$ \begin{array}{c c}  & & & & & & \\  & -6 & \sin \frac{1}{2}(\phi + q) \\  & +0 & \sec \frac{1}{2}(d\phi) \end{array} $		2.077365 9.913183
$\frac{1}{2}(\phi+\phi')$	54 57 57	Δλ	2.0773655 " +119.4993	Corr.	-6	-10	e	1. 990548 '' +97. 85

.

# primary triangulation—Continued

						1 1		1
a	Niebols to	Lazaro				251	17	00.2
Third angle	Ken and L	azaro				- 40	27	12.6
α	Nichols to	Ken				210	49	47.6
Δα				+	9	22.6		
α'	Ken to Nic	hols				180 30	59	10.3
	1							+.1
	°.	11	"	ATT. 1. 1.		100		10 808
ф 14	+ 04	43 3	30. 691 )4. 093	NICHOIS		- 132	11	12.787 28.462
6'	54	54 3	34. 784	Ken	λ'	131	59	44.325
			+1 .					+1
8 005 a	4.379021	sin ² a	8.75804	(24)2	5 6450	-h	~	2,8226 8,1775
B	8. 5097307	C	1. 55337	Ď	2, 3676	E	-	6. 4553
h	2. 8225895		9. 73078		8.0126			7.4554
	"		"					
1st term 2d term	-664.6446 + 0.5380	3d term 4th term	+0.0103 +0.0029					
	-664.1066		•					
3d and 4th }	+ 0.0132	8	4. 379021					
terms j	-664 0034	$\sin \alpha$	9.7096861	Arg.	-10	$\frac{4\lambda}{1}$	4	2,837880
- 20	0 / //	sec \u00f3'	0. 2404325	λL	+8	sec 1/2	¢)	0. 012002
$\frac{1}{2}(\phi + \phi')$	54 49 02.9		2. 8378797	Corr.	- 2			2.750272
			"					11
		Δλ	-688.4616			-1a		- 562. 69

STATION KEN

STATION ROUND

α Third angle	Ken to Laz Round and	aro Lazaro	· ·			273 - 26	, 59 20	" 19.6 08.1
α 1α	Ken to Ro	und				247 +	39 29	11.5 17.8
α'	Round to I	Ken				180 68	08	29.3
φ φL	54 +	54 8	// 34. 785 21. 362	Ken	$\lambda$ $\Delta\lambda$	131	59 35	44. 326 46. 407
φ'	55	02 8	56. 147	Round	λ'	131	23	57.919 -2
s cos α B	4. 614937 9. 5800256 8. 5097172	${{\sin^2 \alpha} \over { m C}}$	9. 22987 9. 93219 1. 55631	$(\delta\phi)^2$ D	5. 4091 2. 3666	−h s² sin² E	α	2. 7046 9. 1621 6. 4604
h	2. 7046798		0. 71837		7.7757			8.3271
1st term 2d term	-506.6171 + 5.2285	3d term 4th term	+0.0058 +0.0212					
3d and 4th )	-501.3886 + 0.0270	8	+49					
terms J —Jø	-501.3616		9. 9660945 8. 5087369 0. 2419389	Arg. 8 4λ	-30 +79		⊦φ') φ)	3. 331712 9. 913254
$\frac{1}{2}(\phi+\phi')$	54 58 46.0		3. 3317122	Corr.	+49			3. 244966
		Δλ	-2146. 4074			1a	- 1	-1757. 79

ŧ.

Final position computation,

Second angle	Lazaro to I Round and	Round l Cat		• 173 + 26	, 27 22	" 30.3 54.0		
α 1α	Lazaro to C	Cat				199 +	50 4	24.3 21.4
α'	Cat to Laz	aro	180 19 89	54 47	45.7 51.7			
$\phi$ $\Delta \phi$	54 +	52 8	57. 820 28. 290	Lazaro	$\begin{bmatrix} \lambda \\ d\lambda \end{bmatrix}$	131	21 5	58. 417 19. 289
φ'	55	01 2	26.110	. Cat $\lambda'$			16	39.128 +1
cos α B	4. 223072 9. 9734251 8. 5097191	$sin^2 \alpha C$	8.44612 9.06164 1.55589	${(\delta\phi)^2 \atop { m D}}$	5. 4124 2. 3667	$s^2 \frac{-h}{E}$	α	2. 7062 7. 5078 6. 4597
h	2.7062162		9.06365		7.7791			6.6737
1st term 2d term	-508.4124 + 0.1158	3d term 4th term	+0.0060 +0.0005	•				
$\left. \begin{array}{c} 3d \text{ and } 4th \\ terms \end{array} \right\} \\ - \Delta \phi$	508. 2966 + 0. 0065 508. 2901	$s \\ sin \alpha \\ A' \\ sec \phi'$	$\begin{array}{r} -3\\ 4,223072\\ 9,5307069\\ 8,5087375\\ 0,2416677\end{array}$	$\begin{array}{c c} -3 \\ 4.223072 \\ 9.5307069 \\ 8.5087375 \\ 0.2416677 \\ \Delta \end{array} Arg.$		$d\lambda$ $\sin \frac{1}{2}(\phi + \phi')$ $\sec \frac{1}{2}(d\phi)$		2. 504184 9. 913117
½(φ+φ')	54 57 42.0	Δλ	2. 5041838 '' -319. 2889	Corr.	-3	10	ĸ	2. 417301 '' -261. 4

STATION CAT

STATION BEAVER

α Second angle	Cat to Rou Round and	ınd 1 Beaver		0 109 + 87	, 42 34	77. 4 37. 4 54. 0		
α Δα	Cat to Bea	ver				197 +	17 1	31. 4 40. 2
α'	Beaver to	Cat	180 17 49	19 58	11.6 13.2			
$\phi$ $\Delta\phi$	55 +	01 3	,, 26. 110 45. 204	Cat	$\lambda$ $\Delta \lambda$	131	16 2	39. 129 02. 231
φ'	55	05	11.314	Beaver	X'	131	14	36.898
δ cos α B	<b>3.</b> 862988 9. 9799133 8. 5097090	$\int_{C}^{S^2} \alpha$	7.7260 8.9465 1.5584	$\overset{(\delta\phi)^2}{\mathrm{D}}$	4. 705 2. 366	-h s² sin² E	α	2. 353 6. 672 6. 464
h	2. 3526103		8.2309		7.071			5. 489
1st term 2d term	-225.2218 + 0.0170	3d term 4th term	+0.0012					
$ \begin{array}{c} 3d \text{ and } 4th \\ terms \\ -\Delta\phi \end{array} $	+ 0.0012 -225.2036		$\begin{array}{r} -1\\ 3.862988\\ 9.4731109\\ 8.5087360\\ 0.2423463\end{array}$	Arg. ⁸ Δλ	1	$d\lambda$ $\sin \frac{1}{2}(\phi - \frac{1}{2})$ $\sec \frac{1}{2}(\omega - \frac{1}{2})$	+ ¢') 1¢)	2. 087181 9. 913657
$\frac{1}{2}(\phi+\phi')$	55 03 18.7		2.0871811	Corr.	-1			2.000838
		Δλ	-122. 2309			-10	¢	-100.19

# primary triangulation—Continued

								1
~	Round to I	97970				353	2	5 52 5
Third angle	Cat and La	zaro				- 63	4	9 14.7
α -	Round to (	Cat				289	3	6 37.8
Δa				+		5 59.6		
						180		
α'	Cat to Rou	nd				109	4	2 37.4
	0.1							
ø	55	02	6. 147	Round	λ	131	2	3 57.917
Δφ	-	1 3	30. 037		42	-		7 18.788
<i>\$</i> '	55	01 2	26.110	Cat	λ'	131	1	6 39.129
8	3.917800	82	7.8356	( ) ( ) 0	0.0000	-h	. 1	1.9535
$\cos \alpha$ B	9. 5258533	Sin ^z α C	9,9481	(80)2 D	3. 9009 2. 3658	gz Sinz E	α	1. 1831 6. 4643
h	1 0533604		0 2422		6 9797		-	8 2015
	1. 000001		0.0120		0. 2121			0. 2010
1st term	+- 89, 8174	3d term	+0.0002					
2d term	+ 0.2199	4th term	-0.0002					
	+90.0373							
3d and 4th )	0	0	+2					
terms }		$\sin \alpha$	9.9740491	Arg.		42		2.642254
$-\Delta\phi$	+90.0373	A'	8.5087375	8	-1 + 3	sin 1(d-	+ ()	9.913558
1/11/10	0 / //	υσο φ	0.010011			500 2(2	-	
² (φ+φ')	55 02 11.1		2. 6422545	Corr.	+2			2.555812
		0	11			1		11
	100	ΔX	-438.7877			-10	2	-359.59

STATION CAT

STATION BEAVER

procession and a second s								the second s
a Third angle	Round to (	Cat				° 289 - 42	3	6 37.8 6 53.0
a Ja	Round to I	Beaver				247	0	9 44.8 7 39.9
α'	Beaver to I	Round	180 67	1	7 24.7			
ф 1ф	55 +	02 2	56. 147 15. 166	131	2	3 57.917 9 21.019		
φ'	55	05 1	11. 313 +1	Beaver	λ'	131	1	4 36.898
8 cos α B	4. 033348 9. 5889657 8. 5097071	$\frac{s^2}{\sin^2 \alpha}$	8.0667 9.9291 1.5586	(ðø)² D	4.264 2.366	$s^2 \frac{-h}{E}$	α	2. 132 7. 996 6. 464
h	2. 1320208		9. 5544		6.630			6. 592
1st term 2d term	'' -135.5254 + 0.3584	3d term 4th term	" +0.0004 +0.0004					
$ \begin{array}{c} 3d \text{ and } 4th \\ terms \end{array} \right\} \\ -\Delta\phi $	-135.1670 + 0.0008 -135.1662		+3 4.033348 9.9645467 8.5087360 0.2423463	Arg. ⁸ Δλ	-2 + 5	$ \begin{array}{c} \Delta\lambda \\ \sin \frac{1}{2}(\phi \\ \operatorname{sec} \frac{1}{2}(\Delta \phi \\ \end{array}) $	+ \$\phi')  \$)	2. 748977 9. 913723
$\frac{1}{2}(\phi+\phi')$	55 04 03.7		2. 7489773	Corr.	+3			2.662700
		Δλ -561.0186					e	-459.94

Final position computation,

	α Second angle	Beaver to Cat and Li	Cat im				$^{\circ}_{+102}$	1	, .9	'' 11. 6 46. 2
	α <u>1</u> α	Beaver to	Lim				119	đ	58 5	57. 8 20. 3
	α'	Lim to Be	aver	180 299 36	6.5 C.	3 4	37. 5 56. 6			
	$\phi$ $\varDelta \phi$	55 +	$ \begin{vmatrix} & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ &$					1	.4	36, 898 30, 508
	φ'	55	07 2	20. 262	Lim	λ'	131	2	1	07.406 +1
	$\frac{s}{B}$	3. 902553 9. 6987431 8. 5097044	${{{\sin^2 \alpha} \over {\rm C}}} $	7.8051 9.8751 1.5591	$\overset{(\partial\phi)^2}{\mathrm{D}}$	4. 222 2. 366	$s^2 \frac{-h}{E}$	α	2 7 6	. 111 . 680 . 465
	h	2. 1110005		9. 2393 "		6.588			6	. 256
	1st term 2d term		3d term 4th term	+0.0004 +0.0002						0
	$\left. \begin{array}{c} \operatorname{3d} \operatorname{and} 4\operatorname{th} \\ \operatorname{terms} \end{array} \right\} \\ - \Delta \phi$	-128.9486 + 0.0006 -128.9480		+2 3.902553 9.9376062 8.5087351 0.2427356	Arg. ⁸ ⊿λ	$^{-1}_{+3}$	$d\lambda \ \sin rac{1}{2}(\phi - sec rac{1}{2}(\Delta c))$	+φ') 1φ)	29	. 591630 . 913918
-	$\frac{1}{2}(\phi+\phi')$	55 06 15.8	1)	2, 5916301 ,, + 390, 5082	Corr.	+2	40	,	2	. 505548 '' +320, 3
			27 +390, 3082							

STATION LIM

STATION SOUTH TWIN

α Second angle	Beaver t Lim and	o Lim l South 7	ſwin		$^{\circ}_{+78}$	, 58 24	,,, 57. 8 37. 0		
α Δα	Beaver t	o South	Twin				198 +	23 1	34. 8 27. 7
α'	South Twin to Beaver First angle of triangle							25 40	02.5 04.7
$\phi$ $\Delta\phi$	55 +	05 3	$ \begin{vmatrix} & & & \\ 05 & & 11.314 \\ 3 & & 04.203 \end{vmatrix}  $ Beaver $\lambda$ $\Delta \lambda$					14 1	36. 898 46. 925
φ'	55	08	08 15.517 South Twin λ' 15.517					12	49. 973 +1 49. 974
s cos α B	3. 778398 9. 977227 8. 509704	$\begin{array}{c c} 3 & s^{3} \\ 71 & sin^{2} \\ 44 & C \end{array}$	α 8. 1.	5568 9984 5591	$\overset{(\delta\phi)^2}{\mathrm{D}}$	4. 530 2. 366	$s^2 \frac{-h}{E} \alpha$		$\begin{array}{c} 2.\ 265 \\ 6.\ 555 \\ 6.\ 465 \end{array}$
h	2. 265329	95	8.	1143		6.896			5. 285
1st term 2d term	-184.216 + 0.013	59 3d to 30 4th t	erm +0.	0008			•		
$\left. \begin{array}{c} \operatorname{3d} \operatorname{and} \operatorname{4th} \\ \operatorname{terms} \end{array} \right\} \\ - \varDelta \phi$	-184.203 + 0.000 -184.203	39 08 sin 31 A sec	α 9. ' 8. φ' 0.	-1 778398 4990449 5087347 2429024	Arg. β Δλ	$-1_{0}$	$d\lambda$ $\sin \frac{1}{2}(\phi - \frac{1}{2})$	+ \$\phi') 1\$\phi)	2. 029080 9. 913958
$\frac{1}{2}(\phi+\phi')$	55 06 43.	4	2. 02907		Corr.	-1		-	1. 943038
		47	:	'' 106. 9252			- <u>1</u> 0	e	-87.7

# primary triangulation—Continued

STATION LIM											
α Third angle α Δα	Cat to Bea Lim and B Cat to Lim	ver eaver		° 197 - 40 - 156	, " 17 31.4 45 17.3 32 14.1 3 40.0						
α'	Lim to Cat		180 336	28 34.1							
ф 1ф	55 +	01 2 5 2	+131	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$							
φ'	55	07 2	0.262	Lim	λ'	131	21 07.407				
s cos α B	4. 077064 9. 9625205 8. 5097090	${\mathop{\sin^2 \alpha}\limits_{\mathrm{C}}^{8^2}}$	8. 1541 9. 1999 1. 5584	$(\delta\phi)^2$ D	5.099 2.366	$s^2 \frac{-h}{E} \alpha$	2. 549 7. 354 6. 464				
h	2. 5492935		8.9124		7.465		6. 367				
1st term 2d term	-354.2367 + 0.0817	3d term 4th term	+0.0029 +0.0002								
2d and 4th )											
$\left\{ \frac{1}{1000} + \frac{1}{1000} \right\}$	+ 0.0031 -354.1519		4.077064 9.6000497 8.5087351 0.2427356	Arg. ⁸ Δλ	$^{-2}_{+2}$	$\frac{d\lambda}{\sin\frac{1}{2}(\phi+\phi')}$ sec $\frac{1}{2}(d\phi)$	2. 428584 9. 913752				
$\frac{1}{2}(\phi+\phi')$	55 04 23.2		2. 4285844		2. 342336						
		Δλ	<i>—</i> Δα	+219.96							

STATION SOUTH TWIN

α Third angle	Lim to Bea South Twin	ver n and Beav	ver			° 299 `— 40	5 5	3 37.5 5 18.4
α Δα	Lim to Sou	th Twin				258 +	5	8 19.1 6 48.1
α'	South Twi	n to Lim				180 79	0	5 07.2
$\phi$ $\Delta\phi$	55 +	07 25	" 20. 262 5. 255	Lim	λ λ	131	2	1 07. 407 8 17. 433
φ'	55	08 1	.5. 517 So	uth Twin	λ'	131	1	2 49.974
cos α B	3. 953192 9. 2816903 8. 5097018	$sin^2 \alpha$	$\begin{array}{c} 7.\ 9064 \\ 9.\ 9838 \\ 1.\ 5597 \end{array}$	$(\mathfrak{g}\phi)_{\mathfrak{z}}$	3. 488 2. 365	$s^2 \frac{-h}{E}$	α	1.744 7.890 6.467
h	1. 7445841		9.4499		5.853		ĺ	6. 101
1st term 2d term	-55.5372 + 0.2818	3d term 4th term	+0.0001 +0.0001					
3d and 4th )	-55. 2554		+2					
terms ∫ −4φ	-55. 2552		9. 9919052 8. 5087347 0. 2429024		+φ') Ιφ)	2. 696734 9. 914053		
$\frac{1}{2}(\phi+\phi')$	55 07 47.9		2. 6967345	+2			2. 610787	
		Δλ	-497. 4329		-10	e	-408.12	

Final position computation,

α Second an	gle Niche	ols to und S	Ken eal						$  \begin{array}{c} \circ \\ 210 \\ + 27 \end{array}  $	4	, 49 51	// 47.6 41.5
α	Nich	ols to	Seal						238 +	4	41 29	29.1 04.7
α'	Seal t	o Nie	ehols						180 59	1	10	33.8
						of triangle	25		37	10.6		
$\phi \\ \Delta \phi$	5		$'^{43}_{12}$	0004	'' 30. 691 22. 365	) )	Nichols	$\lambda$ $\Delta\lambda$	-132		11 35	12.787 34.411
$\phi'$	5		55	1	53.056 1		Seal	λ'	131	:	35	$38.376 \\ +1$
s cos α B	4. 64 9. 71 8. 50	3 <b>215</b> 57086 97307	si	$\overset{s^2}{\overset{n^2}{\mathrm{C}}} \alpha$	9.2 9.8 1.5	964 633 534	$(\partial \phi)^2$	5.747 2.368	s² sin E	2α	2 9 6	. 874 . 160 . 455
h	2.87	86543	-		0.7	131		8,115			8	. 489
1st term 2d term	-747. + 5.	$\begin{array}{c} 5741 \\ 1654 \end{array}$	3d 4th	term term	+0.0 +0.0	, 130 308	2					
3d and 4t terms −4¢	$\left. \begin{array}{c} -742.\\ + 0.\\ -742.\\ \circ \end{array} \right $	4087 0438 3649	- si se	8 η α Λ' c φ'	4.6 9.9 8.5 0.2	+4 $48215$ $31652$ $08740$ $40667$	Arg. ⁸ 4λ	-4 + 8	Δλ sin ½(φ sec ½(,	+φ') 1φ)	3 9	. 329278 . 912450
$\frac{1}{2}(\phi+\phi')$	54 49	54 49 41.9 3.329278 Corr.							-		3	. 241728
6			4	íλ	-2134	4108			40	z		1744. 72

STATION SEAL

STATION MID

α Second a	ngle	Round Lazaro	to I and	Lazaro Mid						$^{353}_{+ 51}$		, 25 05	'' 52.5 14.8
α Δα		Round	to 1	ſſid						- 44		$ \begin{array}{c} 31\\ 6 \end{array} $	07.3 56.5
α'		Mid to	Rou	ınd		F	irst angle	of triang	le	180 224 85		24 15	10.8 12.2
ф 4ф		55		02 4	'' 56.147 57.777		Round	$\lambda$ $\Delta \lambda$		+131		23 8	57.917 28.436
φ'		54		57	58.370		Mid	λ'		131		32	26.353 -1
cos a B		4. 110 9. 853 8. 509	647 103 707	${\mathop{\sin^2 \alpha}\limits_{\mathrm{C}}}^{s^2}$	8.2 9.6 1.5	213 916 586	(ð¢)² D	4.94 2.36	7	$s^2 \frac{-h}{E}$	2α	27	2. 473 7. 913 6. 464
h		2, 473	457		9.4	715		7.31	3			6	. 850
1st ter. 2d teri	m m	+297.4 + 0.2	795 961	3d term 4th term	$\left  \begin{array}{c} +0.0\\ -0.0 \end{array} \right $	021 007		-					
3d and terms	$\left\{ {{_{s}^{4}th}} \right\}$	+297.7 + 0.0 +297.7	756 014 770		4.1 9.8 8.5 0.2	10647 45806 08740 41043	Arg. ⁸ Δλ			<i>Δ</i> λ sin ½(φ- sec ½(	∔φ′) ⊿φ)	29	. 706236 . 913405
½(φ+¢	<i>'</i> )	55 00 2	7.3	<i>Δ</i> λ	2.7 , +508	06236 , , 4356	Corr.			10	e	2	. 619641 '' -416. 52

# primary triangulation—Continued

α Third angle	Ken to Nic Seal and N	ehols ichols				。 30 -126	2. 59 31	" 10. 4 09. 1
α 1α	Ken to Sea	.1				+ .	28 19	01. 3 43. 3
α'	Seal to Ker	n				180 84	47	44.6
	0 1							
ф 4ф	54 +	54 3 1 1	4. 785 .8. 270	Ken	$\lambda$ $\Delta\lambda$	-131	59 24	44. 326 05. 949
φ'	54	55 5	3.055	Seal	λ'	131	35	38.377
s cos α B	$\begin{array}{c} 4.\ 412771\\ 8.\ 984161\\ 8.\ 509717\end{array}$	$\overset{s^2}{\sin^2 \alpha}$ C	8, 8255 9, 9960 1, 5563	(3¢)² D	3. 813 2. 367	$s^2 \frac{-h}{E}$	α	1. 907 8. 821 6. 460
h	1.906649		0. 3778		6.180		-	7.188
1st term 2d term	-80.6583 + 2.3867	3d term 4th term	" +0.0002 +0.0015					
	-78.2716		-13					
terms }	+ 0.0017	sin α	4. 412771	Arg.		12		3. 160153
- <i>1</i> ¢	-78.2699	$\frac{A'}{\sec \phi'}$	8. 508740 0. 240667	8 	$^{-1}_{+4}$	$\sin \frac{1}{2}(\phi + \frac{1}{2})$	-φ') φ)	9, 912942
$\frac{1}{2}(\phi+\phi')$	54 55 13.9		3. 160153	Corr.	+3			3.073095
		Δλ	,, —1445. 949			-1a		,, -1183.30

STATION SEAL

STATION MID

α Third angle	Lazaro to I Mid and R	Round ound				° 173 - 43	, 27 39	,, 30, 3 33, 5
α Δα	Lazaro to 1	lid				129	47 8	56. 8 33. 9
α'	Mid to Laz	aro				180 309	39	$22.9 \\ +.1$
ф 1ф	54 +	52 5 5 0	57. 820 00. 550	Lazaro	$\lambda$ $\Delta\lambda$	131 +	21 10	58. <b>4</b> 17 27. 934
φ'	54	57 57	58.370	Mid	λ'	131	32	26.351 + 1
eos α B	4. 162604 9. 806246 8. 509719	${{{{\rm sin}^2} \alpha } \over {\rm C}}$	8.3252 9.7710 1.5559	(ðø)² D	4. 957 2. 367	s ² sin ² E	α	2. 479 8. 096 3. 460
h	2. 478569		9.6521		7.324			7.035
1st term 2d term	-301.0017 + 0.4488	3d term 4th term	+0.0021 +0.0011					
$\left\{\begin{array}{c} 3d \text{ and } 4th \\ terms \end{array}\right\}$	$\begin{array}{r} -300.5529 \\ + 0.0032 \\ \hline -300.5497 \\ \circ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	$sin \alpha \\ A' \\ sec \phi'$	4. 162604 9. 885527 8. 508740 0. 241043	Arg. $\frac{8}{4\lambda}$		Δλ sin ½(φ- sec ½(Δ	+ \ \ ') (\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	2. 797914 9. 912963
<u></u> δ(φ+φ')	54 55 28.1	Δλ	2. 797914 ,, +627. 9340	Corr.		-10	e   .	2. 710877 '' +513. 90

Final position computation,

			a Bellingersteiner ander			1		1
α Second angle	Round to Cat and Sr	Cat				° 289 +111	, 36 30	" 37.8 08.5
a	Round to a	Spur				41	06	46.3
Δα						-	4	22.7
α'	Spur to Ro	ound	Fi	irst angle o	of triangle	180 221 33	02 20	23. 6 38. 3
	•	1	"	_	1			
$\phi_{\Delta\phi}$	- 55	$\begin{vmatrix} 02\\3 \end{vmatrix}$	56. 147 81. 319	Round	$\lambda$ $\Delta\lambda$	$+^{131}$	23 5	57.917 20.567
φ'	54	59 2	24.828	Spur	λ'	131	29	18.484
${}^{s}_{{}^{cos}\alpha}$	3. 937953 9. 877035 8. 509707	$s^2 \propto c$	7. 8759 9. 6358 1. 5586	(ðø)² D	4.649 2.366	-h $s^2 sin^2$ E	α	2. 325 7. 512 6. 464
h	2. 324695		9.0703		7.015		-	6.301
	"							
1st term 2d term	+211.2006 + 0.1176	3d term 4th term	+0.0010 -0.0002					
	+211.3182		_				9	
3d and 4th }	+ 0.0008	8	3, 937953					
terms J	1 911 9100	$\sin \alpha$	9.817925	Arg.		$\frac{4\lambda}{1/1}$		2.505919
-Δφ	+211.3190	sec $\phi'$	0. 241303	<i>δ</i> <i>Δ</i> λ	1	$sin \frac{1}{2}(\phi)$ sec $\frac{1}{2}(2$	$(\phi)$	9. 913408
$\frac{1}{2}(\phi + \phi')$	55 01 10.5		2. 505919	Corr.			-	2. 419387
								11
		Δλ	+320.5672			-10	z	+262.66

STATION SPUR

STATION SNIPE

α Second angle	Round to C Cat and Sn	Cat ipe				$\begin{vmatrix} & \circ \\ & 289 \\ + & 63 \end{vmatrix}$	, 36 10	37.8 27.2
α_ 1α_	Round to S	Snipe				$+^{352}$	41	7 05.0 29.8
α'	Snipe to R	ound	Fi	rst angle o	of triangle	180 172 79	47	7 34.8 0 09.9
ф • <i>1</i> ф		$\begin{pmatrix} 02\\2\\4 \end{pmatrix}$	6. 147 5. 140	Round	$\lambda$ $\Delta\lambda$	-131	23	57.917 36.371
φ'	55	00 1	1.007	Snipe	λ'	131	23	3 21. 546
8 cos α B	3. 711593 9. 996547 8. 509707	$\overset{\delta^2}{\mathop{\mathrm{Sin}}^2}lpha$	7. 4232 8. 1980 1. 5586	$(\partial\phi)^2$ D	4. 436 2. 366	$s^2 \frac{-h}{E}$	α	2. 218 5. 621 6. 464
h	2. 217847		7.1798		6.802			4.303
1st term 2d term	'' +165.1380 + 0.0015	3d term 4th term	,,, +0.0006					
$\left\{\begin{array}{c} 3d \text{ and } 4th \\ terms \end{array}\right\}$	+ 0.0006 +165.1401	$sin \alpha \\ A' \\ sec \phi'$	$\begin{array}{c} 3.\ 711593\\ 9.\ 098982\\ 8.\ 508738\\ 0.\ 241442 \end{array}$	Arg. ⁸ Δλ		$d\lambda$ $\sin \frac{1}{2}(\phi - \frac{1}{2})$ $\sec \frac{1}{2}(\Delta - \frac{1}{2})$	+φ') 1φ)	1. 560755 9. 913502
$\frac{1}{2}(\phi + \phi')$	55 01 33.6		1.560755	Corr.				1. 474257
		Δλ				-10	e l	'' 

# primary triangulation—Continued

α Third angle	Cat to Rou Spur and H	nd Round			_	° 109 - 35	, 42 09	" 37. 4 13. 4
α	Cat to Spu	r				- 74	33 10	24. 0 22. 1
α'	Spur to Car	t				180 254	23	01. 9
·			// 1					
ф 1ф	55	$\begin{bmatrix} 01\\2\\0 \end{bmatrix}$	6. 110 1. 283	Cat	$\lambda$ $d\lambda$	131 +	16     12	39.129 39.355
φ'	54	59 2	4. 827	Spur	λ'	131	29	18.484
		-						
cos α B	4. 146374 9. 425347 8. 509709	$\left  \begin{array}{c} s^2\\ \sin^2\alpha\\ C \end{array} \right $	8, 2927 9, 9681 1, 5582	(3¢) ² D	4. 163 2. 366	- h s² sin² E	α	2.081 8.261 6.464
h	2.081430		9.8190		6.529			6.806
1st term 2d term	+120.6230 + 0.6592	3d term 4th term	+0.0003 -0.0006					
	+121.2832							
3d and 4th }	-0,0003	8	+1 4, 146374					
erms j	⊥191 9890	$\sin \alpha$	9.984029	Arg.		$\frac{d\lambda}{\sin \frac{1}{d}}$	+ 4')	2.880445
29	0 / 11	sec \$	0. 241303	λL	+1	sec 1(	14)	
$\frac{1}{2}(\phi + \phi')$	55 00 25.5		2. 880445	Corr.	+1			2. 793847
			11					"
		Δλ	+759.3552			-10	۲ I	+622.07

STATION SPUR

STATION SNIPE

α Third angle	Cat to Rou Snipe and	nd Round				° 109 - 37	, 42 39	" 37. 4 23. 0
α 1α	Cat to Snip	98				- 72	03 5	14. 4 29. 7
α	Snipe to Ca	it				180 251	57	44. 7
ф 1ф	5	$ \begin{array}{c c}                                    $	6. 110 5. 103	Cat	$\begin{vmatrix} \lambda \\ \Delta \lambda \end{vmatrix}$	+131	16 6	39. 129 42. 417
φ'	55	00 1	1.007	Snipe	λ'	131	23	21.546
$\frac{8}{B}$	3, 876157 9, 488721 8, 509709	${\mathop{\sin^2\alpha}\limits_{\mathrm{C}}^{8^2}}$	7. 7523 9. 9567 1. 5582	$(\delta\phi)^2$ D	$3.949 \\ 2.366$	$s^2 \frac{-h}{E}$	α	1.975 7.709 6.464
h	1.874587		9. 2672		6.315			6.148
1st term 2d term	+74.9181 + 0.1850	3d term 4th term	" +0.0002 -0.0001					÷
$\left. \begin{array}{c} \operatorname{3d} \operatorname{and} 4\mathrm{th} \\ \mathrm{terms} \end{array} \right\} \\ - \varDelta \phi$	+75.1031 + 0.0001 +75.1032	$\sin \alpha \\ \Lambda' \\ \sec \phi'$	3. 876157 9. 978339 8. 508738 0. 241442	Arg. ⁸ Δλ		$ \frac{d\lambda}{\sin \frac{1}{2}(\phi - \sin \frac{1}{2}(\omega - \omega))} $	+ ¢') I¢)	<b>2. 60</b> 4676 9. 913436
$\frac{1}{2}(\phi+\phi')$	55 00 48,6		2. 604676	Corr.				2. 518112
		Δλ	'' +402. 4167			-40	e	+329.69

### Final position computation, primary triangulation—Continued

### STATION KHWAIN

Second angle	Beaver to ( Cat and K)	Cat hwain				$^{\circ}_{+58}$	, 19 43	" 11.6 19.0
α Δα	Beaver to 1	Khwain				-76	02 5	30.6 17.1
α'	Khwain to	Beaver	F	irst angle o	of triangle	$\begin{array}{r}180\\255\\62\end{array}$	57 13	13.5 31.4
$\phi_{\Delta\phi}$	_55	05 1	" 11. 314 55. 322	Beaver	$\begin{vmatrix} \lambda \\ \Delta \lambda \end{vmatrix}$	131 +	14 6	36.898 26.681
φ'	55	04 1	15.992 -1	Khwain	λ'	131	21	03. 579
s cos α B	3. 849454 9. 3824014 8. 5097044	$s^{s^2}$ $sin^2 \alpha$ C	7.6989 9.9740 1.5591	$(\delta\phi)^2$ D	3.483 2.366	$s^2 \frac{-h}{E}$	α	1.742 7.673 6.465
h	1.7415598		9. 2320		5.849			5.880
1st term 2d term	+55.1518 + 0.1706	3d term 4th term	$+0.0001 \\ -0.0001$					
$\left\{\begin{array}{c} \operatorname{3d} \operatorname{and} 4\mathrm{th} \\ \mathrm{terms} \end{array}\right\}$	+55. 3224 0.0000 +55. 3224 ° ' ''	$s \\ sin \alpha \\ A' \\ sec \phi'$	3. 849454 9. 986983 8. 508736 0. 242180	Arg. ⁸ Δλ		$\frac{d\lambda}{\sin\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}(\phi-\frac{1}{2}$	+φ') 1φ)	2. 587353 9. 913782
$\frac{1}{2}(\phi+\phi')$	55 04 43.7	Δλ	2.587353 '' +386.6812		-10	ĸ	2. 501135 ,, +317. 06	

### STATION KHWAIN*

α Third angle	Cat to Bea Khwain an	ver d Beaver				° 197 — 59		, 17 03	" 31.4 09.7
α Δα	Cat to Khy	vain				138	1	14 3	21.7 36.8
α'	Khwain to	Cat				180 318	]	10	44.9
ф 1ф	55 +	01 2 2 4	26. 110 19. 881	Cat	$\lambda$ $\Delta \lambda$	131 +	]	16 4	39. 129 24. 450
φ'	55	04   1	5.991	Khwain	λ'	131	1	21	03.579
$\frac{s}{B}$	3.847941 9 872700 8.509709	${{\sin^2 \alpha} \over {\rm C}}$	$\begin{array}{c} 7.\ 6959\\ 9.\ 6470\\ 1.\ 5584 \end{array}$	(ðø)2 D	4.461 2.366	s ² sin ³ E	2α	2 7 6	. 230 . 343 . 464
h	2, 230350		8,9013		6.827			6	.037
1st term 2d term	-169.9613 + 0.0797	3d term 4th term	+0.0007 +0.0001						
$\left\{\begin{array}{c} 3d \text{ and } 4th \\ terms \end{array}\right\}$ - $\Delta\phi$	-169.8816 + 0.0008 -169.8808 $\circ$ ' ''	$sin \alpha$ A' sec $\phi'$	3. 847941 9. 823487 8. 508736 0. 242180	$\begin{array}{c} \operatorname{Arg.} \\ s \\ d\lambda \end{array}$	-	$ \begin{array}{c} \Delta \lambda \\ \sin \frac{1}{2}(\phi) \\ \operatorname{sec} \frac{1}{2}(\omega) \end{array} $	+φ') 1φ)	2 9	. 422344 . 913616
$\frac{1}{2}(\phi+\phi')$	55 02 51.1		2. 422344	Corr.				2	. 335960
		Δλ	+264.4502			-10	x	Н	-216.75

* This is right-hand portion of computation above.

#### APPLICATION OF LEAST SQUARES TO TRIANGULATION.

List of geographic positions-Felice Strait, Alaska, southeast Alaska datum

. Station	1	Latit an ongi	tude d tude	Sec- onds in meters	A	zimı	ıth	Back azimuth		To station	Distance	Loga- rithm	
Tower 1907 .	° 54 131	, 35 04	// 27.326 48.015	845.0 862.3	° 201 243	, 43 43	// 27.2 58.0	° 21 63	, 50 51	" 34.8 41.0	Turn Dundas	Meters 25288.4 11361.1	4.402921 4.055419
Lazaro 1907	54 131	52 21	57.820 58.417	1788.0 1041.5	287 313 330	48 40 18	01.7 37.9 17.4	108 134 150	09 02 32	$12.5 \\ 23.3 \\ 18.7$	Turn Dundas Tower	29163.6 39641.7 37351.0	4.464841 4.598152 4.572302
Tow Hill 1908	54 131	04 47	$25.798 \\ 55.665$	797.6 1012.2	197 218	07 47	18.4 56.1	17 39	$\frac{28}{22}$	25.9 58.4	Lazaro Tower	94307.0 74158.2	4.974544 4.870159
Nichols 1907	54 132	43 11	<b>30</b> . 691 12. 787	949.0 228.9	$251 \\ 281 \\ 340$	17 21 40	$\begin{array}{c} 00.2 \\ 55.6 \\ 20.8 \end{array}$	71 102 160	57 16 59	$14.5 \\ 06.1 \\ 16.8$	Lazaro Tower Tow Hill	$\begin{array}{c} 55612.1 \\ 72983.6 \\ 76761.2 \end{array}$	$\begin{array}{r} 4.\ 745169\\ 4.\ 863225\\ 4.\ 885142 \end{array}$
Ken 1907	54 131	54 59	34.785 44.326	1075.7 789.7	273 30	59 59	19.6 10.4	94 210	30 49	$\begin{array}{c} 13.3\\ 47.6\end{array}$	Lazaro Nichols	40495.5 23934.3	$\begin{array}{c} 4.\ 607407\\ 4.\ 379021 \end{array}$
Seal 1907	54 131	55 35	53.055 38.377	1640.6 683.4	290 59 84	15 10 47	$23.0 \\ 33.9 \\ 44.5$	110 238 264	26 41 28	$33.9 \\ 29.1 \\ 01.3$	Lazaro Nichols Ken	$\begin{array}{c} 15582. 6\\ 44485. 1\\ 25868. 5\end{array}$	4. 192639 4. 648215 4. 412771
Mid 1914	$\begin{array}{c} 54\\131\end{array}$	57 32	$\begin{array}{c} 58.370\\ 26.352 \end{array}$	$1805.0 \\ 468.8$	309 78	39 00	$23.0 \\ 16.4$	129 257	47 37	$56.8 \\ 55.6$	Lazaro Ken	$\frac{14541.3}{29834.6}$	$\begin{array}{c} 4.162604 \\ 4.474720 \end{array}$
Round 1914	55 131	02 23	56.147 57.917	1736.3 1028.3	353 44 68	25 31 08	$52.5 \\ 07.3 \\ 29.3$	173 224 247	27 24 39	$30.3 \\ 10.8 \\ 11.5$	Lazaro Mid Ken	$\begin{array}{c} 18624.0\\ 12901.7\\ 41203.8 \end{array}$	$\begin{array}{r} 4.270074 \\ 4.110647 \\ 4.614937 \end{array}$
Spur 1914	54 131	59 29	24.827 18.484	767.7 328.7	221 326	02 44	$\begin{array}{c} \textbf{23.6} \\ \textbf{11.7} \end{array}$	41 146	06 50	46.3 11.9	Round Lazaro	8668.7 14304.3	$3.937953 \\ 4.155468$
Cat 1914	55 131	01 16	26. 110 39. 129	807.4 695.2	19 74 109	54 33 42	45.7 24.0 37.4	199 254 289	50 23 36	$24.3 \\ 01.9 \\ 37.8$	Lazaro Spur Round	$\begin{array}{c} 16713.7\\14007.9\\8275.6\end{array}$	$\begin{array}{c} 4.223072\\ 4.146374\\ 3.917800 \end{array}$
Snipe 1914	55 131	00 23	$\begin{array}{c} 11.007\\ 21.546\end{array}$	340.4 383.0	$172 \\ 251$	47 57	$\begin{array}{c} 34.8\\ 44.7\end{array}$	352 72	47 03	$\begin{array}{c} 05.0\\ 14.4 \end{array}$	Round Cat	5147.5 7518.9	$\begin{array}{c} 3.\ 711593\\ 3.\ 876157 \end{array}$
Beaver 1914	55 131	05 14	11.314 36.898	349.9 654.5	17 45 67 148 198	19 09 17 12 23	$11.6 \\ 02.7 \\ 24.8 \\ 30.2 \\ 34.8$	197 225 247 328 18	17 01 09 08 25	$\begin{array}{r} 31.4\\ 52.7\\ 44.8\\ 19.3\\ 02.5 \end{array}$	Cat Snipe Round Ham South Twin	$\begin{array}{r} 7294.\ 4\\ 13154.\ 2\\ 10798.\ 1\\ 10275.\ 3\\ 6003.\ 4 \end{array}$	$\begin{array}{c} \textbf{3.862988} \\ \textbf{4.119063} \\ \textbf{4.033348} \\ \textbf{4.011793} \\ \textbf{3.778398} \end{array}$
Khwain 1914	55 131	04 21	$15.991 \\ 03.579$	$\begin{array}{r} 494.5\\ 63.5\end{array}$	255 318	57 10	$\begin{array}{c} 13.5\\ 44.9 \end{array}$	76 138	$\begin{array}{c} 02\\ 14 \end{array}$	$\begin{array}{c} 30.6\\ 21.7\end{array}$	Beaver Cat	7070.6 7046.0	3.849454 3.847941
Lim 1914	55 131	07 21	20.262 07.407	626. 6 131. 3	197 258 299 336 359	33 58 53 28 19	$\begin{array}{c} 05.0\\ 19.1\\ 37.5\\ 34.1\\ 01.9 \end{array}$	17 79 119 156 179	34 05 58 32 19	$14.5 \\ 07.2 \\ 57.8 \\ 14.1 \\ 05.0$	Ham South Twin Beaver Cat Khwain	$\begin{array}{r} 4974.6\\8978.3\\7990.1\\11941.6\\5698.8\end{array}$	$\begin{array}{c} 3.\ 696759\\ 3.\ 953192\\ 3.\ 902553\\ 4.\ 077064\\ 3.\ 755783 \end{array}$

### ADJUSTMENT OF TRIANGULATION BY THE METHOD OF VARIATION OF GEOGRAPHIC COORDINATES

#### DEVELOPMENT OF FORMULAS

A scheme of triangulation may be adjusted not only by means of equations of condition * but also by means of observation equations in which the number of independent unknowns is just sufficient to

^{*} There is some confusion in usage as to the term equation of condition, or condition equation. In this publication the meaning is restricted to that of an equation expressing some condition which is imposed a priori and independently of anything arising from the observations themselves, and which must be rigorously satisfied by the adopted results. An equation which expresses the results of an observation, and which will, in general, be satisfied only approximately by the adopted results, is not herein termed an equation of condition, but an observation equation.

determine the entire triangulation. These independent unknowns may very conveniently be taken as the small corrections to the assumed approximate geographic coordinates (that is, the latitudes and longitudes) of the points in the triangulation. To form the observation equations the relation must be found that connects the small change in the direction of a line with the small arbitrary changes in the geographic coordinates of its ends. The following derivation of the formulas is based on the formulas for the computation of geographic positions given in U.S. Coast and Geodetic Survey Special Publication No. 8 and on the notation there used. A " $\delta$ " before the symbol of a quantity denotes a small arbitrary change in that quantity.  $\phi$  and  $\lambda$  are, respectively, the latitude and longitude of  $A_1$ , the initial point of the position computation, which may also be thought of as the occupied point, while  $\phi'$  and  $\lambda'$  are the latitude and longitude of  $B_1$ , the terminal point in the position computation, which may also be thought of as the point sighted on. By definition also,

$$\Delta \phi = \phi' - \phi$$
$$\Delta \lambda = \lambda' - \lambda$$
$$h = sB \cos \alpha$$

 $\alpha$  is the azimuth at  $A_1$  of the line  $A_1B_1$  reckoned from the south toward the west.

 $\Delta \lambda = sA' \sec \phi' \sin \alpha$  $\cos \alpha = \frac{h}{sB}$  $\sin \alpha = \frac{\Delta \lambda}{sA' \sec \phi'}$  $\cot \alpha = \frac{A' \sec \phi'}{B} \frac{h}{\Delta \lambda}$ 

The meaning of A' and B is explained in Special Publication No. 8.

By differentiating the preceding equation and neglecting the effects of changes in A', B, and sec  $\phi'$  there results:

$$-\csc^{2} \alpha \ d\alpha = \frac{A' \sec \phi'}{B} \left[ \frac{\Delta \lambda \delta h - h \delta(\Delta \lambda)}{(\Delta \lambda)^{2}} \right]$$

Multiplying by  $-\sin^2 \alpha = -\frac{(2\lambda)^2}{s^2 A'^2 \sec^2 \phi'}$ 

and dividing by arc 1" in order to express  $d\alpha$  in seconds instead of in radians gives,

$$d\alpha \text{ in seconds} = \frac{1}{s^2 B A' \sec \phi' \arctan 1''} [h \delta(\Delta \lambda) - \Delta \lambda \delta h]$$
  
=  $\frac{sB \cos \alpha}{s^2 B A' \sec \phi' \arctan 1''} \delta(\Delta \lambda) - \frac{sA' \sin \alpha \sec \phi'}{s^2 B A' \sec \phi' \arctan 1''} \delta h$   
=  $\frac{\sin \alpha \cos \alpha}{sA' \sec \phi' \sin \alpha \arctan 1''} \delta(\Delta \lambda) - \frac{\sin \alpha \cos \alpha}{sB \cos \alpha \arctan 1''} \delta h$   
=  $\frac{\sin \alpha \cos \alpha}{\arctan 1''} \left[ \frac{\delta(\Delta \lambda)}{\Delta \lambda} - \frac{\delta h}{h} \right]$ 

By neglecting the variations in all the terms of the expression given for  $\Delta \phi$  in Special Publication No. 8 except the first or principal term, *h*, there results,

$$\delta(\varDelta\phi) = -\delta h = \delta\phi' - \delta\phi$$

Evidently, also,

 $\delta(\varDelta\lambda) = \delta\lambda' - \delta\lambda$ 

It thus appears that, to the degree of approximation here adopted, it is the difference in the changes of coordinates at the ends of a line that turns the line in azimuth. The formulas for computing  $d\alpha$ become,

$$d\alpha \text{ in sec.} = \frac{1}{s^2 B A' \sec \phi' \arctan 1''} [\Delta \lambda (\delta \phi' - \delta \phi) + h (\delta \lambda' - \delta \lambda)]$$
$$= \frac{\sin \alpha \cos \alpha}{\arctan 1''} \left[ \frac{\delta \phi' - \delta \phi}{h} + \frac{\delta \lambda' - \delta \lambda}{\Delta \lambda} \right]$$

In practice  $-\Delta\phi$  may be used for h, but if a position computation has been made over the line, log h will be immediately available. The change in the azimuth  $\alpha'$  at  $B_1$  of the line  $B_1 A_1$  for given changes in the coordinates of  $A_1$  and  $B_1$  may usually be taken the same as the change in  $\alpha$ , the azimuth at  $A_1$  of the line  $A_1 B_1$ .* If the point  $A_1$  is fixed  $\delta\phi$  and  $\delta\lambda$  are zero, and if  $B_1$  is fixed  $\delta\phi'$  and  $\delta\lambda'$  are zero.

This formula will now be applied to three examples, first, the adjustment of a quadrilateral, next the adjustment of three new points connected with a number of fixed points, and, lastly, to a figure involving a closure in geographic position. The steps to be taken and the precautions to be observed will be explained as they arise in the course of the examples.

^{*} For more exact formula to be used with longer lines, see Dr. F. R. Helmert's Höhere Geodäsie, vol. 1, pp. 495 and 496. For such lines some of the approximations made in the derivation here given are no longer permissible.

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In all cases treated by this method, however complicated they may be, a start is made with the assumed positions of the points to be determined and the assumed azimuths and lengths of the lines sighted over. These positions, azimuths, and lengths must be consistent with each other and not too far from the final result so that the corrections to the assumed quantities are in fact small, as is implied in the development of the formulas. Otherwise it is not important how these preliminary quantities are found.

#### ADJUSTMENT OF A QUADRILATERAL WITH TWO POINTS FIXED

As a simple example a quadrilateral,  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ , with two points,  $A_1$  and  $A_2$ , fixed is adjusted. The coordinates of  $A_1$  and  $A_2$ and the length and direction of the line  $A_1 - A_2$  are fixed as shown in the first lines of the position computation that follows. The angles of the preliminary computation of the triangles are obtained from the list of directions. To obtain the preliminary positions, directions and lengths, the triangles  $A_1, A_2, A_3$ , and  $A_2, A_3, A_4$  were made to close by correcting each angle by approximately one-third of the error of closure as indicated in the triangle computation. This determined the entire quadrilateral. In each of the other triangles two sides and an included angle became known and thus their remaining parts were computed.

	List of Observ	eu un eccions			
	AT A ₂		AT A3		
Station	Direction †	Station	Direction †		
Initial A1 A3 A4	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Initial A4 A2 A1	$\begin{array}{cccccccccccccccccccccccccccccccccccc$		
	AT A1		AT A4		
Initial A 3	$\begin{array}{cccccc} 0 & 00 & 00.0+z_2 \\ 0 & 00 & 00.0+v_4 \end{array}$	Initial A2	$\begin{array}{cccccccccccccccccccccccccccccccccccc$		

26 47 * See fig. 1 on p. 16.

40 23.  $5+v_5$ 31 20.  $2+v_6$ 

A 3 A 4

As

† Each observed value has its symbolic correction affixed.

 $A_2$  $A_1$ 

As

 $00.0+v_{10}$ 16.2+ $v_{11}$ 

 $20.0+v_{19}$ 

Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
	0 / //	,,		,,		
$\begin{array}{c}A_2 - A_1\\A_3\\A_2\\A_1\\A_1\end{array}$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$^{+0.8}_{+0.7}_{-0.8}$	53.3 45.8 21.0	0.1	45.7	<b>3.772745</b> 0.291566 9.990809 9.867787
A3-A1 A3-A2		+2.3		0.1		4.055120 3.932098
$\begin{array}{c}A_2-A_1*\\A_4\\A_2\\A_1\\A_1\end{array}$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$		17.3 45.8 57.0	0.1	45.7	<b>3</b> . <b>772745</b> 0. <b>3</b> 69934 9. 857694 9. <b>5</b> 51339
A4-A1 A4-A2	-	+0.9		0.1		4.000373 2.694018
A 2-A 3 A 4 A 2 A 3	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$-1.2 \\ -1.2 \\ -1.2 \\ -1.2$	18.8 00.0 41.3	0.1	18.7	3. 932098 0. 049306 9. 726024 9. 712614
A4-A3 A4-A2	-	-3.6		0.1		3.707428 3.694018
$A_{1}-A_{3}^{*}$ $A_{4}$ $A_{1}$ $A_{3}$	91 32 03.8 26 40 23.5 61 47 35.0		$01.5 \\ 24.0 \\ 34.6$	0.1	01.4	4.055120 0.000156 9.652153 9.945097
A4-A3 A4-A1		-2.2		0.1		3.707429 ⁻¹ 4.000373

# Preliminary computation of triangles

* This triangle is computed from two sides and the included angle.  $91865^{\circ}$ —15—7

Preliminary position computation,

α Second angle	$A_2$ to $A_1$ $A_1$ and $A$	3				$^{\circ}_{+101}$	, 20 44	" 26.6 45.8
α 1α	$A_2$ to $A_8$					258 +	05 8	12.4 05.9
α'	$A_3$ to $A_2$		Firs	t angle of t	riangle	180 78 30	00 13 43	00.00 18.3 53.3
ф 4ф	60 +	56 01. 56.	, 089 720	A 2	λ ⊿λ	149	34 9	19. 237 15. 877
φ'	60	56 57.	809 .	A ₃	λ'	149	25	03.360
$\frac{1}{2}(\phi+\phi')$	° / / 60 56 29		$\begin{array}{c} 3.932098\\ 9.314773\\ 8.509299 \end{array}$	${\mathop{\sin^2 \alpha}\limits^{8^2} {\mathbb{C}}} {\mathbb{C}}$	7.8 9.9 1.6	6420 8109 5750	h² D	$3.512 \\ 2.322$
1st term	-57.038	3 h	1.756170		9.0	5279		5.834
$\left\{\begin{array}{c} 2d \text{ and } 3d \\ terms \end{array}\right\}$	+ 0.318	4	-		+0.3	3183 0001		
$-\Delta\phi$	-56.720	1						
	$sin \alpha$ A' sec $\phi'$	3, 932098 9, 990544 8, 508600 0, 313737	$\int_{1}^{\Delta\lambda} \sin \frac{1}{2}(\phi+\phi)$	') <u>2</u> . 9.	- 744979 941572			
		2.744979		2.	686551			
	Δλ		Δα	-	,, 485.90			

STATION A8

STATION A₄

and the second s	the second se	the second se						
α Second angle	$A_2$ to $A_3$ $A_2$ and $A_3$					$^{\circ}$ 258 $^{+32}$	, 05 09	" 12.4 00.0
α Δα	$A_2$ to $A_4$	1				290	14 4	12.4 29.0
α'	$A_4$ to $A_2$		Firs	t angle of t	riangle	180 110 116	00 18 47	00.00 41.4 18.8
ф 4ф	_60	56 01.	089 . 340 .	A 2	$\lambda$ $\Delta\lambda$	149	34 5	19.237 07.794
φ'	60	55 05.	749	A4	λ'	149	29	11. 443
$\frac{1}{2}(\phi+\phi')$	° / // 60 55 3	$\begin{array}{c} 8 \\ \cos \alpha \\ B \end{array}$	$\begin{array}{c} 3.\ 694018\\ 9.\ 538951\\ 8.\ 509299 \end{array}$	${\mathop{\sin^2 \alpha}\limits_{\mathrm{C}}}^{8^2} \alpha$	7.3 9.9 1.6	38804 94466 35750	h² D	3. 484 2. 322
$\left.\begin{array}{c} 1 \text{st term} \\ 2 \text{d and } 3 \text{d} \\ \text{terms} \end{array}\right\}$	+55.2418 + 0.0979	3 h 9	1.742268		8.9	99020 9978		5.806
-44	+ 55, 3393	7			+0.0	0001		
	$sin \alpha$ $\Lambda'$ $sec \phi'$	3. 694018 9. 972328 8. 508601 0. 313313	$\left  \begin{array}{c} \Delta \lambda \\ \sin \frac{1}{2}(\phi + \phi) \end{array} \right $	·') 2. 9.	. 488260 . 941507			
		2. 488260 //	-	2.	. 429767			
	Δλ	307. 7939	-Δα		-269.0			

secondary triangulation.

0 , 11  $\begin{array}{cc} \alpha & A_1 \text{ to } A_2 \\ \text{Third angle} & A_3 \text{ and } A_2 \end{array}$ 336 -47 18 31 08.4 21.0 46 10 47.4 24.3  $A_1$  to  $A_3$ 288 α 1α + 180 108 00 57 00.00  $\alpha'$ As to A1 11.7 0 1 11  $\phi_{\Delta\phi}$ 60 58 56.416  $A_1$ λ ⊿λ 149 36 57. 360 54. 000 58.607 1 11 φ' 60 56 57.809 λ' 149 03.360 25  $A_3$ 4. 055120 9. 507765 8. 509295 8, 11024 9, 95248 1, 65837 0 82 -h 2.072 8  $sin^2 \alpha$ C  $s^2 sin^2 \alpha E$  $\frac{1}{2}(\phi + \phi')$ 60 57 57 cos a h² D 4.1442.3228.063 6.640 В ,, 1st term 2d, 3d, and 4th terms +118.0810 h 2.072180 9.72109 6.466 6.775 + 0.5258 +0.5261 +0.0003 -0.0006 +118.60_8  $-\Delta\phi$ sin a A' 4.055120 9.976241 8.508600 0.313737 2. 853698 9. 941676  $\sin \frac{J\lambda}{2}(\phi+\phi')$ sec \$' 2.853698 2. 795374 11 11 Δλ -713.9996-1α -624.27

STATION A3

STATION A4

						0	,	,,
a Third angle	$A_3$ to $A_2$ $A_4$ and $A_4$	1 2				$-\frac{78}{31}$	13 03	18.3 41.3
α	$A_3$ to $A_4$					_ 47	09	37.0 36.8
α	A ₄ to A ₈					180 227	00 06	00. 00 00. 2
ф 1ф	60	$ \begin{array}{c}                                     $	809 As		λ _1λ	149 +	25 4	03. 360 08. 084
φ'	60	55 05.	749 44		λ'	149	29	11.444 -1
$\frac{1}{2}(\phi+\phi')$	60 56 0	$ \begin{array}{c}                                     $	3. 707428 9. 832477 8. 509298	$\begin{bmatrix} 8^2\\ \sin^2 \alpha\\ C \end{bmatrix}$	7.4 9.7 1.6	1486 3052 h ³ 5808 D	2	4.098 2.322
1st term 2d and 3d terms	+111.996 + 0.063	2 h 9 .	2.049203		8.8 +0.0	0346 636		6.420
- <i>4</i> φ	+112.060	1		1	+0.0	003		
		$\begin{array}{c} 3.\ 707428\\ 9.\ 865257\\ 8.\ 508601\\ 0.\ 313313\end{array}$	$\int_{\sin\frac{1}{2}(\phi+\phi')}^{\Delta\lambda}$	2. 3 9. 9	94599 41540			
		2. 394599		2. 3	36139			
	Δλ	+248.0841	-1a	+216	, 3.8			

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### FORMATION OF OBSERVATION EQUATIONS

The observation equations used in making the adjustments are formed on the assumptions of the direction method.* Each pointing of the telescope is treated as an independent observation and the sum of the squares of the corrections to the separate pointings is to be made a minimum. A single pointing, however, taken by itself determines nothing, for if each of the pointings at a station be changed by the same amount the set of pointings has the same significance as The effect is simply a change in the zero direction, which is before. a purely arbitrary matter. If a set of corrections to directions at a point has been determined by any method and the mean of these corrections is not zero, the sum of the squares of these corrections can always be diminished by subtracting from each correction the mean of all of the corrections so that the algebraic sum of the reduced corrections is zero. Hence in any set of directions adjusted by the method of least squares the algebraic sum of the corrections at a point is zero.[†] To allow for this change of zero direction, or for the constant correction to all directions at a point, an unknown constant correction, "z," is introduced into all equations expressing the results of observations at a point, a different "z" for each point where observations are taken.

The observation equation may be written,

### Assumed azimuth $+ d\alpha$ - observed azimuth + z - v = 0.

The coefficients of the  $\partial \phi$ 's and  $\partial \lambda$ 's come from the last equation on page 93. As a sample, take those in the expression for  $v_9$ .  $A_1$  corresponds to the  $A_1$  and  $A_3$  to the  $B_1$  of the explanation of the formulas. Sin  $\alpha$ , cos  $\alpha$ , h, and  $\Delta \lambda$  come from the position computation on page 97.

$\log \sin \alpha$	9.9762n		4.7984n		4.7984n
$\log \cos \alpha$	9.5078	$\log h$	2.0722	$\log \Delta \lambda$	2.8537n
colog arc 1"	5. 3144				
-			2.7262n		1.9447
	4.7984n	Number	-532	Number	+88

The observed angles in the following formation of equations come from the list of directions on page 94.

Azimuth $A_2$ to $A_1$ (initial direction)	156	20	26.6
Observed angle initial direction to $A_1$	0	00	$00.0 - z_1 + v_1$
Observed azimuth $A_2$ to $A_1$	156	20	26.6 $-z_1+v_1$
Assumed azimuth $A_2$ to $A_1$	156	20	26.6 $+d\alpha$
Assumed azimuth-observed azimuth			$0 = 0.0 + d\alpha + z_1 - v_1$

* See Wright and Hayford, Adjustment of Observations, Chap. VII.

[†] This does not necessarily hold good when a line whose direction has already been fixed enters into the set.

Azimuth $A_2$ to $A_1$ is fixed. Therefore $d\alpha = 0$ and $v_1 = z_1$
Azimuth $A_2$ to $A_1$ (initial direction)1562026.6Observed angle initial direction to $A_3$ 10144 $45.1-z_1+v_2$ Observed azimuth $A_2$ to $A_3$ 25805 $11.7-z_1+v_2$ Assumed azimuth $A_2$ to $A_3$ 25805 $12.4+d\alpha$ Assumed azimuth -observed azimuth.0=+0.7+d\alpha+z_1-v_2
$d\alpha = -730\delta\phi_3 - 75\delta\lambda_3$ . Therefore $v_2 = z_1 - 730 \ \delta\phi_3 - 75\delta\lambda_3 + 0.7$ .
Azimuth $A_2$ to $A_1$ (initial direction)
$d\alpha = -1212 \ \delta \phi_4 + 218 \ \delta \lambda_4. \ \ \text{Therefore} \ v_3 = z_1 - 1212 \ \delta \phi_4 + 218 \ \delta \lambda_4 - 0.5$
In the same way at $A_1$ $v_4 = z_2 - 532 \ \delta \phi_3 + 88 \ \delta \lambda_3 - 0.8$ $v_5 = z_2 - 447 \ \delta \phi_4 + 221 \ \delta \lambda_4 - 0.3$ $v_6 = z_2$
Azimuth $A_3$ to $A_4$ (initial direction)470937.0Observed angle initial direction to $A_4$ 000 $00.0-z_3+v_7$ Observed azimuth $A_3$ to $A_4$ 4709 $37.0-z_3+v_7$ Assumed azimuth $A_3$ to $A_4$ 4709 $37.0-d\alpha$ Assumed azimuth $-observed$ azimuth000 $0.0+d\alpha+z_3-v_7$
$\begin{array}{ll} d\alpha = +  918  \left( \delta \phi_4 - \delta \phi_3 \right) + 414  \left( \delta \lambda_4 - \delta \lambda_3 \right). & \text{Therefore } v_7 \! = \! z_3 - 918  \delta \phi_3 \\ -  414  \delta \lambda_3 + 918  \delta \phi_4 + 414  \delta \lambda_4 + 0.0 & \cdot \\ \text{Similarly} & \cdot \end{array}$
$ \begin{array}{l} v_8 = z_3 - 730 \ \partial \phi_3 - 75 \ \partial \lambda_3 - 1. \ 2 \\ v_9 = z_3 - 532 \ \partial \phi_3 + 88 \ \partial \lambda_3 - 0. \ 4 \\ v_{10} = z_4 - 1211 \ \partial \phi_4 + 218 \ \partial \lambda_4 + 0. \ 0 \\ v_{11} = z_4 - 447 \ \partial \phi_4 + 221 \ \partial \lambda_4 + 1. \ 1 \\ v_{12} = z_4 - 918 \ \partial \phi_3 - 414 \ \partial \lambda_3 + 918 \ \partial \phi_4 + 414 \ \partial \lambda_4 - 1. \ 2 \end{array} $
$ \begin{array}{l} v_8 = z_3 - 730 \ \partial \phi_3 - 75 \ \partial \lambda_3 - 1.2 \\ v_9 = z_3 - 532 \ \partial \phi_3 + 88 \ \partial \lambda_3 - 0.4 \\ v_{10} = z_4 - 1211 \ \partial \phi_4 + 218 \ \partial \lambda_4 + 0.0 \\ v_{11} = z_4 - 447 \ \partial \phi_4 + 221 \ \partial \lambda_4 + 1.1 \\ v_{12} = z_4 - 918 \ \partial \phi_3 - 414 \ \partial \lambda_3 + 918 \ \partial \phi_4 + 414 \ \partial \lambda_4 - 1.2 \end{array} $ We have then the set of observation equations:
$\begin{split} v_8 &= z_3 - 730 \ \partial \phi_3 - 75 \ \partial \lambda_3 - 1.2 \\ v_9 &= z_3 - 532 \ \partial \phi_3 + 88 \ \partial \lambda_3 - 0.4 \\ v_{10} &= z_4 - 1211 \ \partial \phi_4 + 218 \ \partial \lambda_4 + 0.0 \\ v_{11} &= z_4 - 447 \ \partial \phi_4 + 221 \ \partial \lambda_4 + 1.1 \\ v_{12} &= z_4 - 918 \ \partial \phi_3 - 414 \ \partial \lambda_3 + 918 \ \partial \phi_4 + 414 \ \partial \lambda_4 - 1.2 \end{split}$ We have then the set of observation equations: $\begin{aligned} v_1 &= z_1 \\ v_2 &= z_1 - 730 \ \partial \phi_3 - 75 \ \partial \lambda_3 + 0.7 \\ v_3 &= z_1 - 1212 \ \partial \phi_4 + 218 \ \partial \lambda_4 - 0.5 \end{split}$
$\begin{aligned} v_8 &= z_3 - 730 \ \partial \phi_3 - 75 \ \partial \lambda_3 - 1.2 \\ v_9 &= z_3 - 532 \ \partial \phi_3 + 88 \ \partial \lambda_3 - 0.4 \\ v_{10} &= z_4 - 1211 \ \partial \phi_4 + 218 \ \partial \lambda_4 + 0.0 \\ v_{11} &= z_4 - 447 \ \partial \phi_4 + 221 \ \partial \lambda_4 + 1.1 \\ v_{12} &= z_4 - 918 \ \partial \phi_3 - 414 \ \partial \lambda_3 + 918 \ \partial \phi_4 + 414 \ \partial \lambda_4 - 1.2 \end{aligned}$ We have then the set of observation equations: $\begin{aligned} v_1 &= z_1 \\ v_2 &= z_1 - 730 \ \partial \phi_3 - 75 \ \partial \lambda_3 + 0.7 \\ v_3 &= z_1 - 1212 \ \partial \phi_4 + 218 \ \partial \lambda_4 - 0.5 \\ v_4 &= z_2 - 532 \ \partial \phi_3 + 88 \ \partial \lambda_3 - 0.8 \\ v_5 &= z_2 - 447 \ \partial \phi_4 + 221 \ \partial \lambda_4 - 0.3 \\ v_6 &= z_2 \end{aligned}$
$v_{8} = z_{3} - 730 \ \partial \phi_{3} - 75 \ \partial \lambda_{3} - 1.2$ $v_{9} = z_{3} - 532 \ \partial \phi_{3} + 88 \ \partial \lambda_{3} - 0.4$ $v_{10} = z_{4} - 1211 \ \partial \phi_{4} + 218 \ \partial \lambda_{4} + 0.0$ $v_{11} = z_{4} - 447 \ \partial \phi_{4} + 221 \ \partial \lambda_{4} + 1.1$ $v_{12} = z_{4} - 918 \ \partial \phi_{3} - 414 \ \partial \lambda_{3} + 918 \ \partial \phi_{4} + 414 \ \partial \lambda_{4} - 1.2$ We have then the set of observation equations: $v_{1} = z_{1}$ $v_{2} = z_{1} - 730 \ \partial \phi_{3} - 75 \ \partial \lambda_{3} + 0.7$ $v_{3} = z_{1} - 1212 \ \partial \phi_{4} + 218 \ \partial \lambda_{4} - 0.5$ $v_{4} = z_{2} - 532 \ \partial \phi_{3} + 88 \ \partial \lambda_{3} - 0.8$ $v_{5} = z_{2} - 447 \ \partial \phi_{4} + 221 \ \partial \lambda_{4} - 0.3$ $v_{6} = z_{2}$ $v_{7} = z_{3} - 918 \ \partial \phi_{3} - 414 \ \partial \lambda_{3} + 918 \ \partial \phi_{4} + 414 \ \partial \lambda_{4} + 0.0$ $v_{8} = z_{3} - 730 \ \partial \phi_{3} - 75 \ \partial \lambda_{3} - 1.2$ $v_{9} = z_{3} - 532 \ \partial \phi_{3} + 88 \ \partial \lambda_{3} - 0.4$

 $v_{10} = z_4 - 1211 \ \delta \phi_4 + 218 \ \delta \lambda_4 + 0.0$  $v_{11} = z_4 - 447 \ \delta \phi_4 + 221\delta \ \lambda_4 + 1.1$ 

$$v_{12} = z_4 - 918 \ \partial \phi_3 - 414 \ \partial \lambda_3 + 918 \ \partial \phi_4 + 414 \ \partial \lambda_4 - 1.2$$

These equations contain z's which are of no particular interest in themselves. The normal equations might be formed and the z's eliminated in the regular way, but this work is made easier by the following mechanical rule, the effect of which is to form at once the

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reduced normal equations with the z's eliminated. For the proof of the rule and further particulars see Jordan's Handbuch der Vermessungskunde, Vol. I, pages 151–171, of the third edition. Each direction is assumed to have equal weight. Write the observation equations dropping the z's and giving each unit weight. Add together as they stand all observation equations containing the z for any particular point. Drop the z term out and treat the resulting equation as a new observation equation with a negative weight equal to -1/r, where r is the total number of directions, both fixed and to be determined, that have been observed at the point in question. To reduce the new fictitious observation to unit weight it

must be multiplied through by 
$$\sqrt{\frac{-1}{r}} = \frac{1}{r}\sqrt{r}i$$
 where  $i = \sqrt{-1}$ .

Table 1 below shows the coefficients of the unknowns, the coefficients formed by adding the equations containing any particular z, and the weights. Table 2 shows these equations divided through by 100 for convenience. This has no effect on the relative weights. The table also contains the fictitious observation equa-

tions obtained by multiplying the sum equation by  $\sqrt{\frac{-1}{r}}$ . From

Table 2 the normal equations which do not contain the z's are formed in the ordinary way for observation equations of equal weight, using the *i*'s strictly according to algebraic laws. Thus in the first line of Table 2  $(-4.23i)^2$  contributes to the first diagonal coefficient not +17.8929 but  $+17.8929i^2$ , or -17.8929, and (-4.23i) $\times + (1.26i)$  contributes toward the side coefficient not  $-5.3298i^2$  or +5.3298i.

		ð <b>¢</b> 3	δλ3	δφι	δλ4	ı	p	$\sqrt{p}$
Sum	$2_1$ 1 1 1 3	730 730	— 75 — 75	-1212 -1212	+218 +218	+0.7 -0.5 +0.2	1 1 	1 1 1 0. 58 <i>i</i>
Sum	22 1 1 1 3	- 532 - 532	+ 88 + 88	- 447 - 447	+221 +221	-0.8 -0.3 -1.1	$     \begin{array}{c}             1 \\             1 \\         $	1 1 1 0. 58 <i>i</i>
Sum	$2_{3}$ 1 1 1 3	918 730 532 2180	-414 - 75 + 88 - 401	+ 918 + 918	+414 +414	+0.0 -1.2 -0.4 -1.6	1 1 1 -13	1 1 1 0. 58 <i>i</i>
Sum	24 1 1 1 3	- 918 - 918	-414 -414	-1211 - 447 + 918 - 740	+218 +221 +414 +853	+0.0 +1.1 -1.2 -0.1		1 1 1 0. 58 <i>i</i>

Table for formation of normals, No. 1

	δφ3	$\partial \lambda_3$	841	δλ4	l	Σ
23	- 7.30	-0.75	-12.12	+2.18	+0.007 -0.005	- 8.043 - 9.945
21 4 5	-4.23i -5.32	-0.44i +0.88	-7.03i	+1.26i +2.21	+0.00116i -0.008 -0.003	-10.43884i -4.448 -2.263
2 ₂ 7	-3.09i - 9.18	+0.51i -4.14	-2.59i + 9.18	+1.28i +4.14	-0.00638i +0.0	- 3. 89638 <i>i</i> 0. 0
8 9 23	-7.30 -5.32 -12.64i	-0.75 +0.88 -2.33i	+ 5.32i	+2.401	-0.012 -0.004 -0.00928i	$ \begin{array}{r} - 8.002 \\ - 4.441 \\ - 7.25928i \end{array} $
10 11 12	- 9.18	-4.14	-12.11 - 4.47 + 9.18	+2.18 +2.21 +4.14	+0.0 +0.011 -0.012	$\begin{array}{r} - 9.93 \\ - 2.249 \\ - 0.012 \end{array}$
24	-5.32i	-2.40i	- 4.29 <i>i</i>	+4.95i	-0.00058i	- 7.06058 <i>i</i>

Table for formation of normals, No. 2

#### Normal equations

	<i>δ</i> φ ₃	323	ð¢4	<i>δλ</i> 4	η	Σ
1 2 3 4	+116.2166	+35,0927 +25,3104	-161.8628 - 75.6831 +399.2176	-10.0554-16.9056+24.0721+20.0637	$\begin{array}{r} +0.\ 0753 \\ +0.\ 0236 \\ -0.\ 0468 \\ -0.\ 01105 \end{array}$	$\begin{array}{r} - & 20.\ 5336 \\ - & 32.\ 1620 \\ + 185.\ 6970 \\ + & 17.\ 16375 \end{array}$

The forward and back solution of the normals, conducted according to the Doolittle method, is next shown.

To compute the v's from the observation equations a knowledge of the z's is required. Substitute the  $\delta \phi$ 's and  $\delta \lambda$ 's in the right-hand side of the sum equation formed from the observation equations that contain the z in question as if the z were not there and divide the result of the substitution by the weight -r. As a check the sum of the v's about a point should equal zero. The computation of the v's is shown in the table on page 102. Below each v as computed to 3 decimals is given its value as adopted and reduced to 1 decimal.

Following the computation of the v's there is given a computation of the triangles using the adjusted directions.

$\partial \phi_3$	δλ3	∂φ4	<i></i> ∂λ₄	η	Σ
$+116.2166 \\ \delta \phi_{3}$	+35.0927 - 0.301959	-161.8628 + 1.392768	-10.0544 + 0.086523	+0.0753 -0.000648	-20.5336 + 0.176684
1	+25.3104 -10.5966	-75.6831 + 48.8759	-16.9056 + 3.0363	+0.0236 -0.0227	-32.1620 + 6.2003
	+14.7138 δλ ₃	-26.8072 + 1.821909	-13.8693 + 0.942605	+0.0009 -0.000061	$\begin{array}{r} - 25.9618 \\ + 1.764452 \end{array}$
	1 2	+399.2176 -225.4373 - 48.8403	+24.0721 -14.0048 -25.2686	-0.0468 +0.1049 +0.0016	+185.6970 - 28.5985 - 47.3000
		$+124.9400$ $\delta \phi_4$	-15.2013 + 0.121669	+0.0597 -0.000478	+109.7984 - 0.878809
		1 2 3	$\begin{array}{r} +20.\ 0637 \\ -\ 0.\ 8700 \\ -13.\ 0733 \\ -\ 1.\ 8495 \end{array}$	$\begin{array}{r} -0.\ 01105 \\ +0.\ 00652 \\ +0.\ 00085 \\ +0.\ 00726 \end{array}$	$\begin{array}{r} + 17.16375 \\ - 1.77663 \\ - 24.47172 \\ + 13.35904 \end{array}$
			+ 4.2709 $\partial \lambda_4$	+0.00358 -0.000838	+ 4.27448 - 1.000838

#### Solution of normals

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δλ4	δφ4	δλ3	$\delta \phi_3$
-0.00084 -0.00084	0.00048 0.00010 0.00058	0,00006 0,00079 0,00106 0,00191	$\begin{array}{r} -0,00065\\ -0.00007\\ -0.00081\\ +0.00058\\ \hline -0.00095\end{array}$

### Back solution

$1 = z_1$	2	3	$z_1$
-0.519 -0.5	+0.6935 +0.1432 +0.7 -0.519	$\begin{array}{c} +0.\ 7030\\ -0.\ 1831\\ -0.\ 5\\ -0.\ 519\end{array}$	+0.6935 +0.1432 +0.7030 -0.1831 +0.2
	+1.018 +1.0	-0. 499 -0. 5	$+1.5566 \div -3$ -0.519
4	5	$6 = z_2$	22
+0.5054 -0.1681 -0.8 +0.230	+0.2593 -0.1856 -0.3 +0.230	+0.230 +0.3	+0.5054 -0.1681 +0.2593 -0.1856 -1.1
-0.233 -0.2	+0.004 0.0		$-0.689 \div -3$ +0.230
7	8	9	Z3
7 + 0.8721 + 0.7907 - 0.5324 - 0.3478 - 0.119	8 +0.6935 +0.1432 -1.2 -0.119	9 +0.5054 -0.1681 -0.4 -0.119	$\begin{array}{c} z_3 \\ \hline +2.0710 \\ +0.7659 \\ -0.5324 \\ -0.3473 \\ -1.6 \end{array}$
7 +0. 8721 +0. 7907 -0. 5324 -0. 3478 -0. 119 +0. 664 +0. 7	8 +0.6935 +0.1432 -1.2 -0.119 -0.482 -0.5	9 +0.5054 -0.1681 -0.4 -0.119 -0.182 -0.2	$\begin{array}{c} z_3 \\ +2.0710 \\ +0.7659 \\ -0.5324 \\ -0.3473 \\ -1.6 \\ +0.3567 \\ -0.119 \end{array}$
7 +0.8721 +0.7907 -0.5324 -0.3478 -0.119 +0.664 +0.7	8 +0.6935 +0.1432 -1.2 -0.119 -0.482 -0.5	$\begin{array}{c} 9 \\ \hline +0.5054 \\ -0.1681 \\ -0.4 \\ -0.119 \\ \hline -0.182 \\ -0.2 \\ \hline 12 \end{array}$	$\begin{array}{c} z_3 \\ +2.0710 \\ +0.7659 \\ -0.5324 \\ -0.3478 \\ -1.6 \\ +0.3567 \\ -0.119 \end{array}$
$\begin{array}{c} 7 \\ +0.8721 \\ +0.7907 \\ -0.5324 \\ -0.3478 \\ -0.119 \\ +0.664 \\ +0.7 \\ \hline \\ 10 \\ \hline \\ +0.7024 \\ -0.1831 \\ -0.425 \\ +0.094 \end{array}$	$\frac{8}{\begin{array}{c} +0, 6935\\ +0, 1432\\ -1, 2\\ -0, 119\\ \hline \\ -0, 482\\ -0, 5\\ \hline \\ 11\\ \hline \\ +0, 2593\\ -0, 1856\\ +1, 1\\ -0, 425\\ \hline \end{array}}$	$\begin{array}{c} 9\\ \hline +0,5054\\ -0,1681\\ -0,4\\ -0,119\\ \hline -0,182\\ -0,2\\ \hline \\ 12\\ \hline \\ +0,8721\\ +0,7907\\ -0,5324\\ -0,3478\\ -0,3478\\ -1,2\\ \end{array}$	$\begin{array}{c} z_{3} \\ \hline +2,0710 \\ +0.7659 \\ -0.5324 \\ -0.3473 \\ -1.6 \\ \hline +0.3567+-3 \\ -0.119 \\ \hline z_{4} \\ \hline \\ +0.8721 \\ +0.7907 \\ +0.4292 \\ -0.7165 \\ -0.1 \\ \hline \end{array}$

1

Computation of corrections

Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
-8+9 -1+2 -4+6	Az-A1 Az A2 A1	°         ′         ′′           30         43         52.5           101         44         45.1           47         31         20.2	" +0.3 +1.5 +0.5	" 52.8 46.6 20.7	" 0.0 9.1 0.0	52.8 46.5 20.7	<b>3. 772745</b> 0. 291568. 9. 990809 9. 867787
	A3-A1 A3-A2	-	+2.3		0.1		4.055122 3.932100
-10+11 - 1+ 3 - 5+ 6	A2-A1 A4 A2 A1	25 15 16.2 133 53 46.3 20 50 56.7	+0.6 0.0 +0.3	16.8 46.3 57.0	0.0 0.1 0.0	16.8 46.2 57.0	<b>3. 772745</b> <b>0. 369936</b> 9. 857693 9. 551339
	A4-A1 A4-A3		+0.9		0.1		4.000374 3.694020
-10+12 - 2+ 3 - 7+ 8	A2-A3 A4 A2 A3	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	-0.9 -1.5 -1.2	19.1 59.7 41.3	0.1 0.0 0.0	19.0 59.7 41.3	3.932100 0.049306 9.726023 9.712614
	A 4-A3 A 4-A2		-3.6		0.1		3.707429 3.694020
-11+12 - 4+ 5 - 7+ 9	A1-A3 A4 A1 A3	91 32 03.8 26 40 23.5 61 47 35.0	-1.5 + 0.2 - 0.9	02.3 23.7 34.1	0, 1 0, 0 0, 0	02. 2 23. 7 34. 1	4.055122 0.000156 9.652151 9.945096
	A 4-A3 A 4-A1		-2.2		0.1		3. 707429 4. 000374

Adjusted computation of triangles

ADJUSTMENT OF THREE NEW POINTS CONNECTED WITH SEVERAL FIXED POINTS BY VARIATION OF GEOGRAPHIC COORDINATES

#### GENERAL STATEMENT

The method of adjustment by geographic coordinates seems to be especially suitable for the adjustment of a few new points depending upon a number of fixed points. The number of normal equations in such case is 2n, n being the number of new points. In the figure used the number of condition equations would be 15, which would form a very intricate set of normals. By the method of coordinates the number of normal equations is only six.

The adjustment of figure 6 is carried out in two different ways, the first one being more rigorous but a trifle longer than the second. The first method corresponds in its treatment of observed directions to the method developed in Jordan's Vermessungskunde, volume 1, pages 144–173, of the third edition. The second method resembles somewhat the method given by Jordan on pages 173–179 for the approximate treatment of the z's and corresponds in its treatment of fixed directions to the ordinary practice of the Coast and Geodetic Survey for subsidiary triangulation as treated by the method of condition equations.



### APPLICATION OF LEAST SQUARES TO TRIANGULATION. 105

The solution by the method of condition equations was carried out for figure 6 and gave almost the same results, the greatest difference in the correction to a direction being 0.2''. This difference was quite to be expected in view of the different formulas and the fact that the fixed positions, distances, and azimuths may not be strictly consistent with each other to the last figure given.

### FIRST METHOD

The first method is fundamentally the same as the method used in the adjustment of the quadrilateral previously given, but the greater complication of the figure, particularly the great number of fixed lines, brings to light points that need mention. The groundwork of the adjustment by either method is shown in the tables of observed directions and of fixed positions, azimuths, and lengths which follow. In the list of directions the names of stations that are sighted on over fixed lines are shown in heavy type. For these stations the directions corrected from a previous adjustment are also shown. In forming the table of triangles for the preliminary computation these corrected directions were taken with the directly observed directions of new points in order to obtain such of the angles in the column "Observed angle" as have a fixed line for one of its sides.* No particular procedure to obtain the consistent set of positions, azimuths, and lengths necessary to form the observation equations is essential to the method. In this particular case the corrections to the angles of the triangles Gunner-Larrabee-Mam, Cranberry Point-Gunner-Lubec Channel Lighthonse, and Telegraph-Cranberry Point-Gunner were arbitrarily assumed as shown in the table of preliminary computation of triangles. These assumptions, with the lines already fixed, determined enough parts in every one of the other triangles to make possible its solution with results as shown in the table.

Following the table of triangles the necessary preliminary computation of positions is included.

^{*} This corresponds to the idea followed out in the second method of solution, but in the preliminary computation this is of no consequence, as is shown in the next sentence.

# Lists of directions

AT LARRABEE

Stations observed	O di	bser rect	Seconds after adjust- ment*		
Larrabee Mam Lubec Channel Light-	0 66 95	, 00 55 24	" 00.0 01.0 38.4	$0^{''}_{01.5}\\01.2\\41.2$	
Gunner Lubec Church Spire	114 117	00 33	37.5 55.5	71.9	

AT INDIAN POINT

Stations observed	O di	bsei rect	ved ions	Seconds after adjust- ment*
	0	,	11	"
Indian Point Mam	0	00	00.0	56.7
Lubec Channel Light- house	312	58	58.5	55.0
Lubec Church Spire Gunner	$\frac{315}{325}$	$\frac{12}{58}$	$19.0 \\ 24.9$	24.9
Duck	336	12	51.0	50.6

#### AT MAM

0	00	00.0	55.4
34	52	43.6	46.7
317	37	23.5	
318	56	54.1	55.2
322	01	44.8	
336	18	52.1	52.5
	0 34 317 318 322 336	0 00 34 52 317 37 318 56 322 01 336 18	$\begin{array}{cccccccccccccccccccccccccccccccccccc$

#### AT DUCK

Lubec Channel Light-	0	00	00.0	59.9
house Gunner Larrabee	<b>33</b> 269	11 09	41.8 40.7	40.9
Mam (computed)	336	10	2011	44.0

#### AT GUNNER

Indian Point Larrabee Mam	0 31 94	00 57 56	$   \begin{array}{c}     00.0 \\     41.4 \\     05.9   \end{array} $	
Lubec Channel Light- house	101	48	54.9	
Telegraph Lubec Church Spire	168 186	28 30	59.0 29.8	
Cranberry Point	191	54	53.6	
Duck	340	14	12.0	

AT TREAT 2

 $\begin{array}{cccc} 0 & 00 & 00.0 \\ 17 & 34 & 38.1 \end{array}$ 

Cranberry Point Lubec Church Spire

#### AT CRANBERRY POINT

Lubec Channel Light-	75	00 45	$00.0 \\ 12.8$
Mam	78	37	05.9
Telegraph	153	39	19.7
Lubec Church Spire	174	08	32.3
Treat 2	191	52	35.2

#### AT TELEGRAPH

|--|

* Refers to final values of heavy lines in Fig. 6, p. 104, obtained from a previous adjustment.

45.4

List of fixed positions

La	titu ongi	de and itude	Az	imu	ith	Back azimuth		Back azimuth		Back azimuth		Back azimuth		muth	To station	Loga- rithm of dis- tance
0	/	//	<b>.</b>	,	,,	٥	,	,,								
66	51 59	38. 470 17. 418														
44 66	50 58	31.652 38.299														
44 66	52 59	44. 333 25. 919	354	45	17.5	174	45	23.5	Lubec Church Spire	3, 309982						
44 66	50 57	03. 537 12. 788	114	48	33.8	294	47	33.5	Lubec Channel Light- house	3.315762						
			136	58	04.6	316	56	36.7	Lubec Church Spire	3.603123						
44 66	49 57	10. 841 38. 857	152	22	33.8	332	21	51.9	Lubec Channel Light- house	3. 449573						
			154 199	36 23	03.7 35.7	334 19	34 23	$54.3 \\ 54.1$	Lubec Church Spire Indian Point	3.702872 3.236668						
44 66	50 57	33. 886 47. 822	355 86	36 26	23. 1 42. 1	175 266	$\frac{36}{26}$	29.4 06.5	Larrabee Lubec Channel Light- house	3, 410111 3, 045619						
44	49 59	57.369 26.892	225	14	19.0	45	14	53.3	Lubec Channel Light-	3. 176968						
50	50	20,002	242 266 301	36 17 10	16.3 19.2 10.5		$37 \\ 18 \\ 11$	$26.2 \\ 53.8 \\ 26.7$	Duck Indian Point Larrabee	3.389282 3.470097 3.443126						
	Laall 1	Latitu longi • , 44 51 66 59 44 50 66 58 44 52 66 59 44 50 66 57 44 49 66 57 44 49 66 57 44 49 66 59	Latitude and longitude • , , , 44 51 38.470 66 59 17.418 44 50 31.652 66 58 38.299 44 52 44.333 66 59 25.919 44 50 03.537 66 57 12.788 44 49 10.841 66 57 38.857 44 50 33.886 66 57 47.822 44 49 57.369 66 59 26.892	Latitude and longitude         Az           • ' ''         •           44 51 38.470         •           66 59 17.418         •           44 50 31.652         •           66 58 25.919         •           44 50 03.537         114           66 57 12.788         136           44 90 03.537         114           66 57 38.857         154           66 57 38.857         154           66 57 47.822         86           44 9 57.369         225           66 59 26.892         242           242         26.892           244 30         33.486           66 57 36.9         225           66 59 26.892         242           242         242           26         301	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$						
# Preliminary computation of triangles

Symbol	Station	Observed angle	Correc- tion	Spheri- cal angle	Spheri- cal excess	Plane angle	Loga- rithm
-1+3 +24 -22	Duck-Larrabee Gunner Duck Larrabee	°         ′         ′′           45         43         29.4           124         01         60.9           10         14         25.7		" 34.2 59.0 26.8		0 / //	<b>3. 410111</b> 0. 145080 9. 918405 9. 249896
	Gunner-Larabee Gunner-Duck		+ 4.0				3, 473596 2, 805087
-1+4 + 24 - 21	Duck-Mam Gunner Duck Mam	108         41         53.9           57         00         57.8           14         17         07.7	+ 3.6 - 1.9 - 1.1	57.5 55.9 06.6			<b>3.389282</b> 0.023552 9.923668 9.392254
	Gunner-Mam Gunner-Duck		+ 0.6				3, 336502 2, 805088 ⁻¹
-1+5 +24	Duck-Lubec Chan- nel Lighthouse Gunner Duck Lubec Channel Lighthouse Gunner-Lubec Channel Light-	115 34 42.9 33 11 41.9 35.2	+7.1 -1.9 -5.2	50. 0 40. 0 30. 0		31 13 30.0	3.045619 0.044803 9.738370 9.714665 2.828792 ⁺¹
	house Gunner-Duck						2 805087
-2+3 +23 -22	Indian Point-Lar- rabee Gunner Indian Point Larrabee	31 57 41.4 114 00 36.0 34 01 32.0	+7.0 +2.5 +1.1	48. 4 38. 5 33. 1			<b>3. 236668</b> 0. 276234 9. 960694 9. 747852
	Gunner-Larrabee Gunner-Indian Point		+10.6				3. 473596 3. 260754
-2+4 +23 -21	Indian Point-Mam Gunner Indian Point Mam	94         56         05.9         9           47         05         36.3         37         58         10.6	+5.8 + 2.5 - 1.1	11.7 38.8 03.5			<b>3. 470097</b> 0. 001614 9. 864792 9. 789044
	Gunner-Mam Gunner-Indian Point		+ 7.2				$\begin{array}{c} 3.\ 336503^{-1}\\ 3.\ 260755^{-1} \end{array}$
	Indian Point-Lu- bec Channel						3.315762
-2+5 +23	Gunner Indian Point Lubec Channel	101 48 54.9 18 35 56.3 68.8	+ 9.3 + 2.5	$64.2 \\ 58.8 \\ 57.0$		59 34 57.0	0,009304 9,503728 9,935688
	Lighthouse Gunner-Lubec Channel Light- house Gunner-Indian Point						2. 828794-1 3. 260754
-3+4 + 22 - 21	Larrabee-Mam Gunner Larrabee Mam	62 58 24.5 44 10 37.0 72 51 01.9	-1.2 -1.1 -1.1	23. 3 35. 9 00. 8			3. 443126 0. 050223 9. 843153 9. 980247
	Gunner-Mam Gunner-Larrabee		- 3.4				3.336502 3.473596

Symbol	Station	Observed angle	Correc- tion	Spheri- cal angle	Spheri- cal excess	Plane angle	Loga- rithm
	Larrabee-Lubec Channel Light-	0 / //	"	"		0 / //	3. 449573
-3+5 + +22	nouse Gunner Larrabee Lubec Channel Lighthouse	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	+ 2.3 - 1.1	$15.8 \\ 28.8 \\ 15.4$		97 09 15.4	0.027417 9.351803 9.996606
	Channel Light- house Gunner-Larrabee						2.828793 3.473596
1	Larrabee-Lubec						3. 702872
-3+7 +22	Gunner Larrabee Lubec church spire G u n n er – I. u b ec church spire	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	+20.7 - 1.1	$\begin{array}{c} 69.\ 1 \\ 58.\ 9 \\ 52.\ 0 \end{array}$		33 09.1 14 40 52.0	0.366851 9.271388 9.403873 3.341111
	Gunner-Larrabee						3.473596
	Mam-Lubec Chan- nel Lighthouse						3. 176968
- 4+ 5 +21	Gunner Mam Lubec Channel Lighthouse	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	+ 3.5 + 1.1	52.5 50.7 16.8	-	170 02 16.8	0. 921500 8. 730324 9. 238033
	Gunner-Lubec Channel Light-						$2.828792^{+1}$
	house Gunner-Mam						3. 336501+1
	spire-Indian Point						3.603122
+2-7	Gunner Lubec church	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-27.7	$     \begin{array}{c}       02.5 \\       85.6     \end{array}   $		2 57 25.6	0.945080 8.712552
-23	spire Indian Point Gunner-Indian Point	3 33 34.4	- 2.5	31.9			8.792909 3.260754
	Gunner-Lubec church spire						3.341111
	Gunner-Lubec Channel Light-						2.828793
-9+10 -5+8	Cranberry Point Gunner Lubec Channel	$\begin{array}{cccc} 75 & 45 & 12.8 \\ 90 & 05 & 58.7 \\ & & 48.5 \end{array}$	0.0 0.0	$12.8 \\ 58.7 \\ 48.5$		14 08 48.5	0.013566 9.999999 9.388114
	Cranberry Point-						2.842358
	Lighthouse Cranberry Point- Gunner						2.230473
$- 9+11 \\ - 4+8 \\ -20+21$	Gunner-Mam Cranberry Point Gunner Mam	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	-13.1 + 3.5 - 5.3	$52.8 \\ 51.2 \\ 16.0$			$\begin{array}{c} 3.336502\\ 0.008631\\ 9.996768\\ 8.885341 \end{array}$
	Cranberry Point-		-14.9				3.341901
	Mam Cranberry Point- Gunner						2.230474-1
1	Gunner-Lubec				1		3.341111
- 9+13 - 7+ 8	church spire Cranberry l'oint Gunner Lubec church spire Cranberry l'oint- Lubec church	174 08 32.3 5 24 23.8 03.9	+11.5 -18.4	$\begin{array}{c} 43.8\\05.4\\10.8\end{array}$		0 27 10.8	0.991389 8.973748 7.897971 3.306248
	spire Cranberry Point- Gunner						2.230471+2

# Preliminary computation of triangles-Continued

# APPLICATION OF LEAST SQUARES TO TRIANGULATION. 109

Preliminary computation of triangles-Continued

Symbol	Station	Observed angle	Correc- tion	Spheri- cal angle	Spheri- cal excess	Plane angle	Loga- rithm
-10+11 -20	Lubec Channel Lighthouse-Mam Cranberry Point Lighthouse Mam Cranberry Point- Mam Cranberry Point- Lubec Channel Lighthouse	• / // 2 51 53.1 35.2 1 19 31.7	'' -13.1 - 6.4	" 40.0 54.7 25.3		° / "	3. 176968 1. 301768 8. 863166 8. 363626 3. 341902 ⁻¹ 2. 842362 ⁻⁴
-13+14 -19	Lubec church spire-Treat ₃ Cranberry Point Lubec church spire Treat ₃ Cranberry Point- Treat ₃ Cranberry Point- Lubec church spire	17 43 62.9 19.0 17 34 38.1	- 4.7 - 4.3	58. 2 28. 0 33. 8		144 41 28.0	<b>3. 309982</b> 0. 516300 9. 761916 9. 479966 3. 588198 3. 306248
-15+16 -12+13	Lubec church spire-Cranberry Point Telegraph Lubec church spire Cranberry Point Telegraph-Lubec berry Point Telegraph-Lubec church spire	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-52.6 +14.2	07.3 85.9 26.8		30 52 25.9	3. 306248 0. 107274 9. 710244 9. 544138 3. 123706 2. 957660
-15+17 - 6+ 7	Lubec church spire-Gunner Telegraph Lubec church spire Gunner Telegraph-Gunner Telegraph - Lubec church spire	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-54.8 +15.8	58.3 75.1 46.6		$\begin{array}{rrrr} 32 & 58.3 \\ 30 & 25 & 15.1 \end{array}$	3.341111 0.125876 9.704449 9.490673 3.171436 2.957660
-16+17 - 9+12 - 6+ 8	Cranberry Point- Gunner Cranberry Point Gunner Telegraph-Gunner Telegraph-Cran-	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{r} -2.2 \\ -2.7 \\ -2.6 \\ \hline -7.5 \end{array} $	51.0 17.0 52.0			2.230473 1.293796 9.647167 9.599497 3.171436 3.123766
$-16+18 \\ -10+12$	berry Point Cranberry Point- Lubee Channel Lighthouse Telegraph Lubec Channel Lighthouse Telegraph-Lubec Channel Light- house Telegraph-Cran- berry Point	29 52 44.5 77 54 06.9 08.6	- 9.6 - 2.7	34.9 04.2 20.9		72 13 20.9	2. 842358 0. 302657 9. 990244 9. 978751 3. 135259 ⁺¹ 3. 123766
-17+18 - 5+ 6	Gunner-Lubec Channel Light- house Telegraph Gunner Lubec Channel Lighthouse Telegraph-Lubec Channel Light- house Telegraph-Gunner	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	- 7.4 + 2.6	43. 9 06. 7 09. 4		86 22 09.4	2. 828793 0. 343516 9. 962951 9. 999127 3. 135260 3. 171436

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## Preliminary position computation,

α Second angle	Duck to I Lubec Ch	Lubec Cha annel Ligi	nnel I ithous	Lighthou se and G	se unnei	r		° + 33	, 26 11	42.1 40.0
α 1α	Duck to (	Junner						$-^{119}$	38	22.1 17.8
α'	Gunner to	) Duck		Fi	rst ar	ngle o	f triangle	180 299 115	00 38 34	00.00 04.3 50.0
$\phi$ $\Delta\phi$	44 +	50	" 33.88 10.22	36 27	Ducl	ĸ	λ λ	66 +	57	47.822 25.265
φ'	44	50	44.11	13 0	Gunn	er	λ'	66	58	13.087
$\frac{1}{2}(\phi+\phi')$	• / // 44 50 39 //	$cos \alpha B$	8	2. 805087 9. 694202 8. 510480	sin (	$\frac{2}{2} \alpha$	5.61 9.87 1.40	02 82 16		
1st term 2d term	-10.2275 + 0.0008	h	1	L. 009769			6,89	00		
40	-10. 2267									
	$\frac{s}{A'} \\ \sec \phi'$	2.80 9.93 8.50 0.14	5087 9097 8994 9348	$\int \Delta \lambda \sin \frac{1}{2} (\phi +$	- <i>φ</i> ′)		1.402526 9.848301			
		1.40	2526				1.250827 //			
	Δλ	+25.2	2654	<i>—</i> ⊿α			+17.82			

STATION GUNNER

#### STATION CRANBERRY POINT

α Second angle	Gunner to Lu Lubec Channe	bec Channel 1 el Lighthouse	nt	° + 90	, 12 05	'' 54. 3 58. 7		
α Δα	Gunner to Cra	anberry Point		145	- 18	53. 0 03. 1		
α'	Cranberry Poi	int to Gunner	riangle	180 325 75	00 18 45	00. 00 49. 9 12. 8		
$\phi \\ \varDelta \phi$	44 50 +	0 44.113 04.529	Gunn	ier	$\lambda$ $\Delta\lambda$	+ 66	58	13.087 04.405
φ'	44 50	0 48.642	Cranberry	y Point	λ'	66	58	17.492
$\frac{1}{2}(\phi+\phi')$	° ′ ′′ 44 50 46	$\begin{array}{c c} s & 2.\\ \cos \alpha & 9.\\ B & 8. \end{array}$	230473 915025 sin 510480	$\begin{bmatrix} s^2 \\ 1^2 \\ C \end{bmatrix}$	4. 46 9. 51 1. 40	09 03 16		
1st term 2d term	-4.5288 0.0000	h 0.0	655978		5.37	28		
-40	-4.5288							
	$ \begin{bmatrix} s \\ \sin \alpha \\ A' \\ \sec \phi' \end{bmatrix} $	2. 230473 9. 755164 8. 508994 0. 149357 s	$d\lambda$ in $\frac{1}{2}(\phi+\phi')$	09	. 643988 . 848315			
		, 492303						
	Δλ	+4. 4054	-Δα		,,, +3.11			

## secondary triangulation

α Third angle	Lubec Ch Gunner a	annel Ligh nd Duck		° 266 — 31	, 26 13	" 06.5 30.0			
α 1α	Lubec Ch	annel Ligh		235 +	-12	36.5 17.8			
α'	Gunner to	o Lubec Ch		180 55	00 12	00.00 54.3			
ø	° 44	50	31. 652	Lubec	Channel	λ	66	58	38. 299
44	+		12.461	Ligi	nthouse	Δλ	-		25. 212
φ'	44	50	44.113	G	unner	λ'	66	58	13.087
½(¢+¢')	• / // 44 50 36	δ cos α B	2. 82 9. 75 8. 51	28793 56308 10480	$\frac{s^2}{\sin^2 \alpha}$	5.65 9.82 1.40	76 89 16		
1st term 2d term	-12.4618 + 0.0008	h h	1.09	95581		6.88	81		
-40	-12. 4610	)							
-	$\frac{\sin \alpha}{\Lambda'}$ sec $\phi'$	2, 828 9, 914 8, 508 0, 149	793 174 994 348 sir	<i>Δ</i> λ 1 ½(φ+4	¢')	1. 401609 9. 848294			
		1. 4010	509		-	1. 249903			
	Δλ	-25.2	121	-Δα		-17.78			

#### STATION GUNNER

STATION CRANBERRY POINT

α Third angle	Lubec Ch Cranberry	Lubec Channel Lighthouse to Gunner Cranberry Point and Gunner								" 36.5 48.5
α 1α	Lubec Ch	Lubec Channel Lighthouse to Cranberry Point						+221	03	48.0 14.7
α'	Cranberry	Cranberry Point to Lubec Channel Lighthouse							00 04	00. 00 02. 7
ø	° 44	50	" 31.652	Lube	e Ch	nannel	. λ	66	58	38, 299
14	+		16.990		5	CLU U	<i>Δ</i> λ	-		20.807
φ'	44	50	48.642	Cran	berry	Point	t λ'	66	58	17.492
$\frac{1}{2}(\phi + \phi')$ 1st term 2d term	• , , , , , , , , , , , , , , , , , , ,	$\begin{array}{c c} & & & \\ & & & \\ & & & \\ B & & \\ B & & h \\ \hline & & & \\ \end{array}$	2.8 9.8 8.5 1.2	42358 77362 10480 30200	sin	$C^{2}$	5. 68 9. 63 1. 40 6. 72	47 50 16 13		
-40	-16,9898	3								
		2. 84 9. 81 8. 50 0. 14	2358 7494 8994 9357 si	<i>Δλ</i> n ½(φ+	⊦¢′)		1. 318203 9. 848303			
		1.31	1.318203				1.100506			
	<i>Δ</i> λ	-20.8	8067	—⊿a			-14.67			

91865°—15——8

Preliminary position computation,

Second angle	Cranberry Lubec Ch	Cranberry Point to Lubec Channel Lighthouse Lubec Channel Lighthouse and Telegraph							'' 02.7 04.2
α 1α	Cranberry	Point to '		118	58	06.9 37.4			
α'	Telegraph	to Cranbe	riangle	180 298 29	00 57 52	00.00 29.5 34.9			
ф 4ф	° 44 +	50	" 48.642 20.860	Cranberry	7 Point	$\lambda$ $\Delta\lambda$	66 +	58	17.492 52.980
φ'	44	51	09.502	] Telegra	aph	λ'	66	59	10.472
$\frac{1}{2}(\phi+\phi')$	• / // 44 50 59 //	$\begin{bmatrix} s \\ \cos \alpha \\ B \end{bmatrix}$	3.1 9.6 8.5	23766 85141 sin 510480 0	$\begin{bmatrix} 3^2 \\ 1^2 \\ C \end{bmatrix}$	6.247 9.883 1.401	5 9 3		
1st term 2d term	-20.8635 + 0.0034	h	1.3	319387		7. 533	)		
$-\Delta\phi$	-20.8001	2 192	1 766_1	1	1				
	$\sin \alpha$ A' $\sec \phi'$	9, 941 8, 508 0, 149	951 994 401 si	$\int \lambda$ in $\frac{1}{2}(\phi + \phi')$	$\frac{1}{9}$	.724112 .848343			
		1. 724112 1. 57245							
	Δλ	$"' +52.9800 - \Delta \alpha +37.36$							

#### STATION TELEGRAPH

## secondary triangulation—Continued.

#### STATION TELEGRAPH

α Third angle	Lubec Ch Telegraph	annel Lighthon and Cranberr	use to Cranberr y Point use to Telegram	y Point	° 221 - 72	, 03 13	" 48.0 20.9
<u>Δ</u> α α'	Telegranh	to Lubec Cha	nnel Lighthous	20		00	22.7 00.00
ф 1ф	44 +	50 31. 6 37. 8	552 Lubec Cl	$\begin{array}{c c} \text{nannel} & \lambda \\ \text{ouse} & & \lambda \\ & \lambda \end{array}$	66 +	58	38. 299 32. 173
\$	44	51 09.8	502 Telegra	aph $\lambda'$	66	59	10. 472
$\frac{1}{2}(\phi+\phi')$	44 50 50	cos α B	3. 135260 9. 932338 8. 510480	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	05 77 .6		
lst term 2d term —40	-37.8511 + 0.0012 -37.8499	h	1. 578078	7.099	18		
-	$ \begin{array}{c}                                     $	3. 135260 9. 713841 8. 508994 0. 149401	$\frac{d\lambda}{\sin\frac{1}{2}(\phi+\phi')}$	1. 507496 9. 848324			
	<i>Δ</i> λ	1. 507496 " +32. 1733	— <i>]</i> α	1. 355820 '' +22. 69			

#### FORMATION OF OBSERVATION EQUATIONS

In the first column of the following table is given the assumed azimuths of the various lines. Under station Gunner the azimuth to Duck, 299° 38′ 04′′.3, comes from the position computation on page 110, and the other azimuths are obtained by adding to this the corrected angles from the preliminary computation of triangles. Thus in the first triangle in that list, Gunner-Duck-Larrabee, the angle at Gunner is  $45^{\circ}$  43′ 34.″2, which, added to the azimuth of Duck, gives  $345^{\circ}$  21′ 38″.5, as shown in the table. For any one station the assumed and observed azimuths of some one station may be taken as identical. At Gunner they are identical on station Duck. The observed azimuths in the second column of the table have their symbolic corrections affixed. These azimuths are obtained by adding the observed angles as derived from the list of observed directions on page 106 to the azimuth of the line Gunner-Duck.

At the fixed stations given in the lower part of the table the method of computing the assumed and observed azimuths is somewhat different. The assumed azimuths of the fixed lines come from the table of fixed positions on page 106. The assumed azimuths of the new lines are found by adding to one of these fixed azimuths the appropriate corrected angle from the computation of triangles on pages 107–109. In the second column of the table the observed azimuth of one fixed line used as an initial line is taken identical with its assumed azimuth, and the other observed azimuths, whether of fixed lines or of new ones, are found by adding to this azimuth the observed angles between the initial line and each of the others as derived from the list of directions.

The coefficients of the  $\partial \phi$ 's and  $\partial \lambda$ 's are found from the formulas on page 93.

1-			1			I wanted and the second			
	Station observed	Duck Duck Larrabeo Mam Lubec Channel L. H. Telegraph Lubec church spire Cranberry Point		Gunner Lubbe Channel L. H. Aam Telegraph Lubee church spire Treat ₃		Lubee church spire Granberry Point Gunner Lubee Channel L, H.		Cranberry Point Lubec church spire	X
	Equation	$ \begin{array}{l} v_{1}=z_{1}+8069\phi_{1}-35000\lambda_{1}+0.0\\ v_{2}=z_{1}+5289\phi_{1}-14730\lambda_{1}+0.0\\ v_{3}=z_{1}+5419\phi_{1}-1473\lambda_{1}+4.8\\ v_{3}=z_{1}+5419\phi_{1}-1473\lambda_{1}+4.8\\ v_{3}=z_{1}-21916\phi_{1}-1373\lambda_{1}+3.6\\ v_{3}=z_{1}-21916\phi_{1}+1012\lambda_{1}+36430\lambda_{1}+3.6\\ v_{3}=z_{1}-2193\lambda_{3}+1012\lambda_{1}+36430\lambda_{1}+25.5\\ v_{3}=z_{1}-21313\delta\phi_{1}+219000\lambda_{1}+25.5\\ v_{3}=z_{1}-21313\delta\phi_{1}+219000\lambda_{1}+25.5\\ v_{3}=z_{1}-21313\delta\phi_{1}+219000\lambda_{1}+22.2\\ v_{3}=z_{1}-21313\delta\phi_{1}+219000\lambda_{1}+22.6\\ v_{3}=z_{1}-21313\delta\phi_{1}+218000\lambda_{1}+22.6\\ v_{3}=z_{1}-21313\delta\phi_{1}+218000\lambda_{1}+22.6\\ v_{3}=z_{1}-21313\delta\phi_{1}+218000\lambda_{1}+22.6\\ v_{3}=z_{1}-21313\delta\phi_{1}+218000\lambda_{1}+22.6\\ v_{3}=z_{1}-21313\delta\phi_{1}+218000\lambda_{1}+22.6\\ v_{3}=z_{1}-213000\lambda_{1}+22.6\\ v_{3}=z_{1}-213000\lambda_{1}+2.6\\ v_{3}=z_{1}-213000\lambda_{1}+2.6\\ v_{3}=z_{1}-21300\lambda_{1}+2.6\\ v_{3}=z_{1}-21300\lambda_{1}+2.6\\ v_{3}=z_{1}-21300\lambda_{1}+2.6\\ v_{3}=z_{1}-21300\lambda_{1}+2.6\\ v_{3}=z_{1}-21300\lambda_{1}+2.6\\ v_{3}=z_{1}-21300\lambda_{1}+2.6\\ v_{3}=z_{1}-21300\lambda_{1}+2.6\\ v_{3}=z_{1}-2100\lambda_{1}+2.6\\ v_{3}=z_{1}-210\lambda_{1}+2.6\\ v_{3}=z_{1}-200\lambda_{1}+2.6\\ v_{3}=z_{1}-200\lambda_{1}+$	CRANBERRY POINT	$ \begin{array}{l} v_{3}=z_{2}-21313\lambda\phi_{1}+21900\lambda_{3}+0.0\\ v_{10}=z_{2}-0013\delta\phi_{2}-910\lambda_{3}+0.0\\ v_{11}=z_{2}-0013\delta\phi_{2}-410\lambda_{3}+0.0\\ v_{11}=z_{2}-1180\lambda\phi_{4}+165\lambda\phi_{2}+113\lambda_{3}\\ v_{21}=z_{2}-1180\lambda\phi_{4}+165\lambda\phi_{2}+118\lambda\phi_{3}-1650\lambda_{3}-2.7\\ v_{12}=z_{2}-2045\lambda\phi_{3}+1701\lambda_{3}+11.5\\ v_{13}=z_{2}-637\phi_{3}+1070\lambda_{3}+6.8 \end{array} $	TELEGRAPH	$\begin{array}{l} v_{1s}=z_{3}-1181\partial\phi_{3s}+4922\lambda_{3s}+0.0\\ v_{1s}=z_{3}-1183\partial\phi_{3s}+1650\lambda_{3s}+41899\phi_{3s}-1650\lambda_{3s}-52.6\\ v_{1r}=z_{1}-30433\phi_{3r}+16122\lambda_{1}+50453\phi_{3s}-16122\lambda_{3}-54.8\\ v_{1s}=z_{3}+2413\phi_{3s}-2839\lambda_{3s}-62.2\end{array}$	TREAT ²	$v_{19} = 2_4 - 637\delta\phi_2 + 10783\lambda_2 + 4.3$ $v_{19}' = 2_4 + 0.0$	
	Observed azimuth	$\begin{array}{cccccccccccccccccccccccccccccccccccc$		$\begin{array}{cccccccccccccccccccccccccccccccccccc$		$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		$\begin{array}{rrrr} 337 & 10 & 39.4 - z_4 + v_{10}' \\ 354 & 45 & 17.5 - z_4 + v_{10}' \end{array}$	
	Assumed azimuth	• ' ''' 299 38 04.3 299 38 04.3 345 23 36.1 345 20 01.8 48 20 01.8 121 53 01.0 133 54 47.6 145 18 53.0		325 18 49.9 41 04 02.7 43 55 42.7 118 55 42.7 118 58 06.9 118 53 06.9 157 11 31.9		170         19         22.2           208         57         20.5           301         52         20.5           328         50         04.4		337 10 43.7 354 45 17.5	

GUNNER

APPLICATION OF LEAST SQUARES TO TRIANGULATION. 115

Station observed	Cranberry Point Lubec Channel L. H. Gumer Duck Indian Point Larrabee		Mam Lubee Channel L. H. Lubee church spire Gunnet Duck Indian Point		Latrabee Mam Lubee Channel L. H. Gunner Lubee church spire		Larrabee Mam Lubee Channel L. H. Gunner,
Equation	$\begin{array}{l} v_{99}=z_5-2010\delta \phi_{29}-1485\delta\lambda_5+11.0\ (+6.4) \\ v_{99}=z_5+5.7\ (+1.1) \\ v_{91}=z_5+5.0\ (+1.1) \\ v_{92}=z_2+5.0\ (+0.4) \\ v_{92}=z_5+5.0\ (-4.6) \\ v_{93}=z_5+0.0\ (-4.6) \\ v_{93}=z_5+7.7\ (+3.1) \end{array}$	LARRABEE	$\begin{array}{l} \mathbb{P}_{\mathbf{x}'}=z_{\mathbf{z}}+2.6(-0.2)\\ \mathbb{P}_{\mathbf{x}'}=z_{\mathbf{z}}-0.4(-3.2)\\ \mathbb{P}_{\mathbf{x}'}=z_{\mathbf{z}}+9.0(-0.2)\\ \mathbb{P}_{\mathbf{x}'}=z_{\mathbf{z}}+9.16(-0.2)\\ \mathbb{P}_{\mathbf{x}'}^{(1)}=z_{\mathbf{z}}+2.7(-0.1)\\ \mathbb{P}_{\mathbf{x}'}^{(2)}=z_{\mathbf{z}}+0.0(-2.8)\\ \mathbb{P}_{\mathbf{x}'}^{(2)}=z_{\mathbf{z}}+0.0(-2.8) \end{array}$	INDIAN POINT	$p_{23}''=z_1+0.0(-3.8)$ $p_{23}''=z_1-1.3(-5.0)$ $p_{23}''=z_7+1.3(-2.4)$ $p_{23}=z_7+22383\phi_{21}-17093\Lambda_1+1.0(-2.8)$ $p_{23}''''=z_7+15.0(+11.2)$	DUCK	$v_{24} = z_8 + 0.3 (+0.2)$ $v_{54} = z_8 + 0.0 (-0.1)$ $v_{26} = z_8 + 8689\delta_{\phi 1} = 35093\lambda_1 - 1.8 (-1.9)$
Observed azimuth	• ' '' 223 54 42.7-2 ₃ +0 ₃₀ 225 14 13.3-2 ₅ +0 ₃₀ ' 228 19 04.0-2 ₅ +0 ₃₀ ' 242 86 11.3-2 ₅ +0 ₃₀ '' 242 86 17 19.2-2 ₅ +0 ₃₀ ''' 201 10 02.8-2 ₅ +0 ₃₀ '''		$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		$\begin{array}{cccccccccccccccccccccccccccccccccccc$
Assumed azimuth	• " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " "		121 11 26.7 152 22 33.8 154 36 03.7 155 32 03.6 165 22 02.6 175 38 29.4 199 23 35.7		19         23         54.1           86         18         53.8           81         33.8           114         48         33.8           133         24         32.6           136         58         04.6		355 36 23.1 62 37 26.2 86 26 42.1 119 38 22.1

MAM

5

Figure 6 taken with the following two tables shows that  $z_1$  is for directions taken at Gunner,  $z_2$  for directions at Cranberry Point,  $z_3$  for directions at Telegraph, and  $z_5$  for directions at Mam. The scheme for eliminating these z's by the use of the sum equations, as fictitious additional observation equations with negative weights, is used here in the same manner as in the previous example. Each weight is the negative reciprocal of the total number of observed lines in the adjustment that radiates from the point in question. The weights are, respectively, -1/8, -1/6, -1/4, and -1/6, as shown in Table 1.

At Treat₂, Larrabee, Indian, and Duck where only one new line is to be determined the same process might be used, but the following method is identical in results and slightly shorter. Use is made of the fact that the directions taken at a point may each be changed by the same amount, a change equivalent to using merely a different zero point. Correct each of the directions by the averages of all the corrections necessary to reduce the observed results to the accepted results on the lines that have already been fixed. Then drop the z from the observation equation of the new line and assign the equation

a positive weight equal to  $\frac{s}{s+1}$ , where s is the number of lines

already fixed and therefore s+1 is the total number of lines. Thus at Larrabee the constant terms of the observation equations representing pointings on lines already fixed are +2.6, -0.4, +9.0, -0.1, and 0.0, the mean of which is +2.8. Subtracting this from each of the preceding numbers we have -0.2, -3.2, +6.2, -0.1, and -2.8as the new constant terms, also -0.8 instead of +2.0 on Gunner, the new point. These new values are inclosed in parentheses and are used in forming the normal equations. There are five fixed lines, so the weight of the new equation without z that is used to replace the six equations containing z is 5/6 and the equation itself is

$$v_{22} = +541\delta\phi_1 - 1473\delta\lambda_1 - 0.8$$

which in Table 2 corresponds to the line No. 22,

$$+0.49\delta\phi_1 - 1.34\delta\lambda_1 - 0.07.$$

The z's are computed from the sum equations as in the previous example, the result of substitution in the right-hand side being divided by -1/r, r being the total number of lines through the point to which z applies. For fixed points where only one new line occurs, substitute  $\partial \phi$  and  $\partial \lambda$  in the right-hand side of the observation equation on the new line omitting the z, and divide the result by -1/r. Thus at Duck (see p. 116),

 $z_8 = (8669\delta\phi_1 - 3509\delta\lambda_1 - 1.9) \div (-3)$ 

as shown in the computation below.

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When the z's are known the v's or corrections are computed from the equations on pages 115 and 116. The details are shown in the table on page 121.

For convenience of solution in the normals it is best to divide the constant terms by 10 and the coefficients by 1000. The solution will then give  $100\delta\phi_n$  and  $100\delta\lambda_n$ .

-										
		1	2	3	4	5	6			
		$\partial \phi_1$	$\partial \lambda_1$	δφ2	δλ2	δφ3	δλ3	- ŋ	p	$\sqrt{p}$
1 2 3 4 5 6 7 8 Sum	$     \begin{bmatrix}       z_1 \\       1 \\       1 \\       1 \\       1 \\       1 \\       1 \\       1 \\       1 \\       8     $	$\begin{array}{r} + 8669 \\ + 2338 \\ + 541 \\ - 2191 \\ - 7756 \\ - 3643 \\ - 1870 \\ - 21313 \\ - 25025 \end{array}$	$\begin{array}{r} -3509\\ -1709\\ -1473\\ -1388\\ -3833\\ +1612\\ +1580\\ +21909\\ +13189\end{array}$	+21313 +21313	-21909 -21909	+3643 +3643	-1612 -1612	$\begin{array}{r} + & 0.0 \\ - & 2.22 \\ + & 4.8 \\ + & 3.6 \\ + & 7.1 \\ + & 9.7 \\ + & 25.5 \\ + & 7.1 \\ + & 55.6 \end{array}$	1 1 1 1 1 1 1 1 1 	1 1 1 1 1 1 1 1 0.35355 <i>i</i>
9 10 11 12 13 14 Sum		-21313 -21313	+21909	$\begin{array}{r} +21313\\ -\ 6013\\ -\ 2010\\ -\ 4189\\ -\ 2045\\ -\ 637\\ +\ 6419\end{array}$	$\begin{array}{r} -21909 \\ - 4910 \\ - 1485 \\ + 1650 \\ + 1701 \\ + 1078 \\ - 23875 \end{array}$	+4189 +4189	—1650 —1650	$\begin{array}{r} + & 0.0 \\ + & 0.0 \\ - & 13.1 \\ - & 2.7 \\ + & 11.5 \\ + & 6.8 \\ + & 2.5 \end{array}$	1 1 1 1 1	1 1 1 1 1 0. 4083 <i>i</i>
15 16 17 18 Sum 19	23 1 1 1 1 4	— 3643 — 3643	+ 1612 + 1612	- 4189 - 4189 - 637	+ 1650 + 1650 + 1078	-1181 + 4189 + 3643 + 2413 + 9064	+4922 -1650 -1612 -2839 -1179	$\begin{array}{r} + & 0.0 \\ - & 52.6 \\ - & 54.8 \\ - & 62.2 \\ -169.6 \\ + & 4.3 \end{array}$	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 0. 5 <i>i</i> 0. 707
20 21 Sum 22 23 24	²⁵ 1 1 6	$\begin{array}{r} - 2191 \\ - 2191 \\ + 541 \\ + 2538 \\ + 8669 \end{array}$	$\begin{array}{r} - & 1388 \\ - & 1388 \\ - & 1473 \\ - & 1709 \\ - & 3509 \end{array}$	- 2010 - 2010	— 1485 — 1485			$ \begin{array}{r} + & 6.4 \\ + & 1.1 \\ + & 7.5 \\ - & 0.8 \\ - & 2.8 \\ - & 1.9 \end{array} $	1 1 rie seje sja sijs	1 0. 4083 <i>i</i> 0. 9129 0. 8944 0. 8165

Table for formation of normals No. 1

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	δφ1	$\partial \lambda_1$	δφ2	δλ2	ðøs	$\partial \lambda_8$	η	Σ
1 2 3 4 5 6 7 8 <i>z</i> 1	$\begin{array}{r} + 8.67 \\ + 2.54 \\ + 0.54 \\ - 2.19 \\ - 7.76 \\ - 3.64 \\ - 1.87 \\ - 21.31 \\ - 8.85i \end{array}$	$\begin{array}{r} - 3.51 \\ - 1.71 \\ - 1.47 \\ - 3.83 \\ + 1.61 \\ + 1.58 \\ + 21.91 \\ + 4.66i \end{array}$	+21.31 + 7.54 <i>i</i>	-21.91 - 7.75i	+3.64 +1.29i	-1.61 -0.57i	$\begin{array}{r} +0.00\\ -0.22\\ +0.48\\ +0.36\\ +0.71\\ +0.97\\ +2.55\\ +0.71\\ +1.97i\end{array}$	$\begin{array}{r} + 5.16 \\ + 0.61 \\ - 0.45 \\ - 3.22 \\ -10.88 \\ + 0.97 \\ + 2.26 \\ + 0.71 \\ - 1.71i \end{array}$
9 10 11 12 13 14 22	-21.31 - 8.70 <i>i</i>	+21.91 + 8.95 <i>i</i>	$\begin{array}{r} +21.31 \\ -6.01 \\ -2.01 \\ -4.19 \\ -2.04 \\ -0.64 \\ +2.62i \end{array}$	$\begin{array}{r} -21. \ 91 \\ -4. \ 91 \\ -1. \ 48 \\ +1. \ 65 \\ +1. \ 70 \\ +1. \ 08 \\ -9. \ 75i \end{array}$	+4.19 +1.71 <i>i</i>	-1.65 -0.67 <i>i</i>	$\begin{array}{c} +0.00 \\ +0.00 \\ -1.31 \\ -0.27 \\ +1.15 \\ +0.68 \\ +0.10i \end{array}$	$\begin{array}{r} + \ 0.\ 00 \\ -10.\ 92 \\ - \ 4.\ 80 \\ - \ 0.\ 27 \\ + \ 0.\ 81 \\ + \ 1.\ 12 \\ - \ 5.\ 74i \end{array}$
15 16 17 18 23	-3.64 - 1.82 <i>i</i>	+ 1.61 + 0.81 <i>i</i>	- 4.19 - 2.09 <i>i</i>	+ 1.65 + 0.82i	-1.18+4.19+3.64+2.41+4.53i	$\begin{array}{r} +4.92 \\ -1.65 \\ -1.61 \\ -2.84 \\ -0.59i \end{array}$	+0.00 -5.26 -5.48 -6.22 -8.48 <i>i</i>	$\begin{array}{r} + 3.74 \\ - 5.26 \\ - 5.48 \\ - 6.65 \\ - 6.82i \end{array}$
19 20 21 25	-2.19 -0.89i	- 1.39 - 0.57 <i>i</i>	$\begin{array}{r} - & 0.45 \\ - & 2.01 \\ - & 0.82i \end{array}$	+ 0.76 - 1.48 - 0.61 <i>i</i>			+0.30 +0.64 +0.11 +0.31 <i>i</i>	$\begin{array}{r} + \ 0.61 \\ - \ 2.85 \\ - \ 3.47 \\ - \ 2.58i \end{array}$
22 23 24	+ 0.49 + 2.27 + 7.08	$\begin{array}{r} - 1.34 \\ - 1.53 \\ - 2.86 \end{array}$					-0.07 -0.25 -0.16	$\begin{array}{r} - 0.92 \\ + 0.49 \\ + 4.06 \end{array}$

# Table for formation of normals No. 2

# Normal equations

1	2	3	4	5	6	η	\$
+987.3526	852, 5451 +913, 2320	- 823. 2428 + 876. 4443 + 923. 5619	+781.3412 -837.7306 -831.4801 +842.4946	$\begin{array}{r} + & 8.0389 \\ - & 13.2644 \\ - & 39.8513 \\ + & 36.7824 \\ + & 43.7028 \end{array}$	$\begin{array}{r} - & 0.2265 \\ + & 3.9464 \\ +18.6471 \\ -15.9112 \\ -33.6441 \\ +41.7793 \end{array}$	$\begin{array}{r} - & 8.9085 \\ + & 6.5262 \\ + & 4.1465 \\ + & 2.6136 \\ - & 18.8752 \\ + & 30.2371 \end{array}$	$\begin{array}{r} + & 91.8098 \\ + & 96.6088 \\ + 128.2256 \\ - & 21.8901 \\ - & 17.1109 \\ + & 44.8281 \end{array}$

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ы	+ 91, 8098 - 0, 0929858	+ 96.6088 + 79.2746	+175.8834 -0.9931944	+128.2256 + 76.5499 -164.4754	+ 40.3001 - 0.489729	$\begin{array}{r} - & 21.8901 \\ - & 72.6536 \\ + 161.9595 \\ + & 13.4747 \end{array}$	+ 80. 8905 - 1. 247908	$\begin{array}{rrrr} - & 17.  1109 \\ - & 0.7475 \\ + & 6.  2801 \\ + & 13.  3381 \\ - & 19.  3324 \end{array}$	- 17.5726 + 0.572491	$\begin{array}{c} + 44.8281 \\ + 0.0211 \\ - 3.7253 \\ - 7.3218 \\ + 9.0837 \\ - 15.3544 \end{array}$	+ 27. 5314 - 1. 86892
ł.	- 8,9085 + 0,0000226	+ 6.5262 - 7.6922	-1.1660 + 0.0065843	+ 4. 1465 - 7. 4278 + 1. 0904	- 2, 1909 + 0. 026624	+ 2.6136 + 7.0497 - 1.0737 - 0.7326	+ 7.8570 - 0.121211	-18, 8752 + 0, 0725 - 0, 0416 - 0, 7251 - 1, 8778	-21.4472 + 0.698720	$\begin{array}{r} +30.\ 2371\\ -\ 0.\ 0020\\ +\ 0.\ 0247\\ +\ 0.\ 3980\\ -18.\ 7399\end{array}$	+12.8002 -0.86892
	- 0. 2265 + 0. 0002294	+ 3.9464 - 0.1956	+ 3.7508 - 0.0211804	+18.6471 - 0.1889 - 3.5075	+14.9507 - 0.181682	-15, 9112 + 0.1792 + 3.4539 + 4.9989	- 7. 2792 + 0. 112297	$\begin{array}{c} -33.6441 \\ + 0.0019 \\ + 0.1339 \\ + 4.9482 \\ + 1.7397 \end{array}$	-26,8204 + 0,873771	$\begin{array}{c} +41.7793 \\ -0.0001 \\ -0.0794 \\ -2.7163 \\ -0.8174 \\ -23.4349 \end{array}$	+14.7312 $\delta\lambda_{6}$
IJ	+ 8.0389 - 0.0081419	-13.2644 + 6.9413	- 6.3231 + 0.0357059	-39.8513 + 6.7027 + 5.9130	-27.2356 + 0.330969	+36.7824 - 6.3616 - 5.8225 - 9.1065	+15.4918 - 0.238994	+ 43. 7028 - 0.0655 - 0.2258 - 9.0141 - 3.7024	+30.6950 $\delta\phi_3$	<b>⊣</b> 0,0,4,10	
4	+781, 3412 - 0. 7913497	-837.7306 +674.6613	-163.0693 + 0.9208345	-831,4801 +651,4730 +152,4924	- 27.5147 + 0.334360	$\begin{array}{c} +842, 4946\\ -618, 3141\\ -150, 1598\\ -9, 1998\end{array}$	+ 64.8209 $\delta \lambda_2$	H0100 4		- 1	
m	-823, 2428 + 0.8337881	+876.4443 -710.8419	+165.6024 -0.9351387	+923.5619 -686.4101 -154.8612	+ 82.2906 $\delta\phi_2$	351		-			
5	$-\frac{852}{4}.5451$ + 0.8634657	+913.2320 -736.1434	+177.0886 $\delta \lambda_{1}$	21			•				
1	+987.3526 $\delta\phi_{1}$	1									•

Solution of normals

Baci	6 80	luti	on

-	δλ3	δφ ₃	δλ2	δφ ₂ ±0.02662	$\delta \lambda_1$ +0.00658	∂φ ₁
-	-0.86892	-0.75924	$-0.09758 \\ +0.01446 \\ -0.20433$	$+0.02003 \\ -0.02003 \\ -0.06832 \\ +0.09614$	+0.01840 -0.00216 -0.18815 -0.08990	$\begin{array}{r} -0.00020 \\ +0.00049 \\ +0.16170 \\ +0.08016 \\ -0.22038 \end{array}$
					-0.20020	+0.03079

# Computation of corrections

1	2	3	4	5	6	7	8
+2.669 + 8.956 -11.412	$\begin{array}{r} + \ 0.781 \\ + \ 4.362 \\ -11.412 \\ - \ 2.2 \end{array}$	+ 0.167 + 3.760 - 11.412 + 4.8	$\begin{array}{r} - 0.675 \\ + 3.543 \\ -11.412 \\ + 3.6 \end{array}$	$\begin{array}{r} - & 2.388 \\ + & 9.783 \\ - & 11.412 \\ + & 7.1 \end{array}$	$-1.122 \\ -4.114 \\ -2.205 \\ +14.007$	$\begin{array}{r} - & 0.576 \\ - & 4.033 \\ -11.412 \\ +25.5 \end{array}$	-6.562 -55.918 +20.490 +44.767
+ 0.213 + 0.2	- 8.469 - 8.5	- 2.685 - 2.7	- 4.944 - 4.9	+ 3.083 + 3.1	$ \begin{array}{r} -11.412 \\ +9.7 \\ \hline +4.854 \\ +4.9 \end{array} $	+ 9.479 + 9.5	$ \begin{array}{r} -11.412 \\ +7.1 \\ \hline -1.535 \\ -1.5 \\ \end{array} $
<i>z</i> 1	9	10	11	12	13	14	Z2
$\begin{array}{r} -7.705 \\ -33.662 \\ +20.490 \\ +44.767 \\ -2.205 \\ +14.007 \\ +55.6 \end{array}$	$\begin{array}{r} - \ 6.562 \\ -55.918 \\ +20.490 \\ +44.767 \\ - \ 1.129 \end{array}$ + 1.648 + 1.7	$ \begin{array}{r} -5.781 \\ +10.033 \\ -1.129 \\ +3.123 \\ +3.1 \end{array} $	$\begin{array}{r} -1.932 \\ +3.035 \\ -1.129 \\ -13.1 \\ \hline \\ -13.126 \\ -13.1 \end{array}$	$\begin{array}{r} - 4.027 \\ - 3.371 \\ - 2.535 \\ + 14.337 \\ - 1.129 \\ - 2.7 \\ + 0.575 \\ + 0.6 \end{array}$	$ \begin{array}{r} -1.966 \\ -3.476 \\ -1.129 \\ +11.5 \\ \hline +4.929 \\ +5.0 \\ \end{array} $	$ \begin{array}{r} -0.612 \\ -2.203 \\ -1.129 \\ +6.8 \\ \end{array} $ + 2.856 + 2.9	$\begin{array}{r} - \ 6.562 \\ -55.918 \\ + \ 6.171 \\ +48.783 \\ - \ 2.535 \\ +14.337 \\ + \ 2.5 \\ \end{array}$
-11.412							- 1.129
15	16	17	18	23	19	24	19'
$ \begin{array}{r} + 0.715 \\ -42.768 \\ +44.369 \\ \hline + 2.316 \\ + 2.3 \end{array} $	$\begin{array}{r} -4.027 \\ -3.371 \\ -2.535 \\ +14.337 \\ +44.369 \\ -52.6 \\ \hline -3.827 \\ -3.8 \end{array}$	$\begin{array}{r} -1.122 \\ -4.114 \\ -2.205 \\ +14.007 \\ +44.369 \\ -54.8 \\ \hline -3.865 \\ -3.8 \end{array}$	-1.460 +24.669 +44.369 -62.2 + 5.378 + 5.4	$\begin{array}{r} - 1.122 \\ - 4.114 \\ - 4.027 \\ - 3.371 \\ - 5.486 \\ + 10.245 \\ - 169.6 \end{array}$	$ \begin{array}{r} -0.612 \\ -2.203 \\ -0.742 \\ +4.3 \\ \hline +0.743 \\ +0.8 \\ \end{array} $	$ \begin{array}{r} -0.612 \\ -2.203 \\ +4.3 \\ \hline +1.485 \\ -0.742 \end{array} $	$- 0.742 \\ - 0.742 \\ - 0.7$
				+ 44.309			
			20'				
-1.932 + 3.035 - 1.912 + 6.4	$\begin{array}{r} - 0.675 \\ + 3.543 \\ - 1.912 \\ + 1.1 \end{array}$	-0.675 + 3.543 - 1.932 + 3.035 + 7.5	$ \begin{array}{r} -1.912 \\ +1.1 \\ \hline -0.812 \\ -0.8 \\ \end{array} $	$ \begin{array}{r} - 1.912 \\ + 0.4 \\ \hline - 1.512 \\ - 1.5 \end{array} $	$ \begin{array}{r} -1.912 \\ -4.6 \\ \hline -6.512 \\ -6.5 \\ \hline -6.5 \\ \hline \end{array} $	-1.912 + 3.1 + 1.188 + 1.2	$\begin{array}{r} + \ 0.167 \\ + \ 3.760 \\ - \ 0.521 \\ - \ 0.8 \end{array}$
+ 5.591 + 5.6	+ 2.056 + 2.1	+11.471 - 1.912					+2.606 + 2.6
26	22′	22''	22'''	22''''	220	23	27
+ 0.167 + 3.760 - 0.8	$-0.521 \\ -0.2 \\ -0.721 \\ -0.721$	$ \begin{array}{r} -0.521 \\ -3.2 \\ \hline -3.721 \\ -3.7 \\ \hline \end{array} $	- 0.521 + 6.2 + 5.679 + 5.7	$ \begin{array}{r} - & 0.521 \\ - & 0.1 \\ \hline - & 0.621 \\ - & 0.6 \\ \end{array} $	$ \begin{array}{r} -0.521 \\ -2.8 \\ \hline -3.321 \\ -3.2 \\ \end{array} $	$\begin{array}{r} + \ 0.781 \\ + \ 4.362 \\ - \ 0.469 \\ - \ 2.8 \end{array}$	+ 0.781 + 4.362 - 2.8
- 0.521		- 3.7	T 0.7		- 3.3	+ 1.874 + 1.9	- 0.469
23'	23''	23'''	23''''	24	28	24'	24''
$ \begin{array}{r} - 0.469 \\ - 3.8 \\ - 4.269 \end{array} $	$ \begin{array}{r} -0.469 \\ -5.0 \\ \hline -5.469 \\ \end{array} $	$ \begin{array}{r} - 0.469 \\ - 2.4 \\ \hline - 2.869 \end{array} $	$ \begin{array}{r} - 0.469 \\ + 11.2 \\ \hline + 10.731 \end{array} $	$\begin{array}{rrrr} + & 2.669 \\ + & 8.956 \\ - & 3.242 \\ - & 1.9 \end{array}$	+2.669 + 8.956 - 1.9	$ \begin{array}{r} -3.242 \\ +0.2 \\ \hline -3.042 \end{array} $	$ \begin{array}{r} -3.242 \\ -0.1 \\ \hline -3.342 \end{array} $
- 4.2	- 5.5	- 2.8	+10.7	+ 6.483 + 6.5	+ 9.725 - 3.242	- 3.0	- 3.3

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Symbol	Station	Observed angle	Correc- tion	Spheri- cal angle	Spher- lcal excess	Plane angle	Loga- rithm
$\begin{array}{c} -1+ \ 3\\ -24'+24\\ -22+22'''' \end{array}$	Duck-Larrabee Gunner Duck Larrabee Gunner-Larrabee	• / // 45 43 29.4 124 02 01.1 10 14 26.1	$ \begin{array}{r} & & & \\ & & -2.9 \\ & +9.5 \\ & -3.2 \\ \hline & +3.4 \end{array} $	" 26.5 10.6 22.9		0 / //	3. 410111 0. 145096 9. 918389 9. 249850 3. 473596
-1+4 -21+20''	Gunner-Duck Duck-Mam Gunner Duck Mam Gunner-Mam Gunner-Duck	108 41 53,9 58,8 14 17 07.3	- 5.1 - 3.6	48.8 67.5 03.7		57 00 67.5	2.805057 3.389282 0.023546 9.923684 9.392230 3.336512 2.805058 ⁻¹
$-1+5 \\ -24''+24$	Duck-Lubec Chan- nel Lighthouse Gunner Duck Lubec Channel Lighthouse Gunner-Lubec Channel Light- house Gunner-Duck	115 34 42.9 33 11 41.8 35.3	+ 2.9 + 9.8	45, 8 51, 6 22, 6		31 13 22.6	3. 045619 0. 044799 9. 738407 9. 714639 2. 828825+2 2. 805057
-2+3 -23'+23 -22+22 v	Indian Point-Lar- rabee Gunner Indian Point Larrabee	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	+5.8 + 6.1 - 5.9	• 47. 2 43. 6 29. 2			3. 236668 0. 276238 9. 960689 9. 747840
	Gunner-Larrabee Gunner - Indian Point		+ 6.0				3. 473595+1 3. 260746
-2+ 4 -23''+23 -21+20'''	Indian Point–Mam Gunner Indian Point Mam	94         56         05.9         9           47         05         36.5         37         58         15.2	+ 3.6 + 7.4 - 8.6	09.5 43.9 06.6			<b>3.470097</b> 0.001614 9.864802 9.789036
10	Gunner-Mam Gunner-Indian Point		+ 2.4				3.336513-1 3.260747-1
-2+5 -23'''+23	Indian Point-Lu- bee Channel Lighthouse Gunner Indian Point Lubee Channel Lighthouse Gunner-Lubee Channel Light- house Gunner-Indian Point	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$^{+11.6}_{+ 4.7}$	66.5 63.8 49.7		59 34 49.7	<ol> <li>3. 315762</li> <li>0. 009305</li> <li>9. 503759</li> <li>9. 935679</li> <li>2. 828826⁺¹</li> <li>3. 260746</li> </ol>
-3+4 -22'+22 -21+20''''	Larrabee-Mam Gunner Larrabee Mam	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-2.2 + 3.3 - 0.9	22.3 39.8 57.9			<b>3. 443126</b> 0. 050224 9. 843162 9. 980246
1	Gunner–Mam Gunner–Larrabee		+ 0.2				3.336512 3.473596
$-3+5 \\ -22''+22$	Larrabee-Lubee Channel Light- house Gunner Larrabee Lubee Channel Lighthouse Gunner-Lubec Channel Light-	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	+5.8 +6.3	19.3 32.7 08.0		97 09 08.0	3. <b>449573</b> 0. 027415 9. 351839 9. 996608 2. 828827
	Gunner-Larrabee						3.473596

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# Final computation of triangles

Final computation of triangles-Continued	
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Symbol	Station	0	bser ang	rved ;le	Correc- tion	Spheri- cal angle	Spher- ical excess	Pla	ine	angle	Loga- rithm
	Larrabee-Lubec	•	,	"	"	"		0	,	"	3. 702872
-3+7 -22'''+22	Gunner Larrabee Lubec church spire Gunner-Lubec church spire Gunner-Larrabee	154 10	32 46	48.4 05.9 65.7	+12.2, $-3.1$	60.6 02.8 56.6		14	40	56.6	0.366814 9.271431 9.403910 3.341117 3.473596
	Mam-Lubec Chan-										3.176968
-4+5 -20'+21	nel Lighthouse Gunner Mam Lubec Channel Lighthouse	6 3	52 04	49.0 50.7 20.3	+ 8.0 + 2.9	57.0 53.6 09.4		170	02	09.4	0.921421 8.730438 9.238122
	Channel Light-										2.020021
i -	Gunner-Mam										3.336511+1
	Lubec church spire- Indian Point	170	00	20.0	18.0	10.0					3.603122
+2-7 -23+23''''	Lubec church spire Indian Point Gunner-Ind ian Point	3	33	11.8 18.0	+ 8.8	21.0 26.8		2	57	21.0	8. 712365 8. 792736 3. 260746
	Gunner-Lubec church spire										3.341117
	Gunner-Lubec Channel Light-										2.828827
-9+10 -5+8	Cranberry Point Gunner Lubec Channel	75 90	45 05	$12.8 \\ 58.7 \\ 48.5$	+ 1.4 - 4.6	$14.2 \\ 54.1 \\ 51.7$		14	08	51.7	$\begin{array}{c} 0.013565 \\ 9.999999 \\ 9.388141 \end{array}$
	Cranberry Point- Lubec Channel										2.842391
	Lighthouse Cranberry Point- Gunner										2.230533+1
-9+11 -4+8 -20+21	Gunner-Mam Cranberry Point Gunner Mam	78 96 4	36 58 24	65.9 47.7 21.3	-14.8 + 3.4 - 3.5	51.1 51.1 17.8					3.336512 0.008632 9.996769 8.885390
	Cranberry Point-				-14.9						3.341913
-	Mam Cranberry Point- Gunner										2.230534
	Gunner-Lubec church spire										3.341117
$-9+13 \\ -7+8$	Cranberry Point Gunner Lubec church spire Cranberry Point- Lubec church	174 5	08 24	32.3 23.8 03.9	$+ 3.28 \\ -11.02$	35.58 12.78 11.64		0	27	11.64	0.991220 8.973913 7.898195 3.306250
	Cranberry Point-										2.230532+2
	Lubec Channel Lighthouse-										3. 176968
-10+11	Cranberry Point Lubec Channel	2	51	$53.1 \\ 36.3$	-16.2	36.9 58.9		175	48	58.9	1.301899 8.863046
-20+20'	Lighthouse Mam	1	19	30.6	- 6.4	24.2					8.363526
	Cranberry Point- Mam Cranberry Point- Lubec Channel										3. 341913 2. 842339-2
1	Lighthouse				1						-

		1	1	1	1	1	
Symbol	Station	Observed angle	Correc- tion	Spheri- cal angle	Spher- ical excess	Plane angle	Loga- rithm
-		0 / //	,,,	,,,		0 1. 11	
	Lubec church spire-						3.309982
-13+14	Cranberry Point	17 44 02.9	- 2.1	00.8			0.516283
-19+19'	Lubec church spire	19.0 17 34 38.1	- 1.5	22.6		144 41 22.6	9.761932 9.479985
	Cranberry Point-						3.588197
	Cranberry Point-						3.306250
	spire						
	Lubec church						3,306250
	spire-Cranberry						01000110
-15+16	Telegraph	128 38 59.9	- 6.1	53.8			0.107352
-12+13	Cranberry Point	20 29 12.6	+ 4.4	49.2		30 51 49.2	9.710115 9.544083
-	Telegraph-Cran- berry Point	1					3.123717
	Telegraph-Lubec						2.957685-1
	church spite	11					0.041117
	Lubec church spire-Gunner						3.341117
-15+17	Telegraph	$131 \ 33 \ 53.1 \ 36 \ 1$	- 6.1	47.0		30 24 37.6	0.125967
- 6+ 7	Gunner Telesrenh Gamman	18 01 30.8	+ 4.6	35.4			9.490600
	Telegraph-Lubec						2.957684
	church spire						
	Cranberry Point- Gunner						2.230534
-16+17	Telegraph Cronborry Beint	2 54 53.2	0.0	53.2			1.293705
-6+8	Gunner	23 25 54.6	- 6.4	48.2			9. 599478
			- 7.5				
	Telegraph-Gunner						3.171399
	berry Point						01100111
	Cranberry Point-						2.842391
	Lighthouse						
-16+18 -10+12	Telegraph Cranberry Point	29 52 44.5 77 54 06.9	+9.3 -2.5	53.8 04.4			0.302588
	Lubec Channel	08.6		01.8		72 13 01.8	9.978738
	Telegraph-Lubec						3.135224
	Channel Light- house						
	Telegraph-Cran- berry Point						3.123717
	Gunner-Lubes						9 999997
	Channel Light-						4.040041
-17+18	Telegraph	26 57 51.3	+ 9.2	60.5			0.343447
- 5+ 6	Gunner Lubec Channel	66 40 04.1 64.6	+ 1.8	05.9 53.6		86 21 53.6	9.962950 9.999125
	Lighthouse Telegraph-Lubec						3 135224
	Channel Light-						0. 100221
	Telegraph-Gunner						3.171399

#### SECOND METHOD.

The only difference between the second method of adjustment and the first is in the treatment of the directions taken at the fixed points. At these points observation equations are written for the directions of new points only and the z's are omitted. The observations taken over the fixed lines are not used, but the observed directions of the new lines are taken in connection with the adjusted direction of a fixed line, all directions being referred to a common initial line.

The equations with z's omitted are the same as if the angle method of adjustment were used. (See p. 196.) In this treatment these equations are given unit weight. Jordan (Vermessungskunde, vol. 1, p. 179, of the third edition) suggests that on some accounts it would be better to assign the equations for observations at fixed points only half weight.

The observation equations for directions taken at Gunner, Cranberry Point, and Telegraph are the same as for the first method given on page 115 and are not repeated here. Below are given the observation equations for the remaining points, formed according to the second method. The assumed azimuths are identical with those used in the first method. As an example, to illustrate the computation of the observed azimuths, take the line Mam-Gunner. Use the observed direction for the new line and the adjusted one for the fixed line.

	0		//
Fixed azimuth Mam to Indian Point, page 106,	=266	17	19.2
Angle Indian Point to Gunner, page 106 (3599	<b>&gt;</b>		
59' 55''.4 to 322° <b>01'</b> 44''.8),	=322	01	49.4
Observed a strength Manual Communi		10	00 0
Observed azimuth Mam to Gunner,	=228	19	08.6

or by reckoning from any other fixed line through Mam the same result is reached, thus,

Fixed azimuth Mam to Lubec Channel Light-	0	1	"						
house, =	=225	14	19.0						
Angle Lubec Channel Lighthouse to Gunner,									
page 106 (318° 56′ 55″.2 to 322° 01′ 44″.8), =	= 3	04	49.6						
Observed azimuth Mam to Gupper	-228	19	08.6						

Note that the coefficients of the  $\delta \phi$ 's and  $\delta \lambda$ 's are exactly the same as for the first method and that the z's are omitted.

	Station observed	Cranberry Point		Cranberry Point Gunner		Gunner		Gumer		Gunner .
TREAT2	Equation	$v_{19} = -637\delta\phi_2 + 1078\delta\lambda_2 + 4.3$	МАМ	$v_{201} = -20105\phi_2 - 14555\lambda_2 + 6.4$ $v_{21} = -21915\phi_1 - 13383\lambda_1 + 1.1$	LARABEE	$v_{22} = +541\delta\phi_1 - 1473\delta\lambda_1 - 1.1$	INDIAN POINT	$v_{23} = +2338\delta\phi_1 - 1709\delta\lambda_1 + 2.5$	DUCK	$v_{24} = +8609\delta\phi_1 - 35093\lambda_1 - 1.9$
1	Observed azimuth	• / // 337 10 39.4+ v19		$\begin{array}{cccccccccccccccccccccccccccccccccccc$		$165 \ 22 \ 03.7 \pm v_{22}$		133 24 $30.1+v_{23}$		119 38 24. $0+v_{24}$
	Assumed azimuth	• / // 337 10 43.7		223 44 53.7 228 19 09.7		165 22 02.6		133 24 32.6		119 38 22.1

Formation of observation equations

The first part of each of tables 1 and 2 for the formation of normals according to the first method, pages 118 and 119, down to the line for  $v_{19}$  will serve for the second method also and is not repeated here. The remainder of the tables according to the second method is given below.

In forming the normal equations the four z's that occur are eliminated by the device of the sum equation serving as a fictitious observation equation with negative weight. The other observations that do not contain z's enter into the formation of the normal equations in the usual way. After the normal equations have been solved the four z's are found from the sum equations in the way previously explained and enter into the computation of the v's, or corrections, from 1 to 18 and 20 and 21, but not into the others.

	1 ∂φ1	2 ∂λ1	3 дф2	4 ∂λ ₂	5 дф8	6 ∂λ ₃	η		$\sqrt{p}$
19 20 21 22 23 24	-2191 +541 +2538 +8669	- 1388 - 1473 - 1709 - 3509	- 637 - 2010	+ 1078 - 1485			$ \begin{array}{r} + 4.3 \\ + 6.4 \\ + 1.1 \\ - 1.1 \\ + 2.5 \\ - 1.9 \\ \end{array} $	1 1 1 1 1 1	1 . 1 1 1 1

Table for formation of normals No. 1

Table for formation of normals No. 2

	1	2	3	4	5	6		
	<i>δ</i> φ1	$\partial \lambda_1$	<i>δ</i> φ2	δλ2	δφ3	δλ3	. η	Σ
19 20 21 22 23 24	-2.19 + 0.54 + 2.54 + 8.67	$ \begin{array}{r} - & 1.39 \\ - & 1.47 \\ - & 1.71 \\ - & 3.51 \end{array} $	- 0.64 - 2.01	+ 1.08 - 1.48			+0.43 +0.64 +0.11 -0.11 +0.25 -0.19	$\begin{array}{r} + \ 0.87 \\ - \ 2.85 \\ - \ 3.47 \\ - \ 1.04 \\ + \ 1.08 \\ + \ 4.97 \end{array}$

Normal equations

1	2	3	4	5	6	η	Σ
+1014.5374	863, 2282 +918, 6459	-822, 5130 +876, 9117 +924, 4414	+781. 8841 -837. 3829 -831. 3291 +843. 4555	+ 8.0389 -13.2644 -39.8513 +36.7824 +43.7028	$\begin{array}{r} - & 0.\ 2265 \\ + & 3.\ 9464 \\ + 18.\ 6471 \\ - & 15.\ 9112 \\ - & 33.\ 6441 \\ + & 41.\ 7793 \end{array}$	$\begin{array}{r} - & 8.5215 \\ + & 5.8167 \\ + & 3.7521 \\ + & 2.6609 \\ - & 18.8752 \\ + & 30.2371 \end{array}$	$\begin{array}{r} +109.\ 9712\\ +\ 91.\ 4452\\ +130.\ 0589\\ -\ 19.\ 8403\\ -\ 17.\ 1109\\ +\ 44.\ 8281\end{array}$

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,												
	М	+109.9712 - 0.1083954	+ 91.4452 + 93.5700	+185.0152 - 1.004641	+130.0589 + 89.1566 -177.8910	+ 41.3245 - 0.473054	$\begin{array}{r} - 19.8403 \\ - 84.7526 \\ + 172.9087 \\ + 15.1150 \end{array}$	+ 83. 4306 - 1. 220852	$\begin{array}{rrrr} - & 17.1109 \\ - & 0.8714 \\ + & 6.4543 \\ + & 12.8467 \\ - & 17.8855 \end{array}$	-16.5668 + 0.520443	+ 44. 82% + 0. 0246 - 3. 7712 - 7. 0269 + 8. 2961 - 14. 2794	+ 28. 0712 - 1. 89000
	li	- 8.5215 + 0.0083994	+ 5.8167 - 7.2506	- 1.4339 + 0.007786	+ 3.7521 - 6.9086 + 1.3787	- 1.7778 + 0.020351	$\begin{array}{r} + & 2.6609 \\ + & 6.5674 \\ - & 1.3401 \\ - & 0.6503 \end{array}$	+ 7.2379 - 0.105913	$\begin{array}{c} -18.8752 \\ + 0.0675 \\ - 0.0500 \\ - 0.5527 \\ - 1.5516 \end{array}$	-20.9620 + 0.658518	+30. 2371 - 0. 0019 + 0. 0292 + 0. 3023 + 0. 7197 -18. 0677	+13.2187 - 0.89000
	9	- 0. 2265 + 0. 0002233	+ 3.9464 - 0.1927	+ 3.7537 - 0.020383	+18.6471 - 0.1836 - 3.6092	+14.8543 - 0.170042	-15.9112 + 0.1746 + 3.5081 + 5.4332	-6.7953 + 0.099437	$\begin{array}{c} -33.6441 \\ + 33.6441 \\ + 0.0018 \\ + 0.1309 \\ + 1.4567 \\ + 1.4567 \end{array}$	-27.4369 + 0.861926	+41, 7793 - 0, 0001 - 0, 0765 - 2, 5259 - 0, 6757 -23, 6486	+14.8525 $\partial\lambda_{3}$
	5	+ 8. 0389 - 0. 0079237	-13.2644 + 6.8400	-6.4244 + 0.034885	-39.8513 + 6.5174 + 6.1770	-27.1569 + 0.310873	$\begin{array}{r} +36.7824 \\ -6.1954 \\ -6.0040 \\ -9.9330 \end{array}$	+14.6500 - 0.214376	$\begin{array}{r} +43.7028 \\ -0.0637 \\ -0.2241 \\ -8.4423 \\ -3.1406 \end{array}$	+31.8321 $\delta\phi_3$	<b>⊣</b> 0,0,4,10	
	4	+781.8841 -0.7706804	-837.3829 +665.2730	-172.1099 + 0.934565	-831.3291 +633.8946 +165,4826	- 31, 9519 + 0. 365763	+ 843. 4555 -602. 5828 -160. 8479 - 11. 6868	+ 68.3380 <i>d</i> λ2	₩ 63 co 44			
	3	-822.5130 + 0.8107271	+876.9117 -699.8425	+177.0692 - 0.961494	+924.4414 -666.8336 -170.2510	+ 87.3568 $\delta\phi_2$	304	-				
	3	-863, 2282 + 0. 8508589	+918.6459 -734.4854	+184.1605 $\delta\lambda_1$	21							
	1	+1014.5374 $\delta\phi$ :	1									

Solution of normals

$\frac{\partial \lambda_3}{-0.89000}$	$\frac{\partial \phi_3}{+0.65852}$ -0.76711 -0.10859	$\begin{array}{c} & & \\ \hline & -0,10591 \\ -0,08850 \\ +0,02328 \\ \hline & -0,17113 \end{array}$	$\begin{array}{c} \delta\phi_{3} \\ \hline +0.02035 \\ +0.15134 \\ -0.03376 \\ -0.06259 \\ \hline +0.07534 \end{array}$	$\begin{array}{c} \delta\lambda_1 \\ \hline \\ +0.00779 \\ +0.01814 \\ -0.00379 \\ -0.15993 \\ -0.07244 \\ \hline \\ -0.21023 \end{array}$	$\begin{array}{c} \partial\phi_1 \\ \hline \\ +0.00840 \\ -0.00020 \\ +0.00086 \\ +0.13189 \\ +0.06108 \\ -0.17888 \\ \hline \\ +0.02315 \end{array}$
---------------------------------------	------------------------------------------------------------	------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------

Computation of corrections

## Back solution

1	2	3	4	5	6	7	8
$ \begin{array}{r} + 2.007 \\ + 7.377 \\ -10.753 \end{array} \\ \hline - 1.369 \\ - 1.4 \end{array} $	$ \begin{array}{r} + 0.588 \\ + 3.593 \\ - 10.753 \\ - 2.2 \\ \hline - 8.772 \\ - 8.8 \\ \end{array} $	$ \begin{array}{r} + 0.125 \\ + 3.097 \\ - 10.753 \\ + 4.8 \\ \hline - 2.731 \\ - 2.8 \\ \end{array} $	$ \begin{array}{r} - 0.507 \\ + 2.918 \\ -10.753 \\ + 3.6 \\ \hline - 4.742 \\ - 4.8 \\ \end{array} $	$ \begin{array}{r} -1.796 \\ +8.058 \\ -10.753 \\ +7.1 \\ \hline +2.609 \\ +2.6 \\ \end{array} $	$ \begin{array}{r} - 0.843 \\ - 3.389 \\ - 3.956 \\ + 14.347 \\ - 10.753 \\ + 9.7 \\ \hline + 5.106 \\ \end{array} $	$- 0.433 \\ - 3.322 \\ -10.753 \\ +25.5 \\ +10.992 \\ +11.0 \\ -$	$ \begin{array}{r} - 4.934 \\ -46.059 \\ +16.057 \\ +37.493 \\ -10.753 \\ + 7.1 \\ \hline - 1.096 \\ \end{array} $
					+ 5.1		- 1.1
<i>z</i> ₁	9	10	11	12	13	14	#2 .
$\begin{array}{r} - 5.793 \\ -27.727 \\ +16.057 \\ +37.493 \\ - 3.956 \end{array}$	- 4.934  -46.059  +16.057  +37.493  - 1.223	-4.530 + 8.402 - 1.223 + 2.649	$\begin{array}{r} - & 1.514 \\ + & 2.541 \\ - & 1.223 \\ - & 13.1 \end{array}$	-3.156 -2.824 -4.549 +14.685 -1.223	$\begin{array}{r} - 1.541 \\ - 2.911 \\ - 1.223 \\ + 11.5 \end{array}$	$\begin{array}{r} - & 0.480 \\ - & 1.845 \\ - & 1.223 \\ + & 6.8 \end{array}$	-4.934 -46.059 +4.836 +40.857 -4.549
+14.347 +55.6	+ 1.334	+ 2.7	$-13.296 \\ -13.3$	- 2.7	+5.825 + 5.8	+ 3.252 + 3.2	+14.685 + 2.5
+86.021 -10.753	Ţ 1.0			+ 0.200 + 0.2			+ 7.336 - 1.223
15	16	17	18	Z3	19	20	21
$     15 \\     + 1.282 \\     -43.806 \\     +44.790   $	$     \begin{array}{r}       16 \\       - 3.156 \\       - 2.824 \\       - 4.549 \\       + 14.685     \end{array} $	$   \begin{array}{r} 17 \\   \hline                                 $	$     18 \\     - 2.620 \\     +25.267 \\     +44.790 \\     -62.2   $	$z_8$ - 0.843 - 3.889 - 3.156 - 2.824	$     \begin{array}{r}       19 \\       - 0.480 \\       - 1.845 \\       + 4.3     \end{array} $	$20 \\ -1.514 \\ + 2.541 \\ + 6.4$	$21 \\ - 0.507 \\ + 2.918 \\ + 1.1$
15     + 1.282     -43.806     +44.790     + 2.266     + 2.2	$     \begin{array}{r}             16 \\             -3.156 \\             -2.824 \\             -4.549 \\             +14.685 \\             +44.790 \\             -52.6 \\         \end{array}     $	$     \begin{array}{r}       17 \\       - 0.843 \\       - 3.389 \\       - 3.956 \\       + 14.347 \\       + 44.790 \\       - 54.8 \\       \end{array} $	$     18 \\     - 2.620 \\     +25.267 \\     +44.790 \\     -62.2 \\     + 5.237 \\     + 5.3   $	$   \begin{array}{r} z_3 \\   \hline                                 $	19     - 0.480     - 1.845     + 4.3     + 1.975     + 2.0     - 1.975     + 2.0     - 1.975     + 2.0     - 1.975     + 2.0     - 1.975     + 2.0     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.975     - 1.97     - 1.975     - 1.975     - 1.97     - 1.975     - 1.97     - 1.97     - 1.97     - 1.97     - 1.97     - 1.97     - 1.97     - 1.97     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9     - 1.9	$20 \\ -1.514 \\ +2.541 \\ +6.4 \\ +7.427 \\ +7.5$	$21 \\ - 0.507 \\ + 2.918 \\ + 1.1 \\ + 3.511 \\ + 3.5$
$   \begin{array}{r}     15 \\     + 1.282 \\     -43.806 \\     +44.790 \\     + 2.266 \\     + 2.2   \end{array} $	$\begin{array}{r} 16 \\ \hline -3.156 \\ -2.824 \\ -4.549 \\ +14.685 \\ +44.790 \\ -52.6 \\ \hline -3.654 \\ -3.7 \end{array}$	$\begin{array}{r} 17 \\ \hline & - & 0.843 \\ - & 3.389 \\ - & 3.956 \\ + & 14.347 \\ + & 44.700 \\ - & 54.8 \\ \hline & - & 3.851 \\ - & 3.9 \end{array}$	$     \begin{array}{r}       18 \\       - 2.620 \\       +25.267 \\       +44.790 \\       -62.2 \\       + 5.237 \\       + 5.3   \end{array} $	$\begin{array}{c} z_8 \\ \hline \\ - & 0.843 \\ - & 3.889 \\ - & 3.156 \\ - & 2.824 \\ - & 9.843 \\ + & 10.493 \\ - & 169.6 \\ \hline \\ - & 179.162 \\ + & 44.790 \end{array}$	$     \begin{array}{r}         19 \\         - 0.480 \\         - 1.845 \\         + 4.3 \\         + 1.975 \\         + 2.0 \\         \end{array}   $	$20 \\ - 1.514 \\ + 2.541 \\ + 6.4 \\ + 7.427 \\ + 7.5$	$21 \\ - 0.507 \\ + 2.918 \\ + 1.1 \\ + 3.511 \\ + 3.5$
$   \begin{array}{r}     15 \\     + 1.282 \\     -43.806 \\     +44.790 \\     + 2.266 \\     + 2.2 \\   \end{array} $ 22	$\begin{array}{r} 16 \\ \hline -3.156 \\ -2.824 \\ -4.549 \\ +14.685 \\ +44.790 \\ -52.6 \\ \hline -3.654 \\ -3.7 \\ \hline \end{array}$	$     \begin{array}{r}         17 \\         - 0.843 \\         - 3.389 \\         - 3.956 \\         +14.347 \\         +44.790 \\         -54.8 \\         - 3.851 \\         - 3.9 \\         24     \end{array} $	$     18 \\     - 2.620 \\     +25.267 \\     +44.790 \\     -62.2 \\     + 5.237 \\     + 5.3   $	$\begin{array}{c} z_{8} \\ \hline \\ - & 0.843 \\ - & 3.889 \\ - & 3.156 \\ - & 2.824 \\ - & 9.843 \\ + & 10.493 \\ - & 169.6 \\ \hline \\ - & 179.162 \\ + & 44.790 \\ \end{array}$	$ \begin{array}{r}     19 \\     - 0, 480 \\     - 1, 845 \\     + 4.3 \\     + 1.975 \\     + 2.0 \\ \end{array} $	$     \begin{array}{r}       20 \\       -1.514 \\       +2.541 \\       +6.4 \\       +7.427 \\       +7.5     \end{array} $	$21 \\ -0.507 \\ +2.918 \\ +1.1 \\ +3.511 \\ +3.5$
$   \begin{array}{r}     15 \\     + 1.282 \\     -43.806 \\     +44.790 \\     + 2.206 \\     + 2.2 \\   \end{array} $ $   \begin{array}{r}     22 \\     + 0.125 \\     + 3.097 \\     - 1.1 \\   \end{array} $	$\begin{array}{r} 16 \\ \hline & -3.156 \\ -2.824 \\ -4.549 \\ +14.685 \\ +44.790 \\ -52.6 \\ \hline & -3.654 \\ -3.7 \\ \hline \\ 23 \\ \hline \\ +0.588 \\ +3.593 \\ +2.5 \\ \end{array}$	$\begin{array}{c} 17 \\ \hline & - & 0.843 \\ - & 3.389 \\ - & 3.956 \\ + & 14.347 \\ + & 44.790 \\ - & 54.8 \\ \hline & - & 3.851 \\ - & 3.9 \\ \hline & \\ 24 \\ \hline & + & 2.007 \\ + & 7.377 \\ - & 1.9 \\ \end{array}$	$     18 \\     - 2.620 \\     +25.267 \\     +44.790 \\     -62.2 \\     + 5.237 \\     + 5.3   $	$\begin{array}{c} z_{3} \\ \hline \\ - & 0.843 \\ - & 3.889 \\ - & 3.156 \\ - & 2.824 \\ - & 9.843 \\ - & 109.64 \\ - & 169.6 \\ - & 179.162 \\ + & 44.790 \\ \end{array}$	$     \begin{array}{r}         19 \\         - 0.480 \\         - 1.845 \\         + 4.3 \\         + 1.975 \\         + 2.0 \\         \end{array}   $	$     20 \\     - 1.514 \\     + 2.541 \\     + 6.4 \\     + 7.427 \\     + 7.5     $	$21 \\ - 0.507 \\ + 2.918 \\ + 1.1 \\ + 3.511 \\ + 3.5$

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Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
-1+3 +24 -22	Duck-Larrabee Gunner Duck Larrabee Gunner-Larrabee Gunner-Duck	<ul> <li><i>i i i</i></li> <li><i>i i</i></li> <li><i>i</i></li> &lt;</ul>	'' - 1.4 + 7.5 - 2.1 + 4.0	" 28.0 08.4 23.6		• / //	3. 410111 0. 145093 9. 918392 9. 249858 3. 473596 ⁻¹ 2. 805062
-1+4 +24 -21	Duck-Mam Gunner Duck Mam Gunner-Mam Gunner-Duck	108 41 53.9 57 00 57.8 14 17 07.7	$ \begin{array}{r} - 3.4 \\ + 7.5 \\ - 3.5 \\ + 0.6 \end{array} $	50.5 65.3 04.2			3. 389282 0. 023547 9. 923681 9. 392234 3. 336510 2. 805063 ⁻¹
-1+5 +24	Duck-Lubcc Channel Light- house Gunner Duck Lubec Channel Lighthouse Gunner-Lu bec Channel Lighthouse Gunner-Duck	$115 \ 34 \ 42.9 \\ 33 \ 11 \ 41.9 \\ 35.2$	+ 4.0 + 7.5	46.9 49.4 23.7		31 13 23.7	<b>3. 045619</b> 0. 044800 9. 738400 9. 714643 2. 828819 2. 805062
-2+3 +23 -22	Indian Point-Larrabce Gunner Indian Point Larrabee Gunner-Larrabee Gunner-Indian Point	31 57 41.4 114 00 36.0 34 01 32.0	+ 6.0 + 6.7 - 2.1 + 10.6	47.4 42.7 29.9		-	3.236668 0.276237 9.960690 9.747842 3.473595 3.260747
-2+4 +23 -21	Indian Point-Mam Gunner Indian Point Mam Gunner-Mam Gunner-Indian Point	94 56 05.9 47 05 36.3 37 58 10.6	+4.0 +6.7 -3.5 +7.2	09.9 43.0 07.1			<b>3. 470097</b> 0. 001614 9. 864800 9. 789037 3. 336511 ⁻¹ 3. 260748 ⁻¹
-2+5 +23	Indian Point-Lubec Channel Lighthouse Gunner Indian Point Lubec Channel Lighthouse Gunner-Lu bec Channel Lighthouse Gunner-Indian Point	101 48 54.9 18 35 56.3 68.8	+11.4 + 6.7	66.3 63.0 50.7		59 3 <b>4 5</b> 0.7	<b>3.315762</b> 0.009305 9.503754 9.935680 2.828821 ⁻¹ 3.260747

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## Final computation of triangles

Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
-3+4 +22 -21	Larrabee-Mam Gunner Larrabee Mam	° ' '' 62 58 24.5 44 10 37.0 72 50 61.9	" - 2.0 + 2.1 - 3.5	" 22.5 39.1 58.4		• 1 11	<b>3.443126</b> 0.050224 9.843160 9.980246
0	Gunner-Mam Gunner-Larrabee		- 3.4	_			3.336510 $3.473596^{-1}$
-3+5 +22	Larrabee-Lubec Channel Lighthouse Gunner Larrabee Lubec Channel Lighthouse Gunner-Lubec Channel Lighthouse Gunner-Larrabee	69 51 13.5 12 59 29.9 16.6	+ 5.4 + 2.1	18.9 32.0 09.1		97 09 09.1	3. 449573 0. 027415 9. 351833 9. 996607 2. 828821-1 3. 473595
-3+7 + 22	Larrabee-Lubec church spire Gunner Larrabee Lubee church spire Gunner-Lubec church spire Gunner-Larrabee	154 32 48.4 10 46 00.0 71.6	+13.8 + 2.1	62.2 02.1 55.7		14 40 55.7	<b>3.702872</b> 0.366819 9.271423 9.403903 3.341114 ⁺¹ 3.473594 ⁺¹
-4+5 +21	Mam-Lubec Channel Light- house Gunner Mam Lubec Channel Lighthouse Gunner-Lubec Channel Light- house Gunner-Mam	6 52 49.0 3 04 49.6 21.4	+ 7.4 + 3.5	56.4 53.1 10.5		170 02 10.5	3. 176968 0. 921432 8. 730418 9. 238109 2. 828818+2 3. 336509+1
+2- 7 -23	Lubee church spire-Indian Point Gunner Lubee church spire Indian Point Gunner-Indian Point Gunner-Lubec church spire	$\begin{array}{c} 173 \ 29 \ 30.2 \\ 56 \ 55.4 \\ 3 \ 33 \ 34.4 \end{array}$	19.8 - 6.7	10. 4 81. 9 27. 7		2 57 21.9	3. 603122 0. 945226 8. 712401 8. 792767 3. 260749 ⁻² 3. 341115
$-9+10 \\ -5+8$	Gunner-Lubec Channel Light- house Cranberry Point Gunner Lubec Channel Lighthouse Cranberry Point-Lubec Chan- nel Lighthouse Cranberry Point-Gunner	75 45 12.8 90 05 58.7 48.5	+1.4 - 3.7	14.2 55.0 50.8		14 08 50.8	2.828820 0.013565 9.999999 9.388133 2.842384 2.230518

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Symbol	Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
-9+11 -4+8 -20+21	Gunner-Mam Cranberry Point Gunner Mam	° ' '' 78 36 65.9 96 58 47.7 4 24 21.3	$ \begin{array}{r} '' \\ -14.6 \\ + 3.7 \\ - 4.0 \\ \hline -14.9 \\ \end{array} $	" 51.3 51.4 17.3		• / //	3.336510 0.008632 9.996768 8.885376
$-9+13 \\ -7+8$	Gunner-Lubec church spire Cranberry Point-Gunner Gunner Lubec church spire Cran berry Point-Lubec church spire Cran berry Point-Lubec	174 08 32.3 5 24 23.8 03.9	+4.5 -12.1	36.8 11.7 11.5		0 27 11.5	3. 341910 2. 230518 3. 341115 0. 991245 8. 973889 7. 898156 3. 306249 3. 230516 ⁺²
-10+11 -20	Lubec Channel Lighthouse- Mam Cranberry Point Lubec Channel Lighthouse Mam Cranberry Point-Mam Cranberry Point-Lubec Chan- nel Lighthouse	2 51 53.1 35.2 1 19 31.7		37.1 58.7 24.2		175 48 58.7	3. 176968 1. 301891 8. 863051 8. 363526 3. 241919 2. 842385 ⁻¹
-13+14 -19	Lubec church spire-Treat ₂ Cranberry Point Lubec church spire Treat ₂ Cranberry Point-Treat ₂ Cranberry Point-Lubec church spire	17 44 02.9 19.0 17 34 38.1	- 2.6 - 2.0	00.3 23.6 36.1		144 41 23.6	<b>3.309982</b> 0.516286 9.761929 9.479981 3.588197 3.306249
-15+16 -12+13	Lubec church spire-Cran- berry Point Telegraph Lubec church spire Cranberry Point Telegraph-Cranberry Point Telegraph-Lubec church spire	128 38 59.9 47.5 20 29 12.6	- 5.9 + 5.6	54.0 47.8 18.2		20 51 47.8	3. 306249 0. 107352 9. 710110 9. 544090 3. 123711 2. 957691
-15+17 -6+ 7	Lubec church spire-Gunner Telegraph Lubec church spire Gunner Telegraph-Gunner Telegraph-Lubec church spire	131 33 53.1 36.1 18 01 30.8	- 6.1 + 5.9	47. 0 36. 3 36. 7		30 24 36.3	3. 341115 0. 125967 9. 704310 9. 490609 3. 171392 2. 957691
-16+17 -9+12 -6+8	Cranberry Point-Gunner Telegraph Cranberry Point Gunner	2 54 53.2 153 39 19.7 23 25 54.6	-0.2 -1.1 -6.2 -7.5	53.0 18.6 48.4			2. 230518 1. 293713 9. 647161 9. 599479
	Telegraph-Gunner Telegraph-Cranberry Point			-			3. 171392 3. 123710+1

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Symbol	Station.	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
-16+18 -10+12	Cranberry Point-Lubee Chan- nel Lighthouse Telegraph Cranberry Point Lubec Channel Lighthouse Telegraph-Lubec Channel Lighthouse Telegraph-Cranberry Point	° / // 29 52 44.5 77 54 06.9 08.6	" + 9.0 - 2.5	" 53.5 04.4 02.1		° ′ ″ 72 13 02.1	2. 842384 0. 302589 9. 990245 9. 978738 3. 135218 3. 123711
-17+18 - 5+6	Gunner-LubecChannel Lighthouse Telegraph Gunner LubecChannelLighthouss Telegraph-LubecChannel Lighthouse Telegraph-Gunner	26 57 51.3 66 40 04.1 64.6	+ 9.2 + 2.5	60. 5 06. 6 52. 9		86 21 52.9	2. 828820 0. 343447 9. 962951 9. 999125 3. 135218 3. 171392

α Second angle	Duck to Lubec Ch	Lubec Chan annel Light	nel Lighthou thouse and G	lse unner		$^{\circ}_{+33}$	, 26 11	" 42.1 49.4
α 1α	Duck to	Gunner				119	38	31.5 17.8
α'	Gunner t	o Duck	F	triangle	180 299 115	38 34	13.7 46.9	
$\phi \\ \varDelta \phi$	44 +	50	33. 886 10. 227	Duck	$\lambda$ $\Delta \lambda$	$+ \frac{66}{100}$	57	47.822 25.263
φ'	44	50	44:113	Gunner	λ'	66	58	13.085
$\frac{1}{2}(\phi + \phi')$ 1st term	• / // 44 50 39 // -10.227	$\begin{array}{c c} s \\ cos \\ B \\ 7 \\ h \end{array}$	2.805062 9.694237 8.510480 1.009779	$\frac{s^2}{C} \alpha$	5. 61 9. 87 1. 40 6. 88	01 82 16 99		
20 term Δφ	+ 0.000 -10.2269	8						
• ,	$\sin \alpha \\ A' \\ \sec \phi'$	2. 805062 9. 939086 8. 508994 0. 149348	$\int_{1}^{\Delta\lambda} \sin \frac{1}{2}(\phi+\phi')$	)	490 301			
	Δλ	+25.2633	1a	+17	// 51 // . 82			

STATION GUNNER

Final position computation,

#### STATION CRANBERRY POINT

α Second angle	Gunner to Lubec Cha	Lubec Cha nnel Light	oint	$^{\circ}_{+ 90}$	, 13 05	// 00. 6 55. 0		
α Δα	Gunner to	Cranberry	Point			145 	18	55.6 03.1
α'	Cranberry	Point to G	unner Fi	rst angle o	f triangle	180 325 75	18 45	52.5 14.2
$\phi_{\Delta\phi}$	44 +	50 4	" 14. 113 04. 529	lunner	$\lambda$ $\Delta \lambda$	66 +	58	13.085 04.406
φ'	44	50 4	18.642 Cran	perry Poin	t λ'	66	58	17. 491
$\frac{1}{2}(\phi+\phi')$	• / // 44 50 46	s cos α B	2. 230518 9. 915029 8. 510480	$\overset{s^2}{\underset{C}{\sin^2 \alpha}}$	4.46 9.51 1.40	10 03 16		
1st term 2d term	-4.5293 + 0.0000	h	0.656027		5.37	29		
-14	-4.5293			l				
	$\begin{array}{c} s\\ \sin\alpha\\ A'\\ \sec\phi' \end{array}$	$\begin{array}{c c c c c c c c c c c c c c c c c c c $						
	Δλ	0. 644025 ,, +4. 4058	Δα	0.492	2340 			

## secondary triangulation

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#### STATION GUNNER

a Third angle	Lubec Channel Lighthouse to Duck Gunner and Duck						, 26 13	'' 06.5 23.7
α 1α	Lubec Cl	nannel Light	house to Gum	ner	-	235 +	12	42.8 17.8
α'	Gunner t	o Lubec Cha	nnel Lighthou	150		180 55	13	00.6
φ	44	50 3	50 31.652 Lubec Channel λ Lighthouse				58	38. 299
Δφ φ'	44	50 4	4.113 G	unner	$\lambda'$	- 66	58	13.085
<u></u> }(φ+φ')	• / // 44 50 30	6 cos a B	2. 828819 9. 756288 8. 510480	sin ² a C	5.65 9.82 1.40	76 90 16		
1st term 2d term	-12.4620 + 0.0008	0 h	1.095587		6.88	82		
<i>4</i> φ	-12.461	2		1				
		9. 914485 8. 508994 0. 149348	$d\lambda$ $\sin \frac{1}{2}(\phi + \phi')$	1. 401 9. 848	1646 3294			
		1. 401646 1. 249940						
	Δλ	-25.2142	-1a	-17	. 78			-

#### STATION CRANBERRY POINT

α Third angle	Lubec Channel Lighthouse to Gunner Cranberry Point and Gunner							, 12 08	" 42. 8 50. 8
a sa	Lubee Ch	annel Light	house	to Cran	berry Poir	nt	221 +	03	52.0 14.7
α'	Cranberry	y Point to L	ubec C	hannel	Lighthous	80	180 41	04	06.7
\$	° 44	50 3	,, 31. 652	Lubec	c Channel	X	66	58	38, 299
Δφ	+	1	16.990			42	-		20, 808
¢'	44	50	18.642	Cranb	erry Point	λ'	66	58	17.491
½(φ+φ')	• • • • • 44 50 40		$\begin{bmatrix} s \\ \cos \alpha \\ B \\ \end{bmatrix} \begin{bmatrix} 2, 842384 \\ 9, 877355 \\ 8, 510480 \\ \end{bmatrix} \begin{bmatrix} s^2 \\ \sin^2 \\ \cos^2 \\ C \\ \end{bmatrix}$			5.68 9.63 1.40	48 50 16		
2d term	+ 0.000	5 n	1.2	30219		6.72	14		
-40	-16.990	5	]						
	$\frac{\sin \alpha}{A'}$ sec $\phi'$	2.842384 9.817504 8.508994 0.149357	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$			239			
	1. 318239 1. 166542								
	<i>Δ</i> λ		-	-Δα	-14	. 67			

Final position computation,

α Second angle	Cranberry Point to Lubee Channel Lighthouse Lubee Channel Lighthouse and Telegraph							。 + ⁽¹ 77	, 01 51	,, 06.7 04.4
α 1α	Cranberry	7 Poin	t to Tele	egrapl	1			118	58	11.1 37.4
α'	Telegraph	ı to Cr	anberry	Poin	t First	angle of t	riangle	180 298 29	57 5 <b>2</b>	33.7 53.4
ф 1ф	• 44 +	, 50	48. 20.	642 858	Cranbe	rry Point	λ Δλ	66 +	58	17. 491 52. 973
φ'	44	51	$\begin{array}{ c c c }\hline 09.500 \\ +1 \end{array}  \  \  \  \  \  \  \  \  \  \  \  \  \$			λ'	66	59	10, 464	
¹ / ₂ (φ+φ')	• / // 44 50 59	0 00	^s Bα B	3.12 9.68 8.51	3711 5157 0480	$\left  \begin{array}{c} s^2 \\ \sin^2 \alpha \\ C \end{array} \right _{C}$	6. 247 9. 883 1. 401	4 9 8		
1st term 2d term	-20.8617 + 0.003	7	h	1.319	9348		7.532	9		
$-\Delta\phi$	20. 8583	3				1				
	$\frac{s}{sin \alpha}_{A'}$ sec $\phi'$	3. 1 9. 9 8. 5 0. 1	23711 41946 08994 49401 s	$\int_{1}^{1}$	λ φ+φ')	1. 72405 9. 84834	2 3			
	Δλ	1.7 +52	24052 , , 9728		lα	1. 57239 " +37. 3	6			

STATION TELEGRAPH

secondary triangulation—Continued.

#### STATION TELEGRAPH

α Third angle	Lubec Channel Lighthouse to Cranberry Point Telegraph and Cranberry Point	° 221 - 72	, 03 13	. 52.0 02.2
α Δα	Lubee Channel Lighthouse to Telegraph	148	50	49.8 22.7
α'	Telegraph to Lubec Channel Lighthouse	180 328	50	27.1
φ	$\begin{array}{c c} \bullet & \bullet \\ \hline 44 & 50 & 31.652 & Lubec Channel \\ \lambda & \\ \end{array}$	66	58	38, 299
Δφ	+ 37.849 Δλ	+		32.164
φ'	44 51 09.501 Telegraph λ'	66	59	10.463
½(φ+φ') 1st term 2d term −4φ	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	4 5 6 - 5		+1
	$\begin{array}{c c c c c c c c c c c c c c c c c c c $			
	$d\lambda$ +32.1644 - $d\alpha$ +22.69			

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	Adopted v's first solution	v ²		Adopted v's second solution	$v^2$ .
$\begin{array}{c} 1\\ 2\\ 3\\ 4\\ 5\\ 6\\ 7\\ 8\\ 9\\ 9\\ 10\\ 11\\ 12\\ 13\\ 14\\ 15\\ 16\\ 17\\ 19\\ 19\\ 20\\ 20\\ 20\\ 22\\ 22\\ 22\\ 22\\ 22\\ 22\\ 22$	$\begin{array}{c} + 0.2 \\ - 8.55 \\ - 2.4,9 \\ + 3.19 \\ + 9.55 \\ - 1.57 \\ + 3.11 \\ + 9.55 \\ - 1.57 \\ - 1.57 \\ - 1.57 \\ - 1.57 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.55 \\ - 1.5$	$\begin{array}{c} 0.04\\ 72.25\\ 7.29\\ 24.01\\ 90.25\\ 2.25\\ 2.89\\ 9.61\\ 171.61\\ 0.36\\ 25.00\\ 8.41\\ 5.29\\ 14.44\\ 14.44\\ 29.16\\ 0.64\\ 0.49\\ 31.36\\ 4.41\\ 0.64\\ 2.25\\ 1.44\\ 6.76\\ 0.49\\ 32.49\\ 0.36\\ 10.89\\ 32.49\\ 0.36\\ 10.89\\ 32.49\\ 33.61\\ 17.64\\ 30.25\\ 7.84\\ 114.49\\ 42.25\\ 9.00\\ 11.56\\ \end{array}$	$1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 16 \\ 17 \\ 18 \\ 19 \\ 20 \\ 21 \\ 22 \\ 23 \\ 24 \\ 24 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 1$	$\begin{array}{c} -1.4\\ -8.8\\ +2.8\\ +2.61\\ +11.0\\ -1.1.3\\ +2.7\\ +3.2\\ 2.7\\ +3.2\\ 2.2\\ +3.2\\ 2.0\\ +5.2\\ 1-3.9\\ +2.0\\ +7.5\\ +2.1\\ +7.5\\ +7.5\\ \end{array}$	$\begin{array}{c} 1,96\\ 77,44\\ 7,84\\ 23,04\\ 6,76\\ 26,01\\ 121,00\\ 1,21\\ 1,69\\ 7,29\\ 176,89\\ 0,04\\ 33,64\\ 10,24\\ 4,84\\ 10,24\\ 4,84\\ 10,24\\ 4,89\\ 15,21\\ 22,59\\ 4,41\\ 43,89\\ 56,25\\ 12,25\\ 4,41\\ 44,89\\ 56,25\\ 734,93\\ \end{array}$

#### Computation of probable errors

In the first method of adjustment, there are 40 equations to determine 14 unknown quantities, namely,  $6\partial\phi$ 's and  $\partial\lambda$ 's and 8z's. The probable error of an observed direction is therefore,

$$0.6745\sqrt{\frac{895.72}{40-14}} = \pm 4.0$$

In the second method there are 24 equations to determine 9 unknown quantities, namely,  $6\delta\phi$ 's and  $\delta\lambda$ 's and 3z's at new points. The probable error of an observed direction is therefore,

$$0.6745\sqrt{\frac{734.93}{15}} = \pm 4.7$$

#### APPLICATION OF LEAST SQUARES TO TRIANGULATION. 139

#### ADJUSTMENT OF A FIGURE CONTAINING LATITUDE, LONGITUDE, AZIMUTH, AND LENGTH CONDITIONS BY THE METHOD OF VARIA-TION OF GEOGRAPHIC COORDINATES

This example illustrates the fitting of a chain of triangulation in between fixed lines at the ends. The necessary preliminary computations of the assumed positions and directions could have been carried out in much the same way as in the preceding examples. A preliminary figure adjustment was, however, available and the results of it were used in the preliminary computations of the triangles and the geographic positions, pages 140–157. The fixed lines at the ends of the chain are shown in the following list of fixed positions. The list of observed directions is not given. The necessary data may be derived from the observed angles of the triangles, pages 140–143, taken in connection with figure 7, page 157.

Station	Latitude and longitude	Azimuth	Back azimuth	To station	Loga- rithm of distance.
Fort Morgan.	° / // 30 13 42.242	0 / //	0 / //		·
Dauphin Island east base.	30 14 56.379 88 08 14.288	281 42 17.9	101 45 44.9	Fort Morgan.	4.050203
Dauphin Island west base.	30 14 21.492 88 14 51.034	264 11 22.1	84 14 41.9	Dauphin Island east base	4.027832
Biloxi Lighthouse.	30 23 39.419 88 54 03.820		1.1		
Ship Island Lighthouse.	30 12 45.341 88 57 57.464	197 12 19.7	17 14 17.6	Biloxi Lighthouse.	4.323998

Table of fixed positions

Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
	0 / //		,,	"	0 / //	
Fort Morgan–Dauphin Island east base Cedar Fort Morgan Dauphin Island east base	43 54 21.8 42 33 37.7 93 31 59.6	+ 0.0 + 0.3 + 0.9	21.8 38.0 60.5	0.1 0.1 0.1	21. 7 37. 9 32 00. 4	<b>4. 050203</b> 0. 158968 9. 830183 9. 999174
Cedar–Dauphin Island east base Cedar–Fort Morgan		+ 1.2		0.3		4. 039354 4. 208345
Dauphin Island east base-Dauphin Is-						4. 027832
Cedar Dauphin Island east base Dauphin Island west base	37 26 33.0 103 55 36.4 38 37 52.5	$   \begin{array}{r}     - 0.9 \\     - 0.9 \\     + 0.2   \end{array} $	32. 1 35. 5 52. 7	0.1 0.1 0.1	32. 0 35. 4 52. 6	0. 216124 9. 987043 9. 795398
Coder Douphin Island west have		- 1.6		0.3		4 920000
Cedar-Dauphin Island west base						4. 039354
Cedar–Dauphin Island east base Cat Cedar Dauphin Island east base	69 30 32.7 60 11 14.2 50 18 11.4	+ 0.8 + 1.4 - 0.3	33.5 15.6 11.1	0.0 0.1 0.1	33.5 15.5 11.0	4.039354 0.028386 9.938349 9.886171
		+ 1.9		0.2		
Cat-Dauphin Island east base Cat-Cedar						4.006089 3.953911
Cedar–Dauphin Island west base Cat Cedar Dauphin Island west base	135 31 54.9 22 44 41.2 21 43 18.7	+ 2.7 + 2.3 + 0.4	57.6 43.5 19.1	0.0 0.1 0.1	57.6 43.4 19.0	4. 230999 0. 154590 9. 587303 9. 568322
Cat-Dauphin Island west base		+ 5.4		0.2		3.972892 3.953911
Dauphin Island east base-Dauphin Is-						4. 027832
land west base	66 01 22 2	1 1 0	94 1	0.1	24.0	0. 039191
Dauphin Island east base Dauphin Island west base	$\begin{bmatrix} 00 & 01 & 22.2 \\ 53 & 37 & 25.0 \\ 60 & 21 & 11.2 \end{bmatrix}$	+ 1.9 - 0.6 + 0.6	24. 1 24. 4 11. 8	0.1 0.1	24.0 24.3 11.7	9. 905869 9. 939066
Cat-Dauphin Island west base Cat-Dauphin Island east base		+ 1.9		0, 3		3.972892 4.006089
Cedar-Cat Pins Cedar Cat	23 22 40.3 30 54 61.5 18.4	- 1.8 - 3.5	38.5 58.0 23.7	0.1 0.1 0.0	38.4 57.9 125 42 23.7	3.953911 0.401445 9.710779 9.909565
Pins_Cat				0.2		4 066135-1
Pins-Cedar						4.264921
Cedar–Dauphin Island west base Pins Cedar Dauphin Island west base	58 45 26.0 53 39 42.7 67 34 57.9	-2.8 -1.2 -2.0	23. 2 41. 5 55. 9	0.2 0.2 0.2	23. 0 41. 3 55. 7	4.230999 0.068049 9.906082 9.965873
Pins–Dauphin Island west base Pins–Cedar		- 6.0		0.6		4. 205130 4. 264921
Cat–Dauphin Island west base Pins Cat Dauphin Island west base	35 22 45.7 35.3 45 51 39.2	- 1.0 - 2.4	44. 7 38. 7 36. 8	0.1 0.0 0.1	98 45 38.7 36.7	3.972892 0.237334 9.994903 9.855908
Pins–Dauphin Island west base Pins–Cat				0.2		4. 205129 ⁺¹ 4. 066134

# Preliminary computation of triangles

Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
Pins–Dauphin Island west base Grand Pins Dauphin Island west base	• / // 54 52 01.6 85 13 07.0 39 54 50.9	" + 1.4 + 1.3 + 1.1	// 00. 2 08. 3 52. 0	" 0.2 0.1 0.2	• / // 00.0 08.2 51.8	4, 205130 0, 087345 9, 998486 9, 807293
Grand-Dauphin Island west base Grand-Pins		+ 1.0		0.5	1	4. 290961 4. 099768
Grand-Pins Petit Grand Pins	33 09 08.7 114 03 53.6 32 46 57.5	-0.3 -0.6 +1.4	08.4 53.0 58.9	0.1 0.1 0.1	08.3 52.9 58.8	4.099768 0.262119 9.960511 9.733565
Petit-Pins Petit-Grand		+ 0.5		0.3		4. 322398 4. 095452
Grand-Dauphin Island west base Petit Grand Dauphin Island west base	81 41 28.2 59 11 52.0 39 06 39.1	+ 0.1 + 0.8 + 0.3	28.3 52.8 39.4	$0.1 \\ 0.2 \\ 0.2$	28. 2 52. 6 39. 2	4. 290961 0. 004583 9. 933964 9. 799908
Petit-Dauphin Island west base Petit-Grand		+ 1.2		0.5		4. 229508 4. 095452
Pins-Dauphin Island west base Petit Pins Dauphin Island west base	48 32 19.5 52 26 09.5 79 01 30.0	+ 0.4 - 0.1 + 1.4	19.9 09.4 31.4	0.2 0.2 0.3	19.7 09.2 31.1	4. 205130 0. 125284 9. 899093 9. 991984
Petit–Dauphin Island west base Petit–Pins		+ 1.7		0.7		4. 229507 ⁺¹ 4. 322398
Grand-Petit Pascagoula Grand Petit	37 39 20.6 104 18 56.1 38 01 38.6	+ 3.0 + 1.5 + 0.6	$23.6 \\ 57.6 \\ 39.2$	0.1 0.2 0.1	23.5 57.4 39.1	4.095452 0.214011 9.986300 9.789603
Pascagoula-Petit Pascagoula-Grand		+ 5.1		0.4		4. 295763 4. 099072
Pascagoula-Grand Horn Pascagoula Grand	38 49 39.0 97 55 54.0 43 14 18.9	+ 3.8 + 3.5 + 1.2	42. 8 57. 5 20. 1	0.1 0.2 0.1	42.7 57.3 20.0	4.099072 0.202738 9.995824 9.835717
Horn-Grand Horn-Pascagoula		+ 8.5		0.4		4. 297634+1 4. 137527
Paseagoula–Petit Horn Paseagoula Petit	77 06 13.2 60 16 33.4 42 37 10.3	+2.9 + 0.5 + 0.3	16.1 33.9 10.6	0.2 0.2 0.2	15. 9 33. 7 10. 4	4. 295763 0. 011094 9. 938732 9. 830670
Horn-Petit Horn-Pascagoula		+ 3.7		0.6		4. 245589 4. 137527
Grand-Petit Horn Grand Petit	38 16 34.2 61 04 37.2 80 38 48.9	-0.9 + 0.3 + 0.9	33.3 37.5 49.8	0. 2 0. 2 0. 2	33. 1 37. 3 49. 6	4.095452 0.207995 9.942142 9.994188
Horn-Petit Horn-Grand		+ 0.3		0.6		4.245589 4.297635

# Preliminary computation of triangles—Continued

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Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
Pascagoula–Horn Belle Pascagoula Horn	• / // 48 58 49. 8 69 43 28. 0 61 17 53. 5	" - 1.8 - 3.4 - 5.6	" 48.0 24.6 47.9	" 0.2 0.1 0.2	° / " 47.8 24.5 47.7	4. 137527 0. 123352 9. 972217 9. 943058
Belle-Horn Belle-Pascagoula		-10.8		0.5		4. 232096 4. 202937
Belle–Pascagoula Club Belle Pascagoula	58 40 43.3 89 28 55.3 31 50 23.4	$+ 1.1 \\ - 0.6 \\ - 2.1$	44. 4 54. 7 \ 21. 3	0.1 0.2 0.1	$44. \ 3 \\ 54. \ 5 \\ 21. \ 2$	4. 202937 0. 068406 9. 999982 9. 722253
Club-Pascagoula Club-Belle		- 1.6		. 0.4		4. 271325 3. 993596
Belle-Horn Clu5 Belle Horn	105 43 56.9 40 30 05.5 ,33 45 53.7	-0.4 +1.2 +3.4	56.5 06.7 57.1	0.1 0.1 0.1	56, 4 06, 6 57, 0	4. 232096 0. 016582 9. 812561 9. 744918
Club–Horn Club–Belle		+ 4.2		0.3		4.061239 3.993596
Pascagoula-Horn Club Pascagoula Horn	47 03 13.6 37 53 04.6 95 03 47.2	-1.5 -1.3 -2.2	12. 1 03. 3 45. 0	$0.1 \\ 0.1 \\ 0.2$	12.0 03.2 44.8	4. 137527 0. 135496 9. 788216 9. 998302
Club-Horn Club-Pascagoula		- 5.0		0.4		4.061239 4.271325
Belle-Club Decr Belle Club	41 02 10,7 102 35 18,5 36 22 26,8	+ 0.7 + 1.5 + 2.0	11.4 20.0 28.8	0.1 0.0 0.1	11.3 20.0 28.7	3.993596 0.182739 9.989432 9.773101
Deer-Club Deer-Belle		+ 4.2		0.2		4.165767
Deer-Belle Ship Deer Belle	33 10 60.2 97 49 37.9 48 59 22.9	-1.8 -1.8 + 2.9	58.4 36.1 25.8	0.1 0.1 0.1	58.3 36.0 25.7	3. 949436 0. 261764 9. 995935 9. 877717
Ship-Belle Ship-Deer		- 0.7		0.3		4.207135 ⁺¹ 4.088917
Deer-Club Ship Deer Club	70 52 35.0 56 47 27.2 52 20 03.5	-0.5 -2.5 -2.3	34.5 24.7 01.2	0.2 0.1 0.1	34.3 24.6 01.1	4.165767 0.024654 9.922554 9.898496
Ship-Club Ship-Deer		- 5.3		0.4		4. 112975 4. 088917
Belle-Club Ship Belle Club	37 41 34.8 53 35 55.6 88 42 30.3	+ 1.3 - 1.4 - 0.3	36.1 54.2 30.0	0.1 0.1 0.1	36. 0 54. 1 29. 9	3.993596 0.213650 9.905729 9.999890
Ship-Club Ship-Belle		- 0.4		0,3		4. 112975 4. 207136

# Preliminary computation of triangles—Continued
Station	Observed angle	Correc- tion	Spher- ical angle	Spher- ical excess	Plane angle	Loga- rithm
Deer-Ship Biloxi Lighthouse Deer Ship	• / // 48 11 17.4 96 30 31.2 35 18 04.4	" + 3.6 + 2.3 + 1.4	" 21.0 33.5 05.8	" 0.1 0.1 0.1	° / // 20.9 33.4 05.7	4.088917 0.127640 9.997191 9.761838
Biloxi Lighthouse–Ship Biloxi Lighthouse–Deer		+ 7.3		0,3		4.213748 3.978395
Isiloxi Lighthouse–Deer Ship Island Lighthouse Biloxi Lighthouse Deer	25 30 02.1 81 55 36.0 72 34 26.4	+ 1.4 - 1.7 - 3.7	03.5 34.3 22.7	$0.2 \\ 0.1 \\ 0.2$	$03.3 \\ 34.2 \\ 22.5$	3. 978395 0. 366001 9. 995674 9. 979593
Ship Island Lighthouse-Deer Ship Island Lighthouse-Biloxi Light- house		- 4.0		0.5		4.340070 4.323989
Biloxi Lighthouse–Ship Ship Island Lighthouse Biloxi Lighthouse Ship	50 31 41.2 33 44 18.6 95 44 07.0	-0.9 -5.3 -0.1	40.3 13.3 06.9	$0.2 \\ 0.2 \\ 0.1$	40.1 13.1 06.8	4.213748 0.112420 9.744591 9.997821
Ship Island Lighthouse-Ship Ship Island Lighthouse-Biloxi Light- house		- 6.3		0.5		4.070759 4.323989
Deer-Ship Ship Island Lighthouse Deer Ship	25 01 39.1 23 56 04.8 131 02 11.4	-2.3 + 6.0 + 1.3	$36.8 \\ 10.8 \\ 12.7$	0.1 0.1 0.1	36.7 10.7 12.6	4.088917 0.373615 9.608227 9.887537
Ship Island Lighthouse–Ship Ship Island Lighthouse–Deer		+ 5.0		0.3		4.070759 4.340069+1

# Preliminary computation of triangles—Continued

91865°—15——10

# Preliminary position computation,

	α Second angle	East base West bas	e to west ba	lse				。 84 +53	, 14 37	" 41.9 24.4
	α 1α	East base	e to Cat					137	52 2	06. 3 08. 4
	α'	Cat to eas	st base		I	First angle of	triangle	$     \begin{array}{r}       180 \\       317 \\       66     \end{array} $	00 49 01	00. 00 57. 9 24. 1
	φ	30	14 5	6. 379	Dauphin	Island east	λ	88	08	14.288
	Δφ_	+	4 0	4.171		<b>G</b> . (	Δλ	+	4	14.637
1	φ'	30 [	19   0	0.550		Cat	1 λ'	1 88	12	28.925
	$\frac{1}{2}(\phi+\phi')$	30 16 5	$\begin{cases} 8 \\ \cos \alpha \\ B \end{cases}$	4.006 9.870 8.511	089 8 ² 173 sin ² 556 C	α 8. 0122 9. 6532 1. 1712	h² D	4.776 2.332	$s^2 \frac{-h}{E} \alpha$	2.388 7.665 5.917
-	1st term 2d, 3d, and 4th terms	-244.240 + 0.070	7 h 0	2.387	818	8.8366 +0.0686		7.108 +0.0013		5.970 +0.0001
	-40	-244.170	7							
- Contraction of the local data			4.006089 9.826616 8.509352 0.063865	sin	$d\lambda \over \frac{1}{2}(\phi + \phi')$	2. 405922 9. 702663				
			2. 405922			2.108585				
		0	11 1254 6373		-10	//				
1	100	21								

STATION CAT

## STATION CEDAR

α Second angle	East base West bas	e to west bas ie and Cedar	3 <del>0</del>					° 84 +103	, 14 55	'' 41. 9 35. 5
α Δα	East base	e to Cedar						188 +	10	17.4 29.4
α'	Cedar to	east base		1	First ang	le of t	triangle	180 8 37	00 10 26	00.00 46.8 32.1
φ	30	14 56	. 379 Dai	ıphir	i Island base	east	λ	88	08	14. <b>2</b> 88
Δ¢	+	5 51	. 941				Δλ			58.265
φ'	30	20 48	$\begin{array}{c c} 320 \\ +1 \end{array}$	0	ledar		λ'	88	07	16.023
½(φ+φ')	• / / 30 17 5: //	$2 \begin{vmatrix} 8 \\ \cos \alpha \\ B \end{vmatrix}$	4. 0393 9. 9955 8. 5115	$\begin{array}{c c}54\\68\\56\end{array}$	$sin^2 \alpha C$		8.0787 8.3054 1.1712	h² D	5. 093 2. 332	
$\left.\begin{array}{c} 1 \text{st term} \\ 2 \text{d and } 3 \text{d} \\ \text{terms} \end{array}\right\}$	-351.947 + 0.006	6 h 3	2.5464	78		+	7. 5553 0. 0036		7.425 +0.0027	
-44	-351.941	3	1					ļ		
		4. 039354 9. 152706 8. 509351 0. 063997 1. 765408	Δλ sin ½(φ-	⊦φ')	1. 76 9. 70 1. 46	5408 2857 8265				
	Δλ	-58.2650	10	:	2	9, 39				

#### secondary triangulation

" 0 West base to east base Cat and east base 264 11 21 22.1 11.8 a Third angle - 60 West base to Cat 203 50 10.3 11.7 α + 1 10 6 . 180 00 00.00 22.0 Cat to west base  $\alpha'$ 23 51 0 1 " Dauphin Island west base 30 14 21.492 ·¢ 88 14 51.034 λ 39.058 JA 14 + 4 2 22.109  $\phi'$ 00.550 30 19 Cat λ' 88 12 28.925 0 , 21 3. 972892 9. 961281 8. 511557 32 7.9458 9.2130 -h $s^2 \sin^2 \alpha$ 2. 445 7. 159 5. 917 8 h2 30 16 41 cos α B  $\sin^2 \alpha$ 4. 891 2. 331  $\frac{1}{2}(\phi + \phi')$ C 1.1711 Ð E ,, 1st term 2d, 3d, and 4th terms -279.0808 h 2.445730 7.222 8.3299 5.521 + 0.0231 +0.0214+0.0017-14 -279.0577 3. 972892 9. 606514 8. 509352 0. 063865 8  $\sin_{\Lambda'} \alpha$ 2.152623 9.702600  $\sin \frac{j\lambda}{(\phi+\phi')}$ sec \quad \langle 2.152623 1.855223 " " Δλ -142.1095 -<u></u>Δα -71.65

#### STATION CAT

#### STATION CEDAR

α Third angle	West base Cedar and	e to east b l east base	aso				° 264 - 38	, 11 37	22. 1 52. 7
α 1α	West base	e to Cedar					225 +	33 3	29.4 49.5
α΄	Cedar to	west base					180 45	00 37	00.00 18.9
	20	ú	1 409 1	Dauphin	Island west		00		F1 024
φ 16	- 00	6 5	26. 829		base		- 88	14	35,011
φ'	30	20 4	8. 321	(	Cedar	λ'		07	16.023
$\frac{1}{2}(\phi + \phi')$ 1st term 2d, 3d, and 4th terms $-4\phi$	$ \begin{array}{c} \circ & , & , \\ 30 & 17 & 35 \\ & , \\ & , \\ & -387. 0517 \\ + & 0. 2227 \\ \hline & -386. 8290 \\ \end{array} $	$\frac{s}{B}$	4. 23099 9. 84521 8. 51155 2. 58776	$\begin{array}{c c}9\\3\\7\\9\end{array} \\ \begin{array}{c}s^2\\sin^2\\C\end{array}$	x 8.4620 9.7073 1.1711 9.3404 +0.2190	h² D	5. 176 2. 331 7. 507 +0. 0032	−h ≉²sin²α E	2. 588 8. 169 5. 917 6. 674 +0. 0005
	8 Δ' Sec φ'	4. 23099 9. 85367 8. 50935 0. 06399 2. 65802 '' -455, 011	$\begin{array}{c c} 9\\5\\1\\7\\2\\2\\1\\-\end{array}$	1λ (φ+φ') -Jα	2. 658022 9. 702795 2. 360817 '' -229, 52				

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# 146 COAST AND GEODETIC SURVEY SPECIAL PUBLICATION NO. 28.

# Preliminary position computation,

~	α Second angle	Cedar to West bas	west base e and Pins					• 45 + 53	, 37 39	" 18.9 41.5
	a sa	Cedar to	Pins					- 99	17 • 5	00. 4 43. 8
	α'	Pins to C	edar		Fir	st angle of t	riangle	180 279 58	$\begin{array}{r} 00\\11\\45\end{array}$	00.00 16.6 23.2
	ф 4	30 +		. 321 . 926	Ce	dar	λ _1λ	+ 88	07 11	16.023 20.238
	$\phi'$	30	22 24	. 247	Pi	ins	λ'	88	18	$\begin{array}{r} 36.261 \\ +1 \end{array}$
	$\frac{1}{2}(\phi+\phi')$	° / // 30 21 30 //	$\begin{array}{c c} & s \\ \cos \alpha \\ B \end{array}$	4. 264921 9. 207685 8. 511550	${{\sin^2 \alpha} \over { m C}}$	$\begin{array}{r} 8.5298 \\ 9.9885 \\ 1.1729 \end{array}$	h² D	3. 968 2. 332	${{\rm s}^2 {{\rm sin}^2 \alpha} \over {\rm E}}$	1.984 8.518 5.919
	1st term 2d, 3d, and 4th terms	-96.4173 + 0.4910	5 h	1.984156		9. 6912 +0. 4911		6.300 +0.0002		6. 421 +0. 0003
	-2 <i>φ</i>	$-95.925$ $sin \alpha$ $\Lambda'$	4, 264921 9, 994274 8, 509350			2. \$32661	I	1		1
		$\sec \phi'$	0.064116	$\sin \frac{1}{2}(\phi$	+\$\$')	9. 703663				
	-	42	+680, 2382	-4	α	+343, 81				
				-						

STATION PINS

STATION GRAND

α Second angle	Pins to w West bas	est base e and Gran	d				$ ^{\circ}_{337}$ + 85	, 56 13	'' 39. 8 08. 3
α Δα	Pins to G	rand					- 63	09 3	48.1 32.3
α'	Grand to	Pins		Fire	st angle of t	triangle	$     \begin{array}{r}       180 \\       243 \\       54     \end{array} $	$\begin{array}{r} 00\\06\\52\end{array}$	00.00 15.8 00.2
$\phi \\ \Delta \phi$		$\begin{array}{c c} 22 \\ 22 \\ 3 \\ 04 \end{array}$		Pi	ns	$\lambda$ $\Delta\lambda$	+ 88	18 7	36. 262 00. 260
φ'	30	19   19	589	Gra	ind	λ'	88	25	36.522
$\frac{1}{2}(\phi+\phi')$	° ' '' 30 20 5:	$\begin{array}{c c} s \\ cos \\ B \end{array}$	4. 099768 9. 654608 8. 511548	$\left  \begin{array}{c} s^2\\ \sin^2\alpha\\ C \end{array} \right $	$\begin{array}{r} 8.1995 \\ 9.9010 \\ 1.1734 \end{array}$	h² D	4. 532 2. 333	$s^2 \frac{-h}{E} \alpha$	2. 266 8. 100 5. 919
1st term 2d, 3d, and 4th terms }	+184.4693 + 0.1884	3 h 4	2.265924		9.2739 +0.1879		6.865 +0.0007		6. 285 0. 0002
$-\Delta\phi$	+184.657	7		1			]		
		4, 099768 9, 950510 8, 509352 0, 063888	$\sin \frac{d\lambda}{2}(\phi$	+ \vert ')	2.623518 9.703504				
		2.623518			2.327022				
	Δλ	+420.2600	-4	α	,, +212.33				2

# secondary triangulation—Continued

STATION PINS

							0	,	
a Third angle	West bas Pins and	e to Cedar Cedar					$-\frac{225}{67}$	33 34	29.4 55.9
α 1α	West bas	e to Pins					-157	58 1	33. 5 53. 7
α'	Pins to w	est base					180 337	00 56	00. 00 39. 8
ø	30	14 2		uphin Is	land west	λ	88	- 14	51.034
Δф	+	8 0	2, 754	D	430	Δλ	+	3	45.228
φ'	30	22 2	4.246 +1	Р	ins	λ'	88	18	36. 262
$\frac{1}{2}(\phi+\phi')$	30 18 23	$\begin{array}{c} 8 \\ \cos \alpha \\ B \end{array}$	4. 205130 9. 967092 8. 511557	${{\sin^2 \alpha} \over { m C}}$	8. 4103 9. 1480 1. 1711	h² D	5, 368 2, 331	${{\rm s}^2 \sin^2 \alpha \atop {\rm E}}$	2.684 7.558 5.917
$ \begin{array}{c} 1 \text{ st term} \\ 2d, 3d, and \\ 4th terms \\ -\Delta \phi \end{array} $	-482.8131 + 0.0587 -482.754	h	2.683779		8, 7294 +0, 0534		7.699 +0.0050		6.159 +0.0001
	8 Sin α Α' Sec φ'	4, 205130 9, 574020 8, 509350 0, 064110 2, 352622	$\frac{d\lambda}{\sin \frac{1}{2}(\phi)}$	, + \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	2, 352622 9, 702967 2, 055589		,		
	<i>Δ</i> λ	+225.2278	3 -4	α	+113.66				

STATION GRAND

α Third angle	West base to Pins Grand and Pins				• 157 - 39	, 58 54	'' 33. 5 52. 0
α 1α	West base to Gran	d			118	03 5	41. 5 25. 5
α'	Grand to west bas	•			180 297	00 58	00.00 16.0
φ	° ′ 30 14	21. 492 Dauphin	Island west base	λ	88	14	51.034
44	+ 4	58.097		Δλ	+	10	45.488
φ'	30 19	19, 589	Grand	λ'	88	25	36. 522
[}] 2(φ+φ')	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c c c} 4.290961 & s^2 \\ 9.672485 & \sin^2 s \\ 8.511557 & C \end{array}$	$\begin{array}{c c} \alpha & 8.5819 \\ 9.8914 \\ 1.1711 \end{array}$	h² D	4,950 2,331	$s^2 \frac{-h}{E} \alpha$	2. 475 8. 473 5. 917
1st term 2d, 3d, and 4th terms	-298.5403 h + 0.4436	2. 475003	9.6444 +0.4410	-	7.281 ⊢0.0019		6.865 +0.0007
-20	$\begin{array}{c c} -298,0967 \\ \hline \\ sin \\ \alpha \\ \lambda' \\ sec \\ \phi' \\ \hline \\ 2,8098 \\ \hline \\ 2,8098 \\ \hline \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $	$\begin{vmatrix} & & \\ 1 \\ 37 \\ 52 \\ 88 \\ 88 \\ 88 \\ 88 \\ 88 \\ 88 \\ 88$	2, 809888 9, 702633 2, 512521		1		
K	$\Delta \lambda$ +645, 48	77 —Δα	+325,48				

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Preliminary position computation,

STATION PETIT

α Second angle	Grand to West bas	west base e and Petit				$^{\circ}_{297}$ + 59	, 58 11	'' 16.0 52.8
α 1α	Grand to	Petit				357 +	10	08.8 11.6
α'	Petit to (	Frand		First ar	gle of triangle	180 177 81	00 10 41	00.00 20.4 28.3
ф 1ф		19 19 6 44.	589 089	Grand	λ Δλ		25	36. 522 23. 005
φ'	30	12 35.	500	Petit	λ'	88	25	13.517
$\frac{1}{2}(\phi + \phi')$ 1st term 2d and 3d terms $-4\phi$	* / // 30 15 58 // + 404.0853 + 0.0041 +404.0894	$\begin{array}{c c} s \\ cos \\ B \\ B \\ h \\ \frac{1}{4} \end{array}$	4.095452 9.999470 8.511551 2.606473	$s^{2}$ $sin^{2} \alpha$ C	$ \begin{array}{r} 8.1909\\ 7.3872\\ 1.1725\\ \hline 6.7506\\ +0.0006\\ \end{array} $	h² D	5. 213 2. 332 7. 545 0. 0035	
	$\frac{s}{A'}$ sec $\phi'$	4. 095452 8. 693623 8. 509354 0. 063392	$\int d\lambda \sin \frac{1}{2}(\phi + \phi')$	1.	361821 702445		•	
1	Δλ	-23.0049	<i>Δ</i> α	-	-11.59			

# STATION HORN

α Second angle	Grand to Petit and	Petit Horn					$  {}^{\circ}_{357} + {}^{61}_{61}$	, 10 04	// 08.8 37.5
α	Grand to	Horn	•				- 58	14 5	46.3 18.1
α'	Horn to (	lrand		101		(	180 238	00 09	00.00 28.2 1
	•		· 1	FI	rst angle of	triangie		10	
ф 1ф	30	19 5 39.	589 578	Gr	and	$\begin{vmatrix} \lambda \\ \Delta \lambda \end{vmatrix}$	88 +	25 10	$36.522 \\ 31.017$
φ'	30	13 40.	011	H	orn	λ'	88	36	07. 539
½(φ+φ')	• / // 30 16 3	$ \begin{array}{c c} 8 \\ \cos \alpha \\ B \\ \end{array} $	4. 297635 9. 721209 8. 511551	${\mathop{\sin^2 \alpha}\limits^{8^2}}_{{ m C}}$	8.5953 9.8592 1.1725	h? D	5.061 2.332	$s^2 \frac{-h}{E} \alpha$	2, 530 8, 454 5, 918
1st term 2d, 3d, and 4th terms	+339.152 + 0.425	5 h 2	2, 530395		9.6270 +0.4236		7.393 +0.0025		6, 902 0, 0008
$-\Delta\phi$	+339.5776 $\sin \alpha$	4. 297635 9. 929581					1	l.	
	$\sec \phi'$	8,509354 0,063471	$\sin \frac{d\lambda}{2}(\phi)$	+ <i>φ</i> ′)	2.800041 9.702560				
		2.800041			2. 502601				
	Δλ	+631.0170	-1	α	+318.13				

secondary triangulation-Continued

α Third angle	West base Petit and	e to Grand Grand					° 118 - 39	, 03 06	" 41.5 39.4
α <u>J</u> α	West base	e to Petit					- 78	57 5	02.1 13.4
α'	Petit to w	vest base					180 258	00 51	00.00 48.7
ф 1ф	_30	' 14 21 1 45	. 492 Da	uphin Is b	sland west	λ λ	+ 88	14 10	51.034 22.484
φ'	30	12 35	. 500	P	etit	λ'	88	25	13.518 -1
$\frac{1}{2}(\phi+\phi')$	° ′ ″ 30 13 28	$\begin{array}{c c} 8 \\ \cos \alpha \\ B \\ \end{array}$	4. 229508 9. 282521 8. 511557	$\frac{s^2}{\sin^2 \alpha}$	8. 4590 9. 9837 1. 1711	h² D	4.047 2.331	^{-h} s² sin² α E	2.024 8.443 5.917
1st term 2d, 3d, and 4th terms	+105.5810 + 0.4109	) h	2.023586		9.6138 +0.4109		6.378 +0.0002		6.384 -0.0002
<i>4</i> ¢	+105.9919	4. 229508 9. 991874	1		1 1	}	I		
	A' sec $\phi'$	8, 509354 0, 063392	$\sin \frac{d\lambda}{2}(\phi$	+¢')	2.794128 9.701905				
	42	2. 794128 " +622. 4837	-4	α	2, 496033 '' +313, 35				
			-						

STATION PETIT

# STATION HORN

Third angle $\alpha$	Petit to G Grand and Petit to H	rand 1 Horn Iorn					° 177 - 80 - 96 -	, 10 38 31 5	" 20. 4 49. 8 30. 6 29. 2
α'	Horn to P	etit					180 276	00 26	00.00 01.4
ф 14	30 +		" 5, 500 4, 511	Pe	etit	$\lambda$ $\Delta \lambda$	+ 88	25 10	13. 517 54. 021
φ'	30	13 40	0.011	H	orn	λ'	88	36	07.538 -1
$\frac{1}{2}(\phi+\phi')$	° ' '' 30 13 08 ''	cos α B	4.245589 9.055530 8.511559	$\frac{\delta^2}{\sin^2 \alpha}$	8. 4912 9. 9943 1. 1706	h² D	3.625 2.331	^{-h} s² sin² α E	1.813 8.485 5.916
$ \begin{array}{c} \text{1st term} \\ \text{2d, 3d, and} \\ \text{4th terms} \\ \end{array} \\ \begin{array}{c} - \mathcal{I} \phi \end{array} $	-64.9648 + 0.4533 -64.5115	h	1.812678		9.6561 +0.4530		5.956 +0.0001		6. 214 +0. 0002
	$\frac{ \underset{A'}{\sin \alpha} }{\underset{\sec \phi'}{\operatorname{sec } \phi'} }$	4. 245589 9. 997178 8. 509354 0. 063471	$\sin \frac{4}{2}(\phi)$	λ +φ')	2.815592 9.701830				
	Δλ	2.815592 ,, +654.0214	-4	α	2. 517422 '' +329. 17				

# Preliminary position computation,

α Second angle α Δα	Grand to Horn and Grand to	Horn l Pascagoula Pascagoula	a					, 14 14 29 3	" 46.3 20.1 06.4 52.8
α'	Pascagou	la to Grand		Fir	st angle of t	triangle	180 281 97	00 25 55	00.00 13.6 57.5
ф 1ф	30 +		. 589 . 006	Gra	und	$\begin{vmatrix} \lambda \\ \Delta \lambda \end{vmatrix}$	+ 88	$25 \\ 7$	36. 522 40. 922
$\phi'$	30	20 40	. 595	Pasca	goula	λ'	88	33	17.444
½(φ+φ')	° ' '' 30 20 00	$\begin{array}{c c} & s \\ \cos \alpha \\ B \\ \end{array}$	4.099072 9.299100 8.511551	$\begin{array}{c} s^2\\ \sin^2\alpha\\ C\end{array}$	8.1981 9.9824 1.1725	h² D	3. 820 2. 332	$s^2 \frac{-h}{E} \alpha$	1.910 8.180 5.918
1st term 2d, 3d, and 4th terms	-81.2312 + 0.225	2 h	1.909723		9.3530 +0.2254		6.152 +0.0001		6.008 +0.0001
$-\Delta\phi$	-81.005	5 [']							
	$sin \alpha \\ A' \\ sec \phi'$	4.099072 9.991216 8.509351 0.063988	$\int \frac{d\lambda}{\sin \frac{1}{2}(\phi)}$	+ \vert ')	2, 663627 9, 703317				
		2.663627			2.366944 //				
	Δλ	+460.9215	-4	α	+232.78				

STATION PASCAGOULA

STATION BELLE

	1							
α Second angle	Paseagoula Horn and J	to Horn Belle				$^{\circ}_{+ 69}$	, 21 43	'' 11.1 24.6
α Δα	Pascagoula	to Belle				- 89	04 5	35.7 01.8
α'	Belle to Pa	scagoula	F	riangle	180 268 48	00 59 58	00.00 33.9 48.0	
$\phi$ $\Delta\phi$	- 30	20 40.4	730 Pas	cagoula	$\lambda$ $\Delta\lambda$	+ 88	33 9	17. 444 57. 323
φ'	30	20 31.8	865 J	Belle	λ'	88	43	14.767
$\frac{1}{2}(\phi+\phi')$	° ' '' 30 20 36	cos α B	4. 202937 8. 207256 8. 511550	$ \begin{bmatrix} 8^2 \\ 1^2 \alpha \\ 0 \end{bmatrix} = \begin{bmatrix} 8.405 \\ 9.999 \\ 1.172 \\ 0 \end{bmatrix} $	9 9 9			
1st term 2d term	+8.3511 +0.3790	h	0. 921743	9. 578 +0. 379	7 0			
$-\Delta\phi$	+8.7301			1				
	$\frac{s}{\Lambda'}_{\substack{\Lambda'\\sec\ \phi'}}$	4. 202937 9. 999944 8. 509351 0. 063977	$d\lambda \\ \sin \frac{1}{2}(\phi + \phi')$	2. 776209 9. 703447				
		2.776209		2. 479656				
	Δλ	+597.3226	- <u></u> Δα	+301.76				

# secondary triangulation-Continued

α Third angle	Horn to ( Pascagou	Grand la and Gi	rand				$ \begin{array}{c c}  & & & \\  & & & \\  & & & & \\  & & & & &$	, 09 49	" 28, 1 42, 8
α Δα	Horn to ]	Pascagoul	la				199 +	19 1	45.3 25.8
α'	Pascagou	la to Hor	n				180 19	00 21	00.00
$\phi$ $\Delta\phi$	30 +	13 7	40.011 00.584	Ho	orn	$\lambda$ $\Delta \lambda$	- 88	36 2	07. 539 50. 094
φ'	30	20	40. 595	Pasca	goula	λ'	88	33	17.445 -1
¹ / ₂ (φ+φ')	° ' '' 30 17 10	$\begin{pmatrix} 8 \\ \cos \alpha \\ B \end{pmatrix}$	$\begin{array}{c} 4.\ 137527\\ 9.\ 974803\\ 8.\ 511558\end{array}$	$sin^2 \alpha$	8. 2750 9. 0396 1. 1709	h² D	5. 248 2. 331	$s^2 \frac{-h}{E} \alpha$	2.624 7.315 5.917
1st term 2d, 3d, and 4th terms	-420.6182 + 0.0343	2 h	2.623888		8.4855 +0.0306		7.579 +0.0038		5.856 +0.0001
— <i>4</i> ¢	-420.583	7   4. 1375	527	1	1	1			1
	$\frac{\sin \alpha}{\Lambda'}$ sec $\phi'$	9, 5198 8, 5093 0, 0639	$\begin{array}{c c} 324 \\ 351 \\ 388 \\ 388 \\ 311 \\ 32(q) $	δ+φ')	<b>2. 230</b> 690 9. 702706				
		2. 2306	90		1. 933396				
	Δλ	-170.09	H4 -4	α	-85.78				

STATION PASCAGOULA

STATION BELLE

							0	,	,,
a Third angle	Horn to P Belle and	ascagoula Pascagoula					$-{}^{199}_{61}$	19 17	45. 3 47. 9
α Δα	Horn to H	Belle					138	01 3	57.4 35.5
α'	Belle to H	lorn					180 317	00 58	00.00 21.9
	0.1								
ф 4	30 +	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	011 853	He	orn	$\lambda$ $\Delta\lambda$	+ 88	36 7	07. 539 07. 228
φ'	30	20 31.	864	Be	elle	λ'	88	43	14.767
<u>}</u> (φ+φ')	° / // 30 17 06 //	cos α B	4. 232096 9. 871296 8. 511558	$\frac{s^2}{C} \alpha$	8.4642 9.6505 1.1709	h² D	5. 230 2. 331		2. 615 8. 115 5. 917
1st term 2d, 3d, and	-412.0501 + 0.1976	h 1	2. 614950		9. 2856 +0. 1936		7.561 +0.0036		6.647 +0.0004
$-2\phi$	-411. 8525								
	$\frac{\sin \alpha}{\Lambda'}$ sec $\phi'$ .	4. 232096 9. 825236 8. 509351 0. 063977	$\int d\lambda \sin \frac{1}{2}(\phi$	+ <i>φ</i> ')	2, 630660 9, 702690				
		2. 630660			2.333350				
	Δλ	" +427.2283	-4	α	" +215,45				

Preliminary position computation,

α Second angle	Belle to I Horn and	Iorn I Club					$^{\circ}_{+40}$	, 58 30	21. 9 06. 7
α <u>1</u> α	Belle to C	lub					$+^{358}$	28	28.6 05.0
α'	Club to B	selle		First	angle of tr	iangle	180 178 105	$\begin{array}{r}00\\28\\43\end{array}$	00. 00 33. 6 56. 5
ф 1ф		20 31. 5 19.	864 886	Belle		$\lambda$ $\Delta\lambda$	- 88	43	14.767 09.812
$\phi'$	30	15 11.	978	Club		λ'	88	43	04.955 + 1
$\frac{1}{2}(\phi + \phi')$ 1st term 2d and 3d	° / // 30 17 52 +319.8836 + 0.0023	$\begin{bmatrix} 8 \\ \cos \alpha \\ B \\ -3 \end{bmatrix} = \begin{bmatrix} 8 \\ -3 \\ -3 \end{bmatrix}$	3,993596 9,999846 8,511550 2,504992	${\mathop{\sin^2 \alpha}\limits_{\mathrm{C}}}^{8^2}$	$     \begin{array}{r}       7.9872 \\       6.8504 \\       1.1729 \\       \hline       6.0105 \\       +0.0001 \\       \end{array} $	h² D	5. 010 2. 332 7. 342 +0. 002	2	
$-4\phi$	+319.8859								
	$\frac{\sin \alpha}{A'}$ $\sec \phi'$	3. 993596 8. 425207 8. 509353 0. 063584 0. 991740	$d\lambda$ $\sin \frac{1}{2}(\phi + \phi$	s)	0. 991740 9. 702856 0. 694596				
- 1	Δλ		<i>—</i> ⊿α		-4.95				-

STATION CLUB

STATION DEER

	1								
$\alpha$ Second angle	Belle to ( Club and	Club Deer					$^{\circ}_{358}_{+102}$	, 28 35	28.6 20.0
Δα	Belle to I	Deer					101	$\begin{array}{c} 03\\ 2\end{array}$	48.6 45.3
α'	Deer to I	Belle					180 281	00 01	00.00
				First	angle of tr	iangle	41	02	+.1 11.4
$\phi$ $\Delta\phi$	30 +	20 31. 55.	864 356	Belle		λ _1λ	+ 88	43 5	14.767 27.103
φ'	30	21 27.	. 220	Deer		λ'	88	48	41.870
$\frac{1}{2}(\phi+\phi')$	° ' ' 30 21 0		3. 949436 9. 283068 8. 511550	$s^2 \sin^2 \alpha C$	7. 8989 9. 9837 1. 1729	h² D	3. 488 2. 332		
$\left. \begin{array}{c} 1st \ term \\ 2d \ and \ 3d \\ terms \end{array} \right\}$	-55.469 + 0.113	5 h 7	1.744054		9.0555 +0.1136		5.820 +0.000	) )1	
$-\Delta\phi$	-55.355	8	1			1 1			
	$sin \alpha \\ A' \\ sec \phi'$	3. 949436 9. 991853 8. 509351 0. 064045	$\int \frac{d\lambda}{\sin \frac{1}{2}(\phi+q)}$	b') 2.	514685 703531		-		
		2. 514685		2.	218216				
	Δλ	" +327.1033	- <u>1</u> a	+	'' 165. 28				

secondary triangulation—Continued

α Third angle	Horn to 1 Club and	Belle Belle					° 138 - 33	, 01 45	" 57.4 57.1
α	Horn to C	Club					104	16 . 3	00. 3 30. 2
α'	Club to E	Iorn					180 284	00 12	00. 00 30. 1
	•	1	"			1			
ф 1¢	30 +	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	. 011 . 967	H	orn	$\lambda$ $\Delta\lambda$	+ 88	36 6	07. 539 57. 418
φ'	30	15 11.	. 978	Cl	ub	λ'	88	43	04.957 -1
$\frac{1}{2}(\phi+\phi')$	° ′ ′′′ 30 14 26	$\begin{array}{c} 8 \\ \cos \alpha \\ B \end{array}$	4. 061239 9. 391705 8. 511558	$sin^2 \alpha$	8. 1225 9. 9728 1. 1709	h² D	3. 929 2. 331	$s^2 \frac{-h}{E} \alpha$	1. 964 8. 095 5. 917
1st term 2d, 3d, and 4th terms	-92.1514 + 0.1848	h 1 3	1.964502		9.2662 +0.1845		6.260 +0.0002		5.976 +0.0001
-4φ	-91.9666	3							
	$\frac{s}{sin \alpha}$ A' Sec $\phi'$	4.061239 9.986395 8.509353 0.063584	$\int \frac{d\lambda}{\sin \frac{1}{2}(\phi)}$	+\$')	2. 620571 9. 702113				`
		2,620571			2.322684				
	Δλ	// +417. 4179	-4	α	+210.22				1

STATION CLUB

STATION DEER

α Third angle α Δα	Club to F Deer and Club to I	Belle Belle Deer					• 178 - 36 142 -	, 28 22 06 2	" 33.6 28.8 04.8 50.0
α'	Deer to C	lub					180 322	00 03	00. 00 14. 8
ф 1ф	30 +		// 1. 978 5. 242	Cl	ub	$\begin{vmatrix} \lambda \\ \Delta \lambda \end{vmatrix}$	+ 88	43 5	04. 956 36. 915
φ'	30	21 2	7.220	De	eer	λ'	88	48	41. 871 -1
$\frac{1}{2}(\phi+\phi')$	° ′ ′′ 30 18 20 ′′	$ \begin{vmatrix} 8 \\ \cos \alpha \\ B \end{vmatrix} $	4. 165767 9. 897131 8. 511556	$sin^2 \alpha$	8. 3315 9. 5767 1. 1713	h² D	5, 149 2, 331	$s^2 \frac{-h}{E} \alpha$	2. 574 7. 908 5. 918
1st term 2d, 3d, and 4th terms	-375.3652 + 0.1233	2 h 3	2. 574454		9.0795 +0.1200		7.480 +0.0030		6.400 +0.0003
-30	$\frac{8}{\text{sin }\alpha}$ $\frac{3}{\text{sec }\phi'}$	4. 165767 9. 788357 8. 509351 0. 064045	$\int \frac{d\lambda}{\sin \frac{1}{2}(\phi)}$	- +φ')	2. 527520 9. 702957				
	4λ	2. 527520 " +336. 9147	-4	α	2. 230477 '' +170. 01				

Preliminary position computation,

α Second angle	Deer to C Club and	lub Ship					$^{\circ}_{ m 322}_{ m + 56}$	, 03 47	// 14. 8 24. 7
· α Δα	Deer to S	Ship					- 18	50 1	<b>39.5</b> 14.8
α'	Ship to I	Deer		First	angle of t	riangle	180 198 70	$\begin{array}{r} 00\\ 49\\ 52 \end{array}$	00. 00 24. 7 34. 5
ф 1ф		$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	220 200	Deer		° <u>λ</u> ^∆λ	-+ 88	48 2	41. 870 28. 269
φ'	30	15   10.	020	Ship		λ'	88	51	10.139
$\frac{1}{2}(\phi + \phi')$ 1st term 2d and 3d terms $\left.\right\}$	° / / 30 18 1 +377.173 + 0.026	$ \begin{array}{c c}                                    $	4. 088917 9. 976075 8. 511549 2. 576541	${{\sin^2 \alpha} \over C}$	8.17789.01841.17318.3693+0.0234	h² D	5.1532.3327.485+0.003	; ; ;1	
— <i>4</i> ¢	$+377.199$ $sin \alpha$ $A'$ sec $\phi'$	4. 088917 9. 509200 8. 509353 0. 063581 2. 171051	$\sin \frac{d\lambda}{2(\phi+\phi)}$	φ') 2. 9. 1.	171051 702952 874003	1			
	Δλ	+148.2692	-Δα	+	-74.82				

STATION SHIP

STATION BILOXI LIGHTHOUSE

α Second angle	Deer to S Ship and	hip Biloxi Lig	hthouse				• 18 + 96	, 50 30	,, 39. 5 33. 5
α Δα	Deer to B	iloxi Light	thouse				115	21 2	13.0 42.9
α'	Biloxi Lig	ghthouse to	o Deer	Fir	st angle of	triangle	180 295 48	00 18 11	00, 00 30, 1 21, 0
$\phi \\ \varDelta \phi$	30 +	$\begin{array}{c c} 21\\ 21\\ 2\end{array}$	7. 220 2. 200	De	er	$\lambda$ $\Delta\lambda$	+ 88	48 5	41. 870 22. 085
φ'	30	23 3	9. 420 I -1 I	Biloxi Li	ghthouse	λ'	88	54	$03.955 \\ -1$
$\frac{1}{2}(\phi + \phi')$	° ′ ′′ 30 22 33	$\begin{array}{c} 8 \\ \cos \alpha \\ B \end{array}$	3. 978395 9. 631650 8. 511549	$\left  \begin{array}{c} s^2 \\ \sin^2 lpha \\ C \end{array} \right $	7. 9568 9. 9120 1. 1731	h² D	4, 243 2, 332	$s^2 \frac{-h}{E} \alpha$	2. 121 7. 869 5. 919
1st term 2d, 3d, and 4th terms	-132.3104 + 0.1107	h	2. 121594		9.0419 +0.1102		6. 575 +0. 0004		5.909 +0.0001
- <i>4</i> φ	-132.1997	3, 978395	5.1	]			1	1	
		9, 956010 8, 509350 0, 064209	$\int d\lambda$ $\sin \frac{1}{2}(\phi)$	+\$\$	2. 507970 9. 703868				
		2. 507970	)		2. 211838				
-	Δλ	+322.0846	3 -1	α	+162.87				1

# secondary triangulation—Continued

0 " Club to Deer Ship and Deer  $-\frac{142}{52}$ 06 20 04.8 01.2 a Third angle 03.6 04.4 Club to Ship 89 46 a 4 180 00 00.00  $\alpha'$ Ship to Club 269 41 59.2 0 1  $^{\prime\prime}$ 11.978 01.958 04. 956 05. 182 30 15 Club 43 φ1  $\lambda_{\Delta}$ 88 + 8 φ' Ship λ' 30 15 10.020 88 51 10.138 +1 ${{\sin^2 \alpha} \over {\rm C}}$ 4. 112975 7. 607988 8. 511556 0 1 8.2260 0.0000 3 30 15 11  $\frac{1}{2}(\phi + \phi')$ cos a В 1.1713 " +1.7081 h 1st term 0. 232519 9.3973 2d term +0.2496+0.2496 +1.9577  $- \mathbf{j} \phi$  $\begin{array}{c} 4.\ 112975\\ 9.\ 999996\\ 8.\ 509353\\ 0.\ 063581 \end{array}$ 8  $\sin \alpha \Lambda'$  $\sin \frac{J\lambda}{\phi+\phi'}$ 2.685905 9.702275  $\sec \phi'$ 2.685905 2.388180 " " +485.1824 Jλ  $-\Delta \alpha$ +244.44

STATION SHIP

#### STATION BILOXI LIGHTHOUSE

				-		0	,	,,		
α Third angle	Ship to D Biloxi Lig	eer hthouse a	and Dee	er				$-\frac{198}{35}$	49 18	24.7 05.8
α Ja	Ship to Bi	iloxi Ligh	thouse					163	31 1	18.9 27.8
α'	Biloxi Lig	hthouse t	o Ship					180 343	00 29	00.00 51.1
÷	0	30 15 10.020 Ship > 88								
$\phi \\ \Delta \phi$	+ 30	$\begin{vmatrix} 15 \\ 8 \end{vmatrix} = 2$	0. 020 29. 399	+ 88	51 2	10. 139 53. 815				
φ'	30 Fixed valu	23 3 1e 3	9. 419 9. 419	88	54	03. 954 03. 820				
$\frac{1}{2}(\phi+\phi')$	° ′ ″ 30 19 25	cos α B	4. 2137 9. 9817 8. 5115	48 8 86 sin 56 C	2α 3	8. 4275 8. 9056 1. 1713	$_{ m D}^{ m h^2}$	5.414 2.331	$s^2 \frac{-h}{E} \alpha$	2.707 7.333 5.918
1st term 2d, 3d, and 4th terms }	-509.4364 + 0.0376	h	2. 7070	90		8. 5044 +0. 0319		7.745 +0.0056		5.958 +0.0001
- <i>1</i> \$	- 509. 3988			1						
	$\frac{s}{A'}$	4. 213743 9. 45278 8. 509356 0. 064209	$\begin{bmatrix} 8\\1\\0\\9 \end{bmatrix}$ sin	_Jλ ½(φ+φ')		2. 240088 9. 703190				
		2. 240088 1. 943278								
	κı	// +173. 815	3	- <u></u> Δα	-	+87.76				

0

Preliminary position computation,

α Second angle	Biloxi Light Ship and Shi	house to S ip Island 1	ship Lighthou	ise			° 343 + 33	, 29 44	" 51. 1 13. 3
α	Biloxi Light	house to S	ship Islar	nd Ligł	hthouse		- 17	14 1	04.4 57.9
α'	Ship Island I	Lighthous	e to Bilo	xi Ligi Fir	nthouse st angle of t	riangle	180 197 50	$\begin{array}{r}00\\12\\31\end{array}$	00.00 06.5 40.3
ф Ja		, ,, 23 39.4 10 54.0	419 Bi 077 Bi	iloxi Li	ighthouse	λ <i>Δ</i> λ	+ 88	54 3	03. 954 53. 590
φ'	30	12 45.3	342   Shij +1	p Isla ho	nd Light- use	λ'	88	57	57.544
$\frac{1}{2}(\phi+\phi')$	° ′ ′′ 30 18 12	$ \begin{array}{c c} s & 4. \\ \cos \alpha & 9. \\ B & 8. \end{array} $	323989 980049 511546	$\overset{8^2}{\sin^2 \alpha}_{\mathrm{C}}^{\mathrm{C}}$	8.6480 8.9434 1.1738	h² D	5. 631 2: 332	${\mathop{\rm S}^2 \sin^2 \alpha \atop {\rm E}}$	2. 816 7. 592 5. 919
1st term 2d, 3d, and 4th terms $-\Delta\phi$	+654.0094 + 0.0673 +654.0767	h 2.	815584		8.7652 +0.0583	-	7.963 +0.0092		6.327 -0.0002
	$ \begin{array}{c c} s \\ \sin \alpha \\ \Lambda' \\ \sec \phi' \end{array} $	4. 323989 9. 471708 8. 509354 0. 063404	$d\lambda$ $\sin \frac{1}{2}(\phi +$	⊦¢′)	2.368455 9.702930				
-	<i>Δ</i> λ +:	2. 368455 ,, 233. 5904			2.071385 " +117.87				

# STATION SHIP ISLAND LIGHTHOUSE

Fixed  $\alpha$  Biloxi Lighthouse to Ship Island Lighthouse,  $17^\circ\,14'\,17.\,6''.$ 

# secondary triangulation-Continued

## STATION SHIP ISLAND LIGHTHOUSE

α Third angle	Ship to B Ship Isla	iloxi Lighth nd Lighthou	nouse ise and B	iloxi I.	ighthouse		° 163 - 95	, 31 44	'' 18.9 06.9
α Δα	Ship to Ship Island Lighthouse			- 67	47 3	12.0 25.1			
α'	Ship Isla	Ship Island Lighthouse to Ship			180 247	00 43	00.00 46.9 1		
ф 1ф		, 15 * 10. 2 24.	. 020 . 677		Ship	λ _1λ	+ 88	51 6	10, 139 47, 405
φ'	30 Fixed val	12 45. lue <b>45</b> .	. 343 Sh . 341	ip Isla b	and Light- ouse	λ'	88	57	57. 544 57. 464
$\frac{1}{2}(\phi+\phi')$	• / // 30 13 55	$\begin{array}{c c} s \\ cos \\ B \\ \end{array} \begin{array}{c} s \\ s $	4. 070759 9. 577556 8. 511556	$s^2$ $sin^2 \alpha$ C	8, 1415 9, 9330 1, 1713	h² D	4. 320 2. 331	${\mathop{\rm S}^2 \sin^2 \alpha \atop {\rm E}}$	2. 160 8. 075 5. 918
1st term 2d, 3d, and 4th term	+144.5010 + 0.1764	) h :	2. 159871		9. 2458 +0. 1761		6. 651 +0. 0004		6. 153 0. 0001
—J\$	+144.6774	4 070759	_		1 1				
		9. 966509 8. 509354 0. 063404	Jλ sin ½(φ	+\$	2. 610026 9. 702011				
-		2. 610026			2.312037				
	λL	+407.4046	-10	x	+205.13				

Biloxi L.H. Deer (11) Belle (9) 3 97 Pascagoula (7) 37 36 Pins(3) 33 Grand (5) 22 58 3 Ship (10) Club(8) Ship Id. L.H. Cedar(1) 4 Cat(2) Horn(6) 200 32 Petit (4) Dauphin Id. w. base Dauphin Id. e. base Ft. Morgan

FIG. 7.

## FORMATION OF OBSERVATION EQUATIONS

The position computation was carried westward from the fixed lines at the eastern end of the scheme and the observation equations were formed in the same order. The treatment of fixed lines is the same as in the first adjustment of figure 6, pages 105 et seq. No new detail arises until the points Deer and Ship are reached, which have lines connecting them with the fixed points Biloxi Lighthouse and Ship Island Lighthouse. Suppose for the moment that Biloxi Lighthouse were not fixed but that its latitude and longitude were to receive corrections of  $\partial \phi_{12}$  and  $\partial \lambda_{12}$  respectively. The observation equation for  $v_{57}$  would then read,

$$v_{57} = z_{13} - 603\delta\phi_{11} + 248\delta\lambda_{11} + 603\delta\phi_{12} - 248\delta\lambda_{12} + 0.5$$

The latitude and longitude of Biloxi Lighthouse as developed by the preliminary position computation are 30° 23′ 39.′′419 and 88° 54′ 03.′′954, while the fixed values are 30° 23′ 39.′′419 and 88° 54′ 03.′′820, so that to reduce the preliminary to the fixed values on which the adjustment is built corrections of  $\partial \phi_{12} = 0.000^*$  and  $\partial \lambda_{12} = -0.134$  are necessary. By substituting these values in the equation for  $v_{57}$  there results,

$$v_{57} = z_{13} - 603\delta\phi_{11} + 248\delta\lambda_{11} + 603 \ (0.000) - 248 \ (-0.134) + 0.5$$
  
or,  
$$v_{57} = z_{13} - 603\delta\phi_{11} + 248\delta\lambda_{11} + 33.7$$

as given in the table page 16.

The equation for the reverse direction,  $v_{63}$ , if Biloxi Lighthouse were not fixed, would be,

$$v_{63} = z_{15} - 603\delta\phi_{11} + 248\delta\lambda_{11} + 603\delta\phi_{12} - 248\delta\lambda_{12} + 0.0$$

which with the use of the above values of  $\partial \phi_{12}$  and  $\partial \lambda_{12}$  becomes,

$$v_{63} = z_{15} - 603\delta\phi_{11} + 248\delta\lambda_{11} + 33.2$$

Similar computations must be made for  $v_{56}$ ,  $v_{58}$ ,  $v_{59}$ ,  $v_{64}$ ,  $v_{67}$ , and  $v_{68}$ .

The known terms in the expressions for  $v_{65}$ , and  $v_{66}$  may be found in a similar way by allowing for the fixity of both ends of the line. If the corrections needed to the preliminary position of Ship Island Lighthouse in order to reduce it to the fixed position are called  $\partial \phi_{13}$ and  $\partial \lambda_{13}$  then for the line Biloxi Lighthouse to Ship Island Lighthouse the formula gives,

$$d\alpha = 89(\delta\phi_{13} - \delta\phi_{12}) + 250 \ (\delta\lambda_{13} - \delta\lambda_{12})$$

If the line were free to be turned in azimuth, then by the adjustment,

$$v_{65} = z_{15} + 89(\delta\phi_{13} - \delta\phi_{12}) + 250(\delta\lambda_{13} - \delta\lambda_{12}) - 1.7$$

^{*} This zero discrepancy is merely accidental.

But to reduce the positions of the preliminary computation to the fixed positions,  $\delta \phi_{13} = -0.002$ ,  $\delta \phi_{12} = 0.000$ ,  $\delta \lambda_{13} = -0.080$ , and  $\delta \lambda_{12} = -0.134$  (see pp. 155, 157). Substituting these values gives,

 $v_{65} = z_{15} + 11.6$ 

as given in the table.  $v_{66}$  is found by a similar process.

The effect of using for the preliminary computation values from a previous adjustment for the figure but not for the positions appears in the constant term of the normal equations until the effect of closure in positions comes in. These constant terms should be zero except for the effect of accumulated errors in the last place of the two computations and a slight difference in the treatment of directions (3) and (3a). They are in fact almost negligible until the effect of closure appears in the equation for  $\partial \phi_8$ , from which point they become quite large.

Fort Morgan-Dauphin Island east base:

Assumed azimuth,	101	45	44.9
Observed azimuth,	101	45	44. $9 - z_1 + v_1$
		0=	$= 0.0 + z_1 - v_1$
		$v_1 =$	$z_1 + 0.0$
Fort Morgan-Cedar:	0	/	11
Assumed azimuth,	144	19	22.9+d $\alpha$
Observed azimuth,	144	19	22. $6 - z_1 + v_2$
		0 =	$+0.3+z_1-v_2+229\partial\phi_1-277\partial\lambda_1$
		$v_2 =$	$=z_1+229\delta\phi_1-277\delta\lambda_1+0.3$

DAUPHIN ISLAND EAST BASE

Assumed azimuth	Observed azimuth	Equation	Station observed	
° / // 84 14 41.9 137 52 06.3 188 10 17.4 281 42 17.9	$ \begin{array}{c} \circ & , & , \\ 84 & 14 & 41, 9-z_2+v_3 \\ 137 & 52 & 06, 9-z_2+v_4 \\ 188 & 10 & 18, 3-z_2+v_5 \\ 281 & 42 & 17, 9-z_2+v_{3a} \end{array} $	$ \begin{aligned} v_3 &= z_2 + 0.0 \\ v_4 &= +z_2 + 420 \partial \phi_2 - 403 \partial \lambda_2 - 0.6 \\ v_5 &= +z_2 - 82 \partial \phi_1 - 498 \partial \lambda_1 - 0.9 \\ v_{3a} &= z_2 + 0.0 \end{aligned} $	West base Cat Cedar Fort Morgan	

#### (1) CEDAR

23 51 22.0 122 37 00.7 248 19 24.4 317 49 57.9	23 51 22. $0-z_4+v_{17}$ 248 19 27. $1-z_4+v_{15}$ 317 49 59. $8-z_4+v_{16}$	$\begin{array}{l} v_{17} = z_4 - 273 \delta \phi_2 - 537 \partial \lambda_2 + 0.0 \\ v_{16} = z_4 - 657 \partial \phi_1 - 226 \partial \lambda_1 + 657 \partial \phi_2 + 226 \partial \lambda_2 - 2.7 \\ v_{16} = z_4 + 420 \partial \phi_2 - 403 \partial \lambda_2 - 1.9 \end{array}$	West base Pins Cedar East base	

(2) CAT

#### DAUPHIN ISLAND WEST BASE

$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{ll} +v_{14} & v_{14}\!=\!z_5\!\!+\!\!0.0 \\ s_{1}\!+\!v_{9} & v_{9}\!=\!z_5\!\!+\!367\partial\phi_4\!\!+\!62\partial\lambda_4\!\!+\!0.4 \\ s_{1}\!+\!v_{10} & v_{10}\!=\!z_5\!\!+\!287\partial\phi_5\!\!-\!133\partial\lambda_5\!\!+\!0.7 \\ s_{1}\!+\!v_{11} & v_{11}\!=\!z_5\!\!+\!14\partial\phi_3\!\!-\!313\partial\lambda_3\!\!+\!1.8 \\ s_{1}\!+\!v_{12} & v_{12}\!=\!z_5\!\!-\!273\partial\phi_2\!\!-\!537\partial\lambda_2\!\!-\!0.6 \\ s_{2}\!+\!v_{13} & v_{13}\!=\!z_5\!\!-\!266\partial\phi_1\!\!-\!226\partial\lambda_1\!\!-\!0.2 \end{array}$	East base Petit Grand Pins Cat Cedar
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Assumed azimuth Observed azimuth		Equation	Station observed
° ' '' 279 11 16.6 302 33 55.1 337 56 39.8 30 22 49.2 63 09 48.1	$\begin{array}{c} \circ & \prime & \prime \\ 279 & 11 & 16. & 6-z_6+v_{18} \\ 302 & 33 & 56. & 9-z_6+v_{19} \\ 337 & 56 & 42. & 6-z_6+v_{20} \\ 30 & 22 & 52. & 1-z_6+v_{21} \\ 63 & 09 & 49. & 6-z_6+v_{22} \end{array}$	$\begin{array}{l} v_{18} = z_6 - 341_\partial \phi_1 + 48_\partial \lambda_1 + 341_\partial \phi_3 - 48_\partial \lambda_3 + 0.0 \\ v_{19} = z_6 - 450_\partial \phi_2 + 255_\partial \lambda_3 + 450_\partial \phi_3 - 2.8 \\ v_{29} = z_6 + 148_\partial \phi_3 - 118_\partial \lambda_3 - 2.8 \\ v_{21} = z_6 - 153_\partial \phi_3 - 228_\partial \lambda_3 + 153_\partial \phi_4 + 228_\partial \lambda_4 - 2.9 \\ v_{22} = z_6 - 450_\partial \phi_3 - 198_\partial \lambda_3 + 450_\partial \phi_6 + 198_\partial \lambda_5 - 1.5 \end{array}$	Cedar Cat West base Petit Grand

# · (4) PETIT

96 31 30.6	96 31 30. $6-z_7+v_{28}$	$\begin{array}{l} v_{23} = z_7 - 35 \aleph_2 \phi_4 + 36 \vartheta_1 \lambda_4 + 35 \aleph_2 \phi_6 - 36 \vartheta_1 \kappa_6 + 0.0 \\ v_{22} = z_7 - 20 \vartheta_2 \phi_4 + 211 \vartheta_1 \lambda_4 + 20 \vartheta_2 \phi_7 - 211 \vartheta_1 \lambda_7 + 0.3 \\ v_{30} = z_7 - 25 \vartheta_2 \phi_4 + 42 \vartheta_1 \lambda_4 + 25 \vartheta_2 \phi_5 - 442 \vartheta_1 \lambda_7 + 0.9 \\ v_{31} = z_7 - 153 \vartheta_2 \phi_5 - 28 \vartheta_1 \lambda_3 + 153 \vartheta_2 \phi_4 + 22 \vartheta_1 \lambda_4 + 0.6 \\ v_{32} = z_7 + 367 \vartheta_2 \phi_4 + 62 \vartheta_1 \lambda_4 + 1.0 \end{array}$	Horn
139 08 41.2	139 08 40. $9-z_7+v_{29}$		Pascagoula
177 10 20.4	177 10 19. $5-z_7+v_{30}$		Grand
210 19 28.8	210 19 28. $2-z_7+v_{31}$		Pins
258 51 48.7	258 51 47. $7-z_7+v_{32}$		West base

# (5) GRAND

243 06 15.8	243 06 15. $8-z_8+v_{22}$	$ \begin{array}{l} v_{22} = z_8 - 450 \partial_t \phi_3 - 198 \partial_t \lambda_3 + 450 \partial_t \phi_5 + 198 \partial_t \lambda_5 + 0.0 \\ v_{24} = z_8 + 287 \partial_t \phi_6 - 133 \partial_t \delta_5 - 1.4 \\ v_{23} = z_8 - 252 \partial_t \phi_4 + 423 \partial_t \lambda_4 + 253 \partial_t \phi_5 - 442 \partial_t \lambda_5 - 0.6 \\ v_{23} = z_8 - 272 \partial_t \phi_5 - 146 \partial_t \lambda_5 + 272 \partial_t \phi_5 + 146 \partial_t \lambda_5 - 0.3 \end{array} $	Pins
297 58 16.0	297 58 17. $4-z_8+v_{24}$		West base
357 10 08.8	357 10 09. $4-z_8+v_{25}$		Petit
58 14 46.3	58 14 46. $6-z_8+v_{26}$		Horn
101 29 06.4	101 29 05. $5-z_8+v_{27}$	$v_{27} = z_8 - 495 \partial \phi_5 + 87 \partial \lambda_5 + 495 \partial \phi_7 - 87 \partial \lambda_7 + 0.9$	Pascagoula

#### (6) HORN

#### (7) PASCAGOULA

$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c} 281 \ 25 \ 13. \ 6-z_{10}+v_{33} \\ 319 \ 04 \ 34. \ 2-z_{10}+v_{34} \\ 19 \ 21 \ 07. \ 6-z_{10}+v_{35} \\ 57 \ 14 \ 12. \ 2-z_{10}+v_{36} \\ 89 \ 04 \ 35. \ 6-z_{10}+v_{37} \end{array}$	$\begin{array}{l} v_{33} \!\!=\!\! z_{10} \!\!-\!\! 495\partial\phi_5 \!\!+\!\!87\partial\lambda_5 \!\!+\!\!495\partial\phi_7 \!\!-\!\!87\partial\lambda_7 \!\!+\!\!0.0 \\ v_{34} \!\!=\!\! z_{10} \!\!-\!\!209\partial\phi_4 \!\!+\!\!211\partial\lambda_4 \!\!+\!\!209\partial\phi_7 \!\!-\!\!211\partial\lambda_7 \!\!+\!\!3.0 \\ v_{35} \!\!=\!\! z_{10} \!\!+\! 53\partial\phi_4 \!\!+\! 379\partial\lambda_6 \!\!+\!\!153\partial\phi_7 \!\!-\!\!379\partial\lambda_7 \!\!+\!\!3.5 \\ v_{36} \!\!=\!\! z_{10} \!\!-\!\!286\partial\phi_7 \!\!-\!\!160\partial\lambda_7 \!\!+\!\!286\partial\phi_8 \!\!+\!160\partial\lambda_8 \!\!+\!2.2 \\ v_{37} \!\!=\!\! z_{10} \!\!-\!\!398\partial\phi_7 \!\!-\!\!6\partial\lambda_7 \!\!+\!\!398\partial\phi_9 \!\!+\!6\partial\lambda_9 \!\!+\!0.1 \end{array}$	Grand Petit Horn Club Belle
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#### (9) BELLE

$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c} 268 \ 59 \ 33, 9-z_{11}+v_{43} \\ 317 \ 58 \ 23, 7-z_{11}+v_{44} \\ 358 \ 28 \ 29, 2-z_{11}+v_{45} \\ 52 \ 04 \ 24, 8-z_{11}+v_{46} \\ 101 \ 03 \ 47, 7-z_{11}+v_{47} \end{array}$	$\begin{array}{l} p_{43} = z_{11} - 398 \delta \phi_7 - 6 \beta \lambda_7 + 398 \delta \phi_9 + 6 \beta \lambda_9 + 0.0 \\ p_{44} = z_{11} - 249 \delta \phi_8 + 240 \beta \lambda_9 + 249 \beta \phi_9 - 240 \beta \lambda_9 - 1.8 \\ p_{45} = z_{11} - 77 \delta \phi_8 + 559 \lambda_9 + 17 \delta \phi_9 - 559 \lambda_9 - 0.6 \\ p_{46} = z_{11} - 311 \delta \phi_9 - 211 \delta \lambda_9 + 311 \delta \phi_{10} + 211 \delta \lambda_{10} - 2.0 \\ p_{47} = z_{11} - 700 \delta \phi_9 + 119 \delta \lambda_9 + 700 \delta \phi_{11} - 119 \delta \lambda_{11} + 0.9 \end{array}$	Pascagoula Horn Club Ship Deer
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#### (8) CLUB

89 46 03.6 142 06 04.8 178 28 33.6 237 09 18.0 284 12 30.1	$\begin{array}{c} 89 \ 46 \ 03. \ 6 - z_{12} + v_{48} \\ 142 \ 06 \ 07. \ 1 - z_{12} + v_{49} \\ 178 \ 28 \ 33. \ 9 - z_{12} + v_{50} \\ 237 \ 09 \ 17. \ 2 - z_{12} + v_{51} \\ 284 \ 12 \ 30. \ 8 - z_{12} + v_{52} \end{array}$	$\begin{array}{l} \cdot\\ g_{49}=z_{12}-490\partial_{\phi_8}-2\partial_{\lambda_8}+490\partial_{\phi_{10}}+2\partial_{\lambda_{10}}+0.0\\ p_{49}=z_{12}-266\partial_{\phi_8}+297\partial_{\lambda_8}+266\partial_{\phi_{11}}-297\partial_{\lambda_{11}}-2.3\\ p_{50}=z_{12}-17\partial_{\phi_8}+559\partial_{\lambda_8}+17\partial_{\phi_9}-559\partial_{\lambda_9}-0.3\\ p_{61}=z_{12}-286\partial_{\phi_7}-100\partial_{\lambda_7}+286\partial_{\phi_8}+160\partial_{\lambda_8}+0.8\\ p_{52}=z_{12}-535\partial_{\phi_6}+118\partial_{\lambda_8}+535\partial_{\phi_8}+118\partial_{\lambda_8}-0.7 \end{array}$	Ship Deer Belle Pascagoula Horn
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(3)	P	TN	S
(0)	Τ.	74.	~

#### (11) DEER

Assumed azimuth	Observed azimuth	Equation	Station observed		
° ' '' 281 01 03.4 322 03 14.8 18 50 39.5 42 46 50.3 115 21 13.0	$ \begin{array}{c} \circ & , & , & , \\ 281 & 01 & 03, 4-z_{13}+v_{53} \\ 322 & 03 & 14, 1-z_{13}+v_{54} \\ 18 & 50 & 41, 3-z_{13}+v_{55} \\ 42 & 46 & 46, 1-z_{13}+v_{56} \\ 115 & 21 & 12, 5-z_{13}+v_{57} \end{array} $	$ \begin{array}{l} v_{83} = z_{13} - 700 \partial_t \phi_2 + 119 \partial_t \phi_3 + 700 \partial_t \phi_{11} - 119 \partial_t \lambda_{11} + 0.0 \\ v_{84} = z_{13} - 265 \partial_t \phi_4 + 297 \partial_{18} + 266 \partial_t \phi_{11} - 297 \partial_{11} + 0.7 \\ v_{95} = z_{13} + 167 \partial_t \phi_1 + 425 \partial_t \lambda_{10} - 167 \partial_t \phi_{11} - 425 \partial_t \lambda_{11} - 1.8 \\ v_{96} = z_{13} - 197 \partial_t \phi_{11} - 185 \partial_t \lambda_{11} - 11.0 \\ v_{97} = z_{13} - 603 \partial_t \phi_{11} + 248 \partial_t \lambda_{11} + 33.7 \end{array} $	Belle Club Ship Ship Island Lighthouse. Biloxi Lighthouse		

#### (10) SHIP

67 47 12.0	67 47 12. $0-z_{14}+v_{58}$	$v_{58} = z_{14} - 500 \partial \phi_{10} - 177 \partial \lambda_{10} - 15.2$	Ship Island
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{l} v_{59}\!=\!z_{14}\!-\!110\partial\phi_{10}\!+\!323\partial\lambda_{10}\!+\!43.2\\ v_{50}\!=\!z_{14}\!+\!167\partial\phi_{10}\!+\!425\partial\lambda_{10}\!-\!167\partial\phi_{11}\!-\!425\partial\lambda_{11}\!+\!1.3\\ v_{91}\!=\!z_{14}\!-\!311\partial\phi_{20}\!-\!11\partial\lambda_{23}\!+\!311\partial\phi_{21}\!+\!211\partial\lambda_{10}\!-\!0.5\\ v_{63}\!=\!z_{14}\!-\!490\partial\phi_{6}\!-\!2\partial\lambda_{8}\!+\!490\partial\phi_{10}\!+\!23\lambda_{10}\!+\!0.8 \end{array}$	Biloxi Lighthouse Deer Belle Club

#### BILOXI LIGHTHOUSE

295 18 30,1 343 29 51,1 17 14 04,4	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{l} v_{63} \! = \! z_{15} \! - \! 603 \delta \phi_{11} \! + \! 248 \delta \lambda_{11} \! + \! 33.2 \\ v_{64} \! = \! z_{15} \! - \! 110 \delta \phi_{10} \! + \! 323 \delta \lambda_{10} \! + \! 46.9 \\ v_{65} \! = \! z_{15} \! + \! 11.6 \end{array}$	Deer Ship Ship Island Lighthouse
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#### SHIP ISLAND LIGHTHOUSE

$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{l} v_{06}=z_{16}+13.3\\ v_{67}=z_{16}-197\partial\phi_{11}-185\partial\lambda_{11}-13.8\\ v_{68}=z_{16}-500\partial\phi_{10}-177\partial\lambda_{10}-16.1 \end{array}$	Biloxi Lighthouse Deer Ship
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In order to get the quantities on a better relative basis, it is best to adopt  $100\partial\phi_1$ ,  $100\partial\lambda_1$ , etc., as unknowns in the equations. The coefficients throughout will then be divided by 100, and from the solution we shall determine one hundred times the corrections in seconds to the various latitudes and longitudes.

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	d,1	0.707i		0. 5i	$\begin{array}{c} 1 \\ 1 \\ 1 \\ 1 \\ 0.447i \end{array}$	$\begin{array}{c} 1\\ 1\\ 1\\ 1\\ 0.577i \end{array}$			0.408i		0.447i		0.447i
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	ðφ8												
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	δφ7											+209	+ 209
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1	ბრი								-			+358	+358
	ð À5		-				-133		-133		+198 + 198	-412	-442
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	δφ3				+341 +341			+148	+148	+341 +459 +148 -153	-450 + 345	-153	-153
	δλ2		403	403	+226 +226	-537 +226 -403 -714		-537	-537	+255	+255		
	δφ2		+420	+420	+657 +657	-273 +657 +420 +804	-	-273	-273	-439	-459		
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Table for formation of normals, No. 1-Continued

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	ιιφρ						+700	+266	+266	+700 +266 -167 -167	- 603	- 167	-167
	δλie					+211	+211	+	+	+425	+425	-177 + 323 + 425	+211 + 2 + 784
	δφ10					+311	+311	+490	+490	+167	+167	-110	+311 +490 +358
	δλ9	-240	-240		99 ++	+ 6 -240 -559 -211	+119 - 885	-559	-559	+119	+119	110	-211
	<i>дф</i> 8	+249	+249		+398 + 398	+398 +249 +17 -311	-700 -347	+ 17	+ 17	-700	-700	FFG	-311
	δλ8	-118	-118	+160	+160	+559	+559	+297 +559 +160	+896	+297	+297		62 62 
	ô¢8	+535	+535	+286	+286	- 17	- 17	-490 -266 +286 +286	+ 48	-266	-266		- 490
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	δφι	- 153	-153	+495 +209 -153 -286	-398 -133	398	-398	-286	-286				
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	•	2	$\begin{array}{c} ++0.3\\ +-0.21\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\0.0\\ -$	-4.02i ++0.3	+1.0 +1.25 <i>i</i> -1.4	-0.6 + 0.9 -0.63 <i>i</i>	
	14	ð λ ₇		-2.11	-0.94i	-0.87 -0.39i	
	13	ô¢1	· -	+2.09	+0.93i	+4.95 +2.21 <i>i</i>	
	12	٥٦٥	,	-0.36	-0.16i	+1.46 +0.65 <i>i</i>	ded by 100
	11	δφ6		+3.58	+1.60i	+2.72 +1.22i	been divi
~ · OAT	10	δλ5	- 1.33 - 1.54 <i>i</i>	+0.89 <i>i</i> -4.42	-1.98i +1.98 -1.33	-4.42 -1.46 +0.87 -1.95i	umns have
(empil lon	9	δφδ	+2.87 +1.17 <i>i</i> +4.50	+2.01i +0.25	+0.11i +4.50 +2.87	+0.25 -2.72 -4.95 -0.02i	and Z col
fo uman	8	374	+0.25 <i>i</i> +2.28	+1.02i +2.11 +2.28 +2.28	+0.62 +4.38 <i>i</i>	+4.42 +1.98 <i>i</i>	ose in the r
unof inf	4	õ¢4	+3.67 +1.50 <i>i</i> +1.53	+0.68i +1.53	+3.67 -0.32 <i>i</i>	-0.25 -0.11 <i>i</i>	excent the
SAUDA L	9	õλa		-4.68 <i>i</i> -2.28	-1.02i -1.98	0, 89 <i>i</i>	this table
	νQ	δφ3	++++++++++++++++++++++++++++++++++++++	+1.54i	-0.68 <i>i</i> -4.50	-2.01i	ll values in
¥.	4	δλ2	$\begin{array}{c} -4.08\\ -4.08\\ -2.02i\\ -5.37\\ -4.12i\\ -4.12i\\ -5.37\\ -4.12i\\ -4.12i\\ -4.25\\ +2.55\end{array}$	+1.14i			V *
	en	<i>д</i> ф2	++.20 +2.10 <i>i</i> +2.10 <i>i</i> +2.57 +2.57 +4.20 +4.64 +4.64 -1.11 <i>i</i> -4.59	-2.05i			
	2	δλī	$\begin{array}{c} -2, 77\\ -1, 36i\\ -1, 98i\\ -2, 37i\\ -2, 28i\\ -5, 27i\\ -1, 30i\\ -1, 30i\\ +0, 48i\\ -1, 28i\\ +0, 48i\\ -1, 28i\\ +0, 48i\\ -1, 30i\\ +0, 48i\\ -1, 30i\\ -1, 30$	+0.21 <i>i</i>			
	1	δφι	$\begin{array}{c} ++2.29\\ +1.62i\\ -0.82\\ -0.82\\ -0.82\\ -0.82\\ -1.341\\ -3.41\\ -3.70i\\ -1.3.70i\\ -3.41\\ -3.41\\ -3.41\end{array}$	-1.52i			

Table for formation of normals, No. 2

# APPLICATION OF LEAST SQUARES TO TRIANGULATION. 167

F	1	$\begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 $
1	h	$\begin{array}{c} 0.0\\ 0.1\\ 0.1\\ 0.1\\ 0.2\\ 0.2\\ 0.2\\ 0.2\\ 0.2\\ 0.2\\ 0.2\\ 0.2$
22	δλ ₁₁	$\begin{array}{c} -1.19 \\ -0.534 \\ -2.97 \\ -2.97 \\ -2.97 \\ -2.97 \\ -1.138 \\ -2.97 \\ -1.348 \\ -3.484 \\ -1.25 \\ -4.25 \\ -4.25 \\ -4.25 \\ -1.96 \\ +1.436 \\ -1.07 \\ -1.07 \\ -1.07 \end{array}$
21	δφιι	+7, 00 +3, 138 +2, 66 +2, 66 +1, 194 +7, 00 -1, 67 -1, 67 -6, 03 -3, 488 -3, 488 -1, 97 -1, 97 -1, 144
20	δλ10	+2,11 +2,11 +0,02 +4,02 +4,25 +4,25 +4,25 +4,25 +4,25 +4,25 +4,25 +4,25 +4,25 +1,367 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +1,567 +
19	ô¢10	+3.11 +3.11 +4.90 +2.19t +1.67 +1.67 +1.67 +1.67 +1.67 +1.67 +1.67 +1.60 -1.10 -0.63i -1.10 -1.10 -1.2.88i
18	δλg	$\begin{array}{c} -2.40 \\ -1.071 \\ -1.071 \\ -1.071 \\ -2.40 \\ -2.40 \\ -2.40 \\ -2.51 \\ -2.51 \\ -1.19 \\ -1.19 \\ -2.51 \\ -2.51 \\ -2.11 \\ -2.11 \\ -2.11 \\ -0.94 \\ \end{array}$
17	дфе	+2.49 +1.11 <i>i</i> +1.11 <i>i</i> +1.78 <i>i</i> +1.78 <i>i</i> +1.78 <i>i</i> +1.78 <i>i</i> +1.75 <i>i</i> -1.55 <i>i</i> -1.55 <i>i</i> -1.55 <i>i</i> -1.55 <i>i</i> -1.38 <i>i</i> -1.38 <i>i</i> -1.38 <i>i</i>
16	ð À B	$\begin{array}{c} -1.18\\ -0.53i\\ +1.60\\ +2.59\\ +5.59\\ +5.59\\ +2.97\\ +1.33i\\ +1.33i\\ +1.33i\\ -0.01i\\ \end{array}$
15	δφ8	+5.35 +2.394 +2.86 +1.284 +1.284 -0.17 -0.084 +2.66 -0.17 +5.35 +0.211 -2.66 -1.194 -2.194 -2.194
14	٥٨٦	-3, 73 -1, 694 -0, 87 -0, 60 -0, 60 -0, 60 -0, 60 -0, 724 -0, 724
13	δφτ	-1. 53 -0. 68 <i>i</i> -1. 53 -1. 58 -0. 596 -1. 28 <i>i</i> -1. 28 <i>i</i> -1. 28 <i>i</i>
12	٥٨٥	+1.113 +2.40 +3.79 +3.79 +1.036 +1.07i +1.07i +1.07i +0.53i
11	346	$\begin{array}{c} -5.35 \\ -2.495 \\ +1.53 \\ +2.535 \\ +1.53 \\ +2.49 \\ -2.349 \\ -2.334 \\ -2.334 \\ -2.334 \\ \end{array}$
10	٥٨٥	945 0
6	δφδ	-2. 72 -1. 25 <i>i</i> -2. 21 <i>i</i>
×	άλ₄	++0. 36 +2. 11 +0. 944
1-	344	

168 COAST AND GEODETIC SURVEY SPECIAL PUBLICATION NO. 28.

 $\begin{array}{c} -13,9036\\ +81,51355\\ +81,4539\\ 5951,4539\\ 5951,4539\\ 5952,5951\\ +83,2955\\ 5952,5952\\ +1,53,2955\\ -1,23317\\ -2,29555\\ -1,23317\\ -2,2955\\ -1,23317\\ -2,2955\\ -1,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ -2,23317\\ 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0. \ 8560 \\ - & 2. \ 8738 \\ + 27, \ 9899 \\ + 50, \ 9179 \end{array}$ ສ 00  $\begin{array}{c} + & 6.7770 \\ - & 2.6480 \\ + & 5.2774 \\ + & 1.6185 \\ - & 43.9722 \\ - & 13.4344 \\ - & 12.7934 \\ - & 12.7934 \\ + & 106.8200 \end{array}$ 6686 2372 0590 5098 5098 0677 2687 8618 8618 50 P - 1 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 P - 2 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0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 0.273\\ 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0.273\\ 0.273\\ 0.273\\$ 4.0.0.0.0.0.0.0.4 4.0.0.0.0.0.0.0.4 10 21.12. 1+1++  $\begin{array}{c} - & 0. \ 1784 \\ - & 0. \ 5920 \\ + & 0. \ 9446 \\ - & 0. \ 5923 \\ + 24. \ 4953 \\ - \ 6. \ 7932 \\ - \ 0. \ 3391 \\ - 19. \ 7152 \\ + 63. \ 1452 \end{array}$ -41.7538-17.5325+33.7556+78.702716 4  $\begin{array}{rrr} - & 57.5385 \\ - & 3.5323 \\ + 117.5659 \end{array}$  $\begin{array}{c} 5.\,0144\\ 1.\,5856\\ 5.\,7446\\ 1.\,0543\\ 5.\,7023\\ 1.\,0790\\ 13.\,8524\\ 0.\,1385\\ 0.\,1385\\ 122.\,2200 \end{array}$ 2 ŝ  $\begin{array}{c} -1.4231\\ -1.3059\\ -1.3059\\ -1.3059\\ -1.3059\\ -1.6849\\ -1.6849\\ -3.7637\\ -3.7637\\ -15.4350\\ +1.1818\\ +25.6494 \end{array}$ 4.1730 14 3 ++  $\begin{array}{c} + & 5.0745 \\ - & 9.8322 \\ - & 9.8322 \\ + & 1.0340 \\ -51.1966 \\ + & 14.5520 \\ - & 13.4998 \\ - & 6.7278 \\ + & 99.0967 \end{array}$ +90.015013 =

Normal equations

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51	-13.9036 + 0.154459	+40.5135 + 0.6446	+41.1581 -0.909587	+81.4539 -8.8873 +0.7867	+73.3535 -0.908175	$\begin{array}{r} +59.5951 \\ -6.4492 \\ +14.1867 \\ -6.1467 \end{array}$	+61.1858 - 1.145975	$\begin{array}{c} + & 8.3278\\ - & 1.9580\\ -11.0063\\ +26.8689\\ -12.0299\end{array}$	+10.2025 -0.153605	$\begin{array}{c} + & 3.9182 \\ - & 0.9738 \\ + & 1.3538 \\ + & 2.5190 \\ - & 0.9372 \end{array}$	+13.9098 - 0.777492
h	+0.5960 -0.006621	$^{+1.0071}_{-0.0276}$	+0.9795 -0.021647	-0.4396 + 0.3310 + 0.0187	-0.0399 +0.000494	+0.5291 +0.2765 +0.3376 +0.0033	+1.1468 -0.021479	$\begin{array}{c} -0.\ 2811 \\ +0.\ 0839 \\ -0.\ 2619 \\ -0.\ 0146 \\ -0.\ 2255 \end{array}$	-0.6992 +0.010527	-0.1405 +0.0417 +0.0322 -0.0014 +0.1505 +0.0642	+0.1467 -0.008200
14								-1.4231	-1.4231 +0.021426	-1.3059 +0.1307	-1.1752 +0.065688
13								+5.0745	+5.0745 -0.076400	+2.9155 -0.4662	+2. 4493 -0. 136904
12								+1.1977	+1.1977 -0.018032	+0.4153 -0.1100	+0.3053 -0.017065
11							_	+3.5402	+3.5402 -0.053300	+2.7178	+2.3926 -0.133735
10	+ 0.7642 - 0.008490	- 0.6837 - 0.0354	- 0. 7191 + 0. 015892	+ 1.2251 + 0.4885 - 0.0137	+ 1.6999 - 0.021046	- 2. 1972 + 0. 3545 - 0. 2479 - 0. 1424	-2.2330 + 0.041823	-24.1325 + 0.1076 + 0.1923 + 0.4390 + 0.4390	-22.7709 + 0.342829	$\begin{array}{c} - & 8. & 1327 \\ + & 0. & 0535 \\ - & 0. & 0237 \\ + & 0. & 0584 \\ + & 0. & 0584 \\ + & 2. & 0918 \end{array}$	-6.2458 + 0.349111
6	+ 4.3305 - 0.048109	+ 0.6543	+ 0.4535 - 0.010022	+ 5. 4192 + 2. 7681 + 0.0087	+ 8.1960	+ 0.2709 + 2.0087 + 0.1563 - 0.6868	+ 1.7491 - 0.032760	-44.2628 + 0.6099 - 0.1213 + 3.0021 - 0.3439	-41.1160 + 0.619026	- 6. 7978 + 0. 3033 + 0. 0149 + 0. 2815 + 0. 2296	- 2. 1915 + 0. 122494
ø	+1.8229 -0.020251	+0.0158 -0.0845	-0.0687 +0.001518	+2.3685 +1.1652 -0.0013	+3.5324 -0.043734	-0.6153 +0.8456 -0.0237 -0.2360	-0.0894 +0.001674	$\begin{array}{c} -1.7394 \\ +0.2567 \\ +0.0184 \\ +1.2939 \\ +0.0176 \end{array}$	-0.1528 +0.002300	$\begin{array}{c} +0. \ 9316 \\ +0. \ 1277 \\ -0. \ 0023 \\ +0. \ 1213 \\ -0. \ 0117 \\ +0. \ 0140 \end{array}$	+1.1806 -0.065990
1-	+2.6686 -0.029646	+1.2372 -0.1237	+1.1135 -0.024608	+3.0590 +1.7058 +0.0213	+4.7861 -0.059256	+2.5098 +1.2378 +0.3838 -0.4011	+3.7303 -0.069866	$\begin{array}{c} -7.\ 0677\\ +0.\ 3758\\ -0.\ 2978\\ +1.\ 7531\\ -0.\ 7334\end{array}$	-5.9700 +0.089882	$\begin{array}{c} -2.2687 \\ +0.1869 \\ +0.1866 \\ +0.1864 \\ +0.1644 \\ +0.4896 \\ +0.5484 \end{array}$	-0.8428 +0.047109
9	- 6.3049 + 0.070043	- 1. 7807 + 0. 2923	- 1.4884 + 0.032893	+ 1. 2849 - 4. 0302 - 0. 0284	- 2.7737 + 0.034341	$\begin{array}{c} - & 3.8022 \\ - & 2.9246 \\ - & 0.5130 \\ + & 0.2324 \end{array}$	- 7.0074 + 0.131245	+ 6. 2298 + 0. 8879 + 0. 3980 - 1. 0160 + 1. 3777	+ 6. 1016 - 0. 091863	+19. 9567 - 0. 4416 - 0. 0490 - 0. 0953 - 0. 9197	+17. 8906 3 \ 3
ŝ	-12.6766 + 0.140828	+11.5126 + 0.5877	+12.1003 -0.267415	-21.7139 -8.1030 +0.2313	-29.5856 + 0.366294	$\begin{array}{c} + & 9. & 7277 \\ - & 5. & 8801 \\ + & 4. & 1708 \\ + & 2. & 4791 \end{array}$	+10.4975 -0.196612	$\begin{array}{c} +84. \ 3424 \\ -1. \ 7852 \\ -3. \ 2358 \\ -10. \ 8370 \\ -2. \ 0639 \end{array}$	+66. 4205 8 \$\$	H 01 03 49 46	,
4	-41.7538 + 0.463854	-17.5325 + 1.9357	-15.5968 + 0.344687	+33.7556 -26.6894 -0.2981	+ 6.7681 - 0.083795	$\begin{array}{r} +78.7027\\ -19.3677\\ -5.3760\\ -0.5671\end{array}$	+53.3919 $\delta\lambda_{9}$				
ę	-57.5385 + 0.639210	- 3.5323 + 2.6674	- 0.8649 + 0.019114	$\begin{array}{r} +117.5659 \\ -36.7792 \\ -0.0165 \end{array}$	+ 80.7702 3\$2	90 P	1	1			
5	+ 4.1730 - 0.046359	+45.4427 - 0.1935	+45.2492 8 Å1	51							
1	+90.0150 841	1									-

APPLICATION OF LEAST SQUARES TO TRIANGULATION. 169

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	εų	$\begin{array}{c} +38.2322\\ +0.4122\\ -1.0128\\ -4.3466\\ -4.2748\\ +0.9170\\ +0.6553\end{array}$	+30.5824 -0.521574	$\begin{array}{c} -2.\ 9055\\ +0.\ 2816\\ +0.\ 0625\\ -3.\ 2080\\ +0.\ 1024\\ +0.\ 1024\\ +0.\ 3194\\ -0.\ 9179\\ -6.\ 2420\\ \end{array}$	+0.183542	+15.2886 +0.6689 -0.4125 -7.4434	-2.0044 +6.3156 +1.7039 +6.1376 +0.2170	+20.4707 -0.256262	+0.0595 +0.1180 +0.6541 -1.5438 +2.5590	+3.4977 +4.8561 +0.7308 -5.0151 +2.0310	+7.9474 -0.570127
. ×	ų	$\begin{array}{c} +0.0662\\ -0.0177\\ -0.0241\\ +0.0024\\ -0.0801\\ -0.0628\\ +0.0069\end{array}$	-0.1092 + 0.001862	-0.1210 -0.0121 +0.0015 +0.0017 +0.0019 -0.0016 -0.0016 -0.0016	+0.004128	+0.8374 -0.0287 -0.0098 +0.0040	-0.0376 -0.4328 +0.0180 -0.0219 +0.0049	+0.3335 -0.004175	$+0.2900 \\ -0.0051 \\ +0.0156 \\ +0.0008 \\ +0.0480$	-0.2397 +0.0512 -0.0026 -0.1128 +0.0331	+0.0785 -0.005631
	18	-1.6841	-1.6841 +0.028722	+0,1430 -0.0176 +0.1254	-0.003687	-1.2391	-0.3380 -0.0044	-1.5815 +0.019798	-0.7072	-0.0402 +0.1008 -0.1569	-0.8035 +0.057641
	17	+3.4314	+3.4314 -0.058522	-1. 8508 +0. 0358 -1. 8150	+0.053369	+5.2880	+0.6886 +0.0631	+6.0397 -0.075608	+0.0273	+0.0820 -1.4583 +0.5992	-0.7498 +0.053789
	16	-0.1784	-0.1784 +0.003043	-0.5920 -0.0019	+0.017463	+0.9446	-0.0358 +0.0206	+0.9294 -0.011635	-0.6253	-0.0043 -0.4772 +0.0922	-1.0146 + 0.072785
man	15	+5.0144	+5.0144 -0.085519	-1.5856 +0.0524	+0.045083	+5.7446	+1.0063 +0.0533	+6.8042 -0.085178	+1.0543	+0.1198 -1.2318 +0.6751	+0.6174 -0.044291
	14	+2.2660 -0.1279 -0.0554	+2.0827 -0.035520	-0.2006 -0.0033 +0.0776 +0.0217 -0.1046	+0.003076	-1.6849	-0.8809 -0.1440 +0.4180 +0.0036	-2.2882 + 0.028645	-3.7637	-0.4879 -0.4103 +0.0498 -0.0840 -0.2270	-4.9231 +0.353171
mail inner fin a	13	- 9.8322 + 0.4561 + 0.1154	-9.2607 + 0.157939	+ 1.0340 + 0.0117 - 0.1616 + 0.0967 + 0.7874	- 0.023153	-51.1966	+ 3. 1412 + 0. 3000 - 1. 8585 - 0. 0274	-49.6413 + 0.621434	+14.5520	+ 1. 7397 + 0. 8551 - 0. 2213 + 0. 6326 - 4. 9251	+12.6330 -0.906261
	12	+10.2336 + 0.1077 + 0.0144	+10.3557 -0.176614	- 3.0404 + 0.0028 + 0.1081	+ 0.086731	+ 0.4469	$\begin{array}{c} + & 0.7414 \\ + & 0.0374 \\ + & 2.0783 \\ + & 0.1025 \end{array}$	+ 3.4065 - 0.042644	- 1.5081	+ 0.4106 + 0.1066 + 0.2475 + 0.3380 + 0.3380	-2.7753 + 0.199093
	11	-24.3542 + 0.3182 + 0.1127	-23.9233 + 0.408005	- 7.4852 + 0.0081 - 0.1579 - 0.2498	+ 0.231847	-13,4456	$\begin{array}{c} + & 2.  1915 \\ + & 0.  2931 \\ - & 4.  8012 \\ + & 0.  2741 \end{array}$	-15.4881 + 0.193888	- 2.6606	$\begin{array}{c} + & 1.2137 \\ + & 0.8353 \\ - & 0.5717 \\ - & 6.3350 \\ - & 1.5366 \end{array}$	$\left \begin{array}{c} 9.0549 \\ + \end{array} \right  0.649576$
	10	$\begin{array}{l} + & 0.8894 \\ - & 0.0227 \\ + & 0.0177 \\ - & 0.1007 \\ + & 0.1560 \\ - & 2.0467 \\ - & 0.2942 \end{array}$	- 1.4012 + 0.023897	-27, 5748 - 0.0155 - 0.0111 - 0.0011 - 0.037 - 0.037 + 0.4122 + 0.4122 - 0.0524 - 0.0146	+ 0. 803450	+ 6. 3958 - 0. 0368 + 0. 0072 - 0. 1725	+ 0.0432 -14.0958 - 0.7651 - 0.2812 + 0.9499	-7.9253 + 0.099213	$\begin{array}{c} +46.8472 \\ -0.0065 \\ -0.0114 \\ -0.0358 \\ -0.0334 \end{array}$	$\begin{array}{r} - 7.8065 \\ - 2.1805 \\ - 0.0335 \\ - 21.9536 \\ - 0.7863 \end{array}$	+13.9397 825
	6	$\begin{array}{c} - & 7.2211 \\ - & 0.1284 \\ - & 0.0112 \\ - & 0.4857 \\ - & 0.1222 \\ - & 3.6956 \\ - & 0.1032 \end{array}$	- 11.7674 + 0.200690	$\begin{array}{c} + 1.6977 \\ - 0.0877 \\ + 0.0007 \\ - 0.3584 \\ - 0.3584 \\ - 0.3584 \\ - 0.03584 \\ - 0.03584 \\ - 0.1246 \\ - 0.1229 \\ - 0.1229 \end{array}$	- 0.034/05	$\begin{array}{r} +109.1066 \\ - 0.2083 \\ - 0.0045 \\ - 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.8317 \\ 0.831$	$\begin{array}{c} - & 0.00.03 \\ - & 25.4519 \\ - & 0.2684 \\ - & 2.3616 \\ - & 0.0411 \end{array}$	+ 79.8818 $\partial \phi_5$	H 01 00 44	10 00 -1 0 00 0	
	~	$\begin{array}{c} - & 0.3988 \\ - & 0.0540 \\ + & 0.0017 \\ - & 0.2093 \\ - & 0.0137 \\ + & 0.0556 \end{array}$	- 0.6123 + 0.010443	+34, 2849 - 0, 0369 - 0, 1545 - 0, 1545 - 0, 1545 - 0, 0001 - 0, 0004 +34, 0086 +34, 0086	0A4	-000	********				•
	2	+59.8618 - 0.0791 - 0.0274 - 0.2336 - 0.2836 - 0.2836 - 0.5386	+58.6348 844	-1007100F						6	
		1004100									

Solution of normals-Continued

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APPLICATION O	F LEAST	SQUARES 7	TO TRIANGULAT	ION.
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4	$\begin{array}{r} - 4.4519 \\ - 0.5438 \\ - 1.8602 \\ + 12.4778 \\ - 1.4472 \\ + 3.9690 \\ + 5.1624 \end{array}$	+13.3061 -0.161640	$\begin{array}{c} - & 0. \ 2802 \\ - & 0. \ 1840 \\ - & 0. \ 1840 \\ - & 0. \ 2374 \\ - & 0. \ 5414 \\ - & 0. \ 5413 \\ + & 1. \ 5823 \\ + & 0. \ 7360 \\ - & 5. \ 1990 \\ + & 0. \ 204684 \\ + & 0. \ 204684 \end{array}$	$\begin{array}{c} 3.5317\\ -0.7795\\ +1.9043\\ +1.8023\\ +1.2024\\ +12.7212\\ +12.7212\\ +12.7212\\ +12.7212\\ +13.0893\\ +1.2.023\\ +1.2.023\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10633\\ +1.10$	21778 2186 2186 10.9137 -0.9137 -0.1983 -0.01993 -0.01993 -0.15864 +2.8068 +2.8068 +3.7470 -0.363486 -0.363486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.3633486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.363486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -0.364486 -
ţ,	$\begin{array}{c} -0.5202\\ +0.0373\\ -0.0196\\ -0.0196\\ -0.0326\\ +0.0326\\ +0.0647\\ +0.0510\end{array}$	-0.4640 +0.005637	$\begin{array}{c} -0.0948\\ +0.0126\\ -0.0025\\ +0.0193\\ +0.0192\\ -0.0122\\ -0.0122\\ -0.0122\\ +0.0156\\ -0.0257\\ -0.0257\\ +0.004012\\ \end{array}$	$\begin{array}{c} -0.2161\\ +0.0534\\ -0.0501\\ +0.033\\ +0.2072\\ +0.2072\\ -0.0711\\ -0.0711\\ -0.0711\\ -0.0738\\ +0.0338\end{array}$	+0.0496 -0.0150 -0.0150 +0.0003 -0.0003 -0.003 +0.0003 +0.0033 +0.0038 +0.0038 +0.0038 +0.0038
22	-3.7670	$-3.7670 \\ +0.045761$	+1.2720 -0.2084 +1.0036 -0.041874	-2.6458 -2.6458 -0.8746 +0.0663 -3.45400	-0.9735 -0.9735 -0.5213 +0.7255 +0.0760 -0.6953 +0.06749
21	+6.3184	+6.3184 -0.076755	-3.9798 -3.9795 +0.3495 -3.6303 +0.142925	+7.0346 +7.0346 -0.2262 +8.3354 -0.2262 -0.00000	+0.9507 +0.8743 -2.4096 -0.1833 -0.1833 +0.080312
20	+1.0673	+1.0673 -0.012965	-1.0111 +0.0590 +0.35144	+1.6800 +0.2478 +0.0593 +1.8746 -0.0593	+0.0354 +0.0354 +0.1477 -0.6417 -0.0412 +0.049066
19	+6, 7770	$+6.7770 \\ -0.082326$	-2.6450 +0.3748 -2.2732 +0.089496	+5.2774 +5.2774 -0.1416 +6.7034 +6.7036	+1.6185 +1.6185 -0.1378 -0.1378 +0.823 +0.823 +0.8233 +0.83249
18	$\begin{array}{c} + 1.5610 \\ - 0.6871 \\ + 0.0291 \\ - 0.3066 \\ - 0.5219 \end{array}$	+ 0.0745 - 0.000905	- 1, 9532 + 0.2074 + 0.0109 + 0.0674 + 0.0674 + 0.0041 + 0.0041 + 0.08244	$\begin{array}{c} -11.4363\\ -11.4363\\ -0.2060\\ -0.0029\\ -0.0029\\ +0.0029\\ +0.0173\\ +0.0173\\ -0.1080\\ -12.0505\\ -12.0505\\ \end{array}$	$\begin{array}{c} -3.6212\\ -3.6212\\ +0.0098\\ +0.00453\\ -0.09538\\ +0.09538\\ +0.0103\\ +1.1792\\ +0.2651\\ +0.2651\\ +0.455043\end{array}$
17	-15.1399 + 1.4000 - 0.4208 - 0.4208 - 0.4871	-13.4768 + 0.163714	+ 6.3530 - 0.6060 - 0.1574 - 0.1574 - 0.1574 - 0.7454 + 4.4373 - 0.174696	-32.5324 -32.5324 + 0.5420 + 3.7533 + 0.6795 - 3.1290 + 0.2764 + 0.2764	+ 8.1200 + 8.1200 - 0.0556 + 0.1730 - 0.2548 + 0.0556 + 3.0155 + 0.679 + 9.7222 - 0.943125
16	+24.4953 -0.0728 -0.1377 +0.1802 -0.6591	+23.8059 - 0.289190	- 6.7932 + 0.0315 - 0.0315 - 0.0315 - 0.0315 + 1.3168 + 1.3168 + 0.202005 + 0.202005	$\begin{array}{c} + & 0.4952 \\ - & 0.4952 \\ - & 0.0282 \\ + & 0.0138 \\ + & 0.5776 \\ + & 0.9196 \\ + & 5.5271 \\ - & 0.3575 \\ - & 0.3575 \\ + & 7.14751 \\ \end{array}$	$\begin{array}{c} - 0.3391 \\ - 0.3391 \\ - 0.0018 \\ - 0.0018 \\ - 0.0018 \\ - 0.3553 \\ - 0.3553 \\ - 0.3553 \\ - 0.3553 \\ - 0.13592 \\ - 0.135982 \\ + 0.138982 \end{array}$
15	-57.7023 + 2.0459 - 0.3555 + 1.3193 + 0.4010	-54.2916 + 0.659525	$\begin{array}{r} + 1.3790 \\ - 0.8856 \\ - 0.8856 \\ - 0.1330 \\ - 0.1230 \\ - 3.0030 \\ - 3.0030 \\ + 0.110626 \end{array}$	$\begin{array}{c} -13.8524 \\ + 0.7920 \\ + 4.2284 \\ + 4.2284 \\ - 0.5595 \\ - 12.6052 \\ - 0.1751 \\ - 22.1303 \\ - 22.1303 \\ \end{array}$	$\begin{array}{c} 0.1385 \\ -0.1385 \\ -0.1781 \\ -0.1949 \\ -0.1949 \\ -1.55127 \\ -1.55127 \\ +0.4869 \\ +0.4869 \\ +0.858098 \end{array}$
14		-11.3911 + 0.138377	$\begin{array}{c} -15.\ 4350\\ +\ 0.\ 0257\\ +\ 0.\ 0257\\ -\ 0.\ 3078\\ -\ 0.\ 0378\\ -\ 0.\ 0378\\ -\ 0.\ 0076\\ -\ 0.\ 0076\\ -\ 0.\ 0301\\ -\ 0.\ 0302\\ -\ 0.\ 0302\\ -\ 0.\ 0302\\ -\ 0.\ 0302\\ -\ 0.\ 0302\\ -\ 0.\ 0302\\ -\ 0.\ 0302\\ -\ 0.\ 0.\ 0302\\ -\ 0.\ 0.\ 0302\\ -\ 0.\ 0.\ 0.\ 0.\ 0.\ 0.\ 0.\ 0.\ 0.\ 0.$	$\begin{array}{c} + & 1.1318 \\ + & 0.1087 \\ + & 0.1087 \\ + & 0.1009 \\ + & 0.0024 \\ + & 4.4016 \\ - & 2.6447 \\ - & 1.0765 \\ - & 1.0765 \\ + & 1.01105 \\ \end{array}$	+25. 6494 +25. 6494 -0.0772 -0.0772 -0.0773 -0.0773 -0.0773 -0.0773 -0.0773 -0.0773 -0.0772 -0.0772 -0.0772 +10.3055 +10.3055 +10.3055
13	$\begin{array}{c} -13.4998\\ -13.4998\\ -0.2705\\ -0.3276\\ -0.3276\\ +0.1826\\ -9.6249\\ +8.2061\end{array}$	-19.1125 + 0.232175	$\begin{array}{c} -6.7278\\ -0.0915\\ -0.0915\\ +1.6556\\ +2.16556\\ +2.1693\\ -1.0572\\ -1.0572\\ -1.0572\\ +2.5151\\ -1.5824\\ +0.062299\end{array}$	+ 99. 0967 + 99. 0967 - 0. 3877 - 0. 3853 - 1. 4626 - 1. 4626 - 3858 - 30. 8858 - 30. 8858 - 11. 4488 - 1. 4488 - 1. 4488 - 0. 0986 +50. 0593	13110984480 131110984480
12	$\begin{array}{c} - & 6.8476\\ - & 6.8476\\ - & 0.0638\\ + & 0.0408\\ + & 0.408\\ + & 0.6605\\ - & 1.8028\\ \end{array}$	- 4.5532 + 0.055312	$\begin{array}{c} +28.4613\\ -0.0216\\ -0.0326\\ -1.8290\\ -1.8290\\ -1.8290\\ -0.2553\\ -0.2553\\ -0.2553\\ -0.2518\\ -25401\\ +25.4001\\ -2548\\ -\partial\lambda_6\end{array}$	10008-100	
11	$\begin{array}{c} +103.3016\\ -103.3016\\ -0.3200\\ -103200\\ -13283\\ -13283\\ -3.0030\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.8818\\ -5.$	$+ \frac{82.3192}{\delta\phi_6}$	15098465		
	1000-1001				

# Solution of normals-Continued

54	$\begin{array}{c} +28, 6369\\ -2, 6154\\ -2, 6154\\ -2, 6154\\ -2, 6154\\ -2, 6154\\ -1, 7337\\ -3, 1146\\ +3, 7757\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2153\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152\\ +3, 2152$	$\begin{array}{c} -0.564539\\ -0.564539\\ -0.654539\\ -0.2211\\ +0.0681\\ -0.2382\\ -0.2382\\ -0.2382\\ -0.2382\\ -1.1745\\ -0.785\\ +1.776\\ -1.1745\\ +1.2008\\ +1.2008\end{array}$	$\begin{array}{c} - & 9.7446 \\ + & 0.182018 \\ + & 0.182018 \\ + & 30.0408 \\ - & 1.7597 \\ - & 1.7597 \\ - & 1.7577 \\ + & 1.7755 \\ + & 1.2477 \\ + & 2.1754 \\ + & 2.2758 \\ + & 1.3331 \\ + & 2.2758 \\ + & 1.3331 \\ + & 3.339 \\ + & 3.339 \\ + & 3.339 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.3271 \\ + & 3.327$
ů	+37, 1447 + 0, 0093 - 0, 0063 - 0, 0063 - 0, 0035 - 0, 0035 - 0, 0113 - 0, 0113 - 0, 0113 - 0, 0113 - 0, 0113 - 0, 0132 + 36, 6829	$\begin{array}{c} -0.5232 \\ -0.52328 \\ -0.52398 \\ -0.0025 \\ -0.0027 \\ +0.0273 \\ +0.0239 \\ +0.0239 \\ +0.0239 \\ +1.4995 \end{array}$	$\begin{array}{c} - & 8.8717\\ + & 0.165713\\ + & 0.165713\\ + 43.2741\\ - & 0.0075\\ - & 0.0075\\ + & 0.0072\\ - & 0.0780\\ - & 0.0780\\ + & 0.0178\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.0128\\ + & 0.01$
22	+ 7, 7351 + 7, 7351 - 2, 4844 - 0, 13274 - 0, 5966 + 3, 2444	$\begin{array}{c} - \begin{array}{c} - \begin{array}{c} - \begin{array}{c} - \begin{array}{c} - \begin{array}{c} - \end{array} \\ - \begin{array}{c} - \end{array} \\ - \end{array} \\ - \begin{array}{c} - \begin{array}{c} - \end{array} \\ - \end{array} \\ - \end{array} \\ - \begin{array}{c} - \end{array} \\ - \end{array} \\ - \end{array} \\ - \begin{array}{c} - \end{array} \\ - \end{array} \\ - \end{array} \\ - 0 \\ - \end{array} \\ - \end{array} $	$\begin{array}{c} -4.5152\\ +0.084339\\ +2.4115\\ +2.4115\\ -0.1858\\ -0.1858\\ +1.2590\\ +1.55416\\ +1.5416\\ +2.9700\\ -0.031213\end{array}$
21	-15, 7932 -15, 7932 + 4, 1671 + 3, 64016 - 0, 7104 - 9, 0522	$\begin{array}{c} + & 0.332572 \\ + & 0.1338572 \\ + & 3.1960 \\ - & 0.8272 \\ - & 0.8272 \\ - & 0.1151 \\ - & 0.3700 \\ - & 0.3700 \end{array}$	$\begin{array}{c} -1.1265\\ +\ 0.021042\\ -94.2862\\ -94.2862\\ +\ 0.0344\\ +\ 0.0344\\ +\ 5.0366\\ -\ 0.3846\\ +\ 0.3846\\ -\ 0.3846\\ -\ 0.944871\\ +\ 0.944871\end{array}$
20	+ 9, 8031 + 0, 7039 + 0, 7039 + 0, 1053 - 0, 4340 + 10, 7966	- 1.1.2009 - 1.1.2009 - 4.8829 - 4.8829 - 0.3087 - 0.2151 - 0.2151 + 0.4413	- 5, 3033 + 0, 099060 - 0, 8560 - 0, 8560 - 0, 1747 + 0, 1747 + 1, 1372 + 1, 0994 - 0, 074610
19	-43.9722 +4.4696 +2.26315 +0.7399 -38.0474	$\begin{array}{c} + 0.5310\\ - 0.3310\\ - 13.4344\\ - 13.4344\\ - 0.5135\\ - 0.5739\\ + 0.1198\\ - 1.4735\end{array}$	$\begin{array}{c} -18,\ 2193\\ +\ 0,\ 340315\\ -12,\ 7934\\ -12,\ 7934\\ -12,\ 7934\\ +\ 0,\ 340315\\ +\ 0,\ 34031\\ -13,\ 9779\\ +\ 0,\ 2206\\ -15,\ 7973\\ +\ 0,\ 160018\\ \end{array}$
18	$\begin{array}{c} + & 3. 1998 \\ + & 0. 1440 \\ + & 0. 0056 \\ + & 0. 0356 \\ + & 0. 0355 \\ + & 0. 0491 \\ + & 0. 0491 \\ - & 5. 3288 \\ - & 4. 1136 \\ - & 6. 0554 \end{array}$	$\begin{array}{c} + 0.00370 \\ - 43.5742 \\ - 0.0051 \\ - 0.0051 \\ + 0.0184 \\ - 0.0385 \\ + 0.0184 \\ - 0.03816 \\ - 0.03816 \\ - 0.03816 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\ - 0.0316 \\$	$\begin{array}{c} -43,5239\\ +0,812976\\ -21,3622\\ +0,0067\\ +0,0067\\ +0,0195\\ +0,0192\\ +0,0122\\ +0,0122\\ +0,0122\\ +13202\\ +14,3212\\ -2,3302\\ +14,322\\ +14,322\\ +14,322\\ +14,3202\\ +11,481\\ +0,117159\end{array}$
17	11. 8987 0. 2018 11. 8987 0. 2018 11. 8987 11. 8988 11. 13. 14909 11. 13. 14909 13. 14909 14. 14	$\begin{array}{c} + & 0.338042\\ + & 0.338042\\ + & 8.9105\\ + & 1.00317\\ - & 0.0317\\ - & 0.0316\\ + & 1.0024\\ + & 1.0024\\ + & 1.3312\\ - & 1.0725\\ - & 1.0725\end{array}$	$\begin{array}{c} + 18.2788 \\ - 0.311427 \\ + 1122.9446 \\ - 0.3008 \\ - 0.2008 \\ - 0.2008 \\ - 0.4566 \\ - 0.4566 \\ - 0.4566 \\ - 0.4566 \\ - 0.4566 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 \\ - 0.1632 $
16	$\begin{array}{c} -19,  7152 \\ +  0. 0133 \\ -  0. 0268 \\ -  0. 0792 \\ +  0. 0792 \\ +  15,  7006 \\ -  1. 2348 \\ -  3. 1606 \\ -  1. 2294 \\ -  2. 7640 \end{array}$	$\begin{array}{c} + & 0.04376 \\ + & 0.040376 \\ + & 0.0104 \\ - & 0.0104 \\ - & 0.0103 \\ - & 0.0738 \\ - & 0.0738 \\ - & 0.0738 \\ - & 0.0738 \\ - & 0.0738 \\ - & 0.0138 \\ - & 0.0138 \\ - & 0.0138 \\ - & 0.0138 \\ - & 0.0138 \\ - & 0.0018 \\ - & 0.0018 \\ - & 0.0018 \\ - & 0.0018 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.0008 \\ - & 0.00$	+53,5365 $2\lambda_8$ $2\lambda_8$ 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 1111 11111 11111 111111 11111111
. 15	+122, 2200 - 0.4288 - 0.4288 - 0.691 - 0.5796 - 0.5796 - 0.5796 - 0.57396 - 0.57596 - 0.57	офа 968 111 112 113 113 115 115	
	11110 <b>9</b> 87		

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# Solution of normals-Continued

	18	19	20	21	22	77	Σ
7 8 9 10 11 12 13 14 15 16 17	$\begin{array}{r} + \ 61, 5179 \\ - \ 0.0484 \\ - \ 0.0005 \\ - \ 0.0013 \\ - \ 0.0063 \\ - \ 0.0001 \\ - \ 0.1183 \\ - \ 2.9008 \\ - \ 2.2294 \\ - \ 0.5441 \\ - \ 35.339 \\ - \ 1.3061 \end{array}$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$\begin{array}{r} - & 2.8738 \\ - & 0.0010 \\ - & 0.0650 \\ + & 0.4512 \\ - & 0.2352 \\ + & 0.9685 \\ - & 4.3115 \\ + & 0.8318 \end{array}$	$\begin{array}{r} + 31.3248 \\ - 0.0057 \\ - 0.2477 \\ + 2.0065 \\ - 0.3850 \\ - 0.8120 \\ - 0.9158 \\ - 10.5336 \end{array}$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$\begin{array}{r} + & 7.1924 \\ + & 0.8784 \\ + & 0.0230 \\ + & 0.4053 \\ + & 0.4581 \\ - & 0.0120 \\ - & 0.3548 \\ + & 1.0955 \\ + & 1.7425 \\ + & 3.4243 \\ - & 7.9221 \\ + & 5.7131 \end{array}$
	+ 18.9087 ∂λ9	$\begin{array}{r} - & 19.0796 \\ + & 1.009038 \end{array}$	$\begin{array}{r} - 5.2350 \\ + 0.276857 \end{array}$	+ 20. 4315 - 1. 080534	$\begin{array}{r} - & 12.3081 \\ + & 0.650923 \end{array}$	+ 10. 5259 - 0. 556670	+ 13.2434 - 0.700387
	$11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 17 \\ 18$	$\begin{array}{r} +106.\ 8200\\ -\ 0.\ 5579\\ -\ 0.\ 2034\\ -\ 0.\ 8992\\ -\ 0.\ 0721\\ -\ 19.\ 2169\\ -\ 6.\ 2003\\ -\ 2.\ 6226\\ -\ 19.\ 2520\\ \end{array}$	$\begin{array}{r} +27,9899\\ -\ 0,0879\\ -\ 0,0852\\ -\ 0,2512\\ +\ 0,0423\\ +\ 5,7557\\ -\ 1,8048\\ +\ 1,1786\\ -\ 5,2823\end{array}$	$\begin{array}{r} - 16.8102 \\ - 0.5202 \\ - 0.3249 \\ - 1.1172 \\ + 0.0693 \\ - 4.8257 \\ - 0.3834 \\ - 14.9264 \\ + 20.6162 \end{array}$	$\begin{array}{rrrr} - & 7.0763 \\ + & 0.3101 \\ + & 0.0952 \\ + & 0.4629 \\ + & 0.0582 \\ + & 1.7296 \\ - & 1.5366 \\ + & 0.4931 \\ - & 12.4193 \end{array}$	$\begin{array}{r} + \ 34.\ 6511 \\ + \ 0.\ 0382 \\ - \ 0.\ 0091 \\ + \ 0.\ 0234 \\ + \ 0.\ 0037 \\ + \ 19.\ 5557 \\ - \ 3.\ 0192 \\ + \ 10.\ 0264 \\ + \ 10.\ 6210 \end{array}$	$\begin{array}{r} + 85.3611 \\ - 1.0954 \\ - 0.4653 \\ - 0.9440 \\ - 0.3134 \\ + 20.3509 \\ - 3.3162 \\ + 8.0956 \\ + 13.3631 \end{array}$
		+ 57.7956 δφ10	+27.4551 - 0.475038	$\begin{array}{r} - 18.2225 \\ + 0.315292 \end{array}$	$\begin{array}{r} - & 17.8831 \\ + & 0.309420 \end{array}$	+ 71.8912 - 1.243887	+121.0363 - 2.094213
		11 12 13 14 15 16 17 18 19	$\begin{array}{r} +50,9179\\ -0,0138\\ -0,0357\\ -0,0702\\ -0,0248\\ -1,7239\\ -0,5253\\ -0,5297\\ -1,4493\\ -13,0422 \end{array}$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$\begin{array}{rrrr} - & 26.1027 \\ + & 0.0488 \\ + & 0.0399 \\ + & 0.1293 \\ - & 0.0341 \\ - & 0.5180 \\ - & 0.4473 \\ - & 0.2216 \\ - & 3.4076 \\ + & 8.4952 \end{array}$	$\begin{array}{r} +167.\ 6744\\ +\ 0.\ 0060\\ -\ 0.\ 0038\\ +\ 0.\ 0065\\ -\ 0.\ 0022\\ -\ 5.\ 8571\\ -\ 0.\ 8788\\ -\ 4.\ 5060\\ +\ 2.\ 9142\\ -\ 34.\ 1511\end{array}$	$\begin{array}{r} +214,2334\\ -&0,1725\\ -&0,1949\\ -&0,2637\\ +&0,1839\\ -&6,0953\\ -&0,9653\\ -&0,9653\\ -&3,6382\\ +&3,6665\\ -&57,4968 \end{array}$
			$+33.5030 \\ \partial \lambda_{10}$	+ 12. 5701 - 0. 375193	-22.0181 + 0.657198	+125.2021 - 3.737041	+149.2571 - 4.455037
			$11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 17 \\ 18 \\ 19 \\ 20$	$\begin{array}{c} +173.0271\\ -0.4850\\ -0.5189\\ -1.3879\\ -0.0665\\ -1.2118\\ -0.0237\\ -84.9517\\ -22.0769\\ -5.7454\\ -4.7162\end{array}$	$\begin{array}{r} -35.3120\\ +\ 0.2891\\ +\ 0.5751\\ -\ 0.0558\\ +\ 0.4343\\ -\ 0.0950\\ +\ 2.8063\\ +\ 13.2993\\ -\ 5.6384\\ +\ 8.2610 \end{array}$	$\begin{array}{r} -162,3283\\ +\ 0,0356\\ -\ 0,0146\\ +\ 0,0291\\ -\ 0,0036\\ +\ 4,9108\\ -\ 0,1867\\ +\ 57,0642\\ -\ 11,3736\\ +\ 22,6667\\ -\ 46,9750\\ \end{array}$	$\begin{array}{c} -115.8122\\ -1.0213\\ -0.7431\\ -1.1728\\ +0.3009\\ +5.1105\\ -0.2050\\ +46.0750\\ -14.3099\\ +38.1618\\ -56.0002 \end{array}$
				$+ 51.8431 \\ \delta \phi_{11}$	$\begin{array}{rrr} - & 15.2841 \\ + & 0.294815 \end{array}$	-136.1754 + 2.626683	$\begin{array}{r} - 99.6164 \\ + 1.921498 \end{array}$
				$11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 17 \\ 18 \\ 19 \\ 20 \\ 21$	$\begin{array}{r} + 54.7848 \\ - 0.1724 \\ - 0.0445 \\ - 0.2383 \\ - 0.0469 \\ - 0.1557 \\ - 0.3808 \\ - 0.0927 \\ - 8.0116 \\ - 5.5334 \\ - 14.4703 \\ - 4.5060 \end{array}$	$\begin{array}{r} +188.1235\\ -0.0212\\ +0.0043\\ -0.0120\\ -0.0030\\ -1.7601\\ -0.7482\\ -1.8851\\ +6.8516\\ +22.2446\\ +82.2826\\ -40.1466\end{array}$	$\begin{array}{r} +163.8779\\ +\ 0.6089\\ +\ 0.2177\\ +\ 0.4860\\ +\ 0.2527\\ -\ 1.8317\\ -\ 0.8218\\ -\ 1.5220\\ +\ 8.6204\\ +\ 37.4511\\ +\ 98.0915\\ -\ 29.3684 \end{array}$
					+ 21.1322 $\delta \lambda_{11}$	+254.9304 - 12.06360	+276.0626 - 13.06360

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 22	21	20	19	18	17	16	15
	+2.6267 -3.5565 -0.9298	$ \begin{array}{r} -3.7370 \\ -7.9282 \\ +0.3489 \\ \hline -11.3163 \end{array} $	-1.2439-3.7327-0.2932+5.3757+0.1059	$\begin{array}{r} - \ 0.5567 \\ - \ 7.8525 \\ + \ 1.0047 \\ - \ 3.1330 \\ + \ 0.1069 \end{array}$	$-0.6347 \\ +0.3765 \\ -0.8785 \\ +0.8443 \\ +0.0176 \\ -1.2220 \\ \hline -1.4968$	$\begin{array}{r} +0.1657\\ -1.0174\\ -0.0196\\ -1.1210\\ +0.0360\\ -8.4798\\ +0.5110\\ \hline \end{array}$	$\begin{array}{r} -0.5425 \\ +0.5788 \\ -0.1245 \\ +1.8069 \\ +0.0565 \\ -0.9356 \\ -0.5808 \\ -0.4057 \\ \hline \end{array}$
14	13	12	11	10	9	8	7
$\begin{array}{c} +0.0043\\ -0.8137\\ -0.0747\\ -0.5552\\ -0.0089\\ -4.8507\\ +1.4117\\ -1.3794\\ -0.1261\\ \hline \end{array}$	$\begin{array}{c} +0.0035\\ -0.8324\\ +0.1548\\ +0.4238\\ -0.0142\\ -2.5109\\ -0.9080\\ +1.4171\\ -0.0650\\ +0.1406\end{array}$	$\begin{array}{c} +0.0040\\ +0.5052\\ -0.1329\\ -0.4242\\ +0.0095\\ -0.7118\\ +0.2615\\ -2.2421\\ -0.0163\\ -4.3487\\ -0.1365\\ \hline \end{array}$	$\begin{array}{c} +0.0056\\ -0.5520\\ +0.0714\\ +0.1467\\ -0.0087\\ +0.0097\\ +0.2450\\ +2.8702\\ -0.0968\\ -0.8846\\ -0.8846\\ -0.4000\\ +0.40075\end{array}$	$\begin{array}{c} -0.0056\\ -0.6012\\ -0.0805\\ -0.7224\\ +0.0065\\ -2.2577\\ +1.9853\\ -1.4399\\ +0.2647\\ \hline -2.8508\\ \end{array}$	$\begin{array}{c} -0.0042\\ -0.2065\\ +0.1132\\ +0.1155\\ +0.0125\\ -0.1831\\ -1.3614\\ +0.3084\\ +0.0790\\ -0.2828\\ \hline \end{array}$	$\begin{array}{c} +0.0041 \\ +0.0385 \\ -0.0799 \\ -0.1733 \\ -0.0066 \\ -0.0197 \\ +0.0507 \\ -0.6273 \\ +0.0945 \\ -2.2905 \\ +0.0490 \\ \hline -2.9605 \\ \end{array}$	$\begin{array}{c} +0.0019\\ -0.2996\\ +0.0876\\ -0.0302\\ +0.0126\\ +0.2271\\ -0.3460\\ +1.2773\\ +0.1663\\ -0.0681\\ -0.2829\\ -0.0309\\ \hline +0.7151\end{array}$
6	5	4	3	2	1		,
$\begin{array}{r} -0.0082\\ -0.4199\\ +0.2999\\ +0.1234\\ -0.0545\\ -0.9952\\ -0.1726\\ +0.1954\\ +0.0337\\ \hline \end{array}$	$\begin{array}{c} +0.0105\\ -0.1370\\ +0.1674\\ +0.1304\\ -0.0217\\ -0.9773\\ -0.8725\\ -0.0068\\ +0.0643\\ +0.0917\\ \hline \end{array}$	$\begin{array}{c} -0.0215\\ -0.1192\\ +0.0462\\ -0.0050\\ -0.0500\\ -0.1310\\ +0.3049\\ \hline +0.0244 \end{array}$	$\begin{array}{c} +0.0005\\ +0.0600\\ +0.1430\\ +0.1295\\ -0.0424\\ -0.0343\\ -0.5681\\ -0.0020\\ \hline \end{array}$	$-0.0216 \\ -0.0453 \\ +0.0141 \\ -0.0045 \\ -0.0176 \\ -0.0328 \\ +0.4148 \\ +0.0084 \\ -0.0060 \\ \hline +0.3095$	$\begin{array}{c} -0.0066\\ +0.0242\\ +0.0678\\ +0.0600\\ -0.0212\\ -0.0699\\ -0.2184\\ +0.0113\\ -0.2006\\ -0.0143\\ \hline -0.3677\end{array}$		

# Back solution

1	2	<i>z</i> 1	3	4	5	3a	Z2
+0.700 +0.7	$-0.842 \\ -0.857 \\ +0.700 \\ +0.3$	-0.842-0.857+0.3-1.399	$^{+1.039}_{+1.0}$	$-1.318 \\ -0.098 \\ +1.039 \\ -0.6$	$+0.301 \\ -1.541 \\ +1.039 \\ -0.9$	+1.039 +1.0	$\begin{array}{r} +0.301 \\ -1.541 \\ -1.318 \\ -0.098 \\ -1.5 \end{array}$
	0.699 -0.7	+0.700		-0.977 -1.0	$-1.101 \\ -1.1$		-4.156 +1.039
4a	5a	6	7	8	Z3	17	15
-0.842-0.857+1.592-0.107-0.1	$+0.301 \\ -1.541 \\ +1.592 \\ +0.352 \\ +0.4$	$+0.978 \\ -0.699 \\ +1.592 \\ -0.9 \\ +0.971$	+2.416 -0.699 -2.062 +0.055 +1.592 +1.4	+1.254+0.149-5.289+0.479+1.592-2.1	+4.107 -3.649 -2.062 +0.055 -5.289 +0.479	$\begin{array}{r} +0.857 \\ -0.131 \\ +1.860 \\ \hline \\ +2.586 \\ +2.6 \end{array}$	+2.416 -0.699 -2.062 +0.055 +1.860 -2.7
		+1.0	+2.702 +2.7	-3.915 -3.9	$\frac{-1.6}{-7.959} \\ +1.592$		-1.130 -1.1
16	24	14	9	10	11	12	13
$\begin{array}{r} -1.318 \\ -0.098 \\ +1.860 \\ -1.9 \end{array}$	+2.416 -0.699 -2.523 -0.174	-0.753 -0.8	$+2.624 \\ -1.836 \\ -0.753 \\ +0.4$	-4.045 +3.792 -0.753 +0.7	$\begin{array}{r} -2.295 \\ +3.174 \\ -0.753 \\ +1.8 \end{array}$	+0.857 -0.131 -0.753 -0.6	$\begin{array}{r} +0.978 \\ -0.699 \\ -0.753 \\ -0.2 \end{array}$
-1.456 -1.4	$-5.580 \\ +1.860$		+0.435 +0.4	$-0.306 \\ -0.3$	+1.926 +1.9	-0.627 -0.7	-0.674 -0.7
Z5	18	19	20	21	22	Z6	
$\begin{array}{r} +0.978 \\ -0.699 \\ +0.857 \\ -0.131 \\ -2.295 \\ +3 174 \\ +2.624 \\ -1.836 \\ -4.045 \end{array}$	+1.254+0.149-5.289+0.479+3.728+0.321+0.321	+1.440+0.062-7.119+2.545+3.728-1.8-1.144-1.2	$\begin{array}{r} -2.295 \\ +3.174 \\ +3.728 \\ -2.8 \\ \hline +1.807 \\ +1.8 \end{array}$	+2.373 +2.275 +1.094 -6.750 +3.728 -2.9 -0.180 -0.2	+6.980+1.976-6.342-5.645+3.728-1.5-0.803-0.8	+ 1.254 + 0.149 + 1.440 + 0.062 - 5.351 +10.449 + 1.094 - 6.750 - 6.249	
+3.792 +2.1		-1.2		-0.2	-0.8	$\begin{array}{r} - 0.342 \\ - 5.645 \\ - 9.0 \end{array}$	
+4.519 -0.753						-18.640 + 3.728	
28	29	30	31	32	27		6
$\begin{array}{r} -2,560 \\ -1,066 \\ +1,454 \\ +2,604 \\ -0,633 \end{array}$	$- 1.495 \\ - 6.247 \\ - 4.579 \\ + 13.489 \\ - 0.633 \\ + 0.3$	$\begin{array}{r} -0.179 \\ -13.085 \\ -0.352 \\ +12.601 \\ -0.633 \\ +0.9 \end{array}$	$\begin{array}{r} +2.373\\ +2.275\\ +1.094\\ -6.750\\ -0.633\\ +0.6\end{array}$	$\begin{array}{r} +2.624 \\ -1.836 \\ -0.632 \\ +1.0 \\ \hline \\ +1.155 \end{array}$	$\begin{array}{r} + 2.373 \\ + 2.275 \\ - 0.515 \\ -28.983 \\ - 0.352 \\ + 12.601 \end{array}$		
$-0.201 \\ -0.1$	+ 0.835 + 0.9	-0.748 - 0.7	$-1.041 \\ -1.0$	+1.2	$\begin{array}{r} + 1.454 \\ + 2.604 \\ - 4.579 \\ + 13.489 \\ + 2.8 \end{array}$		
				1	+ 3.167 - 0.633		

# Computation of corrections.

91865°—15——12

23	24	25	26	27	<i>2</i> 8
$\begin{array}{r} +6.980\\ +1.976\\ -6.342\\ -5.645\\ +1.588\\ \hline \\ -1.443\\ -1.4 \end{array}$	$\begin{array}{r} -4.045 \\ +3.792 \\ +1.588 \\ -1.4 \\ \hline -0.065 \\ -0.0 \end{array}$	$\begin{array}{c} - \ 0.179 \\ - \ 0.322 \\ + 12.601 \\ + 1.588 \\ - \ 0.6 \end{array}$	$\begin{array}{r} + 3.834 \\ + 4.162 \\ + 1.108 \\ - 10.559 \\ + 1.588 \\ - 0.3 \\ \hline - 0.167 \\ - 0.2 \end{array}$	$\begin{array}{r} + 6.977 \\ - 2.480 \\ - 10.844 \\ + 5.562 \\ + 1.588 \\ + 0.9 \end{array}$	$\begin{array}{c} + \ 6.980 \\ + \ 1.976 \\ - \ 0.179 \\ - \ 13.085 \\ + \ 0.070 \\ + 12.429 \\ + \ 1.108 \\ - \ 10.559 \\ - \ 10.844 \\ + \ 5.562 \\ - \ 1.4 \end{array}$
38	39	40	41	42	29
$\begin{array}{r} - 2.180 \\ - 8.534 \\ - 0.786 \\ +11.712 \\ - 1.284 \end{array}$	$\begin{array}{r} -1.015\\ -17.358\\ -3.727\\ +25.033\\ -1.284\\ +3.4 \end{array}$	$\begin{array}{r} + \ 0.\ 623 \\ -27.\ 410 \\ + \ 3.\ 352 \\ +24.\ 228 \\ - \ 1.\ 284 \\ - \ 2.\ 2 \end{array}$	$\begin{array}{r} + 3.834 \\ + 4.162 \\ + 1.108 \\ -10.559 \\ - 1.284 \\ + 1.6 \end{array}$	$\begin{array}{r} -2.560 \\ -1.066 \\ +1.459 \\ +2.604 \\ -1.284 \\ +0.7 \end{array}$	$\begin{array}{r} -2.560 \\ -1.066 \\ +3.834 \\ +4.162 \\ -0.004 \\ -61.258 \\ +3.352 \end{array}$
- 1.1	+ 5.049 + 5.0	-2.691 -2.7	- 1.139 - 1.2	- 0.147 - 0.1	$\begin{array}{r} + 3.328 \\ + 24.228 \\ - 0.786 \\ + 11.712 \\ - 3.727 \\ + 25.033 \\ + 3.5 \end{array}$
					+ 6.420 - 1.284
33	34	35	36	37	Z10
$\begin{array}{r} + \ 6.977 \\ - \ 2.480 \\ - 10.844 \\ + \ 5.562 \\ - \ 2.538 \\ \hline - \ 3.323 \\ - \ 3.3 \end{array}$	$\begin{array}{r} -1.495 \\ -6.247 \\ -4.579 \\ +13.489 \\ -2.538 \\ +3.0 \\ \hline +1.630 \\ +1.7 \end{array}$	$\begin{array}{r} + \ 0.\ 623 \\ -27.\ 410 \\ + \ 3.\ 352 \\ +24.\ 228 \\ - \ 2.\ 528 \\ + \ 3.\ 5 \end{array}$	$\begin{array}{r} + \ 6.265 \\ + \ 10.228 \\ - \ 0.420 \\ - \ 15.880 \\ - \ 2.538 \\ + \ 2.2 \end{array}$	$\begin{array}{r} +8.719 \\ +0.384 \\ -5.957 \\ -0.626 \\ -2.538 \\ +0.1 \\ \end{array}$	$\begin{array}{r} -1.495\\ -6.247\\ +6.977\\ -2.480\\ +0.623\\ -27.410\\ +2.914\\ +53.890\\ -0.420\\ -15.880\\ -5.957\\ -5.957\\ -0.626\\ +8.8 \end{array}$
					+12.689 - 2.538
43	44	45	46	47	z ₁₁
$\begin{array}{r} +8.719 \\ +0.384 \\ -5.957 \\ -0.626 \\ -2.716 \end{array}$	$\begin{array}{r} -1.015 \\ -17.358 \\ -3.727 \\ +25.033 \\ -2.716 \\ -1.8 \end{array}$	$\begin{array}{r} + \ 0.025 \\ -55.481 \\ - \ 0.254 \\ +58.307 \\ - \ 2.716 \\ - \ 0.6 \end{array}$	$\begin{array}{r} + 4.655 \\ +22.009 \\ + 0.329 \\ -23.877 \\ - 2.716 \\ - 2.0 \end{array}$	$+10.478 \\ -12.412 \\ -6.509 \\ +14.356 \\ -2.716 \\ +0.9$	$\begin{array}{r} -1.015 \\ -17.358 \\ +8.719 \\ +0.384 \\ +0.025 \\ -55.481 \end{array}$
-0.196 -0.2	-1.583 -1.6	- 0.719 - 0.7	- 1.600 - 1.6	+ 4.097 + 4.1	$\begin{array}{r} + 5.194 \\ +92.311 \\ + 0.329 \\ -23.877 \\ - 6.509 \\ +14.356 \\ - 3.5 \end{array}$
		•			+13.578 - 2.716

# Computation of corrections-Continued

	48	49	50	51	52	Z12	
	$\begin{array}{c} +0.720 \\ +0.199 \\ +0.519 \\ -0.226 \\ -1.196 \\ \hline \\ +0.016 \\ +0.0 \end{array}$	$\begin{array}{r} + \ 0.391 \\ - 29.478 \\ - 32.473 \\ + 35.829 \\ - 1.196 \\ - 2.3 \\ + \ 0.773 \\ + \ 0.8 \end{array}$	$\begin{array}{r} + \ 0.025 \\ - 55. \ 481 \\ - \ 0.254 \\ + 58. \ 306 \\ - \ 1.196 \\ - \ 0.3 \\ \end{array}$	$\begin{array}{r} + \ 6.265 \\ +10.228 \\ - \ 0.420 \\ -15.880 \\ - \ 1.196 \\ + \ 0.8 \end{array}$	$\begin{array}{r} - 2.180 \\ - 8.534 \\ - 0.786 \\ +11.712 \\ - 1.196 \\ - 0.7 \\ - 1.684 \\ - 1.7 \end{array}$	$\begin{array}{r} -2.180\\ -8.534\\ +6.265\\ +10.228\\ -0.071\\ -88.929\\ -0.254\\ +58.308\\ +0.519\\ -0.226\\ -2.473\\ +35.829\\ -2.5\\ \hline +5.982\\ -1.196\\ \end{array}$	
	53	54	55	56	57	Z13	
	$\begin{array}{r} +10.\ 478\\ -12.\ 412\\ -6.\ 509\\ +14.\ 356\\ -7.\ 305\\ \hline -1.\ 394\\ -1.\ 4\end{array}$	$\begin{array}{r} + \ 0.391 \\ - \ 29.473 \\ - \ 2.473 \\ + \ 35.829 \\ - \ 7.305 \\ + \ 0.7 \\ \hline - \ 2.336 \\ - \ 2.3 \end{array}$	$\begin{array}{r} + \ 0.177 \\ -48.094 \\ + \ 1.553 \\ +51.270 \\ - \ 7.305 \\ - \ 1.8 \end{array}$	$ \begin{array}{r} + 1,832 \\ + 22.318 \\ - 7.305 \\ - 11.0 \\ \hline + 5.845 \\ + 5.8 \\ \end{array} $	$ \begin{array}{r} + 5.607 \\ - 29.918 \\ - 7.305 \\ + 33.7 \\ \hline + 2.084 \\ + 2.1 \\ \end{array} $	$\begin{array}{r} + \ 0.391 \\ - 29.478 \\ + 10.478 \\ - 12.412 \\ + \ 0.177 \\ - 48.094 \\ + \ 0.009 \\ + 93.855 \\ + 21.6 \end{array}$	
	58	59	60	61	62	214	
	$\begin{array}{r} - \ 0.530 \\ + 20.030 \\ - \ 4.333 \\ - 15.2 \\ \hline \\ - \ 0.033 \\ - \ 0.0 \end{array}$	$\begin{array}{r} - 0.116 \\ -36.552 \\ - 4.333 \\ +43.2 \\ \hline + 2.199 \\ + 2.2 \end{array}$	$\begin{array}{r} + \ 0.177 \\ - 48.094 \\ + \ 1.553 \\ + 51.270 \\ - \ 4.333 \\ + \ 1.3 \\ \end{array}$	$\begin{array}{r} + \ 4.\ 655 \\ + 22.\ 009 \\ + \ 0.\ 329 \\ - 23.\ 877 \\ - \ 4.\ 333 \\ - \ 0.\ 5 \\ \hline \\ \hline - \ 1.\ 717 \\ - \ 1.7 \end{array}$	$\begin{array}{r} +0.720 \\ +0.199 \\ +0.519 \\ -0.226 \\ -4.333 \\ +0.8 \end{array}$	$\begin{array}{r} + \ 0.\ 720 \\ + \ 0.\ 199 \\ + \ 4.\ 655 \\ + 22.\ 009 \\ + \ 0.\ 379 \\ - \ 88.\ 720 \\ + \ 1.\ 553 \\ + 51.\ 270 \\ + 29.\ 6 \end{array}$	•
						+21.665 - 4.333	
63	64	65	· Z ₁₅	66	67	68	Z16
+ 5.607 -29.918 -10.240 +33.2	$- 0.116 \\ -36.552 \\ -10.240 \\ +46.9$	$ \begin{array}{r} -10.240 \\ +11.6 \\ \hline +1.360 \\ +1.3 \\ \end{array} $	$\begin{array}{r} - \ 0.116 \\ -36.552 \\ + \ 5.607 \\ -29.918 \\ +91.7 \end{array}$	$ \begin{array}{r} -9.016 \\ +13.3 \\ +4.284 \\ +4.2 \end{array} $	$ \begin{array}{r} + 1.832 \\ +22.318 \\ - 9.016 \\ -13.8 \end{array} $	-0.530 +20.030 -9.016 -16.1	$\begin{array}{r} - 0.530 \\ +20.030 \\ + 1.832 \\ +22.318 \\ -16.6 \end{array}$
-1.351 -1.3	-0.008 -0.0		+30.721 -10.240		+1.334 + 1.3	-5.616 - 5.6	+27.050 - 9.016

Computation of corrections—Continued

Symbol	Station	Observed angle	Cor- rec- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Loga- rithm
-	Fort Morgan-Dauphin Island	0 / //	"		"	• / //	4 050202
-4a+5a - 1+ 2 +3a- 5	east base Cedar Fort Morgan Dauphin Island east base	43 54 21.8 42 33 37.7 93 31 59.6	$^{+0.5}_{-1.4}_{+2.1}$	$22.3 \\ 36.3 \\ 61.7$	0.1 0.1 0.1	$\begin{array}{r} 22.2\\ 36.2\\ 32 \ 01.6\end{array}$	0. 158967 9. 830179 9. 999173
	Cedar–Dauphin Island east base Cedar–Fort Morgan		+1.2		0.3		4.039349 4.208343
	Dauphin Island east base-Dau- phin Island west base						4. 027832
-5a+6 -3+5 -13+14	Cedar Dauphin Island east base Dauphin Island west base	$\begin{array}{c} 37 \ 26 \ 33.0 \\ 103 \ 55 \ 36.4 \\ 38 \ 37 \ 52.5 \end{array}$	$+0.6 \\ -2.1 \\ -0.1$	33.6 34.3 52.4	$\begin{array}{c} 0.1\\ 0.1\\ 0.1\end{array}$	33.5 34.2 52.3	0.216120 9.987043 9.795397
	Cedar–Dauphin Island west base Cedar–Dauphin Island east base		-1.6		0.3		4. 230995 4. 039349
-15+16 -5a+7 -4+5	Cedar–Dauphin Island east base Cat Cedar Dauphin Island east base	69 30 32.7 60 11 14.2 50 18 11.4	-0.3 + 2.3 - 0.1	32. 4 16. 5 11. 3	0.0 0.1 0.1	32.4 16.4 11.2	4.039349 0.028387 9.938350 9.886171
	Cat-Dauphin Island east base Cat-Cedar		+1.9		0.2		4. 006086 3. 953907
-15+17 - 6+ 7 -12+13	Cedar–Dauphin Island west base Cat Cedar Dauphin Island west base	$\begin{array}{c} 135 \ 31 \ 54.9 \\ 22 \ 44 \ 41.2 \\ 21 \ 43 \ 18.7 \end{array}$	+3.7 +1.7 0.0	58.6 42.9 18.7	$0.1 \\ 0.0 \\ 0.1$	58.5 42.9 18.6	4.230995 0.154592 9.587301 9.568320
	Cat-Dauphin Island west base Cat-Cedar		+5.4	-	0.2		3.972888 3.953907
	Dauphin Island east base–Dau- phin Island west base						4. 027832
$ \begin{array}{r} -16+17 \\ -3+4 \\ -12+14 \end{array} $	Cat Dauphin Island east base Dauphin Island west base	$\begin{bmatrix} 66 & 01 & 22.2 \\ 53 & 37 & 25.0 \\ 60 & 21 & 11.2 \end{bmatrix}$	+4.0 -2.0 -0.1	$ \begin{array}{c c} 26.2 \\ 23.0 \\ 11.1 \end{array} $	$ \begin{array}{c} 0.1 \\ 0.1 \\ 0.1 \end{array} $	26.1 22.9 11.0	0.039189 9.905867 9.939065
	Cat–Dauphin Island west base Cat–Dauphin Island east base		+1.9		0.3		3.972888 4.006086
$ \begin{vmatrix} -18 + 19 \\ -7 + 8 \end{vmatrix} $	Cedar-Cat Pins Cedar Cat	$\begin{array}{c} 23 \ 22 \ 40.3 \\ 30 \ 54 \ 61.5 \\ 18.4 \end{array}$	-1.5 -6.6	38.8 54.9 26.5	0.1 0.1 0.0	38.754.8125 42 26.5	3. 953907 0. 401443 9. 710768 9. 909561
3.0	Pins-Cat Pins-Cedar			-	0.2		4.066118 4.264911
$ \begin{array}{c} -18 + 20 \\ -6 + 8 \\ -11 + 13 \end{array} $	Cedar–Dauphin Island west base Pins Cedar Dauphin Island west base	58 45 26.0 53 39 42.7 67 34 57.9	$+1.5 \\ -4.9 \\ -2.6$	27.5 37.8 55.3	$0.2 \\ 0.2 \\ 0.2 \\ 0.2$	27.3 37.6 55.1	• 4.230995 0.068044 9.906076 9.965872
	Pins-Dauphin Island west base Pins-Cedar		-6.0		0.6		$\begin{array}{c} 4.205115\\ 4.264911 \end{array}$
-19+20 -11+12	Cat-Dauphin Island west base Pins Cat Dauphin Island west base	35 22 45.7 35.3 45 51 39.2	+3.0 -2.6	48.7 34.9 36.6	$0.1 \\ 0.0 \\ 0.1$	48.6 98 45 34.9 36.5	3.972888 0.237322 9.994905 9.855908
	Pins-Dauphin Island west base Pins-Cat				0.2		4.205115 4.066118

# Final computation of triangles
Symbol	Station	Observed angle	Cor- rec- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Loga- rithm
-23+24 -20+22 -10+11	Pins–Dauphin Island west base Grand Pins Dauphin Island west base	° ' '' 54 52 01.6 85 13 07.0 39 54 50.9	'' +1.4 -2.6 +2.2	" 03.0 04.4 53.1	" 0.2 0.1 0.2	° / // 02.8 04.3 52.9	4.205115 0.087341 9.998486 9.807296
	Grand-Dauphin Island west base Grand-Pins		+1.0		0.5	_	4.290942 4.099752
-30+31 -23+25 -21+22	Grand-Pins Petit Grand Pins	33 09 08.7 114 03 53.6 32 46 57.5	-0.3 + 1.4 - 0.6	08.4 55.0 56.9	$0.1 \\ 0.1 \\ 0.1$	08.3 54.9 56.8	4.099752 0.262119 9.960510 9.733559
	Petit-Pins Petit-Grand		+0.5		0.3		$\begin{array}{c} 4.322381 \\ 4.095430^{-1} \end{array}$
-30+32 -24+25 -9+10	Grand–Dauphin Island west base Petit Grand Dauphin Island west base	81 41 28.2 59 11 52.0 39 06 39.1	+1.9 0.0 -0.7	30.1 52.0 38.4	$0.1 \\ 0.2 \\ 0.2$	30.0 51.8 38.2	4.290942 0.004582 9.933962 9.799905
-	Petit-Dauphin Island west base Petit-Grand		+1.2		0.5		4.229486 4.095429
-31+32 -20+21 -9+11	Pins–Dauphin Island west base Petit Pins Dauphin Island west base	48 32 19.5 52 26 09.5 79 01 30.0	$+2.2 \\ -2.0 \\ +1.5$	21.7 07.5 31.5	$0.2 \\ 0.2 \\ 0.3$	21.5 07.3 31.2	4,205115 0,125281 9,899090 9,991984
	Petit-Dauphin Island west base Petit-Pins		+1.7		0.7	-	$\begin{array}{c} \textbf{4.229486} \\ \textbf{4.322380^{+1}} \end{array}$
-33+34 -25+27 -29+30	Grand-Petit Pascagoula Grand Petit	37 39 20.6 104 18 56.1 38 01 38.6	+5.0 +1.7 -1.6	$25.6 \\ 57.8 \\ 37.0$	$0.1 \\ 0.2 \\ 0.1$	25.5 57.6 36.9	4.095429 0.214006 9.986300 9.789603
	Pascagoula-Petit Pascagoula-Grand		+5.1		0.4		4.295735 4.099038
-40+41 -33+35 -26+27	Pascagoula-Grand Horn Pascagoula Grand	38 49 39.0 97 55 54.0 43 14 18.9	+1.5 +5.1 +1.9	40.5 59.1 20.8	$\begin{array}{c} 0.1\\ 0.2\\ 0.1 \end{array}$	40.4 58.9 20.7	4.099038 0.202744 9.995824 9.835719
	Horn-Grand Horn-Pascagoula		+8.5		0.4		4.297606 4.137501
-40+42 -34+35 -28+29	Pascagoula-Petit Horn Pascagoula Petit	77 06 13.2 60 16 33.4 42 37 10.3	+2.6 +0.1 +1.0	15.8 33.5 11.3	$0.2 \\ 0.2 \\ 0.2 \\ 0.2$	15.6 33.3 11.1	4,295735 0,011094 9,938731 9,830672
	Horn-Petit Horn-Pascagoula		+3.7		0.6		4.245560 4.137501
-41+42 -25+26 -28+30	Grand-Petit Horn Grand Petit	38 16 34.2 61 04 37.2 80 38 48.9	$+1.1 \\ -0.2 \\ -0.6$	35.3 37.0 48.3	$0.2 \\ 0.2 \\ 0.2 \\ 0.2$	35. 1 36. 8 48. 1	4.095429 0.207989 9.942142 9.994187
	Horn-Petit Horn-Grand		+0.3		0.6	-	4.245560 4.297605 ⁺¹

# Final computation of triangles—Continued

Symbol	Station	Observed angle	Cor- rec- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Loga- rithm
-43+44 -35+37 -39+40	Pascagoula-Horn Belle Pascagoula Horn	° ' '' 48 58 49.8 69 43 28.0 61 17 53.5	" - 1.4 - 1.7 - 7.7	" 48.4 26.3 45.8	" 0.1 0.2 0.2	• / // 48.3 26.1 45.6	4. 137501 0. 122351 9. 972219 9. 943055
	Belle–Horn Belle–Pascagoula		-10.8		0.5		4.232071 4.202907
-50+51 -43+45 -36+37	Belle–Pascagoula Club Belle Pascagoula	58 40 43.3 89 28 55.3 31 50 23.4	-1.3 -0.5 +0.2	42.0 54.8 23.6	0.1 0.2 0.1	41. 9 54. 6 23. 5	4.202907 0.068410 9.999982 9.722261
	Club-Pascagoula Club-Belle		- 1.6		0.4		4.271299 3.993578
-50+52 -44+45 -38+39	Belle–Horn Club Belle Horn	105 43 56.9 40 30 05.5 33 45 53.7	-2.8 + 0.9 + 6.1	$54.1 \\ 06.4 \\ 59.8$	0.1 0.1 0.1	54. 0 06. 3 59. 7	4.232071 0.016580 9.812560 9.744927
	Club-Horn Club-Belle		+ 4.2		0.3		4. 061211 3. 993578
-51+52 -35+36 -38+40	Pascagoula-Horn Club Pascagoula Horn	47 03 13.6 37 53 04.6 95 03 47.2	-1.5 -1.9 -1.6	$12.1 \\ 02.7 \\ 45.6$	$0.1 \\ 0.2 \\ 0.1$	12. 0 02. 5 45. 5	4. 137501 0. 135496 9. 788214 9. 998302
	Club-Horn Club-Pascagoula		- 5.0		0.4		4. 061211 4. 271299
-53+54 -45+47 -49+50	Belle-Club Deer Belle Club	$\begin{array}{r} 41 \ 02 \ 10.7 \\ 102 \ 35 \ 18.5 \\ 36 \ 22 \ 26.8 \end{array}$	-0.9 + 4.8 + 0.3	$09.8 \\ 23.3 \\ 27.1$	0.1 0.0 0.1	09.7 23.3 27.0	3. 993578 0. 182743 9. 989430 9. 773096
_ \	Deer-Club Deer-Belle		+ 4.2		0.2		4. 165751 3. 949417
-60+61 -53+55 -46+47	Deer–Belle Ship Deer Belle	33 10 60.2 97 49 37.9 48 59 22.9	-3.6 -2.8 +5.7	56.6 35.1 28.6	0. 1 0. 1 0. 1	56, 5 35, 0 28, 5	3.949417 0.261770 9.995936 9.877722
	Ship-Belle Ship-Deer		- 0.7		0.3		4. 207123 4. 088909
-60+62 -54+55 -48+49	Deer-Club Ship Deer Club	70 52 35.0 56 47 27.2 52 20 03.5	-4.2 -1.9 + 0.8	30. 8 25. 3 04. 3	0.2 0.1 0.1	30. 6 25. 2 04. 2	$\begin{array}{r} 4.\ 165751\\ 0.\ 024657\\ 9.\ 922555\\ 9.\ 898501 \end{array}$
	Ship-Club Ship-Deer	1	- 5.3		0.4		4. 112963 4. 088909
-61+62 -45+46 -48+50	Belle-Club Ship Belle Club	37 41 34.8 53 35 55.6 88 42 30.3	-0.6 -0.9 +1.1	34. 2 54. 7 31. 4	0.1 0.1 0.1	$34.1 \\ 54.6 \\ 31.3$	3. 993578 0. 213655 9. 905730 9. 999890
	Ship-Club Ship-Belle		- 0.4		0.3	_	4. 112963 4. 207123

Final computation of triangles-Continued

# APPLICATION OF LEAST SQUARES TO TRIANGULATION. 181

Symbol	Station	Observed angle	Cor- rec- tion	Spher- ical angle	Spher- ical excess	Plane an- gle	Loga- rithm
-63+64 -55+57 -59+60	Deer-Ship BiloxI Lighthouse Deer Ship	48 11 17.4 96 30 31.2 35 18 04.4	'' + 1.3 + 6.3 - 0.3	" 18.7 37.5 04.1	" 0, 1 0, 1 0, 1	• / // 18.6 37.4 04.0	4. 088909 0. 127644 9. 997190 9. 761833
	Biloxi Lighthouse-Ship Biloxi Lighthouse-Deer		+ 7.3		0.3	_	4. 213743 3. 978386
-56+57 -66+67 -63+65	Ship Island Lighthouse-Biloxi Lighthouse Deer Ship Island Lighthouse Biloxi Lighthouse	72 34 26.4 25 29 62.1 81 55 36.0	-3.7 -2.9 +2.6	22. 7 59. 2 38. 6	0, 1 0, 2 0, 2	22. 6 59. 0 38. 4	<b>4. 323999</b> <b>0. 0</b> 20407 <b>9. 633980</b> <b>9. 995675</b>
	Deer-Biloxi Lighthouse Deer-Ship Island Lighthouse		- 4.0		0.5		3. 978386 4. 340081
-58+59 -66+68 -64+65	Ship Island Lighthouse–Biloxi Lighthouse Ship Ship Island Lighthouse Biloxi Lighthouse	95 44 07.0 50 31 41.2 33 44 18.6	+2.2 - 9.8 + 1.3	09.2 31.4 19.9	0.1 0.2 0.2	09. 1 31. 2 19. 7	<b>4. 323999</b> 0. 002180 9. 887564 9. 744612
	Ship–Biloxi Lighthouse Ship–Ship Island Lighthouse		- 6.3		0.5		4. 213743 4. 070791
$-67+68 \\ -55+56 \\ -58+60$	Deer-Ship Ship Island Lighthouse Deer Ship	25 01 39.1 23 56 04.8 131 02 11.4	-6.9 +10.0 + 1.9	32.2 14.8 13.3	0.1 0.1 0.1	32.1 14.7 13.2	4. 088909 0. 373636 9. 608246 9. 877536
	Ship Island Lighthouse-Ship Ship Island Lighthouse-Deer		+ 5.0		0.3		4. 070791 4. 340081

# Final computation of triangles-Continued

								1	
α Second angle	East base West base	to west ba	ise T		+		。 84 +103	, 14 55	'' 41.9 34.3
α Δα	East base	to Cedar					188 +	10	16. 2 29. 4
α'	Cedar to	Cedar to east base First angle of triangle							00. 00 45. 6 33. 6
ø	° 30	14 5	'' 6. 379	Dauphin	Island east	λ	88	08	14.288
Δφ φ'	+	5 5 20 4	1. 937 8. 316 +1	C	edar	⊿λ λ'	- 88	07	58. 262 16. 026
½(φ+φ')	30 17 52	$2 \begin{array}{c} 8 \\ \cos \alpha \\ B \end{array}$	4. 039 9. 995 8. 511	$\begin{vmatrix} 349 \\ 568 \\ 556 \\ 556 \\ 172 \end{vmatrix}$	8.0787 8.3054 1.1712	h² D	5.093 2.332		
$\left\{\begin{array}{c} 1 \text{ st term} \\ 2d \text{ and } 3d \\ \text{ terms} \end{array}\right\}$	-351.9433 + 0.0063 -351.9372		2, 540	4/3	+0.0036		+0.0027		2
	$sin \alpha$ A' sec $\phi'$	4. 03934 9. 15268 8. 50935 0. 06399	9 8 1 7 sin	<i>Δ</i> λ 1 ½(φ+φ')	1. 765385 9. 702857				
	Дλ	1.76538 '' -58.262	5	Δα	1. 468242 '' 29. 39				

STATION CEDAR

Final position computation,

## STATION CAT

							0	,	,,
Second angle	East base West base	to west base and Cat	Э				$+ 53^{84}$	14 37	41. 9 23. 0
α Δα	East base	to Cat					137	52 2	04.9 08.4
α'	Cat to eas	t base		F	irst angle of	triangle	180 317 66	00 49 01	00.00 56.5 26.2
φ	30	14 56.	379 Da	uphin t	Island east base		88	08	14.288
4¢	+	4 04.	168 547	(	Cat	$\Delta \lambda$	+	6	14.637 28.925
φ ½(φ+φ')	° ' '' 30 16 58	$\begin{array}{c c} s \\ s \\ cos \\ B \\ B \\ \end{array} \begin{array}{c} 4 \\ 9 \\ 8 \\ 8 \\ 8 \end{array}$	. 006086 . 870171 8. 511556	$sin^2 o$	x 8.0122 9.6532 1.1712	h ² D	4. 776 2. 332	$s^2 \sin^2 \alpha$ E	2. 388 7. 665 5. 917
1st term 2d, 3d, and 4th terms	-244.2379 + 0.0700	) h 2	2, 387813		8.8366 +0.0686		7.108 +0.0013		5.970 +0.0001
$-\Delta\phi$	-244.10%	4.006086 9.826619			0 405000				
	sec $\phi'$	0,063865 2,405922	$\sin \frac{d}{2}(\phi$	+¢')	2. 403922 9. 702663 2. 108585				
	<i>Δ</i> λ	,, +254.6373	-4	α	,'' +128.40				

# secondary triangulation

STATION CEDAR

α Third angle	West bas Cedar and	e to east base 1 east base	6				° 264 - `38	, 11 37	// 22.1 52.4
α 1α	West bas	Vest base to Cedar					225 +	33 3	29.7 49.5
α'	Cedar to	west base					180 45	00 37	00.00 19.2
φ	30	14 21.	492 Da	uphin	Island west	λ	88	14	51.034
44	+	6 26.	825	D	ase	Δλ	-	7	35.008
6'	30	20 48.	317	Ce	dar	λ'	88	07	16.026
¹ / ₂ (φ+φ')	° / // 30 17 3	$ \begin{array}{c c} 8 \\ 5 \\ \hline 0 \\ B \\ \hline 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\ 8 \\$	4. 230995 9. 845212 8. 511557	$s^{s^2}$ $sin^2 \alpha$	8.4620 9.7073 1.1711	h² D	5.176 2.331	$s^2 \frac{-h}{E} \alpha$	2.588 8.169 5.917
1st term	-387.047	3 h 🖸	2. 587764		9.3404		7.507		6.674
2d, 3d, and 4th terms	+ 0.222	7			+0.2190		+0.0032		+0.0005
-14	-386.824	6							
-		4. 230995 9. 853676 8. 509351 0. 063997	$\int d\lambda \sin \frac{1}{2}(\phi$	+\$`)	2. 658019 9. 702795				
		2.658019			2.360814				
		"			"				
	Δλ	-455.0080	-4	x	-229.52				

### STATION CAT

α Third angle	West base Cat and e	e to east bas	<b>50</b>				° 264 - 60	, 11 21	,, 22. 1 11. 1
α 1α	West base	e to Cat					203 +	50 1	11.0 11.7
α'	Cat to we	st base					180 23	00 51	00. 00 22. 7
φ	30	14 21		uphin I ba	sland west	λ	88	14	51.034
Δφ φ'	30	4 39	. 547	С	at	Δλ λ'	88	12	22.109
½(φ+φ')	<b>30</b> 16 41	$\begin{array}{c} 8\\ \cos \alpha\\ B\end{array}$	3.972888 9.961280 8.511557	$\begin{array}{c} s^2\\ \sin^2\alpha\\ C\end{array}$	7. 9458 9. 2130 1. 1711	h² D	4. 89 <b>1</b> 2. 331	-h s ² sin ² α E	2.445 7.159 5.917
1st term 2d, 3d, and 4th terms	-279.0770 + 0.0231	h l	2. 445725		8.3299 +0.0214	1	7.222 +0.0017		5. 521
<i>4</i> ¢	-279.054	3.972888	1	]		1			
	$\frac{\operatorname{SHI} \alpha}{\operatorname{A'}}$ $\operatorname{sec} \phi'$	9.000317 8.509352 0.063865	$\int d\lambda \sin \frac{1}{2}(\phi)$	+ \vert ')	2.152622 9.702600				
		2.152622 //	-4	~	1. 853222 ''				
	24	1 100 1002		_					

Final position computation,

α Second angle	Cedar to west base West base and Pi	e ns				° + 53	, 37 39	" 19.2 37.8
α Δα	Cedar to Pins					- 99	$ \begin{array}{c} 16 \\ 5 \end{array} $	57.0 43.8
α'	Pins to Cedar		Fir	st angle of t	triangle	180 279 58	00 11 45	00.00 13.2 27.5
$\phi$ $\Delta\phi$	$ \begin{array}{c c}  & & & & & \\  & & & & & \\  & & & & & \\  & & & &$	48. 317 35. 914	Ced	lar	À AÀ	+ 88	07 11	16.026 20.225
φ'	30   22	24.231	Pii	15	λ'	88	18	36.251 +1
¹ / ₂ (φ+φ')	$\begin{array}{c} \circ & \prime & \prime \\ 30 & 21 & 36 \\ \prime & B \end{array} \begin{array}{c} s \\ \cos \alpha \\ B \end{array}$	4.264911 9.207641 8.511550	$s^2 \alpha C$	8. 5298 9. 9885 1. 1729	h² D	3. 968 2. 332	$s^2 \frac{-h}{E} \alpha$	1. 984 8. 518 5. 919
1st term 2d, 3d, and 4th terms	-96.4055 h + 0.4916	1.984102		9.6912 +0.4911	-	6.300 +0.0002		6. 421 +0. 0003
- <i>Δ</i> φ	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{vmatrix} 1 \\ 54 \\ 603 \\ 6 \\ 6 \\ - \\ \sin \frac{1}{2}(\phi + \phi) \end{vmatrix}$	-φ')	1 1 2. 832653 9. 703663	-	1		-
	$\begin{array}{c c} 2.83265\\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ &$	27 225 — Δα		2. 536316  +343. 81				

STATION PINS

STATION GRAND

α Second angle	Pins to w West base	est base and Gran	d				* 337 + 85	, 56 13	'' 40.7 04.4
α 1α	Pins to G	rand					- 63	09 3	45.1 32.3
α'	Grand to	Pins		Firs	st angle of t	triangle	180 243 54	00 06 52	00.00 12.8 03.0
ф 4ф	30	22 3 04	" 4. 231 4. 656	Pir	15	$\lambda$ $\Delta\lambda$	+ 88	18 7	36. 252 00. 241
φ'	30	19   19	9. 575	Grø	nd	λ'	88	25	36.493
2(φ+φ')	30 20 52	$\begin{array}{c c} & s \\ \cos \alpha \\ B \end{array}$	4. 099752 9. 654620 8. 511548	$s^2 \\ sin^2 \\ C$	8, 1995 9, 9010 1, 1734	h² D	4. 532 2. 333	$s^2 \frac{-h}{E} \alpha$	2. 266 8. 100 5. 919
1st term 2d, 3d, and 4th terms	+184.4676 + 0.1884	h	2.265920		9. 2739 +0. 1879		6.865 +0.0007		6,285 -0,0002
-40	+184.6560						]		
	$sin \alpha \\ A' \\ sec \phi'$	4.099752 9.9505064 8.509352 0.063888	$\int \frac{d\lambda}{\sin \frac{1}{2}(\phi)}$	+¢')	2. 623498 9. 703504				
	Δλ	+420. 2409	-4	α	,,, +212.32				

#### secondary triangulation—Continued

0 , *11* 225 29.7 55.3 West base to Cedar Pins and Cedar 33 34 Third angle - 67 34.4 53.7 West base to Pins 157 58 α Δα 1 00 00.00 180  $\alpha'$ Pins to west base 337 56 , " 0 14 21.492 Dauphin Island west 88 51.034 30 14 λ ø base 8 02.739 *Δ*λ 3 45.218 ++ 14 λ' 6' 30 22 24.231 Pins 88 18 36, 252 1 " 4. 205115 9. 967093 8. 511557  $\frac{\delta^2}{\sin^2 \alpha}$  $s^2 \frac{-h}{E} \alpha$ 2.684 7.558 5.917 8 8.4102 30 18 23 h² D 5.368 2.331  $\frac{1}{2}(\phi + \phi')$ cos α B 8.1480 1.1711 11 1st term 2d, 3d, and 4th terms -482.7974 h 2.683765 8.7293 7.699 6.159 + 0.0587 +0.0536 +0.0050 +0.0001 -482.7387 -16 8 sin α Α' 4.205115 9.5740212 8.5093503 2.352602  $d\lambda$  $\sin \frac{1}{2}(\phi + \phi')$ sec \$ 0.064116 9. 702967 12.3526025 2.055569 11 11 +225.2177+113.65Δλ  $-\Delta \alpha$ 

#### STATION PINS

STATION GRAND

α Third angle	West base Grand and	e to Pins d Pins					° 157 - 39	, 58 54	'' 34.4 53.1
α	West base	West base to Grand						03 5	41. 3 25. 5
α'	Grand to	west base					180 297	00 58	00.00 15.8
φ	30	14 2	" 1. 492 D	auphin I	sland west	X	88	14	51.034
44	+	4 5	8. 083	Da	50	1	+	10	45. 459
φ'	30	19 1	9. 575	Gra	nd	λ'	88	25	36. 493
¹ ⁄ ₂ (φ+φ')	° ′ ′′ 30 16 50	$\begin{vmatrix} 8 \\ \cos \alpha \\ B \end{vmatrix}$	4. 290942 9. 672484 8. 511557	$\begin{vmatrix} s^2\\ \sin^2 \alpha\\ C \end{vmatrix}$	8, 5818 9, 8914 1, 1711	h² D	4, 950 2, 331	$s^2 \frac{-h}{E} \alpha$	2. 475 8. 473 5. 917
1st term 2d, 3d, and 4th terms	-298.5266 + 0.4435	h	2. 474983		9.6443 +0.4409		7.281 +0.0019		6.865 +0.0007
-14	-298.0831			1	1				
	$\frac{s}{sin \alpha}_{A'}$ sec $\phi'$	4. 290942 9. 945687 8. 509352 0. 063888	۵) sin ½(¢	5+¢')	2. 809869 9. 702633				
		2.809869			2.512502				
	42	-+645. 4595	5 -4	α	+325.46				

Final position computation,

	1						
. Second angle	Grand to west base West base and Peti	t			° 297 + 59	, 58 11	" 15.8 52.0
α Δα	Grand to Petit				357 +	10	07.8 11.6
α	Petit to Grand	1	First angle of t	riangle	180 177 81	00 10 41	00.00 19.4 30.1
ф 1ф	$ \begin{array}{c c}  & & & & & \\  & & & & & & \\  & & & & & $	9. 575 4. 068	Grand	$\lambda$ $\Delta \lambda$	_ 88	25	36. 493 23. 006
φ'	30 12 3	5. 507	Petit	λ'	88	25	13. 487
$\frac{\frac{1}{2}(\phi+\phi')}{\begin{array}{c} 1 \text{ st term} \\ 2d \text{ and } 3d \\ \text{ terms} \end{array}}$	$ \begin{array}{c} \circ & i & i' \\ 30 & 15 & 58 \\ & i'' \\ +404.0639 \\ + & 0.0041 \end{array} $	4.095429 9.999470 8.511551 2.606450	$ \begin{array}{c} s^2 \\ C \\ c$	- h² D	5. 21; 2. 33; 7. 54; +0. 00;	3 2 5 35	
-40	+404.0680						
	$\begin{array}{c ccccc} s & 4.095429 \\ \sin \alpha & 8.693666 \\ A' & 8.509354 \\ \sec \phi' & 0.063392 \end{array}$	$\frac{\Delta\lambda}{\sin\frac{1}{2}(\phi+\phi')}$	1. 361841 9. 702445				
	1. 361841		1.064286				•
	Δλ -23.006	-Δα	-11.59				

STATION PETIT

STATION HORN

α Second angle	Grand to Petit Petit and Horn				• 357 + 61	, 10 04	07.8 37.0
α Δα	Grand to Horn				- 58	14 5	44.8 18.1
α'	Horn to Grand		First angle of a	triangle	180 238 38	00 09 16	00.00 26.7 35.3
$\phi \\ \Delta \phi$	30 19 5	" 19. 575 39. 559	Grand	$\lambda$ $\Delta\lambda$	+ 88	25 10	36. 493 30. 972
φ'	30   13	40.016	Horn	λ'	88	36	07.465
$\frac{1}{2}(\phi+\phi')$	$\begin{array}{c} \circ & \prime & \prime \\ 30 & 16 & 30 \\ \end{array} \begin{array}{c} \circ & \circ \\ \cos \alpha \\ B \end{array}$	4. 297606 9. 721214 8. 5115514	$ \begin{array}{c c} s^2 & 8.5953 \\ 1^2 \alpha & 9.8592 \\ C & 1.1725 \end{array} $	h ² D	5.061 2.332	$s^2 \frac{-h}{E} \alpha$	2. 530 8. 454 5. 918
1st term 2d, 3d, and 4th terms }	+339.1338 h + 0.4253	2. 5303714	9.6270 +0.4236	3 -	7. 393 +0. 0025		6.902 -0.0008
$-4\phi$	+339.5591	1 1	1.00	1 1			
	$\begin{array}{c} s & 4.2976\\ \sin \alpha & 9.9295\\ A' & 8.5093\\ \sec \phi' & 0.0634\\ \hline 2.8000 \end{array}$	$\frac{\begin{array}{c} 06\\79\\54\\71\\10\end{array}}{4\lambda} \\ \sin \frac{1}{2}(\phi+\phi') \end{array}$	2. 800010 9. 702560 2. 502570				
-	$\Delta \lambda$ +630.97	19 — <u>1</u> a	" +318.10				

### secondary triangulation-Continued

, " 0 West base to Grand Petit and Grand 118 03 06 41.3 38.4 a Third angle - 39 West base to Petit 78 57 5 02.9 13.3 α 180 00 00.00 Petit to west base  $\alpha'$ 258 51 49.6 -.10 , 21.492 Dauphin Island west ø 30 14 λ 88 14 51.034 base 1 45.985 Δλ 10 22,452 44 + φ' 30 12 35.507 Petit λ' 25 13.486 + 188 , "  $s^2 \frac{-h}{E} \alpha$ 0 4. 229486 82 8.4590 2.024 8  $\frac{\sin^2 \alpha}{C}$ 4.047 2.331 30 13 28 cos α B 9.282513 8.511557 9.9837 h² D  $\frac{1}{2}(\phi + \phi')$ 8.443 5.917 ... 1st term 2d, 3d, and 4th terms +105.5737h 2.023556 9.6138 6.378 6.384 + 0.4109 +0.4109+0.0002-0.0002 +105.9846  $-4\phi$ sin α A' 4. 229486 9. 991874 8. 509354 0. 063392 2.794106 9.701905  $\sin \frac{d\lambda}{2}(\phi+\phi')$ sec \$' 2. 794106 2.496011 " " +622.4522+313.34Δλ -1a

#### STATION PETIT

STATION HORN

α Third angle	Petit to ( Horn and	Grand I Grand					• 177 - 80	, 10 38	" 19.4 48.3
α Δα	Petit to I	Iorn					- 96	31 5	31. 1 29. 1
α'	Horn to 1	Petit		180 276	00 26	00.00 02.0			
	•	· 1.				1			
ф 14	+ 30	$\begin{array}{c c}12&3\\1&0\end{array}$	35.507 )4.509	Pe	tit	$\lambda$ $\Delta\lambda$	+ 88	25 10	13.487 53.978
φ'	30	13 4	0.016	Ho	rn	ג'	88	36	07.465
$\frac{1}{2}(\phi+\phi')$	° ' '' 30 13 08	$\begin{array}{c c} & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & &$	4.245560 9.055539 8.511559	$ \begin{array}{c} s^2\\ \sin^2\alpha\\ C \end{array} $	8. 4912 9. 9943 1. 1706	h² D	3. 625 2. 331	s ² sin ² α E	1.813 8.485 5.916
1st term 2d, 3d, and 4th terms	-64.9618 + 0.4533	h B	1. 812658		9.6561 +0.4530		5.956 +0.0001		6.214 +0.0002
- <i>4</i> φ	-64.508	5				1	1	. () ·	
	$\frac{\sin \alpha}{\Lambda'}$ sec $\phi'$	+4 4. 245560 9. 9971774 8. 5093541 0. 063471 2. 815563	$ \begin{bmatrix} \frac{4}{3} \\ \frac{4}{3} \\ \frac{5}{3} \end{bmatrix} (\phi) $	+\$\$	2. 815563 9. 701830 2. 517393				
	Δλ	" +653.9778	3 -40	α .	" + <b>329.</b> 15				

Final position computation,

Second angle $\alpha$	Grand to Horn and Grand to	Horn 1 Pascagoul 9 Pascagoula	a					, 14 14 29 3	" 44.8 20.8 05.6 52.8
α'	Pascagou	ila to Grand	l	Fir	st angle of	triangle	180 281 97	4 00 25 55	00. 00 12. 8 59. 1
$\phi \\ \Delta \phi$	30 +	19 19 1 20	9. 575 0. 998	Gra	nd	$\lambda$ $\Delta\lambda$	+ 88	25 7	36. 493 40. 886
φ'	30	20 40	). 573	Pasca	goula	λ'	88	. 33	17.379
$\frac{1}{2}(\phi+\phi')$	° ′ ′ 30 20 0	$ \begin{pmatrix} & s \\ \cos \alpha \\ B \end{pmatrix} $	4. 099038 9. 299092 8. 511551	${{{{{\rm sin}^2}}\atop{{\rm C}}}^{8^2}\alpha}$	8. 1981 9. 9824 1. 1725	h² D	3. 820 2. 332	$s^2 \frac{-h}{E} \alpha$	1.910 8.180 5.918
$\left. \begin{array}{c} 1 \text{st term} \\ 2 \text{d}, 3 \text{d}, \text{and} \\ 4 \text{th terms} \end{array} \right\}$	-81.223 + 0.225	2 h 6	1.909681		9. 3530 +0. 2254		6.152 +0.0001		6.008 +0.0001
$-\Delta\phi$	-80.997	6		1			1		
		4. 099038 9. 991216 8. 509351 0. 063988	$\sin \frac{d\lambda}{2}(\phi$	+\$\$	2. 663593 9. 703317				
		2.663593			2.366910				
	Δλ	+460. 8859	-4	α	+232.76				

STATION PASCAGOULA

STATION BELLE

α Second angle	Pascagoul Horn and	a to Horn Belle					• 19 + 69	, 21 43	'' 11. 9 26. 3
α 1α	Pascagoul	a to Belle					- 89	04 5	38. 2 01. 7
α'	Belle to P	ascagoula	•	First	angle of t	triangle	180 268 48	00 59 58	00. 00 36. 5 48. 4
$\phi_{\Delta\phi}$		<b>20</b> 40 08	. 573 . 724	Pascago	ula	$\lambda$ $\Delta\lambda$	+ 88	33 9	17. 379 57. 281
φ'	30	20 31	. 849	Belle		λ'	88	43	14.660 +2
½(φ+φ')	30 20 36	s cos α B	4. 202907 8. 206975 8. 511550	$\int_{C}^{S^2} \alpha$	8. 4059 9. 9999 1. 1729	$\frac{9}{2}$ h ² D	1. 8 2. 3	44 32	
$2d \text{ and } 3d \\ terms \}$	+8.3451 +0.3790 +8.7241	-	0. 921432		+0. 3790		4. 1	10	
	$ \begin{array}{c c}                                    $	4. 202907 9. 999944 8. 509351 0. 063977	$\int \frac{d\lambda}{\sin \frac{1}{2}(\phi +$	φ') 2. 9.	776179 703447				
	Δλ	2. 776179 '' +597. 2814	1a	2.	479626 // 301. 73				1

secondary triangulation-Continued

0 , " 09 49 26.7 40.5 Horn to Grand  $-\frac{238}{38}$ α Third angle Pascagoula and Grand Horn to Pascagoula 19 46.2 25.8 199 α Δα + 1 180 00 00.00 12.0  $\alpha'$ Pascagoula to Horn 19 21 -.1 0 *11* 13 7 40.016 30 Horn 36 2 07.465 50.086 \$ \$\$  $\lambda$  $\Delta\lambda$ 88 + 40.573 6' λ' 30 20 Pascagoula 88 33 17.379 • , " 2.624 7.315 5.917 s cos α B 4. 137501 9. 974802 8. 511558  $\frac{s^2}{\sin^2 \alpha}$ 8.2750 9.0396 1.1709 30 17 10 5.248 2.331 h² D  $\frac{1}{2}(\phi + \phi')$ ,, 1st term 2d, 3d, and 4th terms -420. 5920 h 2.623861 8.4855 7.579 5.856 +0.0306 +0.0038 +0.0001+ 0.0345  $-4\phi$ -420.5575  $sin \alpha$ A' 4. 137501 9. 519828 8. 509351 2.230667 9.702706  $\frac{d\lambda}{\sin \frac{1}{2}(\phi + \phi')}$  $\sec \phi'$ 0.063988 2.230668 1.933373 " " *Δ*λ -170.0858-85.78  $-\Delta \alpha$ 

#### STATION PASCAGOULA

STATION BELLE

~	Horn to 1	Paseagoula					0	/	11
Third angle	Belle and	Pascagoula	3				- 61	17	45.8
α 1α	Horn to l	Belle					138	02 3	00. 4 35. 4
α'	Belle to I	Iorn					180 317	00 58	$ \begin{array}{c} 00.00 \\ 25.0 \\1 \end{array} $
ф 1ф	30 +	13 40 6 51	. 016 . 834	H	orn	λ 	+ 88	36 7	07. 465 07. 197
φ'	30	20 31	. 850	Be	elle	λ'	88	43	14.662
}(φ+φ')	° ' '' 30 17 06	$\begin{array}{c c} & s \\ \cos \alpha \\ B \end{array}$	4. 232071 9. 871302 8. 511558	$sin^2 \alpha$	8. 4642 9. 6505 1. 1709	h² D	5. 230 2. 331	s ² sin ² α E	2. 615 8. 115 5. 917
1st term 2d, 3d, and 4th terms	-412.0321 + 0.1976	h 3	2. 614931		9.2856 +0.1936		7.561 +0.0036		6. 647 +0. 0004
-40	-411.8345	5	1		1	1			
	$\frac{\sin \alpha}{\Lambda'}$ sec $\phi'$	4. 232071 9. 825229 8. 509351 0. 063977		+\$\$	2. 630628 9. 702690				
		2. 630628			2. 333318				
	Δλ	+427.1968	-10	α	+215.44				

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.

Final position computation,

α Second angle	Belle to I Horn and	Horn 1 Club	~				。 317 +40	, 58 30	" 24.9 06.4
α Δα	Belle to	Club					358 +	28	31.3 05.0
α'	Club to 1	Belle		First	angle of tr	iangle	180 178 105	00 28 43	$00.00 \\ 36.3 \\ 54.1$
$\phi \\ \Delta \phi$		20 31. 5 19.	. 849 . 873	Belle		λ <i>Δ</i> λ	88	43	14.662 09.806
φ'	30	15 11.	. 976	Club		λ'	88	43	04.856
$\frac{1}{2}(\phi + \phi')$ 1st term 2d and 3d terms $-\Delta\phi$	• ' ' 30 17 5 	$ \begin{array}{c c}                                    $	3. 993578 9. 999846 8. 511550 2. 504974	$\overset{3^2}{\overset{{ m S}^2}{ m C}} \alpha$	7.9872 6.8500 1.1729 6.0101 +0.0001	h² D	5. 010 2. 332 7. 342 +0. 002	2	
	$sin \alpha$ A' sec $\phi'$	3.993578 8.424985 8.509353 0.063584 0.991500	$\sin \frac{d\lambda}{2}(\phi+\phi)$	¢') 0.6	991500 702856 994356				
- 1	Δλ	-9.8062	-Δα	-	4.95				

STATION CLUB

STATION DEER

α Second angle	Belle to Club Club and Deer				$358 \\ +102$	, 28 35	" 31.3 23.3
α 1α	Belle to Deer				101	03 2	54.6 45.3
α'	Deer to Belle		First angle of t	triangle	$\begin{array}{r}180\\281\\41\end{array}$	00 01 02	00. 00 09. 3 09. 8
ф 1ф	$\begin{array}{c c} 30 \\ + \end{array} \begin{array}{ c c } 20 \\ 55 \\ 55 \\ 55 \\ 55 \\ 55 \\ 55 \\ 55 \\$	1. 849 5. 361	Belle	$\lambda$ $\Delta\lambda$		43 5	14.662 27.087
φ'	30 21 22	7.210	Deer	λ'	88	48	41.749
$\frac{1}{2}(\phi+\phi')$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	3.949417 9.283133 8.511550 sit	$ \begin{array}{c c} s^2 & 7.8989 \\ n^2 \alpha & 9.9837 \\ C & 1.1729 \end{array} $	h ² D	3. 488 2. 332		
$\left.\begin{array}{c} 1 \text{st term} \\ 2 \text{d and } 3 \text{d} \\ \text{terms} \end{array}\right\}$	$\begin{array}{c c} -55.4752 & h \\ + 0.1137 \\ \hline -55.3615 \end{array}$	1.744100	9.0555 +0.1136		5.820 +0.000	1	
	$\begin{array}{c} s \\ \sin \alpha \\ \Lambda' \\ \sec \phi' \end{array} \begin{array}{c} 3.949417 \\ 9.991850 \\ 8.509351 \\ 0.064045 \\ 2.514663 \end{array}$	$- \sin \frac{d\lambda}{2(\phi + \phi')}$	2. 514663 9. 703531 2. 218194				
	<i>Δ</i> λ +327.0872	- <u>1</u> a	,, +165.27				

#### secondary triangulation-Continued

STATION CLUB



#### STATION DEER

α Third angle α Δα	Club to H Deer and Club to D	selle Belle Deer					• 178 -36 142 -	, 28 22 06 2	" 36.3 27.1 09.2 50.0
α'	Deer to C	lub					180 322	00 03	$00,00 \\ 19,2 \\1$
ф 1 <b>ф</b>	30 +	15 11 6 14	,, 1. 976- 5. 234	Ch	ıb	λ <i>Δ</i> λ	88 +	43 `5	04. 856 36. 893
$\phi'$ $\frac{1}{2}(\phi+\phi')$	30   • / // 30 18 20	$\begin{array}{c c} 21 & 21 \\ s \\ \cos \alpha \end{array}$	4. 165751         9. 897138	$\frac{8^2}{\sin^2 \alpha}$	er 8. 3315 9. 5767	λ' h ²	5.149	-h $s^2 \sin^2 \alpha$	41.749 2.574 7.908
1st term 2d, 3d, and 4th terms		B h B	8. 511556 2. 574445	С	$     \begin{array}{r}       1.1713 \\       9.0795 \\       +0.1200     \end{array} $	D	2.331 7.480 +0.0030	E	5.918 6.400 +0.0003
-14	$-375.2341$ $sin \alpha$ $A'$ $sec \phi'$	4. 165751 9. 788345 8. 509351 0. 064045	$\int \frac{d\lambda}{\sin \frac{1}{2}(\phi)}$	+φ')	2. 527492 9. 702957	I			
	<i>Δ</i> λ	2. 527492 ,, +336. 8930		α	2.230449 '' +170.00				

91865°-15-13

Final position computation,

	α Second angle α Δα	Deer to C Club and Deer to S	lub Ship hip					$ \begin{array}{c}                                     $	, 03 47 50 1	" 19.1 25.3 44.4 14.8
	α'	Ship to I	)eer		Fi	rst angle of t	riangle	180 198 70	00 49 52	00. 00 29. 6 30. 8
1	$\phi \\ 4\phi$	30	$ \begin{array}{c c}             21 & 27 \\             21 & 6 & 17 \\             6 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\             17 & 17 \\          $	. 210 . 189	D	eer	λ Δλ	+ 88	48 2	41. 749 28. 277
1	$\phi'$	30	15 10	. 021	SI	nip	λ'	88	51	10.026
	$\frac{1}{2}(\phi+\phi')$	° ' ' 30 18 1'	$\beta = \frac{8}{B}$	4.088909 9.976071 8.511549	$sin^2 \alpha$	8.1778 9.0184 1.1731	h² D	5. 153 2. 332		
	$\left\{\begin{array}{c} 1 \text{ st term} \\ 2d \text{ and } 3d \\ \text{ terms} \end{array}\right\}$	+377.162 + 0.026	5 h	2. 576529		8.3693		7.485 +0.0031		
	$-\Delta\phi$	+377.189	£			1				
		$sin \alpha \\ A' \\ sec \phi'$	4.088909 9.509230 8.509353 0.063581	$\int d\lambda \sin \frac{1}{2}(\phi$	+\$\$	2. 171073 9. 702952				
1			2.171073			1.874025				
		Δλ	" +148. 2767	-4	α	" +74.82				

STATION SHIP

STATION BILOXI LIGHTHOUSE

α	Deer to S	hip	-=		1		° 18	, 50	,, 44.4
Second angle	Ship and	Biloxi Ligh	thouse				+ 96	30	37.5
α	Deer to I	iloxi Lightl	house				115	$21 \\ 2$	21. 9 42. 9
α'	Biloxi Li	ghthouse to	Deer	Fi	rst angle of	triangle	$\begin{array}{r}180\\295\\48\end{array}$	00 18 11	00. 00 39. 0 18. 7
ф 1ф	30 +		. 210 . 209	D	eer	$\lambda_{\Delta\lambda}$	+ 88	48 5	41. 749 22. 071
φ'	30	23 39	. 419 I	Biloxi I	ighthouse	λ'	88	54	03.820
$\frac{1}{2}(\phi + \phi')$	° ' '' 30 22 3 ''	$\begin{array}{c} 8\\ \cos \alpha\\ B\\ \end{array}$	3.978386 9.631690 8.511549		7. 9568 9. 9120 1. 1731	h² D	4. 243 2. 332	$s^2 \frac{-h}{E}$	2. 121 7. 869 5. 919
2d, 3d, and }	+ 0.110		2.121020		+0. 1102		+0.0004		+0.0001
4th terms J	-132, 209								
		3.978386 9.956007 8.509350 0.064209	$\sin \frac{d\lambda}{2}(\phi$	+\$\$	2. 507952 9. 703868	,			
		2.507952			2.211820				
	Δλ	+322. 0713	-4	α	" +162.86				

## secondary triangulation-Continued

STATION SHIP



STATION BILOXI LIGHTHOUSE

α Third angle	Ship to D Biloxi Lij	eer ghthouse an	d Deer				° 198 - 35	, 49 18	'' 29.6 04.1
α Δα	Ship to B	iloxi Lighth	101150		•		-163	31 1	25. 5 27. 7
α	Biloxi Li	ghthouse to	Ship				180 343	00 29	00.00 57.8 1
ф 14	30 +	, 15 10. 8 29.	021 398	SI	hip	λ Δλ	+ 88	51 2	10.026 53.794
φ'	30 Fixed val	23 39. ue <b>39</b> .	419 E	Biloxi L	ighthouse	λ'	88	54	03. 820 03. 820
½(φ+φ')	° ' '' 30 19 23		4. 213743 9. 981790 8. 511556	$\begin{array}{c} \delta^2\\ \sin^2\alpha\\ C\end{array}$	8. 4275 8. 9056 1. 1713	h² D	5. 414 2. 331	$s^2 \frac{-h}{E} \alpha$	2.707 7.333 5.918
1st term 2d, 3d, and 4th terms }	-509.4353 + 0.0376 -509.3977	3 h :	2. 707089		8. 5044 +0. 0319		7.745 +0.0056		5. 958 +0. 0001
		4. 213743 9. 452733 8. 509350 0. 064209	$\sin \frac{d\lambda}{d(\phi)}$	, ; ;+ \$\$')	2. 240035 9. 703190				•
	λL	2. 240035 '' +173. 7941	-4	α	1.943225 '' +87.74				

# 194 COAST AND GEODETIC SURVEY SPECIAL PUBLICATION NO. 28.

Final position computation,

م Second angle	Biloxi Lighth Ship and Ship	ouse to Ship Island Ligi	) hthouse			° 343 + 33	, 29 44	" 57.7 19.9
α 1α	Biloxi Lighth	ouse to Ship	- 17	14 1	17.6 57.9			
α' ·	Ship Island L	ighthouse to	riangle	180 197 50	00 12 31	00.00 19.7 31.4		
$\phi$ $\Delta\phi$		3 39.419 54.078	Biloxi I	ighthouse	$\lambda$ $d\lambda$	+ 88	54 3	03. 820 53. 644
φ'	30 1	2 45.341	Ship Isl	and Light- ouse	λ'	88	57	57.464
$\frac{1}{2}(\phi+\phi')$	30 18 12 0 "	$ \begin{array}{c c} s \\ \cos \alpha \\ B \\ \end{array} \begin{array}{c} 4.323 \\ 9.980 \\ 8.511 \end{array} $	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	8.6480 8.9436 1.1738	h² D	5.631 2.332	$s^2 \frac{-h}{E} \alpha$	2.816 7.592 5.919
$\left. \begin{array}{c} \text{1st term} \\ \textbf{2d, 3d, and} \\ \text{4th terms} \end{array} \right\}$	+654.0109 + 0.0673	h 2.815	5585	8.7654 +0.0583		7.963 +0.0092		6. 327 -0. 0002
<i>4</i> ¢	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	. 323999 . 471798 . 509354		2.368555				-
	$\sec \phi' = 0$	2. 368555	1 <u>*</u> (φ+φ')	2.071485				
1	$\Delta \lambda$ +2	33.6442	- <u>1</u> a	+117.89				

STATION SHIP ISLAND LIGHTHOUSE

# secondary triangulation—Continued

α Third angle	Ship to B Ship Islar	iloxi Lighth nd Lighthou	nouse 1se and Biloxi	Lighthouse		° 163 - 95	, 31 44	,, 25.5 09.2
α 1α	Ship to S	hip Island I	Lighthouse		- 67	47	16.3 25.2	
α'	Ship Islar	nd Lighthou	180 247	00 43	00.00 51.1			
ф 1ф	_30	<b>15</b> <b>15</b> <b>10</b> <b>2</b> <b>24</b>	.021 .681	Ship	$\lambda$ $\Delta\lambda$	+ 88	51 6	10.026 47.438
φ'	30   Fixed val	12 45. lue 45.	.340 Ship Is +1 1 .341	land Light- house	λ'	88	57	57. 464 <b>57. 464</b>
½(φ+φ')	° ′ ′′ 30 13 58	δ cos α B	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	α 8.1416 9.9330 1.1713	h² D	4. 320 2. 331	$e^{2\sin^2\alpha}$	2.160 8.075 5.918
1st term 2d, 3d, and 4th terms }	+144.5043 + 0.1765	3 h	2. 159881	9. 2459 +0. 1762	-	6. 651 +0. 0004		6, 153 -0, 0001
-10	+144.6808	4.070791	1	1 1	1	1		
		9.966513 8.509354 0.063404	$d\lambda$ $\sin \frac{1}{2}(\phi + \phi')$	2. 610062 9. 702011				
		2. 610062		2. 312073				
	Δλ	+407.4385	-10	+205.15				

## STATION SHIP ISLAND LIGHTHOUSE

## ADJUSTMENTS BY THE ANGLE METHOD

If the adjustment be made according to the angle method* the complications due to the presence of the z's are avoided. An angle is the difference of two directions and the observation equation for an observed angle is the difference of the observation equations of its two sides, and in taking the difference the z drops out. To illustrate this suppose that at station Gunner, Figure 6, page 104, the following angles were observed: Duck to Indian Point, Indian Point to Larrabee, Larrabee to Mam, Mam to Lubec Channel Lighthouse, and Lubec Channel Lighthouse to Lubec Church spire. Call the corrections to the observed angles  $u_1, u_2, u_3, u_4$ , and  $u_5$  respectively, and suppose the observed and assumed values to be as given on page 115.

$$\begin{split} & u_1\!=\!v_2\!-\!v_1\!=\!-6131\delta\phi_1\!+\!1800\delta\lambda_1\!-\!2.2 \\ & u_2\!=\!v_3\!-\!v_2\!=\!-1997\delta\phi_1\!+\!236\delta\lambda_1\!+\!7.0 \end{split}$$

In a similar way,

$$\begin{split} & u_3 = -2732\delta\phi_1 + 85\delta\lambda_1 - 1.2 \\ & u_4 = -5565\delta\phi_1 - 2445\delta\lambda_1 + 3.5 \\ & u_5 = +5886\delta\phi_1 + 5413\delta\lambda_1 + 18.4 \end{split}$$

These contain no z's and the normal equations may be formed in the usual way.

Observation equations of this kind would arise when at an unknown point angles are taken on known points, as for example when angles are taken with a sextant from a point off-shore to determine its position, and for such observations the angle method is both easier and more logical than the direction method.

*Wright and Hayford, Adjustment of observations, p. 180.

## ADJUSTMENT OF VERTICAL OBSERVATIONS

#### GENERAL STATEMENT

When reciprocal vertical observations are made over the lines of a triangulation scheme a computation of the differences of elevations is

Stack

made by the usual Coast and Geodetic Survey formula. For an account of these observations and of the method of computation, see United States Coast and Geodetic Survey Special Publication No. 19, page 140 et seq. As there are always several lines from each station, rigid conditions are present in the figure. Thus it becomes necessary to make an adjustment of the observed values by the method of least squares. In the following figure the differences of elevations as observed are first computed and then the results are adjusted by the method employed in the United States Coast and Geodetic Survey.

The formula used in the following computations is the one given in Special Publication No. 19, mentioned above. On pages 205 et seq. there is given a new development of the formula that takes into account some of the small terms that Craggy Bosley Pollywog Elk Packsaddle High Divide Long Ridge Bald Hill Child Rothe Reating Rock water level Fig. 8.

are needed in computation over longer and higher lines. The final form of the new formula differs slightly from the one used in this computation.

Station 1	Pollywog	Pollywog	Pack Sad-	Pack Sad-	Elk	Elk
Station 2	Pack Sad- dle	Elk	High Di- vide	Elk	Long Ridge	High Di- vide
$\begin{array}{c} \zeta_1 \\ \zeta_2 \\ \zeta_2-\zeta_1 \\ \frac{1}{2}(\zeta_2-\zeta_1) \\ \tan \frac{1}{2}(\zeta_2-\zeta_1) \\ \log s \\ \log s \\ \log s \\ \frac{1}{2}(\zeta_2-\zeta_1) \\ \operatorname{Second term} \\ \operatorname{Third term} \\ \operatorname{h_2-h_1} \\ 2 \log s \\ \log p = 9-2 \\ \log s \\ p \text{ of } \operatorname{h_2-h_1} \end{array}$	$ \begin{smallmatrix} \bullet & \prime & \prime & \prime \\ 90 & 04 & 159 \\ 90 & 04 & 59 \\ + & 23 \\ 6.04732 \\ 4.27444 \\ 0.32176 \\ + 2.10 \\ 0.00 \\ 0.00 \\ + 2.10 \\ 8.549 \\ 0.451 \\ 2.82 \\ \end{smallmatrix} $	$ \begin{smallmatrix} \bullet & \prime & \prime & \prime \\ 90 & 57 & 44 \\ 89 & 11 & 15 \\ -1 & 46 & 29 \\ -53 & 14 \\ 8. & 18994 \\ 4. & 29253 \\ 2. & 48247 \\ -303. & 72 \\ 0. & 00 \\ 0. & 03 \\ -303. & 75 \\ 8. & 585 \\ 0. & 415 \\ 2. & 60 \\ \hline \end{tabular} $	•         /           90         30         00           89         37         33           -         52         27           -         26         14           7.88258         4.15543         2.03801           -         109.15         0.00         0.01           -         109.16         -         8.311           -         0.689         4.89         -	• / " 91 53 50 88 10 59 - 3 42 51 - 1 51 26 8.51090 3.98144 - 310.70 0.00 0.03 - 310.73 7.963 1.037 10.89	$ \begin{smallmatrix} \bullet & \prime & \prime & \prime \\ 88 & 33 & 16 & 54 \\ 91 & 36 & 54 \\ + & 3 & 03 & 38 \\ + & 1 & 31 & 49 \\ 8. & 42675 \\ 4. & 3.74199 \\ + & 552.06 \\ 0.00 \\ 0.066 \\ + & 552.12 \\ 8.630 \\ 0.370 \\ 2.34 \\ \end{smallmatrix} $	$\begin{array}{c} \circ & \prime & \prime \\ 89 & 15 & 25 \\ 90 & 51 & 04 \\ +1 & 35 & 39 \\ + & 47 & 50 \\ 2.31498 \\ +206.53 \\ 0.00 \\ 0.02 \\ +206.55 \\ 8.343 \\ 0.657 \\ 4.54 \end{array}$
Station 1	High Di- vide	High Di- vide	High Di- vide	Long Ridge	Long Ridge	Gordon Bold Hill
Station 2		• / //	• / //	• / //		
$\begin{array}{l} \zeta_1\\ \zeta_2\\ \zeta_2-\zeta_1\\ \frac{1}{2}(\zeta_2-\zeta_1)\\ \log s\\ \log s \tan \frac{1}{2}(\zeta_2-\zeta_1)\\ \log s \tan \frac{1}{2}(\zeta_2-\zeta_1)\\ \mathrm{Second term}\\ \mathrm{Third term}\\ \mathrm{h_2-h_1}\\ 2\log s\\ \log p = 9-2\log s\\ p \mathrm{of} \mathrm{h_2-h_1} \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{r} 88 & 28 & 23 \\ 91 & 40 & 22 \\ + & 3 & 11 & 59 \\ + & 1 & 36 & 00 \\ & 8 & 44611 \\ & 4.29195 \\ 2.73806 \\ & +547.09 \\ & 0.00 \\ & 0.08 \\ & +547.17 \\ & 8.584 \\ & 0.416 \\ & 2.61 \end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
Station 1 Station 2	Gordon Red Moun- tain	Gordon Rattle	Gordon Child	Child Rattle	Child Red Moun- tain	Rattle Red Moun- tain
C1 C2 C3 C3-C1 $\frac{1}{2}(2_{2}-C_{1})$ $\log s$ $\ln \frac{1}{2}(2_{2}-C_{1})$ $\log s \tan \frac{1}{2}(2_{2}-C_{1})$ Second term Third term $h_{2}-h_{1}$ $2\log s$ $\log p = 9-2\log s$ $p \text{ of } h_{2}-h_{1}$	$ \begin{smallmatrix} \circ & \prime & \prime & \prime \\ 90 & 03 & 28 \\ 90 & 10 & 44 \\ + & 07 & 16 \\ + & 03 & 38 \\ 7.02404 \\ 4.48786 \\ 1.51190 \\ + & 32.51 \\ 8.976 \\ 0.00 \\ 0.01 \\ + & 32.51 \\ 8.976 \\ 0.024 \\ 1.06 \\ \end{smallmatrix} $		$\begin{array}{c} \bullet & \prime & \prime & \prime \\ 91 & 56 & 00 \\ 88 & 11 & 27 \\ -3 & 44 & 33 \\ -1 & 52 & 16 & 5 \\ 8 & 51416 \\ 4 & 23223 \\ 2 & 74639 \\ -557 & 69 \\ 0 & 0 & 0 \\ 0 \\ -557 & 78 \\ 8 & 464 \\ 0 & 536 \\ 3 & 43 \end{array}$	$\begin{array}{c} \circ & \prime & \prime \\ 87 56 & 00 \\ 92 & 09 & 03 \\ + & 4 13 & 03 \\ + & 2 & 06 & 31.5 \\ 8.56610 \\ 4.03839 \\ 2.60449 \\ + 402.24 \\ 0.00 \\ 0.06 \\ + 402.30 \\ 8.077 \\ 0.923 \\ 8.38 \end{array}$	$\begin{array}{c} \circ & \prime & \prime & \prime \\ 88 & 33 & 47 \\ 91 & 36 & 13 \\ + & 3 & 02 & 26 \\ + & 1 & 31 & 13 \\ 8 & 42390 \\ 4 & 34662 \\ 2 & 77052 \\ + 589 & 55 \\ 0 & 0.00 \\ 0 & 0.09 \\ + 589 & 64 \\ 8 & 693 \\ 0 & 307 \\ 2 & 03 \end{array}$	$ \begin{smallmatrix} \bullet & \prime & \prime & \prime \\ 89 & 07 & 26 \\ 90 & 57 & 56 \\ + & 15 & 30 \\ + & 55 & 15 \\ 8 & 20610 \\ 4 & 06606 \\ 2 & 27216 \\ + & 187 & 14 \\ 0 & 00 \\ 4 & + & 187 & 18 \\ 8 & 132 \\ 0 & 868 \\ 7 & 38 \\ \end{smallmatrix} $

Computation of elevations from reciprocal observations

Station Occ. 1.	Pollywog	Pollywog	Pollywog	Elk	Pack Sad-	Long Ridge
Station Obs. 2.	Bosley	Stack	Craggy	Bosley	Bosley	Pack Sad-
Obj. sighted	0 / //	0 / //	0 / //	0 / //	0 / //	0 / //
$\begin{cases} \zeta & 90^{\circ} - \zeta & 90^{\circ} - \zeta & \text{in secs.} \\ \log & 00^{\circ} - \zeta & \text{in secs.} \\ \log & \delta & \delta & \delta & \delta \\ \log s & \delta & \delta & \delta & \delta \\ \log & \delta & \delta & \delta & \delta \\ \log & (0.5 - m) & 2 & \log s & \delta \\ 2 & \log & s & \delta & \delta \\ \end{cases}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	$\begin{array}{cccccccc} 91 & 01 & 00 \\ -1 & 01 & 00 \\ & 3660 \\ 3.56348 \\ 4.68562 \\ 4.15591 \\ 2.40501 \\ 151.8 & 42.0 \\ 9.66001 \\ 8.31182 \end{array}$
$\begin{array}{l} \log \left( 0.5-m \right) s^{2} \\ \log \rho \\ \log \left( 2d \ \text{term} \right) \\ s \ \text{cot} \ \zeta \\ \text{Second term} \\ \text{Third term} \\ t-0 \end{array}$	$\begin{array}{c} 7.98493\\ 6.80535\\ 1.17958\\ +211.63\\ 15.12\\ 0.01\\ 1.51\end{array}$	$\begin{array}{r} 8.63245\\ 6.80439\\ 1.82806\\ +182.03\\ 67.31\\ 0.01\\ 1.51\end{array}$	$\begin{array}{r} 8.04401\\ 6.80376\\ 1.24025\\ +536.44\\ 17.39\\ 0.04\\ 1.51\end{array}$	$\begin{array}{r} 8.30572 \\ 6.80399 \\ 1.50173 \\ +497.83 \\ 31.75 \\ 0.04 \\ 1.45 \end{array}$	$\begin{array}{r} 8.51750 \\ 6.80446 \\ 1.71304 \\ +174.09 \\ 51.65 \\ 0.01 \\ 1.50 \end{array}$	$\begin{array}{c} 7.97183\\ 6.80409\\ 1.16774\\ -254.10\\ 14.71\\ 0.01\\ 1.40 \end{array}$
$ \begin{array}{c} h_2 - h_1 \\ \log p = 9 - 2 \log s \\ p \end{array} $	+228.27 0.657 4.54	$+250.86 \\ 0.009 \\ 1.02$	+555.38 0.598 3.96	+531.07 0.334 2.16	$+227.25 \\ 0.145 \\ 1.40$	$-237.98 \\ 0.688 \\ 4.88$
Station Occ. 1.	Bald Hill	Rattle	Red Moun-			
Station Obs. 2. Obj. sighted	Red Moun- tain	Redding Rock Water level	Redding Rock Water level			
$\begin{cases} \zeta_0 & -\zeta \\ \tan 90^\circ - \zeta \\ \log s \\ \log s \cot \zeta \\ \alpha \text{ and mean } \phi \\ \log (0.5 - m) \\ 2 \log s \end{cases}$	• / " 88 41 22.5 + 1 18 37.5 8.35936 4.44942 2.80878 21.4 41.6 9.62941 8.89884	$\begin{array}{c} \circ & \prime & \prime \\ 91 & 51 & 30 \\ - & 1 & 51 & 30 \\ 8. & 51115 \\ 4. & 56765 \\ 3. & 07880 \\ 31. & 3 & 41.5 \\ 9. & 64207 \\ 9. & 13530 \end{array}$	$\begin{array}{c} \circ & \prime & \prime \\ 92 & 32 & 45 \\ - & 2 & 32 & 45 \\ 8. & 64799 \\ 4. & 48393 \\ 3. & 13102 \\ 48.0 & 41.4 \\ 9. & 62747 \\ 8. & 96786 \end{array}$			
$\begin{array}{c} \log \left( 0.5-m \right)  s^2 \\ \log \rho \\ \log \left( 2d \text{ term} \right) \\ s \cot \zeta \\ \text{Second term} \\ \text{Third term} \\ t-0 \end{array}$	$\begin{array}{r} 8.52825\\ 6.80387\\ 1.72438\\ +643.84\\ +53.01\\ 0.06\\ 1.36\end{array}$	$\begin{array}{r} 8.77737\\ 6.80410\\ 1.97327\\ -1198.95\\ + 94.03\\ 0.21\\ 1.45\end{array}$	$\begin{array}{r} 8.59533\\ 6.80466\\ 1.79067\\ -1354.94\\ + 61.75\\ 0.27\\ 1.43\end{array}$			
h ₂ -h ₁ Cor. for reduc- tion to mean sea level	+698.27	-1103.26 + 0.15	-1291.49 + 0.82		1	
$h_2-h_1$ (corrected) $\log p=9-2\log s$ p	0. 101 1. 26	-1103.11 9.865 0.73	$-1290.67 \\ 0.032 \\ 1.07$			

Computation of elevations from nonreciprocal observations

The adjustment of vertical observations as practiced in the United States Coast and Geodetic Survey is made by means of observation equations and differs somewhat from the method of conditions. Of course condition equations could be employed if it were desired, just as triangulation can be adjusted by observation equations. (See the adjustment by the Variation of Geographic Coordinates, p. 91 et seq.)

Elevations for the various stations are assumed somewhat near what the final values will be. To these are added x's to be determined by the adjustment. (See table of assumed elevations on p. 200.) By means of these, observation equations are formed by the comparison of the assumed  $h_2 - h_1$  with that determined by computation. The method of formation is shown below and a tabulated form of all of the computation on page 201.

Fixed elevations.

	Meters
Bosley	. 1037.35
Stack	. 1062.69
Craggy	. 1368.31
Redding Rock	•]
Mean sea level	} 0.00

Assumed and adjusted elevations

	Elevation					
Station	Assumed + correc- tion	Adjusted				
Pollywog Elk Pack Saddle High Divide Long Ridge Bald Hill Gordon Child Rattle Red Mountain	$\begin{array}{c} Mcters\\ 811+x_1\\ 507+x_2\\ 817+x_3\\ 710+x_4\\ 1059+x_5\\ 589+x_6\\ 1259+x_7\\ 701+x_8\\ 1103+x_9\\ 1290+x_{10} \end{array}$	Meters 811.06 504.61 815.74 708.77 1055.96 585.16 1256.12 698.19 1100.46 1287.70				

## FORMATION OF OBSERVATION EQUATIONS

The observation equations are formed as follows:

(1) Pollywog, assumed elevat	$x_{100}^{*} = 811 + x_{10}^{*}$
(2) Craggy, fixed elevation	= 1368.31
$h_2 - h_1$ (assumed)*	$= +557.31 - x_1$
$h_2 - h_1$ (observed)*	$= +555.38 + v_1$
Observed – assumed*	$= -1.93 + x_1 + v_1 = 0$
	$-v_1 = -1.93 + x_1$
	$p = \frac{1}{3}$ of $3.96 = 1.32$
(1) Elk, assumed elevation*	$= 507 + x_2$
(2) Pollywog, assumed elevat	$x_{100}^{*} = 811 + x_{1}$
$h_2 - h_1$ (assumed)*	$= +304 + x_1 - x_2$
$h_2 - h_1$ (observed)*	$= +303.75 + v_5$
Observed – assumed*	$= -0.25 - x_1 + x_2 + v_5 = 0$
	$-v_5 = -0.25 - x_1 + x_2$
	p = 2.60

In a similar manner the remaining equations are formed. These are usually formed as in the following table. The constant term is found in the column "Observed minus assumed," and the remainder of the equation in the column "Symbol."

*Including symbolic correction.

pv2	4, (159 2, 2016 5, 2016 5, 2016 2, 2016 1, 723 1, 733 1, 733 1, 735 1, 735 1
Minus † <i>pv</i>	+ + + + + + + + + + + + + + + + + + +
pv	++++++++++++++++++++++++++++++++++++++
Adjusted minus observed v	++++++++++++++++++++++++++++++++++++++
Adjusted difference of $h_2 - h_1$	$\begin{array}{c} + 557, 25\\ + 2531, 65\\ + 2526, 29\\ + 5525, 29\\ - 310, 45\\ - 310, 45\\ - 310, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ - 311, 55\\ -$
Symbol	
O bserved minus assumed	$\begin{array}{c} -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 $
Observed difference of $h_2 - h_1$	$\begin{array}{c} + 555, 38\\ + 230, 39\\ + 531, 07\\ + 531, 07\\ + 531, 07\\ - 330, 75\\ + 330, 75\\ + 330, 75\\ + 330, 75\\ + 330, 16\\ - 337, 19\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 39\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 337, 30\\ - 33$
Assumed difference of $h_2 - h_1$	$\begin{array}{c} + & 557, 31\\ + & 251, 63\\ + & 251, 33\\ - & 250, 35\\ - & 304 & 35\\ - & 304 & 35\\ - & 304 & 35\\ - & - & 203 & 3\\ - & - & 203 & 3\\ - & - & 203 & 3\\ - & - & - & 203 & 3\\ - & - & - & 203 & 3\\ - & - & - & 203 & 3\\ - & - & - & 203 & 3\\ - & - & - & 203 & 3\\ - & - & - & - & 203 & 3\\ - & - & - & - & - & 2\\ - & - & - & - & - & - & 2\\ - & - & - & - & - & - & -\\ - & - & - &$
Weight	101288288800000000000000000000000000000
Station 2	Craggy Stack Stack Bosley Bosley Bosley Bosley Follywog Bosley Follywog Bosley Follywog Bosley Follywog Bosley Follywog Follywog Follywog Follywog Follywog Follywog Follywog Folly Divide Ling Ridge Boald Hill Gordon Reef Mountain Reef Mountain Reef Mountain Reef Mountain
Station 1	*Pollywog *Pollywog *Pollywog *Elk Pack Saddle Tack Saddle High Divide High Di

Table of formation of observation equations

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*Computed from nonreciprocal observations. Weight used  $=\frac{1}{2}p$  from the computation.  $\ddagger$  This column added for convenience in computing.

1

COMPUTATION OF PROBABLE ERROR

 $\begin{aligned} \text{Probable error} &= \pm 0.6745 \sqrt{\frac{\Sigma p v^2}{\text{No. observations} - \text{No. unknowns}} \\ &= \pm \sqrt{\frac{0.455 \ \Sigma p v^2}{n_o - n_u}} \\ &\Sigma p v^2 = 146.394, \log = 2.16552 \\ \text{No. observations} - \text{No. unknowns} = 27 - 10 = 17, \quad \text{colog} = 8.76955 \\ &\text{Constant} = 0.455, \quad \log = 9.65801 \\ &\log \text{ (probable error)}^2 = 0.59308 \\ &\log \text{ probable error} = 0.29654 \\ &\text{Probable error of unit weight} = \pm 1.98 \ \text{m.} \\ &\log \text{ (probable error, unit weight)}^2 = 0.59308 \\ &\text{Weight coefficient for Long Ridge} = 2.843, \log = 0.45378 \\ &\log \text{ (probable error)}^2 = 0.13930 \\ &\log \text{ probable error} = 0.06965 \\ &\text{Probable error for Long Ridge} = \pm 1.17 \ \text{m.} \end{aligned}$ 

The following equations are formed from the table just given:

 $\begin{array}{c} -v_1\!=\!-1.93\!+\!x_1\\ -v_2\!=\!-0.83\!+\!x_1\\ -v_3\!=\!+1.92\!+\!x_1\\ -v_4\!=\!+0.72\!+\!x_2\\ -v_5\!=\!-0.25\!-\!x_1\!+\!x_2 \end{array}$ 

and so on for the rest of the 27 v's.

The function u to be made a minimum is  $\sum p_n v_n^2$ , or

$$\begin{split} & u \!=\! +1.32(-1.93\!+\!x_1)^2 \!+\! 0.34(-0.83\!+\!x_1)^2 \!+\! 1.51(+1.92\!+\!x_1)^2 \!+\! 0.72(+0.72\!+\!x_2)^2 \\ & +2.60(-0.25\!-\!x_1\!+\!x_2)^2 \!+\! 10.89(-0.73\!-\!x_2\!+\!x_3)^2 \!+\! 0.47(+6.90\!+\!x_3)^2 \!+\! 2.82(+3.90\!-\!x_1\!+\!x_3)^2 \!+\! 4.54(-3.55\!-\!x_2\!+\!x_4)^2 \!+\! 4.89(+2.16\!-\!x_3\!+\!x_4)^2 \!+\! 8.53(+1.61\!-\!x_4\!+\!x_5)^2 \\ & +2.34(-0.12\!-\!x_2\!+\!x_5)^2 \!+\! 1.63(+4.02\!-\!x_3\!+\!x_5)^2 \!+\! 3.71(\!+\!2.90\!-\!x_4\!+\!x_6)^2 \!+\! 2.63(-0.08\!-\!x_5\!+\!x_6)^2 \!+\! 4.93(-1.58\!-\!x_6\!+\!x_7)^2 \!+\! 2.61(\!+\!1.83\!-\!x_4\!+\!x_7)^2 \!+\! 5.19(\!+\!0.31\!-\!x_5\!+\!x_7)^2 \\ & +0.36(-0.67\!+\!x_{10})^2 \!+\! 0.42(\!+\!2.73\!-\!x_6\!+\!x_{10})^2 \!+\! 1.06(-1.51\!-\!x_7\!+\!x_{10})^2 \!+\! 3.43 \\ & (-0.22\!-\!x_7\!+\!x_8)^2 \!+\! 2.03(\!+\!0.64\!+\!x_8\!-\!x_{10})^2 \!+\! 0.24(\!-\!0.11\!+\!x_9)^2 \!+\! 8.38(\!-\!0.30\!-\!x_8\!+\!x_9)^2 \\ & +2.37(\!+\!0.27\!-\!x_7\!+\!x_9)^2 \!+\! 7.38(\!+\!0.18\!+\!x_9\!-\!x_{10})^2 . \end{split}$$

The function will be rendered a minimum by equating to zero the partial differential coefficients with respect to  $x_1$ ,  $x_2$ , etc. By this means the following equations are derived:

 $\begin{array}{l} +1.32(-1.93+x_1)+0.34(-0.83+x_1)+1.51(+1.92+x_1)-2.60(-0.25-x_1+x_2)-2.82\\ (+3.90-x_1+x_3)=0\\ +0.72(+0.72+x_2)+2.60(-0.25-x_1+x_2)-10.89(-0.73-x_2+x_3)-4.54(-3.55-x_2+x_4)\\ -2.34(-0.12-x_2+x_5)=0 \end{array}$ 

^{*} This vertical net is not of a high degree of accuracy, it being a small spur of secondary triangulation that was executed in some haste with slight attention to vertical observations. It was selected on account of its small size. The more accurate work is usually in larger nets. See list of probable errors ranging from ±0.23 m. to ±1.83 m. in United States Coast and Geodetic Survey Special Publication No. 13.

# APPLICATION OF LEAST SQUARES TO TRIANGULATION. 203

$+10.89(-0.73-x_2+x_3)+0.47(+0.90+x_3)+2.02(+5.90-x_1+x_3)-4.09(+2.10-x_3+x_4)$
$-1.63(+4.02-x_3+x_5)=0$
$+4.54(-3.55-x_2+x_4)+4.89(+2.16-x_3+x_4)-8.53(+1.61-x_4+x_5)-3.71(+2.90)$
$-x_4 + x_6) - 2.61(+1.83 - x_4 + x_7) = 0$
$+8.53(+1.61-x_4+x_5)+2.34(-0.12-x_2+x_5)+1.63(+4.02-x_3+x_5)-2.63(-0.08)$
$-x_5 + x_6) - 5.19(+0.31 - x_5 + x_7) = 0$
$+3.71(+2.90-x_4+x_6)+2.63(-0.08-x_5+x_6)-4.93(-1.58-x_6+x_7)-0.42(+2.73)$
$-x_6+x_{10})=0$
$+4.93(-1.58-x_6+x_7)+2.61(+1.83-x_4+x_7)+5.19(+0.31-x_5+x_7)-1.06(-1.51)$
$-x_7 + x_{10} - 3.43(-0.22 - x_7 + x_8) - 2.37(+0.27 - x_7 + x_9) = 0$
$+3.43(-0.22-x_7+x_8)+2.03(+0.64+x_8-x_{10})-8.38(-0.30-x_8+x_9)=0$
$+0.24(-0.11+x_9)+8.38(-0.30-x_8+x_9)+2.37(+0.27-x_7+x_9)+7.38(+0.18+x_9)$
$-x_{10})=0$
$+0.36(-0.67+x_{10})+0.42(+2.37-x_6+x_{10})+1.06(-1.51-x_7+x_{10})-2.03(+0.64)$
$+x_8-x_{10})-7.38(+0.18+x_9-x_{10})=0$

By multiplying and collecting, we obtain the following normals:

$+8.59x_1 - 2.60x_2 - 2.82x_3$	-10.2786=0
$-2.60x_1+21.09x_2-10.89x_3-4.54x_4-2.34x_5$	+24.2159=0
$-2.82x_1 - 10.89x_2 + 20.70x_3 - 4.89x_4 - 1.63x_5$	-10.8237 = 0
$-4.54x_2 - 4.89x_3 + 24.28x_4 - 8.53x_5 - 3.71x_6 - 2.61x_7$	-34.8232 = 0
$-2.34x_{2}-1.63x_{3}-8.53x_{4}+20.32x_{5}-2.63x_{6}-5.19x_{7}$	+18.6066 = 0
$-3.71x_4 - 2.63x_5 + 11.69x_6 - 4.93x_7 - \dots 0.42x_{10}$	+17.1914 = 0
$-2.61x_4 - 5.19x_5 - 4.93x_6 + 19.59x_7 - 3.43x_8 - 2.37x_9 - 1.06x_{10}$	+ 0.3111 = 0
$-3.43x_7+13.84x_8-8.38x_9-2.03x_{10}$	+ 3.0586 = 0
$-2.37x_7 - 8.38x_8 + 18.37x_9 - 7.38x_{10}$	- 0.5721=0
$- 0.42x_6 - 1.06x_7 - 2.03x_8 - 7.38x_9 + 11.25x_{10} \dots \dots$	- 3.3228=0

(See the table of normals on p. 204.)

The normals are most conveniently formed from the table given on page 204. The various observation equations are written along the horizontal lines in the columns of their respective x's. The normals are then formed as in condition equations, except that the constant terms must also be multiplied by each column and the sums taken for the constant terms in the normals, as may be seen from the direct computation of the normals above.

After the x's are determined from the solution of the normals, they are added to the assumed elevations, giving the adjusted final elevations. The v's are most easily determined by computing  $h_2 - h_1$ from the adjusted values; if the observed  $h_2 - h_1$  is subtracted from the adjusted value the respective v results. They could, of course, be computed by substituting the x's in the observation equations, but this would require more work.

For a check the  $\Sigma$  pv at any station should equal zero, with the possible exception of a small amount due to dropping the decimals on the x's. In the table on page 201, use pv from the first column if the x is positive and from the second column if the x is negative.

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	p	N	1	2	3	4	5	6	7	8	9	10	pN		x's
$\begin{array}{c}1\\1\\2\\3\\3\\4\\4\\5\\6\\7\\7\\8\\9\\10\\11\\1\\21\\13\\14\\15\\16\\17\\18\\19\\20\\21\\22\\23\\24\\4\\25\\26\\27\end{array}$	$\begin{array}{c} 1.32\\ 0.34\\ 1.51\\ 0.72\\ 2.60\\ 10.89\\ 0.47\\ 2.82\\ 4.54\\ 4.89\\ 8.53\\ 2.34\\ 4.89\\ 8.53\\ 2.34\\ 4.93\\ 2.61\\ 1.63\\ 3.713\\ 2.61\\ 1.06\\ 3.43\\ 2.03\\ 0.24\\ 8.38\\ 2.37\\ 7.38\\ \end{array}$	$\begin{array}{c} -1.93\\ -0.83\\ +1.92\\ +0.72\\ -0.25\\ -0.73\\ +6.90\\ +3.90\\ -3.55\\ +2.16\\ +1.61\\ -0.12\\ +4.02\\ +2.90\\ -0.08\\ +1.83\\ +0.31\\ -0.02\\ +2.73\\ -1.51\\ -0.02\\ +0.64\\ +1.83\\ +0.31\\ -0.02\\ +0.11\\ -0.02\\ +0.11\\ -0.37\\ +0.18\end{array}$	+1 +1 +1 +1 -1 -1 -1	+1 +1 -1 -1 -1 -1	+1 +1 +1 -1 -1	+1 +1 -1 -1	+1 + 1 + 1 + 1 - 1 - 1 - 1	+1 +1 -1 -1	+1 +1 +1 +1 -1 -1 -1	+1 +1 -1	+1 +1 +1 +1	+1 +1 +1 +1 -1 -1	$\begin{array}{c} -2.5476\\ -0.2822\\ +2.8992\\ +0.5184\\ -0.6500\\ +10.0980\\ +10.0980\\ +10.0980\\ -16.1170\\ +10.5624\\ +13.733\\ -0.2808\\ +6.5526\\ +10.7590\\ -0.2104\\ +1.763\\ +1.6089\\ -0.2412\\ +1.1466\\ -0.77894\\ +1.1466\\ -0.7540\\ -1.6006\\ -0.7546\\ +1.2992\\ -0.0264\\ +1.2992\\ +2.5140\\ +2.5140\\ +1.3284\end{array}$	1 2 3 4 5 6 7 7 8 9 10	$\begin{array}{c} +0.0595\\ -2.3925\\ -1.2577\\ -1.2304\\ -3.8408\\ -2.8757\\ -2.8107\\ -2.5441\\ -2.2951\end{array}$

# Table for formation of normal equations

# Normal equations

	1 -	2	3	4	5	6	7	8	9	10	η	Σ
1 2 3 4 5 6 7 8 9 10	+8.59	- 2.60 +21.09	- 2.82 -10.89 +20.70	- 4.54 - 4.89 +24.28	-2.34 -1.63 -8.53 +20.32	-3.71 -2.63 +11.69	-2.61 -5.19 -4.93 +19.59	— 3.43 +13.84	- 2.37 - 8.38 +18.37	-0.42 -1.06 -2.03 -7.38 +11.25	$\begin{array}{c} -10.2786\\ +24.2159\\ -10.8237\\ -34.8232\\ +18.6066\\ +17.1914\\ +\ 0.3111\\ +\ 3.0586\\ -\ 0.5721\\ -\ 3.3228\end{array}$	$\begin{array}{r} - & 7.1086\\ + 24.9359\\ - & 10.3537\\ - & 34.8232\\ + & 18.6066\\ + & 17.1914\\ + & 0.3111\\ + & 0.3111\\ + & 3.0586\\ - & 0.3321\\ - & 2.9628 \end{array}$

# Solution of normal equations

1	2	3	4	5	6	7	ŋ	Σ
$+8.59 \\ x_1$	-2.60 + 0.30268	-2.82 + 0.32829					-10.2786 + 1.19658	-7.1086 + 0.82754
1	+21.09 - 0.7870	-10.89 - 0.8536	- 4.54	- 2.34			$+24.2159 \\ - 3.1111$	+24.9359 - 2.1516
	+20.3030 $x_2$	-11.7436 + 0.57842	-4.54 + 0.22361	-2.34 + 0.11525			$+21.1048 \\ -1.03949$	+22.7842 - 1.12221
	$\frac{1}{2}$	+20.70 - 0.9258 - 6.7927	-4.89 -2.6260	- 1.63 - 1.3535			-10.8237 - 3.3744 +12.2074	-10.3537 - 2.3337 +13.1788
	-	+12.9815 $x_3$	-7.5160 + 0.57898	-2.9835 + 0.22983			-1.9907 + 0.15335	+ 0. 4913 - 0. 03785
		23	+24.28 - 1.0152 - 4.3516	$\begin{array}{r} - 8.53 \\ - 0.5232 \\ - 1.7274 \end{array}$	-3.71	-2.61	$\begin{array}{r} -34.8232 \\ + 4.7192 \\ - 1.1526 \end{array}$	-34.8232 + 5.0948 + 0.2845
			$+18.9132 \\ x_4$	-10.7806 + 0.570004	-3.71 +0.196159	-2.61 +0.137999	-31.2566 + 1.652634	-29.4440 + 1.556796

9	8	10	7	6	5	η	2
+18.37 x9	-8.38 + 0.45618	-7.38 + 0.40174	-2.37 + 0.12901 ⁵			- 0.5721 + 0.03114	-0.3321 + 0.01808
9	+13.84 - 3.8228	-2.03 -3.3666	-3.43 - 1.0811			+ 3.0586 - 0.2610	+ 3.0586 - 0.1515
	+10.0172 x ₈	-5.3966 + 0.53873	-4.5111 + 0.45034			+2.716 -0.27928	+2.9071 - 0.29021
	9 8	+11.25 - 2.9648 - 2.9073	$ \begin{array}{r} -1.06 \\ -0.9521 \\ -2.4303 \end{array} $	- 0.42		$\begin{array}{r} - 3.3228 \\ - 0.2298 \\ + 1.5072 \end{array}$	$\begin{array}{r} - 2.9628 \\ - 0.1334 \\ + 1.5661 \end{array}$
		$+ 5.3779 \\ x_{10}$	-4.4424 + 0.82605	-0.42 + 0.07810		-2.0454 + 0.38033	-1.5299 + 0.28448
		4 9 8 10	$\begin{array}{r} +19.59 \\ -0.3602 \\ -0.3058 \\ -2.0315 \\ -3.6696 \end{array}$	-4.93 -0.5120 -0.3469	-5.19 -1.4877	$\begin{array}{r} + \ 0.3111 \\ - \ 4.3134 \\ - \ 0.0738 \\ + \ 1.2599 \\ - \ 1.6896 \end{array}$	$\begin{array}{r} + \ 0.3111 \\ - \ 4.0632 \\ - \ 0.0428 \\ + \ 1.3092 \\ - \ 1.2638 \end{array}$
			+13.2229 x7	-5.7889 + 0.43779	-6.6777 + 0.50501	-4.5058 + 0.34076	-3.7495 + 0.28356
			4 10 7	$\begin{array}{r} +11.69 \\ -0.7277 \\ -0.0328 \\ -2.5343 \end{array}$	$ \begin{array}{r} - 2.63 \\ - 2.1148 \\ - 2.9234 \end{array} $	$\begin{array}{r} +17.1914 \\ - 6.1313 \\ - 0.1597 \\ - 1.9726 \end{array}$	$\begin{array}{r} +17.1914 \\ -5.7757 \\ -0.1195 \\ -1.6415 \end{array}$
				$+ \frac{9.3952}{x_6}$	-7.6681 + 0.91339	+ 8.9279 - 1.06345	+ 9.6550 - 1.15006
	-			2 3 4 7 6	$\begin{array}{r} +20.32 \\ -0.2697 \\ -0.6857 \\ -6.1450 \\ -3.3723 \\ -7.0040 \end{array}$	$\begin{array}{r} +18.6066\\ +\ 2.4323\\ -\ 0.4575\\ -17.8164\\ -\ 2.2755\\ +\ 8.1547\end{array}$	$\begin{array}{r} +18.6066\\ +2.6259\\ +0.1129\\ -16.7832\\ -1.8935\\ +8.8188\end{array}$
					$+ 2.8433 \\ x_5$	+ 8.6442 - 3.04020	+11.4875 - 4.04020

### Solution of normal equations-Continued

Back solution

5	6	7	10	8	9	4	3	2	1
-3.0402 -3.0402	-1.0634 -2.7769 -3.\$403	+0.3408 -1.5353 -1.6812 -2.8757	+0.3803 -0.2999 -2.3755 -2.2951	$-0.2793 \\ -1.2950 \\ -1.2364 \\ -2.8107$	$\begin{array}{r} +0.0311\\ -0.3710\\ -0.9220\\ -1.2822\\ \hline -2.5441\end{array}$	$+1.6526 \\ -1.7329 \\ -0.7533 \\ -0.3968 \\ -1.2304$	+0.1534 -0.6987 -0.7124 -1.2577	$-1.0395 \\ -0.3504 \\ -0.2751 \\ -0.7275 \\ -2.3925$	$+1.1966 \\ -0.4129 \\ -0.7242 \\ +0.0595$

## DEVELOPMENT OF FORMULAS FOR TRIGONOMETRIC LEVELING

#### GENERAL STATEMENT

The formulas used on pages 198 and 199 in the computation of vertical observations were found to be lacking in some of the quantities that were appreciable when the lines were very long and high. Accordingly, a new derivation is now given that takes into account some of these quantities. As a result, the formulas derived in this development differ slightly from those used in the computation cited above, but they ought to give practically the same result in computing over lines of such length as occur therein.

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The following derivation of the formulas for trigonometric leveling is based on certain approximate assumptions which fall under four general heads:

1. Geometric approximations.—The verticals at the two points  $(P_1$  the point occupied and  $P_2$  the point sighted on) are treated as if they lay in one plane and the intersection of this plane with the ellipsoid that represents the surface of the earth is treated as the arc of a circle whose radius is the mean radius of curvature of a vertical section through  $P_1$  and  $P_2$ . Helmert (in his Höhere Geodäsie, Vol. I, p. 520, and Vol. II, p. 563) investigates the error arising from these assumptions and finds it to be about 1/40 meter at a maximum when the distance  $P_1 P_2$  is about 100 kilometers.

2. Geodetic approximations.—The difference between the geodetic zenith and the astronomic zenith, i. e., the deflection of the plumb line, is ignored. If these deflections are known, corrections may be applied to the measured zenith distances (which, of course, are referred to the astronomical zenith) to reduce them to the geodetic zenith. Furthermore, the elevations obtained by trigonometric leveling between two points are referred to an assumed ellipsoid, while spirit leveling gives elevations referred to the geoid, so that the distances between gooid and ellipsoid must be known to make the two kinds of leveling comparable. If trigonometric leveling could be carried out with great precision, its use in connection with spirit leveling would give just this information as to the distance of the ellipsoid from the geoid. The change in the distance from geoid to ellipsoid occurring between  $P_1$  and  $P_2$  may be found from the deflections of the vertical at those points, provided it is assumed that the deflections vary uniformly between  $P_1$  and  $P_2$ , an assumption which may be considerably in error.

3. Optical approximations.—The path of the ray of light between  $P_1$  and  $P_2$  is assumed to be the arc of a circle in a vertical plane through  $P_1$  and  $P_2$ . The angle between the chord  $P_1 P_2$  and the tangent to the circle at either point is the refraction in zenith distance and it is evidently implied that this refraction is equal at  $P_1$  and  $P_2$ . If we call O (see figure 9) the center of the circle referred to in approximation 1, and call the angle  $P_1OP_2 = \theta$ , the refraction in zenith distance of the angle  $TP_1P_2$  ( $= \angle TP_2P_1$ ) is written as  $m\theta$  and m is termed the coefficient of refraction. The course of a ray of light through the atmosphere depends on the variations in pressure, temperature and humidity of the medium through which it passes and may be far from circular. Our lack of knowledge of the conditions which govern the refraction is the greatest obstacle to precision in trigonometric leveling.

4. Algebraic approximations.—After the approximations mentioned above have been made, there is the further approximation arising from the dropping of small terms after an expansion in series. In the following developments it will be seen that only extremely small terms are dropped, and that in cases arising in practice their effect even on the sixth place of logarithms is unimportant, while in fact logarithms of only five places are commonly used for this sort of computation. The accuracy of the developments is confirmed by the numerical agreement between the approximate and the exact formulas in the examples given. (*Exact* is used in the sense of dispensing with the use of series. The formula is *inexact*, owing to the first three sets of approximations.) The examples represent rather extreme cases of those arising in practice, and other numerical examples of extreme cases give a similar agreement.

#### DEVELOPMENT OF THE FORMULAS

Figure 9 represents the vertical plane of approximation 1 common to  $P_1$  and  $P_2$ , being in fact the plane parallel to both verticals (see

Helmert, Höhere Geodäsie, Vol. I, p. 519) on which the several points are projected.

The measured zenith distances are assumed equal to

$$\angle V_1 P_1 T = \zeta_1$$
$$\angle V_2 P_2 T = \zeta_2.$$

The measurements are not made exactly in this plane, but the error, which is part of that involved in approximation 1, is negligible.

The refraction in zenith distance is, according to approximation 3,

$$\Delta \zeta = \angle TP_1P_2 = \angle TP_2P_1 = m\theta.$$

 $S_1$  and  $S_2$  are points on the earth's surface in the verticals of  $P_1$  and  $P_2$ , so that the re-



FIG. 9.

spective elevations of  $P_1$  and  $P_2$  above the surface are

$$h_1 = S_1 P_1$$
  
 $h_2 = S_2 P_2.$ 

and

and

The mean radius of curvature  $\rho$  of approximation 1 is given by  $\rho = OS_1 = OS_2$ .

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If s denotes the distance  $P_1P_2$  measured along the arc and if  $\theta$  be expressed in radians,  $s = \rho \theta$ 

or if  $\theta$  be in seconds,

$$\theta^{\prime\prime} = \frac{s}{\rho \sin 1^{\prime\prime}}.$$

There are two cases to be considered according as to whether both or only one of the zenith distances have been measured.

CASE I. Reciprocal zenith distances

In the triangle  $P_1 O P_2$ 

$$\begin{split} & \angle P_2 P_1 O = 180^\circ - \zeta_1 - \varDelta \zeta = 180^\circ - \zeta_1 - m\theta \\ & \angle P_1 P_2 O = 180^\circ - \zeta_2 - \varDelta \zeta = 180^\circ - \zeta_2 - m\theta \\ & O P_1 = \rho + h_1 \\ & O P_2 = \rho + h_2, \end{split}$$

also and

Therefore by the law of sines

$$\frac{\rho + k_1}{\rho + h_2} = \frac{\sin(\zeta_2 + m\theta)}{\sin(\zeta_1 + m\theta)}$$

Treating this as a proportion and taking by division,

$$\frac{(\rho+h_2)-(\rho+h_1)}{\rho+h_1} = \frac{\sin (\zeta_1+m\theta)-\sin (\zeta_2+m\theta)}{\sin (\zeta_2+m\theta)}$$

or

$$h_{2} - h_{1} = \frac{2 \left(\rho + h_{1}\right) \sin\left(\frac{\zeta_{1} - \zeta_{2}}{2}\right) \cos\left(\frac{\zeta_{1} + \zeta_{2}}{2} + m\theta\right)}{\sin\left(\zeta_{2} + m\theta\right)} \cdot$$
(A)

Since the sum of the angles of a triangle is 180°,

$$180^{\circ} - \zeta_1 - m\theta + 180^{\circ} - \zeta_2 - m\theta + \theta = 180^{\circ}$$

which gives

$$\frac{\zeta_1+\zeta_2}{2}+m\theta=90^\circ+\frac{\theta}{2}$$

also

$$\zeta_2 + m\theta = \frac{\zeta_2 + \zeta_1}{2} + m\theta + \frac{\zeta_2 - \zeta_1}{2} = 90^{\circ} + \frac{\theta}{2} + \frac{\zeta_2 - \zeta_1}{2}$$

whence  $(\Lambda)$  becomes

$$h_{2} - h_{1} = \frac{2(\rho + h_{1})\sin\left(\frac{\zeta_{2} - \zeta_{1}}{2}\right)\sin\frac{\theta}{2}}{\cos\left(\frac{\zeta_{2} - \zeta_{1}}{2} + \frac{\theta}{2}\right)}.$$
 (1)

The quantity  $2(\rho + h_1) \sin \frac{\theta}{2}$  has a simple geometrical interpretation In the figure make  $OL_2 = OP_1$  and draw  $OM \perp P_1L_2$ . Then

$$P_1 M = L_2 M = OP_1 \sin P_1 OM = (\rho + h_1) \sin \frac{\theta}{2}$$

Then  $2(\rho + h_1) \sin \frac{\theta}{2}$  is the chord  $P_1L_2$  or the chord  $S_1S_2$  increased to allow for the elevation of  $P_1$  above the earth's surface. In fact, the relation (1) might have been obtained by applying the law of sines directly to the triangle  $P_1P_2L_2$ , which makes it evident why  $P_1L_2$ appears.

For convenient computation^{*} (1) may be transformed as follows: By the sine series

$$2\sin\frac{\theta}{2} = 2\left\lfloor\frac{\theta}{2} - \frac{1}{6}\left(\frac{\theta}{2}\right)^{s} + \cdots\right]$$
$$2(\rho + h_{1})\sin\frac{\theta}{2} = \rho\left(1 + \frac{h_{1}}{\rho}\right)\left(\theta - \frac{\theta^{s}}{24} + \cdots\right)$$
$$= \rho\theta\left(1 + \frac{h_{1}}{\rho}\right)\left(1 - \frac{\theta^{2}}{24}\right) = s\left(1 + \frac{h_{1}}{\rho}\right)\left(1 - \frac{s^{2}}{24\rho^{2}}\right). \quad (2)$$

The remaining factors of the right-hand side of (1) may be written,

$$\frac{\sin\left(\frac{\zeta_2-\zeta_1}{2}\right)}{\cos\left(\frac{\zeta_2-\zeta_1}{2}+\frac{\theta}{2}\right)} = \frac{\sin\left(\frac{\zeta_2-\zeta_1}{2}\right)}{\cos\left(\frac{\zeta_2-\zeta_1}{2}\right)\cos\frac{\theta}{2}-\sin\left(\frac{\zeta_2-\zeta_1}{2}\right)\sin\frac{\theta}{2}}$$
$$= \frac{\tan\left(\frac{\zeta_2-\zeta_1}{2}\right)\sec\frac{\theta}{2}}{1-\tan\frac{\theta}{2}\tan\left(\frac{\zeta_2-\zeta_1}{2}\right)}$$
$$= \tan\left(\frac{\zeta_2-\zeta_1}{2}\right)\left(1+\frac{\theta}{2}\right)\left[1+\frac{\theta}{2}\tan\left(\frac{\zeta_2-\zeta_1}{2}\right)\right]. \tag{3}$$

The last transformation comes by expanding sec  $\frac{\theta}{2}$  in powers of  $\theta$ and noting that  $\tan \frac{\theta}{2} = \frac{\theta}{2}$  nearly, and that the product  $\frac{\theta}{2} \tan \frac{\zeta_2 - \zeta_1}{2}$  is small, so that,

$$\frac{1}{1 - \frac{\theta}{2} \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right)} = 1 + \frac{\theta}{2} \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) \text{ very nearly.}$$

By combining (2) and (3) and using  $\theta = \frac{s}{\rho}$ , equation (1) becomes

$$h_{2}-h_{1}=s\left(1+\frac{h_{1}}{\rho}\right)\tan\left(\frac{\zeta_{2}-\zeta_{1}}{2}\right)\left[1+\frac{s}{2\rho}\tan\left(\frac{\zeta_{2}-\zeta_{1}}{2}\right)\right]\left[1+\frac{s^{2}}{12\rho^{2}}\right]$$
  
or  $h_{2}-h_{1}=s\tan\left(\frac{\zeta_{2}-\zeta_{1}}{2}\right)ABC$  (4)

* See also note 1, p. 219.

where 
$$A = 1 + \frac{h_1}{\rho} =$$
correction for elevation of station whose elevation is known,

 $B = 1 + \frac{s}{2\rho} \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) = \text{correction for approximate difference}$  of elevation,

 $C = 1 + \frac{s^2}{12o^2} =$ correction for distance.

The logarithms of A, B, and C are given in the tables on pages 218 and 219 with the respective arguments  $h_1$ ,  $\log \left[s \tan \left(\frac{\zeta_2 - \zeta_1}{2}\right)\right]$ , and  $\log s$ . The tables show the limiting values of the respective arguments for which logarithms of A, B, and C become 1, 2, 3, etc., units of the fifth place of decimals.

Equation (4) may be compared with the expression more commonly given for  $h_2 - h_1$ ,

$$h_2 - h_1 = s \, \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) \left[1 + \frac{h_1 + h_2}{2\rho} + \frac{s^2}{12\rho^2}\right] \tag{5}$$

With the tables here given (5) will probably be found slightly more convenient for logarithmic computation than (4). The two forms are equally accurate.

## Case II. Only one zenith distance $(\zeta_1)$ observed

Where two zenith distances are known, the formula, either (4) or (5), does not involve the coefficient of refraction (m) explicitly. Where only one zenith distance is known, a value of m must be assumed from the best sources of information available.

In the triangle  $P_1 L_2 P_2$ 

$$\angle P_1 \ L_2 \ P_2 = 90^\circ + \frac{\theta}{2} = \angle \ V_1 \ P_1 \ L_2$$

$$\angle P_2 \ P_1 \ L \ = \angle \ V_1 \ P_1 \ L_2 - \angle \ V_1 \ P_1 \ P_2$$

$$= 90^\circ + \frac{\theta}{2} - (\zeta_1 + \varDelta\zeta) = 90^\circ - \zeta + (\frac{1}{2} - m)\theta$$

For the third angle we find, by subtracting the sum of the other angles from  $180^{\circ}$ 

$$\angle P_1 P_2 L = \zeta_1 - (1 - m)\theta.$$

By the law of sines

$$\frac{L_2 I_2}{P_1 L_2} = \frac{\sin I_2 I_1 L_2}{\sin P_1 P_2 L_2}$$

$$h_2 - h_1 = P_1 L_2 \frac{\cos \left[\zeta_1 - (\frac{1}{2} - m)\theta\right]}{\sin \left[\zeta_1 - (1 - m\theta)\right]}.$$
(6)

or

The chord 
$$P_1L_2 = \text{chord } S_1S_2 \times \frac{\rho + h_1}{\rho} = \text{chord } S_1S_2 \times A$$
, A having the meaning previously given; chord  $S_1S_2 = \text{arc } s$  very nearly; or, if greater precision is desired,  $P_1L_2 = sAR$ , where R is the reduction factor from arc to chord.

#### APPLICATION OF LEAST SQUARES TO TRIANGULATION. 211

The logarithm of the reduction factor from arc to sine is given in the Coast and Geodetic Survey Special Publication No. 8 (Formulæ and Tables for the Computation of Geodetic Positions), page 17. The logarithm of the reduction to chord is very nearly one-fourth of the reduction from arc to sine. Granting approximations 1, 2, and 3, equation (6) may be rewritten as the so-called exact formula in the following form:

$$h_{2} - h_{1} = sAR \frac{\cos\left(\zeta_{1} - (\frac{1}{2} - m)\frac{s}{\rho\sin 1^{\prime\prime}}\right)}{\sin\left[\zeta_{1} - (\frac{1}{2} - m)\frac{s}{\rho\sin 1^{\prime\prime}} - \frac{1}{2}\frac{s}{\rho\sin 1^{\prime\prime}}\right]}.$$
 (7)

Sin 1'' is introduced to convert the angle from radians to seconds of arc. A and R have the meanings previously indicated. The quantity  $(\frac{1}{2}-m)$  appears in the computation of the refraction from reciprocal zenith distances on the Coast and Geodetic Survey forms. A mean of the determinations of  $(\frac{1}{2}-m)$  from the reciprocal zenith distances should be used in computing the nonreciprocal observations. Having found the angle  $\zeta_1 - (\frac{1}{2}-m) \frac{s}{\rho \sin 1''}$  for the numerator, the computer should subtract  $\frac{1}{2} \frac{s}{\rho \sin 1''}$  from it to get the angle for the denominator. The angle in the denominator need not be carried out very accurately, as it is always near 90° where the sine varies slowly.

The former Coast and Geodetic Survey formula was

$$h_2 - h_1 = s \cot \zeta_1 + \frac{(\frac{1}{2} - m) s^2}{\rho} + \frac{(1 - m) s^2 \cot^2 \zeta_1}{\rho}.$$
 (8)

It is obtained from (6) or (7) by expanding in series and dropping certain small quantities. On some of the longer lines the quantities dropped are appreciable in computations with five-place logarithms. The development hereafter given will show that the general form of (8) may be retained by the introduction of correction-factors  $D_1$  and  $D_2$ , which are nearly unity, and by the further factor A, the correction-factor for elevation of the occupied station. The full formula will then be,

$$h_2 - h_1 = A D_1 s \cot \zeta_1 + \frac{(\frac{1}{2} - m) A D_2 s^2}{\rho} + \frac{(1 - m) s^2 \cot^2 \zeta_1}{\rho}.$$

This form may be obtained from (6) as follows: As before

$$P_1 L_2 = 2(\rho + h_1) \sin \frac{\theta}{2}$$

or expanding by the sine series

$$P_{1}L_{2} = \rho \left(1 + \frac{h_{1}}{\rho}\right) \left[\theta - \frac{\theta^{3}}{24} + \cdots \right] = A\rho \left(\theta - \frac{\theta^{3}}{24} + \cdots \right).$$
(9)

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The factor  $\cos \left[\zeta_1 - \left(\frac{1}{2} - m\right) \theta\right]$  in (6) may be written

 $\cos\left[\zeta_1 - \left(\frac{1}{2} - m\right) \theta\right] = \cos\zeta_1 \cos\left[\left(\frac{1}{2} - m\right) \theta\right] + \sin\zeta_1 \sin\left[\left(\frac{1}{2} - m\right) \theta\right]$ 

Since  $(\frac{1}{2} - m) \ \theta$  is a small quantity, the series forms for its sine and cosine may be used, giving

$$\cos \left[\zeta_{1} - \left(\frac{1}{2} - m\right)\theta\right] = \cos \zeta_{1} \left[1 - \left(\frac{1}{2} - m\right)^{2} \frac{\theta^{2}}{2} + \cdots \right] + \sin \zeta_{1} \left[\left(\frac{1}{2} - m\right)\theta - \left(\frac{1}{2} - m\right)^{3} \frac{\theta^{3}}{6} + \cdots \right]$$
(10)

The third factor on the right-hand side of (6), namely,

$$\frac{1}{\sin\left[\zeta_1 - (1-m)\theta\right]} = \operatorname{cosec}\left[\zeta_1 - (1-m)\theta\right]$$

may be expanded in powers of  $(1-m)\theta$  by Taylor's theorem.

$$\begin{aligned} f(\zeta_1) &= \operatorname{cosec} \, \zeta_1 \\ f'(\zeta_1) &= -\cot \, \zeta_1 \, \operatorname{cosec} \, \zeta_1 \\ f''(\zeta_1) &= \operatorname{cosec} \, \zeta_1 \, (1+2 \, \cot^2 \, \zeta_1) \\ f'''(\zeta_1) &= -6 \, \operatorname{cosec}^3 \zeta_1 \, \cot \, \zeta_1 + \cot \, \zeta_1 \, \operatorname{cosec} \, \zeta_1. \end{aligned}$$

This gives,

$$\frac{1}{\sin [\zeta_1 - (1 - m) \ \theta]} = \operatorname{cosec} \ \zeta_1 + \operatorname{cosec} \ \zeta_1 \ \cot \zeta_1 \ (1 - m) \ \theta + \operatorname{cosec} \ \zeta_1 \ (1 + 2 \ \cot^2 \zeta_1) (1 - m)^2 \frac{\theta^2}{2}$$
(11)  
+  $\operatorname{cosec} \ \zeta_1 \ \cot \zeta_1 \ (6 \ \operatorname{cosec^2} \ \zeta_1 - 1) (1 - m)^3 \frac{\theta^3}{6} + \cdot \cdot \cdot$ 

The expressions (9), (10), and (11) for the factors on the right-hand side of (6) are now to be multiplied together.

In cases that actually occur,  $\theta$  and cot  $\zeta_1$  are small quantities of about the same order of magnitude. If we call cot  $\zeta_1$  a quantity of the first order, it is evident that cosec  $\zeta_1$  differs from unity by a quantity of the second order. In forming the product from (9), (10), and (11) it is seen that the product is of the second order, and will moreover contain only terms of even order, so that if terms of the fourth order are retained the error will be of the sixth order, or the proportional error (the error as compared with the quantity itself) will be

of the fourth order or of the order of  $\frac{1}{30^4}$  part of the difference of eleva-

tion, if we suppose a quantity of the first order may be as large as  $\frac{1}{30}$ , a liberal allowance. The error, then, of the omitted terms should not affect the fifth place of logarithms and probably not the sixth. It will be seen that the expansions (9), (10), and (11) have been carried out sufficiently far for the purpose in hand, and if these expressions

be multiplied together, retaining in the product no terms of higher order than the fourth, the result may be written:

$$h_{2} - h_{1} = (\rho + h_{1}) \left\{ \theta \cot \zeta_{1} \left[ 1 + \frac{6 (1 - m)^{2} - 1}{6} \cdot \theta^{2} \right] + (\frac{1}{2} - m) \theta^{2} \left[ 1 + \frac{5 - 10 m + 4 m^{2}}{12} \cdot \theta^{2} \right] + (1 - m) \theta^{2} \cot^{2} \zeta_{1} \right\}$$
(12)

Since  $\theta = \frac{s}{\rho}$ , we may write

N

$$h_2 - h_1 = AD_1 s \cot \zeta_1 + \frac{AD_2(\frac{1}{2} - m)s^2}{\rho} + \frac{(1 - m)s^2 \cot^2 \zeta_1}{\rho}$$
(13)

where 
$$D_1 = 1 + \frac{6(1-m)^2 - 1}{6} \cdot \frac{s^2}{\rho^2}$$
  
 $D_2 = 1 + \frac{5 - 10m + 4m^2}{12} \cdot \frac{s^2}{\rho^2}$ 
(13a)

The factor A has been omitted from the last term as being unnecessary, the latter being small and A near unity.  $D_1$  and  $D_2$  are also near unity. Their logarithms are tabulated in the same manner as the other quantities, the tables showing the limiting values of the argument between which  $\log D_1$  or  $\log D_2$  may be taken as 1, 2, 3, etc., units of the fifth decimal.

It may be noted that in some European surveys the term  $(1-m)\frac{s^2 \cot^2 \zeta_1}{\rho}$  is dropped and the formula for difference of elevation written as

$$h_2 - h_1 = s \cot \zeta_1 + (\frac{1}{2} - m) \frac{s^2}{\rho}$$
 (14)

The dropped terms or factors all represent quantities of the fourth order in our expansion. The term  $\frac{(1-m)s^2 \cot^2 \zeta_1}{\rho}$  is, however, the largest of such quantities as a rule, and might be noticeable where  $D_1$  and  $D_2$  would not be.

Probably for short lines and small differences of elevation the most convenient formula would be

$$h_2 - h_1 = As \cot \zeta_1 + A(\frac{1}{2} - m) \frac{s^2}{\rho}$$
(15)

and for other lines formula (7).

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#### EXAMPLES

The data for the following examples, which illustrate the use of the formulas, come from The Transcontinental Triangulation, Special Publication No. 4, page 273, et. seq.

	At Mo	At Snow Mountain West			At Ross Mountain		
$\zeta \\ \phi \\ \alpha \\ Approx. elev.$	° 91 39 18 2146	, 13 22 56 56 5 me	" 39.1 38 18 ters	° 89 38 197 67	, 34 30 49 2 m	" 04.8 20 29 eters	
log 8=5 007341							

For mean  $\alpha$  and  $\phi$  on the Clarke spheroid of 1866,  $\log \rho = 6.80369$ .

Example 1. Difference of elevation for reciprocal zenith distances, assuming Snow Mountain West as the known elevation from formula (5).

Example 2. Same data as Example 1 worked by formula (4).

Example 3. Assuming Ross Mountain as known elevation, solve by (4).

Example 4. With refraction from reciprocal zenith distances, but with only zenith distance at Snow Mountain West appearing explicitly, find difference of elevation by (7).

Example 5. Same data as Example 4, worked by (13).

Example 6. Like example 4, except zenith distance at Ross Mountain is used.

Example 7. Like example 5, except zenith distance at Ross Mountain is used.

The agreement of the differences of elevation as computed by the various combinations of data and formulas will give an idea of the accuracy of the latter.
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Exan	iple 1		Example 2	Example 3
Station 1	{Snow Mountain West			
Station 2	Ross Mountain			
$\zeta_1$ $\zeta_2^{-1}$ $\zeta_2^{-1}$ $\zeta_2^{-1}$ $\zeta_2^{-1}$ is secs. log ditto T log s	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$			
log s tan $\frac{1}{2}(\zeta_2-\zeta_1)$ s tan $\frac{1}{2}(\zeta_2-\zeta_1)$ Second term* Third term*	$\begin{array}{r} 3.168203n \\ -1473.00 \\ - 0.03 \\ - 33 \end{array}$	$\frac{\log s \tan \frac{1}{2}(\zeta_2 - \zeta_1)}{\log B}$ $\log C$	$\begin{array}{r} 3.168203n \\ +146 \\ -50 \\ +11 \end{array}$	3.168203 + 46 + 50 + 11
$h_2 - h_1$	-1473.36	$\log(h_2-h_1)$	3.168310n	3.168310
$\begin{array}{c} h_1 \\ h_2 \end{array}$	2145.66 672.30	<i>h</i> ₂ — <i>h</i> ₁		+1473.30
$\zeta_1 + \zeta_2 - 180^{\circ}$ $\zeta_1 + \zeta_2 - 180 \text{ in secs.}$ $\log \text{ ditto}$ $\log \rho$	$\begin{array}{rrr} 47 & 43.9 \\ 2803.9 \\ 3.450958 \\ 6.803090 \end{array}$			
$\log \frac{1}{8}$	4.992659			
$\log \frac{\sin 1''}{2} = 4.38454$	4.384545			
log(0.5-m) (0.5-m)	9.637852 0.43436			

Example	Example 6		
$\log s.$ colog $\rho$ colog sin 1"	5. 007341 3. 196310 5. 314425	(Same as ex- ample 4)	
$\log \theta^{\dagger}_{\log (0.5-m)}$	3.518076 9.637852		
$\log \begin{array}{c} (0.5-m)\theta \\ (0.5-m)\theta \end{array}$	3.155928 1431.″95		
$\overset{\zeta_1}{(0.5-m)} heta$	91° 13′ 39.″1 23 51. 95	89° 34′ 04.″8 23 51. 95	
$\frac{\zeta_1 - (0.5 - m)\theta}{\frac{\theta}{2}}$	90 49 47. 15 27 28	89 10 12. 85 27 28	
$\begin{array}{c} \zeta_1 - (1-m)\theta \\ \log s \\ \log A \\ \log R \\ \log \cos \left[\zeta_1 - (0.5-m)\theta\right] \\ \operatorname{colog} \sin \left[\zeta_1 - (1-m)\theta\right] \end{array}$	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$		
$\log_{h_2-h_1}^{\log(h_2-h_1)}$	3.168308n 	3.168309 + 1473.36	

*Second and third terms in example 1 computed by aid of table in General Instructions for Field Work, Coast and Geodetic Survey, pp. 36-37 (edition of 1908).

 $\dagger \theta$  is used for  $\frac{\vartheta}{\rho \sin 1^{\prime\prime}}$ , as in the text.

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Example 5					
$\log s$ $\log A$ $\log D_1$ $\cot \zeta_1$	$5.007341 + 146 + 79 \\ 8.330975n$	$\begin{array}{c} \log \left( 0.5 - m \right) \\ \log s^2 \\ \operatorname{colog} \rho \\ \log A \end{array}$	9.637852 10.014682 3.196310 146	$\frac{\log s^2}{\operatorname{colog} \rho} \\ \frac{\cot^2 \zeta_1}{\log (1-m)}$	$10.015 \\ 3.196 \\ 6.662 \\ 9.971$
log first	3.338541n	$\log D_2$	39	log third	9.844
First Second Third	-2180.424 + 706.365 + .698	log second	2.849029	`	
h2h1	-1473.361				
Example 7					
$\log s \\ \log A \\ \log D_1 \\ \cot \zeta_1$	5.007341 + 46 + 79 7.877369	$\begin{array}{c} \log \left( 0.5 - m \right) \\ \log s^2 \\ \operatorname{colog} \rho \\ \log A \end{array}$	$\begin{array}{r} 9.637852 \\ 10.014682 \\ 3.196310 \\ +46 \end{array}$	$     \log s^2     \cos^2 \zeta_1     \log (1-m) $	10.015 3.196 5.755 9.971
log first	2.884835	$\log D_2$	+39	log third	8.937
First Second Third $h_2 - h_1$	$\begin{array}{r}+767.070\\+706.202\\+.087\end{array}$	log second	2.848929	0.0	

#### RECAPITULATION OF FORMULAS

(Numbered as in foregoing discussion)

Case I. Reciprocal observations

Former Coast and Geodetic Survey form,

$$h_2 - h_1 = s \, \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) \left[1 + \frac{h_1 + h_2}{2\rho} + \frac{s^2}{12\rho^2}\right]. \tag{5}$$

Reference: Page 210 and General Instructions for Field Work Coast and Geodetic Survey, pages 34–37 (edition of 1908).

Logarithmic form,

$$h_2 - h_1 = s \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) ABC. \tag{4}$$

Reference: Page 209 and tables.

Case II. Nonreciprocal observations

Former Coast and Geodetic Survey form,

$$h_2 - h_1 = s \cot \zeta_1 + \frac{0.5 - m}{\rho} s^2 + \frac{(1 - m) s^2 \cot^2 \zeta_1}{\rho}.$$
 (8)

Reference: Page 211 and General Instructions for Field Work Coast and Geodetic Survey, pages 34–37 (edition of 1908).

Corrected form,

$$h_2 - h_1 = AD_1 \ s \ \cot \zeta_1 + \frac{0.5 - m}{\rho} \ AD_2 \ s^2 + \frac{(1 - m) \ s^2 \ \cot^2 \zeta_1}{\rho} \quad . \tag{13}$$

Reference: Page 213 and tables.

"Exact" form,

$$h_{2} - h_{1} = sAR \frac{\cos\left[\zeta_{1} - (\frac{1}{2} - m)\frac{s}{\rho \sin 1^{\prime\prime}}\right]}{\sin\left[\zeta_{1} - (\frac{1}{2} - m)\frac{s}{\rho \sin 1^{\prime\prime}} - \frac{s}{2\rho \sin 1^{\prime\prime}}\right]} \quad .$$
(7)

Reference: Page 211 and tables; also Formulæ and Tables for Position Computation, Coast and Geodetic Survey Special Publication No. 8, for R.

See also additional note, page 220.

#### NOTES ON CONSTRUCTION AND USE OF TABLES

The tables are constructed with mean values of  $\rho$  and m.

log  $\rho = 6.80444$  corresponding to mean radius of curvature in latitude 40° for Clarke's spheroid of 1866.

 $\dot{m} = 0.06$ . *m* varies between 0.05 and 0.10 in the great majority of cases. This value near the smaller limit was taken as probably nearer the truth for the high lines, in which the correction terms tabulated are most likely to appear, than an intermediate value of 0.07 or 0.08

A, B, C,  $D_1$  and  $D_2$  are all very near unity. To compute their logarithms the approximate expression log (1+x) = Mx was used, M being the modulus of common logarithms =0.43429.

Formulas for constructing tables:

$$A = 1 + \frac{h}{\rho} \qquad \log A = \frac{Mh}{\rho} \qquad h = \frac{\rho}{M} \log A = 146.78 \log A$$

 $\log A$  being in units of fifth place.

$$\begin{split} B &= 1 + \frac{s}{2\rho} \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) & \log B = \frac{Ms}{2\rho} \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) \\ & \log\left[s \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right)\right] = \log\frac{2\rho}{M} + \log(\log B) \\ &= 7.4677 + \log(\log B) \\ C &= 1 + \frac{s^2}{12\rho^2} & \log C = \frac{Ms^2}{12\rho^2} & \log s = \log\left(\rho\sqrt{\frac{12}{M}}\right) + \frac{1}{2}\log(\log C) \\ &= 7.5251 + \frac{1}{2}\log(\log C) \\ D_1 &= 1 + \frac{6(1 - m)^2 - 1}{6}\frac{s^2}{\rho^2} & \log D_1 = M \frac{6(1 - m)^2 - 1}{6}\frac{s^2}{\rho^2} \\ &\log s = 7.0578 + \frac{1}{2}\log(\log D_1) \\ D_2 &= 1 + \frac{10 - 20 \ m + 8 \ m^2}{24}\frac{s^2}{\rho^2} & \log D_2 = M\left(\frac{5 - 10m + 4 \ m^2}{12}\right)\frac{s^2}{\rho^2} \\ &\log s = 7.2027 + \frac{1}{2}\log(\log D_2) \end{split}$$

The values of log A, log B, etc., were taken successively at 0.5, 1.5, 2.5, etc., units of the fifth place, namely, at the point where the value

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of log A, log B, as rounded off to 5 decimals would change by one in the fifth place. The corresponding values of h, log  $\left[s \tan\left(\frac{\zeta_2-\zeta_1}{2}\right)\right]$ and log s were then computed by the formulas above. These values are carried out far enough so that the values of log A, log B, etc., may be obtained by interpolation to six decimals. In the numerical examples here given the values of log A, log B, etc., were computed independently for the actual values of  $\rho$  and m. These results as used in the example all agree within a unit of the sixth decimal place with those found by interpolating in the tables.

The unit of length throughout the tables and formulas is the meter.

Elevation of occupied station h ₁	log A units of fifth place	Elevation of occupied station h ₁	log A units of tifth place		
Meters		Meters			
0	0.0	3009	20.5		
73	0.5	3156	21.5		
220	1.5	3303	22.0		
507	2.0	3449	20.0		
661	4.5	3743	- 25.5		
807	5.5	3890	26.5		
954	6.5	4036	27.5		
1101	7.5	4183	28.5		
1248	8.5	4330	29.5		
1394	9.5	4477	30.5		
1541	10.5	4024	31.5		
1038	11.0	4770	32.5		
1082	13.5	5064	34.5		
2128	14.5	5211	35.5		
2275	15.5	5357	36.5		
2422	16.5	5504	37.5		
2569	17.5	5651	38.5		
2715	18.5	5798	39.5		
2862	19.5	5945	40.5		

Tables

log A is *positive* except in the rare case when  $h_1$  indicates a depression below mean sea level.

A is used for both reciprocal and nonreciprocal observations.

For reciprocal observations only (unless formula, p. —, is used)		For nonreciprocal observations					
$\log \operatorname{approx-imate}_{\text{imate}}$ $\operatorname{difference}_{\text{elevation}} = \log s \tan \left(\frac{\zeta_2 - \zeta_1}{2}\right) *$	log B units of 5th place	log s	log C	log s	log D ₁ units of 5th place	log s	log D2 units of 5th place
$\begin{array}{c} 2.\ 167\\ 2.\ 644\\ 2.\ 866\\ 3.\ 011\\ 3.\ 208\\ 3.\ 281\\ 3.\ 343\\ 3.\ 397\\ 3.\ 445\\ 3.\ 489\\ 3.\ 528\\ 3.\ 565\\ 3.\ 598\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 3.\ 658\\ 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2.5\\ 3.5\\ 4.5\\ 5.5\\ 6.5\\ 5.5\\ 7.5\\ 8.5\\ 10.5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 11.5\\ 5\\ 21.5\\ 22.5\\ 5\\ 23.5\\ 5\\ 25.5\\ 23.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5\\ 5\\ 25.5$	$\begin{array}{c} 4.552\\ 4.791\\ 4.902\\ 4.975\\ 5.029\\ 5.073\\ 5.109\\ 5.107\\ 5.107\\ 5.107\\ 5.213\\ 5.233\\ 5.251\\ 5.251\\ \end{array}$	$\begin{array}{c} 0.0\\ 0.5\\ 1.5\\ 2.5\\ 3.5\\ 4.5\\ 5.5\\ 6.5\\ 7.5\\ 8.5\\ 9.5\\ 10.5\\ 11.5\\ 12.5\end{array}$

* Or log s cot  $\zeta_1 = (0.5 - m) \frac{s}{s \sin 1''}$  for nonreciprocal observations. (See note 2, p. 220.)

log B has the same sign as the approximate difference of elevation. log C is always positive.

 $\log D_1$  and  $\log D_2$  are always positive.

# NOTES ON THE DEVELOPMENTS

NOTE 1.—The transformation of (1), page 208, may be conducted rather more simply than is there given.

$$h_2 - h_1 = \frac{2\left(\rho + h_1\right)\sin\left(\frac{\zeta_2 - \zeta_1}{2}\right)\sin\frac{\theta}{2}}{\cos\left[\left(\frac{\zeta_2 - \zeta_1}{2}\right) + \frac{\theta}{2}\right]} \tag{1}$$

$$h_2 - h_1 = \frac{2 \left(\rho + h_1\right) \sin\left(\frac{\zeta_2 - \zeta_1}{2}\right) \sin\frac{\theta}{2}}{\cos\left(\frac{\zeta_2 - \zeta_1}{2}\right) \cos\frac{\theta}{2} - \sin\left(\frac{\zeta_2 - \zeta_1}{2}\right) \sin\frac{\theta}{2}}$$

or

Divide numerator and denominator by  $\cos\left(\frac{\zeta_2-\zeta_1}{2}\right)\cos\frac{\theta}{2}$ ,

$$h_2 - h_1 = \frac{2 \left(\rho + h_1\right) \tan \frac{\theta}{2} \tan \left(\frac{\zeta_2 - \zeta_1}{2}\right)}{1 - \tan \frac{\theta}{2} \tan \left(\frac{\zeta_2 - \zeta_1}{2}\right)}$$

or expanding  $\tan \frac{\theta}{2}$  in series and using  $\theta = \frac{s}{\rho}$ ,

$$h_2 - h_1 = \left(1 + \frac{h}{\rho}\right) s \left(1 + \frac{s^2}{12\rho^2}\right) \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) \left[1 + \frac{s \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right)}{2\rho}\right]$$
$$= s \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) ABC,$$

which is equation (4).

NOTE 2.—The formula for nonreciprocal observations may be put in the same form as that for reciprocal observations.

From the equation on page 208

$$\begin{aligned} \zeta_2 &= 180^\circ - \zeta_1 - 2m \ \theta + \theta \\ \frac{\zeta_2 - \zeta_1}{2} &= 90 - \zeta_1 + (0.5 - m) \ \theta \\ \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) &= \cot\left[\zeta_1 - (0.5 - m) \ \theta\right] = \cot\left[\zeta_1 - (0.5 - m) \ \frac{s}{\rho \sin 1''}\right] \end{aligned}$$

Substitute in (4)

$$h_2 - h_1 = s \cot [\zeta_1 - (0.5 - m) \frac{s}{\rho \sin 1''}] ABC$$

for nonreciprocal observations analogous to

$$h_2 - h_1 = s \tan\left(\frac{\zeta_2 - \zeta_1}{2}\right) ABC$$

for reciprocal observations. B should be taken from table with argument

$$\log s \cot \left[ \zeta_1 - (0.5 - m) \frac{s}{\rho \sin 1^{\prime\prime}} \right]$$

This is the present Coast and Geodetic Survey formula for non-reciprocal observations.

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