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MANUAL OF PLANE-COORDINATE COMPUTATION

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NOTICE

After this publication had been carried through the final proof-reading, it was decided to change the constant added to the x values in the transverse Mercator grids from 2,000,000 to 500,000. The latter value is to be used for all States having systems on this projection. A constant of 600,000 was used in the sample computations for Rhode Island given in this publication. This should be changed to 500,000. The change also affects all x values in Georgia and Indiana that appear in this publication. To make the x values here given consistent with the State lists of coordinates, 1,500,000 should be subtracted from all x values for these two States given in this publication.

This change in no way affects the sample computations explaining the use of the grid coordinates, because in all cases differences of coordinates are involved and the additive constant is canceled in the process of obtaining these differences.

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MANUAL OF PLANE-COORDINATE COMPUTATION

INTRODUCTION

In response to the demand from the engineers of the country, systems of plane coordinates for each of the various States were computed by this Bureau. After these were completed there was need of a manual of computations that would show clearly how the resulting grids could be used in actual calculation. Although two different systems were used in adapting the grids to the different States, yet the method of using the results after the coordinates have been computed is essentially the same in both of the systems. It is hoped that the sample computations given in the text will illustrate the close similarity in the methods of application. We believe that enough material has been included to serve as a model for practically any case that may arise in actual engineering operations.

No doubt most of the work that will be computed on the grids will consist of traverse lines that start from a fixed point and end on another fixed point. With this thought in mind more attention has been given to this kind of computation. It is also shown how to pass from one grid system to another even on a different system of projection without causing any difficulty in the adjustment. The same method could be used in crossing the boundary of two systems in the same State. Our hope is that this publication may serve to encourage engineers and surveyors to base their work on geodetic control so as to coordinate it with the national control system. In this way their work will have increased importance, and it in turn can serve as control for future surveys.

NATURE OF SURVEYING

Surveying is divided into different classes, such as geodetic surveying, cadastral surveying, public-works surveying, and many other kinds. But whatever class of work is being done, the observations are made on the surface of the earth. The actual surface, however, is very irregular, consisting of hills and valleys and mountain ranges. The most extensive surveying is geodetic surveying which has for its field of operations a whole country and often a whole continent. In this case it is necessary to adopt some regular size and shape of the earth upon which to make the computations. For this class of work, therefore, the earth is assumed to be an ellipsoid of revolution with the polar axis the shorter. This figure approximates the sea-level surface of the earth but is not exactly equivalent to it; even the sea-level surface has slight irregularities and this surface forms the geoid. The mathematical ellipsoidal surface is entirely regular and forms an acceptable basis for surveying computations.

GEODETIC SURVEYING

Since geodetic surveying has such a broad field of operation it is necessary to take into consideration all refinements in the computation of the work. The observations for such work generally consist of the measurement of the angles of a chain of triangles commonly grouped in quadrilaterals for extra checks on the observations. At frequent intervals a line of the chain is measured directly for control of the length. After this is adjusted to reconcile the discrepancies in the measurements, the geographic positions of the stations forming the chain are computed. The final result of the work is a table of geographic positions, together with the lengths of the lines forming the triangles and finally the azimuths of the lines which define these directions on the ellipsoid. In the final result we have the whole related to the system of parallels and meridians that have been uniquely defined upon the ellipsoidal surface. Since a given latitude and longitude applies to only one place on the surface of the earth, it results that all of the stations are definitely located on the spheroid. Various refinements in the observation and in the computation of geodetic work are introduced to give the greatest possible accuracy, but it is not necessary in this discussion to enter into these.

MORE RESTRICTED CLASSES OF SURVEYING

In cadastral surveying and in surveying for public works in general a more restricted region forms the basis of operations. Because of this it is not necessary to enter into so much refinement in the computation of the work. In most work of this kind a local system of plane coordinates is established and the computations are made by the principles of ordinary plane analytic geometry. If the earth's surface were only a real plane surface this method would be perfectly satisfactory and it could be used for all work however extensive. Unfortunately, this is not the case, and any plane system of this kind will introduce discrepancies in the computations. These discrepancies become increasingly greater the farther the work is extended from the origin. These inconsistencies become especially troublesome when surveys are extended sufficiently to produce an overlap of two neighboring systems of local plane coordinates. This is almost sure to occur whenever a careful survey is made of a region for extensive public works.

NEED OF PLANE SYSTEMS COVERING GREATER AREAS

The progressive engineers of the country have become convinced that there is need for plane-coordinate systems that can be extended over wider territory without the introduction of discrepancies that vitiate the value of the work. Of course if all engineers would use geodetic computations there would not be need for such aids, but they do not favor this method of handling the situation. Work is started as a limited project for which a local coordinate system is amply sufficient and it is only when the undertaking is broadened to wider fields that the difficulties arise. When it becomes necessary to make use of the national control surveys to serve as basis for local work, the need for the more extensive coordinate systems is most painfully evident. It is quite a task to base local engineering work on

basic control that has been computed geodetically; that is, the results of which are expressed in latitudes, longitudes, azimuths, and lengths. It can be done, of course, but not as satisfactorily as it could be done if the control work were computed directly on a plane-coordinate system. These are the reasons that have led to the insistent demand for the establishment of systems for whole States or for as large sections of each State as could be constructed without the introduction of too many complications in the method of using the system when it is once established.

ADVANTAGES TO LOCAL SURVEYORS

The Coast and Geodetic Survey has already some 40,000 miles of control surveys fairly evenly distributed throughout the country at large. This network is being rapidly extended, and soon any place in the country will be near enough to this control system to make it a valuable asset as a basis for any engineering work. If the extended plane-coordinate systems are established and this control work is computed on the resulting grids, then the local surveyor can start his work from neighboring control points and make all of his computations on the general plane system just as he would do on any local system that he might establish. He would have the added advantage that his work would be coordinated with the general control system of the country and, therefore, if his work should be preserved, it could form the control for future engineering operations in that vicinity.

CHOICE OF PLANE SYSTEMS

In adopting a plane system to serve as computation basis for engineering and surveying operations of various kinds, it is necessary to look at the problem in a different way from what one would in considering what projections would be suitable for mapping purposes. Both problems are problems of map projections, but the ultimate aim may be different, although in certain cases they may coincide. In the first place, greater accuracy and greater definiteness are needed for a computation projection than is needed for mapping purposes. For a given scale map, we are limited to the number of figures in a number that can be shown in the plotting. For computation we wish to be exact to the last figure retained in the final result. The preservation of angles in the projection is also an important factor entering into the consideration. Since variations in scale are inevitable, it is of great advantage to adopt a scheme that will give definite scale values in certain directions, so that a table can be made for use in the applications. These various considerations lead inevitably to the adoption of one of the conformal projections. After due consideration, it was decided to employ the Lambert conformal projection with two standard parallels for States with greatest extent in an east and west direction and the transverse Mercator projection for States with greatest extent in a north and south direction. Both of these projections are conformal and each is especially suitable for the States in which it is employed.

In the Lambert projection the scale varies with the distance from the central parallel; hence this projection is suitable for States with limited north-south extent or for those that could most conveniently be divided into separate systems in that manner. On the other hand,

in the transverse Mercator projection the scale varies with the distance from the central meridian and hence it is fitted for use in those States with limited east-west extent or for those that could most conveniently be divided into separate sections in that manner.

Tables for the various States have been prepared by this Bureau and lithographed copies can be secured by application to the Director of the United States Coast and Geodetic Survey, Washington, D. C. Only such State tables as are necessary for the proper understanding of the examples given in the text are included in this publication. Similar tables for all of the other States are available together with small maps of each State showing such data as may be needed for those desiring to make use of the projections.

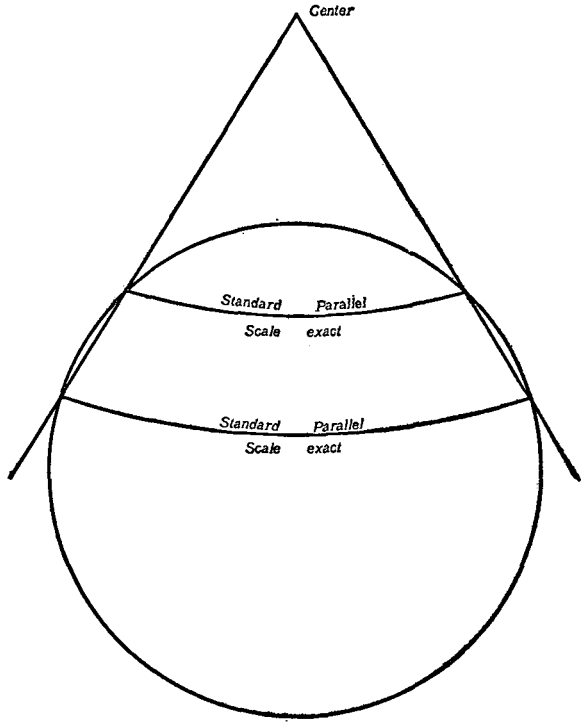


FIGURE 1.—Sphere with intersecting cone for Lambert projection.

FORMULAS FOR THE LAMBERT PROJECTION

The general theory of the Lambert projection is given in Special Publication No. 53 of the United States Coast and Geodetic Survey. In this publication we shall confine ourselves to the formulas necessary for the computation of the grid tables. Those who wish to look into the reasons for the various steps and for their derivation can consult the above-mentioned publication.

The first step in the computation is to calculate the constant l by means of the formula:

$$l=\frac{\log\cos\phi_1-\log\cos\phi_2-\log A_1+\log A_2}{\log\tan\frac{z_1}{2}-\log\tan\frac{z_2}{2}}$$

The latitudes of the standard parallels are denoted by ϕ_1 and ϕ_2, with ϕ_1 as the one farther south; A_1 and A_2 are the A-position factors for the respective parallels: z_1 and z_2 are the isometric or conformal colatitudes of the same parallels. The A's are given in Special Publication No. 8 to seven places but they are required to more places in these computations. They can be computed directly by means of the formula given in the above-mentioned publication if such computation needs to be made.

The z-values are computed in the following way. Let χ be the isometric latitude,

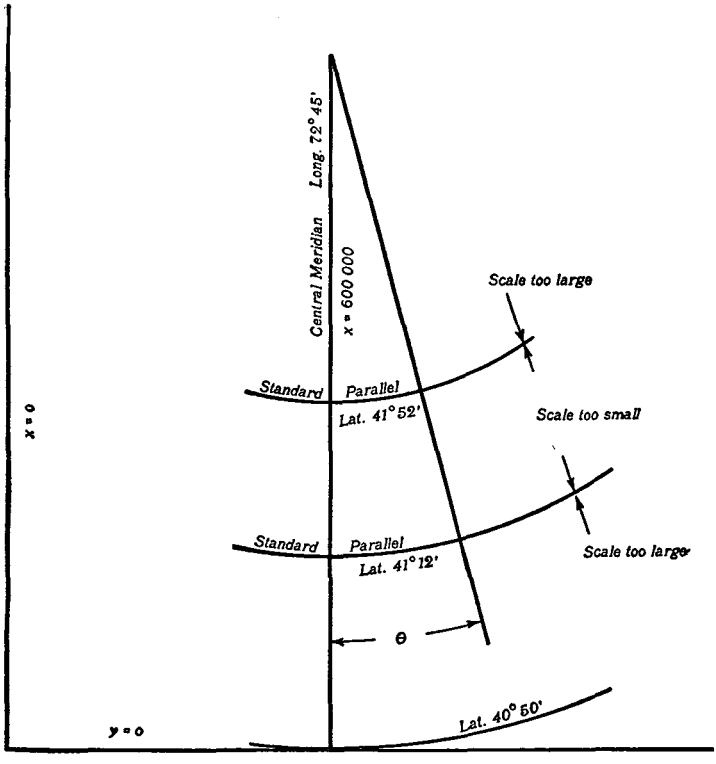


FIGURE 2.—Diagram of the Lambert projection shown on the plane.

then
$$\phi-\chi=+700''.042715 \sin 2\phi-0''.989995 \sin 4\phi +0''.001747 \sin 6\phi-0''.000003 \sin 8\phi.$$

After ϕ_1 is reduced by this formula, then $z_1=\frac{\pi}{2}-\chi_1$, with a similar formula for z_2. After l is known, we can compute the constant K by the two formulas:

$$K=\frac{\cos \phi_1}{A_1 \sin 1'' \, l \tan^l \frac{z_1}{2}}=\frac{\cos \phi_2}{A_2 \sin 1'' \, l \tan^l \frac{z_2}{2}}$$

The double computation will serve as a check on the work.

We now compute the projection radii of the two standard parallels.

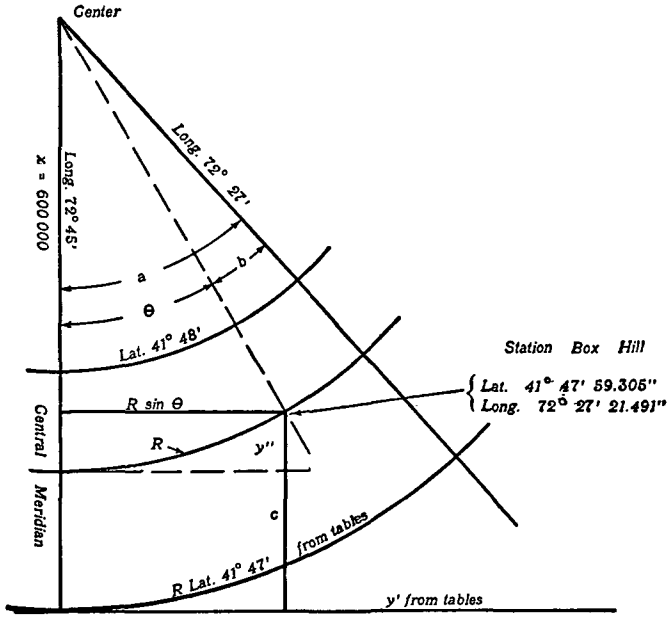
$$R_1 = K \tan^l \frac{z_1}{2},$$

and

$$R_2 = K \tan^l \frac{z_2}{2}$$

If a cone tangent at the parallel determined by the relation $\sin \phi_0 = l$ were assumed, it would have the same form as the one holding the two standard parallels. The latitude ϕ_0 is always a few seconds greater than the mean of ϕ_1 and ϕ_2. After ϕ_0 is computed, we calculate R_0 by the formula

$$R_0 = K \tan^l \frac{z_0}{2}$$



a Θ (for min. of λ) from tables
b Cor. for sec. of λ
c Cor. for sec. of φ

FIGURE 3.—Diagram illustrating how coordinates are computed on Lambert projection.

We next compute the scale reduction at ϕ_0 by the formula:

$$k_0 = \frac{l R_0 A_0 \sin 1''}{\cos \phi_0}$$

or in logarithms

$$\log k_0 = \log l + \log R_0 + \log A_0 + \log \sin 1'' - \log \cos \phi_0$$

This will give a negative result expressed in units of the final places of the logs used in the computation. It can either be retained as a logarithmic correction or it can be reduced to a scale ratio of correction.

If we should start with a tangent cone and compute the table it would only be necessary to reduce all of the elements by the above amount to have the table holding the two standard parallels. The parallel of ϕ_0 thus plays an important part in the computation.

The R's are large numbers, and in their computation it is necessary to carry a great many decimal places to insure the accuracy of the final places of the results. To obviate this difficulty, it is better to develop a ΔR in series to be applied to R_0; then any R will be determined by the relation

$$R=R_0+\Delta R$$

This is what we should use for a tangent cone, but if R_0 is determined as above for the two standard parallels, then ΔR must be reduced for the scale reduction at ϕ_0. Let this be denoted by m, then for the table

$$R=R_0+m\Delta R.$$

If s denotes the meridional distance of a given parallel from the parallel of ϕ_0, we have

$$\Delta R=s+\frac{s^3}{6{\rho_0}^2}-\frac{s^4\tan\phi_0}{24{\rho_0}^3}$$

In this formula ρ_0 is a mean proportional between the radius of curvature in the meridian and that perpendicular to the meridian at the latitude of ϕ_0. In terms of the position factors,

$$\frac{1}{{\rho_0}^2}=A_0B_0\sin^2 1''\left(\frac{1{,}200}{3{,}937}\right)^2$$

The numerical factor is included because the grid tables are to be expressed in feet. In the formula, s is counted plus to the southward and when the given parallel is north of ϕ_0 the three terms add together and the whole is subtracted numerically from R_0. The fourth-power term is always small within the limits of the grid tables as they are computed; for this reason it is sufficiently accurate to use this term as given although the rigid development gives an additional factor very slightly different from unity.

With this series development, we make a check computation of R_1 and R_2. If this gives a satisfactory check, we then consider that our computed constants are correct and we proceed to compute the other R's. By computing every 10 minutes of latitude, the remaining R's can be interpolated by using the successive differences.

The scale factor can be computed in the following way. By differentiation of the formula for ΔR, we get

$$\frac{d(\Delta R)}{ds}=1+\frac{s^2}{2{\rho_0}^2}-\frac{s^3\tan\phi_0}{6{\rho_0}^3}$$

If the second and third terms are computed and added algebraically to 1, it will express the scale as a ratio on a projection in which the parallel of ϕ_0 is held exact in scale. By reducing this scale ratio to a logarithm and afterward adding algebraically the log reduction at ϕ_0, the scale in units of seven places of logarithms for the given grid

is obtained. Of course, we could compute the scale just as we did in the case of that at ϕ_0, but this involves more computation than is required by this method.

In most cases the tabulated y' values are merely the differences between the first-tabulated R and the R for the given parallel. This is so if the first tabulated y' value is zero. In one or two cases some constant value is added to each of the tabulated values and this will be shown on the first tabulated value. The tabular difference for 1″ is merely the difference between successive R's or y''s divided by 60. This outline explains the elements in table I of the Lambert projection.

Since the parallels on the Lambert projection are represented by a system of concentric circles, the mapping angle at the center is proportional to the longitude out from the central meridian. If λ denotes the longitude reckoned out from the central meridian, the mapping angle will be $l\lambda$ taken positive to the eastward. Table II lists this mapping angle for the minutes of longitude, so it is only necessary to compute the additional value for the seconds of longitude to get the full value of the mapping angle. This is denoted by the symbol θ.

FORMULAS FOR THE TRANSVERSE MERCATOR PROJECTION

The transverse Mercator projection is merely the ordinary Mercator projection turned through an angle of 90° so that it is related to a meridian in the same way that the ordinary Mercator projection is related to the Equator. If we should construct an ordinary Mercator projection for a few degrees north and south of the Equator and then in place of calling the central parallel the Equator if we called it a certain meridian, we should have the basic framework for a transverse Mercator projection. The straight lines that were parallels in the original construction now become small circles related to the meridian in the same way as the parallels are related to the Equator. Now, in addition, if we reduce the scale of the original projection in such a way as to hold the scale true along two parallels, let us say 30 miles north and south of the Equator, then this projection turned about would give us the exact counterpart of what we actually compute for the States in which this projection is used.

In the ordinary Mercator projection of the sphere the distance of a given parallel from the Equator is determined by the integral

$$y=a\int_0^{\phi}\frac{d\phi}{\cos\phi},$$

in which a is the radius of the sphere and ϕ is the latitude.
If sec ϕ is developed in a series to two terms, we have

$$\sec\phi=1+\frac{1}{2}\phi^2+\ldots\ldots$$

To this approximation we get

$$y=a\left(\phi+\frac{\phi^3}{6}\right).$$

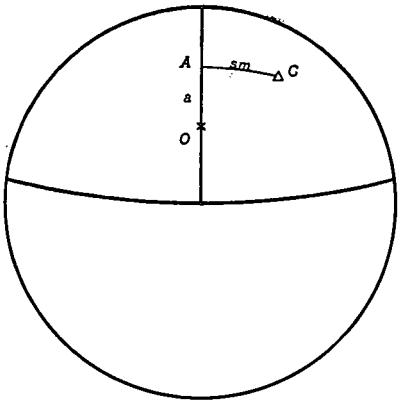
But

$$a\phi=s, \text{ or } \phi=\frac{s}{a}$$

in which s is the length of the meridian from the Equator to the given parallel. By substituting the value of ϕ we get

$$y=s+\frac{s^3}{6a^2}+\ldots\ldots$$

When the projection is transversed, the central meridian corresponds to the Equator and great circles perpendicular to the central meridian correspond to the meridians in the original projection. If we still consider a sphere it would merely be necessary to compute the length of the meridian from some chosen latitude assumed to be



C Station
A Foot of perpendicular dropped upon central meridian
O Origin
sm Geodetic distance
a Length of meridian from O to A

FIGURE 4.—Sphere illustrating the elements of the transverse Mercator projection.

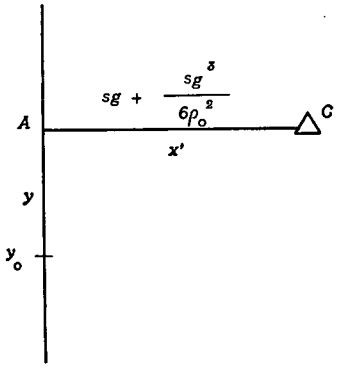


FIGURE 5.—Transverse Mercator coordinates in the plane.

zero for the y-value of the projection and the length of the perpendicular distance of the given station from the central meridian would be the s-value for the computation of the x-value.

At this point we encounter a difficulty, for the earth is an ellipsoid of revolution and not a sphere. It is generally customary to assume a sphere with radius equal to the square root of the product of the radius of curvature in the meridian and that perpendicular to the meridian for the mean latitude. If this is done the scale will vary along the central meridian. To avoid this, it was decided to make the y value proportional to the true length of the meridian and to com-

pute the true length of the perpendicular to the meridian passing through the given station. The y value thus becomes the length of the meridian from the chosen initial or y_0 to the intersection of the above-mentioned perpendicular with the central meridian. The length of the perpendicular is the s value and for the a of the formula we use the mean proportional between the above-mentioned radii of curvature. This causes a slight departure from conformality but for the small distance that is included in an east and west direction it will not cause any trouble in the applications.

The first thing to do is to compute the length of the perpendicular upon the central meridian and the latitude of the foot of this perpendicular. In Special Publication No. 8, we have the formula for the computation of $\Delta\lambda$ in the form

$$\log \Delta\lambda = \log s + C_{\log \Delta\lambda} - C_{\log s} + \log \sin \alpha + \log A' + \log \sec \phi'.$$

If we consider that we are computing from the foot of the perpendicular on the central meridian, α will be 90° or 270° and hence $\log \sin \alpha = 0$. The latitude of the given station is the ϕ' of this formula and A' is to be taken for this value of ϕ'. Also $\Delta\lambda$ is known since it is the longitude out from the central meridian. We can therefore drop the prime and our formula becomes

$$\log s = \log \Delta\lambda - C_{\log \Delta\lambda} + \log \cos \phi + \operatorname{colog} A + C_{\log s}$$

The value of s can be computed by this formula. Since the table for colog A is computed for meters this value of s will be in meters and a factor for reduction to feet must be included. With this value of s we then compute x' by the formula:

$$x' = s + \frac{s^3}{6\rho_0^2}$$

in which ρ_0^2 is the product of the two radii of curvature for the mean latitude as explained above. With the A and B factors from the table in Special Publication No. 8, taken out for the mean latitude ϕ_0,

$$\frac{1}{\rho_0^2} = A\,B \sin^2 1'' \left(\frac{1{,}200}{3{,}937}\right)^2$$

This gives the value of $\frac{1}{\rho_0^2}$ expressed in feet.

The amount to be added to ϕ to get the latitude of the foot of the perpendicular must next be determined. In the position computation formula for $\Delta\phi$, we see that all terms except the second become either zero or so small that they are negligible for such lengths of s as we need. Again $\sin \alpha = 1$, so

$$-\Delta\phi = s^2 C.$$

In this, the s-value in meters must be used because the value of C is computed for meters. Now C should be taken from the table for the latitude of the foot of the perpendicular. We can, however, take out a preliminary value for the latitude of the station and thus get

an approximate value of this latitude denoted by ϕ'. With this approximate value the C can again be taken from the table and in this way the correct value of $\Delta\phi$ is determined. The minus sign would apply in going from ϕ' to ϕ but since we are going in the opposite direction we must always add the value of this term to pass from ϕ to ϕ'. In other words, the latitude of the foot of the perpendicular is always greater than that of the station in question by the value computed by the above formula.

The description thus far given is for a projection which holds true scale on the central meridian. In order to balance the scale throughout the projection, an arbitrary reduction is made on all the elements. This brings about true scale at a certain distance east and west of the central meridian. On the sphere these would be small circles related to the central meridian in the same way as the parallels are related to the Equator. If in the ordinary Mercator projection we should arrange to hold the scale true along the parallels of 1° north and south, we should have a condition analogous to what we provide for in these transverse projections. Because of the fact that the earth is a spheroid and not a true sphere, these lines of true scale would not be exactly small circles parallel to the central meridian, but they can be so considered for all practical purposes.

If we differentiate the formula for x, we shall get

$$\frac{dx}{ds}=1+\frac{s^2}{2\rho_0^2}$$

This gives the scale in case of a projection of true scale along the central meridian. After this is computed for the greatest distance out from the central meridian, one-half of it expressed as a logarithm is placed as a reduction on all elements so as to give the proper balance. Let us suppose the increase of scale from the original computation is given as 1 part in 5,000. In that case

$$\frac{dx}{ds}=1.0002.$$

The logarithm of this number is 868 in the seventh place of decimals. We should then put −434 as the reduction on all quantities, and the scale on the central meridian would be 1 part in 10,000 too small and at the outer limit of the projection 1 part in 10,000 too large. The table of scales would be computed by the scale formula with the −434 added in with each value. This would give a zero value for the distance at which

$$\log\left(1+\frac{s^2}{2\rho_0^2}\right)=0.0000434$$

or where

$$\frac{s^2}{2\rho_0^2}=\frac{1}{10,000} \text{ or } s=\frac{\sqrt{2}\,\rho_0}{100}.$$

Table I in the transverse Mercator projections is merely the length of the meridian reckoned from the latitude for which y is taken zero reduced for the scale reduction at the center. This scale reduction is the R-value on the computation forms and it is a constant for

any given system. For 1 part in 10,000 it is −434.3, for 1 part in 40,000 it is −108.6, and so on.

Since the s values are somewhat greater than those usually found in the ordinary position computations, a table of colog A and log C, given to one place farther than those given in Special Publication No. 8, are included in each table for the extent of latitude of the given State. The values are tabulated for every minute of latitude, and straight-line interpolation can be made for the seconds of a given station.

LIST OF STATES WITH THEIR RESPECTIVE GRIDS

LAMBERT SYSTEM

1. Arkansas
2. California
3. Colorado
4. Connecticut
5. Iowa
6. Kansas
7. Kentucky
8. Louisiana
9. Maryland
10. Massachusetts
11. Minnesota
12. Montana
13. Nebraska
14. North Carolina
15. North Dakota
16. Ohio
17. Oklahoma
18. Oregon
19. Pennsylvania
20. South Carolina
21. South Dakota
22. Tennessee
23. Texas
24. Utah
25. Virginia
26. Washington
27. West Virginia
28. Wisconsin
29. Long Island
30. Nantucket and Marthas Vineyard

TRANSVERSE MERCATOR SYSTEM

1. Alabama
2. Arizona
3. Delaware
4. Georgia
5. Idaho
6. Illinois
7. Indiana
8. Maine
9. Michigan
10. Mississippi
11. Missouri
12. Nevada
13. New Hampshire
14. New Jersey
15. New Mexico
16. New York
17. Rhode Island
18. Vermont
19. Wyoming

BOTH SYSTEMS

1. Florida

EXPLANATION OF PLANE OR GRID AZIMUTH

The plane or grid azimuth of either system of projection is referred to the central meridian which forms the Y-axis of the original computation. The geodetic azimuth is referred to the meridian through the given station and hence differs from the grid azimuth due to the convergence of the meridians. There is also an added difficulty due to the fact that the straight line on the plane joining two points does not represent exactly the geodetic line joining them. The geodetic line is represented by a curved line that makes a small angle with the straight line. In the systems using the Lambert projection, in case both stations lie on the same side of the parallel of ϕ_0, the curve representing the geodetic line will lie on the side of the straight line farther away from this parallel. In other words, if the stations are north of the parallel of ϕ_0, the geodetic line will lie north of the straight line. In the same way in the transverse Mercator projection, the geodetic line lies on the side of the straight line away from

the central meridian when both points are on the same side of the central meridian.

This fact causes a small correction term to be present that has to be taken into account in passing from the geodetic azimuth to the grid azimuth or vice versa. This correction has been developed into a series, but for practical purposes the first term is sufficient for the limits of the projections as needed for the States. For the Lambert projection the relation between geodetic azimuth and grid azimuth is given by the formula:

$$\text{Geodetic azimuth}-\text{grid azimuth}=+\theta-\frac{x_2-x_1}{2\rho_0{}^2\sin 1''}\left(y_1-y_0+\frac{y_2-y_1}{3}\right).$$

In this formula θ is the mapping angle for the station at which the azimuth arises, x_1 and y_1 are the grid coordinates of this station, and x_2 and y_2 are the grid coordinates of the point observed; y_0 is the y-value for the intersection of the parallel of ϕ_0 with the central meridian and ρ_0 is the quantity already described. The logarithm of $\frac{1}{2\rho_0{}^2\sin 1''}$ is a constant for any given system and is given among the list of constants. This is true also of y_0. The correction term can then be computed from the coordinates and the given constants.

In the transverse Mercator projection, the azimuth relation becomes the following:

$$\text{Geodetic azimuth}-\text{grid azimuth}=\Delta\alpha+\frac{(y_2-y_1)(2x_1'+x_2')}{(6\rho_0{}^2\sin 1'')_g}.$$

The sub-one coordinates are the coordinates of the origin of the line and the sub-two coordinates are those of the end of the line. The value of $\Delta\alpha$ is merely the convergence of the meridians and it is computed with the coordinates. $\text{Log}\left(\frac{1}{(6\rho_0{}^2\sin 1'')_g}\right)$ is given among the constants of the projection. Further terms of the correction series could be given but within the limits of the State systems they are of no practical importance. The higher terms for the Lambert projection are very complicated and they would require too much computation to warrant their use. Those for the transverse Mercator are more regular but they too are not needed for practical use of the grid as limited for the States.

In the computation of the tables in each of the systems, the object has been to give just as much as is needed for the computation of the coordinates of the stations when their latitudes and longitudes are known. The interval of minutes was chosen so as to make it possible to make the required interpolations with first differences alone. This makes the necessary computation both shorter and simpler. It was desired to have everything so direct that anyone could compute the coordinates who knew how to use logarithms and trigonometric tables. A knowledge of how the tabular values are computed is not essential but some insight into the nature of the projection is helpful to any who may use the tables in actual computations.

In the use of plane coordinates it is much more convenient to have all of the values with plus sign. No danger of a mistake in sign is then apt to occur and no signs are necessary in listing the coordinates. In computing the coordinates the x-values are counted positive to

the eastward. To prevent the appearance of negative values, it is necessary to add some arbitrary constant to the values that are directly computed. On the general form a constant of 2,000,000 is used so as to give a value large enough for any State. For any given system a value could be adopted smaller than this if the greatest distance west of the central meridian is correspondingly less than this quantity. A value large enough to offset such negative values as are liable to occur must be assumed. Also it is most convenient to assume a round number, for such a value is more easily added algebraically. When a value is once assumed it should be considered as a constant for the given system and so used in all of the coordinate computations.

In all of the systems the y-values are started far enough to the south to give assurance that no negative values will occur. This means that all of the coordinates are placed in the first quadrant and all attention to sign is removed. The origin of the coordinates is arbitrarily moved to the westward and placed far enough south to accomplish the end in view. In the use of the coordinates no attention needs to be paid to this origin. All applications have to do with differences of coordinates, and these would be the same wherever the origin lies. The positions of the X and Y axes are perfectly arbitrary, except that the Y-axis is parallel to the central meridian and the X-axis perpendicular to the same. No attempt should be made to locate the arbitrary origin, for it makes no difference where it is.

In setting forth the principles of the two systems we have aimed to avoid too much theory and to give merely the results that are founded on the general theory. Those who wish to consider the matter more fully may consult the more extensive works on projections, or, better still, consult the original papers of the masters on the subject. This publication is intended as a working manual and does not aim to be rigorously scientific or to overburden the reader with elaborate mathematical developments.

COMPUTING PLANE COORDINATES ON LAMBERT PROJECTION

As an example, the coordinates of "Ivy" are computed on page 20. Starting with the position of "Ivy"; latitude 41°52′18.″045, longitude 73°13′27.″979, the following operations are performed.

From the projection tables of Connecticut (see fig. 6) [1] on page 16, opposite latitude 41°52′ the values of R (for minutes of ϕ), y' (for minutes of ϕ) and the tabular difference of R for 1 sec. of ϕ are taken. These are: 23,537,876.76; 376,512.26; and 101.22217 respectively. The 101.22217 is multiplied by the seconds of ϕ, 18.045, giving 1,826.55 to be subtracted from R and added to y'.

From the same tables on page 18, opposite longitude 73°13′ the value of θ (for minutes of λ) is $-0°18'33.''9398$. From this is subtracted algebraically the product of the seconds of λ, 27.979, and the value of θ for 1 sec. of longitude, 0.6630594147, found on page 18. This gives the correction to θ for seconds of λ, 18.″5517 which subtracted from θ (for minutes of λ), gives $-0°18'52.''4915$, or reduced to seconds, -1132.4915.

At this time $\frac{\theta}{2}$ is taken to hundredths of a second, here $-0°09'26.''25$, and written on the right half of the form. The logarithm

[1] For State map of Connecticut showing elements of grid, see fig. 59, p. 261.

LAMBERT PROJECTION FOR CONNECTICUT

Table I.

Lat.	R feet	y' y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
40° 50'	23,914,389.02	0	101.20933	+248.7	1.0000573
51	23,908,316.46	6,072.56	101.20933	+233.6	1.0000538
52	23,902,243.90	12,145.12	101.20917	+218.9	1.0000504
53	23,896,171.35	18,217.67	101.20933	+204.5	1.0000471
54	23,890,098.79	24,290.23	101.20917	+190.4	1.0000438
55	23,884,026.24	30,362.78	101.20917	+176.8	1.0000407
40° 56'	23,877,953.69	36,435.33	101.20917	+163.5	1.0000376
57	23,871,881.14	42,507.88	101.20917	+150.5	1.0000347
58	23,865,808.59	48,580.43	101.20917	+138.0	1.0000318
59	23,859,736.04	54,652.98	101.20917	+125.8	1.0000290
41° 00	23,853,663.49	60,725.53	101.20933	+113.9	1.0000262
41° 01'	23,847,590.93	66,798.09	101.20917	+102.4	1.0000236
02	23,841,518.38	72,870.64	101.20933	+ 91.3	1.0000210
03	23,835,445.82	78,943.20	101.20933	+ 80.5	1.0000185
04	23,829,373.26	85,015.76	101.20950	+ 70.1	1.0000161
05	23,823,300.69	91,088.33	101.20950	+ 60.1	1.0000138
41° 06'	23,817,228.12	97,160.90	101.20950	+ 50.5	1.0000116
07	23,811,155.55	103,233.47	101.20967	+ 41.1	1.0000095
08	23,805,082.97	109,306.05	101.20967	+ 32.2	1.0000074
09	23,799,010.39	115,378.63	101.20983	+ 23.6	1.0000054
10	23,792,937.80	121,451.22	101.21000	+ 15.4	1.0000035
41° 11'	23,786,865.20	127,523.82	101.21000	+ 7.5	1.0000017
12	23,780,792.60	133,596.42	101.21017	0.0	1.0000000
13	23,774,719.99	139,669.03	101.21033	- 7.1	0.9999984
14	23,768,647.37	145,741.65	101.21050	- 13.8	0.9999968
15	23,762,574.74	151,814.28	101.21050	- 20.2	0.9999953
41° 16'	23,756,502.11	157,886.91	101.21083	- 26.3	0.9999939
17	23,750,429.46	163,959.56	101.21100	- 32.0	0.9999926
18	23,744,356.80	170,032.22	101.21117	- 37.3	0.9999914
19	23,738,284.13	176,104.89	101.21117	- 42.2	0.9999903
20	23,732,211.46	182,177.56	101.21167	- 46.8	0.9999892
41° 21'	23,726,138.76	188,250.26	101.21167	- 51.0	0.9999883
22	23,720,066.06	194,322.96	101.21183	- 54.8	0.9999874
23	23,713,993.35	200,395.67	101.21217	- 58.3	0.9999866
24	23,707,920.62	206,468.40	101.21233	- 61.4	0.9999859
25	23,701,847.88	212,541.14	101.21267	- 64.2	0.9999852

FIGURE 6.—Lambert projection tables for Connecticut.

LAMBERT PROJECTION FOR CONNECTICUT

Table 1 (Cont'd).

Lat.	R feet	y' y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
41° 26'	23,695,775.12	218,613.90	101.21283	- 66.6	0.9999847
27	23,689,702.35	224,686.67	101.21317	- 68.6	0.9999842
28	23,683,629.56	230,759.46	101.21333	- 70.3	0.9999838
29	23,677,556.76	236,832.26	101.21367	- 71.6	0.9999835
30	23,671,483.94	242,905.08	101.21400	- 72.5	0.9999833
41° 31'	23,665,411.10	248,977.92	101.21417	- 73.0	0.9999832
32	23,659,338.25	255,050.77	101.21450	- 73.2	0.9999831
33	23,653,265.38	261,123.64	101.21483	- 73.0	0.9999832
34	23,647,192.49	267,196.53	101.21517	- 72.5	0.9999833
35	23,641,119.58	273,269.44	101.21533	- 71.6	0.9999835
41° 36'	23,635,046.66	279,342.36	101.21583	- 70.3	0.9999838
37	23,628,973.71	285,415.31	101.21617	- 68.6	0.9999842
38	23,622,900.74	291,488.28	101.21650	- 66.6	0.9999847
39	23,616,827.75	297,561.27	101.21683	- 64.2	0.9999852
40	23,610,754.74	303,634.28	101.21717	- 61.5	0.9999858
41° 41'	23,604,681.71	309,707.31	101.21750	- 58.4	0.9999866
42	23,598,608.66	315,780.36	101.21800	- 54.9	0.9999874
43	23,592,535.58	321,853.44	101.21833	- 51.0	0.9999883
44	23,586,462.48	327,926.54	101.21883	- 46.8	0.9999892
45	23,580,389.35	333,999.67	101.21917	- 42.2	0.9999903
41° 46'	23,574,316.20	340,072.82	101.21950	- 37.3	0.9999914
47	23,568,243.03	346,145.99	101.22000	- 32.0	0.9999926
48	23,562,169.83	352,219.19	101.22050	- 26.3	0.9999939
49	23,556,096.60	358,292.42	101.22083	- 20.3	0.9999953
50	23,550,023.35	364,365.67	101.22133	- 13.9	0.9999968
41° 51'	23,543,950.07	370,438.95	101.22183	- 7.1	0.9999984
52	23,537,876.76	376,512.26	101.22217	0.0	1.0000000
53	23,531,803.43	382,585.59	101.22283	+ 7.5	1.0000017
54	23,525,730.06	388,658.96	101.22317	+ 15.4	1.0000035
55	23,519,656.67	394,732.35	101.22367	+ 23.7	1.0000055
41° 56'	23,513,583.25	400,805.77	101.22433	+ 32.3	1.0000074
57	23,507,509.79	406,879.23	101.22467	+ 41.3	1.0000095
58	23,501,436.31	412,952.71	101.22533	+ 50.7	1.0000117
59	23,495,362.79	419,026.23	101.22567	+ 60.4	1.0000139
42° 00	23,489,289.25	425,099.77	101.22633	+ 70.5	1.0000162

FIGURE 6.—Lambert projection tables for Connecticut—Continued.

LAMBERT PROJECTION FOR CONNECTICUT

Table 1 (Cont'd).

Lat.	R feet	y' y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
42° 01'	23,483,215.67	431,173.35	101.22700	+ 81.0	1.0000187
02	23,477,142.05	437,246.97	101.22733	+ 91.8	1.0000211
03	23,471,068.41	443,320.61	101.22800	+103.0	1.0000237
04	23,464,994.73	449,394.29	101.22850	+114.6	1.0000264
05	23,458,921.02	455,468.00	101.22917	+126.5	1.0000291
42° 06'	23,452,847.27	461,541.75	101.22983	+138.8	1.0000320
07	23,446,773.48	467,615.54	101.23033	+151.5	1.0000349
08	23,440,699.66	473,689.36	101.23083	+164.6	1.0000379
09	23,434,625.81	479,763.21	101.23167	+178.0	1.0000410
10	23,428,551.91	485,837.11	101.23217	+191.8	1.0000442
42° 11'	23,422,477.98	491,911.04	101.23283	+206.0	1.0000474
12	23,416,404.01	497,985.01	101.23333	+220.5	1.0000508
13	23,410,330.01	504,059.01	101.23417	+235.4	1.0000542
14	23,404,255.96	510,133.06	101.23483	+250.7	1.0000577
15	23,398,181.87	516,207.15	101.23533	+266.3	1.0000613
42° 16'	23,392,107.75	522,281.27	101.23617	+282.3	1.0000650
17	23,386,033.58	528,355.44	101.23667	+298.7	1.0000688
18	23,379,959.38	534,429.64	101.23750	+315.4	1.0000726
19	23,373,885.13	540,503.89	101.23817	+332.5	1.0000766
20	23,367,810.84	546,578.18		+350.0	1.0000806

$\ell = 0.6630594147$

$\log \ell = 9.8215524459 - 10$

$\log k = 7.6025745968$

$$\text{Geod. Az.} - \text{Grid. Az.} = -\frac{x_2 - x_1}{2\rho_0^2 \sin 1''}\left(y_1 - y_0 + \frac{y_2 - y_1}{3}\right) + \theta$$

$y_0 = 255,155.48$

$$\log \frac{1}{2\rho_0^2 \sin 1''} = 0.3723907 - 10$$

FIGURE 6.—Lambert projection tables for Connecticut—Continued.

LAMBERT PROJECTION FOR CONNECTICUT

Table II.

1' of long. = 0".66305941 47 of θ

Long.	θ	Long.	θ	Long.	θ
71° 30'	+0° 49' 43".7674	72° 06'	+0° 25' 51".5590	72° 41'	+0° 02' 39".1343
31	+0 49 03.9838	07	+0 25 11.7755	42	+0 01 59.3507
32	+0 48 24.2002	08	+0 24 31.9919	43	+0 01 19.5671
33	+0 47 44.4167	09	+0 23 52.2083	44	+0 00 39.7836
34	+0 47 04.6331	10	+0 23 12.4248	45	0 00 00.0000
35	+0 46 24.8495				
71° 36'	+0 45 45.0660	72° 11'	+0 22 32.6412	72° 46'	-0 00 39.7836
37	+0 45 05.2824	12	+0 21 52.8576	47	-0 01 19.5671
38	+0 44 25.4988	13	+0 21 13.0741	48	-0 01 59.3507
39	+0 43 45.7153	14	+0 20 33.2905	49	-0 02 39.1343
40	+0 43 05.9317	15	+0 19 53.5069	50	-0 03 18.9178
71° 41'	+0 42 26.1482	72° 16'	+0 19 13.7234	72° 51'	-0 03 58.7014
42	+0 41 46.3646	17	+0 18 33.9398	52	-0 04 38.4850
43	+0 41 06.5810	18	+0 17 54.1562	53	-0 05 18.2685
44	+0 40 26.7975	19	+0 17 14.3727	54	-0 05 58.0521
45	+0 39 47.0139	20	+0 16 34.5891	55	-0 06 37.8356
71° 46'	+0 39 07.2303	72° 21'	+0 15 54.8056	72° 56'	-0 07 17.6192
47	+0 38 27.4468	22	+0 15 15.0220	57	-0 07 57.4028
48	+0 37 47.6632	23	+0 14 35.2384	58	-0 08 37.1863
49	+0 37 07.8796	24	+0 13 55.4549	59	-0 09 16.9699
50	+0 36 28.0961	25	+0 13 15.6713	73° 00	-0 09 56.7535
71° 51'	+0 35 48.3125	72° 26'	+0 12 35.8877	73° 01'	-0 10 36.5370
52	+0 35 08.5289	27	+0 11 56.1042	02	-0 11 16.3206
53	+0 34 28.7454	28	+0 11 16.3206	03	-0 11 56.1042
54	+0 33 48.9618	29	+0 10 36.5370	04	-0 12 35.8877
55	+0 33 09.1782	30	+0 09 56.7535	05	-0 13 15.6713
71° 56'	+0 32 29.3947	72° 31'	+0 09 16.9699	73° 06'	-0 13 55.4549
57	+0 31 49.6111	32	+0 08 37.1863	07	-0 14 35.2384
58	+0 31 09.8275	33	+0 07 57.4028	08	-0 15 15.0220
59	+0 30 30.0440	34	+0 07 17.6192	09	-0 15 54.8056
72° 00	+0 29 50.2604	35	+0 06 37.8356	10	-0 16 34.5891
72° 01'	+0 29 10.4769	72° 36'	+0 05 58.0521	73° 11'	-0 17 14.3727
02	+0 28 30.6933	37	+0 05 18.2685	12	-0 17 54.1562
03	+0 27 50.9097	38	+0 04 38.4850	13	-0 18 33.9398
04	+0 27 11.1262	39	+0 03 58.7014	14	-0 19 13.7234
05	+0 26 31.3426	40	+0 03 18.9178	15	-0 19 53.5069

FIGURE 6.—Lambert projection tables for Connecticut—Continued.

LAMBERT PROJECTION FOR CONNECTICUT

Table II (Cont'd).

1" of long. = 0".6630594147 of θ

Long.	θ	Long.	θ
73° 16'	-0° 20' 33".2905	73° 51'	-0° 43' 45".7153
17	-0 21 13.0741	52	-0 44 25.4988
18	-0 21 52.8576	53	-0 45 05.2824
19	-0 22 32.6412	54	-0 45 45.0660
20	-0 23 12.4248	55	-0 46 24.8495
73° 21'	-0 23 52.2083	73° 56'	-0 47 04.6331
22	-0 24 31.9919	57	-0 47 44.4167
23	-0 25 11.7755	58	-0 48 24.2002
24	-0 25 51.5590	59	-0 49 03.9838
25	-0 26 31.3426	74° 00	-0 49 43.7674
73° 26'	-0 27 11.1262		
27	-0 27 50.9097		
28	-0 28 30.6933		
29	-0 29 10.4769		
30	-0 29 50.2604		
73° 31'	-0 30 30.0440		
32	-0 31 09.8275		
33	-0 31 49.6111		
34	-0 32 29.3947		
35	-0 33 09.1782		
73° 36'	-0 33 48.9618		
37	-0 34 28.7454		
38	-0 35 08.5289		
39	-0 35 48.3125		
40	-0 36 28.0961		
73° 41'	-0 37 07.8796		
42	-0 37 47.6632		
43	-0 38 27.4468		
44	-0 39 07.2303		
45	-0 39 47.0139		
73° 46'	-0 40 26.7975		
47	-0 41 06.5810		
48	-0 41 46.3646		
49	-0 42 26.1482		
50	-0 43 05.9317		

FIGURE 6.—Lambert projection tables for Connecticut—Continued.

Plane coordinates on Lambert projection

State Connecticut Station Ivy

ϕ = 41° 52′ 18.045 λ = 73° 13′ 27.979

Tabular difference of R for 1″ of ϕ = 101.22217

R (for min. of ϕ)		23,537,876.76	y′ (for min. of ϕ)		376,512.26
Cor. for sec. of ϕ		− 1,826.55	Cor. for sec. of ϕ		+ 1,826.55
R		23,536,050.21	y′		378,338.81
			y″ (=2R $\sin^2 \frac{\theta}{2}$)		+ 354.75
θ (for min. of λ)		− 0° 18′ 33.9398	y		378,693.56
Cor. for sec. of λ		− 18.5517			
θ		− 0 18 52.4915	$\frac{\theta}{2}$		0° 09′ 26.25
θ''	For machine computation	− 1132.″4915		For machine computation	
			log θ''		3.05403495 n
log θ''		3.05403495 n	colog 2		9.69897000 -10
S for θ		4.68557269 -10	S for $\frac{\theta}{2}$		4.68557432 -10
log sin θ	sin θ	7.73960764 -10 n	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	7.43857927 -10 n
log R		7.37173359		R sin $\frac{\theta}{2}$	
log x′		5.11134123 n	log $\sin^2 \frac{\theta}{2}$	R $\sin^2 \frac{\theta}{2}$	4.87715854 -10
x′	R sin θ	− 129,223.42	log R		7.37173359
		600,000.00	log 2		0.30103000
x		470,776.58	log y″		2.54992213

$x = 2{,}000{,}000.00 + R \sin \theta$

$y = y' + 2R \sin^2 \frac{\theta}{2}$

y' = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y', and θ are given in special tables

FIGURE 7.—Computation of coordinates for Connecticut.

Plane coordinates on Lambert projection

State Connecticut Station Box Hill

ϕ = 41° 47′ 59″.305 λ = 72° 27′ 21″.491

Tabular difference of R for 1″ of ϕ = 101.22000

R (for min. of ϕ)		23,568,243.03	y′ (for min. of ϕ)		346,145.99
Cor. for sec. of ϕ		− 6,002.85	Cor. for sec. of ϕ		+ 6,002.85
R		23,562,240.18	y′		352,148.84
			y″ (=2R sin² $\frac{\theta}{2}$)		+ 136.40
θ (for min. of λ)		+ 0° 11′ 56″.1042	y		352,285.24
Cor. for sec. of λ		− 14.2498			
θ		+ 0 11 41.8544	$\frac{\theta}{2}$		0° 05′ 50″.93
θ''	For machine computation	+ 701″.8544		For machine computation	
			log θ''		2.84624702
log θ''		2.84624702	colog 2		9.69897000 −10
S for θ		4.68557403 −10	S for $\frac{\theta}{2}$		4.68557466 −10
log sin θ	sin θ	7.53182105 −10	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	7.23079168 −10
log R		7.37221658		R sin $\frac{\theta}{2}$	
log x′		4.90403763	log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	4.46158336 −10
x′	R sin θ	+ 80,174.75	log R		7.37221658
		600,000.00	log 2		0.30103000
x		680,174.75	log y″		2.13482994

$x = 2{,}000{,}000.00 + R \sin \theta$

$y = y' + 2R \sin^2 \frac{\theta}{2}$

y' = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y', and θ are given in special tables

FIGURE 7.—Computation of coordinates for Connecticut—Continued.

of θ'' (θ in seconds) is written in the proper place on both the left and right sides of the form. The S-values for θ and $\frac{\theta}{2}$ are taken from the table of S and T values. Addition then gives log sin θ on the left and log sin $\frac{\theta}{2}$ on the right. The latter is multiplied by 2 to give log $\sin^2 \frac{\theta}{2}$. The logarithm of the final R is added to log sin θ giving log x'. The number corresponding to this logarithm is $-129{,}223.42$, the sign being determined by the sign of θ. This is added algebraically to the constant for the State, in this case 600,000*, giving x, in this case 470,776.58 feet.

The logarithm of the final R is also added to log $\sin^2 \frac{\theta}{2}$ and log 2 giving log y'' $\left(=2R \sin^2\frac{\theta}{2}\right)$. The number corresponding to this logarithm, 354.75, is always added to y', giving the final value of y, in this case 378,693.56.

The grid azimuth Ivy to Box Hill is computed on page 23. The coordinates of Ivy are denoted by x_1, y_1 and those of Box Hill by x_2, y_2. Then the tangent of the grid azimuth is equal to x_2-x_1 divided by y_2-y_1. The signs of these two terms are changed to determine in which quadrant the azimuth lies.

If one has a copy of Shortrede's Table of Sines and Tangents, this method of the mere change of signs of x_2-x_1 and y_2-y_1 will suffice for locating the quadrant of the grid azimuth. We have chosen to reckon grid azimuths from the south to be in accord with the use of geodetic azimuths. The Shortrede Table gives the values with their proper signs for all of the quadrants. This is an admirable feature, but many tables do not have such a tabulation. If one is using a table with argument in the first quadrant alone, then the following outline will serve the purpose of locating the quadrant of the grid azimuth. Let us suppose that the angle in the first quadrant determined from the tangent without regard to sign is denoted by α; then four cases may arise. Let us denote x_2-x_1 by Δx and y_2-y_1 by Δy, x_1, and y_1, being the coordinates of the station from which the line radiates.

(1) If both Δx and Δy are negative, then the azimuth$=\alpha$.
(2) If Δx is negative and Δy positive, then the azimuth$=180°-\alpha$.
(3) If both Δx and Δy are positive, then the azimuth$=180°+\alpha$.
(4) Finally if Δx is positive and Δy negative, then the azimuth$=360°-\alpha$.

These simple directions will serve to locate the azimuth in any given case directly from consideration of the signs of the coordinate differences.

The grid distance is obtained by dividing x_2-x_1 by sin α or by dividing y_2-y_1 by cos α. These results are in feet which may be converted to meters if desired by multiplying by the factor $\frac{1{,}200}{3{,}937}$. The grid distance may be converted to the geodetic distance by applying the scale-reduction factor derived from the table on page 16. This factor

* For most States the constant is 2,000,000. Since Connecticut is smaller than many States 600,000 is large enough to keep all coordinates positive.

is computed as follows: The latitudes of the two stations are the argument. The values taken from the table are:

Computation of mean scale

Latitude	Scale	Weight	Weighted scale
° ′			
41 48.0	−26.3	0.5	−13.15
41 49	−20.3	1	−20.3
41 50	−13.9	1	−13.9
41 51	−7.1	1	−7.1
41 52.3	0.0	0.8	0.0
		4.3	−54.45

$\frac{-54.45}{4.3} = -12.7$

The tabulated value opposite 41°48′, in this table −26.3, applies to all latitudes between 41°47.5′ and 41°48.5′. As one of the stations is 41°48.0′, only 0.5 of the value −26.3 is used in taking the mean. At the other end, the 0.0 opposite 41°52′ has a weight of 0.8 since 52.3 is 0.8 larger than 51.5, the value at which the factor 0.0 first comes in. The total of the scale factors divided by the total weight gives the scale correction which is subtracted from the logarithm of the grid length to give the logarithm of the geodetic length.

The geodetic azimuth may be computed from the grid azimuth by means of the equation on page 13. θ is taken directly from the computation of the coordinates. The values of y_o and $\log \frac{1}{2\rho_o^2 \sin 1''}$ are found on page 17. These two are constant for a given system. After the correction is computed as in the example, it is subtracted from θ and the result added to the grid azimuth. This gives the geodetic azimuth between the two points whose coordinates are given at the beginning.

Computation of Grid Azimuth and Check

Ivy-Box Hill

x_2	=	680,174.75	$\log(x_2 - x_1)$	=	5.32097288
x_1	=	470,776.58	Co-log sin α	=	0.00342657
$x_2 - x_1$	=	209,398.17	$\log \frac{1200}{3937}$	=	9.48401583 -10
			Scale correction	=	4127
y_2	=	352,285.24	Log distance	=	4.80841655
y_1	=	378,693.56	From list	=	4.8084168
$y_2 - y_1$	=	-26,408.32			
			y_1	=	378,693.56
$\log (x_2 - x_1)$	=	5.32097288	y_0	=	255,155.48
$\log (y_2 - y_1)$	=	4.42174077 n	$y_1 - y_0$	=	123,538.08
$\log \tan \alpha$	=	0.89923211 n	$\frac{y_2 - y_1}{3}$	=	- 8,802.77
Grid α	=	277° 11′ 16.54″			114,735.31
θ	=	- 0 18 52.49			
Correction	=	- 5.66			
Geod. azimuth	=	276 52 18.39	$\log$	=	5.0596971
From list	=	276 52 18.43	$\log (x_2 - x_1)$	=	5.3209729
			$\log \frac{1}{2\rho'' \sin 1''}$	=	0.3723907 -10
			log (correction)	=	0.7530607
			correction	=	+5.66

FIGURE 8.—Computation of grid azimuth and check.

COMPUTING PLANE COORDINATES ON THE TRANSVERSE MERCATOR PROJECTION

The coordinates of station Sakonnet are computed on page 28, as an example of computation on this projection. The preliminary data are the latitude, 41°27′37″.129, and longitude, 71°11′22″.621.

The coordinates are computed in the following manner. From the projection table for Rhode Island (see fig. 9) [2] the λ for the central meridian is 71°30′00″.000. This is constant for a given projection system. From this is subtracted the λ (longitude) of the station, giving $\Delta\lambda$, in this case +18′37″.379 which reduced to seconds is +1117″.379. The logarithm of this number is 3.04820050. The correction, arc to sine, may be found on page 17 of United States Coast and Geodetic Survey Special Publication No. 8, Formulas and Tables for the Computation of Geodetic Positions. With $\Delta\lambda$ as the argument, the correction 212 is taken out in the eighth decimal place. This correction is subtracted from log $\Delta\lambda$ giving log $\Delta\lambda_1$, to which is added log cos ϕ, from the eight-place trigonometric table, and colog A, taken from the projection table on page 26. The argument for taking out colog A is ϕ, interpolating for the seconds. The sum of these three logarithms is log s_1.

The correction, sine to arc, is taken from the table in Special Publication No. 8, as just explained above, for the correction arc to sine. However log s_1 is the argument instead of log $\Delta\lambda$ as before. This correction, 119, is added to log s_1 giving log s_m. To this is added the logarithm of the reduction factor for converting meters to feet. From this sum is subtracted log R which is a reduction factor, constant for a given system, and found on page 27. These two operations are performed simultaneously on the form giving log s_g as a result. This is multiplied by 3 to give log s_g^3. From the table on page 27 the constant log $\left(\frac{1}{6\rho_o^2}\right)_g$ is 4.580836−20. This is added to log s_g^3 giving, in this case, 9.370302−10. The numbers corresponding to log s_g and log $\left(\frac{s_g^3}{6\rho_o^2}\right)_g$ are added together to give x', in this case +85,079.13. The sign is the same as the sign of $\Delta\lambda$. x' is finally added algebraically to the constant for the State, here 600,000, giving x, in this case 685,079.13.

Now log s_m is multiplied by 2 giving log s_m^2. This is carried to six decimal places and added to log C. Log C is taken from the table on page 26 with ϕ as the argument. This is 1.350566−10 which added to log s_m^2 gives log $\Delta\phi$ equal to 0.178247. The number corresponding to this logarithm is added to ϕ giving an approximate value of ϕ', equal to 41°27′38″.6365. With ϕ' as the argument, log C is again taken from the table. After this change is made the final $\Delta\phi$ is determined and consequently ϕ'. In this case the change in log C is not great enough to cause a change in $\Delta\phi$. From the table on page 25 opposite latitude 41°27′, the tabular difference of y for 1″ of ϕ' is 101.21400, and the y (for minutes of ϕ') is 133,598.10. This tabular difference is multiplied by the seconds of ϕ', 38.6365, giving 3,910.55. The product added to the y (for minutes of ϕ') gives the final y value, in this case 137,508.65.

[2] For State map of Rhode Island showing elements of grid see fig. 60, p. 262.

TRANSVERSE MERCATOR PROJECTION FOR RHODE ISLAND

TABLE I

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. of lat.
41° 05'	0.00	101.20750	41° 41'	218,619.56	101.21833
06	6,072.45	101.20783	42	224,692.66	101.21850
07	12,144.92	101.20817	43	230,765.77	101.21883
08	18,217.41	101.20850	44	236,838.90	101.21917
09	24,289.92	101.20883	45	242,912.05	101.21950
10	30,362.45	101.20900			
41° 11'	36,434.99	101.20933	41° 46'	248,985.22	101.21967
12	42,507.55	101.20967	47	255,058.40	101.22017
13	48,580.13	101.20983	48	261,131.61	101.22033
14	54,652.72	101.21033	49	267,204.83	101.22067
15	60,725.34	101.21050	50	273,278.07	101.22083
41° 16'	66,797.97	101.21083	41° 51'	279,351.32	101.22133
17	72,870.62	101.21117	52	285,424.60	101.22150
18	78,943.29	101.21133	53	291,497.89	101.22183
19	85,015.97	101.21167	54	297,571.20	101.22217
20	91,088.67	101.21200	55	303,644.53	101.22250
41° 21'	97,161.39	101.21233	41° 56'	309,717.88	101.22267
22	103,234.13	101.21267	57	315,791.24	101.22300
23	109,306.89	101.21283	58	321,864.62	101.22333
24	115,379.66	101.21333	59	327,938.02	101.22367
25	121,452.46	101.21350	42° 00	334,011.44	101.22400
41° 26'	127,525.27	101.21383	42° 01'	340,084.88	101.22417
27	133,598.10	101.21400	02	346,158.33	101.22450
28	139,670.94	101.21433	03	352,231.80	101.22483
29	145,743.80	101.21483	04	358,305.29	101.22517
30	151,816.69	101.21500	05	364,378.80	101.22533
41° 31'	157,889.59	101.21517	42° 06'	370,452.32	101.22583
32	163,962.50	101.21567	07	376,525.87	101.22600
33	170,035.44	101.21583	08	382,599.43	101.22633
34	176,108.39	101.21617	09	388,673.01	101.22650
35	182,181.36	101.21650	10	394,746.60	101.22700
41° 36'	188,254.35	101.21683	42° 11'	400,820.22	101.22717
37	194,327.36	101.21700	12	406,893.85	101.22750
38	200,400.38	101.21733	13	412,967.50	101.22783
39	206,473.42	101.21767	14	419,041.17	101.22817
40	212,546.48	101.21800	15	425,114.86	

FIGURE 9.—Transverse Mercator projection tables for Rhode Island.

TRANSVERSE MERCATOR PROJECTION FOR RHODE ISLAND

TABLE II

Lat.	Colog A	Log C	Lat.	Colog A	Log C
41° 05'	1.49090910	1.344840	41° 41'	1.49092442	1.353949
06	953	5094	42	484	4201
07	1.49090995	5347	43	527	4454
08	1.49091038	5601	44	569	4706
09	080	5855	45	612	4959
10	123	6108			
			41° 46'	655	5212
41° 11'	1.49091165	1.346361	47	697	5464
12	208	6614	48	740	5717
13	250	6867	49	782	5969
14	293	7120	50	825	6222
15	335	7374			
			41° 51'	1.49092868	1.356474
41° 16'	378	7627	52	910	6727
17	420	7880	53	953	6979
18	463	8133	54	1.49092996	7232
19	505	8386	55	1.49093038	7484
20	548	8639			
			41° 56'	081	7736
41° 21'	1.49091590	1.348892	57	124	7989
22	633	9145	58	167	8241
23	675	9398	59	209	8494
24	718	9651	42° 00'	252	8746
25	761	1.349904			
			42° 01'	1.49093295	1.358998
41° 26'	803	1.350156	02	337	9251
27	846	0409	03	380	9503
28	888	0662	04	422	1.359755
29	931	0915	05	465	1.360008
30	1.49091973	1168			
			42° 06'	508	0260
41° 31'	1.49092016	1.351421	07	550	0512
32	058	1674	08	593	0764
33	101	1926	09	635	1017
34	143	2179	10	678	1269
35	186	2432			
			42° 11'	1.49093721	1.361521
41° 36'	229	2685	12	764	1774
37	271	2938	13	806	2026
38	314	3190	14	849	2278
39	356	3443	15	1.49093892	1.362530
40	1.49092399	1.353696			

FIGURE 9.—Transverse Mercator projection tables for Rhode Island—Continued.

TRANSVERSE MERCATOR PROJECTION FOR RHODE ISLAND

TABLE III

x^1 (feet)	Scale in units of 7th place of logs	Scale expressed as a ratio	x^1 (feet)	Scale in units of 7th place of logs	Scale expressed as a ratio
0	- 27.1	0.9999938	175,000	+124.9	1.0000288
5,000	- 27.0	0.9999938	180,000	+133.8	1.0000308
10,000	- 26.6	0.9999939	185,000	+142.8	1.0000329
15,000	- 26.0	0.9999940	190,000	+152.1	1.0000350
20,000	- 25.1	0.9999942	195,000	+161.7	1.0000372
25,000	- 24.0	0.9999945	200,000	+171.5	1.0000395
30,000	- 22.6	0.9999948	205,000	+181.5	1.0000418
35,000	- 21.0	0.9999952	210,000	+191.9	1.0000442
40,000	- 19.2	0.9999956	215,000	+202.4	1.0000466
45,000	- 17.0	0.9999961	220,000	+213.2	1.0000491
50,000	- 14.7	0.9999966			
55,000	- 12.1	0.9999972			
60,000	- 9.2	0.9999979	x (Central Meridian)		=71° 30' 00".000
65,000	- 6.1	0.9999986			
70,000	- 2.8	0.9999994	R =	- 27.1	
75,000	+ 0.8	1.0000002	$\log \left(\frac{1}{6\rho''}\right)$ g	=	4.5808361 -20
80,000	+ 4.7	1.0000011			
85,000	+ 8.8	1.0000020	$\log \left(\frac{1}{6\rho'' \sin 1''}\right)$ g	=	9.8952612 -20
90,000	+ 13.1	1.0000030			
95,000	+ 17.7	1.0000041			
100,000	+ 22.5	1.0000052			
105,000	+ 27.6	1.0000064	Cor. to azimuth =		
110,000	+ 33.0	1.0000076			
115,000	+ 38.6	1.0000089			
120,000	+ 44.4	1.0000102	$\left(\frac{+y_m - y_1}{6\rho'' \sin 1''}\right)$ g		$(2x' + x')$
125,000	+ 50.5	1.0000116			
130,000	+ 56.8	1.0000131			
135,000	+ 63.4	1.0000146			
140,000	+ 70.2	1.0000162			
145,000	+ 77.3	1.0000178			
150,000	+ 84.6	1.0000195			
155,000	+ 92.2	1.0000212			
160,000	+100.0	1.0000230			
165,000	+108.1	1.0000249			
170,000	+116.4	1.0000268			

FIGURE 9.—Transverse Mercator projection tables for Rhode Island—Continued.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Rhode Island Station Sakonnet

ϕ 41° 27′ 37.129″

λ (Central meridian) 71° 30′ 00.000″

λ 71 11 22.621

$\Delta\lambda$ (Central meridian−λ) + 18′ 37.379″

$\Delta\lambda$ (in sec.) + 1117.379

log $\Delta\lambda$	3.04820050	log S_m^2	8.827681
Cor. arc to sine	− 212	log C*	72 1.350566 −10
log $\Delta\lambda_1$	3.04819838	log $\Delta\phi$	0.178247
log cos ϕ	9.87472210 −10		53
colog A	1.49091872	ϕ	41° 27′ 37.129″
log S_1	4.41383920	$\Delta\phi$	+ 1.5075
Cor. sine to arc	+ 119	ϕ'	41 27 38.6365
log S_m	4.41384039		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.21400
log R	− 271		
log S_g	4.92982185	y (for min. of ϕ')	133,598.10
log S_g^3	14.789466	y (for seconds of ϕ')	+ 3,910.55
log $1/6\rho_o^2R^2$	4.580836 −20	y	137,508.65
log $(S_g^3/6\rho_o^2)_g$	9.370302 −10		
		log sin $\frac{\phi+\phi'}{2}$	9.8209261 −10
S_g	+ 85,078.896	log $\Delta\lambda$	3.0482005
$(S_g^3/6\rho_o^2)_g$	+ .235	log $\Delta\alpha_1$	2.8691266
x′	+ 85,079.13		
	600,000.00	log $(\Delta\lambda)^3$	9.145
x	685,079.13	log F	7.863 −20
		log b	7.008 −10
		$\Delta\alpha_1$	+ 739.821″
		b	.001
		$\Delta\alpha$	+ 739.82″
		$\Delta\alpha$	+ 0° 12′ 19.82″

[a] Take out C first for ϕ and correct for approximate ϕ'

FIGURE 10.—Computation of coordinates for Rhode Island.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Rhode Island Station Block Island

		λ (Central meridian)	71° 30′ 00.000″
41° 10′ 31.525″		λ	71 35 30.763
		Δλ (Central meridian−λ)	− 5 30.763
		Δλ (in sec.)	− 330.763
log Δλ	2.51951692 n	log S_m^2	7.774097
Cor. arc to sine	− 19	log C*	1.346242 -10
log $\Delta\lambda_1$	2.51951673 n	log Δφ	9.120338 -10
log cos φ	9.87662040 -10		
colog A	1.49091145	φ	41° 10′ 31.″525
log S_1	3.88704858 n	Δφ	+ .1319
Cor. sine to arc	+ 11	φ′	41 10 31.6569
log S_m	3.88704869 n		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of φ′	101.20900
log R	− 271		
log S_g	4.40303015 n	y (for min. of φ′)	30,362.45
log S_g^3	13.209090 n	y (for seconds of φ′)	+ 3,203.96
log $1/6\rho_o^2R^2$	4.580836 -20	y	33,566.41
log $(S_g^3/6\rho_o^2)_g$	7.789926 -10 n		
		log sin $\frac{\phi+\phi'}{2}$	9.8184680 -10
S_g	− 25,294.736	log Δλ	2.5195169 n
$(S_g^3/6\rho_o^2)_g$	− .006	log Δa_1	2.3379849 n
x′	− 25,294.74		
	600,000.00	log $(\Delta\lambda)^3$	7.559 n
x	574,705.26	log F	7.863 -20
		log b	5.422 -10 n
		Δa_1	− 217.763
		b	.000
		Δa	− 217.76″
		Δa	− 0° 03′ 37.76″

* Take out C first for φ and correct for approximate φ′.

FIGURE 10—Computation of coordinates for Rhode Island—Continued.

The rest of the computation is for reducing a geodetic azimuth to a grid azimuth or vice versa. The log sin $\frac{\phi+\phi'}{2}$ is added to log $\Delta\lambda$, which has already appeared on the form, giving log $\Delta\alpha_1$, in this case 2.8691266. The log $\Delta\lambda$ is multiplied by 3 and added to log F, taken from Special Publication No. 8 with the mean ϕ as the argument. The result is log b, here 7.008—10. The numbers corresponding to log $\Delta\alpha_1$, and log b are added to give $\Delta\alpha$, in this case +739.82 seconds, or +0°12′19″.82. This value $\Delta\alpha$ subtracted algebraically from a geodetic azimuth at station Sakonnet gives the corresponding grid azimuth.

As an example for computing the grid azimuth and distance between two stations, Sakonnet, with coordinates x_1, y_1 and Block Island with coordinates x_2, y_2, are chosen. As shown x_2-x_1 divided by y_2-y_1 gives the tangent of the grid azimuth. The signs of x_2-x_1 and y_2-y_1 are changed to determine in which quadrant the azimuth α lies. The grid distance is obtained by dividing x_2-x_1, by sin α or by dividing y_2-y_1 by cos α. This result is in feet. If desired this can easily be converted to meters by multiplying by the reduction factor $\frac{1,200}{3,937}$.

To derive the geodetic length from the grid length the reduction factor from page 27 is used. The x''s of the two ends of the line are the arguments. The mean is taken by adding all of the values between the two x''s, in this case −25,000 and +85,000 feet. For example, the values are:

Computation of mean scale

x'	Scale	Weight	Weighted scale
−25,000	−24.0	0.5	−12.0
−20,000	−25.1	1	−25.1
−15,000	−26.0	1	−26.0
−10,000	−26.6	1	−26.6
−5,000	−27.0	1	−27.0
0	−27.1	1	−27.1
+5,000	−27.0	1	−27.0
+10,000	−26.6	1	−26.6
+15,000	−26.0	1	−26.0
+20,000	−25.1	1	−25.1
+25,000	−24.0	1	−24.0
+30,000	−22.6	1	−22.6
+35,000	−21.0	1	−21.0
+40,000	−19.2	1	−19.2
+45,000	−17.0	1	−17.0
+50,000	−14.7	1	−14.7
+55,000	−12.1	1	−12.1
+60,000	−9.2	1	−9.2
+65,000	−6.1	1	−6.1
+70,000	−2.8	1	−2.8
+75,000	+0.8	1	+0.8
+80,000	+4.7	1	+4.7
+85,000	+8.8	0.5	+4.4
		22	−387.3

$\frac{-387.3}{22}=-17.6$

Interpolation is made at the two ends. The value opposite 25,000 may be considered as extending from 22,500 to 27,500 so that if the length starts with 25,000 the final sum should receive but 0.5 of this value. Likewise, the value at 85,000 is given but 0.5 weight. Since

the two stations are on opposite sides of the central meridian, with $x''s$ of opposite sign, the mean scale factor cannot be taken directly between 25,000 and 85,000 but must be computed from one up to the central meridian where x' is 0, and then back down to the other, thus crossing the central meridian. This scale reduction is subtracted from the logarithm of the grid distance to give the geodetic distance. An approximate geodetic azimuth may be computed from the grid azimuth by adding to it the $\Delta\alpha$ appearing on the sheet with the computation of the coordinates of the station. For a more exact geodetic azimuth the correction to azimuth term must be computed by the equation given on page 13. This correction is worked out in the example and added with $\Delta\alpha$ to the grid azimuth giving the geodetic azimuth. For short lines a grid azimuth may be obtained by subtracting $\Delta\alpha$ alone from the geodetic azimuth.

Computation of Grid Azimuth and Check

Sakonnet-Block Island

x_2	= 574,705.26	y_2	= 33,566.41
x_1	= 685,079.13	y_1	= 137,508.65
x_2-x_1	= -110,373.87	y_2-y_1	=-103,942.24
log (x_2-x_1)	= 5.04286627	log (x_2-x_1)	= 5.04286627
log (y_2-y_1)	= 5.01679207	colog sin α	= 0.13786903
log tan α	= 0.02607420	log $\frac{1200}{3937}$	= 9.48401583 -10
			4.66475113
Grid azimuth	= 46° 43' 08.15"	Scale reduction	= +176
$\Delta\alpha$	= + 0 12 19.82		
Correction	= - 1.18	log distance	= 4.6647529
Geodetic azimuth	= 46° 55' 26.79"	From list	= 4.6647527
From list	= 46° 55' 26.87"		

$2x_1'$	= 170,158.26
x_2'	= -25,294.74
$2x_1' + x_2'$	= 144,863.52
log $(2x_1' + x_2')$	= 5.1609591
log $(y_2 - y_1)$	= 5.0167921 n
log $\left(\frac{1}{6\rho_o'' \sin 1''}\right)_g$	= 9.8952612 -20
log (correction)	= 0.0730124 n
Correction	= -1.18

Computation of Grid Azimuth from Geodetic Azimuth for Short Lines

Sakonnet-reference mark no. 1.

Geodetic azimuth	= 179° 06' 19.9"
$\Delta\alpha$	= - 0 12 19.8
Grid azimuth	= 178 54 00.1

FIGURE 11.—Computation of grid azimuth and check, and computation of grid azimuth from geodetic azimuth for short lines.

APPLICATIONS OF THE GRIDS TO COMPUTATION

Although we have adopted two different systems in the adaptations to the various States, yet we wish to emphasize the fact the use of the coordinates in plane computations is essentially the same in both cases. The initial reductions from geodetic positions to plane coordinates is different in the two systems but after the control stations are reduced to grid coordinates then computations based upon them are identical in the two systems. We shall now give some sample computations on each of the systems and these will illustrate the fact that we have nothing but the application of the principles of plane geometry in either case. The two classes of observational data that will be computed by the grids consist of triangulation and traverse. Since traverse is the simplest form of observational work that will be computed by means of coordinates, we shall make use of a sample computation of such a system of measurements as the first to be given. A particular State must be used as a basis for the computations but the method is similar in any State, whether the grid is based on the Lambert projection or on the transverse Mercator projection. This will be illustrated by computations on each kind of grid and these computations will demonstrate that the nature of the plane computation is independent of the kind of grid.

COMPUTATION OF A FIRST-ORDER TRAVERSE IN NORTH CAROLINA

A first-order traverse from station Sanford to station Cary in North Carolina was selected as a typical example. (Tables for North Carolina are given in Fig. 12.)[3] At the starting end, stations Allenby and Sanford were fixed by triangulation, and at the other end, stations Cary and Raleigh were also fixed by triangulation. The plane coordinates for these four stations had to be computed first to fix the control data on the plane grid. The coordinates of the first two stations were computed by logarithms and those of the last two stations by calculating machine. With these coordinates, the grid azimuths of Allenby to Sanford and of Cary to Raleigh were computed in the usual way. As an approximate check on the calculation an attempt was made to reproduce the known geodetic length by application of the scale factor. In most cases this will differ slightly from the geodetic length given in the list of geographic positions if the end points are not sufficiently exact to hold seven decimal places in the logarithm of the length. To make an accurate comparison an inverse-position computation should be made to determine just what logarithm of the length would correspond to the two listed positions. This same statement applies to the attempt to check the geodetic azimuth by the computation of the correction term. In the case of a short line the azimuth and back azimuth resulting from the inverse position may differ a few seconds from the value given in the list of geodetic positions. This means that the fourth or fifth decimal place in the positions has an effect on the azimuth of the line.

[3] For State map of North Carolina showing elements of grid see fig. 61, p. 262.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE I.

Lat.	B ft.	y^1 y value on central meridian feet	Tabular difference for one sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
33°45'	30,183,611.25	0	101.10250	+923	1.000212
46	30,177,545.10	6,066.15	101.10200	+891	1.000205
47	30,171,478.98	12,132.27	101.10150	+858	1.000198
48	30,165,412.89	18,198.36	101.10100	+826	1.000190
49	30,159,346.83	24,264.42	101.10067	+795	1.000183
50	30,153,280.79	30,330.46	101.10017	+763	1.000176
33°51'	30,147,214.78	36,396.47	101.09967	+734	1.000169
52	30,141,148.80	42,462.45	101.09933	+704	1.000162
53	30,135,082.84	48,528.41	101.09883	+674	1.000155
54	30,129,016.91	54,594.34	101.09833	+644	1.000148
55	30,122,951.01	60,660.24	101.09800	+615	1.000142
33°56'	30,116,885.13	66,726.12	101.09767	+587	1.000135
57	30,110,819.27	72,791.98	101.09733	+557	1.000128
58	30,104,753.43	78,857.82	101.09700	+529	1.000122
59	30,098,687.61	84,923.64	101.09650	+501	1.000115
34°00	30,092,621.82	90,989.43	101.09600	+472	1.000109
34°01'	30,086,556.06	97,055.19	101.09583	+446	1.000105
02	30,080,490.31	103,120.94	101.09567	+420	1.000097
03	30,074,424.57	109,186.68	101.09533	+394	1.000091
04	30,068,358.85	115,252.40	101.09483	+368	1.000085
05	30,062,293.16	121,318.09	101.09450	+342	1.000079
34°06'	30,056,227.49	127,383.76	101.09433	+316	1.000073
07	30,050,161.83	133,449.42	101.09400	+292	1.000067
08	30,044,096.19	139,515.06	101.09367	+267	1.000062
09	30,038,030.57	145,580.68	101.09333	+243	1.000056
10	30,031,964.97	151,646.28	101.09333	+219	1.000050
34°11'	30,025,899.37	157,711.88	101.09317	+196	1.000045
12	30,019,833.78	163,777.47	101.09283	+172	1.000040
13	30,013,768.21	169,843.04	101.09250	+150	1.000034
14	30,007,702.66	175,908.59	101.09217	+127	1.000029
15	30,001,637.13	181,974.12	101.09183	+105	1.000024
34°16'	29,995,571.62	188,039.63	101.09150	+83	1.000019
17	29,989,506.13	194,105.12	101.09117	+62	1.000014
18	29,983,440.66	200,170.59	101.09100	+41	1.000009
19	29,977,375.20	206,236.05	101.09083	+21	1.000005
20	29,971,309.75	212,301.50	101.09067	0	1.000000

FIGURE 12.—Lambert projection tables for North Carolina.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE I (Cont'd)

Lat.	R_ϕ feet	y^1 y value on central meridian feet	Tabular difference for one sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
34°21'	29,965,244.31	218,366.94	101.09067	-20	0.999995
22	29,959,178.87	224,432.38	101.09050	-40	0.999991
23	29,953,113.44	230,497.81	101.09033	-59	0.999987
24	29,947,048.02	236,563.23	101.09000	-77	0.999982
25	29,940,982.62	242,628.63	101.09000	-96	0.999978
34°26'	29,934,917.22	248,694.03	101.08983	-114	0.999974
27	29,928,851.83	254,759.42	101.08983	-131	0.999970
28	29,922,786.44	260,824.81	101.08950	-149	0.999966
29	29,916,721.07	266,890.18	101.08950	-166	0.999962
30	29,910,655.70	272,955.55	101.08950	-182	0.999958
34°31'	29,904,590.33	279,020.92	101,08933	-199	0.999954
32	29,898,524.97	285,086.28	101.08917	-215	0.999950
33	29,892,459.62	291,151.63	101.08917	-230	0.999947
34	29,886,394.27	297,216.98	101.08900	-245	0.999944
35	29,880,328.93	303,282.32	101.08900	-260	0.999940
34°36'	29,874,263.59	309,347.66	101.08900	-275	0.999937
37	29,868,198.25	315,413.00	101.08883	-288	0.999934
38	29,862,132.92	321,478.33	101.08900	-302	0.999930
39	29,856,067.58	327,543.67	101.08900	-316	0.999927
40	29,850,002.24	333,609.01	101.08883	-329	0.999924
34°41'	29,843,936.91	339,674.34	101.08883	-341	0.999921
42	29,837,871.58	345,739.67	101.08883	-353	0.999919
43	29,831,806.25	351,805.00	101.08883	-365	0.999916
44	29,825,740.92	357,870.33	101.08883	-377	0.999913
45	29,819,675.59	363,935,66	101.08883	-387	0.999911
34°46'	29,813,610.26	370,000.99	101.08900	-399	0.999908
47	29,807,544.92	376,066.33	101.08883	-410	0.999906
48	29,801,479.59	382,131.66	101.08900	-419	0.999903
49	29,795,414.25	388,197.00	101.08900	-428	0.999901
50	29,789,348.91	394,262.34	101.08917	-438	0.999899
34°51'	29,783,283.56	400,327.69	101.08917	-447	0.999897
52	29,777,218.21	406,393.04	101.08933	-455	0.999895
53	29,771,152.85	412,458.40	101.08933	-464	0.999893
54	29,765,087.49	418,523.76	101.08950	-472	0.999891
55	29,759,022.12	424,589.13	101.08967	-479	0.999890
34°56'	29,752,956.74	430,654.51	101.08967	-486	0.999888
57	29,746,891.36	436,719.89	101.09000	-493	0.999887
58	29,740,825.96	442,785.29	101.09000	-499	0.999885
59	29,734,760.56	448,850.69	101.09017	-506	0.999883
35°00	29,728,695.15	454,916.10	101.09033	-511	0.999882

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE I (Cont'd)

Lat.	B	y^1 y value on central meridian	Tabular difference for one sec. of lat.	Scale in units of 7th place of logs.	Scale expressed as a ratio
	feet	feet	feet		
35°01'	29,722,629.73	460,981.52	101.09050	-516	0.999881
02	29,716,564.30	467,046.95	101.09050	-522	0.999880
03	29,710,498.87	473,112.38	101.09083	-526	0.999879
04	29,704,433.42	479,177.83	101.09100	-530	0.999878
05	29,698,367.96	485,243.29	101.09117	-534	0.999877
35°06'	29,692,302.49	491,308.76	101.09133	-538	0.999876
07	29,686,237.01	497,374.24	101.09167	-542	0.999875
08	29,680,171.51	503,439.74	101.09183	-545	0.999875
09	29,674,106.00	509,505.25	101.09200	-547	0.999874
10	29,668,040.48	515,570.77	101.09233	-549	0.999874
35°11'	29,661,974.94	521,636.31	101.09250	-551	0.999873
12	29,655,909.39	527,701.86	101.09283	-552	0.999873
13	29,649,843.82	533,767.43	101.09300	-552	0.999873
14	29,643,778.24	539,833.01	101.09333	-553	0.999873
15	29,637,712.64	545,898.61	101.09350	-554	0.999873
35°16'	29,631,647.03	551,964.22	101.09400	-553	0.999873
17	29,625,581.39	558,029.86	101.09433	-552	0.999873
18	29,619,515.73	564,095.52	101.09450	-552	0.999873
19	29,613,450.06	570,161.19	101.09483	-551	0.999873
20	29,607,384.37	576,226.88	101.09517	-549	0.999874
35°21'	29,601,318.66	582,292.59	101.09550	-547	0.999874
22	29,595,252.93	588,358.32	101.09583	-545	0.999875
23	29,589,187.18	594,424.07	101.09600	-542	0.999875
24	29,583,121.42	600,489.83	101.09650	-539	0.999876
25	29,577,055.63	606,555.62	101.09700	-535	0.999877
35°26'	29,570,989.81	612,621.44	101.09733	-531	0.999878
27	29,564,923.97	618,687.28	101.09767	-527	0.999879
28	29,558,858.11	624,753.14	101.09783	-522	0.999880
29	29,552,792.24	630,819.01	101.09833	-517	0.999881
30	29,546,726.34	636,884.91	101.09867	-512	0.999882
35°31'	29,540,660.42	642,950.83	101.09917	-507	0.999883
32	29,534,594.47	649,016.78	101.09967	-500	0.999885
33	29,528,528.49	655,082.76	101.10033	-495	0.999886
34	29,522,462.47	661,148.78	101.10067	-488	0.999888
35	29,516,396.43	667,214.82	101.10100	-481	0.999889
35°36'	29,510,330.37	673,280.88	101.10150	-474	0.999891
37	29,504,264.28	679,346.97	101.10200	-466	0.999893
38	29,498,198.16	685,413.09	101.10233	-458	0.999895
39	29,492,132.02	691,479.23	101.10300	-449	0.999897
40	29,486,065.84	697,545.41	101.10350	-439	0.999899

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE I (Cont'd)

Lat.	R feet	y^1 y value on central meridian feet	Tabular difference for one sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
35°41'	29,479,999.63	703,611.62	101.10383	-430	0.999901
42	29,473,933.40	709,677.85	101.10450	-420	0.999903
43	29,467,867.13	715,744.12	101.10500	-410	0.999905
44	29,461,800.83	721,810.42	101.10550	-400	0.999908
45	29,455,734.50	727,876.75	101.10600	-389	0.999910
35°46'	29,449,668.14	733,943.11	101.10667	-378	0.999913
47	29,443,601.74	740,009.51	101.10717	-366	0.999916
48	29,437,535.31	746,075.94	101.10767	-354	0.999918
49	29,431,468.85	752,142.40	101.10833	-342	0.999921
50	29,425,402.35	758,208.90	101.10883	-330	0.999924
35°51'	29,419,335.82	764,275.43	101.10950	-317	0.999927
52	29,413,269.25	770,342.00	101.11017	-304	0.999930
53	29,407,202.64	776,408.61	101.11067	-290	0.999933
54	29,401,136.00	782,475.25	101.11117	-276	0.999937
55	29,395,069.33	788,541.92	101.11200	-262	0.999940
35°56'	29,389,002.61	794,608.64	101.11250	-246	0.999943
57	29,382,935.86	800,675.39	101.11317	-232	0.999947
58	29,376,869.07	806,742.18	101.11383	-216	0.999950
59	29,370,802.24	812,809.01	101.11450	-200	0.999954
36°00	29,364,735.37	818,875.88	101.11517	-183	0.999958
36°01'	29,358,668.46	824,942.79	101.11583	-166	0.999962
02	29,352,601.51	831,009.74	101.11650	-149	0.999966
03	29,346,534.52	837,076.73	101.11733	-132	0.999970
04	29,340,467.48	843,143.77	101.11783	-115	0.999973
05	29,334,400.41	849,210.84	101.11867	- 97	0.999978
36°06'	29,328,333.29	855,277.96	101.11933	-78	0.999982
07	29,322,266.13	861,345.12	101.12017	-59	0.999986
08	29,316,198.92	867,412.33	101.12083	-40	0.999991
09	29,310,131.67	873,479.58	101.12150	-20	0.999995
10	29,304,064.38	879,546.87	101.12233	0	1.000000
36°11'	29,297,997.04	885,614.21	101.12317	+21	1.000005
12	29,291,929.65	891,681.60	101.12383	+41	1.000009
13	29,285,862.22	897,749.03	101.12467	+62	1.000014
14	29,279,794.74	903,816.51	101.12533	+84	1.000019
15	29,273,727.22	909,884.03	101.12617	+106	1.000024

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE I (Cont'd)

Lat.	R ft	y^1 y value on central meridian feet	Tabular difference for one sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
36°16'	29,267,659.65	915,951.60	101.12717	+127	1.000029
17	29,261,592.02	922,019.23	101.12800	+150	1.000034
18	29,255,524.34	928,086.91	101.12867	+173	1.000040
19	29,249,456.62	934,154.63	101.12950	+196	1.000045
20	29,243,388.85	940,222.40	101.13033	+220	1.000051
36°21'	29,237,321.03	946,290.22	101.13117	+245	1.000056
22	29,231,253.16	952,358.09	101.13217	+270	1.000062
23	29,225,185.23	958,426.02	101.13283	+294	1.000068
24	29,219,117.26	964,493.99	101.13383	+320	1.000074
25	29,213,049.23	970,562.02	101.13467	+345	1.000079
36°26'	29,206,981.15	976,630.10	101.13567	+370	1.000085
27	29,200,913.01	982,698.24	101.13633	+397	1.000091
28	29,194,844.83	988,766.42	101.13733	+424	1.000098
29	29,188,776.59	994,834.66	101.13833	+451	1.000104
30	29,182,708.29	1,000,902.96	101.13933	+478	1.000110
36°31'	29,176,639.93	1,006,971.32	101.14017	+506	1.000117
32	29,170,571.52	1,013,039.73	101.14100	+535	1.000123
33	29,164,503.06	1,019,108.19	101.14217	+563	1.000130
34	29,158,434.53	1,025,176.72	101.14300	+593	1.000137
35	29,152,365.95	1,031,245.30	101.14417	+622	1.000143
36°36'	29,146,297.30	1,037,313.95	101.14500	+652	1.000150
37	29,140,228.60	1,043,382.65	101.14600	+680	1.000157
38	29,134,159.84	1,049,451.41	101.14717	+710	1.000163
39	29,128,091.01	1,055,520.24	101.14800	+742	1.000171
40	29,122,022.13	1,061,589.12		+773	1.000178

$l = 0.57717077$

$\log l = 9.76130433 - 10$

$\log K = 7.63584335$

$y_o = +546,552$ feet

$\log \frac{1}{2\rho_o'' \sin 1''} = 0.3730186 - 10$

$$\text{Geodetic azimuth} - \text{grid azimuth} = +\theta - \frac{x_2 - x_1}{2\rho_o'' \sin 1''}\left(y_1 - y_o + \frac{y_2 - y_1}{3}\right)$$

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE II.

1" of Long. = 0".57717077 of θ

Long.	θ		Long.	θ		Long.	θ	
75°20'	+2°06'	58".6542	76°01'	+1°43'	18".8141	76°41'	+1°20'	13.6042
21	+2 06	24.0239	02	+1 42	44.1838	42	+1 19	38.9740
22	+2 05	49.3937	03	+1 42	09.5536	43	+1 19	04.3437
23	+2 05	14.7634	04	+1 41	34.9233	44	+1 18	29.7135
24	+2 04	40.1332	05	+1 41	00.2931	45	+1 17	55.0832
25	+2 04	05.5029						
			76°06'	+1 40	25.6628	76°46'	+1 17	20.4530
75°26'	+2 03	30.8727	07	+1 39	51.0326	47	+1 16	45.8227
27	+2 02	56.2424	08	+1 39	16.4023	48	+1 16	11.1925
28	+2 02	21.6122	09	+1 38	41.7721	49	+1 15	36.5623
29	+2 01	46.9819	10	+1 38	07.1419	50	+1 15	01.9320
30	+2 01	12.3517						
			76°11'	+1 37	32.5116	76°51'	+1 14	27.3018
75°31'	+2 00	37.7215	12	+1 36	57.8814	52	+1 13	52.6715
32	+2 00	03.0912	13	+1 36	23.2511	53	+1 13	18.0413
33	+1 59	28.4610	14	+1 35	48.6209	54	+1 12	43.4110
34	+1 58	53.8307	15	+1 35	13.9906	55	+1 12	08.7808
35	+1 58	19.2005						
			76°16'	+1 34	39.3604	76°56'	+1 11	34.1505
75°36'	+1 57	44.5702	17	+1 34	04.7301	57	+1 10	59.5203
37	+1 57	09.9400	18	+1 33	30.0999	58	+1 10	24.8900
38	+1 56	35.3097	19	+1 32	55.4696	59	+1 09	50.2598
39	+1 56	00.6795	20	+1 32	20.8394	77°00	+1 09	15.6295
40	+1 55	26.0492						
			76°21'	+1 31	46.2091	77°01'	+1 08	40.9993
75°41'	+1 54	51.4190	22	+1 31	11.5789	02	+1 08	06.3691
42	+1 54	16.7887	23	+1 30	36.9487	03	+1 07	31.7388
43	+1 53	42.1585	24	+1 30	02.3184	04	+1 06	57.1086
44	+1 53	07.5283	25	+1 29	27.6882	05	+1 06	22.4783
45	+1 52	32.8980						
			76°26'	+1 28	53.0579	77°06'	+1 05	47.8481
75°46'	+1 51	58.2678	27	+1 28	18.4277	07	+1 05	13.2178
47	+1 51	23.6375	28	+1 27	43.7974	08	+1 04	38.5876
48	+1 50	49.0073	29	+1 27	09.1672	09	+1 04	03.9573
49	+1 50	14.3770	30	+1 26	34.5369	10	+1 03	29.3271
50	+1 49	39.7468						
			76°31'	+1 25	59.9067	77°11'	+1 02	54.6968
75°51	+1 49	05.1165	32	+1 25	25.2764	12	+1 02	20.0666
52	+1 48	30.4863	33	+1 24	50.6462	13	+1 01	45.4363
53	+1 47	55.8560	34	+1 24	16.0159	14	+1 01	10.8061
54	+1 47	21.2258	35	+1 23	41.3857	15	+1 00	36.1759
55	+1 46	46.5955						
			76°36'	+1 23	06.7555	77°16'	+1 00	01.5456
75°56'	+1 46	11.9653	37	+1 22	32.1252	17	+0 59	26.9154
57	+1 45	37.3351	38	+1 21	57.4950	18	+0 58	52.2851
58	+1 45	02.7048	39	+1 21	22.8647	19	+0 58	17.6549
59	+1 44	28.0746	40	+1 20	48.2345	20	+0 57	43.0246
76°00'	+1 43	53.4443						

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE II (Cont'd)

1" of Long. = 0".57717077 of θ

Long.	θ		Long.	θ		Long.	θ	
77°21'	+0°57'	08".3944	78°01'	+0°34'	03".1845	78°41'	+0°10'	57".9747
22	+0 56	33.7641	02	+0 33	28.5543	42	+0 10	23.3444
23	+0 55	59.1339	03	+0 32	53.9240	43	+0 09	48.7142
24	+0 55	24.5036	04	+0 32	19.2938	44	+0 09	14.0839
25	+0 54	49.8734	05	+0 31	44.6635	45	+0 08	39.4537
77°26'	+0 54	15.2431	78°06'	+0 31	10.0333	78°46'	+0 08	04.8234
27	+0 53	40.6129	07	+0 30	35.4030	47	+0 07	30.1932
28	+0 53	05.9827	08	+0 30	00.7728	48	+0 06	55.5630
29	+0 52	31.3524	09	+0 29	26.1426	49	+0 06	20.9327
30	+0 51	56.7222	10	+0 28	51.5123	50	+0 05	46.3025
77°31'	+0 51	22.0919	78°11'	+0 28	16.8821	78°51'	+0 05	11.6722
32	+0 50	47.4617	12	+0 27	42.2518	52	+0 04	37.0420
33	+0 50	12.8314	13	+0 27	07.6216	53	+0 04	02.4117
34	+0 49	38.2012	14	+0 26	32.9913	54	+0 03	27.7815
35	+0 49	03.5709	15	+0 25	58.3611	55	+0 02	53.1512
77°36'	+0 48	28.9407	78°16'	+0 25	23.7308	78°56'	+0 02	18.5210
37	+0 47	54.3104	17	+0 24	49.1006	57	+0 01	43.8907
38	+0 47	19.6802	18	+0 24	14.4703	58	+0 01	09.2605
39	+0 46	45.0499	19	+0 23	39.8401	59	+0 00	34.6302
40	+0 46	10.4197	20	+0 23	05.2098	79°00	0 00	00.0000
77°41'	+0 45	35.7894	78°21'	+0 22	30.5796	79°01'	-0 00	34.6302
42	+0 45	01.1592	22	+0 21	55.9494	02	-0 01	09.2605
43	+0 44	26.5290	23	+0 21	21.3191	03	-0 01	43.8907
44	+0 43	51.8987	24	+0 20	46.6889	04	-0 02	18.5210
45	+0 43	17.2685	25	+0 20	12.0586	05	-0 02	53.1512
77°46'	+0 42	42.6382	78°26'	+0 19	37.4284	79°06'	-0 03	27.7815
47	+0 42	08.0080	27	+0 19	02.7981	07	-0 04	02.4117
48	+0 41	33.3777	28	+0 18	28.1679	08	-0 04	37.0420
49	+0 40	58.7475	29	+0 17	53.5376	09	-0 05	11.6722
50	+0 40	24.1172	30	+0 17	18.9074	10	-0 05	46.3025
77°51'	+0 39	49.4870	78°31'	+0 16	44.2771	79°11'	-0 06	20.9327
52	+0 39	14.8567	32	+0 16	09.6469	12	-0 06	55.5630
53	+0 38	40.2265	33	+0 15	35.0166	13	-0 07	30.1932
54	+0 38	05.5962	34	+0 15	00.3864	14	-0 08	04.8234
55	+0 37	30.9660	35	+0 14	25.7562	15	-0 08	39.4537
77°56'	+0 36	56.3358	78°36'	+0 13	51.1259	79°16'	-0 09	14.0839
57	+0 36	21.7055	37	+0 13	16.4957	17	-0 09	48.7142
58	+0 35	47.0753	38	+0 12	41.8654	18	-0 10	23.3444
59	+0 35	12.4450	39	+0 12	07.2352	19	-0 10	57.9747
78°00	+0 34	37.8148	40	+0 11	32.6049	20	-0 11	32.6049

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE II (Cont'd)

1" of Long. = 0".57717077 of θ

Long.	θ		Long.	θ		Long.	θ	
79°21'	-0°12'	07".2352	80°01'	-0°35'	12".4450	80°41'	-0°58'	17".6549
22	-0 12	41.8654	02	-0 35	47.0753	42	-0 58	52.2851
23	-0 13	16.4957	03	-0 36	21.7055	43	-0 59	26.9154
24	-0 13	51.1259	04	-0 36	56.3358	44	-1 00	01.5456
25	-0 14	25.7562	05	-0 37	30.9660	45	-1 00	36.1759
79°26'	-0 15	00.3864	80°06'	-0 38	05.5962	80°46'	-1 01	10.8061
27	-0 15	35.0166	07	-0 38	40.2265	47	-1 01	45.4363
28	-0 16	09.6469	08	-0 39	14.8567	48	-1 02	20.0666
29	-0 16	44.2771	09	-0 39	49.4870	49	-1 02	54.6968
30	-0 17	18.9074	10	-0 40	24.1172	50	-1 03	29.3271
79°31'	-0 17	53.5376	80°11'	-0 40	58.7475	80°51'	-1 04	03.9573
32	-0 18	28.1679	12	-0 41	33.3777	52	-1 04	38.5876
33	-0 19	02.7981	13	-0 42	08.0080	53	-1 05	13.2178
34	-0 19	37.4284	14	-0 42	42.6382	54	-1 05	47.8481
35	-0 20	12.0586	15	-0 43	17.2685	55	-1 06	22.4783
79°36'	-0 20	46.6889	80°16'	-0 43	51.8987	80°56'	-1 06	57.1086
37	-0 21	21.3191	17	-0 44	26.5290	57	-1 07	31.7388
38	-0 21	55.9494	18	-0 45	01.1592	58	-1 08	06.3691
39	-0 22	30.5796	19	-0 45	35.7894	59	-1 08	40.9993
40	-0 23	05.2098	20	-0 46	10.4197	81°00	-1 09	15.6295
79°41'	-0 23	39.8401	80°21'	-0 46	45.0499	81°01'	-1 09	50.2598
42	-0 24	14.4703	22	-0 47	19.6802	02	-1 10	24.8900
43	-0 24	49.1006	23	-0 47	54.3104	03	-1 10	59.5203
44	-0 25	23.7308	24	-0 48	28.9407	04	-1 11	34.1505
45	-0 25	58.3611	25	-0 49	03.5709	05	-1 12	08.7808
79°46'	-0 26	32.9913	80°26'	-0 49	38.2012	81°06'	-1 12	43.4110
47	-0 27	07.6216	27	-0 50	12.8314	07	-1 13	18.0413
48	-0 27	42.2518	28	-0 50	47.4617	08	-1 13	52.6715
49	-0 28	16.8821	29	-0 51	22.0919	09	-1 14	27.3018
50	-0 28	51.5123	30	-0 51	56.7222	10	-1 15	01.9320
79°51'	-0 29	26.1426	80°31'	-0 52	31.3524	81°11'	-1 15	36.5623
52	-0 30	00.7728	32	-0 53	05.9827	12	-1 16	11.1925
53	-0 30	35.4030	33	-0 53	40.6129	13	-1 16	45.8227
54	-0 31	10.0333	34	-0 54	15.2431	14	-1 17	20.4530
55	-0 31	44.6635	35	-0 54	49.8734	15	-1 17	55.0832
79°56'	-0 32	19.2938	80°36'	-0 55	24.5036	81°16'	-1 18	29.7135
57	-0 32	53.9240	37	-0 55	59.1339	17	-1 19	04.3437
58	-0 33	28.5543	38	-0 56	33.7641	18	-1 19	38.9740
59	-0 34	03.1845	39	-0 57	08.3944	19	-1 20	13.6042
80°00	-0 34	37.8148	40	-0 57	43.0246	20	-1 20	48.2345

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE II (Cont'd)

1" of Long. = 0".57717077 of θ

Long.	θ		Long.	θ		Long.	θ	
81°21'	-1°21'	22".8647	82°01'	-1°44'	28".0746	82°41'	-2°07'	33".2844
22	-1 21	57.4950	02	-1 45	02.7048	42	-2 08	07.9147
23	-1 22	32.1252	03	-1 45	37.3351	43	-2 08	42.5449
24	-1 23	06.7555	04	-1 46	11.9653	44	-2 09	17.1751
25	-1 23	41.3857	05	-1 46	46.5955	45	-2 09	51.8054
81°26'	-1 24	16.0159	82°06'	-1 47	21.2258	82°46'	-2 10	26.4356
27	-1 24	50.6462	07	-1 47	55.8560	47	-2 11	01.0659
28	-1 25	25.2764	08	-1 48	30.4863	48	-2 11	35.6961
29	-1 25	59.9067	09	-1 49	05.1165	49	-2 12	10.3264
30	-1 26	34.5369	10	-1 49	39.7468	50	-2 12	44.9566
81°31'	-1 27	09.1672	82°11'	-1 50	14.3770	82°51'	-2 13	19.5869
32	-1 27	43.7974	12	-1 50	49.0073	52	-2 13	54.2171
33	-1 28	18.4277	13	-1 51	23.6375	53	-2 14	28.8474
34	-1 28	53.0579	14	-1 51	58.2678	54	-2 15	03.4776
35	-1 29	27.6882	15	-1 52	32.8980	55	-2 15	38.1079
81°36'	-1 30	02.3184	82°16'	-1 53	07.5283	82°56'	-2 16	12.7381
37	-1 30	36.9487	17	-1 53	42.1585	57	-2 16	47.3683
38	-1 31	11.5789	18	-1 54	16.7887	58	-2 17	21.9986
39	-1 31	46.2091	19	-1 54	51.4190	59	-2 17	56.6288
40	-1 32	20.8394	20	-1 55	26.0492	83°00	-2 18	31.2591
81°41'	-1 32	55.4696	82°21'	-1 56	00.6795	83°01'	-2 19	05.8893
42	-1 33	30.0999	22	-1 56	35.3097	02	-2 19	40.5196
43	-1 34	04.7301	23	-1 57	09.9400	03	-2 20	15.1498
44	-1 34	39.3604	24	-1 57	44.5702	04	-2 20	49.7801
45	-1 35	13.9906	25	-1 58	19.2005	05	-2 21	24.4103
81°46'	-1 35	48.6209	82°26'	-1 58	53.8307	83°06'	-2 21	59.0406
47	-1 36	23.2511	27	-1 59	28.4610	07	-2 22	33.6708
48	-1 36	57.8814	28	-2 00	03.0912	08	-2 23	08.3011
49	-1 37	32.5116	29	-2 00	37.7215	09	-2 23	42.9313
50	-1 38	07.1419	30	-2 01	12.3517	10	-2 24	17.5616
81°51'	-1 38	41.7721	82°31'	-2 01	46.9819	83°11'	-2 24	52.1918
52	-1 39	16.4023	32	-2 02	21.6122	12	-2 25	26.8220
53	-1 39	51.0326	33	-2 02	56.2424	13	-2 26	01.4523
54	-1 40	25.6628	34	-2 03	30.8727	14	-2 26	36.0825
55	-1 41	00.2931	35	-2 04	05.5029	15	-2 27	10.7128
81°56'	-1 41	34.9233	82°36'	-2 04	40.1332	83°16'	-2 27	45.3430
57	-1 42	09.5536	37	-2 05	14.7634	17	-2 28	19.9733
58	-1 42	44.1838	38	-2 05	49.3937	18	-2 28	54.6035
59	-1 43	18.8141	39	-2 06	24.0239	19	-2 29	29.2338
82°00	-1 43	53.4443	40	-2 06	58.6542	20	-2 30	03.8640

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

LAMBERT PROJECTION FOR NORTH CAROLINA

TABLE II (Cont'd)

1" of Long. = 0".57717077 of θ

Long.	θ		Long.	θ		Long.	θ
83°21'	-2°30'	38".4943	83°56'	-2°50'	50".5529		
22	-2 31	13.1245	57	-2 51	25.1831		
23	-2 31	47.7548	58	-2 51	59.8134		
24	-2 32	22.3850	59	-2 52	34.4436		
25	-2 32	57.0152	84°00	-2 53	09.0739		
83°26'	-2 33	31,6455	84°01'	-2 53	43.7041		
27	-2 34	06.2757	02	-2 54	18.3344		
28	-2 34	40.9060	03	-2 54	52.9646		
29	-2 35	15.5362	04	-2 55	27.5948		
30	-2 35	50.1665	05	-2 56	02.2251		
83°31'	-2 36	24.7967	84°06'	-2 56	36.8553		
32	-2 36	59.4270	07	-2 57	11.4856		
33	-2 37	34.0572	08	-2 57	46.1158		
34	-2 38	08.6875	09	-2 58	20.7461		
35	-2 38	43.3177	10	-2 58	55.3763		
83°36'	-2 39	17.9480	84°11'	-2 59	30.0066		
37	-2 39	52.5782	12	-3 00	04.6368		
38	-2 40	27.2084	13	-3 00	39.2671		
39	-2 41	01.8387	14	-3 01	13.8973		
40	-2 41	36.4689	15	-3 01	48.5276		
83°41'	-2 42	11.0992	84°16'	-3 02	23.1578		
42	-2 42	45.7294	17	-3 02	57.7880		
43	-2 43	20.3597	18	-3 03	32.4183		
44	-2 43	54.9899	19	-3 04	07.0485		
45	-2 44	29.6202	20	-3 04	41.6788		
83°46'	-2 45	04.2504	84°21'	-3 05	16.3090		
47	-2 45	38.8807	22	-3 05	50.9393		
48	-2 46	13.5109	23	-3 06	25.5695		
49	-2 46	48.1412	24	-3 07	00.1998		
50	-2 47	22.7714	25	-3 07	34.8300		
83°51'	-2 47	57.4016	84°26'	-3 08	09.4603		
52	-2 48	32.0319	27	-3 08	44.0905		
53	-2 49	06.6621	28	-3 09	18.7208		
54	-2 49	41.2924	29	-3 09	53.3510		
55	-2 50	15.9226	30	-3 10	27.9812		

FIGURE 12.—Lambert projection tables for North Carolina—Continued.

Plane coordinates on Lambert projection

State North Carolina Station Allenby

ϕ = 35° 31′ 16.065 λ = 79° 09′ 39.910

Tabular difference of R for 1″ of ϕ = 101.09917

R (for min. of ϕ)		29,540,660.42	y′ (for min. of ϕ)		642,950.83
Cor. for sec. of ϕ		− 1,624.16	Cor. for sec. of ϕ		+ 1,624.16
R		29,539,036.26	y′		644,574.99
			y″ (=2R sin² $\frac{\theta}{2}$)		+ 38.89
θ (for min. of λ)		− 0° 05′ 11″.6722	y		644,613.88
Cor. for sec. of λ		− 23.0349			
θ		− 0 05 34.7071	$\frac{\theta}{2}$		° 02′ 47.35
θ″	For machine computation	− 334″.7071		For machine computation	
			log θ″		2.52466493 n
log θ″		2.52466493 n	colog 2		9.69897000-10
S for θ		4.68557468-10	S for $\frac{\theta}{2}$		4.68557482-10
log sin θ	sin θ	7.21023961-10 n	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	6.90920975-10 n
log R		7.47039632		R sin $\frac{\theta}{2}$	
log x′		4.68063593 n	log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	3.81841950-10
x′	R sin θ	− 47,933.15	log R		7.47039632
		2,000,000.00	log 2		0.30103000
x		1,952,066.85	log y″		1.58984582

x = 2,000,000.00 + R sin θ

y = y′ + 2R sin² $\frac{\theta}{2}$

y′ = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine

(see log tables)

R, y′, and θ are given in special tables

FIGURE 13.—Computation of coordinates for North Carolina.

Plane coordinates on Lambert projection

State North Carolina Station Sanford

ϕ = 35° 27′ 05.797 λ = 79° 10′ 25.744

Tabular difference of R for 1″ of ϕ = 101.09767

R (for min. of ϕ)		29,564,923.97	y′ (for min. of ϕ)		618,687.28
Cor. for sec. of ϕ		− 586.06	Cor. for sec. of ϕ		+ 586.06
R		29,564,337.91	y′		619,273.34
			y″ (=2R $\sin^2 \frac{\theta}{2}$)		+ 45.32
θ (for min. of λ)		− 0° 05′ 46.3025	y		619,318.66
Cor. for sec. of λ		− 14.8587			
θ		− 0 06 01.1612	$\frac{\theta}{2}$		0° 03′ 00.58
θ''	For machine computation	− 361″1612		For machine computation	
			log θ''		2.55770108 n
log θ''		2.55770108 n	colog 2		9.69897000 -10
S for θ		4.68557465-10	S for $\frac{\theta}{2}$		4.68557481 -10
log sin θ	sin θ	7.24327573-10 n	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	6.94224589 -10 n
log R		7.47076815		R sin $\frac{\theta}{2}$	
log x′		4.71404388 n	log $\sin^2 \frac{\theta}{2}$	R $\sin^2 \frac{\theta}{2}$	3.88449178 -10
x′	R sin θ	− 51,765.91	log R		7.47076815
		2,000,000.00	log 2		0.30103000
x		1,948,234.09	log y″		1.65628993

$x = 2{,}000{,}000.00 + R \sin \theta$

$y = y' + 2R \sin^2 \frac{\theta}{2}$

y' = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y', and θ are given in special tables

FIGURE 13.—*Computation of coordinates for North Carolina—Continued.*

Plane coordinates on Lambert projection

State North Carolina Station Cary

ϕ = 35° 46′ 57.345″ λ = 78° 46′ 53.441″

Tabular difference of R for 1″ of ϕ = 101.10667

R (for min. of ϕ)		29,449,668.14	y′ (for min. of ϕ)		733,943.11
Cor. for sec. of ϕ		− 5,797.96	Cor. for sec. of ϕ		+ 5,797.96
R		29,443,870.18	y′		739,741.07
			y″ (=2R sin² $\frac{\theta}{2}$)		+ 71.32
θ (for min. of λ)		+ 0° 08′ 04″.8234	y		739,812.39
Cor. for sec. of λ		− 30.8446			
θ		+ 0 07 33.9789	$\frac{\theta}{2}$		0° 03′ 46″.9894
θ''	For machine computation	"		For machine computation	
			log θ''		
log θ''			colog 2		9.69897000 -10
S for θ			S for $\frac{\theta}{2}$		
log sin θ	sin θ	0.0022009501	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	0.00110048
log R				R sin $\frac{\theta}{2}$	32402.4
log x′			log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	35.66
x′	R sin θ	+ 64,804.49	log R		
		2,000,000.00	log 2		0.30103000
x		2,064,804.49	log y″		

x = 2,000,000.00 + R sin θ

y = y′ + 2R sin² $\frac{\theta}{2}$

y′ = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y′, and θ are given in special tables

FIGURE 13.—Computation of coordinates for North Carolina—Continued.

Plane coordinates on Lambert projection

State North Carolina Station Raleigh

ϕ = 35° 46′ 36.998 λ = 78° 38′ 21.582

Tabular difference of R for 1″ of ϕ = 101.10667

R (for min. of ϕ)		29,449,668.14	y′ (for min. of ϕ)		733,943.11
Cor. for sec. of ϕ		− 3,740.74	Cor. for sec. of ϕ		+ 3,740.74
R		29,445,927.40	y′		737,683.85
			y″ (=2R sin² $\frac{\theta}{2}$)		+ 194.35
θ (for min. of λ)		+ 0° 12′ 41.″8654	y		737,878.20
Cor. for sec. of λ		− 12.4565			
θ		+ 0 12 29.4089	$\frac{\theta}{2}$		0 ° 06′ 14.″7044
θ″	For machine computation	″		For machine computation	
			log θ″		
log θ″			colog 2		9.69897000 -10
S for θ			S for $\frac{\theta}{2}$		
log sin θ	sin θ	0.0036332289	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	0.00181662
log R				R sin $\frac{\theta}{2}$	53,492.1
log x′			log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	97.175
x′	R sin θ	+ 106,983.79	log R		
		2,000,000.00	log 2		0.30103000
x		2,106,983.79	log y″		

x = 2,000,000.00 + R sin θ

y = y′ + 2R sin² $\frac{\theta}{2}$

y′ = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine

(see log tables)

R, y′, and θ are given in special tables

FIGURE 13.—Computation of coordinates for North Carolina—Continued.

Computation of Grid Azimuths

	x		y
Sanford	1,948,234.09		619,318.66
Allenby	1,952,066.85		644,613.88
	-3,832.76		-25,295.22
log Δ x	= 3.58351163	log Δ y	= 4.40303846
log Δ y	= 4.40303846	log sec. grid az.	= 0.00492904
log tan grid az.	= 9.18047317-10	log grid length in ft.	= 4.40796750
			0.51598417
Grid az. Allenby to Sanford	= 8° 36' 57.54"	log in meters	= 3.89198333
		Scale correction	= +515
		log approx. geodetic length in meters	= 3.8920348

	x		y
Raleigh	2,106,983.79		737,878.20
Cary	2,064,804.49		739,812.39
	42,179.30		- 1,934.19
log Δ y	= 3.28649913	log Δ x .	= 4.6250994
log Δ x	= 4.62509937	log cosec. grid az.	= 0.0004561
log cotan, grid az.	= 8.66139976-10	log grid length in ft.	= 4.6255555
			0.5159842
Grid az. Cary to Raleigh	= 272° 37' 31.94"	log grid length in m.	= 4.1095713
		Scale correction	= +369
		log approx. geodetic length in meters	= 4.1096082

FIGURE 14.—Computation of grid azimuths.

Starting now with the grid azimuth, Allenby-Sanford, the grid azimuths of the various lines of the traverse were computed by adding the angle at each station and by turning 180° for each back azimuth. On arriving at the fixed value, Cary–Raleigh, a discrepancy of −3".6 was found by subtracting the fixed value from the computed value. The computed value must then be increased by this amount by proportional corrections to the various angles. This gives the grid azimuths adjusted for azimuth closure. These values should then be used to compute the coordinates through the traverse.

Computation of grid azimuths

Traverse lines	Grid azimuths unadjusted			Correction for closure	Grid azimuths adjusted for closure	Traverse lines	Grid azimuths unadjusted			Correction for closure	Grid azimuths adjusted for closure
	°	′	″	″	″		°	′	″	″	″
Allenby-Sanford	8	36	57.5		57.5	Dot-Dos	229	45	20.2		21.9
	218	21	53.5	+0.1	53.6	Dos-Dot	49	45	20.2		21.9
Allenby-Osgood	226	58	51.0		51.1		169	54	49.8	+0.1	49.9
Osgood-Allenby	46	58	51.0		51.1	Dos-Dor	219	40	10.0		11.8
	132	14	43.1	+0.1	43.2	Dor-Dos	39	40	10.0		11.8
Osgood-Davis	179	13	34.1		34.3		169	53	29.2	+0.1	29.3
Davis-Osgood	359	13	34.1		34.3	Dor-Dop	209	33	39.2		41.1
	208	21	44.6	+0.1	44.7	Dop-Dor	29	33	39.2		41.1
Davis-Gibbons	207	35	18.7		19.0		235	53	08.5	+0.1	08.6
Gibbons-Davis	27	35	18.7		19.0	Dop-Don	265	26	47.7		49.7
	184	22	53.8	+0.1	53.9	Don-Dop	85	26	47.7		49.7
Gibbons-Esprey	211	58	12.5		12.9		162	05	28.0	+0.1	28.1
Esprey-Gibbons	31	58	12.5		12.9	Don-Baldwin	247	32	15.7		17.8
	163	46	10.2	+0.1	10.3	Baldwin-Don	67	32	15.7		17.8
Esprey-Farley	195	44	22.7		23.2		138	47	04.0	+0.1	04.1
Farley-Esprey	15	44	22.7		23.2	Baldwin-Apex	206	19	19.7		21.9
	195	43	53.2	+0.1	53.3	Apex-Baldwin	26	19	19.7		21.9
Farley-Dro	211	28	15.9		16.5		179	50	40.7	+0.1	40.8
Dro-Farley	31	28	15.9		16.5	Apex-Dom	206	10	00.4		02.7
	222	15	45.8	+0.1	45.9	Dom-Apex	26	10	00.4		02.7
Dro-Moncure	253	44	01.7		02.4		201	15	30.2	+0.1	30.3
Moncure-Dro	73	44	01.7		02.4	Dom-Dol	227	25	30.6		33.0
	216	03	49.9	+0.1	50.0	Dol-Dom	47	25	30.6		33.0
Moncure-Dri	289	47	51.6		52.4		202	06	49.4	+0.1	49.5
Dri-Moncure	109	47	51.6		52.4	Dol-Dok	249	32	20.0		22.5
	202	36	07.9	+0.1	08.0	Dok-Dol	69	32	20.0		22.5
Dri-Dre	312	23	59.5		60.4		163	49	24.7	+0.1	24.8
Dre-Dri	132	23	59.5		60.4	Dok-Doi	233	21	44.7		47.3
	158	56	13.1	+0.1	13.2	Doi-Dok	53	21	44.7		47.3
Dre-Dra	291	20	12.6		13.6		149	48	27.6	+0.2	27.8
Dra-Dre	111	20	12.6		13.6	Doi-Doh	203	10	12.3		15.1
	117	25	57.9	+0.1	58.0	Doh-Doi	23	10	12.3		15.1
Dra-Doz	228	46	10.5		11.6		208	34	13.3	+0.2	13.5
Doz-Dra	48	46	10.5		11.6	Doh-Dog	231	44	25.6		28.6
	154	08	43.7	+0.1	43.8	Dog-Doh	51	44	25.6		28.6
Doz-Doy	202	54	54.2		55.4		212	24	13.3	+0.2	13.5
Doy-Doz	22	54	54.2		55.4	Dog-Dof	264	08	38.9		42.1
	202	22	20.0	+0.1	20.1	Dof-Dog	84	08	38.9		42.1
Doy-Dox	225	17	14.2		15.5		231	01	52.2	+0.2	52.4
Dox-Doy	45	17	14.2		15.5	Dof-Cary	315	10	31.1		34.5
	191	10	05.5	+0.1	05.6	Cary-Dof	135	10	31.1		34.5
Dox-Dow	236	27	19.7		21.1		137	26	57.2	+0.2	57.4
Dow-Dox	56	27	19.7		21.1	Cary-Raleigh	272	37	28.3		31.9
	180	21	02.0	+0.1	02.1	Fixed value	272	37	31.9		
Dow-Dov	236	48	21.7		23.2						
Dov-Dow	56	48	21.7		23.2	Discrepancy			−3.6		
	188	28	29.2	+0.1	29.3						
Dov-Dot	245	16	50.9		52.5						
Dot-Dov	65	16	50.9		52.5						
	164	28	29.3	+0.1	29.4						

COMPUTATION OF COORDINATES

The sign of the functions to be used in the computation of the grid coordinates is determined by reckoning the grid azimuths from the north, that is 180° should be subtracted from those given in the above table. To tell whether to add or to subtract the grid increments, one needs only to remember in what quadrant one is working. Thus the third quadrant has both sine and cosine positive when one is reckoning from the south. Thus by counting from the north the signs follow the regular signs of the functions. It is possible to use the azimuths just as they are given if the sign is reversed in looking up the functions. Probably a less number of mistakes will be made if the signs are determined by the direction of progress. Eastward progress makes the sine positive and northward progress makes the cosine positive and vice versa. This procedure will make it easy for anyone to be sure about the sign of the functions.

It is best to make a list of the sines and cosines indicating their respective signs. If the calculation is to be made by machine, the natural function values should be listed each with its appropriate sign. If logarithms are to be used, it is best to indicate a negative value by a small "n" written after the logarithm. This means that the corresponding numerical value is negative and that the resulting Δx or Δy is to have the minus sign. Those values not so labeled are all to have the plus sign. Great care should be taken with this step, for an error made here will throw the whole computation off, and much correction will have to be made. With the list of sines and cosines can be included a list of the geodetic lengths, together with their reductions for the scale of the grid. Second-order traverses could probably be computed without this refinement but first-order work should take account of this element. An approximate correction for each length can be made as soon as the coordinates of the first station are reached and a better result after the coordinates of both ends of the line are known. It is sufficiently accurate to take a mean of the y values and interpolate in the table of y' values. A more accurate scale factor could be obtained if we knew the latitude of the two stations, but of course these are not known in this preliminary computation.

Natural sines and cosines of the adjusted grid azimuths when reckoned from north

Sines	Cosines	Geodetic length	Grid length	Sines	Cosines	Geodetic length	Grid length
		Feet	*Feet*			*Feet*	*Feet*
+0.73112585	+0.68224262	16,676.7	16,674.78	+0.90837138	+0.41816436	7,941.7	7,940.93
−0.01360505	+0.99990880	3,840.0	3,839.56	+0.76330107	+0.64604294	1,426.8	1,426.66
+0.46311987	+0.88629565	4,279.5	4,279.02	+0.63836412	+0.76973453	4,487.4	4,486.97
+0.52947886	+0.84832314	5,219.0	5,218.42	+0.49335623	+0.86982735	3,440.6	3,440.27
+0.27126873	+0.96250365	2,427.8	2,427.53	+0.99684452	+0.07937882	3,018.6	3,018.32
+0.52207066	+0.85290224	10,798.4	10,797.23	+0.92413499	+0.38206613	1,608.9	1,608.75
+0.95997168	+0.28009710	4,460.9	4,460.42	+0.44342712	+0.89631043	4,236.8	4,236.41
+0.94089325	−0.33870325	1,121.9	1,121.78	+0.44099553	+0.89750930	8,478.3	8,477.53
+0.73845403	−0.67430382	1,887.9	1,887.70	+0.73640220	+0.67654401	2,693.2	2,692.96
+0.93145575	−0.36385462	5,094.2	5,093.65	+0.93691391	+0.34956019	5,832.9	5,832.39
+0.75206864	+0.65908479	5,893.7	5,893.07	+0.80243373	+0.59674124	1,156.3	1,156.20
+0.38937136	+0.92108086	3,575.3	3,574.92	+0.39347442	+0.91933557	6,506.0	6,505.44
+0.71064771	+0.70304803	1,474.4	1,474.24	+0.78522267	+0.61921349	2,071.4	2,071.23
+0.83346038	+0.55257923	11,057.3	11,056.13	+0.99478329	+0.10201079	1,988.7	1,988.53
+0.83682590	+0.54746911	27,221.4	27,218.65	+0.70492828	−0.70927859	2,420.9	2,420.70

The lengths in feet as given by the previous adjustment were taken as the exact length. The values are found in Special Publication No. 101—Precise Triangulation, Traverse, and Leveling in North Carolina. The angles resulting from the azimuths in this publication were also used in computing the table of grid azimuths. In the region of the projection in which this traverse lies, the scale of the projection is too small. Accordingly, to work as accurately as possible, the scale correction was applied to the lengths before the x and y differences were computed. In the table giving the radii, scales, etc., the proper value to use for this correction can be found by taking the mean of the y's for the two ends of the line. For the line Allenby to Osgood the approximate mean for the y's is 650,302. From the table it is seen that the ratio factor for this y is 0.999885. The geodetic length multiplied by this factor gives the grid length. That is, a length of 16,674.78 feet on the grid represents a length on the earth of 16,676.7 feet. These grid lengths have been taken to hundredths so

as to hold the geodetic values to tenths as adopted from the previous adjustment. It may be objected that at first we have the y value for only one end of a line but a preliminary ratio value can be used at first and a more accurate value can be determined after the y coordinate for the other end has been computed.

In making this computation the whole traverse was computed with approximate values using some estimate for what the mean of the y's was going to be. Then after it was all carried through, the lengths were reduced more accurately and a change of only a few hundredths was found. This, of course, is the method for the most accurate work but the scheme is so simple that it can be easily applied in all work. In this way any discrepancies will be due to the work since the error of scale of the projection is practically eliminated. This grid length should then be used to multiply the sines and cosines of the azimuths to get the Δx's and Δy's.

If logarithms are being used in the computation, the procedure is also very simple.

$$\log 16{,}676.7 = 4.2221101$$

The scale error in the seventh place of logarithms for this line is given in the table as -500. Therefore the log of the grid length is found by adding this quantity algebraically to the last places of the log above.

$$\begin{array}{r} 4.2221101 \\ -500 \\ \hline 4.2220601 \end{array}$$

This value is found to be the log of 16,674.78 which is the same value that has already been found by use of the ratio. If the problem were the reverse; that is if a length were determined from the difference of the coordinates of two points on the grid the procedure would be reversed. We should have to subtract algebraically the log correction, or divide by the scale expressed as a ratio. We should then want to start with the grid length 16,674.78 and obtain the geodetic length of 16,676.7. The process is reversed as it is evident that it should be. Since this is a precise traverse, the work needs to be computed as accurately as possible. For that reason these refinements have been applied. However the scheme is so simple of application that it might just as well be applied in all cases so as to get the best possible result out of the work.

Now starting with the plane coordinates of Allenby the Δx and the Δy of Allenby to Osgood are found by multiplying this grid length of 16,674.78 by the sine and the cosine of the azimuth given in the table.

$$\Delta x = 16{,}674.78 \times 0.73112585 = 12{,}191.36$$
$$\Delta y = 16{,}674.78 \times 0.68224262 = 11{,}376.25$$

This result is to be added or subtracted according to the sign of the given function. In this case both quantities are to be added. These added respectively to the x and y of Allenby give the preliminary x and y of Osgood. These results are now tabulated to show the further procedure.

Computation and adjustment of the coordinates

Station	*x* coordinate			*y* coordinate		
	Uncorrected	Correction for closure	Corrected (final figures)	Uncorrected	Correction for closure	Corrected (final figures)
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
Allenby (fixed by triangulation)	1,952,066.85 +12,191.36			644,613.88 +11,376.25		
Osgood	1,964,258.21 −51.85	−0.42	7.79	655,990.13 +3,839.21	+0.20	0.33
Davis	1,964,206.36 +1,981.70	−.52	5.84	659,829.34 +3,792.48	+.24	.58
Gibbons	1,966,188.06 +2,763.04	−.63	7.43	663,621.82 +4,426.91	+.29	2.11
Esprey	1,968,951.10 +658.51	−.76	.34	668,048.73 +2,336.51	+.36	9.09
Farley	1,969,609.61 +5,636.92	−.82	8.79	670,385.24 +9,208.98	+.39	.63
Dro	1,975,246.53 +4,281.88	−1.09	5.44	679,594.22 +1,249.35	+.51	.73
Moncure	1,979,528.41 +1,055.48	−1.21	7.20	680,843.57 −379.95	+.57	4.14
Dri	1,980,583.89 +1,393.98	−1.24	2.65	680,463.62 −1,272.88	+.58	4.20
Dre	1,981,977.87 +4,744.51	−1.28	6.59	679,190.74 −1,853.35	+.60	1.34
Dra	1,986,722.38 +4,431.99	−1.41	.97	677,337.39 +3,884.03	+.66	8.05
Doz	1,991,154.37 +1,391.97	−1.56	2.81	681,221.42 +3,292.79	+.73	2.15
Doy	1,992,546.34 +1,047.67	−1.65	4.69	684,514.21 +1,037.20	+.78	.99
Dox	1,993,594.01 +9,214.85	−1.69	2.32	685,551.41 +6,109.39	+.79	2.20
Dow	2,002,808.86 +22,777.27	−1.97	6.89	691,660.80 +14,901.37	+.93	1.73
Dov	2,025,586.13 +7,213.31	−2.66	3.47	706,562.17 +3,320.61	+1.25	3.42
Dot	2,032,799.44 +1,088.97	−2.86	6.58	709,882.78 +921.68	+1.34	4.12
Dos	2,033,888.41 +2,864.32	−2.90	5.51	710,804.46 +3,453.78	+1.36	5.82
Dor	2,036,752.73 +1,697.28	−3.01	49.72	714,258.24 +2,992.44	+1.41	9.65
Dop	2,038,450.01 +3,008.80	−3.10	46.91	717,250.68 +239.59	+1.45	2.13
Don	2,041,458.81 +1,486.70	−3.17	5.64	717,490.27 +614.65	+1.49	1.76
Baldwin	2,042,945.51 +1,878.54	−3.21	2.30	718,104.92 +3,797.14	+1.51	6.43
Apex	2,044,824.05 +3,738.55	−3.32	0.73	721,902.06 +7,608.66	+1.56	3.62
Dom	2,048,562.60 +1,983.10	−3.54	59.06	729,510.72 +1,821.91	+1.66	2.38
Dol	2,050,545.70 +5,464.45	−3.60	2.10	731,332.63 +2,038.77	+1.69	4.32

Computation and adjustment of the coordinates—Continued

Station	x coordinate			y coordinate		
	Uncorrected	Correction for closure	Corrected (final figures)	Uncorrected	Corrected for closure	Corrected (final figures)
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
Dok	2,056,010.15 +927.77	−3.75	06.40	733,371.40 +689.95	+1.76	3.16
Doi	2,056,937.92 +2,559.72	−3.78	4.14	734,061.35 +5,980.68	+1.78	3.13
Doh	2,059,497.64 +1,626.38	−3.95	3.69	740,042.03 +1,282.53	+1.85	3.88
Dog	2,061,124.02 +1,978.16	−4.00	0.02	741,324.56 +202.85	+1.88	6.44
Dof	2,063,102.18 +1,706.42	−4.05	098.13	741,527.41 −1,716.95	+1.90	9.31
Cary	2,064,808.60	−4.11	4.49	739,810.46	+1.93	2.39
Fixed value	2,064,804.49			739,812.39		
Discrepancy	+4.11			−1.93		

The x-coordinate for Cary came out 4.11 feet too large as computed through the traverse and the y-coordinate was too small by 1.93 feet. These are the amounts that have to be distributed throughout the traverse. To accomplish this, the lengths were added through the traverse and at each station an amount of the whole discrepancy was applied that was in proportion of the accumulated length to the whole length. The figures are the following:

Accumulated lengths

Station	Accumulated length	Station	Accumulated length	Station	Accumulated length
	Feet		*Feet*		*Feet*
Osgood	16,676.7 3,840.0	Doz	61,700.0 3,575.3	Baldwin	126,952.4 4,236.8
Davis	20,516.7 4,279.5	Doy	65,275.3 1,474.4	Apex	131,189.2 8,478.3
Gibbons	24,796.2 5,219.0	Dox	66,749.7 11,057.3	Dom	139,667.5 2,693.2
Esprey	30,015.2 2,427.8	Dow	77,807.0 27,221.4	Dol	142,360.7 5,832.9
Farley	32,443.0 10,798.4	Dov	105,028.4 7,941.7	Dok	148,193.6 1,156.3
Dro	43,241.4 4,460.9	Dot	112,970.1 1,426.8	Doi	149,349.9 6,506.0
Moncure	47,702.3 1,121.9	Dos	114,396.9 4,487.4	Doh	155,855.9 2,071.4
Dri	48,824.2 1,887.9	Dor	118,884.3 3,440.6	Dog	157,927.3 1,988.7
Dre	50,712.1 5,094.2	Dop	122,324.9 3,018.6	Dof	159,916.0 2,420.9
Dra	55,806.3 5,893.7	Don	125,343.5 1,608.9	Cary	162,336.9
Doz	61,700.0	Baldwin	126,952.4		

The discrepancy in each case was then divided by 162,336.9 and this number set on the multiplying machine and multiplied successively by the number of feet distance from Allenby as shown by the above table. These values have then been applied to the coordinates with the resultant final figures shown.

Final grid coordinates

Station	Coordinates, x and y	Station	Coordinates, x and y	Station	Coordinates, x and y
	Feet		*Feet*		*Feet*
Sanford	1, 948, 234. 09 619, 318. 66	Dos	2, 033, 885. 51 710, 805. 82	Doz	1, 991, 152. 81 681, 222. 15
Allenby	1, 952, 066. 85 644, 613. 88	Dor	2, 036, 749. 72 714, 259. 65	Doy	1, 992, 544. 69 684, 514. 99
Osgood	1, 964, 257. 79 655, 990. 33	Dop	2, 038, 446. 91 717, 252. 13	Dom	2, 048, 559. 06 729, 512. 38
Davis	1, 964, 205. 84 659, 829. 58	Don	2, 041, 455. 64 717, 491. 76	Dol	2, 050, 542. 10 731, 334. 32
Gibbons	1, 966, 187. 43 663, 622. 11	Baldwin	2, 042, 942. 30 718, 106. 43	Dok	2, 056, 006. 40 733, 373. 16
Esprey	1, 968, 950. 34 668, 049. 09	Apex	2, 044, 820. 73 721, 903. 62	Doi	2, 056, 934. 14 734, 063. 13
Farley	1, 969, 608. 79 670, 385. 63	Dro	1, 975, 245. 44 679, 594. 73	Doh	2, 059, 493. 69 740, 043. 88
Dox	1, 993, 592. 32 685, 552. 20	Moncure	1, 979, 527. 20 680, 844. 14	Dog	2, 061, 120. 02 741, 326. 44
Dow	2, 002, 806. 89 691, 661. 73	Dri	1, 980, 582. 65 680, 464. 20	Dof	2, 063, 098. 13 741, 529. 31
Dov	2, 025, 583. 47 706, 563. 42	Dre	1, 981, 976. 59 679, 191. 34	Cary	2, 064, 804. 49 739, 812. 39
Dot	2, 032, 796. 58 709, 884. 12	Dra	1, 986, 720. 97 677, 338. 05	Raleigh	2, 106, 983. 79 737, 878. 20

COMPUTATION OF ADJUSTED GRID AZIMUTH

The preceding table gives the adjusted grid coordinates for the stations between Allenby and Cary, including Sanford and Raleigh, which were fixed by connection with triangulation. If the grid azimuth of any of the lines is needed, it must be computed from these adjusted coordinates since it will differ slightly from the value given in the table. We will take as an example the line Dow to Dov.

Azimuth computation

	x (*Feet*)	y (*Feet*)
Dov	2, 025, 583. 47	706, 563. 42
Dow	2, 002, 806. 89	691, 661. 73
	+22, 776. 58	+14, 901. 69

log Δx	= 4. 35748851
log Δy	= 4. 17323553
log tan grid azimuth	= 0. 18425298

Grid azimuth reckoned from north = 56° 48′ 18″.30
Grid azimuth reckoned from south = 236° 48′ 18″.30

log Δx	= 4. 35748851
log cosec grid azimuth	= 0. 07737164
log grid length	= 4. 43486015
log Δy	= 4. 17323553
log sec grid azimuth	= 0. 26162462
log grid length	= 4. 43486015

COMPUTATION OF GEOGRAPHIC POSITIONS FROM COORDINATES

As an example we will now compute the geodetic positions of each of these stations from their grid coordinates.

$$y' = R_{33°45'} - R$$

$$y = R_{33°45'} - R + 2R\sin^2\frac{\theta}{2}$$

$$= R_{33°45'} - R + R(1-\cos\theta)$$

$$= R_{33°45'} - R\cos\theta$$

Hence

$$R\cos\theta = R_{33°45'} - y$$

$$R\sin\theta = x - 2{,}000{,}000$$

$$\tan\theta = \frac{x-2{,}000{,}000}{R_{33°45'}-y}$$

$$R_{33°45'} = 30{,}183{,}611.25$$

For station Dov

$$\tan\theta = \frac{2{,}025{,}583.47 - 2{,}000{,}000}{30{,}183{,}611.25 - 706{,}563.42}$$

$$= \frac{25{,}583.47}{29{,}477{,}047.83}$$

$$\log 25{,}583.47 = 4.40795945$$
$$\log 29{,}477{,}047.83 = 7.46948398$$

$$\log\tan\theta = 6.93847547 - 10$$
$$T = 4.68557498 - 10$$

$$\log\theta = 2.25290049 \quad (\theta \text{ in seconds})$$
$$\text{colog } l = 0.23869567$$

$$\log\Delta\lambda = 2.49159616 \quad (\Delta\lambda \text{ in seconds})$$
$$\Delta\lambda = 310''.1674$$

Hence the longitude is 5′10″.1674 east of the seventy-ninth meridian.

$$79°00'00''.0000$$
$$-5\ 10.1674$$

Longitude of station Dov = 78°54′49″.8326

To determine the latitude we must compute the intersection of the parallel with the central meridian; that is, we must compute an approximate R and from that $2R\sin^2\frac{\theta}{2}$ and subtract this value from y. If we used enough places in the computation of R, this value in itself would be sufficient; but, if R is to be correct to the hundredths decimal, at least 10 places would be required in the computation. A much smaller number of figures is needed for the computation of $2R\sin^2\frac{\theta}{2}$.

$\log \theta$	$=2.25290049$ (θ in seconds)
colog 2	$=9.69897000-10$
$\log \frac{\theta}{2}$	$=1.95187049$
S	$=4.68557485-10$
$\log \sin \frac{\theta}{2}$	$=6.63744534-10$
$\log \sin^2 \frac{\theta}{2}$	$=3.27489068-10$
θ	$=2'\ 59''.02$
log 29,477,047.83	$=7.46948398$
log sec θ	$=0.00000016$
$\log R$	$=7.46948414$
log 2	$=0.30103000$
$\log \sin^2 \frac{\theta}{2}$	$=3.27489068-10$
$\log \left(2R \sin^2 \frac{\theta}{2}\right)$	$=1.04540482$
$2R \sin^2 \frac{\theta}{2}$	$=11.10$
y	$=706,563.42$
$2R \sin^2 \frac{\theta}{2}$	$=11.10$
y'	$=706,552.32$
y' for 35°41′	$=703,611.62$
	$2,940.70$

Seconds of ϕ $=\frac{2,940.70}{101.10383}=29''.0859$

ϕ of Dov$=35°41'29''.0859$
λ of Dov$=78\ 54\ 49.8326$

Now we will make a similar computation for station Dow.

$$\tan \theta = \frac{2,002,806.89-2,000,000}{30,183,611.25-691,661.73}$$

$$= \frac{2,806.89}{29,491,949.52}$$

log 2,806.89	=3. 44822539
log 29,491,949.52	=7. 46970349
log tan θ	=5. 97852190−10
T	=4. 68557487−10
log θ	=1. 29294703 (θ in seconds)
colog l	=0. 23869567
log $\Delta\lambda$	=1. 53164270 ($\Delta\lambda$ in seconds)
θ	= 19″63
$\Delta\lambda$	= 34″0128
	79°00′00″0000
	−34. 0128
λ of Dow	=78 59 25. 9872
log θ	=1. 29294703 (θ in seconds)
colog 2	=9. 69897000−10
log $\frac{\theta}{2}$	=0. 99191703 (θ in seconds)
S	=4. 68557487−10
log $\sin\frac{\theta}{2}$	=5. 67749190−10
log $\sin^2\frac{\theta}{2}$	=1. 35498380−10
log 29,491,949.52	=7. 46970349
log sec θ	=0. 00000000
log R	=7. 46970349
log 2	=0. 30103000
log $\sin^2\frac{\theta}{2}$	=1. 35498380−10
$\log\left(2R\sin^2\frac{\theta}{2}\right)$	=9. 12571729−10
$2R\sin^2\frac{\theta}{2}$	= 0. 13
y	=691, 661. 73
$2R\sin^2\frac{\theta}{2}$	= 0. 13
y'	=691, 661. 60
y' for 35°39′	=691, 479. 23
	182. 37
Seconds of ϕ	$=\frac{182.37}{101.10300}$=01″8038
ϕ of Dow	=35°39′01″8038
λ of Dow	=78 59 25.9872

To get the geodetic length and azimuth of the line Dow to Dov, we will take their geodetic positions and make an inverse-position computation. Then we shall show that practically the same values could have been obtained from the grid azimuth and distance. In order to make the computations of the same degree of accuracy, the

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 662
Rev. April, 1921

INVERSE POSITION COMPUTATION

$$s_1 \sin\left(\alpha+\frac{\Delta\alpha}{2}\right)=\frac{\Delta\lambda_1 \cos\phi_m}{A_m}$$

$$s_1 \cos\left(\alpha+\frac{\Delta\alpha}{2}\right)=\frac{-\Delta\phi_1 \cos\frac{\Delta\lambda}{2}}{B_m}$$

$$-\Delta\alpha=\Delta\lambda \sin\phi_m \sec\frac{\Delta\phi}{2}+F(\Delta\lambda)^3$$

In which $\log \Delta\lambda_1=\log(\lambda'-\lambda)-$correction for arc to sin*; $\log \Delta\phi_1=\log(\phi'-\phi)-$correction for arc to sin*; and $\log s=\log s_1+$ correction for arc to sin*.

NAME OF STATION

1. ϕ	35°	39′	01.8038	Dow λ	78°	59′	25.9872
2. ϕ'	35	41	29.0859	Dov λ'	78	54	49.8326
$\Delta\phi\ (=\phi'-\phi)$	+	2	27.2821	$\Delta\lambda\ (=\lambda'-\lambda)$	−	4	36.1546
$\frac{\Delta\phi}{2}$		1	13.64	$\frac{\Delta\lambda}{2}$		2	18.08
$\phi_m\left(=\phi+\frac{\Delta\phi}{2}\right)$	35	40	15.445				
$\Delta\phi$ (secs.)	+	147.″	2821	$\Delta\lambda$ (secs.)	−	276.″	1546

$\log \Delta\phi$	2.1681500			$\log \Delta\lambda$	2.4411523	
corr. arc→sin	− 0			corr. arc→sin	− 0	
$\log \Delta\phi_1$	2.1681500			$\log \Delta\lambda_1$	2.4411523	
$\log \cos\frac{\Delta\lambda}{2}$	9.9999999			$\log \cos\phi_m$	9.9097588	
$\operatorname{colog} B_m$	1.4888249			$\operatorname{colog} A_m$	1.4907738	
$\log\left\{s_1 \cos\left(\alpha+\frac{\Delta\alpha}{2}\right)\right\}$	3.6569748		(opposite in sign to $\Delta\phi$)	$\log\left\{s_1 \sin\left(\alpha+\frac{\Delta\alpha}{2}\right)\right\}$	3.8416849	
				$\log\left\{s_1 \cos\left(\alpha+\frac{\Delta\alpha}{2}\right)\right\}$	3.6569748	
$\log \Delta\lambda$	2.4411523	3 $\log \Delta\lambda$		$\log \tan\left(\alpha+\frac{\Delta\alpha}{2}\right)$	0.1847101	
$\log \sin\phi_m$	9.7657650	$\log F$		$\alpha+\frac{\Delta\alpha}{2}$	236° 49′	57.″74
$\log \sec\frac{\Delta\phi}{2}$	0	$\log b$		$\log \sin\left(\alpha+\frac{\Delta\alpha}{2}\right)$	9.9227653	
$\log a$	2.2069173			$\log \cos\left(\alpha+\frac{\Delta\alpha}{2}\right)$	9.7380552	
a	− 161.03			$\log s_1$	3.9189196	
b	0			corr. arc→sin	+ 0	
$-\Delta\alpha$ (secs.)	− 161.″03			$\log s$	3.9189196	
$-\frac{\Delta\alpha}{2}$	− 80.″52					
	− ° 1′	20.″52				
$\alpha+\frac{\Delta\alpha}{2}$	236 49	57.74				
α (1 to 2)	236 48	37.22				
$\Delta\alpha$	+ 2	41.03				
	180					
α' (2 to 1)	56 51	18.25				

*Use the table on the back of this form for correction of arc to sin.

NOTE.—For log s up to 4.52 and for $\Delta\phi$ or $\Delta\lambda$ (or both) up to 10′, omit all terms below the heavy line except those printed (in whole or in part) in heavy type or those underscored, if using logarithms to 6 decimal places.

FIGURE 15.—Inverse position computation, North Carolina.

geodetic positions have been computed to four places of decimals. The third place in position corresponds roughly to tenths of feet and the fourth place to hundredths. Hence to obtain a complete check it is necessary to make use of the fourth decimal in the position

although the Coast and Geodetic Survey in listing positions carries only three places of decimals.

The log of the grid length in feet has been found to be 4.4348602.

Log grid length in feet	=4.4348602
Log reduction	=0.5159842
Log grid length in meters	=3.9188760
Correction for scale	=+437
Log geodetic length	=3.9189197

This differs but one unit in the seventh place from the value found by the inverse-position computation. Since the inverse computation was made with seven-place logarithms, this is as close a check as could be expected.

	°	′	″
Grid azimuth Dow–Dov	=236	48	18.30
θ at Dow	=	+	19.64
Approximate geodetic azimuth	=236	48	37.94

To this we must add algebraically a correction computed by the formula:

$$\text{Cor.} = -\frac{x_2 - x_1}{2\rho_0^2 \sin 1''}\left(y_1 - y_0 + \frac{y_2 - y_1}{3}\right)$$

$x_2 - x_1 = 22{,}776.58 = \Delta x$
$\log \Delta x = 4.357489$
$y_0 = 546{,}552$ (a constant)
$y_1 = 691{,}662$
$y_1 - y_0 = 145{,}110$
$\frac{y_2 - y_1}{3} = 4{,}967$
$150{,}077$
$\log 150{,}077 = 5.176314$
$\log \left(\frac{1}{2\rho_0^2 \sin 1''}\right) = 0.3730186 - 10$ (a constant)

	4.357489
	5.176314
	0.373019−10
log correction	=9.906812n−10
Correction	= −0.81

Approximate geodetic azimuth	=236°	48′	37.″94
Correction	=		− 0.81
Geodetic azimuth resulting from grid computation	=236	48	37.13

This value differs only 0.″09 from that obtained from the inverse computation. The formula for this correction is an approximate one

so the check is probably as close as could be expected. It is certainly sufficient for any practical application.

Thus we have given samples of the various computations for traverse that may arise in using the grid in the calculation of surveys. None of the computations are long or difficult. After a little experience they could be carried through easily and accurately by one who is familiar with the use of tables.

SCALE FACTORS

In all of the tables, the scale factors are given as they must be applied to reduce geodetic lengths to grid lengths. In case of reduction from grid length to geodetic length the scale in the seventh place of logs must be subtracted from the log of the grid length, or, if the scale expressed as a ratio is used, the grid length must be divided by it to give the geodetic length. With the log correction the same result is obtained by simply changing the sign when the reduction is to be made from the grid to the geodetic value.

In computing the scale for any given line it is best to take the mean of the various tabular values for the length of the line. Each tabular value can be interpreted as extending from the half interval below to the half interval above the particular value for which it is given. It is probably sufficiently accurate to take the nearest tenth of an interval. That is, for the Lambert system, take the nearest tenth of a minute for the latitude of the station. On the transverse Mercator the nearest 500 feet will be exact enough.

As an example let us suppose we have a line in South Carolina—South with the end points in latitude 33°31.′1 and 33°45.′2, respectively. The tabular value for 33°31′ is −117.1. This value can be considered as extending to 33°31.′5 or 0.4 of an interval.

Computation of mean scale factor, Lambert grid

Interval	Scale factor (7th decimal place of logs)
0.4 (31.′1 to 31.′5)	−46.8 (−117.1×0.4)
1.0 (31.′5 to 32.′5)	−105.6
1.0	−93.7
1.0	−81.4
1.0	−68.7
1.0	−55.7
1.0	−42.3
1.0	−28.6
1.0	−14.5
1.0	0.0
1.0	+14.9
1.0	+30.1
1.0	+45.7
1.0	+61.6
0.7 (44.′5 to 45.′2)	+54.5 (+77.9×0.7)
14.1	−330.5

$$\text{Mean value} = \frac{-330.5}{14.1} = -23.4$$

In working with a traverse for which the positions are not known, either the approximate latitude can be determined from a topographic map, or, if near the central meridian, the y values can be used as if

they were y' values and these used in the table for interpolation. In most cases the beginning and end of a traverse will be known in latitude, and this can be used as a guide. The most exact value for the scale factor does not have to be determined since an approximate one is better to be used than none at all. These directions should be sufficient for the use of the Lambert projection.

With the transverse Mercator projection it should be borne in mind that the scale changes equally in both directions from the central meridian. In case a line crosses the central meridian the values should be taken upward in the table to the zero value which corresponds to the central meridian and then downward in the table for the remainder of the line.

Let us suppose that we have a line in Georgia beginning at $x'=+46{,}500$ to the nearest 500 feet approximation, and ending at $x'=-21{,}000$ to the same approximation. The value given for 45,000 is −424.2 and this can be considered as extending from 42,500 to 47,500. But from 42,500 to 46,500 is 4,000 or 0.8 interval.

Computation of mean scale factor, transverse Mercator grid

Interval	Scale factor (7th decimal place of logs)
0.8 (46,500 to 42,500)	−339.4 (−424.2×0.8)
1.0	−426.3
1.0	−428.2
1.0	−429.2
1.0	−431.2
1.0	−432.3
1.0	−433.2
1.0	−433.8
1.0	−434.2
1.0	−434.3 (Central meridian)
1.0	−434.2
1.0	−433.8
1.0	−433.2
0.7 (−17,500 to −21,000)	−302.6 (−432.3×0.7)
13.5	−5,825.9

$$\text{Mean value}=\frac{-5{,}825.9}{13.5}=-431.5$$

The two illustrative examples should indicate clearly a reasonable method for the determination of the scale factor in either of the systems of projection. Reference was made to particular tables but similar computations could be made for any one of the State tables by a simple change of the figures to correspond to the tables desired. The examples should, therefore, be sufficient to indicate a method that will be applicable in all cases.

ADJUSTMENT OF SECOND-ORDER TRIANGULATION BY VARIATION OF PLANE COORDINATES

Computations of surveys by means of plane coordinates will in most cases be applied to traverse rather than to triangulation, because most work of second and third order will consist of traverse lines between stations fixed by triangulation. However it was thought best to include a small adjustment of triangulation to serve as a sample for those who may wish to make such computations.

DERIVATION OF EQUATIONS

With plane coordinates the azimuth of a line is given by the relation,

$$\tan \alpha = \frac{x_2 - x_1}{y_2 - y_1}$$

or

$$\alpha = \tan^{-1}\left(\frac{x_2 - x_1}{y_2 - y_1}\right).$$

Hence

$$d\alpha = \frac{d\left(\frac{x_2 - x_1}{y_2 - y_1}\right)}{1 + \left(\frac{x_2 - x_1}{y_2 - y_1}\right)^2}$$

$$d\alpha = \frac{\frac{(y_2 - y_1)(dx_2 - dx_1) - (x_2 - x_1)(dy_2 - dy_1)}{(y_2 - y_1)^2}}{1 + \left(\frac{x_2 - x_1}{y_2 - y_1}\right)^2}$$

$$= \frac{(y_2 - y_1)(dx_2 - dx_1) - (x_2 - x_1)(dy_2 - dy_1)}{(y_2 - y_1)^2 + (x_2 - x_1)^2}$$

If s denotes the length of the line, we have

$$s^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2$$
$$x_2 - x_1 = s \sin \alpha$$
$$y_2 - y_1 = s \cos \alpha$$

Substituting these values, we get

$$d\alpha = \frac{\cos \alpha}{s}(dx_2 - dx_1) - \frac{\sin \alpha}{s}(dy_2 - dy_1)$$

Since we wish $d\alpha$ to be expressed in seconds, we must divide the second member by the arc of 1 second, or to a sufficient approximation by the sine of 1 second. Also it is better in these computations to denote the variation of the coordinates by the symbol Δ rather than by the letter d. Thus our equation becomes

$$\Delta\alpha(\text{in seconds}) = \frac{\cos \alpha}{s \sin 1''}(\Delta x_2 - \Delta x_1) - \frac{\sin \alpha}{s \sin 1''}(\Delta y_2 - \Delta y_1)$$

An angle is equal to the difference of two azimuths, so we must form our equations in accordance with this fact.

Let us take a triangle denoting the vertices by letters as shown in figure 16.

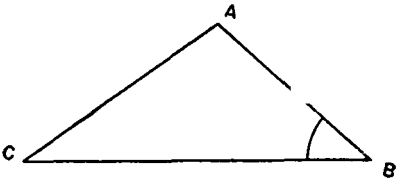


FIGURE 16.—Triangle illustrating formation of equation.

Let B be the angle under consideration; then the direction BA with the azimuth α will have the correction $\Delta\alpha$.

$$\Delta\alpha=\frac{\cos\alpha}{s\sin 1''}(\Delta x_A-\Delta x_B)-\frac{\sin\alpha}{s\sin 1''}(\Delta y_A-\Delta y_B).$$

Similarly the direction BC with the azimuth α' will have the correction $\Delta\alpha'$

$$\Delta\alpha'=\frac{\cos\alpha'}{s'\sin 1''}(\Delta x_C-\Delta x_B)-\frac{\sin\alpha'}{s'\sin 1''}(\Delta y_C-\Delta y_B).$$

Now the angle B is equal to $\alpha-\alpha'$
Azimuth of

$$BA=\alpha+\frac{\cos\alpha}{s\sin 1''}(\Delta x_A-\Delta x_B)-\frac{\sin\alpha}{s\sin 1''}(\Delta y_A-\Delta y_B)$$

Azimuth of

$$BC=\alpha'+\frac{\cos\alpha'}{s'\sin 1''}(\Delta x_C-\Delta x_B)-\frac{\sin\alpha'}{s'\sin 1''}(\Delta y_C-\Delta y_B)$$

$$\angle B=\alpha-\alpha'+\frac{\cos\alpha}{s\sin 1''}(\Delta x_A-\Delta x_B)-\frac{\sin\alpha}{s\sin 1''}(\Delta y_A-\Delta y_B)$$

$$-\frac{\cos\alpha'}{s'\sin 1''}(\Delta x_C-\Delta x_B)+\frac{\sin\alpha'}{s'\sin 1''}(\Delta y_C-\Delta y_B)$$

By subtracting from this the observed value of $\angle B$ and equating the result to the given v, we get the observation equation required.

A set of assumed coordinates have to be computed for all of the stations. The fixed stations also have the final or fixed coordinates. All of the observed independent angles are then numbered as is shown in figure 20. Before the computed azimuths are used they must be corrected for the correction term by subtracting it from the grid

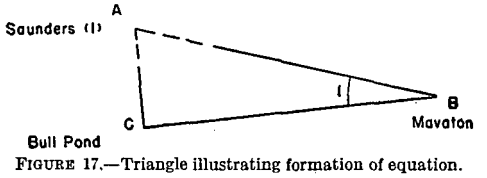


FIGURE 17.—Triangle illustrating formation of equation.

azimuth. Another method of handling the problem is to *add* the same value to the observed direction before the angle is taken out from the list. All of these corrections that apply to a given triangle have to add up to the spherical excess of the triangle. After they are computed they must be tested for this and the final values adopted so that they will sum up to the spherical excess.

In geodetic work azimuths are reckoned clockwise from the south but when the plane coordinates are used they have to be considered as reckoned from the north to be consistent with the adopted system.

In taking out the sine and cosine it is only necessary to give the opposite sign to each of the functions to what they would be when taken directly from the table. This is an easier way to handle the matter than to add or subtract 180° from each of the azimuths as given. The computation of the azimuths from the assumed coordinates of the stations as also the computation and subtraction of the correction term are given on pages 73 to 84 inclusive.

We shall now give some samples of the formation of the observation equations for the angles. Take the triangle Saunders–Mavaton–Bull Pond with the angle no. 1 at Mavaton. Bull Pond and Mavaton are fixed and cannot vary. So Saunders is the only point that can vary. This station has the coordinates x_1, y_1 with the variations Δx_1 and Δy_1. Now label the triangle ABC in a clockwise direction with B at the angle in question so as to agree with the form of the equation as already given (p. 62). We thus see that the variable station is the A station. The coefficients are computed on page 87. The azimuth of the line B to A is 105°+. The cosine of this angle would be minus and the sine plus. By changing the signs as explained above the coefficient for the x part becomes plus and that for the y part minus.

Corrected α's:

	°	′	″
Mavaton to Saunders	105	10	01. 6
Mavaton to Bull Pond	86	25	35. 3
∠ Bull Pond–Saunders	18	44	26. 3
Observed ∠	18	44	26. 1
			+ 0. 2

The coefficients computed for the line BA are $+1.54$ and -5.69 as given on page 87. From the figure we see that this applies to the A vertex. For this angle the B and C variations are zero since the coordinates at these stations are fixed. From the general equation it is seen that the coefficient of Δx_A is plus the computed value while that of Δy_A is minus the computed value. Accordingly, the equation becomes

$$v_1 = +0.2 + 1.54\Delta x_1 + 5.69\Delta y_1.$$

As a further illustration we will take the case of an angle that has two variable stations.

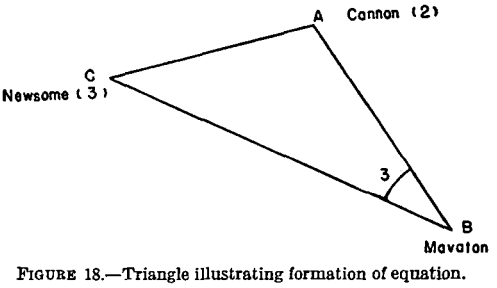


FIGURE 18.—Triangle illustrating formation of equation.

In the triangle Cannon–Mavaton–Newsome, the station Mavaton is fixed. Letter the vertices as before with B as the angle under consideration.

Corrected α's:

	°	′	″
Mavaton to Cannon	164	55	33.3
Mavaton to Newsome	129	31	31.1
∠ Newsome–Cannon	35	24	02.2
Observed ∠	35	24	08.6
			−6.4

The coefficients computed for BA are $+5.53$ and -1.49 and for BC are $+2.71$ and -3.28 as given on page 87. Now we have the A angle and the C angle subject to variation with the B values equal to zero. The signs to apply to the coefficients are plus and minus for the A angle and minus and plus for the C angle. Accordingly we have

$$v_3 = -6.4 + 5.53\Delta x_2 + 1.49\Delta y_2 - 2.71\Delta x_3 - 3.28\Delta y_3.$$

Finally we will take the case of an angle that has all three stations variable. In the triangle Mason–Cannon–Newsome we have all

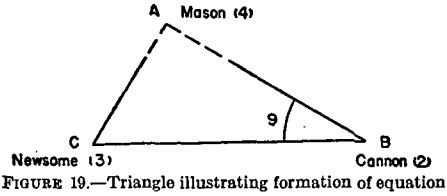


FIGURE 19.—Triangle illustrating formation of equation.

vertices variable. We letter the angle ABC with B at the vertex of the angle in question.

Corrected α's:

	°	′	″
Cannon to Mason	121	52	38.9
Cannon to Newsome	82	05	26.7
∠ Newsome–Mason	39	47	12.2
Observed ∠	39	47	12.3
			−0.1

The computed coefficients for BA are $+3.52$ and -5.67 and for BC they are -1.00 and -7.21 as given on page 88. It is convenient in practice to arrange the general equation in the following form:

$+\Delta x_A$	$-\Delta y_A$	$-\Delta x_C$	$+\Delta x_C$
$-\Delta x_B$	$+\Delta y_B$	$+\Delta x_B$	$-\Delta y_B$

The signs before the Δ's indicate the ones to be applied to the computed coefficients. This scheme makes it possible to write out the observation equation with little mental effort. This tabulation copied on a slip of paper and placed immediately beneath the list of coefficients makes it possible to write down the equation for any angle. Arranged that way in this instance we should have

$+3.52$	-5.67	-1.00	-7.21
$+\Delta x_A$	$-\Delta y_A$	$-\Delta x_C$	$+\Delta y_C$
$-\Delta x_B$	$+\Delta y_B$	$+\Delta x_B$	$-\Delta y_B$

Hence we get, since $B=2$, $C=3$, and $A=4$,

$$v_9 = -0.1 - 4.52\Delta x_2 + 1.54\Delta y_2 + 1.00\Delta x_3 - 7.21\Delta y_3 + 3.52\Delta x_4 + 5.67\Delta y_4$$

This should be sufficient description of the method of formation of the equations for the v's. The formation and solution of the normal equations and the computation of the final v's are carried out as in any other solution of problems by the theory of least squares.

When the coefficients for one end of a line have been computed those of the other end of the line are found by a simple change of the sign of each of them. It is thus not necessary to recompute them.

A full computation of the triangles and positions together with the computations of the positions from the adjusted coordinates is given to show that the agreement of the results is fairly satisfactory. In general, for purposes of the grid, the computation could be finished as soon as the final coordinates were obtained. If geodetic positions are desired they can be computed from the final coordinates and the geodetic azimuth and the length of any line by an inverse position computation.

It should be noted that, if all of the equations for the v's in a given closed triangle are added, the constant terms should add up to the closure of the triangle and the total sum of the coefficients should be zero. This furnishes a good check on the formation of the equations and should be applied in all cases before making up the normal equations. As an example we will take the triangle Cannon–Mavaton–Newsome which has the angles 3, 6, 7, 8, and 14.

$v_3 = -6.4+5.53\Delta x_2+1.49\Delta y_2-2.71\Delta x_3-3.28\Delta y_3$

$v_6 = +4.1-1.46\Delta x_2-4.00\Delta y_2$

$v_7 = -1.3-4.22\Delta x_1+4.02\Delta y_1+0.15\Delta x_2-1.51\Delta y_2$

$v_8 = +0.4+4.22\Delta x_1-4.02\Delta y_1-3.22\Delta x_2-3.19\Delta y_2-1.00\Delta x_3+7.21\Delta y_3$

$v_{14} = +0.1-1.00\Delta x_2+7.21\Delta y_2+3.71\Delta x_3-3.93\Delta y_3$

$-6.4+4.1-1.3+0.4+0.1 = -3.1$, the value needed to close the triangle which is the correct result.

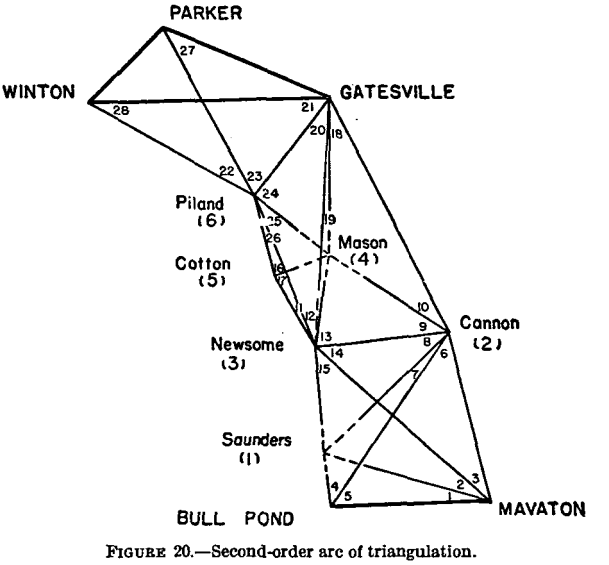


FIGURE 20.—Second-order arc of triangulation.

Adding the plus coefficients, we get

+5.53+1.49+4.02+0.15+4.22+7.21+7.21+3.71= +33.54,

and for the negative coefficients, we get

−2.71−3.28−1.46−4.00−4.22−1.51−4.02−3.22

−3.19−1.00−1.00−3.93= −33.54

The sum of the plus coefficients thus is equal to the sum of the minus coefficients and hence the total sum is zero as it should be.

Plane coordinates on Lambert projection

State North Carolina Station Mavaton

ϕ = 36° 10′ 25″.198 λ = 76° 38′ 37″.560

Tabular difference of R for 1″ of ϕ = 101.12233

R (for min. of ϕ)		29,304,064.38	y′ (for min. of ϕ)		879,546.87
Cor. for sec. of ϕ		− 2,548.08	Cor. for sec. of ϕ		+ 2,548.08
R		29,301,516.30	y′		882,094.95
			y″ (=2R $\sin^2 \frac{\theta}{2}$)		+ 8,253.53
θ (for min. of λ)		+ 1° 21′ 57″.4950	y		890,348.48
Cor. for sec. of λ		− 21.6785			
θ		+ 81 35.8165	$\frac{\theta}{2}$		° 40′ 47″.91
θ''	For machine computation	+ 4895.″8165		For machine computation	
			log θ''		3.68982513
log θ''		3.68982513	colog 2		9.69897000 -10
S for θ		4.68553408 -10	S for $\frac{\theta}{2}$		4.68556467 -10
log sin θ	sin θ	8.37535921 -10	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	8.07435980 -10
log R		7.46689009		R sin $\frac{\theta}{2}$	
log x′		5.84224930	log $\sin^2 \frac{\theta}{2}$	R $\sin^2 \frac{\theta}{2}$	6.14871960 -10
x′	R sin θ	+ 695,423.40	log R		7.46689009
		2,000,000.00	log 2		0.30103000
x		2,695,423.40	log y″		3.91663969

$x = 2{,}000{,}000.00 + R \sin \theta$

$y = y' + 2R \sin^2 \frac{\theta}{2}$

y′= the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine

(see log tables)

R, y′, and θ are given in special tables

FIGURE 21.— Computation of coordinates, North Carolina.

Plane coordinates on Lambert projection

State North Carolina Station Bull Pond

ϕ = 36° 10′ 12″.766 λ = 78° 45′ 08″.551

Tabular difference of R for 1″ of ϕ = 101.12233

R (for min. of ϕ)		29,304,064.38	y′ (for min. of ϕ)		879,546.87
Cor. for sec. of ϕ		− 1,290.93	Cor. for sec. of ϕ		+ 1,290.93
R		29,302,773.45	y′		880,837.80
			y″ (=2R sin² $\frac{\theta}{2}$)		+ 7,510.54
θ (for min. of λ)		+ 1° 17′ 55″.0832	y		888,348.34
Cor. for sec. of λ		− 4.9354			
θ		+ 77 50.1478	$\frac{\theta}{2}$		° 38′ 55″.07
θ″	For machine computation	+ 4670″.1478		For machine computation	
			log θ″		3.66933063
log θ″		3.66933063	colog 2		9.69897000 -10
S for θ		4.68553776 -10	S for $\frac{\theta}{2}$		4.68556559 -10
log sin θ	sin θ	8.35486839 -10	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	8.05386622 -10
log R		7.46690873		R sin $\frac{\theta}{2}$	
log x′		5.82177712	log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	6.10773244 -10
x′	R sin θ	+ 663,402.52	log R		7.46690873
		2,000,000.00	log 2		0.30103000
x		2,663,402.52	log y″		3.87567117

x = 2,000,000.00 + R sin θ

y = y′ + 2R sin² $\frac{\theta}{2}$

y′ = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine

(see log tables)

R, y′, and θ are given in special tables

Mavaton-Bull Pond

2,663,402.52	888,348.34	890,348
2,695,423.40	890,348.48	546,552
-32,020.88	-2,000.14	343,796
		- 667
4.5054333	4.5054333	343,129
3.3010604	0.0008456	
1.2043729	4.5062789	5.5355
		4.5054 n
		0.3730-10
		0.4139 n

Grid α	86°	25′	32.67″		+ °	81′	35.82″
	+ 1	21	38.41		+		2.59
Geod α	87	47	11.08		+ 1	21	38.41

mputation of coordinates, North Carolina—Continued.

Plane coordinates on Lambert projection

State North Carolina Station Gatesville

ϕ = 36° 24′ 13.″573 λ = 76° 45′ 30.″879

Tabular difference of R for 1″ of ϕ = 101.13383

R (for min. of ϕ)		29,219,117.26	y′ (for min. of ϕ)		964,493.99
Cor. for sec. of ϕ		− 1,372.69	Cor. for sec. of ϕ		+ 1,372.69
R		29,217,744.57	y′		965,866.68
			y″ (=2R sin² $\frac{\theta}{2}$)		+ 7,447.48
θ (for min. of λ)		+ 1° 17′ 55.″0832	y		973,314.16
Cor. for sec. of λ		− 17.8225			
θ		+ 77 37.2607	$\frac{\theta}{2}$		° 38′ 48.″63
θ''	For machine computation	+ 4657.″2607		For machine computation	
			log θ''		3.66813055
log θ''		3.66813055	colog 2		9.69897000 -10
S for θ		4.68553796 -10	S for $\frac{\theta}{2}$		4.68556564 -10
log sin θ	sin θ	8.35366851 -10	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	8.05266619 -10
log R		7.46564668		R sin $\frac{\theta}{2}$	
log x′		5.81931519	log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	6.10533238 -10
x′	R sin θ	+ 659,652.46	log R		7.46564668
		2,000,000.00	log 2		0.30103000
x		2,659,652.46	log y″		3.87200906

x = 2,000,000.00 + R sin θ

y = y′ + 2R sin² $\frac{\theta}{2}$

y′ = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y′, and θ are given in special tables

Gatesville-Parker

2,625,165.11	986,740.96	973,314
2,659,652.46	973,314.16	546,552
− 34,487.35	+ 13,426.80	426,762
		4,475
		431,237
4.53765983	4.53765983	5.6347160
4.12797252	0.03064597	4.5376598 n
0.40968731	4.56830580	0.3730186 -10
	9.48401583 -10	0.5453944 n
	4.05232163	− 3.51
	− 3545	
	4.05228618	
	4.0522870	
Grid α 111° 16′ 20.″01		+ 1° 17′ 37.″26
+ 1 17 40.77		+ 3.51
Geod α 112 34 00.78		+ 1 17 40.77
00.58		

FIGURE 21.—Computation of coordinates, North Carolina—Continued.

Plane coordinates on Lambert projection

State North Carolina Station Winton

ϕ = 36° 23′ 51.″367 λ = 76° 55′ 49.″440

Tabular difference of R for 1″ of ϕ = 101.13283

R (for min. of ϕ)		29,225,185.23	y′ (for min. of ϕ)			958,426.02
Cor. for sec. of ϕ		− 5,194.89	Cor. for sec. of ϕ			+ 5,194.89
R		29,219,990.34	y′			963,620.91
			y″ (=2R $\sin^2 \frac{\theta}{2}$)			+ 6,349.95
θ (for min. of λ)		+ 1° 12′ 08.″7808	y			969,970.86
Cor. for sec. of λ		− 28.5353				
θ		+ 71 40.2455	$\frac{\theta}{2}$			° 35 50.12
θ''	For machine computation	+ 4300.″2455		For machine computation		
			log θ''			3.63349325
log θ''		3.63349325	colog 2			9.69897000 -10
S for θ		4.68554341 -10	S for $\frac{\theta}{2}$			4.68556700 -10
log sin θ	sin θ	8.31903666 -10	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$		8.01803025 -10
log R		7.46568007		R sin $\frac{\theta}{2}$		
log x′		5.78471673	log sin$^2 \frac{\theta}{2}$	R sin$^2 \frac{\theta}{2}$		6.03606050 -10
x′	R sin θ	+ 609,139.45	log R			7.46568007
		2,000,000.00	log 2			0.30103000
x		2,609,139.45	log y″			3.80277057

x = 2,000,000.00 + R sin θ

y = y′ + 2R $\sin^2 \frac{\theta}{2}$

y′ = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y′, and θ are given in special tables

Winton-Gatesville

2,659,652.46
2,609,139.45
+ 50,513.01

4.70340325
3.52417535
1.17922790

973,314.16
969,970.86
+ 3,343.30

4.70340325
0.00094918
4.70435243
9.48401583
4.18836826
-3210
4.18833616
4.1883369

969,971
546,552
423,419
1,114
424,533

5.6279115
4.7034032
0.3730186 -10
0.7043333
+ 5.06

Grid α 266° 12′ 47.″85
+ 1 11 35.19
Geod α 267 24 23.04
23.11

+ 1° 11′ 40.″25
- 5.06
+ 1 11 35.19

FIGURE 21.—Computation of coordinates, North Carolina—Continued.

Plane coordinates on Lambert projection

State N. Carolina Station Parker

ϕ = 36° 26′ 33″.802 λ = 76° 52′ 29″.094

Tabular difference of R for 1″ of ϕ = 101.13676

R (for min. of ϕ)		29,206,981.15	y' (for min. of ϕ)		976,630.10
Cor. for sec. of ϕ		− 3,418.59	Cor. for sec. of ϕ		+ 3,418.59
R		29,203,562.56	y'		980,048.69
			y'' (=2R sin² $\frac{\theta}{2}$)		+ 6,692.27
θ (for min. of λ)		+ 1°13′52″.6715	y		986,740.96
Cor. for sec. of λ		− 16.7922			
θ		+ 73 35.8793	$\frac{\theta}{2}$		° 36′47″.94
θ''	For machine computation	4415 ″.8793		For machine computation	
			log θ''		3.64501720
log θ''		3.64501720	colog 2		9.69897000-10
S for θ		4.68554169-10	S for $\frac{\theta}{2}$		4.68556657-10
log sin θ	sin θ	8.33055889-10	log sin. $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	8.02955377-10
log R		7.46543584		R sin $\frac{\theta}{2}$	
log x'		5.79599473	log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	6.05910754-10
x'	R sin θ	+625,165.11	log R		7.46543584
		2,000,000.00	log 2		0.30103000
x		2,625,165.11	log y''		3.82557338

x = 2,000,000.00 + R sin θ

y = y' + 2R sin² $\frac{\theta}{2}$

y' = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y', and θ are given in special tables

	Parker	−	Winton
	2,609,139.45		969,970.86
	2,625,165.11		986,740.96
	−16,025.66		−16,770.10
	4.20481593		4.22453565
	4.22453565		0.14087890
	9.98028028-10		4.36541455
Grid α	43° 41′ 58.74		9.48401583-10
+	1 13 37.52		3.84943038
Geod α	44 55 36.26		−3531
	36.24		3.84939507
			3.8493953

986,741.
546,552
440,189
−5,590
434,599

5.6380887
4.2048159 n
0.3730186-10
(0.2159232 n
(−1.64

+ 1 13 35.88
+ 1.64
+ 1 13 37.52

FIGURE 21.—Computation of coordinates, North Carolina—Continued.

Fixed positions

Station	Plane coordinates	
	x	y
	Feet	*Feet*
Bull Pond	2,663,402.52	888,348.34
Mavaton	2,695,423.40	890,348.48
Gatesville	2,659,652.46	973,314.16
Winton	2,609,139.45	969,970.86
Parker	2,625,165.11	986,740.96

Computation of azimuths

Line	Azimuth and angle			Line	Azimuth and angle		
	°	′	″		°	′	″
Mavaton–Bull Pond	86	25	32.7	Newsome–Cannon	262	05	24.2
	+18	44	26.1		−77	00	13.2
Mavaton–Saunders	105	09	58.8	Newsome–Mason	185	05	11.0
Saunders–Mavaton	285	09	58.8	Mason–Newsome	5	05	11.0
	−61	32	04.2		+57	48	49.9
Saunders–Cannon	223	37	54.6	Mason–Cotton	62	54	00.9
Cannon–Saunders	43	37	54.6		+60	59	21.5
	+38	27	29.6	Mason–Piland	123	53	22.4
Cannon–Newsome	82	05	24.2				

Computation of preliminary coordinates

MAVATON-SAUNDERS

Log sin α plus log dist.	Log cos α plus log dist.	x	y
9.9846040−10n	9.4176744−10	2,695,423.40	890,348.48
4.5440915	4.5440915	−33,782.79	+9,157.27
4.5286955n	3.9617659	2,661,640.61	899,505.75

SAUNDERS-CANNON

9.8388628−10	9.8596117−10	2,661,640.61	899,505.75
4.5488447	4.5488447	+24,417.85	+25,612.76
4.3877075	4.4084564	2,686,058.46	925,118.51

CANNON-NEWSOME

9.9958482−10n	9.1386704−10n	2,686,058.46	925,118.51
4.4521406	4.4521406	−28,053.61	−3,897.72
4.4479888n	3.5908110n	2,658,004.85	921,220.79

NEWSOME-MASON

8.9477163−10	9.9982864−10	2,658,004.85	921,220.79
4.3075877	4.3075877	+1,800.13	+20,224.33
3.2553040	4.3058741	2,659,804.98	941,445.12

MASON-COTTON

9.9494948−10n	9.6585275−10n	2,659,804.98	941,445.12
4.0420496	4.0420496	−9,807.19	−5,018.54
3.9915444n	3.7005771n	2,649,997.79	936,426.58

MASON-PILAND

9.9191377−10n	9.7463180−10	2,659,804.98	941,445.12
4.2700754	4.2700754	−15,460.13	+10,384.69
4.1892131n	4.0163934	2,644,344.85	951,829.81

Computations of final coordinates

Station	Assumed coordinates	Correction	Adjusted coordinates
1. Saunders	2,661,640.61	+0.09	2,661,640.70
	899,505.75	+0.05	899,505.80
2. Cannon	2,686,058.46	+0.05	2,686,058.51
	925,118.51	−0.37	925,118.14
3. Newsome	2,658,004.85	+0.06	2,658,004.91
	921,220.79	−0.57	921,220.22
4. Mason	2,659,804.98	−0.11	2,659,804.87
	941,445.12	−1.05	941,444.07
5. Cotton	2,649,997.79	+0.01	2,649,997.80
	936,426.58	−1.35	936,425.23
6. Piland	2,644,344.85	−0.49	2,644,344.36
	951,829.81	−1.98	951,827.83

Computation of Grid Azimuths

Mavaton-Bull Pond

	2,663,402.52	888,348.34	y_1	=	890,348
	2,695,423.40	890,348.48	y_0	=	546,552
Δx	= - 32,020.88	Δy = -2,000.14	$y_1 - y_0$	=	343,796
			$\frac{\Delta y}{3}$	=	-667
$\log \Delta x$	= 4.5054333 n		Sum	=	343,129
$\log \Delta y$	= 3.3010604 n		log sum	=	5.535
			log Δx	=	4.505 n
$\log \tan\alpha$	= 1.2043729		$\log \frac{1}{2\rho'' \sin 1''}$	=	0.373 -10
			log correct. term	=	0.413 n
α	= 86° 25' 32".7 + 2".6 = 35".3		Correct. term	=	-2".6

Mavaton-Saunders

(Azimuth previously computed.)

105° 09' 58".8 + 2".8 = 61".6	890,348	5.540
	546,552	4.529 n
	343,796	0.373 -10
	+ 3,052	0.442 n
	346,848	-2".8

Mavaton-Newsome

2,658,004.85	921,220.79		890,348
2,695,423.40	890,348.48		546,552
- 37,418.55	+ 30,872.31		343,796
			+ 10,291
			354,087
4.5730870 n	$\log \Delta x$ = 4.57309		5.549
4.4895691	$\log \sin\alpha$ = 9.88725 -10		4.573 n
0.0835179 n	log s = 4.68584		0.373 -10
			0.495 n
129° 31' 28".0 + 3".1 = 31".1			- 3".1

FIGURE 22.—Computation of grid azimuths and corrections.

Mavaton-Cannon

2,686,058.46	925,118.51	890,348
2,695,423.40	890,348.48	546,552
- 9,364.94	+34,770.03	343,796
		+11,590
3.9715050 n		355,386
4.5412051		5.551
9.4302999 -10_n		3.972 n
		0.373 -10
		9.896 -10_n
164° 55' 32".5 + 0".8 = 33".3		- 0".8

Bull Pond-Saunders

2,661,640.61	899,505.75	888,348
2,663,402.52	888,348.34	546,552
- 1,761.91	+11,157.41	341,796
		+ 3,719
3.2459838 n		345,515
4.0475634		5.538
9.1984204 -10_n		3.246 n
		0.373 -10
		9.157 -10_n
171° 01' 34".7 + 0".1 = 34".8		- 0".1

Bull Pond-Cannon

2,686,058.46	925,118.51	888,348
2,663,402.52	888,348.34	546,552
+ 22,655.94	+ 36,770.17	341,796
		+12,257
4.3551821	4.56550	354,053
4.5654956	9.93012 -10	5.549
9.7896865-10	4.63538	4.355
		0.373 -10
		0.277
211° 38' 21".5 - 1".9 = 19".6		+ 1".9

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Bull Pond-Mavaton

	888,348	5.535
	546,552	4.505
	341,796	0.373 -10
	+ 667	0.413
266° 25' 32".7 - 2".6 = 30".1	342,463	+ 2".6

Cannon-Mavaton

	925,119	5.565
	546,552	3.972
	378,567	0.373 -10
344° 55' 32".5 - 0".8 = 31".7	-11,590	9.910 -10
	366,977	+ 0".8

Cannon-Bull Pond

	925,119	5.564
	546,552	4.355 n
	378,567	0.373 -10
31° 38' 21".5 + 2".0 = 23".5	-12,257	0.292 n
	366,310	- 2".0

Cannon-Saunders

2,661,640.61	899,505.75	925,119
2,686,058.46	925,118.51	546,552
- 24,417.85	-25,612.76	378,567
		-8,537
4.3877074 n		370,030
4.4084563 n		5.568
9.9792511 -10		4.388 n
		0.373 -10
		0.329 n
43° 37' 54".6 + 2".1 = 56".7		- 2".1

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Cannon-Newsome

2,658,004.85	921,220.79	925,119
2,686,058.46	925,118.51	546,552
-28,053.61	-3,897.72	378,567
		-1,299
4.4479888 n		377,268
3.5908106 n		5.577
		4.448 n
0.8571782		0.373 -10
		0.398 n
82° 05' 24".2 + 2".5 = 26".7		- 2".5

Cannon-Mason

2,659,804.98	941,445.12	925,119
2,686,058.46	925,118.51	546,552
-26,253.48	+ 16,326.61	378,567
		+ 5,442
4.4191869 n		384,009
4.2128960		5.584
		4.419 n
0.2062909 n		0.373 -10
		0.376 n
121° 52' 36".5 + 2".4 = 38".9		- 2".4

Cannon-Gatesville

2,659,652.46	973,314.16	925,119
2,686,058.46	925,118.51	546,552
-26,406.00	+ 48,195.65	378,567
		+16,065
4.4217026 n	4.68301	394,632
4.6830078	9.94300 -10	5.596
		4.422 n
9.7386948 -10_n	4.74001	0.373 -10
		0.391 n
151° 16' 55".3 + 2".4 = 57".7		- 2".5 adopt -2.4

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Newsome-Cotton

2,649,997.79	936,426.58	921,221
2,658,004.85	921,220.79	546,552
- 8,007.06	+ 15,205.79	374,669
		+ 5,069
3.9034731 n		379,738
4.1820090		5.579
		3.903 n
9.7214641 -10_n		0.373 -10
		9.855 -10_n
$152^\circ\ 13'\ 46.''6 + 0.''7 = 47.''3$		$- 0.''7$

Newsome-Piland

2,644,344.85	951,829.81	921,221
2,658,004.85	921,220.79	546,552
-13,660.00	+ 30,609.02	374,669
		+10,203
4.1354507 n	4.48585	384,872
4.4858494	9.96056 -10	5.585
		4.135 n
9.6496013 -10_n	4.52529	0.373 -10
		0.093 n
$155^\circ\ 57'\ 00.''2 + 1.''2 = 01.''4$		$- 1.''2$

Newsome-Mason

2,659,804.98	941,445.12	921,221
2,658,004.85	921,220.79	546,552
+ 1,800.13	+20,224.33	374,669
		+ 6,741
3.2553039		381,410
4.3058742		5.581
		3.255
8.9494297 -10		0.373 -10
		9.209 -10
$185^\circ\ 05'\ 11.''0 - 0.''2 = 10.''8$		$+ 0.''2$

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Newsome-Cannon

262° 05' 24".2 - 2".5 = 21".7

921,221		5.575
546,552		4.448
374,669		0.373 -10
+ 1,299		0.396
375,968		+ 2".5

Newsome-Mavaton

309° 31' 28".0 - 3".3 = 24".7

921,221		5.562
546,552		4.573
374,669		0.373 -10
-10,291		0.508
364,378		+ 3".2 adopt +3.3

Newsome-Saunders

2,661,640.61	899,505.75	921,221
2,658,004.85	921,220.79	546,552
+ 3,635.76	-21,715.04	374,669
		-7,238
		367,431
3.5605952		5.565
4.3367606 n		3.561
9.2238346 -10_n		0.373 -10
		9.499 -10
350° 29' 42".4 - 0".3 = 42".1		+ 0".3

Cotton-Piland

2,644,344.85	951,829.81	936,427
2,649,997.79	936,426.58	546,552
- 5,652.94	+ 15,403.23	389,875
		+ 5,134
		395,009
3.7522744 n		5.597
4.1876118		3.752 n
9.5646626 -10_n		0.373 -10
		9.722 -10_n
159° 50' 49".2 + 0".5 = 49".7		- 0".5

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Cotton-Mason

2,659,804.98	941,445.12	936,427
2,649,997.79	936,426.58	546,552
+ 9,807.19	+5,018.54	389,875
		+ 1,673
3.9915446		391,548
3.7005774		5.593
		3.992
0.2909672		0.373 -10
		9.958 -10
242° 54' 00".9 - 0".9 = 00".0		+ 0".9

Cotton-Newsome

	936,427	5.585
	546,552	3.903
	389,875	0.373 -10
332° 13' 46".6 - 0".7 = 45".9	-5,069	9.861 -10
	384,806	+ 0".7

Gatesville-Cannon

	973,314	5.614
	546,552	4.422
	426,762	0.373 -10
331° 16' 55".3 - 2".6 = 52".7	-16,065	0.409
	410,697	+ 2".6

Gatesville-Mason

2,659,804.98	941,445.12	973,314
2,659,652.46	973,314.16	546,552
+ 152.52	-31,869.04	426,762
		-10,623
2.1833268	4.50337	416,139
4.5033689 n	0.00000	5.619
		2.183
7.6799579 -10_n	4.50337	0.373 -10
		8.175 -10
359° 43' 32".9 - 0".0 = 32".9		+ 0".0

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Gatesville-Newsome

2,658,004.85	921,220.79	973,314
2,659,652.46	973,314.16	546,552
-1,647.61	-52,093.37	426,762
		-17,364
3.2168544 n	4.71678	409,398
4.7167825 n	9.99978 -10	5.612
		3.217 n
8.5000719 -10	4.71700	0.373 -10
		9.202 -10 n
$1^{\circ}\ 48'\ 41''.6 + 0''.2 = 41''.8$		$-\ 0''.2$

Gatesville-Piland

2,644,344.85	951,829.81	973,314
2,659,652.46	973,314.16	546,552
-15,307.61	-21,484.35	426,762
		-7,161
4.1849074 n	4.33212	419,601
4.3321222 n	9.91085 -10	5.623
		4.185 n
9.8527852 -10	4.42127	0.373 -10
		0.181 n
$35^{\circ}\ 28'\ 11''.6 + 1''.5 = 13''.1$		$-\ 1''.5$

Gatesville-Winton

2,609,139.45	969,970.86	973,314
2,659,652.46	973,314.16	546,552
-50,513.01	-3,343.30	426,762
		-1,114
4.7034033 n	4.70340	425,648
3.5241753 n	9.99990 -10	5.629
		4.703 n
1.1792280	4.70350	0.373 -10
		0.705 n
$86^{\circ}\ 12'\ 47''.8 + 5''.0 = 52''.8$		$-\ 5''.1$ adopt -5.0

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Gatesville-Parker

2,625,165.11	986,740.96	973,314
2,659,652.46	973,314.16	546,552
-34,487.35	+ 13,426.80	426,762
		+ 4,476
4.5376598 n		431,238
4.1279725		5.635
		4.538 n
0.4096873 n		0.373 -10
		0.546 n
111° 16' 20".0 + 3".5 = 23".5		- 3".5

Piland-Winton

2,609,139.45	969,970.86	951,830
2,644,344.85	951,829.81	546,552
-35,205.40	+ 18,141.05	405,278
		+ 6,047
4.5466093 n	4.54661	411,325
4.2586624	9.94886-10	5.614
		4.547 n
0.2879469 n	4.59775	0.373 -10
		0.534 n
117° 15' 42".0 + 3".4 = 45".4		- 3".4

Piland-Parker

2,625,165.11	986,740.96	951,830
2,644,344.85	951,829.81	546,552
-19,179.74	+ 34,911.15	405,278
		+ 11,637
4.2828427 n	4.54296	416,915
4.5429642	9.94272 -10	5.620
		4.283 n
9.7398785 -10_n	4.60024	0.373 -10
		0.276 n
151° 12' 58".2 + 1".9 = 60".1		1".9

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Piland-Gatesville

215° 28' 11".6 - 1".5 = 10".1

951,830
546,552
405,278
+ 7,161
412,439

5.615
4.185
0.373 -10
0.173
+ 1".5

Piland-Mason

2,659,804.98
2,644,344.85
+ 15,460.13

941,445.12
951,829.81
-10,384.69

951,830
546,552
405,278
-3,462
401,816

4.1892132
4.0163935 n
0.1728197 n

5.604
4.189
0.373 -10
0.166
+ 1".5

303° 53' 22".4 - 1".5 = 20".9

Piland-Newsome

335° 57' 00".2 - 1".3 = 58".9

951,830
546,552
405,278
-10,203
395,075

5.597
4.135
0.373 -10
0.105
+ 1".3

Piland-Cotton

339° 50' 49".2 - 0".6 = 48".6

951,830
546,552
405,278
-5,134
400,144

5.602
3.752
0.373 -10
9.727 -10
+ 0".5 adopt +0.6

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Parker-Gatesville

291° 16' 20".0 - 3".7 = 16".3

986,741		5.639
546,552		4.538
440,189		0.373 -10
-4,476		0.550
435,713		+ 3".5 adopt +3.7

Parker-Piland

331° 12' 58".2 - 1".8 = 56".4

986,741		5.632
546,552		4.283
440,189		0.373 -10
-11,637		0.288
428,552		+ 1".9 adopt +1.8

Parker-Winton

2,609,139.45	969,970.86	986,741
2,625,165.11	986,740.96	546,552
-16,025.66	-16,770.10	440,189
		- 5,590
4.2048159 n		434,599
4.2245357 n		5.638
9.9802802 -10		4.205 n
		0.373 -10
43° 41' 58".7 + 1".6 = 60".3		0.216 n
		- 1".6

Winton-Parker

223° 41' 58".7 - 1".6 = 57".1

969,971		5.632
546,552		4.205
423,419		0.373 -10
+ 5,590		0.210
429,009		+ 1".6

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

Winton-Gatesville

	969,971	5.628	
	546,552	4.703	
		0.373	-10
	423,419	0.704	
266° 12' 47".8 - 5".1 = 42".7	+1,114	+ 5".1	
	424,533		

Winton-Piland

	969,971	5.621	
	546,552	4.547	
		0.373	-10
	423,419	0.541	
297° 15' 42".0 - 3".5 = 38".5	-6,047	+ 3".5	
	417,372		

FIGURE 22.—Computation of grid azimuths and corrections—Continued.

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
FORM 25
Ed. Jan., 1929

COMPUTATION OF TRIANGLES

State: North Carolina

NO.	STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3						4.5062782
1	Saunders	(65 51 35.0)				35.0	0.0397448
2	Mavaton	18 44 26.1				26.1	9.5068888
3	Bull Pond	95 23 59.0			0.1	58.9	9.9980685
	1-3						4.0529118
	1-2						4.5440915
	2-3						4.5440915
1	Cannon	58 42 22.2			0.1	22.1	0.0682806
2	Mavaton	59 45 33.9			0.1	33.8	9.9364726
3	Saunders	(61 32 04.2)			0.1	04.1	9.9440403
	1-3						4.5488447
	1-2						4.5564124
	2-3						4.5488447
1	Newsome	88 24 18.3			0.1	18.2	0.0001683
2	Cannon	38 27 29.6				29.6	9.7937511
3	Saunders	(53 08 12.2)				12.2	9.9031276
	1-3						4.3427641
	1-2						4.4521406
	2-3						4.4521406
1	Mason	(63 12 34.6)				34.6	0.0493132
2	Cannon	39 47 12.3				12.3	9.8061339
3	Newsome	77 00 13.2			0.1	13.1	9.9887303
	1-3						4.3075877
	1-2						4.4901841

FIGURE 23.—Computation of triangles, North Carolina.

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
FORM 23
Ed. Jan., 1929

COMPUTATION OF TRIANGLES

State: North Carolina

NO.	STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
2-3							4.3075877
1	Cotton	89 19 45.9			0.1	45.8	0.0000297
2	Mason	(57 48 49.9)				49.9	9.9275357
3	Newsome	32 51 24.3				24.3	9.7344322
1-3							4.2351531
1-2							4.0420496
2-3							4.0420496
1	Piland	35 57 26.8				26.8	0.2312257
2	Mason	(60 59 21.5)				21.5	9.9417743
3	Cotton	83 03 11.7				11.7	9.9968001
1-3					0.0		4.2150496
1-2							4.2700754

FIGURE 23 - Computation of triangles, North Carolina—Continued.

Observation Equations

α_1	log cos α_1	log sin α_1	log cos α_1	log sin α_1
α_2	$\log \frac{1}{s_1}$	$\log \frac{1}{s_1}$	$\log \frac{1}{s_2}$	$\log \frac{1}{s_2}$
$\angle$ Obs $\angle$	$\log \frac{1}{\sin 1''}$	$\log \frac{1}{\sin 1''}$	$\log \frac{1}{\sin 1''}$	$\log \frac{1}{\sin 1''}$
105° 10' 01".6	9.41767 -10	9.98460 -10_n		
86 25 35.3	5.45591 -10	5.45591 -10		
18 44 26.3	5.31443	5.31443		
18 44 26.1	0.18801	0.75494 n		
+0.2	+1.54	- 5.69		

$v_1 = +0.2 + 1.54 \Delta x_1 + 5.69 \Delta y_1$

129° 31' 31".1	9.80374 -10	9.88725 -10 n	9.41767 -10	9.98460 -10_n
105 10 01.6	5.31416 -10	5.31416 -10	5.45591 -10	5.45591 -10
24 21 29.5	5.31443	5.31443	5.31443	5.31443
24 21 25.3	0.43233	0.51584 n	0.18801	0.75494 n
+4.2	+2.71	- 3.28	+ 1.54	- 5.69

$v_2 = +4.2 - 1.54 \Delta x_1 - 5.69 \Delta y_1 + 2.71 \Delta x_3 + 3.28 \Delta y_3$

164° 55' 33".3	9.98479 -10	9.41509 -10_n		
129 31 31.1	5.44359 -10	5.44359 -10		
35 24 02.2	5.31443	5.31443		
35 24 08.6	0.74281	0.17311 n		
-6.4	+ 5.53	- 1.49	+ 2.71	-3.28

$v_3 = - 6.4 + 5.53 \Delta x_2 + 1.49 \Delta y_2 - 2.71 \Delta x_3 - 3.28 \Delta y_3$

211° 38' 19".6	9.93012 -10	9.71980 -10	9.99465 -10	9.19307 -10_n
171 01 34.8	5.36462 -10	5.36462 -10	5.94709 -10	5.94709 -10
40 36 44.8	5.31443	5.31443	5.31443	5.31443
40 36 46.0	0.60917	0.39885	1.25617	0.45459 n
-1.2	+ 4.07	+ 2.51	+ 18.04	- 2.85

$v_4 = -1.2 - 18.04 \Delta x_1 - 2.85 \Delta y_1 + 4.07 \Delta x_2 - 2.51 \Delta y_2$

FIGURE 24.—Observation equations.

266° 25' 30".1						
211 38 19.6						
54 47 10.5						
54 47 13.0						
	- 2.5			+ 4.07		+ 2.51

$v_5 = - 2.5 - 4.07 \Delta x_2 + 2.51 \Delta y_2$

31° 38' 23".5		9.93012 -10$_n$		9.71980 -10$_n$	9.98479 -10$_n$	9.41509 -10
344 55 31.7		5.36462 -10		5.36462 -10	5.44359 -10	5.44359 -10
46 42 51.8		5.31443		5.31443	5.31443	5.31443
46 42 47.7		0.60917 n		0.39885 n	0.74281 n	0.17311
	+ 4.1	- 4.07		- 2.51	- 5.53	+ 1.49

$v_6 = + 4.1 - 1.46 \Delta x_2 - 4.00 \Delta y_2$

43° 37' 56".7		9.85961 -10$_n$	9.83886 -10$_n$		
31 38 23.5		5.45116 -10	5.45116 -10		
		5.31443	5.31443		
11 59 33.2					
11 59 34.5		0.62520 n	0.60445 n		
	-1.3	- 4.22	- 4.02	- 4.07	- 2.51

$v_7 = - 1.3 - 4.22 \Delta x_1 + 4.02 \Delta y_1 + 0.15 \Delta x_2 - 1.51 \Delta y_2$

82° 05' 26".7		9.13867 -10$_n$	9.99585 -10$_n$		
43 37 56.7		5.54786 -10	5.54786 -10		
		5.31443	5.31443		
38 27 30.0					
38 27 29.6		0.00096 n	0.85814 n		
	+ 0.4	- 1.00	- 7.21	- 4.22	- 4.02

$v_8 = + 0.4 + 4.22 \Delta x_1 - 4.02 \Delta y_1 - 3.22 \Delta x_2 - 3.19 \Delta y_2 - 1.00 \Delta x_3 + 7.21 \Delta y_3$

121° 52' 38".9		9.72271 -10	9.92900 -10$_n$			
82 05 26.7		5.50982 -10	5.50982 -10			
		5.31443	5.31443			
39 47 12.2						
39 47 12.3		0.54696	0.75325 n			
	-0.1	+ 3.52	- 5.67	- 1.00	- 7.21	

$v_9 = - 0.1 - 4.52 \Delta x_2 + 1.54 \Delta y_2 + 1.00 \Delta x_3 - 7.21 \Delta y_3 + 3.52 \Delta x_4 + 5.67 \Delta y_4$

FIGURE 24.—Observation equations—Continued.

151° 16' 57".7	9.94300 -10	9.68169 -10$_n$			
121 52 38.9	5.25999 -10	5.25999 -10			
	5.31443	5.31443			
29 24 18.8					
29 24 21.4	0.51742	0.25611 n			
-2.6	+ 3.29	- 1.80	+ 3.52	- 5.67	

$v_{10} = -2.6 + 0.23 \Delta x_2 + 3.87 \Delta y_2 - 3.52 \Delta x_4 - 5.67 \Delta y_4$

155° 57' 01".4	9.96056 -10	9.61016 -10$_n$	9.94686 -10	9.66832 -10$_n$
152 13 47.3	5.47471 -10	5.47471 -10	5.76485 -10	5.76485 -10
	5.31443	5.31443	5.31443	5.31443
3 43 14.1				
3 43 09.5	0.74970	0.39930 n	1.02614	0.74760 n
+4.6	+ 5.62	- 2.51	+ 10.62	- 5.59

$v_{11} = +4.6 + 5.00 \Delta x_3 + 3.08 \Delta y_3 - 10.62 \Delta x_5 - 5.59 \Delta y_5 + 5.62 \Delta x_6 + 2.51 \Delta y_6$

185° 05' 10".8	9.99829 -10	8.94772 -10		
155 57 01.4	5.69241 -10	5.69241 -10		
	5.31443	5.31443		
29 08 09.4				
29 08 14.8	1.00513	9.95456 -10		
-5.4	+ 10.12	+ 0.90	+ 5.62	- 2.51

$v_{12} = -5.4 - 4.50 \Delta x_3 + 3.41 \Delta y_3 + 10.12 \Delta x_4 - 0.90 \Delta y_4 - 5.62 \Delta x_6 - 2.51 \Delta y_6$

262° 05' 21".7	9.13867 -10	9.99585 -10		
185 05 10.8	5.54786 -10	5.54786 -10		
	5.31443	5.31443		
77 00 10.9				
77 00 13.2	0.00096	0.85814		
-2.3	+ 1.00	+ 7.21	+ 10.12	+ 0.90

$v_{13} = -2.3 + 1.00 \Delta x_2 - 7.21 \Delta y_2 + 9.12 \Delta x_3 + 6.31 \Delta y_3 - 10.12 \Delta x_4 + 0.90 \Delta y_4$

309° 31' 24".7	9.80374 -10$_n$	9.88725 -10		
262 05 21.7	5.31416 -10	5.31416 -10		
	5.31443	5.31443		
47 26 03.0				
47 26 02.9	0.43233 n	0.51584		
+0.1	- 2.71	+ 3.28	+ 1.00	+ 7.21

$v_{14} = +0.1 - 1.00 \Delta x_2 + 7.21 \Delta y_2 + 3.71 \Delta x_3 - 3.93 \Delta y_3$

FIGURE 24.—Observation equations—Continued.

350° 29' 42".1	9.99400 -10$_n$	9.21783 -10			
309 31 24.7	5.65724 -10	5.65724 -10			
40 58 17.4	5.31443	5.31443			
40 58 15.4	0.96567 n	0.18950			
+2.0	- 9.24	+ 1.55	- 2.71	• 3.88

$v_{15} = +2.0 - 9.24\,\Delta x_1 - 1.55\,\Delta y_1 + 6.53\,\Delta x_3 - 1.73\,\Delta y_3$

242° 54' 00".0	9.65853 -10	9.94949 -10	9.97256 -10	9.53722 -10$_n$
159 50 49.7	5.95795 -10	5.95795 -10	5.78495 -10	5.78495 -10^n
83 03 10.3	5.31443	5.31443	5.31443	5.31443
83 03 11.7	0.93091	1.22187	1.07194	0.63660 n
-1.4	+ 8.53	+ 16.67	+ 11.80	- 4.33

$v_{16} = -1.4 + 8.53\,\Delta x_4 - 16.67\,\Delta y_4 + 3.27\,\Delta x_5 + 21.00\,\Delta y_5 - 11.80\,\Delta x_6 - 4.33\,\Delta y_6$

332° 13' 45".9	9.94686 -10$_n$	9.66832 -10		
242 54 00.0	5.76485 -10^n	5.76485 -10		
89 19 45.9	5.31443	5.31443		
89 19 45.9	1.02614 n	0.74760		
0.0	- 10.62	+ 5.59	+8.53	+ 16.67

$v_{17} = 0.0 - 10.62\,\Delta x_3 - 5.59\,\Delta y_3 - 8.53\,\Delta x_4 + 16.67\,\Delta y_4 + 19.15\,\Delta x_5 - 11.08\,\Delta y_5$

359° 43' 32".9	0.00000 n	7.67993 -10	9.94300 -10$_n$	9.68169 -10
331 16 52.7	5.49663 -10	5.49663 -10	5.25999 -10^n	5.25999 -10
28 26 40.2	5.31443	5.31443	5.31443	5.31443
28 26 38.0	0.81106 n	8.49099 -10	0.51742 n	0.25611
+ 2.2	- 6.47	+ 0.03	- 3.29	+ 1.80

$v_{18} = +2.2 + 3.29\,\Delta x_2 + 1.80\,\Delta y_2 - 6.47\,\Delta x_4 - 0.03\,\Delta y_4$

1° 46' 41".8	9.99978 -10$_n$	8.49986 -10$_n$		
359 43 32.9	5.28300 -10	5.28300 -10		
2 05 08.9	5.31443	5.31443		
2 05 10.0	0.59721 n	9.09729 -10$_n$		
-1.1	- 3.96	- 0.13	- 6.47	+ 0.03

$v_{19} = -1.1 - 3.96\,\Delta x_3 + 0.13\,\Delta y_3 + 6.47\,\Delta x_4 + 0.03\,\Delta y_4$

FIGURE 24.—Observation equations—Continued.

35°	28'	13".1	9.91085 -10$_n$	9.76363 -10$_n$		
1	48	41.8	5.57873 -10	5.57873 -10		
			5.31443	5.31443		
33	39	31.3				
33	39	26.2	0.80401 n	0.65679 n		
		+5.1	- 6.37	- 4.54	- 3.96	- 0.13

$$v_{20} = +5.1 + 3.96\,\Delta x_3 - 0.13\,\Delta y_3 - 6.37\,\Delta x_6 + 4.54\,\Delta y_6$$

86°	12'	52".8				
35	28	13.1				
50	44	39.7				
50	44	46.5				
		-6.8			- 6.37	- 4.54

$$v_{21} = -6.8 + 6.37\,\Delta x_6 - 4.54\,\Delta y_6$$

151	13	00.1	9.94272 -10	9.68260 -10$_n$	9.66092 -10	9.94886 -10$_n$
117	15	45.4	5.39976 -10	5.39976 -10	5.40225 -10	5.40225 -10
			5.31443	5.31443	5.31443	5.31443
33	57	14.7				
33	57	14.2	0.65691	0.39679 n	0.37760	0.66554 n
		+0.5	+4.54	- 2.49	+ 2.39	- 4.63

$$v_{22} = +0.5 - 2.15\,\Delta x_6 + 2.14\,\Delta y_6$$

215°	28'	10".1	9.91085 -10	9.76363 -10		
151	13	00.1	5.57873 -10	5.57873 -10		
			5.31443	5.31443		
64	15	10.0				
64	14	54.4	0.80401	0.65679		
		+15.6	+ 6.37	+ 4.54	+ 4.54	- 2.49

$$v_{23} = +15.6 - 1.83\,\Delta x_6 + 7.03\,\Delta y_6$$

303°	53'	20".9	9.74632 -10$_n$	9.91914 -10		
215	28	10.1	5.72992 -10	5.72992 -10		
			5.31443	5.31443		
88	25	10.8				
88	25	06.0	0.79067 n	0.96349		
		+4.8	- 6.17	+9.19	+ 6.37	+ 4.54

$$v_{24} = +4.8 - 6.17\,\Delta x_4 - 9.19\,\Delta y_4 + 12.54\,\Delta x_6 + 4.65\,\Delta y_6$$

FIGURE 24.—Observation equations—Continued.

335° 56' 58".9	9.96056	-10_n	9.61016	-10			
303 53 20.9	5.47471	-10	5.47471	-10			
32 03 38.0	5.31443		5.31443				
32 03 38.8	0.74970	n	0.39930				
-0.8	- 5.62		+ 2.51		- 6.17		+ 9.19

$$v_{25} = -0.8 - 5.62\Delta x_3 - 2.51\Delta y_3 + 6.17\Delta x_4 + 9.19\Delta y_4 - 0.55\Delta x_6 - 6.68\Delta y_6$$

339° 50' 48".6	9.97256	-10_n	9.53722	-10			
335 56 58.9	5.78495	-10	5.78495	-10			
3 53 49.7	5.31443		5.31443				
3 53 48.0	1.07194	n	0.63660				
+ 1.7	- 11.80		+ 4.33		- 5.62		+ 2.51

$$v_{26} = +1.7 + 5.62\Delta x_3 + 2.51\Delta y_3 - 11.80\Delta x_5 - 4.33\Delta y_5 + 6.18\Delta x_6 + 1.82\Delta y_6$$

331° 12' 56".4	9.94272	-10_n	9.68260	-10
291 16 16.3	5.39976	-10	5.39976	-10
39 56 40.1	5.31443		5.31443	
39 56 48.5	0.65691	n	0.39679	
-8.4	- 4.54		+ 2.49	

$$v_{27} = -8.4 - 4.54\,\Delta x_6 - 2.49\,\Delta y_6$$

297° 15' 38".5	9.66090	-10_n	9.94887	-10
266 12 42.7	5.40225	-10	5.40225	-10
31 02 55.8	5.31443		5.31443	
31 03 07.5	0.37758	n	0.66555	
-11.7	- 2.39		+ 4.63	

$$v_{28} = -11.7 - 2.39\,\Delta x_6 - 4.63\,\Delta y_6$$

FIGURE 24.—Observation equations—Continued.

Table for formation of normal equations

	Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	Δx_5	Δy_5	Δx_6	Δy_6	η	Σ
1	+1.54	+5.69											+0.2	+7.43
2	−1.54	−5.69			+2.71	+3.28							+4.2	+2.96
3			+5.53	+1.49	−2.71	−3.28							−6.4	−5.37
4	−18.04	−2.85	+4.07	−2.51									−1.2	−20.53
5			−4.07	+2.51									−2.5	−4.06
6			−1.46	−4.00									+4.1	−1.36
7	−4.22	+4.02	+0.15	−1.51									−1.3	−2.86
8	+4.22	−4.02	−3.22	−3.19	−1.00	+7.21							+0.4	+0.40
9			−4.52	+1.54	+1.00	−7.21	+3.52	+5.67					−0.1	−0.10
10			+0.23	+3.87			−3.52	−5.67					−2.6	−7.69
11					+5.00	+3.08			−10.62	−5.59	+5.62	+2.51	+4.6	+4.60
12					−4.50	+3.41	+10.12	−0.90			−5.62	−2.51	−5.4	−5.40
13			+1.00	−7.21	+9.12	+6.31	−10.12	+0.90					−2.3	−2.30
14			−1.00	+7.21	+3.71	−3.93							+0.1	+6.09
15	−9.24	−1.55			+6.53	−1.73							+2.0	−3.99
16							+8.53	−16.67	+3.27	+21.00	−11.80	−4.33	−1.4	−1.40
17					−10.62	−5.59	−8.53	+16.67	+19.15	−11.08			0.0	0.00
18			+3.29	+1.80			−6.47	−0.03					+2.2	+0.79
19					−3.96	+0.13	+6.47	+0.03					−1.1	+1.57
20					+3.96	−0.13					−6.37	+4.54	+5.1	+7.10
21											+6.37	−4.54	−6.8	−4.97
22											−2.15	+2.14	+0.5	+0.49
23											−1.83	+7.03	+15.6	+20.80
24							−6.17	−9.19			+12.54	+4.65	+4.8	+6.63
25					−5.62	−2.51	+6.17	+9.19			−0.55	−6.68	−0.8	−0.80
26					+5.62	+2.51			−11.80	−4.33	+6.18	+1.82	+1.7	+1.70
27											−4.54	−2.49	−8.4	−15.43
28											−2.39	−4.63	−11.7	−18.72

93324°—35——7

Normal equations

	Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	Δx_5	Δy_5	Δx_6	Δy_6	η	Σ
Δx_1	+451.1792	+49.3324	−87.6442	+38.1908	−68.7306	+41.3602							+4.1820	+427.8698
Δy_1		+107.5980	+1.9479	+13.9071	−21.5214	−44.9659							−29.2740	+77.0241
Δx_2			+109.5406	−10.8751	−10.8763	+1.4746	−48.1263	−26.1312					−32.8780	−103.5680
Δy_2				+167.8332	−38.3140	−112.8209	+53.1176	−19.7541					−17.4640	+73.8206
Δx_3					+408.8340	+121.6312	−104.0224	−210.8740	−322.7890	+65.3850	+65.9874	+89.5934	+106.5830	+80.8863
Δy_3						+248.7355	−21.6901	−154.5190	−169.3761	+33.8517	+15.8658	+19.9165	+21.2300	+0.6935
Δx_4							+534.9910	−148.8966	−135.4564	+273.6424	−238.2937	−132.2422	−90.4170	−57.3937
Δy_4								+790.6096	+264.7196	−534.7736	+81.4669	−29.6826	−11.2600	+0.9050
Δx_5									+629.4398	−33.0522	−171.1944	−62.2913	−73.4900	−73.4900
Δy_5										+613.7634	−305.9752	−112.8415	−62.4750	−62.4750
Δx_6											+513.6042	+99.6038	+104.5310	+165.5958
Δy_6												+223.7671	+301.7710	+397.5942
η													+709.2700	+930.3090
Σ														+1857.7716

Solution of normal equations

Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	Δx_5	Δy_5	Δx_6	Δy_6	η	Σ
+451.1792	+49.3324	−87.6442	+38.1908	−68.7306	+41.3602							+4.1820	+427.8698
Δx_1	−0.109341	+0.194256	−0.084647	+0.152335	−0.091671							−0.009269	−0.948337
	+107.5980	+1.9479	+13.9071	−21.5214	−44.9659							−29.2740	+77.0241
Δx_1	−5.3941	+9.5831	−4.1758	+7.5151	−4.5224							−0.4573	−46.7837
	+102.2039	+11.5310	+9.7313	−14.0063	−49.4883							−29.7313	+30.24043
	Δy_1	−0.112823	−0.095215	+0.137043	+0.484211							+0.290902	− 0.295882
		+109.5406	−10.8751	−10.8763	+1.4746	−48.1263	−26.1312					−32.8780	−103.5680
	Δx_1	−17.0254	+7.4188	−13.3513	+8.0345							+0.8124	+83.1163
	Δy_1	−1.3010	−1.0979	+1.5802	+5.5834							+3.3544	−3.4118
		+91.2142	−4.5542	−22.6474	+15.0925	−48.1263	−26.1312					−28.7112	−23.86356
		Δx_2	+0.049929	+0.248288	−0.165462	+0.527618	+0.286482					+0.314767	+0.261622
			+167.8332	−38.3140	−112.8209	+53.1176	−19.7541					−17.4640	+73.8206
		Δx_1	−3.2327	+5.8178	−3.5010							−0.3540	−36.2179
		Δy_1	−0.9266	+1.3336	+4.7120							+2.8309	−2.8793
		Δx_2	−0.2274	−1.1308	+0.7536	−2.4029	−1.3047					−1.4335	−1.1915
			+163.4465	−32.2934	−110.8563	+50.7147	−21.0588					−16.4206	+33.537921
			Δy_2	+0.197578	+0.678242	−0.310283	+0.128842					+0.100465	−0.205156
				+408.8340	+121.6312	−104.0224	−210.8740	−322.7890	+65.3850	+65.9874	+89.5934	+106.5830	+80.8863
			Δx_1	−10.4701	+6.3006							+0.6371	+65.1795
			Δy_1	−1.9195	−6.7820							−4.0745	+4.1442
			Δx_2	−5.6231	+3.7473	−11.9492	−6.4881					−7.1286	−5.9250
			Δy_2	−6.3805	−21.9028	+10.0201	−4.1608					−3.2443	+6.6252
				+384.4408	+102.9943	−105.9515	−221.5229	−322.7890	+65.3850	+65.9874	+89.5934	+92.7727	+150.9102
				Δx_3	−0.267907	+0.275599	+0.576221	+0.839633	−0.170078	−0.171645	−0.233049	−0.241319	−0.392545
					+248.7355	−21.6901	−154.5190	−169.3761	+33.8517	+15.8658	+19.9165	+21.2300	+0.6935
				Δx_1	−3.7915							−0.3834	−39.2233
				Δy_1	−23.9628							−14.3962	+14.6427
				Δx_2	−2.4972	+7.9631	+4.3237					+4.7506	+3.9485
				Δy_2	−75.1874	+34.3968	−14.2830					−11.1371	+22.7429
				Δx_3	−27.5929	+28.3851	+59.3475	+86.4774	−17.5171	−17.6785	−24.0027	−24.8545	−40.4299
					+115.7037	+49.0549	−105.1308	−82.8987	+16.3346	−1.8127	−4.0862	−24.7906	−37.62568
					Δy_3	−0.423970	+0.908621	+0.716474	−0.141176	+0.015667	+0.035316	+0.214259	+0.325191

	Δx_4	Δy_4	Δx_5	Δy_5	Δx_6	Δy_6	η	Σ
	+534.9910	−148.8966	−135.4564	+273.6424	−238.2937	−132.2422	−90.4170	−57.3937
Δx_2	−25.3923	−13.7873					−15.1485	−12.5909
Δy_2	−15.7359	+6.5342					+5.0950	−10.4044
Δx_3	−29.2001	−61.0515	−88.9603	+18.0200	+18.1861	+24.6919	+25.5681	+41.5907
Δy_3	−20.7978	+44.5723	+35.1466	−6.9254	+.7685	+1.7324	+10.5105	+15.9522
	+443.8649	−172.6289	−189.2701	+284.7370	−219.3391	−105.8179	−64.3919	−22.8460
	Δx_4	+.388922	+.426414	−.641495	+.494157	+.238401	+.145071	+.051470
		+790.6096	+264.7196	−534.7736	+81.4669	−29.6826	−11.2600	+.9050
	Δx_2	−7.4861					−8.2252	−6.8365
	Δy_2	−2.7133					−2.1157	+4.3203
	Δx_3	−127.6461	−185.9978	+37.6762	+38.0233	+51.6256	+53.4576	+86.9576
	Δy_3	−95.5241	−75.3235	+14.8420	−1.6471	−3.7128	−22.5253	−34.1876
	Δx_4	−67.1392	−73.6113	+110.7405	−85.3058	−41.1549	−25.0434	−8.8853
		+490.1008	−70.2130	−371.5149	+32.5373	−22.9247	−15.7120	+42.2735
		Δy_4	+.143262	+.758038	−.066389	+.046775	+.032059	−.086255
			+629.4398	−33.0522	−171.1944	−62.2913	−73.4900	−73.4900
		Δx_3	−271.0243	+54.8994	+55.4052	+75.2256	+77.8950	+126.7092
		Δy_3	−59.3948	+11.7033	−1.2988	−2.9277	−17.7618	−26.9579
		Δx_4	−80.7074	+121.4158	−93.5293	−45.1222	−27.4576	−9.7419
		Δy_4	−10.0589	−53.2240	+4.6614	−3.2842	−2.2509	+6.0562
			+208.2544	+101.7423	−205.9559	−38.3998	−43.0653	+22.5757
			Δx_5	−.488548	+.988963	+.184389	+.206792	−.108404
				+613.7634	−305.9752	−112.8415	−62.4750	−62.4750
			Δx_3	−11.1206	−11.2230	−15.2379	−15.7786	−25.6665
			Δy_3	−2.3061	+.2559	+.5769	+3.4998	+5.3119
			Δx_4	−182.6574	+140.7049	+67.8817	+41.3071	+14.6556
			Δy_4	−281.6224	+24.6645	−17.3778	−11.9103	+32.0449
			Δx_5	−49.7060	+100.6193	+18.7601	+21.0395	−11.0293
				+86.3509	−50.9536	−58.2385	−24.3175	−47.1587
				Δy_5	+.590076	+.674440	+.281613	+.546129
					+513.6042	+99.6038	+104.5310	+165.5958
				Δx_3	−11.3264	−15.3783	−15.9240	−25.9030
				Δy_3	−.0284	−.0640	−.3884	−.5895
				Δx_4	−108.3880	−52.2907	−31.8197	−11.2895
				Δy_4	−2.1601	+1.5219	+1.0431	−2.8065
				Δx_5	−203.6828	−37.9760	−42.5900	+22.3265
				Δy_5	−30.0665	−34.3651	−14.3492	−27.8272
					+157.9520	−38.9484	+.5028	+119.5064
					Δx_6	+.246584	−.003183	−.756599
						+223.7671	+301.7710	+397.5942
					Δx_3	−20.8797	−21.6206	−35.1695
					Δy_3	−.1443	−.8755	−1.3288
					Δx_4	−25.2271	−15.3511	−5.4465
					Δy_4	−1.0723	−.7349	+1.9773
					Δx_5	−7.0805	−7.9408	+4.1627
					Δy_5	−39.2784	−16.4007	−31.8057
					Δx_6	−9.6041	+.1240	+29.4684
						+120.4807	+238.9714	+359.4521
						Δy_6	−1.983483	−2.983483
							+709.2700	+930.3090
						Δx_1	−.0388	−3.9659
						Δy_1	−8.6489	+8.7970
						Δx_2	−9.0373	−7.5115
						Δy_2	−1.6497	+3.3688
						Δx_3	−22.3878	−36.4175
						Δy_3	−5.3116	−8.0617
						Δx_4	−9.3414	−3.3143
						Δy_4	−.5037	+1.3552
						Δx_5	−8.9056	+4.6685
						Δy_5	−6.8481	−13.2805
						Δx_6	−.0016	−.3804
						Δy_6	−473.9957	−712.9671
							+162.5998	+162.5996
								+1857.7716
							Δx_1	−405.7648
							Δy_1	−8.9476
							Δx_2	−6.2432
							Δy_2	−6.8793
							Δx_3	−59.2390
							Δy_3	−12.2356
							Δx_4	−1.1759
							Δy_4	−3.6463
							Δx_5	−2.4473
							Δy_5	−25.7547
							Δx_6	−90.4184
							Δy_6	−1072.4192
								+162.6003

Back solution

Δy_6	Δx_6	Δy_5	Δx_5	Δy_4	Δx_4
−1.9835	−0.0032	+0.2816	+0.2068	+0.0321	+0.1451
	−0.4891	−1.3378	−0.3657	−0.0928	−0.4729
	−0.4923	−0.2905	−0.4869	+0.0327	−0.2433
		−1.3467	+0.6579	−1.0208	+0.8639
			+0.0121	+0.0017	+0.0052
				−1.0471	−0.4072
					−0.1092
Δy_3	Δx_3	Δy_2	Δx_2	Δy_1	Δx_1
+0.2143	−0.2413	+0.1005	+0.3148	+0.2909	−0.0093
−0.0700	+0.4623	−0.1349	−0.3000	−0.2759	+0.0522
−0.0077	+0.0845	+0.0339	−0.0576	+0.0087	+0.0097
+0.1901	+0.2290	−0.3864	+0.0943	+0.0356	+0.0317
+0.0087	+0.0102	+0.0126	+0.0158	−0.0055	+0.0094
−0.9514	−0.6034		−0.0187		−0.0059
+0.0463	−0.0301	−0.3743		+0.0538	
	+0.1526		+0.0486		+0.0878
−0.5697					
	+0.0638				

Computation of corrections

1	2	3	4	5	6	7
+0.200	+4.200	−6.400	−1.200	−2.500	+4.100	−1.300
+0.135	−0.135	+0.269	−1.584	−0.198	−0.071	−0.371
+0.306	−0.306	−0.558	−0.153	−0.939	+1.497	+0.216
+0.641	+0.173	−0.173	+0.198	−3.637	+5.526	+0.007
+0.6	−1.869	+1.869	+0.939	−3.6	+5.5	+0.565
	+2.063	−4.993	−1.800			−0.883
	+2.1	−5.0	−1.8			−0.8
8	9	10	11	12	13	14
+0.400	−0.100	−2.600	+4.600	−5.400	−2.300	+0.100
+0.371	−0.220	+0.011	+0.319	−0.287	+0.049	−0.049
−0.216	−0.576	−1.449	−1.755	−1.943	+2.699	−2.699
−0.156	+0.064	+0.384	−0.129	−1.105	+0.582	+0.237
+1.194	+4.108	+5.937	+7.528	+0.942	−3.595	+2.239
−0.064	−0.384	+2.283	−2.767	+2.767	+1.105	−0.172
−4.108	−5.937	+2.3	−4.979	+4.979	−0.942	−0.2
−2.579	−3.045		+2.817	−0.047	−2.402	
−2.6	−3.1		+2.8	0.0	−2.4	
15	16	17	18	19	20	21
+2.000	−1.400	0.000	+2.200	−1.100	+5.100	−6.800
−0.811	−0.931	−0.678	+0.160	−0.253	+0.253	−3.136
−0.083	+17.455	+3.185	−0.674	−0.074	+0.074	+9.005
+0.417	+0.040	+0.931	+0.707	−0.707	+3.136	−0.931
+0.986	−28.281	−17.455	+0.031	−0.031	−9.005	−0.9
+2.509	+5.809	+0.232	+2.424	−2.165	−0.442	
+2.4	+8.589	+14.921	+2.4	−2.2	−0.4	
	+1.281	+1.136				
	+1.3	+1.1				
22	23	24	25	26	27	28
+0.500	+15.600	+4.800	−0.800	+1.700	−8.400	−11.700
+1.058	+0.901	+0.674	−0.359	+0.359	+2.235	+1.177
−4.245	−13.944	+9.623	+1.430	−1.430	+4.939	+9.184
−2.687	+2.557	−6.173	−0.674	−0.143	−1.226	−1.339
−2.9	+2.7	−9.223	−9.623	+5.831	−1.4	−1.3
		−0.299	+0.271	−3.042		
		−0.3	+13.250	−3.610		
			+3.495	−0.335		
			+3.5	−0.3		

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COMPUTATION OF TRIANGLES

State: North Carolina

NO.		STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM	
	2-3							3.990294	
	1	Saunders	(65 51 35.0)	(+4.8)	39.8		39.8	0.039740	3
1	2	Mavaton	18 44 26.1	+0.6	26.7		26.7	9.506892	6
4+5	3	Bull Pond	95 23 59.0	+5.4	53.6	0.1	53.5	9.998069	6
	1-3					0.1		3.536927	
	1-2							4.028104	
	2-3							3.990294	
6	1	Cannon	46 42 47.7	+5.5	53.2	.1	53.1	0.137898	9
1+ 2+3	2	Mavaton	78 30 00.0	-2.3	57.7	.1	57.6	9.991191	7
5	3	Bull Pond	54 47 13.0	-3.6	09.4	.1	09.3	9.912223	7
	1-3			-0.4				4.119385	
	1-2		00.7			.3		4.040417	
	2-3							4.028104	
6+7	1	Cannon	58 42 22.2	+4.7	26.9	0.1	26.8	0.068274	6
2+3	2	Mavaton	59 45 33.9	-2.9	31.0	0.1	30.9	9.936469	0
	3	Saunders	(61 32 04.2)	(-1.8)	02.4	0.1	02.3	9.944038	2
	1-3					0.3		4.032846	
	1-2							4.040417	
	2-3							3.536927	
7	1	Cannon	11 59 34.5	-0.8	33.7		33.7	0.682381	7
4	2	Bull Pond	40 36 46.0	-1.8	44.2		44.2	9.813538	9
	3	Saunders	(127 23 39.6)	(+2.6)	42.2	.1	42.1	9.900076	0
	1-3					0.1		4.032846	
	1-2							4.119385	

FIGURE 25.—Final computation of triangles, North Carolina.

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COMPUTATION OF TRIANGLES

State: North Carolina

NO.	STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM	
	2-3						4.040417	
14	1 Newsome	47 26 02.9	-0.2	02.7	.1	02.6	0.132827	6
6+								
7+8	2 Cannon	97 09 51.8	+2.1	53.9		53.9	9.996595	3
3	3 Mavaton	35 24 08.6	-5.0	03.6	.1	03.5	9.762899	8
	1-3		-3.1		0.2		4.169840	
	1-2	03.3					3.936144	
	2-3						4.032848	
14+								
15	1 Newsome	88 24 18.3	+2.2	20.5	.1	20.4	0.000168	2
8	2 Cannon	38 27 29.6	-2.6	27.0		27.0	9.793744	3
	3 Saunders	(53 08 12.2)	(+0.4)	12.6		12.6	9.903128	3
	1-3				0.1		3.826760	
	1-2						3.936144	
	2-3						4.028104	
15	1 Newsome	40 58 15.4	+2.4	17.8	.1	17.7	0.183305	0
2	2 Mavaton	24 21 25.3	+2.1	27.4	.1	27.3	9.615350	4
	3 Saunders	(114 40 19.5)	(-4.5)	15.0		15.0	9.958430	5
	1-3				0.2		3.826759	+1
	1-2						4.169840	

FIGURE 25.—Final computation of triangles, North Carolina—Continued.

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COMPUTATION OF TRIANGLES

State: North Carolina

NO.		STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM	
	2-3							3.936144	
	1	Mason	(63 12 34.6)	(+5.5)	40.1		40.1	0.049307	4
9	2	Cannon	39 47 12.3	-3.1	09.2		09.2	9.806126	0
13	3	Newsome	77 00 13.2	-2.4	10.8	0.1	10.7	9.988729	1
	1-3					0.1		3.791577	
	1-2							3.974181	
	2-3							3.974181	
18	1	Gatesville	28 26 38.0	+2.4	40.4	.1	40.3	0.322112	4
10	2	Cannon	29 24 21.4	+2.3	23.7	.1	23.6	9.691084	5
	3	Mason	(122 09 00.8)	(-4.7)	56.1		56.1	9.927713	1
	1-3					0.2		3.987378	
	1-2							4.224006	
	2-3							3.936144	
18+19	1	Gatesville	30 31 48.0	+0.2	48.2	.1	48.1	0.294144	9
9+10	2	Cannon	69 11 33.7	-0.8	32.9	.1	32.8	9.970708	8
	3	Newsome	(80 16 38.6)	(+0.6)	39.2	.1	39.1	9.993717	1
	1-3					0.3		4.200998	
	1-2							4.224006	
	2-3							3.791577	
19	1	Gatesville	2 05 10.0	-2.2	07.8		07.8	1.439008	4
	2	Mason	(174 38 24.4)	(-0.6)	23.8		23.8	8.970413	0
12+20+24+25	3	Newsome	(3 16 25.6)	+2.8	28.4		28.4	8.756793	3
	1-3					0		4.200998	
	1-2							3.987379	-1

FIGURE 25.—Final computation of triangles, North Carolina—Continued.

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U. S. COAST AND GEODETIC SURVEY
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COMPUTATION OF TRIANGLES

State: North Carolina

NO.	STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3						3.754065
16	1 Cotton	83 03 11.7	+1.3	13.0		13.0	0.003199 6
25+26	2 Piland	35 57 26.8	+3.2	30.0		30.0	9.768783 7
	3 Mason	(60 59 21.5)	(-4.5)	17.0		17.0	9.941769 1
	1-3				0		3.526048
	1-2						3.699034
	2-3						4.009272
16+17	1 Cotton	172 22 57.6	+2.4	60.0		60.0	0.877637 6
26	2 Piland	3 53 48.0	-0.3	47.7		47.7	8.832226 5
11	3 Newsome	3 43 09.5	+2.8	12.3		12.3	8.812124 8
	1-3		+4.9		0		3.719136+1
	1-2	55.1					3.699034
	2-3						3.791577
17	1 Cotton	89 19 45.9	+1.1	47.0	0.1	46.9	0.000029 7
	2 Mason	(57 48 49.9)	(-3.9)	46.0		46.0	9.927530 5
11+12	3 Newsome	32 51 24.3	+2.8	27.1		27.1	9.734441 3
	1-3						3.719137
	1-2						3.526048

FIGURE 25.—Final computation of triangles, North Carolina—Continued.

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COMPUTATION OF TRIANGLES

State: North Carolina

NO.		STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM.
	2-3							3.987378
24	1	Piland	88 25 06.0	-0.3	05.7	.1	05.6	0.000165 5
19+20	2	Gatesville	35 44 36.2	-2.6	33.6		33.6	9.766521 2
	3	Mason	(55 50 17.9)	(+2.9)	20.8		20.8	9.917749 1
	1-3					0.1		3.754065
	1-2							3.905293
	2-3							4.200998
24+25	1	Piland	120 28 44.8	+3.2	48.0		48.0	0.064590 3
20	2	Gatesville	33 39 26.2	-0.4	25.8	.1	25.7	9.743684 0
	3	Newsome	(25 51 49.2)	(-2.8)	46.4	.1	46.3	9.639704 2
	1-3					0.2		4.009272
	1-2							3.905293
	2-3							3.791577
25	1	Piland	32 03 38.8	+3.5	42.3		42.3	0.275042 2
	2	Mason	(118 48 06.5)	(-3.5)	03.0	.1	02.9	9.942652 7
12	3	Newsome	29 08 14.8	0.0	14.8		14.8	9.687445 4
	1-3					0.1		4.009272
	1-2							3.754065

FIGURE 25.—Final computation of triangles, North Carolina—Continued.

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COMPUTATION OF TRIANGLES

State: North Carolina.

NO.	STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3						3.905293
27	1 Parker	39 56 48.5	-1.4	47.1	.1	47.0	0.192417 3
21	2 Gatesville	75 48 16.9	-0.9	16.0		16.0	9.986531 9
23	3 Piland	64 14 54.4	+2.7	57.1	.1	57.0	9.954576 3
	1-3		+0.4		0.2		4.084242
	1-2						4.052287
		59.8					
	2-3						4.084242
28	1 Winton	73 33 53.3	-1.3	52.0		52.0	0.018118 6
-27	2 Parker	72 28 55.5	+1.4	56.9	.1	56.8	9.979377 6
22	3 Piland	33 57 14.2	-2.9	11.3	.1	11.2	9.747034 2
	1-3		-2.8		0.2		4.081738
	1-2	03.0					3.849395
	2-3						3.905293
28	1 Winton	31 03 07.5	-1.3	06.2	.1	06.1	0.287509 3
21	2 Gatesville	50 44 46.5	-0.9	45.6	.1	45.5	9.888936 3
22+23	3 Piland	98 12 08.6	-0.2	08.4		08.4	9.995534 5
	1-3		-2.4		0.2		4.081739 -1
	1-2	02.6					4.188337

FIGURE 25.—Final computation of triangles, North Carolina—Continued.

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POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

					°	′	″						°	′	″
α	2	to 3			87	47	10.6	α	3	to 2			267	43	19.8
2d ∠	&				+18	44	26.7	3d ∠	&				-95	23	53.6
α	2	to 1			106	31	37.3	α	3	to 1			172	19	26.2
Δα					-	04	01.7	Δα						-	10.9
					180	00	00.0						180	00	00.0
α′	1	to 2			286	27	35.6	α′	1	to 3			352	19	15.3+1
		First Angle of Triangle			65	51	39.8								
	°	′	″						°	′	″				
φ	36	10	25.198	2	Mavaton	λ	76	38	37.560	φ	36	10	12.766	3 Bull Pond	λ	76	45	08.551
Δφ	+	01	38.269			Δλ	+	06	49.399	Δφ	+	01	50.701		Δλ		+	18.408
φ′	36	12	03.467	1	Saunders	λ′	76	45	26.959	φ′	36	12	03.467	1 Saunders	λ′	76	45	26.959

	Logarithms	Values in seconds						Logarithms	Values in seconds					
s	4.028104			½(φ+φ′)	36 11 14.3		s	3.536927			½(φ+φ′)	36 11 06.1	
Cos α	9.4540328				Logarithms ±1	Values in seconds	Cos α	9.9960908				Logarithms	Values in seconds
B	8.5111382			s	4.028104		B	8.5111385			s	3.536927	
h	1.9932750	1st term	-98.″4634	Sin α	9.9816762		h	2.0441563	1st term	+110.″7022	Sin α	9.1257156	
s²	8.05621			A′	8.5092133		s²	7.07386			A′	8.5092133	
Sin² α	9.96335			Sec φ′	0.0931531		Sin² α	8.25143			Sec φ′	0.0931531	
C	1.26892			Δλ	2.6121467	+409.″3990	C	1.26887			Δλ	1.2650090	+18.″4081
	9.28848	2d term	+0.1943	Sin ½(φ+φ′)	9.7711661			6.59416	2d term	+0.0004	Sin ½(φ+φ′)	9.7711525	
h²	3.9865			-Δα	2.3833128	+241.72	h²	4.0883			-Δα	1.0361515	+10.87
D	2.3712		+0.0001				D	2.3712					
	6.3577	3d term	+0.0002					6.4595	3d term	+0.0003			
		-Δφ	-98.2688						-Δφ	-110.7015			

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FIGURE 26.—Computation of geodetic positions, North Carolina.

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POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

		°	′	″
α	2 to 3	106	31	37.3
3d ∠	&	+ 59	45	31.0
α	2 to 1	166	17	08.3
Δα		-	01	01.6
		180	00	00.0
α′	1 to 2	346	16	06.7
	First Angle of Triangle	58	42	26.9

		°	′	″
α	3 to 2	286	27	35.6
3d ∠	&	- 61	32	02.4
α	3 to 1	224	55	33.2
Δα		+	03	00.4
		180	00	00.0
α′	1 to 3	44	58	33.6

	°	′	″			°	′	″
φ	36	10	25.198	2 Mavaton	λ	76	38	37.560
Δφ	+	05	45.919		Δλ	+	01	44.246
φ′	36	16	11.117	1 Cannon	λ′	76	40	21.806

	°	′	″			°	′	″
φ	36	12	03.467	3 Saunders	λ	76	45	26.959
Δφ	+	04	07.650		Δλ	-	05	05.153
φ′	36	16	11.117	1 Cannon	λ′	76	40	21.806

	Logarithms	Values in seconds	
s	4.040417		
Cos α	9.9874383		
B	8.5111382		
h	2.5389935	1st term	-345.9342
s²	8.08083		
Sin² α	8.74980		
C	1.26892		
	8.09955	2d term	+0.0126
h²	5.0780		
D	3.3712		
	7.4492	3d term	+0.0028
		−Δφ	-345.9188

½(φ+φ′) 36° 13′ 18.2″

	Logarithms 2	Values in seconds
s	4.040417	
Sin α	9.3748979	
A′	8.5092115	
Sec φ′	0.0935353	
Δλ	2.0180615	+104.2465
Sin ½(φ+φ′)	9.7715225	
−Δα	1.7895840	+61.60

	Logarithms	Values in seconds	
s	4.032848		
Cos α	9.8500460		
B	8.5111362		
h	2.3940302	1st term	+247.7594
s²	8.06570		
Sin² α	9.69784		
C	1.26936		
	9.03290	2d term	+0.1079
h²	4.7881		
D	2.3713		+0.0002
	7.1594	3d term	+0.0014
		−Δφ	-247.6499

½(φ+φ′) 36° 14′ 07.3″

	Logarithms 1	Values in seconds
s	4.032848	
Sin α	9.8489225	
A′	8.5092115	
Sec φ′	0.0935353	
Δλ	2.4845172	-305.1527
Sin ½(φ+φ′)	9.7716636	
−Δα	2.2561808	-180.38

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FIGURE 26.—Computation of geodetic positions, North Carolina—Continued

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FORM 27
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POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

		°	′	″
α	2 to 3	44	58	33.6
2d ∠	&	+38	27	27.0
α	2 to 1	83	26	00.6
Δα		-	03	23.2
		180	00	00.0
α′	1 to 2	263	22	37.4
		88	24	20.5

		°	′	″
α	3 to 2	224	55	33.2
3d ∠	&	-53	08	12.6
α	3 to 1	171	47	20.6
Δα			-	22.7
		180	00	00.0
α′	1 to 3	351	46	57.9

First Angle of Triangle

	°	′	″			°	′	″
φ	36	16	11.117	2 Cannon	λ	76	40	21.806
Δφ		-	32.166		Δλ	+	05	43.545
φ′	36	15	38.951	1 Newsome	λ′	76	46	05.351

	°	′	″			°	′	″
φ	36	12	03.467	3 Saunders	λ	76	45	26.959
Δφ	+	03	35.484		Δλ		+	38.392
φ′	36	15	38.951	1 Newsome	λ′	76	46	05.351

	Logarithms	Values in seconds
s	3.9361444	
Cos α	9.0582602	
B	8.5111312	
h	1.5055354	1st term +32.0284
s²	7.87229	
Sin²α	9.99428	
C	1.27044	
	9.13701	2d term +0.1371
h²	3.0111	
D	2.3717	
	5.3828	3d term +0.0000
		−Δφ +32.1657

	°	′	″
½(φ+φ′)	36	15	55.0

	Logarithms −1	Values in seconds
s	3.9361444	
Sin α	9.9971416	
A′	8.5092117	
Sec φ′	0.0934856	
Δλ	2.5359830	+343.545
Sin ½(φ+φ′)	9.7719729	
−Δα	2.3079559	+203.22

	Logarithms	Values in seconds
s	3.826760	
Cos α	9.9955251	
B	8.5111362	
h	2.3334213	1st term +215.4871
s²	7.65352	
Sin²α	8.30956	
C	1.26936	
	7.23244	2d term +0.0017
h²	4.6669	
D	2.3713	
	7.0382	3d term +0.0011
		−Δφ −215.4843

	°	′	″
½(φ+φ′)	36	13	51.2

	Logarithms −1	Values in seconds
s	3.826760	
Sin α	9.1547829	
A′	8.5092117	
Sec φ′	0.0934856	
Δλ	1.5842401	+38.3919
Sin ½(φ+φ′)	9.7716174	
−Δα	1.3558575	+22.69

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FIGURE 26.—Computation of geodetic positions, North Carolina—Continued.

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POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

					°	′	″								°	′	″
α	2		to 3		83	26	00.6	α	3		to 2				263	22	37.4
2d ∠			&		+ 39	47	09.2	3d ∠			&				- 77	00	10.8
α	2		to 1		123	13	09.8	α	3		to 1				186	22	26.6
Δα					-	03	07.0	Δα								+	16.3
					180	00	00.0								180	00	00.0
α′	1		to 2		303	10	02.8	α′	1		to 3				6	22	42.9
			First Angle of Triangle		63	12	40.1										
	°	′	″		°	′	″		°	′	″		°	′	″		
φ	36	16	11.117	2 Cannon	λ	76	40	21.806	φ	36	15	38.951	3 Newsome	λ	76	46	05.350
Δφ	+	02	47.366		Δλ	+	05	16.004	Δφ	+	03	19.532		Δλ		-	27.541
φ′	36	18	58.483	1 Mason	λ′	76	45	37.810	φ′	36	18	58.483	1 Mason	λ′	76	45	37.809

	Logarithms	Values in seconds						Logarithms	Values in seconds				
s	3.974181			½(φ+φ′)	36 17 34.8			3.791577			½(φ+φ′)	36 17 18.7	
Cos α	9.7386588				Logarithms	Values in seconds	Cos α	9.9973069				Logarithms	Values in seconds
B	8.5111312			s	3.974181		B	8.5111319			s	3.791577	
h	2.2239710	1st term	167.4831	Sin α	9.9225070		h	2.3000158	1st term	199.5335	Sin α	9.0453971	
s²	7.94836			A′	8.5092104		s²	7.58315			A′	8.5092104	
Sin² α	9.84501			Sec φ′	0.0937940		Sin² α	8.09079			Sec φ′	0.0937940	
C	1.27044			Δλ	2.4996924	+316.0039	C	1.27030			Δλ	1.4399784	-27.5409
	9.06381	2d term	+0.1158	Sin ½(φ+φ′)	9.7722591			6.94424	2d term	+0.0009	Sin ½(φ+φ′)	9.7722129	
h²	4.4480			−Δα	2.2719515	+187.05	h²	4.6001			−Δα	1.2121913	-16.30
D	2.3717		+0.0001				D	2.3717					
	6.8197	3d term	+0.0007					6.9718	3d term	+0.0009			
		−Δφ	-167.3665						−Δφ	-199.5317			

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FIGURE 26.—Computation of geodetic positions, North Carolina—Continued.

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POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

		°	′	″
α	2 to 3	6	22	42.9
2d∠	&	+57	48	46.0
α	2 to 1	64	11	28.9
Δα		-	01	11.7
		180	00	00.0
α′	1 to 2	244	10	17.2
		89	19	47.0

FIRST ANGLE OF TRIANGLE

	°	′	″			°	′	″
φ	36	18	58.483	2 Mason	λ	76	45	37.809
Δφ		-	47.445		Δλ	+	02	01.156
φ′	36	18	11.038	1 Cotton	λ′	76	47	38.965

	Logarithms	Values in seconds
s	3.526048	
Cos α	9.6388553	
B	8.5111277	
h	1.6760310	1st term +47.″4276
s²	7.05213	
Sin²α	9.90873	
C	1.27117	
	8.23203	2d term +0.0171
h²	3.3521	
D	2.3719	
	5.7240	3d term +0.0001
		−Δφ +47.4448

	°	′	″	Logarithms	Values in seconds
½(φ+φ′)	36	18	34.8		
s				3.526048	
Sin α				9.9543646	
A′				8.5092107	
Sec φ′				0.0937207	
Δλ				2:0833440	+121.″1557
Sin½(φ+φ′)				9.7724311	
−Δα				1.8557751	+71.74

	°	′	″
α	3 to 2	186	22	26.6
3d∠	&	-32	51	27.1
α	3 to 1	153	30	59.5
Δα			-	55.4
		180	00	00.0
α′	1 to 3	333	30	04.1

	°	′	″			°	′	″
φ	36	15	38.951	3 Newsome	λ	76	46	05.350
Δφ	+	02	32.087		Δλ	+	01	33.615
φ′	36	18	11.038	1 Cotton	λ′	76	47	38.965

	Logarithms	Values in seconds
s	3.719137	
Cos α	9.9518536	
B	8.5111319	
h	2.1821225	1st term +152.″0976
s²	7.43827	
Sin²α	9.29855	
C	1.27030	
	8.00712	2d term +0.0102
h²	4.3642	
D	2.3717	
	6.7359	3d term +0.0005
		−Δφ −152.0869

	°	′	″	Logarithms	Values in seconds
½(φ+φ′)	36	16	55.0		
s				3.719137	
Sin α				9.6492761	
A′				8.5092107	
Sec φ′				0.0937207	
Δλ				1.9713445	+93.″6148
Sin½(φ+φ′)				9.7721450	
−Δα				1.7434895	+55.40

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FIGURE 26.—Computation of geodetic positions, North Carolina—Continued.

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POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

			°	′	″
α	2 to 3		64	11	28.9
2d ∠	&		+60	59	17.0
α	2 to 1		125	10	45.9
Δα			-	01	50.2
			180	00	00.0
α′	1 to 2		305	08	55.7
			35	57	30.0

			°	′	″
α	3 to 2		244	10	17.1
3d ∠	&		-83	03	13.0
α	3 to 1		161	07	04.1
Δα				-	38.4
			180	00	00.0
α′	1 to 3		341	06	25.7

FIRST ANGLE OF TRIANGLE

	°	′	″			°	′	″			°	′	″			°	′	″
φ	36	18	58.483	2 Mason	λ	76	45	37.809	φ	36	18	11.038	3 Cotton	λ	76	47	38.965
Δφ	+	01	46.061		Δλ	+	03	06.055	Δφ	+	02	33.505		Δλ	+	01	04.900
φ′	36	20	44.544	1 Piland	λ′	76	48	43.864	φ′	36	20	44.543	1 Piland	λ′	76	48	43.865

	Logarithms	Values in seconds
s	3.754065	
Cos α	9.7605271	
B	8.5111277	
h	2.0257198	1st term +106.″1011
s²	7.50813	
Sin² α	9.82482	
C	1.27117	
	8.60412	2d term +0.0402
h³	4.0514	
D	2.3719	
	6.4233	3d term +0.0003
		-Δφ -106.0606

	°	′	″	Logarithms	Values in seconds
½(φ+φ′)	36	19	51.5		
s				3.754065	
Sin α				9.9124090	
A′				8.5092097	
Sec φ′				0.0939584	
Δλ				2.2696421	+186.″0553
Sin ½(φ+φ′)				9.7726508	
-Δα				2.0422929	+110.23

	Logarithms	Values in seconds
s	3.699034	
Cos α	9.9759765	
B	8.5111287	
h	2.1861392	1st term +153.″5109
s²	7.39807	
Sin² α	9.02008	
C	1.27097	
	7.68912	2d term +0.0049
h³	4.3723	
D	2.3718	
	6.7441	3d term +0.0006
		-Δφ -153.5054

	°	′	″	Logarithms	Values in seconds
½(φ+φ′)	36	19	27.8		
s				3.699034	
Sin α				9.5100399	
A′				8.5092097	
Sec φ′				0.0939584	
Δλ				1.8122420	+64.″8996
Sin ½(φ+φ′)				9.7725829	
-Δα				1.5848249	+38.44

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FIGURE 26.—Computation of geodetic positions, North Carolina—Continued.

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POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

					°	′	″							°	′	″
α	2	to 3			125	10	45.9	α	3	to 2				305	08	55.7
2d ∠		&			+ 55	50	20.8	3d ∠		&				- 88	25	05.7
α	2	to 1			181	01	06.7	α	3	to 1				216	43	50.0
Δα						+	04.1	Δα						+	01	54.4
					180	*00*	*00.0*							*180*	*00*	*00.0*
α′	1	to 2			1	01	10.8	α′	1	to 3				36	45	44.4
			FIRST ANGLE OF TRIANGLE		35	44	33.6									
	°	′	″		°	′	″		°	′	″			°	′	″
φ	36	18	58.483	2 Mason	λ	76	45	37.809	φ	36	20	44.544	3 Piland	λ	76	48	43.864
Δφ	+	05	15.089		Δλ		-	06.929	Δφ	+	03	29.029		Δλ	-	03	12.985
φ′	36	24	13.572	+1 1 Gatesville	λ′	76	45	30.880	φ′	36	24	13.573	1 Gatesville	λ′	76	45	30.879

	Logarithms	Values in seconds		°	′	″	Values in seconds
s	3.987378		½(φ+φ′)	36	21	36.0	
Cos α	9.9999314			Logarithms			
B	8.5111277		s	3.987378			
h	2.4984371	1st term 315.0918	Sin α	8.2498274			
s²	7.97476		A′	8.5092083			
Sin²α	6.49965		Sec φ′	0.0942825			
C	1.27117		Δλ	0.0846960	-6.9294		
	5.74558	2d term +0.0001	Sin ½(φ+φ′)	9.7729498			
h²	4.9969		-Δα	0.6136458	- 4.11		
D	2.3719						
	7.3688	3d term +0.0023					
		-Δφ = 315.0894					

	Logarithms	Values in seconds		°	′	″	Values in seconds
s	3.905293		½(φ+φ′)	36	22	29.0	
Cos α	9.9038801			Logarithms			
B	8.5111254		s	3.905293			
h	2.3202985	1st term 209.0733	Sin α	9.7767394			
s²	7.81059		A′	8.5092083			
Sin²α	9.55348		Sec φ′	0.0942825			
C	1.27166		Δλ	2.2855231	-192.9848		
	8.63573	2d term +0.0432	Sin ½(φ+φ′)	9.7731014			
h²	4.6406		-Δα	2.0586245	-114.45		
D	2.3721	+0.0001					
	7.0127	3d term +0.0010					
		-Δφ = 209.0290					

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FIGURE 26.—Computation of geodetic positions, North Carolina—Continued.

Geodetic positions from Lambert coordinates

State North Carolina Station Saunders

x	2,661,640.70	$R_b + A$	30 183 611.25
C	2,000,000.00	y	899,505.80
x' (= x−C)	661,640.70	$R_b + A - y$	29,284,105.45
			1.0002552085
tan θ	.0225938505	R	
θ	1° 17′ 39.″5234		
	4659.″5234	y	899,505.80
$\frac{\theta}{\ell}$ (= Δλ)	8073.0411	y″	− 7,473.55
		y′	892,032.25
λ (central mer.)	79° 00′ 00.″0000		
− Δλ	02 14 33.0411	φ (by interpolation)	36° 12′ 03.″4675
λ	76 45 26.9589		

$\frac{\theta}{\ell}$ = .5771707700

Station Cannon

x	2,686,058.51	$R_b + A$	30,183,611.25
C	2,000,000.00	y	925,118.14
x' (= x−C)	686,058.51	$R_b + A - y$	29,258,493.11
		Sec	1.0002748712
tan θ	.0234481833	R	
θ	1° 20′ 35.″6489		
	4835.″6489	y	925,118.14
$\frac{\theta}{\ell}$ (= Δλ)	8378.1944	y″	− 8,042.32
		y′	917,075.82
λ (central mer.)	79° 00′ 00.″0000		
− Δλ	02 19 38.1944	φ (by interpolation)	36° 16′ 11.″1169
λ	76 40 21.8056		

$\tan\theta = \frac{x - C}{R_b + A - y}$

$\Delta\lambda = \frac{\theta}{\ell}$

$\lambda = \lambda$ (central mer.) $- \Delta\lambda$

$R = (R_b + A - y) \sec\theta$

$y'' = 2R \sin^2\frac{\theta}{2}$

$y' = y - y''$

C is constant added to x′ in computation of coordinates

R_b is map radius of lowest parallel

A is value of y′ for R_b; in most cases it is zero

φ is interpolated from table of y′

FIGURE 27.—Computation of geodetic positions from coordinates, North Carolina.

Geodetic positions from Lambert coordinates

State N. Carolina Station Newsome

x	2,658,004.91	$R_b + A$	30,183,611.25
C	2,000,000.00	y	921,220.22
x' (= x−C)	658,004.91	$R_b + A - y$	29,262,391.03
		Sec	1.0002527867
tan θ	.0224863686	R	
θ	1° 17′ 17.″3650		
	4637.″3650	y	921,220.22
$\frac{\theta}{l}$ (= Δλ)	8034.6498	y″	− 7,397.14
		y′	913,823.08
λ (central mer.)	79° 00′ 00.″0000		
− Δλ	02 13 54.6998	φ (by interpolation)	36° 15′ 38.″9518
λ	76 46 05.3502		

l = .5771707700

Station Mason

x	2,659,804.87	$R_b + A$	30,183,611.25
C	2,000,000.00	y	941,444.07
x' (= x−C)	659,804.87	$R_b + A - y$	29,242,167.18
		Sec	1.0002545230
tan θ	.0225634737	R	
θ	1° 17′ 33.″2610		
	4653.″2610	y	941,444.07
$\frac{\theta}{l}$ (= Δλ)	8062.1910	y″	− 7,442.80
		y′	934,001.27
λ (central mer)	79° 00′ 00.″0000		
− Δλ	02 14 22.1910	φ (by interpolation)	36° 18′ 58.″4835
λ	76 45 37.8090		

$\tan\theta = \frac{x - C}{R_b + A - y}$

$\Delta\lambda = \frac{\theta}{l}$

$\lambda = \lambda$ (central mer) $- \Delta\lambda$

$R = (R_b + A - y) \sec\theta$

$y'' = 2R \sin^2 \frac{\theta}{2}$

$y' = y - y''$

C is constant added to x′ in computation of coordinates

R_b is map radius of lowest parallel

A is value of y′ for R_b, in most cases it is zero

φ is interpolated from table of y′

FIGURE 27.—Computation of geodetic positions from coordinates, North Carolina—Continued.

Geodetic positions from Lambert coordinates

State N. Carolina Station Cotton

x	2,649,997.80	R_b+A	30,183,611.25
C	2,000,000.00	y	936,425.23
x' (= x−C)	649,997.80	R_b+A-y	29,247,186.02
		Sec.	1.0002469292
tan θ	.0222242851	R	
θ	1° 16′ 23.″3334		
	4583.″3334	y	936,425.23
$\frac{\theta}{l}$ (= Δλ)	7941.0352	y″	− 7,221.98
		y′	929,203.25
λ (central mer.)	79° 00′ 00.″0000		
− Δλ	− 02 12 21.0352	φ (by interpolation)	36° 18′ 11.″0388
λ	76 47 38.9648		

l = .5771707700

Station Piland

x	2,644,344.36	R_b+A	30,183,611.25
C	2,000,000.00	y	951,827.83
x' (= x−C)	644,344.36	R_b+A-y	29,231,783.42
		Sec	1.0002429088
tan θ	.0220425949	R	
θ	1° 15′ 45.″8754		
	4545.″8754	y	951,827.83
$\frac{\theta}{l}$ (= Δλ)	7876.1359	y″	− 7,100.66
		y′	944,727.17
λ (central mer.)	79° 00′ 00.″0000		
− Δλ	02 11 16.1359	φ (by interpolation)	36° 20′ 44.″5442
λ	76 48 43.8641		

$\tan\theta = \frac{x-C}{R_b+A-y}$

$\Delta\lambda = \frac{\theta}{l}$

$\lambda = \lambda_{(\text{central mer.})} - \Delta\lambda$

$R = (R + A - y)\sec\theta$

$y'' = 2R\sin^2\frac{\theta}{2}$

$y' = y - y''$

C is constant added to x′ in computation of coordinates

R_b is map radius of lowest parallel

A is value of y′ for R_b; in most cases it is zero

φ is interpolated from table of y′

FIGURE 27.—Computation of geodetic positions from coordinates, North Carolina—Continued.

ADJUSTMENT OF A QUADRILATERAL WITH ONE SIDE FIXED ENTIRELY AND WITH AN OPPOSITE SIDE FIXED IN LENGTH

This condition does not occur very frequently but it was thought worth while to include this small adjustment to show how such cases could be handled if they should occur. In order to hold the measured

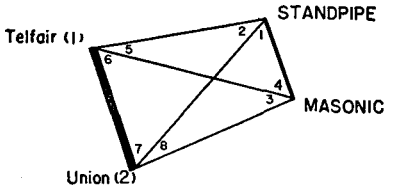

FIGURE 28.—Quadrilateral with two fixed lengths

length of the line Telfair to Union in Georgia (see fig. 28) it was necessary to introduce a condition equation between the coordinates of the two stations Telfair and Union. By means of this equation it was possible to eliminate one of the unknowns from the equations wherever it occurred. This is the method to be followed in case an arc of triangulation should include a measured base. A study of the adjustment will show the method of procedure in such cases. The condition equations for the fixed line are determined in the following way. The proper reduction was applied to the log of the geodetic length and this resulting grid length was used in the computation of the assumed coordinates of Union as computed from Telfair. This means that the grid length of the line is correct and we have only to hold the length as determined by the coordinates.

We have then

$$s^2=(x_2-x_1)^2+(y_2-y_1)^2$$

$$s\Delta s=(x_2-x_1)(\Delta x_2-\Delta x_1)+(y_2-y_1)(\Delta y_2-\Delta y_1)$$

Dividing through by s, we get,

$$\Delta s=(\Delta x_2-\Delta x_1)\sin\alpha+(\Delta y_2-\Delta y_1)\cos\alpha.$$

But $\Delta s=0$, since the line is already correct in length and we accordingly get,

$$\Delta y_2-\Delta y_1=-(\Delta x_2-\Delta x_1)\tan\alpha,$$

or

$$\Delta y_2=\Delta y_1-(\Delta x_2-\Delta x_1)\tan\alpha$$

This is the equation that is to be used in eliminating Δy_2 from the observation equations.

The grid tables for Georgia are given in figure 29.[4]

[4] For State map of Georgia showing elements of the two grids covering the State, see fig. 62, p. 263.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA (EAST & WEST)

Table I.

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. of lat.
30° 00'	0	101.01100			
01	6,060.66	101.01117	30° 36'	218,193.46	101.02033
02	12,121.33	101.01150	37	224,254.68	101.02050
03	18,182.02	101.01167	38	230,315.91	101.02083
04	24,242.72	101.01200	39	236,377.16	101.02117
05	30,303.44	101.01217	40	242,438.43	101.02133
30° 06'	36,364.17	101.01250	30° 41'	248,499.71	101.02167
07	42,424.92	101.01283	42	254,561.01	101.02183
08	48,485.69	101.01300	43	260,622.32	101.02217
09	54,546.47	101.01333	44	266,683.65	101.02250
10	60,607.27	101.01350	45	272,745.00	101.02267
30° 11'	66,668.08	101.01383	30° 46'	278,806.36	101.02283
12	72,728.91	101.01400	47	284,867.73	101.02333
13	78,789.75	101.01433	48	290,929.13	101.02350
14	84,850.61	101.01450	49	296,990.54	101.02367
15	90,911.48	101.01483	50	303,051.96	101.02400
30° 16'	96,972.37	101.01517	30° 51'	309,113.40	101.02417
17	103,033.28	101.01533	52	315,174.85	101.02450
18	109,094.20	101.01567	53	321,236.32	101.02483
19	115,155.14	101.01583	54	327,297.81	101.02500
20	121,216.09	101.01617	55	333,359.31	101.02533
30° 21'	127,277.06	101.01633	30° 56'	339,420.83	101.02567
22	133,338.04	101.01667	57	345,482.37	101.02583
23	139,399.04	101.01700	58	351,543.92	101.02600
24	145,460.06	101.01717	59	357,605.48	101.02633
25	151,521.09	101.01733	31° 00	363,667.06	101.02667
30° 26'	157,582.13	101.01767	31° 01'	369,728.66	101.02700
27	163,643.19	101.01800	02	375,790.28	101.02717
28	169,704.27	101.01833	03	381,851.91	101.02733
29	175,765.37	101.01850	04	387,913.55	101.02767
30	181,826.48	101.01867	05	393,975.21	101.02800
30° 31'	187,887.60	101.01900	31° 06'	400,036.89	101.02817
32	193,948.74	101.01933	07	406,098.58	101.02850
33	200,009.90	101.01950	08	412,160.29	101.02883
34	206,071.07	101.01983	09	418,222.02	101.02900
35	212,132.26	101.02000	10	424,283.76	101.02917

FIGURE 29.—Transverse Mercator projection tables for Georgia.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA (EAST & WEST)

Table I (Cont'd).

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. of lat.
31° 11'	430,345.51	101.02950	31° 46'	642,517.03	101.03883
12	436,407.28	101.02983	47	648,579.36	101.03917
13	442,469.07	101.03017	48	654,641.71	101.03933
14	448,530.88	101.03033	49	660,704.07	101.03967
15	454,592.70	101.03050	50	666,766.45	101.04000
31° 16'	460,654.53	101.03083	31° 51'	672,828.85	101.04017
17	466,716.38	101.03117	52	678,891.26	101.04050
18	472,778.25	101.03150	53	684,953.69	101.04067
19	478,840.14	101.03167	54	691,016.13	101.04100
20	484,902.04	101.03183	55	697,078.59	101.04133
31° 21'	490,963.95	101.03217	31° 56'	703,141.07	101.04150
22	497,025.88	101.03250	57	709,203.56	101.04183
23	503,087.83	101.03267	58	715,266.07	101.04200
24	509,149.79	101.03300	59	721,328.59	101.04233
25	515,211.77	101.03333	32° 00	727,391.13	101.04267
31° 26'	521,273.77	101.03350	32° 01'	733,453.69	101.04283
27	527,335.78	101.03383	02	739,516.26	101.04317
28	533,397.81	101.03400	03	745,578.85	101.04350
29	539,459.85	101.03433	04	751,641.46	101.04367
30	545,521.91	101.03450	05	757,704.08	101.04383
31° 31'	551,583.98	101.03483	32° 06'	763,766.71	101.04433
32	557,646.07	101.03517	07	769,829.37	101.04450
33	563,708.18	101.03533	08	775,892.04	101.04467
34	569,770.30	101.03567	09	781,954.72	101.04500
35	575,832.44	101.03600	10	788,017.42	101.04533
31° 36'	581,894.60	101.03617	32° 11'	794,080.14	101.04567
37	587,956.77	101.03633	12	800,142.88	101.04583
38	594,018.95	101.03683	13	806,205.63	101.04617
39	600,081.16	101.03700	14	812,268.40	101.04633
40	606,143.38	101.03717	15	818,331.18	101.04667
31° 41'	612,205.61	101.03750	32° 16'	824,393.98	101.04683
42	618,267.86	101.03783	17	830,456.79	101.04717
43	624,330.13	101.03800	18	836,519.62	101.04750
44	630,392.41	101.03833	19	842,582.47	101.04783
45	636,454.71	101.03867	20	848,645.34	101.04800

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA (EAST & WEST)

Table I (Cont'd).

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. of lat.
32° 21'	854,708.22	101.04817	32° 56'	1,066,919.27	101.05783
22	860,771.11	101.04850	57	1,072,982.74	101.05800
23	866,834.02	101.04883	58	1,079,046.22	101.05833
24	872,896.95	101.04917	59	1,085,109.72	101.05867
25	878,959.90	101.04933	33° 00	1,091,173.24	101.05883
32° 26'	885,022.86	101.04967	33° 01'	1,097,236.77	101.05917
27	891,085.84	101.04983	02	1,103,300.32	101.05933
28	897,148.83	101.05017	03	1,109,363.88	101.05967
29	903,211.84	101.05050	04	1,115,427.46	101.06000
30	909,274.87	101.05067	05	1,121,491.06	101.06033
32° 31'	915,337.91	101.05100	33° 06'	1,127,554.68	101.06050
32	921,400.97	101.05133	07	1,133,618.31	101.06083
33	927,464.05	101.05150	08	1,139,681.96	101.06100
34	933,527.14	101.05167	09	1,145,745.62	101.06133
35	939,590.24	101.05217	10	1,151,809.30	101.06167
32° 36'	945,653.37	101.05233	33° 11'	1,157,873.00	101.06183
37	951,716.51	101.05267	12	1,163,936.71	101.06217
38	957,779.67	101.05283	13	1,170,000.44	101.06250
39	963,842.84	101.05317	14	1,176,064.19	101.06267
40	969,906.03	101.05333	15	1,182,127.95	101.06300
32° 41'	975,969.23	101.05367	33° 16'	1,188,191.73	101.06317
42	982,032.45	101.05400	17	1,194,255.52	101.06350
43	988,095.69	101.05433	18	1,200,319.33	101.06383
44	994,158.95	101.05450	19	1,206,383.16	101.06417
45	1,000,222.22	101.05467	20	1,212,447.01	101.06433
32° 46'	1,006,285.50	101.05517	33° 21'	1,218,510.87	101.06467
47	1,012,348.81	101.05533	22	1,224,574.75	101.06483
48	1,018,412.13	101.05550	23	1,230,638.64	101.06517
49	1,024,475.46	101.05583	24	1,236,702.55	101.06550
50	1,030,538.81	101.05617	25	1,242,766.48	101.06567
32° 51'	1,036,602.18	101.05633	33° 26'	1,248,830.42	101.06600
52	1,042,665.56	101.05667	27	1,254,894.38	101.06633
53	1,048,728.96	101.05700	28	1,260,958.36	101.06650
54	1,054,792.38	101.05733	29	1,267,022.35	101.06683
55	1,060,855.82	101.05750	30	1,273,086.36	101.06717

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA (EAST & WEST)

Table I (Cont'd).

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. of lat.
33° 31'	1,279,150.39	101.06733	34° 06'	1,491,401.74	101.07717
32	1,285,214.43	101.06767	07	1,497,466.37	101.07733
33	1,291,278.49	101.06783	08	1,503,531.01	101.07767
34	1,297,342.56	101.06833	09	1,509,595.67	101.07783
35	1,303,406.66	101.06850	10	1,515,660.34	101.07817
33° 36'	1,309,470.77	101.06867	34° 11'	1,521,725.03	101.07850
37	1,315,534.89	101.06900	12	1,527,789.74	101.07867
38	1,321,599.03	101.06933	13	1,533,854.46	101.07900
39	1,327,663.19	101.06967	14	1,539,919.20	101.07933
40	1,333,727.37	101.06983	15	1,545,983.96	101.07950
33° 41'	1,339,791.56	101.07017	34° 16'	1,552,048.73	101.07983
42	1,345,855.77	101.07033	17	1,558,113.52	101.08017
43	1,351,919.99	101.07067	18	1,564,178.33	101.08033
44	1,357,984.23	101.07100	19	1,570,243.15	101.08067
45	1,364,048.49	101.07133	20	1,576,307.99	101.08100
33° 46'	1,370,112.77	101.07150	34° 21'	1,582,372.85	101.08117
47	1,376,177.06	101.07167	22	1,588,437.72	101.08150
48	1,382,241.36	101.07217	23	1,594,502.61	101.08183
49	1,388,305.69	101.07233	24	1,600,567.52	101.08200
50	1,394,370.03	101.07267	25	1,606,632.44	101.08233
33° 51'	1,400,434.39	101.07283	34° 26'	1,612,697.38	101.08267
52	1,406,498.76	101.07317	27	1,618,762.34	101.08300
53	1,412,563.15	101.07350	28	1,624,827.32	101.08317
54	1,418,627.56	101.07367	29	1,630,892.31	101.08350
55	1,424,691.98	101.07400	30	1,636,957.32	101.08367
33° 56'	1,430,756.42	101.07433	34° 31'	1,643,022.34	101.08400
57	1,436,820.88	101.07450	32	1,649,087.38	101.08433
58	1,442,885.35	101.07483	33	1,655,152.44	101.08467
59	1,448,949.84	101.07517	34	1,661,217.52	101.08483
34° 00	1,455,014.35	101.07550	35	1,667,282.61	101.08517
34° 01'	1,461,078.88	101.07567	34° 36'	1,673,347.72	101.08533
02	1,467,143.42	101.07583	37	1,679,412.84	101.08583
03	1,473,207.97	101.07633	38	1,685,477.99	101.08600
04	1,479,272.55	101.07650	39	1,691,543.15	101.08617
05	1,485,337.14	101.07667	40	1,697,608.32	101.08650

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA (EAST & WEST)

Table 1 (Cont'd).

Lat.	y (feet)	Tabular difference for 1 sec. of lat.
34° 41'	1,703,673.51	101.08683
42	1,709,738.72	101.08717
43	1,715,803.95	101.08733
44	1,721,869.19	101.08767
45	1,727,934.45	101.08800
34° 46'	1,733,999.73	101.08817
47	1,740,065.02	101.08850
48	1,746,130.33	101.08883
49	1,752,195.66	101.08900
50	1,758,261.00	101.08933
34° 51'	1,764,326.36	101.08967
52	1,770,391.74	101.09000
53	1,776,457.14	101.09017
54	1,782,522.55	101.09050
55	1,788,587.98	101.09067
34° 56'	1,794,653.42	101.09100
57	1,800,718.88	101.09133
58	1,806,784.36	101.09167
59	1,812,849.86	101.09183
35° 00	1,818,915.37	101.09217
35° 01'	1,824,980.90	101.09250
02	1,831,046.45	101.09267
03	1,837,112.01	101.09300
04	1,843,177.59	101.09317
05	1,849,243.18	101.09367
35° 06'	1,855,308.80	101.09383
07	1,861,374.43	101.09417
08	1,867,440.08	101.09433
09	1,873,505.74	101.09467
10	1,879,571.42	101.09500
35° 11'	1,885,637.12	101.09533
12	1,891,702.84	101.09550
13	1,897,768.57	101.09583
14	1,903,834.32	101.09600
15	1,909,900.08	101.09633

Lat.	y (feet)	Tabular difference for 1 sec. of lat.
35° 16'	1,915,965.86	101.09667
17	1,922,031.66	101.09700
18	1,928,097.48	101.09717
19	1,934,163.31	101.09750
20	1,940,229.16	

λ(Central Meridian [East]) = 82° 10' 00".000

λ(Central Meridian [West]) = 84° 10' 00".000

$\log (1/6\rho_0^2)_g = 4.5817896 - 20$

$\log (1/6\rho_0^2 \sin 1'')_g = 9.8962147 - 20$

Geod. Az. − Grid Az. = $+\Delta\alpha + \frac{(y_2 - y_1)(2x_1' + x_2')}{(6\rho_0^2 \sin 1'')g}$

$\log R = -434.3$

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA (EAST & WEST)

Table II.

x' (feet)	Scale in units of 7th place of logs	Scale expressed as a ratio	x' (feet)	Scale in units of 7th place of logs	Scale expressed as a ratio
0	-434.3	0.9999000	175,000	-282.0	0.9999351
5,000	-434.2	0.9999000	180,000	-273.2	0.9999371
10,000	-433.8	0.9999001	185,000	-264.1	0.9999392
15,000	-433.2	0.9999003	190,000	-254.8	0.9999413
20,000	-432.3	0.9999005	195,000	-245.2	0.9999435
25,000	-431.2	0.9999007	200,000	-235.4	0.9999458
30,000	-429.8	0.9999010	205,000	-225.3	0.9999481
35,000	-428.2	0.9999014	210,000	-215.0	0.9999505
40,000	-426.3	0.9999018	215,000	-204.4	0.9999529
45,000	-424.2	0.9999023	220,000	-193.6	0.9999554
50,000	-421.9	0.9999029	225,000	-182.5	0.9999580
55,000	-419.3	0.9999035	230,000	-171.2	0.9999606
60,000	-416.4	0.9999041	235,000	-159.7	0.9999632
65,000	-413.3	0.9999048	240,000	-147.9	0.9999659
70,000	-409.9	0.9999056	245,000	-135.8	0.9999687
75,000	-406.3	0.9999064	250,000	-123.5	0.9999716
80,000	-402.5	0.9999073	255,000	-110.9	0.9999745
85,000	-398.4	0.9999083	260,000	- 98.1	0.9999774
90,000	-394.0	0.9999093	265,000	- 85.1	0.9999804
95,000	-389.4	0.9999103	270,000	- 71.8	0.9999835
100,000	-384.6	0.9999114	275,000	- 58.2	0.9999866
105,000	-379.5	0.9999126	280,000	- 44.4	0.9999898
110,000	-374.1	0.9999139	285,000	- 30.4	0.9999930
115,000	-368.5	0.9999151	290,000	- 16.1	0.9999963
120,000	-362.7	0.9999165	295,000	- 1.5	0.9999997
125,000	-356.6	0.9999179	300,000	+ 13.3	1.0000031
130,000	-350.3	0.9999193	305,000	+ 28.3	1.0000065
135,000	-343.7	0.9999209	310,000	+ 43.6	1.0000100
140,000	-336.8	0.9999224	315,000	+ 59.1	1.0000136
145,000	-329.7	0.9999241	320,000	+ 74.9	1.0000172
150,000	-322.4	0.9999258	325,000	+ 91.0	1.0000210
155,000	-314.8	0.9999275	330,000	+107.3	1.0000247
160,000	-307.0	0.9999293	335,000	+123.8	1.0000285
165,000	-298.9	0.9999312	340,000	+140.6	1.0000324
170,000	-290.6	0.9999331	345,000	+157.6	1.0000363

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA (EAST & WEST)

Table II (Cont'd).

x' (feet)	Scale in units of 7th place of logs	Scale expressed as a ratio
350,000	+174.9	1.0000403
355,000	+192.4	1.0000443
360,000	+210.2	1.0000484
365,000	+228.2	1.0000525
370,000	+246.5	1.0000568
375,000	+265.0	1.0000610
380,000	+283.8	1.0000653
385,000	+302.8	1.0000697
390,000	+322.1	1.0000742
395,000	+341.6	1.0000787
400,000	+361.4	1.0000832
405,000	+381.4	1.0000878
410,000	+401.6	1.0000925
415,000	+422.1	1.0000972
420,000	+442.9	1.0001020
425,000	+463.9	1.0001068
430,000	+485.2	1.0001117
435,000	+506.7	1.0001167
440,000	+528.5	1.0001217
445,000	+550.5	1.0001268
450,000	+572.7	1.0001319
455,000	+595.2	1.0001370
460,000	+618.0	1.0001423
465,000	+641.0	1.0001476
470,000	+664.2	1.0001529
475,000	+687.7	1.0001583
480,000	+711.4	1.0001638
485,000	+735.4	1.0001693
490,000	+759.7	1.0001749
495,000	+784.2	1.0001806
500,000	+808.9	1.0001863
505,000	+833.9	1.0001920
510,000	+859.1	1.0001978
515,000	+884.6	1.0002037
520,000	+910.4	1.0002096

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA

Table III.

Lat.	Colog A	Log C	Lat.	Colog A	Log C
30° 00'	1.49064120	1.166914			
01	157	7204	30° 36'	1.49065463	1.177300
02	194	7494	37	500	7587
03	231	7784	38	538	7874
04	268	8074	39	575	8160
05	305	8364	40	613	8447
30° 06'	1.49064342	1.168654	30° 41'	1.49065651	1.178733
07	380	8944	42	688	9020
08	417	9233	43	726	9306
09	454	9523	44	763	9592
10	491	1.169812	45	801	1.179878
30° 11'	1.49064528	1.170101	30° 46'	1.49065839	1.180164
12	566	0390	47	876	0450
13	603	0679	48	914	0736
14	640	0968	49	952	1022
15	677	1257	50	1.49065989	1307
30° 16'	1.49064715	1.171546	30° 51'	1.49066027	1.181592
17	752	1835	52	065	1878
18	789	2123	53	103	2163
19	827	2412	54	140	2449
20	864	2700	55	178	2734
30° 21'	1.49064901	1.172988	30° 56'	1.49066216	1.183019
22	939	3276	57	254	3304
23	1.49064976	3564	58	291	3589
24	1.49065013	3852	59	329	3873
25	051	4140	31° 00	367	4158
30° 26'	1.49065088	1.174427	31° 01'	1.49066405	1.184443
27	126	4715	02	443	4727
28	163	5002	03	481	5012
29	200	5290	04	519	5296
30	238	5577	05	556	5580
30° 31'	1.49065275	1.175864	31° 06'	1.49066594	1.185864
32	313	6152	07	632	6148
33	350	6439	08	670	6432
34	388	6726	09	708	6716
35	425	7013	10	746	7000

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA

Table III (Cont'd).

Lat.	Colog A	Log C	Lat.	Colog A	Log C
31° 11'	1.49066784	1.187284	31° 46'	1.49068119	1.197161
12	822	7567	47	157	7442
13	860	7851	48	196	7722
14	898	8134	49	234	8003
15	936	8418	50	272	8283
31° 16'	1.49066974	1.188701	31° 51'	1.49068311	1.198563
17	1.49067012	8984	52	349	8844
18	050	9267	53	388	9124
19	088	9550	54	426	9404
20	126	1.189833	55	465	9684
31° 21'	1.49067164	1.190116	31° 56'	1.49068503	1.199964
22	202	0399	57	541	1.200244
23	240	0681	58	580	0524
24	278	0964	59	618	0803
25	317	1247	32° 00	657	1083
31° 26'	1.49067355	1.191529	32° 01'	1.49068695	1.201362
27	393	1811	02	734	1642
28	431	2094	03	772	1920
29	469	2376	04	811	2200
30	507	2658	05	850	2479
31° 31'	1.49067545	1.192940	32° 06'	1.49068888	1.202758
32	583	3222	07	927	3037
33	622	3504	08	1.49068965	3316
34	660	3786	09	1.49069004	3594
35	698	4068	10	042	1.203873
31° 36'	1.49067736	1.194349	32° 11'	1.49069081	1.204152
37	775	4631	12	120	4430
38	813	4912	13	158	4709
39	851	5194	14	197	4988
40	889	5475	15	236	5266
31° 41'	1.49067927	1.195756	32° 16'	1.49069274	1.205545
42	1.49067966	6037	17	313	5823
43	1.49068004	6318	18	352	6101
44	042	6599	19	390	6380
45	081	6880	20	429	6658

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA

Table III (Cont'd).

Lat.	Colog A	Log C	Lat.	Colog A	Log C
32° 21'	1.49069468	1.206936	32° 56'	1.49070830	1.216616
22	507	7214	57	869	6892
23	545	7492	58	908	7167
24	584	7769	59	947	7442
25	623	8047	33° 00	1.49070986	7717
32° 26'	1.49069662	1.208324	33° 01'	1.49071025	1.217992
27	700	8602	02	065	8267
28	739	8879	03	104	8542
29	778	9156	04	143	8817
30	817	9433	05	182	9091
32° 31'	1.49069856	1.209710	33° 06'	1.49071221	1.219366
32	894	1.209987	07	261	9641
33	933	1.210264	08	300	1.219915
34	1.49069972	0541	09	339	1.220190
35	1.49070011	0818	10	378	0464
32° 36'	1.49070050	1.211095	33° 11'	1.49071417	1.220738
37	089	1372	12	457	1013
38	128	1649	13	496	1287
39	167	1925	14	535	1561
40	206	2202	15	575	1835
32° 41'	1.49070244	1.212478	33° 16'	1.49071614	1.222109
42	283	2755	17	653	2383
43	322	3031	18	692	2657
44	361	3307	19	732	2930
45	400	3584	20	771	3204
32° 46'	1.49070439	1.213860	33° 21'	1.49071810	1.223478
47	478	4136	22	850	3751
48	517	4411	23	889	4024
49	556	4687	24	929	4298
50	595	4963	25	1.49071968	4571
32° 51'	1.49070634	1.215239	33° 26'	1.49072007	1.224844
52	673	5514	27	047	5117
53	713	5790	28	086	5390
54	752	6065	29	125	5663
55	791	6341	30	165	5936

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA

Table III (Cont'd).

Lat.	Colog A	Log C	Lat.	Colog A	Log C
33° 31'	1.49072204	1.226209	34° 06'	1.49073591	1.235716
32	244	6481	07	631	5987
33	283	6754	08	670	6257
34	323	7026	09	710	6528
35	362	7298	10	750	1.236798
33° 36'	1.49072402	1.227571	34° 11'	1.49073790	1.237068
37	441	7843	12	830	7339
38	481	8116	13	870	7609
39	520	8388	14	909	7879
40	560	8660	15	949	8149
33° 41'	1.49072599	1.228932	34° 16'	1.49073989	1.238419
42	639	9205	17	1.49074029	8689
43	678	9477	18	069	8959
44	718	1.229749	19	109	9228
45	758	1.230021	20	149	9498
33° 46'	1.49072797	1.230293	34° 21'	1.49074189	1.239767
47	837	0565	22	229	1.240037
48	876	0837	23	269	0306
49	916	1108	24	308	0576
50	956	1380	25	348	0844
33° 51'	1.49072995	1.231651	34° 26'	1.49074388	1.241114
52	1.49073035	1923	27	428	1384
53	075	2194	28	468	1653
54	114	2466	29	508	1922
55	154	1.232737	30	548	2191
33° 56'	1.49073194	1.233008	34° 31'	1.49074588	1.242460
57	233	3279	32	628	2729
58	273	3550	33	668	2999
59	313	3821	34	708	3268
34° 00	352	4092	35	748	3536
34° 01'	1.49073392	1.234363	34° 36'	1.49074789	1.243805
02	432	4634	37	829	4074
03	472	4904	38	869	4343
04	511	5175	39	909	4611
05	551	5446	40	949	1.244880

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

TRANSVERSE MERCATOR PROJECTION FOR GEORGIA

Table III (Cont'd).

Lat.	Colog A	Log C	Lat.	Colog A	Log C
34° 41'	1.49074989	1.245148	35° 16'	1.49076398	1.254505
42	1.49075029	5417	17	438	4771
43	069	5685	18	479	5037
44	109	5953	19	519	5304
45	149	6221	20	559	5570
34° 46'	1.49075190	1.246489			
47	230	6757			
48	270	7025			
49	310	7293			
50	350	7561			
34° 51'	1.49075390	1.247829			
52	431	8097			
53	471	8364			
54	511	8632			
55	551	8900			
34° 56'	1.49075591	1.249167			
57	632	9435			
58	672	9702			
59	712	1.249970			
35° 00	752	1.250237			
35° 01'	1.49075793	1.250504			
02	833	0771			
03	873	1038			
04	914	1305			
05	954	1572			
35° 06'	1.49075994	1.251839			
07	1.49076034	2106			
08	075	2373			
09	115	2639			
10	155	2906			
35° 11'	1.49076196	1.253173			
12	236	3439			
13	277	3706			
14	317	3972			
15	357	4238			

FIGURE 29.—Transverse Mercator projection tables for Georgia—Continued.

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 662
Rev. April, 1931

INVERSE POSITION COMPUTATION

$$s_1 \sin\left(\alpha+\frac{\Delta\alpha}{2}\right)=\frac{\Delta\lambda_1 \cos\phi_m}{A_m}$$

$$s_1 \cos\left(\alpha+\frac{\Delta\alpha}{2}\right)=\frac{-\Delta\phi_1 \cos\frac{\Delta\lambda}{2}}{B_m}$$

$$-\Delta\alpha=\Delta\lambda \sin\phi_m \sec\frac{\Delta\phi}{2}+F(\Delta\lambda)^3$$

in which $\log \Delta\lambda_1=\log(\lambda'-\lambda)$—correction for arc to sin*; $\log \Delta\phi_1=\log(\phi'-\phi)$—correction for arc to sin°; and $\log s=\log s_1+$ correction for arc to sin*.

NAME OF STATION

1. ϕ	32°	05′	15.786″	Standpipe	λ	81°	06′	14.907″
2. ϕ'	32	04	22.492	Masonic	λ'	81	05	40.604
$\Delta\phi\ (=\phi'-\phi)$		-	53.294		$\Delta\lambda\ (=\lambda'-\lambda)$		-	34.303
$\frac{\Delta\phi}{2}$		-	26.647		$\frac{\Delta\lambda}{2}$		-	17.152
$\phi_m\left(=\phi+\frac{\Delta\phi}{2}\right)$	32	04	49.139					
$\Delta\phi$ (secs.)		-	53.294		$\Delta\lambda$ (secs.)		-	34.303

$\log \Delta\phi$	1.7266783			$\log \Delta\lambda$	1.5353321	
cor. arc—sin	- 0			cor. arc—sin	- 0	
$\log \Delta\phi_1$	1.7266783			$\log \Delta\lambda_1$	1.5353321	
$\log \cos \frac{\Delta\lambda}{2}$	0			$\log \cos \phi_m$	9.9280395	
$\operatorname{colog} B_m$	1.4885688			$\operatorname{colog} A_m$	1.4906884	
$\log\left\{s_1 \cos\left(\alpha+\frac{\Delta\alpha}{2}\right)\right\}$	3.2152471		(opposite in sign to $\Delta\phi$)	$\log\left\{s_1 \sin\left(\alpha+\frac{\Delta\alpha}{2}\right)\right\}$	2.9540600	n
				$\log\left\{s_1 \cos\left(\alpha+\frac{\Delta\alpha}{2}\right)\right\}$	3.2152471	
$\log \Delta\lambda$	1.5353321	3 log $\Delta\lambda$		$\log \tan\left(\alpha+\frac{\Delta\alpha}{2}\right)$	9.7386129	n
$\log \sin \phi_m$	9.7251824	log F		$\alpha+\frac{\Delta\alpha}{2}$	331 16	31.7
$\log \sec \frac{\Delta\phi}{2}$	0	log b		$\log \sin\left(\alpha+\frac{\Delta\alpha}{2}\right)$	9.6817829	
$\log a$	1.2605145			$\log \cos\left(\alpha+\frac{\Delta\alpha}{2}\right)$	9.9429702	
a	- 18.22			$\log s_1$	3.2722769	
b				cor. arc—sin	+ 0	
$-\Delta\alpha$ (secs.)	- 18.2″			$\log s$	3.2722769	
$-\frac{\Delta\alpha}{2}$	° - ′ 9.1 ″					
$\alpha+\frac{\Delta\alpha}{2}$	331 16 31.7					
α (1 to 2)	331 16 22.6					
$\Delta\alpha$	+ 18.2					
180						
α' (2 to 1)	151 16 40.8					

* Use the table on the back of this form for correction of arc to sin.

NOTE.—For log s up to 4.52 and for $\Delta\phi$ or $\Delta\lambda$ (or both) up to 10′, omit all terms below the heavy line except those printed (in whole or in part) in heavy type or those underscored, if using logarithms to 6 decimal places.

FIGURE 30.—Inverse position computation.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Georgia (east) Station Standpipe

ϕ 32° 05′ 15.786″ — λ (Central meridian) 82° 10′ 00.000″; λ 81 06 14.907; $\Delta\lambda$ (Central meridian−λ) + 1 03 45.093; $\Delta\lambda$ (in sec.) + 3825.093″

log $\Delta\lambda$	3.58264200	log S_m^2	10.002656
Cor. arc to sine	2489	log C*	627 1.202552 -10
log $\Delta\lambda_1$	3.58261711	log $\Delta\phi$	83 1.205208
log cos ϕ	9.92800430 -10		
colog A	1.49068860	ϕ	32° 05′ 15.786″
log S_1	5.00131001	$\Delta\phi$	+ 29 16.046
Cor. sine to arc	+ 1784	ϕ'	32 05 31.8289
log S_m	5.00132785		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.04383
log R	− 4343		
log S_g	5.51726859	y (for min. of ϕ')	757,704.08
log S_g^3	16.5518058	y (for seconds of ϕ')	+ 3,216.11
log $1/6\rho_o^2R^2$	4.5817896 -20	y	760,920.19
log $(S_g^3/6\rho_o^2)_g$	1.1335954		
S_g	+ 329,055.072	log sin $\frac{\phi+\phi'}{2}$	
$(S_g^3/6\rho_o^2)_g$	+ 13.602	log $\Delta\lambda$	
x′	+ 329,068.67	log Δa_1	
	2,000,000.00	log $(\Delta\lambda)^3$	
x	2,329,068.67	log F	
		log b	
		Δa_1	″
		b	
		Δa	″
		$\Delta\alpha$	° ′ ″

* Take out C first for ϕ and correct for approximate ϕ'.

FIGURE 31.—*Computation of coordinates, Georgia.*

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Georgia (east) Station Masonic

ϕ 32° 04′ 22.492″

λ (Central meridian) 82° 10′ 00.000″

λ 81 05 40.604

$\Delta\lambda$ (Central meridian−λ) + 1 04 19.396

$\Delta\lambda$ (in sec.) + 3859.396″

log $\Delta\lambda$	3.58651934	log S_m^2	10.010550
Cor. arc to sine	− 2534	log C*	1.202365 81 -10
log $\Delta\lambda_1$	3.58649400	log $\Delta\phi$	1.212855 931
log cos ϕ	9.92807464 -10		
colog A	1.49068826	ϕ	32° 04′ 22.492″
log S_1	5.00525690	$\Delta\phi$	+ 16.325 79
Cor. sine to arc	+ 1818	ϕ'	32 04 38.817 99
log S_m	5.00527508		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.04367
log R	− 4343		
log S_g	5.52121582	y (for min. of ϕ')	751,641.46
log S_g^3	16.5636475	y (for seconds of ϕ')	+ 3,922.51
log $1/6\rho_o^2R^2$	4.5817896 -20	y	755,563.97
log $(S_g^3/6\rho_o^2)_g$	1.1454371		
S_g	+ 332,059.434	log sin $\frac{\phi+\phi'}{2}$	
$(S_g^3/6\rho_o^2)_g$	+ 13.978	log $\Delta\lambda$	
x′	+ 332,073.41	log $\Delta\alpha_1$	
	2,000,000.00	log $(\Delta\lambda)^3$	
x	2,332,073.41	log F	
		log b	
		$\Delta\alpha_1$	″
		b	
		$\Delta\alpha$	″
		$\Delta\alpha$	° ′ ″

* Take out C first for ϕ and correct for approximate ϕ'.

FIGURE 31.—Computation of coordinates, Georgia—Continued.

Computation of Preliminary Coordinates

Masonic-Standpipe

2,329,068.67	760,920.19	664,147
2,332,073.41	755,563.97	329,069
-3,004.74	+ 5,356.22	993,216
		5.997
		3.729
3.4778069 n		9.896 -20
3.7288584		9.622 -10
9.7489485 -10_n		+ 0".4

150° 42' 30".2 + 0".4 = 30".6

Masonic-Standpipe	150°	42'	30".2	log geodetic length Union-Telfair	= 3.5656256
	- 50	51	40.8	log $\frac{3937}{1200}$	= 0.5159842
Masonic-Telfair	99	50	49.4		4.0816098
Telfair-Masonic	279	50	49.4	grid reduction	= + 71
	+ 48	04	06.7	log grid length	= 4.0816169
Telfair-Union	327	54	56.1		

Masonic-Telfair

9.9935543 -10_n	9.2330437 -10	2,332,073.41	755,563.97
4.2224596	4.2224596	-16,444.24	+ 2,854.32
4.2160139 n	3.4555033	2,315,629.17	758,418.29

Telfair-Union

9.7252321 -10	9.9280200 -10_n	2,315,629.17	758,418.29
4.0816169	4.0816169	+ 6,409.87	-10,224.38
3.8068490	4.0096369 n	2,322,039.04	748,193.91

FIGURE 32.—Computation of preliminary coordinates.

Computation of Grid Azimuths

Standpipe-Masonic

	658,137 332,073
	990,210
	5.996
	3.729 n
	9.896 -20
	9.621 -10_n
$330^\circ\ 42'\ 30''.2 - 0''.4 = 29''.8$	$-\ 0''.4$

Standpipe-Union

2,322,039.04 2,329,068.67	748,193.91 760,920.19	658,137 322,039
-7,029.63	-12,726.28	980,176
		5.991
3.8469325 n	4.10470	4.105 n
4.1047021 n	9.94218 -10	9.896 -20
9.7422304 -10	4.16252	9.992 -10 n
		$-\ 1''.0$
$28^\circ\ 54'\ 53''.9 - 1''.0 = 52''.9$		

Standpipe-Telfair

2,315,629.17 2,329,068.67	758,418.29 760,920.19	658,137 315,629
-13,439.50	-2,501.90	973,766
		5.988
4.1283832 n		3.398 n
3.3982699 n		9.896 -20
0 7301133		9.282 -10_n
		$-\ 0''.2$
$79^\circ\ 27'\ 16''.3 - 0''.2 = 16''.1$		

FIGURE 33.—Computation of grid azimuths.

Masonic-Union

2,322,039.04	748,193.91	664,147
2,332,073.41	755,563.97	322,039
-10,034.37	-7,370.06	986,186
		5.994
4.0014901 n	4.00149	3.867 n
3.8674710 n	9.90632 -10	9.896 -20
0.1340191	4.09517	$9.757 -10_n$
		$- 0''.6$

$53° 42' 12''.2 - 0''.6 = 11''.6$

Masonic-Telfair

2,315,629.17	758,418.29	664,147
2,332,073.41	755,563.97	315,629
-16,444.24	+ 2,854.32	979,776
		5.991
4.2160138 n		3.456
3.4555026		9.896 -20
0.7605112 n		9.343 -10
		$+ 0''.2$

$99° 50' 49''.4 + 0''.2 = 49''.6$

Telfair-Standpipe

	631,258
	329,069
	960,327
	5.982
	3.398
	9.896 -20
	9.276 -10
	$+ 0''.2$

$259° 27' 16''.3 + 0''.2 = 16''.5$

Telfair-Masonic

	631,258
	332,073
	963,331
	5.984
	3.456 n
	9.896 -20
	$9.336 -10_n$
	$- 0''.2$

$279° 50' 49''.4 - 0''.2 = 49''.2$

FIGURE 33.—Computation of grid azimuths—Continued.

Telfair-Union

2,322,039.04	748,193.91	631,258
2,315,629.17	758,418.29	322,039
+ 6,409.87	-10,224.38	953,297
		5.979
3.8068493		4.010 n
4.0096370 n		9.896 -20
9.7972123 -10_n		9.885 -10_n
		- 0".8

327° 54' 56".0 - 0".8 = 55".2

Union-Telfair

	644,078
	315,629
	959,707
	5.982
	4.010
	9.896 -20
	9.888 -10
	+ 0".8

147° 54' 56".0 + 0".8 = 56".8

Union-Standpipe

	644,078
	329,069
	973,147
	5.988
	4.105
	9.896 -20
	9.989 -10
	+ 1".0

208° 54' 53".9 + 1".0 = 54".9

Union-Masonic

	644,078
	332,073
	976,151
	5.990
	3.867
	9.896 -20
	9.753 -10
	+ 0".6

233° 42' 12".2 + 0".6 = 12".8

FIGURE 33.—Computation of grid azimuths—Continued.

PARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 25
Ed. Jan., 1929

COMPUTATION OF TRIANGLES

State: Georgia

NO.	STATION	OBSERVED ANGLE		CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
2-3								3.788257
1	Telfair	20	23	29.8+0.3			30.1	0.457876 7
2	Standpipe	108	44	48.5+0.3			48.8	9.976325 9
3	Masonic	50	51	40.8+0.3			41.1	9.889649 9
1-3								4.222459 6
1-2				59.1				4.135783 6

FIGURE 34.—Triangle computation, Georgia.

Observation Equations

α_1 α_2 $\angle$ Obs.$\angle$	$\log \cos \alpha_1$ $\log \frac{1}{s_1}$ $\log \frac{1}{\sin 1''}$	$\log \sin \alpha_1$ $\log \frac{1}{s_1}$ $\log \frac{1}{\sin 1''}$	$\log \cos \alpha_2$ $\log \frac{1}{s_2}$ $\log \frac{1}{\sin 1''}$	$\log \sin \alpha_2$ $\log \frac{1}{s_2}$ $\log \frac{1}{\sin 1''}$
28° 54' 52".9	9.94218 -10_n	9.68441 -10_n		
330 42 29.8	5.83748 -10	5.83748 -10		
58 12 23.1	5.31443	5.31443		
58 12 19.3	1.09409 n	0.83632 n		
+ 3.8	- 12.42	- 6.86		

$v_1 = +3.8 - 12.42\ \Delta x_2 + 6.86\ \Delta y_2$

79° 27' 16".1	9.26249 -10_n	9.99260 -10_n		
28 54 52.9	5.86422 -10	5.86422 -10		
50 32 23.2	5.31443	5.31443		
50 32 29.2	0.44114 n	1.17125 n		
-6.0	- 2.76	- 14.83	- 12.42	- 6.86

$v_2 = -6.0 - 2.76\ \Delta x_1 + 14.83\ \Delta y_1 + 12.42\ \Delta x_2 - 6.86\ \Delta y_2$

99° 50' 49".6	9.23304 -10	9.99355 -10_n	9.77229 -10_n	9.90632 -10_n
53 42 11.6	5.77754 -10	5.77754 -10	5.90483 -10	5.90483 -10
46 08 38.0	5.31443	5.31443	5.31443	5.31443
46 08 49.1	0.32501	1.08552 n	0.99155 n	1.12558 n
-11.1	+ 2.11	- 12.18	- 9.81	- 13.35

$v_3 = -11.1 + 2.11\ \Delta x_1 + 12.18\ \Delta y_1 + 9.81\ \Delta x_2 - 13.35\ \Delta y_2$

150° 42' 30".6			
99 50 49.6			
50 51 41.0			
50 51 40.8			
+ 0.2		+ 2.11	- 12.18

$v_4 = +0.2 - 2.11\ \Delta x_1 - 12.18\ \Delta y_1$

FIGURE 35.—Observation equations.

279° 50' 49".2	9.23304 -10$_n$	9.99355 -10	9.26249 -10	9.99260 -10
259 27 16.5	5.77754 -10	5.77754 -10	5.86422 -10	5.86422 -10
	5.31443	5.31443	5.31443	5.31443
20 23 32.7				
20 23 29.8	0.32501 n	1.08552	0.44114	1.17125
+ 2.9	- 2.11	+ 12.18	+ 2.76	+ 14.83

$v_5 = +2.9 + 4.87\ \Delta x_1 - 2.65\ \Delta y_1$

327° 54' 55".2	9.92802 -10$_n$	9.72523 -10		
279 50 49.2	5.91838 -10	5.91838 -10		
	5.31443	5.31443		
48 04 06.0				
48 04 06.7	1.16083 n	0.95804		
-0.7	- 14.48	+ 9.08	- 2.11	+ 12.18

$v_6 = -0.7 + 12.37\ \Delta x_1 - 3.10\ \Delta y_1 - 14.48\ \Delta x_2 - 9.08\ \Delta y_2$

208° 54' 54".9	9.94218 -10	9.68441 -10	9.92802 -10	9.72523 -10$_n$
147 54 56.8	5.83748 -10	5.83748 -10	5.91838 -10	5.91838 -10
	5.31443	5.31443	5.31443	5.31443
60 59 58.1				
60 59 57.4	1.09409	0.83632	1.16083	0.95804 n
+ 0.7	+ 12.42	+ 6.86	+ 14.48	- 9.08

$v_7 = +0.7 - 14.48\ \Delta x_1 - 9.08\ \Delta y_1 + 2.06\ \Delta x_2 + 15.94\ \Delta y_2$

233° 42' 12".8	9.77230 -10	9.90632 -10		
208 54 54.9	5.90483 -10	5.90483 -10		
	5.31443	5.31443		
24 47 17.9				
24 47 13.3	0.99156	1.12558		
+ 4.6	+ 9.81	+ 13.35	+ 12.42	+ 6.86

$v_8 = +4.6 + 2.61\ \Delta x_2 + 6.49\ \Delta y_2$

FIGURE 35.—Observation equations—Continued.

To hold the length Telfair to Union:

$$\frac{\Delta y_2 - \Delta y_1}{\Delta x_2 - \Delta x_1} = -\tan \alpha$$

or

$$\Delta y_2 = \Delta y_1 + 0.6269\ (\Delta x_2 - \Delta x_1)$$

Making this substitution, the above equations become:

$$v_1 = +3.8 - 4.30\ \Delta x_1 + 6.86\ \Delta y_1 - 8.12\ \Delta x_2$$
$$v_2 = -6.0 + 1.54\ \Delta x_1 + 7.97\ \Delta y_1 + 8.12\ \Delta x_2$$
$$v_3 = -11.1 + 10.48\ \Delta x_1 - 1.17\ \Delta y_1 + 1.44\ \Delta x_2$$
$$v_4 = +0.2 - 2.11\ \Delta x_1 - 12.18\ \Delta y_1$$
$$v_5 = +2.9 + 4.87\ \Delta x_1 - 2.65\ \Delta y_1$$
$$v_6 = -0.7 + 18.06\ \Delta x_1 - 12.18\ \Delta y_1 - 20.17\ \Delta x_2$$
$$v_7 = +0.7 - 24.47\ \Delta x_1 + 6.86\ \Delta y_1 + 12.05\ \Delta x_2$$
$$v_8 = +4.6 - 4.07\ \Delta x_1 + 6.49\ \Delta y_1 + 6.68\ \Delta x_2$$

Station	Assumed coordinates	Correction	Adjusted coordinates
	Feet	*Feet*	*Feet*
1. Telfair	2,315,629.17	+0.37	2,315,629.54
	758,418.29	−0.02	758,418.27
2. Union	2,322,039.04	+0.39	2,322,039.43
	748,193.91	−0.01	748,193.90

Table for formation of normal equations

	Δx_1	Δy_1	Δx_2	η	Σ
1	−0.43	+0.69	−0.81	+0.38	−0.17
2	+0.15	+0.80	+0.81	−0.60	+1.16
3	+1.05	−0.12	+0.14	−1.11	−0.04
4	−0.21	−1.22		+0.02	−1.41
5	+0.49	−0.27		+0.29	+0.51
6	+1.81	−1.22	−2.02	−0.07	−1.50
7	−2.45	+0.69	+1.21	+0.07	−0.48
8	−0.41	+0.65	+0.67	+0.46	+1.37

Normal equations

	Δx_1	Δy_1	Δx_2	η	Σ
Δx_1	+11.0408	−4.3440	−6.2786	−1.7678	−1.3496
Δy_1		+5.0788	+3.8071	+0.2454	+4.7873
Δx_2			+7.3252	−0.4149	+4.4388
η				+2.0424	+0.1051
Σ					+7.9816

Solution of normal equations

Δx_1	Δy_1	Δx_2	η	Σ
+11.0408	−4.3440	−6.2786	−1.7678	−1.3496
Δx_1	+0.39345	+0.56867	+0.16012	+0.12224
	+5.0788	+3.8071	+0.2454	+4.7873
Δx_1	−1.7091	−2.4703	−0.6955	−0.5310
	+3.3697	+1.3368	−0.4501	+4.25634
	Δy_1	−0.39671	+0.13357	−1.26314
		+7.3252	−0.4149	+4.4388
	Δx_1	−3.5705	−1.0053	−0.7675
	Δy_1	−0.5303	+0.1786	−1.6886
		+3.2244	−1.2416	+1.98278
		Δx_2	+0.38506	−0.61494
			+2.0424	+0.1051
		Δx_1	−0.2831	−0.2161
		Δy_1	−0.0601	+0.5685
		Δx_2	−0.4781	+0.7635
			+1.2211	+1.2210
				+7.9816
			Δx_1	−0.1650
			Δy_1	−5.3764
			Δx_2	−1.2193
				+1.2209

Back solution

Δx_2	Δy_1	Δx_1
+0.3851	+0.1336	+0.1601
	−0.1528	+0.2190
	−0.0192	−0.0076
		+0.3715

Computation of Δy_2
(See p. 137)

$\Delta y_1 = -0.0192$
$0.6269(\Delta x_2 - \Delta x_1) = +0.0085$
$\Delta y_2 = -0.0107$

Computation of corrections

1	2	3	4	5	6	7	8
+0.380	−0.600	−1.110	+0.020	+0.290	−0.070	+0.070	+0.460
−0.160	+0.056	+0.390	−0.078	+0.182	+0.672	−0.910	−0.152
−0.013	−0.015	+0.002	+0.023	+0.005	+0.023	−0.013	−0.012
−0.312	+0.312	+0.054			−0.778	+0.466	+0.258
			−0.035	+0.477			
−0.105	−0.247	−0.664			−0.153	−0.387	+0.554
−1.0	−2.5	−6.6	−0.4	+4.8	−1.5	−3.9	+5.5

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
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COMPUTATION OF TRIANGLES

State: Georgia

NO.	STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3						3.272277
5	1 Telfair	20 23 29.8	+4.8			34.6	0.457851 3
1+2	2 Standpipe	108 44 48.5	-3.5			45.0	9.976328 7
4	3 Masonic	50 51 40.8	-0.4			40.4	9.889648 7
	1-3						3.706457
	1-2	59.1					3.619777
	2-3						3.619777
7	1 Union	60 59 57.4	-3.9			53.5	0.058188 3
5+6	2 Telfair	68 27 36.5	+3.3			39.8	9.968561 5
2	3 Standpipe	50 32 29.2	-2.5			26.7	9.887660 5
	1-3						3.646527
	1-2	03.1					3.565626
	2-3						3.706457
7+8	1 Union	85 47 10.7	+1.6			12.3	0.001175 3
6	2 Telfair	48 04 06.7	-1.5			05.2	9.871537 8
3	3 Masonic	46 08 49.1	-6.6			42.5	9.857993 8
	1-3						3.579170
	1-2	06.5					3.565626
	2-3						3.272277
8	1 Union	24 47 13.3	+5.5			18.8	0.377505 4
1	2 Standpipe	58 12 19.3	-1.0			18.3	9.929388 0
3+4	3 Masonic	97 00 29.9	-7.0			22.9	9.996744 8
	1-3						3.579170
	1-2	02.5					3.646527

FIGURE 36.—Final computation of triangles, Georgia.

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 27
Ed. April, 1929

POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

					°	′	″							°	′	″
α	2	to 3			331	16	22.6	α	3	to 2				151	16	40.8
2d ∠	&				+ 58	12	18.3	3d ∠	&					-97	00	22.9
α	2	to 1			29	28	40.9	α	3	to 1				54	16	17.9
$\Delta\alpha$						-	44.1	$\Delta\alpha$						-	01	02.3
					180	00	00.0							180	00	00.0
α'	1	to 2			209	27	56.8	α'	1	to 3				234	15	15.6
		First Angle of Triangle			24	47	18.8									
	°	′	″			°	′	″		°	′	″			°	′	″
ϕ	32	05	15.786	2 Standpipe	λ	81	06	14.907	ϕ	32	04	22.492	3 Masonic	λ	81	05	40.604
$\Delta\phi$	-	02	05.249		$\Delta\lambda$	+	01	23.122	$\Delta\phi$	-	01	11.956		$\Delta\lambda$	+	01	57.425
ϕ'	32	03	10.537	1 Union	λ'	81	07	38.029	ϕ'	32	03	10.536	1 Union	λ'	81	07	38.029

	Logarithms	Values in seconds		
s	3.646527			
Cos α	9.9397907			
B	8.5114307			
h	2.0977484	1st term	+125.2415	
s^2	7.2930			
$\sin^2\alpha$	9.3841			
C	1.2025			
	7.8796	2d term	+0.0076	
h^3	4.196			
D	2.346			
	6.542	3d term	+0.0003	
		$-\Delta\phi$	+125.2494	

	°	′	″	Logarithms	Values in seconds
$\frac{1}{2}(\phi+\phi')$	32	04	13.1		
s				3.646527	
Sin α				9.6920443	
A′				8.5093122	
Sec ϕ'				0.0718305	
$\Delta\lambda$				1.9197140	+83.1216
Sin $\frac{1}{2}(\phi+\phi')$				9.7250613	
$-\Delta\alpha$				1.6447753	+44.13

	Logarithms	Values in seconds		
s	3.579170			
Cos α	9.7663706			
B	8.5114317			
h	1.8569723	1st term	+71.9403	
s^2	7.1583			
$\sin^2\alpha$	9.8189			
C	1.2023			
	8.1795	2d term	+0.0151	
h^3	3.714			
D	2.346			
	6.060	3d term	+0.0001	
		$-\Delta\phi$	+71.9555	

	°	′	″	Logarithms	Values in seconds
$\frac{1}{2}(\phi+\phi')$	32	03	46.5		
s				3.579170	
Sin α				9.9094461	
A′				8.5093122	
Sec ϕ'				0.0718305	
$\Delta\lambda$				2.0697588	+117.4245
Sin $\frac{1}{2}(\phi+\phi')$				9.7249720	
$-\Delta\alpha$				1.7947308	+62.33

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FIGURE 37.—Computation of geodetic positions, Georgia.

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Form 27
Ed. April, 1923

POSITION COMPUTATION, THIRD-ORDER TRIANGULATION

				°	′	″						°	′	″
α	2	to 3		29	28	40.9	α	3	to 2			209	27	56.8
2d ∠		&		+50	32	26.7	3d ∠		&			- 60	59	53.5
α	2	to 1		80	01	07.6	α	3	to 1			148	28	03.3
Δα				-	01	23.1	Δα						-	38.9
				180	*00*	*00.0*						*180*	*00*	*00.0*
α′	1	to 2		259	59	44.5	α′	1	to 3			328	27	24.4-1
				68	27	39.8								

First Angle of Triangle

	°	′	″			°	′	″			°	′	″
φ	32	05	15.786	2 Standpipe	λ	81	06	14.907	φ	32	03	10.536	3 Union	λ	81	07	38.029
Δφ		-	23.473		Δλ	+	02	36.470	Δφ	+	01	41.777		Δλ	+	01	13.348
φ′	32	04	52.313	1 Telfair	λ′	81	08	51.377	φ′	32	04	52.313	1 Telfair	λ′	81	08	51.377

	Logarithms	Values in seconds
s	3.619777	
Cos α	9.2388623	
B	8.5114307	
h	1.3700700	1st term +23.″4461
s²	7.2395	
Sin²α	9.9868	
C	1.2025	
	8.4288	2d term +0.0268
h³	2.740	
D	2.346	
	5.086	3d term +
		−Δφ +23.4729

½(φ+φ′)	° 32	′ 05	″ 04.1	
		Logarithms		Values in seconds
s		3.619777		
Sin α		9.9933765		
A′		8.5093115		
Sec φ′		0.0719647		
Δλ		2.1944297		+156.″4695
Sin ½(φ+φ′)		9.7252327		
−Δα		1.9196624		+83.11

	Logarithms	Values in seconds
s	3.565626	
Cos α	9.9306151	
B	8.5114331	
h	2.0076742	1st term +101.″7828
s²	7.1312	
Sin²α	9.4370	
C	1.2020	
	7.7702	2d term +0.0059
h³	4.015	
D	2.346	
	6.361	3d term +0.0002
		−Δφ −101.7767

½(φ+φ′)	° 32	′ 04	″ 01.4	
		Logarithms		Values in seconds
s		3.565626		
Sin α		9.7184858		
A′		8.5093115		
Sec φ′		0.0719647		
Δλ		1.8653880		+73.″3479
Sin ½(φ+φ′)		9.7250220		
−Δα		1.5904100		+38.94

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FIGURE 37.—Computation of geodetic positions, Georgia—Continued.

93324°—35——10

TWO SHORT TRAVERSE ADJUSTMENTS EACH BEGINNING AND ENDING ON THE SAME CONTROL LINE

Two short traverse adjustments in Georgia, each starting from one end of a fixed line and ending on the other end, have been included as samples on a transverse Mercator grid. The first is from Manta to Clark and the second from Brooklyn to Renfroe. The following table shows the details of the adjustment which in all respects are similar to what have been described in previous adjustments. There is no essential difference between these computations and those on a Lambert grid.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Ga. (West) Station Manta

ϕ 32° 17′ 32.532

λ (Central meridian) 84° 10′ 00″.000

λ 84 43 04.401

$\Delta\lambda$ (Central meridian−λ) − 33 04.401

$\Delta\lambda$ (in sec.) − 1984.401

log $\Delta\lambda$	3.29762944 n	log S_m^2	9.430697
Cor. arc to sine	− 670	log C*	1.205974 − 10
log $\Delta\lambda_1$	3.29762274 n	log $\Delta\phi$	0.636671
log cos ϕ	9.92702781 − 10		
colog A	1.49069334	ϕ	32° 17′ 32″.532
log S_1	4.71534389 n	$\Delta\phi$	+ 4.3320
Cor. sine to arc	+ 478	ϕ'	32 17 36.8640
log S_m	4.71534867 n		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.04717
log R	− 4343		
log S_8	5.23128941 n	y (for min. of ϕ')	830,456.79
log S_8^3	15.6938682 n	y (for seconds of ϕ')	+ 3,725.00
log $1/6\rho_0^2R^2$	4.5817896 − 20	y	834,181.79
log $(S_8^3/6\rho_0^2)_8$	0.2756578 n		
S_8	− 170,329.318	log sin $\frac{\phi+\phi'}{2}$	
$(S_8^3/6\rho_0^2)_8$	− 1.887	log $\Delta\lambda$	
x′	− 170,331.20	log $\Delta\alpha_1$	
	2,000,000.00	log $(\Delta\lambda)^3$	
x	1,829,668.80	log F	
		log b	
		$\Delta\alpha_1$	″
		b	
		$\Delta\alpha$	″
		$\Delta\alpha$	° ′ ″

* Take out C first for ϕ and correct for approximate ϕ'.

FIGURE 38.—Computations of coordinates on traverse in Georgia.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Ga. (West) Station Clark

ϕ 32° 18′ 30.977″ — λ (Central meridian) 84° 10′ 00.000″; λ 84° 43′ 53.109″; $\Delta\lambda$ (Central meridian−λ) −33′ 53.109″; $\Delta\lambda$ (in sec.) −2033.109″

log $\Delta\lambda$	3.30816066 n	log S_m^2	9.451605 66
Cor. arc to sine	− 703	log C*	1.206245 71 −10
log $\Delta\lambda_1$	3.30815363 n	log $\Delta\phi$	0.657859
log cos ϕ	9.92695002 − 10		
colog A	1.49069372	ϕ	32° 18′ 30.977″
log S_1	4.72579737 n	$\Delta\phi$	+ 4.5485
Cor. sine to arc	+ 502	ϕ'	32 18 35.5255
log S_m	4.72580239 n		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.04750
log R	− 4343		
log S_g	5.24174313 n	y (for min. of ϕ')	836,519.62
log S_g^3	15.7252294 n	y (for seconds of ϕ')	+ 3,589.76
log $1/6\rho_o^2R^2$	4.5817896 − 20	y	840,109.38
log $(S_g^3/6\rho_o^2)_g$	0.3070190 n		
S_g	− 174,478.988	log sin $\frac{\phi+\phi'}{2}$	
$(S_g^3/6\rho_o^2)_g$	− 2.028	log $\Delta\lambda$	
x′	− 174,481.02	log $\Delta\alpha_1$	
	2,000,000.00	log $(\Delta\lambda)^3$	
x	1,825,518.98	log F	
		log b	
		$\Delta\alpha_1$	″
		b	
		$\Delta\alpha$	″
		$\Delta\alpha$	° ′

* Take out C first for ϕ and correct for approximate ϕ'

FIGURE 38.—Computations of coordinates on traverse in Georgia—Continued.

Grid azimuth

MANTA-CLARK

	x	y
Clark	1,825,518.98	840,109.38
Manta	1,829,668.80	834,181.79

(x_2-x_1) −4,149.82 (y_2-y_1) +5,927.59

log (x_2-x_1) 36180293n
log (y_2-y_1) 3.7728782

log tan α 9.8451511 − 10n

Grid α 145°00′16″.9

Adjustment of traverse, Manta to Clark, on transverse Mercator projection

Line	Azimuth, unadjusted	Sine	Cosine	Geodetic length	Grid length	$x+\Delta x$	Adjustment correction	$y+\Delta y$	Adjustment correction	Proportional length
	° ′ ″			*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	
Manta-Clark	**145 00 16.9**					**1,829,668.80**		**834,181.79**		
	359 57 03.3					−3,030.34		+4,320.65		
Manta-Manta *A*	144 57 20.2	−0.57421089	+0.81870743	5277.7	5277.4	1,826,638.46	+0.02	838,502.44	−0.10	5277.4
Manta *A*-Manta	324 57 20.2					**1,826,638.48**		**838,502.34**		
	195 17 10.7					−535.94		+1,492.06		
Manta *A*-Manta *B*	160 14 30.9	−0.33804950	+0.94112833	1585.5	1585.4	1,826,102.52	+0.03	839,994.50	−0.13	6862.8
Manta *B*-Manta *A*	340 14 30.9					**1,826,102.55**		**839,994.37**		
	120 54 26.9					−583.57		+115.02		
Manta *B*-Clark	101 08 57.8	−0.98112635	+0.19336777	594.8	594.8	1,825,518.95	+0.03	840,109.52	−0.14	7457.6
Clark-Manta *B*	281 08 57.8					**1,825,518.98**		**840,109.38**		
	43 51 19.1					−0.03		+0.14		
Clark-Manta	325 00 16.9									
Clark-Manta	325 00 16.9									

Fixed and final values are shown in **bold-faced** type in the above table.

Geodetic positions from transverse Mercator coordinates

State Ga (West) Station Manta A

x	1,826,638.48	log S_g	5.23894772 n
C	2,000,000.00	log (1200/3937)	9.48401583 - 10
x' (=x−C)	- 173,361.52	log (1/R)	4343
$x'^3/(6\rho_o^2)_g$	+ 1.99	log S_m	4.72300698 n
S_g	- 173,359.53	cor. arc to sine	- 495
		log S_1	4.72300203 n
log S_m^2	9.446014	log A	8.50930638 - 10
log C	1.206192 - 10	log sec ϕ	0.07302889
log $\Delta\phi$	0.652206	log $\Delta\lambda_1$	3.30533730 n
		cor. sine to arc	+ 694
y	838,502.34	log $\Delta\lambda$	3.30534424 n
ϕ'(by interpolation)	32° 18′ 19″.6216	$\Delta\lambda$	- 2019″.9668
$\Delta\phi$	- 4.4896	λ (central mer.)	84° 10′ 00″.000
ϕ	32 18 15.1320	$\Delta\lambda$	33 39.9668
		λ	84 43 39.9668

Station Manta B

x	1,826,102.55	log S_g	5.24028819 n
C	2,000,000.00	log (1200/3937)	9.48401583 - 10
x' (=x−C)	- 173,897.45	log (1/R)	4343
$x'^3/(6\rho_o^2)_g$	+ 2.01	log S_m	4.72434745 n
S_g	- 173,895.44	cor. arc to sine	- 498
		log S_1	4.72434247 n
log S_m^2	9.448695	log A	8.50930629 - 10
log C	1.206261 - 10	log sec ϕ	0.07304851
log $\Delta\phi$	0.654956	log $\Delta\lambda_1$	3.30669727 n
		cor. sine to arc	+ 698
y	839,994.37	log $\Delta\lambda$	3.30670425 n
ϕ'(by interpolation)	32° 18′ 34″.3873	$\Delta\lambda$	-2026″.3024
$\Delta\phi$	- 4.5181	λ (central mer.)	84° 10′ 00″.000
ϕ	32 18 29.8692	$\Delta\lambda$	33 46.3024
		λ	84 43 46.3024

FIGURE 39.—Computation of geodetic positions from coordinates, Georgia.

Adjustment of traverse, Brooklyn to Renfroe, on transverse Mercator projection

Line	Azimuth			Sine	Cosine	Geodetic length	Grid length	$x+\Delta x$	Adjustment correction	$y+\Delta y$	Adjustment correction	Proportional length
	Unadjusted	Closure correction	Adjusted for closure									
	° ′ ″	″	″			*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	
Brooklyn-Renfroe	170 15 32.4		32.4					**1,835,914.35**		**796,057.91**		
	18 49 31.0		31.0					+203.18		+1,270.76		
Brooklyn-Brooklyn *A*	189 05 03.4		03.4	+0.15788711	+0.98745717	1287.0	1286.9	1,836,117.53	−0.01	797,328.67	+0.01	1286.9
Brooklyn *A*-Brooklyn	9 05 03.4		03.4					**1,836,117.52**		**797,328.68**		
	146 42 39.3		39.3					−1,395.31		+3,104.01		
Brooklyn *A*-Brooklyn *B*	155 47 42.7		42.7	−0.40999953	+0.91208573	3403.4	3403.2	1,834,722.22	−0.02	800,432.68	+0.05	4690.1
Brooklyn *B*-Brooklyn *A*	335 47 42.7		42.7					**1,834,722.20**		**800,432.73**		
	183 00 34.2		34.2					−2,422.52		+6,247.14		
Brooklyn *B*-Brooklyn *C*	158 48 16.9		16.9	−0.36154818	+0.93235343	6700.9	6700.4	1,832,299.70	−0.05	806,679.82	+0.12	11390.5
Brooklyn *C*-Brooklyn *B*	338 48 16.9		16.9					**1,832,299.65**		**806,679.94**		
	194 55 21.5		21.5					−115.50		+1,050.77		
Brooklyn *C*-Brooklyn *D*	173 43 38.4		38.4	−0.10926012	+0.99401319	1057.2	1057.1	1,832,184.20	−0.05	807,730.59	+0.13	12447.6
Brooklyn *D*-Brooklyn *C*	353 43 38.4		38.4					**1,832,184.15**		**807,730.72**		
	159 50 55.7		55.7					−496.85		+999.86		
Brooklyn *D*-Brooklyn *E*	153 34 34.1		34.1	−0.44500816	+0.89552651	1116.6	1116.5	1,831,687.35	−0.06	808,730.45	+0.14	13564.1
Brooklyn *E*-Brooklyn *D*	333 34 34.1		34.1					**1,831,687.29**		**808,730.59**		
	236 45 57.4	+0.1	57.5					+1,586.31		+2,710.07		
Brooklyn *E*-Renfroe	210 20 31.5		31.6	+0.50516206	+0.86302450	3140.4	3140.2	1,833,273.66	−0.07	811,440.52	+0.17	16704.3
Renfroe-Brooklyn *E*	30 20 31.5		31.6					**1,833,273.59**		**811,440.69**		
	319 55 00.7	+0.1	00.8					+0.07		−0.17		
Renfroe-Brooklyn	350 15 32.2		32.4									
Renfroe-Brooklyn	**350 15 32.4**		**32.4**									
	−0.2											

Fixed and final values are shown in bold-faced type in the above table.

ADJUSTMENT OF A TRAVERSE THAT LIES PARTLY IN ONE SYSTEM OF COORDINATES AND PARTLY IN A SECOND SYSTEM

Cases will arise in which a traverse extends beyond the limit of one system of coordinates into an adjoining system. A considerable overlap of neighboring systems has been provided in the tables so it is possible to take care of any such instances as may arise in practice. Unless the traverse is a very long one it can be computed and adjusted entirely on one grid and then such points as desired can be transferred to the second grid by first computing the geodetic positions from the coordinates and then from these positions the coordinates on the second grid.

As an example of the adjustment of a traverse on two grids, a section of traverse lying partly in South Carolina and partly in Georgia has been selected because it furnishes an example not only of passing from one grid to another but of the more complicated case of passing from a Lambert grid to a transverse Mercator grid. (For grid table of South Carolina see fig. 40.)[5] This traverse is such that it could be computed and adjusted either entirely on the South Carolina grid or entirely on that of Georgia. However, for the sake of an example, it is computed partly on the one grid and partly on the other. It is only necessary to compute 2 stations in the overlap section on the first grid and then by passing through the geodetic positions to place the coordinates of these 2 stations on the second grid together with the grid azimuth on the new grid. Then the rest of the coordinates can be computed on the new grid to determine the closing error. Since the general direction of the traverse is north and south, the corrections to the geodetic angles were computed and applied to the angles in the Georgia section which is based on a transverse Mercator projection. This gave marked improvement in the closure of the traverse. The corrections were not computed on the part in South Carolina because a north and south line on the Lambert grid has very small correction and for our purpose is negligible.

No attempt was made to close the azimuth before distributing the closure in coordinates because it would entail further complications. The distribution of the closure in x and y coordinates takes care of this element just as well in the long run. The discrepancy would have been somewhat reduced by applying the azimuth closure first but it was not thought advisable to introduce any further complications than were necessary. A study of the procedure followed in this example will show clearly how to handle traverses that pass from one grid into another. The two grids can just as well be of the same class as of different classes as in this case. This computation can therefore serve as an example for any such case as may arise in practice.

[5] For State map of South Carolina showing elements of the 2 grids covering the State see fig. 63, p. 264

Lambert Projection for South Carolina - North

Table I.

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
33° 00'	31,127,724.75	0	101.09167	+987.1	1.0002273
01	31,121,659.25	6,065.50	101.09117	+957.5	1.0002205
02	31,115,593.78	12,130.97	101.09083	+928.3	1.0002137
03	31,109,528.33	18,196.42	101.09033	+899.5	1.0002071
04	31,103,462.91	24,261.84	101.09000	+871.0	1.0002006
05	31,097,397.51	30,327.24	101.08967	+842.9	1.0001941
33° 06'	31,091,332.13	36,392.62	101.08933	+815.1	1.0001877
07	31,085,266.77	42,457.98	101.08883	+787.7	1.0001814
08	31,079,201.44	48,523.31	101.08850	+760.6	1.0001751
09	31,073,136.13	54,588.62	101.08833	+733.9	1.0001690
10	31,067,070.83	60,653.92	101.08783	+707.6	1.0001629
33° 11'	31,061,005.56	66,719.19	101.08750	+681.6	1.0001569
12	31,054,940.31	72,784.44	101.08733	+656.0	1.0001510
13	31,048,875.07	78,849.68	101.08683	+630.7	1.0001452
14	31,042,809.86	84,914.89	101.08667	+605.8	1.0001395
15	31,036,744.66	90,980.09	101.08633	+581.3	1.0001338
33° 16'	31,030,679.48	97,045.27	101.08600	+557.1	1.0001283
17	31,024,614.32	103,110.43	101.08583	+533.3	1.0001228
18	31,018,549.17	109,175.58	101.08550	+509.8	1.0001174
19	31,012,484.04	115,240.71	101.08517	+486.7	1.0001121
20	31,006,418.93	121,305.82	101.08500	+464.0	1.0001068
33° 21'	31,000,353.83	127,370.92	101.08483	+441.6	1.0001017
22	30,994,288.74	133,436.01	101.08450	+419.6	1.0000966
23	30,988,223.67	139,501.08	101.08433	+398.0	1.0000916
24	30,982,158.61	145,566.14	101.08400	+376.7	1.0000867
25	30,976,093.57	151,631.18	101.08400	+355.8	1.0000819
33° 26'	30,970,028.53	157,696.22	101.08367	+335.2	1.0000772
27	30,963,963.51	163,761.24	101.08350	+315.0	1.0000725
28	30,957,898.50	169,826.25	101.08317	+295.2	1.0000680
29	30,951,833.51	175,891.24	101.08317	+275.7	1.0000635
30	30,945,768.52	181,956.23	101.08300	+256.6	1.0000591
33° 31'	30,939,703.54	188,021.21	101.08283	+237.9	1.0000548
32	30,933,638.57	194,086.18	101.08267	+219.5	1.0000505
33	30,927,573.61	200,151.14	101.08250	+201.4	1.0000464
34	30,921,508.66	206,216.09	101.08233	+183.8	1.0000423
35	30,915,443.72	212,281.03	101.08233	+166.5	1.0000383

FIGURE 40.—Lambert projection tables for South Carolina.

Lambert Projection for South Carolina - North

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central Meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
33° 36'	30,909,378.78	218,345.97	101.08217	+149.6	1.0000344
37	30,903,313.85	224,410.90	101.08200	+133.0	1.0000306
38	30,897,248.93	230,475.82	101.08200	+116.8	1.0000269
39	30,891,184.01	236,540.74	101.08183	+100.9	1.0000232
40	30,885,119.10	242,605.65	101.08183	+ 85.4	1.0000197
33° 41'	30,879,054.19	248,670.56	101.08167	+ 70.3	1.0000162
42	30,872,989.29	254,735.46	101.08167	+ 55.5	1.0000128
43	30,866,924.39	260,800.36	101.08150	+ 41.1	1.0000095
44	30,860,859.50	266,865.25	101.08150	+ 27.1	1.0000062
45	30,854,794.61	272,930.14	101.08150	+ 13.4	1.0000031
33° 46'	30,848,729.72	278,995.03	101.08150	0.0	1.0000000
47	30,842,664.83	285,059.92	101.08150	- 12.9	0.9999970
48	30,836,599.94	291,124.81	101.08150	- 25.5	0.9999941
49	30,830,535.05	297,189.70	101.08133	- 37.7	0.9999913
50	30,824,470.17	303,254.58	101.08150	- 49.6	0.9999886
33° 51'	30,818,405.28	309,319.47	101.08150	- 61.1	0.9999859
52	30,812,340.39	315,384.36	101.08133	- 72.3	0.9999834
53	30,806,275.51	321,449.24	101.08150	- 83.1	0.9999809
54	30,800,210.62	327,514.13	101.08167	- 93.5	0.9999785
55	30,794,145.72	333,579.03	101.08150	-103.5	0.9999762
33° 56'	30,788,080.83	339,643.92	101.08167	-113.2	0.9999739
57	30,782,015.93	345,708.82	101.08167	-122.5	0.9999718
58	30,775,951.03	351,773.72	101.08183	-131.5	0.9999697
59	30,769,886.12	357,838.63	101.08183	-140.1	0.9999677
34° 00	30,763,821.21	363,903.54	101.08200	-148.3	0.9999659
34° 01'	30,757,756.29	369,968.46	101.08217	-156.2	0.9999640
02	30,751,691.36	376,033.39	101.08217	-163.7	0.9999623
03	30,745,626.43	382,098.32	101.08217	-170.8	0.9999607
04	30,739,561.50	388,163.25	101.08250	-177.6	0.9999591
05	30,733,496.55	394,228.20	101.08250	-184.0	0.9999576
34° 06'	30,727,431.60	400,293.15	101.08267	-190.0	0.9999563
07	30,721,366.64	406,358.11	101.08283	-195.7	0.9999549
08	30,715,301.67	412,423.08	101.08300	-201.0	0.9999537
09	30,709,236.69	418,488.06	101.08317	-205.9	0.9999526
10	30,703,171.70	424,553.05	101.08333	-210.5	0.9999515

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - North

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
34° 11'	30,697,106.70	430,618.05	101.08350	-214.7	0.9999506
12	30,691,041.69	436,683.06	101.08367	-218.6	0.9999497
13	30,684,976.67	442,748.08	101.08400	-222.1	0.9999489
14	30,678,911.63	448,813.12	101.08417	-225.2	0.9999481
15	30,672,846.58	454,878.17	101.08433	-227.9	0.9999475
34° 16'	30,666,781.52	460,943.23	101.08450	-230.3	0.9999470
17	30,660,716.45	467,008.30	101.08483	-232.3	0.9999465
18	30,654,651.36	473,073.39	101.08500	-234.0	0.9999461
19	30,648,586.26	479,138.49	101.08533	-235.3	0.9999458
20	30,642,521.14	485,203.61	101.08550	-236.2	0.9999456
34° 21'	30,636,456.01	491,268.74	101.08583	-236.8	0.9999455
22	30,630,390.86	497,333.89	101.08617	-237.0	0.9999454
23	30,624,325.69	503,399.06	101.08633	-236.8	0.9999455
24	30,618,260.51	509,464.24	101.08667	-236.3	0.9999456
25	30,612,195.31	515,529.44	101.08700	-235.4	0.9999458
34° 26'	30,606,130.09	521,594.66	101.08733	-234.1	0.9999461
27	30,600,064.85	527,659.90	101.08767	-232.5	0.9999465
28	30,593,999.59	533,725.16	101.08800	-230.5	0.9999469
29	30,587,934.31	539,790.44	101.08817	-228.1	0.9999475
30	30,581,869.02	545,855.73	101.08867	-225.4	0.9999481
34° 31'	30,575,803.70	551,921.05	101.08900	-222.3	0.9999488
32	30,569,738.36	557,986.39	101.08933	-218.9	0.9999496
33	30,563,673.00	564,051.75	101.08983	-215.1	0.9999505
34	30,557,607.61	570,117.14	101.09000	-210.9	0.9999514
35	30,551,542.21	576,182.54	101.09050	-206.3	0.9999525
34° 36'	30,545,476.78	582,247.97	101.09100	-201.4	0.9999536
37	30,539,411.32	588,313.43	101.09133	-196.1	0.9999548
38	30,533,345.84	594,378.91	101.09167	-190.4	0.9999562
39	30,527,280.34	600,444.41	101.09217	-184.4	0.9999575
40	30,521,214.81	606,509.94	101.09267	-178.0	0.9999590
34° 41'	30,515,149.25	612,575.50	101.09300	-171.2	0.9999606
42	30,509,083.67	618,641.08	101.09350	-164.1	0.9999622
43	30,503,018.06	624,706.69	101.09383	-156.6	0.9999639
44	30,496,952.43	630,772.32	101.09450	-148.7	0.9999658
45	30,490,886.76	636,837.99	101.09483	-140.5	0.9999676

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - North

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
34° 46'	30,484,821.07	642,903.68	101.09533	-131.9	0.9999696
47	30,478,755.35	648,969.40	101.09600	-122.9	0.9999717
48	30,472,689.59	655,035.16	101.09633	-113.6	0.9999738
49	30,466,623.81	661,100.94	101.09683	-103.9	0.9999761
50	30,460,558.00	667,166.75	101.09733	- 93.8	0.9999784
34° 51'	30,454,492.16	673,232.59	101.09800	- 83.3	0.9999808
52	30,448,426.28	679,298.47	101.09850	- 72.5	0.9999833
53	30,442,360.37	685,364.38	101.09900	- 61.3	0.9999859
54	30,436,294.43	691,430.32	101.09950	- 49.8	0.9999885
55	30,430,228.46	697,496.29	101.10017	- 37.9	0.9999913
34° 56'	30,424,162.45	703,562.30	101.10067	- 25.6	0.9999941
57	30,418,096.41	709,628.34	101.10117	- 13.0	0.9999970
58	30,412,030.34	715,694.41	101.10183	0.0	1.0000000
59	30,405,964.23	721,760.52	101.10250	+ 13.4	1.0000031
35° 00	30,399,898.08	727,826.67	101.10317	+ 27.2	1.0000063
35° 01'	30,393,831.89	733,892.86	101.10367	+ 41.3	1.0000095
02	30,387,765.67	739,959.08	101.10417	+ 55.8	1.0000128
03	30,381,699.42	746,025.33	101.10500	+ 70.7	1.0000163
04	30,375,633.12	752,091.63	101.10567	+ 85.9	1.0000198
05	30,369,566.78	758,157.97	101.10617	+101.5	1.0000234
35° 06'	30,363,500.41	764,224.34	101.10683	+117.4	1.0000270
07	30,357,434.00	770,290.75	101.10750	+133.8	1.0000308
08	30,351,367.55	776,357.20	101.10833	+150.5	1.0000347
09	30,345,301.05	782,423.70	101.10883	+167.6	1.0000386
10	30,339,234.52	788,490.23	101.10950	+185.0	1.0000426
35° 11'	30,333,167.95	794,556.80	101.11033	+202.8	1.0000467
12	30,327,101.33	800,623.42	101.11100	+221.0	1.0000509
13	30,321,034.67	806,690.08	101.11183	+239.6	1.0000552
14	30,314,967.96	812,756.79	101.11233	+258.5	1.0000595
15	30,308,901.22	818,823.53	101.11317	+277.8	1.0000640
35° 16'	30,302,834.43	824,890.32	101.11400	+297.4	1.0000685
17	30,296,767.59	830,957.16	101.11467	+317.5	1.0000731
18	30,290,700.71	837,024.04	101.11550	+337.9	1.0000778
19	30,284,633.78	843,090.97	101.11617	+358.7	1.0000826
20	30,278,566.81	849,157.94	101.11700	+379.8	1.0000875

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - North

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
35° 21'	30,272,499.79	855,224.96	101.11783	+401.3	1.0000924
22	30,266,432.72	861,292.03	101.11850	+423.2	1.0000974
23	30,260,365.61	867,359.14	101.11950	+445.5	1.0001026
24	30,254,298.44	873,426.31	101.12017	+468.1	1.0001078
25	30,248,231.23	879,493.52	101.12100	+491.1	1.0001131
35° 26'	30,242,163.97	885,560.78	101.12183	+514.4	1.0001184
27	30,236,096.66	891,628.09	101.12267	+538.2	1.0001239
28	30,230,029.30	897,695.45	101.12350	+562.3	1.0001295
29	30,223,961.89	903,762.86	101.12450	+586.8	1.0001351
30	30,217,894.42	909,830.33		+611.6	1.0001408

$\ell = 0.56449738$

$\log \ell = 9.7516619306 - 10$

$\log K = 7.6419678060$

$$\text{Geod. Az.} - \text{Grid. Az.} = -\frac{x_2 - x_1}{2\rho_o^2 \sin 1''}\left(y_1 - y_o + \frac{y_2 - y_1}{3}\right) + \theta$$

$y_o = 497{,}599.22$ feet

$$\log \frac{1}{2\rho_o^2 \sin 1''} = 0.3731036 - 10$$

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - North

Table II.

1" of long. = 0"56449738 of θ

Long.	θ	Long.	θ	Long.	θ
78° 20'	+1° 30' 19"1748				
21	+1 29 45.3050	78° 56'	+1° 09' 59"8605	79° 31'	+0° 50' 14"4160
22	+1 29 11.4352	57	+1 09 25.9907	32	+0 49 40.5462
23	+1 28 37.5653	58	+1 08 52.1208	33	+0 49 06.6763
24	+1 28 03.6955	59	+1 08 18.2510	34	+0 48 32.8065
25	+1 27 29.8256	79° 00	+1 07 44.3811	35	+0 47 58.9366
78° 26'	+1 26 55.9558	79° 01'	+1 07 10.5113	79° 36'	+0 47 25.0668
27	+1 26 22.0859	02	+1 06 36.6415	37	+0 46 51.1970
28	+1 25 48.2161	03	+1 06 02.7716	38	+0 46 17.3271
29	+1 25 14.3463	04	+1 05 28.9018	39	+0 45 43.4573
30	+1 24 40.4764	05	+1 04 55.0319	40	+0 45 09.5874
78° 31'	+1 24 06.6066	79° 06'	+1 04 21.1621	79° 41'	+0 44 35.7176
32	+1 23 32.7367	07	+1 03 47.2922	42	+0 44 01.8477
33	+1 22 58.8669	08	+1 03 13.4224	43	+0 43 27.9779
34	+1 22 24.9970	09	+1 02 39.5526	44	+0 42 54.1081
35	+1 21 51.1272	10	+1 02 05.6827	45	+0 42 20.2382
78° 36'	+1 21 17.2574	79° 11'	+1 01 31.8129	79° 46'	+0 41 46.3684
37	+1 20 43.3875	12	+1 00 57.9430	47	+0 41 12.4985
38	+1 20 09.5177	13	+1 00 24.0732	48	+0 40 38.6287
39	+1 19 35.6478	14	+0 59 50.2033	49	+0 40 04.7588
40	+1 19 01.7780	15	+0 59 16.3335	50	+0 39 30.8890
78° 41'	+1 18 27.9081	79° 16'	+0 58 42.4637	79° 51'	+0 38 57.0192
42	+1 17 54.0383	17	+0 58 08.5938	52	+0 38 23.1493
43	+1 17 20.1685	18	+0 57 34.7240	53	+0 37 49.2795
44	+1 16 46.2986	19	+0 57 00.8541	54	+0 37 15.4096
45	+1 16 12.4288	20	+0 56 26.9843	55	+0 36 41.5398
78° 46'	+1 15 38.5589	79° 21'	+0 55 53.1144	79° 56'	+0 36 07.6699
47	+1 15 04.6891	22	+0 55 19.2446	57	+0 35 33.8001
48	+1 14 30.8192	23	+0 54 45.3748	58	+0 34 59.9303
49	+1 13 56.9494	24	+0 54 11.5049	59	+0 34 26.0604
50	+1 13 23.0796	25	+0 53 37.6351	80° 00	+0 33 52.1906
78° 51'	+1 12 49.2097	79° 26'	+0 53 03.7652	80° 01'	+0 33 18.3207
52	+1 12 15.3399	27	+0 52 29.8954	02	+0 32 44.4509
53	+1 11 41.4700	28	+0 51 56.0255	03	+0 32 10.5810
54	+1 11 07.6002	29	+0 51 22.1557	04	+0 31 36.7112
55	+1 10 33.7304	30	+0 50 48.2859	05	+0 31 02.8414

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - North

Table II (Cont'd).

1" of long. = 0".56449738 of θ

Long.	θ	Long.	θ	Long.	θ
80° 06'	+0° 30' 28".9715	80° 41'	+0° 10' 43".5270	81° 16'	-0° 09' 01".9175
07	+0 29 55.1017	42	+0 10 09.6572	17	-0 09 35.7873
08	+0 29 21.2318	43	+0 09 35.7873	18	-0 10 09.6572
09	+0 28 47.3620	44	+0 09 01.9175	19	-0 10 43.5270
10	+0 28 13.4921	45	+0 08 28.0476	20	-0 11 17.3969
80° 11'	+0 27 39.6223	80° 46'	+0 07 54.1778	81° 21'	-0 11 51.2667
12	+0 27 05.7525	47	+0 07 20.3080	22	-0 12 25.1365
13	+0 26 31.8826	48	+0 06 46.4381	23	-0 12 59.0064
14	+0 25 58.0128	49	+0 06 12.5683	24	-0 13 32.8762
15	+0 25 24.1429	50	+0 05 38.6984	25	-0 14 06.7461
80° 16'	+0 24 50.2731	80° 51'	+0 05 04.8286	81° 26'	-0 14 40.6159
17	+0 24 16.4032	52	+0 04 30.9587	27	-0 15 14.4858
18	+0 23 42.5334	53	+0 03 57.0889	28	-0 15 48.3556
19	+0 23 08.6636	54	+0 03 23.2191	29	-0 16 22.2254
20	+0 22 34.7937	55	+0 02 49.3492	30	-0 16 56.0953
80° 21'	+0 22 00.9239	80° 56'	+0 02 15.4794	81° 31'	-0 17 29.9651
22	+0 21 27.0540	57	+0 01 41.6095	32	-0 18 03.8350
23	+0 20 53.1842	58	+0 01 07.7397	33	-0 18 37.7048
24	+0 20 19.3143	59	+0 00 33.8698	34	-0 19 11.5747
25	+0 19 45.4445	81° 00	0 00 00.0000	35	-0 19 45.4445
80° 26'	+0 19 11.5747	81° 01'	-0 00 33.8698	81° 36'	-0 20 19.3143
27	+0 18 37.7048	02	-0 01 07.7397	37	-0 20 53.1842
28	+0 18 03.8350	03	-0 01 41.6095	38	-0 21 27.0540
29	+0 17 29.9651	04	-0 02 15.4794	39	-0 22 00.9239
30	+0 16 56.0953	05	-0 02 49.3492	40	-0 22 34.7937
80° 31'	+0 16 22.2254	81° 06'	-0 03 23.2191	81° 41'	-0 23 08.6636
32	+0 15 48.3556	07	-0 03 57.0889	42	-0 23 42.5334
33	+0 15 14.4858	08	-0 04 30.9587	43	-0 24 16.4032
34	+0 14 40.6159	09	-0 05 04.8286	44	-0 24 50.2731
35	+0 14 06.7461	10	-0 05 38.6984	45	-0 25 24.1429
80° 36'	+0 13 32.8762	81° 11'	-0 06 12.5683	81° 46'	-0 25 58.0128
37	+0 12 59.0064	12	-0 06 46.4381	47	-0 26 31.8826
38	+0 12 25.1365	13	-0 07 20.3080	48	-0 27 05.7525
39	+0 11 51.2667	14	-0 07 54.1778	49	-0 27 39.6223
40	+0 11 17.3969	15	-0 08 28.0476	50	-0 28 13.4921

FIGURE 40.—Lambert projection tables for South Carolina--Continued.

Lambert Projection for South Carolina - North

Table II (Cont'd).

1" of long. = 0".56449738 of θ

Long.	θ	Long.	θ	Long.	θ
81° 51'	-0° 28' 47".3620	82° 26'	-0° 48' 32".8065	83° 01'	-1° 08' 18".2510
52	-0 29 21.2318	27	-0 49 06.6763	02	-1 08 52.1208
53	-0 29 55.1017	28	-0 49 40.5462	03	-1 09 25.9907
54	-0 30 28.9715	29	-0 50 14.4160	04	-1 09 59.8605
55	-0 31 02.8414	30	-0 50 48.2859	05	-1 10 33.7304
81° 56'	-0 31 36.7112	82° 31'	-0 51 22.1557	83° 06'	-1 11 07.6002
57	-0 32 10.5810	32	-0 51 56.0255	07	-1 11 41.4700
58	-0 32 44.4509	33	-0 52 29.8954	08	-1 12 15.3399
59	-0 33 18.3207	34	-0 53 03.7652	09	-1 12 49.2097
82° 00	-0 33 52.1906	35	-0 53 37.6351	10	-1 13 23.0796
82° 01'	-0 34 26.0604	82° 36'	-0 54 11.5049	83° 11'	-1 13 56.9494
02	-0 34 59.9303	37	-0 54 45.3748	12	-1 14 30.8192
03	-0 35 33.8001	38	-0 55 19.2446	13	-1 15 04.6891
04	-0 36 07.6699	39	-0 55 53.1144	14	-1 15 38.5589
05	-0 36 41.5398	40	-0 56 26.9843	15	-1 16 12.4288
82° 06'	-0 37 15.4096	82° 41'	-0 57 00.8541	83° 16'	-1 16 46.2986
07	-0 37 49.2795	42	-0 57 34.7240	17	-1 17 20.1685
08	-0 38 23.1493	43	-0 58 08.5938	18	-1 17 54.0383
09	-0 38 57.0192	44	-0 58 42.4637	19	-1 18 27.9081
10	-0 39 30.8890	45	-0 59 16.3335	20	-1 19 01.7780
82° 11'	-0 40 04.7588	82° 46'	-0 59 50.2033	83° 21'	-1 19 35.6478
12	-0 40 38.6287	47	-1 00 24.0732	22	-1 20 09.5177
13	-0 41 12.4985	48	-1 00 57.9430	23	-1 20 43.3875
14	-0 41 46.3684	49	-1 01 31.8129	24	-1 21 17.2574
15	-0 42 20.2382	50	-1 02 05.6827	25	-1 21 51.1272
82° 16'	-0 42 54.1081	82° 51'	-1 02 39.5526	83° 26'	-1 22 24.9970
17	-0 43 27.9779	52	-1 03 13.4224	27	-1 22 58.8669
18	-0 44 01.8477	53	-1 03 47.2922	28	-1 23 32.7367
19	-0 44 35.7176	54	-1 04 21.1621	29	-1 24 06.6066
20	-0 45 09.5874	55	-1 04 55.0319	30	-1 24 40.4764
82° 21'	-0 45 43.4573	82° 56'	-1 05 28.9018	83° 31'	-1 25 14.3463
22	-0 46 17.3271	57	-1 06 02.7716	32	-1 25 48.2161
23	-0 46 51.1970	58	-1 06 36.6415	33	-1 26 22.0859
24	-0 47 25.0668	59	-1 07 10.5113	34	-1 26 55.9558
25	-0 47 58.9366	83° 00	-1 07 44.3811	35	-1 27 29.8256

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - South

Table I.

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
31° 50'	32,676,887.65	0	101.06367	+600.7	1.0001383
51	32,670,823.83	6,063.82	101.06333	+575.4	1.0001325
52	32,664,760.03	12,127.62	101.06317	+550.5	1.0001268
53	32,658,696.24	18,191.41	101.06283	+526.0	1.0001211
54	32,652,632.47	24,255.18	101.06250	+501.8	1.0001155
55	32,646,568.72	30,318.93	101.06217	+478.0	1.0001101
31° 56'	32,640,504.99	36,382.66	101.06200	+454.5	1.0001047
57	32,634,441.27	42,446.38	101.06167	+431.4	1.0000993
58	32,628,377.57	48,510.08	101.06133	+408.7	1.0000941
59	32,622,313.89	54,573.76	101.06117	+386.3	1.0000889
32° 00	32,616,250.22	60,637.43	101.06100	+364.3	1.0000839
32° 01'	32,610,186.56	66,701.09	101.06067	+342.6	1.0000789
02	32,604,122.92	72,764.73	101.06050	+321.3	1.0000740
03	32,598,059.29	78,828.36	101.06033	+300.4	1.0000692
04	32,591,995.67	84,891.98	101.06000	+279.8	1.0000644
05	32,585,932.07	90,955.58	101.05983	+259.6	1.0000598
32° 06'	32,579,868.48	97,019.17	101.05983	+239.8	1.0000552
07	32,573,804.89	103,082.76	101.05950	+220.3	1.0000507
08	32,567,741.32	109,146.33	101.05933	+201.2	1.0000463
09	32,561,677.76	115,209.89	101.05917	+182.4	1.0000420
10	32,555,614.21	121,273.44	101.05900	+164.0	1.0000378
32° 11'	32,549,550.67	127,336.98	101.05883	+146.0	1.0000336
12	32,543,487.14	133,400.51	101.05867	+128.3	1.0000295
13	32,537,423.62	139,464.03	101.05867	+111.0	1.0000256
14	32,531,360.10	145,527.55	101.05850	+ 94.0	1.0000216
15	32,525,296.59	151,591.06	101.05833	+ 77.4	1.0000178
32° 16'	32,519,233.09	157,654.56	101.05833	+ 61.2	1.0000141
17	32,513,169.59	163,718.06	101.05817	+ 45.4	1.0000105
18	32,507,106.10	169,781.55	101.05800	+ 29.9	1.0000069
19	32,501,042.62	175,845.03	101.05800	+ 14.8	1.0000034
20	32,494,979.14	181,908.51	101.05800	0.0	1.0000000
32° 21'	32,488,915.66	187,971.99	101.05783	- 14.4	0.9999967
22	32,482,852.19	194,035.46	101.05783	- 28.4	0.9999935
23	32,476,788.72	200,098.93	101.05783	- 42.1	0.9999903
24	32,470,725.25	206,162.40	101.05767	- 55.4	0.9999872
25	32,464,661.79	212,225.86	101.05783	- 68.4	0.9999842

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - South

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
32° 26'	32,458,598.32	218,289.33	101.05767	- 81.0	0.9999813
27	32,452,534.86	224,352.79	101.05767	- 93.2	0.9999785
28	32,446,471.40	230,416.25	101.05767	-105.1	0.9999758
29	32,440,407.94	236,479.71	101.05767	-116.6	0.9999732
30	32,434,344.48	242,543.17	101.05767	-127.7	0.9999706
32° 31'	32,428,281.02	248,606.63	101.05783	-138.5	0.9999681
32	32,422,217.55	254,670.10	101.05783	-148.9	0.9999657
33	32,416,154.08	260,733.57	101.05783	-159.0	0.9999634
34	32,410,090.61	266,797.04	101.05783	-168.7	0.9999612
35	32,404,027.14	272,860.51	101.05783	-178.0	0.9999590
32° 36'	32,397,963.67	278,923.98	101.05800	-187.0	0.9999569
37	32,391,900.19	284,987.46	101.05800	-195.6	0.9999550
38	32,385,836.71	291,050.94	101.05817	-203.8	0.9999531
39	32,379,773.22	297,114.43	101.05833	-211.7	0.9999513
40	32,373,709.72	303,177.93	101.05833	-219.2	0.9999496
32° 41'	32,367,646.22	309,241.43	101.05850	-226.3	0.9999479
42	32,361,582.71	315,304.94	101.05850	-233.1	0.9999463
43	32,355,519.20	321,368.45	101.05867	-239.5	0.9999449
44	32,349,455.68	327,431.97	101.05883	-245.5	0.9999435
45	32,343,392.15	333,495.50	101.05900	-251.2	0.9999422
32° 46'	32,337,328.61	339,559.04	101.05917	-256.5	0.9999409
47	32,331,265.06	345,622.59	101.05933	-261.4	0.9999398
48	32,325,201.50	351,686.15	101.05950	-266.0	0.9999388
49	32,319,137.93	357,749.72	101.05967	-270.2	0.9999378
50	32,313,074.35	363,813.30	101.05983	-274.1	0.9999369
32° 51'	32,307,010.76	369,876.89	101.06000	-277.6	0.9999361
52	32,300,947.16	375,940.49	101.06017	-280.7	0.9999354
53	32,294,883.55	382,004.10	101.06050	-283.5	0.9999347
54	32,288,819.92	388,067.73	101.06067	-285.9	0.9999342
55	32,282,756.28	394,131.37	101.06083	-287.9	0.9999337
32° 56'	32,276,692.63	400,195.02	101.06117	-289.6	0.9999333
57	32,270,628.96	406,258.69	101.06133	-290.9	0.9999330
58	32,264,565.28	412,322.37	101.06167	-291.8	0.9999328
59	32,258,501.58	418,386.07	101.06183	-292.4	0.9999327
33° 00	32,252,437.87	424,449.78	101.06217	-292.6	0.9999326

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - South

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
33° 01'	32,246,374.14	430,513.51	101.06250	-292.4	0.9999327
02	32,240,310.39	436,577.26	101.06283	-291.9	0.9999328
03	32,234,246.62	442,641.03	101.06300	-291.0	0.9999330
04	32,228,182.84	448,704.81	101.06333	-289.7	0.9999333
05	32,222,119.04	454,768.61	101.06367	-288.1	0.9999337
33° 06'	32,216,055.22	460,832.43	101.06400	-286.1	0.9999341
07	32,209,991.38	466,896.27	101.06433	-283.8	0.9999347
08	32,203,927.52	472,960.13	101.06467	-281.1	0.9999353
09	32,197,863.64	479,024.01	101.06500	-278.0	0.9999360
10	32,191,799.74	485,087.91	101.06533	-274.5	0.9999368
33° 11'	32,185,735.82	491,151.83	101.06583	-270.7	0.9999377
12	32,179,671.87	497,215.78	101.06600	-266.5	0.9999386
13	32,173,607.91	503,279.74	101.06650	-261.9	0.9999397
14	32,167,543.92	509,343.73	101.06700	-257.0	0.9999408
15	32,161,479.90	515,407.75	101.06733	-251.7	0.9999420
33° 16'	32,155,415.86	521,471.79	101.06767	-246.0	0.9999434
17	32,149,351.80	527,535.85	101.06817	-240.0	0.9999447
18	32,143,287.71	533,599.94	101.06850	-233.6	0.9999462
19	32,137,223.60	539,664.05	101.06900	-226.8	0.9999478
20	32,131,159.46	545,728.19	101.06933	-219.7	0.9999494
33° 21'	32,125,095.30	551,792.35	101.07000	-212.2	0.9999511
22	32,119,031.10	557,856.55	101.07033	-204.4	0.9999529
23	32,112,966.88	563,920.77	101.07083	-196.2	0.9999548
24	32,106,902.63	569,985.02	101.07117	-187.6	0.9999568
25	32,100,838.36	576,049.29	101.07183	-178.6	0.9999589
33° 26'	32,094,774.05	582,113.60	101.07233	-169.3	0.9999610
27	32,088,709.71	588,177.94	101.07283	-159.6	0.9999633
28	32,082,645.34	594,242.31	101.07333	-149.5	0.9999656
29	32,076,580.94	600,306.71	101.07367	-139.1	0.9999680
30	32,070,516.52	606,371.13	101.07433	-128.3	0.9999705
33° 31'	32,064,452.06	612,435.59	101.07500	-117.1	0.9999730
32	32,058,387.56	618,500.09	101.07550	-105.6	0.9999757
33	32,052,323.03	624,564.62	101.07600	- 93.7	0.9999784
34	32,046,258.47	630,629.18	101.07650	- 81.4	0.9999813
35	32,040,193.88	636,693.77	101.07717	- 68.7	0.9999842

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - South

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
33° 36'	32,034,129.25	642,758.40	101.07767	- 55.7	0.9999872
37	32,028,064.59	648,823.06	101.07833	- 42.3	0.9999903
38	32,021,999.89	654,887.76	101.07900	- 28.6	0.9999934
39	32,015,935.15	660,952.50	101.07950	- 14.5	0.9999967
40	32,009,870.38	667,017.27	101.08000	0.0	1.0000000
33° 41'	32,003,805.58	673,082.07	101.08083	+ 14.9	1.0000034
42	31,997,740.73	679,146.92	101.08133	+ 30.1	1.0000069
43	31,991,675.85	685,211.80	101.08217	+ 45.7	1.0000105
44	31,985,610.92	691,276.73	101.08267	+ 61.6	1.0000142
45	31,979,545.96	697,341.69	101.08333	+ 77.9	1.0000179
33° 46'	31,973,480.96	703,406.69	101.08400	+ 94.6	1.0000218
47	31,967,415.92	709,471.73	101.08467	+111.7	1.0000257
48	31,961,350.84	715,536.81	101.08550	+129.1	1.0000297
49	31,955,285.71	721,601.94	101.08600	+146.9	1.0000338
50	31,949,220.55	727,667.10	101.08683	+165.1	1.0000380
33° 51'	31,943,155.34	733,732.31	101.08750	+183.6	1.0000423
52	31,937,090.09	739,797.56	101.08817	+202.5	1.0000466
53	31,931,024.80	745,862.85	101.08900	+221.8	1.0000511
54	31,924,959.46	751,928.19	101.08967	+241.5	1.0000556
55	31,918,894.08	757,993.57	101.09050	+261.5	1.0000602
33° 56'	31,912,828.65	764,059.00	101.09117	+281.9	1.0000649
57	31,906,763.18	770,124.47	101.09200	+302.6	1.0000697
58	31,900,697.66	776,189.99	101.09267	+323.7	1.0000745
59	31,894,632.10	782,255.55	101.09350	+345.2	1.0000795
34° 00	31,888,566.49	788,321.16	101.09433	+367.1	1.0000845
34° 01'	31,882,500.83	794,386.82	101.09517	+389.3	1.0000896
02	31,876,435.12	800,452.53	101.09583	+411.9	1.0000948
03	31,870,369.37	806,518.28	101.09683	+434.9	1.0001001
04	31,864,303.56	812,584.09	101.09750	+458.3	1.0001055
05	31,858,237.71	818,649.94	101.09833	+482.0	1.0001110
34° 06'	31,852,171.81	824,715.84	101.09933	+506.1	1.0001165
07	31,846,105.85	830,781.80	101.10000	+530.6	1.0001222
08	31,840,039.85	836,847.80	101.10100	+555.4	1.0001279
09	31,833,973.79	842,913.86	101.10183	+580.6	1.0001337
10	31,827,907.68	848,979.97		+606.2	1.0001396

$\ell = 0.54465157$

$\log \ell = 9.7361187599 - 10$

$\log K = 7.6521509551$

$$\text{Geod. Az.} - \text{Grid. Az.} = -\frac{x_2 - x_1}{2\rho_0^2 \sin 1''}\left(y_1 - y_0 + \frac{y_2 - y_1}{3}\right) + \theta$$

$y_0 = 424{,}761.35$ feet

$$\log \frac{1}{2\rho_0^2 \sin 1''} = 0.3732337 - 10$$

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - South

Table II.

1" of long. = 0.54465157 of θ

Long.	θ	Long.	θ	Long.	θ
78° 45'	+1° 13' 31".6777				
46	+1 12 58.9986	79° 21'	+0° 53' 55".2303	79° 56'	+0° 34' 51".4620
47	+1 12 26.3195	22	+0 53 22.5512	57	+0 34 18.7829
48	+1 11 53.6404	23	+0 52 49.8721	58	+0 33 46.1038
49	+1 11 20.9613	24	+0 52 17.1930	59	+0 33 13.4247
50	+1 10 48.2822	25	+0 51 44.5139	80° 00	+0 32 40.7457
78° 51'	+1 10 15.6032	79° 26'	+0 51 11.8349	80° 01'	+0 32 08.0666
52	+1 09 42.9241	27	+0 50 39.1558	02	+0 31 35.3875
53	+1 09 10.2450	28	+0 50 06.4767	03	+0 31 02.7084
54	+1 08 37.5659	29	+0 49 33.7976	04	+0 30 30.0293
55	+1 08 04.8868	30	+0 49 01.1185	05	+0 29 57.3502
78° 56'	+1 07 32.2077	79° 31'	+0 48 28.4394	80° 06'	+0 29 24.6711
57	+1 06 59.5286	32	+0 47 55.7603	07	+0 28 51.9920
58	+1 06 26.8495	33	+0 47 23.0812	08	+0 28 19.3129
59	+1 05 54.1704	34	+0 46 50.4021	09	+0 27 46.6338
79° 00	+1 05 21.4913	35	+0 46 17.7230	10	+0 27 13.9547
79° 01'	+1 04 48.8122	79° 36'	+0 45 45.0439	80° 11'	+0 26 41.2756
02	+1 04 16.1331	37	+0 45 12.3648	12	+0 26 08.5965
03	+1 03 43.4540	38	+0 44 39.6857	13	+0 25 35.9174
04	+1 03 10.7749	39	+0 44 07.0066	14	+0 25 03.2383
05	+1 02 38.0958	40	+0 43 34.3275	15	+0 24 30.5592
79° 06'	+1 02 05.4167	79° 41'	+0 43 01.6484	80° 16'	+0 23 57.8801
07	+1 01 32.7376	42	+0 42 28.9693	17	+0 23 25.2011
08	+1 01 00.0586	43	+0 41 56.2903	18	+0 22 52.5220
09	+1 00 27.3795	44	+0 41 23.6112	19	+0 22 19.8429
10	+0 59 54.7004	45	+0 40 50.9321	20	+0 21 47.1638
79° 11'	+0 59 22.0213	79° 46'	+0 40 18.2530	80° 21'	+0 21 14.4847
12	+0 58 49.3422	47	+0 39 45.5739	22	+0 20 41.8056
13	+0 58 16.6631	48	+0 39 12.8948	23	+0 20 09.1265
14	+0 57 43.9840	49	+0 38 40.2157	24	+0 19 36.4474
15	+0 57 11.3049	50	+0 38 07.5366	25	+0 19 03.7683
79° 16'	+0 56 38.6258	79° 51'	+0 37 34.8575	80° 26'	+0 18 31.0892
17	+0 56 05.9467	52	+0 37 02.1784	27	+0 17 58.4101
18	+0 55 33.2676	53	+0 36 29.4993	28	+0 17 25.7310
19	+0 55 00.5885	54	+0 35 56.8202	29	+0 16 53.0519
20	+0 54 27.9094	55	+0 35 24.1411	30	+0 16 20.3728

FIGURE 40.—Lambert projection tables for South Carolina—Continued.

Lambert Projection for South Carolina - South

Table II (Cont'd).

1" of long. = 0".54465157 of θ

Long.	θ	Long.	θ	Long.	θ
80° 31'	+0° 15' 47".6937	81° 06'	-0° 03' 16".0746	81° 41'	-0° 22' 19.8429
32	+0 15 15.0146	07	-0 03 48.7537	42	-0 22 52.5220
33	+0 14 42.3355	08	-0 04 21.4328	43	-0 23 25.2011
34	+0 14 09.6564	09	-0 04 54.1118	44	-0 23 57.8801
35	+0 13 36.9774	10	-0 05 26.7909	45	-0 24 30.5592
80° 36'	+0 13 04.2983	81° 11'	-0 05 59.4700	81° 46'	-0 25 03.2383
37	+0 12 31.6192	12	-0 06 32.1491	47	-0 25 35.9174
38	+0 11 58.9401	13	-0 07 04.8282	48	-0 26 08.5965
39	+0 11 26.2610	14	-0 07 37.5073	49	-0 26 41.2756
40	+0 10 53.5819	15	-0 08 10.1864	50	-0 27 13.9547
80° 41'	+0 10 20.9028	81° 16'	-0 08 42.8655	81° 51'	-0 27 46.6338
42	+0 09 48.2237	17	-0 09 15.5446	52	-0 28 19.3129
43	+0 09 15.5446	18	-0 09 48.2237	53	-0 28 51.9920
44	+0 08 42.8655	19	-0 10 20.9028	54	-0 29 24.6711
45	+0 08 10.1864	20	-0 10 53.5819	55	-0 29 57.3502
80° 46'	+0 07 37.5073	81° 21'	-0 11 26.2610	81° 56'	-0 30 30.0293
47	+0 07 04.8282	22	-0 11 58.9401	57	-0 31 02.7084
48	+0 06 32.1491	23	-0 12 31.6192	58	-0 31 35.3875
49	+0 05 59.4700	24	-0 13 04.2983	59	-0 32 08.0666
50	+0 05 26.7909	25	-0 13 36.9774	82° 00	-0 32 40.7457
80° 51'	+0 04 54.1118	81° 26'	-0 14 09.6564	82° 01'	-0 33 13.4247
52	+0 04 21.4328	27	-0 14 42.3355	02	-0 33 46.1038
53	+0 03 48.7537	28	-0 15 15.0146	03	-0 34 18.7829
54	+0 03 16.0746	29	-0 15 47.6937	04	-0 34 51.4620
55	+0 02 43.3955	30	-0 16 20.3728	05	-0 35 24.1411
80° 56'	+0 02 10.7164	81° 31'	-0 16 53.0519	82° 06'	-0 35 56.8202
57	+0 01 38.0373	32	-0 17 25.7310	07	-0 36 29.4993
58	+0 01 05.3582	33	-0 17 58.4101	08	-0 37 02.1784
59	+0 00 32.6791	34	-0 18 31.0892	09	-0 37 34.8575
81° 00	0 00 00.0000	35	-0 19 03.7683	10	-0 38 07.5366
81° 01'	-0 00 32.6791	81° 36'	-0 19 36.4474	82° 11'	-0 38 40.2157
02	-0 01 05.3582	37	-0 20 09.1265	12	-0 39 12.8948
03	-0 01 38.0373	38	-0 20 41.8056	13	-0 39 45.5739
04	-0 02 10.7164	39	-0 21 14.4847	14	-0 40 18.2530
05	-0 02 43.3955	40	-0 21 47.1638	15	-0 40 50.9321

FIGURE 40.—Lambert projection tables for South Carolina—Continued

Computation of grid azimuth

OMAR–SPRING

	x	y
Spring	1, 927, 066. 27	398, 339. 17
Omar	1, 926, 745. 82	381, 328. 82
	$\Delta x = +320.45$	$\Delta y = +17,010.35$

$$\log \Delta x = 2.50576028$$
$$\log \Delta y = 4.23071325$$

$$\log \tan \alpha = 8.27504703 - 10$$

Grid α Omar–Spring = 181° 04' 45".3

Adjustment of traverse, South Carolina end

Line	Azimuth, unadjusted	Sine	Cosine	Geodetic length	Grid length	$x+\Delta x$	Adjustment correction	$y+\Delta y$	Adjustment correction	Proportional length
	° ′ ″			*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	
Omar–Spring	**181 04 45.3**					**1,926,745.82**		**381,328.82**		
	180 13 58.4					−446.60		−19,497.62		
Omar–Luray	1 18 43.7	−0.02289914	−0.99973777	19503.98	19502.73	1,926,299.22	−0.80	361,831.20	−0.37	19503.98
Luray–Omar	181 18 43.7					**1,926,298.42**		**361,830.83**		
	180 10 11.9					−311.56		−12,041.74		
Luray–Canton	1 28 55.6	−0.02586483	−0.99966545	12046.52	12045.77	1,925,987.66	−1.30	349,789.46	−0.59	31550.50
Canton–Luray	181 28 55.6					**1,925,986.36**		**349,788.87**		
	179 36 52.7					−276.36		−14,435.50		
Canton–Estill	1 05 48.3	−0.01914073	−0.99981680	14439.01	14438.15	1,925,711.30	−1.89	335,353.96	−0.87	45989.51
Estill–Canton	181 05 48.3					**1,925,709.41**		**335,353.09**		
	180 28 00.3					−258.59		−9,473.94		
Estill–Ben	1 33 48.6	−0.02728483	−0.99962770	9478.01	9477.47	1,925,452.71	−2.29	325,880.02	−1.05	55467.52
Ben–Estill	181 33 48.6					**1,925,450.42**		**325,878.97**		
	179 29 32.2					−230.88		−12,528.29		
Ben–Carolina	1 03 20.8	−0.01842576	−0.99983023	12531.10	12530.42	1,925,221.83	−2.80	313,351.73	−1.28	67998.62
Carolina–Ben	181 03 20.8					**1,925,219.03**		**313,350.45**		
	180 21 08.5					−345.62		−14,060.21		
Carolina–Scotia	1 24 29.3	−0.02457418	−0.99969801	14065.18	14064.46	1,924,876.21	−3.38	299,291.52	−1.55	82063.80
Scotia–Carolina	181 24 29.3					**1,924,872.83**		**299,289.97**		
	179 51 22.7					−433.07		−19,620.56		
Scotia–Garnett	1 15 52.0	−0.02206693	−0.99975650	19626.25	19625.34	1,924,443.14	−4.19	279,670.96	−1.92	101690.05
Garnett–Scotia	181 15 52.0					**1,924,438.95**		**279,669.04**		
	185 45 41.6					−2,744.11		−22,265.49		
Garnett–Savannah	7 01 33.6	−0.12231974	−0.99249075	22434.83	22433.95	1,921,699.03	−5.11	257,405.47	−2.34	124124.88
Savannah–Garnett	187 01 33.6					**1,921,693.92**		**257,403.13**		
	198 30 32.0					−5,473.98		−11,458.48		
Savannah–Garner	25 32 05.6	−0.43106062	−0.90232297	12699.29	12698.87	1,916,225.05	−5.64	245,946.99	−2.58	136824.17
						1,916,219.41		**245,944.41**		

Fixed and final values are shown in **bold-faced** type in the above table

Geodetic positions from Lambert coordinates

State South Carolina (South) Station Savannah

x	1,921,699.03	$R_b + A$	32,676,887.65
C	2,000,000.00	y	257,405.47
x' (= x−C)	− 78,300.97	$R_b + A - y$	32,419,482.18
	4.89376714		
	7.51080607		
tan θ	7.38296107 - 10	R	32,419,576.74
θ	0° 08′ 18.″17893		
	"	y	257,405.47
$\frac{\theta}{\ell}$ (= Δλ)	− 914.6746	y″	− 94.56
		y′	257,310.91
λ (central mer.)	81° 00′ 00.″0000		
− Δλ	0 15 14.6746	φ (by interpolation)	32° 32′ 26.″1317
λ	81 15 14.6746		

Georgia

South Carolina (South) Grid Station Garner

x	1,916,225.05	$R_b + A$	32,676,887.65
C	2,000,000.00	y	245,946.99
x' (= x−C)	−83,774.95	$R_b + A - y$	32,430,940.66
	4.92311418		
	7.51095955		
tan θ	7.41215463 - 10	R	32,431,048.86
θ	0° 08′ 52.″81789		
	"	y	245,946.99
$\frac{\theta}{\ell}$ (= Δλ)	- 978.2729	y″	− 108.20
		y′	245,838.79
λ (central mer.)	81° 00′ 00.″0000		
− Δλ	+ 0 16 18.2729	φ (by interpolation)	32° 30′ 32.″6113
λ	81 16 18.2729		

$\tan\theta = \frac{x - C}{R_b + A - y}$

$\Delta\lambda = \frac{\theta}{\ell}$

$\lambda = \lambda$ (central mer.) $- \Delta\lambda$

$R = (R_b + A - y) \sec\theta$

$y'' = 2R \sin^2\frac{\theta}{2}$

$y' = y - y''$

C is constant added to x′ in computation of coordinates

R_b is map radius of lowest parallel

A is value of y′ for R_b, in most cases it is zero

φ is interpolated from table of y′

FIGURE 41.—Computation of geodetic positions from Lambert coordinates, South Carolina.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State S.C. Ga.(East) Grid Station Savannah

ϕ 32° 32′ 26.1317″

		λ (Central meridian)	82° 10′ 00.0000″
		λ	81 15 14.6746
		$\Delta\lambda$ (Central meridian−λ)	+ 54 45.3254
		$\Delta\lambda$ (in sec.)	+ 3285.3254″
log $\Delta\lambda$	3.51657839	log S_m^2	9.866210 63
Cor. arc to sine	− 1837	log C*	1.210107 73 − 10
log $\Delta\lambda_1$	3.51656002	log $\Delta\phi$	1.076317
log cos ϕ	9.92583302 − 10		
colog A	1.49069911	ϕ	32° 32′ 26.1317″
log S_1	4.93309215	$\Delta\phi$	+ 11.92 27
Cor. sine to arc	+ 1303	ϕ'	32 32 38.0544
log S_m	4.93310518		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.05133
log R	− 4343		
log S_g	5.44904592	y (for min. of ϕ')	921,400.97
log S_g^3	16.3471378	y (for seconds of ϕ')	+ 3,845.45
log $1/6\rho_o^2R^2$	4.5817896 − 20	y	925,246.42
log $(S_g^3/6\rho_o^2)_g$	0.9289274		
S_g	281,219.819	log sin $\frac{\phi+\phi'}{2}$	9.7307188 − 10
$(S_g^3/6\rho_o^2)_g$	8.490	log $\Delta\lambda$	3.5165784
x′	+ 281,228.31	log $\Delta\alpha_1$	3.2472972
	2,000,000.00	log $(\Delta\lambda)^3$	10.550
x	2,281,228.31	log F	7.874 − 20
		log b	8.424 − 10
		$\Delta\alpha_1$	1767″.247
		b	0.027
		$\Delta\alpha$	+ 1767.27
		$\Delta\alpha$	+ 0° 29′ 27.27″

*Take out C first for ϕ and correct for approximate ϕ'.

FIGURE 42.—Computation of coordinates on transverse Mercanter projects, Georgia.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Georgia (East) Station Garner

ϕ 32° 30′ 32.6113″

λ (Central meridian) 82° 10′ 00.0000″

λ 81 16 18.2729

Δλ (Central meridian−λ) + 53 41.7271

Δλ (in sec.) + 3221.7271″

log Δλ	3.50808875	log S_m^2	9.849535 636
Cor. arc to sine	− 1766	log C*	1.209584 − 10
log $\Delta\lambda_1$	3.50807109	log Δφ	1.059119 71
log cos φ	9.92598544 −10		
colog A	1.49069838	φ	32° 30′ 32.6113″
log S_1	4.92475491	Δφ	+ 11.458 96
Cor. sine to arc	+ 1254	φ′	32 30 44.0709
log S_m	4.92476745		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of φ′	101.05067
log R	− 4343		
log S_g	5.44070819	y (for min. of φ′)	909,274.87
log S_g^3	16.3221246	y (for seconds of φ′)	+ 4,453.39
log $1/6\rho_o^2R^2$	4.5817896 − 20	y	913,728.26
log $(S_g^3/6\rho_o^2)_g$	0.9039142		
S_g	275,872.362	log sin $\frac{\phi+\phi'}{2}$	9.7303432 − 10
$(S_g^3/6\rho_o^2)_g$	8.015	log Δλ	3.5080888
x′	+ 275,880.38	log Δa_1	3.2384320
	2,000,000.00	log $(\Delta\lambda)^3$	10.524
x	2,275,880.38	log F	7.874 − 20
		log b	8.398
		Δa_1	1731.″538
		b	0.025
		Δa	+ 1731.″56
		Δa	+ 0° 28′ 51.″56

* Take out C first for φ and correct for approximate φ′.

FIGURE 42.—Computation of coordinates on transverse Mercator projection, Georgia—Continued.

Geodetic positions from Lambert coordinates

State South Carolina (South) Station Garner

x	1,916,219.41	$R_b + A$	32,676,887.65
C	2,000,000.00	y	245,944.41
x' (= x−C)	− 83,780.59	$R_b + A - y$	32,430,943.24
	4.92314342		
	7.51095958		
tan θ	7.41218384 − 10	R	32,431,051.46
θ	0° 08′ 52.85373″		
	−532.85373	y	245,944.41
$\frac{\theta}{\gamma}$ (= Δλ)	−978.3387	y''	− 108.22
		y'	245,836.19
λ (central mer.)	81° ′ ″		
− Δλ	+ 0 16 18.3387	φ (by interpolation)	32° 30′ 32″.5856
λ	81 16 18.3387		

FIGURE 43.—Computation of geodetic position from coordinates, South Carolina.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Georgia (East) Station Garner

ϕ 32° 30′ 32.5856″

λ (Central meridian) 82° 10′ 00″

λ 81 16 18.3387

$\Delta\lambda$ (Central meridian−λ) 0 53 41.6613

$\Delta\lambda$ (in sec.) + 3221.6613

log $\Delta\lambda$	3.50807988	log $S_m{}^2$	9.849517 636
Cor. arc to sine	− 1766	log C*	1.209583 53 -10
log $\Delta\lambda_1$	3.50806222	log $\Delta\phi$	1.059100
log cos ϕ	9.92598548 -10		
colog A	1.49069838	ϕ	32° 30′ 32.5856″ 92
log S_1	4.92474608	$\Delta\phi$	+ 11.4577 48
Cor. sine to arc	+ 1254	ϕ'	32 30 44.0433
log S_m	4.92475862		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.05067
log R	− 4343		
log S_g	5.44069936	y (for min. of ϕ')	909,274.87
log $S_g{}^2$	16.3220981	y (for seconds of ϕ')	+ 4,450.76
log $1/6\rho_o{}^2R^2$	4.5817896 -20	y	913,725.63
log $(S_g{}^3/6\rho_o{}^2)_g$	0.9038877		
S_g	275,866.753	log sin $\frac{\phi+\phi'}{2}$	
$(S_g{}^3/6\rho_o{}^2)_g$	8.015	log $\Delta\lambda$	
x′	275,874.77	log $\Delta\alpha_1$	
	2,000,000.00	log $(\Delta\lambda)^3$	
x	2,275,874.77	log F	
		log b	
		$\Delta\alpha_1$	″
		b	
		$\Delta\alpha$	″
		$\Delta\alpha$	° ″

* Take out C first for ϕ and correct for approximate ϕ'

FIGURE 44.—Computation of coordinates from geodetic position, Georgia.

Computation of grid azimuth

GARNER–SAVANNAH

	x	y
Savannah	2,281,228.31	925,246.42
Garner	2,275,880.38	913,728.26
	$\Delta x = +5{,}347.93$	$\Delta y = +11{,}518.16$

$\log \Delta x = 3.72818572$

$\log \Delta y = 4.06138311$

$\log \tan \alpha = 9.66680261 - 10$

Grid α Garner–Savannah $= 204°54'20''.3$

Preliminary computation of traverse, Georgia end

Line	Azimuth, unadjusted	Sine	Cosine	Geodetic length	Grid length	$x+\Delta x$	$y+\Delta y$
	° ′ ″			*Feet*	*Feet*	*Feet*	*Feet*
Garner–Savannah	204 54 20.3					2,275,880.38	913,728.26
	146 51 20.0					+1,702.27	−11,756.54
Garner–Clyo	351 45 40.3	+0.14329926	−0.98967941	11,879.28	11,879.14	2,277,582.65	901,971.72
Clyo–Garner	171 45 40.3						
	179 52 09.6					+2,582.95	−17,556.43
Clyo–Berryville	351 37 49.9	+0.14555591	−0.98935003	17,745.61	17,745.42	2,280,165.60	884,415.29
Berryville–Clyo	171 37 49.9						
	180 04 21.0					+2,689.05	−18,439.58
Berryville–Stillwell	351 42 10.9	+0.14430391	−0.98953342	18,634.79	18,634.62	2,282,854.65	865,975.71
Stillwell–Berryville	171 42 10.9						
	180 06 06.2					+2,891.50	−20,077.41
Stillwell–Cleveland	351 48 17.1	+0.14254688	−0.98978805	20,284.70	20,284.55	2,285,746.15	845,898.30
Cleveland–Stillwell	171 48 17.1						
	179 41 49.3					+1,582.03	−10,587.88
Cleveland–Rincon	351 30 06.4	+0.14777872	−0.98902045	10,705.48	10,705.42	2,287,328.18	835,310.42
Rincon–Cleveland	171 30 06.4						
	180 06 51.5					+2,434.63	−16,519.36
Rincon–Exley	351 36 57.9	+0.14580533	−0.98931330	16,697.87	16,697.80	2,289,762.81	818,791.06
Exley–Rincon	171 36 57.9						
	180 08 44.3					+2,571.22	−17,758.97
Exley–Roosevelt	351 45 42.2	+0.14329014	−0.98968072	17,944.19	17,944.14	2,292,334.03	801,032.09
Roosevelt–Exley	171 45 42.2						
	160 48 19.8					+5,178.57	−9,976.50
Roosevelt–Meinhard	332 34 02.0	+0.46070761	−0.88755197	11,240.47	11,240.47	2,297,512.60	791,055.59
Meinhard–Roosevelt	152 34 02.0						
	179 52 14.6					+5,921.80	−11,345.65
Meinhard–Burke	332 26 16.6	+0.46270904	−0.88651020	12,798.06	12,798.10	2,303,434.40	779,709.94
						2,303,416.77	**779,703.19**
						+17.63	+6.75

Fixed values are shown in **bold-faced** type in the above table.

Computation of azimuth corrections

	Garner to Savannah	Clyo to Berryville	Garner to Clyo	Berryville to Clyo	Clyo to Garner
$2x_1'$	551, 761	555, 166	551, 760	560, 332	555, 166
x_2'	281, 228	280, 166	277, 583	277, 583	275, 880
	832, 989	835, 332	829, 343	837, 915	831, 046
log $(2x_1'+x_2')$	5. 92064	5. 92186	5. 918783	5. 92320	5. 91983
log (y_2-y_1)	4. 06138	4. 2443n	4. 07028n	4. 24443	4. 07028
log constant	9. 89621−20	9. 89621−20	9. 89621−20	9. 89621−20	9. 89621−20
log azimuth correction	9. 87823−10	0. 06250n	9. 88522−10n	0. 06384	9. 88612−10
Azimuth correction	+0. 76	−1. 15	−0. 77	+1. 16	+0. 77

	Berryville to Stillwell	Stillwell to Berryville	Stillwell to Cleveland	Rincon to Exley	Roosevelt to Meinhard
$2x_1'$	560, 332	565, 710	565, 710	574, 656	584, 668
x_2'	282, 855	280, 166	285, 746	289, 763	295, 513
	843, 187	845, 876	851, 456	864, 419	882, 181
log $(2x_1'+x_2')$	5. 92592	5. 92730	5. 93016	5. 93672	5. 94556
log (y_2-y_1)	4. 26576n	4. 26576	4. 30270n	4. 21798n	3. 99898n
long constant	9. 89621−20	9. 89621−20	9. 89621−20	9. 89621−20	9. 89621−20
log azimuth correction	0. 08789n	0. 08927	0. 12907n	0. 05091n	9. 84075−10n
Azimuth correction	−1. 22	+1. 23	−1. 35	−1. 12	−0. 69

	Cleveland to Stillwell	Exley to Rincon	Meinhard to Roosevelt	Cleveland to Roosevelt	Exley to Roosevelt
$2x_1'$	571, 492	579, 526	595, 026	571, 492	579, 526
x_2'	282, 855	287, 328	292, 334	287, 328	292, 334
	854, 347	866, 584	887, 360	858, 820	871, 860
log $(2x_1'+x_2')$	5. 93163	5. 93795	5. 94810	5. 93390	5. 94045
log (y_2-y_1)	4. 30270	4. 21798	3. 99898	4. 02481n	4. 24942n
log constant	9. 89621−20	9. 89621−20	9. 89621−20	9. 89621−20	9. 89621−20
log azimuth correction	0. 13054	0. 05214	9. 84329−10	9. 85492−10n	0. 08608n
Azimuth correction	+1. 35	+1. 13	+0. 70	−0. 72	−1. 22

	Meinhard to Burke	Rincon to Cleveland	Roosevelt to Exley	Burke to Meinhard	Burke to Chatham
$2x_1$	595, 026	574, 656	584, 668	606, 868	606, 868
x_2'	303, 434	285, 746	289, 763	297, 513	309, 633
	898, 460	860, 402	874, 431	904, 381	916, 501
log $(2x_1'+x_2')$	5. 95350	5. 93470	5. 94173	5. 95635	5. 96213
log (y_2-y_1)	4. 05484n	4. 02481	4. 24942	4. 05484	4. 07933n
log constant	9. 89621−20	9. 89621−20	9. 89621−20	9. 89621−20	9. 89621−20
log azimuth correction	9. 90455−10n	9. 85572−10	0. 08736	9. 90740−10	9. 93676−10n
Azimuth correction	−0. 80	+0. 72	+1. 22	+0. 81	−0. 87

Adjustment of traverse, Georgia end

Line	Azimuth, unadjusted	Sine	Cosine	Geodetic length	Grid length	$x+\Delta x$	Adjustment correction	$y+\Delta y$	Adjustment correction	Proportional length
	° ′ ″			*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	
Garner–Savannah	204 54 20.3					2,275,880.38	−5.61	913,728.26	−2.63	
						2,275,874.77		**913,725.63**		
	146 51 21.5					+1,702.19		−11,756.55		
Garner–Clyo	351 45 41.8	+0.14329206	−0.98968044	11,879.28	11,879.14	2,277,582.57	−6.13	901,971.71	−2.80	148,703.45
Clyo–Garner	171 45 41.8					**2,277,576.44**		**901,968.91**		
	179 52 11.5					+2,582.66		−17,556.47		
Clyo–Berryville	351 37 53.3	+0.14553960	−0.98935242	17,745.61	17,745.42	2,280,165.23	−6.86	884,415.24	−3.14	166,449.06
Berryville–Clyo	171 37 53.3					**2,280,158.37**		**884,412.10**		
	180 04 23.4					+2,688.53		−18,439.65		
Berryville–Stillwell	351 42 16.7	+0.14427609	−0.98953747	18,634.79	18,634.62	2,282,853.76	−7.63	865,975.59	−3.49	185,083.85
Stillwell–Berryville	171 42 16.7					**2,282,846.13**		**865,972.10**		
	180 06 08.8					+2,890.68		−20,077.52		
Stillwell–Cleveland	351 48 25.5	+0.14250657	−0.98979386	20,284.70	20,284.55	2,285,744.44	−8.46	845,898.07	−3.87	205,368.55
Cleveland–Stillwell	171 48 25.5					**2,285,735.98**		**845,894.20**		
	179 41 51.4					+1,581.49		−10,587.96		
Cleveland–Rincon	351 30 16.9	+0.14772838	−0.98902797	10,705.48	10,705.42	2,287,325.93	−8.90	835,310.11	−4.07	216,074.03
Rincon–Cleveland	171 30 16.9					**2,287,317.03**		**835,306.04**		
	180 06 53.3					+2,433.64		−16,519.50		
Rincon–Exley	351 37 10.2	+0.14574633	−0.98932199	16,697.87	16,697.80	2,289,759.57	−9.59	818,790.61	−4.39	232,771.90
Exley–Rincon	171 37 10.2					**2,289,749.98**		**818,786.22**		
	180 08 46.7					+2,569.96		−17,759.15		
Exley–Roosevelt	351 45 56.9	+0.14321961	−0.98969093	17,944.19	17,944.14	2,292,329.52	−10.33	801,031.46	−4.73	250,716.09
Roosevelt–Exley	171 45 56.9					**2,292,319.19**		**801,026.73**		
	160 48 21.7					+5,177.77		−9,976.92		
Roosevelt–Meinhard	332 34 18.6	+0.46063618	−0.88758904	11,240.47	11,240.47	2,297,507.29	−10.79	791,054.54	−4.94	261,956.56
Meinhard–Roosevelt	152 34 18.6					**2,297,496.50**		**791,049.60**		
	179 52 16.1					+5,920.80		−11,346.17		
Meinhard–Burke	332 26 34.7	+0.46263125	−0.88655081	12,798.06	12,798.10	2,303,428.09	−11.32	779,708.37	−5.18	274,754.62
						2,303,416.77		**779,703.19**		
						+11.32		+5.18		

Fixed and final values are shown in **bold-faced** type in the above table.

ADJUSTMENT OF A SMALL ARC OF TRIANGULATION IN AN OVERLAP SECTION OF TWO SYSTEMS

To illustrate the similarity of procedure in the Lambert and the transverse Mercator systems, a small arc was chosen along the Ohio-Indiana boundary. Then the same adjustment could be made on each of the grids and a direct comparison of the adjustments could then be made. It is true that the arc lies in the most unfavorable section of each of the systems, but this could not be avoided if such a twofold adjustment was to be made.

In this example the computed corrections to the azimuths were applied directly to the lists of directions, after they were adopted, to offset the spherical excess of the triangles. This gives lists of directions for the plane, and from them the plane angles for the grid triangles could be taken out directly. This is probably the most satisfactory way to handle the problem in practice since all the elements are directly shown in the lists of directions.

The adjustment was made in the same way on both of the grids but the resulting corrections differ slightly although either of them is a perfectly satisfactory result. If everything were absolutely rigid, and if all computations were carried to many decimal places, the resulting v's should be the same in both cases. However, for reasons of economy no attempt is ever made to obtain perfect rigidity in practical computations. It will be seen that the Σv^2 is smaller for the adjustment on the transverse Mercator grid than for that on the Lambert grid and hence the former is nearer the ideal solution than the latter, but as a practical adjustment, either one is perfectly admissible.

DISCUSSION OF THE AZIMUTH CORRECTIONS FOR THE LAMBERT GRID

The azimuth correction term for the Lambert projection depends entirely upon the distance of the stations from the parallel that has y' equal to y_0, and on the direction of the line with respect to the meridian. The R for this parallel is not tabulated but it can be found by subtracting y_0 from the R_0. In the table for Ohio (South) (see fig. 45) [6] denoting the radius for this parallel by R_c, we have

$$R_c=26{,}027{,}071.12-504{,}195.32=25{,}522{,}875.80.$$

We know then that the correction should be the same whether the line is near the central meridian or not. If we limit the correction to the first term, the value we get will vary as the line is moved farther and farther from the central meridian. The best value will be found if we use for y's the meridional grid distance of each station from the parallel of R_c, and for x_2-x_1 the grid length multiplied by the sine of the geodetic azimuth. This can be done by computing the R and θ from the assumed coordinates and then using for y the value R_c-R and for geodetic azimuth the value grid azimuth$+\theta$. By this means we can get values that will give a satisfactory correction to use in the computation.

In the case of this Ohio-Indiana boundary we are at a considerable distance from the central meridian, and hence the corrections computed with a single term are not satisfactory. However, since the

[6] For State map of Ohio showing elements of the two grids covering the State see Figure 64, p. 265

arc runs north and south, we can make use of another scheme to accomplish the same purpose. For use in this computation we do not need to have the coordinates with any great accuracy. We first list the assumed coordinates with the central meridian as Y axis and with its intersection with the parallel of R_c as origin. That is, 2,000,000 is subtracted from the x's and 504,195 from the y's, taking each coordinate to the nearest foot. Then we find that $-1°28'$ is a fairly good mean for the θ angles. Now turn the axes through the angle $-1°28'$ which will make the new Y axis parallel to the meridian having this θ angle. In addition move the origin down the distance $2R_c \sin^2 \theta/2$, in which R_c and θ are the quantities already defined. For this computation $2R_c \sin^2 \theta/2$ is found to be $+8{,}362$ feet.

If we consider the θ as a positive angle the transformation formulas become

$$x' = x \cos \theta - y \sin \theta$$
$$y' = +8362 + x \sin \theta + y \cos \theta$$
$$\sin \theta = 0.02559537$$
$$\cos \theta = 0.99967238$$

This transformation was made and resulted in the list of transformed coordinates tabulated below. From these transformed coordinates a tabulation was made of $x_2' - x_1'$ and $2y_1' + y_2'$ with the correct sign in each case. With these values the correction can be computed by the formula

$$\text{Correction} = \frac{(x_2' - x_1')(2\ y_1' + y_2')}{6\rho_0^2 \sin 1''}$$

From the table on page 185, we find

$$\log \left(\frac{1}{2\rho_0^2 \sin 1''} \right) = 0.3726089 - 10,$$

hence

$$\frac{1}{2\rho_0^2 \sin 1''} = 2.3583 \times 10^{-10}$$

and

$$\frac{1}{6\rho_0^2 \sin 1''} = 0.7861 \times 10^{-10}.$$

With a calculating machine the correction can readily be computed. The 10^{-10} factor for the constant can be accounted for by pointing off 5 places in each of the other factors before the multiplication is performed. That is, for Oxford–Billings, we have

$$\text{Cor.} = -0.38274 \times 1.68325 \times 0.7861$$
$$= -0.51$$

It can be seen that approximate values are sufficient, for we get the same value by using three significant figures in each case

$$\text{Cor.} = -0.383 \times 1.68 \times 0.786$$
$$= -0.51$$

The complete work of the two adjustments is now given to serve as an example for similar cases.

Lambert Projection for Ohio – North

Table I.

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
39° 40'	24,559,158.47	0	101.20633	+1019.6	1.0002348
41	24,553,086.09	6,072.38	101.20600	+ 989.3	1.0002278
42	24,547,013.73	12,144.74	101.20567	+ 959.4	1.0002209
43	24,540,941.39	18,217.08	101.20533	+ 929.9	1.0002141
44	24,534,869.07	24,289.40	101.20483	+ 900.7	1.0002074
45	24,528,796.78	30,361.69	101.20450	+ 871.9	1.0002008
39° 46'	24,522,724.51	36,433.96	101.20417	+ 843.4	1.0001942
47	24,516,652.26	42,506.21	101.20383	+ 815.3	1.0001877
48	24,510,580.03	48,578.44	101.20333	+ 787.6	1.0001814
49	24,504,507.83	54,650.64	101.20317	+ 760.2	1.0001750
50	24,498,435.64	60,722.83	101.20267	+ 733.2	1.0001688
39° 51'	24,492,363.48	66,794.99	101.20250	+ 706.5	1.0001627
52	24,486,291.33	72,867.14	101.20217	+ 680.2	1.0001566
53	24,480,219.20	78,939.27	101.20183	+ 654.3	1.0001507
54	24,474,147.09	85,011.38	101.20150	+ 628.7	1.0001448
55	24,468,075.00	91,083.47	101.20117	+ 603.5	1.0001390
39° 56'	24,462,002.93	97,155.54	101.20100	+ 578.6	1.0001332
57	24,455,930.87	103,227.60	101.20067	+ 554.1	1.0001276
58	24,449,858.83	109,299.64	101.20050	+ 529.9	1.0001220
59	24,443,786.80	115,371.67	101.20017	+ 506.1	1.0001165
40° 00	24,437,714.79	121,443.68	101.19983	+ 482.7	1.0001111
40° 01'	24,431,642.80	127,515.67	101.19967	+ 459.6	1.0001058
02	24,425,570.82	133,587.65	101.19950	+ 436.9	1.0001006
03	24,419,498.85	139,659.62	101.19917	+ 414.5	1.0000954
04	24,413,426.90	145,731.57	101.19900	+ 392.5	1.0000904
05	24,407,354.96	151,803.51	101.19883	+ 370.9	1.0000854
40° 06'	24,401,283.03	157,875.44	101.19867	+ 349.6	1.0000805
07	24,395,211.11	163,947.36	101.19850	+ 328.7	1.0000757
08	24,389,139.20	170,019.27	101.19817	+ 308.1	1.0000709
09	24,383,067.31	176,091.16	101.19817	+ 287.9	1.0000663
10	24,376,995.42	182,163.05	101.19783	+ 268.1	1.0000617
40° 11'	24,370,923.55	188,234.92	101.19783	+ 248.6	1.0000572
12	24,364,851.68	194,306.79	101.19750	+ 229.5	1.0000528
13	24,358,779.83	200,378.64	101.19750	+ 210.8	1.0000485
14	24,352,707.98	206,450.49	101.19733	+ 192.4	1.0000443
15	24,346,636.14	212,522.33	101.19733	+ 174.4	1.0000402

FIGURE 45.—Lambert projection tables for Ohio.

Lambert Projection for Ohio - North

Table I (Cont'd).

Lat.	y^N ft.	Y^1 Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
40° 16'	24,340,564.30	218,594.17	101.19717	+156.7	1.0000361
17	24,334,492.47	224,666.00	101.19700	+139.4	1.0000321
18	24,328,420.65	230,737.82	101.19683	+122.5	1.0000282
19	24,322,348.84	236,809.63	101.19683	+105.9	1.0000244
20	24,316,277.03	242,881.44	101.19683	+ 89.7	1.0000207
40° 21'	24,310,205.22	248,953.25	101.19667	+ 73.8	1.0000170
22	24,304,133.42	255,025.05	101.19667	+ 58.4	1.0000134
23	24,298,061.62	261,096.85	101.19650	+ 43.2	1.0000099
24	24,291,989.83	267,168.64	101.19650	+ 28.5	1.0000066
25	24,285,918.04	273,240.43	101.19650	+ 14.1	1.0000032
40° 26'	24,279,846.25	279,312.22	101.19650	0.0	1.0000000
27	24,273,774.46	285,384.01	101.19650	- 13.6	0.9999969
28	24,267,702.67	291,455.80	101.19633	- 27.0	0.9999938
29	24,261,630.89	297,527.58	101.19650	- 39.9	0.9999908
30	24,255,559.10	303,599.37	101.19650	- 52.5	0.9999879
40° 31'	24,249,487.31	309,671.16	101.19633	- 64.7	0.9999851
32	24,243,415.53	315,742.94	101.19650	- 76.6	0.9999824
33	24,237,343.74	321,814.73	101.19650	- 88.1	0.9999797
34	24,231,271.95	327,886.52	101.19667	- 99.3	0.9999771
35	24,225,200.15	333,958.32	101.19650	-110.1	0.9999746
40° 36'	24,219,128.36	340,030.11	101.19667	-120.5	0.9999723
37	24,213,056.56	346,101.91	101.19683	-130.5	0.9999700
38	24,206,984.75	352,173.72	101.19683	-140.2	0.9999677
39	24,200,912.94	358,245.53	101.19683	-149.5	0.9999656
40	24,194,841.13	364,317.34	101.19700	-158.5	0.9999635
40° 41'	24,188,769.31	370,389.16	101.19700	-167.1	0.9999615
42	24,182,697.49	376,460.98	101.19717	-175.4	0.9999596
43	24,176,625.66	382,532.81	101.19733	-183.2	0.9999578
44	24,170,553.82	388,604.65	101.19750	-190.7	0.9999561
45	24,164,481.97	394,676.50	101.19750	-197.9	0.9999544
40° 46'	24,158,410.12	400,748.35	101.19767	-204.7	0.9999529
47	24,152,338.26	406,820.21	101.19800	-211.1	0.9999514
48	24,146,266.38	412,892.09	101.19800	-217.2	0.9999500
49	24,140,194.50	418,963.97	101.19817	-222.9	0.9999487
50	24,134,122.61	425,035.86	101.19833	-228.2	0.9999475

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - North

Table I (Cont'd).

Lat.	R. ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
40° 51'	24,128,050.71	431,107.76	101.19850	-233.2	0.9999463
52	24,121,978.80	437,179.67	101.19883	-237.8	0.9999452
53	24,115,906.87	443,251.60	101.19883	-242.0	0.9999443
54	24,109,834.94	449,323.53	101.19917	-245.8	0.9999434
55	24,103,762.99	455,395.48	101.19950	-249.3	0.9999426
40° 56'	24,097,691.02	461,467.45	101.19950	-252.4	0.9999419
57	24,091,619.05	467,539.42	101.19983	-255.2	0.9999412
58	24,085,547.06	473,611.41	101.20017	-257.6	0.9999407
59	24,079,475.05	479,683.42	101.20033	-259.6	0.9999402
41° 00	24,073,403.03	485,755.44	101.20067	-261.3	0.9999398
41° 01'	24,067,330.99	491,827.48	101.20083	-262.6	0.9999395
02	24,061,258.94	497,899.53	101.20117	-263.5	0.9999393
03	24,055,186.87	503,971.60	101.20150	-264.1	0.9999392
04	24,049,114.78	510,043.69	101.20167	-264.3	0.9999391
05	24,043,042.68	516,115.79	101.20200	-264.1	0.9999392
41° 06'	24,036,970.56	522,187.91	101.20233	-263.6	0.9999393
07	24,030,898.42	528,260.05	101.20267	-262.7	0.9999395
08	24,024,826.26	534,332.21	101.20300	-261.4	0.9999398
09	24,018,754.08	540,404.39	101.20333	-259.8	0.9999402
10	24,012,681.88	546,476.59	101.20367	-257.8	0.9999406
41° 11'	24,006,609.66	552,548.81	101.20417	-255.4	0.9999412
12	24,000,537.41	558,621.06	101.20433	-252.7	0.9999418
13	23,994,465.15	564,693.32	101.20483	-249.6	0.9999425
14	23,988,392.86	570,765.61	101.20517	-246.2	0.9999433
15	23,982,320.55	576,837.92	101.20550	-242.3	0.9999442
41°16'	23,976,248.22	582,910.25	101.20600	-238.1	0.9999452
17	23,970,175.86	588,982.61	101.20633	-233.6	0.9999462
18	23,964,103.48	595,054.99	101.20683	-228.7	0.9999473
19	23,958,031.07	601,127.40	101.20717	-223.4	0.9999486
20	23,951,958.64	607,199.83	101.20767	-217.7	0.9999499
41° 21'	23,945,886.18	613,272.29	101.20817	-211.7	0.9999513
22	23,939,813.69	619,344.78	101.20850	-205.3	0.9999527
23	23,933,741.18	625,417.29	101.20900	-198.5	0.9999543
24	23,927,668.64	631,489.83	101.20950	-191.4	0.9999559
25	23,921,596.07	637,562.40	101.20983	-183.9	0.9999577

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - North

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
41° 26'	23,915,523.48	643,634.99	101.21050	-176.0	0.9999595
27	23,909,450.85	649,707.62	101.21100	-167.8	0.9999614
28	23,903,378.19	655,780.28	101.21133	-159.2	0.9999633
29	23,897,305.51	661,852.96	101.21200	-150.2	0.9999654
30	23,891,232.79	667,925.68	101.21233	-140.9	0.9999676
41° 31'	23,885,160.05	673,998.42	101.21300	-131.2	0.9999698
32	23,879,087.27	680,071.20	101.21350	-121.1	0.9999721
33	23,873,014.46	686,144.01	101.21417	-110.7	0.9999745
34	23,866,941.61	692,216.86	101.21450	- 99.9	0.9999770
35	23,860,868.74	698,289.73	101.21533	- 88.7	0.9999796
41° 36'	23,854,795.82	704,362.65	101.21567	- 77.1	0.9999822
37	23,848,722.88	710,435.59	101.21633	- 65.2	0.9999850
38	23,842,649.90	716,508.57	101.21700	- 52.9	0.9999878
39	23,836,576.88	722,581.59	101.21750	- 40.2	0.9999907
40	23,830,503.83	728,654.64	101.21800	- 27.2	0.9999937
41° 41'	23,824,430.75	734,727.72	101.21883	- 13.8	0.9999968
42	23,818,357.62	740,800.85	101.21933	0.0	1.0000000
43	23,812,284.46	746,874.01	101.22000	+ 14.1	1.0000032
44	23,806,211.26	752,947.21	101.22067	+ 28.6	1.0000066
45	23,800,138.02	759,020.45	101.22117	+ 43.5	1.0000100
41° 46'	23,794,064.75	765,093.72	101.22200	+ 58.8	1.0000135
47	23,787,991.43	771,167.04	101.22267	+ 74.4	1.0000171
48	23,781,918.07	777,240.40	101.22317	+ 90.4	1.0000208
49	23,775,844.68	783,313.79	101.22400	+106.8	1.0000246
50	23,769,771.24	789,387.23	101.22467	+123.5	1.0000284
41° 51'	23,763,697.76	795,460.71	101.22533	+140.6	1.0000324
52	23,757,624.24	801,534.23	101.22617	+158.1	1.0000364
53	23,751,550.67	807,607.80	101.22667	+175.9	1.0000405
54	23,745,477.07	813,681.40	101.22750	+194.1	1.0000447
55	23,739,403.42	819,755.05	101.22833	+212.7	1.0000490
41° 56'	23,733,329.72	825,828.75	101.22900	+231.7	1.0000534
57	23,727,255.98	831,902.49	101.22967	+251.0	1.0000578
58	23,721,182.20	837,976.27	101.23050	+270.7	1.0000623
59	23,715,108.37	844,050.10	101.23133	+290.8	1.0000670
42° 00	23,709,034.49	850,123.98	101.23200	+311.2	1.0000717

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio — North

Table I (Cont'd).

Lat.	R ft.	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs	Scale expressed as a ratio
42° 01'	23,702,960.57	856,197.90	101.23283	+332.0	1.0000764
02	23,696,886.60	862,271.87	101.23367	+353.2	1.0000813
03	23,690,812.58	868,345.89	101.23450	+374.8	1.0000863
04	23,684,738.51	874,419.96	101.23533	+396.7	1.0000913
05	23,678,664.39	880,494.08	101.23600	+419.0	1.0000965
42° 06'	23,672,590.23	886,568.24	101.23700	+441.7	1.0001017
07	23,666,516.01	892,642.46	101.23767	+464.7	1.0001070
08	23,660,441.75	898,716.72	101.23867	+488.1	1.0001124
09	23,654,367.43	904,791.04	101.23950	+511.9	1.0001179
10	23,648,293.06	910,865.41		+536.1	1.0001234

$\ell = 0.65695032$

$\log \ell = 9.8175325281 - 10$

$\log K = 7.6044837793$

$$\text{Geod. Az.} - \text{Grid. Az.} = -\frac{x_2 - x_1}{2\rho_0^2 \sin 1''}\left(y_1 - y_0 + \frac{y_2 - y_1}{3}\right) + \theta$$

$y_0 = +510,419.96$ feet.

$$\log \frac{1}{2\rho_0^2 \sin 1''} = 0.3724381 - 10$$

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - North

1" of Long. = 0".65695032 of θ

Table II.

Long.	θ	Long.	θ	Long.	θ
80° 00'	+1° 38' 32".55288				
01	+1 37 53.13586	80° 36'	+1° 14' 53".54019	81° 11'	+0° 51' 53".94452
02	+1 37 13.71884	37	+1 14 14.12317	12	+0 51 14.52750
03	+1 36 34.30182	38	+1 13 34.70615	13	+0 50 35.11048
04	+1 35 54.88480	39	+1 12 55.28913	14	+0 49 55.69346
05	+1 35 15.46778	40	+1 12 15.87211	15	+0 49 16.27644
80° 06'	+1 34 36.05076	80° 41'	+1 11 36.45509	81°16'	+0 48 36.85942
07	+1 33 56.63375	42	+1 10 57.03807	17	+0 47 57.44240
08	+1 33 17.21673	43	+1 10 17.62105	18	+0 47 18.02538
09	+1 32 37.79971	44	+1 09 38.20404	19	+0 46 38.60836
10	+1 31 58.38269	45	+1 08 58.78702	20	+0 45 59.19134
80° 11'	+1 31 18.96567	80° 46'	+1 08 19.37000	81° 21'	+0 45 19.77432
12	+1 30 39.54865	47	+1 07 39.95298	22	+0 44 40.35731
13	+1 30 00.13163	48	+1 07 00.53596	23	+0 44 00.94029
14	+1 29 20.71461	49	+1 06 21.11894	24	+0 43 21.52327
15	+1 28 41.29759	50	+1 05 41.70192	25	+0 42 42.10625
80° 16'	+1 28 01.88057	80° 51'	+1 05 02.28490	81° 26'	+0 42 02.68923
17	+1 27 22.46355	52	+1 04 22.86788	27	+0 41 23.27221
18	+1 26 43.04653	53	+1 03 43.45086	28	+0 40 43.85519
19	+1 26 03.62952	54	+1 03 04.03384	29	+0 40 04.43817
20	+1 25 24.21250	55	+1 02 24.61682	30	+0 39 25.02115
80° 21'	+1 24 44.79548	80° 56'	+1 01 45.19980	81° 31'	+0 38 45.60413
22	+1 24 05.37846	57	+1 01 05.78279	32	+0 38 06.18711
23	+1 23 25.96144	58'	+1 00 26.36577	33	+0 37 26.77009
24	+1 22 46.54442	59	+0 59 46.94875	34	+0 36 47.35308
25	+1 22 07.12740	81° 00	+0 59 07.53173	35	+0 36 07.93606
80° 26'	+1 21 27.71038	81° 01'	+0 58 28.11471	81° 36'	+0 35 28.51904
27	+1 20 48.29336	02	+0 57 48.69769	37	+0 34 49.10202
28	+1 20 08.87634	03	+0 57 09.28067	38	+0 34 09.68500
29	+1 19 29.45932	04	+0 56 29.86365	39	+0 33 30.26798
30	+1 18 50.04230	05	+0 55 50.44663	40	+0 32 50.85096
80° 31'	+1 18 10.62528	81° 06'	+0 55 11.02961	81° 41'	+0 32 11.43394
32	+1 17 31.20827	07	+0 54 31.61259	42	+0 31 32.01692
33	+1 16 51.79125	08	+0 53 52.19557	43	+0 30 52.59990
34	+1 16 12.37423	09	+0 53 12.77856	44	+0 30 13.18288
35	+1 15 32.95721	10	+0 52 33.36154	45	+0 29 33.76586

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - North

1" of Long. = 0".65695032 of θ

Table II (Cont'd).

Long.	θ	Long.	θ	Long.	θ
81° 46'	+0° 28' 54".34884	82° 21'	+0° 05' 54".75317	82° 56'	-0° 17' 04".84250
47	+0 28 14.93183	22	+0 05 15.33615	57	-0 17 44.25952
48	+0 27 35.51481	23	+0 04 35.91913	58	-0 18 23.67654
49	+0 26 56.09779	24	+0 03 56.50212	59	-0 19 03.09356
50	+0 26 16.68077	25	+0 03 17.08510	83° 00	-0 19 42.51058
81° 51'	+0 25 37.26375	82° 26'	+0 02 37.66808	83° 01'	-0 20 21.92760
52	+0 24 57.84673	27	+0 01 58.25106	02	-0 21 01.34461
53	+0 24 18.42971	28	+0 01 18.83404	03	-0 21 40.76163
54	+0 23 39.01269	29	+0 00 39.41702	04	-0 22 20.17865
55	+0 22 59.59567	30	0 00 00.00000	05	-0 22 59.59567
81° 56'	+0 22 20.17865	82° 31'	-0 00 39.41702	83° 06'	-0 23 39.01269
57	+0 21 40.76163	32	-0 01 18.83404	07	-0 24 18.42971
58	+0 21 01.34461	33	-0 01 58.25106	08	-0 24 57.84673
59	+0 20 21.92760	34	-0 02 37.66808	09	-0 25 37.26375
82° 00	+0 19 42.51058	35	-0 03 17.08510	10	-0 26 16.68077
82° 01'	+0 19 03.09356	82° 36'	-0 03 56.50212	83° 11'	-0 26 56.09779
02	+0 18 23.67654	37	-0 04 35.91913	12	-0 27 35.51481
03	+0 17 44.25952	38	-0 05 15.33615	13	-0 28 14.93183
04	+0 17 04.84250	39	-0 05 54.75317	14	-0 28 54.34884
05	+0 16 25.42548	40	-0 06 34.17019	15	-0 29 33.76586
82° 06'	+0 15 46.00846	82° 41'	-0 07 13.58721	83° 16'	-0 30 13.18288
07	+0 15 06.59144	42	-0 07 53.00423	17	-0 30 52.59990
08	+0 14 27.17442	43	-0 08 32.42125	18	-0 31 32.01692
09	+0 13 47.75740	44	-0 09 11.83827	19	-0 32 11.43394
10	+0 13 08.34038	45	-0 09 51.25529	20	-0 32 50.85096
82° 11'	+0 12 28.92336	82° 46'	-0 10 30.67231	83° 21'	-0 33 30.26798
12	+0 11 49.50635	47	-0 11 10.08933	22	-0 34 09.68500
13	+0 11 10.08933	48	-0 11 49.50635	23	-0 34 49.10202
14	+0 10 30.67231	49	-0 12 28.92336	24	-0 35 28.51904
15	+0 09 51.25529	50	-0 13 08.34038	25	-0 36 07.93606
82° 16'	+0 09 11.83827	82° 51'	-0 13 47.75740	83° 26'	-0 36 47.35308
17	+0 08 32.42125	52	-0 14 27.17442	27	-0 37 26.77009
18	+0 07 53.00423	53	-0 15 06.59144	28	-0 38 06.18711
19	+0 07 13.58721	54	-0 15 46.00846	29	-0 38 45.60413
20	+0 06 34.17019	55	-0 16 25.42548	30	-0 39 25.02115

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - North

1" of Long. = 0"65695032 of θ

Table II (Cont'd).

Long.	θ	Long.	θ	Long.	θ
83° 31'	-0° 40' 04443817	84° 06'	-1° 03' 04403384	84° 41'	-1° 26' 03462952
32	40 43.85519	07	-1 03 43.45086	42	-1 26 43.04653
33	41 23.27221	08	-1 04 22.86788	43	-1 27 22.46355
34	42 02.68923	09	-1 05 02.28490	44	-1 28 01.88057
35	42 42.10625	10	-1 05 41.70192	45	-1 28 41.29759
83° 36'	43 21.52327	84° 11'	-1 06 21.11894	84° 46'	-1 29 20.71461
37	44 00.94029	12	-1 07 00.53596	47	-1 30 00.13163
38	44 40.35731	13	-1 07 39.95298	48	-1 30 39.54865
39	45 19.77432	14	-1 08 19.37000	49	-1 31 18.96567
40	45 59.19134	15	-1 08 58.78702	50	-1 31 58.38269
83° 41'	46 38.60836	84° 16'	-1 09 38.20404	84° 51'	-1 32 37.79971
42	47 18.02538	17	-1 10 17.62105	52	-1 33 17.21673
43	47 57.44240	18	-1 10 57.03807	53	-1 33 56.63375
44	48 36.85942	19	-1 11 36.45509	54	-1 34 36.05076
45	49 16.27644	20	-1 12 15.87211	55	-1 35 15.46778
83° 46'	49 55.69346	84° 21'	-1 12 55.28913	84° 56'	-1 35 54.88480
47	50 35.11048	22	-1 13 34.70615	57	-1 36 34.30182
48	51 14.52750	23	-1 14 14.12317	58	-1 37 13.71884
49	51 53.94452	24	-1 14 53.54019	59	-1 37 53.13586
50	52 33.36154	25	-1 15 32.95721	85° 00	-1 38 32.55288
83° 51'	53 12.77856	84° 26'	-1 16 12.37423	85° 01'	-1 39 11.96990
52	53 52.19557	27	-1 16 51.79125	02	-1 39 51.38692
53	54 31.61259	28	-1 17 31.20827	03	-1 40 30.80394
54	55 11.02961	29	-1 18 10.62528	04	-1 41 10.22096
55	55 50.44663	30	-1 18 50.04230	05	-1 41 49.63798
83° 56'	56 29.86365	84° 31'	-1 19 29.45932	85° 06'	-1 42 29.05500
57	57 09.28067	32	-1 20 08.87634	07	-1 43 08.47201
58	57 48.69769	33	-1 20 48.29336	08	-1 43 47.88903
59	58 28.11471	34	-1 21 27.71038	09	-1 44 27.30605
84° 00	59 07.53173	35	-1 22 07.12740	10	-1 45 06.72307
84° 01'	59 46.94875	84° 36'	-1 22 46.54442	85° 11'	-1 45 46.14009
02	00 26.36577	37	-1 23 25.96144	12	-1 46 25.55711
03	01 05.78279	38	-1 24 05.37846	13	-1 47 04.97413
04	01 45.19980	39	-1 24 44.79548	14	-1 47 44.39115
05	02 24.61682	40	-1 25 24.21250	15	-1 48 23.80817
				85° 16'	-1° 49 03"22519
				17	-1 49 42.64221
				18	-1 50 22.05923
				19	-1 51 01.47624
				20	-1 51 40.89326

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - South

Table I

Latitude	R feet	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio.
38° 00'	26,027,071.12	0	101.17617	+975.6	1.0002246
01	26,021,000.55	6,070.57	101.17583	+945.7	1.0002178
02	26,014,930.00	12,141.12	101.17533	+916.2	1.0002110
03	26,008,859.48	18,211.64	101.17500	+887.0	1.0002042
04	26,002,788.98	24,282.14	101.17450	+858.1	1.0001976
05	25,996,718.51	30,352.61	101.17433	+829.7	1.0001910
38° 06'	25,990,648.05	36,423.07	101.17383	+801.6	1.0001846
07	25,984,577.62	42,493.50	101.17350	+773.8	1.0001782
08	25,978,507.21	48,563.91	101.17317	+746.4	1.0001719
09	25,972,436.82	54,634.30	101.17283	+719.4	1.0001656
10	25,966,366.45	60,704.67	101.17250	+692.7	1.0001595
38° 11'	25,960,296.10	66,775.02	101.17217	+666.4	1.0001534
12	25,954,225.77	72,845.35	101.17200	+640.4	1.0001475
13	25,948,155.45	78,915.67	101.17150	+614.8	1.0001416
14	25,942,085.16	84,985.96	101.17133	+589.6	1.0001358
15	25,936,014.88	91,056.24	101.17100	+564.7	1.0001300
38° 16'	25,929,944.62	97,126.50	101.17067	+540.2	1.0001244
17	25,923,874.38	103,196.74	101.17050	+516.0	1.0001188
18	25,917,804.15	109,266.97	101.17033	+492.2	1.0001133
19	25,911,733.93	115,337.19	101.16983	+468.8	1.0001079
20	25,905,663.74	121,407.38	101.16983	+445.7	1.0001026
38° 21'	25,899,593.55	127,477.57	101.16950	+423.0	1.0000974
22	25,893,523.38	133,547.74	101.16917	+400.6	1.0000922
23	25,887,453.23	139,617.89	101.16900	+378.6	1.0000872
24	25,881,383.09	145,688.03	101.16883	+357.0	1.0000822
25	25,875,312.96	151,758.16	101.16867	+335.7	1.0000773
38° 26'	25,869,242.84	157,828.28	101.16850	+314.8	1.0000725
27	25,863,172.73	163,898.39	101.16833	+294.2	1.0000677
28	25,857,102.63	169,968.49	101.16800	+274.0	1.0000631
29	25,851,032.55	176,038.57	101.16783	+254.2	1.0000585
30	25,844,962.48	182,108.64	101.16783	+234.7	1.0000540
38° 31'	25,838,892.41	188,178.71	101.16767	+215.6	1.0000496
32	25,832,822.35	194,248.77	101.16750	+196.8	1.0000453
33	25,826,752.30	200,318.82	101.16733	+178.4	1.0000411
34	25,820,682.26	206,388.86	101.16717	+160.4	1.0000369
35	25,814,612.23	212,458.89	101.16717	+142.7	1.0000329

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - South

Table I (Cont'd)

Latitude		R feet	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat feet	Scale in units of 7th place of logs.	Scale expressed as a ratio.
38°	36'	25,808,542.20	218,528.92	101.16700	+125.4	1.0000289
	37	25,802,472.18	224,598.94	101.16683	+108.5	1.0000250
	38	25,796,402.17	230,668.95	101.16683	+ 91.9	1.0000212
	39	25,790,332.16	236,738.96	101.16667	+ 75.7	1.0000174
	40	25,784,262.16	242,808.96	101.16667	+ 59.8	1.0000138
38°	41'	25,778,192.16	248,878.96	101.16667	+ 44.3	1.0000102
	42	25,772,122.16	254,948.96	101.16650	+ 29.2	1.0000067
	43	25,766,052.17	261,018.95	101.16650	+ 14.4	1.0000033
	44	25,759,982.18	267,088.94	101.16650	0.0	1.0000000
	45	25,753,912.19	273,158.93	101.16633	- 14.0	0.9999968
38°	46'	25,747,842.21	279,228.91	101.16633	- 27.7	0.9999936
	47	25,741,772.23	285,298.89	101.16650	- 41.0	0.9999906
	48	25,735,702.24	291,368.88	101.16633	- 54.0	0.9999876
	49	25,729,632.26	297.438.86	101.16633	- 66.6	0.9999847
	50	25,723,562.28	303,508.84	101.16633	- 78.8	0.9999819
38°	51'	25,717,492.30	309,578.82	101.16650	- 90.7	0.9999791
	52	25,711,422.31	315,648.81	101.16650	-102.2	0.9999765
	53	25,705,352.32	321,718.80	101.16650	-113.4	0.9999739
	54	25,699,282.33	327,788.79	101.16650	-124.1	0.9999714
	55	25,693,212.34	333,858.78	101.16650	-134.6	0.9999690
38°	56'	25,687,142.35	339,928.77	101.16667	-144.6	0.9999667
	57	25,681,072.35	345,998.77	101.16667	-154.3	0.9999645
	58	25,675,002.35	352,068.77	101.16683	-163.6	0.9999623
	59	25,668,932.34	358,138.78	101.16683	-172.6	0.9999603
39°	00	25,662,862.33	364,208.79	101.16700	-181.2	0.9999583
39°	01'	25,656,792.31	370,278.81	101.16717	-189.4	0.9999564
	02	25,650,722.28	376,348.84	101.16717	-197.3	0.9999546
	03	25,644,652.25	382,418.87	101.16733	-204.8	0.9999528
	04	25,638,582.21	388,488.91	101.16750	-211.9	0.9999512
	05	25,632,512.16	394,558.96	101.16750	-218.7	0.9999496
39°	06'	25,626,442.11	400,629.01	101.16767	-225.1	0.9999482
	07	25,620,372.05	406,699.07	101.16800	-231.2	0.9999468
	08	25,614,301.97	412,769.15	101.16800	-236.8	0.9999455
	09	25,608,231.89	418,839.23	101.16833	-242.1	0.9999443
	10	25,602,161.79	424,909.33	101.16833	-247.1	0.9999431

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - South

Table I (Cont'd)

Latitude		R feet	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
39°	11'	25,596,091.69	430,979.43	101.16867	-251.7	0.9999420
	12	25,590,021.57	437,049.55	101.16883	-255.9	0.9999411
	13	25,583,951.44	443,119.68	101.16900	-259.8	0.9999402
	14	25,577,881.30	449,189.82	101.16917	-263.3	0.9999394
	15	25,571,811.15	455,259.97	101.16950	-266.4	0.9999387
39°	16'	25,565,740.98	461,330.14	101.16967	-269.2	0.9999380
	17	25,559,670.80	467,400.32	101.17000	-271.6	0.9999375
	18	25,553,600.60	473,470.52	101.17017	-273.6	0.9999370
	19	25,547,530.39	479,540.73	101.17033	-275.3	0.9999366
	20	25,541,460.17	485,610.95	101.17067	-276.6	0.9999363
39°	21'	25,535,389.93	491,681.19	101.17100	-277.5	0.9999361
	22	25,529,319.67	497,751.45	101.17133	-278.1	0.9999360
	23	25,523,249.39	503,821.73	101.17150	-278.3	0.9999359
	24	25,517,179.10	509,892.02	101.17183	-278.2	0.9999359
	25	25,511,108.79	515,962.33	101.17217	-277.6	0.9999361
39°	26'	25,505,038.46	522,032.66	101.17250	-276.7	0.9999363
	27	25,498,968.11	528,103.01	101.17283	-275.5	0.9999366
	28	25,492,897.74	534,173.38	101.17317	-273.9	0.9999369
	29	25,486,827.35	540,243.77	101.17350	-271.9	0.9999374
	30	25,480,756.94	546,314.18	101.17383	-269.5	0.9999379
39°	31'	25,474,686.51	552,384.61	101.17433	-266.8	0.9999386
	32	25,468,616.05	558,455.07	101.17450	-263.7	0.9999393
	33	25,462,545.58	564,525.54	101.17500	-260.2	0.9999401
	34	25,456,475.08	570,596.04	101.17533	-256.4	0.9999410
	35	25,450,404.56	576,666.56	101.17583	-252.2	0.9999419
39°	36'	25,444,334.01	582,737.11	101.17617	-247.6	0.9999430
	37	25,438,263.44	588,807.68	101.17650	-242.7	0.9999441
	38	25,432,192.85	594,878.27	101.17700	-237.4	0.9999453
	39	25,426,122.23	600,948.89	101.17750	-231.7	0.9999466
	40	25,420,051.58	607,019.54	101.17783	-225.7	0.9999480
39°	41'	25,413,980.91	613,090.21	101.17833	-219.3	0.9999495
	42	25,407,910.21	619,160.91	101.17867	-212.5	0.9999511
	43	25,401,879.49	625,231.63	101.17933	-205.4	0.9999527
	44	25,395,768.73	631,302.39	101.17967	-197.9	0.9999544
	45	25,389,697.95	637,373.17	101.18017	-190.1	0.9999562

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - South

Table I (Cont'd)

Latitude		R feet	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
39°	46'	25,383,627.14	643,443.98	101.18067	-181.8	0.9999581
	47	25,377,556.30	649,514.82	101.18117	-173.2	0.9999601
	48	25,371,485.43	655,585.69	101.18167	-164.2	0.9999622
	49	25,365,414.53	661,656.59	101.18217	-154.9	0.9999643
	50	25,359,343.60	667,727.52	101.18283	-145.2	0.9999666
39°	51'	25,353,272.63	673,798.49	101.18317	-135.1	0.9999689
	52	25,347,201.64	679,869.48	101.18383	-124.7	0.9999713
	53	25,341,130.61	685,940.51	101.18433	-113.8	0.9999738
	54	25,335,059.55	692,011.57	101.18500	-102.7	0.9999764
	55	25,328,988.45	698,082.67	101.18550	- 91.1	0.9999790
39°	56'	25,322,917.32	704,153.80	101.18600	- 79.2	0.9999818
	57	25,316,846.16	710,224.96	101.18667	- 66.9	0.9999846
	58	25,310,774.96	716,296.16	101.18717	- 54.2	0.9999875
	59	25,304,703.73	722,367.39	101.18783	- 41.2	0.9999905
40°	00	25,298,632.46	728,438.66	101.18850	- 27.8	0.9999936
40°	01'	25,292,561.15	734,509.97	101.18917	- 14.1	0.9999968
	02	25,286,489.80	740,581.32	101.18967	- 0.0	1.0000000
	03	25,280,418.42	746,652.70	101.19033	+ 14.5	1.0000033
	04	25,274,347.00	752,724.12	101.19100	+ 29.4	1.0000068
	05	25,268,275.54	758,795.58	101.19167	+ 44.7	1.0000103
40°	06'	25,262,204.04	764,867.08	101.19233	+ 60.3	1.0000139
	07	25,256,132.50	770,938.62	101.19300	+ 76.2	1.0000175
	08	25,250,060.92	777,010.20	101.19367	+ 92.6	1.0000213
	09	25,243,989.30	783,081.82	101.19433	+109.3	1.0000252
	10	25,237,917.64	789,153.48	101.19500	+126.4	1.0000291
40°	11'	25,231,845.94	795,225.18	101.19567	+143.9	1.0000331
	12	25,225,774.20	801,296.92	101.19650	+161.7	1.0000372
	13	25,219,702.41	807 368.71	101.19717	+179.9	1.0000414
	14	25,213,630.58	813,440.54	101.19800	+198.5	1.0000457
	15	25,207,558.70	819,512.42	101.19867	+217.5	1.0000501
40°	16'	25,201,486.78	825,584.34	101.19933	+236.8	1.0000545
	17	25,195,414.82	831,656.30	101.20017	+256.5	1.0000591
	18	25,189,342.81	837,728.31	101.20100	+276.6	1.0000637
	19	25,183,270.75	843,800.37	101.20167	+297.0	1.0000684
	20	25,177,198.65	849,872.47	101.20250	+317.8	1.0000732

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - South

Table I (Cont'd)

Latitude		R feet	Y' Y value on central meridian feet	Tabular difference for 1 sec. of lat. feet	Scale in units of 7th place of logs.	Scale expressed as a ratio
40°	21'	25,171,126.50	855,944.62	101.20333	+339.0	1.0000781
	22	25,165,054.30	862,016.82	101.20417	+360.5	1.0000830
	23	25,158,982.05	868,089.07	101.20483	+382.4	1.0000880
	24	25,152,909.76	874,161.36	101.20583	+404.7	1.0000932
	25	25,146,837.41	880,233.71	101.20650	+427.4	1.0000984
40°	26'	25,140,765.02	886,306.10	101.20733	+450.4	1.0001037
	27	25,134,692.58	892,378.54	101.20833	+473.8	1.0001091
	28	25,128,620.08	898,451.04	101.20917	+497.6	1.0001146
	29	25,122,547.53	904,523.59	101.20983	+521.7	1.0001201
	30	25,116,474.94	910,596.18	101.21083	+546.2	1.0001258
40°	31'	25,110,402.29	916,668.83	101.21167	+571.1	1.0001315
	32	25,104,329.59	922,741.53	101.21267	+596.3	1.0001373
	33	25,098,256.83	928,814.29	101.21350	+622.0	1.0001432
	34	25,092,184.02	934,887.10	101.21433	+648.0	1.0001492
	35	25,086,111.16	940,959.96	101.21533	+674.4	1.0001553
40°	36'	25,080,038.24	947,032.88	101.21617	+701.1	1.0001614
	37	25,073,965.27	953,105.85	101.21717	+728.2	1.0001677
	38	25,067,892.24	959,178.88	101.21817	+755.7	1.0001740
	39	25,061,819.15	965,251.97	101.21900	+783.6	1.0001804
	40	25,055,746.01	971,325.11		+811.8	1.0001869

$\ell = 0.63451954$

$\log \ell = 9.8024450034 - 10$

$\log K = 7.6121307246$

$$\text{Geod. Az.} - \text{Grid. Az.} = -\frac{x_2 - x_1}{2\rho_0^2 \sin 1''}\left(y_1 - y_0 + \frac{y_2 - y_1}{3}\right) + \theta$$

$y_0 = +504{,}195.32$ feet

$$\log \frac{1}{2\rho_0^2 \sin 1''} = 0.3726089 - 10$$

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - South

1" of Long. = 0"63451954 of θ

Table II.

Long.	θ	Long.	θ	Long.	θ
80° 00'	+1° 35' 10"67589	80° 36'	+1° 12' 20"11368	81° 11'	+0° 50' 07"62264
01	+1 34 32.60472	37	+1 11 42.04251	12	+0 49 29.55147
02	+1 33 54.53355	38	+1 11 03.97133	13	+0 48 51.48029
03	+1 33 16.46238	39	+1 10 25.90016	14	+0 48 13.40912
04	+1 32 38.39120	40	+1 09 47.82899	15	+0 47 35.33795
05	+1 32 00.32003				
80° 06'	+1 31 22.24886	80° 41'	+1 09 09.75782	81° 16'	+0 46 57.26677
07	+1 30 44.17769	42	+1 08 31.68664	17	+0 46 19.19560
08	+1 30 06.10651	43	+1 07 53.61547	18	+0 45 41.12443
09	+1 29 28.03534	44	+1 07 15.54430	19	+0 45 03.05326
10	+1 28 49.96417	45	+1 06 37.47313	20	+0 44 24.98208
80° 11'	+1 28 11.89300	80° 46'	+1 05 59.40195	81° 21'	+0 43 46.91091
12	+1 27 33.82182	47	+1 05 21.33078	22	+0 43 08.83974
13	+1 26 55.75065	48	+1 04 43.25961	23	+0 42 30.76857
14	+1 26 17.67948	49	+1 04 05.18844	24	+0 41 52.69739
15	+1 25 39.60831	50	+1 03 27.11726	25	+0 41 14.62622
80° 16'	+1 25 01.53713	80° 51'	+1 02 49.04609	81° 26'	+0 40 36.55505
17	+1 24 23.46596	52	+1 02 10.97492	27	+0 39 58.48388
18	+1 23 45.39479	53	+1 01 32.90375	28	+0 39 20.41270
19	+1 23 07.32361	54	+1 00 54.83257	29	+0 38 42.34153
20	+1 22 29.25244	55	+1 00 16.76140	30	+0 38 04.27036
80° 21'	+1 21 51.18127	80° 56'	+0 59 38.69023	81° 31'	+0 37 26.19919
22	+1 21 13.11010	57	+0 59 00.61905	32	+0 36 48.12801
23	+1 20 35.03892	58	+0 58 22.54788	33	+0 36 10.05684
24	+1 19 56.96775	59	+0 57 44.47671	34	+0 35 31.98567
25	+1 19 18.89658	81° 00	+0 57 06.40554	35	+0 34 53.91449
80° 26'	+1 18 40.82541	81° 01'	+0 56 28.33436	81° 36'	+0 34 15.84332
27	+1 18 02.75423	02	+0 55 50.26319	37	+0 33 37.77215
28	+1 17 24.68306	03	+0 55 12.19202	38	+0 32 59.70098
29	+1 16 46.61189	04	+0 54 34.12085	39	+0 32 21.62980
30	+1 16 08.54072	05	+0 53 56.04967	40	+0 31 43.55863
80° 31'	+1 15 30.46954	81° 06'	+0 53 17.97850	81° 41'	+0 31 05.48746
32	+1 14 52.39837	07	+0 52 39.90733	42	+0 30 27.41629
33	+1 14 14.32720	08	+0 52 01.83616	43	+0 29 49.34511
34	+1 13 36.25603	09	+0 51 23.76498	44	+0 29 11.27394
35	+1 12 58.18485	10	+0 50 45.69381	45	+0 28 33.20277

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - South

1" of Long. = 0".63451954 of θ

Table II (Cont'd).

Long.	θ	Long.	θ	Long.	θ
81° 46'	+0° 27' 55".13160	82° 21'	+0° 05' 42".64055	82° 56'	−0° 16' 29".85049
47	+0 27 17.06042	22	+0 05 04.56938	57	−0 17 07.92166
48	+0 26 38.98925	23	+0 04 26.49821	58	−0 17 45.99283
49	+0 26 00.91808	24	+0 03 48.42704	59	−0 18 24.06401
50	+0 25 22.84691	25	+0 03 10.35586	83° 00	−0 19 02.13518
81° 51'	+0 24 44.77573	82° 26'	+0 02 32.28469	83° 01'	−0 19 40.20635
52	+0 24 06.70456	27	+0 01 54.21352	02	−0 20 18.27752
53	+0 23 28.63339	28	+0 01 16.14235	03	−0 20 56.34870
54	+0 22 50.56221	29	+0 00 38.07117	04	−0 21 34.41987
55	+0 22 12.49104	30	0 00 00.00000	05	−0 22 12.49104
81° 56'	+0 21 34.41987	82° 31'	−0 00 38.07117	83° 06'	−0 22 50.56221
57	+0 20 56.34870	32	−0 01 16.14235	07	−0 23 28.63339
58	+0 20 18.27752	33	−0 01 54.21352	08	−0 24 06.70456
59	+0 19 40.20635	34	−0 02 32.28469	09	−0 24 44.77573
82° 00	+0 19 02.13518	35	−0 03 10.35586	10	−0 25 22.84691
82° 01'	+0 18 24.06401	82° 36'	−0 03 48.42704	83° 11'	−0 26 00.91808
02	+0 17 45.99283	37	−0 04 26.49821	12	−0 26 38.98925
03	+0 17 07.92166	38	−0 05 04.56938	13	−0 27 17.06042
04	+0 16 29.85049	39	−0 05 42.64055	14	−0 27 55.13160
05	+0 15 51.77932	40	−0 06 20.71173	15	−0 28 33.20277
82° 06'	+0 15 13.70814	82° 41'	−0 06 58.78290	83° 16'	−0 29 11.27394
07	+0 14 35.63697	42	−0 07 36.85407	17	−0 29 49.34511
08	+0 13 57.56580	43	−0 08 14.92524	18	−0 30 27.41629
09	+0 13 19.49463	44	−0 08 52.99642	19	−0 31 05.48746
10	+0 12 41.42345	45	−0 09 31.06759	20	−0 31 43.55863
82° 11'	+0 12 03.35228	82° 46'	−0 10 09.13876	83° 21'	−0 32 21.62980
12	+0 11 25.28111	47	−0 10 47.20993	22	−0 32 59.70098
13	+0 10 47.20993	48	−0 11 25.28111	23	−0 33 37.77215
14	+0 10 09.13876	49	−0 12 03.35228	24	−0 34 15.84332
15	+0 09 31.06759	50	−0 12 41.42345	25	−0 34 53.91449
82° 16'	+0 08 52.99642	82° 51'	−0 13 19.49463	83° 26'	−0 35 31.98567
17	+0 08 14.92524	52	−0 13 57.56580	27	−0 36 10.05684
18	+0 07 36.85407	53	−0 14 35.63697	28	−0 36 48.12801
19	+0 06 58.78290	54	−0 15 13.70814	29	−0 37 26.19919
20	+0 06 20.71173	55	−0 15 51.77932	30	−0 38 04.27036

FIGURE 45.—Lambert projection tables for Ohio—Continued.

Lambert Projection for Ohio - South

1° of Long. = 0.63451954 of θ

Table II (Cont'd).

Long.	θ	Long.	θ	Long.	θ
83° 31'	-0° 38' 42.34153	84° 06'	-1° 00' 54.83257	84° 41'	-1° 23' 07.32361
32	-0 39 20.41270	07	-1 01 32.90375	42	-1 23 45.39479
33	-0 39 58.48388	08	-1 02 10.97492	43	-1 24 23.46596
34	-0 40 36.55505	09	-1 02 49.04609	44	-1 25 01.53713
35	-0 41 14.62622	10	-1 03 27.11726	45	-1 25 39.60831
83° 36'	-0 41 52.69739	84° 11'	-1 04 05.18844	84° 46'	-1 26 17.67948
37	-0 42 30.76857	12	-1 04 43.25961	47	-1 26 55.75065
38	-0 43 08.83974	13	-1 05 21.33078	48	-1 27 33.82182
39	-0 43 46.91091	14	-1 05 59.40195	49	-1 28 11.89300
40	-0 44 24.98208	15	-1 06 37.47313	50	-1 28 49.96417
83° 41'	-0 45 03.05326	84° 16'	-1 07 15.54430	84° 51'	-1 29 28.03534
42	-0 45 41.12443	17	-1 07 53.61547	52	-1 30 06.10651
43	-0 46 19.19560	18	-1 08 31.68664	53	-1 30 44.17769
44	-0 46 57.26677	19	-1 09 09.75782	54	-1 31 22.24886
45	-0 47 35.33795	20	-1 09 47.82899	55	-1 32 00.32003
83° 46'	-0 48 13.40912	84° 21'	-1 10 25.90016	84° 56'	-1 32 38.39120
47	-0 48 51.48029	22	-1 11 03.97133	57	-1 33 16.46238
48	-0 49 29.55147	23	-1 11 42.04251	58	-1 33 54.53355
49	-0 50 07.62264	24	-1 12 20.11368	59	-1 34 32.60472
50	-0 50 45.69381	25	-1 12 58.18485	85° 00	-1 35 10.67589
83° 51'	-0 51 23.76498	84° 26'	-1 13 36.25603	85° 01'	-1 35 48.74707
52	-0 52 01.83616	27	-1 14 14.32720	02	-1 36 26.81824
53	-0 52 39.90733	28	-1 14 52.39837	03	-1 37 04.88941
54	-0 53 17.97850	29	-1 15 30.46954	04	-1 37 42.96059
55	-0 53 56.04967	30	-1 16 08.54072	05	-1 38 21.03176
83° 56'	-0 54 34.12085	84° 31'	-1 16 46.61189	85° 06'	-1 38 59.10293
57	-0 55 12.19202	32	-1 17 24.68306	07	-1 39 37.17410
58	-0 55 50.26319	33	-1 18 02.75423	08	-1 40 15.24528
59	-0 56 28.33436	34	-1 18 40.82541	09	-1 40 53.31645
84° 00	-0 57 06.40554	35	-1 19 18.89658	10	-1 41 31.38762
84° 01'	-0 57 44.47671	84° 36'	-1 19 56.96775	85° 11'	-1 42 09.45879
02	-0 58 22.54788	37	-1 20 35.03892	12	-1 42 47.52997
03	-0 59 00.61905	38	-1 21 13.11010	13	-1 43 25.60114
04	-0 59 38.69023	39	-1 21 51.18127	14	-1 44 03.67231
05	-1 00 16.76140	40	-1 22 29.25244	15	-1 44 41.74348
				85° 16'	-1° 45' 19.81466
				17	-1 45 57.88583
				18	-1 46 35.95700
				19	-1 47 14.02817
				20	-1 47 52.09935

FIGURE 45.—Lambert projection tables for Ohio—Continued.

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table I.

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. of lat.
37° 30'	0.00	101.14167			
31	6,068.50	101.14200	38° 06'	218,477.05	101.15217
32	12,137.02	101.14233	07	224,546.18	101.15250
33	18,205.56	101.14267	08	230,615.33	101.15267
34	24,274.12	101.14283	09	236,684.49	101.15300
35	30,342.69	101.14317	10	242,753.67	101.15333
37° 36'	36,411.28	101.14333	38° 11'	248,822.87	101.15367
37	42,479.88	101.14383	12	254,892.09	101.15383
38	48,548.51	101.14400	13	260,961.32	101.15417
39	54,617.15	101.14433	14	267,030.57	101.15450
40	60,685.81	101.14467	15	273,099.84	101.15483
37° 41'	66,754.49	101.14483	38° 16'	279,169.13	101.15500
42	72,823.18	101.14517	17	285,238.43	101.15533
43	78,891.89	101.14550	18	291,307.75	101.15567
44	84,960.62	101.14567	19	297,377.09	101.15600
45	91,029.36	101.14617	20	303,446.45	101.15617
37° 46'	97,098.13	101.14633	38° 21'	309,515.82	101.15650
47	103,166.91	101.14667	22	315,585.21	101.15683
48	109,235.71	101.14683	23	321,654.62	101.15717
49	115,304.52	101.14717	24	327,724.05	101.15733
50	121,373.35	101.14750	25	333,793.49	101.15767
37° 51'	127,442.20	101.14783	38° 26'	339,862.95	101.15800
52	133,511.07	101.14817	27	345,932.43	101.15833
53	139,579.96	101.14833	28	352,001.93	101.15850
54	145,648.86	101.14867	29	358,071.44	101.15883
55	151,717.78	101.14900	30	364,140.97	101.15917
37° 56'	157,786.72	101.14917	38° 31'	370,210.52	101.15950
57	163,855.67	101.14950	32	376,280.09	101.15967
58	169,924.64	101.14983	33	382,349.67	101.16000
59	175,993.63	101.15017	34	388,419.27	101.16033
38° 00	182,062.64	101.15050	35	394,488.89	101.16067
38° 01'	188,131.67	101.15067	38° 36'	400,558.53	101.16083
02	194,200.71	101.15100	37	406,628.18	101.16117
03	200,269.77	101.15117	38	412,697.85	101.16150
04	206,338.84	101.15167	39	418,767.54	101.16183
05	212,407.94	101.15183	40	424,837.25	101.16217

FIGURE 46.—Transverse Mercator projection tables for Indiana.

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table I (Cont'd).

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. lat.
38° 41'	430,906.98	101.16233	39° 16'	643,358.38	101.17267
42	436,976.72	101.16267	17	649,428.74	101.17300
43	443,046.48	101.16283	18	655,499.12	101.17317
44	449,116.25	101.16333	19	661,569.51	101.17350
45	455,186.05	101.16350	20	667,639.92	101.17367
38° 46'	461,255.86	101.16383	39° 21'	673,710.34	101.17417
47	467,325.69	101.16417	22	679,780.79	101.17433
48	473,395.54	101.16433	23	685,851.25	101.17467
49	479,465.40	101.16467	24	691,921.73	101.17500
50	485,535.28	101.16500	25	697,992.23	101.17533
38° 51'	491,605.18	101.16533	39° 26'	704,062.75	101.17550
52	497,675.10	101.16550	27	710,133.28	101.17583
53	503,745.03	101.16583	28	716,203.83	101.17617
54	509,814.98	101.16617	29	722,274.40	101.17650
55	515,884.95	101.16650	30	728,344.99	101.17667
38° 56'	521,954.94	101.16683	39° 31'	734,415.59	101.17700
57	528,024.95	101.16700	32	740,486.21	101.17733
58	534,094.97	101.16733	33	746,556.85	101.17767
59	540,165.01	101.16767	34	752,627.51	101.17783
39° 00	546,235.07	101.16783	35	758,698.18	101.17817
39° 01'	552,305.14	101.16833	39° 36'	764,768.87	101.17850
02	558,375.24	101.16850	37	770,839.58	101.17883
03	564,445.35	101.16867	38	776,910.31	101.17917
04	570,515.47	101.16917	39	782,981.06	101.17933
05	576,585.62	101.16933	40	789,051.82	101.17967
39° 06'	582,655.78	101.16967	39° 41'	795,122.60	101.18000
07	588,725.96	101.17000	42	801,193.40	101.18017
08	594,796.16	101.17033	43	807,264.21	101.18067
09	600,866.38	101.17050	44	813,335.05	101.18083
10	606,936.61	101.17083	45	819,405.90	101.18117
39° 11'	613,006.86	101.17117	39° 46'	825,476.77	101.18133
12	619,077.13	101.17150	47	831,547.65	101.18183
13	625,147.42	101.17167	48	837,618.56	101.18200
14	631,217.72	101.17200	49	843,689.48	101.18233
15	637,288.04	101.17233	50	849,760.42	101.18267

FIGURE 46.—Transverse Mercator projection tables for Indiana—Continued.

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table I (Cont'd).

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. of lat.
39° 51'	855,831.38	101.18283	40° 26'	1,068,326.04	101.19317
52	861,902.35	101.18317	27	1,074,397.63	101.19350
53	867,973.34	101.18350	28	1,080,469.24	101.19383
54	874,044.35	101.18383	29	1,086,540.87	101.19417
55	880,115.38	101.18417	30	1,092,612.52	101.19450
39° 56'	886,186.43	101.18433	40° 31'	1,098,684.19	101.19467
57	892,257.49	101.18467	32	1,104,755.87	101.19500
58	898,328.57	101.18500	33	1,110,827.57	101.19533
59	904,399.67	101.18533	34	1,116,899.29	101.19567
40° 00	910,470.79	101.18550	35	1,122,971.03	101.19600
40° 01'	916,541.92	101.18583	40° 36'	1,129,042.79	101.19617
02	922,613.07	101.18617	37	1,135,114.56	101.19650
03	928,684.24	101.18650	38	1,141,186.35	101.19683
04	934,755.43	101.18667	39	1,147,258.16	101.19700
05	940,826.63	101.18717	40	1,153,329.98	101.19750
40° 06'	946,897.86	101.18733	40° 41'	1,159,401.83	101.19767
07	952,969.10	101.18750	42	1,165,473.69	101.19800
08	959,040.35	101.18800	43	1,171,545.57	101.19833
09	965,111.63	101.18817	44	1,177,617.47	101.19850
10	971,182.92	101.18850	45	1,183,689.38	101.19883
40° 11'	977,254.23	101.18883	40° 46'	1,189,761.31	101.19917
12	983,325.56	101.18917	47	1,195,833.26	101.19950
13	989,396.91	101.18950	48	1,201,905.23	101.19983
14	995,468.28	101.18967	49	1,207,977.22	101.20000
15	1,001,539.66	101.19000	50	1,214,049.22	101.20050
40° 16'	1,007,611.06	101.19033	40° 51'	1,220,121.25	101.20067
17	1,013,682.48	101.19050	52	1,226,193.29	101.20083
18	1,019,753.91	101.19083	53	1,232,265.34	101.20133
19	1,025,825.36	101.19117	54	1,238,337.42	101.20150
20	1,031,896.83	101.19150	55	1,244,409.51	101.20183
40° 21'	1,037,968.32	101.19183	40° 56'	1,250,481.62	101.20217
22	1,044,039.83	101.19217	57	1,256,553.75	101.20250
23	1,050,111.36	101.19233	58	1,262,625.90	101.20267
24	1,056,182.90	101.19267	59	1,268,698.06	101.20300
25	1,062,254.46	101.19300	41° 00	1,274,770.24	101.20333

FIGURE 46.—Transverse Mercator projection tables for Indiana—Continued.

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table I (Cont'd).

Lat.	y (feet)	Tabular difference for 1 sec. of lat.	Lat.	y (feet)	Tabular difference for 1 sec. of lat.
41° 01'	1,280,842.44	101.20367	41° 36'	1,493,380.67	101.21400
02	1,286,914.66	101.20400	37	1,499,453.51	101.21433
03	1,292,986.90	101.20417	38	1,505,526.37	101.21467
04	1,299,059.15	101.20450	39	1,511,599.25	101.21500
05	1,305,131.42	101.20483	40	1,517,672.15	101.21517
41° 06'	1,311,203.71	101.20517	41° 41'	1,523,745.06	101.21550
07	1,317,276.02	101.20533	42	1,529,817.99	101.21583
08	1,323,348.34	101.20567	43	1,535,890.94	101.21617
09	1,329,420.68	101.20600	44	1,541,963.91	101.21633
10	1,335,493.04	101.20633	45	1,548,036.89	101.21683
41° 11'	1,341,565.42	101.20667	41° 46'	1,554,109.90	101.21700
12	1,347,637.82	101.20683	47	1,560,182.92	101.21733
13	1,353,710.23	101.20717	48	1,566,255.96	101.21750
14	1,359,782.66	101.20750	49	1,572,329.01	101.21800
15	1,365,855.11	101.20783	50	1,578,402.09	101.21817
41° 16'	1,371,927.58	101.20817	41° 51'	1,584,475.18	101.21850
17	1,378,000.07	101.20833	52	1,590,548.29	101.21883
18	1,384,072.57	101.20867	53	1,596,621.42	101.21900
19	1,390,145.09	101.20900	54	1,602,694.56	101.21950
20	1,396,217.63	101.20917	55	1,608,767.73	101.21967
41° 21'	1,402,290.18	101.20967	41° 56'	1,614,840.91	101.22000
22	1,408,362.76	101.20983	57	1,620,914.11	101.22033
23	1,414,435.35	101.21017	58	1,626,987.33	101.22050
24	1,420,507.96	101.21050	59	1,633,060.56	101.22100
25	1,426,580.59	101.21067	42° 00	1,639,133.82	
41° 26'	1,432,653.23	101.21117			
27	1,438,725.90	101.21133			
28	1,444,798.58	101.21167			
29	1,450,871.28	101.21200			
30	1,456,944.00	101.21217			
41° 31'	1,463,016.73	101.21250			
32	1,469,089.48	101.21283			
33	1,475,162.25	101.21317			
34	1,481,235.04	101.21350			
35	1,487,307.85	101.21367			

λ(Central Meridian [East]) = 85° 40' 00".000

λ(Central Meridian [West]) = 87° 05' 00".000

$\log R = -144.8$

$\log (1/6\rho_0^2)_g = 4.5810462 - 20$

$\log (1/6\rho_0^2 \sin 1'')_g = 9.8954713 - 20$

Geod. Az. − Grid Az. =

$$+\Delta\alpha + \frac{(y_2 - y_1)(2x_1' + x_2')}{(6\rho_0^2 \sin 1'')_g}$$

FIGURE 46.—Transverse Mercator projection tables for Indiana—Continued

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table II.

Lat.	Colog A	Log C	Lat.	Colog A	Log C
37° 30'	1.49081881	1.289744			
31	81923	1.290004	38° 06'	1.49083376	1.299076
32	81964	0265	07	83418	9334
33	82005	0524	08	83460	9592
34	82047	0784	09	83501	1.299851
35	82088	1044	10	83543	1.300109
37° 36'	1.49082130	1.291303	38° 11'	1.49083585	1.300367
37	82171	1563	12	83626	0626
38	82213	1823	13	83668	0884
39	82254	2082	14	83710	1143
40	82296	2342	15	83752	1401
37° 41'	1.49082337	1.292601	38° 16'	1.49083793	1.301658
42	82379	2860	17	83835	1917
43	82420	3121	18	83877	2175
44	82462	3380	19	83918	2433
45	82503	3639	20	83960	2691
37° 46'	1.49082545	1.293898	38° 21'	1.49084002	1.302949
47	82586	4157	22	84043	3207
48	82628	4416	23	84085	3465
49	82669	4676	24	84127	3723
50	82711	4935	25	84168	3980
37° 51'	1.49082752	1.295195	38° 26'	1.49084210	1.304239
52	82794	5453	27	84252	4496
53	82835	5712	28	84294	4753
54	82877	5972	29	84335	5012
55	82918	6230	30	84377	5269
37° 56'	1.49082960	1.296489	38° 31'	1.49084419	1.305526
57	83001	6748	32	84461	5785
58	83043	7007	33	84502	6042
59	83085	7265	34	84544	6299
38° 00	83126	7525	35	84586	6557
38° 01'	1.49083168	1.297783	38° 36'	1.49084628	1.306814
02	83209	8042	37	84670	7072
03	83251	8300	38	84711	7330
04	83293	8558	39	84753	7587
05	83334	8817	40	84795	7844

FIGURE 46.—Transverse Mercator projection tables for Indiana—Continued.

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table II (Cont'd).

Lat.	Colog A	Log C	Lat.	Colog A	Log C
38° 41'	1.49084837	1.308102	39° 16'	1.49086304	1.317085
42	84879	8358	17	86346	7342
43	84920	8615	18	86388	7598
44	84962	8873	19	86430	7853
45	85004	9130	20	86472	8110
38° 46'	1.49085046	1.309387	39° 21'	1.49086514	1.318366
47	85088	9644	22	86556	8621
48	85129	1.309901	23	86598	8878
49	85171	1.310158	24	86640	9134
50	85213	0415	25	86682	9389
38° 51'	1.49085255	1.310672	39° 26'	1.49086724	1.319645
52	85297	0929	27	86766	1.319901
53	85339	1186	28	86808	1.320157
54	85381	1443	29	86850	0413
55	85423	1699	30	86892	0668
38° 56'	1.49085464	1.311957	39° 31'	1.49086935	1.320924
57	85506	2213	32	86977	1179
58	85548	2469	33	87019	1434
59	85590	2727	34	87061	1690
39° 00	85632	2983	35	87103	1946
39° 01'	1.49085674	1.313240	39° 36'	1.49087145	1.322201
02	85716	3497	37	87187	2457
03	85758	3753	38	87229	2713
04	85800	4009	39	87271	2968
05	85842	4266	40	87314	3223
39° 06'	1.49085884	1.314522	39° 41'	1.49087356	1.323478
07	85926	4779	42	87398	3734
08	85968	5036	43	87440	3989
09	86010	5292	44	87482	4245
10	86052	5548	45	87524	4500
39° 11'	1.49086094	1.315805	39° 46'	1.49087566	1.324755
12	86136	6061	47	87609	5011
13	86178	6316	48	87651	5266
14	86220	6573	49	87693	5521
15	86262	6829	50	87735	5777

FIGURE 46.—Transverse Mercator projection tables for Indiana—Continued.

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table II (Cont'd).

Lat.	Colog A	Log C	Lat.	Colog A	Log C
39° 51'	1.49087777	1.326031	40° 26'	1.49089256	1.334945
52	87819	6286	27	89299	5198
53	87862	6542	28	89341	5453
54	87904	6797	29	89383	5707
55	87946	7051	30	89426	5961
39° 56'	1.49087988	1.327307	40° 31'	1.49089468	1.336216
57	88030	7562	32	89510	6470
58	88073	7816	33	89553	6723
59	88115	8071	34	89595	6978
40° 00	88157	8327	35	89638	7232
40° 01'	1.49088199	1.328581	40° 36'	1.49089680	1.337485
02	88242	8836	37	89722	7740
03	88284	9091	38	89765	7994
04	88326	9346	39	89807	8247
05	88368	9600	40	89849	8502
40° 06'	1.49088411	1.329855	40° 41'	1.49089892	1.338755
07	88453	1.330110	42	89934	9009
08	88495	0364	43	89977	9263
09	88537	0620	44	90019	9517
10	88580	0874	45	90061	1.339770
40° 11'	1.49088622	1.331128	40° 46'	1.49090104	1.340024
12	88664	1383	47	90146	0278
13	88706	1638	48	90189	0531
14	88749	1892	49	90231	0784
15	88791	2147	50	90273	1038
40° 16'	1.49088833	1.332401	40° 51'	1.49090316	1.341292
17	88876	2655	52	90358	1545
18	88918	2910	53	90401	1799
19	88960	3165	54	90443	2053
20	89002	3419	55	90486	2306
40° 21'	1.49089045	1.333674	40° 56'	1.49090528	1.342560
22	89087	3928	57	90571	2814
23	89129	4182	58	90613	3067
24	89172	4437	59	90655	3321
25	89214	4691	41° 00	90698	3574

FIGURE 46.—Transverse Mercator projection tables for Indiana—Continued.

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table II (Cont'd).

Lat.	Colog A	Log C	Lat.	Colog A	Log C
41° 01'	1.49090740	1.343827	41° 36'	1.49092229	1.352686
02	90783	4080	37	92271	2938
03	90825	4334	38	92314	3191
04	90868	4588	39	92357	3445
05	90910	4841	40	92399	3698
41° 06'	1.49090953	1.345095	41° 41'	1.49092442	1.353952
07	90995	5348	42	92484	4204
08	91038	5601	43	92527	4456
09	91080	5854	44	92569	4709
10	91123	6108	45	92612	4962
41° 11'	1.49091165	1.346360	41° 46'	1.49092655	1.355214
12	91208	6614	47	92697	5466
13	91250	6867	48	92740	5719
14	91293	7120	49	92782	5972
15	91335	7374	50	92825	6224
41° 16'	1.49091378	1.347627	41° 51'	1.49092868	1.356475
17	91420	7880	52	92910	6727
18	91463	8132	53	92953	6980
19	91505	8386	54	92996	7233
20	91548	8639	55	93038	7485
41° 21'	1.49091590	1.348892	41° 56'	1.49093081	1.357737
22	91633	9145	57	93124	7990
23	91675	9398	58	93166	8242
24	91718	9651	59	93209	8494
25	91761	1.349904	42° 00	93252	8746
41° 26'	1.49091803	1.350157			
27	91846	0410			
28	91888	0663			
29	91931	0916			
30	91973	1168			
41° 31'	1.49092016	1.351423			
32	92058	1675			
33	92101	1927			
34	92144	2179			
35	92186	2433			

FIGURE 46.—Transverse Mercator projection tables for Indiana—Continued.

TRANSVERSE MERCATOR PROJECTION FOR INDIANA (EAST & WEST)

Table III.

x' (feet)	Scale in units of 7th place of logs	Scale expressed as a ratio	x' (feet)	Scale in units of 7th place of logs	Scale expressed as a ratio
0	-144.8	0.9999667	175,000	+ 7.3	1.0000017
5,000	-144.7	0.9999667	180,000	+ 16.1	1.0000037
10,000	-144.3	0.9999668	185,000	+ 25.1	1.0000058
15,000	-143.7	0.9999669	190,000	+ 34.4	1.0000079
20,000	-142.8	0.9999671	195,000	+ 44.0	1.0000101
25,000	-141.7	0.9999674	200,000	+ 53.8	1.0000124
30,000	-140.3	0.9999677	205,000	+ 63.9	1.0000147
35,000	-138.7	0.9999681	210,000	+ 74.2	1.0000171
40,000	-136.9	0.9999685	215,000	+ 84.7	1.0000195
45,000	-134.8	0.9999690	220,000	+ 95.5	1.0000220
50,000	-132.4	0.9999695	225,000	+106.6	1.0000245
55,000	-129.8	0.9999701	230,000	+117.9	1.0000271
60,000	-126.9	0.9999708	235,000	+129.4	1.0000298
65,000	-123.8	0.9999715	240,000	+141.2	1.0000325
70,000	-120.5	0.9999723	245,000	+153.2	1.0000353
75,000	-116.9	0.9999731	250,000	+165.5	1.0000381
80,000	-113.0	0.9999740	255,000	+178.0	1.0000410
85,000	-108.9	0.9999749	260,000	+190.8	1.0000439
90,000	-104.6	0.9999759	265,000	+203.9	1.0000469
95,000	-100.0	0.9999770	270,000	+217.2	1.0000500
100,000	- 95.2	0.9999781	275,000	+230.7	1.0000531
105,000	- 90.1	0.9999793	280,000	+244.5	1.0000563
110,000	- 84.7	0.9999805	285,000	+258.5	1.0000595
115,000	- 79.1	0.9999818	290,000	+272.8	1.0000628
120,000	- 73.3	0.9999831	295,000	+287.3	1.0000662
125,000	- 67.2	0.9999845	300,000	+302.1	1.0000696
130,000	- 60.9	0.9999860	305,000	+317.1	1.0000730
135,000	- 54.3	0.9999875	310,000	+332.3	1.0000765
140,000	- 47.5	0.9999891	315,000	+347.8	1.0000801
145,000	- 40.4	0.9999907	320,000	+363.6	1.0000837
150,000	- 33.1	0.9999924	325,000	+379.6	1.0000874
155,000	- 25.5	0.9999941	330,000	+395.9	1.0000912
160,000	- 17.7	0.9999959	335,000	+412.4	1.0000950
165,000	- 9.6	0.9999978	340,000	+429.2	1.0000988
170,000	- 1.3	0.9999997	345,000	+446.2	1.0001027
			350,000	+463.4	1.0001067

FIGURE 46.—Transverse Mercator projection tables for Indiana—Continued.

ADJUSTMENT ON THE LAMBERT GRID OF OHIO, SOUTH

The following computations are based on the Lambert grid system for the southern half of Ohio.

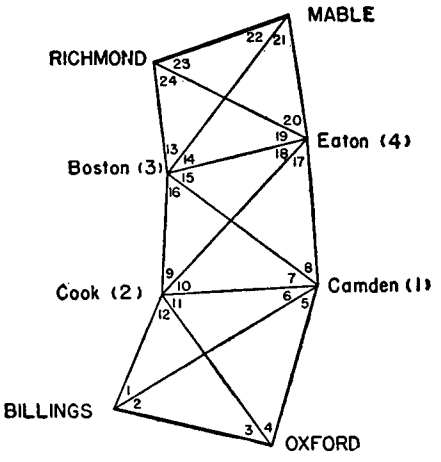

FIGURE 47.—Arc of first-order triangulation.

Plane coordinates on Lambert projection

State Ohio (south) Station Oxford

ϕ = 39°31'47."931 λ = 84°46'29."612

Tabular difference of R for 1" of ϕ = 101.17433

R (for min. of ϕ)		25,474,686.51	y' (for min. of ϕ)		552,384.61
Cor. for sec. of ϕ		− 4,849.39	Cor. for sec. of ϕ		+ 4,849.39
R		25,469,837.12	y'		557,234.00
			y'' (=2R sin² $\frac{\theta}{2}$)		+ 8,082.39
θ (for min. of λ)		− 1°26'17."67948	y		565,316.39
Cor. for sec. of λ		− 18.78939			
θ		− 86 36.46887	$\frac{\theta}{2}$		°43'18."23
θ''	For machine computation	− 5196."46887		For machine computation	
			log θ''		3.71570833 n
log θ''		3.71570833 n	colog 2		9.69897000-10
S for θ		4.68552893-10	S for $\frac{\theta}{2}$		4.68556338-10
log sin θ	sin θ	8.40123726-10 n	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	8.10024171-10 n
log R		7.40602616		R sin $\frac{\theta}{2}$	
log x'		5.80726342 n	log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	6.20048342-10
x'	R sin θ	− 641,598.61	log R		7.40602616
		2,000,000.00	log 2		0.30103000
x		1,358,401.39	log y''		3.90753958

$x = 2{,}000{,}000.00 + R \sin \theta$

$y = y'' + 2R \sin^2 \frac{\theta}{2}$

y' = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y', and θ are given in special tables

FIGURE 48.—Computation of coordinates, Ohio.

Plane coordinates on Lambert projection

State Ohio (south) Station Billings

ϕ = 39° 33′ 18″.743 λ = 84° 54′ 38″.240

Tabular difference of R for 1″ of ϕ = 101.17500

R (for min. of ϕ)		25,462,545.58	y' (for min. of ϕ)			564,525.54
Cor. for sec. of ϕ		− 1,896.32	Cor. for sec. of ϕ			+ 1,896.32
R		25,460,649.26	y'			566,421.86
			y'' (=2R $\sin^2 \frac{\theta}{2}$)			+ 9,072.29
θ (for min. of λ)		− 1°31′22.″24886	y			575,494.15
Cor. for sec. of λ		− 24.26403				
θ		− 91 46.51289	$\frac{\theta}{2}$			° 45 53.26
θ''	For machine computation	− 5506.″51289		For machine computation		
			log θ''			3.74087666 n
log θ''		3.74087666 n	colog 2			9.69897000 -10
S for θ		4.68552328 -10	S for $\frac{\theta}{2}$			4.68556197 -10
log sin θ	sin θ	8.42639994 -10 n	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$		8.12540863 -10 n
log R		7.40586948		R sin $\frac{\theta}{2}$		
log x'		5.83226942 n	log $\sin^2 \frac{\theta}{2}$	R $\sin^2 \frac{\theta}{2}$		6.25081726 -10
x'	R sin θ	− 679,625.12	log R			7.40586948
		2,000,000.00	log 2			0.30103000
x		1,320,374.88	log y''			3.95771674

x = 2,000,000.00 + R sin θ

y = y' + 2R $\sin^2 \frac{\theta}{2}$

y' = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y', and θ are given in special tables

FIGURE 48.—Computation of coordinates, Ohio—Continued.

Plane coordinates on Lambert projection

State Ohio (south) Station Mable

ϕ = 39 49 09.341 λ = 84° 44' 45".362

Tabular difference of R for 1" of ϕ = 101.18217

R (for min. of ϕ)		25,365,414.53	y' (for min. of ϕ)		661,656.59
Cor. for sec. of ϕ		− 945.14	Cor. for sec. of ϕ		+ 945.14
R		25,364,469.39	y'		662,601.73
			y'' (=2R sin² $\frac{\theta}{2}$)		+ 7,845.35
θ (for min. of λ)		− 1° 25' 01".53713	y		670,447.08
Cor. for sec. of λ		− 28.78308			
θ		− 85 30.32021	$\frac{\theta}{2}$		° 42' 45".16
θ''	For machine computation	− 5130".32021		For machine computation	
			log θ''		3.71014447 n
log θ''		3.71014447 n	colog 2		9.69897000 -10
S for θ		4.68553009-10	S for $\frac{\theta}{2}$		4.68556367 -10
log sin θ	sin θ	8.39567456-10 n	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	8.09467814 -10 n
log R		7.40422578		R sin $\frac{\theta}{2}$	
log x'		5.79990034 n	log sin² $\frac{\theta}{2}$	R sin² $\frac{\theta}{2}$	6.18935628 -10
x'	R sin θ	− 630,812.57	log R		7.40422578
		2,000,000.00	log 2		0.30103000
x		1,369,187.43	log y''		3.89461206

x = 2,000,000.00 + R sin θ

y = y' + 2R sin² $\frac{\theta}{2}$

y' = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine

(see log tables)

R, y', and θ are given in special tables

FIGURE 48.—Computation of coordinates, Ohio—Continued.

Plane coordinates on Lambert projection

State Ohio (south) Station Richmond

ϕ = 39°47′06.″065 λ = 84°52′07.″947

Tabular difference of R for 1″ of ϕ = 101.18117

R (for min. of ϕ)		25,377,556.30	y′ (for min. of ϕ)		649,514.82
Cor. for sec. of ϕ		− 613.66	Cor. for sec. of ϕ		+ 613.66
R		25,376,942.64	y′		650,128.48
			y″ (=2R $\sin^2 \frac{\theta}{2}$)		+ 8,731.99
θ (for min. of λ)		-1°30′06.″10651	y		658,860.47
Cor. for sec. of λ		− 05.04253			
θ		− 1 30 11.14904	$\frac{\theta}{2}$		0°45′05.″57
θ''	For machine computation	− 5411.″14904		For machine computation	
			log θ''		3.73328950 n
log θ''		3.73328950 n	colog 2		9.69897000 -10
S for θ		4.68552505-10	S for $\frac{\theta}{2}$		4.68556241 -10
log sin θ	sin θ	8.41881455-10 n	log sin $\frac{\theta}{2}$	sin $\frac{\theta}{2}$	8.11782191 -10 n
log R		7.40443930		R sin $\frac{\theta}{2}$	
log x′		5.82325385 n	log $\sin^2 \frac{\theta}{2}$	R $\sin^2 \frac{\theta}{2}$	6.23564382 -10
x′	R sin θ	− 665,662.13	log R		7.40443930
		2,000,000.00	log 2		0.30103000
x		1,334,337.87	log y″		3.94111312

x = 2,000,000.00 + R sin θ

y = y′ + 2R $\sin^2 \frac{\theta}{2}$

y′ = the value of y on the central meridian for the latitude of the station

S = log of ratio for reducing arc expressed in seconds to sine (see log tables)

R, y′, and θ are given in special tables

FIGURE 48.—Computation of coordinates, Ohio—Continued.

Computation of grid azimuth and geodetic length

BILLINGS-OXFORD

x	y
1,358,401.39	565,316.39
1,320,374.88	575,494.15
$\Delta x = +38,026.51$	$\Delta y = -10,177.76$
$\log \Delta x = 4.58008646$	$\log \Delta x = 4.5800865$
$\log \Delta y = 4.00765221$	$\log \sin \alpha = 9.9849764$
	log grid length in feet = 4.5951101
$\log \tan \alpha = 0.57243425$	log conv. factor = 0.5159842
	log grid length in meters = 4.0791259
	Scale factor = +256
$\alpha = 284°59'02.24''$	log geodetic length in meters = 4.0791515

Computation of azimuths

Line	Azimuth and angle
	° ′ ″
Billings-Oxford	284 59 02.24
	−41 16 59.02
Billings-Camden	243 42 03.22
Camden-Billings	63 42 03.22
	+28 00 08.04
Camden-Cook	91 42 11.26
	+38 39 58.82
Camden-Boston	130 22 10.08
Boston-Camden	310 22 10.08
	−57 05 28.83
Boston-Eaton	253 16 41.25

Computation of coordinates

BILLINGS–CAMDEN

9. 9525470 4. 7745494	9. 6464598 4. 7745494	1, 320, 374. 88 +53, 345. 33	575, 494. 15 +26, 363. 87
4. 7270964	4. 4210092	1, 373, 720. 21	601, 858. 02
CAMDEN–COOK			
9. 9998081*n* 4. 6041193	8. 4730606 4. 6041193	1, 373, 720. 21 −40, 172. 36	601, 858. 02 +1, 194. 48
4. 6039274*n*	3. 0771799	1, 333, 547. 85	603, 052. 50
CAMDEN–BOSTON			
9. 8818887*n* 4. 6659692	9. 8113833 4. 6659692	1, 373, 720. 21 −35, 306. 76	601, 858. 02 +30, 015. 98
4. 5478579*n*	4. 4773525	1, 338, 413. 45	631, 874. 00
BOSTON–EATON			
9. 9812352 4. 5726854	9. 4589794 4. 5726854	1, 338, 413. 45 +35, 803. 10	631, 874. 00 +10, 756. 35
4. 5539206	4. 0316648	1, 374, 216. 55	642, 630. 35

Fixed coordinates

Station	Coordinates	Station	Coordinates
	Feet		*Feet*
Billings	1, 320, 374. 88 575, 494. 15	Mable	1, 369, 187. 43 670, 447. 08
Oxford	1, 358, 401. 39 565, 316. 39	Richmond	1, 334, 337. 87 658, 860. 47

Adjusted coordinates

Station	Assumed coordinates	Correction	Adjusted coordinates
	Feet	*Feet*	*Feet*
1: Camden	1, 373, 720. 21 601, 858. 02	+0. 28 −0. 28	1, 373, 720. 49 601, 857. 74
2. Cook	1, 333, 547. 85 603, 052. 50	+0. 19 +0. 14	1, 333, 548. 04 603, 052. 64
3. Boston	1, 338, 413. 45 631, 874. 00	+0. 42 +0. 11	1, 338, 413. 87 631, 874. 11
4. Eaton	1, 374, 216. 55 642, 630. 35	+0. 84 −0. 16	1, 374, 217. 39 642, 630. 19

Computation of Azimuths

Billings-Cook

1,333,547.85	603,052.50
1,320,374.88	575,494.15
+ 13,172.97	+ 27,558.35

4.11968370
4.44025321
9.67943049 -10

205° 32' 52".56

Billings-Camden

1,373,720.21	601,858.02
1,320,374.88	575,494.15
+ 53,345.33	+ 26,363.87

4.72709641
4.42100916
0.30608725

243° 42' 03".22

Billings-Oxford

284° 59' 02".24

Oxford-Billings

104° 59' 02".24

Oxford-Cook

1,333,547.85	603,052.50
1,358,401.39	565,316.39
-24,853.54	+ 37,736.11

4.39538825 n
4.57675713
9.81863112 -10_n

4.57676
9.92177 -10
4.65499

146° 37' 49".9

Oxford-Camden

1,373,720.21	601,858.02
1,358,401.39	565,316.39
+ 15,318.82	+ 36,541.63

4.18522532
4.56278791
9.62243741 -10

202° 44' 39".08

Camden-Oxford

22° 44' 39".08

Camden-Billings

63° 42' 03".22

Camden-Cook

1,333,547.85	603,052.50
1,373,720.21	601,858.02
-40,172.36	+ 1,194.48

4.60392734 n
3.07717888
1.52674846 n

91° 42' 11".25

Camden-Boston

1,338,413.45	631,874.00
1,373,720.21	601,858.02
-35,306.76	+ 30,015.98

4.54785787 n
4.47735253
0.07050534 n

130° 22' 10".08

FIGURE 49.—Computation of azimuths.

Camden-Eaton

1,374,216.55	642,630.35
1,373,720.21	601,858.02
+ 496.34	+ 40,772.33

2.69577928
4.61036553
8.08541375 -10

180° 41' 50".83

Cook-Boston

1,338,413.45	631,874.00
1,333,547.85	603,052.50
+ 4,865.60	+ 28,821.50

3.68713640
4.45971658
9.22741982 -10

189° 34' 56".04

Cook-Eaton

1,374,216.55	642,630.35
1,333,547.85	603,052.50
+ 40,668.70	+ 39,577.85

4.60926029
4.59745219
0.01180810

225° 46' 43".74

Cook-Camden

271° 42' 11".25

Cook-Oxford

326° 37' 49".91

Cook-Billings

25° 32' 52".56

Boston-Richmond

1,334,337.87	658,860.47
1,338,413.45	631,874.00
-4,075.58	+ 26,986.47

3.61018942	4.43114608	
4.43114608	9.99510294	-10
9.17904334 -10	4.43604314	

171° 24' 42".89

Boston-Mable

1,369,187.43	670,447.08
1,338,413.45	631,874.00
+ 30,773.98	+ 38,573.08

4.48818367	4.58628	
4.58628432	9.89303	-10
9.90189935 -10	4.69325	

218° 34' 59".55

FIGURE 49.—Computation of azimuths—Continued.

Boston-Eaton

4,216.55	642,630.35
38,413.45	631,874.00
35,803.10	+ 10,756.35

55392063
.03166493
0.52225570

253° 16' 41."23

Boston-Camden

310° 22' 10."08

Boston-Cook

9° 34' 56."04

Eaton-Camden

0° 41' 50."83

Eaton-Cook

45° 46' 43."74

Eaton-Boston

73° 16' 41."23

Eaton-Richmond

1,334,337.87	658,860.47
1,374,216.55	642,630.35
-39,878.68	+ 16,230.12

4.60074078
4.21032173
0.39041905

112° 08' 44."53

Eaton-Mable

1,369,187.43	670,447.08
1,374,216.55	642,630.35
-5,029.12	+ 27,816.73

3.70149200 n
4.44430608
9.25718592 -10_n

4.44431
9.99300 -10
4.45131

169° 45' 06."92

Richmond-Mable

1,369,187.43	670,447.08
1,334,337.87	658,860.47
+ 34,849.56	+ 11,586.61

4.54219730	4.54220
4.06395638	9.97725 -10
0.47824092	4.56495

251° 36' 33."55

Richmond-Eaton

292° 08' 44."53

Richmond-Boston

351° 24' 42."89

Mable-Eaton

349° 45' 06."92

Mable-Boston

38° 34' 59."55

Mable-Richmond

71° 36' 33."55

FIGURE 49.—Computation of azimuths—Continued.

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
FORM 25
Ed. Jan., 1929

COMPUTATION OF TRIANGLES

State: Ohio-Indiana

NO.	STATION	Geodetic OBSERVED ANGLE	CORR'N	SPHER'L EXCESS	Geod ANGLE	CORRECTN EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
2-3							(log in ft)	4.5951358
1	Camden	40 57 24.18	-0.27	23.91		0.12	23.79	0.1834357
2	Oxford	97 45 37.97	-0.27	37.70		0.12	37.58	9.9960041
3	Billings	41 16 59.02	-0.27	58.75		0.12	58.63	9.8193979
1-3			-0.81			0.36		4.7745756
1-2		01.17						4.5979694
2-3								4.7745756
1	Cook	113 50 40.37	+0.43	40.80		0.09	40.71	0.0387474
2	Camden	28 00 08.04	+0.44	08.48		0.09	08.39	9.6716426
3	Billings	38 09 10.55	+0.44	10.99		0.09	10.90	9.7908225
1-3			+1.31			0.27		4.4849656
1-2		58.96						4.6041455
2-3								4.6041455
1	Boston	59 12 45.94	+0.13	46.07		0.09	45.98	0.0659694
2	Camden	38 39 58.82	+0.13	58.95		0.09	58.86	9.7957300
3	Cook	82 07 15.12	+0.14	15.26		0.10	15.16	9.9958805
1-3			+0.40			0.28		4.4658449
1-2		59.88						4.6659954
2-3								4.6659954
1	Eaton	72 34 51.29	-0.40	50.89		0.12	50.77	0.0203879
2	Camden	50 19 41.44	-0.41	41.03		0.11	40.92	9.8863283
3	Boston	57 05 28.83	-0.41	28.42		0.11	28.31	9 9240395
1-3			-1.22			0.34		4.5727116
1-2		01.56						4.6104228

An approximate grid reduction of -262 in the last places was applied to each of these logs. in computing the assumed coordinates.

FIGURE 50.—Computation of triangles.

LIST OF DIRECTIONS

Station: Billings State: Indiana

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
	° ′ ″	″	″		° ′ ″	″
Cook	0 00 00.00	+0.21	00.21		00.53	00.32
Camden	38 09 10.55	+0.89	11.44		11.75	10.86
Oxford	79 26 09.57	+0.53	10.10		09.47	08.94

LIST OF DIRECTIONS

Station: Oxford State: Ohio

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
	° ′ ″	″	″		° ′ ″	″
Peoria	0 00 00.00				0 00 00.00	
Billings	82 16 00.82	-0.52	00.30		00.19	00.71
Cook	123 54 49.15	-0.40	48.75		48.92	49.32
Camden	180 01 38.79	+0.21	39.00		38.93	38.72

FIGURE 51.—Lists of directions.

LIST OF DIRECTIONS

Station: Camden State: Ohio

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Oxford	0 00 00.00	-0.27	59.73		59.49	59.76
Billings	40 57 24.18	-1.00	23.18		23.03	24.03
Cook	68 57 32.22	-0.85	31.37		31.89	32.74
Boston	107 37 31.03	-0.85	30.19		30.34	31.19
Eaton	157 57 12.48	-0.02	12.46		12.20	12.22

LIST OF DIRECTIONS

Station: Cook State: Indiana

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Boston	0 00 00.00	+0.10	00.10		00.04	59.94
Eaton	36 11 47.38	+0.97	48.35		48.55	47.58
Camden	82 07 15.12	+0.85	15.97		15.74	14.89
Oxford	137 02 53.21	+0.47	53.68		53.33	52.86
Billings	195 57 55.49	-0.25	55.24		55.66	55.91

FIGURE 51.—Lists of directions—Continued.

LIST OF DIRECTIONS

Station: Boston State: Indiana

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Richmond	0 00 00.00	-0.15	59.85		59.93	00.08
Mable	47 10 17.84	+0.93	18.77		18.77	17.84
Eaton	81 52 02.78	+1.03	03.81		03.66	02.63
Camden	138 57 31.61	+0.93	32.54		32.10	31.17
Cook	198 10 17.55	-0.10	17.45		17.95	18.05

LIST OF DIRECTIONS

Station: Eaton State: Ohio

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Camden	0 00 00.00	+0.01	00.01		00.75	00.74
Cook	45 04 54.46	-1.09	53.37		53.25	54.34
Boston	72 34 51.29	-1.06	50.23		50.45	51.51
Richmond	111 26 52.74	-1.30	51.44		50.81	52.11
Mable	169 03 08.58	-0.19	08.39		08.16	08.35

FIGURE 51.—Lists of directions—Continued.

LIST OF DIRECTIONS

Station: Mable State: Ohio

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Eaton	0 00 00.00	+ 0.20	00.20		00.36	00.16
Boston	48 49 59.05	- 1.02	58.03		57.76	58.78
Richmond	81 51 33.98	- 1.26	32.72		32.82	34.08

LIST OF DIRECTIONS

Station: Richmond State: Indiana

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Walting	0 00 00.00					
Mable	65 41 52.60	+ 1.23	53.83		53.90	52.67
Eaton	106 14 02.85	+ 1.34	04.19		04.09	02.75
Boston	165 29 59.81	+ 0.16	59.97		60.00	59.84

FIGURE 51.—Lists of directions—Continued.

Observation Equations

α_1 α_2 $\angle$ Obs. $\angle$	log cos α_1 $\log \frac{1}{s_1}$ $\log \frac{1}{\sin 1''}$	log sin α_1 $\log \frac{1}{s_1}$ $\log \frac{1}{\sin 1''}$	log cos α_1 $\log \frac{1}{s_2}$ $\log \frac{1}{\sin 1''}$	log sin α_1 $\log \frac{1}{s_2}$ $\log \frac{1}{\sin 1''}$
243° 42' 03".22	9.64646 -10	9.95255 -10	9.95531 -10	9.63475 -10
205 32 52.56	5.22542 -10	5.22542 -10	5.51503 -10	5.51503 -10
	5.31443	5.31443	5.31443	5.31443
38 09 10.66				
38 09 11.23	0.18631	0.49240	0.78477	0.46421
-0.57	+ 1.54	+ 3.11	+ 6.09	+ 2.91

$v_1 = -0.57 + 1.54 \Delta x_1 - 3.11 \Delta y_1 - 6.09 \Delta x_2 + 2.91 \Delta y_2$

284° 59' 02".24				
243 42 03.22				
41 16 59.02				
41 16 58.66				
+ 0.36			+ 1.54	+ 3.11

$v_2 = +0.36 - 1.54 \Delta x_1 + 3.11 \Delta y_1$

146 37 49.91	9.92177 -10	9.74037 -10$_n$		
104 59 02.24	5.34501 -10	5.34501 -10		
	5.31443	5.31443		
41 38 47.67				
41 38 48.45	0.58121	0.39981 n		
-0.78	+ 3.81	- 2.51		

$v_3 = -0.78 + 3.81 \Delta x_2 + 2.51 \Delta y_2$

202° 44' 39".08	9.96483 -10	9.58734 -10		
146 37 49.91	5.40203 -10	5.40203 -10		
	5.31443	5.31443		
56 06 49.17				
56 06 50.25	0.68129	0.30380		
-1.08	+ 4.80	+ 2.01	+ 3.81	- 2.51

$v_4 = -1.08 + 4.80 \Delta x_1 - 2.01 \Delta y_1 - 3.81 \Delta x_2 - 2.51 \Delta y_2$

FIGURE 52.—Observation equations.

63° 42' 03".22	9.64646 -10$_n$	9.95255 -10$_n$	9.96483 -10$_n$	9.58734 -10$_n$
22 44 39.08	5.22542 -10	5.22542 -10	5.40203 -10	5.40203 -10
	5.31443	5.31443	5.31443	5.31443
40 57 24.14				
40 57 23.45	0.18631 n	0.49240 n	0.68129 n	0.30380 n
+ 0.69	- 1.54	- 3.11	- 4.80	- 2.01

$$v_5 = +0.69 - 3.26\,\Delta x_1 - 1.10\,\Delta y_1$$

91° 42' 11".25	8.47306 -10	9.99981 -10$_n$		
63 42 03.22	5.39585 -10	5.39585 -10$_n$		
	5.31443	5.31443		
28 00 08.03				
28 00 08.19	9.18334 -10	0.71009 n		
-0.16	+0.15	- 5.13	- 1.54	- 3.11

$$v_6 = -0.16 - 1.69\,\Delta x_1 - 2.02\,\Delta y_1 + 0.15\,\Delta x_2 + 5.13\,\Delta y_2$$

130° 22' 10".08	9.81138 -10	9.88189 -10$_n$		
91 42 11.25	5.33400 -10	5.33400 -10		
	5.31443	5.31443		
38 39 58.83				
38 39 58.82	0.45981	0.53032 n		
+ 0.01	+ 2.88	- 3.39	+ 0.15	- 5.13

$$v_7 = +0.01 - 2.73\,\Delta x_1 + 1.74\,\Delta y_1 - 0.15\,\Delta x_2 - 5.13\,\Delta y_2 + 2.88\,\Delta x_3 + 3.39\,\Delta y_3$$

180° 41' 50".83	9.99997 -10	8.08538 -10		
130 22 10.08	5.38958 -10	5.38958 -10		
	5.31443	5.31443		
50 19 40.75				
50 19 42.27	0.70398	8.78939 -10		
-1.52	+ 5.06	+ 0.06	+ 2.88	- 3.39

$$v_8 = -1.52 - 2.18\,\Delta x_1 + 3.45\,\Delta y_1 - 2.88\,\Delta x_3 - 3.39\,\Delta y_3 + 5.06\,\Delta x_4 - 0.06\,\Delta y_4$$

225° 46' 43".74	9.84350 -10	9.85531 -10	9.99390 -10	9.22132 -10
189 34 56.04	5.24605 -10	5.24605 -10	5.53416 -10	5.53416 -10
	5.31443	5.31443	5.31443	5.31443
36 11 47.70				
36 11 48.25	0.40398	0.41579	0.84249	0.06991
-0.55	+ 2.53	+ 2.60	+ 6.96	+ 1.17

$$v_9 = -0.55 + 4.43\,\Delta x_2 + 1.43\,\Delta y_2 - 6.96\,\Delta x_3 + 1.17\,\Delta y_3 + 2.53\,\Delta x_4 - 2.60\,\Delta y_4$$

FIGURE 52.—Observation equations—Continued.

271°	42'	11".25	8.47306 -10$_n$	9.99981 -10		
225	46	43.74	5.39585 -10	5.39585 -10		
			5.31443	5.31443		
45	55	27.51				
45	55	27.62	9.18334 n	0.71009		
		-0.11	- 0.15	+ 5.13	+ 2.53	+ 2.60

$$v_{10} = -0.11 - 0.15\Delta x_1 - 5.13\Delta y_1 + 2.68\Delta x_2 + 2.53\Delta y_2 - 2.53\Delta x_4 + 2.60\Delta y_4$$

326°	37'	49".91	9.92177 -10$_n$	9.74037 -10		
271	42	11.25	5.34501 -10	5.34501 -10		
			5.31443	5.31443		
54	55	38.66				
54	55	37.71	0.58121 n	0.39981		
		+ 0.95	- 3.81	+ 2.51	- 0.15	+ 5.13

$$v_{11} = +0.95 + 0.15\Delta x_1 + 5.13\Delta y_1 + 3.66\Delta x_2 - 2.62\Delta y_2$$

25°	32'	52".56	9.95531 -10$_n$	9.63475 -10$_n$		
326	37	49.91	5.51503 -10	5.51503 -10		
			5.31443	5.31443		
58	55	02.65				
58	55	01.56	0.78477 n	0.46421 n		
		+ 1.09	- 6.09	- 2.91	- 3.81	+ 2.51

$$v_{12} = +1.09 + 2.28\Delta x_2 - 5.42\Delta y_2$$

218°	34'	59".55	9.89303 -10	9.79496 -10	9.99510 -10	9.17421 -10$_n$
171	24	42.89	5.30675 -10	5.30675 -10	5.56393 -10	5.56393 -10
			5.31443	5.31443	5.31443	5.31443
47	10	16.66				
47	10	18.92	0.51421	0.41614	0.87346	0.05257 n
		-2.26	+ 3.27	+ 2.61	+ 7.47	- 1.13

$$v_{13} = -2.26 + 4.20\Delta x_3 + 3.74\Delta y_3$$

253°	16'	41".23	9.45898 -10	9.98124 -10		
218	34	59.55	5.42729 -10	5.42729 -10		
			5.31443	5.31443		
34	41	41.68				
34	41	45.04	0.20070	0.72296		
		-3.36	+ 1.59	+ 5.28	+ 3.27	+ 2.61

$$v_{14} = -3.36 + 1.68\Delta x_3 + 2.67\Delta y_3 + 1.59\Delta x_4 - 5.28\Delta y_4$$

FIGURE 52.—Observation equations—Continued.

310° 22' 10.08	9.81138 -10$_n$	9.88189 -10				
253 16 41.23	5.33400 -10	5.33400 -10				
57 05 28.85	5.31443	5.31443				
57 05 28.73	0.45981 n	0.53032				
+ 0.12	- 2.88	+ 3.39	+ 1.59	+ 5.28		

$$v_{15} = +0.12 - 2.88\Delta x_1 - 3.39\Delta y_1 + 4.47\Delta x_3 - 1.89\Delta y_3 - 1.59\Delta x_4 + 5.28\Delta y_4$$

9° 34' 56.04	9.99390 -10$_n$	9.22132 -10$_n$		
310 22 10.08	5.53416 -10	5.53416 -10		
59 12 45.96	5.31443	5.31443		
59 12 44.91	0.84249 n	0.06991 n		
+ 1.05	- 6.96	- 1.17	- 2.88	+ 3.39

$$v_{16} = +1.05 + 2.88\Delta x_1 + 3.39\Delta y_1 - 6.96\Delta x_2 + 1.17\Delta y_2 + 4.08\Delta x_3 - 4.56\Delta y_3$$

45° 46' 43.74	9.84350 -10$_n$	9.85531 -10$_n$	9.99997 -10$_n$	8.08538 -10$_n$
0 41 50.83	5.24605 -10	5.24605 -10	5.38958 -10	5.38958 -10
45 04 52.91	5.31443	5.31443	5.31443	5.31443
45 04 53.36	0.40398 n	0.41579 n	0.70398 n	8.78939 -10$_n$
-0.45	- 2.53	+ 2.60	- 5.06	+ 0.06

$$v_{17} = -0.45 + 5.06\Delta x_1 - 0.06\Delta y_1 - 2.53\Delta x_2 + 2.60\Delta y_2 - 2.53\Delta x_4 - 2.54\Delta y_4$$

73° 16' 41.23	9.45898 -10$_n$	9.98124 -10$_n$		
45 46 43.74	5.42729 -10	5.42729 -10		
27 29 57.49	5.31443	5.31443		
27 29 56.86	0.20070 n	0.72296 n		
+ 0.63	- 1.59	- 5.28	- 2.53	+ 2.60

$$v_{18} = +0.63 + 2.53\Delta x_2 - 2.60\Delta y_2 - 1.59\Delta x_3 + 5.28\Delta y_3 - 0.94\Delta x_4 - 2.68\Delta y_4$$

112° 08' 44.53	9.57629 -10	9.96672 -10$_n$		
73 16 41.23	5.36595 -10	5.36595 -10		
38 52 03.30	5.31443	5.31443		
38 52 01.21	0.25667	0.64710 n		
+ 2.09	+ 1.81	- 4.44	- 1.59	+ 5.28

$$v_{19} = +2.09 + 1.59\Delta x_3 - 5.28\Delta y_3 - 3.40\Delta x_4 + 0.84\Delta y_4$$

FIGURE 52.—Observation equations—Continued.

169°	45'	06".92	9.99300 -10	9.25053 -10$_n$			
112	08	44.53	5.54869 -10	5.54869 -10			
			5.31443	5.31443			
57	36	22.39					
57	36	16.95	0.85612	0.11365 n			
		+ 5.44	+ 7.18	- 1.30	+ 1.81		4.44

$v_{20} = +5.44 - 5.37\,\Delta x_4 + 3.14\,\Delta y_4$

38°	34'	59".55	9.89303 -10$_n$	9.79496 -10$_n$	9.99300 -10$_n$	9.25053 -10			
349	45	06.92	5.30675 -10	5.30675 -10	5.54869 -10	5.54869 -10			
			5.31443	5.31443	5.31443	5.31443			
48	49	52.63							
48	49	57.83	0.51421 n	0.41614 n	0.85612 n	0.11365			
		-5.20	- 3.27	- 2.61	- 7.18	+ 1.30			

$v_{21} = -5.20 - 3.27\,\Delta x_3 + 2.61\,\Delta y_3 + 7.18\,\Delta x_4 + 1.30\,\Delta y_4$

71°	36'	33".55		
38	34	59.55		
33	01	34.00		
33	01	34.69		
		-0.69	- 3.27	- 2.61

$v_{22} = -0.69 + 3.27\,\Delta x_3 - 2.61\,\Delta y_3$

292°	08'	44".53	9.57629 -10$_n$	9.96672 -10
251	36	33.55	5.36595 -10	5.36595 -10
			5.31443	5.31443
40	32	10.98		
40	32	10.36	0.25667 n	0.64710
		+ 0.62	- 1.81	+ 4.44

$v_{23} = +0.62 - 1.81\,\Delta x_4 - 4.44\,\Delta y_4$

351°	24'	42".89	9.99510 -10$_n$	9.17421 -10		
292	08	44.53	5.56393 -10	5.56393 -10		
			5.31443	5.31443		
59	15	58.36				
59	15	55.78	0.87346 n	0.05257		
		+ 2.58	- 7.47	+ 1.13	- 1.81	+ 4.44

$v_{24} = +2.58 - 7.47\,\Delta x_3 + 1.13\,\Delta y_3 + 1.81\,\Delta x_4 + 4.44\,\Delta y_4$

FIGURE 52.—Observation equations—Continued.

Computation of corrections to directions

Station	Approximate coordinates, x and y	Transformed coordinates, x' and y'	Station	Approximate coordinates, x and y	Transformed coordinates, x' and y'
	Feet	*Feet*		*Feet*	*Feet*
Oxford	−641, 599	−642, 953	Eaton	−625, 783	−629, 121
	+61, 121	+53, 041		+138, 435	+130, 735
Billings	−679, 625	−681, 227	Boston	−661, 587	−664, 638
	+71, 299	+62, 243		+127, 679	+119, 065
Camden	−626, 280	−628, 575	Mable	−630, 813	−634, 861
	+97, 663	+89, 993		+166, 252	+158, 414
Cook	−666, 452	−668, 764	Richmond	−665, 663	−669, 404
	+98, 857	+90, 129		+154, 665	+145, 938

Computation of azimuth corrections

Line	$x_2'-x_1'$	$2y_1'+y_2'$	Correction	Adopted correction
	Feet	*Feet*	"	"
Oxford-Billings	−38, 274	+168, 325	−0. 51	−0. 52
Billings-Oxford	+38, 274	+177, 527	+0. 53	+0. 53
Oxford-Cook	−25, 811	+196, 211	−0. 40	−0. 40
Cook-Oxford	+25, 811	+233, 299	+0. 47	+0. 47
Oxford-Camden	+14, 378	+196, 075	+0. 22	+0. 21
Camden-Oxford	−14, 378	+233, 027	−0. 26	−0. 27
Billings-Cook	+12, 463	+214, 615	+0. 21	+0. 21
Cook-Billings	−12, 463	+242, 501	−0. 24	−0. 25
Billings-Camden	+52, 652	+214, 479	+0. 89	+0. 89
Camden-Billings	−52, 652	+242, 229	−1. 00	−1. 00
Camden-Cook	−40, 189	+270, 115	−0. 85	−0. 85
Cook-Camden	+40, 189	+270, 251	+0. 85	+0. 85
Camden-Boston	−36, 063	+299, 051	−0. 85	−0. 85
Boston-Camden	+36, 063	+328, 123	+0. 93	+0. 93
Camden-Eaton	−546	+310, 721	−0. 01	−0. 02
Eaton-Camden	+546	+351, 463	+0. 02	+0. 01
Cook-Eaton	+39, 643	+310, 993	+0. 97	+0. 97
Eaton-Cook	−39, 643	+351, 599	−1. 10	−1. 09
Cook-Boston	+4, 126	+299, 323	+0. 10	+0. 10
Boston-Cook	−4, 126	+328, 249	−0. 11	−0. 10
Boston-Eaton	+35, 517	+368, 865	+1. 03	+1. 03
Eaton-Boston	−35, 517	+380, 535	−1. 06	−1. 06
Boston-Mable	+29, 777	+396, 544	+0. 93	+0. 93
Mable-Boston	−29, 777	+435, 893	−1. 02	−1. 02
Boston-Richmond	−4, 766	+384, 068	−0. 14	−0. 15
Richmond-Boston	+4, 766	+410, 941	+0. 15	+0. 16
Eaton-Richmond	−40, 283	+407, 408	−1. 29	−1. 30
Richmond-Eaton	+40, 283	+422, 611	+1. 34	+1. 34
Eaton-Mable	−5, 740	+419, 884	−0. 19	−0. 19
Mable-Eaton	+5, 740	+447, 563	+0. 20	+0. 20
Mable-Richmond	−34, 543	+462, 766	−1. 26	−1. 26
Richmond-Mable	+34, 543	+450, 290	+1. 22	+1. 23

Table for formation of normal equations

	Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	η	Σ	v	Adopted v
1	+1.54	−3.11	−6.09	+2.91					−0.57	−5.32	−0.0118	−0.01
2	−1.54	+3.11							+0.36	+1.93	−0.9355	−0.94
3			+3.81	+2.51					−0.78	+5.54	+0.2746	+0.28
4	+4.80	−2.01	−3.81	−2.51					−1.08	−4.61	−0.2432	−0.24
5	−3.26	−1.10							+0.69	−3.67	+0.0935	+0.09
6	−1.69	−2.02	+0.15	+5.13					−0.16	+1.41	+0.6663	+0.67
7	−2.73	+1.74	−0.15	−5.13	+2.88	+3.39			+0.01	+0.01	−0.3746	−0.37
8	−2.18	+3.45			−2.88	−3.39	+5.06	−0.06	−1.52	−1.52	−0.4042	−0.41
9			+4.43	+1.43	−6.96	+1.17	+2.53	−2.60	−0.55	−0.55	+0.2635	+0.26
10	−0.15	−5.13	+2.68	+2.53			−2.53	+2.60	−0.11	−0.11	−0.4330	−0.43
11	+0.15	+5.13	+3.66	−2.62					+0.95	+7.27	−0.1164	−0.12
12			+2.28	−5.42					+1.09	−2.05	+0.7727	+0.77
13					+4.20	+3.74			−2.26	+5.68	−0.0810	−0.08
14					+1.68	+2.67	+1.59	−5.28	−3.36	−2.70	−0.1440	−0.15
15	−2.88	−3.39			+4.47	−1.89	−1.59	+5.28	+0.12	+0.12	−0.2945	−0.29
16	+2.88	+3.39	−6.96	+1.17	+4.08	−4.56			+1.05	+1.05	+0.9441	+0.94
17	+5.06	−0.06	−2.58	+2.60			−2.53	−2.54	−0.45	−0.45	−0.8581	−0.86
18			+2.53	−2.60	−1.59	+5.28	−0.94	−2.68	+0.63	+0.63	+0.3368	+0.34
19					+1.59	−5.28	−3.40	+0.84	+2.09	−4.16	−0.8527	−0.85
20							−5.37	+3.14	+5.44	+3.21	+0.3993	+0.40
21					−3.27	+2.61	+7.18	+1.30	−5.20	+2.62	−0.4328	−0.43
22					+3.27	−2.61			−0.69	−0.03	+0.3752	+0.37
23							−1.81	−4.44	+0.62	−5.63	−0.1718	−0.17
24					−7.47	−1.13	+1.81	+4.44	+2.58	+0.23	+0.1277	+0.13

Normal equations

	Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	η	Σ
Δx_1	+95.7096	−3.7364	−60.2102	+13.5217	−2.7072	−9.5541	−18.8739	−28.3180	−4.7485	−18.9170
Δy_1		+119.2264	+7.6188	−45.9030	−6.2469	−14.8482	+35.9778	−31.2918	+8.0182	+68.8149
Δx_2			+172.8100	−27.1874	−63.6843	+49.7706	+8.4502	−4.9042	+3.2441	+85.9076
Δy_2				+133.2776	−15.8196	−34.7808	−6.9170	+3.2240	−12.8189	+6.5966
Δx_3					+204.3630	−20.8950	−77.5284	+1.1790	−4.2855	+14.3751
Δy_3						+140.4932	+22.7404	−47.1252	−40.2905	+45.5104
Δx_4							+149.2476	−15.6156	−83.8985	+13.5826
Δy_4								+134.5968	+39.8438	+51.5888
η									+94.0788	−0.8570
Σ										+266.6020

Solution of normal equations

Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	η	Σ
+95.7096	−3.7364	−60.2102	+13.5217	−2.7072	−9.5541	−18.8739	−28.3180	−4.7485	−18.9170
Δx_1	+0.039039	+0.629093	−0.141278	+0.028286	+0.099824	+0.197200	+0.295874	+0.049614	+0.197502
	+119.2264	+7.6188	−45.9030	−6.2469	−14.8482	+35.9778	−31.2918	+8.0182	+68.8149
Δx_1	−0.1459	−2.3505	+0.5279	−0.1057	−0.3730	−0.7368	−1.1055	−0.1854	−0.7385
	+119.0805	+5.2683	−45.3751	−6.3526	−15.2212	+35.2410	−32.3973	+7.8328	+68.0764
	Δy_1	−0.044242	+0.381046	+0.053347	+0.127823	−0.295943	+0.272062	−0.065777	−0.571684
		+172.8100	−27.1874	−63.6843	+49.7706	+8.4502	−4.9042	+3.2441	+85.9076
	Δx_1	−37.8778	+8.5064	−1.7031	−6.0104	−11.8734	−17.8147	−2.9872	−11.9006
	Δy_1	−0.2331	+2.0075	+0.2811	+0.6734	−1.5591	+1.4333	−0.3465	−3.0118
		+134.6991	−16.6735	−65.1063	+44.4336	−4.9823	−21.2856	−0.0896	+70.99524
		Δx_2	+0.123783	+0.483346	−0.329873	+0.036988	+0.158023	+0.000665	−0.5270678
			+133.2776	−15.8196	−34.7808	−6.9170	+3.2240	−12.8189	+6.5966
		Δx_1	−1.9103	+0.3825	+1.3498	+2.6665	+4.0007	+0.6709	+2.6726
		Δy_1	−17.2900	−2.4206	−5.8000	+13.4284	−12.3449	+2.9847	+25.9402
		Δx_2	−2.0639	−8.0591	+5.5001	−0.6167	−2.6348	−0.0111	+8.7880
			+112.0134	−25.9168	−33.7309	+8.5612	−7.7550	−9.1744	+43.99745
			Δy_2	+0.231372	+0.301133	−0.076430	+0.069233	+0.081904	−0.392788
				+204.3630	−20.8950	−77.5284	+1.1790	−4.2855	+14.3751
			Δx_1	−0.0766	−0.2702	−0.5339	−0.8010	−0.1343	−0.5351
			Δy_1	−0.3389	−0.8120	+1.8800	−1.7283	+0.4179	+3.6317
			Δx_2	−31.4689	+21.4768	−2.4082	−10.2883	−0.0433	+34.3153
			Δy_2	−5.9964	−7.8044	+1.9808	−1.7943	−2.1227	+10.1798
				+166.4822	−8.3048	−76.6097	−13.4329	−6.1679	+61.9669
				Δx_3	+0.049884	+0.460168	+0.080687	+0.037048	−0.372213
				+140.4932	+22.7404	−47.1252	−40.2905	+45.5104
				Δx_1	−0.9537	−1.8841	−2.8268	−0.4740	−1.8884
				Δy_1	−1.9456	+4.5046	−4.1411	+1.0012	+8.7017
				Δx_2	−14.6574	+1.6435	+7.0215	+0.0296	−23.4195
				Δy_2	−10.1575	+2.5781	−2.3353	−2.7627	+13.2491
				Δx_3	−0.4143	−3.8216	−0.6701	−0.3077	+3.0912
					+112.3647	+25.7609	−50.0770	−42.8041	+45.2445
					Δy_3	−0.229262	+0.445665	+0.380939	−0.402658

	Δx_1	Δy_1	η	Σ
	+149.2476	−15.6156	−83.8985	+13.5826
Δx_1	−3.7219	−5.5843	−0.9364	−3.7304
Δy_1	−10.4293	+9.5878	−2.3181	−20.1467
Δx_2	−0.1843	−0.7873	−0.0033	+2.6260
Δy_2	−0.6543	+0.5927	+0.7012	−3.3627
Δx_3	−35.2533	−6.1814	−2.8383	+28.5152
Δy_3	−5.9060	+11.4808	+9.8134	−10.3728
	+93.0985	−6.5073	−79.4800	+7.11123
	Δx_4	+0.069897	+0.853719	−0.076385
		+134.5968	+39.8438	+51.5888
	Δx_1	−8.3786	−1.4050	−5.5970
	Δy_1	−8.8141	+2.1310	+18.5210
	Δx_2	−3.3636	−0.0142	+11.2189
	Δy_2	−0.5369	−0.6352	+3.0461
	Δx_3	−1.0839	−0.4977	+4.9999
	Δy_3	−22.3176	−19.0763	+20.1639
	Δx_4	−0.4548	−5.5554	+0.4971
		+89.6473	+14.7910	+104.43873
		Δy_4	−0.164991	−1.164991
			+94.0788	−0.8570
		Δx_1	−0.2356	−0.9385
		Δy_1	−0.5152	−4.4779
		Δx_2	−0.0001	+0.0472
		Δy_2	−0.7514	+3.6036
		Δx_3	−0.2285	+2.2957
		Δy_3	−16.3058	+17.2354
		Δx_4	−67.8536	+6.0711
		Δy_4	−2.4404	−17.2314
			+5.7482	+5.7482
				+266.6020
			Δx_1	−3.7390
			Δy_1	−38.9182
			Δx_2	−37.4194
			Δy_2	−17.2817
			Δx_3	−23.0649
			Δy_3	−18.2181
			Δx_4	−0.5432
			Δy_4	−121.6697
				+5.7478

Back solution

Δy_4	Δx_4	Δy_3	Δx_3	Δy_2	Δx_2	Δy_1	Δx_1
−0.16499	+0.85372	+0.38094	+0.03705	+0.08190	+0.00066	−0.06578	+0.04961
−0.16499	−0.01153	−0.07353	−0.01331	−0.01142	−0.02607	−0.04489	−0.04882
	+0.84219	−0.19308	+0.38755	−0.06437	+0.03115	−0.24924	+0.16608
		+0.11433	+0.00570	+0.03443	−0.03771	+0.01461	+0.01141
			+0.41699	+0.09648	+0.20155	+0.02225	+0.01179
				+0.13702	+0.01696	+0.05221	−0.01936
					+0.18654	−0.00825	+0.11735
						−0.27909	−0.01090
							+0.27716

Computation of corrections

1	2	3	4	5	6	7	8
−0.57	+0.36	−0.78	−1.08	+0.69	−0.16	+0.01	−1.52
+0.4275	−0.4275	+0.7107	+1.3304	−0.9035	−0.4684	−0.7566	−0.6042
+0.8680	−0.8680	+0.3439	+0.5610	+0.3070	+0.5638	−0.4856	−0.9629
−1.1360	−0.9355	+0.2746	−0.7107	+0.0935	+0.0280	−0.0280	−1.2009
+0.3987	−0.94	+0.28	−0.3439	+0.09	+0.7029	−0.7029	−0.3876
−0.0118			−0.2432		+0.6663	+1.2009	+4.2615
−0.01			−0.24		+0.67	+0.3876	+0.0099
						−0.3746	−0.4042
						−0.37	−0.41

9	10	11	12	13	14	15	16
−0.55	−0.11	+0.95	+1.09	−2.26	−3.36	+0.12	+1.05
+0.8264	−0.0416	+0.0416	+0.4253	+1.7514	+0.7005	−0.7982	+0.7982
+0.1959	+1.4317	−1.4317	−0.7426	+0.4276	+0.3053	+0.9461	−0.9461
−2.9023	+0.4999	+0.6827	+0.7727	−0.0810	+1.3391	+1.8639	−1.2983
+0.1338	+0.3467	−0.3590	+0.77	−0.08	+0.8711	−0.2161	+0.1603
+2.1307	−2.1307	−0.1164			−0.1440	−1.3391	+1.7013
+0.4290	−0.4290	−0.12			−0.15	−0.8711	−0.5213
+0.2635	−0.4330					−0.2945	+0.9441
+0.26	−0.43					−0.29	+0.94

17	18	19	20	21	22	23	24
−0.45	+0.63	+2.09	+5.44	−5.20	−0.69	+0.62	+2.58
+1.4024	+0.4719	+0.6630	−4.5226	−1.3636	+1.3636	−1.5244	−3.1149
+0.0167	−0.3563	−0.6037	−0.5181	+0.2984	−0.2984	+0.7326	−0.1292
−0.4719	−0.6630	−2.8634	+0.3993	+6.0469	+0.3752	−0.1718	+1.5244
+0.3563	+0.6037	−0.1386	+0.40	−0.2145	+0.37	−0.17	−0.7326
−2.1307	−0.7917	−0.8527		−0.4328			+0.1277
+0.4191	+0.4422	−0.85		−0.43			+0.13
−0.8581	+0.3368						
−0.86	+0.34						

$\Sigma v^2 = +5.7494$

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COMPUTATION OF TRIANGLES

State: Ohio - Indiana

NO.		STATION	PLANE OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'S EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3							4.5951101
5	1	Camden	40 57 23.45	+0.09			23.54	0.1834363 4
3+4	2	Oxford	97 45 38.70	+0.04			38.74	9.9960037 8
2	3	Billings	41 16 58.66	-0.94			57.72	9.8193957 2
	1-3			-0.81				4.7745502
	1-2							4.5979422
	2-3							4.5979422
11	1	Cook	54 55 37.71	-0.12			37.59	0.0870228 8
5+6	2	Camden	68 57 31.64	+0.76			32.40	9.9700323 1
4	3	Oxford	56 06 50.25	-0.24			50.01	9.9191552 5
	1-3			+0.40				4.6549974
	1-2							4.6041203
	2-3							4.7745502
11+12	1	Cook	113 50 39.27	+0.65			39.92	0.0387467 2
6	2	Camden	28 00 08.19	+0.67			08.86	9.6716443 8
1	3	Billings	38 09 11.23	-0.01			11.22	9.7908234 0
	1-3			+1.31				4.4849413
	1-2							4.6041203
	2-3							4.5951101
12	1	Cook	58 55 01.56	+0.77			02.33	0.0673116 1
3	2	Oxford	41 38 48.45	+0.28			48.73	9.8225196 3
1+2	3	Billings	79 26 09.89	-0.95			08.94	9.9925756 8
	1-3			+0.10				4.4849413
	1-2							4.6549974

FIGURE 53.—Final computation of triangles, Ohio.

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COMPUTATION OF TRIANGLES

State: Ohio - Indiana

NO.	STATION	PLANE OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3						4.6041203
17	1 Eaton	45 04 53.36	-0.86			52.50	0.1499000[1]
7+8	2 Camden	88 59 41.09	-0.78			40.31	9.9999331[2]
10	3 Cook	45 55 27.62	-0.43			27.19	9.8563786[6]
	1-3		-2.07				4.7539534
	1-2						4.6103990
	2-3						4.6103990
15	1 Boston	57 05 28.73	-0.29			28.44	0.0759602[9]
17+18	2 Eaton	72 34 50.22	-0.52			49.70	9.9796113[5]
8	3 Camden	50 19 42.27	-0.41			41.86	9.8863299[0]
	1-3		-1.22				4.6659706
	1-2						4.5726892
	2-3						4.7539534
15+16	1 Boston	116 18 13.64	+0.65			14.29	0.0474711[5]
18	2 Eaton	27 29 56.86	+0.34			57.20	9.6643942[8]
9	3 Cook	36 11 48.25	+0.26			48.51	9.7712645[5]
	1-3		+1.25				4.4658188
	1-2						4.5726891[+1]
	2-3						4.6041203
16	1 Boston	59 12 44.91	+0.94			45.85	0.0659695[8]
7	2 Camden	38 39 58.82	-0.37			58.45	9.7957289[6]
+10	3 Cook	82 07 15.87	-0.17			15.70	9.9958807[1]
	1-3		+0.40				4.4658188
	1-2						4.6659706

FIGURE 53.—Final computation of triangles, Ohio—Continued.

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COMPUTATION OF TRIANGLES

State: Ohio - Indiana

NO.	STATION	PLANE OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3						4.5726892
21	1 Mable	48 49 57.83	-0.43			57.40	0.1233263 3
19+20	2 Eaton	96 28 18.16	-0.45			17.71	9.9972237 7
14	3 Boston	34 41 45.04	-0.15			44.89	9.7552796 2
	1-3		-1.03				4.6932393
	1-2						4.4512952
	2-3						4.4512952
23	1 Richmond	40 32 10.36	-0.17			10.19	0.1871348 4
21+22	2 Mable	81 51 32.52	-0.06			32.46	9.9956012 5
20	3 Eaton	57 36 16.95	+0.40			17.35	9.92653434
	1-3		+0.17				4.6340313
	1-2						4.5649644 1
	2-3						4.6932393
23+24	1 Richmond	99 48 06.14	-0.04			06.10	0.0063861 8
22	2 Mable	33 01 34.69	+0.37			35.06	9.7364168 1
13	3 Boston	47 10 18.92	-0.08			18.84	9.8653888 6
	1-3		+0.25				4.4360423
	1-2						4.5649643
	2-3						4.5726892
24	1 Richmond	59 15 55.78	+0.13			55.91	0.0657313 9
19	2 Eaton	38 52 01.21	-0.85			00.36	9.7976217 2
13+14	3 Boston	81 52 03.96	-0.23			03.73	9.9956106 6
	1-3		-0.95				4.4360423
	1-2						4.6340313

FIGURE 53.—Final computation of triangles, Ohio—Continued.

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COMPUTATION OF TRIANGLES

State: Ohio - Indiana

NO.	STATION	GEODETIC OBSERVED ANGLE			CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3								4.0791519
5	1 Camden	40	57	24.18	+0.09	24 27	0.12	24.15	0.1834348 5
3+4	2 Oxford	97	45	37.97	+0.04	38.01	0.12	37.89	9.9960040 2
2	3 Billings	41	16	59.02	-0.94	58.08	0.12	57.96	9.8193962 9
	1-3				-0.81		0.36		4.2585908
	1-2								4.0819830
				01.17					
	2-3								4.0819830
11	1 Cook	54	55	38.09	-0.12	37.97	0.12	37.85	0.08702249
5+6	2 Camden	68	57	32.22	+0.76	32.98	0.11	32.87	9.97003269
4	3 Oxford	56	06	49.64	-0.24	49.40	0.12	49.28	9.91915422
	1-3				+0.40		0.35		4.1390382
	1-2								4.0881597 +1
				59.95					
	2-3								4.2585908
11+12	1 Cook	113	50	40.37	+0.65	41.02	0.09	40.93	0.03874765
6	2 Camden	28	00	08.04	+0.67	08.71	0.09	08.62	9.67164343
1	3 Billings	38	09	10.55	-0.01	10.54	0.09	10.45	9.79082134
	1-3				+1.31		0.27		3.9689819
	1-2								4.0881598
				58.96					
	2-3								4.0791519
12	1 Cook	58	55	02.28	+0.77	03.05	0.09	02.96	0.06731081
3	2 Oxford	41	38	48.33	+0.28	48.61	0.09	48.52	9.82251913
1+2	3 Billings	79	26	09.57	-0.95	08.62	0.10	08.52	9.99257551
	1-3				+0.10		+0.28		3.9689818
	1-2								4.1390382
				00.18					

FIGURE 53.—Final computation of triangles, Ohio—Continued.

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COMPUTATION OF TRIANGLES

State: Ohio - Indiana

NO.	STATION	GEODETIC OBSERVED ANGLE		CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM	
	2-3							4.0881598	
17	1 Eaton	45	04	54.46-0.86	53.60	0.13	53.47	0.1498979	7
7+8	2 Camden	88	59	40.26-0.78	39.48	0.13	39.35	9.9999330	9
10	3 Cook	45	55	27.74-0.43	27.31	0.13	27.18	9.8563786	4
	1-3			-2.07		0.39		4.2379909	
	1-2							4.0944364	
				02.46					
	2-3							4.0944364	
15	1 Boston	57	05	28.83-0.29	28.54	0.11	28.43	0.07596031	
17+18	2 Eaton	72	34	51.29-0.52	50.77	0.12	50.65	9.97961198	
8	3 Camden	50	19	41.44-0.41	41.03	0.11	40.92	9.8863282	5
	1-3			-1.22		0.34		4.1500087	
	1-2							4.0567250	
				01.56					
	2-3							4.2379909	
15+16	1 Boston	116	18	14.77+0.65	15.42	0.07	15.35	0.0474722	5
18	2 Eaton	27	29	56.83+0.34	57.17	0.08	57.09	9.6643938	3
9	3 Cook	36	11	47.38+0.26	47.64	0.08	47.56	9.7712618	2
	1-3			+1.25		0.23		3.9498570	-1
	1-2							4.0567250	
				58.98					
	2-3							4.0881598	
16	1 Boston	59	12	45.94+0.94	46.88	0.09	46.79	0.0659684	0
7	2 Camden	38	39	58.82 -0.37	58.45	0.00	58.36	9.7957287	2
9+10	3 Cook	82	07	15.12-0.17	14.95	0.10	14.85	9.99588047	
	1-3			+0.40		0.28		3.9498569	
	1-2							4.1500087	
				59.88					

FIGURE 53.—Final computation of triangles, Ohio—Continued.

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COMPUTATION OF TRIANGLES

State: Ohio - Indiana

NO.	STATION	GEODETIC OBSERVED ANGLE		CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3							4.0567250
21	1 Mable	48	49	59.05 -0.43	58.62	0.08	58.54	0.1233242 4
19+20	2 Eaton	96	28	17.29 -0.45	16.84	0.09	16.75	9.9972239 9
14	3 Boston	34	41	44.94 -0.15	44.79	0.08	44.71	9.7552790 7
	1-3			-1.03		0.25		4.1772732
	1-2							3.9353283
				01.28				
	2-3							3.9353283
23	1 Richmond	40	32	10.25 -0.17	10.08	0.08	10.00	0.1871353 1
21+22	2 Mable	81	51	33.98 -0.06	33.92	0.08	33.84	9.9956016 6
20	3 Eaton	57	36	15.84 +0.40	16.24	0.08	16.16	9.9265327 4
	1-3			+0.17		0.24		4.1180653
	1-2							4.0489964
				00.07				
	2-3							4.1772732
23+24	1 Richmond	99	48	07.21 -0.04	07.17	0.07	07.10	0.0063865 5
22	2 Mable	33	01	34.93 +0.37	35.30	0.08	35.22	9.7364173 3
13	3 Boston	47	10	17.84 -0.08	17.76	0.08	17.68	9.8653366 0
	1-3			+0.25		0.23		3.9200771
	1-2							4.0489964
				59.98				
	2-3							4.0567250
24	1 Richmond	59	15	56.96 +0.13	57.09	0.08	57.01	0.0657300 2
19	2 Eaton	38	52	01.45 -0.85	00.60	0.08	00.52	9.7976221 4
13+14	3 Boston	81	52	02.78 -0.23	02.55	0.08	02.47	9.9956102 8
	1-3			-0.95		0.24		3.9200772 -1
	1-2							4.1180653
				01.19				

FIGURE 53.—Final computation of triangles, Ohio—Continued.

ADJUSTMENT ON THE TRANSVERSE MERCATOR GRID OF INDIANA, EAST

The following computations are based on the transverse Mercator grid system for the eastern half of Indiana. (For grid table of Indiana, see fig. 46.)[7] They cover the same stations as those used in the preceding computations which were based on the Lambert grid system for the southern half of Ohio.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Indiana (East) Station Oxford

ϕ 39° 31′ 47.931″

λ (Central meridian) 85° 40′ 00.000″

λ 84° 46′ 29.612″

$\Delta\lambda$ (Central meridian−λ) + 0° 53′ 30.388″

$\Delta\lambda$ (in sec.) + 3210.388″

log $\Delta\lambda$	3.50655753	log S_m^2	9.769277
Cor. arc to sine	− 1754	log C*	1.321128 80 −10
log $\Delta\lambda_1$	3.50653999	log $\Delta\phi$	1.090425 57
log cos ϕ	9.88721862−10		
colog A	1.49086969	ϕ	39° 31′ 47.931″
log S_1	4.88462830	$\Delta\phi$	+ 12.3118 56
Cor. sine to arc	+ 1042	ϕ'	39 32 00.2458 66
log S_m	4.88463872		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.17733
log R	− 1448		
log S_g	5.40060841	y (for min. of ϕ')	740,486.21
log S_g^3	16.2018252	y (for seconds of ϕ')	+ 24.95
log $1/6\rho_0^2R^2$	4.5810462−20	y	740,511.16
log $(S_g^3/6\rho_0^2)_g$	0.7828714		
		log sin $\frac{\phi+\phi'}{2}$	9.8038019 −10
S_g	251,540.782	log $\Delta\lambda$	3.5065575
$(S_g^3/6\rho_0^2)_g$	6.066	log Δa_1	3.3103594
x′	251,546.85		
	2,000,000.00	log $(\Delta\lambda)^9$	10.519
x	2,251,546.85	log F	7.870 − 20
		log b	8.389 −10
		Δa_1	+ 2043″.428
		b	0.024
		Δa	+ 2043.45″
		Δa	+ 0° 34′ 03.45″

* Take out C first for ϕ and correct for approximate ϕ'.

FIGURE 54.—Computation of coordinates, Indiana.

[7] For State map of Indiana showing the elements of the two grids covering the State, see fig. 65, p. 266.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Indiana (East) Station Billings

ϕ 39° 33' 18.743

λ (Central meridian) 85° 40' 00.000
λ 84 54 38.240
$\Delta\lambda$ (Central meridian−λ) + 0 45 21.760
$\Delta\lambda$ (in sec.) 2721.760

log $\Delta\lambda$	3.43484983	log $S_m{}^2$	9.625552 52
Cor. arc to sine	− 1260	log C*	1.321514 104 − 10
log $\Delta\lambda_1$	3.43483723	log $\Delta\phi$	0.947066
log cos ϕ	9.88706077-10		
colog A	1.49087032	ϕ	39° 33' 18.743
log S_1	4.81276832	$\Delta\phi$	+ 8.8533
Cor. sine to arc	+ 749	ϕ'	39 33 27.5963
log S_m	4.81277581		
log 3937/1200	0.51598417	Tabular difference of y for 1" of ϕ'	101.17767
log R	− 1448		
log S_g	5.32874550	y (for min. of ϕ')	746,556.85
log $S_g{}^3$	15.9862365	y (for seconds of ϕ')	+ 2,792.13
log $1/6\rho_o{}^2R^2$	4.5810462-20	y	749,348.98
log $(S_g{}^3/6\rho_o{}^2)_g$	0.5672827		
		log sin $\frac{\phi+\phi'}{2}$	9.8040289 − 10
S_g	213,179.529	log $\Delta\lambda$	3.4348498
$(S_g{}^3/6\rho_o{}^2)_g$	3.692	log $\Delta\alpha_1$	3.2388787
x'	+ 213,183.22		
	2,000,000.00	log $(\Delta\lambda)^3$	10.305
x	2,213,183.22	log F	7.870 -20
		log b	8.175 -10
		$\Delta\alpha_1$	+ 1733.320
		b	0.015
		$\Delta\alpha$	+ 1733.34
		$\Delta\alpha$	+ 0° 28' 53.34

* Take out C first for ϕ and correct for approximate ϕ'.

FIGURE 54.—Computation of coordinates, Indiana—Continued.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Indiana (East) Station Mable

ϕ 39° 49′ 09.341″

λ (Central meridian) 85° 40′ ″

λ 84 44 45.362

$\Delta\lambda$ (Central meridian−λ) + 0 55 14.638

$\Delta\lambda$ (in sec.) + 3314.638″

log $\Delta\lambda$	3.52043611	log S_m^2	9.793411 617
Cor. arc to sine	− 1869	log C*	1.325563 − 10 9028
log $\Delta\lambda_1$	3.520417 42	log $\Delta\phi$	1.118974
log cos ϕ	9.88539983−10		
colog A	1.49087700	ϕ	39° 49′ 09.341″
log S_1	4.89669425	$\Delta\phi$	+ 13.1531
Cor. sine to arc	+ 1102	ϕ'	39 49 22.4941
log S_m	4.89670527		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.18233
log R	− 1448		
log S_g	5.41267496	y (for min. of ϕ')	843,689.48
log S_g^3	16.2380249	y (for seconds of ϕ')	+ 2,276.01
log $1/6\rho_0^2R^2$	4.5810462−20	y	845,965.49
log $(S_g^3/6\rho_0^2)_g$	0.8190711		
S_g	258,627.653	log sin $\frac{\phi+\phi'}{2}$	9.8064462 − 10
$(S_g^3/6\rho_0^2)_g$	6.593	log $\Delta\lambda$	3.5204361
x′	258,634.25	log $\Delta\alpha_1$	3.3268823
	2,000,000.00	log $(\Delta\lambda)^3$	10.561
x	2,258,634.25	log F	7.870 − 20
		log b	8.431 − 10
		$\Delta\alpha_1$	+ 2122.″669
		b	0.027
		$\Delta\alpha$	2122.″70
		$\Delta\alpha$	+ 0° 35′ 22.″70

* Take out C first for ϕ and correct for approximate ϕ'.

FIGURE 54.—Computation of coordinates, Indiana—Continued.

PLANE COORDINATES ON TRANSVERSE MERCATOR PROJECTION

State Indiana (East) Station Richmond

λ (Central meridian) 85° 40′ 00″.000

ϕ 39° 47′ 06″.065 λ 84 52 07.947

$\Delta\lambda$ (Central meridian–λ) + 47 52.053

$\Delta\lambda$ (in sec.) + 2872″.053

log $\Delta\lambda$	3.45819245	log S_m^2	9.669358 79
Cor. arc to sine	− 1403	log C*	1.325037 437 -10
log $\Delta\lambda_1$	3.45817842	log $\Delta\phi$	0.994395
log cos ϕ	9.88561611-10		
colog A	1.49087613	ϕ	39° 47′ 06″.065
log S_1	4.83467066	$\Delta\phi$	+ 9.878 27 77
Cor. sine to arc	+ 829	ϕ'	39 47 15.9368
log S_m	4.83467895		
log 3937/1200	0.51598417	Tabular difference of y for 1″ of ϕ'	101.18183
log R	− 1448		
log S_g	5.35064864	y (for min. of ϕ')	831,547.65
log S_g^3	16.0519459	y (for seconds of ϕ')	+ 1,612.61
log $1/6\rho_0^2R^2$	4.5810462-20	y	833,160.26
log $(S_g^3/6\rho_0^2)_g$	0.6329921		
S_g	+ 224,206.727	log sin $\frac{\phi+\phi'}{2}$	
$(S_g^3/6\rho_0^2)_g$	+ 4.295	log $\Delta\lambda$	
	+ 224,211.02	log Δa_1	
	2,000,000.00	log $(\Delta\lambda)^3$	
x	2,224,211.02	log F	
		log b	
		Δa_1	"
		b	
		Δa	"
		Δa	

* Take out C first for ϕ and correct for approximate ϕ'.

FIGURE 54.—Computation of coordinates, Indiana—Continued.

Computation of geodetic azimuth

BILLINGS-OXFORD

2, 251, 546. 85 2, 213, 183. 22	740, 511. 16 749, 348. 98		426, 366 251, 547
38, 363. 63	−8, 837. 82		677, 913 5. 83117
4. 58391969 3. 94634515*n*	4. 5839197 0. 0112287	4. 5951484 0. 5159842	3. 94635*n* 9. 89547−20
0. 63757454*n*	4. 5951484 −120	4. 0791642	9. 67299−10*n* −. 47
282 58 22. 39 +28 53. 34 −. 47	4. 5951364 0. 5159842		
283 27 15. 26	4. 0791522		

LIST OF DIRECTIONS

Station: Billings State: Indiana

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Cook	0 00 00.00	-1.44	58.56		58.85	00.29
Camden	38 09 10.56	-1.54	09.01		09.31	10.85
Oxford	79 26 09.57	+0.47	10.04		09.44	08.97

LIST OF DIRECTIONS

Station: Oxford State: Ohio

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Peoria	0 00 00.00					
Billings	82 16 00.82	-0.50	00.32		00.18	00.68
Cook	123 54 49.15	-2.11	47.04		47.21	49.32
Camden	160 01 38.79	-2.24	36.55		36.53	39.77

FIGURE 55.—List of directions.

LIST OF DIRECTIONS

Station: Camden State: Ohio

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Oxford	0 00 00.00	+2.28	02.28		02.18	59.84
Billings	40 57 24.18	+1.65	25.83		25.64	23.99
Cook	68 57 32.22	+0.01	32.23		32.70	32.69
Boston	107 37 31.04	-1.72	29.32		29.46	31.18
Eaton	157 57 12.48	-2.55	09.93		09.65	12.20

LIST OF DIRECTIONS

Station: Cook State: Indiana

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Boston	0 00 00.00	-1.55	58.45		58.40	59.95
Eaton	36 11 47.38	-2.30	45.08		45.25	47.55
Camden	82 07 15.12	-0.01	15.11		14.87	14.88
Oxford	137 02 53.21	+2.04	55.25		54.97	52.93
Billings	195 57 55.49	+1.46	56.95		57.35	55.89

FIGURE 55.—Lists of directions—Continued.

LIST OF DIRECTIONS

Station: Boston State: Indiana

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Richmond	0 00 00.00	-1.44	58.56		58.64	00.08
Mable	47 10 17.84	-2.23	15.61		15.51	17.74
Eaton	81 52 02.78	-0.68	02.10		01.94	02.62
Camden	138 57 31.61	+1.64	33.25		32.88	31.24
Cook	198 10 17.55	+1.55	19.10		19.65	18.10

LIST OF DIRECTIONS

Station: Eaton State: Ohio

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Camden	0 00 00.00	+2.55	02.55		03.37	00.82
Cook	45 04 54.46	+2.43	56.89		56.80	54.37
Boston	72 34 51.29	+0.72	52.01		52.24	51.52
Richmond	111 26 52.74	-0.88	51.86		51.21	52.09
Mable	169 03 08.58	-1.71	06.87		06.58	08.29

FIGURE 55.—Lists of directions—Continued.

LIST OF DIRECTIONS

Station: Mable State: Ohio

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Eaton	0 00 00.00	+1.70	01.70		01.89	00.19
Boston	48 49 59.05	+2.33	61.38		61.12	58.79
Richmond	81 51 33.98	+0.75	34.73		34.81	34.06

LIST OF DIRECTIONS

Station: Richmond State: Indiana

Observed Station	Observed Geodetic Direction	Correction	Observed Plane Direction		Adjusted Plane Direction	Adjusted Geodetic Direction
Walting	0 00 00.00					
Mable	65 41 52.60	-0.71	51.89		51.89	52.60
Eaton	106 14 02.85	+0.83	03.68		03.60	02.77
Boston	165 29 59.81	+1.43	61.24		61.33	59.90

FIGURE 55.—Lists of directions—Continued.

Computation of grid azimuths

Line	Azimuth and angle
Billings–Oxford	282 58 22.39
	−41 16 59.02
Billings–Camden	241 41 23.37
Camden–Billings	61 41 23.37
	+28 00 08.04
Camden–Cook	89 41 31.41
	+38 39 58.82
Camden–Boston	128 21 30.23
Boston–Camden	308 21 30.23
	−57 05 28.83
Boston–Eaton	251 16 01.40

Computation of coordinates

[The lengths are taken from the triangles on page 208 without grid reduction.

BILLINGS-CAMDEN			
9.9446766−10	9.6760023−10	2,213,183.22	749,348.98
4.7745756	4.7745756	+52,390.46	+28,221.36
4.7192522	4.4505779	2,265,573.68	777,570.34
CAMDEN-COOK			
9.9999937−10 *n*	7.7303438−10 *n*	2,265,573.68	777,570.34
4.6041455	4.6041455	−40,191.96	−216.02
4.6041392 *n*	2.3344893 *n*	2,225,381.72	777,354.32
CAMDEN-BOSTON			
9.8943960−10 *n*	9.7927968−10	2,265,573.68	777,570.34
4.6659954	4.6659954	−36,340.54	+28,760.22
4.5603914 *n*	4.4587922	2,229,233.14	806,330.56
BOSTON-EATON			
9.9763618−10	9.5067182−10	2,229,233.14	806,330.56
4.5727116	4.5727116	+35,405.72	+12,006.87
4.5490734	4.0794298	2,264,638.86	818,337.43

Fixed coordinates

Station	Coordinates x and y	Station	Coordinates x and y
	Feet		*Feet*
Billings	2,213,183.22 749,348.98	Mable	2,258,634.25 845,965.49
Oxford	2,251,546.85 740,511.16	Richmond	2,224,211.02 833,160.26

Adjusted coordinates

Station	Assumed coordinates	Correction	Adjusted coordinates
	Feet	*Feet*	*Feet*
1. Camden	2,265,573.68 777,570.34	+1.49 +1.17	2,265,575.17 777,571.51
2. Cook	2,225,381.72 777,354.32	+0.18 +0.75	2,225,381.90 777,355.07
3. Boston	2,229,233.14 806,330.56	−0.23 +1.33	2,229,232.91 806,331.89
4. Eaton	2,264,638.86 818,337.43	+0.51 +2.79	2,264,639.37 818,340.22

Computation of Azimuths

Billings-Cook

2,225,381.72	777,354.32
2,213,183.22	749,348.98
+ 12,198.50	+ 28,005.34
4.08630643	426,366
4.44724085	225,382
9.63906558 -10	651,748
	5.81408
	4.44724
	9.89547 -20
	0.15679
	+ 1".44

203° 32' 12".71

Billings-Camden

2,265,573.68	777,570.34
2,213,183.22	749,348.98
+ 52,390.46	+ 28,221.36
4.71925221	426,366
4.45057794	265,574
0.26867427	691,940
	5.84007
	4.45058
	9.89547 -20
	0.18612
	+ 1".54

241° 41' 23".37

Billings-Oxford

- 0".47

282° 58' 22".38

Oxford-Billings

503,094
213,183
716,277
5.85508
3.94635
9.89547 -20
9.69690 -10
+ 0".50

102° 58' 22".38

Oxford-Cook

2,225,381.72	777,354.32
2,251,546.85	740,511.16
-26,165.13	+ 36,843.16
4.41772290 n	4.56636
4.56635687	9.91133 -10
9.85136603 -10_n	4.65503
	503,094
	225,382
	728,476
	5.86242
	4.56636
	9.89547 -20
	0.32425
	+ 2".11

144° 37' 06".75

Oxford-Camden

2,265,573.68	777,570.34
2,251,546.85	740,511.16
+ 14,026.83	+ 37,059.18
4.14695953	
4.56889581	
9.57806372 -10	
	503,094
	265,574
	768,668
	5.88574
	4.56890
	9.89547 -20
	0.35011
	+ 2".24

200° 43' 53".61

FIGURE 56.—Computation of azimuths.

Camden-Oxford

	531,147
	251,547
	782,694
	5.89359
	4.56890 n
	9.89547 -20
	0.35796 n
	- 2".28

20° 43' 53".61

Camden-Billinge

	531,147
	213,183
	744,330
	5.87177
	4.45058 n
	9.89547 -20
	0.21782 n
	- 1".65

61° 41' 23".37

Camden-Cook

2,225,381.72	777,354.32
2,265,573.68	777,570.34
-40,191.96	- 216.02
4.60413919 n	531,147
2.33449396 n	225,382
2.26964523	756,529
	5.87883
	2.33449 n
	9.89547 -20
	8.10879 -10_n
	- 0".01

89° 41' 31".40

Camden-Boston

2,229,233.14	806,330.56
2,265,573.68	777,570.34
-36,340.54	+ 28,760.22
4.56039137 n	531,147
4.45879220	229,233
0.10159917 n	760,340
	5.88103
	4.45879
	9.89547 -20
	0.23529
	+ 1".72

128° 21' 30".24

Camden-Eaton

2,264,638.86	818,337.43
2,265,573.68	777,570.34
- 934.82	+ 40,767.09
2.97072800 n	531,147
4.61030971	264,639
8.36041829 -10_n	795,786
	5.90080
	4.61031
	9.89547 -20
	0.40658
	+ 2".55

178° 41' 11".02

Cook-Boston

2,229,233.14	806,330.56
2,225,381.72	777,354.32
+ 3,851.42	+ 28,976.24
3.58562088	450,763
4.46204203	229,233
9.12357885 -10	679,996
	5.83251
	4.46204
	9.89547 -20
	0.19002
	+ 1".55

187° 34' 16".23.

FIGURE 56.—Computation of azimuths—Continued.

Cook-Eaton

2,264,638.86	818,337.43
2,225,381.72	777,354.32
+ 39,257.14	+40,983.11
4.59391866	4.61260
4.61260491	9.85863 -10
9.98131375 -10	4.75397
	450,763
	264,639
	715,402
	5.85455
	4.61260
	9.89547 -20
	0.36262
	+ 2".30

223° 46' 03".92

Cook-Camden

450,763	
265,574	
716,337	
5.85512	
2.33449	
9.89547	-20
8.08508	-10
+ 0".01	

269° 41' 31".40

Cook-Oxford

450,763	
251,547	
702,310	
5.84653	
4.56636	n
9.89547	-20
0.30836	n
- 2".03	adopt-2".04

324° 37' 06".75

Cook-Billings

450,763	
213,183	
663,946	
5.82213	
4.44724	n
9.89547	-20
0.16484	n
- 1".46	

23° 32' 12".71

Boston-Richmond

2,224,211.02	833,160.26
2,229,233.14	806,330.56
-5,022.12	+ 26,829.70
3.70088709	n
4.42861582	
9.27227127 -10	n
	458,466
	224,212
	682,678
	5.83422
	4.42859
	9.89547 -20
	0.15828
	+ 1".44

169° 23' 51".99

Boston-Mable

2,258,634.25	845,965.49
2,229,233.14	806,330.56
+ 29,401.11	+ 39,634.93
4.46836372	4.59808
4.59807809	9.90480 -10
9.87028563 -10	4.69328
	458,466
	258,634
	717,100
	5.85558
	4.59808
	9.89547 -20
	0.34913
	+ 2".23

216° 34' 04".61

FIGURE 56.—Computation of azimuths—Continued.

Boston-Eaton

2,264,638.86	813,337.43
2,229,233.14	806,330.56
+ 35,405.72	+ 12,006 87
4.54907343	458,466
4.07942981	264,639
0.46964362	723,105
	5 85920
	4 07943
	9 89547 -20
	9.83410 -10
	+ 0".68

251° 16' 01".40

Boston-Camden

	458,466
	265,574
	724,040
	5.85976
	4.45879 n
	9.89547 -20
	0.21402 n
	- 1".64

308° 21' 30".24

Boston-Cook

	458,466
	225,382
	683,848
	5.83496
	4.46204 n
	9.89547 -20
	0.19247 n
	- 1".56 adopt -1".55

7° 34' 16".23

Eaton-Camden

	529,278
	265,574
	794,852
	5.90029
	4.61031 n
	9.89547 -20
	0.40607 n
	- 2".55

358° 41' 11".02

Eaton-Cook

	529,278
	225,382
	754,660
	5.87775
	4.61260 n
	9.89547 -20
	0.38582 n
	- 2".43

43° 46' 03".92

Eaton-Boston

	529,278
	229,233
	758,511
	5.87996
	4.07943 n
	9.89547 -20
	9.85486 -10_n
	- 0".72

71° 16' 01".40

FIGURE 56.—Computation of azimuths—Continued.

Eaton-Richmond

2,224,211.02	833,160.26
2,264,638.86	818,337.43
-40,427.84	+14,822.83
4.60668054 n	
4.17093113	
0.43574941 n	
	529,278
	224,212
	753,490
	5.87708
	4.17088
	9.89547 -20
	9.94343 -10
	+0.88

110° 08' 07.49

Eaton-Mable

2,258,634.25	845,965.49
2,264,638.86	818,337.43
-6,004.61	+27,628.06
3.77848480 n	4.44135
4.44135039	9.98998 -10
9.33713441 -10n	4.45137
	529,278
	258,634
	787,912
	5.89648
	4.44135
	9.89547 -20
	0.23330
	+1.71

167° 44' 17.44

Richmond-Mable

2,258,634.25	845,965.49
2,224,211.02	833,160.26
+34,423.23	+12,805.23
4.53685162	4.53684
4.10738739	9.97185 -10
0.42946423	4.56499
	448,424
	258,634
	707,058
	5.84946
	4.10744
	9.89547 -20
	9.85237 -10
	+0.71

249° 35' 42.39

Richmond-Eaton

	448,424
	264,639
	713,063
	5.85313
	4.17088 n
	9.89547 -20
	9.91948 -10n
	-0.83

290° 08' 07.49

FIGURE 56.—Computation of azimuths—Continued.

Richmond-Boston

448,424	
229,233	
677,657	
5.83101	
4.42859	n
9.89547	-20
0.15507	n
- 1".43	

349° 23' 51".99

Mable-Eaton

517,268	
264,639	
781,907	
5.89316	
4.44135	n
9.89547	-20
0.22998	n
- 1".70	

347° 44' 17".44

Mable-Boston

517,268	
229,233	
746,501	
5.87303	
4.59808	n
9.89547	-20
0.36658	n
- 2".33	

36° 34' 04".61

Mable-Richmond

517,268	
224,212	
741,480	
5.87010	
4.10744	n
9.89547	-20
9.87301	-10_n
- 0".75	

69° 35' 42".39

FIGURE 56.—Computation of azimuths—Continued.

Observation Equations

α_1 α_2 $\angle$ Obs. $\angle$			log cos α_1 log $\frac{1}{s_1}$ log $\frac{1}{\sin 1''}$	log sin α_1 log $\frac{1}{s_1}$ log $\frac{1}{\sin 1''}$	log cos α_1 log $\frac{1}{s_2}$ log $\frac{1}{\sin 1''}$	log sin α_1 log $\frac{1}{s_2}$ log $\frac{1}{\sin 1''}$
241°	41'	23.37"	9.67600 -10	9.94468 -10	9.96228 -10	9.60134 -10
203	32	12.71	5.22542 -10	5.22542 -10	5.51503 -10	5.51503 -10
			5.31443	5.31443	5.31443	5.31443
38	09	10.66				
38	09	10.45	0.21585	0.48453	0.79174	0.43080
		+ 0.21	+ 1.64	+ 3.05	+ 6.19	+ 2.70

$v_1 = + 0.21 + 1.64 \Delta x_1 - 3.05 \Delta y_1 - 6.19 \Delta x_2 + 2.70 \Delta y_2$

282°	58'	22.38"				
241	41	23.37				
41	16	59.01				
41	17	01.03				
		-2.02			+ 1.64	+ 3.05

$v_2 = - 2.02 - 1.64 \Delta x_1 + 3.05 \Delta y_1$

144°	37'	06.75"	9.91133 -10	9.76269 -10		
102	58	22.38	5.34497 -10	5.34497 -10		
			5.31443	5.31443		
41	38	44.37				
41	38	46.72	0.57073	0.42209 n		
		-2.35	+ 3.72	- 2.64		

$v_3 = - 2.39 + 3.72 \Delta x_2 + 2.64 \Delta y_2$

200°	43'	53.61"	9.97093 -10	9.54899 -10		
144	37	06.75	5.40203 -10	5.40203 -10		
			5.31443	5.31443		
56	06	46.86				
56	06	49.51	0.68739	0.26545		
		-2.65	+ 4.87	+ 1.84	+ 3.72	- 2.64

$v_4 = - 2.65 + 4.87 \Delta x_1 - 1.84 \Delta y_1 - 3.72 \Delta x_2 - 2.64 \Delta y_2$

FIGURE 57.—Observation equations.

61° 41' 23".37	9.67600 -10$_n$	9.94468 -10$_n$	9.97093 -10$_n$	9.54899 -10$_n$
20 43 53.61	5.22542 -10	5.22542 -10	5.40203 -10	5.40203 -10
40 57 29.76	5.31443	5.31443	5.31443	5.31443
40 57 23.55	0.21585 n	0.48453 n	0.68739 n	0.26545 n
+6.21	- 1.64	- 3.05	- 4.87	- 1.84

$v_5 = +6.21 - 3.23\,\Delta x_1 - 1.21\,\Delta y_1$

89° 41' 31".40	7.73035 -10$_n$	9.99999 -10$_n$		
61 41 23.37	5.39585 -10	5.39585 -10		
28 00 08.03	5.31443	5.31443		
28 00 06.40	8.44063 -10$_n$	0.71027 n		
+ 1.63	- 0.03	- 5.13	- 1.64	- 3.05

$v_6 = +1.63 - 1.61\,\Delta x_1 - 2.08\,\Delta y_1 - 0.03\,\Delta x_2 + 5.13\,\Delta y_2$

128° 21' 30".24	9.79280 -10	9.89440 -10$_n$		
89 41 31.40	5.33400 -10	5.33400 -10		
38 39 58.84	5.31443	5.31443		
38 39 57.09	0.44123	0.54283 n		
+1.75	+ 2.76	- 3.49	- 0.03	- 5.13

$v_7 = +1.75 - 2.79\,\Delta x_1 + 1.64\,\Delta y_1 + 0.03\,\Delta x_2 - 5.13\,\Delta y_2 + 2.76\,\Delta x_3 + 3.49\,\Delta y_3$

178° 41' 11".02	9.99989 -10	8.36030 -10$_n$		
128 21 30.24	5.38958 -10	5.38958 -10		
50 19 40.78	5.31443	5.31443		
50 19 40.61	0.70390	9.06431 -10$_n$		
+0.17	+ 5.06	- 0.12	+ 2.76	- 3.49

$v_8 = +0.17 - 2.30\,\Delta x_1 + 3.37\,\Delta y_1 - 2.76\,\Delta x_3 - 3.49\,\Delta y_3 + 5.06\,\Delta x_4 + 0.12\,\Delta y_4$

223° 46' 03".92	9.85863 -10	9.83994 -10	9.99620 -10	9.11978 -10
187 34 16.23	5.24603 -10	5.24603 -10	5.53416 -10	5.53416 -10
36 11 47.69	5.31443	5.31443	5.31443	5.31443
36 11 46.63	0.41909	0.40040	0.84479	9.96837 -10
+1.06	+ 2.62	+ 2.51	+ 7.00	+ 0.93

$v_9 = +1.06 + 4.38\,\Delta x_2 + 1.58\,\Delta y_2 - 7.00\,\Delta x_3 + 0.93\,\Delta y_3 + 2.62\,\Delta x_4 - 2.51\,\Delta y_4$

FIGURE 57.—Observation equations—Continued.

269°	41'	31.″40	7.73035	-10	9.99999	-10			
223	46	03.92	5.39585	-10	5.39585	-10			
			5.31443		5.31443				
45	55	27.48							
45	55	30.03	8.44063	-10	0.71027				
		-2.55	+ 0.03		+ 5.13		+ 2.62		+ 2.51

$$v_{10} = -2.55 + 0.03\,\Delta x_1 - 5.13\,\Delta y_1 + 2.59\,\Delta x_2 + 2.62\,\Delta y_2 - 2.62\,\Delta x_4 + 2.51\,\Delta y_4$$

324°	37'	06.″75	9.91133	-10_n	9.76269	-10			
269	41	31.40	5.34497	-10	5.34497	-10			
			5.31443		5.31443				
54	55	35.35							
54	55	40.14	0.57073		0.42209				
		-4.79	- 3.72		+ 2.64		+ 0.03		• 5.13

$$v_{11} = \cdot\ 4.79 - 0.03\,\Delta x_1 + 5.13\,\Delta y_1 + 3.75\,\Delta x_2 - 2.49\,\Delta y_2$$

23°	32'	12.″71	9.96228	-10_n	9.60134	-10_n			
324	37	06.75	5.51503	-10	5.51503	-10			
			5.31443		5.31443				
58	55	05.96							
58	55	01.70	0.79174	n	0.43080	n			
		+ 4.26	- 6.19		- 2.70		- 3.72		+ 2.64

$$v_{12} = +4.26 + 2.47\,\Delta x_2 - 5.34\,\Delta y_2$$

216°	34'	04.″61	9.90480	-10	9.77508	-10	9.99252	-10	9.26472	-10_n
169	23	51.99	5.30672	-10	5.30672	-10	5.56393	-10	5.56393	-10
			5.31443		5.31443		5.31443		5.31443	
47	10	12.62								
47	10	17.05	0.52595		0.39623		0.87088		0.14308	n
		-4.43	+ 3.36		+ 2.49		+ 7.43		- 1.39	

$$v_{13} = -4.43 + 4.07\,\Delta x_3 + 3.88\,\Delta y_3$$

251°	16'	01.″40	9.50672	-10	9.97636	-10			
216	34	04.61	5.42729	-10	5.42729	-10			
			5.31443		5.31443				
34	41	56.79							
34	41	46.49	0.24844		0.71808				
		+ 10.30	+ 1.77		+ 5.22		• 3.36		+ 2.49

$$v_{14} = +10.30 + 1.59\,\Delta x_3 + 2.73\,\Delta y_3 + 1.77\,\Delta x_4 - 5.22\,\Delta y_4$$

FIGURE 57.—Observation equations—Continued.

308°	21'	30.24	9.79280 -10$_n$	9.89440 -10			
251	16	01.40	5.33400 -10	5.33400 -10			
			5.31443	5.31443			
57	05	28.84					
57	05	31.15	0.44123 n	0.54283			
		-2.31	-2.76	+ 3.49	+ 1.77	+ 5.22	

$$v_{15} = -2.31 - 2.76\Delta x_1 - 3.49\Delta y_1 + 4.53\Delta x_3 - 1.73\Delta y_3 - 1.77\Delta x_4 + 5.22\Delta y_4$$

7°	34'	16.23	9.99620 -10$_n$	9.11978 -10$_n$		
308	21	30.24	5.53416 -10	5.53416 -10		
			5.31443	5.31443		
59	12	45.99				
59	12	45.85	0.84479 n	9.96837 -10$_n$		
		+ 0.14	- 7.00	- 0.93	- 2.76	+ 3.49

$$v_{16} = +0.14 + 2.76\Delta x_1 + 3.49\Delta y_1 - 7.00\Delta x_2 + 0.93\Delta y_2 + 4.24\Delta x_3 - 4.42\Delta y_3$$

43°	46'	03.92	9.85863 -10$_n$	9.83994 -10$_n$	9.99989 -10$_n$	8.36030 -10		
358	41	11.02	5.24603 -10	5.24603 -10	5.38958 -10	5.38958 -10		
45	04	52.90	5.31443	5.31443	5.31443	5.31443		
45	04	54.34	0.41909 n	0.40040 n	0.70390 n	9.06431 -10		
		-1.44	- 2.62	- 2.51	- 5.06	+ 0.12		

$$v_{17} = -1.44 + 5.06\Delta x_1 + 0.12\Delta y_1 - 2.62\Delta x_2 + 2.51\Delta y_2 - 2.44\Delta x_4 - 2.63\Delta y_4$$

71°	16'	01.40	9.50672 -10$_n$	9.97636 -10$_n$		
43	46	03.92	5.42729 -10	5.42729 -10		
			5.31443	5.31443		
27	29	57.48				
27	29	55.12	0.24844 n	0.71808 n		
		+ 2.36	- 1.77	- 5.22	- 2.62	- 2.51

$$v_{18} = +2.36 + 2.62\Delta x_2 - 2.51\Delta y_2 - 1.77\Delta x_3 + 5.22\Delta y_3 - 0.85\Delta x_4 - 2.71\Delta y_4$$

110°	08'	07.49	9.53683 -10	9.97261 -10$_n$		
71	16	01.40	5.36595 -10	5.36595 -10		
			5.31443	5.31443		
38	52	06.09				
38	51	59.85	0.21721	0.65299 n		
		+ 6.24	+ 1.65	- 4.50	- 1.77	- 5.22

$$v_{19} = +6.24 + 1.77\Delta x_3 - 5.22\Delta y_3 - 3.42\Delta x_4 + 0.72\Delta y_4 + 1.65\Delta x_5 + 4.50\Delta y_5$$

FIGURE 57.—Observation equations—Continued.

167° 44' 17".44	9.98998 -10	9.32711 -10_n				
110 08 07.49	5.54863 -10	5.54863 -10				
57 36 09.95	5.31443	5.31443				
57 36 15.01	0.85304	0.19017 n				
-5.06	+ 7.13	- 1.55	+ 1.65	- 4.50		

$$v_{20} = - 5.06 - 5.48 \Delta x_4 + 2.95 \Delta y_4$$

36° 34' 04".61	9.90480 -10_n	9.77508 -10_n	9.98998 -10_n	9.32711 -10		
347 44 17.44	5.30672 -10^n	5.30672 -10^n	5.54863 -10^n	5.54863 -10		
48 49 47.17	5.31443	5.31443	5.31443	5.31443		
48 49 59.68	0.52595 n	0.39623 n	0.85304 n	0.19017		
-12.51	- 3.36	- 2.49	- 7.13	+ 1.55		

$$v_{21} = - 12.51 - 3.36 \Delta x_3 + 2.49 \Delta y_3 + 7.13 \Delta x_4 + 1.55 \Delta y_4$$

69° 35' 42".39				
36 34 04.61				
33 01 37.78				
33 01 33.35				
+ 4.43			+ 3.36	- 2.49

$$v_{22} = + 4.43 + 3.36 \Delta x_3 - 2.49 \Delta y_3$$

290° 07' 07".49	9.53683 -10_n	9.97261 -10		
249 35 42.39	5.36595 -10	5.36595 -10		
40 32 25.10	5.31443	5.31443		
40 32 11.79	0.21721	0.65299		
+ 13.31	- 1.65	+ 4.50		

$$v_{23} = + 13.31 - 1.65 \Delta x_4 - 4.50 \Delta y_4$$

349° 23' 51".99	9.99252 -10_n	9.26472 -10		
290 08 07.49	5.56393 -10	5.56393 -10		
59 15 44.50	5.31443	5.31443		
59 15 57.56	0.87088 n	0.14308		
-13.06	- 7.43	+ 1.39	- 1.65	+ 4.50

$$v_{24} = - 13.06 - 7.43 \Delta x_3 - 1.39 \Delta y_3 + 1.65 \Delta x_4 + 4.50 \Delta y_4$$

FIGURE 57.—Observation equations—Continued.

Table for formation of normal equations

	Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	η	Σ	v	Adopted v
1	+1.64	−3.05	−6.19	+2.70					+0.21	−4.69	+0.0139	+0.01
2	−1.64	+3.05							−2.02	−0.61	−0.8996	−0.90
3			+3.72	+2.64					−2.35	+4.01	+0.3104	+0.31
4	+4.87	−1.84	−3.72	−2.64					−2.65	−5.98	−0.1937	−0.19
5	−3.23	−1.21							+6.21	+1.77	−0.0271	−0.03
6	−1.61	−2.08	−0.03	+5.13					+1.63	+3.04	+0.6582	+0.66
7	−2.79	+1.64	+0.03	−5.13	+2.76	+3.49			+1.75	+1.75	−0.3328	−0.33
8	−2.30	+3.37			−2.76	−3.49	+5.06	+0.12	+0.17	+0.17	−0.4222	−0.42
9			+4.38	+1.58	−7.00	+0.93	+2.62	−2.51	+1.06	+1.06	+0.2244	+0.22
10	+0.03	−5.13	+2.59	+2.62			−2.62	+2.51	−2.55	−2.55	−0.4090	−0.41
11	−0.03	+5.13	+3.75	−2.49					−4.79	+1.57	−0.0374	−0.04
12			+2.47	−5.34					+4.26	+1.39	+0.6753	+0.68
13					+4.07	+3.88			−4.43	+3.52	−0.1807	−0.18
14					+1.59	+2.73	+1.77	−5.22	+10.30	+11.17	−0.0658	−0.06
15	−2.76	−3.49			+4.53	−1.73	−1.77	+5.22	−2.31	−2.31	−0.2109	−0.21
16	+2.76	+3.49	−7.00	+0.93	+4.24	−4.42			+0.14	+0.14	+0.9175	+0.92
17	+5.06	+0.12	−2.62	+2.51			−2.44	−2.63	−1.44	−1.44	−0.9059	−0.91
18			+2.62	−2.51	−1.77	+5.22	−0.85	−2.71	+2.36	+2.36	+0.3191	+0.32
19					+1.77	−5.22	−3.42	+0.72	+6.24	+0.09	−0.8768	−0.88
20							−5.48	+2.95	−5.06	−7.59	+0.3578	+0.36
21					−3.36	+2.49	+7.13	+1.55	−12.51	−4.70	−0.4452	−0.45
22					+3.36	−2.49			+4.43	+5.30	+0.3384	+0.34
23							−1.65	−4.50	+13.31	+7.16	−0.0810	−0.08
24					−7.43	−1.39	+1.65	+4.50	−13.06	−15.73	+0.1733	+0.17

Normal equations

	Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	η	Σ
Δx_1	+96. 0358	−4. 4701	−60. 9154	+13. 0453	−2. 1528	−9. 1345	−19. 1778	−27. 9157	−37. 6616	−52. 3468
Δy_1		+118. 8360	+7. 0423	−45. 1284	−5. 7869	−15. 4258	+36. 3773	−31. 0053	−12. 5006	+47. 9385
Δx_2			+174. 7794	−25. 8627	−64. 8946	+48. 7945	+8. 8556	−4. 7025	−0. 6063	+82. 4903
Δy_2				+131. 4046	−16. 8329	−33. 6471	−6. 7157	+2. 8112	−24. 4919	−5. 4176
Δx_3					+205. 8766	−18. 5745	−78. 2746	+0. 0137	+146. 2388	+165. 6128
Δy_3						+139. 0908	+21. 5470	−46. 3344	−23. 4727	+62. 8433
Δx_4							+150. 2830	−15. 0302	−92. 1731	+5. 6915
Δy_4								+133. 4958	−225. 9630	−214. 6304
η									+836. 7994	+566. 1690
Σ										+658. 3506

Solution of normal equations

Δx_1	Δy_1	Δx_2	Δy_2	Δx_3	Δy_3	Δx_4	Δy_4	η	Σ
+96.0358	−4.4701	−60.9154	+13.0453	−2.1528	−9.1345	−19.1778	−27.9157	−37.6616	−52.3468
Δx_1	+0.046546	+0.634299	−0.135838	+0.022417	+0.095116	+0.199694	+0.290680	+0.392162	+0.545076
	+118.8360	+7.0423	−45.1284	−5.7869	−15.4258	+36.3773	−31.0053	−12.5006	+47.9385
Δx_1	−0.2081	−2.8354	+0.6072	−0.1002	−0.4252	−0.8926	−1.2994	−1.7530	−2.4365
	+118.6279	+4.2069	−44.5212	−5.8871	−15.8510	+35.4847	−32.3047	−14.2536	+45.502019
	Δy_1	−0.035463	+0.375301	+0.049627	+0.133619	−0.299126	+0.272320	+0.120154	−0.383568
		+174.7794	−25.8627	−64.8946	+48.7945	+8.8556	−4.7025	−0.6063	+82.4903
	Δx_1	−38.6386	+8.2746	−1.3655	−5.7940	−12.1645	−17.7069	−23.8887	−33.2035
	Δy_1	−0.1492	+1.5789	+0.2088	+0.5621	−1.2584	+1.1456	+0.5055	−1.6136
		+135.9916	−16.0092	−66.0513	+43.5626	−4.5673	−21.2638	−23.9895	+47.67321
		Δx_2	+0.117722	+0.485701	−0.320333	+0.033585	+0.156361	+0.176404	−0.35053960
			+131.4046	−16.8329	−33.6471	−6.7157	+2.8112	−24.4919	−5.4176
		Δx_1	−1.7720	+0.2924	+1.2408	+2.6051	+3.7920	+5.1159	+7.1107
		Δy_1	−16.7089	−2.2094	−5.9489	+13.3174	−12.1240	−5.3494	+17.0769
		Δx_2	−1.8846	−7.7757	+5.1283	−0.5377	−2.5032	−2.8241	+5.6122
			+111.0391	−26.5256	−33.2269	+8.6691	−8.0240	−27.5495	+24.3822
			Δy_2	+0.238885	+0.299236	−0.078072	+0.072263	+0.248106	−0.219582
			+205.8766	−18.5745	−78.2746	+0.0137	+146.2388	+165.6128
		Δx_1	−0.0483	−0.2048	−0.4299	−0.6258	−0.8443	−1.1735
		Δy_1	−0.2922	−0.7866	+1.7610	−1.6032	−0.7074	+2.2581
		Δx_2	−32.0812	+21.1584	−2.2183	−10.3278	−11.6517	+23.1549
		Δy_2	−6.3366	−7.9374	+2.0709	−1.9168	−6.5812	+5.8245
			+167.1183	−6.3449	−77.0909	−14.4599	+126.4542	+195.6768
			Δx_3	+0.037967	+0.461295	+0.086525	−0.756675	−1.170888
				+139.0908	+21.5470	−46.3344	−23.4727	+62.8433
			Δx_1	−0.8688	−1.8241	−2.6552	−3.5822	−4.9790
			Δy_1	−2.1180	+4.7414	−4.3165	−1.9046	+6.0799
			Δx_2	−13.9545	+1.4631	+6.8115	+7.6846	−15.2713
			Δy_2	−9.9427	+2.5941	−2.4011	−8.2438	+7.2960
			Δx_3	−0.2409	−2.9269	−0.5490	+4.8011	+7.4293
				+111.9659	+25.5946	−49.4447	−24.7176	+63.3982
				Δy_3	−0.228593	+0.441605	+0.220760	−0.566228

	Δx_4	Δy_4	η	Σ
	+150.2830	−15.0302	−92.1731	+5.6915
Δx_1	−3.8297	−5.5746	−7.5208	−10.4533
Δy_1	−10.6144	+9.6632	+4.2636	−13.6108
Δx_2	−0.1534	−0.7141	−0.8057	+1.6011
Δy_2	−0.6768	+0.6264	+2.1508	−1.9036
Δx_3	−35.5616	−6.6703	+58.3327	+90.2647
Δy_3	−5.8507	+11.3027	+5.6503	−14.4924
	+93.5964	−6.3969	−30.1022	+57.09723
	Δx_4	+0.068346	+0.321617	−0.610037
		+133.4958	−225.9630	−214.6304
	Δx_1	−8.1145	−10.9475	−15.2162
	Δy_1	−8.7972	−3.8815	+12.3911
	Δx_2	−3.3248	−3.7510	+7.4542
	Δy_2	−0.5798	−1.9908	+1.7619
	Δx_3	−1.2511	+10.9414	+16.9309
	Δy_3	−21.8350	−10.9154	+27.9970
	Δx_4	−0.4372	−2.0574	+3.9024
		+89.1562	−248.5652	−159.40910
		Δy_4	+2.787974	+1.787974
			+836.7994	+566.1690
		Δx_1	−14.7694	−20.5284
		Δy_1	−1.7126	+5.4672
		Δx_2	−4.2318	+8.4097
		Δy_2	−6.8352	+6.0494
		Δx_3	−95.6847	−148.0637
		Δy_3	−5.4567	+13.9958
		Δx_4	−9.6814	+18.3635
		Δy_4	−692.9933	−444.4281
			+5.4343	+5.4344
				+658.3506
			Δx_1	−28.5330
			Δy_1	−17.4531
			Δx_2	−16.7123
			Δy_2	−5.3539
			Δx_3	−229.1156
			Δy_3	−35.8978
			Δx_4	−34.8315
			Δy_4	−285.0191
				+E.4343

Back solution

Δy_4	Δx_4	Δy_3	Δx_3	Δy_2	Δx_2	Δy_1	Δx_1
+2.78797	+0.32162	+0.22076	−0.75668	+0.24811	+0.17640	+0.12015	+0.39216
	+0.19055	+1.23118	+0.24123	+0.20147	+0.43593	+0.75922	+0.81041
	+0.51217	−0.11708	+0.23626	−0.03999	+0.01720	−0.15320	+0.10228
		+1.33486	+0.05068	+0.39944	−0.42760	+0.17836	+0.12697
			−0.22851	−0.05459	−0.11099	−0.01134	−0.00512
				+0.75444	+0.08881	+0.28314	−0.10248
					+0.17975	−0.00637	+0.11402
						+1.16996	+0.05446
							+1.49270

Computation of corrections

1	2	3	4	5	6	7	8
+0.2100	−2.0200	−2.3500	−2.6500	+6.2100	+1.6300	+1.7500	+0.1700
+2.4480	−2.4480	+0.6687	+7.2694	−4.8214	−2.4032	−4.1646	−3.4332
−3.5684	+3.5684	+1.9917	−2.1527	−1.4157	−2.4335	+1.9187	+3.9428
−1.1127	−0.8996	+0.3104	−0.6687	−0.0271	−0.0054	+0.0054	+0.6307
+2.0370			−1.9917		+3.8703	−3.8703	−4.6587
+0.0139	−0.90	+0.31	−0.1937	−0.03	+0.6582	−0.6307	+2.5916
						+4.6587	+0.3346
+0.01			−0.19		+0.66	−0.3328	−0.4222
						−0.33	−0.42

9	10	11	12	13	14	15	16
+1.0600	−2.5500	−4.7900	+4.2600	−4.4300	+10.3000	−2.3100	+0.1400
+0.7873	+0.0448	−0.0448	+0.4440	−0.9300	−0.3633	−4.1199	+4.1199
+1.1920	−6.0019	+6.0019	−4.0287	+5.1793	+3.6442	−4.0832	+4.0832
+1.5996	+0.4656	+0.6741	+0.6753	−0.1807	+0.9065	−1.0352	−1.2582
+1.2414	+1.9766	−1.8786			−14.5532	−2.3093	+0.7016
+1.3419	−1.3419	−0.0374	+0.68	−0.18	−0.0658	−0.9065	−0.9689
−6.9978	+6.9978					+14.5532	−5.9001
+0.2244	−0.4090	−0.04			−0.06	−0.2109	+0.9175
+0.22	−0.41					−0.21	+0.92

17	18	19	20	21	22	23	24
−1.4400	+2.3600	+6.2400	−5.0600	−12.5100	+4.4300	+13.3100	−13.0600
+7.5531	+0.4709	−0.4045	−2.8067	+0.7678	−0.7678	−0.8451	+1.6978
+0.1404	−1.8936	−6.9680	+8.2245	+3.3238	−3.3238	−12.5459	−1.8555
−0.4709	+0.4045	−1.7516	+0.3578	+3.6518	+0.3384	−0.0810	+0.8451
+1.8936	+6.9680	+2.0073		+4.3214			+12.5459
−1.2497	−0.4353	−0.8768	+0.36	−0.4452	+0.34	−0.08	+0.1733
−7.3324	−7.5554						
−0.9059	+0.3191	−0.88		−0.45			+0.17
−0.91	+0.32						

$\Sigma p^2 = +5.4332$

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 25
Ed. Jan., 1929

COMPUTATION OF TRIANGLES

State: Ind. & Ohio

Plane

NO.		STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3							4.5951484
12	1	Cook	58 55 01.70	+0.68			02.38	0.0673115 5
3	2	Oxford	41 38 46.72	+0.31			47.03	9.8225156 0
1+2	3	Billings	79 26 11.48	-0.89			10.59	9.9925763 2
	1-3			+0.10				4.4849756
	1-2		59.90					4.6550363
	2-3							4.5951484
5	1	Camden	40 57 23.55	-0.03			23.52	0.1834363 9
3+4	2	Oxford	97 45 36.23	+0.12			36.35	9.9960044 6
2	3	Billings	41 17 01.03	-0.90			00.13	9.8194015 0
	1-3			+0.81				4.7745892
	1-2		00.81					4.5979863
	2-3							4.6550363
5+6	1	Camden	68 57 29.95	+0.63			30.58	0.0299691 6
4	2	Oxford	56 06 49.51	-0.19			49.32	9.9191542 8
11	3	Cook	54 55 40.14	-0.04			40.10	9.9129808 4
	1-3			+0.40				4.6041597
	1-2		59.60					4.5979863
	2-3							4.4849756
6	1	Camden	28 00 06.40	+0.66			07.06	0.3283627 5
1	2	Billings	38 09 10.45	+0.01			10.46	9.7908213 6
11+12	3	Cook	113 50 41.84	+0.64			42.48	9.9612509 0
	1-3			+1.31				4.6041597
	1-2		58.69					4.7745892

FIGURE 58.—Final computation of triangles, Indiana.

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State: Ind. & Ohio

Plane

NO.		STATION	OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3							4.6041597
16	1	Boston	59 12 45.85	+0.92			46.77	0.0659684 3
7	2	Camden	38 39 57.09	-0.33			56.76	9.7957245 1
9+10	3	Cook	82 07 16.66	-0.19			16.47	9.9958809 4
	1-3			+0.40				4.4658526 +1
	1-2		59.60					4.6660091
	2-3							4.6041597
17	1	Eaton	45 04 54.34	-0.91			53.43	0.1498980 6
7+8	2	Camden	88 59 37.70	-0.75			36.95	9.9999330 0
10	3	Cook	45 55 30.03	-0.41			29.62	9.8563836 1
	1-3			-2.07				4.7539908
	1-2		02.07					4.6104414
	2-3							4.6660091
17+18	1	Eaton	72 34 49.46	-0.59			48.87	0.0203892 0
8	2	Camden	50 19 40.61	-0.42			40.19	9.8863269 8
15	3	Boston	57 05 31.15	-0.21			30.94	9.9240431 2
	1-3			-1.22				4.5727253
	1-2		01.22					4.6104414
	2-3							4.4658527
18	1	Eaton	27 29 55.12	+0.32			55.44	0.3356128 4
9	2	Cook	36 11 46.63	+0.22			46.85	9.7712597 8
15+16	3	Boston	116 18 17.00	+0.71			17.71	9.9525252 9
	1-3			+1.25				4.5727253
	1-2		58.75					4.7539908

FIGURE 58.—Final computation of triangles, Indiana—Continued.

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State: Ind. & Ohio.

NO.	STATION	Plane OBSERVED ANGLE	CORR'N	SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3						4.5727253
24	1 Richmond	59 15 57.56	+0.17			57.73	0.0657291 2
19	2 Eaton	38 51 59.85	-0.88			58.97	9.7976180 9
13+14	3 Boston	81 52 03.54	-0.24			03.30	9.9956105 3
	1-3		-0.95				4.4360725
	1-2	00.95					4.6340649
	2-3						4.5727253
21	1 Mable	48 49 59.68	-0.45			59.23	0.1233229 7
19+20	2 Eaton	96 28 14.86	-0.52			14.34	9.9972245 7
14	3 Boston	34 41 46.49	-0.06			46.43	9.7552843 0
	1-3		-1.03				4.6932728
	1-2	01.03					4.4513326 -1
	2-3						4.6340649
21+22	1 Mable	81 51 33.03	-0.11			32.92	0.0043986 1
20	2 Eaton	57 36 15.01	+0.36			15.37	9.9265316 9
23	3 Richmond	40 32 11.79	-0.08			11.71	9.8128689 1
	1-3		+0.17				4.5649952 -1
	1-2	59.83					4.4513324 +1
	2-3						4.4360725
22	1 Mable	33 01 33.35	+0.34			33.69	0.2635876 2
13	2 Boston	47 10 17.05	-0.18			16.87	9.8653350 2
23+24	3 Richmond	99 48 09.35	+0.09			09.44	9.9936126 1
	1-3		+0.25				4.5649951
	1-2	59.75					4.6932727 +1

FIGURE 58.—Final computation of triangles, Indiana—Continued.

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State: Indiana and Ohio

NO.		STATION	Geodetic OBSERVED ANGLE	CORR'N	Geod. SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3							4.0791519
12	1	Cook	58 55 02.28	+0.68	02.96	0.09	02.87	0.0673109 3
3	2	Oxford	41 38 48.33	+0.31	48.64	0.09	48.55	9.8225192 0
1+2	3	Billings	79 26 09.57	-0.89	08.68	0.10	08.58	9.9925755 3
	1-3			+0.10		0.28		3.9689820
	1-2		00.18					4.1390384
	2-3							4.0791519
5	1	Camden	40 57 24.18	-0.03	24.15	0.12	24.03	0.1834351 5
3+4	2	Oxford	97 45 37.97	+0.12	38.09	0.12	37.97	9.9960040 0
2	3	Billings	41 16 59.02	-0.90	58.12	0.12	58.00	9.8193963 9
	1-3			-0.81		0.36		4.2585910
	1-2		01.17					4.0819834
	2-3							4.1390384
5+6	1	Camden	6 57 32.22	+0.63	32.85	0.11	32.74	0.0299674 1
4	2	Oxford	56 06 49.64	-0.19	49.45	0.12	49.33	9.9191543 0
11	3	Cook	54 55 38.09	-0.04	38.05	0.12	37.93	9.9129776 3
	1-3			+0.40		0.35		4.0881601 -1
	1-2		59.95					4.0819834
	2-3							3.9689820
6	1	Camden	28 00 08.04	+0.66	08.70	0.09	08.61	0.3283566 1
1	2	Billings	38 09 10.55	+0.01	10.56	0.09	10.47	9.7908213 9
11+12	3	Cook	113 50 40.37	+0.64	41.01	0.09	40.92	9.9612523 5
	1-3			+1.31		0.27		4.0881600
	1-2		58.96					4.2585910

FIGURE 58.—Final computation of triangles, Indiana—Continued.

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COMPUTATION OF TRIANGLES

State: Indiana and Ohio

NO.		STATION	Geodetic OBSERVED ANGLE	CORR'N	Geod. SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3							4.0881600
16	1	Boston	59 12 45.94	+0.92	46.86	0.09	46.77	0.0659684 3
7	2	Camden	38 39 58.82	-0.33	58.49	0.09	58.40	9.7957288 3
9+10	3	Cook	82 07 15.12	-0.19	14.93	0.10	14.83	9.9958804 6
	1-3			+0.40		0.28		3.9498573
	1-2		59.88					4.1500089
	2-3							4.0881600
17	1	Eaton	45 04 54.46	-0.91	53.55	0.13	53.42	0.1498980 8
7+8	2	Camden	88 59 40.26	-0.75	39.51	0.13	39.38	9.9999330 9
10	3	Cook	45 55 27.74	-0.41	27.33	0.13	27.20	9.8563786 8
	1-3			-2.07		0.39		4.2379912
	1-2		02.46					4.0944368
	2-3							4.1500089
17+18	1	Eaton	72 34 51.29	-0.59	50.70	0.12	50.58	0.0203880 7
8	2	Camden	50 19 41.44	-0.42	41.02	0.11	40.91	9.8863282 3
15	3	Boston	57 05 28.83	-0.21	28.62	0.11	28.51	9.9240398 0
	1-3			-1.22		0.34		4.0567252
	1-2		01.56					4.0944368
	2-3							3.9498573
18	1	Eaton	27 29 56.83	+0.32	57.15	0.08	57.07	0.3356062 5
9	2	Cook	36 11 47.38	+0.22	47.60	0.08	47.52	9.7712617 1
15+16	3	Boston	116 18 14.77	+0.71	15.48	0.07	15.41	9.9525276 8
	1-3			+1.25		0.23		4.0567253 -1
	1-2		58.98					4.2379912

FIGURE 58.—Final computation of triangles, Indiana—Continued.

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NO.		STATION	Geodetic OBSERVED ANGLE	CORR'N	Geod. SPHER'L ANGLE	SPHER'L EXCESS	PLANE ANGLE AND DISTANCE	LOGARITHM
	2-3							4.0567252
24	1	Richmond	59 15 56.96	+0.17	57.13	0.08	57.05	0.0657299 7
19	2	Eaton	38 52 01.45	-0.88	00.57	0.08	00.49	9.7976220 6
13+14	3	Boston	81 52 02.78	-0.24	00.54	0.08	02.46	9.9956102 8
	1-3			-0.95		0.24		3.9200772+1
	1-2		01.19					4.1180654
	2-3							4.0567252
21	1	Mable	48 49 59.05	-0.45	58.60	0.08	58.52	0.1233242 7
19+20	2	Eaton	96 28 17.29	-0.52	16.77	0.09	16.68	9.9972240 1
14	3	Boston	34 41 44.94	-0.06	44.88	0.08	44.80	9.7552793 4
	1-3			-1.03		0.25		4.1772735
	1-2		01.28					3.9353288-1
	2-3							4.1180654
21+22	1	Mable	81 51 33.98	-0.11	33.87	0.08	33.79	0.0043983 5
20	2	Eaton	57 36 15.84	+0.36	16.20	0.08	16.12	9.9265326 9
23	3	Richmond	40 32 10.25	-0.08	10.17	0.08	10.09	9.8128649 1
	1-3			+0.17		0.24		4.0489964
	1-2		00.07					3.9353287
	2-3							3.9200773
22	1	Mable	33 01 34.93	+0.34	35.27	0.08	35.19	0.2635827 6
13	2	Boston	47 10 17.84	-0.18	17.66	0.08	17.58	9.8653364 0
23+24	3	Richmond	99 48 07.21	+0.09	07.30	0.07	07.23	9.9936134 1
	1-3			+0.25		0.23		4.0489965-1
	1-2		59.98					4.1772735

FIGURE 58.—Final computation of triangles, Indiana—Continued.

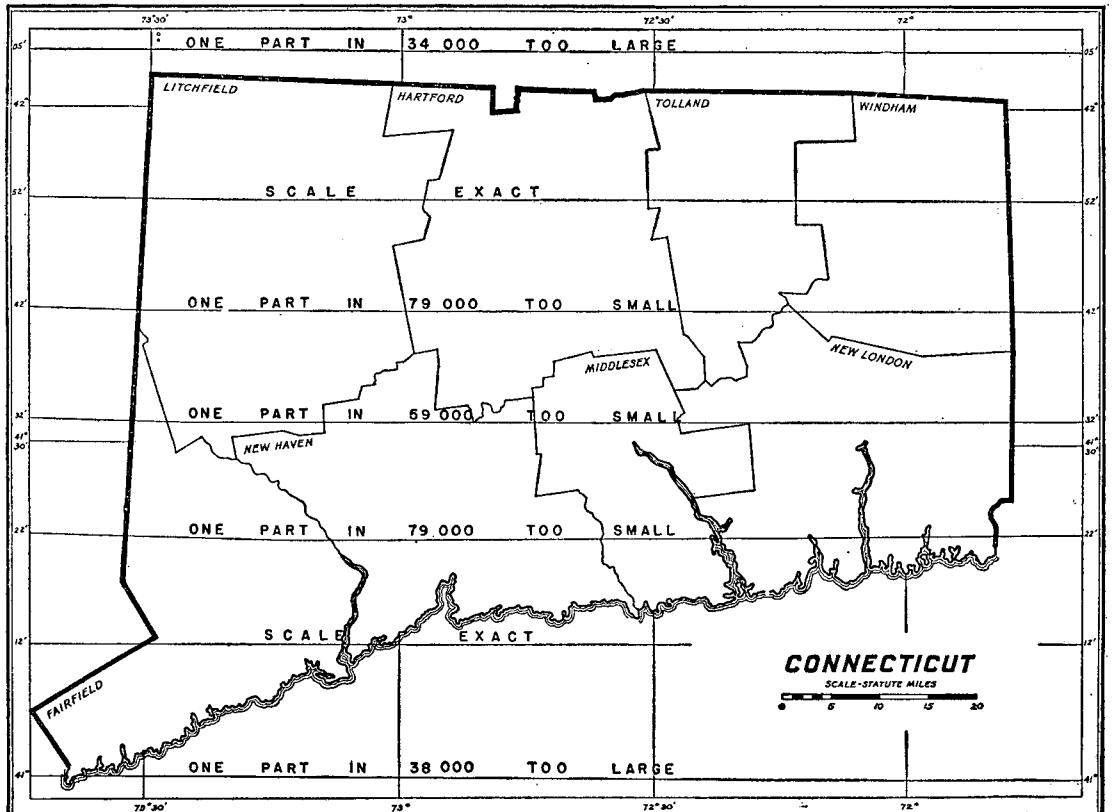

FIGURE 59.—Map of Connecticut with grid system outline.

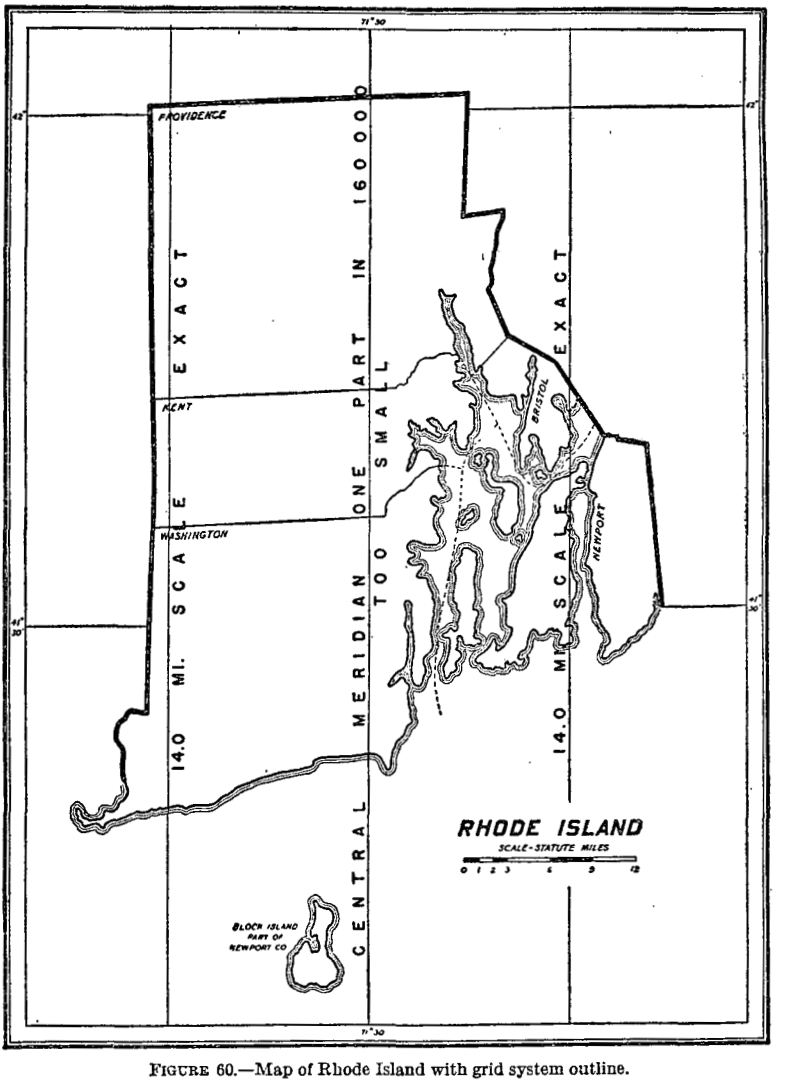

FIGURE 60.—Map of Rhode Island with grid system outline.

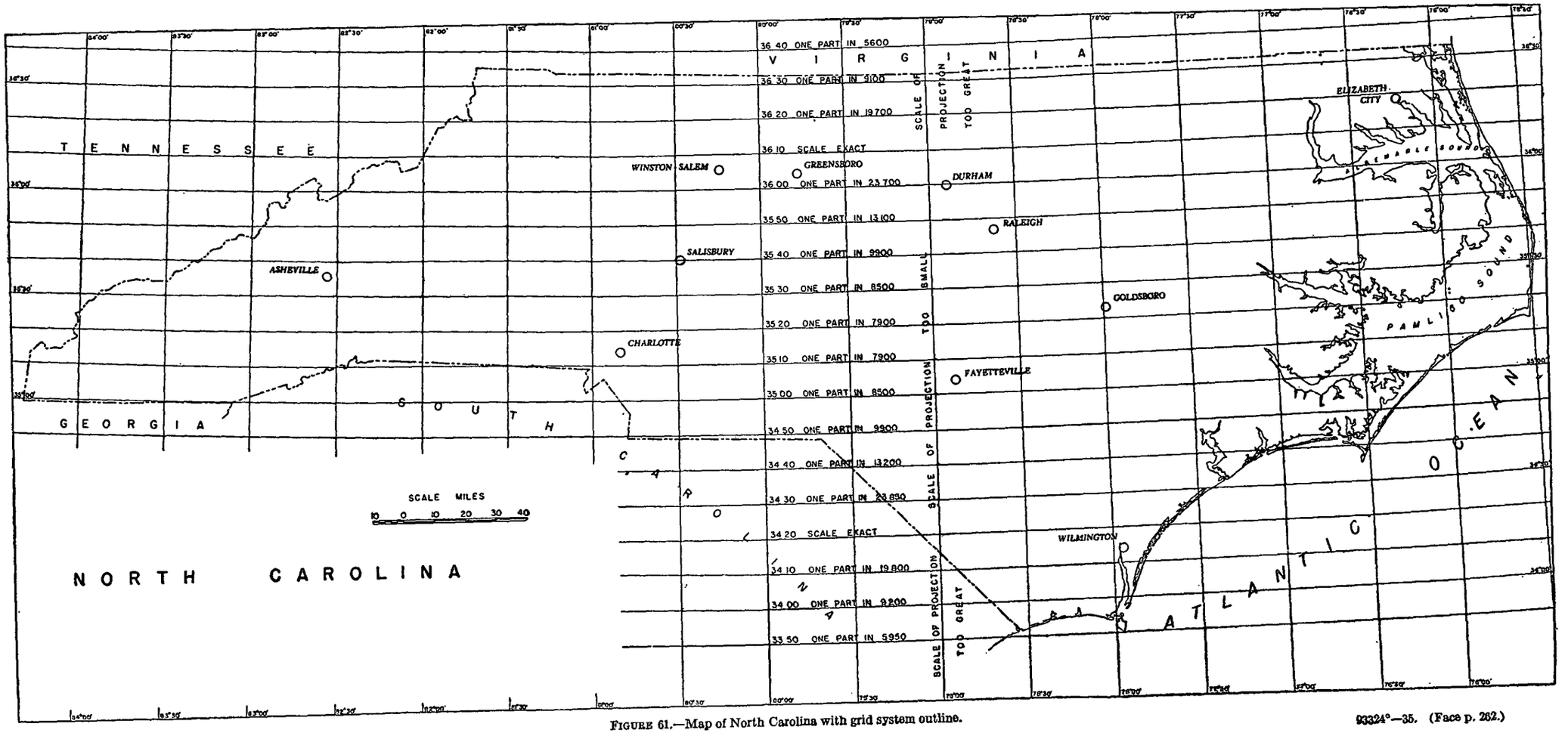

FIGURE 61.—Map of North Carolina with grid system outline.

93324°—35. (Face p. 262.)

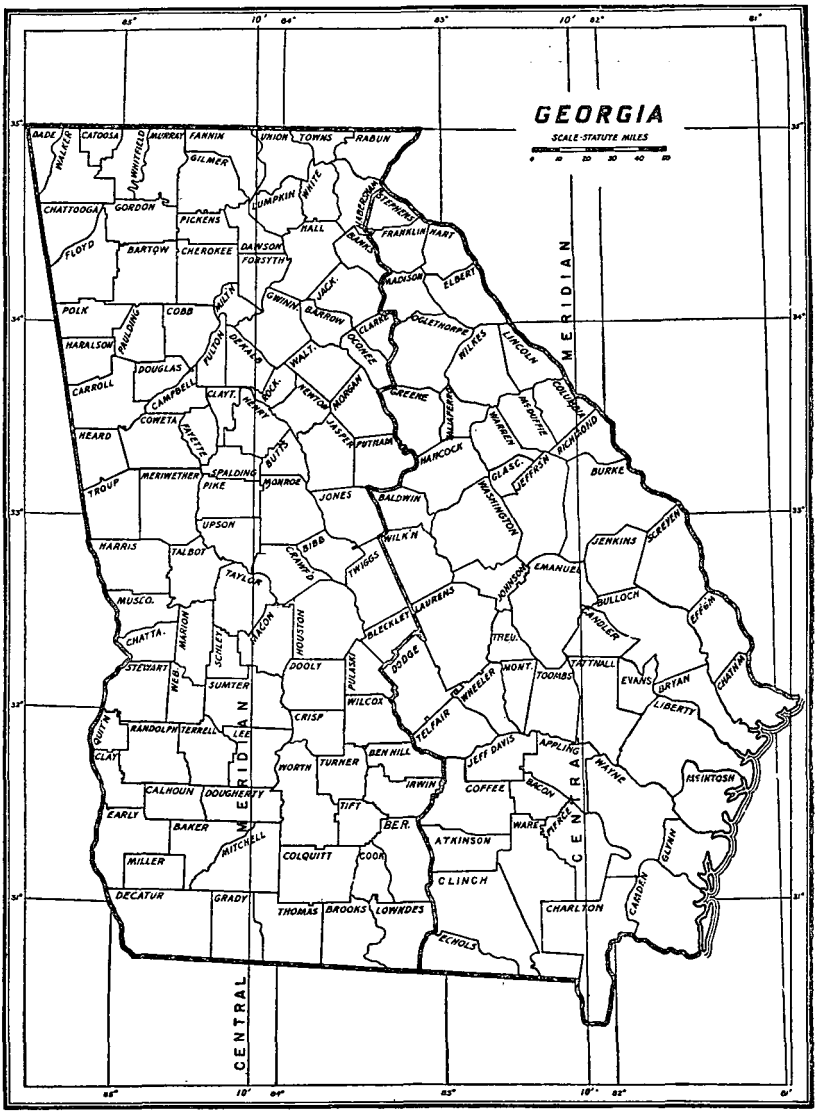

FIGURE 62.—Map of Georgia with grid system outline.

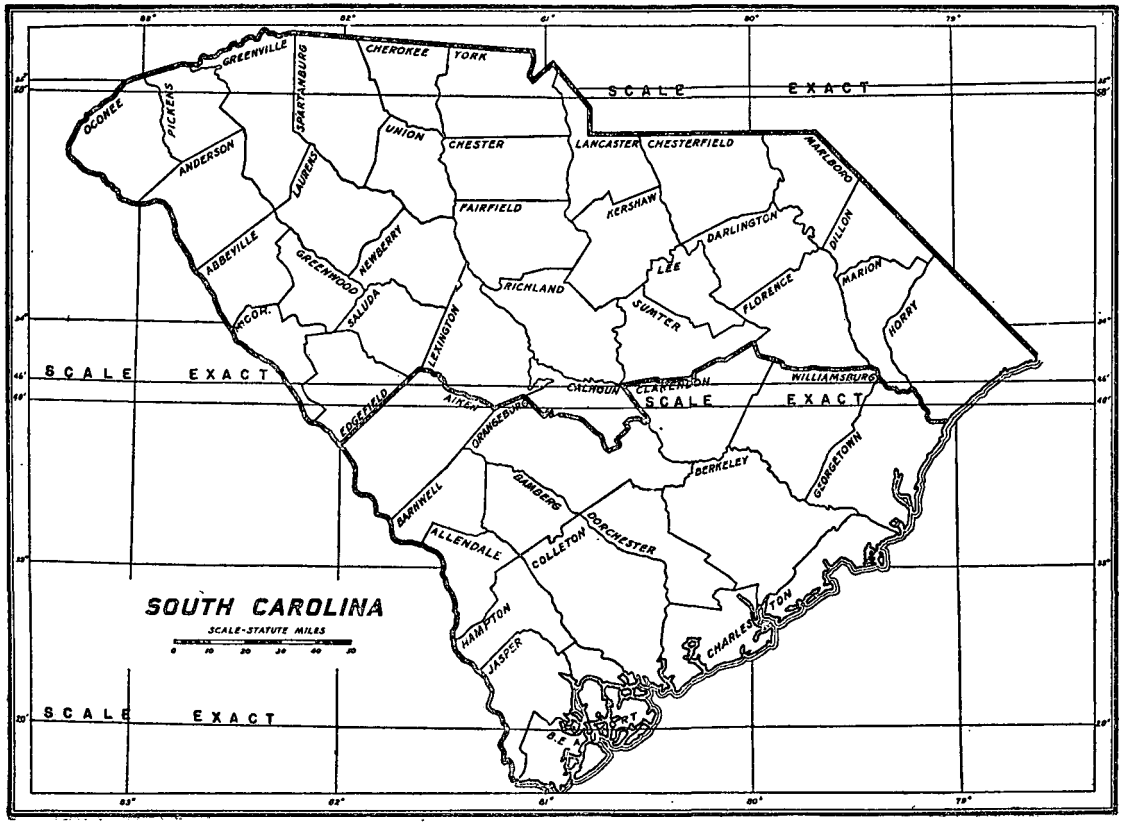

FIGURE 63.—Map of South Carolina with grid system outline.

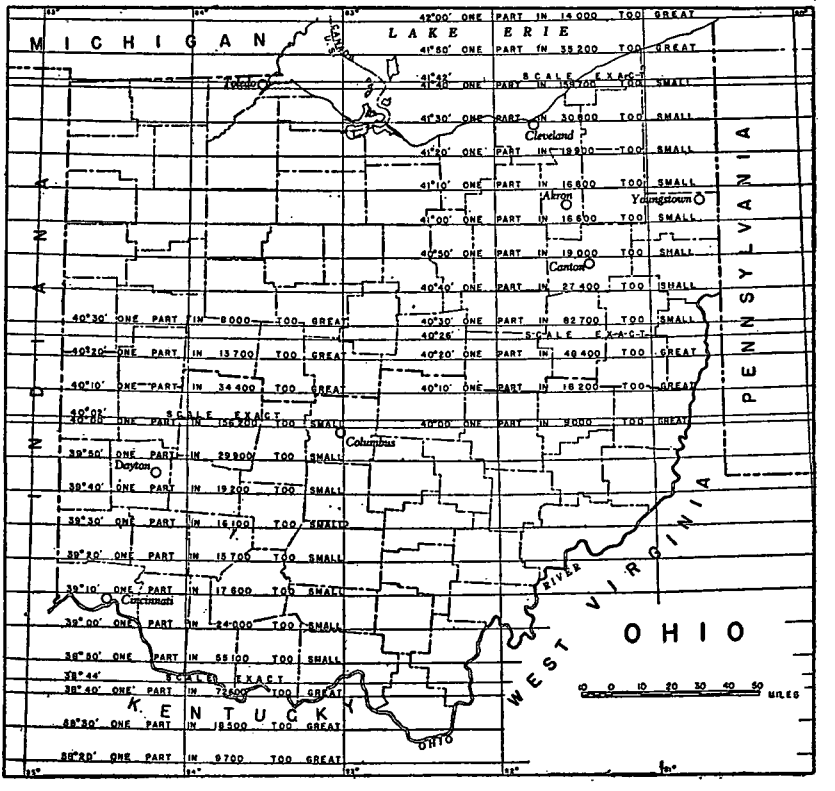

FIGURE 64.—Map of Ohio with grid system outline.

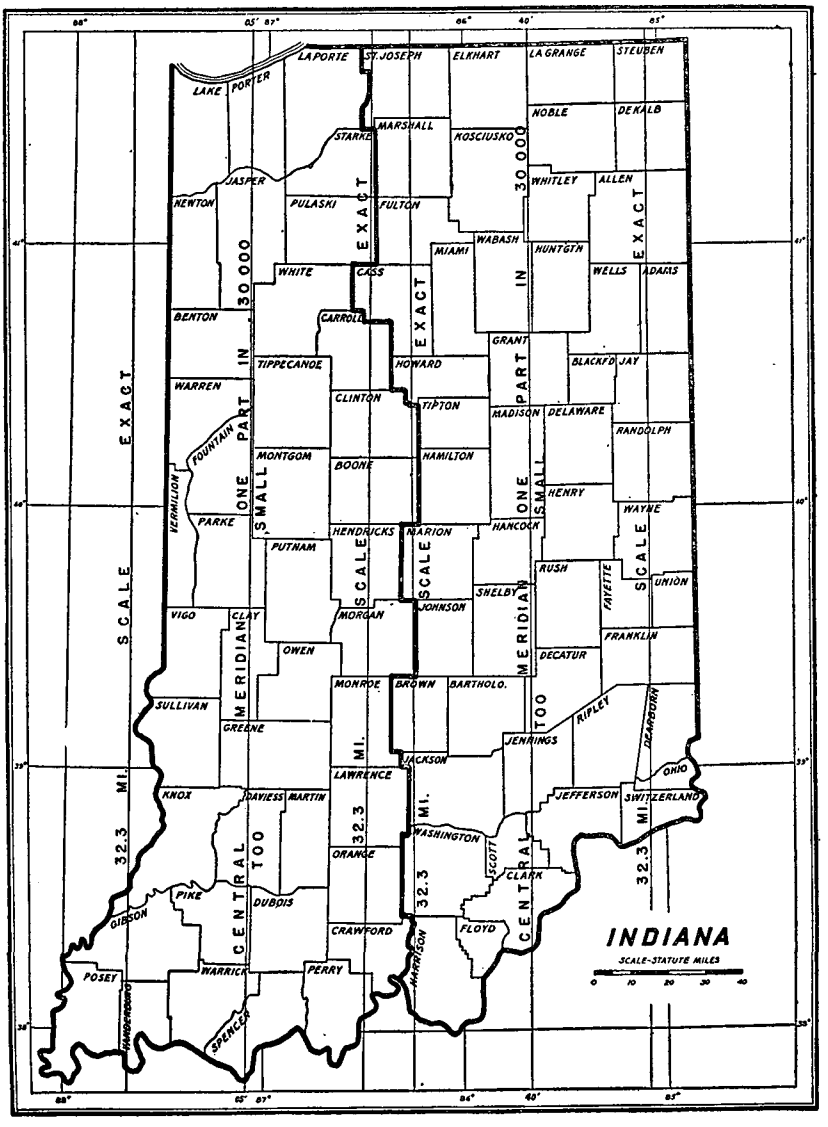

FIGURE 65.—Map of Indiana with grid system outline.

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